FEDERAL UNIVERSITY OF TECHNOLOGY, MINNA, NIGERIA

CENTRE FOR OPEN DISTANCE AND e-LEARNING (CODeL)

ENGINEERING WORKSHOP PRACTICE
WKS 110

COURSE DEVELOPMENT TEAM

ENGINEERING WORKSHOP PRACTICE
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ENGINEERING WORKSHOP PRACTICE

INTRODUCTION

Modern engineering workshops are equipped with machine tools capable of producing components to such accurate limits that hand fitting at the bench is no longer necessary. Mass production methods render the skills possessed by old-time fitters in danger of being forgotten forever. Also, in many situations the ability to complete a job using only hand tools is a great asset. Moreover, it is often quicker to bring a component to the correct dimensions using a hand method than it is to spend time setting up the job in a milling machine or shaper, even if one is available.

Machine tools owned by the model engineer are often limited to a lathe and perhaps, a bench drilling machine, so he *has* to become skilled in the use of hand tools. The purpose of this course is to describe the basic skills necessary to maintain a workshop as well the necessary safety measures required in the workshop. It takes a great deal of practice to reach the standard required and although disappointment may be experienced at first, with the slow progress made, the satisfaction when the job is concluded is well worth the work involved.

Course Objectives

At the end of the course, the student should be able to:

(i) Describe the regulations for safety at work
(ii) Acquire skills in the basic engineering workshop practice
(iii) Acquire necessary skills in workshop technology
(iv) Acquire practical skills in the trade
(v) Identify the basic hand tools and instruments used in workshops

Reading

Tubal Cain "Workshop Drawings, 2nd Edition. Special Interest Model Books Ltd., London

Home Workshop Hints and Tips Edited by Vic Smeed. Nexus Special Interest Books, London.

Bruce J. Black "Workshop Processes, Practices and Materials" 3rd Edition. Elsevier Books

UNIT 1: SAFETY PRACTICES

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) Describe the general health and safety precautions inside engineering workshops
(ii) Describe the regulations for safety at work
(iii) Identify employer's responsibilities
(iv) Identify employee's responsibilities

3.0 Main Body

3.1 Safe Practice in Engineering Workshop

Almost everyone working in a factory has at some stage in his or her career suffered an injury requiring some kind of treatment or first aid. It may have been a cut finger or something more serious. The cause may have been carelessness by the victim or a colleague, defective safety equipment, not using the safety equipment provided or inadequate protective clothing. Whatever the explanation given for the accident, the true cause was most likely a failure to think ahead. You must learn to work safely. Your workplace will have its own safety rules so obey them at all times. Ask if you don't understand any instruction and do report anything which seems dangerous, damaged or faulty

Self-Assessment Exercise

3.2 Health and Safety at Work Act

The purpose of the Act is to provide a legal framework to encourage high standards of health and safety at work.

Its aims are:

- to secure the health, safety and welfare of people at work;
- to protect other people against risks to health or safety arising from the activity of people at work;
- to control the keeping and use of dangerous substances and prevent people from unlawfully having or using them;
- control the release into the atmosphere of noxious or offensive substances, from prescribed premises.

Self-Assessment Exercise

3.3 Employer's Responsibilities

Employers have a general duty under the HSW Act 'to ensure, so far as is reasonably practicable, the health, safety and welfare at work of their employees'. The HSW Act specifies five areas which in particular are covered by the employer's general duty as illustrated in Figures 1.1 to 1.3

.To provide and maintain machinery, equipment and other plant, and systems of work that are safe and without risk to health. ('Systems of work' means the way in which the work is organized and includes layout of the workplace, the order in which jobs are carried out or special precautions to be taken before carrying out certain hazardous tasks.)

1. Ensure ways in which particular articles and substances (e.g. machinery and chemicals) are used, handled, stored and transported are safe and without risk to health.
2. Provide information, instruction, training and supervision necessary to ensure health and safety at work. *Information* means the background knowledge needed to put the instruction and training into context. *Instruction* is when someone shows others how to do something by practical demonstration. *Training* means having employees practise a task to improve their performance. *Supervision* is needed to oversee and guide in all matters related to the task.
3. Ensure any place under their control and where their employees' work is kept in a safe condition and does not pose a risk to health. This includes ways into and out of the workplace.
4. Ensure the health and safety of their employees' working environment (e.g. heating, lighting, ventilation, etc.). They must also provide adequate arrangements for the welfare at work of their employees (the term 'welfare at work' covers facilities such as seating, washing, toilets, etc.).

Self-Assessment Exercise

3.4 Safety Policy

The HSW Act requires every employer employing more than five people to prepare a written statement of their safety policy. The written policy statement must set out the employers' aims and objectives for improving health and safety at work.

The purpose of a safety policy is to ensure that employers think carefully about hazards at the workplace and about what should be done to reduce those hazards to make the workplace safe and healthy for their employees.

Another purpose is to make employees aware of what policies and arrangements are being made for their safety. For this reason, you must be given a copy which you must read, understand and follow.

The written policy statement needs to be reviewed and revised jointly by employer and employees' representatives as appropriate working conditions change or new hazards arise.

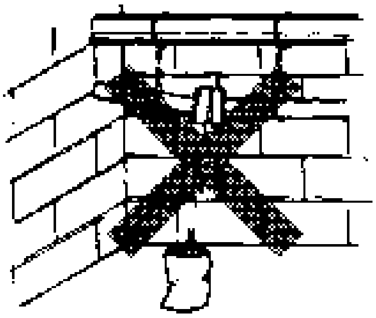


Figure 1.1: Plant must be safe and in good working order

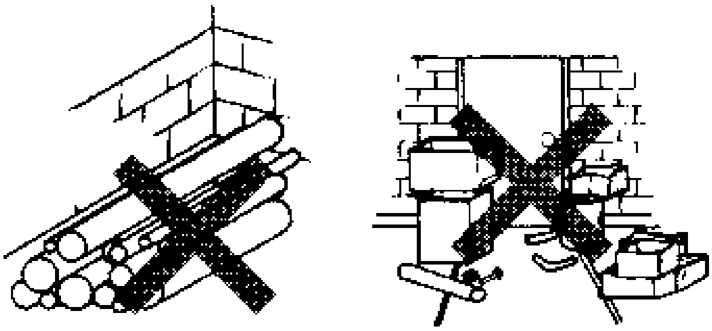


Figure 1.2: Entry and exit must be safe

Figure 1.3: Safety instructions and training must and adequate facilities must be Provided

Self-Assessment Exercise

3.5 Employees' Responsibilities

Under the HSW Act it is the duty of every employee while at work:

- To take reasonable care for their own health and safety and that of others who may be affected by what they do or don't do.

This duty implies not only avoiding silly or reckless behaviour but also understanding hazards and complying with safety rules and procedures. This means that you correctly use all work items provided by your employer in accordance with the training and instruction you received to enable you to use them safely.

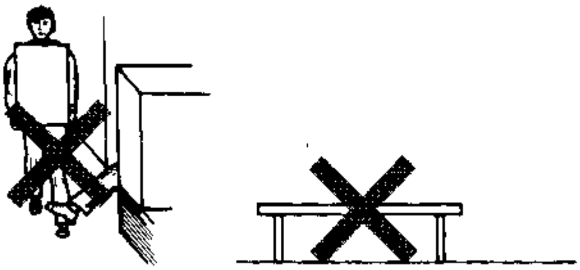
- To cooperate with their employer on health and safety.

  This duty means that you should inform, without delay, of any work situation which might be dangerous and notify any shortcomings in health and safety arrangements so that remedial action may be taken.

The HSW Act also imposes a duty on all people, both people at work and members of the public, including children to not intentionally interfere with or misuse anything that has been provided in the interests of health, safety and welfare.

The type of things covered include fire escapes and fire extinguishers, perimeter fencing, warning notices, protective clothing, guards on machinery and special containers for dangerous substances.

You can see that it is essential for you to adopt a positive attitude and approach to health and safety in order to avoid, prevent and reduce risks at work. Your training is an important way of



Every employee must take reasonable care of the safety of himself and others

Never interfere with anything provided in the interests of safety

Figure 1.3 Duties of employees

achieving this and contributes not only to your own, but to the whole organisation's, health and safety culture.

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0Tutor-Marked Assignment

1 State 2 major responsibilities of an employee under the HSW Act.

`2. Give two responsibilities of an employer

7.0 References

UNIT 2: WORKSHOP HEALTH REGULATIONS

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) List the general regulations for safety at work
(ii) Describe workplace safety as regards to health and welfare
(iii) Discuss the need for hazardous substances control

3.0 Main Body

3.1 New Regulations for Health and Safety at Work

Six new sets of health and safety at work regulations came into force on 1 January 1993. The new regulations implement European Community (EC) directives on health and safety at work in the move towards a single European Union. At the same time they are part of a continuing modernization of existing UK law.

Most of the duties in the new regulations are not completely new but clarify and make more explicit what is in current health and safety law. A lot of out-of-date law will be repealed by the new regulations, e.g. many parts of the Factories Act 1961.

The six regulations are:

- Management of Health and Safety at Work Regulations 1999;
- Provision and Use of Work Equipment Regulations 1998;
- Workplace (Health, Safety and Welfare) Regulations 1992;
- Personal Protective Equipment at Work Regulations 1992;
- Health and Safety (Display Screen Equipment) Regulations 1992 (covers computer monitors and

is not relevant to this book);

- Manual Handling Operations Regulations 1992.

Self-Assessment Exercise

3.2 Workplace (Health, Safety and Welfare) Regulations 1992

These Regulations will also tidy up a lot of existing requirements. They will replace many pieces of old law, including parts of the Factories Act 1961. They will be much easier to understand making it clearer what is expected of everyone. They came into force on 1 January 1993 but for existing workplaces the Regulations took effect on 1 January 1996.

These Regulations set general requirements which are listed here for broad areas

Working environment

i) ventilation;
ii) temperature in indoor workplace;
iii) lighting including emergency lighting;
iv) room dimensions and space;
v) suitability of workstations and seating.

- *Safety*

i) safe passage of pedestrians and vehicles (e.g. traffic routes, must be wide enough and marked where necessary, and there must be enough of them);
ii) windows and skylights (safe opening, closing and cleaning);
iii) transparent or translucent surfaces in doors and partitions (use of safety material and marking);
iv) doors, gates and escalators (safety devices);
v) floors (construction and maintenance, obstructions and slipping and tripping hazards);
vi) falling from heights and into dangerous substances;
vii) falling objects.

- *Facilities*

i) toilets;
ii) washing, eating and changing facilities;
iii) clothing storage;
iv) drinking water;
v) rest areas (and arrangements to protect people from the discomfort of tobacco smoke).

- *Housekeeping*

i) maintenance of workplace, equipment and facilities;
ii) cleanliness;
iii) removal of waste materials.

Self-Assessment Exercise

3.3 Personal Protective Equipment at Work Regulations 1992

These Regulations came into force on 1 January 1993 and set out in legislation, sound principles of selecting, providing and using personal protective equipment (PPE). They replace parts of over 20 old pieces of law (e.g. The Protection of Eyes Regulations 1974 has been revoked). They do not replace the recently introduced laws dealing with PPE (e.g. Control of Substances Hazardous to Health or Noise at Work Regulations).

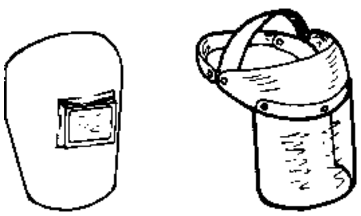
PPE should always be relied upon as a last resort to protect against risks to health and safety. Engineering controls and safe systems of work should always be considered first. Where the risks are not adequately controlled by other means, the employer has a duty to ensure that suitable PPE is provided, free of charge. PPE will only be suitable if it is appropriate for the risks and the working conditions; takes account of the workers' needs and fits properly; gives adequate protection and is compatible with any other item. The employer also has duties to:

- assess the risks and PPE intended to be issued and that it is suitable;
- maintain, clean and replace PPE;
- provide storage for PPE when it is not being used;
- ensure that PPE is properly used; and
- give training, information and instruction to employees on the use of PPE and how to look after it.

PPE is defined as all equipment which is intended to be worn or held to protect against risk to health and safety. This includes most types of protective clothing and equipment such as: eye, head, foot and hand protection; and protective clothing for the body. It does not include ear protectors and respirators which are covered by separate existing regulations.

Eye protection: Serves as a guard against the hazards of impact, splashes from chemicals or molten metal, liquid droplets (chemical mists and sprays), dust, gases and welding arcs. Eye protectors include safety spectacles, eye-shields, goggles, welding filters, face shields and hoods (Fig. 1.4).

Spectacles (with sideshield) Eyeshields Goggles



Facescreen Faceshield

Figure 1.4: Eye protection

Head protection: Includes industrial safety helmets to protect against falling objects or impact with fixed objects; industrial scalp protectors to protect against striking fixed obstacles, scalping or entanglement and caps and hairnets to protect against scalping and entanglement.

Foot protection: Includes safety boots or shoes with steel toe caps; foundry boots with steel toe caps, which are heat resistance and designed to keep out molten metal; wellington boots to protect against water and wet conditions and anti-static footwear to prevent the build-up of static electricity on the wearer.

Irritation and dermatitis and contact with toxic or corrosive liquids. Barrier creams may sometimes be used as an aid to skin hygiene in situations where gloves cannot be used.

Protective clothing: Types of clothing used for body protection include coveralls, overalls and aprons to protect against chemicals and other hazardous substances; outfits to protect against cold, heat and bad weather; and clothing to protect against machinery such as chain saws. Types of clothing worn on the body to protect the person include high-visibility clothing; life-jackets and buoyancy aids.

Self-Assessment Exercise

3.4 The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations 1995 (RIDDOR)

RIDDOR came into effect in April 1996. These Regulations require injuries, diseases and occurrences in specified categories to be notified to the relevant enforcing authority. In the case of a factory, the enforcing authority is the Health and Safety Executive.

The enforcing authority must be notified without delay, normally by a phone call, followed by a completed accident report within ten days.

Immediate notification is required for the following:

- any fatal injuries to employees or other people in an accident connected with your business;
- any major injuries to employees or other people in an accident connected with your business (major injuries include fractures, amputation, loss of sight, injury from electric shock and any other injury which results in the person being admitted to hospital for more than 24 hours). A completed accident report must be sent within ten days of any other injury to an employee which results in an absence of more than three working days;
- any of the dangerous occurrences listed in the Regulations (these include the collapse, overturning or failure of lifts, hoists and cranes, explosion of vessels, electrical fires, the sudden release of highly flammable liquids);
- report notifying specific disease related to particular work activities listed in the Regulations (the general diseases covered include certain poisonings, some skin diseases, lung diseases, infections and other conditions such as occupational cancer).

