HIGHER PRODUCTIVITY AND A BETTER PLACE TO WORK

Practical ideas for owners and managers of small and medium-sized industrial enterprises

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International Labour Office
Geneva
HIGHER PRODUCTIVITY
AND A BETTER PLACE TO WORK
The International Programme for the Improvement of Working Conditions and Environment (PIACT) was launched by the International Labour Organisation in 1976 at the request of the International Labour Conference and after extensive consultations with member States.

PIACT is designed to promote or support action by member States to set and attain definite objectives aiming at “making work more human”. The Programme is thus concerned with improving the quality of working life in all its aspects: for example, the prevention of occupational accidents and diseases, a wider application of the principles of ergonomics, the improvement of the content and organisation of work and of conditions of work in general, a greater concern for the human element in the transfer of technology. To achieve these aims, PIACT makes use of and co-ordinates the traditional means of ILO action, including:

- the preparation and revision of international labour standards;
- tripartite meetings between representatives of governments, employers and workers, including industrial committees to study the problems facing major industries, regional meetings and meetings of experts;
- action-oriented studies and research;
- clearing-house activities, especially through the International Occupational Safety and Health Information Centre (CIS); and
- operational activities, including the dispatch of multi-disciplinary teams to assist member States on request.

This publication is the outcome of a PIACT project.
Preface

This manual shows how to take simple, effective, low-cost action which raises productivity while improving conditions at the workplace. Owners and managers of small and medium-sized enterprises will find useful ideas on key topics such as the handling and storage of materials, lighting, work-station design, safe and efficient machine operation, plant layout and work organisation. These ideas are based on the actual experience of hundreds of owners and managers of small and medium-sized enterprises who have participated in training programmes organised by the ILO. The emphasis is on practical, locally appropriate measures directly related to productivity.

Workers also benefit from action based on this manual. Low productivity and poor quality of work often result from the same difficulties and lack of organisation that make work hazardous and unpleasant. Moreover, in those factories where management develops a long-term commitment to improvements in productivity, the involvement of workers is part of the strategy of motivation and change.

We are indebted to many individuals and institutions for ideas and examples used in this book. The entrepreneurs who allowed us into their factories and who contributed their practical knowledge and enthusiasm were essential. The training events could not have occurred without the help of employers' organisations, productivity centres, training institutions and labour inspectorates. We are grateful to the following for substantial contributions: Mr. Allan A. Gibb, Director, Small Business Centre, Durham University Business School, United Kingdom; Mr. David Gold, Training Officer, Occupational Safety and Health Branch, ILO, Geneva; Dr. Peter Hasle, Occupational Health Service, City Council of Copenhagen, Denmark; Mr. Juan Carlos Hiba, Laboratorio de Ergonomía Aplicada, Universidad Nacional de Rosario, Argentina; and Ms. Gabriele Trah, Conditions of Work and Welfare Facilities Branch, ILO, Geneva. Finally, the organisation of notes, handouts, sketches and other assorted scraps of paper and their various revisions into a final text would not have been possible without the patience and skill of Mrs. Susan Chevalier.

This Action manual is accompanied by a Trainers’ manual which describes innovative ways of organising training events. Both manuals are intended to meet an important gap in the existing literature concerned with productivity and conditions at the workplace. We hope that they will be found useful in practice.
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Introduction

If you own or manage a small or medium-sized factory, you are responsible for an important contribution to the national economy. People depend on you for jobs and for your products. Most of the growth in almost every country is expected to come from enterprises like yours.

In spite of their importance, many small or medium-sized businesses fail to grow and even to survive. It isn’t easy to succeed in business. Problems of finance, production and marketing lead thousands to bankruptcy every year.

This is a book about survival and growth through building a more effective enterprise. The ideas you will find in this book are practical and low-cost. Many of them may already be applied in your own enterprise and in similar companies nearby.

As an entrepreneur, you are no doubt very busy. You have to face so many problems that you may not have had time to take a close look at some parts of your operation to see if they can be improved. There are probably a number of limits on productivity and quality which have built up over time. A small investment of your time could have a big impact.

What this book is about

The practical ideas you will find here are the result of several years of ILO action in co-operation with owners and managers just like you. In each case, the starting-point was a concern for survival and growth of the enterprise. Many entrepreneurs were asked the question, "How can you reduce costs and improve your production operations?" Their answers are probably a lot like yours, such as to:

- minimise waste of raw materials;
- cut damage to work items;
- increase quality of work;
- improve maintenance and repair of machines and equipment;
- introduce more efficient layout;
- cut idle machine time;
- reduce wasted time of workers;
- reduce stocks;
- allow more efficient change-over to new products;
- prevent accidents;
- introduce better work methods;
- organise more effectively.

A second question was also asked, "How can workers help?" It is no surprise that workers could improve in many ways, including:

- learning more skills;
- paying more attention to productivity and quality;
- taking better care of machines and equipment;
- avoiding absences and lateness;
- keeping the company’s interests in mind;
- using proper work methods and organisation;
- working harder;
- adapting faster;
- following rules;
- meeting quotas and standards;
- being more disciplined and co-operative;
- avoiding accidents;
- making useful suggestions.

An enterprise which can constantly reduce costs, increase productivity and improve quality is much more likely to survive and grow. This means that you need to:

- make the best possible use of your facilities, machines and equipment; and
- get the highest level of efficiency from your workers.

Neither of these goals is simple to accomplish. There are constant problems to be solved in a small or medium-sized factory. You may have to cope with inappropriate machines; too small a building; problems with electricity, water or transport; poor-quality raw materials; and unskilled or poorly motivated workers.

This book indicates some basic principles and gives many examples of improvements which have a direct impact both on your production facilities and operations and on the motivation and efficiency of your workers. The improvements are low-cost, concrete and very practical. They fall under the following headings:
- **Materials storage and handling.** The storage and handling of parts and products is an essential part of all production processes. Done efficiently, it ensures that work flows smoothly and helps to avoid many delays and bottlenecks. However, storage and handling by themselves are not a source of additional value or profit. During these operations, goods do not acquire any new qualities. Just the opposite happens: materials are damaged or deteriorate, capital costs must be paid and accidents occur. For the entrepreneur, improved materials storage and handling mean recovery of misused space, less production time spent searching for tools and materials, lower capital costs due to less work-in-progress, simplified inventory control, fewer unnecessary operations and a better overall factory appearance.

- **Work-station design.** Most work is carried out at work-stations where workers perform the same task hundreds of times per day. The benefits from small improvements are thus multiplied many times. Awkward work postures and movements mean lower productivity and quality as well as greater fatigue. Simple improvements such as jigs, fixtures, stable work-surfaces or placing tools and materials within easy reach can have large payoffs.

- **Productive machine safety.** While no one wants accidents to happen, machine safety is often ignored because it is seen as costly or inefficient. This applies to workers as well as managers. However, using techniques such as modern feeding and ejection devices, it is often possible to increase productivity while at the same time eliminating the hazard. Where guards must be used, they need not be costly and above all they need not reduce productivity.

- **Control of hazardous substances.** Hazardous substances of one form or another can be found in almost all small and medium-sized enterprises. Exposure to many chemical substances causes fatigue, headache, dizziness and irritation of eyes and air passageways, resulting in a reduction of productivity and quality and increased absenteeism and turnover of staff. High levels of dust, oil, paints and other sprays, etc., interfere with efficient operations, require extra inspection and cleaning and may spoil materials or final products. Through simple and inexpensive means, it is possible to control most of these problems.

- **Lighting.** Better lighting and related visual improvements very often increase productivity and reduce difficulties and strain for workers. This is especially important for rapid or detailed work or for quality products. Better lighting does not need to mean higher cost. Use of daylight and regular cleaning and maintenance can improve lighting while reducing the electricity bill.

- **Welfare facilities and services.** Welfare facilities are an essential part of any enterprise. During each working day, workers need to drink water or some other beverage, eat meals and snacks, wash their hands, visit a lavatory, and rest and recover from fatigue. Welfare facilities are not something extra, nor a luxury to be attended to when all other conditions are satisfied and productivity is high. Good welfare facilities are essential to higher productivity. They improve the workers’ health, morale, motivation, job satisfaction and attendance.

- **Work premises.** Most small enterprises are located in buildings which were not carefully designed for their current use. In addition, new equipment is often placed wherever there is the most space, which gradually results in a haphazard layout. Much can be done, even with older buildings, to improve ceilings, walls and floors. The impact of simple measures on ventilation, heat and pollution can be dramatic.

- **Work organisation.** Improvements in the way production is organised and scheduled can have a very large impact on both productivity and motivation. Modern work organisation techniques such as recombining tasks, setting up buffer stocks, introducing multitasking, developing group work-stations and using product-based organisation have numerous advantages. These include smoother and more efficient work flow, higher product quality, greater flexibility, reduced down-time of expensive machines and reduced need for supervision. These techniques are a source of dangerous competition from large companies: their introduction makes the smaller enterprise more likely to survive and grow.

In addition to these eight technical themes, this book contains two chapters which are practical tools to help you identify improvements and take action. Chapter 2 is a checklist designed to introduce you to the technical subjects and to suggest practical ideas for improvement. Chapter 11 completes the book with a procedure for the systematic implementation of improvements, especially complicated or difficult ones. It also explains how improvement can become a permanent process in your company, not just a one-time measure.

**How to use this book**

Some of the entrepreneurs using this book will be participants in courses organised by employers’ organisations, productivity centres, labour ministries.
or other agencies. They will be able to go through the chapters in an organised and systematic way and will have an opportunity to move very quickly to a continuing process of making improvements and profiting from them.

If you are using this book by yourself, you should try to arrange to develop some of the opportunities provided by the courses. One of the best ideas is to work together with other owners and managers of similar enterprises. This will allow you to get free advice, to learn how others have solved the same problems you have, to see other enterprises in action and in general to benefit from the knowledge and experience of people you can respect because they have successfully built up their own company. You may be able to find a group of five to eight owners and managers through a trade organisation or chamber of commerce, among neighbouring enterprises or among your friends. If you can organise a small action group you should try to follow these basic steps:

1. Carry out the checklist exercise (Chapter 2) in each enterprise in the group. Discuss the results together and let each owner come up with a list of priority actions.

2. Discuss together each of the technical chapters (Chapters 3 to 10) and see if you can improve on your list of actions.

3. Ask each group member to try out one of the more complex improvements in this list in the way suggested by Chapter 11 on the implementation of changes. Discuss the results as a group.

4. Carry out improvements on your list. Meet with the group occasionally to talk about problems and new ideas.

It may seem to you that organising a group is a lot of effort and that you would be better off to spend the time in your own factory. You will be surprised how many good ideas can come from practical people like you who look at your factory and production methods with a fresh eye. You will also find that helping other owners and managers based on your own experience is often enjoyable.

If you cannot organise a group of people like yourself, you can still profit from the ideas in this book. Use the checklist, study the chapters, try out some improvements and then repeat the process. Change and improvement are dynamic. If you stop, you will lose what you had. If you continue, you will consolidate and build on what you have already accomplished.

One final point: it is always a good idea to be in touch with a trade association, productivity centre or government agency or other source of information and support. If you have followed a course they have organised, try to continue to benefit from follow-up and other activities. If you are working alone or in a small group, you may still be able to get technical help. If you feel that courses should be organised, suggest that a local agency or institute take a look at the Trainers’ manual which accompanies this Action manual. They may be interested in setting up a programme which can expand your possibilities for action and growth.
Checklist

The checklist found in this chapter is a powerful tool for identifying improvements which can be made in your enterprise. The items it contains are ideas for action, not simply areas to check for possible problems. Most of the ideas are simple and can be easily applied. More information on each point is found in the following chapters.

The checklist should be filled out individually. It helps a great deal if several people fill the checklist out separately and then discuss their responses as a group. If you are taking a course, these group discussions will be part of the programme. If you have organised your own small group, make photocopies of the checklist to give everyone a chance to use it in each enterprise. If you are working alone, consider asking supervisors or some of your workers to fill out the checklist and discuss it with you. It is an effective suggestion scheme.

Once the checklist has helped you to identify improvements in your workplace, use the rest of this book to learn how to design and introduce improvements. The chapters follow the same order as the checklist.
Checklist

How to use the checklist

1. If you are not looking at your own company, you will need some general information. Ask the owner or manager any questions you have. You should learn about the main products and production methods, the number of workers (male and female), the hours of work (including lunch break, other breaks and overtime) and any important operational or labour problems.

2. Define the work area to be checked. In the case of a small enterprise the whole production area can be checked. In the case of a larger enterprise, particular work areas can be defined for separate checking.

3. Read through the checklist and spend a few minutes walking around the work area before starting to check.

4. Read each item carefully. Look for a way to apply the measure. If necessary, ask the owner or workers questions. If the measure has already been applied or it is not needed, mark NO under "Do you propose action?" If you think the measure would be worth while, mark YES. Use the space under REMARKS to put a description of your suggestion or its location.

5. After you have finished, look again at the items you have marked YES. Choose a few where the benefits seem likely to be the most important. Mark PRIORITY for these items.

6. Before finishing, make sure that for each item you have marked NO or YES, and that for some items marked YES you have marked PRIORITY.

Materials storage and handling

1. Clear everything out of the work area which is not in frequent use.

   Do you propose action?
   □ No   □ Yes   □ Priority

   Remarks

2. Provide convenient storage racks for tools, raw materials, parts and products.

   Do you propose action?
   □ No   □ Yes   □ Priority

   Remarks

3. Use specially designed pallets to hold and move raw materials, semi-finished goods and products.

   Do you propose action?
   □ No   □ Yes   □ Priority

   Remarks

4. Put stores, racks, work-benches, etc., on wheels for easy handling.

   Do you propose action?
   □ No   □ Yes   □ Priority

   Remarks

5. Use carts, movable racks, cranes, conveyers or other mechanical aids when moving heavy loads.

   Do you propose action?
   □ No   □ Yes   □ Priority

   Remarks
## Work-stations

<table>
<thead>
<tr>
<th></th>
<th>Action</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6</strong></td>
<td>Put switches, tools, controls and materials within easy reach of workers.</td>
<td>Do you propose action? &lt;br&gt;☐ No  ☐ Yes  ☐ Priority</td>
</tr>
<tr>
<td><strong>7</strong></td>
<td>Use lifts, levers, or other mechanical measures to reduce the effort required by the worker.</td>
<td>Do you propose action? &lt;br&gt;☐ No  ☐ Yes  ☐ Priority</td>
</tr>
<tr>
<td><strong>8</strong></td>
<td>Provide a stable work-surface at each work-station.</td>
<td>Do you propose action? &lt;br&gt;☐ No  ☐ Yes  ☐ Priority</td>
</tr>
<tr>
<td><strong>9</strong></td>
<td>Use jigs, clamps, vices or other fixtures to hold items while work is done.</td>
<td>Do you propose action? &lt;br&gt;☐ No  ☐ Yes  ☐ Priority</td>
</tr>
<tr>
<td><strong>10</strong></td>
<td>Adjust the height of equipment, controls or work-surfaces to avoid bending postures or high hand positions.</td>
<td>Do you propose action? &lt;br&gt;☐ No  ☐ Yes  ☐ Priority</td>
</tr>
<tr>
<td><strong>11</strong></td>
<td>Change work methods so that the workers can alternate standing and sitting while at work.</td>
<td>Do you propose action? &lt;br&gt;☐ No  ☐ Yes  ☐ Priority</td>
</tr>
<tr>
<td><strong>12</strong></td>
<td>Provide chairs or benches of correct height with a sturdy backrest.</td>
<td>Do you propose action? &lt;br&gt;☐ No  ☐ Yes  ☐ Priority</td>
</tr>
</tbody>
</table>

## Productive machine safety

<table>
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<tr>
<th></th>
<th>Action</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>13</strong></td>
<td>Attach proper guards to dangerous moving parts of machines and power transmission equipment.</td>
<td>Do you propose action? &lt;br&gt;☐ No  ☐ Yes  ☐ Priority</td>
</tr>
</tbody>
</table>

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*Notice: This document contains a table with rows for actions, columns for proposing actions, and options for no, yes, and priority. The table also includes a section for remarks.*
14. Use safety devices which prevent operation of machines while the worker’s hands are in danger.

Do you propose action?
☐ No  ☐ Yes  ☐ Priority
Remarks

15. Redesign guards which interfere with visibility, production or maintenance.

Do you propose action?
☐ No  ☐ Yes  ☐ Priority
Remarks

16. Use mechanical devices or magazines for machine feeding to avoid hazards and increase production.

Do you propose action?
☐ No  ☐ Yes  ☐ Priority
Remarks

17. Make sure machines are well maintained and have no broken or unstable parts.

Do you propose action?
☐ No  ☐ Yes  ☐ Priority
Remarks

18. Substitute hazardous chemicals such as organic solvents with less hazardous substances such as caustic soda or soap.

Do you propose action?
☐ No  ☐ Yes  ☐ Priority
Remarks

19. Make sure that all organic solvents, paints, glue, etc., are in covered containers.

Do you propose action?
☐ No  ☐ Yes  ☐ Priority
Remarks

20. Introduce or improve local exhaust ventilation.

Do you propose action?
☐ No  ☐ Yes  ☐ Priority
Remarks

21. Make sure workers exposed to dangerous substances wash their hands with soap before eating or drinking and that they wash and change clothes before going home.

Do you propose action?
☐ No  ☐ Yes  ☐ Priority
Remarks
22 Provide adequate numbers and appropriate types of protective goggles, face shields, masks, earplugs, safety footwear, helmets or gloves.

