International Labour Organisation
Programme of Industrial Activities

TEXTILES COMMITTEE

NINTH SESSION
GENEVA, 1973

SAFETY AND HEALTH
IN THE TEXTILE INDUSTRY

Third Item on the Agenda

GENEVA
INTERNATIONAL LABOUR OFFICE
1973
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INTRODUCTION

The third item on the agenda of the Ninth Session of the Textiles Committee, as approved by the Governing Body of the International Labour Office at its 183rd and 184th Sessions (1971 and 1972), is as follows: "Safety and health in the textile industry".

The International Labour Organisation has long been conscious of the need to improve safety, health and welfare in general in all industries and in the textile industry in particular. Its achievements in this field include the Model Code of Safety Regulations for Industrial Establishments for the Guidance of Governments and Industry, which contains detailed standards on the guarding of spinning, weaving and knitting machines (Regulation No. 106); these standards were brought up to date in 1956. The Textiles Committee itself has also dealt with certain aspects of occupational safety and health, more especially noise and byssinosis. The International Labour Organisation has an obligation to continue its efforts to contribute to the prevention of employment injuries and occupational diseases and to promote the humanisation of work in the industry.

The purpose of the present report is to provide the meeting with material which will assist its examination of this question of safety and health in the textile industry. There is a special chapter on safety in the cotton and synthetic fibre industries, although developments in the wool industry are included. Various health aspects, more especially such questions as byssinosis, noise and ergonomics as applied to the textile industry are also dealt with in order to make it possible to take stock of the present position.

The Office wishes to express its appreciation of the help received in the preparation of this report from the TUC Centenary Institute of Occupational Health, London School of Hygiene and Tropical Medicine. Both employers' and workers' organisations have supplied material, and this joint contribution augurs well for the effectiveness of future efforts to reduce the health hazards encountered in the textile industry.
CHAPTER I

SAFETY PROBLEMS

Introduction

The prevention of employment injuries involves a whole series of measures varying in nature but converging on the same objective, which is to adapt the work to the worker as fully as possible. Although these measures are chiefly a matter of training and production management, they also affect such matters as plant or workshop layout, the design of machines and equipment, work study and planning, physical environmental factors and more generally, the quality of the working environment in which individuals have to spend a major part of their lives.

These preventive measures, which nowadays interest all the social partners, are increasingly regarded by the workers as a fundamental necessity. Although usually a matter for managements in the past, prevention is now increasingly a joint responsibility.

In some countries, the organisation of accident prevention and the elimination of health hazards are co-ordinated in certain industries by joint committees on which the workers play a prominent part and make a practical contribution by assisting in the detection of dangerous situations and the introduction of the necessary measures.

Joint committees of this type already exist in the textile industries of several countries and it is to be hoped that the example will spread and become one of the features of all organised attempts to combat industrial accidents.

Without going into all the aspects of safety in the textile industry, which to some extent vary in importance with technological development and machine design, it can be said that, by and large, the commonest hazards are due to the layout of working premises, the characteristics of the machinery and the handling of materials. There is also one special hazard - fire which, although not frequent, may have disastrous consequences.

Layout of Working Premises

It is important to pay close attention to proper housekeeping, which should be maintained at a high level. In particular, walkways should be kept free of obstructions or other hazards such as grease or oil spills which may cause people to slip and fall, often with more serious results than in accidents involving moving machinery. Working premises should provide a safe and healthy environment in which employees can achieve the maximum productivity compatible with their personal comfort and well-being. Many textile factories are relatively old, but by careful planning, optimum conditions can be achieved. Legislation usually provides that premises should be safe, workrooms kept clean, and a certain minimum height of workroom and minimum space given to each worker; flooring should be properly maintained, adequate lighting installed, a continuous supply of fresh air ensured and certain amenities provided.
Most important is the layout of the factory and its machinery. Adequate space must be provided, including storage facilities for materials in process. Requirements should be based on a straight flow from one process to the next, with the goods progressing, for the most part, from one end of the factory to the other. Many textile factories cannot, however, provide these ideal space requirements, though the layout of machinery should conform to certain minimum space standards if accident hazards are to be avoided. Adequate space around machines is necessary for several reasons, e.g. to allow ready, safe access to the machine for the operations involved and for adequate machine supervision; to facilitate adjustments and repairs to the machine; and to provide temporary storage for the machinery input and output as well as facilitating its handling.

It is important to bear in mind that too much space between machines may entail excessive movements on the part of the operative in carrying out the normal occupational routine, produce undue fatigue, and possibly hamper proper supervision where a number of machines are tended by one person.

Modern building developments have reduced the number of roof support pillars, and this facilitates proper machine layout.

**Spinning**

Space requirements in the spinning department have been the object of careful study and a number of specifications have been worked out concerning free space between cards, between draw frames, around slubbing frames, etc.

However, recent increases in the size of cans, the introduction of travelling cleaning devices and new creeling methods, have led to wider spacing between machines and the following figures are representative of modern spinning mill conditions:

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<th>Requirement</th>
<th>Minimum</th>
<th>Maximum</th>
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<tr>
<td>Distance between cards</td>
<td>76 cm</td>
<td>91 cm</td>
</tr>
<tr>
<td>Back of cards</td>
<td>182 cm</td>
<td>273 cm</td>
</tr>
<tr>
<td>Between card fronts</td>
<td>244 cm</td>
<td>91 cm</td>
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<tr>
<td>Between blocks of cards and blocks of draw frames</td>
<td>366 cm</td>
<td>273 cm</td>
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<tr>
<td>Between drawframe, finisher box and end of speed frames</td>
<td>244 cm</td>
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<td>Between speed frames, spindle to spindle</td>
<td>182 cm</td>
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<td>Space at rear of speed frames</td>
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**Weaving**

The minimum clearances between machines, articles in process or fixed obstructions are:
Main alleys 122 cm (4 ft.)
Cross alleys 76 cm (2 ft. 6 in.), but where there are no unprotected mov­ ing parts next to the alley, the width must be not less than 23 cm (1 ft. 9 in.)
Weavers' alleys 23 cm (1 ft. 9 in.)
Back alleys 30 cm (1 ft.) more than the diameter of the largest beam in use

Finishing

The spacing of machines in the finishing section of the industry varies between factories. Provided that the criteria for safe machine spacing are met, the individual circumstances at each factory must determine the actual layout of machinery and equipment. The problems associated with spacing large numbers of machines in a work­ room (for instance, in carding, spinning and weaving) do not arise in finishing.

It is important to provide adequate space in the alleys used for moving goods to and from machines, and to ensure that they are kept free from obstruction by use of the "clearway" principle, whereby the space between two white or yellow lines painted on the sides of the alleys must never be used to keep articles. It must be kept clear for the movement of goods at all times. To prevent congestion around the machinery, systems must be devised for the movement and temporary storage of materials used in the manufacturing process without encroaching on the free space around the machines or on the gangways and alleyways, and without creating hazards from falling materials or impeding the movements of the operative. Cleanliness and tidiness (including the provision of receptacles for machine waste and refuse and their regular emptying) are essential in reduc­ ing accident and fire hazards.

Mechanical safety for basic types of machinery

Prime movers (engines, motors or other appliances which provide mechanical energy derived from water, wind, electricity, the combus­ tion of fuel or other source). Every moving part of any prime mover and every flywheel connected to a prime mover must be securely guarded, unless it is safe by inherent construction or by position.

Transmission and other machinery (any shaft, wheel, drum, pulley, system of fast and loose pulleys, coupling, clutch, driving belt or other device by which the motion of a prime mover is transmitted to or received by any machine or appliance). Every part of transmis­ sion machinery and every dangerous part of other machinery must be securely guarded unless it is safe by inherent construction or by position.
Construction and sale of machinery. According to ILO Convention No. 119 on the guarding of machinery, no machine should be sold or hired unless in particular (Article 2):

"3. All set-screws, bolts and keys, and, to the extent prescribed by the competent authority, other projecting parts of any moving part of machinery also liable to present danger to any person coming into contact with them when they are in motion, shall be so designed, sunk or protected as to prevent such danger.

4. All flywheels, gearing, cone and cylinder friction drives, cams, pulleys, belts, chains, pinions, worm gears, crank arms and slide blocks, and, to the extent prescribed by the competent authority, shafting (including the journal ends) and other transmission machinery also liable to present danger to any person coming into contact with them when they are in motion, shall be so designed or protected as to prevent such danger. Controls also shall be so designed or protected as to prevent danger."

Except in certain instances, dangerous parts of machinery are not specified in national rules or regulations, but the following are commonly accepted in the textile industry as dangerous:

- Revolving shafts, couplings, spindles, mandrels and bars.
- In-running nips between pairs of rotating parts.
- In-running nips of the belt and pulley type.
- Projections on revolving parts.
- Discontinuous rotating parts.
- Revolving beaters, spiked cylinders and drums.
- Revolving high-speed cages in casings.
- Abrasive wheels.
- Revolving cutting tools.
- Reciprocating knives and saws.
- Projecting belt fasteners and fast running belts.
- Nips between connecting rods or links, and rotating wheels, cranks or discs.
- Pawl and notched wheel devices for intermittent feed motion.
- Nips between reciprocating and fixed parts, other than tools and dies.

If dangerous parts of machinery are unguarded, or ineffectively guarded, accidents causing personal injuries will happen and will often be very serious. No reliance whatsoever should be placed on careful behaviour by employees in avoiding accidents from machinery in motion. Intrinsic safety should be a basic feature of machinery design and, where this cannot be achieved, the arrangement should be such as to allow more guards to be fitted by the user.

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1 The Convention had been ratified by thirty countries on 31 December 1972.
This principle involves the following considerations:

Design should attempt to secure an inherently safe shape of machine parts.
Design should be aimed at eliminating traps.
Those parts which cannot be rendered inherently safe should be encased.
Most maintenance operations should be capable of being carried out without exposure to dangerous parts.
Those parts of the machine structure that are removable and which cover dangerous parts should be interlocked so as to prevent their removal while the machine is in motion.
Where the nature of the guard may vary according to the circumstances of use, provision should be made to facilitate the fitting of alternative types of guard.

The responsibility of the machinery manufacturer for the guarding of the working parts of the machinery is usually limited, and while the manufacturer in some countries does guard textile machinery sold in the home market, the main responsibility for machine safety rests on the user. This is clearly stipulated in the Guarding of Machinery Convention (Article 7).

Construction and maintenance of guarding

All guards must be of substantial construction and constantly maintained and kept in position while the parts guarded are moving and in use, except when it is necessary - with very stringent precautions - to expose those parts for examination, lubrication or adjustment. Various types of guard are manufactured, but in general the following are used:

Prime movers. Fixed guards (i.e. a barrier, usually of metal sheet bars or strong mesh, surrounding a danger zone and either forming an integral part of the machine or firmly secured in position) are invariably used on prime movers.

Transmission machinery. Solid fixed guards, where possible with provision for lubrication without removing the guards. Any removable cover plates are usually secured so that unauthorised persons cannot open them. Where solid fixed guards are impracticable, perforated metal or wire mesh is used; expanded metal guards are not normally used because of the hazard from rough edges and the difficulty of keeping them clean in a textile factory. Again, where possible, provision is made for lubrication without moving the guards. All guards should be as smooth as possible.

Other machinery. Fixed guards are normally used for shielding the dangerous parts. Where openings are necessary to feed the material to be processed into the machine, these openings are usually only sufficient for that purpose. Increasing reliance is now placed on some form of mechanical delivery into the machine. All guards which give immediate access to dangerous parts should either be screwed down or interlocked. In some instances they should be both screwed down and interlocked where practicable. Where it is necessary, for production reasons, to see the parts under guard, strong transparent sheet material is used. Interlocked guards should only be used where fixed guards are impracticable, and the interlocking guards must: protect the machine parts before they can
be set in motion or used; not be removable so long as a dangerous part is in motion or use; in the case of modern machinery, fail safe.