A record must be kept of any injury, occurrence or case of disease requiring report. This should include the date, time and place, personal details of those involved and a brief description of the nature of the event.

Self-Assessment Exercise

3.5 Control of Substances Hazardous to Health Regulations 2002 (COSHH)

Using chemicals and other hazardous substances at work can put peoples health at risk. So the law requires employers to control exposure to hazardous substances to prevent ill health.

Effects from hazardous substances include:

- skin irritation or dermatitis as a result of skin contact;
- asthma as a result of developing allergy to substances used at work;

Irritation and dermatitis and contact with toxic or corrosive liquids. Barrier creams may sometimes be used as an aid to skin hygiene in situations where gloves cannot be used.

Protective clothing: Types of clothing used for body protection include coveralls, overalls and aprons to protect against chemicals and other hazardous substances; outfits to protect against cold, heat and bad weather; and clothing to protect against machinery such as chain saws. Types of clothing worn on the body to protect the person include high-visibility clothing; life-jackets and buoyancy aids.

- Losing consciousness as a result of being overcome by toxic fumes
- cancer, which may appear long after exposure to the substances which caused it.

Hazardous substances include:

- substances used directly in work activities, e.g. adhesives, paints and cleaning agents;
- substances generated during work activities, e.g. fumes from soldering or welding;
- naturally occurring substances, e.g. wood dust.

COSHH sets out eight basic measures that employers and employees must take to comply with the Regulations.

1. Assess the risks to health arising from hazardous substances present in their workplace.
2. Decide the precautions needed to avoid exposing employees to hazardous substances.
3. Prevent or adequately control exposure of employees to hazardous substances.
4. Ensure that control measures are used and maintained.
5. Monitor the exposure of employees to hazardous substances if necessary.
6. Carry out appropriate health surveillance where COSHH sets specific requirements.
7. Prepare plans and procedures to deal with accidents, incidents and emergencies.
8. Ensure that employees are properly informed, trained and supervised.

Employees must make full and proper use of any control measure; personal protective equipment (PPE) or any facility provided and report any defects found in these. Follow all instructions and safety information provided and only use and dispose of substances in the recommended manner. You should know the warning symbols and pay particular attention to any container bearing any of the symbols shown in Fig. 1.5.

Figure **1.5** Warning symbols

Self-Assessment Exercise

3.6 Noise at Work Regulations 1989

These Regulations are intended to reduce hearing damage caused by loud noise. Sound and noises are an important part of everyday life. In moderation they are harmless but if they are too loud they can permanently damage your hearing. The danger depends on how loud the noise is and how long the person is exposed to the noise. Damage builds up gradually and you may not notice immediately, but once the damage is done there is no cure.

As a general rule, if you cannot hear a normal conversation clearly when you are 2 metres away from someone or if you have ringing in your ears after work, there is p

Employers have a legal duty to protect the hearing of their employees. They have to reduce the risk of damage to employees hearing and take specific actions where the noise exposure of their employees is likely to be at or above any one of the three action levels.

Two of the action levels are values of 'daily personal noise exposure' expressed as LEP, d. These depend on the noise level given in decibels, dB(A), in the working areas and how long people spend in them during the working day.

- First action level is an LEP, d of 85 dB(A).
- Second action level is an LEP, d of 90 dB(A).
- Peak action level of 200 pascals for the maximum pressure reached by the sound wave.

The peak action level is important where short loud sources such as cartridge operated tools are used.

Example levels are shown in Table 1.1.

Table 1.1

Noise source	*Noise level dB(A)*
Normal conversation	50–60
Loud radio	65–75
Busy street	78–85
Electric drill	87

Sheet metal shop	93
Circular saw	99
Hand grinding metal	108
Chain saw	115–120
Jet aircraft taking off	140
25 m away	

Employers are required to take specific measures at these levels including

- carrying out noise assessments;
- reducing exposure;
- providing information and training for employees;
- issuing personal hearing protection.

Exposure to noise is reduced in two ways.

1. By controlling or getting rid of the noise at source, e.g. using a different, quieter process or equipment, avoiding metal to metal impacts, isolating vibrating machinery, fitting silencers to air exhausts and nozzles. Using enclosures, barriers, screens to block the direct path of sound, using absorbent materials to reduce reflected sound and segregating noisy machinery and processes from quieter areas.
2. By the use of suitable ear protection in areas in which a noise hazard exists. The need to wear ear protection should be the last resort. The Regulation requires the employer, so far as is reasonably practicable, to reduce employees exposure to noise in ways other than by providing hearing protection as outlined in point 1 above.

The main types of hearing protection are:

- earmuffs, which completely cover the ear;
- earplugs, which are inserted into the ear canal;
- semi-inserts (also called 'canal caps') which cover the entrance to the ear canal.

Where required, your employer must provide effective hearing protection. For your part as an employee you should at all times

- use the provided protection when in an 'Ear Protection Zone';
- look after your ear protectors;
- do not use faulty protectors – ask you employer for replacement;
- do not neglect your hearing – if you think there is something wrong with your hearing, consult a doctor.

Self-Assessment Exercise

3.7 The Health and Safety (Safety Signs and Signals) Regulations 1996

- These Regulations cover various means of communicating health and safety information. These include the use of illuminated signs, hand and acoustic signals (e.g. fire alarms), spoken communication and the marking of pipework containing dangerous substances. These are in addition to traditional signboards such as prohibition and warning signs. Fire safety signs are also covered.

- The Regulations require employers to provide specific safety signs where there is a significant risk to health and safety which has not been avoided or satisfactorily controlled by other means, e.g. by engineering controls and safe systems of work.

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. What are the action levels set out in the Noise at Work Regulations?
2. Name four of the main groups of hazardous substances defined by COSHH

7.0 References

UNIT 3: WORKSHOP HAZARDS

CONTENTS

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) Itemize the various sources of workshop hazards
(ii) List workshop safety signs
(iii) Discuss the various causes of accident in the workshop

3.0 Main Body

3.1 Electrical Hazards

Electrical equipment of some kind is used in every factory. Electricity should be treated with respect – it cannot be seen or heard, but it can kill. Even if it is not fatal, serious disablement can result through shock and burns. Also, a great deal of damage to property and goods can be caused, usually through fire or explosion as a result of faulty wiring or faulty equipment.

The Electricity at Work Regulations 1989 came into force on 1 April 1990. The purpose of the Regulation is to require precautions to be taken against the risk of death or personal injury from electricity in work activities.

The Institution of Electrical Engineers Regulations for electrical installations (IEE Wiring Regulations), although non-statutory, is widely recognised and accepted in the UK and compliance with these is likely to mean compliance with the relevant parts of the Electricity at Work Regulations 1989.

The major hazards arising from the use of electrical equipment are:

Electric shock: The body responds in a number of ways to electric current flowing through it, any one of which can be fatal. The chance of electric shock is increased in wet or damp conditions, or close to conductors such as working in a metal tank. Hot environments where sweat or humidity reduce the insulation protection offered by clothing increase the risk.

Electric burn: This is due to the heating effect caused by electric current passing through body tissue, most often the skin at the point of contact giving rise to the electric shock.

Fire: Caused by electricity in a number of ways including, overheating of cables and electrical equipment due to overloading; leakage currents due to poor or inadequate insulation; overheating of flammable materials placed too close to electrical equipment; ignition of flammable materials by sparking of electrical equipment.

Arcing: Generates ultra-violet radiation causing a particular type of burn similar to severe sunburn. Molten metal resulting from arcing can penetrate, burn and lodge in the flesh. Ultra-violet radiation can also cause damage to sensitive skin and to eyes, e.g. arc eye in metal arc welding.

Explosion: These include the explosion of electrical equipment, e.g. switchgear or motors, or where electricity causes the ignition of flammable vapours, gases, liquids and dust by electric sparks or high temperature electrical equipment.

Electrical precautions

Where it is possible for electrical equipment to become dangerous if a fault should arise, then precautions must be taken to prevent injury. These precautions include:

Double insulation: The principle is that the live conductors are covered by two discrete layers of insulation. Each layer would provide adequate insulation in itself but together they ensure little likelihood of danger arising from insulation failure. This arrangement avoids the need for an earth wire. Double insulation is particularly suitable for portable equipment such as drills. However, safety depends on the insulation remaining in sound condition and the equipment must be properly constructed, used and maintained.

Earthing: In the UK, the electricity supply is connected to earth. It is this system that enables earth faults on electrical equipment to be detected and the electrical supply to be cut off automatically. This automatic cut-off is performed by fuses or automatic circuit breakers: if a fault occurs the fuse will blow and break the circuit. Although they do not eliminate the risk of electric shock, danger may be reduced by the use of a residual current device (RCD) designed to operate rapidly at small leakage currents. RCDs should only be considered as providing a second line of defence. It is essential to regularly operate the test trip button to maintain their effectiveness.

Use of safe voltages: Reduced voltage systems (110 volts) are particularly suitable for portable electrical equipment in construction work and in high conducting locations such as boilers, tunnels and tanks; where the risk to equipment and trailing cables is high; and where the body may be damp.

The human body as part of a circuit

In order to minimize the risk of shock and fire, any metalwork other than the current-carrying conductor must be connected to earth. The neutral of the electrical supply is earthed at the source of distribution, i.e. the supply transformer, so that, if all appliances are also connected to earth, a return path for the current will be available through earth when a fault occurs (see Fig. 1.9). To be effective, this earth path must be of sufficiently low resistance to pass a relatively high current when a fault occurs. This higher current will in turn operate the safety device in the circuit, i.e. the fuse will blow.

Accidents happen when the body provides a direct connection between the live conductors – when the body or a tool touches equipment connected to the supply. More often, however, the connection of the human body is between one live conductor and earth, through the floor or adjacent metalwork (see Fig. 1.10). Metal pipes carrying water, gas or steam, concrete floors, radiators and machine structures all readily provide a conducting path of this kind.

Any article of clothing containing any metal parts increases the likelihood of accidental electrical contact. Metal fittings such as buttons, buckles, metal watch or wrist bracelets or dog tags, and even rings could result in shock or burns.

Wetness or moisture at surfaces increases the possibility of leakage of electricity, by lowering the resistance and thus increasing the current. Contact under these conditions therefore increases the risk of electric shock.

All metals are good electrical conductors and therefore all metallic tools are conductors. Any tool brought near a current carrying conductor will bring about the possibility of a shock. Even tools with insulated handles do not guarantee that the user will not suffer shock or burns.

Electric shock and treatment

If the human body accidentally comes in contact with an electrical conductor which is connected to the supply, a current may, depending on the conditions, flow through the body. This current will at least produce violent muscular spasms which may cause the body to be flung across the room or fall off a ladder. In extreme cases the heart will stop beating.

Burns are caused by the current acting on the body tissue and internal heating can also take place leading to partial blockage of blood flow through the blood vessels.

In the event of someone suffering electric shock know what to do – it should form part of your training.

1. Shout for help – if the casualty is still in contact with electric current, switch off or remove the plug.
2. If the current cannot be switched off, take special care to stand on a dry nonconducting surface and pull or push the victim clear using a length of dry cloth, jacket or a broom. Remember: do not touch the casualty as you will complete the circuit and also receive a shock.
3. Once free, if the casualty is breathing, put in recovery position and get the casualty to hospital; if the casualty is not breathing give mouth-to-mouth resuscitation, check pulse, and, if absent, apply chest compressions and call for medical assistance.

Posters giving the detailed procedure to be followed in the event of a person suffering electric shock must be permanently displayed in your workplace. With this and your training you should be fully conversant with the procedures – remember it could save a life.

General electrical safety rules

- Ensure that a properly wired plug is used for all portable electrical equipment (see Fig. 1.6)

  brown wire **live** conductor

  blue wire **neutral** conductor

  green/yellow wire**earth** conductor.

- Never improvise by jamming wires in sockets with nails or matches.
- Moulded rubber plugs are preferable to the brittle plastic types, since they are less prone to damage.
- All electrical connections must be secure, loose wires or connections can arc.
- A fuse of the correct rating must be fitted – this is your safeguard if a fault develops – never use makeshift fuses such as pieces of wire.
- Any external metal parts must be earthed so that if a fault develops, the fuse will blow and interrupt the supply.
- Never run power tools from lamp sockets.
- Connection between the plug and equipment should be made with the correct cable suited to the current rating of the equipment.
- Old or damaged cable should never be used.
- Equipment should always be disconnected from the mains supply before making any adjustment, even when changing a lamp.

Do not, under any circumstances, interfere with any electrical equipment or attempt to repair it yourself. All electrical work should be done by a qualified electrician. A little knowledge is often sufficient to make electrical equipment function but a much higher level of knowledge and expertise is usually needed to ensure safety.

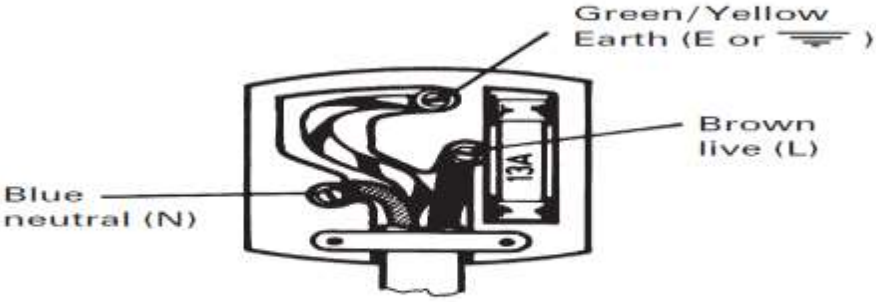


Figure 1.11 Correctly wired plug

Do not, under any circumstances, interfere with any electrical equipment or attempt to repair it yourself. All electrical work should be done by a qualified electrician. A little knowledge is often sufficient to make electrical equipment function but a much higher level of knowledge and expertise is usually needed to ensure safety.

Self-Assessment Exercise

3.2 Safety Signs and Colours

Colours play an essential safety role in giving information for use in the prevention of accidents, for warning of health hazards, to identify contents of gas cylinders, pipeline and services, the identification and safe use of cables and components in electronic and electrical installations as well as the correct use of fire-fighting equipment.

