Information on this subject and related matters may also be found in *ACC report*, journal of the Accident Compensation Commission, and in other publications issued by the Commission.

The Accident Compensation has three main functions: the prevention of accidents, the rehabilitation of people who suffer personal injury by accident and the provision of compensation for such people or to certain dependants of people whose deaths result from accidents.

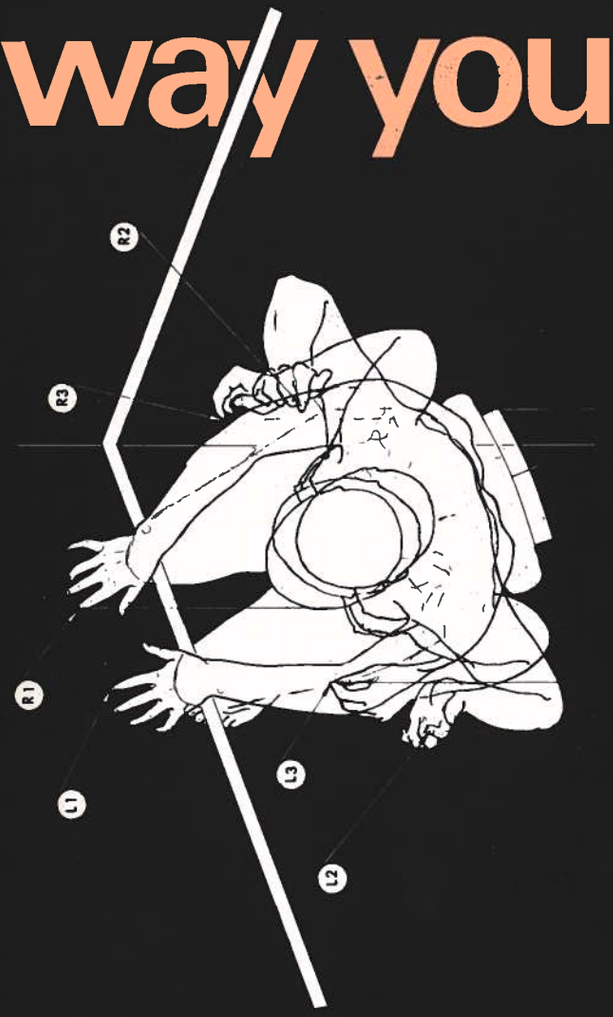
Contact your nearest ACC office for advice, or write to—

Public Affairs Section
Accident Compensation Commission
Private Bag
Wellington

At left, James Coe at his office draughting board. The chair is at an optimum height for his body height of 175 cm (5 ft 9 in). The seat angled back and the position of the back support are personalized, fitted to his bone structure. The sight angles are optimum. The lighting from the ceiling is from tubes in three separate phases, giving diffused general illumination. The directional light attached to the board moves laterally with Mr Coe and is angled to beam on the drawing and not to reflect on James Coe's face.

illustration from *ACC report*, vol. 2, no. 4

You and the way you sit



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You and the way you sit

Prepared by the Accident Compensation Commission
Special technical illustrations and assistance: James B. Coe

You and the way you sit

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Accident Compensation Commission

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This booklet has been prepared with the special assistance of James B. Coe, former Senior Tutor in Ergonomics, Wellington Polytechnic, and lecturer to the School of Architecture, Victoria University of Wellington.

James Coe is a Fellow of the New Zealand Society of Industrial Designers and a member of the Ergonomics Society, Australia and New Zealand.

Advice and assistance have also been given freely by individual physiotherapy, medical and surgical professionals in particular.

The publication is issued by the Accident Compensation Commission in the interests of accident prevention. An outline only, it does not purport to be a final statement.

Readers are invited to pass on to the Publications Section of the Commission any constructive advice which can be taken into account in any further revision of the publication.

Contents

Cover illustration

A kinetosphere study of a machine operator at her work station. See also pages 8-9.

Take a look at your desk, seat, bench, machine . . .

Your back is affected by equipment which fails to support the body properly or fails to match normal body movements. Such equipment includes many seats, desks, work-benches and machines. They contribute to or cause an estimated 90% of back complaints. You can begin to do something about the situation.

You need to do something because the inadequately designed or malpositioned equipment is also contributing to other troubles —

Sprains and strains

Varicose veins

Malformation of spine and joints

Fatigue and boredom

Diminished efficiency.

This booklet briefly outlines how such troubles occur and what can be done to eliminate many of the causes, with special attention to office desks, chairs and machine stands.

Details are drawn from experience and research in the field of ergonomics, in New Zealand especially. This is an interdisciplinary science which has also been called human factors engineering. Its main purpose is to fit machine to man instead of man to machine.

This is the seriousness of the problem

Between 18 000 and 20 000 New Zealand men and women each year have spinal complaints, and this estimate refers only to complaints resulting in loss of production.

Many more troubles go unreported. Surveys overseas suggest that about half the workforce or more has suffered or is suffering *bad backs*. It is an epidemic.

Denmark

A Danish authority on posture reports that nearly 50% of the population of Denmark is thought to be suffering from some form of back complaint.

Sweden

Another authority reports that back ailments affect about 60% of Sweden's workforce — or 52.7% of people in light work, 64.4% of people in heavy work.

Britain

A further authority estimates that Britain in 1976 lost workdays amounting to £200 million as a result of back pain. This authority states —

About 60% of adults suffer from backache at least once in their lives.

Disease of the intervertebral disc and associated joints is the most commonly diagnosed back complaint.

Much of the back trouble could be avoided if office workers in particular were properly seated.

To return to you. "My back's killing me!" This is the commonest complaint. You may not have reached this stage, but there is a strong chance you will. It is almost certain that you are far from *sitting pretty*.

Opposite: Photogrammetry studies to provide accurate cross-sections of the body. In this case, the emphasis was on the actions of the arm while washing the hair. This was for the design of a washing facility.

Your comfort — this is the issue

Nearly all offices are based on the traditional principle of simply seating the worker at a desk.

Adjustable seats have been introduced in recent years, but with little or no advantage when in most cases the desks and typewriter stands remain at standard heights.

The end-result is that the worker, whatever his or her physical characteristics, is required to adjust to the *system*.

It is difficult and often painful to so adjust the individual; it is much better to adjust the system.

Your difficulty in adjusting to badly designed or positioned equipment encourages the idea that restful equipment, especially seating, is desirable. All research, however, shows otherwise —

The need for rest is most often a result of fatigue and boredom.

Restful situations promote fatigue and boredom.

But comfortable situations promote job interest and efficiency.

The times when you seek a restful posture result mainly because there is a lack of the comfort that comes from attention to suitable equipment-design and placement.

How often have you watched a friend using more energy and losing more time fidgeting in search of comfort?

It is true — when you can do the job while maintaining a comfortable rather than restful posture, you are happier, using least energy and working longer and better.

Your posture
this is the key

Your sleeping posture is the optimum short-term posture.

The body weight is distributed over the maximum area. There is only minor muscular activity, and there are therefore fewer of the chemical reactions that accompany muscular contractions.

These reactions involve oxygen which converts toxic lactic acid — a muscle energy by-product — into the waste materials of carbon dioxide and water, disposed of through bloodstream and respiration.

Nevertheless, in a good night's sleep, as an average person you make as many as 200 movements, mainly at point loadings such as hips, base of spine, shoulders, elbows, wrists, hands, neck and head.

This promotes blood circulation in occluded areas of the soft tissue, a function which is monitored by the central mechanism through the massive network of the sensory nervous system.

From this are derived these fundamentals to good posture:

Good distribution of body weight is a normal requirement.

This is not only to maintain the body or its segments in equilibrium, but to minimize the static loading of any particular muscle group by balanced use of the antagonistic muscles.

This reduces circulatory blockages and the accompanying fatigue and pain which result from unrelieved muscle contractions, and pressure-loadings on body tissue.

Apart from periods of normal rest a healthy living body is never naturally immobilized.

Immobilization stems (occludes) or slows the local blood flow.

Occlusion continued for even a short time results in the local death of tissue, which with people who are disabled and bedridden can mean serious bedsores at points of pressure.

The position of the body increases or decreases the effects of gravity (g-force) on the body.

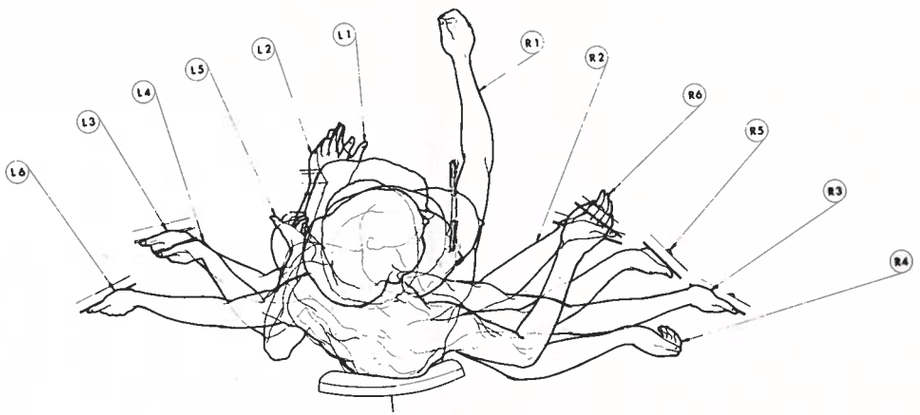
The body is designed to give optimum physical performance when equilibrium is maintained with the least amount of physical effort, either seated or standing.

The g-force effect increases in proportion to deviation from this condition.

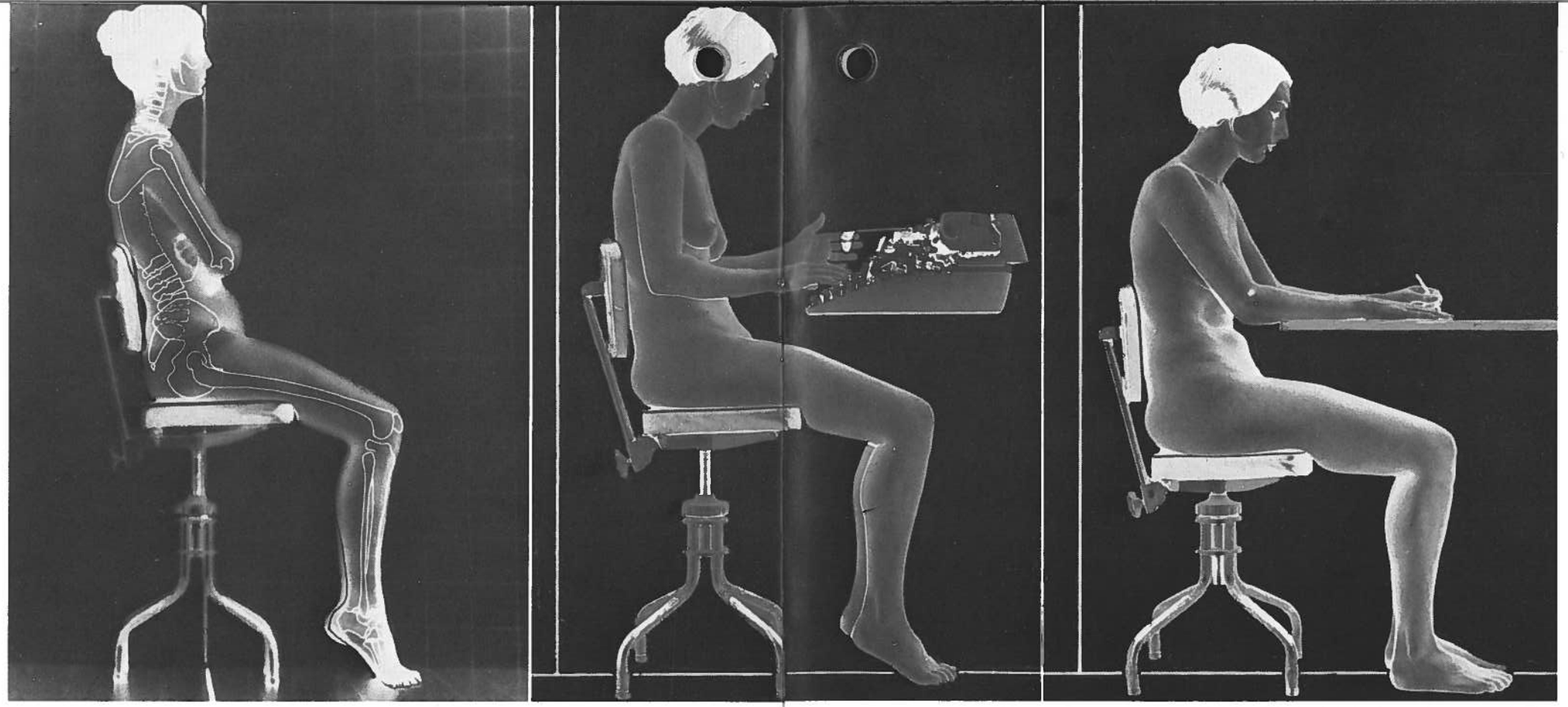
The greater the effort the greater the need for good blood circulation.

Poor circulation results in numbness and sleepiness.

It can also contribute to sprains and strains and a build-up of lactic acid in muscle tissue; much muscular pain in the back and elsewhere is a symptom of lactic acid.



Illustrated:
A kinetosphere study of a machine operator at his work station. Deriving from synchronized pulsed multi-camera studies, such charts of movements enable the best placement of controls. A similar illustration appears on the front cover.



Above: Poor seat and work heights. The back is inadequately supported. The front edge of the seat is digging into the thighs. There is insufficient maintenance of the inward lower back (lumbar) spinal curve (lordosis).

Your basic requirements

Physical movement

Physical movement is essential to restore your blood circulation if a posture imposes static loading on any muscle or muscle group.

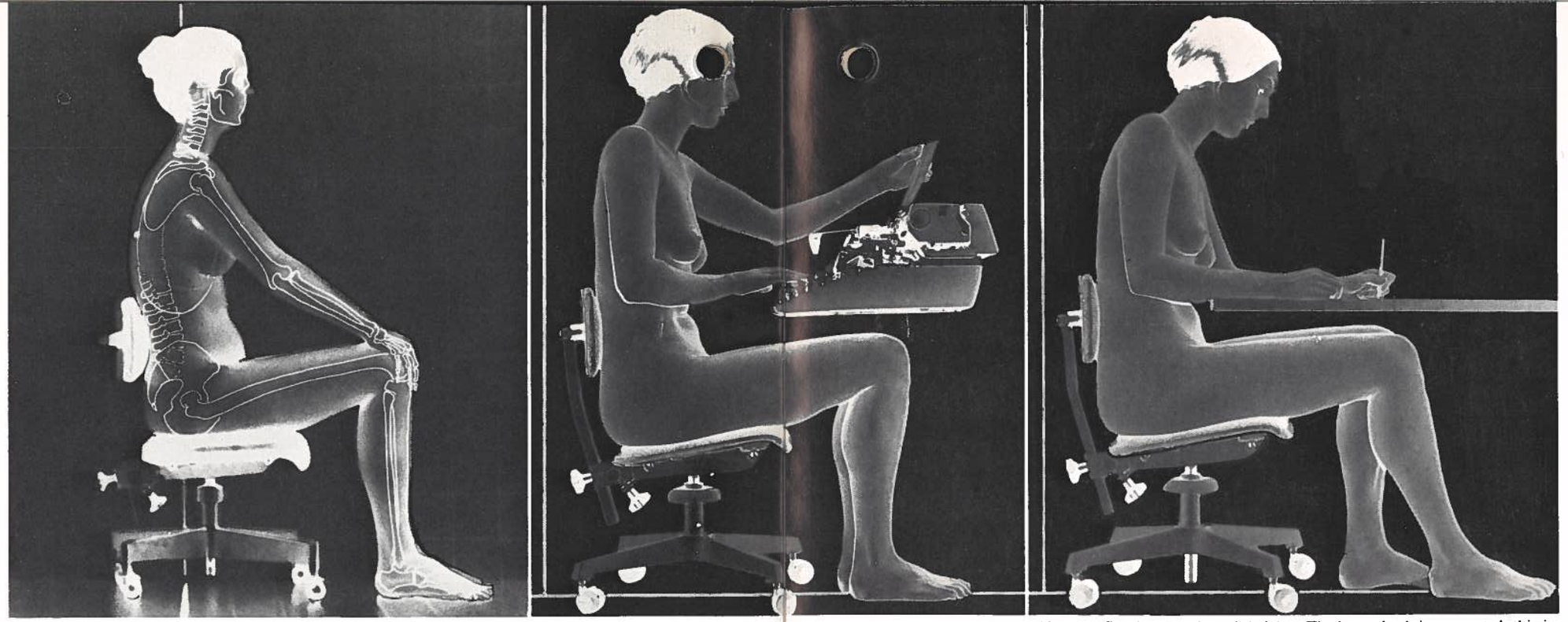
Sensible movement is desirable for blood circulation and hence to good posture and comfort.

The worker whose postures are restricted by a work station, as with a typist, should have sufficient flexibility in furniture design and arrangement to assume with

ease any of several good postures. This is to maintain balance with the antagonistic muscles, particularly in the trunk, neck and shoulders.

Lower-back support

Your lumbar spine (lower spine) should be fully supported in lordosis (ie., with the proper inward curve of the spine maintained here) when seated to avoid spinal malformation through prolonged outward curvature, or unrelieved static loading of spinal muscles. The higher vertebrae are thus held by the positioning of the weight of the trunk, not by continual muscle contraction.



Above: Good seat and work heights. The lower back is supported: this is vital for the maintenance of the inward lumbar curve of the spine, and this curve is seen most easily in the skeleton illustrated at left. The thighs are not crushed. Feet are square on the floor. Machine and desk top are at convenient heights for the subject.

The support is needed mainly at the second, third and fourth lumbar sections, which span about 10 cm in the middle of the lumbar spine that lies between your pelvis and rib cage.

The support should contact your lumbar spine evenly, and this is facilitated by slightly tilting the seat backward to be at right angles to the trunk.

Unrelieved static loading of spinal muscles causes fatigue and pain. It limits muscle function to the extent that bending or rotating your trunk may cause spinal disc rupture or, more likely, irritation to soft tissues within the immediate area.

Suitable seating

To avoid deforming the soft tissue on the underside of your thigh, and consequently restricting circulation, the chair seat should be firm, should not be dished, and should be angled back not more than seven degrees, just enough to press your lumbar spine against the back support and to prevent you from sliding forward.

The angle between thigh and spine should be not less than 90 degrees.

You should be sitting on the bones of your bottom — ischial tuberosities — not on your buttock muscles which become numb within minutes. These muscles, your body's largest, are required to maintain the trunk in an upright posture at the hip joint when either standing or seated. They become numb and will malfunction if compressed by the weight of your trunk in a sitting posture. Soft cushions placed under the thighs will accelerate this condition. Consequent instability can overtax your spinal muscles, resulting in aggravation of any current or old back conditions.

Proper height

Again, this is necessary to avoid pressure on the soft tissue under your thigh. Pressure here will also compress your sciatic nerve and may cause loss of feeling in

the feet, subsequent malfunction of muscles controlling your weight-bearing joints, and dysfunction associated with the sciatic nerve.

The seat should be lowered until your feet are squarely on the floor or equivalent.

The upper and lower legs should form a right angle, **and not more or less than this** for the basic posture.

Distances

Your work station should be arranged so that, whatever the task, the stretch-distance is the most favourable.

This is 41 to 51 cm for **reading** or (for **typing**) just sufficient to keep the elbows vertically beneath the shoulders. Eye and arm muscle fatigue are thereby reduced.

Your **desk top** should be level with the elbow.

Telephones, calculators and the like should be kept within a radius of 23 cm from the front of your body so as to avoid sudden bending and rotating while sitting. Normally your spine can withstand point-loading pressure equivalent to more than half a tonne. As an average person, your spinal disc between the fourth and fifth lumbar segments alone is usually supporting, in trunk weight, the equivalent of a sack of cement on about six sq cm of the spinal segment. Sudden bending often increases these pressures beyond tolerance.

Check off your equipment

Desk height — machine keyboard

Wrong	when your forearms must be angled upward or downward
Correct	when the upper arms and forearms form right angles.

Back support

Wrong	when the worker has to sit with a gap between spine and back of chair
Correct	when the centre three of the five lumbar spinal segments are evenly and firmly supported.

Seating — seat height

Wrong	when the underside of the thigh tissue is splayed by pressure against the seat
Correct	when the feet are squarely on the floor and the thighs can be easily moved without raising the feet.

Balance

Wrong	when the seated body has to be supported by desk edge, or shoulder has to be supported by elbow, or feet have to be supported by a rail.
Correct	when the trunk and head are supported by the spine, the shoulders are supported by the head and spine, and the feet are square on the floor.

Modified equipment

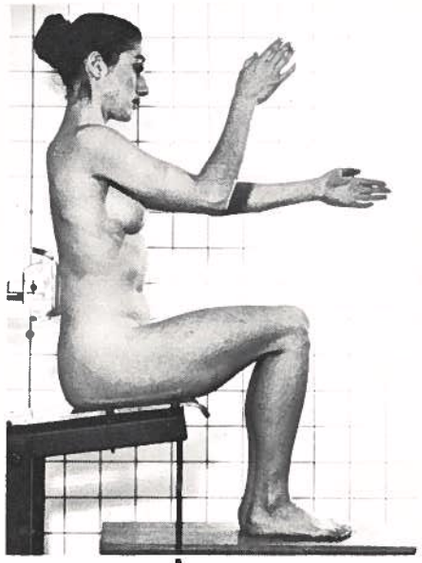
Adjustable seats are readily obtainable, but those for typists especially do not always go low enough.