Machinery designers should obviously study further the possible hazards caused by the lack of sound "fail safe" arrangements on textile machinery. In some instances, of course, it is virtually impossible to guard the dangerous parts by enclosure, because of the inherent function of the machine. Trip guards or "electric eye" devices are usually fitted in these instances, stopping the machine when the operative comes into contact with the trip device. However, certain machine hazards (e.g. the sley movement on a loom) cannot be removed by guarding, which means careful training of the operative concerning the serious hazards involved. The ILO Model Code of Safety Regulations for Industrial Establishments for the Guidance of Governments and Industry, contains detailed provisions on the guarding of spinning and weaving machines (Regulation No. 106) (last amended in 1956). Detailed rules or recommendations have been issued in various countries.

Handling materials

Over the whole field of manufacturing industry, the largest single hazard is that associated with the lifting, carrying, moving of loads. In the British textile industry, over 20 per cent of the accidents each year are caused by handling goods and materials. ILO Convention No. 127 and Recommendation No. 128 lay down international standards with regard to the regular lifting and carrying of loads. The Convention does not specify any figure for a permissible maximum weight, but the Recommendation prescribes that the load should not exceed 55 kgs. It also contains provisions concerning women and young workers and lays down standards concerning training, and supplementary mechanical help. It is desirable that national law should specify maximum weights to be carried manually in most occupations.

It is of great importance that operatives be trained to lift correctly so as to avoid injury. There is, however, an increasing tendency in all sections of the textile industry towards the mechanisation of a large number of handling operations. Certainly, such mechanisation speeds up production as well as reducing injuries from handling, but it also brings its own risks and dangers which, unless anticipated and guarded against, may merely replace one type of injury by another.

The handling of bales of raw cotton and fibre needs mechanical handling; lifting tackle is used to unload lorries and fork-lift trucks are generally used to take the bales to the warehouse and on to the opening rooms. Automation is now being introduced in the operations of opening and breaking bales. One example is a carousel-type machine loaded with bales by means of a fork-lift truck. Tufts of material are stripped from the bales and carried by air current to in-line automatic cleaning and blending machines.

The hazards associated with the handling of laps from the preparatory stages to carding engines are gradually being eliminated by the introduction of direct chute feed to the cards. At the carding stage, several hazards (e.g. risk of injury from moving machinery, dust, accumulations of card waste, fire), are created by the manual removal of droppings from under the cards. These hazards can be and are being eliminated by the introduction of suction-operated devices which automatically remove the waste from the base of the cards, and through portable units, from other sections of the card. The waste is then taken through trunking to a central waste-collecting station.

The carrying of card cans is often a source of injury and the elimination of this operation can be achieved by directly linking a group of cards to a single delivery draw frame. The card slivers produced from a number of carding engines are conveyed by means of a belt system to a single delivery draw frame fitted with a sliver regulating system; suction cleaning devices to draw off the waste, and an automatic can change arrangement are incorporated into the machine.

Recent innovations at the ring spinning stage are eliminating the need for the manual handling of the output from these machines. A creel staging system is being developed to enable block creeling of ring frames. A lifting device is used to transport full and empty spinning creels from a staging area. Hazards are also being eliminated by use of travelling cleaners to clean the working surfaces of ring frames and floors and roofs. Mechanical roller pickers are used by operatives to clean the drafting areas of frames and pneumatic under-cleayers are an integral part of the machines, the waste being removed by trunking to a central collection station.

The operation of doffing frames can result in back strain, and automatic doff preparation systems are available on modern spinning frames. Many types of automatic doffing equipment completely eliminate the need for manual handling. Similarly, systems for the transport of full ring tubes to the winding process are now available and in use.

Several manufacturers now market automatic winding machines with automatic feeding, piecing and doffing incorporated; and conveyor systems are used to transport wound cones to the warping creel. The handling of beams can involve hazards, and power-assisted beam removal is being incorporated into machines.

In weaving operations, the hazards associated with the manual handling of inputs to and outputs from the loom have caused some concern. Increased spacing of looms can reduce the risk of body strains, but mechanical handling installations are now increasing. These are removing some of the dangers and are eliminating a lot of previously arduous work. Where manual handling is still practised, the greatest care is needed and adequate training must be given to those concerned. The manual handling of loom weights can also cause injury. It has been greatly reduced, however, by the adoption of loom weighting motions, some of which incorporate weights which are rolled and not lifted. Additionally, a system of automatic winding of weft on the loom reduces the need for the manual handling of input to the machine.
In the finishing section, lifting tackle, fork-lift trucks and palletisation of stacks are the methods by which injuries resulting from the manual handling of materials are being reduced.

But modern technology can never replace the human being totally in the handling field, and the lifting of a light load, for example, in cramped conditions can often produce quite serious injury. It is essential that systems of work should be devised to prevent undue strains on the worker and that these systems should be enforced. Adequate space must also be provided in which the operations can be done safely. Training of operatives in correct handling and lifting methods is vital. The use of protective footwear should also be encouraged in all operations involving the handling of heavy weights. This has resulted in an encouraging reduction in injuries to feet.

Electricity and fire

In a high fire-risk environment, careful attention to the installation, maintenance and use of electrical equipment is a high priority. Since all electrical accidents can be slight or fatal, it is prudent to take all practicable steps to prevent them.

It is important that each textile firm should have the services of a qualified electrical engineer, either on the staff or by using an outside contractor. Legislation normally lays down stringent requirements concerning the installation and maintenance of electrical equipment precisely because of the dangers associated with it.

Any new installation or extension of an existing one should be carefully planned with a view to the future. Nothing is more likely to lead to confusion, and possibly to accidents, than an installation that has been added to at various times to meet immediate requirements. Careful planning and clear, permanent labelling is essential. Any system that waits for something to go wrong before measures are taken to put the fault right, is likely to result in a serious accident or loss of production. Regular inspection and testing of all electrical installations is important, and this applies particularly to portable electrical equipment, automatic control units, limit switches and stop buttons.

About a third of the fatal accidents in the British industry are associated with the use of portable electrical devices and their accessories, such as flexible cables, couplers and plugs. They should be well designed, properly installed, well maintained and used properly. On all AC supplies and on all DC supplies above 150V, the metal frame of the tool must be earthed, and this requires a separate core in the flexible cable for the purpose. If the cable has a metal sheath, this must not be the only means of earthing the frame. Means should be immediately at hand for cutting off the electricity supply from the portable device and the flexible cable. In order to prevent arcing, particularly in a textile mill, it is usual to fit a switch to the supply plug of the unit and to interlock it so that the plug can only be inserted and withdrawn with the switch in the "off" position.

An additional safety measure with portable hand lamps is that the metal lampholder must not be in contact with any earthed metal and not itself be earthed. The wire guard fitted to insulated types
of hand lamps is essential. It is provided to protect the bulb, since a breakage of glass exposes a conductor which is live from the supply. The guard should be fixed to the insulated body in such a way that there is no risk of its becoming live.

All conductors and apparatus exposed to the weather, wet, corrosion, inflammable surroundings, and such like, must be made and protected to take account of this special risk.

Normally, when portable electrical equipment is used on AC current, the voltage has to be transformed down to 25V. This can be achieved either by the use of a permanent transformer or by means of a portable transformer plugged into the usual wall socket. The use of inspection lamps with long leads in damp, rough and confined spaces is dangerous and the practice is strongly deprecated.

Factories in the cotton and allied sector represent a high fire risk and the maximum precautions must be taken to minimise it. They include:

1. Measures to prevent the start of a fire.
2. Measures to reduce the risk of fire spreading (e.g. proper design, construction and proofing of buildings); the installation of effective sprinkler and alarm systems; the provision of adequate extinguishing equipment; and the maintenance of good housekeeping throughout the factory.
3. The provision of safe means of escape in case of fire.
4. Adequate training of personnel in fire prevention.
5. Liaison on fire prevention standards with insurance companies and fire authorities.

Precautions against the start of fire must take full account of the inherent risks in a textile factory: the flammability of the material being processed as well as the risks common through industry: smoking and matches; defective and improperly operated heating equipment; careless disposal of waste products; defective or improperly installed and operated electrical equipment and services; friction and static sparks; careless handling of flammable liquids; careless use of open flame appliances (oxyacetylene or electric welding and cutting plant and blow-lamps or blow-torches); spontaneous ignition of oily rags or waste materials; hazards from repairs and alterations to machinery, buildings, and so on. Such hazards can be largely eliminated by proper care and attention.

Good housekeeping in a textile factory is extremely important and accumulations of process waste on floors, walls, pillars and roofs should be prevented. Not only do these accumulations present a fire hazard in themselves, but they also contribute materially to the spread of fire. Smoking, and materials used for smoking, (lighters, matches, etc.) present important fire hazards, and smoking is forbidden in all textile factories, except in special smoking areas which are properly supervised. But matches may fall into accumulated waste and into material being processed and may be ignited, causing a swift outbreak of fire in gangways or machines. There should be a forceful campaign in the textile industry to persuade operatives to use safety matches.
Heating appliances constitute a common fire hazard, particularly if combustible waste is exposed to abnormal temperature. Frequent testing and inspection of electrical installations and equipment are necessary if electrical fire risk is to be minimised. Moving machinery can also present serious fire hazards - bearings become overheated through insufficient lubrication, faulty assembly or the presence of fine dusts, belts may overheat if not fitted properly, and mechanical and electrical sparks can occur. Frequent inspection of machinery and equipment must be carried out to reduce these risks. Special precautions should be taken in the use of open-flame appliances.

However, in spite of all precautions, fires do occur, and it is vital to take measures to prevent the spread of these outbreaks. In some instances, reliance is placed on automatic extinguishers, in others the portable extinguisher is favoured.

Most spinning factories provide sprinkler systems, particularly useful when the factory is unoccupied. All sprinkler systems incorporate an audible warning and, in many instances, this warning system links with the local fire station. Some modern blowing and opening room machines incorporate automatic extinguishing equipment. If a fire breaks out inside a machine, a fusible link is broken and a dry powder is sprayed, extinguishing the outbreak.

Portable extinguishing equipment is usually of two types - units from which water (or, in the case of electrical fires, carbon dioxide) is expelled, and hose reels connected to the mains water supply and fitted with a hand-controlled nozzle. Buckets filled with water are also made available in workrooms as a first-aid measure in firefighting.

Nearly all fires start in a small way and usually develop slowly at first so that if suitable fire-fighting equipment is at hand, they can be put out before severe damage is done. The effectiveness of portable extinguishers is limited by the need to restrict their weight. Fixed hose reels are preferable. Operatives should be trained to use fire-fighting equipment quickly and efficiently.

Precautions taken in the design and construction of buildings, and the efficient stacking of goods, can make a most positive contribution to controlling fire-spread and restricting damage. High fire risk areas should be compartmentalised and protected by fire-resisting walls and floors. But the usefulness of such action can be destroyed if the design allows openings through which smoke, heat and fire can pass. Open doorways should be fitted with fire resisting doors, and all staircases, chutes and hoists should be enclosed in fire-resisting walls and fitted with fire-resisting doors or shutters.

Should a fire get out of control, there must be means of escape enabling the orderly evacuation of all personnel. The following requirements must be satisfied before escape routes can be considered adequate:

1. No one should need to go towards the fire in order to escape.
2. All escape routes should be as short as possible, of adequate capacity, and should lead to open air at ground level, either directly or by way of a fire-resisting enclosure.
3. Protected sections of escape routes should not be exposed at any point to penetration by smoke or fire.

Here again, fire drill should be given to all personnel. The training should include raising the alarm, putting out the fire and escape. It is important that an employee of senior status should be made responsible for taking a prompt decision on whether some or all of the personnel should be evacuated. General employee training should include:

1. The means of operating the fire-warning system.
2. Familiarisation with the sound of the fire-warning.
3. Means of ensuring the safe and speedy escape of personnel.
4. Familiarisation with both the normal and emergency escape routes.
5. The use of the fire extinguishers and hose reels provided.
6. The accurate reporting of the location and extent of outbreaks and the location of people in danger.
7. Closing doors to prevent the fire spreading.