The purpose of a system of safety colours and safety signs is to draw attention to objects and situations which affect or could affect health and safety. The use of a system of safety colours and safety signs does not replace the need for appropriate accident prevention measures.

Table 1.2

Safety colour	*Meaning*	*Examples of use*
Red (white background colour with black symbols)	Stop Stop signs Prohibition (**Don't** do)	Emergency stops Prohibition signs
Red (white symbols and text)	Fire equipment	Position of fire equipment, alarms, hoses, extinguishers, etc.
Yellow (black symbols and text)	Warning (risk of danger)	Indication of hazards (electrical, explosive, radiation, chemical, vehicle, etc.) Warning of threshold, low passages, obstacles
Green (white symbols and text)	Safe condition (the safe way)	Escape routes Emergency exits Emergency showers First-aid and rescue stations
Blue (white symbols and	Mandatory action	Obligation to wear personal

text)	(**MUST** do)	safety equipment

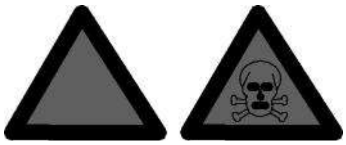
British Standards BS 5499-5: 2002 Graphical Symbols and Signs is concerned with a system for giving information which does not, in general require the use of words and covers safety signs, including fire safety signs

Red Smoking prohibited

Figure 1.6 Prohibition – indicates certain behaviour is prohibited

Red Fire extinguisher

Figure 1.7 Fire equipment



Yellow Caution

Figure 1.8 Warning – indicates warning of possible hazard

Green First aid

Figure 1.9 Safe condition – conveys information about safe conditions

Blue Head protection must be worn

Figure 1.10 Mandatory – indicates specific course of action to be taken

The safety colours, their meaning, and examples of their use are shown in Table 1.2. Examples of the shape and colour of the signs are shown in Figs 1.6–1.10.

Portable fire extinguishers

All fire extinguishers manufactured to European Standard BS EN 3 are coloured red with icons to indicate the type of fire to which they are suited and the means of operation.

The European Standards allows a small colour zone at the top half front of extinguisher body relating to the old British Standard extinguisher colour coding system, i.e. red for water, cream for foam, blue for powder, black for CO_2 and canary yellow for wet chemical

Self-Assessment Exercise

3.3 Fire

Fire is a phenomenon in which combustible materials, especially organic materials containing carbon, react chemically with the oxygen in the air to produce heat. Flame arises from the combustion of volatile liquids and gases evolved and spreads the fire.

No-one should underestimate the danger of fire. Many materials burn rapidly and the fumes and smoke produced, particularly from synthetic material, including plastics, may be deadly.

There are a number of reasons for fires starting:

- malicious ignition: i.e. deliberate fire raising;
- misuse or faulty electrical equipment; e.g. incorrect plugs and wiring, damaged cables, overloaded sockets and cables, sparking and equipment such as soldering irons left on and unattended;
- cigarettes and matches: smoking in unauthorised areas, throwing away lighted cigarettes or matches;
- mechanical heat and sparks: e.g. faulty motors, overheated bearings, sparks produced by grinding and cutting operations;
- heating plant: flammable liquids/substances in contact with hot surfaces;
- rubbish burning: casual burning of waste and rubbish.

There are a number of reasons for the spread of fire including:

- delayed discovery;
- presence of large quantities of combustible materials;
- lack of fire separating walls between production and storage areas;
- openings in floors and walls between departments;
- rapid burning of dust deposits;
- oils and fats flowing when burning;
- combustible construction of buildings;
- combustible linings of roofs, ceilings and walls.

Fire prevention

The best prevention is to stop a fire starting:

- where possible use materials which are less flammable;
- minimise the quantities of flammable materials kept in the workplace or store;
- store flammable material safely, well away from hazardous processes or materials, and where appropriate, from buildings;
- warn people of the fire risk by a conspicuous sign at each workplace, storage area and on each container;
- some items, like oil-soaked rags, may ignite spontaneously; keep them in a metal container away from other flammable material;
- before welding or similar work remove or insulate flammable material and have fire extinguishers to hand;
- control ignition sources, e.g. naked flames and sparks, and make sure that ‘no smoking’ rules are obeyed;

- do not leave goods or waste to obstruct gangways, exits, stairs, escape routes and fire points;
- make sure that vandals do not have access to flammable waste materials;
- comply with the specific precautions for highly flammable gas cylinders such as acetylene;
- after each spell of work, check the area for smouldering matter or fire;
- burn rubbish in a suitable container well away from buildings and have fire extinguishers to hand;
- never wedge open fire-resistant doors designed to stop the spread of fire and smoke;
- have enough fire extinguishers, of the right type and properly maintained, to deal promptly with small outbreaks of fire.

The Fire Precautions (Workplace) Regulations 1997

These Regulations bring into UK law the fire requirements of two EU directives. They do not apply to premises that have a current fire certificate issued under the Fire Precautions Act.

The Regulations require the occupiers or owners of all premises to which they apply to carry out an assessment of fire risk and to provide adequate safety measures. Provisions made must include,

- adequate means of escape in case of fire;
- adequate means of giving warning in the event of a fire;
- the provision of adequate firefighting equipment;
- the preparation of an emergency plan, identification of those who will implement the plan and training for them.

Fire fighting

Every employee should know where the portable fire extinguishers, the hose reels and the controls for extinguishing are located and how to operate extinguishers in their working area. Training must include the use of extinguishers on simulated fires. Tackling a small fire with an extinguisher may make the difference between a small incident and a full-scale disaster.

It must be stressed that fire fighting should only be attempted if it is safe to do so and that an escape route must always be available.

It is also essential to emphasise the limits of first-aid fire fighting in order to show the need to attempt this safely and the importance of first raising the alarm.

As previously stated, a fire requires fuel, oxygen (air) and heat. This is shown by the ‘fire triangle’ in Fig. 1.17, where one side stands for fuel, another for heat and the third for air or oxygen. If any one side is removed the fire inside will go out.

The extinguishing of a fire is generally brought about by depriving the burning substances of oxygen and by cooling them to a temperature below which the reaction is not sustained.

By far the most important extinguishing agent, by reason of its availability and general effectiveness, is water. It is more effective than any other common substance in absorbing heat, thereby reducing the temperature of the burning mass. The steam produced also has a smothering action by lowering the oxygen content of the atmosphere near the fire.

For these reasons the use of a water hose reel in factories is common and is suitable for most fires except those involving flammable liquids or live electrical equipment.

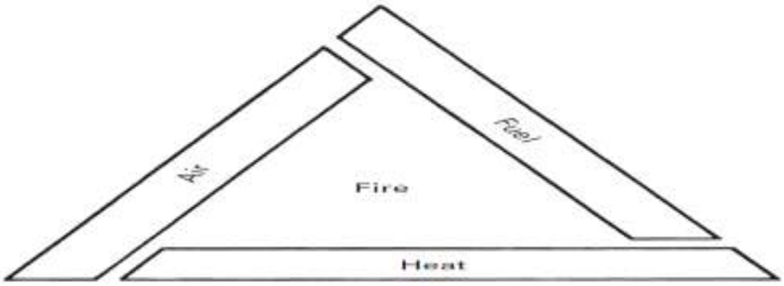


Figure 1.11: Fire Triangle

Types of fire are classified as follows while the corresponding icons which have been established to provide easy identification regardless of language are as shown in Table 1.3.

- Class A fires – freely burning fires fuelled by ordinary combustible materials such as cloth, wood, paper and fabric.
- Class B fires – fires fuelled by flammable liquids such as oils, spirits and petrol.
- Class C fires – fires fuelled by flammable gases such as propane, butane and North Sea gas.
- Class D fires – fires involving flammable metals such as Magnesium, Lithium or Aluminium powders or swarf.
- Fires involving electrical hazards.
- Class F fires – fires fuelled by cooking oils and fats. Use of a wet chemical is the most effective way of extinguishing this type of fire.

Table 1.3

Which extinguisher to use	*Freely burning materials*	*Flammable liquids*	*Flammable gases*	*Flammable metals*	*Electrical hazards*	*Cooking oils and fat*
Water	✔					
Water with additive	✔					
Spray foam	✔	✔				
Dry powder	✔	✔	✔		✔	
Dry powder special metal				✔		
CO_2 gas		✔			✔	
Wet chemical	✔					✔

Types of portable fire extinguishers

Water (Fig. 1.12): Colour coded red – these are suitable for class A types of fires. Water is a fast, efficient means of extinguishing these materials and works by having a rapid cooling effect on the fire so that insufficient heat remains to sustain burning and continuous ignition ceases.

Water with additives: These are suitable for class A types of fire. They contain special additives and are particularly effective for cooling and penetrating the fire and can be up to 300% more effective than the ordinary jet water extinguisher.

Spray foam (Fig. 1.12): Colour coded red with cream colour zone – these are ideal in multi-risk situations where both class A and B type fires are likely. Spray foam has a blanketing effect which both smothers the flame and prevents re-ignition of flammable vapours by sealing the surface of the material.

Dry powder (Fig. 1.14): Colour coded red with blue colour zone – these are suitable for class A, B and C fires and for vehicle protection. Because dry powder is non-conductive it is ideal for electrical hazards. Dry powder is a highly effective means of extinguishing fires as it interferes with the combustion process and provides rapid fire knockdown. A specialist range designed to tackle flammable metals is available.

Figure 1.12 Water fire extinguisher

Figure 1.13 Spray foam fire extinguisher

Figure 1.14 Dry powder fire extinguisher

Figure 1.15 Carbon dioxide (CO_2 gas) fire extinguisher

Carbon dioxide (CO_2 gas) (Fig. 1.15): Colour coded red with black colour zone – these are suitable for class B type fires and are also ideal for electrical hazards because CO_2 is non-conductive. CO_2 is an extremely fast fire control medium. These extinguishers deliver a powerful concentration of CO_2 gas under great pressure, which smothers the flames very rapidly by displacing air from the local area of the fire. CO_2 is a non-toxic, non-corrosive gas that is harmless to most delicate equipment and materials found in situations such as computer rooms.

Wet chemical: Colour coded red with canary yellow colour zone. These have been specifically developed to deal with cooking oils and fat fires. The specially formulated wet chemical, when applied to the burning liquid, cools and emulsifies the oil changing it into soap form, extinguishing the flame and sealing the surface to prevent re-ignition. It is also capable of fighting class A fires.

Table 1.3 shows the portable extinguishers most suited to each class of fire.

Self-Assessment Exercise

3.4 First Aid at Work

People at work can suffer injuries or fall ill. It doesn't matter whether the injury or illness is caused by the work they do or not, what is important is that they receive immediate attention and that an ambulance is called in serious cases.

The Health and Safety (First Aid) Regulations 1981 requires the employer to provide adequate and appropriate equipment, facilities and personnel to enable first aid to be given to employees if they are injured or become ill at work. It is important to remember that accidents can happen at any time and so first aid provision must be available at all times people are at work.

The minimum first aid provision for any workplace is

- a suitably stocked first aid box
- an appointed person to take charge of first aid arrangements.

An appointed person is someone the employer chooses to

- take charge when someone is injured or falls ill, including calling an ambulance if required.
- look after the first aid equipment, e.g. restocking the first aid box.

Appointed persons should not attempt to give first aid for which they have not been trained. Depending on the category of risk and the number of people employed, it may be necessary to appoint a first aider.

A first aider is someone who has undergone a training course, approved by the Health and Safety Executive, in administering first aid at work and holds a current first aid at work certificate.

Employees must be informed of all first aid arrangements. Putting up notices, telling staff who and where the first aiders or appointed persons are, and where the first aid box is situated, will usually be sufficient.

Details of all first aid treatments should be recorded either in the statutory accident book or in a record system developed by the employer.

Self-Assessment Exercise

3.5 Causes of Accidents

Workplace accidents can be prevented – you only need commitment, commonsense and to follow the safety rules set out for your workplace. Safety doesn't just happen – you have to make it happen.

Most accidents are caused by carelessness, through failure to think ahead or as a result of fatigue. Fatigue may be brought on by working long hours without sufficient periods of rest or even through doing a second job in the evening.

Taking medicines can affect peoples' ability to work safely, as can the effects of alcohol. Abuse of drugs or substances such as solvents can also cause accidents at work.

Serious injury and even death have resulted from horseplay, practical jokes or silly tricks. There is no place for this type of behaviour in the workplace.

Improper dress has led to serious injury: wearing trainers instead of safety footwear, and loose cuffs, torn overalls, floppy woollen jumpers, rings, chains, watch straps and long hair to get tangled up.

Don’t forget, quite apart from the danger to your own health and safety, you are breaking the law if you fail to wear the appropriate personal protective equipment.

Unguarded or faulty machinery, and tools are other sources of accidents. Again within the health and safety law you must not use such equipment and furthermore it is your duty to report defective equipment immediately.

Accidents can occur as a result of the work place environment, e.g. poor ventilation, temperature too high or too low, bad lighting, unsafe passages, doors, floors and dangers from falls and falling objects.

They can also occur if the workplace, equipment and facilities are not maintained, are not clean and rubbish and waste materials are not removed.

Many accidents befall new workers in an organization, especially the young, and are the result of inexperience, lack of information, instruction, training or supervision all of which is the duty of the employer to provide.

Self-Assessment Exercise

3.6 General Health and Safety Precautions

As already stated you must adopt a positive attitude and approach to health and safety. Your training is an important way of achieving competence and helps to convert information into healthy and safe working practices.

Remember to observe the following precautions

- *Horseplay*
  i) work is not the place for horseplay, practical jokes, or silly tricks.

- *Hygiene*
  i) always wash your hands using suitable hand cleaners and warm water before meals, before and after going to the toilet, and at the end of each shift;
  ii) dry your hands carefully on the clean towels or driers provided – don’t wipe them on old rags;
  iii) paraffin, petrol or similar solvents should never be used for skin-cleaning purposes;
  iv) use appropriate barrier cream to protect your skin;
  v) conditioning cream may be needed after washing to replace fatty matter and prevent dryness.

- *Housekeeping*
  i) never throw rubbish on the floor;
  ii) keep gangways and work area free of metal bars, components, etc.;
  iii) if oil, or grease is spilled, wipe it up immediately or someone might slip and fall.

- *Moving about*
  i) always walk – never run;
  ii) keep to gangways – never take shortcuts;
  iii) look out for and obey warning notices and safety signs;
  iv) never ride on a vehicle not made to carry passengers, e.g. fork-lift trucks.