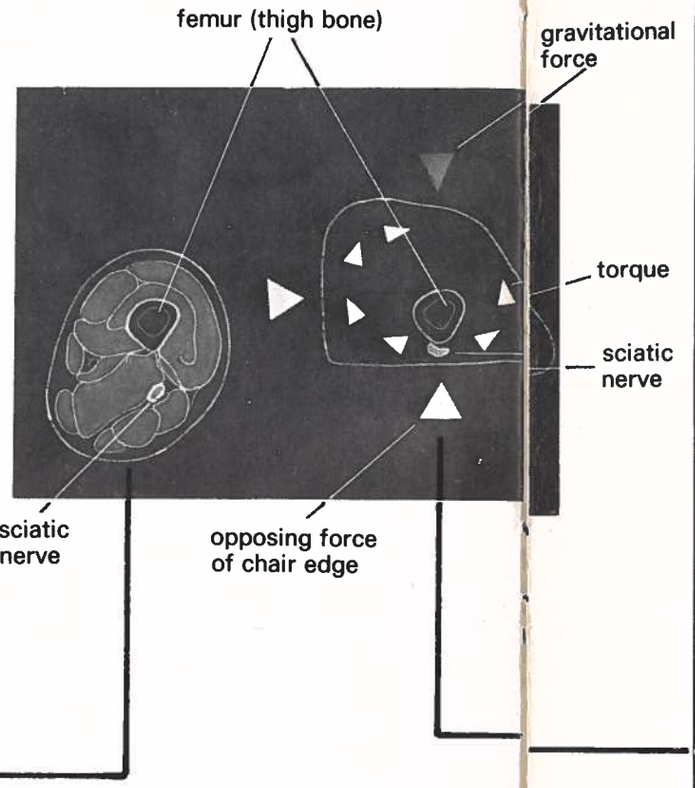
Adjustable desks, return sections or typewriter stands are not yet common. Specialist advice should be sought when equipment is or can be replaced.

The Ergonomics Laboratory of Wellington Polytechnic is among interests which have initiated equipment modifications tailored as required to workplaces.

The modifications and continuing research suggest that in future many desk tops may be mounted on simple foot-controlled raising and lowering mechanisms, while drawer units may be mounted outside instead of beneath desk tops.

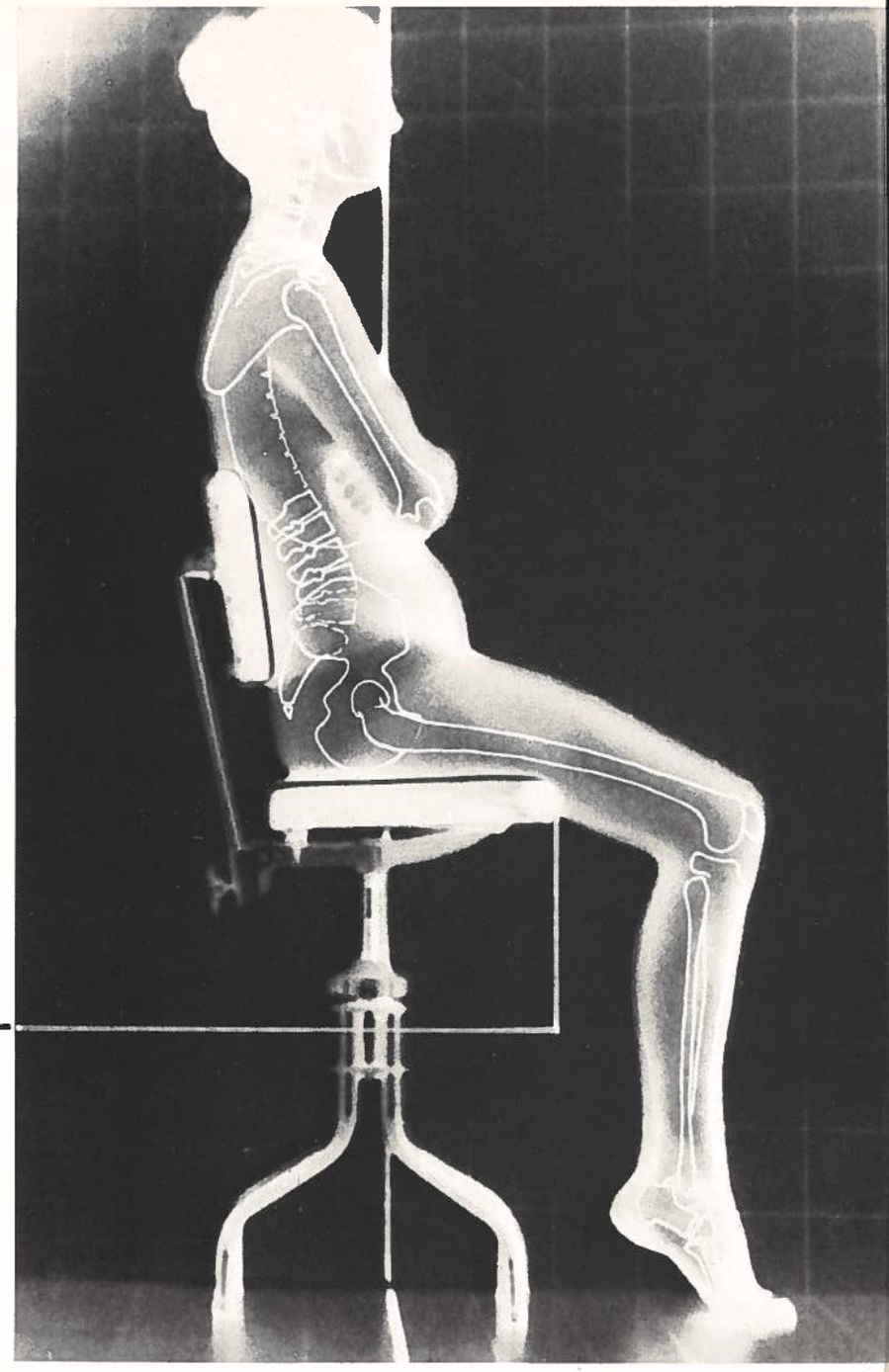
At right: Profile of a typist in a typist's ordinary chair raised to 58 cm (23 in) so that the typist's hands are in a reasonable position for the keyboard. At this seat height, however, the typist's posture puts undue pressure on the circulatory and nervous systems, as shown in the second of the diagrams **at centre.** This diagram illustrates gross distortion of the thigh, particularly the underside, and the thigh bone bearing down on the sciatic nerve.





At left: The typist is at optimum seating height, properly supported in the lumbar (lower back) region of her spine, as shown in the first of the diagrams **at centre** where there is no distortion of the thigh. In this case the typewriter was just 25 mm (1 in) above the typist's knees.

illustration from *ACC report*, vol. 2, no. 4



INDUSTRY

- SAFETY
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- WELFARE

THE ERGONOMICS OF MACHINE GUARDING

Published by the
DEPARTMENT of LABOUR · NEW ZEALAND

FOREWORD

Sections 15, 16 and 17 of the Machinery Act 1950 require moving parts of prime movers, every part of transmission machinery and every dangerous part of any machinery to be securely fenced unless it is in such a position or of such construction as to be as safe to every person employed or working on the premises as it would be if securely fenced.

These sections of the Act have received judicial consideration both in criminal and civil proceedings and the requirements of the law have been enunciated in several Court decisions. Instead of reproducing these decisions we thought it would be more helpful to machine designers and owners to provide some guide to the principles which should be followed in the construction of machine guards based on human measurements.

A considerable amount of research and experimentation was undertaken by officers of the Department of Labour to obtain reliable data on human measurements and to determine the standards required to comply with the law.

This booklet contains the results of this research and should provide a uniform approach to machine guarding by everybody concerned with this problem.

We hope this information will be of assistance to designers and owners of machines.

I.W./4/P16/10,000/97

THE ERGONOMICS OF MACHINE GUARDING

ERGONOMICS is an important and comparatively new science. It gets its name from the word *erg*, defined in the dictionary as a unit of work. Ergonomics, then, is the science of work—but in a limited kind of way. It deals with the relationship between man and his working environment, or more particularly, with the limitation which human size, strength, shape, and function place upon the work a man can do. Because of these limitations, man's working environment needs to be planned to suit his capacities—his eyesight, his reach, his height, his strength, his speed of movement, and so on.

Ergonomics is not, strictly speaking, a scientific discipline in its own right, but it draws upon and co-ordinates in its field of interest the research and findings of other scientific disciplines. Principally, it applies anatomical, physiological, sociological, and psychological knowledge to the study of the working environment, including the machines man works with, the workplaces in which they are situated, the design of machine controls, seating, lighting, and other factors.

The findings of ergonomics and especially data on human measurements, have an important influence upon the proper design of machine guards.

Reach

A person can reach—

UPWARDS
OVER
AROUND OR ALONG
INTO

These capacities are illustrated in Fig. 1. Reach is limited by the arms and, in the case of openings, by fingers and hands also. The distance a man can reach determines the minimum height of certain kinds of guards, or the minimum distance of barriers from the machines they are intended to fence.

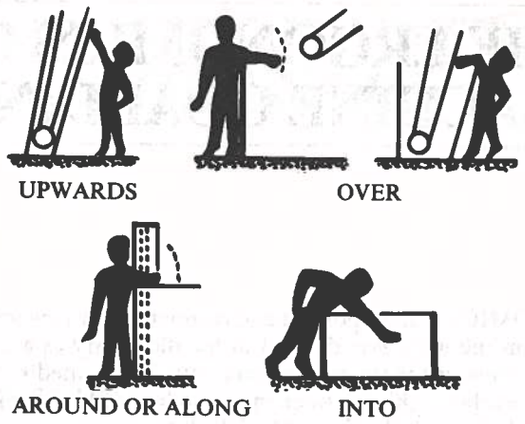


Fig. 1—Showing various types of reach in relation to the guarding of machinery

Reach Upwards

Schroeder in *Anatomy for Interior Designers* places the average limit of reach when on tiptoes at 2400 mm. No doubt many can reach further, and it is probably for this reason that the *International Safety Code* published by the International Labour Office at Geneva establishes 2600 mm as the dividing line beyond which positional safety is assumed.

In New Zealand the Department of Labour has adopted 2440 mm from the working surface as a reasonable limit of reach upwards. In doing so it has applied administratively the tests laid down in two English legal decisions, Burns *v.* Joseph Terry & Sons Ltd (1950), and Carrol *v.* Andrew Barclay & Sons Ltd (1948), where it was decided that the question to be answered was: "Is a dangerous part *so fenced or so placed* as to give security from such dangers as may be a possible cause of injury to anybody acting in a way a human being may be *reasonably expected to act* in circumstances which may *reasonably be expected to occur?*"

Fig. 2—Reach over a barrier.

A dangerous part that is beyond an upward reach of 2440 mm is regarded as notionally safe by position unless the particular facts destroy that possibility. *On the other hand, a dangerous part that is within 2440 mm should be fenced.*

Reach Over Barriers

It is common practice with some types of machinery to fence it with a barrier and then regard it as safe by position. How far should it be from such a barrier?

Reach over a barrier is interrupted by the body at the point of contact with the barrier. Where the barrier is low, the body can be bent and therefore the extent of reach is longer than the arm. Where the barrier is at armpit height, reach is equal to the length of the arm. If the barrier is above shoulder height, interruption is at the elbow, or when higher still, at the wrist or fingers. This is illustrated in Fig. 2.

Figure 3 supplies a table showing the distance in mm that guards of

Distance of guards from transmission for guard heights of:-

Height of transmission from floor level	1220	1370	1520	1680	1830	1980	2130	2280	2440
2440	0	0	0	0	0	0	0	0	0
2360	230	230	230	230	230	150	130	100	
2280	380	380	380	380	300	230	180	100	
2210	530	530	530	460	380	300	200	0	
2130	610	610	610	530	460	300	200		
2060	680	610	610	610	460	300	80		
1980	760	680	680	610	460	300	0		
1900	840	680	680	610	460	230			
1830	840	760	680	610	460	0			
1750	910	760	680	610	460				
1680	910	760	680	610	380				
1600	910	760	680	610	380				
1520	910	760	680	610	230				
1450	910	760	680	530	0				
1370	910	760	680	460					
1300	910	760	680	380					
1220	910	760	610	0					
1140	910	760	610						
1070	910	680	530						
990	910	680	460						
910	840	610	300						
840	840	530	0						
760	760	380							
680	610	150							
610	530	0							
530	380								
460	0								
380									
300									

When the guard is positioned close to the transmission, consideration must be given to the size of any opening in the guard.

Fig. 3

various heights should be from dangerous parts (transmission machinery) of various heights to conform to these principles of average human reach.

A man's arm reaching over a barrier can describe a curve. It is the curve which determines at what distances from the barrier dangerous parts of machinery of varying heights are safe by position. A series of curves experimentally determined are contained in the graph shown as Fig. 4. Each curve is marked with its relative barrier or guard height. These curves are the basis of the table in Fig. 3.

How are the table and graph used in practice?

Consider the table (Fig. 3) first. The left column gives the height of the transmission or dangerous part to be fenced. Imagine that this is 1370 mm. Place a ruler across the table immediately below 1370 mm in the left column, and the columns to the right will give the distances the guard should be from the transmission or dangerous part for the various guard heights given at the head of the columns.

The reach curves (Fig. 4) are interpreted in a similar fashion. To calculate again the guard distance for transmission 1370 mm from the floor or working platform, place a pencil at the point 1370 mm up the left side of the graph, and follow this line across to the right until it intersects the reach curves. Each of these is marked with the height of the guard to which it applies. At the point of intersection, place a ruler vertically and read off on the bottom scale of the graph the distance of reach. Thus, the 1370 mm line intersects the reach curve for a guard 1520 mm high at a point which indicates (reading the bottom scale) that a guard of the height should be placed 680 mm from the transmission. The other reach curves gives distances for guards of different heights:

Height of Transmission or Dangerous Part	*Height of Guard*	*Distance of Guards from Transmission, Etc.*
1370 mm	1220 mm	940 mm
1370 mm	1370 mm	780 mm
1370 mm	1520 mm	680 mm
1370 mm	1680 mm	480 mm
1370 mm	1830 mm	Working clearance

The manner of measuring the guard distance is important. The distance of the guard is the *horizontal measurement from the plane of the guard of the height shown to the transmission or dangerous part. The point at which the*

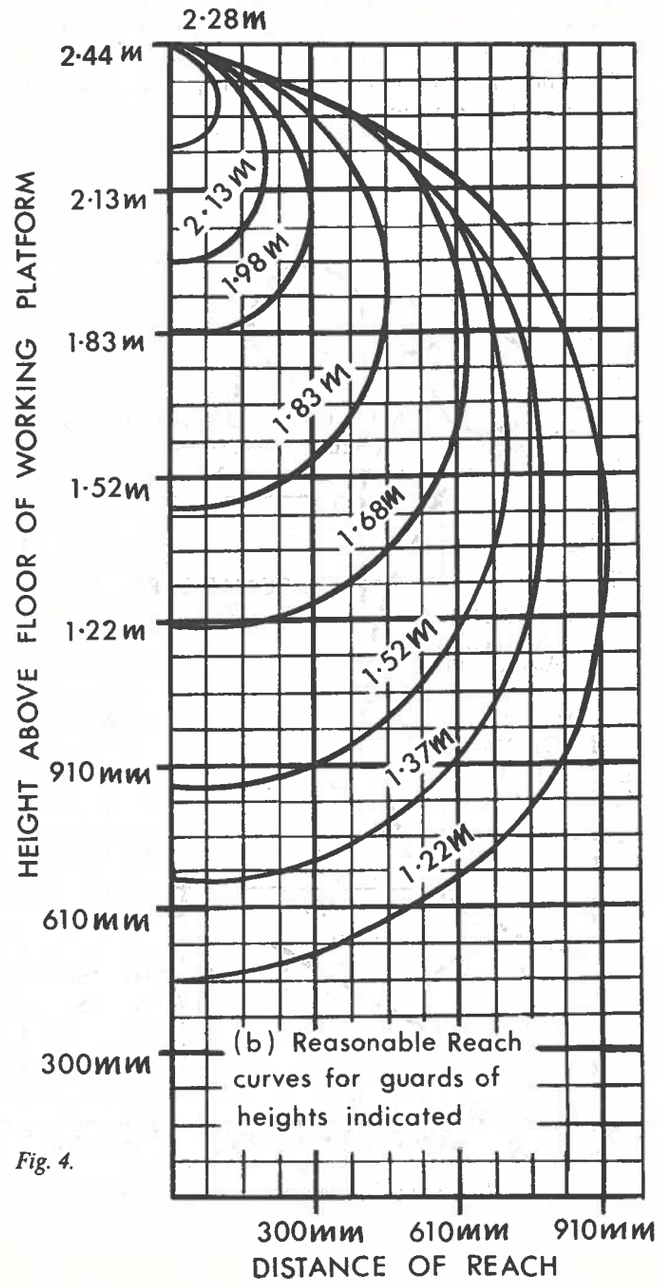


Fig. 4.

measurement is to be taken is where the transmission or dangerous part contacts the reach curve. This is not necessarily the part of the transmission that is nearest to the plane of the guard. This is made clear in Fig. 5, where the two illustrations of transmission nearest the plane of the guard do not enter the reasonable reach zone.

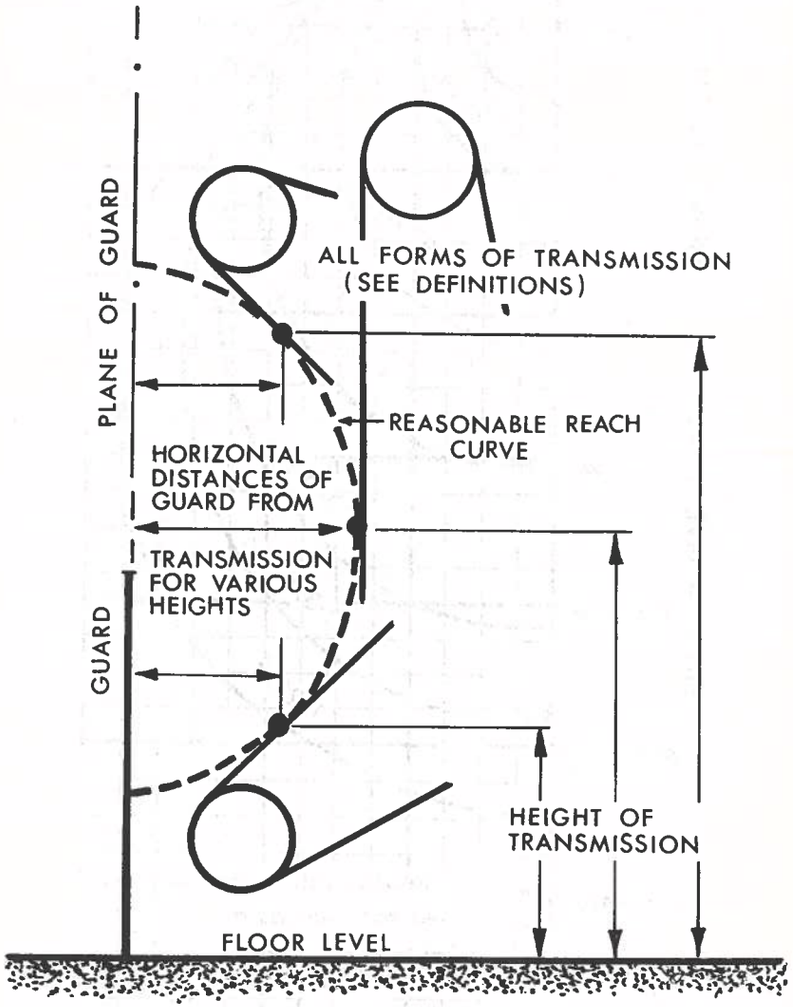


Fig. 5.—Illustrating how to measure guard distances.

Fig. 6.—Reach into containers.

Reach into Containers

Reach into containers is really the same as reach over barriers. The height of the side of the container determines the extent of the reach (Fig. 6.) By experience, the reasonable reach zone for containers of various heights can be determined in the same way as for barriers. This is shown in Fig. 7.

In order to present a complete range, the graph includes cases where an individual lies, for example, on the floor in order to reach into a container. It should not be overlooked that an unfenced opening permitting such an action is probably in breach of the secure fencing requirements of the law.

Reach Around Barriers

In this case reach depends upon the distance that the side of the barrier extends from the body position. When the body is close to a low barrier reach is longer than the length of the arm because the body may be bent.

A side on the barrier (Fig. 8a) means that reach is interrupted by the elbow joint. If the side is longer, the wrist interrupts reach. Where the barrier is horizontal (Fig 8b), reach again is interrupted by the elbow joint and wrist. Fig 8c shows the effective reach when the arm must be placed first through an opening and then around a barrier.

The reasonable reach values already given may be used as a basis for determining the extent of reach around barriers. The ability to reach around barriers is determined by the distance of the elbow joint and wrist joint from the reach curve (i.e., from the finger tip). In the experiments which led to the determination of reach curves, the elbow joint was found to be an average of 460 mm from the finger tip. Therefore, if an additional barrier is placed with its edge only 430 mm (or less) from the curve, the forearm cannot by fully bent around it. This is illustrated in Fig. 9.

However, if the arm is retracted until the wrist is near the edge of the additional barrier, the hand can be bent around the barrier and may reach the dangerous part if it is too close. It has been found by experience that it is not reasonable to expect the hand to reach as far as 200 mm around that point (Fig. 10a).