Do you propose action?
☐ No ☐ Yes ☐ Priority

Remarks
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

23 Instruct and train workers about proper use and maintenance of personal protective equipment and regularly monitor its use.

Do you propose action?
☐ No ☐ Yes ☐ Priority

Remarks
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Lighting

24 Add skylights and keep skylights and windows clean.

Do you propose action?
☐ No ☐ Yes ☐ Priority

Remarks
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

25 Paint ceilings white and walls in light colours and keep them clean.

Do you propose action?
☐ No ☐ Yes ☐ Priority

Remarks
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

26 Provide general artificial lighting adequate for the type of work done, by adding light sources, installing reflectors, or repositioning existing lights.

Do you propose action?
☐ No ☐ Yes ☐ Priority

Remarks
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

27 Reduce distraction and eyestrain from glare by shielding or repositioning lamps, by using matt instead of shiny surfaces or by positioning workers so they do not face bright light from windows or other sources.

Do you propose action?
☐ No ☐ Yes ☐ Priority

Remarks
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

28 Provide local lighting or adjustable lamps, especially for precision work.

Do you propose action?
☐ No ☐ Yes ☐ Priority

Remarks
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

29 Clean and maintain light fixtures and replace bulbs regularly.

Do you propose action?
☐ No ☐ Yes ☐ Priority

Remarks
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
**Welfare facilities**

**30** Provide an adequate supply of cool, safe drinking water in all workplaces.

**Do you propose action?**

- [ ] No  
- [ ] Yes  
- [ ] Priority

Remarks

**31** Provide regularly cleaned sanitary facilities close to the work area, including soap for washing and separate toilets for women.

**Do you propose action?**

- [ ] No  
- [ ] Yes  
- [ ] Priority

Remarks

**32** Provide a separate, comfortable and hygienic place for meals.

**Do you propose action?**

- [ ] No  
- [ ] Yes  
- [ ] Priority

Remarks

**33** Provide storage for clothing, bicycles or other personal belongings.

**Do you propose action?**

- [ ] No  
- [ ] Yes  
- [ ] Priority

Remarks

**34** Provide first-aid equipment and train a qualified first-aider.

**Do you propose action?**

- [ ] No  
- [ ] Yes  
- [ ] Priority

Remarks

**Premises**

**35** Improve the heat protection of the building by backing metal walls and roofs with insulating materials.

**Do you propose action?**

- [ ] No  
- [ ] Yes  
- [ ] Priority

Remarks

**36** Increase natural ventilation by having more roof and wall openings, windows or open doorways.

**Do you propose action?**

- [ ] No  
- [ ] Yes  
- [ ] Priority

Remarks

**37** Move sources of heat, noise, fumes, arc welding, etc., out of the shop or install adequate exhaust, barriers, screens or other solutions.

**Do you propose action?**

- [ ] No  
- [ ] Yes  
- [ ] Priority

Remarks

**38** Provide enough fire extinguishers within easy reach and be sure workers know how to use them.

**Do you propose action?**

- [ ] No  
- [ ] Yes  
- [ ] Priority

Remarks
<p>| | | | | | |</p>
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<tbody>
<tr>
<td>39</td>
<td>Provide at least two unobstructed ways out of every floor or every big room.</td>
<td>Do you propose action?</td>
<td>□ No □ Yes □ Priority</td>
<td>Remarks</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Clear passageways and provide markings or barriers to keep them clear. Keep them clear for movement of people and materials.</td>
<td>Do you propose action?</td>
<td>□ No □ Yes □ Priority</td>
<td>Remarks</td>
<td></td>
</tr>
<tr>
<td>41</td>
<td>Eliminate frayed, irregular, entangled or octopus wiring connections.</td>
<td>Do you propose action?</td>
<td>□ No □ Yes □ Priority</td>
<td>Remarks</td>
<td></td>
</tr>
<tr>
<td>42</td>
<td>Eliminate tasks by using machines which can combine operations.</td>
<td>Do you propose action?</td>
<td>□ No □ Yes □ Priority</td>
<td>Remarks</td>
<td></td>
</tr>
<tr>
<td>43</td>
<td>Keep workers alert and reduce fatigue through frequent changes in tasks, opportunities to change posture, short breaks, opportunities to talk with other workers, or music.</td>
<td>Do you propose action?</td>
<td>□ No □ Yes □ Priority</td>
<td>Remarks</td>
<td></td>
</tr>
<tr>
<td>44</td>
<td>Use buffer stocks to keep work flow constant while allowing self-paced work.</td>
<td>Do you propose action?</td>
<td>□ No □ Yes □ Priority</td>
<td>Remarks</td>
<td></td>
</tr>
<tr>
<td>45</td>
<td>Use quality circles or group work to improve productivity and quality.</td>
<td>Do you propose action?</td>
<td>□ No □ Yes □ Priority</td>
<td>Remarks</td>
<td></td>
</tr>
<tr>
<td>46</td>
<td>Rearrange layout and the order of operations to improve production flow.</td>
<td>Do you propose action?</td>
<td>□ No □ Yes □ Priority</td>
<td>Remarks</td>
<td></td>
</tr>
</tbody>
</table>

**Work organisation**
Materials storage and handling

The storage and handling of raw materials, components and products is an integral part of all production processes. Done efficiently, it can ensure that work flows smoothly and helps to avoid delays and bottlenecks. However, storage and handling by themselves are not the source of additional value or profit. During these operations, goods do not acquire any new qualities. Just the opposite happens: materials are damaged and lose their value, accidents occur and scarce capital is tied up in unnecessary stock.

In this chapter we discuss ways of attaining three goals:
- Better organised storage.
- Fewer and shorter transport and handling operations.
- Fewer and more efficient heavy lifting operations.

In each of these areas you will find ideas arranged according to a few basic rules. If you apply these ideas in your enterprise, you can expect numerous benefits, including recovery of space for production, more efficient materials flow, faster capital turnover, improved inventory control, reduction of time lost on unproductive work and a more orderly and attractive factory.

Better organised storage

If in doubt, take it out

Extra stock is a waste. It requires storage, record keeping and handling. It ties up capital, and some materials tend to rust, spoil or become obsolete.

Leaving stock around in the production area reduces the space available for production operations. The more cluttered your shop-floor is, the more likely tools and materials will be lost. Workers spend valuable time looking for things.

Consider each tool, each piece of raw material, each component or spare part. Is it in use? Is it really needed? If not, take it away.

Some of the most modern and efficient industrial enterprises practise "kanban" or "just in time" inventory methods. Nothing is to be in the production area until at most one hour before it is needed. If you want to compete, you should be willing to try the same ideas.

Figure 1
A cluttered shop-floor.
Figures 1 and 2 show the same work area before and after unnecessary items were removed. Do you feel the change has contributed to efficiency? To quality? Is it likely to make a better impression on customers?

**Avoid placing materials on the floor**

The owners of small enterprises often complain about the shortage of space in their workshops. But if we take a critical look, very often almost half the floor space is occupied by work items, tools, raw materials and scrap. Some of these goods have been sitting there for years, getting rusty and dirty.

Are we so rich as to tolerate the luxury of wasting half our production space? To face constantly the danger of accidents and fire? To bear the expenses of extra handling and of damage to materials?

The best way to stop this bad habit is to *prohibit placing anything on the floor* and to *monitor strictly the execution of this rule*.

The rule by itself is not likely to work unless special storage is made available for each item. It is not difficult to obtain or to make wooden pallets, supporting bars, containers, storage racks and shelves.

**Figure 3**
- (a) Storage rack for metal pieces and rolls of wire.
- (b) Wooden support frame for heavy metal bars.
- (c) Container for scrap and rubbish.
Save space by introducing multi-level racks

Here are some examples:

Figure 4
Vertical rack. Metal rods and bars of different profile can be stored efficiently in a limited area or near the job. Tray-type shelves provide room for small pieces.

Figure 6
Horizontal bar rack. This free-standing unit may be used singly to store short pieces or two of these racks placed in line to store long pieces.

Figure 5
Metal and scrap rack. In this free-standing storage unit, the front section \( (a) \) slopes and has a number of compartments for storing angle iron, flats and bars. The back section \( (b) \) provides room for vertical storage of full-length metal sheets. Cut sheets can be stored in the centre section \( (c) \) on the shelves.

Figure 7
Multi-level horizontal storage rack for metal sheets or plywood. Remember to keep everything dry, otherwise water tends to spread between the sheets and damage them.

The total wall space can be larger than the floor area of your production shop. Multi-level racks help you to use it fully. This means:
- savings in floor space;
- easy accessibility of work items and tools;
- improved inventory control.
A wall cabinet for tool storage. Made of wood panels and equipped with four locking doors, it provides easy access to any tool and takes an absolute minimum of floor space.

Shelving designed to use wall space fully.

Multi-storey racks for relatively light metal bars, rods and tubes.
Figure 11
A metal storage rack can be fitted to the wall at any point and used for storage of metal rods and bars of various lengths.

Figure 12
An open-front rack designed to provide frontal access to the materials stored.

Provide a "home" for each tool and work item

Observe your production process closely and it is very likely that you will find that some of your workers lose time in search of "lost" tools, instruments and small work items. Even if you urge them to put everything in order, in a few days you will find the same problems as before unless care is taken to allocate a special, permanent place and a holder or a container for each tool or work item.

Consider the size, shape and weight of the item in order to choose the most appropriate means and place of storage.
Figure 13
Simple home-made flat tool storage makes it easy to control inventory and to find the required tool quickly.

Figure 14
The outline of each tool should be drawn to show where it goes. This helps maintain order and immediately shows if anything is missing from the tool board.

Figure 15
Tool inserts are ideal for storing tapes, drills, cutters, etc., in sloping storage units varying in depth and width. Labels can be fitted on the front side of the cross beams.

Figure 16
Rotating bins. Revolving shelves eliminate wasted space usually found at the back of a shelf. This is very appropriate for servicing a group of operators sharing one work-station.
Figures 17, 18, 19 and 20

Hand bin containers (figure 17) for storage of small parts. The front opening makes the parts easy to see and provides ready access to the stock. The bins can be stacked at the work-bench or placed on special racks (figure 18) or on rotary racks (figure 19) or regular shelves (figure 20).

Fewer and shorter transport and handling operations

Every time a worker handles a work item, time and energy are lost. Analyse your work operations and see whether each handling operation is really justified. If not, find a way to eliminate it.

The number of handling operations is of course closely related to the number of different tasks in the production process. It is also related to the order in which machines and work-stations are placed around the shop. These subjects are part of the overall organisation of production and layout of your factory. They are covered in Chapter 10 because you will need to take into account the ideas from several chapters before you are ready to make complex improvements in work organisation.

However, there are several things which you can do to improve handling operations without making any major organisational changes.
Figure 21
Placement of tools in accordance with frequency of use. (a) Before. (b) After.
The more you use it, the closer it should be.

In the next chapter, on work-station design, we will see how to ensure that all frequently used tools are in easy reach of the worker. However, it is frequently impossible in practice to place all tools and materials at the work-station where they will be used.

The way to resolve this problem is to rank all tools and work items in order of frequency of use and to allocate their places accordingly. The ones which are used continuously should be placed on the work-bench or suspended, so no time and effort is lost in reaching them. Less frequently used tools and materials can be placed on shelves and racks next to the work-station. Tools needed only once or twice a day can be held in central storage.

Use mobile storage

Even after you have removed everything which is unnecessary from the shop-floor, you will have a large number of items which need to be moved between work-stations or between storage areas and work areas. Often this is done in a haphazard way, which can mean many extra trips and loose inventory control. If you think about handling at the same time that you design your storage arrangements, you can achieve the following:
- fewer materials handling operations;
- less idle machine time;
- increased layout flexibility;
- reduced physical strain and injuries;
- simple, effective inventory control;
- reduced damage to work items;
- cheaper and more efficient housekeeping.

A good first step is to **design pallets or containers to move several items at the same time**. Often this is not done because the goods to be moved are shaped oddly or because they are easy to damage. But if you involve your workers and think it over carefully, solutions can be found.

Pallets, containers or racks on wheels can be easily moved from one work-station to another or to the warehouse. To save storage space, the racks should be standardised and it should be possible to stack them.

**Figure 22**

A pallet for round, easily damaged parts. In this example, each pallet holds seven items and can be stored on a shelf. They can be stacked on a cart when they are needed on the shop-floor.
A movable storage rack with multiple uses. This carrier for storage pallets allows them to be fitted either horizontally (a, b, c) or at a 45° angle (d). Each pallet is designed to accommodate different types of work item.
In many cases, it is worth while to invest in designing special movable racks for different work items. This helps to utilise rack capacity more fully and make handling easier.

Figure 24
A flat two-sided movable rack, a real “space saver” for a small factory with narrow passages, can be successfully used for many types of work-piece.

Figure 25
A mobile bin cart helps to ensure smooth work flow in assembly shops where numerous operations are performed at each work-station.

Figure 26
A rack on wheels specially designed for storage and handling of motorcycle silencers.

Figure 27
An easy-to-move tool cart provides orderly storage and protection of tools and instruments.

Make your equipment easy to move to where it is needed

In small enterprises, workers can often be seen going back and forth from their usual workplaces to a temporary work-station, such as a heavy unit being assembled or a machine being repaired. At the temporary work-station they lack tools, equipment and materials. They may also lack a proper work-stand or bench.
Much improvement can be attained by introducing tool carts, trolleys, cylinder trucks or mobile work-stations, or even by putting some machine tools on wheels.

Figure 28
A tool trolley with adjustable shelves occupies little space, but contributes much in improving the efficiency of automobile mechanics and machine tool repair workers.

Figure 30
A small mobile repair bench enables maintenance and repair workers to be self-sufficient at any place on the shop-floor.

Figure 29
A cylinder truck with cylinder retainer chains. A divider makes handling safer.

Figure 31
A mobile work-station for a metalworker.
Fewer and more efficient lifting operations

Don’t lift loads higher than necessary

Lifting operations are a prime source of accidents, property damage and unproductive costs. It is therefore always better to eliminate lifting whenever possible. Sometimes it’s even worth while to place equipment (for example a metal saw) below ground level in order to avoid lifting heavy items such as metal bars.

Time and effort can be saved by using platforms or lower vehicles so that goods do not have to be lifted during loading and unloading operations.

Figure 32
A support frame with wheels for a machine tool increases production flexibility.

Figure 33
Match the height of the vehicle bed to that of the loading area.
In selecting materials-handling devices and methods of manual carrying, give preference to the ones with a minimum of elevation of the load.

It is not difficult and can be very profitable to design and build special devices for handling different heavy items, as shown below.

**Figure 34**

A heavy-duty sack truck (figure 34), portable gantries (figure 35), and a low-lift pallet trolley (figure 36) are reliable, safe and easy to operate. They provide means of carrying heavy loads a short distance with minimum elevation.

**Figure 35**

This small cart enables one worker to move heavy metal bars.

**Figure 36**

Figures 34, 35 and 36

A heavy-duty sack truck (figure 34), portable gantries (figure 35), and a low-lift pallet trolley (figure 36) are reliable, safe and easy to operate. They provide means of carrying heavy loads a short distance with minimum elevation.

**Figure 37**

This barrel handling device not only makes work much easier but also helps to avoid damaging barrels.

**Figure 38**

This barrel handling device not only makes work much easier but also helps to avoid damaging barrels.
Use of a yoke for carrying loads. Minimum elevation makes the work more efficient and safer.

In designing methods of manual carrying, we should keep in mind the fact that the higher the load, the bigger the percentage of energy is spent on lifting and less on actual transport. The logical conclusion is to make work more efficient by using methods with a minimal elevation of the load over ground level.

You can easily produce simple devices like single- or double-handle tongs (figures 40 and 41). Keep in mind the benefits of minimum load elevation. These devices will help improve efficiency and reduce physical strain, minimise the risk of accidents and eliminate direct contact of workers with the load (in the case of acid batteries, hot iron bars, etc.).
This set of tools helps to ensure safe handling of molten metals at minimum elevation in small foundries. It includes:
(a) a crucible pouring tool;
(b) a crucible pouring rack;
(c) a one-man crucible lifter.

Unfortunately, we cannot always avoid the need to lift heavy goods. Quite often it is necessary to raise loads so that they can be machined or assembled. In such cases we have to see that materials are moved through the production cycle at working height. This minimises the time and energy lost in raising and lowering.

One possibility is to install a suspended or floor-mounted transport system of appropriate height, where heavy loads are moved manually or by gravity between work-stations (figure 43).

Another solution is to employ mobile work-stands (figure 44). Goods in production are fixed on specially designed trolleys and manually moved along the production area. Correct height of the trolley and provision of a rotatable top make it a good substitute for a stationary work-stand. It can be moved to different machines or work areas. This means that parts do not have to be brought to the product — the product moves to the parts.

This system helps:
- to improve the efficiency of materials handling;
- to have greater flexibility in layout and product flow;
- to reduce the risk of accidents.
A passive conveyor line for moving heavy motor castings at working height.

An engine assembly stand. It allows a full 360° rotation of the engine and locks it securely in any position.

A mobile assembly work-stand equipped with a rotating top and storage for tools and parts.

Figure 45
An engine assembly stand. It allows a full 360° rotation of the engine and locks it securely in any position.

Make lifting more efficient and safer

A heavy load suspended in the air is always a danger, especially in a small overcrowded workshop. Preference should always be given to floor-based lifting devices which use the minimum necessary elevation. The figures which follow illustrate such devices.
Overhead cranes and hoists bring hazards to the workshop which may result in serious accidents. Remember that:

- no lifting machinery should be used unless it has been tested by the maker or some other competent person and a certificate specifying the safe working load has been obtained;
- the maximum safe working load should be plainly marked on all lifting tackle;
- lifting machines, chains, ropes and other lifting tackle require regular maintenance and periodic inspection;
- it is important to consult legislation, regulations or the inspectorate for detailed safety regulations.