- *Personal protective equipment*
  i) use all personal protective clothing and equipment, such as ear and eye protectors, dust masks, overalls, gloves, safety shoes and safety helmets;
  ii) get replacements if damaged or worn.
- *Ladders*
  i) do not use ladders with damaged, missing or loose rungs;
  ii) always position ladders on a firm base and at the correct angle – the height of the top support should be four times the distance out from the base;
  iii) ensure the ladder is long enough – at least one metre above the landing place;
  iv) make sure the ladder is tied at the top or secured at the bottom;
  v) never over-reach from a ladder – be safe, get down and move it;
  vi) take all necessary precautions to avoid vehicles or people hitting the bottom of the ladder.
- *Machinery*
  i) ensure you know how to stop a machine before you set it in motion;
  ii) keep your concentration while the machine is in motion;
  iii) never leave your machine unattended while it is in motion;
  iv) take care not to distract other machine operators;
  v) never clean a machine while it is in motion – always isolate it from the power supply first;
  vi) never clean swarf away with your bare hands – always use a suitable rake;
  vii) keep your hair short or under a cap or hairnet – it can become tangled in drills or rotating shafts;
  viii) avoid loose clothing – wear a snug-fitting boiler suit, done up, and ensure that any neckwear is tucked in and secure;
  ix) do not wear rings, chains or watches at work – they have caused serious injury when caught accidentally on projections;
  x) do not allow unguarded bar to protrude beyond the end of a machine, e.g. in a centre lathe;
  xi) always ensure that all guards are correctly fitted and in position – remember, guards are fitted on machines to protect you and others from accidentally coming in contact with dangerous moving parts.
- *Harmful substances*
  i) learn to recognize hazard warning signs and labels;
  ii) follow all instructions;
  iii) before you use a substance find out what to do if it spills onto your hand or clothes;
  iv) never eat or drink in the near vicinity;
  v) do not take home any clothes which have become soaked or stained with harmful substances;
  vi) do not put liquids or substances into unlabelled or wrongly labelled bottles or containers.
- *Electricity*
  i) make sure you understand all instructions before using electrical equipment;
  ii) do not use electrical equipment for any purpose other than, nor in the area other than the intended one;
  iii) always switch off or isolate before connecting or disconnecting any electrical equipment.
- *Compressed air*
  i) only use compressed air if allowed to do so;
  ii) never use compressed air to clean a machine – it may blow in your face or someone else's and cause an injury.
- *Fire*
  i) take care when using flammable substances;

ii) never smoke in ‘no smoking’ areas;
iii) do not throw rubbish, cigarette ends and matches in corners or under benches;
iv) always make sure that matches and cigarettes are put out before throwing them away;
v) know the correct fire drill.

- *First aid*

i) have first aid treatment for every injury however trivial;
ii) know the first aid arrangements for your workplace.

Self-Assessment Exercise

4.0 Conclusion
5.0 Summary
6.0 Tutor-Marked Assignment

1. What is the purpose of a system of safety colors and safety signs?
2. State four precautions to be taken to avoid accidents when using machine
3 State four major hazards which may arise from the use of electrical equipment.
7.0 Show by means of the fire triangle, the three elements necessary to produce fire.
8.0 List four ways in which accidents may be caused.

7.0 References

UNIT 4: ENGINEER'S FILES AND HACKSAW

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) Identify the various types of files used in the workshop
(ii) Describe how to use and care for files
(iii) Identify the various types of hacksaw blades
(iv) Use the hacksaw

Main Body

3.1 Engineer's Files

Files are used to perform a wide variety of tasks, from simple removal of sharp edges to producing intricate shapes where the use of a machine is

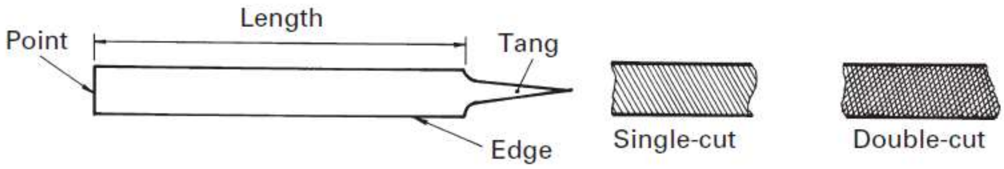


Figure 2.1 Single-cut and double-cut files

impracticable. They can be obtained in a variety of shapes and in lengths from 150 mm to 350 mm. When a file has a single series of teeth cut across its face it is known as *single-cut* file, and with two sets of teeth cut across its face it is known as *double-cut* file, Fig. 2.1.

The grade of cut of a file refers to the spacing of the teeth and determines the coarseness or smoothness of the file. Three standard grades of cut in common use, from coarsest to smoothest, are *bastard, second cut* and *smooth*. In general, the bastard cut is used for rough filing to remove the most material in the shortest time, the second cut to bring the work close to finished size and the smooth cut to give a good finish to the surface while removing the smallest amount of material.

Files are identified either by their general shape – i.e. hand, flat or pillar – or by their cross-section – i.e. square, three-square, round, half-round or knife – Fig. 2.2.

Hand file: The hand file is for general use, typically on flat surfaces. It is rectangular in cross-section, parallel in width along its length, but tapers slightly in thickness for approximately the last third of its length towards the point. It is double-cut on both

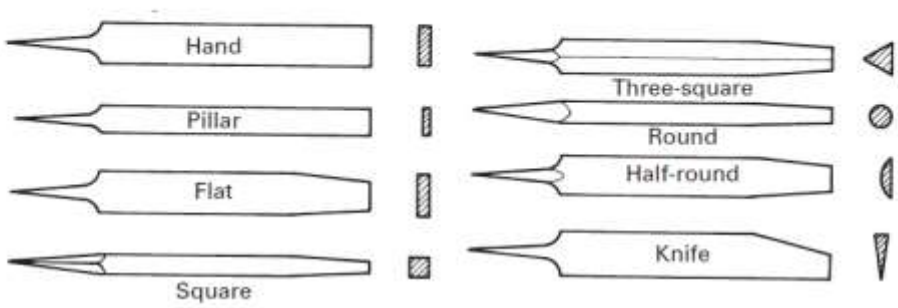


Figure 2.2 Types of file

faces, single-cut on one edge and is plain on the second edge. The plain edge with no teeth is known as the 'safe' edge and is designed to file up to the edge of a surface without damaging it. The taper in thickness enables the file to enter a slot slightly less than its full thickness.

Pillar file: This file has the same section as a hand file but of a thinner section. It is used for narrow slots and keyways.

Flat file: The flat file is also for general use, typically on flat surfaces. It is rectangular in cross-section and tapers in both width and thickness for approximately the last third of its length towards the point. Both faces are double-cut and both edges single-cut. The tapers in width and thickness enable this file to be used in slots which are narrower than its full width and thickness and which require filing on length and width.

Square file: The square file is of square cross-section, parallel for approximately two-thirds of its length, then tapering towards the point. It is double-cut on all sides. This file is used for filing keyways, slots and the smaller square or rectangular holes with 90° sides.

Three-square file: The three-square or triangular file has a 60° triangle cross-section, parallel for approximately two thirds of its length, then tapering towards the point. The three faces are double-cut and the edges sharp. This file is used for surfaces which meet at less than 90°, angular holes and recesses.

Round file: The round file is of circular cross-section, parallel for approximately two-thirds of its length and then tapering towards the point. Second-cut and smooth files are single-cut, while the bastard is double-cut.

This file is used for enlarging round holes, elongating slots and finishing internal round corners.

Half-round file: The half-round file has one flat and one curved side. It is parallel for approximately two-thirds of its length, then tapers in width and thickness towards the point. The flat side is double-cut and the curved side is single-cut on second-cut and smooth files. This is an extremely useful double-purpose file for flat surfaces and for curved surfaces too large for the round file.

Knife file: The knife file has a wedge-shaped cross-section, the thin edge being straight while the thick edge tapers to the point in approximately the last third of its length. The sides are double-cut. This file is used in filing acute angles

Dreadnought Files: When soft material is being filed, the material is more readily removed and the teetn of an engineer’s file become clogged. When this happens, the file no longer cuts but skids over the surface. This results in constant stoppages to clear the file so that it again cuts properly. To overcome the problem of clogging, files have been developed which have deep curved teeth milled on their faces and these are known as *dreadnought* files Fig. 2,4.

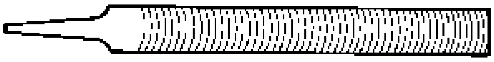


Figure 2.3 Dreadnought file

These files are designed to remove material faster and with less effort, since the deep curved teeth produce small spiral filings which clear themselves from the tooth and so prevent clogging. Their principal use is in filing soft materials such as aluminium, lead, white metal, copper, bronze and brass. They can also be used on large areas of steel, as well as on non-metallic materials such as plastics, wood, fibre and slate.

This type of file is available as hand, flat, half-round and square, from 150 mm to 400 mm long. The available cuts are broad, medium, standard, fine and extra fine.

Needle files: Needle files are used for very fine work in tool making and fitting, where very small amounts of material have to be removed in intricate shapes or in a confined space. This type of file is available from 120 mm to 180 mm long, of which approximately half is file-shaped and cut, the remainder forming a slender circular handle, Fig. 2.4.

Figure 2.4 Needle file

Filing

One of the greatest difficulties facing the beginner is to produce a filed surface which is flat. By carefully observing a few basic principles and carrying out a few exercises, the beginner should be able to produce a flat surface.

Filing is a two-handed operation, and the first stage is to grip the file correctly. The handle is gripped in the palm of the right hand with the thumb on top and the palm of the left hand resting at the point of the file. Having gripped the file correctly, the second stage is to stand correctly at the vice. The left foot is placed well forward to take the weight of the body on the forward stroke. The right foot is placed well back to enable the body to be pushed forward.

Remember that the file cuts on the forward stroke and therefore the pressure is applied by the left hand during the forward movement and is released coming back. Do not lift the file from the work on the back stroke, as the dragging action helps clear the filings from the teeth and also prevents the ‘see-saw’ action which results in a surface which is curved rather than flat. Above all, take your time – long steady strokes using the length of the file will remove metal faster and produce a flatter surface than short rapid strokes.

As already stated, a smooth-cut file is to give a good finish to the surface while removing small amounts of material. An even fine finish to the surface can be achieved by a method known as drawfiling. With this method, the file, rather than being pushed across, is drawn back and forth along the surface at right angles to its normal cutting diretion

An even finer finish can be obtained using abrasive cloth supported by the file to keep the surface flat. Abrasive cloth is available on rolls 25 mm wide, in a variety of grit sizes from coarse to fine. By supporting the cloth strip on the underside of the file and using a traditional filing stroke, extremely fine surface finishes can be obtained while removing very small amounts of material. This process is more of a polishing operation.

Care of files

A file which cuts well saves you extra work. It is important, therefore, that all the teeth are cutting. Never throw files on top of each other in a drawer, as the teeth may be chipped. Never knock the file on its edge to get rid of filings in the teeth – use a file brush. A file brush should be used regularly to remove filings from the teeth, as failure to do so will cause scratching of the work surface and inefficient removal of metal. Always clean the file on completion of the job before putting it away. Do not exert too much pressure when using a new file, or some of the teeth may break off due to their sharpness – work lightly until the fine tooth points are worn slightly. For the same reason, avoid using a new file on rough surfaces of castings, welds or hard scale.

Always use a properly fitted handle of the correct size – on no account should a file be used without a handle or with a handle which is split; remember, one slip and the tang could pierce your hand.

Self-Assessment Exercise

3.2 The Hacksaw

The hacksaw is used to cut metal. Where large amounts of waste metal have to be removed, this is more easily done by hacksawing away the surplus rather than by filing. If the workpiece is left slightly too large, a file can then be used to obtain the final size and surface.

The hacksaw blade fits into a hacksaw frame on two holding pins, one of which is adjustable in order to tension the blade. The hacksaw frame should be rigid, hold the blade in correct alignment, tension the blade easily and have a comfortable grip.

The blade is fitted to the frame with the teeth pointing away from the handle, Fig. 2.5, and is correctly tensioned by turning the wing nut to take up the slack and then applying a further three turns only. A loose blade will twist or buckle and not cut straight, while an overtightened blade could pull out the ends of the blade.

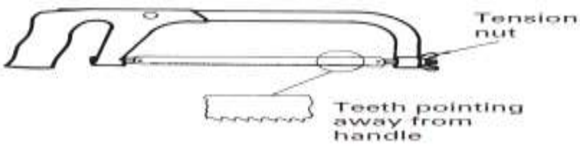


Figure 2.5 Hacksaw

The standard hacksaw blade is 300mm long x 13mm wide x 0,65mm thick and is available with 14, 18, 24 and 32 teeth per 25mm; i.e., for every 25mm length of blade there are 14teeth and so on.

A hacksaw blade should be chosen to suit the type of material being cut, whether hard or soft, and the nature of the cut, whether thick section or thin. Two important factors in the choice of a blade are the pitch, or distance between each tooth and the material from which the blade is made.

When cutting soft metals, more material will be cut on each stroke and this material must have somewhere to go. The only place the material can go is between the teeth, and therefore if the teeth are further apart there is more space for the metal being cut. The largest space is in the blade having the least number of teeth, i.e. 14 teeth per 25 mm. The opposite is true when cutting harder metals. Less material will be removed on each stroke, which will require less space between each tooth. If less space is required, more teeth can be put in the blade, more teeth are cutting and the time and effort in cutting will be less.

When cutting thin sections such as plate, at least three consecutive teeth must always be in contact with the metal or the teeth will straddle the thin section. The teeth will therefore have to be closer together, which means more teeth in the blade, i.e. 32 teeth per 25 mm.

Like a file, the hacksaw cuts on the forward stroke, which is when pressure should be applied. Pressure should be released on the return stroke. Do not rush but use long steady strokes (around 70 strokes per minute when using high-speed-steel blades). The same balanced stance should be used as for filing.

Table 2.1 gives recommendations for the number of teeth per 25 mm on blades used for hard and soft materials of varying thickness.

Table 2.1 Selection of hacksaw blades

Material thickness (mm)	*No. of teeth per 25 mm*	
	Hard materials	*Soft materials*
Up to 3	32	32
3 to 6	24	24
6 to 13	24	18
13 to 25	18	14

Three types of hacksaw blade are available: all-hard, flexible and bimetal.