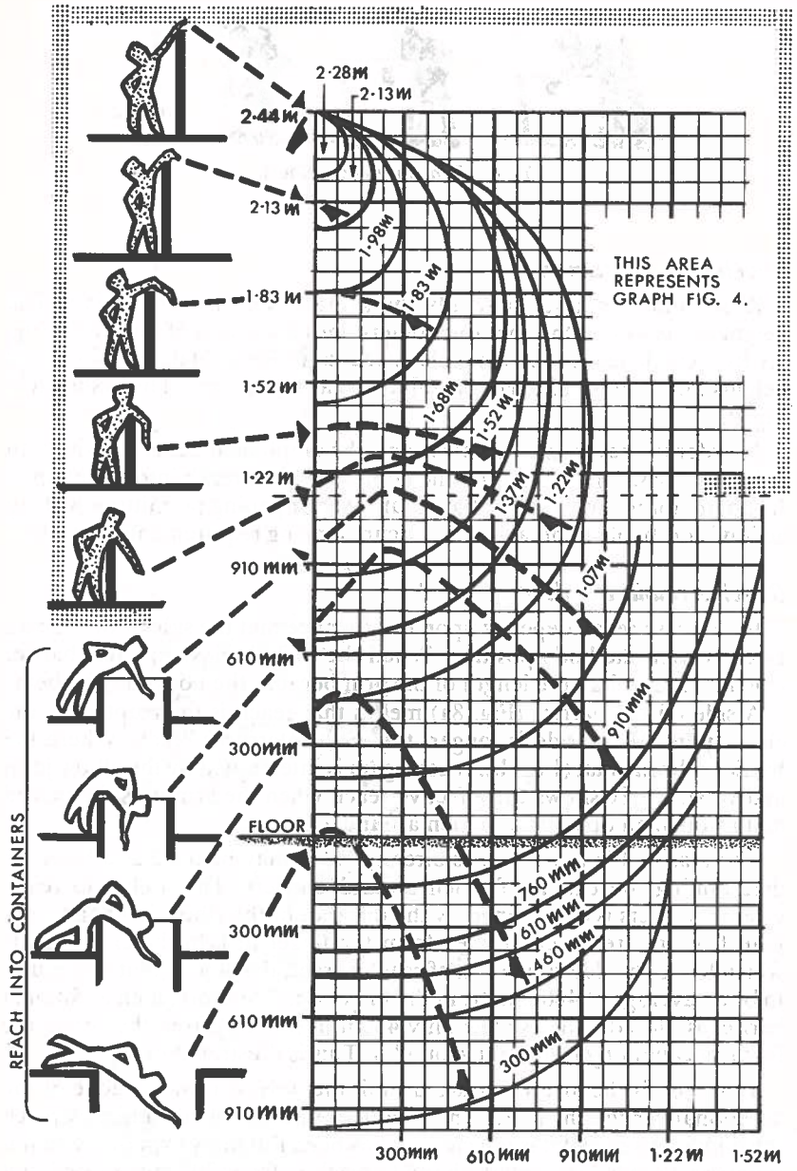


Fig. 7.—Reasonable reach curves for containers of various heights.

Fig. 8 (a). *Fig. 8 (b)* *Fig. 8 (c)*

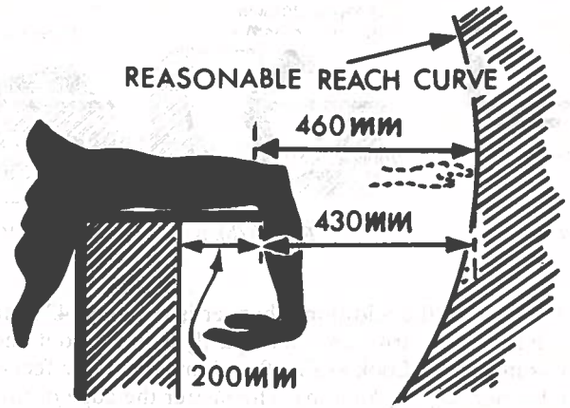


Fig. 9.—The ability to reach round this horizontal barrier is determined by the distance of the elbow joint from the reach curve. When the edge of the barrier is 430 mm or less from the reach curve, the shaded area can be reckoned to be "safe by position" since no part of the arm or hand can reach into it.

The reach of a hand bent round the end of a barrier will therefore be a curve of radius 200 mm with a centre point at the end of the barrier (Fig. 10b).

When the whole hand cannot be bent round a barrier or guard, it may be possible to bend the fingers round it.

The reach of the fingers alone has been found not generally to exceed an 80 mm radius (Fig. 10c).

The practical application of these findings is as follows:

(i) If the edge of the additional (horizontal) barrier is 460 mm or more from the reach curve, the whole forearm and hand can be bent

round it, and therefore the additional barrier is ineffective in providing a safe area below it.

(ii) If the edge of the additional barrier is 430 mm from the reach curve, the forearm and hand can be partly bent round it as shown in Fig. 9, but the barrier has increased the safe-by-position area to the whole of the space shaded in the drawing. The arm can still reach out and down but not back under the barrier, but the hand can reach underneath the barrier to a distance of almost 200 mm from the edge.

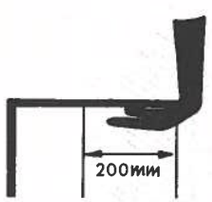


Fig. 10 (a).

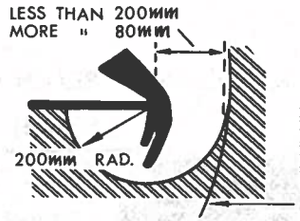


Fig. 10 (b).

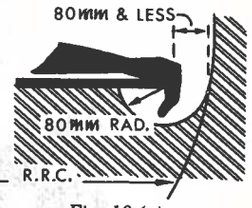


Fig. 10 (c).

(iii) If the edge of the additional barrier is less than 430 mm from the reach curve, the arm can still be partly bent round it, though not so far as in Fig. 9. (Look at Fig. 9 and imagine the effect of widening the barrier, say, by 80 mm). The nearer the edge of the additional barrier is to the reach curve the less can the arm be bent round it, until at 200 mm from the reach curve it is no longer possible because the arm is fully extended forwards for the wrist to reach the edge of the barrier. In all these positions of the barrier it is still possible for the *hand* to reach back underneath the barrier to a maximum of nearly 200 mm from the edge, and therefore this space below the barrier is unsafe (as well as any space in front of the barrier which can be reached by the bent arm and hand).

(iv) When the edge of the additional barrier is only 200 mm from the reach curve, the hand alone can be bent round it. Therefore any dangerous part should be beyond a 200 mm radius from the edge of the barrier. This is shown in Fig. 10b where the shaded area is safe by position. If the barrier is *less* than 200 mm from the reach curve, the bending of the hand becomes more restricted, until at 80 mm only the fingers can be curled under the barrier.

(v) If the fingers alone can be bent round the edge of the barrier, any dangerous part should be beyond 80 mm radius from the edge of the barrier. See Fig. 10c where the shaded area is safe by position.

The reasonable reach curves are determined as in Figs. 3 and 4. Thus, if the barrier is 1220 mm high, the graph in Fig. 4 shows that the reach curve will extend from a height of 460 mm to a height of 2440 mm and to a depth of 940 mm. Therefore, an additional horizontal barrier 460 mm wide will be inadequate to prevent the arm being bent round it as it would leave a further 480 mm from the edge of the barrier to the curve. An additional barrier 510 mm wide would leave 430 mm between the edge and the curve, and would increase the safe-by-position space as in (iii) above. If the barrier were 760 mm wide, it would leave 180 mm from the edge to the curve and it would not be possible to fully bend the hand round it, thus increasing the safe-by-position area further. A barrier 860 mm wide would leave room for finger reach only and except for a radius of 80 mm from the edge of the additional barrier all the space beneath the barrier could be assumed to be safe by position.

Openings, Admitting the Fingers or Hand

It can be assumed for practical purposes that there is no reach possible through an opening less than 10 mm square as the fingers cannot be admitted (Fig. 11a). If the opening will admit one, two or three fingers, the reach is restricted by the roots of the fingers (Fig. 11b). Hence the distance between the guard and the transmission needs to be no greater than the reasonable maximum length of the longest finger plus a clearance allowance.

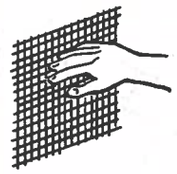


Fig. 11a.

Fig. 11b.

Fig. 11c.

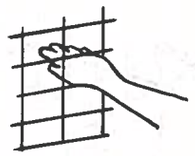


Fig. 11d.

If all four fingers can be admitted through the one opening, the size and shape of the opening will be an important factor in determining the extent of reach possible. In some cases reach will be limited by the root of the thumb, and in others by the thickness of the hand, the wrist or the arm. In a case where reach is restricted by the root of the thumb (Fig. 11c), the distance necessary is the reasonable maximum length of a hand from finger tip to root of thumb, plus clearance.

However, it cannot be overlooked that the thumb can be folded within the palm of the hand. (Fig. 11d), and that the width of the hand in such

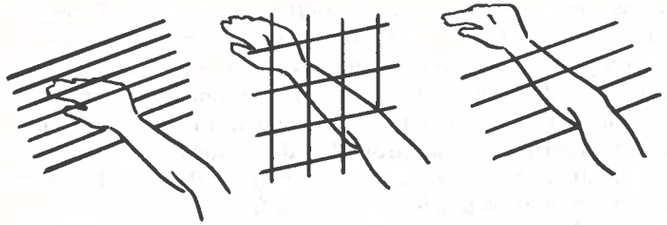


Fig. 12a. *Fig. 12b.* *Fig. 12c.*

cases is the width of the palm. However, the depth of the hand is so increased that the reach through an opening is limited by the thickness of the hand and thumb folded in.

Where the opening admits four fingers and a thumb, reach is limited by the thickness of the hand as in Fig. 12a, or of the wrist and arm at various points as in Figs. 12b, 12c, 12d and 12e. Thus the distance of the guard from the dangerous parts is determined by the maximum reasonable length of fingers and hand, or of fingers, hand and arm at different points.

If the opening is sufficient to admit the whole arm and a portion of the shoulder (but excludes the head and trunk) the reasonable reach is assessed as the distance from fingertips to armpit—determined by experiment as not less than 840 mm. See Fig. 13.

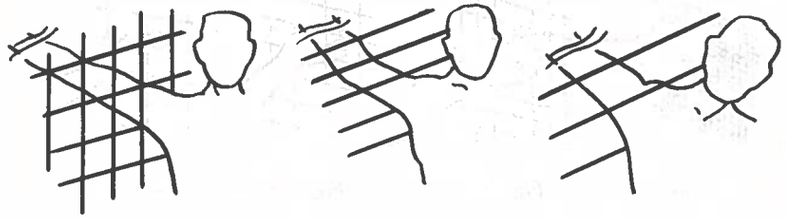


Fig. 12d. *Fig. 12e.* *Fig. 13.*

Reach Through Elongated (or Parallel) Openings

Several formulae have been developed overseas to assess the maximum permissable sizes of openings for guards at different distances from dangerous parts, where the openings are elongated. Probably the two best known are those cited by Imperial Chemical Industries Limited and by H.A. Hepburn, B.Sc. (eng.), A.M.I.Mech.E., who was at one time Chief Inspector of Factories in the United Kingdom. These two formulae have

been modified by the N.Z. Department of Labour as a result of its own measurements on a number of persons, and the following formula is now being applied by the Department:

$$Y = \frac{X}{10} + 6\text{ mm}$$

where x equals the distance of the opening from the transmission or dangerous part and y equals the maximum permissable opening in the guard.

Example: 200/10 + 6 = 20 + 6 = 26 mm opening. This formula is not valid for distances in excess of 760 mm. (i.e. 82 mm opening).

The formula is plotted graphically in Fig. 14. The continuous line "safe average" was first drawn to full scale from a point equivalent to a 12.5 mm opening at 44.5 mm distance on the "small woman" graph to the point "large man". This line excluded two points on the "small woman" graph and was found to be unwieldy when expressed as a formula. A line was then drawn from a point at zero distance equivalent to a 6 mm opening to an upper point at 82 mm equivalent to "large man (actual)". This line provided a convenient formula and embraced all but one point on the "small woman" graph, this point being only 1.5 mm below the line. The "safe average" line on the graph is equivalent to the Departmental formula quoted above.

Departmental Assessment of Reach Values Through Openings

The preceding paragraphs contain the theory and results of experiments on which the Departmental requirements are based. These requirements are the practical application of this theory, and are as follows:

Elongated (Parallel) Openings

(i) Openings up to 6 mm apart can be treated as so small as to be insignificant. Therefore the guard is virtually the same as sheet and a working clearance of 25 mm is all that is required.

(ii) Openings above 6 mm apart but not greater than 13 mm will admit part of a finger. Therefore, the distance required is 50 mm, that is, part of a finger plus a working clearance.

(iii) Openings in excess of 13 mm but not greater than 82 mm are subject to the formula:

$$Y = \frac{X}{10} + 6\text{ mm}$$

(iv) The distance between the guard and the dangerous part in the case

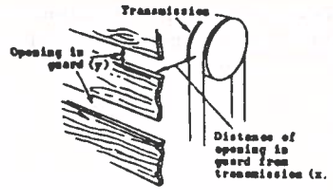
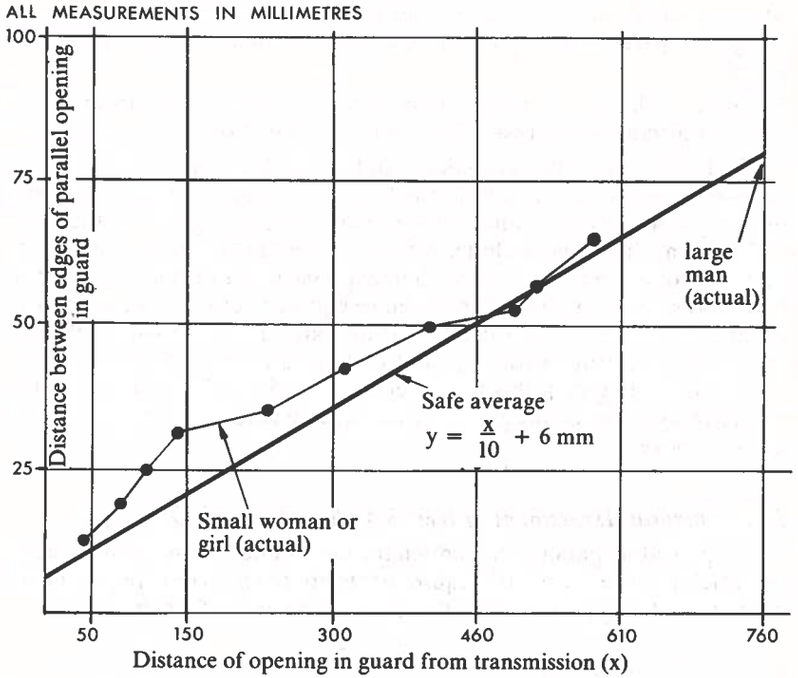


Fig. 14.



of an opening between 82 mm and 152 mm should not be less than 840 mm.

(v) Openings in excess of ~~840~~ 152 mm are subject to the reasonable reach values over guards set out in the early part of this booklet.

Square Openings

Although strictly speaking a square opening is a parallel opening, it has been found that the general rules above for parallel openings cannot be satisfactorily applied to small square openings because the length of the parallels is circumscribed by the other sides of the square—i.e., they are not *elongated* openings in the sense used above.

The following rules apply to square openings:

(i) For openings up to 38 mm square, apply distances as given in Fig. 15. (These distances may also be applied to round openings of diameters equivalent to the squares indicated, and to other shapes such as rectangles and diamonds of diagonal measurement up to 54 mm).

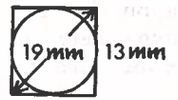
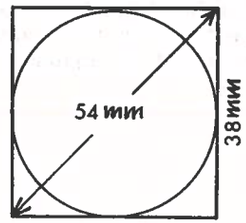
Openings in guard (Up to and including dimensions shown)	Dist. btwn guard and dangerous part	How distance derived
	25mm	Virtually same as sheet, working clearance only.
	50mm	Part of finger length plus working clearance
	100mm	Finger length plus working clearance

Fig. 15

(ii) Square openings above 38 mm but not greater than 82 mm are subject to the formula:

$$y = \frac{x}{10} + 6 \text{ mm}$$

(iii) The distance between the guard and the dangerous part in the case of an opening between 82 mm and 152 mm square must not be less than 840 mm.

(iv) Openings in excess of 152 mm square are subject to the reasonable reach values over guards set out earlier.

Round Openings

(i) Openings up to 38 mm diameter: follow rule (i) for square openings. See Fig. 15.

(ii) Openings between 38 mm and 50 mm diameter: the minimum acceptable distance between the opening and the dangerous part is 152 mm. For an explanation, see note below.

(iii) Openings over 50 mm and up to 82 mm diameter are subject to the formula:

$$y = \frac{x}{10} + 6 \text{ mm}$$

(iv) Openings in excess of 82 mm diameter: apply reasonable reach values over guards.

NOTE: It has been ascertained by experience that an opening 38 mm square is the maximum safe opening permissible at a distance of 100 mm from the dangerous part. Where the opening is 50 mm square a small hand can be inserted, thus making it necessary to apply the rule of reach through openings. In the case of an opening 44 mm square a small hand can almost be squeezed through but in any case the reach through this opening is at least 114 mm.
Experiment has also shown that whereas a small hand can be inserted through a 50 mm square opening it is not possible to do this with a round opening of 50 mm diameter, though it is possible if the diameter is increased to 57 mm.

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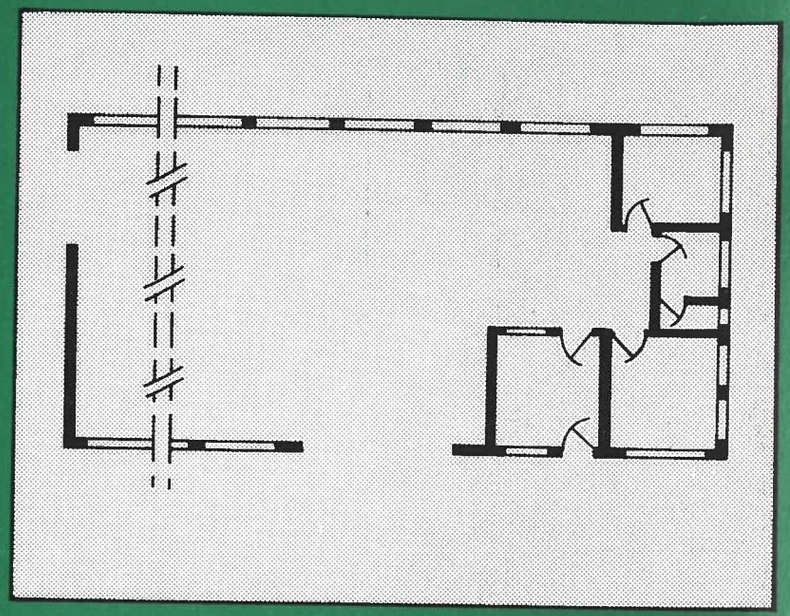
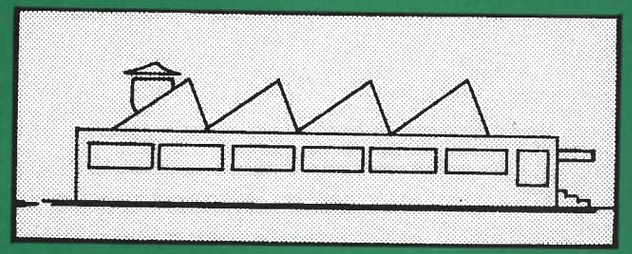
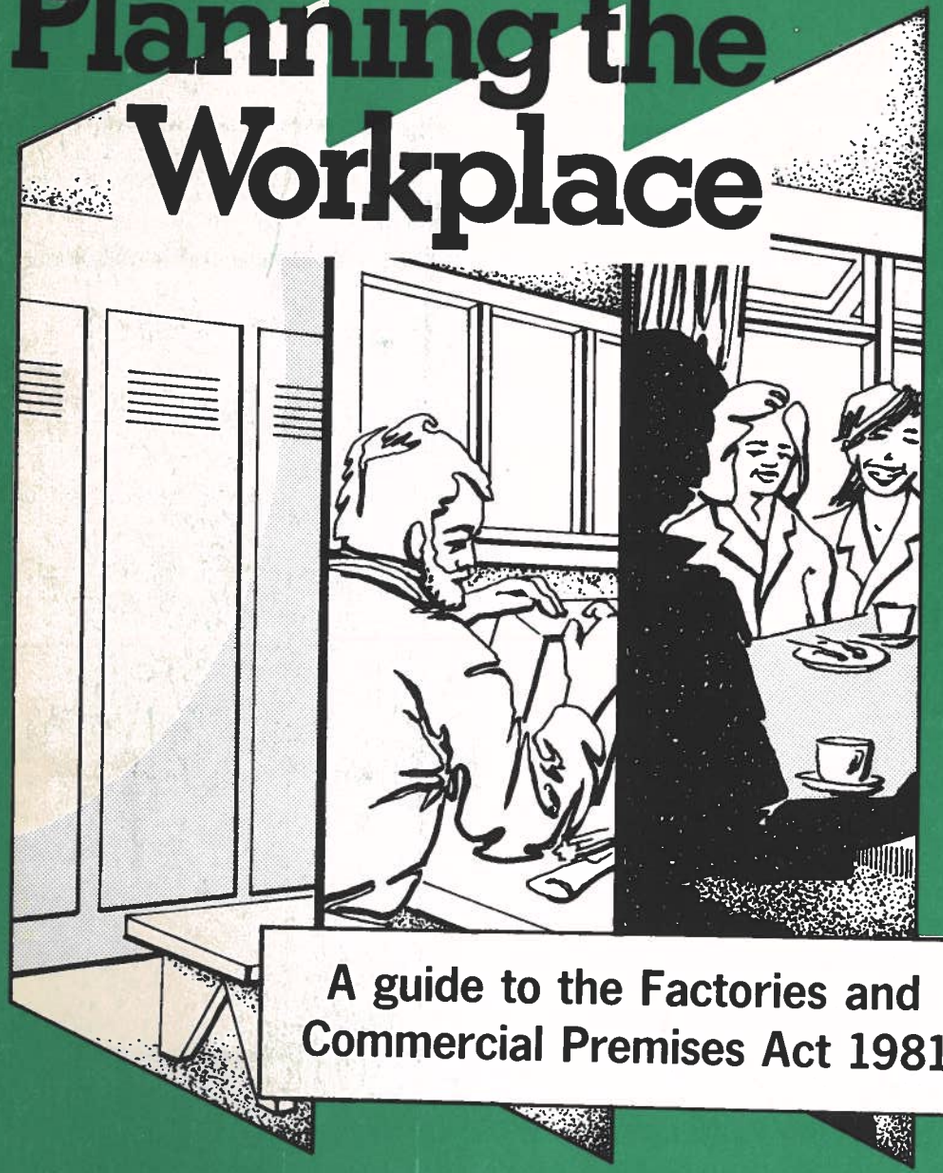




Planning the Workplace



A guide to the Factories and Commercial Premises Act 1981

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Planning the Workplace

A Guide to the Factories and Commercial Premises Act 1981

DEPARTMENT OF LABOUR, N.Z.