In addition, always keep the elevation of the load as low as possible.

Figures 47 and 48
Manually powered hydraulic floor cranes with different load capacities, with a solid (figure 47), or telescopic (figure 48) boom.

Figures 49
(a) A lever hoist is simple to operate and extremely versatile. (b) A chain hoist with a self-activating load brake. (c) An electric chain hoist with butterfly control switch for efficient handling of lighter loads.

It has been shown above that it is not economically or socially justified to tolerate manual lifting of heavy loads. Manual lifts should be considered as a last resort in special cases when the application of mechanical means is not feasible.

In organising lifting work, remember that lowering and raising the body weight in taking weights up from the floor (figure 50) increases the energy expenditure by 50 per cent when compared with lifting a weight from 0.5 m. That's why we always recommend platforms for loading and unloading heavy items.
You can help your workers to avoid back injuries by teaching them the correct lifting technique (figure 51). The idea is to keep the back straight and to raise the load, using the muscle power of the legs and the grip of the hands.

Handling of smaller weights should not be associated with lower productivity. It has been proved in practice that maximum efficiency is usually attained with weights below 20 kg. The physical capacity of a woman is about one-third lower than that of a man and her reach is also considerably shorter. Women should not be assigned jobs involving lifting heavy weights above shoulder level.
1. The feet must be far enough apart to give a balanced distribution of the weight.
2. The knees and hips should be bent, and the back kept as straight as possible, with the chin tucked in.
3. The arms should be held as near to the body as possible. This helps to sustain the load by allowing friction between the load and clothing.
4. Lifts should be made smoothly, no jerks or snatches should occur.

Summary
Rules for efficient materials storage and handling

If in doubt, take it out
Avoid placing materials on the floor
Save space by introducing multi-level racks
Provide a “home” for each tool and work item
The more you use it, the closer it should be
Use mobile storage
Make your equipment easy to move to where it is needed
Don’t lift loads higher than necessary
Move materials at working height
Make lifting more efficient and safer
Work-station design

A well-designed work-station is important for productive work. Workers usually repeat similar operations a great many times. If they can do so quickly and easily, productivity will be higher and quality will be better.

A work-station is a place which a worker occupies when performing a job. The place may be occupied all the time or may be one of several places where work is done. Examples are work-stands or work-tables for machine operation, assembly or inspection.

Each work-station presents a unique combination of workers and tasks. It is important to design the work-station with both workers and tasks in mind so that work is done smoothly and without unnecessary disruptions.

Five rules are described below which will help you to raise productivity through better work-station design. In each case, you should be able to design improvements in your own factory using careful observation and common sense. The cost of such improvements is usually very low; the benefits are often important.

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**Keep materials, tools and controls within easy reach**

Time and effort are saved by placing materials, tools and controls (such as switches, levers, etc.) within easy reach of the worker. Long reaches mean a loss of production time and extra effort. "The more you use it, the closer it should be" applies to the work-station as well as to the factory as a whole.

The distance which can be reached easily without leaning forward or stretching is quite small (figure 52). Any object that is frequently grasped or used should be located between 15 and 40 cm from the front of the work-surface.

When materials are supplied in boxes or bins or on pallets or racks, these should be placed within easy reach and at an appropriate height. If several
Figure 53
Placement of tools on the work-table.

Figure 54
Recommended dimensions for most seated tasks.

- Work surface thickness: 5 cm maximum
- Leg clearance: 40 cm at knee level
  60 cm for the feet
- Thigh clearance: 20 cm minimum
- Seat height: 36-45 cm
  (adjustable to each worker)

Work surface height should be around elbow level

65-72 cm
different kinds of material are used, it is often useful to put them in bins placed in front of the worker or on a work-table next to the worker.

Tools or materials used only occasionally (a few times per hour, for example) may require leaning forward or stretching aside, or may even be placed outside the immediate work area without much loss in productivity. The important items are those used regularly as part of a short work cycle (figure 53).

**Improve work posture for greater efficiency**

When a difficult work position is required, work not only takes longer but also leads quickly to fatigue. For example, operations with the arms raised tire the shoulder muscles rapidly. Operations while bending forward or twisting the body can easily cause back strain. The operation time gradually increases and the worker becomes more likely to damage goods or have accidents.

The following measures help to avoid difficult work positions:

- provide a stable, non-wobbling work-surface on which work items can be firmly placed;
- place materials, tools and controls where they can be reached easily by the worker without bending or twisting the body;
- use platforms so that short workers can be at the proper work height;
- provide good chairs of correct seat height and with a sturdy backrest;
- provide enough leg space to allow easy leg movement.

Recommended dimensions for standing and seated work are given in figures 54 and 55.
Leg space and foot space for both sitting and standing workers. Note also the minimum clearances required for the legs, as indicated in figure 56.

The height of places where work is done with the hands is also an important factor. The elbow rule should be applied to determine the correct hand height (figure 57). Most work operations are best performed around elbow level.

In the case of seated work, an exception should be made for precision work. In this case, the object can be raised slightly above elbow level to allow the worker to see the fine detail. In the case of standing work, the hand height should be a little lower than elbow level in some cases (figure 58). For example, in light assembly work or packing of large things, the hand height should be about 10-15 cm lower. When the use of very strong muscular force is needed, an even lower height is appropriate so as to allow the use of body weight.

Work-surface height or seat height should be adjustable according to each operator’s size, for example by using a lift table or a seat with adjustable height. Similar adjustments can be made by placing wooden platforms or stands under tables, work-surfaces or work items. Footrests can also help.

It is desirable to assign work tasks so that the worker can alternate standing and sitting while at work. If the main tasks are done at standing work-stations, then good chairs should be provided for occasional sitting. If the main tasks are done in a sitting posture, then opportunities should be provided for occasional standing, for example to collect materials from storage.

Use clamps, jigs, levers and other devices to save time and effort

Any work operation requires effort. It is important not to waste it just to hold a work item. In many cases, the work can be done more skilfully and efficiently when the hands are free from such efforts. For example, when a lot of force is applied to hold an unstable work item or to raise a heavy tool, effort is wasted.

There are a number of ways to reduce the effort required to operate tools or machines. All these measures allow the worker to use the energy and time saved for productive work (figure 59). Examples are:

- the use of leverage for moving or lifting materials or operating controls;
- the use of jigs, clamps, vices or other fixtures to hold work items while work is done;
- the use of gravity to save effort, such as the use of counterbalances and the use of chutes or rollers;
Figure 57
Elbow rule for hand height.
- minimising vertical movement when work items are moved from one place to another;
- the use of suspended tools which are easily grasped and moved;
- the use of tools adjusted for easy grip and easy handling.

It is always useful to make motions short, easy and balanced. Repetition of simple motions of a short cycle period, however, should be avoided. It is difficult to continue simple repetitive tasks during the whole workshift. In that case, it is useful to combine different kinds of work operation for each worker.

It also should be remembered that smooth, rapid work motions are hindered when the working space is too narrow. This is especially so when there are areas where the hands or feet may come in danger while at work. So it is important to provide enough space around the work position so that the worker can move around without hitting against obstacles or entering dangerous areas.

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**Improve displays and controls to minimise mistakes**

Products and machines are often damaged by mistake. Accidents are also often ascribed to human mistakes. An effective way to avoid such mistakes is to ensure that each worker can see and identify clearly what he or she is working on. This is a basic condition for good work and for avoiding mistakes. The following points are important:

(a) keep things which are seen, touched or controlled (visual displays, materials, switches, etc.) within easy sight of the worker;

(b) make displays and controls easily distinguishable; and

(c) use good lighting (Chapter 7 covers this subject).
Use a specially designed or universal jig or fixture instead of holding an unstable work piece by hand.

Clamps and vices can hold different sizes and shapes of work pieces steady during work and can free hands as well.

Minimise vertical movement or use chutes or other devices to save the worker's time and effort.

Suspended tools are less tiring to use. They also save the time lost in picking up and putting down the tool.

Figure 59
Examples of releasing the hands from unnecessary tasks so that more productive work can be done.
Figure 60
Different display areas in a typical visual layout for a worker.

Figure 61
Arrangement of dials and switches to minimise mistakes.
Good location of frequently used displays is important. Such displays should be placed at an appropriate distance (about 50-70 cm from the eye for those which should be clearly seen) and within the natural line of sight (10-30° downward from the eye level). A typical visual layout of displays is given in figure 60.

Distinguishability is as important as location. For example, a stop switch should be clearly distinguishable from a start switch, an emergency signal from a normal-condition signal. This is helped by:

- using standard layouts for switches, gauges, etc. (grouping mutually related displays and controls using the same on-off directions, placing displays and controls according to easy-to-identify sequences, etc.);
- attaching clearly visible, simply worded labels;
- using different sizes, shapes or colours for different kinds of switches or signals.

In order to improve displays (signals, dials, gauges and other visual devices), it is useful to make it clear what action is expected. An emergency signal should be outstanding in its position and size and should be red in colour. A switch for machine X should be placed near a gauge for machine X or in a position easily understood as related to machine X. Further, displays should be arranged so that indicator positions requiring action are easy to see. Examples are given in figure 61.

Sometimes workers are confused about the direction of operations. This happens with on-off switches or increase-decrease controls. These directions must be made easy to understand according to common sense and local customs (figure 62).

### Summary

**Rules for design of efficient, comfortable work-stations**

- Keep materials, tools and controls within easy reach
- Improve work posture for greater efficiency
- Use clamps, jigs, levers and other devices to save time and effort
- Improve displays and controls to minimise mistakes
Productive machine safety

Machines are essential to modern production. However, along with increased productivity, they have brought hazards into the workplace. Proper control of machine hazards has traditionally been seen as costly and a constraint on productivity. Moreover, it has been observed that the workers may remove guards or refuse to wear personal protective equipment while working with or around machines. It is not surprising that machine safety is a low priority in many enterprises.

This chapter will demonstrate that many negative attitudes concerning machine safety are unjustified. It is often possible to eliminate a machine hazard while at the same time increasing production. Even when guards are necessary, they need not be costly or reduce productivity.

Machine dangers exist at several distinct locations: at the point of operation, where the power is transmitted to machines and around any other moving parts. This chapter will concentrate on the point of operation, which is usually more difficult to protect and is related to productivity. The other hazards, however, should not be neglected.

Give your machines a productivity check

Walk through the plant and take note of the following:

(a) Are there any delays or bottlenecks caused by specific machines?
(b) Do any machines operate slowly because of feeding or ejection?
(c) Is there fear or hesitation caused by dangerous machines or processes?
(d) Are there situations where machine guards have been altered, removed or destroyed?

If you have answered yes to any of the above questions, the remainder of this guide will assist you in dealing with the problems of machine productivity and safety.

Eliminate the hazard; or install guards; or, as a last resort, use personal protective equipment - always in this order

You certainly do not want an accident to occur: they are always linked with financial losses as well as human suffering. However, avoiding accidents in a workshop where many potential hazards are present is not an easy task. You need a well-developed strategy.

The best idea of all is to remove the hazard entirely. Does this sound impossible? This chapter will show you a number of ways in which you can completely eliminate a hazard while increasing productivity. You should always try to find a way to do this, both because it is best for safety and because it gives you the highest return for the time and money you invest.

If you cannot eliminate a hazard, place a guard around it. However, guards must be very carefully designed or they may get in the way. Have any guards in your factory been removed?

It is well known that just providing personal protective equipment does not ensure that it will be used. Even if you put a lot of effort into persuading your workers to use personal protective equipment you cannot be absolutely certain that it will be used properly at all times. We therefore strongly recommend that you use personal protective equipment as a last resort. If you must invest in personal protective equipment, make sure you monitor its constant and correct use.

Remember:
First: Remove or substitute the hazard with a less dangerous machine or process.
If this is impossible: Erect guards around the hazard.
As a last resort: Provide personal protective equipment until the hazard can be eliminated or guarded.

Purchase safe machines

When a new machine is ordered, care should be taken to specify a machine which is safe by construction. Dangerous parts should be situated in a position where they cannot harm the worker. In particular, points of operation should be free from danger.
Manufacturers or sales personnel may recommend a machine without guards to reduce costs. Catalogues may offer unsafe versions at a lower price. Such machines are usually illegal and can cause you many problems once they are installed. You can save yourself a lot of trouble and expense by choosing the right machines.

As you will learn later in this chapter, automatic or mechanical feeding and ejection devices can eliminate risks while greatly increasing productivity. You should always consider ordering a machine with such devices, because the devices are not expensive relative to the total cost of the machine but they make a big difference in production.

You should also make sure that you have a manual for the machine and that any operating instructions and labels are in the correct language and readily available to the worker.

**Use feeding and ejection devices to increase productivity and reduce machine hazards**

The productivity of many types of machine, especially presses and punches, is limited by the rate at which the product can be fed into the machine and removed from the point of operation.

When feeding or ejection devices are not used, the speed of production will be influenced by the speed of the worker, the complexity of the task, the type of guard and necessary safety measures. Without automatic or mechanical feeding and ejection, the worker will be required to place the stock, remove his or her hands for the machine cycle, remove the stock and clear the stock from the machine. Only about 20 per cent of the time will be used for actual machine production. And this does not take into account the removal and replacement of point-of-operation machine guards if they are not automatic. With feeding and ejection devices, productivity can be greatly increased.

However, safety measures must still be considered with feeding and ejection methods. Extreme care must be exercised during machine set-up, when feeding and ejection systems are set up or adjusted, when misfeeds are removed and during lubrication and maintenance. In addition, care must be taken to evaluate properly the dangers of any new feeding or ejection devices.

**Types of feeding and ejection device**

There are a number of different types of machine feeding and ejection device. We will discuss a few simple ones that can be constructed locally.

The basic idea of manual feeding is to make the operator perform the task without his or her hands entering into a dangerous zone. The simplest form of such feeding devices is a plunger (figure 63). The plunger has a die (a slot or nest) into which the stock is placed outside of the point of operation. When the plunger is pushed into the point of operation, the machine is cycled.

*Figure 63*  
Power press with plunger feed.

*Figure 64*  
Power press with carousel feed.
A *carousel type of feeder* (figure 64) based on the same principle can considerably increase the productivity of press operators. As can be seen in figure 64, the feeder provides automatic ejection and collection of finished stock.

A *gravity feed magazine* (figure 65) can be incorporated into the plunger device, thus saving the worker from having to place new stock at each cycle.

There are many other ways to benefit from “free” gravity. In some cases a *simple inclined chute feeder* (figure 66) can be used to move the stock into the dies. Note that in the illustration, a guard protects the operator from the point of operation.

This easy-to-make gravity feeder (figure 67) can double the productivity of grinding operations.

It is easy to see how much time can be saved by a plunger feed with a magazine compared with manual insertion of stock.

There are many other forms of feeding and ejection system ranging from the very simple to the very complex. Some of the easiest to design and install are semi-automatic and use chutes, dials and plungers. Ejection may be accomplished by using a mechanical device, compressed air, or a device that is part of the feeding system.
Use the right type of guard

Machines have different types of action and production requirement. They also have different types of danger. Rotating shafts, wheels, rollers, pulleys and gears can catch clothing or skin and literally pull the worker into a machine. When one part rolls against another, a "nip point" is created where hands or clothing can also be caught (figure 68). The back and forth movement of machines, reciprocating motion, may catch a worker between the moving machine or stock and a stationary object. Direct contact with cutting operations, punching operations, shearing and bending can also lead to serious accidents. It is important to match guards both to the requirements of the machines and to the specific nature of the hazards involved.

Types of machine guard

Fixed guards are simple guards attached directly to the machine or to a stable surface such as a wall or floor. They should be made of strong material and provide protection against flying fragments. Fixed guards at the point of operation should be accompanied by feeding and ejection systems so as not to limit production. Fixed guards should be removable only by using tools.

Interlock guards are at times combined with fixed guards or covers. They may interrupt the electrical or mechanical cycling of the machine if the guard or cover is opened or removed (figure 69). They may also block access to the point of operation just prior to the work cycle (figure 70). Great care must be taken, when a process has inertia, to see that it takes more time to open the guard than the process takes to stop.

Adjustable guards are guards that can be adjusted to suit the size of stock being introduced into the point of operation and still provide a high degree of protection (figures 71 and 72).
Designing machine guards

Here are some helpful points for designing and building machine guards. Guards frequently can be built on the premises at low cost.

- Complete enclosure is preferable to a partial enclosure. A partial guard should be avoided.
- Guards should fit the danger areas as closely as possible. Caution: A moving belt rubbing against a fixed guard can not only damage the belt but may also be a potential source of fire ignition.
- Guards should be combined with feeding and ejection where possible.
- In order not to reduce productivity, guards should be able to be quickly opened and closed for simple maintenance tasks. A hinged guard that is designed to interfere with production if it is opened for maintenance will encourage replacement before operation.
- Guards should leave the operation easy to see.
- Any guard that reduces productivity should be redesigned.

Maintain machines properly

Even with guards in place, a poorly maintained machine can be dangerous. It will also have more breakdowns and quality problems. Proper maintenance is not lost production time, it is an investment in higher productivity and lower repair costs.

Maintenance should also include machine guards. Frequently a worker will remove a guard to clean a machine, change a die, or perform maintenance tasks and lubrication. A guard is also frequently removed because the visibility at the point of operation may be decreased by the guard and the worker cannot monitor the quality of the product. These guards should be inspected, cleaned and replaced. If necessary they should be redesigned.