- *All hard* – this type is made from hardened high-speed steel. Due to their all-through hardness, these blades have a long blade life but are also very brittle and are easily broken if twisted during sawing. For this reason they are best suited to the skilled user.
- *Flexible* – this type of blade is also made from high-speed steel, but with only the teeth hardened. This results in a flexible blade with hard teeth which is virtually unbreakable and can therefore be used by the less experienced user or when sawing in an awkward position. The blade life is reduced due to the problem of fully hardening the teeth only.
- *Bimetallic* – this type of blade consists of a narrow cutting-edge strip of hardened high-speed steel joined to a tough alloy-steel back by electron beam welding. This blade combines the qualities of hardness of the all-hard blade and the unbreakable qualities of the flexible blade, resulting in a shatterproof blade with long life and fast-cutting properties.

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. Name eight types of file
2. How do you care for files

7.0 References

UNIT 5: MATERIAL REMOVAL TOOLS AND HAMMERS

CONTENTS

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) List the various types of chisels and their use
(ii) Describe how to use scrapers
(iii) List the various types of hammers
(iv) Describe the use of screwdriver

Main Body

3.1 Cold Chisels

Cold chisels are used for cutting metal. They are made from high-carbon steel, hardened and tempered at the cutting end. The opposite end, which is struck by the hammer, is not hardened but is left to withstand the hammer blows without chipping.

Cold chisels are classified as 'flat' or 'cross-cut', according to the shape of the point.

Flat: This chisel has a broad flat point and is used to cut thin sheet metal, remove rivet heads or split corroded nuts. The cutting edge is ground to an angle of approximately 60°, Fig. 2.6.

Figure 2.6 'Flat' cold chisel

Cross-cut: This chisel has a narrower point than the flat chisel and is used to cut keyways, narrow grooves, square corners and holes in sheet metal too small for the flat chisel, Fig. 2.7.

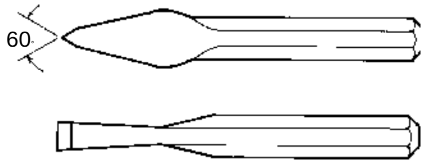


Figure 2.7: ‘Cross-cut’ cold chisel

Using the chisel

When using a cold chisel on sheet-material, great care must be taken not to distort the metal. To prevent distortion, the sheet must be properly supported. A small sheet is best held in a vice, Fig. 2.8. A large sheet can be supported by using two metal bars securely clamped, Fig. 2.9.

To remove a section from the centre of a plate, the plate can be supported on soft metal. It is best to mark out the shape required, drill a series of holes in the waste material, and use the chisel to break through between the holes, Fig. 2.10.

The chisel should be held firmly but not too tight, and the head should be struck with sharp blows from the hammer, keeping your eye on the cutting edge, not the chisel head. Hold the chisel at approximately 40°, Fig. 2.11. Do not hold the chisel at too steep an angle, otherwise it will tend to dig into the metal. Too shallow an angle will cause the

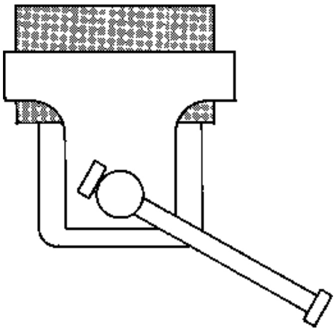


Figure 2.8 Sheet metal in vice

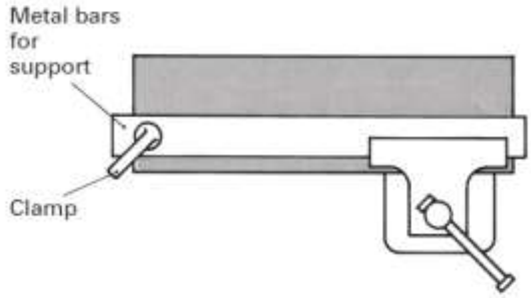
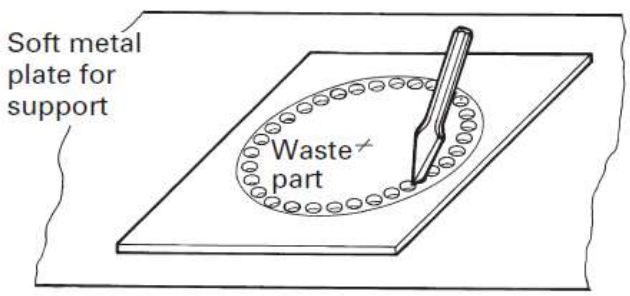


Figure 2.9 Sheet metal in support bars



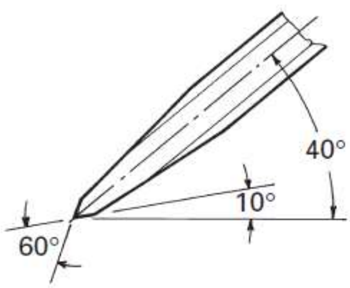


Figure 2.10 Chisel cutting a hole supported on soft metal plate

Figure 2.11 Correct angle of chisel

chisel to skid and prevent it cutting. Use a hammer large enough to do the job, grasping it well back at the end of the handle, not at the end nearest the head. Never allow a large 'mushroom' head to form on the head of a chisel, as a glancing blow from the

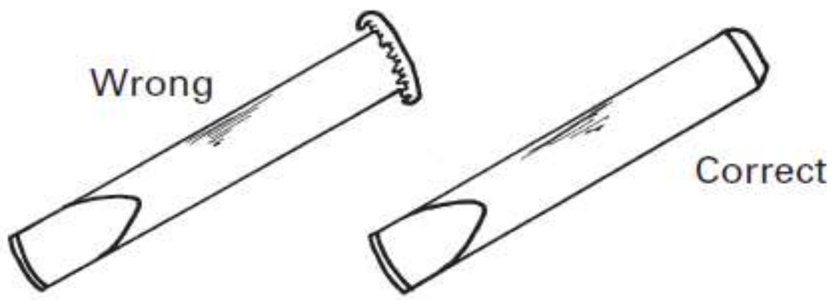


Figure 2.12 Correct chisel

hammer can dislodge a chip which could fly off and damage your eye or hand. Always grind off any sign of a mushroom head as it develops, Fig. 2.12.

Cold chisels can be sharpened by regrinding the edge on an off-hand grinder. When resharpening, do not allow the chisel edge to become too hot, otherwise it will be tempered, lose its hardness and be unable to cut metal.

Self-Assessment Exercise

3.2 Scrapers

Scraping, unlike filing or chiselling, is not done to remove a great deal of material. The material is removed selectively in small amounts, usually to give a flat or a good bearing

Surface. A surface produced by machining or filing may not be good enough as a bearing where two surfaces are sliding or rotating. The purpose of scraping is therefore to remove high spots to make the surface flat or circular, and at the same time to create small pockets in which lubricant can be held between the two surfaces. Surface plates and surface tables are examples of scraping being used when flatness is of prime importance. Examples where both flatness and lubricating properties are required can be seen on the sliding surfaces of centre lathes and milling, shaping and grinding machines.

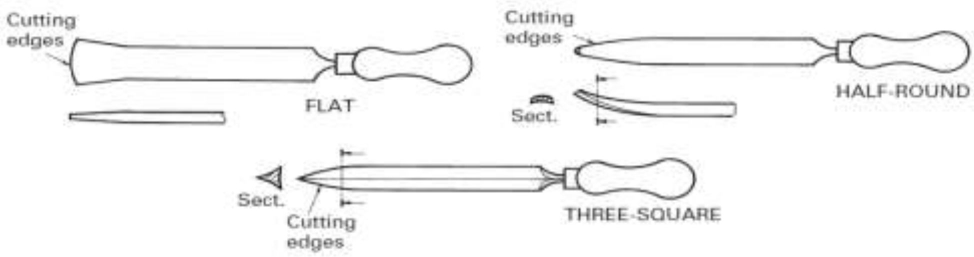


Figure 2.13 Scrapers

The flat scraper, for use on flat surfaces, resembles a hand file thinned down at the point, but it does not have any teeth cut on it, Fig. 2.13. The point is slightly curved, and the cutting edges are kept sharp by means of an oilstone. The scraper cuts on the forward stroke, the high spots being removed one at a time by short forward strokes. The flatness is checked with reference to a surface plate. A light film of engineer's blue is smeared evenly on the surface plate, and the surface being scraped is placed on top and moved slightly from side to side. Any high spots show up as blue spots, and these are reduced by scraping. The surface is again checked, rescraped and the process is repeated until the desired flatness is obtained. Flatness of the surface is indicated when the whole area being scraped is evenly covered by blue from the surface plate.

The same procedure is used on internal curved surfaces, using a half-round scraper slightly hollow on the underside, to prevent digging in, and with a cutting edge on each side, Fig. 2.13. The reference surface in this case is the shaft which is to run in the curved surface and which is smeared with engineer's blue. Entry of the shaft in the bearing indicates the high spots, which are removed by scraping, and this process is repeated until the desired surface is produced.

The three-square or triangular scraper, Fig. 2.13 is commonly used to remove the sharp edges from curved surfaces and holes. It is not suited to scraping internal curved surfaces, due to the steeper angle of the cutting edges tending to dig into the surface. However, the sharp point is useful where a curved surface is required up to a sharp corner.

Self-Assessment Exercise

3.3 Engineer's Hammers

The engineer's hammer consists of a hardened and tempered steel head, varying in mass from 0.1 kg to about 1 kg, firmly fixed on a tough wooden handle, usually hickory or ash.

The flat striking surface is known as the face, and the opposite end is called the pein. The most commonly used is the ball-pein, Fig. 2.14, which has a hemispherical end and is used for riveting over the ends of pins and rivets.

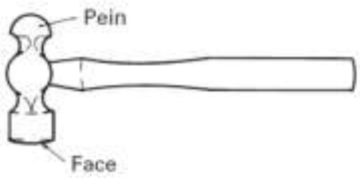


Figure 2.14 Ball-pein hammer

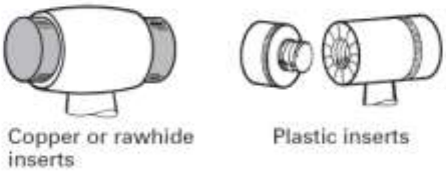


Figure 2.15 Soft-faced hammers

For use with soft metal such as aluminium or with finished components where the workpiece could be damaged if struck by an engineer's hammer, a range of hammers is available with soft faces, usually hide, copper or a tough plastic such as nylon. The soft faces are usually in the form of replaceable inserts screwed into the head or into a recess in the face, Fig. 2.15.

Always use a hammer which is heavy enough to deliver the required force but not too heavy to be tiring in use. The small masses, 0.1 kg to 0.2 kg, are used for centre punching, while the 1 kg ones are used with large chisels or when driving large keys or collars on shafts. The length of the handle is designed for the appropriate head mass, and the hammer should be gripped near the end of the handle to deliver the required blow. To be effective, a solid sharp blow should be delivered and this cannot be done if the handle is held too near the hammer head.

Always ensure that the hammer handle is sound and that the head is securely fixed.

Self-Assessment Exercise

3.4 Screwdrivers

The screwdriver is one of the most common tools, and is also the one most misused. Screwdrivers should be used only to tighten or loosen screws. They should never be used to chisel, open tins, scrape off paint or lever off tight parts such as collars on shafts. Once a screwdriver blade, which is made from toughened alloy steel, has been bent, it is very difficult to keep it in the screw head.

There are two types of screw slot: the straight slot and the cross slot, i.e. 'pozidriv'or 'supadriv'. Always select the screwdriver to suit the size of screw head and the type of slot – use of the incorrect size or type results in damage to both the screwdriver blade and the screw head and in a screw very difficult to loosen or tighten. Cross-slot sizes are numbered 1, 2, 3 and 4, and screwdrivers are available with corresponding point sizes to suit 'pozidriv' and 'supadriv' slots.

Straight slots in screws are machined with parallel sides. It is essential that any screwdriver used in such a slot has the sides of the blade parallel to slightly tapered up to about 10°, Fig. 2.16(a). A screwdriver sharpened to a point like a chisel will not locate correctly and will require great force to keep it in the slot, Fig. 2.16(b). Various blade lengths are available with corresponding width and thickness to suit the screw size.

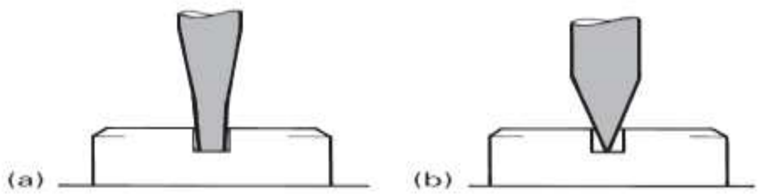


Figure 2.16 Screwdriver point: (a) right (b) wrong

In the interests of personal safety, never hold the work in your hand while tightening or loosening a screw – the blade may slip and cause a nasty injury. Always hold the work securely in a vice or clamped to a solid surface

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. Why is it necessary to keep the cutting edge cool when regrinding a cold chisel?
2. When would a scraper be used rather than filing or chiselling

References

UNIT 1: TAPS AND DIES AND POWER HAND TOOLS

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) Use taps and dies
(ii) Identify the various types of power hand tools used in workshop
(iii) Use power hand tools

3.0 Main Body

3.1 Taps

Tapping is the operation of cutting an internal thread by means of a cutting tool known as a tap. When tapping by hand, straight-flute hand taps are used. These are made from hardened high-speed steel and are supplied in sets of three. The three taps differ in the length of chamfer at the point, known as the lead. The one with the longest lead is referred to as the taper or first tap, the next as the second or intermediate tap and the third, which has a very short lead, as the bottoming or plug tap, Fig. 2.17. A square is provided at one end so that the tap can be easily rotated by holding it in a tap wrench, Fig. 2.18. The chuck type of wrench is used for the smaller tap sizes.