FOREWORD

Modern workplace planning demands production flow charts and the provision of a layout that is efficient in the use of services. Good layout and working conditions are also of prime importance in maintaining a healthy working environment, whether in a factory, shop, office or warehouse.

The designer of any industrial or commercial building must calculate space requirements for plant, equipment, access ways, production tasks, and storage.

Other needs to be taken into account are lighting, ventilation, heating, dining rooms, cloak rooms, and sanitary facilities.

The following summary states some of the factors considered by factory inspectors in determining the suitability of premises in the light of the relevant legislation, in particular the Factories and Commercial Premises Act 1981.

IT IS INTENDED AS A GUIDE ONLY AND IS NOT A SUBSTITUTE FOR THE LEGISLATION.

CONTENTS

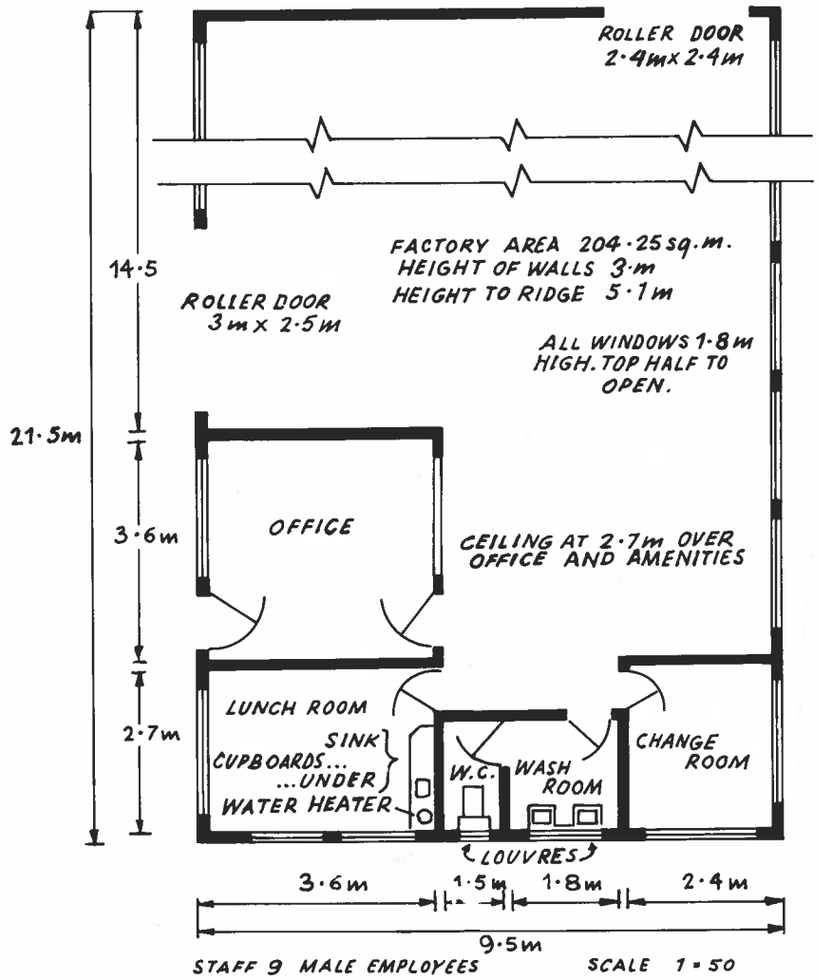

Fig.1—Specimen of type of plan to accompany application for registration. In the case of multi-storeyed buildings a plan of the relevant facilities on each floor will be necessary with an indication of normal and alternative means of access and egress. It is most desirable that a plan of proposed alterations to an existing factory be referred to the inspector to ensure that legislation is being complied with. As with initial planning, this procedure can save much unnecessary future expense and inconvenience. In such cases existing and intended buildings should be clearly shown.

Registration of factories

It is unlawful for any person to occupy or use as a factory any building, office, or place unless it is for the time being registered as a factory under the Factories and Commercial Premises Act 1981.

If a new factory is to be registered, an application on the prescribed form shall be made to the inspector of factories by or on behalf of the intending occupier.

The applicant must deliver with the application a sketch plan of the intended factory, drawn to scale and to the satisfaction of the inspector.

The plan should give details of the dimensions of each room or space, means of access and egress, ventilation (including size and location of windows or louvres, and number that can be opened), full details of sanitary and washing facilities, meal rooms, and other amenities. (A specimen plan is shown in fig. 1).

Consultation with the inspector when planning a new factory, or before altering an existing building, may save the intending occupier much unnecessary expense.

Access and egress

Safe means of access to all working locations is required.

All doors used for access and egress must be kept clear and unlocked during working hours.

A basement whose area exceeds 100 m^2 must have at least two separate safe means of access and egress.

Compliance is required with local authority bylaws and with chapter 5 of NZSS 1900: *Fire resisting construction and means of egress.*

Storage

Provision should be made for sufficient and suitable storage facilities to enable the safe handling and storage of goods and materials.

Floors, accessways, etc.

All floors and accessways must be of sound construction and should be capable of safely supporting the loads (static or moving) for which they are designed.

Pits and other floor openings should be constructed so that, when not in use, they can be suitably covered or securely fenced to a height of at least 1 m above ground level.

Stairs should have handrails and guards on any open sides.*

*Refer to NZSS 1900: *Fire resisting construction and means of egress.* Also refer to Department of Labour booklet *Safe access.*

Safe place of employment

There must be sufficient space for reasonable movement without risk of injury.

Elevated workplaces from which a fall of more than 3 m is possible should:

- have secure footholds and handholds;
- be securely fenced; or
- ensure safety by other means.

Effective drainage is required for wet processes.

Air space and area

A sufficient area should be provided so there is no risk of injury to the health of any employees.

The floor area that should be allowed each person will vary greatly according to the process involved.

There must not be less than 12 m^3 of clear air space per person. In assessing this, no account is to be taken of any ceiling height above 4 m or of areas not kept clear of materials, or not properly lit and ventilated.

Ventilation

Every room in the undertaking shall be ventilated by natural or mechanical means to provide a constant and sufficient supply of fresh air. Window openings should be placed to ensure cross ventilation.

When it is practicable, dust, fumes, steam or other impurities which arise in the course of the work should be removed at the point of origin.

As a good guide, windows should be equivalent to 10 percent of the floor area, and half should be capable of opening.

Lighting

The general lighting system should be designed to provide a uniform distribution of natural and artifical light over the entire workplace including the passages, stairs and amenity rooms.

Artificial lights should be placed and shaded so that no worker is subjected to avoidable glare.

Skylights should be glazed with a shatter-resistant material or be suitably guarded.†

Atmospheric conditions

An optimum temperature is difficult to define, as personal comfort is more or less an individual matter and is also dependent on physical conditions—humidity, air movement, radiation and clothing—and on physiological factors such as sex, age, state of health and physical activity.

Section 38 of the Factories and Commercial Premises Act 1981 requires that, having regard to the process or work carried on in the undertaking, effective and suitable means must be provided in each workroom to control temperature, humidity arising from any process, air velocity, radiation of heat, and the quantity of fresh air in the workroom to ensure that persons work in reasonably comfortable atmospheric conditions.

The first step towards providing a comfortable working environment is to design or adapt a building so that heat losses can be reduced to a minimum. This may involve lining roofs and frame construction walls with (preferably) heat insulating materials, particularly the roof.

It may also require means to prevent leakage of warm air or to avoid heat loss through uninsulated floors.

Properly designed insulation cuts heating costs in winter and helps keep temperatures down to a comfortable level in hot weather.

It is often possible to provide comfortable conditions in winter months by convection heating, i.e., by heating the air of the workroom; but if this is not economic because of cost or the physical characteristics of the building, preliminary advice should be sought from the local factory inspector.‡

Hazardous processes

Hazards exist in a large number of processes and special precautions are necessary when dealing with these, particularly when planning the workplace.

In a general booklet such as this it is not possible to detail the precautions necessary for such processes.

In many cases regulations or codes of practice cover the various aspects of the hazards involved.

Occupiers should make themselves aware of the requirements of any relevant legislation, and are invited to discuss any queries or problems with their local factory inspector.§

Confined spaces

All confined spaces in which temperature, radiation or fumes may affect anyone who enters should:

†For further information regarding illumination levels for various workplaces refer to CP22:1962. *Code of recommended practice for illumination values and design of lighting installations.* Standards Association of New Zealand.

‡The Department of Labour's booklet *Atmospheric conditions* explains the many factors involved in deciding optimum atmospheric conditions.

§The Department of Labour has published guidance notes and codes of practice for various hazardous operations, and a list of these is given in appendix A on p. 13 of this booklet.

- be adequately ventilated; and
- have a clearly marked escape exit which is either always open; or
- can be readily opened from the inside even when securely locked from the outside.

Washing facilities

Wash-hand basins should be provided to the following scale:

	Number of persons or part thereof per fitting
Where the process results in little grime or dirt ...	15
Dirty or grimy trades	10
Where major health hazards exist ...	5

Where troughs or commercial-type washing facilities are installed, mixing valves or other suitable means should be provided so that water temperature can be regulated at the point of flow.

Showers are necessary for certain trades, and are required by some regulations and awards. There should be a separate cubicle for each shower, and each cubicle should be at least 900 mm wide. One shower should be provided for every seven workers or part thereof.

Washing facilities should be close to toilet facilities. They should have hot and cold running water. Cold water only may be adequate for certain clean occupations but hot water is desirable in most cases. (See fig 2.)

Sanitary conveniences

The minimum requirements are:

URINALS:

One urinal where 10 to 50 males are employed. Plus one additional urinal for each additional 50 males or part thereof.

WATERCLOSETS:

One only, where nine or fewer people usually work. Where 10 or more usually work, then separate WC's must be provided, to the following scale:

Males: one WC for the first 20 persons or less, plus one WC for every additional 30 persons or part thereof.

Females: one WC for the first 15 persons or less, plus one WC for every additional 30 persons or part thereof.

GENERAL:

Conveniences for each sex must be separated by solid or double lined walls of full height. They should be readily accessible, well lighted and ventilated and protected from the weather. If situated outside the building, good footpath access with lighting should be provided.

Conveniences must not open directly into workrooms, dining rooms or rooms where food is prepared.

Ventilated isolation compartments are necessary.‖ Doors between isolation compartments and other rooms should be self-closing.

Sanitary facilities for use by both sexes must be:

- completely enclosed; and
- have an efficient inside lock; and
- have satisfactory provision for the disposal of sanitary towels.

Accommodation for clothing

Separate clothing accommodation for members of each sex should be provided, and where a change of clothing is necessary for the work performed, a change room is required.

The change room should have a minimum of 1 m^2 of clear floor area for up to two workers, with an extra 0.5 m^2 of clear floor area allowed for each additional worker.

The room should be equipped with seats or benches with a length of not less than 450 mm for each worker and should be properly lighted and ventilated.

Arrangements for drying clothes may be necessary in certain industries.

‖See Drainage and Plumbing Regulations 1978.

Where no change of clothes is necessary, the following is required:

- For up to six workers, a cloak space or locker accommodation.
- For seven or more workers, a cloak room or cloak area.

Separation of the facilities is required for members of each sex.

The following definitions may be of assistance in interpreting this section:

CLOAK SPACE: An area used exclusively for the accommodation of clothing not worn during working hours and provided by means of a space along a wall screened off with curtains to a minimum height of 2 m. The space is to be at least 600 mm wide, and of such length to provide 300 mm of wall or rack space for each person employed. One double coat-hook is to be provided for each person where a rack is not provided. (See fig 3).

CLOAK ROOM OR CLOAK AREA (See fig 4): A room or area used exclusively for the accommodation of clothing not worn during working hours, access to the clothing being from within the room or area.

Other than a room, it is to consist of an area with rigid walls or partitions not less than 2 m high. If the accommodation is temporary, or in special circumstances, curtains or screens may replace the rigid walls or partitions in whole or in part.

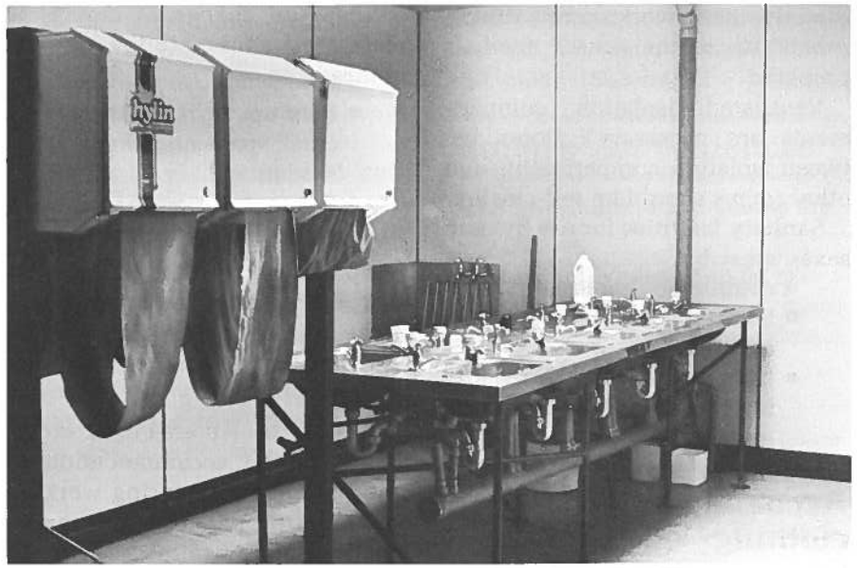

Fig. 2—Hand washing facilities with hot and cold water and roller towels. Walls and floors are smoooth, impervious and easy to clean.

The dimensions of the room or area should provide not less than 300 mm of wall or rack space for each worker, with at least 1.5 m of clear space between opposing lines or in front of single lines.

One double coat-hook is to be provided for each worker or, alternatively, the room or area is to be fitted with racks.

LOCKERS: These should comply with NZSS 1187:1969.

Standard specification for clothes lockers		
Sloping top	–Height at back	1900 mm
	–Height at front	1800 mm
Flat top	–Overall	1800 mm
Internal width	–Type 1	300 mm
	–Type 2	375 mm
Internal depth	–(All lockers)	450 mm

Fig. 3—A suitable cloak space in an office, for clothing not worn at work.

Fig. 4—A change room with full-size lockers conforming to New Zealand Standard 1187:1969, and with seating provided.

Fig. 5—A modern mealroom, with individual seating and small, well arranged tables. It is well ventilated and has a pleasant outlook. There is also provision for screening the windows on sunny days.

VENTILATION: Doors shall be louvred or open mesh. The louvred area of each set of louvres shall have a minimum of free air space of 0.045 m^2, and shall be rodent-proof.

First aid room

Under the First Aid (Factories) Regulations 1966 a factory employing more than 100 persons at any one time is required to provide a first aid room to be used exclusively for giving first aid treatment.

Regulation 13 requires that a first aid room:

- have a minimum floor area of 10 m^2;
- have walls and ceiling of a smooth impervious surface painted a light colour;
- be lighted, heated and ventilated to the satisfaction of a factory inspector;
- be provided with a wash-hand basin with hot and cold running water;
- be fitted with cupboards for the storage of first aid appliances and requisites.

Dining room

A dining room or suitable place for eating is required where there are seven or more workers.

It should be a suitable and pleasant room set apart for the purpose and furnished with tables, chairs and adequate means of boiling water. The room should be well lit and ventilated and should be equipped with a sink and hot and cold running water, together with facilities for storing crockery.

In appropriate cases, and especially where extended hours are worked, an adequate means of heating food should be provided.

Where a kitchen and/or serving space is provided, it should meet the requirements of the Food Hygiene Regulations 1976.

The area of the room should be 1 m^2 per person, with a minimum area of 10 m^2. Where the number of workers is 100 or more, a cafeteria may be required.

The dining room must not be used for clothing accommodation. (See fig 5).

Facilities for rest

Where seven or more persons are usually employed, a suitable place must be provided for any indisposed worker to rest in.

Seating

Suitable seats must be provided for workers whose work, or a substantial part of it, can be done while sitting.

Seating facilities must also be provided for non-sedentary workers to enable them to rest when possible.

Noise

The occupier of any undertaking must take all practicable steps to control at source noise arising from any processes or activities carried out, or to isolate or insulate them.

It is easier and less costly to design premises specifically for a noisy operation than it is to modify and adapt an existing building to comply with legislation.

Drinking water

Every undertaking must have an adequate supply of wholesome drinking water. Unless suitable drinking fountains are installed, suitable drinking vessels shall be provided at the water supply with facilities for rinsing them.

Fire safety

All undertakings are required to comply with the requirements of the appropriate local authority in matters pertaining to fire safety.

Such matters will include number, type and placement of fire fighting devices, fire alarms and egress from the premises.

APPENDIX A

The following is a list of safety guides and codes of practice published by the Department of Labour and available free from any district office.

Asbestos Regulations 1978—a guide
Dust explosion prevention—flour and stock feed mills
Dust explosion prevention—plastics industry
Dust explosion prevention—sulphur fires and explosions
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INDUSTRY

- SAFETY
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NOISE

Notes for Employers on Overcoming the Problem

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FOREWORD

In our modern technological world more and more people are being exposed to appreciably high levels of noise whether during their leisure time or in the workplace itself.

With the recent passing of legislation for the protection of workers' hearing a further step has been taken in the promotion of industrial health and the welfare of the working community. This booklet is intended as a simple introduction to the problem for use by employers.

NOISE AND THE EMPLOYER

Introduction

Noise may be defined as unwanted sound. In our society, noise has become a background accompaniment to almost all our day to day activities. The problem of noise is old, but the realisation of the harm it can cause to people is relatively new. Most people have accepted noisy working conditions as a fact of factory life. It is now recognised that prolonged exposure to harmful levels of noise can do a significant amount of irreversible damage to a person's hearing.

What are Your Obligations?

Where a permanent loss of hearing occurs (either through noisy processes at work or elsewhere) the damage caused to the hearing mechanism is incurable for, once loss of hearing has occurred, the nerves in the ear are destroyed forever. Industrial deafness has been recognised as a compensable injury but, of course, apart from this fact every employer has an obligation to ensure that his employees are protected as far as it is practicable to do so.

If any factory process or activity generates a level of noise which is likely to impair a worker's hearing, his employer is obliged to take effective measures to deal with the problem. He can do so by a reduction of the noise level at source or he can have the process or activity isolated or insulated, so that other parts of the factory are no longer affected by the noise. The employer may be in doubt as to whether the noise in his factory is in fact harmful. In such a case, an approach should be made to the Departments of Labour or Health who will arrange for a sound survey of the factory.

The question of providing hearing protection, on an individual basis, arises only:

(a) During the interval that measures are taken to reduce, insulate, or isolate the noise;

(b) When workers are required to be protected when entering an isolated or insulated noisy area; or

(c) Where it is not practicable to fully apply any of these measures.

Measures to be Taken

Management's aim should be to reduce the noise at its source to a safe level by insulation or isolation of the process. Ideally, an effective hearing conservation programme should be set up composed of four distinct but inter-related parts—each requiring the proper use of expertise for its total success:

(a) *The Noise Survey*—The purpose of the noise survey is to determine the sound level limits within the factory. If the survey discloses levels of noise in excess of 85 decibels, 85dB (on the "A" weighted network of a sound survey meter), damage to hearing over a period of time is highly probable.

(b) *Personal Protection of Employees*—Hearing protection (of an approved type) should be provided and used until the noise is reduced to a safe level. Once hearing protection is provided management should:

- Identify and mark work areas where ear protection is required to be worn.
- Control entry into areas requiring the use of hearing protection.
- Ensure that the ear protection selected is of a type approved by the Medical Officer of Health.
- Make certain that the ear protection is properly fitted and employees are instructed in its use and care. Public health nurses will assist in fitting and will give instruction in the care and use of ear protection. They can be contacted at the occupational health centres or through the local office of the Department of Health.

(c) *Testing the Hearing of Employees*—If the noise level in a factory exceeds 85dB.A. an audiometric test would discover if an employee's hearing had been affected. Remember, industrial deafness is a compensable injury!

(d) *Keeping Records*—The keeping of proper records of sound survey tests, taken at intervals, will ensure the maintenance of the efficiency of the measures taken to reduce noise in the workplace. This ensures continued protection of the employees and provides proof of compliance with the Factories Act 1946. The keeping of your employee's audiometric test results will assist in preventing further damage to his hearing.

Methods of Controlling Noise Exposure—General

The need for noise control should be considered when deciding on the different production methods or processes to be used. It is strongly recommended that design and construction of such measures should be supervised by a person skilled in noise control techniques.

When introducing these measures, care should be taken to ensure that safety and a satisfactory standard of other environmental factors (e.g., temperature and ventilation) are maintained.

