The work environment

Workplaces

Workplace layout design must take into consideration multiple users and the movement of people and materials. It covers more than the individual workspaces and looks at access between workspaces and other functional areas of the organisation eg stores, maintenance, plant room. A workplace can be within a building, a construction site or a mine site; the cab of a vehicle or quite literally 'out in the field' in the case of geologists, farmers, surveyors or environmental officers.

The layout of any workplace should consider traffic flow with the view to reducing slips, trips and falls; manual handling risks; traffic accidents involving vehicles eg forklifts; emergency and fire escapes.

Layout of workspaces

Workstations and workspaces are the immediate physical surroundings of the worker. They can serve a range of different purposes from being the area in which a person works all day to an area that is used by a variety of people for different purposes intermittently. They can be discrete areas such as a computer workstation or part of a larger work area such as a workshop or production line area. No matter what they are workplaces must conform to basic ergonomics principles to accommodate users.

Workspace size

The workspace itself must be of a suitable size. Often this is dictated by external factors that have nothing to do with the people working in the area, the equipment they are using or the activities they are performing.

Within buildings limitations in space and location may be related to the cost of rent, building availability or a lack of planning. Sometimes functions outgrow spaces: more and more people and/or equipment are fitted into the same space and arrangements become increasingly ad hoc. Redundant or infrequently used equipment may not be removed or relocated and may be left to clutter the work area. Lighting, temperature control and ventilation may be inappropriate for changed functions and arrangements. In these cases review is needed urgently. However, no matter how adequate they may seem all workspaces need regular reviews to ensure that they are satisfactory and provide a safe and healthy work area.

In mining and similar industries such as construction and agriculture a person's workspace may change constantly or may be mobile such as the cabin of a piece of plant or machinery. These may be difficult to control fully due to the requirements of the building, farming or mining process. In these cases the same rules apply – the workspace must be adequate for the workers and the functions that they need to perform. The longer the worker is in the workspace during a work shift the more critical the design becomes.

One area of concern when considering workspace size is access by maintenance personnel to machinery in a breakdown situation. Environmental conditions in the field may be difficult and these are compounded by difficult and even dangerous access to components and parts of the machine. Heat, cold, excessive moisture, mud, dust, fumes, restricted spaces and difficult access may add to the problems normally experienced in a workshop where mechanical aids and some protection from the elements are available. Under these conditions each task needs to be assessed for ergonomics risks in conjunction with accident and production risks.

Workspace arrangements

The arrangement of the individual workspace is important especially when the work is stationary and performed in either the sitting or standing position. It depends largely on the type of work being done and the equipment being used. The physical arrangements must permit correct and appropriately supported work posture and unimpeded movements by each worker. The workspace arrangements may have to be modified by for each individual if the work is critical.

A number of competing demands may make it impossible to have a perfectly arranged workplace or to meet all recommendations simultaneously so the aim is to achieve an optimum overall. In any workspace there needs to be sufficient space for the use and storage of a range of equipment including tools and appliances, lifting aids, components and spare parts, computer- related equipment and supplies, manuals and reference material, personal protective equipment (PPE) and fixed items.

The location and storage of tools, fixtures, equipment and material used at the any workstation should be within the reach of the worker and not cause awkward postures during use. In some cases where items are used intermittently it may be preferable to store them away from the workstation. This has two benefits: it allows the employee more space and encourages them to get and move about from time to time. (See also Posture and Movement; Task Design)

In order to accommodate the user the following requirements need to be taken into account:

- horizontal work area;
- work height (the height at which the hands are working);
- adequate viewing distances and angles;
- sufficient leg space for seated or standing work;
- sufficient head space for adequate clearance for the tallest person when standing straight;
- reach distances should not exceed those of the smallest people;
- seat – area needs to be sufficient for easy access and correct adjustment;
- hand tools – both use and storage;
- all loads including tools should be stored so that they can be handled close to the body and at about waist height. Avoid deep storage bins; low, deep or high shelves for heavy or awkward items, and ensure that walkways are kept clear;
- fixed and moveable equipment – proximity to the work area, access, use and storage;
- the flow of product or components;
- size, shape, location and surface of steps. On vehicles and machinery they need to be a minimum of 200 mm deep, the lowest step should be a maximum of 400 mm off the ground and at least two boot widths wide;
- design and location of handrails. These need to be within reach of the smallest person and must comply with the relevant Australian Standards.

Workshops and other industrial work areas

In designing workshops and other industrial work areas, the following factors should be considered:

- **access –** hatches, steps/stairs and walkways need to be adequate for the biggest person wearing PPE and carrying equipment such as tools and testing devices;
- **size of the work area –** the largest workers should be able to adopt comfortable work postures in the work area and it should also accommodate all the equipment that is required to do the work safely;
- **the design and selection of tools and job aids –** particularly where access and workspaces are limited may need special attention;
- **temperature and other environmental conditions –** humidity, heat, cold, fumes, oils and dusts need to be measured and any unwanted effects on the worker must be controlled;
- **visual requirements of the task –** need to be assessed and any special requirements must be met especially where workers need to wear protective or prescription eyewear;
- **noise levels –** currently must be below 85dbA or suitable hearing protection provided. Environmental conditions such as heat and humidity may need to be reassessed if hearing protectors are worn;
- **wearing of PPE –** needs consideration in task and workplace design eg hearing and eye protectors, hard hats, cap lamps and batteries, self-rescuers, and gloves.

Designing for maintenance tasks

There are a number of considerations for maintenance personnel when working on machinery either in a workshop or in the field. Most of these relate to poor access, restricted work spaces especially when large tools need to be used or PPE must be worn, inadequate tool selection and/or design, heat and cold, poor visibility, noise and environmental pollutants.

In the last few years manufacturers have made significant design changes to plant to reduce both the time required to undertake routine maintenance and the health and safety risks for maintenance personnel.

Ergonomics design and risk assessments are now required for the design, manufacture and registration of plant in some Australian states through the respective OHS legislation. There is a lot of information on body size and strength and this should be used to ensure that workspaces for maintenance personnel are adequate. (See also Posture and Movement; Body Size; Physical Strength and Work Capacity)

The following design issues need to be considered in any workplace but especially in workshops, industrial and construction areas and for maintenance tasks:

Design issues

- Free, even and uncluttered walkways on and around the machinery and equipment wide enough to be able to walk forward are provided.
- Changes in levels of walking surfaces are minimised.
- Slip and trips hazards are eliminated (this includes maintaining temporary floors and uneven ground which may be a work area or walkway).
- All holes or depressions where a foot could get stuck or which may pose a trip or a fall hazard are covered or otherwise eliminated.
- Well-designed steps, footholds and ladders for access to the machinery and equipment are provided.
- Sharp edges and protruding obstructions are minimised or eliminated.
- Slip-resistant surfaces on all walkways and steps are provided.
- Work areas are lit adequately.
- Loud noise is controlled at source.
- Work areas are designed to minimise the use of PPE.
- Work areas can accommodate the number of people required to do the job without posing a hazard.
- Height and space restrictions are minimised.
- Pinch points and moving parts that could crush hands, feet, or the body are eliminated.
- Designated storage areas for supplies and equipment with adequate, safe access are provided.
- Reach distances are minimised or reduced especially for moving and handling loads.
- The need for bending especially bending with twisting is minimised.
- There is adequate access and visibility for maintenance and routine checks.
- Minimal work is carried out above the shoulders or below the knees.
- There is minimal manual handling of supplies and equipment, most particularly double or multiple handling.
- There is an optimum location for operators on or near machinery and equipment while working.
- All sized users are considered in the design of the work areas.

KEY PRINCIPLES

- Workspaces must accommodate all users, their equipment and the tasks to be carried out.
- Special consideration needs to be given to access and conditions for maintenance tasks. This may involve specifying or modifying machinery design to meet the requirements of OHS legislation.
- Review workspaces regularly for their suitability for current tasks and users.

Further reading: *• Book 4: Stevenson • Book 5: Clark & Corlett • Book 7 Woodson, Tillman & Tillman • Book 11: Officewise • Book 16: Diffrient, Tilley, Bardagjy • Books 17: Diffrient, Tilley, Harman • NOHSC 1.10: Plant in the Workplace (Employers and Employees) • NOHSC 1.11: Plant in the Workplace • NOHSC 1.22: Workplace Layout & Design*

Illumination and lighting

Whenever visual tasks are undertaken the light intensity (the amount of light which falls on the work surface), must be sufficiently high to allow them to be carried out rapidly and with precision and ease. Apart from light intensity, differences in luminance (contrast) in the visual field are also important. Luminance is the amount of light reflected back to the eyes from the surface of objects in the visual field.

Light intensity is expressed in lux, and luminance (brightness) in candela per square metre (cd m2).

In determining the amount of light that must fall from the surroundings onto a work surface, it is necessary to distinguish between orientation lighting, normal working lighting and special lighting.

Orientation lighting

Select a light intensity of 10-200 lux for orientation tasks. The minimum required intensity to detect obstacles is 10 lux. A light intensity of 10-200 lux is sufficient where the visual aspect is not critical, such as in corridors of public buildings, or for general activities in storerooms, provided no reading is required. A higher light intensity may be necessary for reading or to prevent excessive differences in brightness between adjoining areas. Where eyes need to adjust rapidly when moving between the areas, such as when driving into tunnels, reduce the differences in brightness.

Normal working lighting

Select a light intensity of 200-800 lux for normal visual tasks such as reading normal print, operating machines and carrying out assembly tasks. Where the details are small or hard to read, the person is older or has visual difficulties or where there are great contrasts of light such as near windows, more light will be needed.

Special lighting

Select a light intensity of 800 – 3000 lux for special applications. It is sometimes necessary to use desk lighting to compensate for shadows or reflection on the work surface. Intensive activities requiring precision such as visual inspection tasks require much higher illumination levels to distinguish fine detail.

Avoid excessive differences in brightness within the visual field. Reflections, dazzling light and shadows can all cause difficulty in seeing.

Use a combination of ambient (general) and localised or task lighting for localised tasks. In underground mining situations lighting may be provided by individual miners' cap lamps and machinery lights. In these situations problems can arise from the disabling glare of lamps shining in workers' eyes; shadows and perception difficulties presented by directional lighting; and inadequate light for a task. As well neck, shoulder and back strain can arise where there is a need to tilt the head backwards in order to see a task above the head. Poor lighting arrangements in mining need to be recognised and addressed on a case-by-case basis.

As well miners underground, use cap lamps for all sorts of signalling purposes. There can be problems however when there are misunderstandings or when new employees or visitors do not understand the protocols. Therefore these need to be formally recognised and communicated.

KEY PRINCIPLES

- Quality of light including source, direction, hue and intensity is often just as important as the quantity of light.
- Poor or inappropriate lighting can affect workers' health and safety as well as their efficiency.
- Poor lighting arrangements need to be recognised and addressed on a case-by-case basis.

Further reading: *• Book 1: Dul & Weerdmeester • AS 5.3: AS 1680.2.1:1993) • AS 5.4: AS 1680.2.2:1994 • AS 5.5: AS 1680.2.3:1994 • AS 5.6: AS 1680.2.4:1997 • AS 5.7: AS 1680.2.5:1997 • Other material 8.12: Ergonomics*

Noise

Most noise control programs concentrate on reducing the total amount of noise that a person receives each day in order to conserve his or her hearing. However noise can also be a nuisance without effecting hearing. Nuisance noise can be distracting, affect concentration and reduce productivity. It may also lead to early and unnecessary fatigue.

Noise can also be annoying or distracting and this can be tiring or even dangerous where critical tasks are being performed. In environments that are too quiet i.e. <30dB(A) any noise may become distracting or irritating. Usually a balance needs to be struck.

People react differently to noise but subjective responses should not be ignored, as they may be a warning that noise is excessive.

Noisy conditions can make conversation difficult. The following conditions can act as a guide if people are unsure if noise levels are unacceptable.

When noise levels are:

- above 80 decibels (dB) people have to speak very loudly to be heard;
- between 85 and 90 decibels people have to shout to be heard;
- greater than 90 decibels people have to move very close together and shout to be heard.

Apart from hearing loss and other direct health effects noise can be detrimental to communication and performance.

There are certain steps in identifying and assessing workplace noise problems and deciding what needs to be done. Precise measuring and analysis equipment is used to identify or confirm which people in any workplace are at risk of hearing loss due to noise exposure.

Controlling exposure

There are five basic steps:

- Identify areas of high noise levels;
- Identify those workers who are at risk, and measure their daily exposure;
- Conduct an education program, especially for those at risk, ensuring that supervisors and managers also attend.
- Prepare a noise control program under the headings:
  - engineering solutions (most preferred option);
  - administrative solutions;
  - personal hearing protectors (least preferred option).
- Determine the most effective program in terms of protection and cost.

Isolating the person from the noise through appropriate engineering controls can protect hearing (eg enclosing the workspace from surrounding machinery) or the noise from the person (eg enclosing the source of the noise). Personal protective equipment (PPE) such as earplugs or muffs is less effective but more easily implemented. This equipment may interfere with communication and can cause ear problems in hot, damp environments.

Engineering solutions

The following general guidelines to control damaging and nuisance noise at source apply to all workplaces:

- to preserve hearing keep the noise exposure for each person below 80 decibels on average per day;
- minimise nuisance noise such as high pitch, unexpected or distracting noises for everybody;
- make sure that the general noise level is not too quiet eg <30 dB (A);
- In order to achieve this the following strategies may be employed:
  - use a quiet working method or isolate noisy stages of the process;
  - use quiet machines and make sure they are well maintained;
  - enclose or isolate noisy equipment;
  - separate noisy and quiet work;
  - use sound absorbing materials in the workplace such as the ceiling and screening.

Administrative solutions

Sometimes it is possible to reduce exposures to noise by simply limiting the numbers of people in the area or restricting the times that noisy activities are carried out.

Use of personal hearing protectors

Hearing protectors are the least desirable method of controlling damaging noise. People have difficulty in wearing them in certain environments and where communication is important. However, sometimes they are the only reasonable option.

When choosing hearing protectors the pitch (frequency) of the noise must be taken into account. Different types of protective equipment have maximum damping effects in certain frequency ranges. Data on the characteristics of hearing protectors can be obtained from the suppliers. In order to encourage the use of hearing protectors, personal preferences in comfort and case ease of use must be taken into account. Different types of ear protectors should therefore be available.

- It is always more effective to control noise at source.
- Noise can distract and fatigue as well as damage hearing.
- Hearing protectors must be carefully chosen to provide the right amount of hearing protection as well as comfort and ease of use.

Further reading: *• Book 1: Dul & Weerdmeester • Book 7: Woodson, Tillman & Tillman • NOHSC 1.4: National Code of Practice for Noise and Protection of Hearing at Work • NOHSC 1.6: Management of Noise at Work • NOHSC 1.17: Noise • Other material 8.13: Physical Agents.*

Vibration

The two main types of vibration exposure are hand-transmitted and whole-body (WBV) and. Much is known about the effects on humans of hand-arm vibration but there has been less research into the long-term effects of WBV.

Hand-arm vibration

Hand-arm vibration usually arises from the use of hand held motorised power tools commonly with a frequency between 25 and 150 hz eg chain saws. The consequences for some people are disorders of the circulation of the fingers aggravated by cold (vibration white finger); tingling, numbness and/or reduced sensitivity and dexterity of the fingers; and muscle, joint and bone disorders. Once the conditions have become established they are not reversible so prevention through reduction of exposure duration and intensity is extremely important.

Vibration exposure

Vibration sources:

- Rough roads
- Vehicle activity
- Engine vibration

Modifying factors:

- Condition of roads and work surfaces
- Vehicle activity
- Type and design of vehicle
- Vehicle age and condition, suspension and maintenance
- Seat design, suspension and maintenance
- Cab layout, design and orientation
- Vehicle/Machine speed, driver skills and awareness
- Lighting and visibility
- Task design and work organisation

Figure 5.1: Vibration exposure

Whole-body vibration

Whole-body vibration (WBV) can be transmitted through the feet in standing work or, more likely, through the seat in seated work especially when operating machinery or driving vehicles. It is now believed that it may be a significant risk factor for the development of low back pain and other illnesses.

There appears to be three different scenarios where symptoms arise. The first is prolonged sitting; the second is where injuries result from a one-off severe jolt in an otherwise reasonable ride; and the third situation is where the onset of pain occurs after an extended period of moderate to severe jolts and jars.

WBV exposure arises from rough work surfaces, vehicle activity and engine vibration and there are range of factors that can either accentuate or reduce the impact of these.(See Figure 5.1)

WBV exposure can be measured and current standards give dose limits in terms of exposure times. The new Australian Standard AS 2670.1-2001 uses a combination of methods to assess if vibration and, in particular, jolts and jars commonly experienced in off-road vehicles and which are considered a risks to health. The vibration dose value (VDV) is one way of analysing vibration exposure with jolts and jars and appears to be a good indicator of what drivers, operators and passengers consider to be a rough ride. It is believed that rides with a VDV of ≥17 are likely to cause injury if exposure is prolonged and/or repeated.

In mining many rides exceed time limits for the likely health risk zone using different methods of analysis. The type of vehicle, its speed and condition (particularly its age and suspension system), and the condition of roads strongly influence ride roughness.

Figure 5.2: Drivers' subjective road roughness rating versus measured Vibration Dose Value (VDV)

Ways of reducing the impact of WBV include regular monitoring of vibration levels; operator training; limiting speed; prompt communication and correction of road problems; effective road maintenance programs; appropriate design of vehicles including the isolation of the cab in vehicles where vibration can be excessive; effective maintenance of vehicles; task variation and regular breaks out of the seat.

KEY PRINCIPLES

- Vibration should not result in discomfort eg seats should not 'bottom out' during a rough ride; hands should not feel numb after using vibrating hand tools.
- The duration and intensity of daily exposures should be monitored carefully and limited especially if symptoms such as back pain, headaches, nausea or numbness in the fingers are reported.
- The effects of aggravating factors such as cold and humidity should be minimised when using hand tools.
- The design of equipment can significantly reduce vibration during operation. Reducing vibration at source through the careful selection of tools, seats and machinery saves time and money.
- Equipment must be fit-for-purpose and used appropriately eg speed, type of work, techniques.
- Regular and thorough maintenance of machinery, equipment and tools must be undertaken to minimise vibration.
- Transmission of vibration should be prevented by the use of damping materials and suspension.
- Speed of vehicles and machines should be reduced as an immediate control of harmful whole-body vibration.
- Drivers, operators and users of vehicles and equipment must be competent in specific operating and driving techniques and adequately supervised.

Further reading: *• AS 5.10: AS 2670.1 – 2001 • AS 5.11: AS 2763.1 – 1988 • Book 8: McPhee, Foster & Long) • Book 15: Wilson & Corlett • Book 21: Violante, Armstrong & Kilbom. • Other material 8.13: Physical Agents*

Work in hot or cold environments

Work in the outdoors exposes employees to the extremes of weather and in particular temperature and may be complicated by the lack of facilities such as toilets, protection from the sun and wind and the provision of clean drinking water. In Australia, where heat is usually the main problem, there is also considerable exposure to cold either in the outdoors during winter or in cold stores.

There are six fundamental factors that define human thermal environments. The first four are air temperature; radiant temperature; humidity; and air movement and these basic environmental variables affect human response to heat or cold. Human activity and clothing also change an individual's response to thermal environments. All six need to be taken into account when designing work especially in extreme conditions. Temperature is important but should not be used as the sole indicator for action.