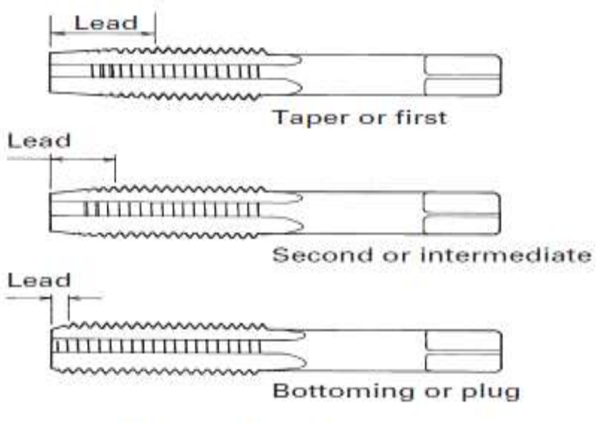


Figure 2.17 Set of taps

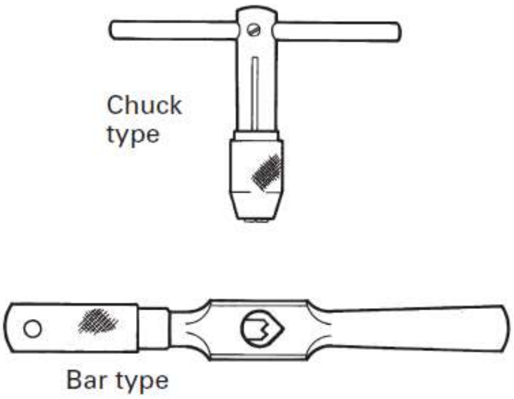


Figure 2.18 Tap wrenches

The first stage in tapping is to drill a hole of the correct size. This is known as the tapping size and is normally slightly larger than the root diameter of the thread. Table 2.2 shows the tapping sizes for ISO metric threads which have replaced most threads previously used in Great Britain.

Tapping is then started using the taper or first tap securely held in a tap wrench. The long lead enables it to follow the drilled hole and keep square. The tap is rotated, applying downward pressure until cutting starts. No further pressure is required, since the tap will then screw itself into the hole. The tap should be turned back quite often, to help clear chips from the flutes.

If the hole being tapped passes through the component, it is only necessary to repeat the operation using the second or intermediate tap. Where the hole does not pass through – known as a blind hole – it is necessary to use the plug or bottoming tap. This tap has a short lead and therefore forms threads very close to the bottom of the hole. When tapping a blind hole, great care should be taken not to break the tap. The tap should be occasionally withdrawn completely and any chips be removed before proceeding to the final depth

Table 2.2 Tapping sizes for ISO metric threads

Thread diameter and pitch (mm)	*Drill diameter for tapping (mm)*
1.6 × 0.35	1.25
2 × 0.4	1.6
2.5 × 0.45	2.05
3 × 0.5	2.5
4 × 0.7	3.3
5 × 0.8	4.2
6 × 1.0	5.0
8 × 1.25	6.8
10 × 1.5	8.5
12 × 1.75	10.2

S

For easier cutting and the production of good-quality threads, a proprietary tapping compound should be used.

Self-Assessment Exercise

3.2 Dies

Dies are used to cut external threads and are available in sizes up to approximately 36 mm thread diameter. The common type, for use by hand, is the circular split die, made from high-

speed steel hardened and tempered and split at one side to enable small adjustments of size to be made, Fig. 2.19.

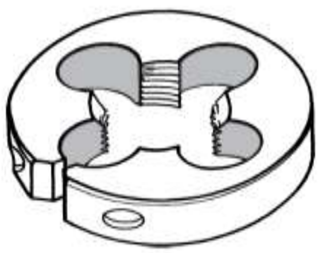


Figure 2.19 Circular split die

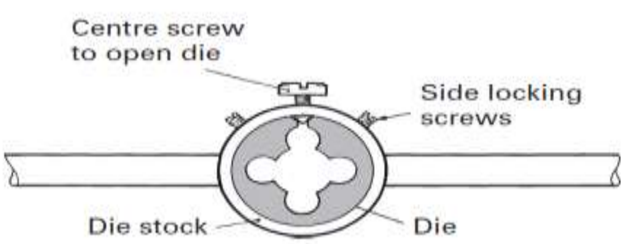


Figure 2.20 Die holder

The die is held in a holder known as a die stock, which has a central screw for adjusting the size and two side locking screws which lock in dimples in the outside diameter of the die, Fig. 2.20. The die is inserted in the holder with the split lined up with the central screw. The central screw is then tightened so that the die is expanded, and the two side locking screws are tightened to hold the die in position.

Dies have a lead on the first two or three threads, to help start cutting, but it is usual also to have a chamfer on the end of the component. The die is placed squarely on the end of the bar and is rotated, applying downward pressure until cutting starts, ensuring that the stock is horizontal. No further pressure is required, since the die then screws itself forward as cutting proceeds. The die should be rotated backwards every two or three turns, to break up and clear the chips. The thread can now be checked with a nut. If it is found to be tight, the central screw is slackened, the side locking screws are tightened, and the die is run down the thread again. This can be repeated until the final size is reached.

As with tapping, easier cutting and better threads are produced when a proprietary cutting compound is used.

Self-Assessment Exercise

3.3 Powered Hand Tools

The main advantages of powered hand tools are the reduction of manual effort and the speeding up of the operation. The operator, being less fatigued, is able to carry out the task more efficiently, and the speeding up of the operation results in lower production costs. Being portable, a powered hand tool can be taken to the work, which can also lead to a reduction in production costs. Accuracy of metal-removal operations is not as good with powered hand tools, since it is difficult to remove metal from small areas selectively. A comparison of hand and powered hand tools is shown in Table 2.3.

Table 2.3 Comparison of hand and powered hand tools

	Speed of production	*Cost of tool*	*Accuracy*	*Fatigue*
Hand tools	Low	Low	High	High
Powered hand tools	High	High	Low	Low

Powered hand tools can be electric or air-operated. In general, electric tools are heavier than the equivalent air tool, due to their built-in motor, e.g. electric screwdrivers weigh 2 kg while an equivalent air-operated screwdriver weighs 0.9 kg. The cost of powered tools is much greater than the equivalent hand tools and must be taken into account when a choice has to be made.

Air-operated tools can be safely used in most work conditions, while electrical tools should not be used in conditions which are wet or damp or where there is a risk of fire or explosion, such as in flammable or dusty atmospheres. A selection of air-operated tools is shown in Fig. 2.21.

Hand drills

Electric and air-operated drills are available with a maximum drilling capacity in steel of about 30 mm diameter for electric and about 10 mm diameter for air models. Air-operated tools are more ideally suited to the rapid drilling of the smaller diameter holes, Fig. 2.21(a).

Screwdriver

Used for inserting screws of all types, including machine, self-tapping, self-drilling and tapping and wood screws. Some models are reversible and can be used with equal ease to remove screws. The tool bits are interchangeable to suit the different screw-head types, such as slotted, 'supadriv', 'pozidriv', hexagon-socket or hexagon-headed. Electric and air-operated screwdrivers are available with a maximum capacity of about 8 mm diameter thread with a variety of torque settings to prevent the screw being overtightened or sheared off, Fig. 2.21(b).

Impact wrench

Used for tightening and also, with the reversal mechanism, for loosening hexagonheaded nuts and screws. Air-powered models are available with a maximum capacity of 32 mm diameter threads and with torque settings to suit a range of thread sizes. They have the advantage of being able to tighten all nuts or screws to the same predetermined load, Fig. 2.21(c).

Grinder

Used to remove metal from the rough surfaces of forgings, castings and welds usually when the metal is too hard or the amount to be removed is too great for a file or a chisel. Electric and air-operated grinders are available with straight grinding wheels up to 230mm diameter or with small mounted points of various shapes and sizes, Fig. 2.21(d).

Metal shears

Used to cut metal, particularly where the sheet cannot be taken to a guillotine or where profiles have to be cut. Electric or air-operated shears are available capable of cutting steel sheet up to 2 mm thick by means of the scissor-like action of a reciprocating blade, Fig. 2.21(e).

Hammer

Can be fitted with a wide range of attachments for riveting, shearing off rivet heads, removing scale or panel cutting. Air-operated models are available which deliver between 3000 and 4000 blows per minute, Fig. 2.21(f).

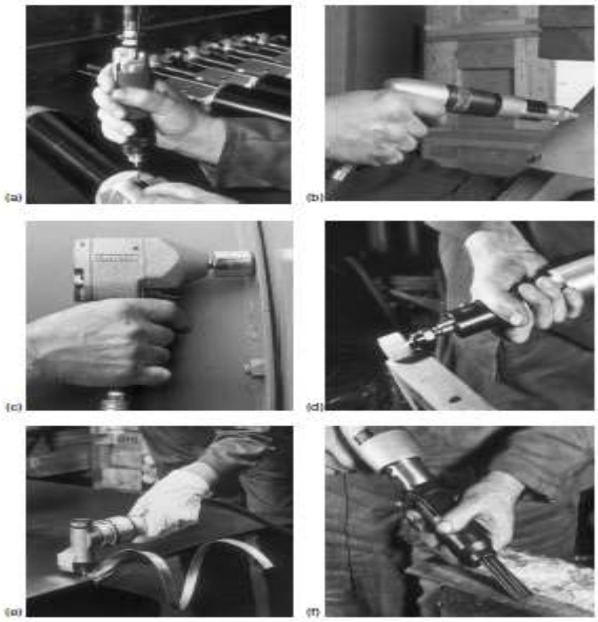


Figure 2.21 Air-operated tools: (a) hand drill (b) screwdriver (c) impact wrench (d) grinder (e) metal shears (f) hammer

Self-Assessment Exercise

1. Why is it necessary to drill the correct tapping size hole when producing an internal thread?
2. What are the main advantages of using power tools?

4.0 Conclusion

5.0 Summary

6.0 Tutor's Marked Assignment

1. Why is it essential to use the correct size screwdriver?
2. Describe how a circular split die may be adjusted to give the correct size thread.
3. Describe where soft-faced hammers are used and name three materials used for the soft faces.
4. Explain the importance of the number of teeth on a hacksaw blade when cutting different types of material.

7.0 References

UNIT 2: MARKING OUT PRINCIPLES

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) Set datum for effective marking out

(ii) Discuss the use of co-ordinate system in marking out

3.0 Main Body

3.1 Datum

The function of a datum is to establish a reference position from which all dimensions are taken and hence all measurements are made. The datum may be a point, an edge or a centre line, depending on the shape of the workpiece. For any plane surface, two datums are required to position a point and these are usually at right angles to each other.

Figure 3.1 shows a workpiece where the datum is a point; Fig. 3.2 shows a workpiece where both datums are edges; Fig. 3.3 shows a workpiece where both datums are centre

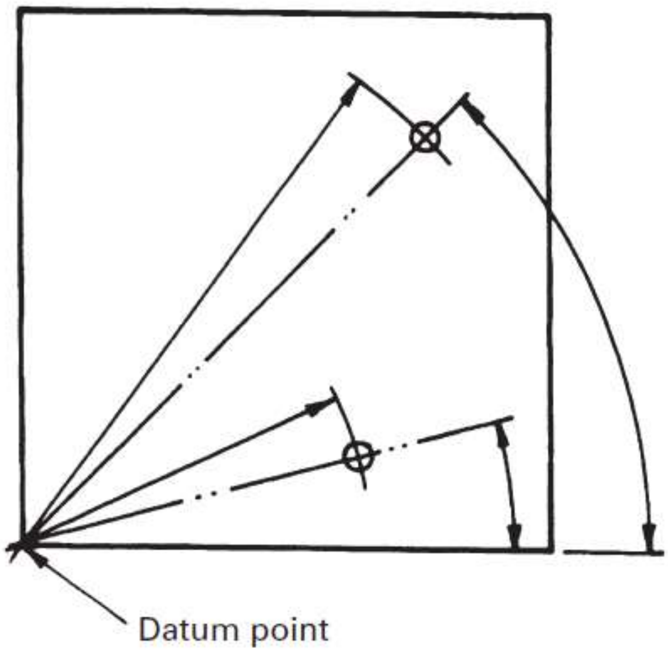


Figure 3.1 Datum point

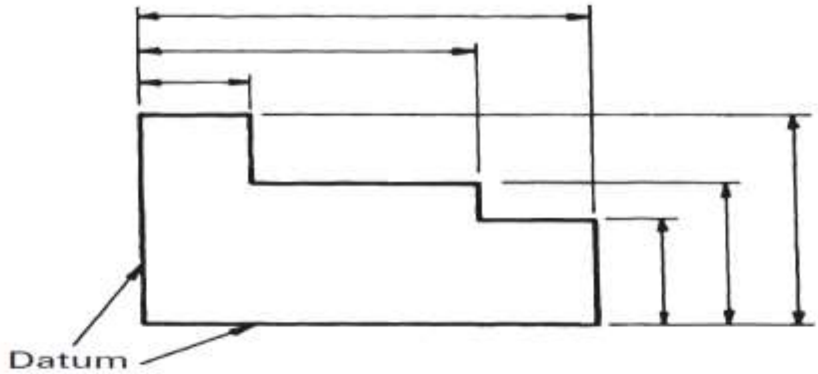


Figure 3.2 Datum edges

lines and Fig. 3.4 shows a workpiece where one datum is an edge and the other is a centre line.

The datums are established by the draughtsman when the drawing is being dimensioned and, since marking out is merely transferring drawing dimensions to the workpiece, the same datums are used.

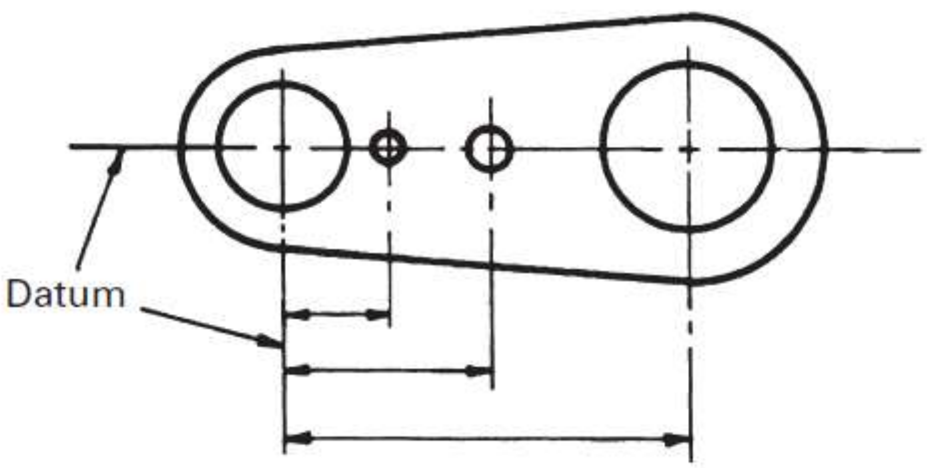


Figure 3.3 Datum centre lines

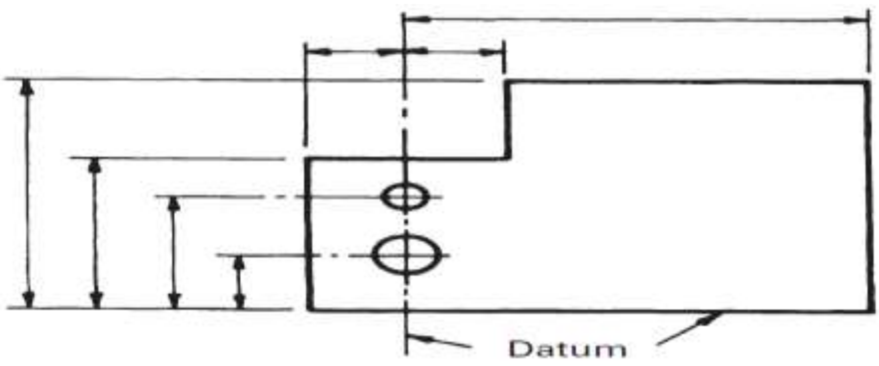


Figure 3.4 Datum edge and centre line

Self-Assessment Exercise

3.2 Co-ordinates

The draughtsman can dimension drawings in one of two ways.