Separation of Noisy Areas

Where practicable, machines or processes producing sound levels in excess of 85dB should be set apart. Suitable partitions may be needed to prevent the spread of noise. It is important that these be of correct size and location in relation to the sound of the noise source, and the frequency of the sound to be intercepted.

Where a room, or building, is being divided into noisy and quiet areas, it is preferable for the separation to be made as complete as possible. This may be achieved by extending partitions to the walls and the ceiling (except where false ceilings are installed) or roof, and by ensuring that there is a minimum of openings in the partition.

It may be advisable to provide sound absorbing material in noisy areas in order to prevent increase of sound level due to reflection from the walls or ceilings. This will, however, in no way reduce the output of noise from a noisy machine. The absorbing material should be such that a fire or health hazard is not introduced.

Exhaust Silencing

Exhaust systems (including internal combustion engines and air exhausts) should be provided with effective silencers, or should be discharged in an area remote from work areas, but not so as to create a hazard or nuisance to the public. Silencers should be regularly inspected and maintained.

Machine Enclosure

Where practicable noisy machines should be provided with sound-insulating enclosures. The operator should normally remain outside the enclosure.

Enclosure of the Operator's Workplace

In certain circumstances it may be possible and advisable to protect the machine operator by providing a sound-reducing enclosure or cabin.

When providing an enclosure for the operator, regard should be paid to his comfort. In particular, efficient ventilation and temperature control should be ensured and the enclosure should be as large as is reasonably practicable.

If enclosure of the operator's normal workplace is not considered possible, it may be practical to provide a noise refuge which he can occupy when not actually working at the machine.

A noise refuge is particularly suitable where an operator has no fixed working position.

Use of Quiet Machines and Processes

When deciding which of different production methods or processes is to be used, the necessity for noise control should be taken into account. It may be possible to control noise by using a quiet process in place of a noisy one. Where appropriate, machines should be supported on anti-vibration mountings and metal-to-metal impact should be eliminated where possible.

Inspection and Maintenance

Where noise control measures have been installed, they should be regularly inspected, by a competent person, for efficiency. It is desirable that all new machines after installation have their noise output assessed by a sound survey meter.

Training

Persons engaged in the specification, layout, and installation of machines in factories should be adequately trained in techniques of noise measurement and control, or should be advised by suitably trained technical personnel.

Persons engaged on installation, maintenance, or operation of machines should receive such training as is necessary to avoid production of unnecessary noise.

Where required, this training should include instruction in the correct lubrication, adjustment, replacement of worn and loose or out-of-balance parts of machines, and in the need for effective and correct maintenance of exhaust silencers or enclosures.

ALL PERSONS EXPOSED TO NOISE SHOULD BE ACQUAINTED WITH THE HAZARDS INVOLVED.

Hearing Protection

Until an employer reduces the noise from a process or activity his employees must be given protection. There is a natural resistance among employees to the wearing of hearing protection devices. Their understanding and use of ear plugs or muffs will involve adopting new attitudes and personal work habits.

Employees must be advised of the advantages to be gained from wearing protection such as:

- When ear protection is worn at work, employees feel less fatigued and less irritable at the end of the day;
- In noisy areas ear muffs can improve the reception of speech;
- Ear protection does protect and preserve hearing;
- After wearing protection for some time most employees adopt the habit of wearing them in the presence of noise, both on and off the job, i.e., when using electric saws at home. Many wearers say they eventually appreciate the comforting dullness ear protection creates at work and won't go into noisy areas without them.

The proper introduction of employees to hearing protection helps to overcome criticisms such as:

- Ear plugs are a "foreign body" in the ear; when properly fitted they may be initially uncomfortable—like new shoes or wearing spectacles for the first time.
- The "dullness" of hearing that ear protection creates is physically disturbing. This feeling, however, is soon adjusted to.

HINTS ON EAR PROTECTION

Cotton Wool

Ordinary dry cotton wool is an extremely poor protector and does not provide proper reduction of noise.

Ear Plugs

Ear plugs should be properly fitted for the users' ears by a trained person. Universal or multi-fit ear plugs are not accepted as they do not provide the same degree of protection as individually fitted plugs.

Ear plugs may be slightly uncomfortable when first fitted if making a good seal, but after this period one becomes unaware of their presence. Employees should be instructed on the correct method of inserting the plugs. They must be kept clean by washing regularly with soap and water.

Ear Muffs

These fit over the ears and are sealed to the head with soft cushion seals; this cushion seal must be checked to see it is in close contact with the head right around the ear. Correct pressure is required; the headband must not be bent to reduce pressure. Seals should be replaced at once if damaged.

Muffs have several advantages compared with ear plugs. One size will fit most people, a higher degree of protection is provided, and they are easy to remove and replace—an advantage for people who frequently move from a noisy area to a quiet area.

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atmospheric conditions

IN FACTORIES

ATMOSPHERIC CONDITIONS IN FACTORIES

It is difficult to define an atmospheric working environment which will suit all workers in every type of process. As well as being a matter of individual choice this optimum environment depends on the one hand on physical conditions such as temperature, humidity, air movement, radiation and clothing, and on the other on physiological factors including sex, age, state of health, acclimatisation and physical activity. To assist in the assessment of the best atmospheric working environment for various processes the Department of Labour has conducted a survey of a selected number of industries where working conditions in both summer and winter were measured and where possible the same workers interviewed on both occasions.

Part One of this booklet discusses the need for consideration of the many factors described above when deciding optimum atmospheric conditions. Part Two gives details of the results of the survey of industry and lists the new standards.

PART ONE

Thermal comfort is achieved when an individual is entirely unaware of any physiological adjustment to the environment, atmospheric or otherwise. Therefore the aim should be a thermal environment which meets, as nearly as possible, the demand of the majority; for it must be accepted that owing to the wide variations in the physical characteristics of different persons an environment which is agreeable to one may prove to be uncomfortable to another. Since it is usually not possible to satisfy everybody the best that can be achieved, particularly in rooms with a considerable number of occupants, is to provide conditions which will be acceptable to the greatest number. By the adjustment of clothing the others can reasonably be expected to accommodate themselves to the conditions selected by the majority.

New Legislation

Everyone knows that sensations of warmth and coldness depend upon the temperature of the air, but as mentioned in the introduction this is not the only factor as these sensations depend as well on the humidity and are also influenced by air movement and radiation. Prior to 1961 the legislation on this subject only had regard for the provision of a reasonable temperature in the workroom which meant, in the case of large areas with low worker density, that the cost to achieve compliance would be out of all proportion to the end result. In many cases too, where workrooms had permanent openings to the outside air, e.g., loading docks, goods entrances, etc., it was virtually impossible to raise the temperature of the air in the workroom since heated air was constantly lost in exchange with colder outside air. Finally, since air temperature is only one of four major factors influencing the feeling of "comfort" of a person it is surely reasonable to permit the adjustment of any one or a combination of these factors to provide a comfortable working environment.

The result was that Section 58 of the Factories Act 1946 was amended (by Section 6 of the Factories Amendment Act 1961) to read as follows:

> "Effective and suitable means, having regard to the process or work carried on in the workroom shall be provided to control, in each workroom of any factory, the temperature, the humidity arising from any process being carried on in the factory, the air velocity, the radiation of heat, and the quantity of fresh air in the workroom so as to ensure that persons work in the factory in reasonably comfortable atmospheric conditions."

These various aspects are now discussed in more detail.

Physiological Aspects

Before the reason for the change in legislation can be fully appreciated, it is necessary to consider the manner in which the heating and cooling mechanisms of the body function.

The first point to appreciate is that the deep body temperature—i.e., the temperature of the major organs like liver, lungs, etc.—must operate at about 98.4° F. and our continued survival depends on the body being able to maintain this temperature in the face of a wide range of environmental changes.

During the process of metabolism—this means the changes undergone by nutritive material in the body—heat is generated in amounts that vary with the level of activity. A man seated or engaged in the lightest of tasks generates approximately 400 British Thermal Units per hour, a woman generates somewhat less, while the heaviest manual work may raise this rate to 5,000 B.T.U. per hour. This heat must be lost to the surroundings but since the body can function satisfactorily only within the narrowest of temperature variations, only the precise amount of heat generated must be lost. For this purpose the body is provided with temperature-regulating mechanisms which are extremely sensitive but which neverthless can only function over a comparatively small range of environmental conditions without discomfort to the individual.

Heat transfer from the body to its surroundings takes place in several ways:

(1) Conduction: this is not of great importance in industrial problems but must not be overlooked.

(2) Convection: by giving up heat to the surrounding air in contact with the clothes and skin.

(3) Radiation: by direct heat rays to surrounding objects.

(4) Evaporation: by the consumption of heat in evaporating sweat from the surface of the body and by the process of breathing.

In low temperatures the body can lose heat both by convection and radiation and is poorly equipped to prevent such loss. Its first step, however, is to restrict the blood flow on the surface of the skin, particularly to the extremities—hands, feet and ears—in an effort to reduce heat loss. Although this increases discomfort the body continues to survive although hands and feet might be blue with cold. If these measures prove insufficient the body's major defence against cold—apart from clothing and artificial adjustment of environment—is an increase in internal heat production by conscious muscular activity—i.e., shivering. In high temperatures the body can lose heat in very considerable quantities and, providing atmospheric conditions are favourable, this heat loss may cause little or no discomfort. As the temperature rises there is increased blood circulation—hands and feet become warm, the body generally becomes flushed with the increased blood flow and heat is lost much more rapidly than at the other end of the scale. If this proves insufficient a further mechanism takes over and the body starts sweating. The evaporation of the film of moisture on the surface of the skin reduces the heat content of the body quite markedly. A similar effect occurs with the food storage containers called "Coolettes"—these are kept moist and evaporation cools their interior for the storage of butter etc. in quite warm weather.

If the body continues to heat up when all of these mechanisms are operating then the internal temperature rises and there is a possibility of heat stroke and even death.

All these processes are well known to us, if only as unco-ordinated facts. We recognise the flushed skin and sweating that accompanies a fever (i.e., a high internal temperature) and we are familiar with fingers blue and numbed with cold. This then is briefly the story of the manner in which the body controls its heating and cooling mechanisms. No single process monopolises the scene but all four referred to operate simultaneously but in varying degrees. The fact that the body can regulate over such a wide range of temperatures does not mean that it is a comfortable process. Somewhere between the extremely cold and extremely hot environment lies a point where we have no conscious feeling of warmth or coolness—merely one of comfort. This point is called the "neutral point" (better known as the "zone of thermal neutrality" or "comfort zone").

It must be stressed again, however, that there is no precise physiological observation that will enable us to evaluate comfort. The neutral point varies with the season, the clothing worn, the degree of activity and all the other factors that control the production of heat within the body.

Factors Effecting Heat Exchange

Sensations of warmth or coldness depend upon the temperature of the air—this is the dry bulb temperature. But as already mentioned this is not the only factor, it may depend also on the humidity—as measured with a wet bulb thermometer, and they are also influenced by air movement and radiation. Dry air at a relatively high temperature may feel cooler than moist air at a much lower temperature. Theoretically, it would be possible to freeze to death with air temperatures of perhaps 140° F. or to die of heat stroke in sub-zero air temperatures. These are not realistic situations but they do point out weaknesses in thinking of comfort in terms of air temperature alone.

Returning to the realms of reality, however,

let us consider a condition where the environment is somewhere near the comfortable level. We know that this comfort depends on air temperature, humidity, air movement and radiation. For the moment we will ignore radiation which presents particular problems and consider only the other three factors. Certain combinations of these three variables can produce the same feeling, e.g., high humidity and low temperature can produce the same feeling as low humidity and high temperature, the important feature is that the body does not recognise the difference—it will feel the same in both situations.

Heating and ventilating engineers have long been aware of these factors and have combined them in curves on a graph which relate the three factors of air temperature, humidity and air movement, and show the thermal equivalence of the various combinations. This equivalence is measured in terms of the effect on the body, in other words, how the body feels about a given situation irrespective of what temperature may be registered. For this reason the combined index of comfort is called the "effective temperature". It is rather an unfortunate use of the word 'temperature' but the operative word is *effective*. This is an empirical index denoting the response of the body to various combinations of air temperature, humidity and air movement. The thing to realise is that no matter what set of circumstances are used to achieve it, the same *effective* temperature promotes the same feeling of comfort.

Let us now look at some of the results that have been tabulated by research workers—mainly in America. The findings come in the form of graphs and the two shown in Figs. 1 and 2 relate to office workers seated at their desks. Let us see what range of temperatures, humidities and air movements we can attempt and still maintain a feeling of comfort. It is generally accepted that 66° effective temperature is the most desirable one for this type of activity. We can see from Fig. 1 that at 66° *air temperature* and 100 per cent *humidity* the worker will feel comfortable provided there is no air movement. Suppose now the air temperature rises to nearly 80° F., can a

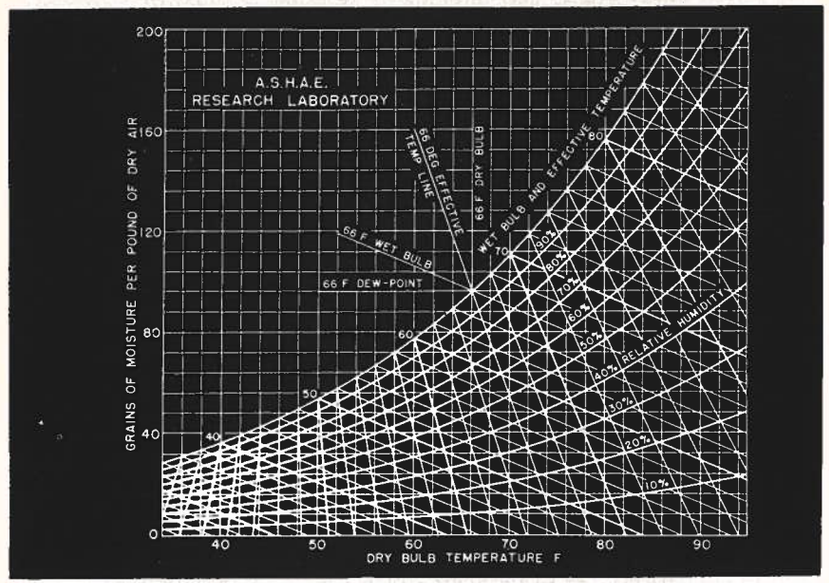


Fig. 1. Psychrometric Chart, persons at rest, normally clothed, in still air.

feeling of comfort be maintained? It is in fact possible, although the requirements are slightly unreal. In dry air (no humidity) with an air movement of about eight miles per hour (700 feet per minute) the worker will feel exactly as before —i.e., the effective temperature is still 66° (see Fig. 2). He may of course have difficulty in keeping papers on his desk due to the draught but he will still feel comfortable in the heating sense even if slightly frustrated.

As an alternative, suppose we specify an *air temperature* of 66° F. in some situation, what range of *effective temperature* could we expect? Working from either graph we see that comfort will exist only in still air at 100 per cent *humidity* —in Fig. 2 the 20 to 30 feet per minute air movement represents still air in most circumstances. However, in dry air and with a considerable draught the effective temperature may be as low as 53½°—a very uncomfortable temperature for such work.

Having suggested that the effective tempera-

ture scale is very suitable as an index of comfort we must now destroy the whole concept by showing that even this improved scale gives only part of the picture. Consider the case of a worker who, by some combination of air temperature, air movement and humidity, has been given an effective temperature of 66° so that he is quite comfortable. Assume now that a two-kilowatt high temperature radiator is placed somewhere just behind him. Very soon he will feel overheated, while neither the air temperature or the effective temperature will have altered in the slightest degree. In other words any temperature index or comfort scale that neglects radiation as one of the factors is sometimes unrealistic.

Radiation of heat is a continuous emission of that form of energy in waves of varying length from all bodies and at all temperatures and follows the laws of light. Radiation does not appreciably heat the air through which it passes but is absorbed in varying degrees by the surfaces of solid bodies in its path.* There is still some controversy as to the merits of warming by radiation or convection but the fact remains that radiant heating is gradually gaining popularity and in certain circumstances it is the most useful and economic method of heating that is possible—in many cases the only method possible. We must therefore expect to see more high temperature radiators strung around the walls, more floor heating and occasionally some extended ceiling heating.

Let us consider a large factory with low worker population density and with loading docks at each end constantly open to the elements. In winter this would be a very cold place in which to work, yet any attempt to heat the air by convection would be quite futile since the warm air would be constantly lost in exchange with the colder outside air. However, the same sensation of warmth (comfort) may be experienced with the air temperature several degrees lower than is required with convection systems of heating, if

* In due course, however, the solid bodies which have absorbed the radiated heat will warm the air in a room by convection.

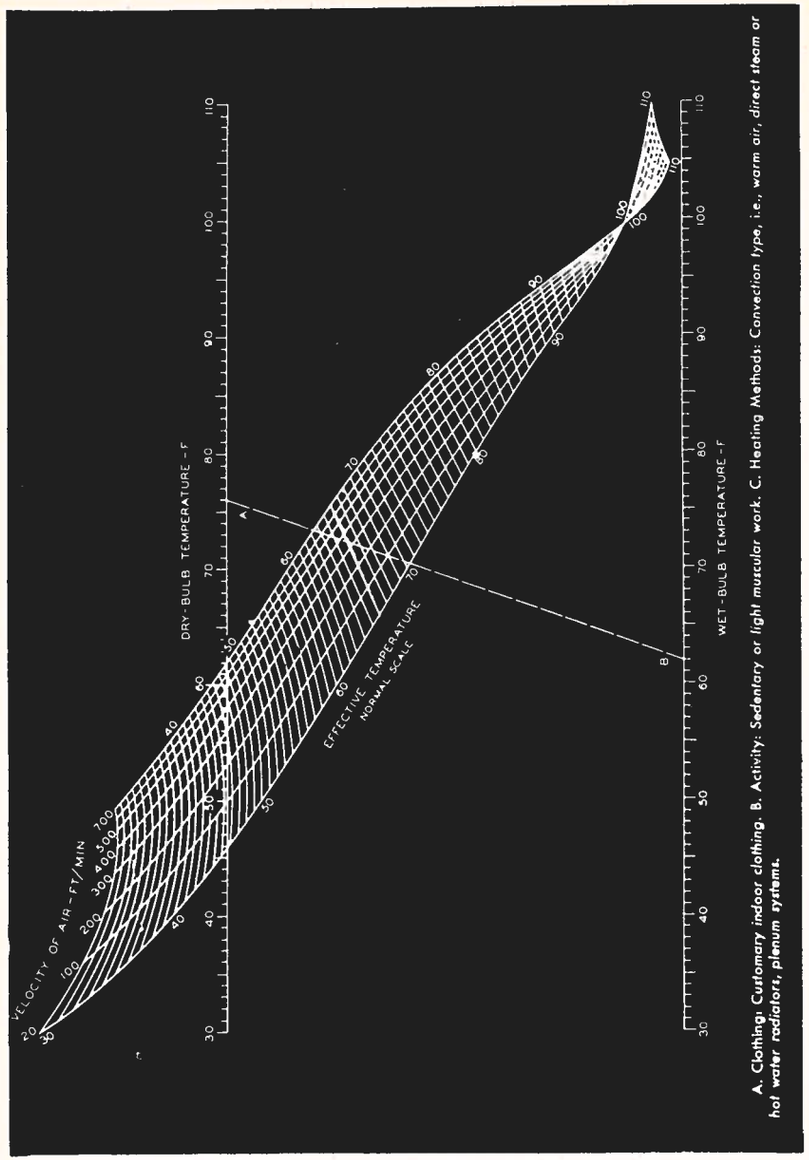


Fig. 2. Effective Temperature Chart showing normal scale of effective temperature.

appliances which emit a high proportion of radiant heat are employed at strategic points throughout the work area.

"Infra-red" radiant heaters with source of heat derived from gas or electricity are fast becoming the accepted method of providing comfort for workers in large work areas with a low population density, workrooms which have large and permanent openings to the outside air, or even these cases where it is quite practicable to provide ordinary convection heating. It is not a new principle. We are heated on earth by infra-red rays from the sun.

The problem where radiant heat is involved is to specify a comfort level. The graphs showing the relationship between air temperature, relative humidity and air movement and *effective temperature* are not appropriate because those graphs do not have any regard for radiant heat. Consequently we will have to look to a graph which gives "equivalent temperatures" having regard for air temperature, air movement and radiation exchange (see Fig. 3). The factor of humidity is ignored in this case. Indeed it is of no great moment in most circumstances unless very moist or very dry conditions arising from some special processing procedure that is peculiar to the plant are involved.

Selection of Plant and Installation

It is not the purpose of this booklet to discuss the many and varied methods for providing comfort in the workplace; that is the prerogative of the experts in this field, the heating and ventilating engineers. Suffice it to say that in designing a convection heating system the first step is to estimate the amount of heat required and this must of course take into account the heat lost by transmission through walls, windows and roof, and in some cases through the floor as well as the heat required to warm the air admitted for ventilation. Too often the fact is overlooked that heat requirements of a building may be substantially reduced by structural insulation and this is particularly true of single-storey factories with a large expanse of roof. Often such

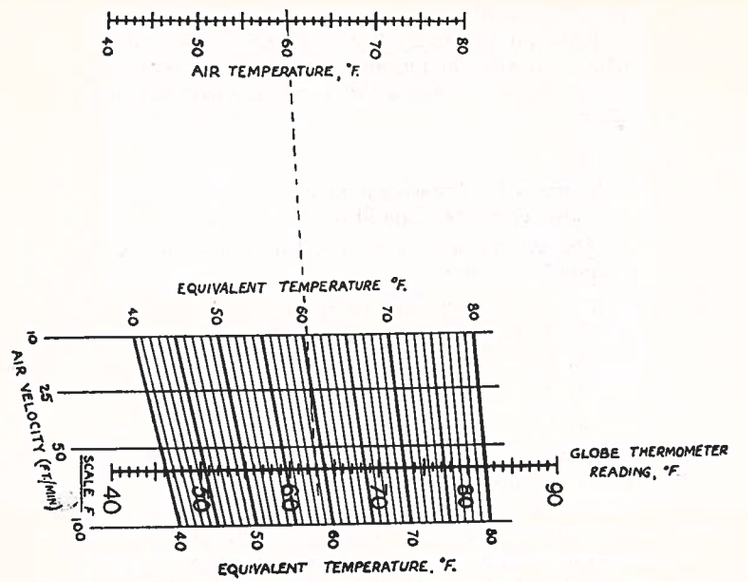


Fig. 3. Chart for the estimation of equivalent temperature from globe thermometer readings.

a roof is of a light nature and the loss of heat in consequence is enormous. Other factors to be considered are heat losses through ventilating systems and dust and fume removal plants and of course sources of heat already available from processes and the workers themselves.