Employees given special responsibilities in the event of fire will, of course, need special training. Fire drills are vital to achieve a reasonable standard of awareness of the correct procedures, and new employees should be taught these procedures as soon as possible.

The prevention of fire is an important aspect of industrial organisation, and close liaison should be maintained with organisations such as insurance companies and fire authorities to ensure that fire prevention standards are in line with modern requirements.
CHAPTER II

HEALTH PROBLEMS

Effects of Dusts on the Respiratory Tract

An Italian doctor, Bernardino Ramazzini, who was a pioneer in industrial medicine, described the asthmatic complaints of carders of hemp and flax at the beginning of the eighteenth century. About a hundred years later, a French physician, Patissier, wrote of similar complaints affecting cotton workers. In the nineteenth and twentieth centuries, as physicians became increasingly aware of the adverse effects of industrial dusts on the respiratory tract, these occupational hazards were confirmed and more precisely defined. Many textile dusts were also found to give rise to symptoms, and jute dust was said to be a cause of chronic respiratory disease.

After a lot of study of textile workers during the last 25 years, it is now generally accepted that hazardous textile dusts fall into two distinct groups. First, there are those of cotton, flax and soft hemp (cannabis sativa), which give rise to a disease called byssinosis (derived from the Greek bassos, meaning linen or fine flax). The disease is characterised by symptoms of chest tightness and breathlessness at work on Mondays after the weekend break, which in the early stages of the disease improve as the week goes on. Second, there are the dusts of jute, manila, sisal, St. Helena and Mauritius hemp, which cause persistent cough and expectoration, but not the symptoms of byssinosis; they apparently do not have the more severe long-term effects of dusts causing byssinosis.

In the manufacture and processing of man-made fibres, there are no risks of respiratory disease. But substitution of natural by artificial fibres offers no solution to the prevention of respiratory disease in the textile industry. The production of cotton is rising at about twice the rate of the production of man-made fibres, owing to rapid expansion in the developing countries. For the latter, the building of new textile factories to process their natural fibres, which are grown locally in abundance, is an important part of their economic expansion.

Two other conditions suffered by textile workers need to be differentiated from these two types of respiratory disease - mill fever and weaver's cough.

Mill fever

This condition occurs in those who have not been previously exposed to cotton or flax dust or who have not been exposed to the dust for a long time. A chill develops during the first day at work, but more frequently after the worker has returned home. There is a fever with a temperature of 37-40°C (100-103°F) which usually disappears by morning. It is frequently accompanied by headache and occasionally by nose bleeding, nausea and vomiting. For the next few nights, the new employee may experience a slight recurrence of the fever and a sense of exhaustion. Because of its temporary nature and the mildness of the symptoms after the first day of exposure, it is usually overlooked and ignored by workers. Its cause is unknown and a synonym for the complaint is Monday fever, although this has led to confusion with byssinosis.
Weaver's cough

This is a condition described among operatives in weaving sheds who handle mildewed yarn. The cause is believed to be moulds growing on heavily sized yarns which have been allowed to retain their moisture to allow weaving. It is not a widespread complaint. It occurs sporadically and can be effectively controlled.

Byssinosis

Cotton. About 25 years ago, byssinosis was thought to be confined to British cotton mills in Lancashire, and affecting only men working in the dusty mixing, blow and card rooms where the fibres are prepared for spinning. It has since been described in countries all over the world, among workers in a wide range of processes ranging from ginning, where the seeds are removed from the picked cotton bolls, through to the final stages of winding the yarn and even in weaving the coarser types of material. Its widespread occurrence has been overlooked largely because the proper methods of surveying cotton workers have not been used. Even as recently as 1961, its incidence in the United States, the largest producer of cotton yarns in the world, was said to be almost nil. Ten years later, prevalences of byssinosis of the order of 25-30 per cent were found in United States cotton factories. It is now officially recognised as a problem, and cotton dust has been designated a health priority target by the US Department of Labor. Other factors which have led to a "spread" of the risk beyond the earlier processes are the introduction of mechanical picking, which has increased the contamination of cotton with the plant debris containing the causal agent(s), and the general speeding up of processes. Both have undoubtedly raised the concentrations of dust in workrooms which follow carding.

Flax. The occurrence of a disease, which was undoubtedly byssinosis, among flax workers in the linen mills in Northern Ireland was described by Purdon in the nineteenth century. More recent studies of mills in the Belfast area have revealed that the disease occurs among workers in the preparatory processes and may be disabling. Similar effects have been found in the flax industry in France. A study in the Netherlands revealed its occurrence among workers exposed to dust from biologically retted flax, but it did not occur during the handling of flax before it was retted, nor while processing chemically retted flax.

While the use of mechanical methods in preparing fibres has increased dust exposure, there is no doubt from the observations of Ramazzini that primitive methods of production entailed a risk. In an Egyptian village where much of flax is processed in people's homes, a high prevalence of byssinosis has been found. Those not working with flax were affected by the dust generated in and around their houses. Young children old enough to talk of their complaints had the characteristic chest tightness.

Soft hemp (cannabis sativa). This is used for making ropes and twines. Although the leaf fibres of manila, sisal and the hard hemsps (St. Helena) and man-made fibres are replacing soft hemp, the latter is still widely used in many countries. An asthma-like complaint called cannabisiosis was described nearly 30 years ago in Spanish workers making ropes from soft hemp. It has since proved
to be indistinguishable from the byssinosis of cotton and flax workers and has been found in Yugoslavia, England and France.

The main risk of byssinosis lies in the cotton manufacturing industry, because it is much larger than the flax and soft hemp industries. Relatively speaking, however, the risk is probably higher among flax and soft hemp workers since recent evidence indicates that at similar levels of dust concentration, the latter have higher prevalence of disease and are more severely affected than cotton workers.

**Symptoms and diagnosis.** In the early stages of byssinosis, there are characteristic symptoms of chest tightness on the first day of work after the weekend. In Western countries with the traditional work break on Saturdays and Sundays, this occurs on Mondays and recent surveys of factory populations show that these symptoms may develop during the first year of exposure and not, as is often stated, after several years. The feeling of tightness or difficulty in breathing usually comes on towards the middle or end of the work-shift and disappears shortly after leaving the workplace. On Tuesdays, the worker has no symptoms, but as the disease progresses, the chest tightness and breathlessness worsen and extend to Tuesdays and then to other days. At this stage, symptoms still improve as the week goes on. Eventually, the worker may become severely affected on every working day, with permanent and severe shortness of breath on exertion. There is also marked impairment of pulmonary function, namely ventilatory capacity (the bellows action of the lung). The worker's condition is no longer improved by leaving the dusty occupation. In its final stages, byssinosis cannot be distinguished from non-occupational chronic bronchitis and emphysema, except for the past history of chest tightness, characteristically worse at the beginning of the working week. The textile worker with byssinosis often forgets his early symptoms and is diagnosed as suffering from non-occupational chronic obstructive pulmonary disease. Diagnosis is made easier by regular medical surveillance which enables early symptoms to be recognised and recorded. Chest X-rays do not show specific changes, nor has any specific pathology been identified in the lungs of workers who have died of this disease. The X-ray and pathological changes in the lungs on present evidence are those found in chronic bronchitis and emphysema.

In the management of patients with byssinosis and in the detection of a risk of this occupational disease in a population, correct diagnosis, and assessment of prevalence, are important. These may be done by questionnaire and lung function tests.

**The questionnaire.** A standardised questionnaire in which respiratory symptoms, and clinical and occupational histories are recorded, has been used extensively in many countries and has proved a valuable aid to diagnosis.

**Ventilatory function tests.** Exposures to the dusts of cotton, flax and soft hemp cause both temporary and permanent changes in ventilatory capacity. The most commonly used test is the Forced Expiratory Volume over 1.0 second (FEV1.0). After taking as deep a breath as possible, the FEV1.0 is the maximum amount of air that can be exhaled in one second.

Measured on a Monday at the beginning and end of the shift, it provides additional evidence of a hazard of byssinosis and helps to identify workers who are susceptible to the dust. In practice,
those with symptoms of byssinosis have a significantly greater decrease in ventilatory capacity during the work-shift than those without symptoms. The main value of this test is that it detects subjects who do not complain of chest tightness but yet are susceptible to dust.

The acute and the permanent effects of cotton dust exposure on ventilatory capacity are well illustrated by the results of a study of male cotton workers in the Netherlands. The cotton workers with byssinosis had significantly lower ventilatory capacities at the beginning of the shift on Mondays than workers without symptoms. They also showed a marked fall in ventilatory capacity during the shift, whereas workers without symptoms showed changes similar to those of non-textile workers.

**Surveys of workers exposed to risk.** The first surveys of cotton and other workers using the techniques described above were undertaken in England, and then in other countries in Western Europe, Egypt and India. Later they were extended to North and South America, Turkey and countries in Eastern Europe, including Romania and Finland. Byssinosis has invariably been identified in cotton, flax and soft hemp workers where these techniques are put into operation. Without them, the disease may not be diagnosed. Its prevalence may also be underestimated. For example, a survey in Poland of some 3,000 cotton workers in which a questionnaire on bronchitis was used, showed a high prevalence of chronic bronchitis associated with a lowered ventilatory capacity but no byssinosis. Similarly in Bulgaria, workers in contact with cotton dust have shown high prevalences of chronic bronchitis, but typical forms of byssinosis have been rarely seen or recognised. Workers in the gins, where the seeds are removed from the cotton dust, present special problems of investigation because their exposure to dust is seasonal; it may be continuous for several months without any weekend break. Diagnosis in ginnery workers depends on asking questions about symptoms and measuring changes in ventilatory capacity during the first two or three days of work.

Surveys of workers actively employed in textile manufacture do not include those who have left the industry because of respiratory disability, and therefore underestimate the extent of the disability caused by exposure to dust. A survey, in a Spanish town, of active and retired soft hemp workers and of others not exposed to dust, revealed the extent of permanent disability which can occur among older men. Hemp workers aged 50-69 had a very much higher proportion (33 per cent) of men with markedly reduced ventilatory capacities than those of similar ages who had never worked in hemp. Among the latter, the proportion was only 4 per cent.

**Pathogenesis.** Physicians who see only disabled textile workers presenting symptoms of chronic bronchitis have been reluctant to recognise byssinosis as an occupational disease. They and many others in occupational health have at first found its odd clinical history and lack of specific radiographs or pathological changes in the lungs unconvincing. Lung function tests used in epidemiological surveys of cotton workers provided additional and objective evidence that byssinosis of Lancashire cotton workers was a separate disease and in its early stages quite unlike the bronchitis prevalent in the mill towns.

The initial symptoms of chest tightness on Mondays may occur in people exposed to dust for the first time and are accompanied by a
temporary decrease in ventilatory function of the lungs and in increase in airways resistance. These changes, which are greater in workers with symptoms of byssinosis, are reversed by bronchodilatory drugs. Workers with byssinosis, particularly those who have had symptoms for some time, have a lower than normal ventilatory capacity even when they are not exposed to dust. Broncho-dilatory drugs have little effect, indicating that these changes are irreversible. A reasonable hypothesis is that the acute effects in ventilatory capacity eventually lead to an irreversible loss of function and that these changes are not primarily caused by a reflex mechanical constriction which may occur as a result of heavy exposure to inert dusts, but by pharmacologically active substances producing broncho-constriction.

The mechanism by which inhaled byssinogenic dusts have their acute effect on pulmonary ventilation is uncertain, although its source in cotton dusts has been identified as the plant debris from the bracts or leaves attached to the cotton boll. It is not contained in the cotton fibres or seeds. There are a number of agents in the plant debris which could cause a narrowing of the bronchioles by muscle contraction and/or oedema (swelling) of the mucous membrane lining the airways. They are histamine, antigenic, and non-antigenic histamine-releasing agents, and 5-hydroxytryptamine; the latter compound and histamine itself are present in such small quantities that they are unlikely to be important.