Other factors may also need to be taken into account eg behavioural factors that include:

- **clothing –** people may take off or put on clothes as their comfort dictates;
- **work postures –** especially those dictated by restricted spaces;
- **acclimatisation –** may influence the effects of heat and cold on individuals.

Individual tolerance to heat and cold

The effects of hot and cold environments vary between individuals. Some research indicates that distraction and /or arousal from feeling too hot or cold at work may reduce work performance and productivity, and could also result in increased absenteeism. Accident rates and unsafe work behaviours may also be affected by thermal comfort especially if people feel too hot.

There are large variations in individual responses to heat and cold and these will vary with the type of work being performed. Assess tolerable climatic conditions by using employee's opinions as well as observing their physiological responses (flushing, sweating, body temperature, skin temperature and heart rate), and changes in work performance. Decreased urine output, changes in behaviour and flushed skin may indicate dehydration and heat stress. Mild heat or cold stress will affect a worker's responses and their ability to perform work. Serious heat or cold stress can lead to strain and possibly death.

Humidity and wind speed

In the heat, humidity can alter a person's perception of how hot it is and his or her ability to undertake strenuous work may be reduced. In high heat and low humidity conditions, fluid loss may be rapid. However, the thirst mechanism in humans is not very sensitive so people exposed to heat must be encouraged to drink more and frequently before they feel thirsty.

The main factor, other than temperature, that produces coldness is wind speed. Therefore workers should be protected from wind in cold environments.

Measuring the effect of heat and cold

Any exact measure of heat and cold and their effects on an employee must take into account air temperature, radiant temperature, air velocity, humidity and the intensity of the work being performed. While there is no entirely satisfactory single measure of heat and cold stress various predetermined measures are available for different ambient and working conditions.

In neutral and cold climates the average resting body will lose about one litre of fluid per day while in warm environments about two litres.

Heat

Physical work raises the body's temperature and the increased heat is transferred to the atmosphere. If conditions impede transfer of this heat the body's temperature will start to rise. Such conditions occur with higher air temperatures (>30° C) especially in combination with higher humidity (>50%) and little airflow. If the worker is wearing heavy protective clothing and there is radiant heat from the sun the heat load on the body can be even greater.

The body cools itself mainly through evaporation of sweat. However, this fluid needs to be replaced by higher levels of water intake otherwise dehydration will occur. In high humidity the effectiveness of sweating is reduced. The body temperature may then start to rise and heat exhaustion and heat stroke can set in. Heat stroke can be fatal.

Heat disorders can occur for any of the following reasons:

- individual factors such as dehydration or lack of acclimatisation;
- inadequate appreciation of the dangers of heat by supervisors or individuals at risk;
- accidental or unforeseeable circumstances leading to very high heat stress.

Control of exposure to heat

As with most other areas of OHS, risks arising from exposure to heat can be controlled through engineering and administrative controls including training. The National Institute of Occupational Safety and Health (NIOSH) in the USA has devised the following control methods.

Engineering controls include:

- reducing the heat source by moving workers or reducing temperatures;
- convective heat control through cooling air and increasing air movement;
- radiant heat control by reducing surface temperatures, shielding etc;
- evaporative heat control through increasing air movement (fans), decreasing water vapour pressure (air conditioning), wet clothing.

Work practices include:

- limiting exposure time and/or temperature e.g. working at cooler times of the day, cool rest areas, extra personnel for job rotation and frequent breaks, increasing water intake;
- reducing metabolic heat through mechanisation, job redesign, reduced work times, increased personnel;
- enhancing tolerance times through heat acclimatisation; physical fitness; ensuring water and electrolyte losses are replaced;
- health and safety training including recognising the signs of heat illness; first aid and contingency plans; personal precautions; use of protective equipment; recognition of effects of non-occupational factors such as alcohol; and buddy system;
- screening for heat intolerance including previous illness and physical unfitness.

Additional programs include:

- Heat alert programs including planning for work in hot weather through timetabling and adequate information, facilities and personnel;
- Auxiliary body cooling and protective clothing including cooled garments and appropriate training;
- Understanding performance degradation when wearing all types of protective clothing including those that reduce heat loss or impair vision or hearing.

The mnemonic SHAFTS can be used to advise people how to increase tolerance to heat: the letters stand for sensible (ie appropriate) behaviour; hydrated; acclimatised; fit; thin; and sober (avoidance of alcohol and other drugs).

Working in the sun

Apart from the heat, the sun is now regarded as a major risk for skin cancer in outdoor workers especially those of European origin. The use of sun hats and other protective clothing, sun screens for the skin, sunglasses, the provision of clean drinking water and recognition of the need to take regular breaks from physical work in high temperatures should be mandatory in most outdoor jobs. These protective measures may alter the way the work is done and will need to be taken into account in the design of the work and the protective clothes, time schedules and payments for work done.

Cold

In air environments cold stress generally produces discomfort before any effect on health occurs. There is a strong behavioural reaction to cold and a person may avoid feeling cold with clothing, activity and/or shelter. Clothing helps reduce heat loss while activity raises the body's heat production. However if there are higher levels of activity sweating may occur and on rest heat loss and discomfort are made worse by damp clothing.

Cold can affect psychological responses including behavioural responses to increased discomfort. It can directly affect performance such as decreased arousal, reduced memory capacity, and perception. Changes can occur in mood and personality especially if the body's core temperature drops.

The effect of cold on the hands of individuals varies enormously under different conditions. These arise from a number of factors including size, structure and shape of the hand and fingers; contact force; surface temperature of the item being handled; material properties; surface mass; and the thermal condition of the whole body, the hands and fingers.

Control of exposure to cold

Workers in cool or cold climates, in cold storage facilities and in food preparation areas will need adequate protective clothing that takes into account the need to manipulate product, controls and tools safely and quickly. Therefore the wearing of bulky clothing, boots and gloves needs to be considered in the design of the job as well as for hand tools, access to and operation of machinery and the use of seating. Each job should be assessed for its particular requirements and reviewed on a regular basis.

The use of PPE such as gloves can minimise any harmful effects of handling cold items. Decreases in manual dexterity after contact with cold material may be offset by problems with dexterity when wearing gloves. However the design of gloves including thermal insulation and gripping qualities and their appropriate use needs to be carefully reviewed.

Issues that need to be addressed for workers in cold environments include:

- whether or not it is necessary for the workers to be in the cold environment in the first place. Are alternatives available such as the use of robotics or separating workers from the cold environments?;
- adequacy of clothing to protect from cold and the likelihood of sweating when workers are active;
- work practices encompassing appropriate behaviours e.g. wearing adequate protective clothing, length of exposure, activity, care when working with certain substances;
- monitoring air temperature, air velocity and equivalent chill temperature;
- screening workers who may have a reduced tolerance to cold.

KEY PRINCIPLES

- Ensure that there is accessible clean drinking water and encourage workers to drink adequate amounts of water in hot conditions. Drinking early and frequently is recommended.
- Protect workers from the sun, heat and cold winds.
- Provide workers with adequate, appropriately designed PPE for heat or cold.
- Provide workers with sun-screens, sunglasses, long sleeved shirts and long trousers when working in the sun.
- Provide equipment that can be used appropriately, safely and easily when wearing PPE.
- Ensure that work procedures are in place to reduce the risks of heat and cold stress. These include adequate work breaks, job rotation, extra personnel and job redesign.
- Train workers in the risks of working in hot and cold conditions and what they need to do to avoid problems including physical fitness, adequate fluids and limiting alcohol intake.
- Regularly monitor thermal conditions and workers responses to them.
- Consider alternatives to placing workers unnecessarily in hot or cold conditions.

Further reading: *• Book 15: Wilson & Corlett • Book 19: Parsons • Queensland DWHS 4.1: Heat Stress: Managing the Risk • Victorian WCA 3.1: Sun protection for Construction and Other Outdoor Workers • ACTU 7.2: Working in Seasonal Heat • Other material 8.13: Cold Environments – Working in the Cold • NOHSC 1.23: Comfort at Work – Too hot? Too Cold?*

Equipment design

Work stations, consoles, work benches

Considerations in designing workstations, consoles and work benches include:

- **horizontal work area –** these spaces need to include the use of materials, tools and equipment in the primary and secondary work areas and in the seldom-repeated activities in the tertiary work areas. The bench or desktop should be as thin as possible where people are seated usually no more than 50 mm. This allows the arms to hang by the side and manipulative tasks to be carried out at a comfortable height (about 500mm below elbow height);.

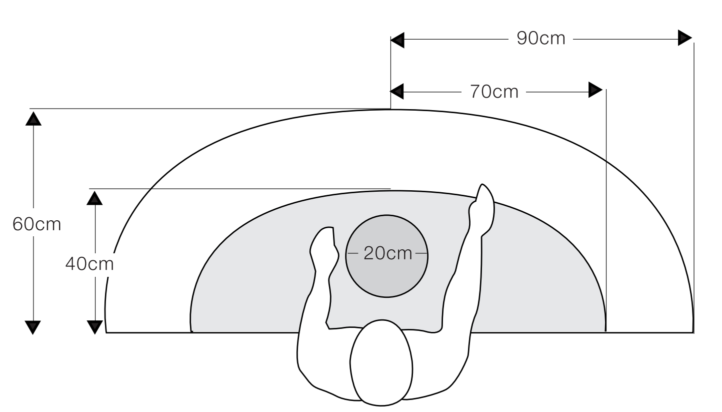


Figure 6.1: Horizontal work area

- **working position –** a sitting position is generally preferred for fine manipulation, and accurate control work; continuous light manual work; close inspection (visual) work; and where foot controls are regularly used. In sitting there should be enough space between the underside of the work surface and the seat for the legs and to allow movement. For standing work toe space should be at least 150mm in depth and height.

An operator should be seated for constant or repetitive use of foot controls. Where multiple functions are carried out the foot should be used for the grosser controls and the hand for the finer controls eg driving a vehicle.

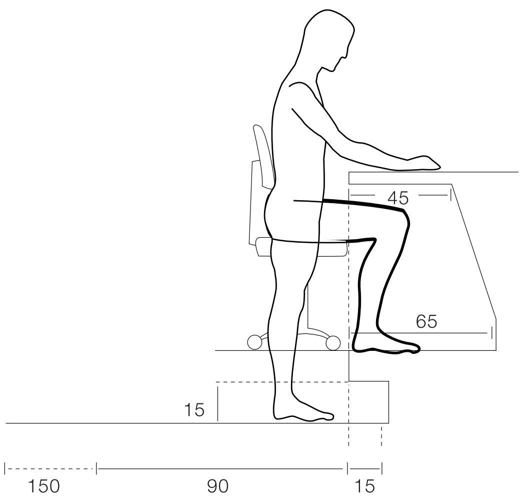


Figure 6.2: Leg space (cm)

A standing position is preferred where heavier manual handling work is performed; where there is no leg room under equipment; or where there are many controls and displays over a wide area that have to be monitored.

Standing work requires even, resilient floor surfaces such as rubber matting or carpet. This also reduces the risks of slipping.

Opportunities to sit or stand during the day, preferably as part of the job also should be included. Large and smaller users should be accommodated in these arrangements. This may be achieved with height adjustable seating, height adjustable work benches or an adjustable standing platform.

• **work height –** preferred work heights depend upon the nature of the task and the need for visual and manual precision as well as the handling of heavy components.
In most manual tasks the work height should be at a level just below the elbow with the upper arm held in a vertical position close to the body. For fine work involving close visual distances the work height should be raised to achieve this with minimal neck flexion and arm supports provided where appropriate.

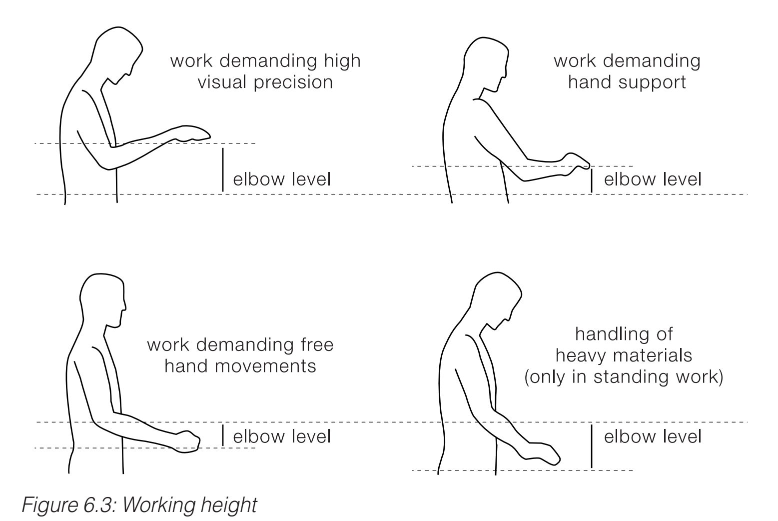


Figure 6.3: Working height

• **viewing distances and angles –** viewing distances for work should be proportional to the size of the work object. A small object requires a shorter viewing distance and a higher work surface. The most frequently viewed object should be centred in front of the worker. Recommended viewing angles vary depending on the work posture from 45° (forward leaning posture such as at a desk) to 15° (backward leaning such as in a control room) and how long a fixed gaze is required. Bent neck postures should not be maintained for more than a few minutes at a time without change. Distances should enable young and older workers to see properly without strain on the eyes or the muscles and joints

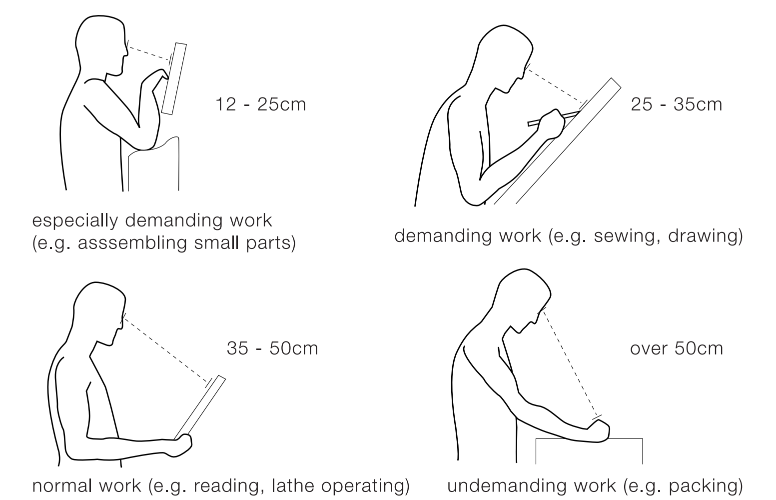
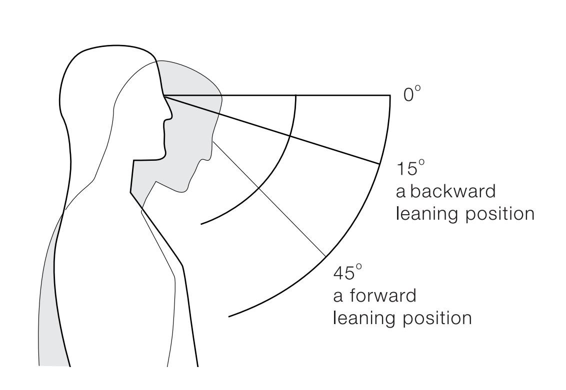


Figure 6.4: Viewing distances



6.5: Viewing angle

• **reach –** arm and leg reach should be based on the dimensions of the shortest user and take into consideration the postural, task requirements and working position (see Figure 6.1).

• **access and clearance –** space allowances for horizontal and vertical clearances and access to the workstation; access to machines and equipment used by operators and for maintenance personnel must be incorporated into the design of the work stations These allowances must be based on the dimensions of the largest user.

Tools

Tools are devices designed to extend human physical capabilities of reach, force application and precision movement thereby enhancing performance. Unfortunately they can also be a source of injury when inappropriately used or incorrectly designed. (See also Posture and Movement; Body Size; Physical Strength and Work Capacity).

Forces are generated from the human musculoskeletal system through the tool to the work piece and vice versa. Stresses arising from excessive forces and poor postures are frequently the result of poor tool design or inappropriate use. In some cases if a tool slips, breaks or looses purchase acute injuries can occur.

Tools are grasped in the hands and may be simple or may have controls. Generally mobile equipment is larger and is activated by controls eg handles, buttons, knobs, that have to be gripped, moved or turned by the application of manual or pedal force. These linkages become part of what is called the user interface. In some cases the status of the equipment can be transmitted to the operator through a display of some kind.

Handles

Gripping characteristics such as handle shape, palmar or pinch grips, output required eg power or precision work should be considered. Tools should have handles that have the proper shape, thickness and length to prevent pressure on the soft tissues of the hands and to allow a good firm grasp. They should be free of sharp edges and pinch points.

Insulate contact surfaces to prevent electric shock, burns or the transmission of unwanted vibration. Use low voltage electrical power and double insulation where possible.

Forces

The forces required to grip tools during use should be minimal and prevent slippage particularly where gloves are required eg hot, dirty or clean work. The grip surface should be compressible, non-conductive to vibration, heat, cold and electricity. Flanges can be used to stop the hand slipping down the tool or to keep a heavy tool slipping out of the hands when being carried.

If the tool is required to deliver power then it should have a power grip handle design ie the hand should be capable of gripping the tool with four fingers on one side of the handle and the thumb reaching around the other side locking on the index finger. (See Figure 5.6)

Where precision work is being required, the tool should have a handle that allows it to be gripped by the thumb and the first finger, or the thumb and the first and second fingers. (See Figure 2.5)

Design

All edges and corners of the tool and associated equipment should be rounded off and sharp, protruding elements avoided.

Tools should be designed so that they can be held and used with wrist and hand in the neutral position (See Figure 2.8) Where the task requires large forces or has to be performed over extended periods, the tool should permit the arms and shoulders to be used.

Align the tool’s centre of gravity with the grasping hand so the operator does not have to overcome rotational movement or tool torque.

Ensure that the transmission of noise and vibration is minimised. Guard all moving parts.

Type of operation

Power operated tools should be used instead of muscle power where possible. Using a single finger to operate a power tool is not recommended especially where it is repetitive and/or is required for extended periods. While the majority of the population prefers to use the right hand tools should be designed so that they can be used with either hand.

Weight

Tool weight should be minimal. Where tools are heavy counterbalancing devices can reduce the weight. The tool should be easy to set down and pick up.

Controls

The control levers, buttons and knobs should be within the reach of the worker when operating the equipment. The forces required to engage the controls should be within the worker's capabilities but not so light as to be inadvertently activated or difficult to control speed or force. The direction of movement of the controls should be consistent with the expected outcome eg moving the control lever forward moves the equipment forward. Ensure that weight-holding is separate from the force, guidance and control functions.