No hard and fast rules can be laid down as to the suitability of a particular type without reference to the circumstances. The simpler forms are, however, the cheaper to install, but they are not necessarily the most economical to run. The first cost of comprehensive schemes is often high but they produce the best results.

Radiant heating can lead to troubles and side effects such as headaches and "hot-head" if not properly installed. However, if radiant heaters are installed as recommended by the agents then no major troubles should result although it is well to realise that radiant heating can never be

as comfortable as ordinary convection heating and should be used only in those circumstances where convection heating is not readily possible or where the expense involved is obviously not warranted.

Instruments for Measurement of Environmental Conditions

The conditions to be measured may be summarised as follows:

(1) Air temperature (dry bulb).
(2) Air temperature (wet bulb).
(3) Relative humidity.
(4) Air movement.
(5) Radiant heat.

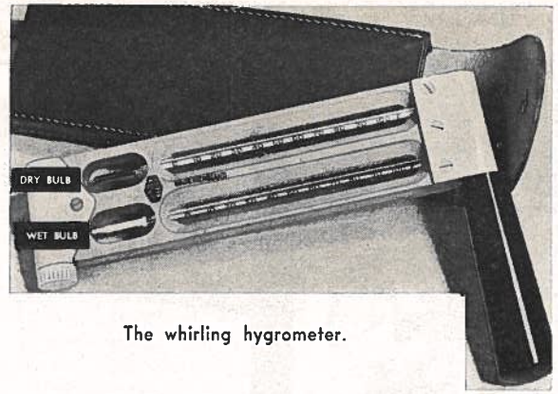
These conditions may be measured by different types of instruments, ranging from the simple portable types to more elaborate continuously recording equipment. Those described in the following paragraphs are of the former types and are suitable for normal assessment of conditions in factory workrooms.

(a) The Mercury Thermometer

Air temperature is usually measured with an ordinary mercury thermometer, which is sufficiently well known to make description unnecessary. This type of thermometer, however, is affected by radiant heat, and where radiant heat is present it is necessary to screen the bulb from the source of radiation. This can be done by means of a brightly polished cylindrical radiation shield enclosing the bulb.

(b) The Hygrometer

Relative humidity may be measured by the difference in reading between "dry bulb" and "wet bulb" thermometers. The wet bulb thermometer is provided with a small fabric sock which fits over the bulb and which by means of a wick is allowed to take up water from a container below. Evaporation rates vary with the amount of moisture in the atmosphere so that the "wet bulb depression" can be made to provide a measurement of the relative humidity of the



The whirling hygrometer.

atmosphere. This is done by means of a psychrometric chart or a set of humidity tables.

There are two common versions of this instrument in general use:

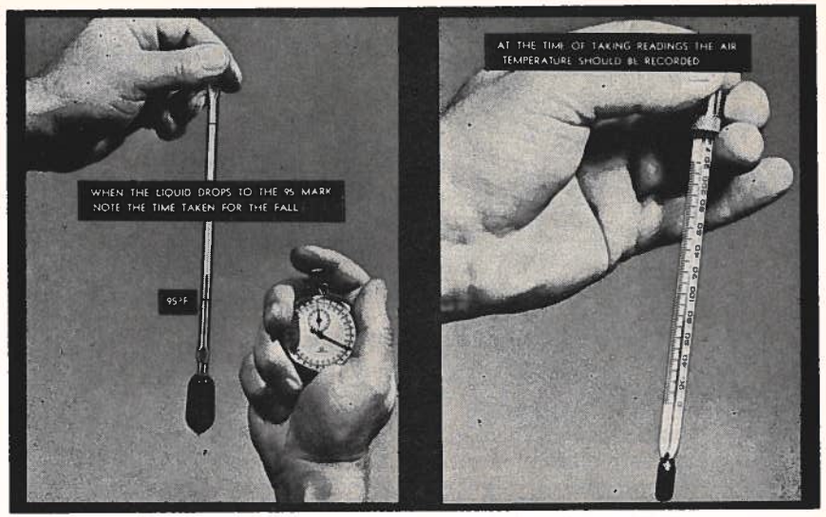
(1) The sling psychrometer or "whirling hygrometer". This is essentially a portable instrument. It is operated by whirling it round in the hand and in the same way as a rattle.

(2) The fixed hygrometer.

(c) The Kata Thermometer

The air movement in a workroom is frequently of the order of around 100 feet per minute and of an eddying nature and, in estimating the *effective temperature*, it is necessary to measure the equivalent air velocity of the eddying currents. The rotating vane anemometer and the velometer are only suitable for unidirectional currents and are not accurate in many cases at such low air speeds. The Kata Thermometer, however, responds like the body to currents from any direction, integrates the cooling effect of eddying currents, and is reasonably accurate for air movements as low as 20 feet per minute.

This instrument is essentially an alcohol thermometer with a large bulb. The stem has two marks, one corresponding to 100° F. and the other 95° F. The instrument is heated above



The Kata thermometer is shown in the left illustration. By taking the temperature of the atmosphere air velocity is computed by applying the Kata reading and the temperature to a Kata chart supplied by the makers. The instrument in the right illustration is an ordinary mercury thermometer.

100° F. in hot water; it is then dried and the liquid level allowed to drop. The time required for the reading to drop from 100° F. to 95° F. is noted and applied to an appropriate chart from which can be ascertained the cooling power, and when the dry bulb air temperature of the surroundings is known, the air velocity.

(d) **The Eupatheoscope**

There are means available whereby a fair assessment can be made of the effects of radiant heat in given circumstances but the methods are not exact and are subject to a good deal of interpretation. The research organisations concerned with this type of work have looked at this problem for many years—how to relate the factors of air temperature, humidity, air movement *and radiation* into a single index that gives a measure of comfort of any environment. The nearest approach has been the development of the eupatheoscope and even this is by no means perfect.

The eupatheoscope is the heating engineer's idea of how a scaled down version of the human body appears. It is a blackened copper cylinder 22 inches high and 7½ inches in diameter, set on a tripod at convenient height. It is painted black because from the point of view of radiation heat-in, the human body is black unless clothed in some very special clothing. To equate with the idea of internal heat production this copper cylinder is heated within by an electric heating element and its surface raised to a temperature that approaches that of the average human skin temperature—about 81° F. Since it has a warm surface the eupatheoscope will respond to air temperature just as the human frame does. If there are draughts then it will be cooled by the passing air, again just like a human being. Moreover—and this is the important point—it responds to radiation and if it receives heat from a high temperature radiator for example, the surface temperature will tend to rise.

Details of the methods of operating the eupatheoscope are unimportant, it is enough to say that of the methods of metering the effect of environment on the human body this is probably the best. It should be noted, however, that it has one deficiency—it cannot sweat so that it does not respond to humidity changes. It was mentioned earlier that even though the body responds to humidity changes in practice this factor can often be ignored. In point of fact the legislation requires this to be considered only where it arises from the process. This does not mean that one should approve of this treatment but merely that if some factor has to be left out humidity is the one that can best be dispensed with.

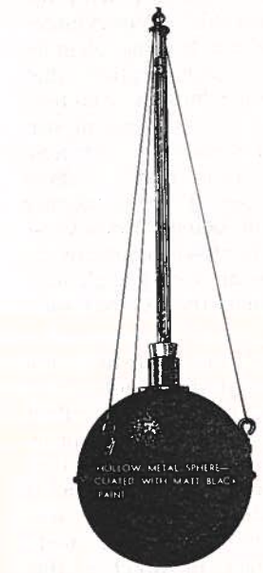
(e) **The Globe Thermometer**

This is another instrument designed for measurement of radiant heat. It comprises a hollow copper sphere, six inches in diameter, with a matt black surface, containing an ordinary mercury thermometer with its bulb at the centre. Heat from radiation falling on the matt black surface is transmitted to the thermometer and an estimate of radiant heat may be made.

One of the most serious objections to the globe thermomemter is the considerable time, sometimes as long as 20 minutes, required to reach equilibrium at a new temperature.

Left: The globe thermometer.

Below: The eupatheoscope.



PART TWO

In this section we discuss the reasons for the survey of industry, describe the method in which it was carried out, describe how the data was processed and finally, establish new standards for which departmental officers will be asking.

Because of the legislative change with the 1961 Amendment to the Factories Act 1946, it has become necesary to have regard to factors other than air temperature in evaluating environmental comfort, e.g. relative humidity, air movement and radiant heat. These factors under certain conditions all have a bearing on whether or not we are comfortable.

Overseas information on comfort heating relates mainly to conditions in offices where levels of activity are generally low. Little is known of the requirements for people working actively. Some limited resarch has been done in special trades, but New Zealand conditions have never previously been surveyed. The survey which is reported here sets up standards which relate to conditions in this country.

Levels of Activity and Sampling

It will be appreciated that different levels of activity require different temperatures—a boilermaker would be thermally comfortable at a much lower temperature than a person engaged on inspection work in a garment factory. Since facilities do not exist for laboratory testing, the survey was carried out in existing factories during their normal run of production. To make the results satistically significant, a large number of people had to be questioned and the factories and people selected had to be typical of the industry throughout the country. An examination of Table 1 will show that the industries represented would account for a large proportion of the industrial working population of the country. A similar criterion was used in selecting the premises examined. They represented an average, in terms of type of construction, worker density, processes,

TABLE 1 — SURVEY GROUPS

Numbers Males	Numbers Females	Work	Comments
GROUP A			
22	9	Clerical	
—	8	Inspection	
3	1	Inspection	
—	20	Hosiery finishing	
—	25	Hosiery folding	
17	180	Machining clothes	
7	13	Plastic bag making	
GROUP B			
88	194	Assembly and packaging	
107	63	Printing	
20	—	Storemen	
—	18	Presswork	**Females only**
27	13	Binding (printing)	
4	14	Folding (printing)	
23	6	Glass making	
—	11	Sports goods mfg.	**Females only**
5	5	Plastic button mfg.	
—	6	Paint manufacturing	**Females only**
9	18	Electric light bulb mfg.	
2	2	Ventian blind manufacturing	
8	2	Fibre suitcase manufacturing	
6	1	Glass grinding	
12	39	Brush manufacturing	
4	8	Glue manufacturing	
GROUP C			
282	5	Engineering (lathes, etc.)	
23	38	Textile spinning and knitting	
9	—	Motor garage	**Males only**
66	—	Joinery assembly	
57	16	Enginering assembly	
85	—	Joinery machining	
136	9	Sheetmetal	
53	—	Presswork	**Males only**
21	—	Sports goods	**Males only**
18	—	Paint manufacturing	**Males only**
7	—	Battery manufacturing	
9	—	Compositing	
108	84	Shoe manufacturing	
17	—	Moulding	
1	5	Plastic moulding	
3	—	Upholstering	
20	—	Polishing and grinding	
17	29	Cable making	
14	—	Corrugated cardboard mfg.	
9	—	Tubular steel work	
55	39	Rubber products manufacturing	

TABLE 2 — COMFORT ZONES

COMFORT ZONE — AIR TEMPERATURE, °F

	Summer	Winter
Group A	66 to 70	63 to 69
Group B	64 to 72	65 to 69
Group C	61 to 68	61 to 67

COMFORT ZONE — EQUIVALENT TEMPERATURE, °E.T.

	Summer	Winter
Group A	62 to 68	60 to 66
Group B	61 to 69	61 to 66
Group C	59 to 66	58 to 64

method of heating and ventilating employed, etc. Altogether, nearly 5,000 persons were used as subjects and these were employed in 36 different types of industries. Premises were visited both in winter and summer and initially male and female staff were treated independently.

Levels of Activity

As a result of subsequent analyses, it was found that only three major groups could be differentiated. These we have designated as groups A, B and C, with group A doing the lightest work and group C doing the heavier work. The level of activity, the type of work being carried out, and the number involved in the survey are shown in Table 1.

It should be appreciated that placement of any group in level A, B or C, was a matter for the discretion of the investigator. He has associated those groups who, in his opinion, are equally active. When a factory inspector is trying to determine the comfort requirements of an industry not covered by the survey, he likewise will have to relate the degree of physical activity involved to one similar to those shown in Table 1.

Measurements

Measurements were always made at some place where it was felt that the readings were representative of the working conditions of the people being questioned. This was occasionally in the middle of a group of workers, or in the middle of the workroom. Care was taken not to take any readings that would have been unduly affected by local heating or cooling appliances unless workers were similarly sited. Summer and winter readings were taken in the same position.

In order to get a complete picture of the environment, direct measurements were made of air temperature and humidity, while radiation and air movement were implied from measurement made with the eupatheoscope. When excessive draught was a cause of complaint, measurements were also made with the Kata thermometer.

Employees were then questioned as to their reaction to the existing atmospheric conditions. No attempt was made at great refinement and they were asked simply whether they were too hot, too cold or comfortable. It was emphasised to them that we were only interested in recording their impressions as at the time during which the tests were being made. The answers from males and females were noted separately at the time, but since the physical layout of most factories makes it impossible to supply different environments to men and women, the data in this form was not used in the analysis. Only where the female members of the staff work in a different room from the male members has it been possible to treat the two groups separately. It will be noticed that in Table 1 this distinction has been made in some cases. All data was then entered in the form of punch cards, and later analysed.

Analysis

In the analysis it was found possible to eliminate humidity as a factor of importance. Humidity did not vary widely from place to place and in a typical survey of 55 factories, involving over 4,000 subjects, seven eighths of these people worked in humidities ranging only between 48 per cent and 68 per cent. In terms of change in effective temperature, this represents a change in air temperature of only about 0.6° F. Since average air temperatures within this same sample varied by over 20° F. it can be seen that humidity is only a minor factor and hence can be safely excluded from subsequent analyses. Where an inspector encounters either very high or very low humidities, he must be cautious in using the subsequent standard.

Analyses were made in terms of both air temperature, which is the simplest comfort index, and again in terms of equivalent temperature. The purpose of this dual analysis was to determine whether radiation or air movement played any great part in factory environment. It was found that in every instance, the most desired air temperature was some 2° to 3° above the most

desired equivalent temperature. This suggests some degree of air movement is present in most factories and that it must be of the order of 100 feet per minute. This is not excessive in open spaces, although it might be regarded as slightly high for offices. The results of the analyses for the three groups are shown in Table 2.

Comfort Zones

As temperatures in work spaces rise above or fall below the preferred level an increasing proportion of the occupants will feel too hot or too cold, and it is important to know the relationship between comfort and temperature.

A seven point scale is often used when polling the subjective feelings of people and their response to a given environment. This self explanatory scale is:—

Much too warm
Too warm
Comfortably warm
Comfortable
Comfortably cool
Too cool
Much too cool

For most individuals it requires a 3 degree change in "temperature" to move one unit up or down this scale. Thus a person who finds 65° F. the most comfortable temperature, will be comfortable between temperatures of 63.5 and 66.5, comfortably warm from 66.5 to 69.5, comfortably cool from 63.5 to 60.5, but too warm or too cool anywhere outside this range.

Because of the diversity of individual opinion as to what constitutes comfortable warmth it is impossible to specify a single temperature which suits everyone. But it is possible to find a range of temperatures or zones and know the proportion of people satisfied at various points within it. Some authorities define the "comfort zone" as those conditions for which not less than 50% of the subjects vote within the range "comfortably warm" to "comfortably cool". However, by this criteria up to 50% of persons can be uncomfortable at temperatures on the boundary of the zone

—this seems too great a proportion to be acceptable. It has been suggested by overseas authorities that the comfort zone should be that in which not less than 86% of the votes range from "comfortably cool" to "comfortably warm" and this narrower zone is acceptable for practical purposes.

Required Standards

In Table 2 are shown the temperatures required to be maintained in work spaces for the various levels of activity. In deriving these temperatures, an 86 per cent level of comfort has been required and this is in line with general overseas practice. In essence, this means that within this temperature range, at least 86 per cent of the people in the work space will feel comfortable and it is felt that this is adequate for most industrial applications.

Comments

It is noticeable that in both winter and summer the temperatures required by Group B are nearly the same as those required by Group A—in most instances they are higher. It is not immediately apparent why Group B, who work harder than Group A, should require a higher temperature. Several explanations are possible. For example, since Group B are more active, they may tend to wear less restrictive clothing in order to perform their work more effectively. They would compensate for this to some extent by demanding higher working temperatures. Many alternative explantions are possible, but no specific cause of this difference has been determined.

In using the figures in Table 2, it will be seen that measurements in terms of air temperature are quite in order, providing there is no significant radiation or draught. When either of these factors is present a more reliable index such as equivalent temperature must be used and a correction applied to the above table. The nature of this correction is a matter of experience and should be referred to other quarters.

It was gratifying to find that in practically every case, management took a considerable interest in the survey. Their co-operation in allowing us to interview their personnel and disrupt their production schedule is very much appreciated.

THE "LABOUR AND EMPLOYMENT GAZETTE"

This booklet is based on material published in the "Labour and Employment Gazette", official organ of the Department of Labour, in which is published material on a wide variety of matters of interest to industry: employment trends, labour turnover, labour legislation, occupational safety and health, employee welfare, industrial relations, apprenticeship, immigration, new awards, changes in unions, decisions of the Arbitration Court, etc.

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- Lifting Gear
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- Circular Saws
- Overhand Planers

COMMON-SENSE RULES FOR AVOIDING BACK INJURY

DO keep fit, watch your weight, eat sensibly, and walk for exercise.

Avoid sudden violent and unaccustomed exertion.

Remember that bulky or unstable objects are particularly hazardous.

Share the load, or divide it, or put it on wheels.

Dress for the job — wear safe shoes.

Always keep a straight back when lifting, pushing, or pulling. Stand close to the load, feet apart facing the way you intend to move. Bend your knees and make your legs do the hard work.

Above all, never jerk at the load or twist your body as you move, and don't carry heavy loads for too long.

Arrange your work-space or kitchen so that you don't have to bend or stretch unnecessarily. If the work-top is too high for you or too low, try sitting on a stool of appropriate height. Kneel rather than stoop to make your bed. Choose chairs which support the small of your back firmly; over-soft or bucket-shaped ones make you adopt an unhealthy and undignified slump. Reading stands or sloping desks may be useful for sedentary work, and make sure the height of your chair is right in relation to the working surface. If possible, avoid spending long hours behind the wheel of a car or lorry, or bending over the engine. Make sure you have a good driving seat: many are badly designed, but can be improved with a backrest.

If you must stoop and bend your back, give it a supporting strut with your knee or arms.

LAST BUT NOT LEAST, CHOOSE A FIRM MATTRESS or put a board under your old and sagging one.

PREVENTION IS BETTER THAN CURE

backpain ASSOCIATION

This folder is from material issued by the Back Pain Association Limited, Middlesex, England. The association, a registered medical charity, is one of the world's leading organizations involved in back trouble avoidance and research. By kind permission, the folder is issued by the Accident Compensation Corporation in the interests of accident prevention. It does not purport to be a final statement.

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SAFETY DIVISION,
ACCIDENT COMPENSATION
CORPORATION,
PRIVATE BAG, WELLINGTON.

Accident Compensation Corporation
New Zealand

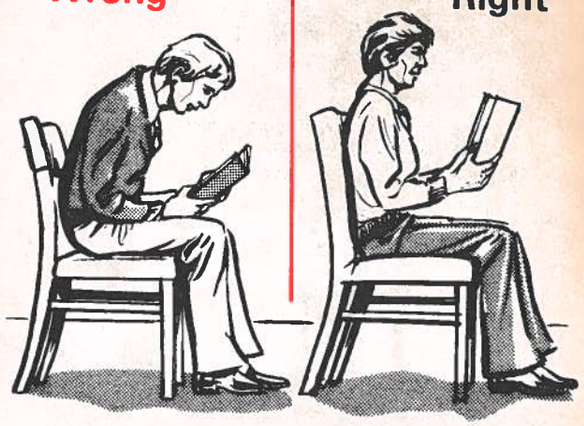
How to prevent back injury

COMMON-SENSE RULES

SITTING

Wrong

Right

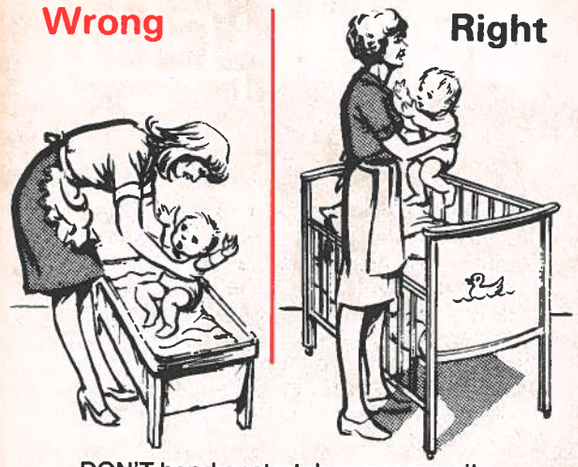


DON'T slouch or slump.
DO choose chairs which support the small of your back.