Extracts of cotton, flax and hemp dust, when incubated with human lung tissue in vitro, cause histamine to be released. Histamine itself is a powerful broncho-constricting agent. When healthy subjects are first exposed to aqueous extracts of cotton dust of the bracts from cotton plants, they suffer a temporary reduction in ventilatory capacity. These extracts have a similar but more pronounced effect on workers with byssinosis. A second exposure to cotton dust extract 24 hours after the first produces less effect. The relatively slow onset of symptoms, particularly in the early stages of the disease, is not like that produced by antigenic histamine release in the asthmatics of subjects who have become sensitised to an antigen such as certain pollens or horse dandruff. Also, the proportion of such sensitised people in a group is usually small and the fact that a large proportion of workers exposed to byssinogenic dusts are affected provides further evidence that the typical symptoms of the disease are not caused by an antigen-antibody type of reaction. The presence of an agent in the dust causing non-antigenic histamine release could explain the Monday symptoms. Most of the available histamine in lung tissue is released and acts upon the airways in the first working day, but little or no histamine is available for release again until the subject has been absent from work. This, however, does not explain why the worker with severe byssinosis suffers on every working day from persistent symptoms which have a fairly rapid onset after dust exposure. It is possible that antigenic histamine release may occur in the late stages of the disease.

The fact that the agent or agents causing byssinosis have not yet been identified and their mode of action is still uncertain need not be a deterrent to preventive action. It will be seen later that there is much that can be done to control byssinosis and prevent workers from becoming permanently disabled. However, identification of these agents should permit the adoption of more certain, more effective and less costly control measures.
Other environmental agents. The relationship between cigarette smoking and respiratory disease is well established. Apart from lung cancer, smoking is now accepted as a major cause of chronic bronchitis. There is also evidence from surveys of cotton workers that those who smoke cigarettes face an increased risk of developing byssinosis. A recent survey of more than 1,000 American workers preparing cotton and producing cotton yarns indicates that it takes about half as much cotton dust to cause a given prevalence in smokers as in non-smokers. Similarly a survey in Britain showed that women cotton workers who smoked had a higher prevalence of byssinosis than non-smokers, in spite of the fact that they were, on average, much younger and had experienced shorter exposures to cotton dust than the non-smokers. The implications are clear: smoking potentiates the effects of byssinogenic dusts and workers at risk, particularly those with symptoms of byssinosis, should be advised not to smoke. If possible, non-smokers or light smokers should be employed in preference to moderate or heavy smokers in workrooms which do not conform to the hygiene standards for dust.

Twenty-five years ago, when disabling byssinosis was regarded as a relatively common disease confined to men employed in the mixing and blow rooms of the Lancashire cotton industry, the adverse environment of the mill towns with their heavily polluted atmosphere was thought to be a vital factor in causing the permanent disability. The world-wide prevalence of byssinosis has discounted this hypothesis. Few climates could be balmier and less polluted than the Nile Delta in Egypt or the Carolinas in the United States, where disabling byssinosis is now known to occur. Nevertheless, there is evidence that air pollution outside the workplace is likely to potentiate the effects of cotton dust exposure. About ten years ago, a comparative survey was made of cotton workers in Lancashire and the Netherlands spinning medium quality American-type cotton. The levels of air pollution, by smoke and sulphur dioxide, in the Lancashire towns were considerably higher than in the Dutch towns where the cotton mills were situated. Although the prevalences of byssinosis were similar among the English and Dutch workers, the latter had a lower prevalence of persistent cough and phlegm and higher ventilatory capacities than the English workers. Air pollution was thought to be one factor which could account for these differences. The relative lack of air pollution in the mill towns of the Southern States of the USA, compared with the high levels of pollution which used to occur in the atmosphere of the Lancashire mill towns, may be a reason why the high mortality and morbidity among the English cotton workers were not noted in the United States.

The most important outcome of these comparative surveys is that in spite of the fact that both smoking and air pollution outside the factory may add to the adverse effects of dust exposure at work, they are only of minor importance in the aetiology (background) of byssinosis. Prevention depends primarily on dust control inside the workplace.

Non-Specific Effects of Textile Dusts

The dusts emitted from processing the hard hems such as St. Helena and Mauritius hemp, manila and sisal do not cause byssinosis, but in high concentrations they exert an irritative effect and cause symptoms of cough and sputum with a decrease in
ventilatory capacity during dust exposure. From the limited evidence available, the latter does not appear to be associated with any significant permanent changes in ventilatory function and the acute changes may be mechanical rather than pharmacological in origin, caused by a rapid reflex response which gives rise to bronchoconstrictions. While such dusts produce much less severe effects than those of cotton, flax and soft hemp, they cannot be disregarded. Control measures to be adopted should follow the same principles as those for byssinosis but they can be less stringent. There is a suggested hygiene standard, based on a study of English rope workers handling manila and sisal, of 2 mg/m$^3$ of total dust. This is much higher than the standard recommended for cotton dust. Medical surveillance of workers exposed to the dusts is also desirable.

Hygiene Standards for Dusts and Methods of Sampling

Since there are no published hygiene standards for flax and soft hemp dusts at present, this section deals only with standards for cotton dust, which have recently been re-examined and revised. In the early 1960s, the American Conference of Governmental Industrial Hygienists recommended a Threshold Limit Value for cotton dust of 1 mg/m$^3$ of total dust (e.g. all particle sizes). Its revision was recommended nearly three years ago by the Sub-Committee on Byssinosis of the Permanent Commission and International Association on Occupational Health on the grounds that measurement of respirable dust is preferable to "total dust", which contains a substantial proportion of non-toxic dust particles that are too large to pass into the lungs.

The British Occupational Hygiene Society (BOHS) has recently published a report which recommends a new Threshold Limit Value (TLV) of 0.5 mg/m$^3$ less fly (e.g. excluding particles which would be caught by a 2 mm wire mesh gauze, wire diameter 0.2 mm, 1.8 mm square aperture). The BOHS committee which comprised scientists and representatives of management and workers, believes that this is a realistic dust standard at which to aim if the risk of workers being permanently affected is to be reduced to as low a level as possible. The Sub-Committee on Byssinosis of the Permanent Commission and International Association on Occupational Health has also recommended a TLV of 0.2 mg/m$^3$ of dust particles (less than 15 mm in diameter). Both standards are likely to produce similar responses; byssinosis will occur at these levels, but prevalences of less than 5 per cent (byssinosis grade 2) would be expected, indicating that medical surveillance is essential to detect workers susceptible to the dust. While it remains impossible to achieve completely safe dust levels, control of the disease will also depend on medical surveillance. These two hygiene standards are based on the use of two different kinds of instruments. That of 0.5 mg/m$^3$ less fly, recommended by the British Occupational Hygiene Society, is best measured by the Hexion Sampler, which has been used in the United Kingdom and other European countries. The other, of 0.2 mg/m$^3$ of particles less than 15 mm in diameter, is best measured by the vertical elutriator.

sampler recently developed and used in cotton mills in the United States. Both instruments are static and sample gravimetrically, that is, by measuring the weight of dust per unit volume of air in particular areas of workplaces.

In theory, personal sampling (a sampler being attached to the worker) is preferable, but it raises practical difficulties, since the amount of dust collected is much smaller and measurements are less accurate. Area sampling is carried out in a workplace defined as the area in which people work on one or a group of similar machines. Dust concentrations in such an area should be determined by sampling continuously during working hours over one week at a minimum of five locations, each location being selected to provide a representative sample of air to which one-fifth of the workers are exposed, or exposed for a fifth of their time. The time interval between sampling depends on the dust concentration in the workroom. Where it exceeds the TLV defined above, air sampling should be repeated within six months; for concentrations below the TLV, the interval can be extended to one year.

Dust sampling for other textile dusts such as manila, sisal and the hard hems should follow the same principles using similar instruments for measuring the dust gravimetrically. At present, this type of systematic environmental monitoring is rarely undertaken in textile factories. It is, however, an essential procedure for achieving adequate dust control and the prevention of occupational respiratory disease.

**Prevention of Occupational Respiratory Diseases**

**Dust and control**

There are three principal methods of controlling exposure to textile dusts which cause respiratory disease. The first is to eliminate at source, or to reduce, the biologically active component in the dust; the second is to reduce airborne concentrations in workrooms of the dust which contains the agent(s); and the third is by means of respirators.

1. The biologically active agent(s) causing byssinosis have not yet been identified, but they are contained in the plant debris and not in the fibres from which textiles are made. If, for example, in the cotton industry, the vegetable foreign matter could be removed at the gin along with the seeds, the problem of byssinosis among cotton workers would be solved. At present, the vegetable matter which contains the active agent is crushed and rolled into the fibres and then has to be removed both for technical and health reasons. There does not appear to be a mechanical method of extracting the plant debris either before or after the cotton is picked. However, another method of removal is being explored in the United States. The pharmacologically active agents of byssinosis are known to be water soluble. It is both economically feasible and technically acceptable to subject raw cotton to steam treatment and then to process it. At present this offers the best chance of removing the agent of byssinosis at source.

2. Reduction of airborne concentrations of dust depends on improved process design, the enclosure of process, local exhaust
ventilation, general exhaust ventilation and filtration of circulated air. Many textile factories employ one or more of these systems for air conditioning workrooms. But if they are to control airborne dust to levels which are acceptable, they will have to be greatly improved. Particular attention needs to be given to the recirculation of exhaust air, which is commonly done in order to reduce heating costs. Generally, recirculated air must be effectively filtered or mixed with fresh air so that it contains less than 0.1 mg/m³ of particulate matter.

3. Prospective respirators may be needed to supplement the above control equipment or to provide protection while it is being installed, maintained or repaired. Whenever it is necessary to work for short periods in a workplace where dust concentrations are very high, respirators should be provided. An oro-nasal dust respirator fitted with an encapsulated high efficiency dust filter is suitable for concentrations up to 10 mg/m³ and should meet most requirements.

Maintenance is an important part of any control programme, and this is especially true for respirators. Regular inspection, cleaning, replacement or repair of worn or deteriorated parts should be done at a central point and supervised by a responsible person.

Medical surveillance

Medical surveillance has two functions. It can be used as a monitoring device in addition to dust sampling. The proportion of active agents in the dust is by no means constant, since the prevalence of byssinosis in environments with similar dustiness varies by more than might be expected. There may be workrooms in which the dust concentration is below the hygiene standard, but the prevalence of grade 2 byssinosis is much higher than expected. Secondly, medical surveillance may be used to detect subjects who are, or who are likely to be, especially sensitive to the dust. It provides an opportunity to prevent such people from becoming permanently disabled by the disease. Medical surveillance comprises initial and periodic examinations.

The initial examination should be done before employment begins or where this is not feasible, as soon as practicable. It aims to exclude from workrooms where there is known to be risk of byssinosis or from other processes where dust concentrations are high (e.g. above 2 mg/m³ total dust for non-byssinogenic textile dusts) people with: (i) a history of asthma; (ii) chronic bronchitis or other obstructive lung disease which may be exacerbated by dust exposure; and (iii) tuberculosis. Those who are to be exposed to dust should be discouraged from smoking and non-smokers should be preferred for such occupations.

The periodic examination detects workers who are susceptible to dust; they can be removed altogether from dust exposure or to a less dusty occupation before developing any substantial disability. The systematic examination of groups of workers is also a valuable method of checking the adequacy of dust control and detecting workrooms where better control is needed. The methods of examination should include an occupational history; the use of a questionnaire relating to the characteristic symptoms of byssinosis as well as the more common respiratory symptoms and smoking habits; and ventilatory
function tests. Chest X-rays are of no value in diagnosing byssinosis, but in some countries where tuberculosis is prevalent, they will be needed, particularly in the initial examination.

Tests of lung function should include the FEV₁₀ and the Forced Vital Capacity (FVC). The FEV₁₀/FVC ratio may be a more useful measure of obstructive lung disease than the FEV₁₀ on its own. Both newly employed and current employees should have these lung function tests performed, the latter on the first day back at work after at least two days’ absence from exposure to dust, with a repeat test at the end of the work shift on the same day. The interval between periodic examinations depends on the degree of risk. Where the hygiene standard is exceeded or the risk is higher than expected, it should be one year, otherwise such examinations should be at least every three years.