KEY PRINCIPLES

- General work position, body and hand postures need to be comfortable and stable.
- Stabilising work materials is essential and may need a jig or other mechanical device.
- Handle characteristics such as shape, thickness, length and contact surfaces are important for grip.
- Controls should be suitable for the type of tool and its use and appropriately located.
- The balance and weight of the tool should enhance its operation and make it as easy as possible for the user to operate correctly and precisely.
- The tool and the work need to be clearly visible while setting up and operating.
- All necessary information on the operation and guidance of the tool needs to be available through training and/or manuals. Manuals need to be properly indexed and easy to use.
- Tool holders may be required between uses. The tool may also need secure storage.
- The electric cord position and the location and operation of controls should enhance operation.
- Guards should be used to protect users and others from moving parts. Debris and sparks need to be minimised.
- Adjustments should be easy to use and give the user feedback on the correct adjustment positions.
- Reduction of vibration, noise and heat may be required where these exceed accepted standards.
- Safety features such an emergency safety switch and prevention of electric shorts need to be incorporated in electrically powered tools. Refer to relevant Standards.
- Maintenance and repair schedules should include day-to-day checks and services, the prevention of parts loosening, as well as planned services after longer periods of operating. These procedures need to be clearly specified and documented.

Further reading: *• Book 3: Sanders & McCormick • Book 4: Stevenson • Book 6: Stevenson • Book 7 Woodson, Tillman & Tillman • Other material 8.12: Ergonomics*

Mechanical aids

Job aids need to be well designed for the purpose and readily accessible if they are to be used when they should. For instance lifting aids need to be compact, easy to move and use, stable and safe. Storage is often a problem and this needs to be considered when purchasing. In some cases moveable lifting aids such as cranes and hoists can be installed overhead thereby overcoming storage problems.

Height adjustable benches and jigs need to be sufficiently adjustable to accommodate all users and work tasks. Anthropometric tables (ranges of people sizes) are often used to guide designers in this. (see also Body Size) Adjustments should be easy and quick to make from the working position.

Wheels on mobile equipment should be of sufficient diameter to enable them to be rolled over rough or uneven surfaces without undue force and without the risk of sudden uncontrolled movements.

Maintenance programs must ensure that job aids meet legislative requirements and function as the manufacturer advises.

Further reading: *• Book 16: Diffrient, Tilley, Bardagjy • Books 17: Diffrient, Tilley, Harman • Book 4: Stevenson*

Displayed and oral information

Ergonomics is concerned with all aspects of communication but most importantly it has contributed substantially to our understanding of displayed and oral information (machines communicating to people). It has also developed some basic principles for communication systems.

In all jobs the communication of information is important. In some jobs it is critical. Depending on its nature and how essential it is to communicate precisely and quickly there are a range of methods that can be used. The objectives of a communication system are:

- **detectability –** the intended receiver can sense the signal;
- **recognisability –** the intended receiver can tell what the signal is;
- **intelligibility –** the intended receiver can tell what the signal means;
- **conspicuousness –** signal is attention-getting.

Consider:

- **Types of information –** Are they spoken messages, flow charts, task surveillance information, pictures?;
- **Time factor –** How rapidly must the information be transmitted?;
- **Number of intended recipients**;
- **Receiving environment –** Is there interference, noise?;
- **Reliability –** Can it be repeated if necessary?;
- **Quality –** Are there accents? What is the level of intelligibility? Is there use of jargon or specific terms?;
- **Language –** People whose first language is not English need to understand and be understood;
- **Personal factors –** Are recipients able to see facial expressions or hear voice inflections?;
- **Directionality –** Are they able to identify the source or the direction of information?;
- **Message capture –** Does there need to be a record of the transmission?;
- **Condition of the recipient(s) –** How busy are they? Are they using hands and eyes for other tasks? Is there physical stress such as vibration?;
- **Critical nature of the information –** What happens if the information is not transmitted or received correctly?

Further information on the design and use of auditory and visual communication can be found in ergonomics textbooks.

Visual displays

Increasingly people are using visual displays for the transfer of information. Simultaneous perception of a large amount of information by humans is best achieved through the eyes and the form in which it is presented must be suited to as many people as possible. Therefore information displays should be clear, concise and precise. There should be no doubt about what information is being communicated to the user. In order to achieve this a range of design rules applies.

Displayed characters may be illuminated such as on a computer screen or on a flat surface such as on the page of book. For legibility consider size, shape, spacing and contrast. In continuous text lower case letters are preferable to upper case. Capitals should be reserved for the first letter in a sentence, and for headings, titles, abbreviations and proper nouns. Use a familiar typeface, plain and without ornamentation. Use proportional spacing for letters and do not right align as the spaces become disproportionate to the words, making it harder to read.

KEY PRINCIPLES

- Use the simplest display concept appropriate for the information transfer needs of the operator.
- Use the simplest display format appropriate to the accuracy required.
- Use the most natural or expected display format for the type of information represented.
- Use the most effective display technique for the viewing environment and operator viewing conditions.
- Optimise the following display features:

  visibility – taking into account viewing distance, size, angle, contrast, glare and illumination and any visual problems in operators

  conspicuousness – ability to attract attention and to be distinguished from background interference and distraction

  legibility – pattern discrimination, colour and brightness, contrast, size, shape, distortion and illusory aspects

  interpretability – how well viewers understand the meaning and apply to their tasks.

Apart from the design of the display its location is critical. For information to be read and interpreted correctly it must be in the user's line of vision, it should not have reflective surfaces or be able to be degraded by high levels of light. The more critical the information the more it must be easily seen and interpreted.

If analogue displays are used (dials and pointers) to indicate levels or speed for instance be sure that increments are sufficient to be able to be detected and they are not subject to parallax error.

Displays should be readable from the user's position without them having to use awkward postures or movements. This is particularly important when information is critical. All information necessary to the normal functioning of the machine, equipment or system needs to be displayed in a readily interpretable form.

Instruments and other visual displays

The design of information displays and instruments should enhance the operator's capacity to determine the state of the machine accurately, easily and when it is needed. The aim is to minimise errors, operator fatigue and wear and tear on machinery.

KEY PRINCIPLES

- Location and layout of the displays need to comply with relevant standards and should be clear and readable from the operator's position.
- Displays should be grouped and/or located according to their function, the critical nature of the information and the frequency of usage. All principal displays need to be in the direct line of sight of the operator.
- Displays that are used infrequently may be out of the direct line of sight but information needs to be large and clear enough to be seen under sub-optimal conditions.
- Provide all the necessary information for operator's to make well-considered decisions.
- Do not provide unnecessary information that may clutter the visual field and/or confuse.
- The purpose and location of all displays needs to be clear.

Further reading: *• Book 3: Sanders & McCormick • Book 7: Woodson, Tillman & Tillman • Book 5: Clark & Corlett • AS 5.14: AS 2956.5: 1988 • AS 5.15: AS 2956.6: 1988*

Warnings

A warning is a message that is intended to provide information concerning a possible unpleasant or negative consequence of either an action or a non-action. Warnings can be provided in several ways:

- **verbal speech –** warnings given by co-workers or supervisors;
- **auditory non-verbal signals –** the timer on the stove sounding that food is cooked;
- **visual signals –** traffic lights;
- **signs, labels or symbols –** a traffic stop sign or a warning label on a hazardous substance or the non-smoking symbol.

The type of warnings given will depend largely upon the situation and for whom the warning is intended. For example, an auditory non-verbal signal would be lost in a noisy work environment.

Organisations should consider what type of warning would be suitable to use in a particular circumstance and ensure that the warning is appropriately designed. For example, when using written signs to convey a warning message, the type of language used in the message should be taken into account. Use short statements in plain language with symbols where appropriate. Colours of the sign, the typeface and the suitable placement of the sign in the workplace need also to be considered.

Where the operator might be in a fixed position the visibility or audibility of warning signals need careful attention.

Colour-blindness needs to be considered where red/green combinations might be used for danger and operational status.

KEY PRINCIPLES

- Warning lights alert the operator to a situation that makes the system inoperative (an error or failure) or may cause damage to the machine.
- Warning lights should be red.
- Yellow lights should alert the operator to a situation where caution, recheck or delay is necessary and if not attended to could lead to a dangerous situation.
- Green should indicate that equipment is operating satisfactorily or that the operator can proceed. It can also indicate the successful completion of steps within a process.
- White should indicate status, alternative functions, selection modes, a test in progress or similar items that imply neither success nor failure of system conditions.
- The use of flashing lights should be minimised and used to increase the conspicuousness of the signal and to alert the operator to a potentially dangerous situation.
- Flashing red lights should be used to indicate extreme danger.
- They should be located directly in front of the operator.
- Warning lights should be clearly visible.
- Redundancy (additional) indicators such as auditory signals should be provided where further information on the status of the system is required.
- Be aware of the need to check individual’s ability to discriminate between colours e.g. colour-blindness especially red/green.

Note: Local or industry standards for displayed information may give contrary information to Australian Standards. The most appropriate Standard must then be followed.

- Additional, auditory alarms may be included to bring the operator’s attention to a problem immediately.
- Auditory alarms should not be used simply to indicate the status of the system.
- Auditory alarms should be able to be heard and identified either through pitch or frequency or both.
- Very loud signals are not acceptable. They may startle listeners, may distract them in an emergency or a critical task and may cause temporary deafness.
- The audible alarms are often unnecessary if the colour coding conventions for visual alarms are followed.

Safety signs

The primary objective of safety signs is to warn or caution. The device should be noticeable, recognisable and understandable. They may fall into specific classifications of warning or caution signals or signs; or hazard advisory or instructional. They need to meet the following criteria:

- **conspicuousness –** the sign should stand out and be located where most people would look;.
- **emphasis –** words or symbols should imply danger. Words such as 'danger', 'hazard', 'caution' and 'warning' are suitable. Symbols should be standardised and immediately indicate the nature of the hazard;
- **legibility –** when words and messages are used the size and style of letters and contrast with them and the background need to be sufficient to be read. A border separates the message from the background;
- **simplicity –** use as few words as possible; keep information short and simple; tell the observer what to do or what not to do; avoid acronyms or abbreviations;
- **intelligibility –** say exactly what the hazard is and what might happen if the warning is ignored;
- **visibility –** make sure that the sign is visible under all expected viewing conditions;
- **permanence –** devices and sign materials need to be resistant to aging, wear, soil, vandalism and deterioration due to sunlight or cleaning;
- **standardisation –** use standard signs and symbols where they already exist. If local, long-term usage is likely to be better understood this might be acceptable. However, consider interpretation by visitors and newcomers. Wherever possible ergonomics principles should apply.

Further reading: *• Book 3: Sanders & McCormick • Book 7: Woodson, Tillman & Tillman • AS 5.8: AS 1319: 1994*

Controls

Layout

Specific considerations in the design of controls should include the following:

- Laid out and designed for easy and safe operation, and to prevent confusion over allocation of control functions or direction of operation. When operators are moving from machine to machine with similar functions controls should be standardised for position, function and operation as far as practicable;
- Organised into primary and secondary groups;
- Arranged so that similar functions are together (dissociate if confusion is likely) and position with sufficient space between controls to prevent unintentional operation;;
- Backlit with a dimmer switch for easier identification at night;

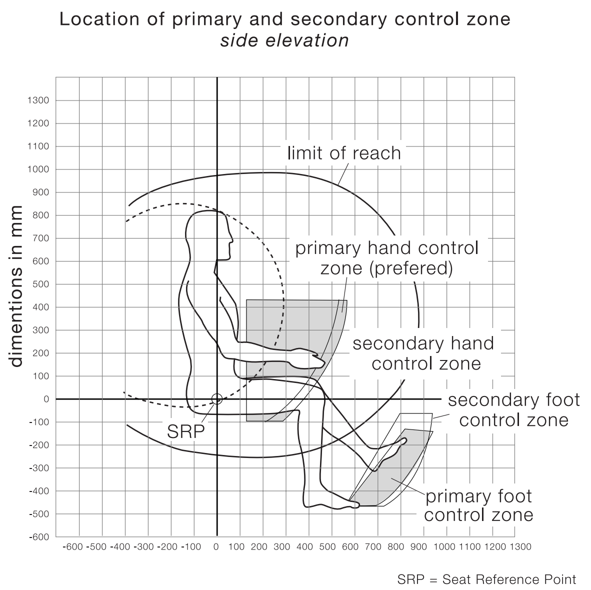


Figure 6.6 (A): SAE envelopes for cab design

- There are safeguards against accidental or inadvertent operation for critical controls eg locate out of easy reach; separate; or use guards, recessing, collars or an opening cover.

Shape and size

Each control should be readily distinguished by its location, type, shape, feel.

The size, shape, colour and location of knobs and switches and other controls must be matched to usage and their importance.

Size should accommodate large feet (pedals) or small/large hands and account for the need to wear protective clothing like gloves or safety shoes

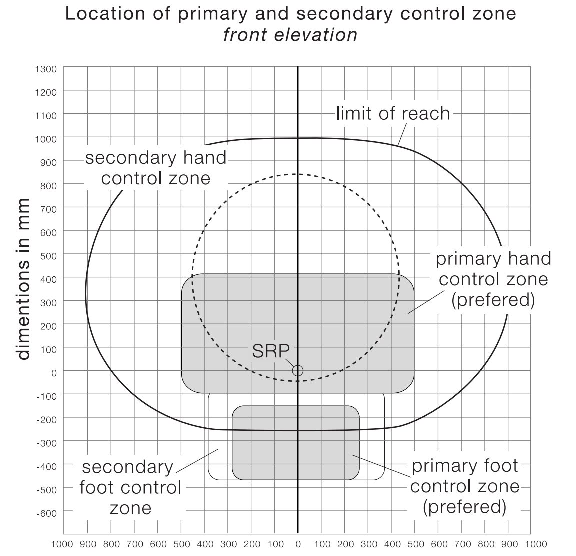
Movement, effort, resistance and feedback

Movement of controls should produce a consistent and expected effect.

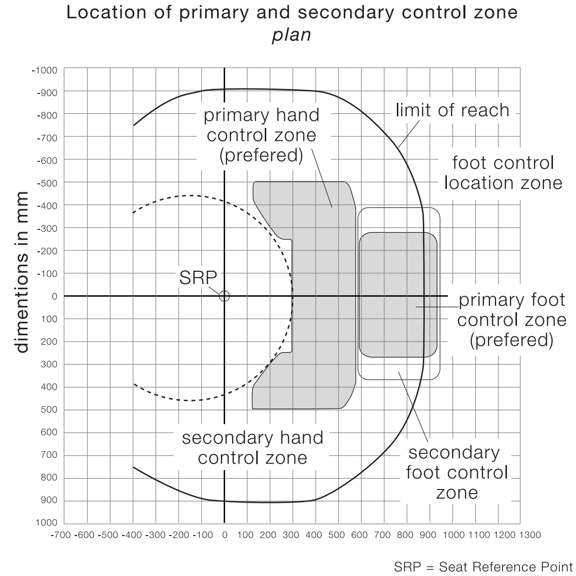
Control force and function need to comply with conventions. Recommended control motions should be observed

Optimum force should be required to activate control and movements should be consistent with the natural movements of the arms or legs. Angle of push or pull should be designed for optimum control and movement. Control type should be selected to provide the most appropriate movement or activation control eg levers for the application of force and speed, smaller controls for fine control and accuracy.

Controls should provide feedback so that operator knows at all times what his/her input is accomplishing. They should have distinct resistance gradients at critical control positions.



Diagrams 6.6 (B): SAE envelopes for cab design



Diagrams 6.6 (C): SAE envelopes for cab design

Function	Direction
On	Down (switches), right, forward, clockwise, pull (pull/push type switch)
Off	Up (switches), left, backward, anticlockwise, push
Right	Clockwise, right
Left	Anti-clockwise, left
Forward	Forward, down
Reverse	Backward, upward
Raise	Up, back, rearward
Lower	Down, forward
Retract	Up, backward, pull, anti-clockwise
Extend	Down, forward, push, clockwise
Increase	Forward, away, right, clockwise, out
Decrease	Backward, towards, left, anti-clockwise, in
Open valve	Anti-clockwise
Close valve	Clockwise
Emergency stop	Push button or pull cord
Remote shutdown	Left, backward, push (switch knobs), up switches

Table 6.1: Direction of movement for controls

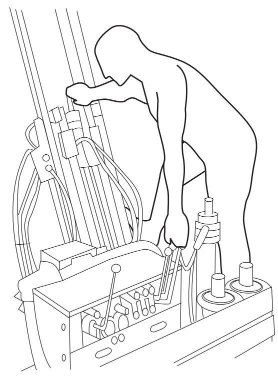


Figure 6.7: Reaching to poorly located and designed bolter controls

Static friction should be minimised (resistance to control movement initiation) as use of excessive force may cause overshoot and correction may be required.

Sensitivity of adjustment controls should be related to the degree of control required especially if they are heavy. Excessive force should not be required for small increases. For instance small movements should not produce large unwanted increases e.g. volume control.

Labelling and identification

The purpose and location of all controls must be clear. Controls should be marked with etched labels or permanent paint of contrasting colour ie white on black or black on white.

Lighted switches can provide quick identification and feedback on condition and function.

Remote control devices

Special attention needs to be paid to the design of remote control devices and there are many aspects where incorrect design could cause disastrous consequences. As a result an Australian and New Zealand Standard has been written to cover this area in mining.

KEY PRINCIPLES

- ***Type of control –*** consistent with the natural motions and postures of the operator's arm and hand or leg and foot.
- ***Feedback –*** the operator knows at all times what his or her input is accomplishing.
- ***Resistance –*** sufficient to dampen inadvertent inputs but not so much as to cause fatigue.
- ***Position of the control –*** the operator does not have to assume awkward postures or long reaches and the control can be manipulated through the entirety of its range. Postures adopted for continuous operation are comfortable eg accelerator pedals.
- ***Size and shape –*** should be compatible with the size of the operator's hands, fingers or feet. Consideration should be given to the wearing of protective clothing such as gloves with sufficient space between controls to prevent inadvertent contact or activation of other controls. The shape of the control should be compatible with the grip or motion required.
- ***Interface surface –*** should depend on the operation required. Surfaces should not be too slippery, sticky or abrasive or have prominent parts that cause injury.
- ***Undue pressure –*** smoothness may be required where changes of position are required. Knurling or serrations for fingers are not recommended in most situations because these can only suit one hand size.
- ***One-handed versus two-handed operation –*** two-handed controls may provide more precision but should not be used when an additional control is required to be operated simultaneously.
- ***Remote control devices*** need to conform to Australian Standards.

Further reading: *• Book 3: Sanders & McCormick • Book 7: Woodson, Tillman & Tillman • Book 5: Clark & Corlett • AS 5.14: AS 2956.5: 1988 • AS 5.15: AS 2956.6: 1988 • AS 5.9: AS/NZS 4240:1994*

Chairs and seating

Seated work and sitting postures

Standard work postures recommended in most guides and textbooks are a starting point for seat and work height adjustment. No posture, no matter how good, can be maintained for more than 15-20 minutes before small changes are required. No seat, no matter how comfortable, will allow the user to sit comfortably for more than about an hour at a time without having to move and make significant changes in posture.

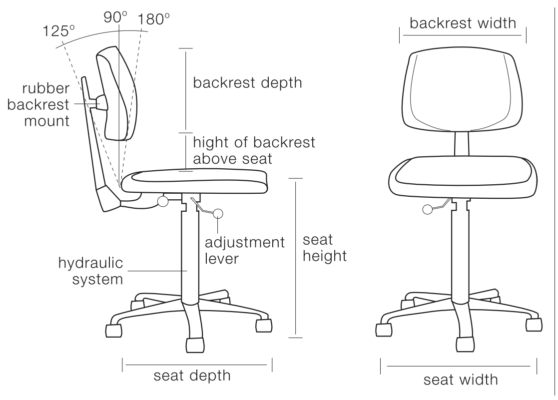


Figure 6.8: A basic office chair for computer, office and control room work

Therefore seated work should be mixed with standing and walking. The best way to guarantee that this happens is to design work with a mix of tasks that require employees to get up from a seat and stand and/or walk.