- *Rectangular co-ordinates* – where the dimensions are taken relative to the datums at right angles to each other, i.e. the general pattern is rectangular. This is the method shown in Figs 3.2 and 3.4.
- *Polar co-ordinates* – where the dimension is measured along a radial line from the datum. This is shown in Fig. 3.1. Marking out polar co-ordinates requires not only accuracy of the dimension along the radial line but accuracy of the angle itself. As the polar distance increases, any slight angular error will effectively increase the inaccuracy of the final position.

The possibility of error is less with rectangular co-ordinates, and the polar co-ordinate dimensions shown in Fig. 3.1 could be redrawn as rectangular co-ordinates as shown in Fig. 3.5.

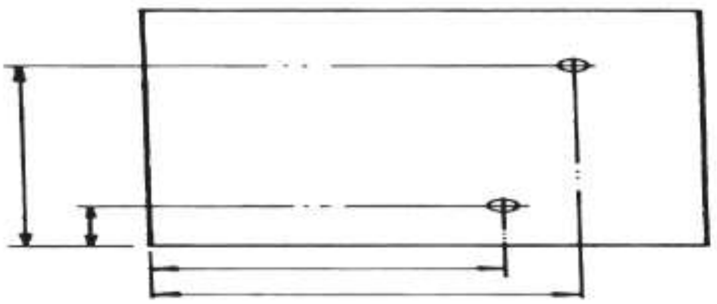


Figure 3.5 Rectangular co-ordinates

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. State the difference between rectangular and polar co-ordinates.
2. Why is it necessary to create a datum when marking out?

7.0 References

UNIT 3: MARKING OUT EQUIPMENT

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) Identify the various marking-out tools in the workshop
(ii) use the application of the various marking-out tools

3.0 Main Body

3.1 Marking Out Equipment

Surface table and surface plate

In order to establish a datum from which all measurements are made a reference surface is required. This reference surface takes the form of a large flat surface called a surface table (Fig. 3.6) upon which the measuring equipment is used.

Surface plates (Fig. 3.7) are smaller reference surfaces and are placed on a bench for use with smaller workpieces. For general use, both surface tables and surface plates are made from cast iron machined to various grades of accuracy. For high-accuracy inspection work and for use in standards rooms, surface tables and plates made from granite are available

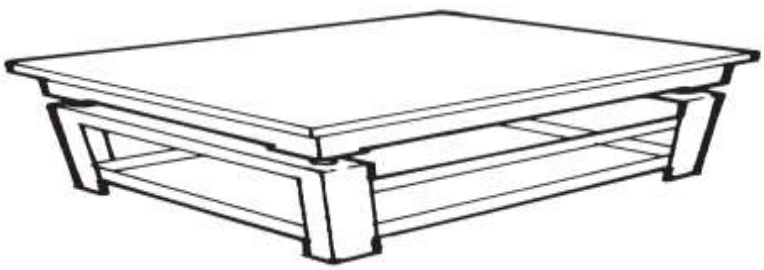


Figure 3.6 Surface table

Parallels (Fig. 3.7)

The workpiece can be set on parallels to raise it off the reference surface and still maintain parallelism. Parallels are made in pairs to precisely the same dimensions, from hardened steel, finish ground, with their opposite faces parallel and adjacent faces square. A variety of sizes should be available for use when marking out.

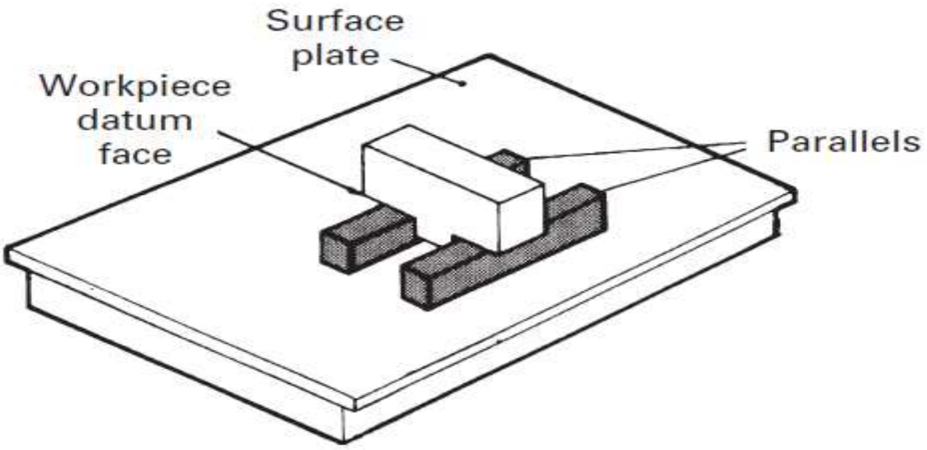


Figure 3.7 Surface plate and parallels

Jacks and wedges

When a forging or casting, has to be marked out, which has an uneven surface or is awkward in shape, it is still essential to maintain the datum relative to the reference surface. Uneven surfaces can be prevented from rocking and kept on a parallel plane by slipping in thin steel or wooden wedges (Fig. 3.8) at appropriate positions. Awkward shapes can be kept in the correct position by support from adjustable jacks (see Fig. 3.9).

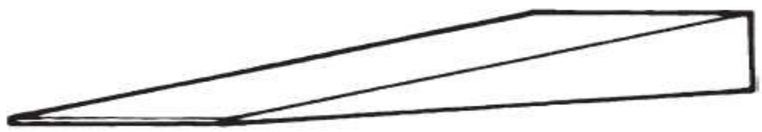


Figure 3.8 Wedge

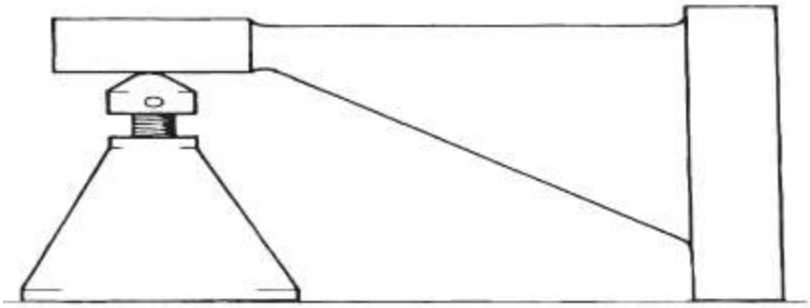


Figure 3.9 Jack used to support

Angle plate

When the workpiece has to be positioned at 90° to the reference surface, it can be clamped to an angle plate (Fig. 3.10). Angle plates are usually made from cast iron and the edges and faces are accurately machined flat, square and parallel. Slots are provided in the faces for easy clamping of the workpiece. Angle plates may be plain or adjustable.

Vee blocks

Holding circular work for marking out or machining can be simplified by using a vee block (Fig. 3.11). The larger sizes are made from cast iron, the smaller sizes from steel hardened and ground, and provided with a clamp. They are supplied in pairs marked for identification. The faces are machined to a high degree of accuracy of flatness, squareness, and parallelism, and the 90° vee is central with respect to the side faces and parallel to the base and side faces.

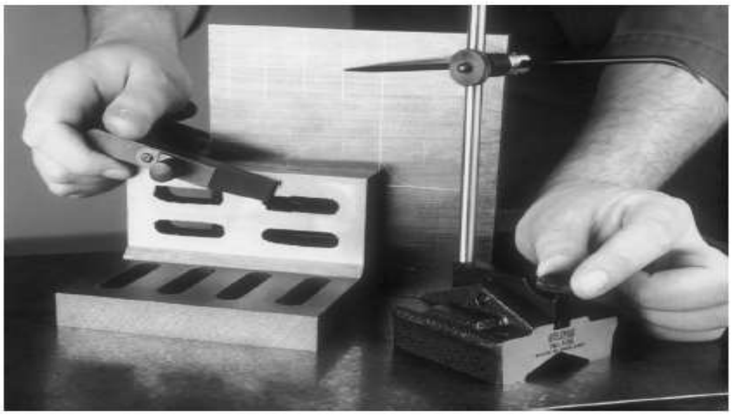


Figure 3.10 Angle plate and surface gauge

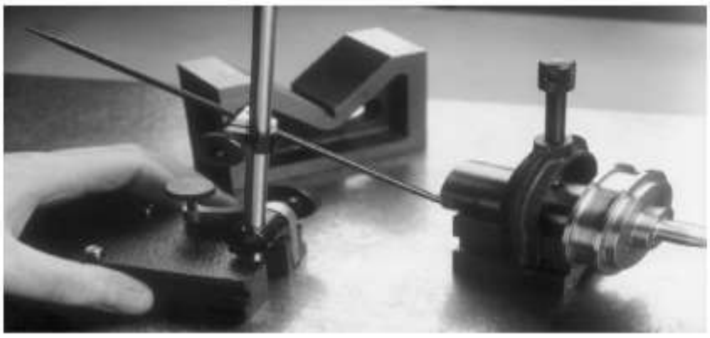


Figure 3.11 Vee block in use

Engineer's square (Fig. 3.12)

An engineer's square is used when setting the workpiece square to the reference surface (see Fig. 3.13) or when scribing lines square to the datum edge (Fig. 3.14). The square consists of a stock and blade made from hardened steel and ground on all faces and edges to give a high degree of accuracy in straightness, parallelism and squareness. It is available in a variety of blade lengths.

Combination set (Fig. 3.15)

The combination set consists of a graduated hardened steel rule on which any of three separate heads – protractor, square or centre head – can be mounted. The rule has a slot in which each head slides and can be locked at any position along its length.

Protractor head (Fig. 3.16): This head is graduated from 0° to 180°, is adjustable through this range, and is used when scribing lines at an angle to a workpiece datum.

Square head (Fig. 3.17(a)): This head is used in the same way as an engineer's square, but, because the rule is adjustable, it is not as accurate. A second face is provided at 45° (Fig. 3.17(b)). A spirit level is incorporated which is useful when setting workpieces such as castings level with the reference surface. Turned on end, this head can also be used as a depth gauge (see Fig. 3.17(c)).

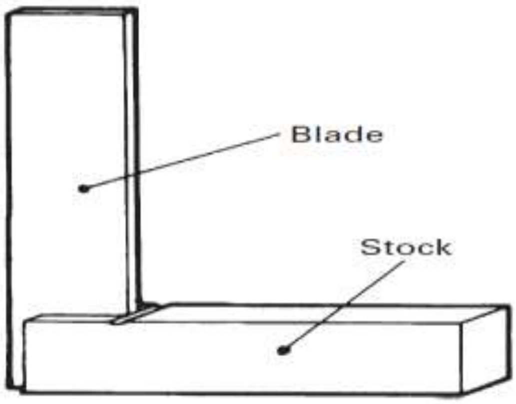


Figure 3.12 Engineer's square

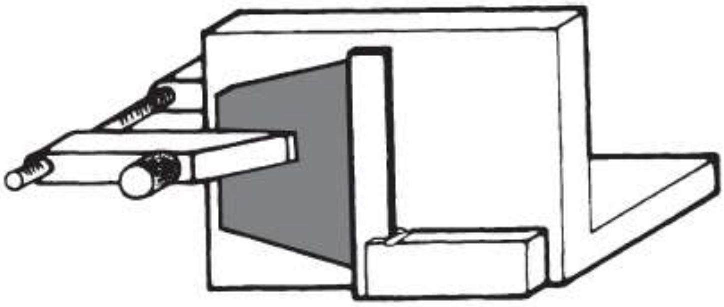


Figure 3.13 Setting workpiece square to reference surface

Figure 3.14 Scribing line square to datum

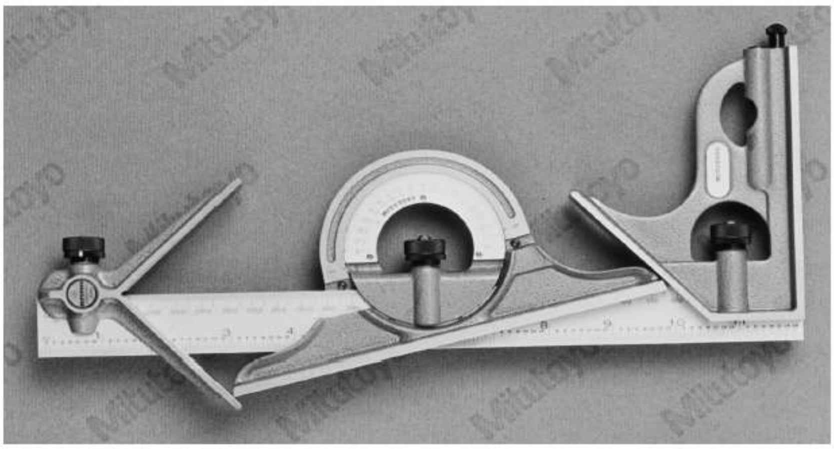


Figure 3.15 Combination set

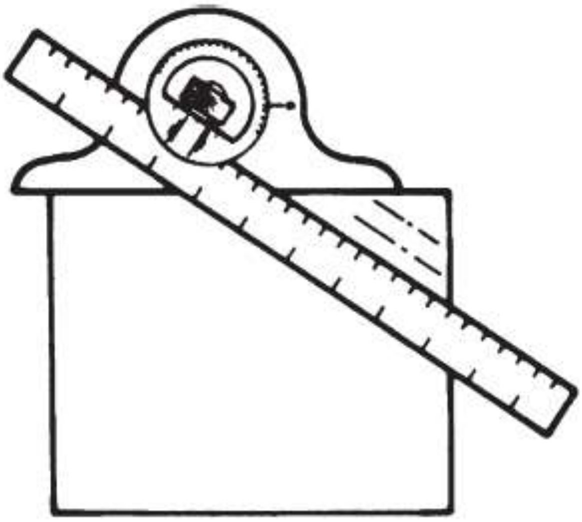


Figure 3.16 Protractor head

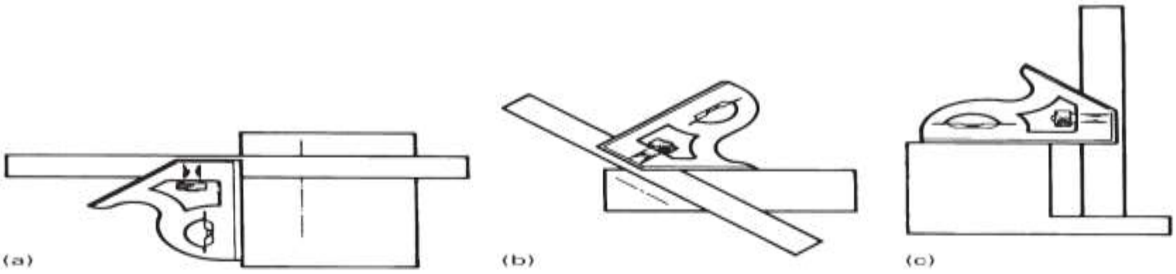


Figure 3.17 Square head

Centre head (Fig. 3.18): With this head the blade passes through the centre of the vee and is used to mark out the centre of a circular workpiece or round bar.