They can be carried out by trained personnel who are not medically qualified, but a physician needs to be in charge of individuals who show definite susceptibility or evidence of chronic effects. Nobody should be advised to leave his work for health reasons without carefully considering the social consequences of making such a change. Generally, however, those who show evidence of definite susceptibility without chronic effects or those with slight chronic effects should be advised to move to lower risk jobs; those with severe byssinosis should be advised to move to work free from risk of respiratory disease.

Future action

The complete eradication of byssinosis by the removal of toxic dust from the workroom is not yet possible. In the meantime, a combination of environmental control and medical surveillance will prevent many, if not all, workers at risk from becoming permanently and severely disabled.

Further development is needed of practical and reliable standard sampling devices for airborne dust and of simple, quick and reliable methods of recording respiratory symptoms and measuring ventilatory capacity. As medical surveillance involves large numbers of people, automated data processing will help to speed up the analysis of data which is essential for quicker and better control. It is important for all countries with textile industries, particularly where there is a risk of byssinosis, to adopt the measures of environmental control and medical surveillance which have been described.

There are still many gaps in our knowledge of chronic respiratory disease in textile workers. Among the more important that need to be filled are (i) the identification of the aetiologital agent or agents causing byssinosis; and (ii) the extent to which the new hygiene standards can be achieved by dust control measures.

Once the causal agent is identified, it may be possible for geneticists and others to produce cotton plants without it or to find ways (such as by steam treatment) to remove it at source.

Continued research is likely to be necessary to improve existing exhaust ventilation, filtration systems and methods of enclosure in order to achieve the new hygiene standards.
Noise

During the development of textile manufacture, one of the most ancient industries, mechanisation usually brought an increase in noise levels. This was the case until recent times, when technology took a turn for the quieter — though even today several processes are very noisy.

Three questions have to be considered. Does the noise impinge on the workers' general health? Does it affect productivity? Does it affect hearing? Here is a brief review of existing knowledge. It should be noted that while there is a lot of evidence concerning the effects of weaving noise on hearing, there is much less about the other aspects.

Effects on health

Excessive noise at work is undesirable. It is sometimes regarded as a cause of stress in workers which, in its more extreme forms, is a cause of ill-health.

The evidence surrounding this proposition is puzzling. In 1959, in Japan, Sakamoto demonstrated that continuous noise produced an apparently stable pattern of endocrine dysfunction. Atherley, Gibbons and Powell (1970) also observed this pattern in the United Kingdom in response to "moderate" noise exposure. But the pattern is in some respects the converse of what would be expected in response to other environmental stresses (such as heat for example) as predicted by Selye's classic work in Canada on the "general adaptation syndrome" (1950). Hence noise does not seem to be typical of stresses in the ordinarily accepted meaning of the term. It is possible that exposure to continuous noise produces a highly characteristic endocrine response. But it is not known whether this response has any undesirable long-term effects on health. There is urgent need for more research on this aspect of occupational health.

Effects on working performance

The question whether noise adversely affects output has interested research workers for many years. The first systematic study was that reported by Weston and Adams in the United Kingdom. They studied the performance of weavers under varying conditions of noise and concluded, from two experiments, that excessive noise had some effect on weavers which handicaps them in the performance of their normal daily work. The effect was observed in weavers who were thoroughly accustomed to working in high noise levels. Essentially, the experiments showed that a reduction in noise at the ears of the weavers, brought about by the use of hearing protectors, had a beneficial effect on their productivity.

Subsequent research (for example by Corcoran in 1962 in the United Kingdom) into the effects of noise on working performance has shown that it appears to produce its effects by over-arousal.

It is interesting to consider whether arousal and the pattern of endocrine dysfunction described by Sakamoto are linked. Further research should lead to a better understanding of the effects of noise on performance — in particular, any possible long-term consequence for the health of textile workers.
Effects on hearing

The great majority of reports of deafness from noise among textile operatives are concerned with weavers, which explains why the following remarks are largely devoted to this group.

The first report of occupational deafness among any textile workers appears to have been made in Russia by Maljutin in 1896. He described damage to weavers' hearing in the form of a sensorineural lesion (an abnormality associated with the nerves of sensation) which became noticeable after five years' exposure to weaving noise, and which increased with length of employment. In 1902, Röpke reported in Germany that fourteen weavers showed a fall in performance at the whispered voice test after only six weeks' work in weaving. In the same year, Wilson in the United Kingdom observed widespread but slight hearing loss among textile operatives.

Between 1896 and 1967, there were at least forty notes and publications on the subject of weavers' deafness. The findings which emerged from these early studies have helped to build up our present picture of weavers' deafness.

Weavers' deafness

Wilson's observation of "slight" deafness has already been mentioned. Tenaglia (1924) in Italy compared weavers with riveters and found the weavers to be less affected. In 1931, Mauthner in Germany found that weavers were more slowly affected than mechanics and pilots. Solger (1931, Germany) found that metal workers were more affected than weavers. Marx (1938, Germany) found weavers' deafness to be insidious.

On the other hand, Beck and Holtzmann (1928, Germany) found that after twenty years' employment, weavers could barely hear whispers, although total deafness was rarely found. Poor performance at the whisper test was commented upon by Temkin. Goedel (1942, Germany) found that weavers' deafness became severe enough to be recognised as an industrial disease after twenty years, even though total deafness was never observed.

More recently, attempts have been made to gain a clearer picture of the degree of social handicap associated with weavers' deafness. In a group of retired female jute weavers of an average age of about sixty-five, Kell, Pearson, Acton and Taylor (1971) found that 90 per cent were using hearing aids, compared with none in an age-matched control group.

They also found other social consequences of impaired hearing ability:

- Difficulty at public meetings (weavers 72 per cent, controls 6 per cent).
- Difficulty in talking with strangers (weavers 80 per cent, controls 15 per cent).
- Difficulty in talking with friends (weavers 77 per cent, controls 15 per cent).
- Difficulty in understanding telephone conversations (weavers 64 per cent, controls 5 per cent).
- Eighty-one per cent of weavers considered that their hearing was impaired (5 per cent controls).
- Fifty-three per cent of weavers and no controls used a form of lip-reading.

Atherley and Noble (1971) used a questionnaire to study occupational deafness in weavers and other noise-exposed populations. They describe an average picture of the deafness in people in their sixties who have spent at least half their working lives in noisy jobs.

In conversation with groups of people at home and outside some difficulty is experienced from time to time. Conversation with one person outside may also present occasional difficulty but there is none at home. On occasion wrong answers are given and sometimes, though not often, speech in television plays appears indistinct. Certain domestic sounds, such as the clock ticking, may be missed. The sufferer is aware that his hearing is less than normal but at the same time he is not prepared to say that his hearing is abnormal for his age.

In 1953, in the USA, Cox, Mansur and Williams demonstrated the recovery effect in weavers. They showed that after 40 hours away from work, hearing was better than during the working week. Yaffle and Jones in 1963, also in the USA, showed that some recovery also took place between 48 and 72 hours post-exposure. Atherley (1964) in the United Kingdom showed that some recovery also occurred between 3 and 16 days post-exposure. Taylor, Pearson, Mair and Burns in 1965, also in the United Kingdom, showed that some recovery could be demonstrated among retired weavers.

None of the authors reports anything like complete recovery of hearing; the effect, although real, is relatively small in magnitude.

Pathology

The observation by Maljutin that the lesion was sensori-neural in character has been confirmed by a number of studies, for example, that by Beck and Holtzmann in 1928 (Germany). McKelvie (1933, United Kingdom) found no sensori-neural cases in weavers with under 10 years' employment. Also, he found that 30 per cent of the weavers were suffering from chronic suppurative otitis media ("weeping" inflammation of the middle ear), which is not caused by noise exposure.

Temkin (1933, Germany) likewise commented upon the prevalence of conductive lesions (of which chronic suppurative otitis media is a major cause), and drew attention to the adverse environmental conditions which he thought were associated with the prevalence. Temkin observed hearing loss at low frequencies as well as the more usual high frequencies. In 1953, Ghirlanda in Italy confirmed Temkin's observation of hearing loss at low frequencies and also the prevalence of conductive lesions.
It is widely recognised that chronic suppurative otitis media is a disease associated with poor social conditions. But it also is one which is prevented by antibiotic therapy when given early enough. Moreover, low frequency hearing loss is characteristic of conductive lesions.

In 1964, Gammarotta and Bartoli, also in Italy, reported once more the presence of low frequency hearing loss in weavers. It would be interesting to follow up the observations about conductive lesions and low frequency loss. If the prevalence were still high for weavers despite the availability of antibiotics for 25 years and the improvement in social conditions, this would support Temkin's notion that there were other factors, besides noise, in weaving sheds capable of harming people's ears.

Deafness among textile operatives other than weavers

For many years, weaving has represented the major noise problem in textiles, and the relatively large number of reports of deafness in weavers as compared with other operatives reflects this predominance. However, spinning is noisy, although not to the same degree as weaving. Comparisons between the hearing of spinners and weavers invariably show that spinners are affected to a lesser degree (for example, Bonjer, 1960, Netherlands; and Costinescu, Iticovici and Macarie, 1960, Romania).

In recent years, attention has been drawn to the high noise levels in false twist texturing machines, and Atherley (1967, United Kingdom, unpublished data) found some evidence of effects on the hearing of young people in this job.

Most card rooms are relatively quiet compared with weaving sheds, but Atherley (op. cit.) found some degree of deafness among card room operatives.

Progress towards the control of noise

Recently there has been a significant advance in our understanding of the relationship between noise and its effect on hearing. Burns and Robinson (1970), as a result of an extensive study of hearing in British industries, found that the degree of injury to hearing was related to the total "dose" of sound energy that had passed into the ears of the people who were exposed. They also found that the A weighted scale of decibels was the best choice for acoustic measurements taken to predict injury to hearing, of occupational origin.

Their work showed quite clearly that habitual exposure to noise levels of 90 dB(A) and less for a working lifetime is associated with a relatively small amount of injury to hearing in most people. This gave confirmation to the authorities in various countries who have recommended that the upper limit for acceptable noise exposure over a working lifetime should be no more than 90 dB(A) and possibly 85 dB(A). At the present state of knowledge, it can be strongly argued that all machinery in use in the textile industry should be designed, constructed and installed so that the noise level at the ears of the operatives is normally less than 85 dB(A) and certainly never higher than 90 dB(A). This may well mean that the noise of individual machines must be kept substantially below these figures.
It is now usual to measure noise in terms of its equivalent continuous noise level (ECNL). This takes into account two factors: the level of the noise and the hours per day for which the workers are exposed. ECNL is a figure which expresses the "average" noise exposure over a working day. It is defined as the level of continuous noise which would deliver over an eight-hour day the same amount of noisv energy as has actually been delivered during the time the workers were in the noise.

Studies of textile machinery noise are being made in a number of countries and knowledge is by no means complete. However, certain conclusions seem to be generally accepted. First, it is acknowledged that the noisiest weaving machines are the automatic type with shuttles. Broadly speaking, the noise level is highest on fast machines, with a high pick rate. The ECNLs commonly lie in the range 95 to 105 dB(A).

Gripper shuttle machines, rapier machines, and air-jet and water-jet machines are all quieter than the automatic machines; their ECNLs are commonly in the range 85 to 95 dB(A).

It would obviously be an improvement if fast automatic looms were to be replaced by the quieter types of machines, such as gripper machines, etc. Although weavers' deafness would by no means disappear, it would certainly become less prevalent.

But weaving machinery is famous for its longevity, and it is likely to be many years before all the old machinery is replaced. Nor can it be assumed that it will be replaced by quiet machinery, unless everyone concerned with the health of textile workers applies as much pressure as possible for quieter machinery. Meanwhile, it is necessary to ask whether any useful reductions in noise can be made by modifications to existing automatic weaving machines of the shuttle type.