A machine maintenance programme, carried out by qualified personnel, will reduce the frequency of repairs and reduce the need of the worker to remove guards. The programme should also include daily cleaning of areas necessary for visual monitoring.

When machines are being repaired or when maintenance tasks are being performed, the control mechanisms of the machines should be locked and have a tag stating "DANGER, DO NOT OPERATE".

Two-hand controls. Accidents often happen because workers are expected to insert a work-piece with one hand while operating a switch with the other, and if their timing is ever off, the machine will cycle with their hand inside. A possible solution is to design controls so that two switches or levers must both be operated at the same time by different hands. The worker’s hands must then be outside the machine before it operates.

However, it is not easy to design control buttons or other devices which cannot be operated with one hand, taped or jammed on, pressed with the knee or otherwise circumvented. It is therefore necessary to monitor that such devices are properly used.
If no other method of protection is available, use personal protective equipment.

The very last resort, if the hazard cannot be eliminated and the worker cannot be protected by properly designed guards, is the use of personal protective equipment. However, there are times when the hazards on the job are such that personal protective equipment should be routinely worn.

If personal protective equipment is necessary, only equipment that meets nationally defined standards for specific hazards should be used. As with other equipment, personal protective equipment must be maintained according to manufacturer's instructions, and when it is damaged or worn, it must be replaced.

Summary

Rules for making machines safer and more productive

Give your machines a productivity check
Eliminate the hazard; or install guards; or, as a last resort, use personal protective equipment – always in this order
Purchase safe machines
Use feeding and ejection devices to increase productivity and reduce machine hazards
Use the right type of guard
Maintain machines properly
If no other method of protection is available, use personal protective equipment
Control of hazardous substances

Hazardous substances of one form or another can be found in almost all small and medium-sized enterprises. There are simple and inexpensive ways to control most of the problems. Improvements often result in cost savings and productivity benefits.

A polluted working environment is often harmful to production. High levels of dust, oil, paints and other sprays, etc., interfere with efficient production, require extra inspection and cleaning operations and may spoil materials or final products. There is excellent potential for increasing productivity and quality.

Exposure to many chemical substances causes fatigue, headache, dizziness and irritation of eyes and air passages, resulting in a reduction of productivity and quality and increased absenteeism and turnover of staff. When conditions are improved, labour output goes up.

Many problems of chemical hazards can be solved at little or no cost and there are often savings in materials and energy. This chapter does not cover all problems where protection is required by laws and regulations. Some identification, measurement, evaluation and control measures may need to be carried out by specialised professionals. Contact the local inspectorate or labour institute if you need help.

Replace a dangerous substance with a less dangerous one

Many small enterprises use organic solvents for cleaning and degreasing metal and other materials. Organic solvents are dangerous and expensive.

It may be possible to replace organic solvents with less dangerous substances.

For example in cleaning, oil and grease can normally be removed with a soap-based cleaning solution. A 5-10 per cent solution of soap will normally be less expensive and less dangerous than an organic solvent (figure 74).

Figure 74
Substitute soap or alkalis for organic solvents.
Figure 75
Lids can significantly reduce evaporation.
More complete degreasing can be achieved by using an alkaline substance such as caustic soda (sodium hydroxide) or calcium hydroxide. A solution using one of these substances will normally degrease metal surfaces sufficiently to allow paint to be applied without problems.

To avoid rust, cleaned products should be dried properly and each unit should be stored separately.

Cleaning and degreasing with soap and alkanes will often be less dangerous and less expensive than with organic solvents. Less ventilation is needed (except when alkalis are heated). Respirators are not normally needed, though goggles and gloves should be used with alkalis.

Substances evaporating from open containers or dripping from leaky containers or pipes are direct losses that raise your costs. They also can threaten workers' health.

Fumes from organic solvents, paint or glue can be controlled by using specially built lids to reduce dangerous and wasteful evaporation (figure 75). Enclosure by means of covers also reduces the amount of dust from machines such as lathes and shapers, grinders or mixers.

Poor machine maintenance can also create unnecessary risks and losses. Dripping oil from a lathe or other machine could get on workers' skin and clothes and create a risk of eczema and skin cancer. Such spillages also constitute a loss of expensive oil.

Some risks can be reduced by isolating the processes in a separate room or an enclosed area. Exposure is limited to a few workers who can be given special protection.

**Save energy used to overheat chemicals**

Hot liquids evaporate and concentrate potentially dangerous substances in the air. This occurs when cleaning/degreasing baths containing organic solvents, alkalis and acids are heated; when glues and coating materials are melted; and when electroplating is done. These processes are frequently carried out without knowledge of the appropriate maximum temperature levels. Overheating increases workers' exposure to dangerous chemicals and means that more energy is used while expensive chemicals evaporate.

A thermostat can help you to maintain the lowest appropriate temperature (figure 76). If the use of a thermostat is not feasible, a thermometer can be used together with manual temperature regulation.

**Use lids, covers, maintenance and isolation of processes to control hazards and reduce losses**

Figure 76

A thermostat can reduce energy consumption and evaporation of dangerous substances.
Clean properly - don't spread dust

Dusts originate from grinding, sawing, mixing, packing, spinning and other manufacturing processes. The size of dust particles and the hazards vary.

Dust increases wear and tear on machinery, which thus requires more maintenance. It may also negatively affect the quality of raw materials and finished products. Dust entering the respiratory system can damage the workers' lungs. Some dusts can also be absorbed through the skin.

Dust should be removed regularly. Most dust should be eliminated at the source by exhaust and ventilation devices (such as those connected to grinding machines and circular saws). Residual dust should be removed daily. More comprehensive cleaning should be carried out as often as necessary. This cleaning should include walls, storage racks and other areas where dust accumulates. Dust on windows, walls and lamps will significantly reduce the lighting in the workplace.

Warning: Do not sweep or blow dust away. Sweeping the floor or blowing dust from work-benches and materials with compressed air are commonly used cleaning methods which are dangerous and of little value. Dust containing very small particles does not fall immediately to the floor after being raised by sweeping and blowing. A 0.001 mm particle will only fall 1 m in 3.5 hours in static air. This means that a particle remains airborne most of the working day and can be inhaled (figure 77). Frequently, dust cannot be seen in the air, but the next day it can be found covering the floors, work-benches, machinery and materials.

Effective methods of controlling dust include using a vacuum cleaner and a water spray. When dust is moistened it can be easily removed with a broom or by water pressure.

Make local ventilation cost-effective

Local ventilation should only be considered as a means of reducing chemical hazards when other means have failed. Many enterprises spend a substantial amount of money to install ventilation systems to control dangerous substances. In some cases expensive ventilation systems are purchased and show poor results. Frequently, low-cost measures will achieve equal or better results. A few very practical ideas can be employed.

Use fans properly

Fans may be utilised to remove dangerous substances from the workplace. Contaminated air can be pushed or blown outside through an opening (figure 78). In some cases dust can be blown into a

Figure 77
It will be a full working day before all the small dust particles have fallen to the ground. That's why the use of vacuum cleaning is strongly recommended.
Figure 78
Use of fans to remove contaminated air.
collection hood (figure 79). A few points should be considered:
- There should be no obstacles between the fan and opening. Anything in the way significantly reduces the desired effect.
- The air speed should be low to reduce turbulence.
- Contaminated air should not pass workers on its way to the opening.
- Air expelled from the workplace should not affect people outside the enterprise.

**Use push and pull ventilation**

The capability of exhaust devices, fans or ventilators to remove polluted air is very limited (figure 80). Exhaust systems used in operations such as spray painting, degreasing and welding are often inadequate.

**Figure 79**
Sawdust can be collected using a hood (shown on the left side of the picture).

**Figure 80**
The difference between pushing and pulling air. In (a), air pushed by a fan or blower still has a useful effect quite far from the outlet. In (b), a fan of the same power which pulls air is effective only up to one-tenth of the distance from the outlet covered by (a).
These systems can be improved by using a small fan to push air in the direction of the exhaust fan. The push fan should have a limited capacity (10-20 per cent of the capacity of the exhaust fan will be sufficient). A higher capacity fan will only create turbulence and reduce the effect (figure 81).

Figure 81
Push and pull ventilation.
Use natural air flow

Air temperature influences air movement. Even a few degrees difference can result in considerable movements of air. Heat sources such as boilers, ovens, and furnaces will move air upwards. If a process is releasing dangerous vapours, this natural air movement should be used to remove the vapours. Ventilation systems working against warm air currents will not work properly (figure 82).

Natural air flows such as wind blowing through or around buildings should also be used to advantage. See Chapter 9.
As a last resort, use personal protective equipment

You learned in Chapter 5 that the best strategy is to eliminate the hazard, and if this is impractical to guard (or enclose) it. However, personal protective equipment (PPE) is very often the response chosen to deal with problems with hazardous substances, even though PPE is very expensive, uncomfortable, and workers often refuse to wear it. Even expensive equipment can be useless if it is improperly chosen, maintained or used. PPE should therefore be introduced only when all other means have been exhausted. A few guide-lines can help to ensure that PPE will work effectively and that the money invested is not wasted. Most problems are related to respirators.

- Choose the appropriate protective device according to the specific hazard. The PPE supplier should be able to assist. It is critical to choose the appropriate filter with respirators. Do not use dust filters to protect against vapours. Organic solvent vapours from spray painting, degreasing and similar activities will pass directly through the dust filter (figure 83).
- Choose respirators which fit snugly. There is almost no protection if the respirator is leaky.
- Change the filter regularly. Filters protecting the worker from vapours should be changed every day or more often if needed.
- Wearing filter respirators is very strenuous due to the breathing effort required. The worker will tire more quickly and work performance will decrease. Therefore, filter respirators should not be worn more than three hours a day. If a longer time is required a respirator supplied with compressed air should be used.
- Maintain respirators regularly. Clean and check valves and rubber edges regularly.
- Change damaged gloves. Rubber or plastic gloves should be worn to avoid skin contact with organic solvents, corrosive agents and other substances. It is important to note that some liquids can penetrate rubber and plastic. Inappropriate or worn-out gloves which allow chemicals to penetrate can be more dangerous than no gloves at all.

As you can see, PPE can mean a lot of trouble and expense for poor results. If it is your only way to obey the law, use it and use it properly. But if you can find a better alternative, you will save money and perhaps save your health and your workers' health as well.

Don't eat or bring home dangerous substances

The most serious exposure to dangerous substances is often related to poor welfare facilities. Eating in the workplace has been the cause of many cases of lead poisoning because of contamination of fingers and food. Cases of lead poisoning and asbestos-induced lung cancer have been found among family members, because workers have carried lead or asbestos fibres home in their hair and work clothes. These facts emphasise the importance of good canteens, washing and changing facilities. See Chapter 8.

Summary

Rules for low-cost chemical hazard control

Replace a dangerous substance with a less dangerous one
Use lids, covers, maintenance and isolation of processes to control hazards and reduce losses
Save energy used to overheat chemicals
Clean properly – don’t spread dust
Make local ventilation cost-effective
As a last resort, use personal protective equipment
Don’t eat or bring home dangerous substances
Appendix to Chapter 6

A short introduction to common dangerous chemical substances

Organic solvents

Organic solvents are widely used in industry. They are used to dissolve grease, oil, paint, plastic, glue, and similar substances. They are also used for the cleaning and degreasing of machinery and metal surfaces. They evaporate very fast and can be recognised by their smell and their capacity to dissolve other materials. Common names are thinner, white spirit, naphtha, xylene, toluene, trichloroethylene, acetone.

Organic solvents can be inhaled and absorbed through the skin. Acute effects include fatigue, headache, dizziness and irritation of skin, eyes and air passageways. They can also cause serious long-term effects such as:
- skin diseases;
- chronic brain damage (loss of memory and intellectual capacity);
- abortion and damage to unborn children;
- cancer.

There should be no skin contact with organic solvents. When there is a smell of organic solvents in the air, preventive control measures should be taken. All workers, and especially young and female workers, should be protected against exposure to organic solvents.

Dusts

Many substances can be found in the air as dusts. They can be solid particles, fumes, smoke or liquid particles. A common effect of all kinds of dust is irritation of the respiratory system, which in the long run may develop into chronic lung disease. The concentration of dust is too high when it is clearly visible. Control measures should be taken.

Asbestos is another extremely dangerous type of dust. It is a fibrous material used for insulation, asbestos concrete products (roof plates, pipes), brakes, clutches, fittings and packing. After long exposure, asbestos can cause a lung disease similar to silicosis. Even more frequently, asbestos causes fatal cancer of the lungs and other internal organs.

Metal dusts and fumes are a serious problem. Common toxic metals are lead, chromium, copper, cadmium, manganese and mercury. They can be found in smoke from furnaces or from welding and soldering, in dust from ore or refining, in paint spraying and in dust from grinding metal or paint with metal-based pigments. Metals can cause a wide range of health problems. The more important ones are chronic bronchitis and other diseases of the air passageways; problems of the central nervous system (lead, manganese); and damage to the kidneys (chromium).
Lighting

It is well known that we receive 80 per cent of all information through our eyes. Although the human eye is very adaptable and can allow a worker to work with an absolute minimum of light, bad lighting leads to low productivity and poor quality as well as eye strain, fatigue and headaches for the worker. It has been confirmed by numerous studies that better lighting pays off through higher efficiency. Improvements in lighting conditions conducted in a number of industries have very often resulted in 10 per cent productivity growth and reduction of errors by 30 per cent.

Better lighting does not mean that more light bulbs must be bought and more electricity used. Natural lighting is often better than artificial lighting. The way lighting is arranged and maintained is equally important. For example, a change in the visual background can enable a worker to perform a task efficiently which otherwise would require tripling the lighting level.

You will learn from this chapter how to attain better lighting. There is a good chance that it will be without an increase in the electricity bill, and you may even pay less. But in any case, your business as well as the workers will definitely benefit from these improvements.

First of all, before starting to do anything, we have to decide whether the existing lighting facilities need improvement. Lighting requirements are dependent on three main factors:
- the nature of the task;
- the sharpness of the worker’s eyesight;
- the environment in which the work is done.

For example, a watchmaker needs much more light than an operator in a machine shop. An older worker may need twice as much light as a younger one.

These factors make it difficult to calculate the required level of lighting using instruments and tables. However, we can learn much from going around the workplace, observing the workers and asking them about their visual problems. If workers adopt an awkward posture, with their eyes very close to the work, it is very likely that there is a problem. If there is a naked light in the worker’s field of view, it definitely reduces efficiency.

Your programme of improvements may not have much impact if the workers’ eyesight is insufficient. One study conducted in a factory discovered that 37 per cent of workers wearing glasses needed a new prescription and 69 per cent of those without glasses needed them. The same may be true for your company. That is why we suggest that you conduct an eyesight test for workers. Even if some of the workers do not follow advice about acquiring glasses, you will be aware of the problem and possible reasons for low efficiency.

With these ideas in mind, six rules are provided below which will help you to improve lighting at your factory.

---

**Make full use of daylight**

Natural light is the best and cheapest source of illumination, but very often small enterprises do not make full use of it. Measure the surface area of your shop-floor and your windows and skylights. If you do not have at least one-third as much window surface as floor surface, you are probably not benefiting fully from natural light. Be careful, however: windows and skylights provide heat as well as light in hot weather (and cause heat loss in cold weather).

When thinking about new windows and skylights, remember that the higher the window, the more light it gives. Skylights can give double the light of a low window, even if the low window was not blocked by machines or storage arrangements. If your factory doesn’t have a skylight, consider replacing one roof panel with a translucent plastic panel.

Lack of regular cleaning can result in the loss of 10 to 20 per cent of light, if not more. Special care should be taken about skylights, which are difficult to reach, so no one cleans them.

Well-chosen paint and finishes on the ceiling, walls and equipment can help to cut a lighting bill by one-quarter. At the same time, this helps to produce better visual conditions and a pleasant, cheerful working environment which encourages high standards of cleanliness and housekeeping. Gains are achieved from: lower losses of reflected
light, better light diffusion and reduction of brightness contrast. In order to spread reflected light diffusely and evenly throughout the interior, ceilings should be made as near white as possible. The matt finish of whitewash is very good. To avoid harmful glare, don’t use bright, shiny, gloss paint for walls. Pale colours are better than white. A slightly darker colour below eye level is helpful. Equipment such as machines, work-benches and desk-tops should normally be darker than walls, and their colours should be different from walls and floors so they can be seen easily.

Unless you have a full skylight system, you are likely to have a problem of unequal light distribution over the work area. Take this into account and change the layout of benches or machines in order to minimise shadow zones. Work-stations with high lighting requirements should be moved closer to the windows and possibly be grouped together for the provision of additional lighting.

**Avoid glare**

Glare means especially bright points or areas within the field of vision. Glare is often a reason for low quality and productivity. It causes a reduction in the ability to see, discomfort, annoyance and eye fatigue. Visibility can be considerably improved by elimination of glare without increasing light intensity.

There are two types of glare: direct glare and reflected (indirect) glare.

**Direct glare** is caused by a light source within the field of view (figure 84).

To reduce glare from windows:
- use blinds, curtains, louvers, shades, trees or vines;
- change the windows to translucent instead of transparent;
- change the orientation of work-stations. The workers, instead of facing the light source, should have their sides or backs towards the window.

To avoid glare from lamps:
- no naked light bulbs or tubes should be in the view of the worker;
- deep shades and shields should be employed. The inside edge of the shades should be painted a dark matt colour;
- shades should be mounted either low enough to ensure that all bright surfaces are completely hidden, or high enough to ensure that they are well outside the normal field of view (figure 85).