Work at desks and standard-height workbenches require a standard adjustable work chair.

Work at sit/stand workstations may require a higher chair. However, these can be unstable and are not recommended where alternative arrangements are possible. In some cases some work can be done in sitting in one part of the work area and in standing at another part. This may require more space as well as planning.

Work chairs

Designing optimum chairs is an ongoing process with much work still to be done. Nevertheless the basic requirements for a work chair do not change. It should provide adequate support for the user while working, should not place any unnecessary stress on any part on his or her body and should positively encourage optimum posture while allowing for comfort and efficiency and minimum muscle fatigue.

There are three major factors that have to be considered when sitting on a work chair.

1. The posture of the spine and in particular the position of and the pressure within the discs;
2. The type and amount of muscle work required to maintain work postures (static and active) and individual fatigue tolerance levels;
3. Compression of tissues (blood vessels and nerves) particularly at the back of the thighs and behind the knees.

Non-adjustable chairs are used in common areas such as tea or waiting rooms, where people are not required to sit for long periods in the same spot every day, or where chairs may need to be stored from time to time. These should suit most of the population (middle 90%) to a reasonable degree. The seat height should be in the range of 410–430 mm with a seat depth of no greater than about 360 mm. The seat should have a backrest which is from 80–130 mm above the seat and where practicable (indoors) should have sufficient padding to prevent ‘bottoming’.

Ergonomics considerations for work chair comfort

- as a starting position elbows should level with the work height, forearms horizontal and upper arms hanging freely.
- the head should be able to held erect with the backrest of the seat conforming with the curve of the lumbar spine.
- there should be room for the buttocks below the backrest.
- there should be adequate space forward for the legs stretched out and for knees and thighs under the bench top or desk.

- chair height should be sufficiently adjustable in relation to work height and lower leg length to accommodate tall and short people.
- feet should be placed flat on the floor to reduce pressure on the soft tissues at the back of the thighs. Very small users may need an adjustable footstool even when the seat height is adjustable.
- the backs of the knees should be free from the front edge of the seat so there is no pressure on the soft tissues.

These considerations provide a starting point for chair and desk/work bench adjustment. Individual requirements and certain jobs will mean that postures may vary from this but the principles will remain the same.

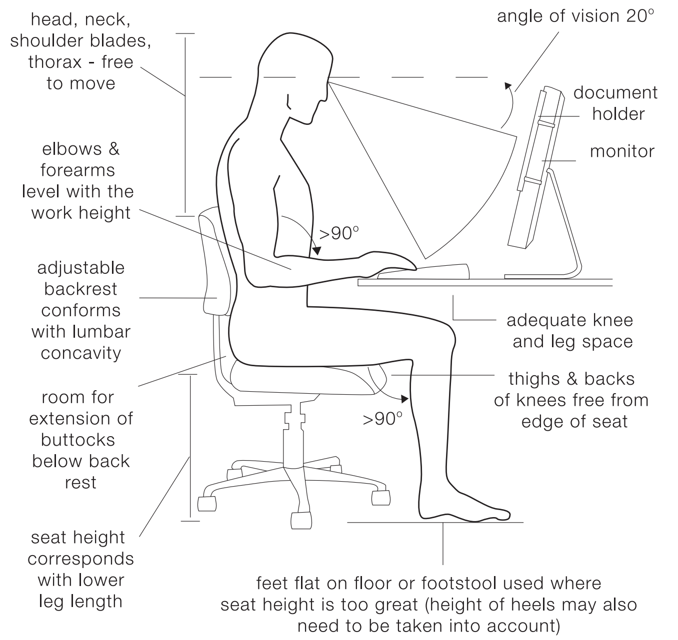


Figure 6.9: Optimum sitting position

KEY PRINCIPLES

- No one posture is suitable all of the time or for all people. Regular changes in sitting posture are to reduce the effects of fatigue. Tasks should be organised so that people can take breaks from sitting periodically.
- No chair has been designed to seat people comfortably for more than about an hour at a time. Even the best designs become uncomfortable over time.
- If people are seated for the majority of the working day they need well designed seating including adjustments and padding.
- Work seating should be adjustable in seat height, backrest height and backrest angle. Other adjustments are desirable depending on individual needs.
- Adequate lumbar support (at the base of the spine) is important for comfort and back care.
- Where computers are used some adjustability in keyboard height, screen height, position and angle are important.
- Desk and chair height should allow users to sit with their feet flat on the floor and their thighs horizontal with minimum pressure on the lower parts of the thighs.
- Where a desk/chair is too high a footrest should be used.

Further reading: *• NOHSC 1.14: Selection of Office Furniture and Equipment • Book 11: Officewise • ACTU 7.1: Screen Based Work • Other guidelines 8.12: Ergonomics*

Vehicle cabs

There is a large body of ergonomics information available for designing cab spaces, and controls and displays in cabs. Much of it relates to control processes generally but is also applicable to cab controls. (See Driving Vehicles and Operating Machines)

Ingress/egress

Adequate hand holds to assist drivers' access to cab should comply with applicable standards. Hand holds must not be placed where driver's hand might be vulnerable to danger.

The Australian Standard AS 3868 – 1991 requires that if entry is more than 400 mm off the ground a step is necessary. The first step should be no more than 400 mm off the ground. However 500 mm is given as an acceptable height in some ergonomics literature.

Minimum width of each step for one foot should be 200 mm. The dimensions and materials suitable to access steps are specified in the Australian Standard.

Door size should allow easy, safe access to the cab without impediment. The minimum door width required by the standard is 450 mm. Optimum door width for transport vehicles is about 700 mm.

Operator's space

The design of the operator's space must be sufficient for comfort, visibility and operation of equipment such as communication devices. Operators should be able to reach controls and see displays comfortably and easily from the seated position.

Any manoeuvres necessary for the operation of the machine should be able to be performed safely and without unnecessary fatigue or discomfort. Controls should be within an 180° radius of the operator and within easy reach especially in free-steered vehicles (not on rails or tracks).

Good access to the seat and within the cab is dependent upon adequate space between the seat and other equipment and fixtures in the cab. Some seat adjustment fore and aft is usually necessary. Seat swivel will be necessary for some machines but there are limited applications for this (cranes, draglines, backhoes etc) and adequate space must be available in the cab.

Tripping or catching hazards and obstructions, both within the cab and while gaining access to it, should be eliminated or modified so as not to cause injury or accidental activation. Sharp corners should be rounded and protrusions padded or recessed or more space provided for access to the seat and equipment.

Line-of-sight requirements for vision outside the cab should be specified. Usually this assumes a control panel in front of the operator and at least 15° uninterrupted line of sight below the horizontal in front of and to the sides of the cab. Rear vision mirrors and other aids to vision should be designed so as not to distort angles, distances or perspective and should give clear and uninterrupted view of the area to be seen. Visibility should be sufficient to see people, obstacles and the state of the work area (the road, objects or materials being moved) that may be critical to the operation or to safety. Mapping the operator's sight lines can be undertaken for different vehicles and machines.

Noise and dust should be minimised through design and maintenance eg appropriate seals on doors and windows and air filtration systems that are well maintained.

There should be adequate, accessible storage space for manuals and other items kept in the cab.

Monitoring should be undertaken to ensure the adequacy of the design and maintenance of the operator's space.

Cab seats

Seat design and adjustments should be suitable for the type of work, the conditions, the vehicle and the operators. It should be robust and not have components that are easily broken, torn or damaged.

The specifications for a cab seat should take into account the range of sizes of operators, their job, the type of machine being operated, and opportunities to leave the seat. The seat should be able to accommodate about 97% of all operators. It should be designed for the job and the type of machine being operated.

The longer an operator is required to sit in the seat without a break the more closely the seat should meet the required specifications. Operators need to get up out of the seat and walk about at least 5-10 minutes in each hour depending on shift length and percentage of the shift spent in the seat.

Height adjustment of the seat is usually necessary to enable short and tall operators to see critical areas outside the cab. However height adjustment of seats in smaller vehicles such as cars and 4WDs are usually not possible due to low roof heights. Some fore/aft adjustment as well as height adjustment in the seat will be necessary to accommodate smaller and taller users. The detrimental effect of the excessive seat height can be reduced to a small degree by a seat tilt adjustment. However, operators may not be able to use the backrest as effectively with the seat tilted forward.

The backrest height needs to allow free shoulder and arm movement (usually below shoulder height) where there is no acceleration or deceleration fore and aft and no significant lateral movement (such as seats in cranes, drag lines and ship loaders).

A higher backrest is required for on-road and off-road vehicles to support the driver during acceleration and deceleration. The backrest should be firm and supportive, adjustable in height, slightly concave laterally with a lumbar support area that is convex vertically. If there is significant lateral movement within the cab the sides on the seat and the backrest should be slightly raised.

The seat cushion should effectively distribute pressure but not 'bottom out' with heavy users. Where there are significant jolts and jars or other types of whole-body vibration suitable seat suspension will be required.

Seat swivel may be required in machines such as cranes, draglines, bulldozers and ship loaders. If it is provided operators should be able to activate the seat swivel quickly and easily and should be encouraged to do so rather than twisting in their seats. As well, some mechanism for preventing swivel when it is not required should be incorporated.

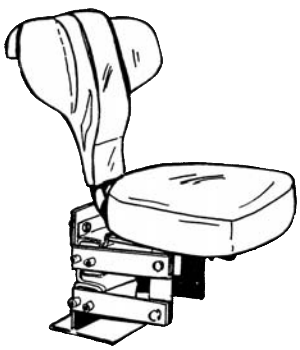


Figure 6.10: Seat for underground vehicle

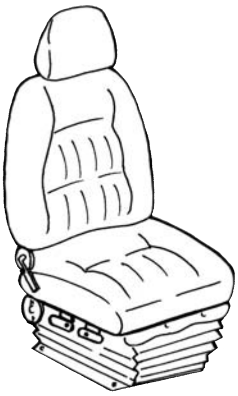


Figure 6.11: Truck seat

Seat	Seat depth – 380–480 mm, Seat width – 450 mm (min) Angle – 5-10° backwards The seat may be slightly dished (raised sides – max 25 mm transverse, 40 mm lengthways). Height adjustment in the seat (at least 130 mm, 200 mm preferred). Height adjustment range above floor level – 370-500 mm At least 150 mm of travel fore/aft adjustment of seat (AS 2956.5). Front edge and sides of the seat – well rounded to avoid pressure on the underside of the operators' thighs (approx. 60 mm radius).
Backrest including lumbar support	Height above seat – approx 200-250 mm (position of mid lumbar support above seat). Angle adjustment of backrest – 95-120° to horizontal.

All adjustments should be achieved easily and quickly from the seat position. Recommendations for adjustment should be provided, preferably attached to seat.

Armrests are usually not recommended in travelling vehicles. Where they are considered to be necessary their length and height need to be specified in keeping with current patterns of use and should not interfere with arm movements. They should be able to be stowed when not in use.

Seat belts should be provided where required.

Recommendations for adjustment and regular and timely maintenance should be provided, preferably permanently attached to the seat in some way or displayed in the cab eg transfers on wall. It should be easy to change or repair seat and backrest covers.

Vehicle displays

Display screens should have characters and graphics that can be read with ease at a specified distance. They need to be stable and adjustable in height, angle and distance from the operator's eyes. Graphics should be clear. Consider design and layout, size, colour, contrast, font and stability of the image.

Reduce specular reflections by matt and non-reflective surfaces and dark colours where appropriate. Consider surface treatments of the screen, careful placement and orientation of the unit and the use of glare-reducing blinds and window treatments. These must be easy to use and clean and there should be no decrease in visibility to the outside at night for the operator.

Primary displays should be in the direct line of sight of the operator. Displays that are used infrequently may be placed out of the direct line of sight of the operator. Information displayed needs to be large and clear enough to be seen under sub-optimal conditions.

The best viewing angle is at approximately 15°-35° below the horizontal line of sight. If operators use bi- or tri-focal spectacles consider height adjustment for screens that allows screens to be lower or spectacles prescribed for each operator for screen work.

Displays should be grouped and/or located according to their function, the critical nature of the information and the frequency of usage.

Illuminated displays should have a dimming feature for night use.

Vehicle controls

The shape, texture and angle of the handle, length of lever, separation, location, resistance and travel of controls need to be specified to optimise the operators' comfort and performance.

Optimum positioning of lever controls in relation to the operator is important. For continuous or repeated use the upper arm should be in a comfortable position and close to the operator's trunk.

The angle of handles should be considered carefully. The position of function is with the thumb up and the palm of the hand facing inwards. A handle that was slightly angled away from the body may be more comfortable than a straight alignment. (See also Posture and Movement)

A round grip provides more flexibility for changes of hand position, if that is required.

Finger convolutions are not recommended for the handle because they cannot suit all users. If friction or better grip is required consider higher friction surfaces. However, if the palm has to rotate around the handle this is inadvisable.

Lever, knob and button motion stereotypes should be observed (See Table 6.1). Where local recommendations or standards apply that are contrary to the general recommendations these need to be examined carefully for risks of incorrect operation and a clear guideline outlining reasons for choosing one or the other should be developed. Training times for inexperienced and new users need to be taken into account.

Levers are good where speed of operation is required but are poor for accuracy.

The size, shape, colour and location of knobs and switches and other controls must be matched to usage and their importance.

Layout of controls

Controls should be:

- laid out and designed to allow easy and safe operation and to prevent confusion over allocation of controls to functions or direction of operation;
- all primary controls including their displacement should be located with their neutral position and, if possible, all other positions in the zone of comfort;
- all secondary controls should be located within the zones of reach. (See Figures 6.6 A, B, C)

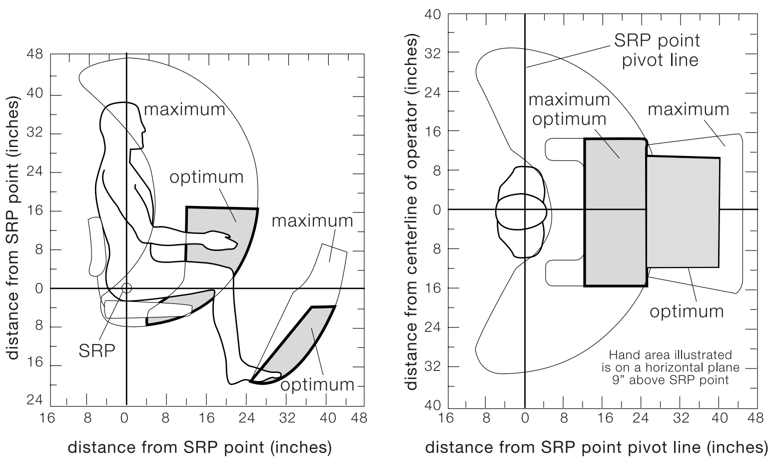


Figure 6.12: SAE space envelope for control locations in construction and industrial equipment

Controls, control linkages, hoses, tubes and connections should be located so they are not likely to be damaged by foreseeable external forces i.e. used as a step, requiring maximum hand or foot forces to be exerted. They should be easily accessible for inspection.

At least 180° of arc of a steering wheel should be located within the zone of comfort.

The distance between control levers, adjacent foot pedals, knobs, handles, operator's body and other machine parts need to be sufficient to allow unhindered operation without unintentional actuation of adjacent controls.

Design controls so that they can be actuated within the appropriate zones to eliminate potential interference between the body limbs when simultaneously operating the hand and foot controls.

Hand controls

In general for larger forces where the operating force is one hand, the arm is extended forward at 30° to the trunk. For high speed and accuracy the hand should be close to and in front of the body. Where switches are incorporated into the handle they should be far enough apart to prevent inadvertent actuation.

No more than six functions (preferably less) should be considered for a single controller. Resistance should be sufficient to dampen any inadvertent movement but not so great as to cause unnecessary operator fatigue.

Foot controls

The exact shape, separation, location, angle, resistance and travel of foot controls are critical for control and ease of use. Some adjustability in seat height may be required to accommodate taller and shorter operators.

Foot controls are quick to use and force can be applied easily. However, they do not give accurate control. Separation should be greater than 50 mm.

The final design should integrate the particular requirements of the operators including the prevention of accidental operation especially in emergencies and ergonomic design principles.

Simultaneous hand and foot control operation fixes the operator's posture and can be tiring for periods of greater than an hour. Therefore regular breaks will be required throughout the day.

Air conditioning controls

Controls for air conditioning should be located with primary or secondary controls. Function of each control should be identified in some way and should be easy and simple to use. Displays of information on the status of the air conditioning unit should be clear and unambiguous requiring minimum instruction to understand.

Noise from an air conditioning unit should be minimal and should be measured on maximum with the machine on full power with the doors closed. Airflow should be adjustable and able to be directed away from the operator. Outlets should be spread around the cab to ensure an even temperature in all areas. Temperature of and airflow into the cabin should be able to be controlled by the operator.

Other cab features

Sound levels in the cab

Noise generated by the vehicle or outside it should not expose the driver or passengers to levels that exceed 85 dB (A) for an eight-hour equivalent. Noise generated by the vehicle or outside it should not expose the driver to peak levels that exceed limits laid down in legislation.

Visibility

Ensuring that all surfaces are matt and non-reflective may reduce specular reflections. Avoid painting bonnets and parts in front of the driver/operator white or other light colours. Blind spots should be reduced to a minimum and where they remain they should be brought to the attention of the operator and others in the area. Line of sight must not blocked in any critical function by controls, displays or other parts of the cab

Mirrors

Mirrors or other devices are used to enhance visibility. They must be large enough and correctly positioned to enable the operator to see behind and to the sides of the vehicle.

Distortions created by curved mirrors should be brought to the attention of the operator and extra training may be required.

Extremities of the vehicle or machine should be visible at all times from the cab

Accessibility of various items

Ease of viewing of fluid level gauges/sight glasses enables regular checks to be made without difficulty or error. Misinterpretation of information should be minimised by the design of the sight glass/gauge, which should be easy to clean.

Ease of access to filling points and batteries for checking, filling or removal helps to reduce the risks of expensive errors, accidents or injury while filling and saves time.

Toolboxes (where they are required) should be easily accessible from either the cab or the ground and should be lockable.

Guidelines and standards

The Society of Automotive Engineers (SAE) in the USA produces standards that are applied widely in the design of vehicle and machinery cabs. They should be referred to for specific design standards. Australian Standards contain information on the minimum design standards for operating cabs generally some of which has been derived from the SAE.

KEY PRINCIPLES

- Optimise the design of the cab especially the displays and controls and the drivers seat.
- Optimise visibility within and outside the cab.
- Ensure regular breaks out of the seat and the vehicle wherever possible.
- Optimise shiftwork systems and be aware that extended hours of operation can lead to fatigue, reduced vigilance and operator error.
- Minimise distractions for the operator particularly in critical situations.