Smith (1970) has made an extensive study of the possibilities for reducing noise from shuttle looms. He thinks that reductions of more than 5 dB(A) would require considerable modification of the existing mechanisms, far beyond what is reasonably practicable. He also found that "quiet" materials applied at points where impacts are produced did not show much promise. Such solutions failed to reduce the noise and were also often unsatisfactory from the point of view of component life. He feels that new designs should involve drastic modification of principles, components and mechanisms.

False twist texturing machines now have the unwelcome distinction of being probably the greatest noise hazard in modern textile processes. The equivalent-continuous noise levels commonly lie in the range 105-115 dB(A), depending on rotation speed. Also, much of the noise energy is in the high frequency range, making the noise especially unpleasant.

Spinning noise lies in the range 80-95 dB(A), depending on the nature of the process. As already stated, there is little doubt that some operatives are at risk in these processes.

The noise of false twist texturing and, to a lesser extent, that of spinning, presents a difficult problem. The high speeds of rotation which are essential to the processes appear inseparable from high noise levels, especially in the high frequency range. "Boxing-in" the noisy parts has not proved a uniformly successful way of dealing with the problem.
There can be no doubt that the textile industry throughout the world is facing a very difficult and expensive problem in attempting to deal with noise. There are encouraging signs of considerable effort to end occupational deafness, but eradication will not be achieved in the immediate future: this makes it necessary to consider interim solutions to the noise problem.

Hearing protectors

The practicable interim solution appears to be the use of hearing protectors where factory noise cannot be reduced below the acceptable limit. The following table from Atherley and Else (1972) gives a guide to the type of protector necessary for the ranges of equivalent-continuous noise level:

<table>
<thead>
<tr>
<th>ECNL in dB(A)</th>
<th>Recommended Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 90</td>
<td>Protectors unnecessary</td>
</tr>
<tr>
<td>90 to 100</td>
<td>Earplugs (including glass down) are adequate for most noises and most people</td>
</tr>
<tr>
<td>100 to 110</td>
<td>Earmuffs are usually required, but occasionally earplugs might be approved after expert measurement of the noise</td>
</tr>
<tr>
<td>More than 110</td>
<td>Only earmuffs are adequate</td>
</tr>
</tbody>
</table>

As Else points out, the protection provided will be severely limited if the protectors are not worn for most of the exposure time. In fact, it can be shown that no protector can provide greater than 10 dB(A) protection to a person against any noise if it is worn for less than 90 per cent of the exposure time. Comfort, therefore, is important, to make hearing protectors acceptable to the workers.

Medical supervision of textile workers with noisy jobs

Should doctors carry out ear examinations on all textile workers? Should they also give routine hearing tests (audiometry)?

The answers depend to some extent upon whether the workers are given general medical examinations as a matter of routine. When these are being carried out, the occupational physician should always examine the ears, nose and throat of textile operatives. The environment in some textile factories may have an adverse effect on the upper respiratory tract, and the possibility of middle ear disease has always to be considered. Workers should be encouraged to report ear trouble as soon as they notice it.

There is also the problem of people with existing middle ear disease and whether it is advisable for them to be employed in textiles.

At present it is not known whether any disease will be worsened by employment in textiles; neither is it known whether sufferers from middle ear disease are especially liable to occupational deafness. Routine medical supervision for such people is therefore highly desirable.
Opinion is sharply divided about the merits of routine audiometry for all workers with noisy jobs. All authorities agree that audiometry is not a substitute for adequate noise control, and that people should be given adequate hearing protectors wherever noise levels are in excess of 85 or 90 dB(A).

Some authorities argue that routine audiometry helps to persuade workers to use hearing protectors, and that it may identify people who are losing hearing either because they do not get sufficient protection from their protectors or because they are not properly using the protectors issued to them.

Those against audiometry argue that effective hearing protection can be achieved without it and that audiometry has the disadvantages of making the prevention of occupational deafness the responsibility of the medical services, whereas, of course, the prevention of occupational deafness, either by noise reduction or by the use of adequate hearing protectors, is the primary responsibility of management.

But in the long term, the real answer is to control the noise of machines.

Dermatitis

Dermatitis and other skin infections can arise from handling cotton and man-made fibre yarns, from dust and oil, and from the chemicals used in the dyeing and finishing sections. Proper facilities for washing should be provided but, additionally, barrier creams and the use of protective gloves reduce the risk of disease. Even so, in spite of these precautions, there is often a relatively high incidence of skin disease, and more effective standards of training in personal hygiene and the use of protection systems are needed to eliminate this problem.
CHAPTER III

ERGONOMICS IN THE TEXTILE INDUSTRY

Introduction

The ILO has displayed its interest in ergonomics for some years past, both as regards machine design and the adaptation of the working environment to human needs. For example, in October 1967 it organised an international symposium in Prague in conjunction with the Czechoslovak Medical Society on "Ergonomics in Machine Design", which covered not only the psychological physiological and anthropological aspects of the question but also the relationship between man and machine and the application of the principles of ergonomics to machine design and production organisation. The papers and other contributions submitted to this symposium were published in two volumes of the Occupational Safety and Health Series.¹

Similarly, the ILO organised in collaboration with the Italian Accident Prevention Institute a symposium on ergonomics and physical environmental factors in Rome in September 1968. The subjects discussed at this meeting included the problems caused by vibration, noise, electro-magnetic radiations, smells, lighting and climatic conditions. The papers submitted to the symposium have been published in another volume of the above-mentioned series.²

The applications of ergonomics to work in general and more particularly the adaptation of the environment to the worker are closely followed by the ILO, and it will be recalled that at its 57th Session in 1972, the International Labour Conference adopted a resolution on the contribution of the ILO to the protection and enhancement of the environment related to work. In this resolution, the Conference requested the Governing Body of the ILO to instruct the Director-General, inter alia, "to ensure that in the Programme of Industrial Activities prominence is given to new problems of the working environment arising in the different branches of the economy".

Definition

Ergonomics as it relates to work in industry, can be defined in terms of the man, the task and the environment. In the ideal system, the demands of the task are matched with the optimum performance of the man. The environment is controlled to allow both man and machine to function efficiently.

The ideal situation may not be achieved in practice for various reasons. Economics determine the availability of new or modernised buildings and of new machinery. Knowledge and policy may influence


the standard of environmental control and the efficient utilisation of manpower. Where economy is the limiting factor, it is necessary to differentiate between the basic requirements of ergonomics and advanced development. Where knowledge is lacking, there is a need to recognise the basic biological and physical factors which are involved with the man, his task and the environment.

The performance of the man can be considered from his ability to carry out his task, maintain an even body temperature, replace energy used and recover from fatigue. There are many areas in which each of these topics interact, but for convenience they can be discussed under the separate topics of machine design, lighting, the thermal environment and the arrangement of working hours.

With present-day knowledge, it is possible to give optimum criteria for many of these aspects; those given here mainly apply to the normal, fully-developed adult. The physical capacity of the man differs from the physical capacity of the woman. This applies to his anthropometry (body size), his endurance and his strength. The young operative and the man nearing retirement are likely to fall outside the optima quoted. In all groups, there are likely to be individuals with exceptional abilities and as many with disabilities (in terms of visual acuity, colour vision, intelligence, sensory co-ordination, and so on).

**Ergonomics in machine design**

The performance of man as a machine operative depends upon his physical capacity to cope with the demands of the task. His main functions are to receive information and to control. To achieve this he maintains physical contact with his task by movement within the work area and controls directly by applying force and indirectly by communication. His ability to function efficiently is related to his visual accuracy, his body size and his muscular activity.

In the man-machine system, the man is a flexible component within fairly wide limits. The machine, by comparison, is predictable but inflexible. For this reason, the activity of the man is dictated by the machine. To achieve efficiency, the machine is designed to match the physical capacity of the operator. The main design features relate to the physical size and arrangement of the machine, the visual presentation of data and the provision of controls.

**The task.** The role of operative in a conventional cotton spinning mill can be used to illustrate the important points. The task is to ensure a continuous flow of material from bale breaking to blending, cleaning, carding, drawing, twisting, spinning, winding and finally despatch.

The operative achieves this by:
- starting and stopping machines;
- selecting speed (where appropriate);
- feeding and doffing;
- transfer of intermediate product.
There are associated tasks of piecing broken ends plus preventive and corrective maintenance. The factors involved are vision, body size and posture.

Presentation of data. Action in these tasks is initiated by presenting information to the operator. The need for presentation, other than that of an over-all visual appreciation of the task, increases as the workload and size of the working area increase. This applies particularly to the operative of several machines, some of which are out of sight at any one time. In this case, the operative requires information on the performance of the machines which are hidden from view.

The following general principles can be applied to the presentation of data for these tasks:

Visual warning: This can be remote from the machine to which it applies. It can take the form of a single coloured lamp which is either on or off and should be located within 30 degrees of the centre of vision.

Audible warning: This should be a readily discernible sound, distinguishable from emergency or other sounds.

Visual indication: Quantitative readings can be presented by a pointer on a dial or by digits shown in a window. The choice of indication which is most suited to a particular job is determined according to the information required. This may be -

- Qualitative - circular dial with pointer;
  - straight dial with pointer.
- Quantitative - counter.
  (steady)
- Quantitative - circular dial with pointer.
  (changing)

It is not possible here to detail all design considerations which relate to these methods of display. In general, the mistake rate will be least where the following criteria are satisfied:

The display is simple and without error.
The scale divisions match the accuracy required.
The scale and digits are clearly readable.

Control: Machine control can be exercised by hand or by foot and in either case, the normal muscular requirement should be well within the maximum ability of the operator. For manual operation, control can be exercised through one of four devices: button, switch, lever and wheel. These can be applied to the task as follows:
<table>
<thead>
<tr>
<th>Main requirement</th>
<th>Method of control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed of action</td>
<td>Knob</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Large crank, push button</td>
</tr>
<tr>
<td>Force</td>
<td>Small crank, push button, hand wheel</td>
</tr>
<tr>
<td>Range of movement</td>
<td>Lever - across, vertical</td>
</tr>
<tr>
<td></td>
<td>Push button</td>
</tr>
<tr>
<td></td>
<td>Rotary selection switch</td>
</tr>
</tbody>
</table>

Compatibility: Errors in control can be reduced by matching the direction of the display to the movement of the control. A movement of a control to the right should move a pointer clockwise (for a dial) or vertically (for a straight indicator). Dials and controls which are inter-connected should be located together on the control panel. Controls should be stressed to eliminate accidental movement.

Location of controls: The spatial arrangement of machinery and controls should be matched with the anthropometry of the group of men and women employed. The relevant dimensions can be determined by direct measurement or by reference to published data. The main considerations are height and arm reach and the position of the visual field. The following principles apply:

1. Stooping, kneeling or crouching positions should be avoided.
2. The seated position is preferable to the standing position.
3. Hand controls should be placed comfortably within reach.
4. The spacing of controls should allow for rapid location and manipulation.
5. The position of dials should be within the natural visual field for either the standing or seated operator.

Posture and seating. The need for matching the seat to the occupant is greatest for the operative who sits for long periods at his task, but the individual who moves around his working area also requires to sit to reduce stress on his legs.

The main considerations are the height of the seat, its length, the backrest and the surface area. Seats with adjustable dimensions can obviously be used to accommodate different individuals where extreme differences of body size exist.

Biometrical studies have now put the relevant data at the disposal of specialists in industrial design and of the research departments of industry. However, the shape of the seat and other characteristics should also adapt to the particular requirements of the work and the layout of the workplace.
Lifting and moving. Such tasks as feeding and doffing require operatives to lift packages and transfer products between working areas. During these tasks, an increased load is exerted on the vertebrae of the spinal column. The risk of damage to the vertebrae is greater when the back is rounded and as the load increases.

For frequent or continuous work, lifting and carrying of loads should be done under proper supervision. International standards for such work, with regard in particular to training, medical examination and maximum weight, have been laid down in the ILO Convention No. 127 and Recommendation No. 128 already mentioned. In order to prevent excess fatigue and accidents, appropriate training, particularly in modern kinetic methods of handling loads, is of paramount importance.