**Reflected (indirect) glare.** Even if we are protected from direct glare, we can still be bothered by reflected glare. To reduce the distraction from light reflection on polished surfaces such as the sides of a machine, we can:
- change the position of the light source;
- lower the brightness of the source;
- make the immediate background brighter by placing a light-coloured surface behind the task.
Choose an appropriate visual task background

Visual tasks that demand close, continuous attention are performed with much less strain if their background is free from eye-catching distractions. Elimination or screening of potential distractions contributes very much to efficiency and safety (figure 88).

A person engaged on critical assembly work may be seriously distracted by the hand movements of a second worker sitting opposite. A partition up the centre of the work-bench can be a solution. The partition should be low enough to allow visual contact (figure 89).
Figure 89
A low partition helps to avoid visual distraction.

Figure 90
Backlighting.

When the work-piece is small and held close to the eyes a plain background is particularly important. To see clearly the outlines of flat items, use a sheet of light-diffusing glass or plastic which is lit from behind by lamps or reflectors (figure 90).

Here is some general guidance for selecting an appropriate work background:

<table>
<thead>
<tr>
<th>Material</th>
<th>Appropriate background colour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel, cast iron</td>
<td>Cream coloured</td>
</tr>
<tr>
<td>Bronze, copper</td>
<td>Grey-blue</td>
</tr>
<tr>
<td>Light-coloured wood</td>
<td>Dark</td>
</tr>
<tr>
<td>Aluminium, tin</td>
<td>Cream coloured</td>
</tr>
<tr>
<td>Dark wood</td>
<td>Grey-blue</td>
</tr>
<tr>
<td>Ground castings</td>
<td>Light</td>
</tr>
</tbody>
</table>

Avoid prolonged work in an isolated pool of light in the middle of a darkened interior. In such a case, the eye has to readjust every time the worker looks away from the brightly lit workpoint. The result: fatigue and low productivity.

**Find the right place for light sources**

By changing the position of lamps and the direction of light falling on an object, it is possible to improve visibility dramatically without increasing the quantity of illumination. Figure 91 demonstrates how a light can be repositioned for better visibility.

Figures 92 to 94 demonstrate the importance of finding the most appropriate light direction in order to:
- distinguish an object from its background;
- reveal its shape;
- reveal its surface texture;
- enable any marking on its surface to be seen easily.
Figure 91
Repositioning of a light source to improve safety and efficiency.

Figure 92
Light from above and behind. The object is difficult to see and there is often a glare problem.

Figure 93
Light from the side and above. This is better but much of the work item is still in shadow.
The best light usually comes over the shoulder. However, the most appropriate direction for light also depends on the type of work and the arrangement of work-surfaces. Here are some examples of different practical arrangements for long, narrow work-benches with workers on both sides.

For work with flat or small items keep the edge of the lampshade below eye level.

For work with bigger work items, place the light units just above head level and perpendicular to the work-bench.

Figure 97 shows a variation on the above arrangements under which the proportion of light coming from the front, on the worker's left, is increased.

For the above cases, lighting units with two long fluorescent tubes can be recommended. Two switches should be provided on each unit so that the workers can select different lighting levels.
Avoid shadows

Shadows make it difficult to work. It is hard to see into a shadow (figure 98), because the eyes will adjust to the surrounding light. Sharp shadows on the work-surface are a source of poor work quality, low productivity, eyestrain, fatigue and sometimes accidents.

Figure 97
Bench lighting variation.

Figure 99
Direct light.

Figure 98
Sharp shadows make it difficult to work.

Figure 100
A mixture of direct and reflected light provides the best visibility.
Many of the suggestions made so far will help to avoid shadows. If you have made improvements in any of the following areas, you have already reduced shadows:
- more and cleaner windows and skylights;
- light-coloured, matt-surfaced ceilings, walls and equipment;
- layout which avoids shadow zones;
- groups of lights for groups of machines;
- use of reflected light to avoid glare;
- avoiding isolated pools of bright light;
- better light direction.

There is more you can do. For example, you can often improve the quality of lighting considerably by allowing from 10 to 40 per cent of light to escape upwards. In this case, light will be much better dispersed due to reflection from the ceiling. (The ceiling should be reasonably low and not obstructed and should be painted white.)

The openings in the tops of industrial lighting units (as shown in figure 101) allow ceiling illumination, better lamp ventilation and lower dirt accumulation than closed-top units.

For general lighting, it is often true that the higher the lights, the better the uniformity and dispersion of light (see figure 102).

Figure 101
Lighting units with upward openings.
Higher lighting gives better dispersion.

Figure 102
(a) Before
(b) After
If only artificial light is used, the spacing of the lights is very important. Figure 103 gives guidance on how to attain more even lighting conditions.

As was mentioned at the beginning of this chapter, the specific light requirements at workplaces would differ very much depending on the nature of the task as well as on the sharpness of the worker’s eyesight. To compensate for the difference, local lights should be used. Properly arranged local lights not only contribute in quality and productivity but also help to keep lighting expenses low.

Even with the best new lighting installation, it is essential to establish a proper maintenance routine. You may be surprised to learn that without maintenance, in a few months’ time the actual level of illumination could be half of the initial level.

There are a few main causes for loss of illumination.

- Dust or other deposits on lamps. The need for regular cleaning of lamps is often overlooked because dust collects relatively slowly and evenly. Dust which may be absorbing a large proportion of the light is often difficult to detect. The table shows that the type of fitting makes a big difference. If you decide to use a closed-top reflector or fitting, clean it every month.

<table>
<thead>
<tr>
<th>Months</th>
<th>% of illumination loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td>6</td>
<td>25</td>
</tr>
<tr>
<td>9</td>
<td>35</td>
</tr>
<tr>
<td>12</td>
<td>40</td>
</tr>
</tbody>
</table>

- Output from bulbs and fluorescent tubes falls steadily throughout their life. For example, a fluorescent lamp can lose 25 to 30 per cent of its initial output before it burns out. That is why one should consider introducing a system of lamp group replacement at the same pre-determined time. Lamps which are removed need not be scrapped; they may be used in places such as corridors or little-used stores. Some of them can be kept to replace lamps from the next batch which fail early.

- Dirt on windows, skylights, ceilings and walls. A 20 per cent increase in illumination or more can often be gained by regular cleaning of all windows and skylights inside and outside. It is also important to clean ceilings, walls and other interior surfaces.

Figure 103

Recommended spacing for industrial type lighting units. The distance from the work-surface to the light fixture is h. When there is a passageway next to the wall, the fixture should be \( \frac{1}{4} h \) from the wall. When work is done close to the walls, the fixture should also be closer.

\[
\begin{align*}
\frac{1}{4} h & (1.5 \text{ m}) \\
1\frac{1}{2} h & (3.0 \text{ m}) \\
\frac{1}{2} h & (1 \text{ m})
\end{align*}
\]

\[
1 \text{ h} (2.0 \text{ m})
\]
Summary

Rules for better lighting without an increase in the electricity bill

Make full use of daylight
Avoid glare
Choose an appropriate visual task background
Find the right place for light sources
Avoid shadows
Ensure regular maintenance

Figure 104

Combination of general and local lights help to meet specific requirements of different jobs.
Work-related welfare facilities

Work-related welfare facilities are often ignored. Who cares about toilets, first-aid kits, lunch rooms or lockers? What do they have to do with the hard realities of production?

One answer is that your workers care. During each working day, workers need to drink water or some other beverage, eat meals and snacks, wash their hands, visit a lavatory and rest and recover from fatigue. This can be difficult or easy, unpleasant or comfortable, a health risk or an aid to hygiene and nutrition. The essential facilities in your factory show whether you care about your workers as much as you care about your machines. Worker dissatisfaction can be costly.

A more positive reason for better facilities is that extra efforts are often appreciated far beyond the time and money invested. Work-related facilities help workers to overcome problems which are important to them. Let your workers express their priorities for improvements and ask them to take responsibility for the work which is required. You may be surprised at the results.

The small enterprise can be a community where workers are loyal, industrial relations are smooth and morale is high. It can also be a place where workers look for the first opportunity to leave and care little about the owner’s success. Which kind of enterprise do you want?

Make sure essential facilities serve their purpose

Fatigue and disease are enemies of efficient work. Essential facilities are more than just a legal requirement. They can do much to reduce fatigue and maintain health. It is important that the quality of such basic facilities is high: otherwise they can spread disease instead of preventing it.

Drinking water

Drinking water is essential for all types of work. Especially in a hot environment, each worker can easily lose several litres of water per shift. If not provided with drinking facilities, workers become thirsty and gradually dehydrated. This greatly increases fatigue and lowers productivity.

Water kept close to workers will minimise the time lost in going to get a drink. Place water containers near each group of workers, or provide taps or fountains with clean water in a central place. However, drinking water should not be placed in washrooms or toilets, near dangerous machines or other hazards or in places where it can be contaminated by dust, chemicals or other substances.

Whenever there is doubt about contamination, water must be thoroughly boiled or properly filtered or treated. Before starting to use a new water source for drinking purposes, it is very advisable to have it tested. Piped water can be used only when a hygienic water supply is guaranteed. Precautions are needed to make a clear distinction between potable and non-potable water taps. A “Safe Drinking Water” sign should be put up at each applicable tap.

Drinking water vessels should be made from materials that can be easily cleaned. Even if the vessels are filled with fresh water, the water inside, if kept for days, can become unhygienic. It should therefore be changed frequently.

It is also important to make sure that the drinking water is cool. If you cannot afford a water-cooler, place the water in the coolest place in the factory. It should not be left in the sun or in a hot place.

There are several types of arrangement for drinking water. Make sure that yours is appropriate:
- **Water bags or bottles**, for outdoor or isolated workers, are used when no other possibilities are available. They should be hung in a shaded place free from dust and with air circulation around them. They should be cleaned and refilled at least once a day.
- **Drinking water containers** are for production sites or temporary worksites. They should be attended by a designated person. Containers should be of impermeable materials. A cooling device would be an advantage. (Unglazed pottery can be used, due to its unique cooling effect, in dust-free places.) Containers should be provided with suitable covers, and kept in a cool place protected from the sun. The water must be changed frequently.
Ways of providing cool, clean water.

- Drinking fountains for production areas are very advantageous from the hygiene point of view. They can be fitted with a jet or bubbler outlet and/or a goose-neck or other outlet for filling drinking cups. The fountain should be free from sharp angles and designed to prevent unnecessary splashing. Water outlets should be above the rim or overflow level so that they will not be contaminated by waste water. The water outlet should be shielded in a manner that prevents the lips of a drinker from being placed against it.

To avoid the possible spread of infection it is preferable to use disposable cups or to provide separate cups for each worker and to arrange for regular washing. When containers are used, it is important to clean them regularly. Cleaning and any necessary maintenance should be assigned to a specific person.

Sanitary facilities

There are several reasons why an opportunity to wash is important:

- where chemicals or other dangerous substances such as heavy metals are used, washing is needed to prevent chemicals from being absorbed through the skin or being eaten during snacks or meals. It is also important to prevent the worker from carrying the substances home;
- dirt and grime can also be ingested and cause sickness or disease, and they are in any case unpleasant and demotivating;
- washing is required for basic hygiene after using the toilet.

The need for toilets is obvious, even if it tends to be neglected.

Sanitary facilities are required by law. Your choice is either to make them appropriate or to let them become a source of complaints, resentment and difficulties. Neglect is the main source of problems with sanitary facilities, and neglect is not the kind of example you want to give.

Sanitary facilities which are sufficient in number and conveniently located help to avoid long walks, waiting and frustration. The law in your country must be followed, but the following are practical minima:

- one toilet for up to five men and two toilets for six to 40 men;
- one separate toilet for up to five women and two toilets for six to 30 women;
- one wash-basin for every 15 workers.
Figure 106
Low cost washing facilities used in places where there is no piped-in water supply.
(a) Foot washing device.
(b) and (c) Handwashing stands for groups and individuals.

Figure 107
Simple washing facilities.
To ensure quick and proper washing, soap must be provided. This can be ordinary cake soap, or a liquid or powder soap in a special dispenser. A degreasing cream such as waterless or solvent-free hand-cleanser may be required in certain types of factories.

Paper towels, roller towels (or individual towels for each worker) should also be provided. An alternative to towels is an electric hand dryer fixed to the wall. Mirrors and shelves at each washing point and wastebins will assist workers with their personal hygiene as well as help to keep the place tidy and clean.

The design of sanitary facilities makes a big difference in the cost and effort required for cleaning. You should design for easy maintenance just as you would for a machine. Avoid wooden floors and difficult-to-reach corners. Provide proper drainage. It is best to use tiles for walls and floors, or at least to make sure that surfaces are smooth and easy to clean. If you do not use tiles, choose the paint carefully. Porcelain is best for washbasins, toilets and urinals.

Be ready for emergencies

Accidents happen. Emergencies can include cuts and bruises, eye injuries, burns, poisoning, and electric shocks. Even in enterprises which seem safe, many types of injury (such as falls) can occur. Every enterprise should therefore have a well-stocked first-aid box and at least one person present at all times of operation who knows what to do in emergencies.

First-aid boxes should be clearly marked and located so that they are readily accessible in an emergency. They should not be more than 100 m from any worksite. Ideally, such kits should be near a wash-basin and in good lighting conditions. Their supplies need to be regularly checked and replenished. The contents of a first-aid box are often regulated by law, with variations according to the size and likely industrial hazards of the enterprise. A typical basic kit may include the following items in a dustproof and waterproof box:
sterile bandages, pressure bandages, dressings (gauze pads) and slings. These should be individually wrapped and placed in a dustproof box or bag. You will need small, medium and large sizes. Be sure to have sufficient quantities, especially of the commonly used sizes. Small cuts and burns should not go untreated. You will also need medical adhesive tape (strip plaster) for fixing bandages and dressings;
- cotton wool for cleaning wounds;
- scissors, tweezers (for splinters) and safety pins;
- an eye bath and eye wash bottle;
- ready-to-use antiseptic solution and cream;
- simple over-the-counter medicines such as aspirin and antacids; and
- a booklet or leaflet giving advice on first-aid treatment.

First aid requires some training, but this is not difficult to arrange in most places. The names and location (including telephone number) of first-aiders should be put on a noticeboard. Workers in remote or isolated areas should be given additional training in first aid to take account of the probable long delays in obtaining medical aid in the event of an emergency.

The procedure for obtaining medical assistance in an emergency should be known by all workers. Small establishments without their own facilities should keep contact with a nearby clinic or hospital so that the time between the occurrence of an accident and medical assistance is very short, preferably much less than 30 minutes. Transport to the clinic or hospital should also be pre-arranged. An outside ambulance may be called in, if necessary. It is always desirable to have a stretcher.

Make sure that rest means recovery

Rest breaks

Workers usually start the day alert and productive, but their activity level decreases as the day goes on. Fatigue grows gradually before it begins to have strong effects. If the worker rests before he or she shows signs of being really tired, recovery is much faster. Short breaks taken frequently are much better than infrequent but long breaks. For most types of work, workers will produce much more with breaks than they could working continuously.

Workers may continue working until they feel very tired, so you should plan breaks. At least one ten-minute break in the morning and one in the afternoon, in addition to a longer break for lunch, is absolutely necessary. A five-minute break every hour is an excellent idea.

Rest areas

A good rest area also helps to reduce fatigue. Workers are not just idle during rest breaks, but recovering from fatigue and getting ready for continued productive work. Getting away from a noisy, polluted or isolated work-station helps them to relax and recover from fatigue. Rest areas should therefore be away from the work-station and free of disturbances. A simple canopy outside the factory may provide a shady rest area, especially if there are plants and breezes. Avoid bright sunlight: the eyes need to rest as well as the body. A table and chairs are needed and a place to lie down can also be a good idea.
Smaller enterprises have a great deal of difficulty in competing for high-quality labour. A common complaint is that as soon as workers are fully trained, they leave for the higher pay and better benefits of larger enterprises. You may find it difficult to compete in terms of wages, but you can accomplish a great deal at low cost if you pay attention to the needs of your workers. The small enterprise has the possibility of treating workers as part of a “family” and thus to gain their loyalty and support.

Workers' needs vary. You undoubtedly know whether your workers have problems with meals, transport or other work-related needs. Perhaps you have some experience with the way that work clothes, lockers or even an opportunity for sports after work are appreciated by workers.

**Use low-cost facilities to attract and retain the best workers**

Work uniforms decorated with the factory emblem can contribute to company loyalty and work discipline. Specially designed work clothes quite often help reduce accidents. Many serious accidents have occurred when loose garments became engaged in rotating equipment.

**Lockers and changing rooms**

Facilities for secure storage of clothes and other personal belongings, such as cloakrooms, coat-hooks, lockable lockers and changing rooms, greatly assist workers with their personal hygiene, appearance and tidiness, and avoid anxiety about the theft of personal possessions.

Storage facilities should be located where they will not impede work or obstruct light or ventilation. They should also be arranged in such a way that clothes and personal belongings can be kept safe from damage or theft. This can be achieved by placing storage facilities within cloakrooms or changing rooms or moving them as far as possible from the work-stations.

Changings rooms are particularly important where the duties of the workers require them to change from street clothes into uniforms or protective clothing, or where wet, dirty or noxious conditions require workers to change clothes. If possible, work clothes...
separate changing rooms giving privacy for each sex should be provided. If there are only a few persons of each sex employed and separate changing rooms would be too costly, some privacy for each sex, such as screened-off areas, should be arranged.

Washing facilities such as washbasins or showers should either be placed within changing rooms or close by. Combined dining and changing rooms are not recommended on hygienic grounds.