Further reading: *• Book 3: Sanders & McCormick • Book 4: Stevenson • Book 5: Clark & Corlett • Book 7: Woodson, Tillman & Tillman • Book 8: McPhee, Foster & Long • Industry material: 6.1: MDG 1 • AS 5.12: AS 2953.1:1988 • AS 5.13: AS 2953.2:1988 • AS 5.10: AS 2670.1:2001 • AS 5.16: AS 3868 – 1991*

Computers and work stations

Computer tasks

Computers are great tools and are used in most jobs these days. However, problems arise when they become a total job with little variation of tasks, postures or movement throughout the day. As with every sedentary job it is important for people's wellbeing and health to ensure that they undertake a variety of activities during a working day. Where possible, mix computer work with other tasks such as filing, telephoning, meetings etc. (See also Task Design)

Software design is also important. Flexibility and ease-of-use are often traded off for more features or a higher-powered system that are not utilised by the majority of users. Training and support facilities such as help functions and fully competent colleagues are essential for most users of computer systems. Flexibility and useability of software decrease the need for highly specialised and expensive training, which should be conducted on a need-to-know basis.

Younger people, especially those who may have studied computing or have used a computer at school will have far more confidence with and understanding of computer systems than older people. People over the age of 60 are less confident users of computers than younger people. Training will need to be organised differently and focussed for older and younger users.

Most users over 45-years-old will need reading spectacles or prescription task spectacles to read the screen as well as any source documents. The size and readability of both the font and display icons will be important for this age group.

Computer equipment

Screen image

Characters, figures and other aspects of the display should be easily read. A black-on-white image is easier to read than the reverse. The use of colours should not diminish the clarity of the image or the information. The information display should not be compromised by additional material on the screen which is not used regularly eg toolbars, rulers.

Larger screens may improve image clarity but need longer focal lengths than the average sized screen and therefore up to 50% more desk depth. Older users will have difficulty with smaller fonts and less contrast.

Keyboard

This should be:

- detached from the screen;
- matt finish;
- clear, etched figures on keys;
- thin (not > 30 mm at home row of keys (starting ASDF);;
- dished keys;
- firm travel and end-feel of keys.

Mouse

The mouse should:

- have adequate resistance to movement;
- be shaped appropriately;
- have firm travel and end-feel of keys;
- be large enough to be easily grasped by the hand but sufficiently sensitive for fine control;
- have adjustable resistance.

Screen

The screen should be adjustable in height, angle (vertical axis), tilt (horizontal axis) and distance from the operator (larger screens need up to 50% more space)

Workstations

These should be carefully designed to take account of:

- **users –** their age, physical characteristics such as height, their education and training, and their experience;
- **type of computer equipment used –** its age, special features, and general design;
- users' tasks (See also Task Design).

Chairs and desks

These should accommodate the range of height and sizes of users. Ideally the desk and chair should be height adjustable, with the chair having a properly shaped and padded adjustable back support.

Alternatively, if cost is a problem, different height chairs with an adjustable footstool or foot rail may be a solution. Most importantly, users should be given instruction on how to adjust the workstation for themselves and why it is important.

Document holders

These should be made available for source material. There are various designs for different types of work and documents. Some work better than others. If source documents are a standard shape and size a raised and tilted surface of any kind may be suitable. Books and special items may need particular designs that are available commercially.

The visual environment

The visual environment should be carefully designed. Lighting, either natural or artificial should create no glare, bright spots or annoying reflections in the visual field of the computer user. Reflections from the screen must be avoided. If possible computers should be positioned away from windows. If this is not possible the terminal should be at right angles to the window. Curtains and/or blinds are necessary to reduce glare from windows.

Generally speaking lighting levels should be lower than is normal for artificially lit rooms. Usually 300-500 lux is recommended as optimum if source documents or reference material are to be read easily.

Similarly, light fittings should be at right angles to the screen and to either side of the user. One-centimetre egg crate light filters reduce glare by shielding direct light from the side of lights. (See Illumination and lighting)

KEY PRINCIPLES

- The screen image must be clear and stable.
- The computer work station including chairs and desks must accommodate the full range of heights and sizes of users. The size of the desk must be appropriate to the size of the screen especially where bigger displays are used. The desk must also be big enough to accommodate all source material.
- There should be suitable storage space close by for all reference material for users.
- Design of the screen, keyboard and the mouse must be optimised for the task.
- A suitable document holder should be used for source or reference materials.
- The visual environment must be carefully designed.
- Computer work should be mixed with other tasks to allow a variety of movements and postures.
- Software used needs to be useable and flexible, and the type, amount and timing of training required must be appropriate.
- The age of the users, their need for training and reading glasses must be taken into account.

Further reading: *• NOHSC 1.14: Selection of Office Furniture and Equipment • Book 11: Officewise • ACTU 7.1: Screen Based Work • Other guidelines 8.12: Ergonomics*

Work organisation

Work organisation refers to the broader context in which the work is done – the culture and the way the workplace functions as a whole. It encompasses management styles, organisation of work groups, responsibilities and accountabilities. It is influenced by the type of industry or business in which it operates; its history and culture; peaks and troughs in demand for services or products; whether or not there is shiftwork, extended hours or flexitime; and profitability. The extent and type of trade union involvement and the need to meet externally determined standards also influence how a workplace is organised and managed.

Ultimately work organisation effects all parts of the workplace and probably has the greatest influence on ergonomics, occupational health and safety (OHS) practices and the development of high quality, satisfying work. Given this the application of ergonomics in the workplace needs to be understood in an organisational and social context.

Flexible work hours

The traditional 9am to 5pm eight-hour-day is no longer the primary work schedule available to many employees. With the introduction of flexible work schedules many individuals have the opportunity to use flexitime arrangements, time-in-lieu, 4-day weeks and other such arrangements.

There can be benefits for both the organisation and the individual in using flexible work schedules. These can be:

For the organisation: The opportunity to extend services and operating times; Increased attractiveness of working conditions for potential employees;

For the individual:The opportunity to balance the demands of private and working lives.

Any changes in the pattern of work in an organisation should be developed in consultation with employees. (See also Employee Participation in Problem Solving).

Peaks and troughs in workloads

One major source of excessive work demands on individuals is the seasonal or cyclical nature of some types of work. Mining, manufacturing and service industries all have problems balancing increased workloads and worker capacity from time to time. Where these peaks and troughs can be anticipated they can be planned for and adjustments can be made. Where they are unexpected careful scheduling is needed. Excessive overtime and unpaid extended work hours can be harmful to health, safety and productivity. These workloads need to be managed at an acceptable level.

Shiftwork and extended hours

Shiftwork involves working outside what are considered to be ‘normal’ working hours, generally between 7am and 6pm. As a rule of thumb the 40-hour week (comprising five 8-hour workdays with two days break) is the ‘gold standard’. The more work hours deviate from this regular pattern the more strategies may be needed to overcome the effects of excessive fatigue and sleep disturbances are needed. An increasing number of workers are performing shiftwork and many suffer adverse effects from it.

Problems arising from shiftwork

Most of the health and safety problems associated with shiftwork arise from the working of irregular hours, often at times that are in conflict with the individual’s internal biological rhythms. The body’s circadian rhythm is normally set for activity during the daytime and for rest and relaxation at night. Disruptions to the body’s circadian rhythm are most evident when an individual is required to work night shifts (between 11pm and 6am) and many people experience sleep problems during the day. During a night shift, an individual’s circadian rhythm is at a low and, when combined with fatigue, performance is generally reduced. Poor performance can affect both safety and productivity on the job.

Health-related problems that have been associated with working irregular hours include gastrointestinal problems resulting from irregular diet and eating habits, an increased risk of stomach ulcers, cardiovascular problems and nervous complaints. Shiftwork also imposes restrictions on social and home life.

Individual differences can play a factor in a worker's adjustment to shiftwork and for a few individuals working irregular hours poses few if any problems.

Minimising OHS problems

It is important to minimise any OHS problems that are associated with shiftwork by:

- Reducing consecutive night shifts where possible, with a maximum of three 8-hour or two 12-hour night shifts a week;
- Rapidly rotating shift rosters, with shift changes every two to three days. These are preferable to slow rotating rosters;
- Forward rotating rosters (day-afternoon-night) are preferable to backward rotating rosters (night-afternoon-day) as they cause the least disruption to the body's circadian rhythm;
- The adoption of compressed work weeks. These have benefited shift workers in some workplaces;
- Identification of individual coping strategies. These lessen some of the adverse effects of shiftwork experienced by many workers.

Importance of uninterrupted sleep

A problem for many shiftworkers, especially those with young families, is getting enough uninterrupted sleep during the day after working a night shift.

Shiftworkers should try to ensure that:

- unwanted noise is controlled eg unplugging the telephone and restricting noisy activities in the home such as vacuuming;
- the bedroom is free from direct sunlight through the use of curtains or blinds;
- heavy foodstuffs and alcohol are avoided before sleep;
- a regular sleep routine is established.

Advantages of shiftwork

For some individuals there are advantages to performing shiftwork as workers do not need to commute to work during peak travel times. Commuting time to and from work can be reduced and shift workers are able to pursue hobbies and other interests and undertake family commitments during daylight hours, although this may be at the expense of sleep.

Compressed work weeks

One alternative to the traditional shiftwork pattern is the adoption of compressed work weeks. These involve the use of a set block of shifts of increased length, usually of 10-12 hours duration, offset by a reduced number of work days and with blocks of three to four days rest.

Compressed work weeks can be useful to the individual as they contain shorter blocks of shifts, fewer successive night shifts, and increased blocks of free time including weekends. Conversely, compressed work weeks involve additional working time per shift, possibly leading to fatigue that could affect performance. Extended work hours may also adversely affect an individual's health and recovery may be prolonged for a worker after completing a block of 10 or 12-hour shifts.

The adoption of compressed work weeks has benefited shiftworkers in some industries through increasing their recreation time, improving the quality and duration of sleep and through improving their physical health and wellbeing. However, this is not always the case. Each workplace and workforce is unique and will require shift rosters that suit their particular requirements.

KEY PRINCIPLES

- Individuals who perform heavy physical work or are exposed to a range of workplace hazards such as heat, noise, vibration or hazardous substances are advised not to work extended shifts. Exposure standards for the extended work days have not been developed for many hazards and therefore it is important to carefully assess daily work demands or exposures to ensure that they are acceptable.
- Workers who are involved in intensive mental work where the consequences of error or non-reaction may be serious are not recommended to adopt compressed work weeks.
- The number of consecutive 12-hour shifts should not exceed four, with no more than two consecutive 12-hour night shifts.
- Overtime is not recommended for individuals working 12-hour shifts.
- Suitable arrangements need to be made to cover workers who are absent from work due to illness.
- It is essential that shiftworkers are consulted and take an active role in determining changes to current shift rosters and how these changes are to be implemented in the workplace.
- Regular evaluation or assessment of the extended work days roster should be undertaken and if needed modification be made to the roster.
- Shiftwork is often inevitable but it can be damaging to health of workers if not managed correctly.
- Common problems with shiftwork include an increase in general fatigue due to disrupted sleep; disrupted biological rhythms leading to restrictions to personal, social and family life; reduced access to leisure and sporting activities; gastrointestinal, cardiovascular and nervous complaints.
- Extended work hours and compressed work weeks can lead to an increase in fatigue and may have other adverse effects. Strategies need to be in place to minimise these.
- Shift patterns need regular review and adjusting to suit changing needs and circumstances.

Further reading: *• Book 14: Monk & Folkard • ACTU 7.3: Shiftwork and Extended Working Hours • NOHSC 1.19: Shiftwork • NIOSH – CDC 8.9: Overtime and Extended Work Shifts • Other material 8.14: Workplace schedules*

Rest and work breaks

Rest and work

Everybody needs to rest for some part of any 24-hour period. How much rest is needed and what form it takes varies widely between individuals and will depend on the intensity of activity in the preceding hours.

Sixteen hours in a 24-hour cycle is the normal period of wakefulness for humans. Beyond this point the body's processes increasingly promote sleep. If work is continued beyond 16 hours substantial performance impairment is observed particularly with respect to attention lapses.

The following is a guide to the average amount of sleep required by individuals. However, some people can do with less, others may need more:

- No less than 5.5hrs sleep in each 24 hours;
- No less than 49hrs sleep in each week;
- No less than 210hrs sleep in each month i.e. No less than an average 7.5hrs sleep per day.

Work by its nature is tiring. During a work day most people need to take regular rest breaks in order to complete eight hours of work without excessive fatigue and the increased risk of injury or illness.

Work pauses

Work pauses are additional, spontaneous breaks not incorporated into the job structure but taken by all individuals in the course of a day. They are not the normal fixed breaks in a working day such as lunch but may be breaks between tasks or a change in routine. They are essential because they delay the onset of fatigue by allowing the body to recover from physical or mental work.

Work breaks

If intensive physical and/or mental work constitutes a significant part of a person's workload during the day it may be necessary to for them to take breaks in addition to the normal lunch and personal breaks.

There is no easy way to determine how long breaks should be to ward off the effects of fatigue at work, even for someone who is undertaking specific tasks. Therefore many work systems now incorporate set breaks to allow for mental and physical recovery. These are usually about 5-10 minutes within each hour for moderately demanding work. In general the length and type of break will depend on how hard the work is, the age and fitness of the worker and environmental conditions such as heat and humidity. Too short a break may lead to progressive or cumulative fatigue. (See also Fatigue)

Employees are usually best placed to determine for themselves when a break should be taken and how long it should be. However, workers often have to be encouraged to pause from work even when they are tired and they must be actively discouraged from accumulating breaks. As work demands sometimes do not allow this to happen, care must be taken not impose too demanding a work schedule with insufficient breaks. Consultation with employees who do the work should be undertaken before fixed work-rest schedules are finalised. Ongoing monitoring should be carried out to ensure that the breaks are appropriate. (See also Repetitive Work)

To estimate reasonable rest allowances in physical work it is necessary to examine the load and work rate against the number of hours the work is carried out during a work shift. There are guidelines on rest allowances for jobs such as heavy, physical work involving manual handling and work where safety is critical e.g. airline pilots. However, care is needed when using these guidelines as risks arising from fatigue may be underestimated. As a general rule, the number and duration of rest allowances must increase as the load and/or the intensity of work increases.

Exercises may be useful in reducing the damaging effects of repetitive or sedentary tasks or work in fixed or awkward postures. However they need careful planning and supervision. (See also Repetitive Work)

KEY PRINCIPLES

- Rest pauses and breaks during physically or mentally demanding work are necessary for recovery and to reduce the effects of fatigue.
- How long and how frequently rest pauses should be taken depends on a range of factors that need to be determined on a jobtask-by-taskjob basis.
- Exercises can be incorporated into work routines but they must be carefully planned and monitored. They can be helpful for some people; others will gain no benefit.

Further reading: *• Book 20: Rodahl • Book 21: Violante, Armstrong & Kilbom • ACTU 7.1: Screen Based Work*

Consultation and feedback

Consultation with workers is now considered a necessary part of the organisation of work and is encompassed in some OHS legislation in Australia. It can be defined as the sharing of information and the exchange of views between employers, employees and their representatives. It includes worker participation in identifying and solving problems, in decision-making and in obtaining feedback from workers on the success of programs and interventions. It is an active and inclusive process and needs to be systematically practiced in order to gain the benefits.

Feedback and communication are necessary for effective worker participation. The process takes time and can be difficult to establish if workers are not used to making decisions and solving problems. An essential component of a safety program is feedback to and from workers. Where there is a steady flow of information on progress, hurdles and developments workers respond better than when this information is absent.

Effective communication is central to all efficient management systems and in order to be effective it must be optimised. Too much information, particularly if it is of marginal value, bogs people down and they may opt out by ignoring all communications. Too little information and employees can feel left out and resentful. Information that comes down through an organisation's hierarchy should be matched by information that goes up. Its impact will be related to its need-to-know qualities. (see also Risk Management)

KEY PRINCIPLES
- Worker consultation and feedback is necessary for any ergonomics program.
- Effective communication is an important element of participation.

Further reading: *• NOHSC 1.21: Workplace Health and Safety Responsibilities • ACTU 7.1: Screen Based Work • NSW WCA 2.2: OHS Consultation*

Work teams

A work team is a collection of individuals who are required to work together to complete a goal or set of tasks. This type of teamwork can reduce worker alienation that can occur in some work places.

Work teams can either be:

- **Self-managed –** the team is given a goal to be achieved. It then determines how the work will be conducted to achieve the goal;
- **Integrated –** a supervisor oversees the work of the team in achieving the goal. This type of teamwork often occurs in mining where the supervisor oversees the work of a crew.

Types of teams

There are four main types of work teams:

- **Involved teams –** usually involved in providing recommendations or making decisions regarding a particular problem eg safety committees and quality circles;
- **Production teams –** usually involved in providing goods and services eg manufacturing or mining teams;
- **Project teams –** usually provide information in the form of reports and/or plans eg research teams or a panel of experts in a particular field;
- **Active teams –** can provide a variety of functions eg sporting teams scoring goals and medical groups performing a successful operation.

Benefits and drawbacks

Some benefits of teamwork include:

- increased problem solving skills;
- improved performance of employees;
- potential increase in lateral thinking and innovative ideas derived from multiple perspectives in brainstorming;
- increased output of the organisation;
- opportunities for managers to direct their attention to more long term strategic goals, rather than rudimentary supervisory functions.

Common drawbacks of working in teams include:

- some individuals may not pull their weight in the team;
- some individuals may have difficulty keeping up and may put themselves and others at risk of injury or overload;
- some team members may not agree on a particular course of action, creating a stalemate;
- conflict and competition may arise within the group.

If teamwork is to be effective team members must have the necessary skills to operate within the team, including both good communication and negotiating skills. The team must have clear goals to fulfil, be committed to completing these goals and have appropriate management support.

KEY PRINCIPLES
- Teamwork provides range of work options for individuals and if properly managed can be effective and efficient.
- There are advantages and disadvantages to team work. Its suitability must be determined taking into account individual and group factors as well as production needs and workplace issues.

Economic and social influences

Work provides a place for social interaction as well as being a source of income. Work behaviour is influenced by social interactions – workers are responsive to the expectations of people around them. Social isolation at work can be created by boring, monotonous tasks where individuals cannot communicate with other workers if they wish to do so. Opportunities for interaction with other workers regularly throughout a work shift needs to be incorporated into the job.

A number of recent changes in the wider community have changed the way people see their workplaces. These include:

- social attitudes towards working women;
- the need for environmental protection;
- more comprehensive laws on occupational health and safety;
- job expectations and
- increasing multicultural influences.

Where unemployment is high, people may place a higher value on their work and turnover may be less. Economic constraints may mean that organisations have to do more with fewer resources.

In these circumstances there are increasing demands placed on managers to perform a wide range of roles and this may be difficult where support from further up the management chain is not forthcoming. However, managers can do a great deal to reduce conflict and improve work organisation, ergonomics and productivity. Consultation with employees, overcoming language and other communication difficulties and increasing flexibility in how the work is organised and performed may make the difference between discord and harmony.

KEY PRINCIPLES

- Social support and assistance at work helps to reduce adverse effects of day-to-day stressors in the work environment.
- Social interaction is a necessary part of work and workers should not be isolated without opportunities to communicate with fellow workers.
- Work should be a very important and positive component of people's lives.

Part C: Measuring the benefits of ergonomics

Measuring human capabilities and limitations

In the last 20 years there has been a lot of progress in the development of measures of effectiveness, performance and outcomes in occupational health and safety (OHS). Most of these methods are estimations of some kind and while they are useful in particular situations and are reasonably reliable. none will tell you exactly what you need to know [not true for all eg heart rate]. For that reasonAs some of these measures are estimates or indirect, measures they should be used as only indicators to identify possible areas for further investigation.