SENSIBLE FURNITURE

Wrong

Right

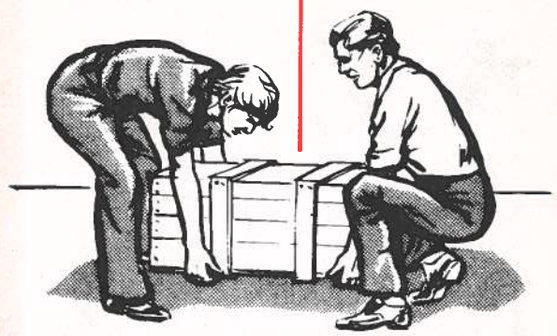


DON'T bend or stretch unnecessarily.
DO choose furniture which is comfortable in use.

LIFTING

Wrong

Right

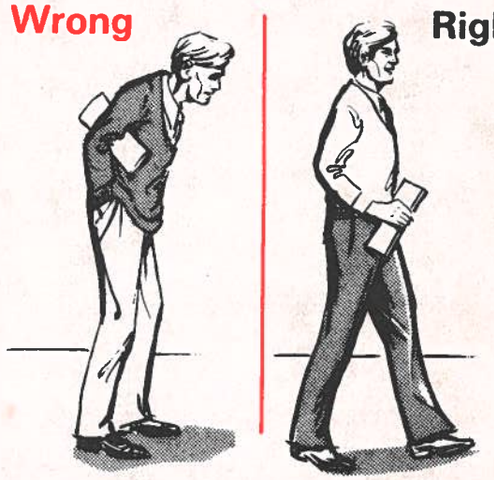


DON'T bend your back.
DO bend your knees and make your legs do the heavy work.

WALKING

Wrong

Right

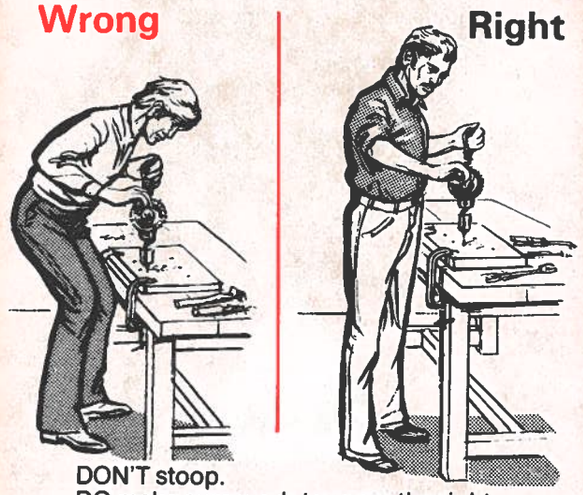


DON'T slouch or hunch your shoulders.
DO stand up straight.

WORKING HEIGHTS

Wrong

Right

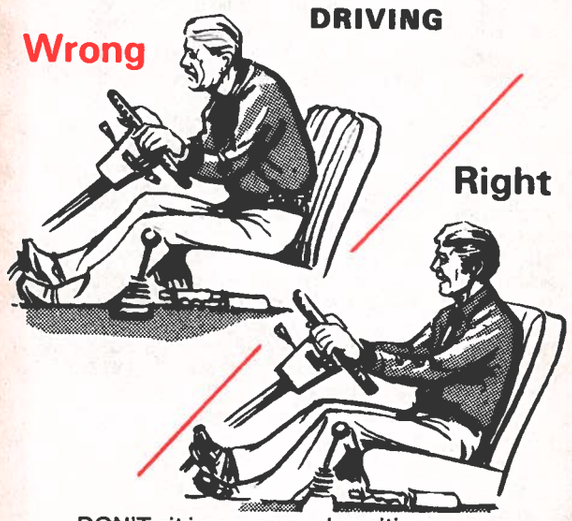


DON'T stoop.
DO make sure work-tops are the right height.

DRIVING

Wrong

Right



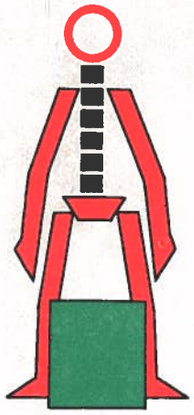
DON'T sit in a cramped position.
DO use a backrest if the seat does not support the small of your back.

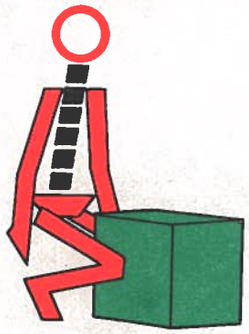
Do you know? No. 40

In NZ over 17 000 people suffer serious back injuries each year.

Cut the Stress

When you lift - bend your knees not your back

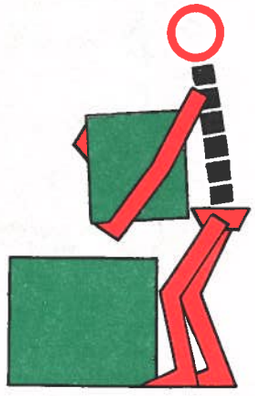
1. 
Size up load — good balance

2. 
Bend knees — keep back straight as possible (not necessarily vertical)

3. 
Grip load with palms of hands and fingers

4. 
Use body weight to start load moving — then lift by pushing up with legs

5. 
Keep arms and elbows close to body

6. 
When lowering load — bend knees — do not stoop

Don't take a risk- if it's too heavy get help.

Accident Compensation Corporation

VDU Agreement

Preamble

1 The PSA and SSC both recognise that VDU's have become indispensable equipment in many workplaces and that their use will become more widespread in the future. Both parties are agreed that they are a desirable tool contributing to the efficiency of the Public Service and that as such it is necessary to ensure that they are introduced in an orderly manner with due account being taken of the health, comfort and well-being of the staff affected. Furthermore, this equipment should be introduced in such a manner as to be of mutual benefit.

2 For the purpose of this agreement, the term Visual Display Unit (VDU) shall be defined as follows:

> Any electronic device which is used to display text or data (on a display screen). This includes for example a : word processor, computer terminal, mini-or-micro computer, electronic accounting or book keeping machine and electronic typesetter. This shall not include radar screens or micro-image readers which will be the subject of separate agreements.

Application

3 This agreement will, in general, apply to all VDU's introduced into the Public Service. Both the Public Service Association and the State Services Commission reserve the right to seek variations to this agreement in either its substance or application in detail. Any variation will be subject to negotiation.

Prior Consultation

4 The introduction of VDU's into the work place will, in all cases, be accompanied by prior notification to the Public Service Association and the staff affected.

5 When the Commission intends to introduce VDU's into the workplace, the Association will be consulted after the initial assessment and preliminary approval stages have been completed. The consultation process will entail making available to the Association as much relevant information as possible, including the considerations which led to the intended course of action.

6 Much of this information will be provided by way of making available the 'advisability study' undertaken by management before a final decision is made. Other information which sheds light on the impact on staff of a system or piece of equipment will also be available to the Association. Confidential government documents and commercial information given to the Commission in confidence will not be available. However, extracts from these papers which relate to staff impact will be provided.

7 By consultation the Commission means that not only will the PSA be fully advised of the situation at the earliest point possible following preliminary approval but that they will be given sufficient time to respond before the final decision is taken and that their views will be taken into account in making that decision.

8 Once final approval has been obtained discussions/negotiations will be held with the PSA regarding staff related issues such as conditions of employment, staff transfers etc as appropriate. Both parties recognise that a satisfactory conclusion to these discussions/negotiations is

desirable for the smooth introduction of any system involving new technology.

9 The Commission's willingness to enter into consultative arrangements with the Association is contingent upon a clear commitment on the part of the Association to observe confidentiality in those cases where the final decision on the introduction of VDU equipment rests with Government, until such time as the final decision has been made.

10 Such confidential discussions with the Association will include the staff directly affected by the introduction of the new equipment. The essence of confidentiality is that no public comment or wider circulation of these discussions should occur until after the Government has made the final decision.

11 After the introduction of VDU's into the workplace, the Commission will conduct a post implementation review/audit. The objectives of these reviews will be to :

1 ascertain that the equipment introduced is meeting the objectives for which it was intended;

2 identify areas where this is not being accomplished;

3 propose appropriate remedial action.

12 The function of such reviews will be extended to include the verification of the advice provided by management in the consultation procedure, in respect of the effects on staff i.e. whether or not they have materialised, and to serve as a forum for the notification to staff of any such changes.

13 The review team will include a representative of the affected staff, nominated by the Association, who will be a full participant in all aspects of the review. Information gathered in the review will be made available to the Public Service Association.

14 Where the introduction of VDU's is of a major nature e.g. the introduction of new, large scale systems or significant enhancements of existing systems, no final decisions or agreements will be made on staff related matters until after the post implementation review has been completed. At this point, if appropriate, further discussions and/or negotiations will be held on these matters.

15 The Association has the right to lodge claims for productivity sharing which fall within the terms of the SSCE Act 1977 Section (7). For its part the Commission undertakes to respond to such a claim on the basis of the criteria set down in Section 7(2), Section 9, Section 10, Section 11 and 12.

Job Design

16 If, as a result of the introduction of VDU's or their associated systems, a surplus of staff is occasioned, immediate discussions will be held with the Association on the redeployment of affected staff members.

17 The Commission as a fundamental objective will make every effort to redeploy such staff in line with individual staff preferences. The Commission shall accord to such staff redeployment provisions which are consistent with those occurring in other staff redeployments. Regard must be had for any special staffing policies, resulting from agreements with the PSA, being operated in individual departments.

18 In the first instance positions will be sought which utilise the same or similar skills and are at a similar location and grading. Alternatively, jobs at different locations and gradings and requiring different skills may be offered.

19 In the case of relocation, transfer costs, in line with the Commission's general redeployment provisions, will be paid. If

required retraining options will also be offered to facilitate redeployment.

20 In the event of an alternative job being at a lower salary than that previously held an equalisation allowance will be paid. This allowance will be adjusted by AGA's, GWO's etc to maintain the previous salary level and will only be abated by subsequent promotions or increments.

21 Success in achieving redeployment for all staff so affected is however contingent, to a considerable extent, on the co-operation and flexibility shown by staff in availing themselves of redeployment opportunities as they arise. The Commission's willingness to make every endeavour to redeploy staff is not however to be construed as a guarantee of continued employment for all staff, rather it is a commitment to the principle that redundancy should be avoided, if at all possible. For its part the Association is committed to an unqualified opposition to any redundancy in the Public Service.

22 The introduction of VDU's into the Public Service means that existing staff members are likely to be considered for placement in new work environments which require, as an integral part of their operations, staff to use VDU's. In considering placement of staff in such situations it is important that their suitability for the work is carefully assessed.

23 It is essential that in evaluating staff suitability the staff are consulted and their preferences taken into account. The sort of factors which need to be considered are:

a a medical condition;

b a physical disability;

c manual dexterity;

d personal aptitude for the work.

Furthermore, if after placement on VDU work, or during training, any of the above factors become apparent a reassessment should be made of staff suitability in discussion with the employee directly concerned.

24 All staff affected by the shift to use of VDU's in their job who are unsuitable for VDU work will be eligible for redeployment on the same basis as those who may become surplus through the introduction of VDU's.

Staff Training

25 When VDU's are introduced into a workplace, it will be the responsibility of management to provide appropriate training to the staff directly affected. Such training will embrace:

- basic technical information on the VDU and its capabilities;
- where appropriate, information concerning the relationship of the particular equipment to wider systems or networks;
- full training to enable staff to utilise the VDU's in the most effective way;
- any health and safety implications or information that will enable staff to operate the equipment without discomfort and will help maintain their general well being.

Details of training to be provided in specific instances will be the subject of discussions between the Commission and the Association.

Health and Safety

26 Eye Tests

These provisions only apply to existing employees who through

the introduction of technology are transferred into VDU work.

(i) The employer shall be responsible for the te. .ing of existing employees who are asked by their employer to operate a VDU as part of their normal duties and for at least 50% of their normal working time. This test shall occur before such work is taken up and at the employee's option.

(ii) In cases where testing identifies staff whose vision needs correction with lenses specifically prescribed for the normal viewing distance of a VDU the cost of providing spectacles shall be borne by the employer up to the maximum prescribed by Treasury Regulations.

(iii) The employer shall agree to reimburse the cost of eye tests and resulting prescription spectacles to the maximum prescribed when it can be shown that the problem which creates a need for spectacles has appeared as a result of VDU work, or an existing condition has been worsened as a result of VDU work.

Software

27 When purchasing or designing new computer systems, every effort will be made to ensure that the dialogue between the operator and the computer is appropriate to the ability and needs of the operator and the task concerned.

28 Software will be specifically discussed at the prior consultation stage and also in any post implementation review/audit discussions/negotiations.

Health and Safety Delegates

29 Should the Association and staff so desire, Health and

Safety Delegates may be elected at each workplace a VDU is sited. The role of such delegates will be to monitor the VDU environment and the ergonomic design of the workplace. In cases where such delegates are elected they shall be given similar recognition to that accorded to the usual PSA delegates.

30 The Commission agrees to arrange to provide suitable public service staff to talk on the health and safety aspects of VDU's at training courses for Health and Safety Delegates run by the PSA.

Variations in Work Patterns

31 It is recognised that staff employed for two hours or more continuously on a VDU terminal need relief. This relief shall be provided by variations in work during the normal work flow. Such variations in work flow are to be arranged to ensure that VDU operators so affected do not spend more than 50 minutes in each hour continuously at work on VDU terminals.

Environmental Standards

32 The following are general standards designed to ensure good working conditions for staff employed on VDU work. The overall intent is to ensure that staff are placed in an environment which is conducive to efficient working practice and which ensures that the staff's general well being and comfort is provided for.

33 Both parties accept that variations to these standards are in some cases necessary and it is agreed that such variations will be subject to negotiation between the affected parties.

PHYSICAL WORKING CONDITIONS

Introduction

This code approaches the requirement to specify working conditions for operators of visual display units on the basis of:

(i) Matters relating to the person.

(ii) Requirements concerning the machine itself.

(iii) The relationship required between the operator, the machine, the copy, furniture and surroundings.

(iv) The general room environment.

The Person

1.1.1 Health authorities, both in New Zealand and overseas, affirm that VDU's do not present a hazard to health. The National Radiation Laboratory has reported that the amount of radiation present with VDU sets is so small as to pose no threat to health.

1.1.2 Departmental authorities ordering equipment are to ensure that it complies with internationally-accepted standards as regards potential radiation hazards.

1.1.3 When new equipment is introduced, the employer will advise employees that the equipment meets the required standards as regards radiation levels, safety shield and flicker rate of the tube.

1.1.4 Positive measures should be taken to make operators aware that fatigue will result from incorrectly-adjusted furniture, incorrect posture, incorrect heights and

viewing angle and too much head movement.

The Machine

2.1.1 The keyboard should be non-reflecting and in neutral shades.

2.1.2 With word processors, it is highly desirable, from the ergonomic view-point, that the keyboard not be integral with the display screen, and orders should be framed accordingly. Any variation from this objective should be discussed with the Association.

2.1.3 The keyboard must be stable.

2.1.4 The face of the keyboard should slope at an angle of between 5^{o} and 15^{o} above the horizontal.

2.1.5 An adequate space should be provided for resting the hands and forearms.

2.1.6 When purchasing equipment, regard must be had to the comfort and well-being of the operator in such matters as size, shape, spacing, pressure and travel of keys, also layout of keyboard.

The following are guidelines to keyboard design:

design :

spacing of keys	18-20mm centres
pressure of keys	0.25-1.25 grm
key travel	1.8-4.8 mm
key size	12.15 mm

Keys should be square, concave and non-reflective and legends should be resistant to wear.

Alphanumeric keys should be in neutral colours such as beige or grey.

For typing related functions the basic QWERTY layout should be used. Numeric keys should thus be above alpha keys. Any variations from this will be subject to discussions with the PSA.

2.2.1 The screen should present sharp and clear images.

2.2.2 Screens should incorporate coatings to reduce glare.

2.2.3 Character height should be 3 mm minimum. The aspect ratio (width:height) is also important to legibility and width should be 70-80% of height. The space between characters should be between 20% and 50% of their height. Row spacing should be 100% to 150% of character height. Stroke width should be 12-17% of character height.

2.2.4 The dot matrix (composition of characters) should be 5 x 7 or better.

2.2.5 Screens should be capable of adjustment for brightness and for contrast, either automatically or manually although if the latter, these adjustments may have to be carried out by a technician.

2.2.6 The refresh rate of the dot display should be 50 hz at least.

2.2.7 The display colour usually preferred is green, but the following are suitable combinations for monochrome screens:

Characters	Background
Yellow	Dark Green
Green	Dark Green
White	Green
White	Grey
Yellow	Grey

2.2.8 The VDU screen should have an explosion/implosion design built into it.

2.2.9 The screen display should remain stable against vibration and knocks in typical operating conditions.

Maintenance

2.3.1 It is essential for the comfort, well-being and efficiency of the operator that the unit is well maintained and adjusted.

2.3.2 Maintenance must be carried out regularly by properly qualified service technicians.

2.3.3 Stability of the display has to be maintained, because flicker can contribute to headaches or nausea. Flicker can be caused by decay of the phosphorescent image.

2.3.4 Screens should be cleaned regularly. Grime can degrade the resolution of the characters. Dust and nicotine deposits are frequent offenders.

2.4.1 There should be stabilisation of voltage within the machine, against fluctuations.

2.5.1 Electrical supply cables should be secured and clear of access areas, so as not to present a hazard. For preference they should be concealed where practicable.

2.6.1 The equipment must comply with international safety standards as regards radiation emission and electrical safety.

Relationship of Machine, Operator, Copy and Surroundings

3.1.1 Copy from which the operator is to key-in information should be held in an adjustable copy-holder. The object is to minimise eye-movement and re-focussing. Working documents should be easily read and paper should for preference be matt surfaced.

3.2.1 In locating the screen in relation to the operator, the object is to ensure that the operator can read the display with minimum head movement.

3.2.2 The optimim distance from the screen to the eye is diameter of screen x 3.

3.2.3 The optimum height relationship of operator and screen is such that the axis of vision from the eye to the centre of the screen is 15^{o}-30^{o} below the horizontal. The height should be maintained, for operators of different height, by adjustment of the height of the chair and/or screen platform.

3.3.1 Chairs should be adjustable: angles of 90^{o} should be maintained between the trunk of the body, the thigh and the lower leg, with the feet flat on the floor. There should be no pressure on the underside of the thighs from the front edge of the chair. The chair should be designed so as to permit a proper postural position, maintaining the natural lordosis of the spine (see illustration). This requires a space below the back rest to accommodate the lower part of the trunk and a support in the lower lumbar region fitting the natural inward curve of the spine. With

these provisions, the operator should be able to work with:

- Head inclined forward at about 20°
- Thighs horizontal
- Upper arms vertical
- No twisting of the head or trunk
- Lower leg vertical
- Sufficient leg room
- Frequent change in visual object should be not more than an angle of 15-30° of the normal viewing direction.

A diagram is appended to illustrate the desirable working position.

3.3.2 A footrest is not normally required if the chair is adjusted to the correct height for the operator and should not be used as a substitute for correct seating. If in any unusual circumstances a footrest is needed, it should be adjustable.

3.3.3 From the ergonomic viewpoint, castors are not favoured for chairs in the workstation situation. Slides are normally preferable. For either case metal not plastic should be used in any situation when static electricity is likely to be present.

3.4.1 Having reached the proper chair adjustment for the individual operator, it is then necessary to:

a position the screen to the correct height to achieve the angle of vision in 3.2.3;

b adjust the height of the keyboard so that the forearms are horizontal

bearing in mind that the proper sequence is to begin with

the person, then adjust the chair, followed by keyboard and screen.

3.5.1 Other furniture should include working surfaces adequate for the functions. Consideration should be given to the need for a working surface of adjustable height. When furnishing a work station discussions should be held with the PSA or staff concerned.

3.5.2 Equipment should be within normal arm reach.

3.5.3 The surface of desk or support platform should have low reflection value.

3.5.4 There should be adequate unobstructed leg-room for the operator which should be shielded against heat from the equipment.

3.5.5 A drawer (or equivalent) should be provided for storage of personal and work items for the operator (other than at multiple-use stations).

3.6.1 Positioning of the work station should be such that the screen is at right-angles to the exterior windows, bringing the line of vision parallel to the external glass. A corner room with windows on both sides is not a good choice because bright reflections are difficult to avoid.

3.6.2 The work-station is to be correctly oriented as above to avoid reflections on the screen. Window curtains, floors and ceilings should have low reflection values.

3.6.3 The operator's field of vision should not include windows (because of high contrast) and should be free from direct reflections from screen, keyboard, furniture or working materials.

3.6.4 As indicated elsewhere, room lighting should be positioned in relation to the screen so as to avoid reflections. The glare index should be between the values of 16 and 19.

Room environment

4.1.1 Lighting is the paramount consideration because of the problems of reflections on the screen, contrast and the ability to be able to read copy while maintaining a low enough level of light to enable the screen to be read. These factors require attention not only to the artificial lighting but also to the placement of the work station in relation to natural light.

4.1.2 The background to the screen requires a suitably subdued level of lighting. It may also be necessary to provide a dark background behind the operator. A portable office screen will usually suffice. The background should have no more than 25% reflection value. Window curtains, floor and ceiling should not have a high reflection rate.

4.1.3 The level of ambient lighting should be lower than that set in the normal office code. A level of approximately 200 lux is considered appropriate. Fluorescent tubes should be well maintained and replaced when showing any signs of flashing.

4.1.4 The position of the lights in relation to the screen should be such as to avoid reflections. Desirably, fluorescent tubes should run at right-angles to the screen.

4.1.5 Supplementary or task lighting may be needed for the operator's work areas, other than the screen. If so, it should be adjustable and glare-controlled.