Adequate seats, mirrors and rubbish bins in the changing room or close to the lockers will assist workers in giving attention to personal appearance and tidiness.

Figure 111
Personal workplace lockers.

Figure 112
A changing room with lockers and showers.
Figure 113
An eating place with simple cooking arrangements.

Figure 114
An eating corner in a rest area.
Eating areas

Some smaller enterprises may not have the resources to start a canteen immediately. The first step for them is to provide an eating place or room in which the workers can eat food brought from home or bought from vendors. This lunchroom could include a small area where workers can prepare drinks or heat their food. It should be situated away from the work-stations to avoid any contact with dirt, dust or dangerous substances used during the work process and should be as comfortable as possible to enable workers to relax during meal-breaks.

It is advisable to set up this eating room or area in a way that it can be upgraded and later turned into a small canteen as the enterprise develops.

Canteens

Establishing canteen services is the best way to guarantee that workers eat sufficient nutritious food during a reasonably short break from work. Sending workers home for meals may not be feasible due to the distances involved, the high cost of transport, the lack of commuting facilities or simply because the meal break is not long enough. Eating facilities near the workplace may also be unsuitable due to the high cost of meals, the poor hygienic conditions of some food-stalls or the poor nutritional value of the food.

Different facilities may be provided, some of which can be quite inexpensive:
- a canteen for cooked or pre-cooked meals;
- a buffet to serve packed meals, snacks and beverages;
- facilities (including space, shelter, water and rubbish bins) for vendors to sell hot food;
- a group restaurant jointly set up by a group of employers; and
- arrangements with a restaurant or canteen near the enterprise.

When a meal is served, it is important to pay attention to hygienic conditions and the nutritional value. It may be a good idea to get advice on both from an expert.

The space needed for setting up a canteen is often less than you might expect. An eating place or room for 50 workers requires only 25 square metres, if workers share the space by eating in different sittings.
Health services

Although most countries try to provide access to health care for every citizen, services are often inadequate. You can help by providing a workplace medical facility such as a small clinic which can give treatment for any occupational injuries and in addition provide general health care. This can help avoid delays, lateness and absence which result from using local services. In case the enterprise is too small for a clinic, several enterprises may be able to establish one together. If not, you can still:

- provide treatment at a local hospital or clinic if a worker gets sick or has an accident;
- arrange regular visits by a doctor or nurse;
- assist in establishing a community health service near the workplace;
- grant loans or salary advances to workers to help meet medical costs; and
- provide health insurance for all workers or encourage workers to join private insurance schemes by covering part of the premiums.

Figure 116
A medical cabinet.

Figure 117
A factory clinic served by a visiting doctor.
Transport facilities

Getting to and from the workplace may be difficult, lengthy and tiring. This, in turn, can cause fatigue, anxiety and financial hardship for the workers, and result in undue lateness, increased worker absenteeism, high labour turnover or declining efficiency for the enterprise.

Small-scale enterprises sometimes pay a transport allowance. If they are unable to do this, assistance may still be provided by adjusting working times to public transport timetables or securing adjustments in the public transport services from local authorities. In some instances informing workers about public transport services, times, costs and monthly or seasonal ticket offers can bring about some improvements.

Costs may also be reduced by establishing a joint transport system with other small enterprises or by joining transport systems of bigger companies. Other possibilities are to help organise shared private transport among the workers themselves or to encourage private transport operators to make reasonable arrangements.

For workers who want to purchase their own means of transport such as motorcycles or bicycles, it may be possible for you to secure cheap bank loans without any cost by guaranteeing suitable repayment schemes.

Recreational facilities

Many workers enjoy spending their time on sports or other recreational activities during their lunch break or after work. Besides being fun, such activities are also likely to increase the physical and mental well-being of the workers.

One important impact of recreational facilities is improved social relations within the enterprise. If supervisors or managers participate in recreational activities, this may greatly help in terms of communication and mutual understanding. The improved morale may also lead to a reduction in absenteeism and staff turnover and facilitate recruitment.

Recreational facilities are often very inexpensive. Providing simple sports equipment such as a ball, goals, nets and so on, or some board games and magazines may be all that is necessary.

Figure 118
A storage area for bicycles.
Figure 119
Examples of some indoor recreational facilities.

Figure 120
A factory child-care room.
Child-care facilities

Many employers find that working mothers are especially loyal and effective workers, but they often need help with the special problems of caring for their children.

A clean room, preferably with access to an enclosed space outside, is the main thing you need. A few items of simple furniture and toys help. Access to cooking facilities or a canteen can solve the feeding problem.

Children should never be allowed on the factory floor. There may be hazardous machines and chemicals and there are almost certainly dusts or fibres in the air which are especially dangerous for the young.

You may be able to find someone who could care for the children at very low cost or the mothers themselves could take turns. Mothers, especially nursing mothers, should be able to visit the children during breaks.

Factory days

Many enterprises have a special day once a year for all the workers and their families. It is an excellent opportunity to build company loyalty. Good food, games, awards and prizes and a pleasant location help to make such days successful.

Summary

Rules for work-related welfare facilities which contribute to productivity and good labour-management relations

- Make sure essential facilities serve their purpose
- Be ready for emergencies
- Make sure that rest means recovery
- Use low-cost facilities to attract and retain the best workers
Premises

Few owners of small businesses are able to design their own factory building or choose one which meets all of their needs. You may have been thinking about repairs and improvements but hesitated because of the cost and the lack of obvious benefits.

This chapter will show you how to make improvements in your factory building which are low in cost and which have definite benefits. Temperature control, better ventilation, properly designed floors and layout and attention to fire and electrical safety can increase your workers' efficiency and avoid large losses. They can also make your factory more attractive to customers and improve your image.

Protect your factory from outside heat and cold

One of the most important conditions for productive work is the correct temperature inside the work premises. The optimum will vary according to local climatic conditions, the season and the type and intensity of work. For sedentary work of average intensity the highest productivity is achieved at 20-25°C, while for heavy manual work the peak will be about 5°C lower. Deviations from the optimum temperature result in lower productivity. However, maintaining the optimum temperature inside the work premises can be very costly unless proper measures are taken to reduce the penetration of heat or cold from outside.

There are two basic ways heat or cold gets inside the shop: direct (through openings such as windows, doors, gaps, skylights) and indirect (due to conduction throughout the roof and walls). In addition, sunlight coming through windows and skylights falls on objects inside the shop and heats them up.

Here are some ways to tackle these problems.
(a) A factory building with corrugated metal walls and roof with a very low level of thermal insulation.
(b) Heat and cold penetration can be considerably reduced by insulating walls and roof panels and providing air gaps between wall and backing.
(c) Construction of a ceiling is another effective way of reducing heat and cold penetration from above.
Let nature help you

Let's start with your factory yard. In hot climates, open, sandy and rocky areas contribute to the problems of heat and dust. Trees, bushes, grass and flowers help to reduce the harmful effects of the sun's radiation and hot winds. They also form a natural "filter", preventing dust from penetrating inside the factory as well as creating a pleasant environment. However, in order to allow fresh breezes to reach the building more easily, keep all bushes shorter than 1.6 m (five feet) and trim trees surrounding the factory building at least 3 m (ten feet) from the ground.

Improve the heat reflection of the walls and roof

The texture and colour of the outside walls and roof are chiefly responsible for the reflection or absorption of heat. Untreated concrete or mud walls transmit much heat into the interior. To reduce this effect, the walls should be smooth in texture and light in colour.

Improve heat insulation

A thin metal wall by itself does not protect against penetration of heat or cold, but a layer of air between two walls is a good insulator. This is why corrugated metal walls, doors and shutters should be backed with some solid insulating material, such as plywood. Backing them with bricks or other thick porous materials is an even more effective solution. The air pockets between the external and the internal walls will contribute much to thermal insulation of the building (figure 122 (a) and (b)).

If your factory has a gable roof, it is often worth investing in the construction of a ceiling. If this is done properly, the investment will mean a considerable improvement in thermal conditions in the workshop. Don't forget to insulate the ceiling with a layer of any heat-insulating material you have at hand. Even earth will do. Openings should be provided to allow air to circulate freely between the roof and the ceiling during hot weather (figure 122 (c)).

Use shades to protect against heat from the sun

Properly designed shades work in two ways: they protect the walls from solar radiation and also absorb outside heat without transmitting it to the interior. Shades can do a lot to keep the temperature down in your factory. Moreover, they help to improve lighting conditions by reducing glare and dispersing the light more evenly.

Good evergreen trees on the sides of the building are a natural and efficient means of providing shade.

Another practical and low-cost solution is to attach light-coloured vertical screens to the outside of the walls (figure 123). They can be permanently fixed (a) or adjustable (b).

In tropical countries, vertical screens can be used effectively only in combination with horizontal shades. The horizontal shades block out the sunlight when the sun is high in the sky. There are many types of horizontal shade and your choice will depend on the building design, materials at hand and amount of effort you are prepared to make. An effective way to combine the benefits of both horizontal and vertical shades is to use louvered screens. Another way of doing this is to use permanent comb-type shades (figure 126), which can be home-made and fixed on the outside walls which are most exposed to the sun.

To improve your protection against solar heat further, you can consider the use of sun-reflecting or even coloured glass. The simplest solution is to paint the upper part of the window glass with a water solution of blue dye or laundry blueing. Try it - it works.

Let natural air-flow improve ventilation

If there is not sufficient exhaust or fresh air, the air in the production area quickly becomes contaminated by vapours, dusts, fumes and gases. In the average workshop, the air needs to be changed between eight and 12 times per hour! There should be at least 10 m³ of air per worker. The smaller the room, the higher the air-flow should be. All working premises have some natural ventilation, but especially in hot countries this fresh air supply is seldom sufficient.

Ventilation should not be confused with air circulation inside the workshop: the first replaces contaminated air by fresh air, whereas the second is intended only to improve thermal comfort by moving the air without renewing it.

Below we give some ideas for improving ventilation in production shops. However, the specific design of your working premises and local climatic conditions can reduce the effectiveness of these suggestions. Use them as a general guide and if possible consult a local architect or specialist in ventilation.
Figure 123
External vertical screens against solar radiation. 
(a) Permanently fixed. (b) Adjustable.

Figure 125
External louvers made of wooden planks give all-day protection against solar radiation.

Figure 124
A canopy made of a row of planks. Provides good protection against heat penetration and better lighting conditions than a solid canopy.

Figure 126
External comb-type shades.

Make better use of horizontal air-flow

Horizontal air-flow helps to improve thermal comfort and remove pollution. Open windows are a popular and simple way of providing cross-ventilation. Multi-section windows help to regulate the air-flow according to wind conditions.
Figure 127
(a) Ventilation.
(b) Air circulation.

Figure 128
Natural ventilation from adjustable openings on opposite sides of a room.
Utilise the tendency of hot air to rise

Usually it is not possible to provide sufficient ventilation in a large production area by opening windows or using wall fans. Inevitably, in the middle of the workshop there will be an area with no air movement at all. This problem can be resolved by using the natural upward flow of heated air, the "chimney" effect. This can be done by providing sufficient openings in the roof, for example by replacing solid glass skylights with adjustable louvers. The shape of the roof very much influences the effectiveness of natural ventilation (figure 129). Inclination of the ceiling towards the roof helps to avoid pockets of hot air.

Unfortunately, sometimes this solution is insufficient or has the side effect of allowing dust to come in from outside. In such cases, electrical exhaust fans should be installed to increase the air-flow (figure 130).

If you cannot afford to use electrical exhaust fans, you can try exhaust deflectors which do not consume energy (figure 131). Even a slight breeze from any direction considerably increases the flow of air through the exhaust.

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**Figure 129**
Air-flow routes in buildings of different design.

**Figure 130**
Combined ventilation system. *(a)* Exhaust fan. *(b)* Louvered skylights.
Having taken measures against outside heat and cold and to improve general ventilation, you may have another problem to solve — the harmful effects of heat, noise, dust and fumes generated inside.

In addition to obvious sources of heat radiation such as furnaces, dryers or ovens, there are many other less visible ones. For example, even the most efficient machines release into the air as heat 80 per cent of the energy they consume. In addition, machines and equipment are sources of noise, dust and fumes. The ultra-violet radiation produced by arc welding is often an additional problem.

Your choice of ways to resolve these problems depends on the local situation, but the rules listed below can be used as general guidance.

The best method is to eliminate the source of pollution, for example, by switching from furnace heating of parts to high frequency electric current methods or from arc to spot welding.

If you cannot eliminate the source, move it outside and place it in a shed or under a canopy (figure 132) or in a separate specially equipped room.
Figure 133
Use of local exhaust against heat radiation and pollution.

Figure 134
Use of an absorbent shield to block heat radiation.
If the source must be inside the workshop, isolate it from the general work-area. In the case of heat sources, use a hood with an exhaust (figure 133) or install:

(i) reflecting shields, which, to be effective, must be polished and maintained in a state of cleanliness;
(ii) absorbent shields, which can be prevented from becoming sources of heat by being cooled with air or water (figure 134).

The radiation from arc welding can be blocked by installing a special welding cabin or by using movable screens.

Dust and fumes require special measures. See the chapter on the control of hazardous substances.

In areas where the air is very hot and dry, it is often worth installing a no-energy-consuming system for cooling and moistening the incoming air. From figure 135 you can see how such a system operates. The incoming hot air is passing through the dampened charcoal, loses heat and becomes more humid.

**Improve your floor**

We are inclined to underestimate the importance of the floor for productive, smooth and safe work. However, inappropriate floor surfaces or poorly maintained floors can be a major source of accidents, work interruptions and product damage.

The most important qualities of the floor surface are:

- **Strength.** A floor should be sufficiently strong to resist crushing due to loads from heavy machines or from traffic or handling of materials. Care must be taken to ensure that the wheels on mobile materials-handling equipment are of adequate width and diameter.

- **Resistance to wear and abrasion.** The floor must have sufficient resistance to abrasion to withstand normal use over a period of several years without deterioration and without excessive signs of local wear. Non-dust-forming properties can be critical for certain industries (electronics, food, etc.).
- **Resistance to chemicals.** It is important that the floor should be resistant to chemicals wherever there is a risk of oils, solvents, acids or other chemicals being spilt. This applies particularly in the chemical and petrochemical industries.

- **Comfort and safety.** The floor should have low thermal conductivity and absorb noise and vibration as well, since these phenomena have a direct effect on the occurrence of fatigue. A machine operator standing the whole day on a concrete surface gets much more tired than a worker on a wooden one. Furthermore, the floor should always help to avoid slipping and be easy to clean.

When considering the cost factor, we should not think exclusively in terms of initial installation but also take into consideration long-term durability, easy maintenance and cleaning.

The following table can help in the selection of appropriate material for the workshop floor.

<table>
<thead>
<tr>
<th>Properties</th>
<th>Clay</th>
<th>Concrete blocks</th>
<th>Poured asphalt</th>
<th>Plastic (vinyl)</th>
<th>Ceramic</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strength</strong></td>
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<td></td>
<td></td>
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<tr>
<td>Compression resistance</td>
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<td>+</td>
<td>--</td>
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<td>--</td>
<td>++</td>
<td>+</td>
<td>--</td>
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<tr>
<td>Resistance to wear and abrasion</td>
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<td></td>
<td></td>
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<tr>
<td>Dust formation</td>
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<td><strong>Resistance to chemicals</strong></td>
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<td>--</td>
<td>+</td>
<td>--</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
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<td>+</td>
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<td>+</td>
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<tr>
<td>Alkali resistance</td>
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<td>+</td>
<td>+</td>
<td>++</td>
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<td>Solvent resistance</td>
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<td>+</td>
<td>--</td>
<td>+</td>
<td>++</td>
</tr>
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<td><strong>Comfort and safety</strong></td>
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<tr>
<td>Thermal insulation</td>
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<td>--</td>
<td>++</td>
<td>--</td>
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</tr>
<tr>
<td>Ease of cleaning</td>
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<td>--</td>
<td>+</td>
<td>++</td>
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<tr>
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<tr>
<td>Dielectric sparking</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

++ = very good, + = good, + = medium, -- = bad, - = very bad, ¹ if dry.

If you have to have a clay floor, there is a way to improve its properties. The addition of slag helps to increase the resilience of the surface (40 per cent clay, 60 per cent slag or gravel). Even better properties can be achieved by making the top layer of a mixture of clay (60 per cent) with metal filings (40 per cent). Take care to tamp properly.

It is also worth considering the high durability, easy maintenance, greater safety and high comfort of a floor made of wood bricks. This type of floor is ideal for small mechanical and assembly shops as well as for storage rooms where relatively heavy parts are handled. Almost any kind of wood can be used and not much skill is needed to make a wood-block floor (figure 136).

Floors which are frequently washed down with water should have a slight, even grade of 1-2 per cent towards a drain to ensure that the water flows away from the traffic area.

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**Build flexibility and adaptability into plant layout**

When you are setting up or modernising your production facilities, it is the right time to improve space allocation, transport arrangements, production routes and the infrastructure of the building.

*Reserve free space in the work area* – otherwise you will find it quickly becomes overcrowded, with no space for extra tasks or increased production. This will also help to avoid blockages of passageways.

*Allocate sufficient passageways and make sure that they are kept clear.* Often in small enterprises, little care is taken to provide adequate passageways for efficient and safe movement of materials. In addition, passageways tend to become filled with
materials and scrap. You should define passageways clearly. Install protecting barriers in dangerous areas, such as corners or places where passageways are next to work-stations. Clearly mark passageways as well as work and storage areas by drawing easily visible border lines of different colours (figure 137). It can also be very useful to paint the whole floor in selected colours (for example, green – work area, brown – passageways, grey – storage area, yellow – lines marking boundaries). Make sure that everyone knows that the zones are to be respected. Never allow anyone to put anything down except where it belongs.