In ergonomics we know a lot about what people can and cannot do because of extensive research and observation carried out in laboratories and workplaces all over the world. As well, some data on limits are derived from statistical analyses and estimates of risks. These are based on outcomes rather than progress or performance.

Most research and statistical findings apply to the majority of the population most of the time. However, every workplace has its own unique set of people, workplace and systems factors that may not fall neatly into categories commonly used in ergonomics. In addition to this people with particular disabilities, educational deficiencies or other conditions that might limit their capacities in some way may need special attention in order to accommodate their needs.

Nevertheless, for the majority of the population there are ways of determining roughly whether or not the work or the environmental conditions are exceeding their capacity to work safely and without risks to their health.

Simple techniques

There are three well-known and easily learned methods for identifying obvious OHS problems in the workplace. When used together they provide excellent information.

1. Observation – a walk-through visit can reveal much about normal day-to-day operations and the people involved. Observation can be formal or informal, structured or unstructured, subjective, with workers who do the job, or objective.

2. Consultation with employees – most people have a good idea about their work and the demands it places on them and whether these could be damaging. Talking with one person can be very helpful but talking to a group is usually more helpful. Given the right environment of trust and openness even shy people will contribute to a general discussion.

3. Statistical data and records. These need careful interpretation and may tell you more about what has happened in the past rather than what is happening now. However, when applied with care they are a useful addition to observation and consultation. They can take the form of:

- fixed data eg plans and layouts, job descriptions, company reports, strategic plans, production records, injury treatment records, workers' compensation records, risk assessments, personnel data records eg job data, individual data, accident and injury data, costing data – eg cost-benefit analysis, overheads, labour costs per hour. Near miss or 'near hit' data.

There can be drawbacks to using data and records in terms of what they tell you – or do not tell you. Data may be collected, analysed and interpreted to show the organisation in the best light or to cover up cost overruns. In some cases data are simply missing or inaccurate because people fail to understand what they are doing or to follow-up. Therefore this information can be considered historically useful at best and unreliable at worst. (See also Ergonomics Risk Management.)

KEY PRINCIPLES

- Every workplace is unique and may not fall neatly into categories commonly used in ergonomics.
- There are ways of determining roughly whether or not the work or the environmental conditions are exceeding the capacity of the majority of the population.
- The simplest methods of identifying problems at work are things that everyone can do – observation, consultation and examining any records or statistics.

Further reading: *• NOHSC 1.3: National Code of Practice for Manual Handling • NOHSC 1.16: Manual Handling*

Measuring physical workload

There are a number of different ways in which we can measure or estimate workloads. However they all have limitations and should be used with care. An individual's knowledge and experience are extremely important in judging when loads may cause him or her harm. The estimations of workloads outlined below supplement but do not replace these personal skills.

There is a range of measures that can be used to quantify physical and psychophysical load on the body. Those outlined below are just of few of the more commonly used ones. For a more detailed description of these methods and many others refer to Book 15: Wilson & Corlett.

Biomechanical methods

Biomechanical methods estimate the mechanical loads on different parts of the body (most notably the low back) through mathematical modelling eg the two dimensional static strength prediction model (2D) or 3D Michigan model, or the Lumbar Motion Monitor (LMM™).

Estimations in the 2D model are made on a split-second movement and calculated using a software package. It is based on a model developed by the USA National Institute of Occupational Safety and Health (NIOSH) and known as the NIOSH equation (see below). The values in the 2D model are given in terms of forces on different parts of the body including the lower lumbar spine given the weight being handled, distance from the body, body posture.

The model is used to evaluate the strength requirements at the major joints and to estimate the low back spinal compression forces for lifting tasks. However, there are many limitations using this method especially where there are unbalanced postures and movements and/or dynamic lifting tasks. In these cases it may underestimate strength and compression forces. The 3D model has overcome some of the problems of the original 2D Model but it is complex to use and there are still limitations in practical work situations.

The LMM™ is a portable stretch gauge shaped rather like the skeleton with a harness that attaches it to the body. It is connected to a portable computer with software that analyses a number of components of movement of the spine including acceleration, velocity and range of movement in three planes. The package allows for comparison of results against LMM™ benchmarks. It has proved useful in research but is less usable in real world situations in highly varied tasks or in cramped spaces.

Physiological methods

Effort can be estimated measuring the cardio-respiratory system's capacity for work eg heart rate, oxygen uptake, and circulation. Heart rate can be measured continuously using telemetry. It may involve the use of equipment including an electronic belt with a transmitter worn around the chest and a receiving microcomputer worn on the wrist. From these measurements energy expenditure can be calculated. This is usually done using the individual's own resting heart rate for base line comparison as no two people are exactly the same. (See also Physical Strength and Work Capacity)

In the Borg rating of perceived exertion (often referred to as the RPE) workers are asked at intervals how hard they think they are working. They can nominate one of 15 precisely defined categories ranging from 'no exertion at all' (6) through 'very light' (9) and 'hard (heavy)' (15) to 'maximal exertion' (20). By adding a zero to the numbers the resulting values roughly equate with heart rate. Higher numbers are then related to the resting heart rate to get an estimation of the individual's capacity and exertion. Modified versions for localised areas such as the legs, back, arms and neck are also used.

Postural methods

These methods estimate the numbers of undesirable postural combinations (those found to be associated with the development of back pain and other sprains and strains) and the proportion of the work task where these postures are required. eg Ovako working posture analysis system (OWAS), rapid upper limb assessment (RULA), rapid entire body assessment (REBA).

In OWAS video recordings are made of work tasks for later analysis of postural load. The working postures adopted during the work are classified by a method that defines the positions of the back, upper and lower limbs as well as force used. Recordings of observations are made on work postures and activities are made on anything from a five to 30 second intervals. They are entered into a computer and a program estimates the proportion of time in certain postures. The least desirable ones are the bent, or bent and twisted postures (work below the knees with or without twisting to the side), standing or balancing on one leg or in an awkward posture, and work above the shoulders. Weights can be added to the calculations but are considered in gross terms only. Combinations of these factors are classified by an experienced ergonomist according to the percentage of time spent in non-neutral postures and force exerted.

RULA and REBA are survey methods developed for use in ergonomics investigations of workplaces where musculoskeletal disorders are reported. They provide a quick assessment of postures along with muscle function and the external loads experienced by the body. A coding system is used to generate an action list that indicates the level of intervention required to reduce risks due to physical loading.

Psychophysical methods

Estimation of the individual's capacity to undertake certain types of physical work can be achieved through questioning people during the task. They are asked to put a numerical or word value on how hard they think they are working and/or whether or not they could maintain that pace for a specified period (usually an eight-hour-shift).

In the USA tables have been developed based on individuals' judgments of acceptable loads for a given work period. These are often referred to the Snook tables after the man who compiled them. The method takes into account the whole job and integrates biomechanical and physiological factors. However, some studies have found that many subjects overestimate and some underestimate their capacities. The tables are useful for assessing weights on the basis of acceptability rather than on safety.

An alternative approach developed in the USA uses three common lifting indices. The first is the lifting index, which was developed with the NIOSH equation (see below). This uses the ratio of the load to be lifted to the recommended weight limit as calculated by the equation. The second is the job severity index. This is calculated from the job demands that are identified through tasks analysis against worker capacity that is either measured or estimated. The third index is the lifting strength rating. It is calculated from the weight handled in the job and the strength of a strong person in the postures observed for handling the weight.

All three indices aim to assess the job demand against the capacity of people working under the job conditions. The last one can be used to assess lifting demands where load and workplace factors vary. Nevertheless they do not quantify precisely the risk involved. They are more useful in comparing the relative severity of two jobs.

NIOSH guidelines and equation

The NIOSH guidelines use biomechanical, physiological and psychological criteria to set lifting limits that are integrated. These are set in terms of the recommended weight limit, which is a formula that takes into account the height at which the lift commences, the vertical travel of the lift, the reach distance, and the frequency of lift. The formula is usually referred to as the NIOSH equation and recognises that risk factors interact and multiply the risk. However, it cannot be used for other manual handling activities such as carrying, pushing pulling or lifting people. It also does not take in account sudden or unpredicted conditions such as a shift in loads or foot slip.

Epidemiological methods

Epidemiology is the study of diseases and disorders in populations. In this approach measures of the health effects of work on people are studied. The effects of exposure to certain hazards such as manual handling can be indirectly calculated by examining the numbers of new or recurring injuries or illnesses recorded in people who carry out manual handling. If the occurrence of certain disorders is higher in a particular group than expected statistically then these can be linked with general or specific parts of the work.

However, some disorders such as those of the musculoskeletal system occur normally as the result of life activities and they are also cumulative in nature. It may take many years before the detrimental effects of the work become apparent and even then the contribution of work to a disorder can be unclear. These disorders are very difficult to study in epidemiology because of this.

A simple epidemiological method that is frequently used to collect information on sprains and strains (musculoskeletal disorders) is the Nordic questionnaire. This is a standardised questionnaire that is used in conjunction with other measures of occupational or task-related workloads. It consists of a series of questions concerned with the individual's history of musculoskeletal problems in both the last week and the last 12 months. Some questions relate specifically to the low back. The rest cover the neck, shoulders, elbows, wrists/hands, upper back, hips, knees and ankles/feet.

Body maps are included with the questionnaire. These are drawings of the body on which individuals mark where they are experiencing discomfort or pain. The questionnaire is easy to administer but requires some specialist knowledge to analyse and interpret.

KEY PRINCIPLES

There are number of other methods that have been developed but all need care in their administration and some specialist knowledge.

There is a range of methods available to measure different aspects of physical load at work. Most are indirect methods and all have practical and functional limitations when used to measure real jobs in the workplace.

Different measures are useful:

- to compare jobs and loads, differences between individuals or groups
- when usable information is to be fed back to manufacturers and suppliers
- if the solution is critical in terms of injury control
- where costs of injuries are unacceptable and the effectiveness of the control needs to be demonstrated
- where information is needed for the record or is required by law.

Further reading: *• Book 15: Wilson and Corlett • Book 20: Rodahl • Other material 8.10: NIOSH. Work Practices Guide for Manual Lifting*

Measuring mental workload

There are four broad methods for measuring loads on human cognitive capabilities. The first is the primary task measure where the performance of a particular task under certain circumstances is assessed. Secondary task measures on the other hand measure the performance of additional tasks to the primary one. Where the secondary task cannot be performed this is taken as an indication the primary task is more demanding than if the secondary task can be performed.

A third method is subjective rating measures including direct and indirect enquiries from subjects about their opinions on the workload of the task under study. This is one of the easiest ways to estimate mental workload.

Finally physiological (or psychophysiological) measures examine changes in a variety of physiological functions as the result of mental workload.

Measuring the impact of ergonomics

There are several measurement tools and techniques that may be used to measure the impact of OHS and ergonomics outcomes.

Positive performance indicators (PPIs)

PPIs (also known as Lead Indicators) can give information about the effectiveness of activities especially within OHS management systems. Ergonomics is one of the areas where these indicators can be useful. However, they will not tell the whole story nor will they in themselves improve performance – they are merely flags indicating progress or the lack of it. Nevertheless PPIs allow an organisation to set standards that are above the minimum and allow efforts towards preventive health and safety programs to be recognised and encouraged.

When benchmarking and making comparisons with other organisations or industries it is important that different measures can be compared. Therefore they need to be reliable (consistent), repeatable, comparable (with other areas or organisations) and valid (measure what they say they are measuring). This can be very complex when systems are so different. As a result organisations often resort to lost time injury frequency rates (LTIFRs) which are a negative performance indicator (NPI) (see below) but which can be applied across a range of industries.

Aspects that lend themselves to the development of PPIs for ergonomics include those used to define OHS systems.

Applying PPIs to ergonomics

Systems area	*Possible measures of performance*
1. Commitment	% of jobs with OHS and ergonomics responsibilities defined
2. Documentation	Level of awareness and use of manuals by the workforce Frequency and timeliness of document updates
3. Purchasing	% of purchase orders with OHS (ergonomics) requirements specified
4. Safe working systems	% of systems controls compared with individual controls % of risk assessments results that have been included in systems management plans
5. Identifying, reporting and correcting deficiencies	Frequency of reviews and % of actions achieved % of incidents/problems where remedial action was taken within an appropriate time frame
6. Monitoring, recording and reviewing	% of OHS standards conformance Level of record keeping required by regulation against potential recorded events
7.Developing skills and competencies.	% of employees assessed as conforming to competency standards

PPIs are process indicators and the way they can be used is often not understood very well. The development of PPIs is still in the early stages in many organisations even though there are often significant positive actions that can be measured and documented.

Negative performance indicators (NPIs)

NPIs (also known as Lag Indicators) such as the LTIFR only tell what has happened in the past and that something went wrong. They give no indication of what has been done well. Simply measuring negative outcomes such as injury rates or the costs of workers' compensation claims does notmay not give a true indication of what is happening now and how effective current risk control measures are. In fact they may give wrong information when they fluctuate or when there are subtle differences in reporting criteria. They may also allow concealing of injuries to provide an apparently better result. Most importantly they are very limited in predicting high consequence, low probability accidents.

However, they measure actual failures and they allow statistics to be compared across industries and from company to company. Organisations can benchmark themselves against others and this is comparison can be useful to a limited degree.

Injury/illness rates

When used in conjunction with some or all of the above measures, injury /illness rates can provide valuable information concerning program implementation. It is important to recognise that there may be a latent period before the rates begin to improve due to the time it takes to implement a mature, effective safety program.

Program evaluation

Evaluation of an ergonomics program needs to measure how well program implementation is progressing as well as whether or not the program objectives were achieved.

What is measured will depend on what is considered necessary to determine if the program is on track. You can:

- determine if the process is working. For instance, if the program involves consultation with users, the identification of problems and development of solutions these can all be measured simply by determining if they have been done and what they have achieved;
- estimate or assess the risks associated with poor ergonomics in broad terms and then reassess these after changes have been implemented. People involved can be asked about the degree of difficulty of the job, the number of near misses or other incidents and perhaps the number of times accidents or injuries have actually occurred;
- ask how workers feel about solutions and if they think the solutions have been effective or not.

However, in many cases it is difficult to show that injuries have been reduced by the changes made. This is because there are so many causes of most injuries and in some cases they develop over time. It takes time and sophisticated measurement techniques to establish that particular interventions have lead to a reduction of injuries.

It is important to develop methods of evaluating positive indicators of work being done that address areas requiring improvement. Then these indicators and resulting improvements can be measured over time. The use of both positive and negative performance indicators give the most balanced approach to evaluation and can act as effective safety program drivers if used carefully.

Strategic planning

Performance can be measured from strategic plans. The mission statement of an organisation can be used to measure performance. The board can be measured by the goals outlined for the organisation. The manager can be measured by the objectives and the staff can be measured by action plans. Key performance indicators (see below) can be identified from strategic plans.

Key performance indicators (KPIs)

KPIs are derived from the use of statistics in process control in manufacturing. The basic concept of statistical process control is that variation in outcomes is inevitable and that the control of this variation determines the quality of the outcome. If there is reduction of variation in one or more stages of the process, then there will be a consistent reduction in the variation of the outcome of the process. Recently this concept has been applied successfully to business processes. The result has been that the whole business process outcome has been developed by the improvement of key variables within the process. This method can also be applied to the process of OHS and ergonomics in organisations.

Program audits

These give a comparison over time of improvements in implementation. They involve the using of a series of predetermined questions to establish how much work has been done to implement and maintain a program. Information provided at audit is verified through document reviews, random sampling, discussions with staff, observation of behaviours and activities and physical conditions surveys.

As with all audits there are always problems in getting the balance right. The evaluation of a program is never black and white – there are always shades of grey. These are hard to evaluate in questionnaires. However they need to be recognised and some credit given where progress has been made but the outcome has not be achieved fully. Therefore the development and use of the audit tools is critical to how much useful information can be derived.

Accident and incident investigation

Accident and incident investigations are part of every OHS program. They are undertaken to find the real and not immediately obvious causes of an accident and to assess the risk of recurrence. Based on this information appropriate control measures can be developed. These may involve changes to the structure of the OHS program as well as fixing the immediate damage or providing the injured person with appropriate medical treatment.

Poor ergonomics is often overlooked in accident investigations because it is not always immediately obvious and its analysis may require specialist input.

Information obtained as a result of the investigations can also be pooled to determine trends and used in to assist program implementation planning.

Cost-benefit models

Justifying expenditure to improve OHS has been difficult in the past. Often direct compensation and medical expenses were the only indicator that poor OHS practices were costly. However, now it is possible to calculate the real costs of injuries to companies using methods and programs that are available commercially. These range in complexity from full company accounting systems to methods that apply to individual jobs or groups of workers.

The feasibility, availability and cost of changes needed to improve ergonomics may be considered in relation to the size and cost of the problem. Sometimes it may be necessary to justify the cost of change or of different changes (termed cost effectiveness) or the costs of doing nothing at all. This is where conducting a cost-benefit or cost effectiveness analysis can be useful.

Such analyses are best done prior to and after changes have been made. Where they are conducted beforehand payback periods can be estimated for budgets. If the payback period is short (3-12 months) this can be used to justify expenditures

Cost-benefit and cost effectiveness programs require some basic information in the following five areas:

- Actual number of productive hours worked per employee per year;
- Salary or wage costs per hour worked;
- Employee turnover and training costs;
- Productivity and product/service quality losses due to absent employees;
- Cost of implementation of intervention(s).

Costs per hour of OHS problems can then be calculated. To this, costs of solutions can be added and a payback period can be estimated. Not all the information is essential but the more that can be supplied and the more accurate it is, the better the true costs and benefits can be predicted.

The costs of wasted product, increased time to undertake the tasks, inadequate or poor quality workmanship, and damage to equipment and product as may have identified in the process can also be added to the OHS costs.

Risk assessment techniques

An essential part of a risk management program is the risk assessment process. If risk is not assessed and analysed accurately money and time can be wasted. Therefore the techniques that an organisation employs to assess risks are critical to long-term success in the prevention of injury and illness at work.

In the past specialist ergonomists have undertaken assessments as individuals, consulting workers and managers as necessary and providing recommendations based on their individual experience and knowledge of ergonomics, systems and OHS. This may still be acceptable for some assessment and analysis, particularly if the job or area is small and uncomplicated.

However, due to the complexity of modern work systems and the interrelated nature of many hazards and risks many risk assessment methods now use a consultative team of people. This includes workers and supervisors as well as specialists in systems, processes, machinery, OHS and ergonomics. Depending on the nature of the problem the team uses different techniques to identify, assess and analyse risks for their potential to cause harm. (See also Ergonomics Risk Management). The team is also valuable in considering possible solutions to problems.

Safety professionals have developed many techniques that are excellent for systematic determination of risk, particularly high-level safety risks. These include:

- hazard and operability studies (Hazop);
- failure mode and effect analysis (FMEA);
- fault tree analysis (FTA);
- machinery hazard identification;
- potential human error identification (PHEI);
- workplace risk identification and control (WRAC).

These techniques are used for specific types of risk assessment such as commissioning of facilities and the implementation of procedures (Hazop); identifying the potential for human error and designing prevention strategies (PHEI); and identifying potential production or maintenance operation problems (WRAC).