4.2.1 Colours should be chosen to avoid strong contrasts between furniture, screen and other equipment. "Quiet" colours should be used and surfaces (including keyboards) should have low light reflection values.

4.3.1 Ventilation If properly located VDU's are intended to be used in ordinary office environments; areas with high solar heat gain should be avoided. A southern aspect is very suitable, both as regards natural lighting and avoidance of heat gain.

4.3.2 The object is to maintain the same standards as regards temperature and humidity as specified elsewhere in the code of physical working conditions. The environmental requirements for operators are the same as for other office workers in terms of the code "Heating and ventilation" i.e.

a The minimum temperature normally to be provided in winter weather conditions and within one hour of starting time should be 19^{o} plus or minus 2^{o}.

b In considering comfort and "effective temperature", air-movement, relative humidity and temperature are all interwoven. The following is an example of a suitable combination of standards at which to aim:

Temperature	18^{o}
Relative humidity	30-80%
Air movement	6-12m per minute
Air supply	.6 cubic m per person

4.4.1 Noise may be a problem when print units and tape decks are present. It is best tackled at source by considering the noise factor when making purchases as it is difficult to solve the problem afterwards. If acoustic screens and sound-absorbent material fail to provide a satisfactory

solution, it may be necessary to wall-off the noisy elements. It is the printer and tape units which need to be placed in a separate room, not the operator and keyboard.

4.4.2 Where a VDU is in a normal office situation noise levels should not exceed those acceptable in other office work areas i.e. a level at which normal speech is interfered with, say 65dba. If in any case the noise level produces a problem for the operator, investigations are to be carried out to endeavour to arrive at a suitable solution.

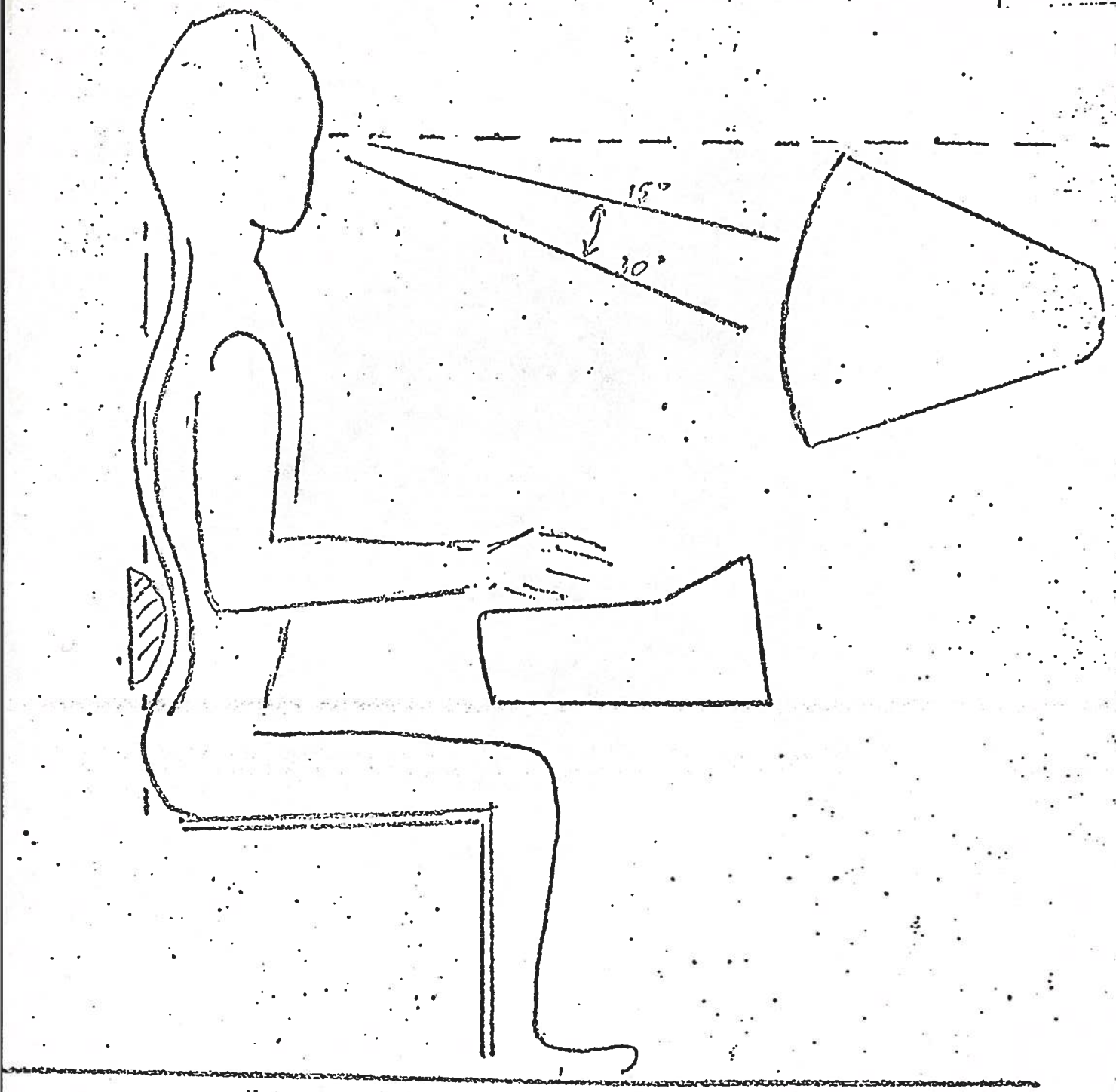
4.5.1 Where carpets are of a wool/synthetic mix, or are wholly synthetic, and static electicity is present, this is to be dealt with by the provision of anti-static mats or by treatment of the carpet.

Colour Visual Display Units

5.1.1 Where it is proposed to introduce visual display units with other than monochrome screens the State Services Commission and the Public Service Association will discuss any additional ergonomic and physical working conditions standards which are appropriate on a case by case basis.

ILLUSTRATION OF RELATIONSHIP OF CHAIR, KEYBOARD AND SCREEN

also OPERATOR'S POSITION



FORM 5 REG 9 (4)

INDUSTRIAL RELATIONS ACT 1973

... OF VOLUNTARY SETTLEMENT

... REGISTRATION

IN THE MATTER of the Industrial Relations Act 1973

AND IN THE MATTER of the Air New Zealand Limited and Safe Air Limited Clerical Workers Dispute of Interest 1981

BETWEEN New Zealand Federated Clerical and Office Staff Employees' Industrial Associaticn of Workers

AND AIR NEW ZEALAND LIMITE

...: THE ... ARBITRATION COURT

... HEREBY ... a signed copy of the terms of voluntary ... mentioned dispute of interest arrived at ... the ... to Section 65 of the Industrial Relations ... 1973 ... by the Arbitration Court as a collective ...

...ED at ... 26th day of August 1981

... AND ...
... NEW Z... ...ED

....
T.M. Clendon
INDUSTRIAL RELATIONS MANAGER

... CLERICAL
... OYEES'
... OF
...ERS

....
J. SLATER
SECRETARY

AIR NEW ZEALAND LIMITED

CLERICAL WORKERS VOLUNTARY COLLECTIVE AGREEMENT

TERMS OF VOLUNTARY SETTLEMENT UNDER SECTION 65 OF THE INDUSTRIAL RELATIONS ACT 1973

ARRANGEMENT

Introduction of Visual Display Unit Word Processors

Preamble

The following agreement is deemed to provide guidelines for the introduction of Visual Display Unit Word Processors into Air New Zealand Limited as provided for in Clause 21 of the Air New Zealand Limited Safe Air Limited Clerical Employees Award.

1. Definition

A visual display unit word processor is a machine which is controlled by a micro processor (electronic) components which can be used for the entry, storage, editing, printing and/or transmission of primarily textual material with possible numeric functions.

It may consist of a standalone unit, or it may be linked to other word processors and/or a computer network, with correspondingly complex functions.

Its component parts may consist of a keyboard, a V.D.U. screen, a memory or memories (which may be shared), text storage facilities and printout facilities.

2. Redeployment

a) If, as a result of the introduction of word processors, there is a surplus of staff, or through the operation of subclause 4 (c) below, immediate discussions will be held with the Union on the redeployment of the affected staff members.

b) The Company shall provide jobs for redeployed staff, and shall make every effort to ensure that redeployment is in line with individual worker's preferences.

c) In the event that the worker is unable to be redeployed in accordance with his/her individual preferences then in the first instance positions shall be sought which utilize the same or similar skills and are located at the same work site. Failing this solution, and at the worker's request, jobs at a different site and/or requiring different skills shall be offered including retraining where necessary.

d) Should a redeployed worker be required to transfer to a different city or town, the Company's transfer provisions as set out in the Personnel Manual, Part 6, Section 1, shall apply.

e) All staff who are required to use word processors in their job and who are unsuitable for such work shall be eligible for redeployment on the same basis as those who may become surplus through the introduction of word processors.

f) i) No person shall lose the protection of award provisions or salary expectation because of the introduction of word processors.

ii) The Company recognises that there may be cases where a worker could be seriously disadvantaged in a situation of redeployment under the terms of subclauses (b) and (c) above. Individual claims in respect of this disadvantage must be lodged by or on behalf of the individual worker within six months of redeployment. Such claim will be reviewed by the Company and the Union according to its merits.

g) The introduction of word processors as defined shall be a matter for local union involvement, as per Clause 21 of the Award. This shall include the setting up of local committees where necessary.

3. Staff Training

All workers required to use word processors will be provided with training to enable them to competently perform their duties. It is the responsibility of the Company to provide appropriate training for the staff directly affected.

Ideally such training will embrace:

- basic technical information on the word processor and its capabilities;

- where appropriate, information concerning the relationship of the particular equipment to wider systems or networks;

- full training to enable staff to utilise the word processor in the most effective way;

- any health and safety implications or information that will enable staff to operate the equipment without discomfort and will help maintain their general well being.

4. Health and Safety

a) Any worker required to use a word processor shall be entitled, before using such equipment, to have their eyes tested at the Company's expense. The administration and arranging of such tests shall be carried out by the Company's medical unit. Further tests will be carried out after 6 months and 12 months use of the equipment and annually thereafter.

Eye tests will be conducted by an agreed registered eye specialist or in the event of the Company purchasing a "Titmus Vision Tester" such tests will be done by suitably qualified Company medical personnel following acceptance by the Union of this method of testing (such acceptance shall be by an exchange of letters).

When eyesight defects are detected by the use of the Titmus Vision Tester the worker shall be referred to an agreed outside specialist. Fees incurred will be reimbursed by the Company.

Health and Safety (cont'd)

b) Should any worker not using visual aids for their current work, be required to purchase and wear glasses and/or any worker currently using visual aid and who requires a change to these for the purpose of using word processor equipment and be required by the Company to use such equipment, the Company will pay 100% of the cost of the lenses. Details of the reimbursement to the worker will be arranged on a local basis with local Union involvement.

c) Where there is a change to the worker's eyesight which results in the worker requiring a new prescription for visual aids to continue using a word processor, then the employer will pay 100% of the cost of the lenses or the worker may be redeployed in terms of Clause 2 above.

d) If a worker is determined by an agreed specialist to be unable to wear glasses, then the employer will pay 100% of the equivalent cost of glasses lenses.

e) Workers continuously operating a VDU word processor for more than half an hour shall have a five minute work break every 30 minutes or a ten minute work break every hour.

f) Company authorities ordering equipment are to ensure that it complies with internationally-accepted standards as regards potential radiation hazards.

g) When new equipment is introduced, the employer will advise employees that the equipment meets the required standards as regards radiation levels, safety shield and flicker rate of the tube.

h) All VDU word processors shall be maintained and serviced at regular intervals to ensure that they are maintained in the best possible working condition. The Company shall not require a worker to use a VDU that is not kept in good repair. Any worker who detects a fault in any of the equipment will report it immediately to management.

i) The Company shall consult with the Union in relation to lighting, environmental and ergonomic factors so that glare, noise, reflection, poor ventilation, fatigue and other possible detrimental effects are minimised. The assistance of an independent advisor

Health and Safety (cont'd)

acceptable to both parties shall be sought if necessary to ensure satisfactory conditions are met.

j) Positive measures should be taken to make operators aware that fatigue will result from incorrectly-adjusted furniture, incorrect posture, incorrect heights and viewing angle and too much head movement.

5. Environmental Standards

The Machine

a) i) The keyboard should be non-reflecting and in neutral shades.

ii) With word processors, it is highly desirable from the ergonomic view-point, that the keyboard be not integral with the display screen, and orders should be framed accordingly. Any variation from this objective should be discussed with the Union.

iii) The keyboard must be stable.

iv) The face of the keyboard should slope at an angle of between 5^{o} and 15^{o} above the horizontal.

v) An adequate space should be provided for resting the hands and forearms.

vi) When purchasing equipment, regard must be had to the comfort and well-being of the operator in such matters as size, shape, spacing, pressure and travel of keys, also layout of keyboard.

The following are guidelines to keyboard design:

Design:

Spacing of keys	18-20 mm centres
Pressure of keys	0.25-1.25 grm
Key travel	1.8-4.8mm
Key size	12-15mm

Keys should be square; concave and non-reflective and legends should be resistant to wear.

Alphanumeric keys should be in neutral colours such as beige or grey.

For typing related functions the basic QWERTY layout should be used. Numeric keys should thus be above alpha keys. Any variations from this will be subject to discussions with the Union.

b) i) The screen should present sharp and clear images.

ii) Screens should incorporate coatings to reduce glare.

iii) Character height should be 3mm minimum. The aspect ratio (width:height) is also important to legibility and width should be 70-80% of height. The space between characters should be between 20% and 50% of their height. Row spacing should be 100% to 150% to character height. Stroke width should be 12-17% of character height.

iv) The dot matrix (composition of characters) should be 5 x 7 or better.

(v) Screens should be capable of adjustment for brightness and for contrast, either automatically or manually although if the latter, these adjustments may have to be carried out by a technician.

(vi) The refresh rate of the dot display should be 50 hz at least.

(vii) The display colour usually preferred is green, but the following are suitable combinations for monochrome screens:

Characters	Background
Yellow	Dark Green
Green	Dark Green
White	Green
White	Grey
Yellow	Grey

(viii) The VDU screen should have an explosion/implosion design built into it.

(vix) The screen display should remain stable against vibration and knocks in typical operating conditions.

Maintenance

(c) (i) It is essential for the comfort, well-being and efficiency of the operator that the unit is well maintained and adjusted.

(ii) Maintenance must be carried out regularly by properly-qualified service technicians.

(iii) Stability of the display has to be maintained, because flicker can contribute to headaches or nausea. Flicker can be caused by decay of the phosphorescent image.

(iv) Screens should be cleaned regularly. Grime can degrade the resolution of the characters. Dust and nicotine deposits are frequent offenders.

(d) (i) There should be stabilisation of voltage within the machine, against fluctuations.

(e) (i) Electrical supply cables should be secured and clear of access areas, so as not to present a hazard. For preference they should be concealed where practicable.

(f) (i) The equipment must comply with international safety standards as regards radiation emission and electrical safety.

Relationship of Machine, Operator, Copy and Surroundings

(g) (i) Copy from which the operator is to key-in information should be held in an adjustable copy-holder. The object is to minimise eye-movement and re-focussing. Working documents should be easily read and paper should for preference be matt surfaced.

(ii) In locating the screen in relation to the operator, the object is to ensure that the operator can read the display with minimum head movement.

(iii) The optimum distance from the screen to the eye is diameter of screen x 3.

(iv) The optimum height relationship of operator and screen is such that the axis of vision from the eye to the centre of the screen is 15° - 30° below the horizontal. The height should be maintained, for operators of different height, by adjustment of the height of the chair and/or screen platform.

(n) (i) Chairs should be adjustable: angles of 90° should be maintained between the trunk of the body, the thigh and the lower leg, with the feet flat on the floor. There should be no pressure on the underside of the thighs from the front edge of the chair. The chair should be designed so as to permit a proper postural position, maintaining the natural lordosis of the spine (see illustration). This requires a space below the back rest to accommodate the lower part of the trunk and a support in the lower lumbar region fitting the natural inward curve of the spine. With these provisions, the operator should be able to work with:

- Head inclined forward at about 20°
- Thighs horizontal
- Upper arms vertical
- No twisting of the head or trunk
- Lower leg vertical
- Sufficient leg room
- Frequent change in visual object should be not more than angle of 15-30° of the normal viewing direction.

A diagram is appended to illustrate the desirable working position.

(ii) A footrest is not normally required if the chair is adjusted to the correct height for the operator and should not be used as a substitute for correct seating. If in any unusual circumstances a footrest is needed, it should be adjustable.

(iii) From the ergonomic viewpoint, castors are not favoured for chairs in the workstation situation. Slides are normally preferable. For either case metal not plastic should be used in any situation when static electricity is likely to be present.

(I) (i) Having reached the proper chair adjustment for the individual operator, it is then necessary to:

a) position the screen to the correct height to achieve the angle of vision in 4. (g) (iv).

b) adjust the height of the keyboard so that the forearms are horizontal.

bearing in mind that the proper sequence is to begin with the person, then adjust the chair, followed by the keyboard and screen.

(j) (i) Other furniture should include working surfaces adequate for the functions. Consideration should be given to the need for a working surface of adjustable height. When furnishing a work station discussions should be held with the Union or staff concerned.

(ii) Equipment should be within normal arm reach.

(iii) The surface of desk or support platform should have low reflectance value.

(iv) There should be adequate unobstructed leg-room for the operator which should be shielded against heat from the equipment.

(v) A drawer (or equivalent) should be provided for storage of personal and work items for the operator (other than at multiple-use stations).

(k) (i) Positioning of the work station should be such that the screen is at right-angles to the exterior windows, bringing the line of vision parallel to the external glass. A corner room with windows on both sides is not a good choice because bright reflections are difficult to avoid.

(ii) The work-station is to be correctly oriented as above to avoid reflections in the screen. Window curtains, floors and ceilings should have low reflectance values.

(iii) The operator's field of vision should not include windows (because of high contrast) and should be free from direct reflections from screen, keyboard, furniture or working materials.

(iv) As indicated elsewhere, room lighting should be positioned in relation to the screen so as to avoid reflections. The glare index should be between the values of 16 and 19.

Room environment

(l) (i) Lighting is the paramount consideration because of the problems of reflections in the screen, contract and the ability to be able to read copy while maintaining a low enough level of light to enable the screen to be read. These factors require attention not only to the artificial lighting, but also the placement of the work station in relation to natural light.

(ii) The background to the screen requires a suitably subdued level of lighting. It may also be necessary to provide a dark background behind the operator. A portable office screen will usually suffice. The background should have no more than 25% reflectance value. Window curtains, floor and ceilings should not have a high reflectance rate.

(iii) The level of ambient lighting requires to be lower than the normal office code. A level of approximately 200 lux is considered appropriate. Fluorescent tubes should be well maintained and replaced when showing any signs of flashing.

(iv) The position of the lights in relation to the screen should be such as to avoid reflections. Desirably, fluorescent tubes should run at right-angles to the screen.

(v) Supplementary or task lighting may be needed for the operator's work areas, other than the screen. If so, it should be adjustable and glare-controlled.

(m) (i) Colours should be chosen to avoid strong contrasts between furniture; screen and other equipment. "Quiet" colours should be used and surfaces (including keyboards) should have low light reflectance values.

(n) (i) Ventilation If properly located VDU's are intended to be used in ordinary office environments; areas with high solar heat gain should be avoided. A southern aspect is very suitable, both as regards natural lighting and avoidance of heat gain.

(ii) The object is to maintain the same standards as regards temperature and humidity, as specified elsewhere in the code of physical working conditions. The environmental requirements for operators are the same as for other office workers in terms of the code "Heating and Ventilation", i.e.

a) The minimum temperature normally to be provided in winter weather conditions and within one hour of starting time should be 19° plus or minus 2°.

b) In considering comfort and "effective temperature", air movement, relative humidity and temperatures are all interwoven. The following is an example of a suitable combination of standards at which to aim:

Temperature	18°
Relative humidity	30 - 80%
Air movement	6 - 12m per minute
Air supply	.6 cubic m per person

(o) (i) Noise may be a problem when print units and tape decks are present. It is best tackled at source by considering the noise factor when making purchases as it is difficult to solve the problem afterwards. If acoustic screens and sound-absorbent material fail to provide a satisfactory solution, it may be necessary to wall-off the noisy elements. It is the printer and tape units which need to be placed in a separate room, not the operator and keyboard.

(ii) Where a VDU word processor is in a normal office situation noise levels should not exceed those acceptable in other office work areas i.e. a level at which normal speech is interfered with, say 65 dba. If in any case the noise level produces a problem for the operator, investigations are to be carried out to endeavour to arrive at a suitable solution.

(q) (i) Where carpets are of a wool/synthetic mix, or wholly synthetic, are in use and static electricity is present, this is to be dealt with by the provision of anti-static mats or by treatment of the carpet.

6. Scope of Agreement

This agreement shall apply to Air New Zealand Limited only and shall operate throughout the Northern, Taranaki, Wellington, Marlborough, Nelson, Westland, Canterbury and Otago and Southland Industrial Districts.

7. Term of Agreement

This agreement shall be deemed to come into force on the 13th day of August 1981 and shall continue in force until the 12th day of August 1982.

In witness whereof the parties hereto have executed these presents on the 26TH day of August 1981.

FOR AND ON BEHALF OF
AIR NEW ZEALAND LIMITED .....

T.M. Clendon
Industrial Relations Manager

FOR AND ON BEHALF OF
THE NEW ZEALAND FEDERATED
CLERICAL AND OFFICE STAFF
EMPLOYEES' INDUSTRIAL
ASSOCIATION OF WORKERS .....

J. Slater
Secretary

ILLUSTRATION OF RELATIONSHIP OF CHAIR, KEYBOARD AND SCREEN

also OPERATOR'S POSITION