Avoid the use of rail-type floor transportation systems, otherwise you will be in trouble when the need comes to alter production flow. Rail systems also interfere with movement in the production area. Give preference to carts, trucks and mobile racks or install an overhead transfer line.

Use production equipment and storage facilities which are easy to assemble and to dismantle. Always give preference to "modular" equipment which enables you to set up, move or replace a work-station in a very short time and with a minimum disturbance to production.

Provide evenly distributed general lighting and supply lines throughout the production area instead of designing them according to the current production layout. This will pay off through easier installation of new equipment or work-station arrangements. Overhead supply lines (for example for electricity, water, compressed air) are most appropriate for production areas and underfloor lines for offices. To cut lighting expenses it is worth while to provide separate switches for groups of lamps inside the shop (for more information see Chapter 7).

**Prevent fires and electrical accidents**

**Fire**

Fire in your work area can ruin your whole business and cause serious injuries or even deaths. Fire protection should always be a priority. Following these simple rules can help you prevent fires or reduce fire damage if one occurs.
Prevention

Prevent fires by making sure that rubbish, sawdust, wood scraps and other burnable materials are cleaned up and placed in metal containers. In addition, follow the rules below concerning common sources of fires:

- Electricity: ensure that electrical circuits are enclosed, insulated, earthed and properly fused; see that electrical circuits are not overloaded (see next section, on electrical hazards).
- Friction: lubricate properly the moving parts of machines; make sure that moving belts or drives do not rub against housings.
- Hot surfaces and open flames: keep combustible and flammable material well away from hot surfaces and open flames, such as furnaces and welding and cutting operations.
- Flammable liquids: store flammable liquids in appropriate containers away from heat sources.
- Spontaneous combustion: dispose of oily used rags in airtight containers.

Escape routes from the work area

Make sure that every floor or large room has at least two ways out and that these exits are kept unobstructed and unlocked. Clearly mark escape routes and exits and provide sufficient lighting so that there is no confusion in reaching exits. Make a plan for emergency escape, including a place to gather outside the factory where you can account for everyone and be sure no one is still inside. Finally, make sure that everyone knows what should be done in case of fire.

Fire fighting

Provide appropriate fire extinguishers and fire-fighting equipment near the sources of potential fire. Check the readiness of equipment regularly. Assign responsibilities for fire fighting and train workers in how to fight fires.

Electrical hazards

Workers tend to ignore electrical hazards. The abuse of safety rules in work with electricity is a prime reason for fatal accidents and fire. The following rules can help you to reduce electrical hazards.

Prevention

Establish a firm rule that any repair or maintenance work on machines should only be done when the power is off and the switch is locked in the OFF position. The key to the lock of the power switch box should be in the pocket of the person doing the work.

In addition to this basic rule:

- Be sure that all electrical wiring is identified and protected. There should not be any exposed wiring.
- All circuits should be protected with circuit breakers or fuses. This protects the machines against damage and the plant against fire.
- All equipment should be earthed. A separate earthing wire should run from the machine to an independent earthing rod.
- Portable tools and equipment should be double insulated or earthed.
- Be certain that electrical power can be shut off immediately in case of emergency. The main power switch should be in easy reach and clearly marked. All other switches should be clearly labelled as to what they control.

Emergency action

Everyone in the plant should know how to help a person suffering an electric shock:

- Turn off the power and remove the person from the source.
- If the switch is not accessible, find a long, dry, clean and non-conducting object to remove the person from the source or the source from the person. This is very dangerous.
- Once the person is clear of the power source, be prepared to administer mouth-to-mouth resuscitation or cardio-pulmonary resuscitation.

Summary

Rules for making your premises a better place to work

Protect your factory from outside heat and cold
Let natural air-flow improve ventilation
Eliminate or isolate sources of pollution
 Improve your floor
Build flexibility and adaptability into plant layout
Prevent fires and electrical accidents
Work organisation

Improving work organisation is one of the best ways to increase productivity, especially since it can often be done without additional capital investments. However, better organisation is not always easy. If you have followed the advice in the previous chapters, you will have established many of the preconditions for efficient organisation. You are ready for more advanced improvements.

Not all the ideas suggested in this chapter can be implemented immediately. Changing the design of machines and products or the layout of the shop-floor can be expensive and time-consuming. There are, however, a number of ideas which can be set up immediately at no cost, such as changing work assignments. You can start with these ideas and work towards the others over a longer period.

Some of the ideas you will find in this chapter may seem "soft" on workers. You may be used to the idea that only strict supervision and strong pressure give good results. Remember that supervision is expensive and that workers, however much they need their jobs, are not fools. They would rather work well for a boss they respect and admire and who treats them fairly.

On the other hand, do not fall into the trap of thinking that being nice to workers is sufficient. Efficient work is difficult to plan and design. You will need to think hard about products, machines, work flow and job assignments.

The benefits of better organisation do not usually show up immediately. New procedures and work methods take time for workers to learn. Adjustments may be necessary before the new system works well. There is normally a "dip" in productivity when organisational change is introduced, followed by a strong improvement if you have done it well. Chapter 11 will help you to do a good job of implementing change.

Get rid of extra tasks and operations

Each work operation is an extra cost — it takes space, machine and operator time and energy. Your first step should therefore be to examine critically every production task and operation. In doing this, ask yourself whether this task or operation is really needed. Can it be eliminated altogether? Can it be performed in combination with other tasks and operations?

We can eliminate tasks by:
- introducing changes into the design of the product;
- switching to new production methods (for example, changing from metal-cutting to stamping or to forming parts from metal powder or plastic);
- performing a number of tasks in one operation by using special multi-task tools or machines;
- machining several parts in one operation.

Defeat monotony to keep workers alert and productive

At your enterprise you are likely to have some work-stations or sections where tasks are highly fragmented, and work operations are simple but monotonous.

At first sight, such arrangements seem to be efficient. Work is done quickly — no extra movement is lost. But monotony and lack of variety cause boredom and fatigue, and repetition of the same movements results in muscle strain and general stress. Attention wanders, quality suffers and the worker looks for excuses to stop the machine. The result is low efficiency and negative work attitudes. In the following sections we will discuss ways of combating this problem through basic organisational changes. However, you can start with some simple steps which improve work quality and efficiency. These steps include:
- Frequent changes in tasks. This exercises different muscles and lets tired muscle groups rest. It also stimulates the worker's attention. Each job should have a variety of tasks which use different muscle groups. You can also rotate workers to different work-stations (job rotation).
- Opportunities to walk around or change from sitting to standing or standing to sitting. You can ask workers to go and get any necessary...
Different work arrangements for performing the same task.
(a) Drilling with a single-head drill.
(b) Use of a multi-head drill.
(c) Drilling a stack of parts with a single-head drill.
(d) Drilling a stack of parts with a multi-head drill.
parts during their work or simply provide appropriate chairs and stools.

- Frequent, short breaks. No one can keep perfect attention for a long time. When attention drops, mistakes are made. Breaks help overcome this problem. Jobs which are repetitive, fast paced, strenuous or which demand close attention to quality will be done much more productively with many short breaks. These breaks can also be an opportunity to move around and even to exercise.

- Opportunities to communicate with other workers or listen to music without leaving their work-station. This stimulates the workers without interrupting work. Music is especially effective during the half-hour before lunch or the end of the day.

Install buffers to make the work flow smoothly

In addition to the above-mentioned measures, there is one further step which should be taken in cases where you have machine-paced assembly-line work. This is to introduce buffer stocks. Buffer stocks are small supplies of goods before and after each machine or work-station. The idea is that the worker or machine should never have to wait for the next work-piece in order to continue work. If there is a small stock of work-pieces ready for work, there is no waiting. If a small stock can be built up after the work-station, the next worker or machine will not have to wait either.

The type, design and capacity of the buffer or magazine depend on product design, work-pace variations, space available, etc. In the case of small work items, simple bins or small pallets with dividers are usually sufficient. For bigger and heavier work-pieces like metal pinions, shafts or metal sheets, special racks and pallets should be made.

In designing buffers one should try to:
- minimise the floor space taken up by the buffer;
- ensure easy maintenance, transport and replacement;

Figure 139
Mobile stores enable you to move buffer stocks from one work-station to another.

Figure 140
Traditional machine-paced assembly line.
- choose the appropriate height for the buffer and design it to minimise the effort needed to put stock in or take it out;
- store work-pieces in a systematic manner so you can get an exact idea at a glance of what is available.

When buffer stocks are present, workers can build up a small advance which they can use to take a few seconds' rest, correct machine settings or get some spare parts without slowing down the operation as a whole. Buffer stocks help to make production continuous and flexible. While they are a simple idea, they are used in all the most modern production systems.
To improve efficiency further you may consider building a table-top rotatable buffer line. The system enables operators to work at their own pace and materials are always at their finger-tips. Having performed a certain operation, an operator places a work item on the shelf assigned to the next work operation (figure 142).

Some other features of this system are that:

- multiple products or sub-assemblies can be run at the same time;
- products of different sizes or shapes can be accommodated;
- any number of people can perform any operation from any position around the carousel.

### Design responsible, flexible jobs

Look around. Your workers are different from each other. One may be very quick but error-prone, another may be slow but precise. One may like to learn new skills while another avoids any changes. The physical capacities of individuals also differ to a considerable degree. It is obvious that there is no "average" worker. But, none the less, we continue to design work for "average" workers who do not exist. As a result, one part of the workforce is under constant strain as their capacity is lower than "average" and we have low quality, work interruptions and absenteeism. Others are underutilised as their capacities exceed the "average".

Poorly designed work leads to many lost opportunities and extra costs. Careful design offers many benefits. Here are some characteristics of well-designed jobs:

- jobs should make clear who is responsible for output and quality;
- jobs should help workers to develop skills and become interchangeable;
- jobs should occupy each worker fully but should remain within each worker’s capacity.

A very important way of following these three principles is to combine production tasks. If you combine enough tasks so that the worker is responsible for a complete product or sub-assembly, it will be easy to measure the worker’s output. It will also be clear that the worker is responsible for the quality of the product. There is no one else to blame for mistakes. All this makes for better feedback and the possibility of payment by results. It also motivates workers by making them feel individually responsible for a significant piece of work rather than just a single fragmented task.

If you do not combine tasks, it is very difficult to keep workers fully occupied. Some tasks take longer than others. In order to “balance” operations, some workers will have an easy time while others will struggle with bottleneck operations.

Combined tasks also help to develop skills. A small enterprise can hardly afford a high level of specialisation of skilled workers. Absences of repair-workers or quality-control specialists can result in production stoppages or shipment of a defective product to the customer. The shortage of management resources in small enterprises should be compensated by developing a sense of responsibility and self-reliance in the workforce. You cannot achieve these goals quickly, but in the long run they can become a foundation for company survival and prosperity.

In order to develop your workers’ skills you may consider the following:

- increasing machine operators’ interchangeability by providing possibilities for operators to acquire multiple skills and by encouraging occasional job rotation to keep skills alive;
- reducing the dependency of machine operators on maintenance and support staff by assigning to them partially or in full the following functions: maintenance of machines and tools; setting up of machines; handling of materials near their work-station; inventory work; and quality control. The possibilities for this depend on a number of factors, among which are workers’ attitudes, the availability of skills to perform new functions efficiently, the difficulty of and time available for the setting-up operation, the frequency of setting-up operations, the degree of rigidity in other production tasks and the need for special auxiliary equipment;
- reducing the cost of constant supervision and thereby increasing motivation by giving workers more chance to decide how work should be organised (for example, setting priorities, planning their own work, and choosing their own methods); by providing on-the-job training through gradually increasing the level of difficulty of tasks; and by letting workers share their experience and knowledge with others by making them responsible for training less-experienced workers.

In some cases you may want to allow each worker to decide when to start and finish work and when to take a break, provided that the work quota is fulfilled or total hours are completed.

In some cases, to make job enlargement possible, a product should be redesigned or divided into a number of modules/sections each of which can be assembled by a worker.
A telephone constructed of modules (a), (b) and (c), each of which can be assembled by one worker.
Set up autonomous groups to improve efficiency and to cut supervisory costs

So far we have been dealing with work assignments of individual workers. Designing each individual job is a complicated and time-consuming task. Are there ways to avoid it altogether? Yes, many companies around the world find it feasible and beneficial to assign work to groups instead of individuals. You may already be doing this in certain cases.

Such group work arrangements have several advantages:
- it is much easier, and less time-consuming, to formulate objectives and set tasks for a group than for an individual;
- the work flows more smoothly, and less supervision is needed;
- it takes less time for new workers to learn a skill, and workers have better opportunities for acquiring multiple skills;
- continuous co-operation between the workers helps them to spot mistakes more promptly and makes it easier to improve methods and eliminate unnecessary work.

Many of the most advanced large companies have introduced group work and experienced very large productivity increases. They have discovered that groups can work faster and better than the same number of separate individuals, even if there are extra supervisors and work study experts. They have also learned that quality circles and other schemes for motivating workers and improving methods are much more effective when work is organised in groups. You can benefit from their experience. Consider the following comparison of cost, productivity and quality of work:

<table>
<thead>
<tr>
<th>Individual jobs</th>
<th>Group work</th>
</tr>
</thead>
<tbody>
<tr>
<td>The pace of work is limited by the slowest job in the line. Bottlenecks must be overcome through intervention by a supervisor.</td>
<td>Workers can flexibly help to overcome bottlenecks by exchanging tasks and sharing work.</td>
</tr>
<tr>
<td>A change of products means that someone must redesign all jobs.</td>
<td>Workers can work out a new arrangement by themselves.</td>
</tr>
<tr>
<td>Absent workers, machine breakdowns, problems with raw materials, etc., require intervention by a supervisor, who must decide what each worker must do.</td>
<td>Workers can learn all jobs in the group.</td>
</tr>
<tr>
<td>Each worker learns how to do one job.</td>
<td>The group is collectively responsible for productivity, quality and discipline.</td>
</tr>
<tr>
<td>Each worker is responsible only for his or her task. Delays, mistakes and other problems can be blamed on someone else.</td>
<td>All these tasks can be handled by the group.</td>
</tr>
<tr>
<td>A separate supervisor must be paid a higher wage for overcoming problems, planning and assigning work, discipline and other tasks.</td>
<td></td>
</tr>
</tbody>
</table>

Figure 144
Traditional conveyer line arrangements.
New arrangements based on group work-stations and buffer stocks.

(a) Buffer stock.
(b) Automated assembly unit.

Note that the buffer stocks and group work-stations allow for partial automation without disruption of the production process.

One way to introduce group work is to replace a rigid conveyer line by "group work-stations", with buffer stocks between them (figures 144 and 145).

Such arrangements facilitate to a considerable degree the gradual introduction of automation with minimum disruption of existing operations.

In the case of manual assembly of electronic and small electrical and mechanical items, you can consider grouping assembly workers around one table. To facilitate easy movement of materials between the operators, a manually rotated carousel device can be installed.

The efficiency of group work depends very much on the individual's attitude towards work as well as on the "work climate" inside the group. Group members should have the right skills for the work being done and be able to "get along" with each other. It is also important that groups be the right size. There should be enough workers to perform the task, but not too many (ideally four to eight).

Rewards should depend on the performance of the group as a whole and not on the performance of individual group members.

Links should be set up between the work group and any other groups who have information and/or expertise that the work group needs (for example, concerning supplies or maintenance).

The group should have control over the methods used to do the work, and the way the work is shared among group members.

The group should be given regular information about its performance.

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**Figure 145**

New arrangements based on group work-stations and buffer stocks.

(a) Buffer stock.
(b) Automated assembly unit.

Note that the buffer stocks and group work-stations allow for partial automation without disruption of the production process.

---

**Figure 146**

Individual work-stations.
A round-table group work-station.
Make the organisation of production fit your business objectives

Thus far we have discussed ways to improve efficiency at separate work-stations and work areas. In order to attain full efficiency, we have to find the most appropriate way to link work together, or to put it another way, we need to select a general pattern of production flow.

Your choice will depend on the type and volume of production, the equipment and skills available and many other factors. However, there will be a common overall task — to improve response to your customers' demands in terms of quality, cost and timing.

How can you organise your production to meet these objectives? It can be done by redesigning work arrangements in such a way that:

- there is one simple, preferably straight-line flow of materials for each product or family of products;
- everyone is concerned not only with the quality of his or her own operation but with the total quality of the product;
- there is constant and rapid feedback between the customer or dealer and everyone engaged in production;
- individual rewards depend not only on performance of a given task but on attaining a common final goal.

In the majority of small enterprises, machines and work-stations are grouped in functional departments. Each specialises in a limited number of operations: metal cutting, plastic forming, assembly, testing, etc. Functional specialisation often goes even further. In some machine shops, separate sections for turning, drilling, milling and grinding can be found (figure 147).

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Figure 147

Functional layout in a machine shop. It includes the following production sections: (a) milling; (b) turning; (c) cutting; (d) pressing; (e) drilling; (f) grinding.
An alternative – product-oriented organisation – is becoming more and more popular. Some machinery, equipment and work-stations are grouped together physically and administratively to form a production section which manufactures entire products or a "family" of complex product components (figure 148).

One big advantage of the product-oriented work system is that each worker can clearly see the connection between his or her own work role and the overall activity of the company. In addition, a supervisor or group of workers can plan work and solve problems concentrated on the real goal of the enterprise: to produce the final product. Other benefits are: much shorter travelling distances for materials, reduced stocks, shorter throughput time for materials, reduced investment in tool handling and setting costs, increased capacity and simplified control of material flow.