Thermal environment

Man needs to maintain his internal body temperature within narrow limits. He achieves this by conserving body heat or by losing it to his surroundings. In the acclimatised man, excess heat is lost by normal physiological changes in his peripheral blood flow (through vessels close to the body's surface) and by evaporative heat loss (sweating). In cold conditions, he maintains body temperature by reduced peripheral circulation and by involuntary muscular activity (shivering). In both cases, heat transfer is effected by convection, radiation and, to a lesser extent, conduction. Comfort conditions at rest are more difficult to maintain than during physical activity. Heavy work at high temperatures rapidly exceeds the capacity to lose heat by physiological methods. Fatigue and stress under these conditions can be reduced by adjusting work and rest periods to assist cooling and recovery.

The most important environmental factor relating to thermal comfort and thermal stress is temperature. This controls the exchange of heat by convection (from the air) or by radiation (from the surroundings). The effect is modified by air movement and the amount of water vapour in the atmosphere (relative humidity, RH). Hence, thermal discomfort can be felt in conditions of acceptable temperature if extremes of air movement and relative humidity exist. Similarly, high humidity increases stress at high temperature by preventing heat loss through sweating.

Comfort in the light tasks. The lightly clad operative who is employed on a task requiring low energy expenditure is not exposed to heat stress. He may, however, experience discomfort due to temperature, air movement and humidity. Optimum temperatures for thermal comfort vary between countries, between the sexes and between summer and winter. For any one individual at rest, the zone of optimum comfort spans only 2-3°C. As an example, the comfort zone for the average British subject is as follows:

<table>
<thead>
<tr>
<th>Temperature</th>
<th>15-20°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air movement</td>
<td>25 cm/sec.</td>
</tr>
<tr>
<td>Relative humidity</td>
<td>50-70 per cent.</td>
</tr>
</tbody>
</table>

The values can be modified by habitual differences in clothing and domestic temperature.
The response of most individuals can be predicted by combining the above factors to form the effective temperature which can be used as an index of warmth. The optimum effective temperature spans a range of 2-4°C. The upper limits for American and British subjects are:

<table>
<thead>
<tr>
<th></th>
<th>USA</th>
<th>Britain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summer</td>
<td>22.8°C</td>
<td>17.2°C</td>
</tr>
<tr>
<td>Winter</td>
<td>21.7°C</td>
<td>21.7°C</td>
</tr>
</tbody>
</table>

Optimum effective temperatures for hotter climates can rise to 27.2°C.

The wide variation between hot and cool climates shows the need to apply criteria which are appropriate to a given working population. In every situation, the temperature at head height should be cooler than at the feet. The temperature at floor level should be high enough to avoid cold feet. The velocity of air currents should be kept below 30 metres/min (100 ft/min) to avoid complaints of draughts.

Continuous work in moderate to heavy tasks. Many processes in the textile industry require operatives to work continuously in a warm environment with high humidity. This can be achieved with the normal rest periods, provided excess body heat can be lost by evaporative cooling. The tolerable limit is expressed in terms of three indices below:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>Effective temperature</td>
<td>27.5°C</td>
</tr>
<tr>
<td>Heat stress index</td>
<td>30</td>
</tr>
<tr>
<td>Wet Bulb Globe Thermometer (WBGT) index</td>
<td>30°C</td>
</tr>
</tbody>
</table>

The literature on the subject suggests that the use of these limits for average industrial operations will prevent heat stress provided the following factors are considered:

1. Clothing can increase stress, equivalent to increasing the wet bulb temperature of 1°C for every kilogram weight.

2. Ageing can result in greater strain for a given environment.

3. Physical fitness: increased effort due to physical disability will induce greater strain.

4. Acclimatisation can result in great improvement in the physiological response to work in heat. The reverse also applies.

5. Physique: stress is more likely to occur in fat people.

6. Sex: differences due to weight of outer clothing and undergarments may be of importance.

7. Fever is detrimental if the individual starts work at an elevated temperature.
8. Nutrition: a normal balanced diet may need to be supplemented with salt in the case of unacclimatised workers.

The effect of the total thermal load on an individual can be estimated by the indices of heat stress, i.e. Effective Temperature (ET); Heat Stress Index (HSI); Predicted 4-hourly Sweat Rate (P4SR); Wet Bulb Globe Thermometer index (WBGT).

The environment of most textile processes has a relatively unimportant radiant heat component and the first three measures above can be applied.

Refreshment: heat stress is likely to affect operatives if continuous daily work is done at temperatures in excess of 28°C for heavy, 31°C for medium-heavy and 35°C for light work. Where work involves heat stress, it is necessary to provide refreshment to replace fluid and electrolyte loss in sweat. Small quantities of liquid should be taken every 10-15 minutes. Sweetened tea or coffee and water are suitable. The drinks should be warm and should be readily available at the workplace. Iced drinks, fruit juices, alcohol and milk are not recommended for refreshment in hot environments.

Arrangement of working hours

There is a normal biological requirement for the alternation of periods of work, rest and sleep. In this way, a balance is achieved between energy spent at work and the recovery of biological resources. Periods of intense physical activity which exceed the optimum work rate cause physical fatigue. This leads to an immediate fall in efficiency in the short term and to a progressive decline in performance in the long term. Periods of inactivity and boredom also lead to a short-term fall in efficiency.

To achieve optimum efficiency, the duration of work, rest and sleep periods is matched to the normal biological requirement. Work periods are shortened as the energy expenditure increases. The job content is arranged to provide sufficient activity and stimulation to maintain the operator in an alert state.

The need for rest depends upon the energy used. The basic energy expenditure of the adult male, with no occupational commitment, is around 1,700 kcal/24 hours. Occupational activities require additional energy, so that for heavy work the energy expenditure may rise to 5,000 kcal/24 hours for men and 3,000 kcal/24 hours for women.

To determine the need for rest pauses, the work can be considered in two categories: light to moderate, and heavy.

Rest pauses (light to moderate tasks). There is a need to punctuate all tasks, even of low energy expenditure, with a minimum number of rest periods. This reduces boredom and allows recovery from mental fatigue.

Most work requires 20-30 per cent of the working day to be given to rest. This includes spontaneous rest, which appears more frequently in strenuous jobs; disguised work of a necessary but secondary nature; work-conditioned pauses created by the timing of the task; and prescribed pauses which are planned as part of the working day.
The prescribed rest pauses should be organised in short periods which occur most frequently towards the end of the morning and late afternoon (or according to shift time).

Where work-conditioned pauses are frequent, it may be acceptable to reduce the number of prescribed pauses, provided the over-all effect is beneficial.

For work of medium intensity, one pause in the first half of the shift and one pause in the second half of the shift, each of 10-15 minutes' duration, can be recommended. This applies where work-conditioned pauses occur in the course of the task.

For work of high intensity, without conditioned pauses, there is an additional requirement for one or two five-minute pauses during each half of the day.

Light refreshment should be available during the longer rest periods.

Rest pauses (heavy tasks). Continuous daily work can be achieved with an energy expenditure of up to 5 kcal/min provided suitable rest periods and refreshments are available. Where this is exceeded, there is a limit to the time for which work can continue, due to the onset of physical fatigue. When work ceases, there is a long period of recovery before the physiological processes return to a pre-work level. The more severe the task in terms of rate of energy expended, the longer the recovery period.

The maximum daily work rate under normal conditions should not exceed 2,400 kcal/day. When this limit is exceeded, it is likely that impaired health and reduced working efficiency will follow.

Time at work. Prescribed rest periods can only have the desired effect if they are planned within the framework of an eight-hour working day. This can be viewed as a basis for achieving a satisfactory level of efficiency. Deviations from this should be viewed in relation to the demands of the task. For intense and heavy tasks, regular daily working hours in excess of eight can be expected to result in lower hourly output through a slowing of working speed and a reduction of performance. While there is an approximate relationship between total daily output and daily work time, in practice, the relationship is constant only for the first eight hours. Between eight and twelve hours, the slowing of the work rate due to fatigue outweighs the effect of more hours at work. A similar fall in hourly output can be expected from regular overtime work. This may also be accompanied by increase in absence due to sickness and accidents.

For less intense and light tasks, increased daily working hours are tolerable, provided the total hours worked compare favourably with the over-all concept of the 40-hour, 5-day week.

Shift work

The timing of the conventional working day is related to the hours of daylight and to biological fluctuations of the human system. Body temperature varies throughout the 24-hour day, being highest in the afternoon and lowest during the normal hours of sleep. Metabolic
rate, oxygen uptake, urine production and the excretion of urinary electrolytes follow a similar pattern.

These diurnal rhythms are an integral part of the man-machine system and logically the hours of work and rest should correspond with the periods of high and low biological activity. With shift work, the matching of these factors becomes impossible. It becomes necessary to avoid stress which may arise in the individual who is unable to adapt to the work regime.

Inversion of diurnal rhythm. Body temperature and the excretion of urinary electrolytes can be monitored in order to establish the extent to which the normal rhythm can adapt to interchange of the normal times of work and rest. The inversion of body temperature can occur in some individuals engaged in active night work within six days. Partial adaptation occurs in others while some show no adaptation. The period of reversion varies between one and three days.

Choice of shift. In the light of these findings, it is apparent that there is no single criterion which can be applied to the benefit of all operatives. However, the rapid reversion to a normal diurnal rhythm can be used as a basis for choosing shift systems which will induce minimum biological stress.

On this basis most stress can be expected with the week on-week off nights. In this case, the man is regularly starting a shift with his biological rhythm in a state of reversion.

The month on-month off nights would be preferable, since the man starts three of his four weeks in an "inverted" state. The facts also favour the short shift of two or three days. In this case there will be insufficient time for inversion to occur and reversion will be unnecessary when changing from night shift to day shift.

Selection of shift personnel. There is as yet no reliable biological basis on which to select people for work on one or other shift systems. There is evidence that a voluntary transfer of personnel occurs when individual incompatibility occurs. This can arise through sleep difficulties which has been found, in one investigation, in the youngest age groups. It is not uncommon to find some individuals who, by comparison, can adapt themselves to continuous work on night shift and who prefer to do so.

Shift work and well-being. A number of recent investigations on this aspect have failed to find any occupational disease which arises directly as a result of shift work. Those who are unable to adapt to a shift pattern are susceptible to adverse effects in the long term. This can be prevented by: selecting workers who are known to adapt on the basis of experience; transfer to other work those who develop difficulties; providing a social structure which meets the requirements of a shift system.

Lighting

The ergonomics of machine design is directed partly at the visual presentation of data to the operator. He in turn receives the information and acts according to his experience and training. The operator normally has binocular sight within a wide visual field.
This allows him to judge distance between objects. He can distinguish between coloured objects and is able to differentiate between surfaces of different brightness. The ability to perceive colour is limited to the visible spectrum, having greatest sensitivity with green and yellow and least with violet and red. The eye can focus upon close objects to within certain limits, and upon distant objects by its ability to accommodate.

Light of the visible spectrum is necessary for the eye to perform its function of seeing. This falls upon the eye either directly from natural or artificial sources or indirectly by reflection from the surroundings. Coloured lights transmit selected wavelengths and similarly coloured objects reflect light of selected wavelengths. The accuracy of vision is proportional to the intensity of light to within certain limits. The eye is disabled in dimly lit conditions and most accurate under optimum conditions of light intensity. The eye is disabled by glaring light which may be seen at source or by reflection.

In industrial situations generally, the requirement for illumination of the task ranges from 200 to 600 lux, a measure of illuminance in lumens per square metre. A task of normal difficulty requires 400 lux, and high levels of 900 to 3,000 lux are necessary for severe tasks requiring great accuracy and prolonged attention. Casual seeing requires a minimum of 100 lux.

The minimum illumination requirement for many textile tasks is not unduly exacting. The preparation of raw cotton up to the spinning process requires a minimum of 200 lux. Weaving and associated tasks require levels of 400 up to 1,300 lux for inspection tasks.