Most of these approaches are interactive with a focus on gaining consensus from the group. They use a qualitative rather than a quantitative approach and the team members' experience and opinion are the main sources for the estimates of risk. If they are to include ergonomics the approach will need to be modified and team members are likely to need training in ergonomics. Alternatively including a specialist ergonomist in the team can provide the necessary expert input that also serves as training for team members. This is especially important in the analysis of the risks. (See also Employee Participation in Problem Solving)

In the oil and chemical industries it is possible to calculate the size of the possible outcomes/impacts mathematically and therefore the risk assessment methods may be quantitative. However, in most other industries and processes this not possible as statistics are not available. Therefore the qualitative approach using people's judgment and experience is most useful.

Many of the techniques assess the range of potential consequences and the likelihood (exposure and probability) of their occurrence. All require some insight by those involved as to what could go wrong. Therefore these approaches may be limited if there is insufficient understanding of what could happen, such as in the more subtle or slowly developing health problems. This may result in an underestimation of risk.

Nevertheless, in most cases, team members' experience, incident and accident reports and injury statistics will be a good guide. However, that information may not help in the development of new systems and new controls where there have been no reports of injury or disorders, or where the link between aspects of the work and the disorder have not been made. In these cases a more exploratory approach may be required and pilot studies and mock-ups will be critically important. These methods should be included in the process of developing solutions to anticipated problems.

Further reading: • Industry material 6.2: MDG 1010 • NOHSC 1.12: Positive Performance Indicators • NOHSC 1.13: Benchmarking OHS • Book 9: Oxenburgh, Marlow & Oxenburgh • Other material 8.1: Benchmarking OHS

Evaluating solutions directly

Ergonomics solutions to current problems, new innovations and new technology all require evaluation to determine if they work in reality. Are people happy with the arrangements? Could the solutions be improved? Have employees been adequately trained and could they improve on the situation if they had input? It is very likely that not all potential problems can be identified in the design or redesign phase.

Evaluation of the solution in operation is often forgotten as people move to solving the next problem. Sometimes the people responsible for the solution are so committed to it they are unwilling to recognise that there are residual difficulties or that it does not work at all. Therefore evaluation is essential.

It is also necessary to evaluate solutions adopted from other workplaces. A solution that is successful elsewhere may be introduced to solve a problem without assessment of local requirements. This may create other problems. Assumptions about the benefits of new equipment, tools, furniture or systems of work need to be challenged and tested before they are universally accepted. It is important that the people who are most likely to be affected make the decision but they must be fully informed of the options, problems and advantages.

Solution must be evaluated at the appropriate time(s). Its immediate success does not guarantee that it will remain successful especially when circumstances or workers change. Evaluations of some sort should be conducted at a minimum of six to 12 monthly intervals.

Ongoing monitoring of ergonomics problems and their solutions should be built into the company's OHS audit system.

Recording and communicating what has been achieved

Gathering information

Information on the effectiveness of solutions may be gathered through informal feedback or discussions with users or with informal or structured interviews. Many people take 'before and after' photographs or videos, undertake follow-up risk assessments, fill out checklists or questionnaires, or repeat measurements made before the changes.

Evaluative evidence information may be gathered by using 'dummy runs', mock-ups or prototypes. Guidance from an ergonomist, to ensure that all key issues have been addressed, can be useful when using these methods.

More formal evaluations may be required:

- when usable information is to be fed back to manufacturers and suppliers;
- if the solution is critical in terms of injury or damage control;
- where costs of injuries are unacceptable and the effectiveness of the control needs to be demonstrated;
- where information is needed for the organisation's records or is required by law.

Keeping records

Keeping a record of ergonomics activities and the lessons learned is important if progress is to be made. So often, particularly when there are changes in personnel, previous work and improvements or the reasons why certain designs were implemented are forgotten. Obviously over time some reassessment must be made but this should be done with all the historical facts to hand.

Information for records can include:

- OHS Committee initiatives and minutes;
- hazard identification processes and reports;
- risk assessment reports;
- design specifications for equipment and work environments;
- modifications to equipment and systems of work;
- risk control measures proposed and implemented;
- risk control monitoring and reviews;
- consultants' and technical reports;
- training and education of employees and other stakeholders.

Feedback

Some OHS professionals consider feedback to employees and senior managers on progress and outcomes of programs, activities, initiatives and suggestions to be one of the most powerful positive influences in improving workplace health and safety. Crew or toolbox talks; newsletters; OHS Alerts; reports and completed audit forms; training sessions; intranet sites; emails; and person-to-person communication all may be used to impart information both from upper management and from the 'shop floor' or 'coal face'. 'Top down' should be matched by 'bottom up' information flow. Comments, suggestions and improvements should be invited as part of the evaluation and feedback process.

If changes are suggested they need to be considered, action taken and further feedback given. When a proposal for change has been made and is rejected then objective reasons for the rejection need to be given. No suggestion should be ruled out simply on the basis of its cost. Benefits that can be derived from changes need to be considered carefully in the context of the work situation. On the other hand no change should be implemented unless there is a demonstrated need for it and it has been evaluated in some way for the particular work situation. These cost-benefit analyses can be done quickly and easily using basic data. This process provides a mechanism for continuous improvement.

KEY PRINCIPLES

- The effectiveness of ergonomics solutions can be measured or assessed in the same way as many other management and engineering changes through positive and negative indicators, and with investigative and risk management techniques.
- It is also necessary to evaluate the immediate impact of ergonomics solutions with respect to solving problems and improving productivity. Often this can be done using relatively simple techniques.
- Keeping records of information on ergonomics activities is necessary to ensure that changes are built upon and there is continuous improvement.
- Feedback to employees and senior managers on progress and outcomes of programs, activities, initiatives and suggestions is essential.

Part D: Further reading
Glossary of Terms
Index

FURTHER READING

Books and other publications

Level 1: Introductory, basic technical information.

Level 2: Written for the ergonomist but technically not too difficult.

Level 3: Technically complex but important reading on the subject.

General

1: Dul and Weerdmeester B. Ergonomics for Beginners. London, Taylor & Francis, 1993.

Level 1:This is an updated version of one of the original textbooks in ergonomics under the heading Vademecum Ergonomie by the early pioneers of ergonomics in the Netherlands. It has since been updated and contains information mainly on physical ergonomics useful for many types of industrial and office work. Unusually it contains some valuable tips on how to make ergonomics work in practice.

2: Kroemer K and Grandjean E. Fitting the Task to the Human – A Textbook of Occupational Ergonomics Approach. London, Taylor & Francis 1997 (5th Ed)

Level 1: This is another early and successful text first written in 1963. The late Professor Etienne Grandjean was a founding father of ergonomics and wrote the original text. Professor Karl Kroemer has updated the latest edition. Although some of the information is not as up-to-date as more specialised publications it is still a classic. It covers most areas in ergonomics very broadly although it does not deal with systems (Organisational design and management).

3: Sanders MS, McCormick EJ. Human Factors in Engineering and Design. New York, McGraw-Hill, 1993.

Level 2: Sanders has revised another classic written by the late Professor Ernest McCormick first published as Human Engineering in 1957. It has strong engineering and design focus and has some excellent summaries of issues and discussions as well as historical information, anthropometric tables and design guidelines.

4: Stevenson MG. Notes on the Principles of Ergonomics. Revised edition. Sydney, Mike Stevenson Ergonomics 1999. (Available from Dr Stevenson, 11 Willawa Street, Balgowlah NSW 2093 Australia).

Level 2: Professor Stevenson has compiled these excellent bound notes suitable for undergraduate ergonomics students. They concentrate on physical aspects of work rather than organisational or psychological aspects. Some information is quite technical and may be more detailed than many people would require in order to solve a problem in the workplace. Nevertheless the Notes contain some information that is not readily available elsewhere such as the Australian anthropometric tables, which are invaluable.

Engineering and Design

5: Clark TS, Corlett EN. The Ergonomics of Workspaces and Machines: A Design Manual. London, Taylor & Francis, 1995, (2nd Ed).

Level 2: This text is written for industrial designers and engineers responsible for implementing ergonomics in the workplace. It contains a range of information on human dimensions and capabilities needed in the design process and has an extensive section on displays, codes and symbols for equipment.

6: Stevenson M. Safety by Design. Sydney, Mike Stevenson Ergonomics. 2003. (Available from Dr Stevenson).

Level 2: This is a handbook for engineers, designers and those responsible for designing safer workplaces. It gives lots of examples of design hazards and their redesign for industrial and construction applications. It includes legal obligations, falls, machine guarding, vehicles accidents and manual handling and a section on ergonomics application.

7: Woodson W, Tillman B, Tillman P. Human Factors Design Handbook: Information Guidelines for the Design of Systems, Facilities, Equipment and Products for Human Use. New York, McGraw-Hill, 1992 (2nd Ed).

Level 2: Like 'The Ergonomics of Workspaces and Machines' this book contains information on design parameters for designers and engineers. It is very comprehensive so it is also useful for professional ergonomists advising clients on design parameters for equipment and systems.

Occupational Health

8: McPhee B, Foster G, and Long A. Bad Vibrations. A Handbook on Whole-body Vibration in Mining. Joint Coal Board Health and Safety Trust, Sydney 2001.

Level 1: This Handbook outlines the sources of Whole-body Vibration (WBV) exposures and their prevention. It aims to assist people to identify and manage the risk of WBV exposure at work. It covers a description of WBV and its effects on humans; how it is measured; identification, assessment, control and monitoring of WBV; check sheets and case studies.

9: Oxenburgh M, Marlow P, and Oxenburgh A. Increasing Productivity and Profit Through Health and Safety. London, Taylor & Francis, 2003 (2nd Ed).

Level 2: This book and the accompanying computer program are invaluable resources for those who wish to understand more about cost benefit in occupational health and safety including ergonomics. The book outlines a number of case studies where improvements have led to savings as well as the method for estimating these. The figures derived from this program can be used to develop a financial justification for change – one of the hardest parts of ergonomics.

10: Pheasant S. Ergonomics, Work and Health. Basingstoke, MacMillan Academic and Professional Ltd, 1991.

Level 1: This is another classic ergonomics text written in an easy-to-read style by the late Dr Stephen Pheasant. It was one of the first books to describe the link between various work-related disorders and ergonomics in such a way that everyone could understand it. It covers physical and psychological factors, job design and work organisation including shiftwork. It was written in 1991. Sadly Dr Pheasant died in 1996 so it may be a little outdated in some technical areas such as vibration. Nevertheless it still remains an excellent introduction to occupational ergonomics.

Office ergonomics

11: Victorian WorkCover Authority (WorkSafe Victoria). Officewise. Melbourne, Victorian WorkCover Authority, 1997.

Level 1: This is a useful book for those interested in office ergonomics and occupational health and safety. It covers different aspects of office work and describes the standards that need to be met in general terms for physical, psychological and social health. It is available as a Handbook and on Victorian WorkCover website under publications.

Shift work and extended work hours

13: Curuso CC, Hitchcock EM, Dick RB, Russo J, Schmidt JM. Overtime and Extended Work Shifts: recent Findings on Illnesses, Injuries and Health Behaviors. Department of Health and Human Sciences, Centers for Disease Control and Prevention, NIOSH (CDC – NIOSH website, see below)

Level 2: This is a review of 52 published studies on long working days conducted all over the world. It is well written and covers a range of topics that impact health and safety in the workplace. It is well worth a read if you want to know what the most recent studies are saying about extended shifts.

14: Monk TH, Folkard S. Making Shift Work Tolerable. London, Taylor & Francis, 1992.

Level 1: This is an information textbook aimed at workers, managers and health and safety professionals who are dealing with shiftwork and its possible negative effects. It is practical and easy to read and is a useful summary of the issues including physical, psychological and social stresses, health and performance consequences and coping and management strategies.

Methods in ergonomics

15: Wilson JR, Corlett EN. Evaluation of Human Work. London, Taylor and Francis, 1995. (2nd Ed)

Level 3: This is a comprehensive guide to the measurement of human activity and its outcomes at work including physiological, psychological, epidemiological and survey techniques. It is one of the most useful textbooks for students of ergonomics who want to get a grasp of the different methods of measuring and their strengths and weaknesses.

Anthropometry

16: Diffrient N, Tilley A, Bardagjy JC. Human Scale 1/2/3. Cambridge, Mass. MIT Press, 1974.

17: Diffrient N, Tilley A, Harman D. Human Scale 4/5/6 and 7/8/9. Cambridge, Mass. MIT Press, 1981.

Level 2: These are set of anthropometric tables and handbooks that are classics, used by designers, ergonomists and students of ergonomics for over 30 years. They consist of ranges of dimensions for different applications printed on plastic wheels. These able to be set at a given dimension and other dimensions can be derived.

18: Pheasant S. Bodyspace. Anthropometry, Ergonomics and Design. London, Taylor & Francis, 1996 (2nd Ed).

Level 1: This book provides good descriptions of human diversity and the need to consider body dimensions in all aspects of design – at work and in the home. It includes detailed anthropometry tables that can be useful to almost anyone and an outline of different aspects of anthropometry as it is applied in different areas. It is an excellent introduction to anthropometry.

Physiology

19: Parsons K. Human Thermal Environments. London, Taylor and Francis, 2003 (2nd Ed)

Level 3: This is a most important text on human work in hot and cold conditions. It is very technical in parts because the subject matter is complex but it is well worth persisting if you need reliable and up-to-date information in this area.

20: Rodahl K. The Physiology of Work. New York. Taylor & Francis, London. 1989.

Level 2: As an introduction to work physiology and the application of physiological knowledge to the design of work this book is an excellent place to start. It covers a range of areas including measurement and assessment in the workplace, shiftwork, stress, muscle tension, and working in polluted atmospheres. It is clear and well written and full of interesting facts.

Task design

21: Violante F, Armstrong T and Kilbom A (Eds). Work Related Musculoskeletal Disorders of the Upper Limb and Back. . London, Taylor and Francis, 2000

Level 3: Contains important information on the causes of work-related musculoskeletal disorders particularly epidemiological research and measurement.

Stress

22: Devereux J. Work related Stress and Musculoskeletal Disorders [Summary of Technical Report] Robens Institute, University of Surrey 2004. Website address: http://www.eihms.surrey.ac.uk/robens/erg/stress.htm

Level 1: This is a recent and excellent summary of research undertaken on the link between musculoskeletal disorders and stress at work.

Work-Related Musculoskeletal Disorders

23: Kuorinka I, Forcier L (Eds). Work Related Musculoskeletal Disorders (WMSDs). A Reference Book for Prevention. London, Taylor & Francis, 1995.

Level 3: This book is for those who need a detailed summary of research and other findings on how musculoskeletal disorders are managed and prevented at work. It covers the history and work-relatedness of these disorders, risk management, surveillance and training. It also contains two excellent chapters on managing solutions, managing change and training.

24: McPhee BJ. Ergonomics for the Control of Sprains and Strains in Mining. Sydney, Worksafe Australia and the Joint Coal Board, 1993. Website address: www.nohsc.gov.au/OHSInformation/Publications

Level 1: This handbook was written in an attempt to introduce the subject of ergonomics to mining, particularly coal mining. It is basic and outlines the process of risk management in manual handling. It also contains information of mining machinery seat design and a broad checklist on the ergonomics of mining machines.

25: Stevenson M (ed). Readings in RSI. The Ergonomics Approach to Repetition Strain Injuries. Sydney, NSW University Press, 1987.

Level 1: This little book may not be available now but it still may be held in university and other libraries. It is well worth a browse if you are interested in the mechanics, management and prevention of overuse injuries (OOS or RSI). It contains some early Australian papers (written in the 1970s and 1980s) on the issues of overuse of the upper limb and what can be done. Despite the enormous adverse publicity that was given to the problem at the time, the amount of research that has been done on the subject since and a plethora of textbooks that have emerged these papers still read well today and contain useful information.

Systems Ergonomics (Organisational Design and Management)

26: Noro K, Imada AS. (Eds). Participatory Ergonomics. London, Taylor & Francis, 1991.

Level 2: This is an excellent summary of the history and approaches that can be used in participatory ergonomics.

27: Langford J, McDonagh D (Eds). Focus Groups. London, Taylor & Francis, 2003.

Level 2: This is a good overview of different methods and tools that can be used by focus (participatory) groups in human factors and ergonomics design. It contains a useful summary of learning for older people.

Aging at work

28: Kumashiro M. (Ed) Aging and Work. London, Taylor & Francis, 2003.

Level 3: Unlike many collections of papers this edited version of conference proceedings contains some seminal contributions including measuring work ability, stress and physiological fitness in older workers.

29: Skiöld L: A look into modern working life. National Institute for Working Life, Stockholm, 2000

Level 2: The Institute of Working Life initiated this book as one of its programs during the Swedish Presidency of the European Union in the first half of 2001. It is the outcome of a series of 63 international scientific workshops held throughout Europe from 1997 to 2000 led by distinguished researchers and practitioners. The aim was to provide a solid base of knowledge through state-of-the-art reports on many different aspects of working life. It covers a wide range of topics and captures the issues in working life of the time very well. It is unlikely that such a broad and deep summary of these issues will appear again for some time.

Human Error

30: Reason J. Human error. Cambridge University Press, New York, 1990.

Level 3: This is one of the bibles on the theory and application of human error principles.

Australian Government Codes and Standards

1: National Occupational Health and Safety Commission [NOHSC]
Website address:
www.nohsc.gov.au/OHSInformation/Publications

NOHSC has produced many Standards, Codes and Guidelines that need to be referred to when implementing ergonomics mainly because they are basis of most other state-based legislative Codes and Guidelines in Australia.

The most relevant Codes related to ergonomics are:

1.1: National Code of Practice for the Prevention of Occupational Overuse Syndrome. [NOHSC 2013 (1994)]

1.2: National Standard for Manual Handling [NOHSC 1001(1990)]

Note: A new Australian National Code of Practice for the Prevention of Musculoskeletal Disorders from Manual Handling at Work is being prepared. Notice of its publication will be made on the NOHSC website.

1.3: National Code of Practice for Manual Handling. [NOHSC 2005 (1990)]

1.4: National Code of Practice for Noise and Protection of Hearing at Work. [NOHSC: 2009(2004) 3rd Edition]

1.5: National Code of Practice for the Prevention of OOS [NOHSC 2013 (1994)]

Some useful Guides include:

1.6: Control Guide – Management of Noise at Work

1.7: Guidance Note on the Prevention of OOS in Keyboard Employment [NOHSC:3005 (1996)]

1.8: Guidance Note on the Prevention of OOS in the Manufacturing Industry [NOHSC:3015 (1996)]

1.10: Plant in the workplace. Making it safe. A guide to managing risks from plant in the workplace for employers and employees.

1.11: Plant in the workplace. Making it safe. A guide to risk management for designers, importers, suppliers and installers of plant.

1.12: Positive Performance Indicators. Beyond Lost time injuries. Parts 1 & 2

1.13: Benchmarking Occupational Health and Safety

1.14: Ergonomics Principles and Checklists for the Selection of Office Furniture and Equipment

Factsheets include:

1.15: Managing Back Pain

1.16: Manual Handling

1.17: Noise

1.18: Overuse Injuries

1.19: Shiftwork

1.20: Stress and Burnout at Work

1.21: Workplace Health and Safety Responsibilities

1.22: Workplace Layout and Design

1.23: Comfort at Work – Too Hot? Too Cold?