But don't rush to restructure your work flow. Product-oriented manufacturing in a pure form requires certain definite conditions and cannot be used in all situations. It is very difficult if:
- there is no stable product mix;
- there are not enough machines to equip all separate production lines;
- production capacity for each product exceeds market requirements.

The table gives you some guidance in making a choice of the most appropriate work arrangements.

Your choice will vary according to the scale of production, the available equipment, the skills of the workers, and the predictability of customer demand.

Even if you find that product-oriented organisation in a pure form is not for you, think of a compromise solution. For example, you could retain expensive universal machine tools in a functional department and decide to group together the equipment and work-stations that produce one type or a family of similar products. You will almost certainly benefit from this innovation.
Table 2
Comparison of two types of production organisation

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Type of work arrangements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Functional</td>
</tr>
<tr>
<td>Material flow</td>
<td>In batches</td>
</tr>
<tr>
<td>Material throughput time</td>
<td>Long</td>
</tr>
<tr>
<td>Stocks of work in progress</td>
<td>High</td>
</tr>
<tr>
<td>Capacity of machine utilisation</td>
<td>High</td>
</tr>
<tr>
<td>Investment in special tooling</td>
<td>High: one set per operation</td>
</tr>
<tr>
<td>Responsibility for quality</td>
<td>Many work units per product</td>
</tr>
<tr>
<td>Spotting of defects</td>
<td>Slow</td>
</tr>
<tr>
<td>Control of material flow</td>
<td>Complex</td>
</tr>
<tr>
<td>Level of co-operation between operators</td>
<td>Low</td>
</tr>
<tr>
<td>Product mix flexibility</td>
<td>High</td>
</tr>
<tr>
<td>Dependence on machine reliability</td>
<td>Relatively low</td>
</tr>
</tbody>
</table>

Once the dimensions and the positions of machinery, storage facilities and auxiliary services have been determined, it is advisable to make a diagram of the proposed layout before proceeding with the actual rearrangement of the workplace, which may be a costly operation. This can be done by the use of templates or pieces of cardboard cut out to scale. Different coloured card may be used to indicate different items of equipment, such as machines, storage racks, work-benches or materials-handling equipment. When positioning these templates, make sure that passageways are wide enough to allow the free movement of materials-handling equipment and goods-in-process and that there is adequate space for intermediate storage and buffer stocks. If necessary, scale models may be used to provide a three-dimensional view of the layout.

**Summary**

**Rules for effective organisation of work**

- Get rid of extra tasks and operations
- Defeat monotony to keep workers alert and productive
- Install buffers to make the work flow smoothly
- Design responsible, flexible jobs
- Set up autonomous groups to improve efficiency and to cut supervisory costs
- Make the organisation of production fit your business objectives
Implementation of improvements

The small or medium-sized enterprise must cope with a very rough world, and it is rapidly getting rougher. If you want to survive and grow, your enterprise must be dynamic. To compete, you need constant improvement. Otherwise you will not be able to take advantage of opportunities or resolve problems rapidly.

When you first looked at Chapters 1 and 2 and used the checklist in your factory, you probably found several isolated measures that were worth while. There are a number of ideas which can be quickly and easily applied in almost all small and medium-sized enterprises, and we hope you have already profited from these ideas.

Now it is time to go further. Chapters 3 to 10 have given you the information you need to take a fresh, intensive look at your factory.

Start with a small, specific area where there are only a few work-stations or jobs. Try to see if you can find ways to make it operate really efficiently. The rest of this chapter will help you to apply the lessons from this Action manual as a whole.

You may have read about quality circles or other advanced management ideas and wondered if they can be applied in your own company. They can. You will have to discard some of your old assumptions and habits and put some real time and work into making your enterprise tough and flexible. If you do, you will be surprised by the opportunities and energy which have been hidden inside your company.

Develop a complete solution

If you have a bottleneck operation or problem area in your workplace, it probably results from a combination of factors. Consider the handling problem in figure 149. Workers must make frequent trips to take the work-pieces from one work-station to another. The work is slow and tiring and there is a risk that workers will fall and damage the parts or injure themselves.

As a first step toward efficiency, we might suggest that the worker carry the work-pieces on a small tray or pallet. An even more important point is that workers can carry many more parts if there is a cart to put the pallet on. However, in order to use a cart, additional measures are necessary.

You will usually need to take several actions at the same time in order to meet the objective you have set. Use the whole checklist to look for ways of achieving a complete solution of your problem. Remember that the limits on the productivity of your workers come from several sources, some of which may at first seem unrelated to your objective. Develop a complete solution. Recheck and see if there is something you have left out in each of the technical areas covered in this book:

- materials storage and handling;
- work-station design;
- productive machine safety;
- control of hazardous substances;
- lighting;
- welfare;
- facilities;
- premises;
- work organisation.

If the problem is especially complex, establish a group of workers to give you advice on it. More will be said about this later.

Make sure your ideas will work

Suppose that one of the changes you have decided on is to improve lighting at a critical work-station. Consider, for example, a worker with a poorly lit work-station, with no source of natural light, with dark walls and ceiling and with a single light source facing him or her. How would you solve this problem?

Many things can go wrong when you try to improve lighting. For example:

- You could create glare or too much contrast between light and dark areas by installing a more powerful lamp.
- You could create heat and glare from an improperly designed and placed skylight.
- You could create glare and distraction by placing a worker facing a window.
- You could improve the situation by cleaning windows, skylights and lamp fixtures only to have the same problem return in a few weeks because of the lack of regular cleaning.
You could increase the quantity of light when the real problem is the direction of light or the task background.

How can you increase your probability of success? There are several ways to try and be sure that the improvement you have chosen is the best one for your enterprise and that it will work.

- Before starting, consider alternative solutions and see which one suits you best.
- Try your ideas first in a small way and see how they work. For example, before you decide to relocate a whole row of machine tools in order to take better advantage of light from windows, try it first with one machine and evaluate the results.
- Observe a similar improvement in the same conditions in another enterprise. It is always better and cheaper to learn from the mistakes of others than from your own.
- Get the advice of someone who has experience in solving similar problems. This is especially important when your enterprise is trying to solve this problem for the first time.

Mobilise worker support

If you make a worker’s job more difficult, the result will be lower productivity and resentment, not higher productivity and appreciation. If your improvements are intended to build loyalty and motivation and to be fully effective, you need to be sure that the workers understand how they will benefit. This requires taking a look from the worker’s point of view at the impact on job security, pay, level of responsibility, type of supervision, difficulty or ease of work, etc. The workers will certainly be thinking about these things.

Ask yourself who will be affected by the change. This means not only, for example, the worker who uses a cart but everyone who has been using the space in the passageway. In what ways will workers be affected positively? Be sure they know about these positive effects, so that they will appreciate and support your actions. In what ways will workers be affected negatively? Could anyone lose their job or have their pay reduced? Workers who expect to be hurt by a change will often find very good ways of making sure that it does not work very well. You need to do two things: avoid any negative impact on workers; and make sure that they know they have nothing to fear.

The following steps help to make sure that changes are accepted:

- Make it known that no one will lose their job, have their pay cut or otherwise be hurt by the change.
- Explain your plans to the workers and give them a chance to make suggestions.
- Provide any necessary training. Even where formal training is unnecessary, you may need to relax performance standards during a brief period of adaptation to the new situation.
- Issue clear instructions and assign specific responsibilities.
- Show your support for the change by paying close attention to developments, by praising progress, and by reacting to any sign of going back to the old methods.
- Consider incentive pay or other rewards based on performance.
- Make sure that workers know they should report any problems to you and take action if unforeseen difficulties arise.

One of the best ways to introduce change smoothly and effectively is to assign responsibility for it to a group of workers. If workers are part of the process of planning and implementing the change, they can be confident that their interests will be taken into account. They will be able to suggest their own ideas and they will feel responsible for the success of the improvement. They will therefore not only be co-operative, they will monitor the change carefully and propose or carry out any necessary adjustments.

Remember, changes which are accepted by the workers will be implemented more smoothly. Information about what you are trying to do is very important for the workers' loyalty and motivation.

**Make improvements which will last**

Even simple and immediately productive ideas are not always followed. Old habits are strong, and they do not die easily. There are two basic strategies which help to make sure that improvements are smoothly introduced, effectively implemented and lasting:
- Change people's habits and behaviour.
- Build the change into equipment and facilities.

For most changes you will need to do both to be successful.

If you follow the advice in the previous section on mobilising worker support, you will do a great deal to make sure that your workers are ready to change. The points on management of improvements in the next section will help you to monitor the changes in behaviour and to take any necessary corrective action. These steps are very important, but for many types of change they are not enough to see that your objectives will be met.

Reconsider the handling problem illustrated in figure 150. There are several ways to build the change into the equipment and facilities. The most obvious ones concern designing and constructing the pallet and cart, repairing the floor and clearing the

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**Figure 150**

Moving the same work-pieces with a cart. What different actions were necessary to make this solution work?
passageways. It may also be necessary to pay attention to storage arrangements or to provide a place for the cart close to the work-station. You may find that two carts are needed, or several pallets. None of these steps, however, will prevent the passageway from getting cluttered and making the new method difficult to use. That is why it is suggested that you paint stripes on the floor to indicate passageways, storage areas and work-stations clearly. It may even be necessary to set up barriers to make sure that the passageways stay clear.

Here are some ways to build changes into equipment and facilities:

- Remove any tools or equipment which make it possible or easier to return to the old situation.
- Build the improvement into machines so that it cannot be removed.
- Design new or modified equipment so that it is easier to use and maintain in the new way.
- Provide barriers, painted lines, bins, or make other changes which make the improvement easily visible and natural to follow.

Manage change

If nothing new ever happened, management would be easy. Instead, change is constant. You have to respond to orders, improve your products, overcome problems with raw materials and equipment, train new workers and in general cope with many challenges every day. Some managers run from one problem to another and never develop any real strategy. Others are able to go beyond their problems, and can build a real management system which generates constant improvements in their workplaces.

This book offers you the opportunity of improving your management skills. Don’t waste the opportunity.

Supervise improvements carefully

Each individual improvement is a challenge to your consistency and determination as a manager. If you pay no attention to what is happening to the improvement, everyone will quickly understand that it is not important to you.

One way to ensure that you will not delay completing an improvement and forget about it is to establish a firm deadline and clearly announce it to everyone concerned. It is especially important that the deadline is not a general intention but the same kind of commitment you would give to completing an order on time.

It is important that you make someone responsible for completing the improvement. If no supervisor or worker knows that the improvement is clearly their responsibility, then everyone may wait for someone else to do the job. In addition, there will be no one with an incentive to get work started and monitor progress.

Of course, most changes which are worth making will require some workers’ time, some materials and perhaps some purchases. You should allocate adequate resources to get the job done.

Once the improvement has started you should request regular reports on progress from the person responsible. This will enable you to take corrective action if necessary and it will make sure that the improvement is not forgotten.

After the improvement is completed and is in operation you should check to ensure that it works well. It is also important to see that the change is accepted by the workers and that it has no unexpected results.

You should make sure that, throughout the improvement process, you and your supervisors lead the way by strictly following the new rules and by frequently praising workers who respond correctly to the improvement.

Make improvement a systematic process

Once you have the experience of making a few improvements, you will begin to see the potential for developing a systematic, dynamic approach to the management of change. Each improvement tends to lead to new possibilities. Improvement can become a habit, with everyone trying to find a better way of working. The implications for productivity and motivation are very powerful.

Improvement requires ideas. If you are working with a group of other factory owners and managers, you know how valuable the exchange of ideas and experiences can be. In addition to other entrepreneurs, you can try:

- visits to other factories;
- productivity and training centres;
- employers’ organisations, trade associations and chambers of commerce;
- government agencies.

All of these are useful sources of ideas and technical information. The best source of information, however, is already in your factory. Your workers can help you a great deal. Many advanced organisational ideas, such as quality circles, are based on using workers as a constant source of ideas for improvement.
Some entrepreneurs do not like to ask questions of their workers. They feel that it is the manager’s job to decide what to do, and the worker’s job to do it. There is much truth in this. The boss must remain the boss. You will find, however, that asking the opinion of workers does not reduce your authority or responsibility for decisions. Instead, it gives you the information you need to make better decisions. At the same time, it gives workers a feeling that they have something to contribute to the company, which increases their loyalty and motivation.

You will only get ideas from your workers if you make it clear that you want their ideas. The following steps are effective ways of doing this:

- Hold a meeting during company time. Explain your goals to the workers (you may find it very useful for yourself to spell out your goals). Make it clear that they have a stake in your company and that they will benefit if your company succeeds. Their jobs and their wages depend on your profits.
- Make it easy for the workers to give you their suggestions. Set aside a time when you are available. Walk through the workshop and ask questions. Listen carefully to the answers. Don’t criticise. Thank anyone who makes an effort.
- Above all, take action on suggestions in a very obvious way. Even if the first suggestions do not seem very interesting, give them a try. The workers will be watching to see if you sincerely intend to pay attention to their advice.

You can also let a group of workers fill out the checklist, discuss the results and present you their conclusions. None of the ideas on the checklist are dangerous. They have been carefully chosen to save you money and raise your productivity. Why not give your workers a chance to get interested in these goals?

**Take action**

Now is the time to act. The annex that follows is a worksheet which summarises this chapter. Take it and a copy of the checklist onto your shop-floor, and start the process of making your enterprise more productive and a better place to work.

<table>
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<th><strong>Summary</strong></th>
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<td><strong>Rules for successful implementation of improvements</strong></td>
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- Develop a complete solution
- Make sure your ideas will work
- Mobilise worker support
- Make improvements which will last
- Manage change
Annex: Summary of Chapter 11

How to implement improvements

Don’t waste your time and money implementing important improvements in a careless way. Even simple improvements often fail because of a lack of foresight and planning. This guide gives five simple rules that will help you to be successful. In addition, they will help you to make improvements happen frequently instead of stopping after three or four have been completed. Continuous improvement is the road to survival and growth.

Develop a complete solution

Improvements sometimes don’t work because they are incomplete. For example, if you want to use carts, you should take a look at the shop-floor. What additional changes may be necessary to make the improvement work well:

- in materials storage and handling?
- in work-station design?
- in productive machine safety?
- in control of hazardous substances?
- in lighting?
- in welfare facilities?
- in premises?
- in work organisation?

Mobilise worker support

Your programme of improvements will fulfil your expectations only with the good will and support of those who are directly affected by the changes. Your workers will be on your side if they fully understand that the changes are in their interests as well as yours.

Are you sure that the improvement will not cause any problems for your workers? Ask yourself:

Who will be directly affected by this change?

- Positively?
- Negatively?

What will you do to eliminate or reduce negative effects?

In order for workers to support what you are doing, they need to understand your intentions. They may have the idea that the changes will affect their job security or pay or make their work more difficult.

What techniques will you use to make sure that your workers are ready for the change and that they give you credit for what you are doing?

- Prior explanation and discussion.
- Involving workers in the design and introduction of the improvement.
- Showing how this innovation works in another shop or factory.
- Provision of additional training.
- Financial rewards.

Make sure your ideas will work

Very often, even improvements which seem simple do not meet your expectations in practice. Anticipate design problems and make sure that all important factors have been taken into account. Ask yourself what makes you believe that this improvement will work well:

- because you have tried out different ways of solving the same problem and this one works best.
- because you have tried it out in a small way and it works well.
Make improvements which will last

Four innovations out of five eventually disappear because no specific actions were taken to make them last. There are two main strategies which help to counteract this:

- Change people's habits and behaviour.
- Build the change into equipment and facilities.

For most changes you will need to do both to be successful.

If you follow this method carefully and involve workers fully, you should make much progress in changing workers' habits and motivation. However, if the improvement is fully dependant on the behaviour of the worker (for example, the use of protective goggles when sharpening tools on a grinder, or preventing the cluttering of passageways), it is very likely that it will not last long. Old habits are very strong. To prevent this, we have to find ways to incorporate the change into machines and facilities, so that the equipment itself would reject the old routine (for example, install a permanent transparent screen on the grinder, or provide storage racks and bins, or clearly mark passageways).

Which steps will you take to make the change last by building it into your plant and equipment?

☐ Remove any tools or equipment which make it possible or easier to return to the old situation.
☐ Build the improvement into machines so that it cannot be removed.
☐ Design new or modified equipment so that it is easier to use and maintain in the new way.
☐ Provide barriers, painted lines, bins, or make other changes which make the improvement easily visible and natural to follow.

Manage change

Be sure that changes will be effectively implemented. Foresee the following steps:

☐ Establish a firm deadline.
☐ Make someone responsible for implementation.
☐ Allocate adequate resources (time, materials, money).
☐ Request regular reports on progress.
☐ Check that the implemented improvement works well, is accepted by the workers and has no unexpected results.
☐ Make sure that you and your supervisors lead the way by following rules and by frequently praising workers who respond correctly to the improvement.

An important management responsibility is to make sure that improvement becomes a permanent part of the way work is done. Ask yourself:

- Do you receive a constant flow of ideas from your staff and workers?
- Is everyone in search of ways for more productive or higher-quality work?

Each individual improvement is an opportunity to become a real manager of change. The following steps will help to make your company more dynamic. How many will you take?

☐ A suggestion scheme with rewards for the best ideas.
☐ Regular meetings at which workers are encouraged to explain their problems and give their ideas.
☐ An exercise in which groups of workers use the checklist and make proposals to you.