These criteria allow operatives to see the task reasonably well, provided they have normal vision and provided the wavelength distribution approximates to that of white light. Levels of light should exceed these criteria by 50 per cent where contrasts and reflectances are abnormally low or where protective goggles are worn. Older people of 50 years and above may benefit from increases of 50-100 per cent. Further increases may result in a marginal improvement in visual acuity which is not justified on economic grounds.

The ratio of minimum to maximum illumination over areas for which reasonably uniform illumination is desirable should not be less than 0.7. This should be used to determine the need for supplementary lighting in existing installations and to determine the placing of artificial lights in new installations.

Where adjacent, inter-connected areas have a widely different lighting requirement, the transition from one area to the other should be gradual.

Existing lighting installations which meet the criteria for reasonable visual performance are likely to need detailed correction. This may be necessary for the correct utilisation of natural daylight, the control of glare, and the use of contrast and colour. Where possible, all these factors should feature in the basic design of new installations.
Daylight. Where there is shift working, full artificial lighting will be needed during the hours of darkness. This may obviate the need for windows, provided their secondary function of providing natural ventilation can be satisfied by mechanical methods.

Where natural lighting still plays a major role in providing levels of illumination for the task, the position and area of windows should be related to floor area and based upon the daylight factor. For top lights, this should be not less than 5 per cent. Side lights are unlikely to provide working values over the whole internal working area.

Dependence upon windows for lighting creates problems of solar heat gain, heat loss and glare. Solar heat gain can be effectively reduced by the use of external slatted blinds, but the resultant decrease in illumination may necessitate supplementary lighting. Blinds can also be effective in reducing direct glare. Heat loss can be effectively reduced by the use of double glazing and internal screens.

It will be appreciated, from what has been said, that dependence upon windows for natural lighting and ventilation produces problems which are mutually antagonistic. This fact favours the windowless factory, provided all the associated environmental requirements can be satisfied.

Glare. Excessive brightness in the visual field produces inability to see accurately. This condition occurs in bright light from windows and from bright unshielded light fittings. Since the cause is excessive light intensity, reduced visibility persists as long as the visual field remains unchanged. The problem is most apparent to the operative who is orientated for long periods towards the offending source(s). Local supplementary lighting should be completely shielded from view. Windows should be fitted with blinds or with tinted screens.

General lighting which is provided by fluorescent luminaires is unlikely to cause disability glare, but discomfort glare can exist due to imbalance in the brightness and area of ceiling lighting.

Where fluorescent luminaires are used, they should be orientated across the field of view rather than along the field of view.

Bright sources which are not directly visible can create glare by reflection from polished surfaces in the task area or in the field of view. This can be reduced by applying a matt finish to the areas concerned. The application of this to interior surfaces is generally considered to be good working practice.

Contrast and colour. The reflectance and colour of the surfaces of the working area can be used to focus attention on the task and also to provide visual relaxation.

The task should have a higher reflectance than its immediate surroundings and it should be more colourful, i.e. higher on the Munsell Chroma scale. Backgrounds with colourful patterns are likely to be distracting. Where supplementary lighting is used on the task, the luminance of adjacent surfaces should not differ by more than 3:1.
Services such as steam, water, air, electricity and gas can be identified by colours which give suitable contrast with adjacent surfaces. Fire escapes and safety appliances can be identified in a similar way.

The distribution of light and its colour are important factors where surface, shape and colour are features of the task. Modelling with shadows can be used to reveal shape and surface texture. Side lighting is the principle employed. Colour matching is influenced by the colour rendering of the light source. The lamp should be chosen according to the requirements of the task.

Maintenance. The illumination of the working area can be expected to decrease with time due to the ageing of lamps and the accumulation of dirt on lamps and windows. There will also be a decrease of reflectance of interior decorated surfaces.

Action should be taken to correct the situation when routine lightmeter checks show a 20 per cent deficiency compared with the minimum service requirements. The frequency of cleaning and redecoration will depend upon local conditions, but annual cleaning of lamps and interior surfaces should be a minimum requirement.

Ageing filament and fluorescent lamps can be replaced on the basis of luminance of intensity checks. Attention should also be given to effects which are peculiar to fluorescent lamps. One effect appears as end tube flicker, which produces discomfort and distraction in susceptible operatives. This can be reduced by shielding the ends of the tube. The other effect appears as stroboscoping, where moving parts of machines appear to move slowly, to be reversed or to appear stationary. This effect can be reduced by installing pairs of tubes, each of which is connected to a different phase of the mains supply.
CHAPTER IV

SERVICES FOR SAFETY AND HEALTH

The task of anticipating and reducing risk to textile workers is constantly changing. Any activities involving the identification of hazards, the monitoring of changes and the policing of regulations can be said to provide a service.

These services have been developed to help protect the operative against the hazards of his industrial life and are affected by the balance between union and employer. They are also conditioned by the close associations, economic as well as physical, within industry. Factors such as these affect the arrangement and scope of a safety, health and welfare service, whatever the country. In one, a union establishes a dental clinic for its members, while in another a company and its employees build a rest and rehabilitation centre. On one hand, an industry joins with its unions to run a convalescent home, while on the other, a national trade union centre sponsors a medical research unit. One State may be totally involved in a national health and welfare service and another may be only selectively involved.

Limiting factors on the provision of services

Employers, as owners of undertakings creating hazards, are in the best position to control them. In any enterprise run for profit and in competition with similar bodies, the organisation of safety and health controls can have what has been described as "a material effect on overhead expenses". The average employer tends to adopt the standards customary in his particular sphere.

Worker attitudes towards safety, to quote one source, "leave a great deal to be desired ... in the struggle for wages and conditions, safety and health (are) often sacrificed". Productivity bargaining threatens safety standards and, lacking technical knowledge and legislative power, the worker is often restricted to suggesting amendments to the proposals of others. There is however at present a growing awareness among workers of the importance of safety and health at the place of work, and consequently more active participation on their part in the tasks of assessment and control.

The State is conscious of its role in industry and, within the prevailing political climate, can vary the level of its involvement from minimal to substantial. Many governments tend to avoid binding legislation as far as practicable, leaving a great deal to persuasion, education and exhortation. They make suggestions and support joint consultation, which in terms of safety, health and welfare services is extremely important. Great differences exist, therefore, from one country to another as far as the organisation of activities in the field of occupational safety and health is concerned. Quite a number of services contribute to these activities, but the practical results are also dependent on the quality and extent of the resources at their disposal and the active participation of the interested parties. As an example of the variety of these services - and of their impact on the various aspects of safety and health - the following list is indicative of the kind of bodies and competences involved.
Factory Inspectorates

The services rendered to the textile industry by a factory inspectorate are valuable, but in a number of countries the number of inspectors remains low and the yearly number of establishments visited tends to decrease. In the United Kingdom, for instance, textile factory inspections showed the following coverage: 1956 = 85 per cent.; 1960 = 82 per cent.; 1968 = 75 per cent.; 1970 = 67 per cent. This is due mainly to the increasing range of duties and responsibilities of the factory inspectorates at a time of industrial expansion and increased workload following the extension of safety and health legislation.

Workplace safety organisations

This may be compulsory or voluntary. In the first case, it may be limited to basic requirements such as first aid, carrying out of inquiries, designation of advisory safety officers, or be more comprehensive and require safety and health committees at the managerial level. In the second case, it generally takes the form of agreements regarding factory safety, health and welfare committees. These committees usually have the task of ensuring that statutory safety requirements are observed, visiting the workplaces and making recommendations, promoting safety education, supervising safety training, particularly of new entrants, studying accident cases and accident records, etc.

Occupational health services

There is a general trend, in both industrialised and developing countries, towards the provision of occupational health services to an increasing number of establishments. These follow in general the principles and requirements laid down in ILO Recommendation No. 112, which has provided a recognised pattern for these services. Their tasks are generally the assessment of the effects of work on health, recognition of occupational hazards, early detection of effect of exposures, emergency treatment, medical assessment of new entrants, periodical examinations, etc. In a growing number of countries, such services are organised under statutory requirements, while in others they are created on a voluntary basis and provide a varying range of services.

Research bodies

Some of these research bodies are statutory (e.g. the British Medical Research Council), while others are attached to laboratories, hospitals or universities. Research centres are also organised within national bodies working specifically on accident prevention and occupational health at the country level (e.g. the research centres of the National Institutes for Accident Prevention in Italy and France).

Notification and compensation

These are generally statutory requirements. Through the timely notification of occupational accidents and diseases, a body of knowledge is assembled concerning the relevance of a given
occupational risk or exposure. These facts allow for statistical studies, provide the basis for improving accident prevention techniques and regulations, lead to the revision of standards for workmen's compensation provisions, etc. Requests for compensation usually set in motion investigation procedures which among others ascertain the degree of application and the efficacy of preventive measures. It may be noted that making claims for damages under workmen's compensation has long been a feature of trade union activity. By this, the trade union is meeting two main requirements: (a) putting pressure on employers and their insurers to reduce risks and (b) providing financial compensation where workers are disabled. Claims also create case law from which evidence can be used when seeking to change legislation or provide grounds for regulations.

Joint committees

In a number of countries, a variety of joint committees have been set up, both at the local and at the national level, either on a statutory or on a voluntary basis. They may be bipartite or tripartite, depending on the circumstances, and are concerned with various problems relating to a specific industry, including the textile industry. Among the subjects that they keep under review are usually those related to accident prevention and industrial hygiene. In certain countries, there are joint committees dealing specifically with occupational safety and health aspects in the textile industry.

Other employers' and workers' activities

In some countries, both the employers' organisations and the trade unions have set up working groups or advisory bodies with a view to studying occupational safety and health problems arising in the textile industry. This is for instance the case in the United Kingdom, where unions have been involved in work on noise, industrial deafness, byssinosis, etc. and the Confederation of British Industry maintains a standing committee on health and safety.

Safety and health institutions, voluntary associations

In a certain number of countries, there are accident prevention institutions organised on either a statutory or a voluntary basis. Some of these are essentially educational bodies and their main contribution to safety and health is through improved education and information. Others put at the disposal of individual enterprises more specific technical services, and provide help in organising accident prevention activities or assessing occupational risks, and give technical advice concerning safety and health problems, safety education and ergonomics.

The growth of the voluntary movement has played an important part in the general understanding of occupational risks and appreciation of improved working standards. This work is supported by subscription or by grants, and sometimes by fees for services rendered. Many institutions especially university departments contribute specific studies of particular problems.
As with other safety, health and welfare services, there is often a lack of co-ordination, some duplication of effort, and an absence of attention to some problems. But without their publications, training activities, seminars and conferences, and the technical services they are able to provide, the task of increasing safety awareness and promoting safer working conditions would be much more difficult.
SUGGESTED POINTS FOR DISCUSSION

On the basis of the information provided in the present report and Committee members' own experience of occupational safety and health problems in the textile industry, the Committee may wish to examine the question of occupational safety and health in the industry with a view to:

(a) identifying and assessing the main occupational safety and health problems, both present and foreseeable, characteristic of the textile industry;

(b) suggesting the preventive action, both statutory and technical, that should be taken at the undertaking and national levels;

(c) recommending a programme of action which the ILO could undertake in order to encourage and assist member States in implementing these preventive measures.

Should the Committee take this view, the discussion might lead to a statement of the practical measures that could be taken at the undertaking, industrial, national and international levels. In such a case, the discussion might be based on the following points:

1. What are, and in the foreseeable future will be, the main problems facing the textile industry as regards:
   (a) safety and accident prevention;
   (b) occupational hygiene, including physical environmental factors, and as regards occupational health hazards and their prevention;
   (c) ergonomics and the adaptation of the job to the worker?

2. In each of the above cases:
   (a) what measures should be taken at the plant level;
   (b) what measures should be taken at the industry level;
   (c) what measures should be taken at the national level;
   (d) what part can be played by official bodies, employers' associations, workers' organisations and accident prevention institutions in order to make these measures fully effective?

3. What action could be undertaken by the ILO in order to assist member States in developing these measures and to encourage their application?