2: NSW Workcover Authority

Website: www.workcover.nsw.gov.au

Useful publications are:

2.1: Risk Management at Work

2.2: OHS Consultation

3: Victorian WorkCover Authority (WorkSafe Victoria)

Website: www.workcover.vic.gov.au

Useful publications are:

3.1 Sun Protection for Construction and Other Outdoor Workers

3.2 Managing Manual Handling Risks in a Small Organisation

3.3 Managing Manual Handling Risks in a Large Organisation

3.4 Code of Practice for Manual Handling (2000)

4: Queensland Department of Workplace Health and Safety.

Website: www.whs.qld.gov.au

Useful publications are:

4.1 Heat Stress: Managing the Risk

4.2 Queensland Advisory Standard: Manual Tasks 2000.

4.3 Queensland Advisory Standard: Manual Tasks Involving the Handling of People 2002.

Australian Standards

Australian Standards assembles groups of experts from industry, government, consumer and other relevant sectors to prepare Standards. The requirements or recommendations contained in published Standards are a consensus of the view of representative interests and also take into account the comments received from other sources. They should reflect the latest scientific and industrial experience. Australian Standards are reviewed from time to time and are updated to take account of changing technology and circumstances. In some cases they are joint Australian and New Zealand Standards.

In some cases, such as earth moving equipment design, Australian Standards may indicate the minimum standards as they are applied to the workplace. They usually supplement and support OHS Standards, Codes of Practice and Guides prepared by NOHSC and other government bodies in Australia.

Local or industry standards may give contrary information to Australian Standards. The most appropriate Standard must then be followed.

5.1 AS 3590 – 1990: Screen-based Workstations. Part 1: Visual Display Units, Part 2: Workstation Furniture, Part 3: Input Devices.

5.2 AS/NZS 4443 – 1997: Office panel systems – Workstations

Level 2: These Standards are somewhat overshadowed by more recent publications from state and Commonwealth governments and do not contain any more information. Nevertheless they are Standards and as such can be helpful.

5.3 AS 1680.2.1 – 1993: Interior lighting – Circulation spaces and other general areas

5.4 AS 1680.2.2 – 1994: Interior lighting – Office and screen-based tasks

5.5 AS 1680.2.3 – 1994 – Interior lighting – Educational and training facilities

5.6 AS/NZS 1680.2.4 – 1997 – Interior lighting – Industrial tasks and processes

5.7 AS/NZS 1680.2.5 – 1997: Interior lighting – Hospital and medical tasks

Level 2: Again these Standards are part of an array of information that is now freely available on Australian and overseas websites. Nevertheless they contain useful information.

5.8 AS 1319 – 1994: Safety signs for the occupational environment

Level 2: Safety signage has been standardised to everybody's relief but this may not contain everything you need to know especially about the ergonomics of signage. Refer to ergonomics textbooks listed here for more on issues such as readability and location.

5.9 AS/NZS 4240 – 1994: Remote controls for mining equipment.

Level 2: This is an essential reference for anyone designing remote control devices. It contains information on ergonomics and the design of controls for remote devices.

5.10 AS 2670 – 2001: Evaluation of human exposure to whole-body vibration – General requirements.

Level 3: This Standard is identical to the International Standard ISO 2631.1 – 1997: Mechanical vibration and shock – Evaluation of human exposure to vibration. The standards for measurement, analysis and exposure to whole-body vibration are significantly upgraded from the previous Australian Standard with more emphasis placed on the assessment of shocks. Many pieces of equipment in use today would not meet the required standards for 7-hours exposure.

5.11 AS 2763 – 1988: Vibration and shock – Hand-transmitted vibration – Guidelines for measurement and assessment of human exposure

Level 3: A lot of research work was done on this subject in the 1970s and 1980s due to increasing problems arising from the use of vibrating mechanical tools in colder climates such as the Nordic countries, Canada and the USA. Although some updating may be required the methods recommended in this Standard are still valid.

5.12 AS 2953.1 – 1988: Earth-moving machinery – Human dimensions. Minimum access.

5.13 AS 2953.2 – 1988: Earth-moving machinery – Human dimensions. Physical dimensions of operators and minimum operator space envelope.

5.14 AS 2956.5 – 1988: Earth-moving machinery – Instrumentation and operator's controls. Zones of comfort and reach for controls.

5.15 AS 2956.6 – 1988: Earth-moving machinery – Instrumentation and operator's controls. Crawler tractors and crawler loaders – Operator's controls.

5.16 AS 3868 – 1991: Earth-moving machinery – Design guide for access systems.

Level 1: These five Standards stipulate the minimum standards for mobile machinery design in terms of cabs space and layout, displays and controls and access. Ergonomics standards are a good deal more demanding than these and therefore are much more likely to be applied in new machines.

5.17 AS/NZS 4360 – 2004: Risk Management.

5.18 HB 436 – 2004: Risk Management Guidelines. Companion to AS/NZS 4360 – 2004

Level 1: This Standard and its accompanying Handbook cover the main generic issues of Risk Management. It is essential reading for anyone required to undertake formal or informal risk management procedures.

5.19 AS/NZS 4804 – 2001: Occupational health and safety management systems – General guidelines on principles, systems and supporting techniques.

5.20 AS/NZS 4801 – 2001: Occupational health and safety management systems – Specification with guidance for use.

Level 1: These two Standards and the accompanying Handbook give guidance on how OHS Management Systems can be set up, monitored and improved. The requirements for ergonomics in OHS are much the same. AS/NZS 4801 – 2001 specifically deals with certification, evaluation and auditing criteria. They are important for those wishing to integrate ergonomics into OHS.

5.21 HB 205- 2004: OHS Risk Management Handbook

Level 1: The handbook is designed to show how AS/NZS 4360 – 2004 and AS/NZS 4804 – 2001 can be adopted to meet the requirements of OHS risk management systems. Again it is essential reading for those involved in making OHS work.

5.22 HB59 -1994: Ergonomics – The human factor. A practical approach to work systems design.

Level 1: Despite its title this publication is somewhat limited in its coverage of ergonomics particularly with respect to the wider field of systems and organisational ergonomics. It contains basic information that can be found in other publications. However, as an Australian Standard publication it may be referred to legitimately and it may be used by some organisations.

Website: www.standards.com.au/catalogue/script

Industry material

Website : www.mineralsnsw.gov.au

NSW Department of Primary Industry (DPI) – Coal Mining Inspectorate – formally with the NSW Department of Mineral Resources (DMR) printed publications.

6.1 MDG 1. Guideline for Free Steered Vehicles. 1995.

MDG 1010. Risk Management Handbook for the Mining Industry. 1997

Note: MDG 1 and MDG 1010 are being revised and the new editions are due for release in the second half of 2005. They may not necessarily have the same number or name.

Australian Council of Trade Unions

Website: www.actu.asn.au

Level 1: The ACTU Guidelines available on this website are comprehensive and give information and guidance in some key areas. These include:

7.1 Screen Based Work

7.2 Working in Seasonal Heat

7.3 Shiftwork and Extended Working Hours

The website also contains extensive links to associated organisations' websites many of which have OHS information.

Other Codes, Standards and Guidelines

Health and Safety Executive (HSE) Britain.

Website: www.hse.gov.uk

The HSE is the British OHS regulatory authority. It publishes numerous information sheets that can be downloaded. Some of the more useful ones in ergonomics include:

8.1 Benchmarking in OHS

8.2 Display screen equipment

8.3 Understanding ergonomics (mainly offices and factories)

8.4 Manual Handling

8.5 Office work

8.6 Stress

Guidance material includes:

8.7 Health & Safety Executive (UK). Manual Handling. Manual Handling Operations Regulations 1992. Guidance on Regulations. L23 (3rd Edition) HSE Books, 2004.

Level 2: This presents a different way to consider manual handling risks. Contains some useful material not covered in the Australian Code of Practice or other NOHSC guidance material. It is available only in the printed version and is awkward to find on the HSE website.

8.8 Getting to Grips with Manual Handling. HSE

Level 1: This is an easy-to-read guide the above Regulation. It is available on the HSE website.

National Institute for Occupational Safety & Health (NIOSH) USA – Centers for Disease Control and Prevention (CDC).
Website: www.cdc.gov/niosh/nioshtic

NIOSH is primarily concerned with OHS research and information. It has a huge website with thousands of publications. Finding what you want is the problem. However the website has a search facility that can lead you the subject matter that you want by using keywords. It is called NIOSHTIC-2.

One recent publication worth a look is:

8.9 Overtime and Extended Work Shifts: recent Findings on Illnesses, Injuries and Health Behaviors. (See Shift Work)

8.10 National Institute for Occupational Safety & Health (NIOSH). Work Practices Guide for Manual Lifting. Cincinnati, NIOSH, 1981. (Publication No 1034 Under Ergonomics/ Musculoskeletal disorders on the website).

Level 3: Some of NIOSH's research has generated codes and guides that have been very useful to both researchers and practitioners. Although this is rather old it is a good summary of methods defining the ways in which disorders associated with manual handling can be analysed.

Robens Institute, University of Surrey, England.
Website address:
www.eihms.surrey.ac.uk/robens/erg/stress.htm

This is a highly esteemed research institute in occupational health and safety and particularly ergonomics.

One recent publication merits reading. It briefly discusses findings of a large research report into the relationship between stress and musculoskeletal disorders. There are some problems getting onto the website but these may have been rectified. It is:

8.11 Devereux J. Work Related Stress and Musculoskeletal Disorders [Summary of Technical Report]

Canadian Centre for Occupational Health and Safety.
Website: www.ccohs.can

This website has a number of useful documents on ergonomics in OHS. Some headings worth exploring are:

8.12 Ergonomics (including a complete summary of the Revised NIOSH Lifting Equation)

Physical agents (especially working in hot and cold environments)

8.13 Workplace schedules (shiftwork)

GLOSSARY OF TERMS:

Accident
An unplanned event that interrupts the completion of an activity, and that may or may not include injury or property damage.

Anthropometry
The dimensions of the human body and how these are measured. It covers the size of people; the length and range of movement of their limbs, head and trunk; and their muscle strength.

Australian Standard
Issued by Standards Australia and provides guidelines relating to the design, operation and maintenance of equipment and systems. An Australian Standard always has a standard number e.g. AS 1470

Awkward
A posture or action required for a task that creates some discomfort for or is unable to be maintained by the worker.

Benchmarking
A tool to identify and assess systematically the differences between an enterprise and world-class performers. It can be used to introduce best practice into enterprises. It is conducted in such a way that there is wide consultation and people are in a position to understand and achieve their full potential.

Best Practice
Refers to the cooperative way in which enterprises and their employees work together continuously to strive to be the best possible in all key business processes. The benefits can be seen in improvements in health and safety, timeliness, cost, quality and customer service.

Biomechanics
The interaction of human movement and posture. It deals with the levers and arches of the skeleton and the forces applied to them by the muscles and gravity.

Change management
An organised and systematic approach to anticipating and managing change in an organisation.

Circadian rhythm
Daily cycles of the human body in terms of physiological and psychological parameters such as temperature, hormone levels, mood, heart rate and blood pressure. These are largely internally generated (endogenous) and often resistant to abrupt changes such as those caused by shift work or intercontinental flights.

Cognitive
The processing of stimuli from the environment and from within the individual. These stimuli are relayed by the sense organs to the brain.

Constrained
Forced, cramped, restrained or unnatural, confined or restricted.

Consultation
The sharing of information and exchange of views between employers, employees and/or employee representatives on health and safety issues. It includes the opportunity to contribute to decision-making in a timely fashion to minimise OHS risks.

Continuous Improvement
This is a keystone of Best Practice. It refers to the incremental beneficial changes that occur through the cooperative efforts of all people in the enterprise. In enterprises that embrace a philosophy of continuous improvement people bring their ideas forward and management provides consistent encouragement, support and feedback.

Decision latitude
The degree to which an individual or group has control over their work processes and outcomes. It implies a certain degree of autonomy with respect to how and when a task/ job is undertaken and completed.

Due diligence
In OHS due diligence requires that employers, supervisors and others understand and carry out their legal duties, assess the risks and hazards in the workplace on an ongoing basis, and take all reasonable precautions with respect to those hazards and risks. Evidence of due diligence may be a defence against prosecution under OHS laws.

Ergonomics
The scientific discipline concerned with the understanding of the interactions among humans and other elements of the system and the profession that applies theory, principles, data and methods to design in order to optimise human well being and overall system performance.

Fatigue
Weariness from physical and/or mental effort.

Hazard
Anything that has potential to cause harm to a person

Health
Freedom from the presence of ill heath, disease or injury in the body.

Human error
An inappropriate or undesirable human decision or behaviour that reduces, or has the potential to reduce effectiveness, health and safety, or system performance.

Hierarchy of controls
Matching appropriate controls (solutions) to the level of risk

Injury
Immediate damage to the body caused by exposure to a hazard.

Job
Specific set of ongoing tasks to be performed by an individual.

Job Analysis
Evaluation of all tasks and factors involved in and completion of various phases of a job in a particular sequence.

Job Design
The process of deciding on the tasks and responsibilities to be included in a particular job. The aim is to satisfy the social and personal requirements of the job holder as well as technological and organisational requirements.

Job Rotation
: The planned interchange of jobs among a group of workers at regular intervals in order to increase variety of motions and postures, share the most stressful tasks, add interest and increase versatility.

Kinesiology
: The science of human movement as it relates to the structure of the musculoskeletal system. It describes motions of the body segments and identifies the muscle actions responsible for those.

Macro ergonomics
: An approach in ergonomics that examines problems and issues in respect to the overall system so that it achieves effective and lasting change.

Mutual Handling
: Includes a wide range of human work activities such as lifting, pushing, pulling, holding, throwing and carrying as well as repetitive tasks including packing, typing, assembling, cleaning and sorting.

Micro ergonomics
: An ergonomics approach that examines localised or individual ergonomics problems and issues with the aim of finding and implementing solutions at that level.

Musculoskeletal system
: The system of bones, muscles and connective tissues (tendons, ligaments, fascia, cartilage) that support and protect the human body and its organs and provide motion. Joints are the junction between bones and allow motion.

Motivation
: An individual's intention or willingness to perform a task to achieve a goal or reward that will satisfy them. Each individual experiences differing amounts and types of motivation and considers different rewards or incentives as being attractive

NIOSH
: National Institute for Occupational Safety and Health (USA) is the federal agency responsible for conducting research and making recommendations for the prevention of work-related injury and illness. It is part of the Centers for Disease Control and Prevention (CDC) in the US Department of Health and Human Services.

NOHSC
: The National Occupational Health and Safety Commission (NOHSC) is Australia's national body that leads and coordinates national efforts to prevent workplace death, injury and disease in Australia.

Noise
: Unwanted sound. High noise levels can be annoying, distracting, fatiguing and may also result in impaired hearing if loud enough.

Occupational ergonomics
: Ergonomics as is applied at work to the design of the workplace and tasks and to work organisation.

OHS
: Occupational Health and Safety (OHS) is the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations; the prevention among workers of departures from health caused by their working conditions; the protection of workers in their employment from risks resulting from factors adverse to health and safety; the placing of and the maintenance of the worker in an occupational environment adapted to physical and mental needs.

ODAM
: Organisational Design and Management. See Macro ergonomics

OOS
: Occupational overuse syndrome (OOS) refers to a range of conditions marked by discomfort or persistent pain and/or other dysfunction in muscles, tendons or other soft tissues of the hand, arm or shoulder and sometimes occurs in the foot and ankle. Synonyms are: repetition strain injury (RSI), cumulative trauma disorder (CTD) and work-related musculoskeletal disorders (WMSD).

Optimum/Optimal
: Best or most favourable balance between the needs of people and real-life limitations such as availability of solutions, their feasibility and costs.

Parallax error
: Mistakes made reading the position of a pointer on a dial or gauge when viewing it at an angle.

Physiology
: The science dealing with the functioning of living organisms or their parts.

PPE
: Personal Protective Equipment (PPE) includes a wide range of devices that are designed to give individual protection from health and safety hazards. Common examples include ear plugs, respirators, glasses and gloves.

Psychophysical factors
: These are concerned with the relationship between physical stimuli from the 'outside world' and the sensations these produce in the body's 'inside' world. They are measured for various reasons at work in such areas as perceived exertion, the development of effort scales, acceptable weights to be lifted, and the design of chairs and workstations.

Psychosocial factors
: Subjective aspects of work organisation and how workers and managers perceive them eg career considerations, clarity of the work role, work schedules, workload and work pace, and the social and technical work environment.

RSI
: See OOS

Risk
: Factor that contributes to the occurrence of injury or loss from a hazard.

Risk Assessment
: Process used to determine the likelihood of people being exposed to injury, illness or disease from any situation identified during the hazard identification process and the severity of the illness, injury or disease.

Risk Control
: Process used after conducting a risk assessment identifying all practicable measures for removing or reducing the likelihood of injury, illness or disease, implementing these measures and reviewing them to ensure their effectiveness.

SAE

Society of Automotive Engineers (USA). Over many years the Society has produced guidelines and recommendations for driver spaces in cars and other vehicles within various design guidelines. These are used all over the world as the basis for cab design.

Safe Work Procedure

A standardised procedure developed for a task or a job to minimise workplace health or Standard Work and safety risks and to optimise efficiency. Procedure (SWP)

Sprain/Strain

Traumatic or cumulative injury resulting in damage to and inflammation of joints and adjacent muscles and connective tissues. It is usually accompanied by pain and stiffness. Swelling and loss of function in the area involved may also result.

Stakeholder

A person, a group or an organisation that has either an interest in, concern for, and/or involvement with OHS and the outcomes of work in OHS. The stakeholder may be directly or indirectly affected by this interest, concern or involvement, which may be seen as a gain or a loss. Stakeholders may be clients (individuals to whom the service is directed), customers (those who pay for the service), fellow workers, employers, trade unions and/or other professionals. The wider community may also be a stakeholder in the sense that it benefits from good OHS practice and it may also pay for such services, or the lack of them, through insurance, taxes, prices for goods and services etc.

Stress

A person's reaction when demands exceed an individual's ability to cope physically and/or mentally. These demands can be personal or work-related or both. It may sometimes be referred to as distress.

System

Systems are the structures that underlie complex situations. A system is a set of interrelated and interdependent parts arranged so that it appears to be and acts like a unified whole.

Task

Set of human actions that contribute to a specific functional objective and ultimately to the output goal of a system.

Task Design

The study of the components of a particular task to improve efficiency and minimise deleterious effects on the people who will perform the task. It includes planning and review of task elements with respect to human capabilities and limitations, and the design of equipment they use, the work environment and the work organisation.

Telemetry

Automatic measuring of something distant or inaccessible and the transmission of measurements to a recording/displaying device.

Violation

An incorrect (inappropriate) action that a person knowingly performs. The actions are carried out as intended.

Vibration

The oscillating or periodic motion of a particle, group of particles, or solid object about its equilibrium position

WMSD

See OOS

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Barbara McPhee is a Certified Professional Ergonomist and Physiotherapist who has worked in occupational health and safety for over 30 years as a consultant, teacher and researcher most particularly in ergonomics. During this time she has worked in all aspects of the field at every level of industry and government throughout Australia and overseas.

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