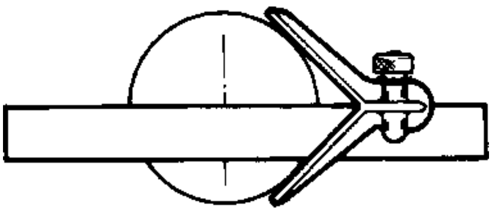


Figure 3.18 Centre head

Marking dye

On surfaces of metal other than bright metals, scribed lines may not be clearly visible. In such cases the surface can be brushed or sprayed with a quick drying coloured dye before marking out. This provides a good contrast, making the scribed lines easy to see

Scriber (Fig. 3.19)

The scriber is used to scribe all lines on a metal surface and is made from hardened and tempered steel, ground to a fine point which should always be kept sharp to give well-defined lines. Another type is shown in Fig. 3.14.

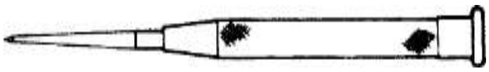


Figure 3.19 Scriber

Surface gauge (Fig. 3.10)

The surface gauge, also known as a scribing block, is used in conjunction with a scriber to mark out lines on the workpiece parallel with the reference surface. The height of the scriber is adjustable and is set in conjunction with a steel rule. The expected accuracy from this set up will be around 0.3 mm but with care this can be improved.

Vernier height gauge (Fig. 3.20)

Where greater accuracy is required than can be achieved using a surface gauge, marking out can be done using a vernier height gauge. The vernier scale carries a jaw upon which various attachments can be clamped. When marking out, a chisel pointed scribing blade is fitted. Care should be taken to allow for the thickness of the jaw, depending on whether the scribing blade is clamped on top or under the jaw. The precise thickness of the jaw is marked on each instrument. These instruments can be read to an accuracy of 0.02 mm and are available in a range of capacities reading from 0 to 1000 mm.

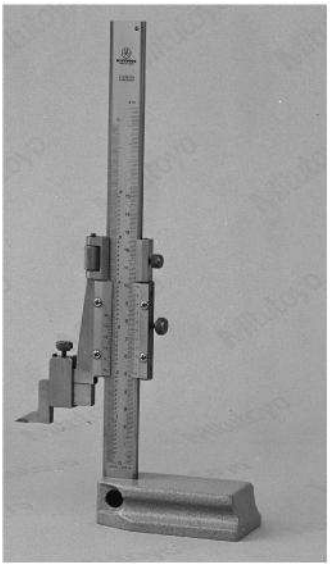


Figure 3.20 Vernier height gauge

Divider sand Trammels

Dividers are used to scribe circles or arcs and to mark off a series of lengths such as hole centres. They are of spring bow construction, each of the two pointed steel legs being hardened and ground to a fine point and capable of scribing a maximum circle of around 150 mm diameter (Fig. 3.21). Larger circles can be scribed using trammels, where the scribing points are adjustable along the length of a beam (Fig. 3.22).

Dividers and trammels are both set in conjunction with a steel rule by placing one point in a convenient graduation line and adjusting the other to coincide with the graduation line the correct distance away.

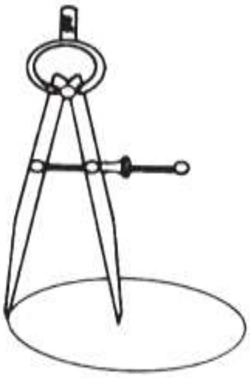


Figure 3.21 Dividers

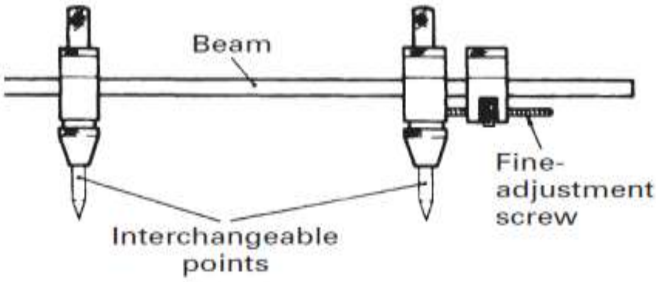


Figure 3.22 Trammels

Hermaphrodite calipers (Fig. 3.23)

These combine a straight pointed divider leg with a caliper or stepped leg and are used to scribe a line parallel to the edge of a workpiece. They are more commonly known as 'odd-legs' or 'jennies'.

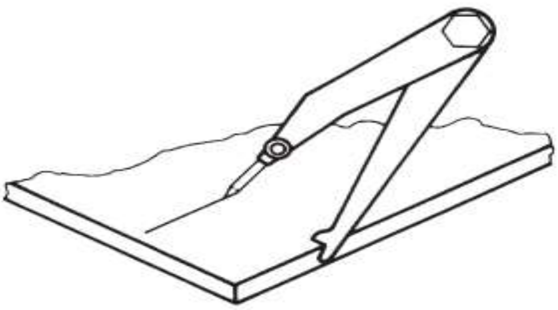


Figure 3.23 Hermaphrodite calipers

Precision Steel Rule

These are made from hardened and tempered stainless steel, photoetched for extreme accuracy and have a non-glare satin chrome finish. Rules are available in lengths of 150 mm and 300 mm and graduations may be along each edge of both faces usually in millimetres and half millimetres.

Accuracy of measurement depends on the quality of the rule and the skill of the operator. The width of the lines on a high-quality rule are quite fine and accuracies of around 0.15 mm can be achieved but an accuracy of double this can more realistically be achieved.

Centre punch (Fig. 3.24)

The centre punch is used to provide a centre location for dividers and trammels when scribing circles or arcs, or to show permanently the position of a scribed line by a row of centre dots. The centre dot is also used as a start for small diameter drills.

Centre punches are made from high carbon steel, hardened and tempered with the point ground at 30° when used to provide a centre location for dividers and at 90° for other purposes.

Care should be taken in the use of centre dots on surfaces which are to remain after machining, since, depending upon the depth, they may prove difficult to remove.

Figure 3.24 Centre punch

Clamps

Clamps are used when the workpiece has to be securely fixed to another piece of equipment, e.g. to the face of an angle plate (Fig. 3.10).

The type most used are toolmaker's clamps (Fig. 3.25), which are adjustable within a range of about 100 mm but will only clamp parallel surfaces. Greater thicknesses can be clamped using 'G' clamps, so named because of their shape (Fig. 3.26). Due to the swivel pad on the end of the clamping screw, the 'G' clamp is also capable of clamping surfaces which are not parallel.

Care should be taken to avoid damage to the surfaces by the .

Figure 3.25 Toolmaker's clamp

Figure 3.26 'G' clamp

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. Where would it be necessary to use a marking dye?
2. Why are surface tables and plates used when marking out?

7.0 References

UNIT 4: MARKING OUT EXAMPLES

CONTENTS

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) Use the application of the various marking-out tools

(ii) Use datum and co-ordinate system for proper marking-out in workshop processes

3.0 Main Body

3.1 Examples of Marking Out

We will now see how to mark out a number of components

Marking Out A Stepped Plate (Fig. (3.27)

The plate shown at step 1 (Fig. 3.27) has been filed to length and width with the edges square and requires the position of the steps to be marked out.

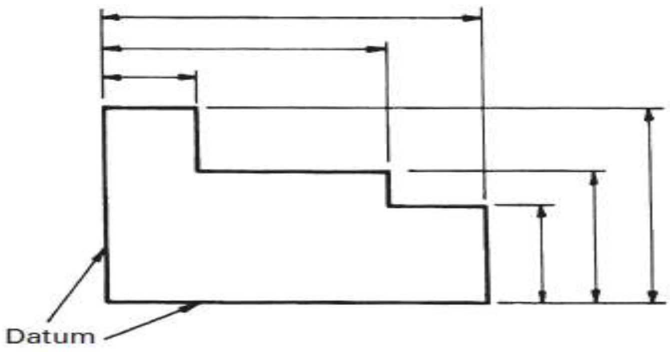
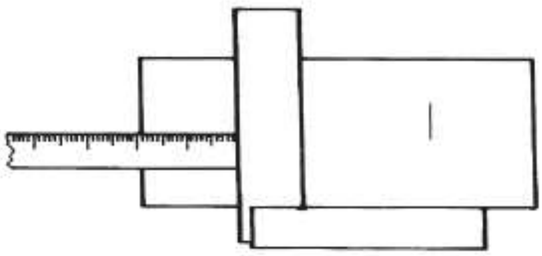
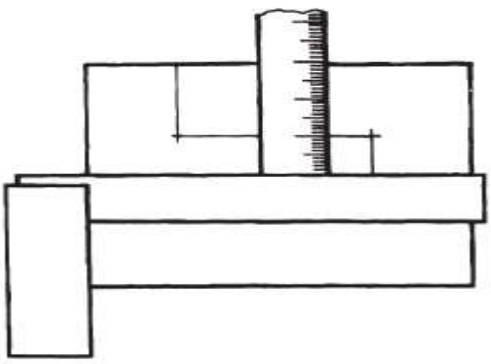


Figure 3.27 Component used in Example 3.1

Step 1: Use a square on one datum edge and measure the distance from the other datum edge using a precision steel rule. Scribe lines.



Step 2: Repeat with the square on the second datum edge and scribe lines to intersect



Self-Assessment Exercise

3.2: Marking Out Hole Features on a Plate (Fig. 3.28)

The plate shown at step 1 has been cut out 2 mm oversize on length and width and has not been filed. All four sides have sawn edges

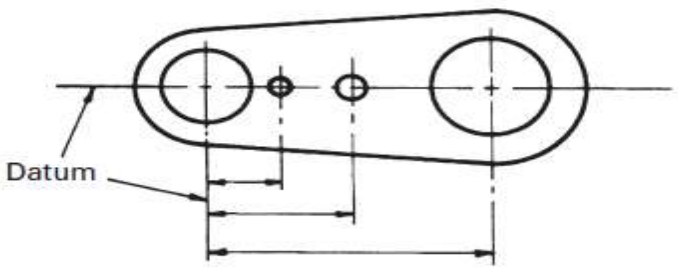
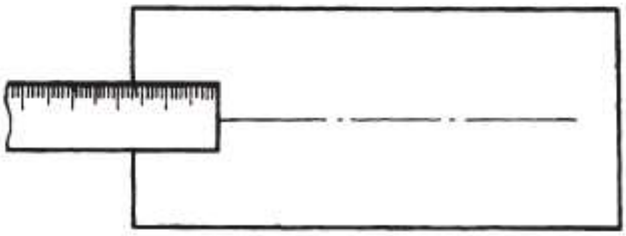
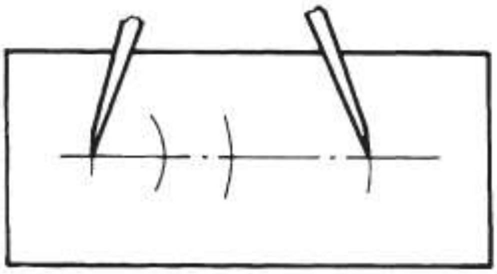


Figure 3.28 Component used in Example 3.2

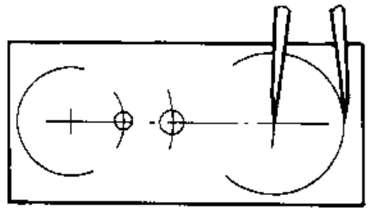
Step 1: Measure from each long edge and find the centre using a precision steel rule. Scribe the centre line using the edge of the rule as a guide. Find the centre of the small radius by measuring from one end the size of the radius plus 1 mm (this allows for the extra left on the end). Centre dot where the lines intersect.



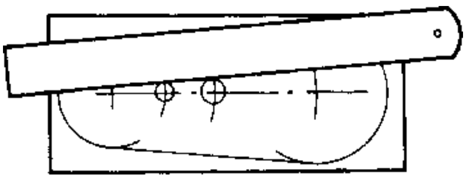
Step 2: Using dividers, set the distance from the centre of the small radius to the centre of the first small hole. Scribe an arc. Repeat for the second small hole and the large radius. Centre dot at the intersection of the centre lines. The dividers are set using the graduations of a precision steel rule.



Step 3: Set dividers to the small radius. Locate on the centre dot and scribe the radius. Repeat for the large radius and if necessary, the two holes.



Step 4: Complete the profile by scribing a line tangential to the two radii using the edge of a precision steel rule as a guide



Self-Assessment Exercise

3.3: Marking Out Plate and Hole Profile (Fig. 3.29)

The plate shown at step 1 has been roughly cut to size and requires complete marking out of the profile and holes.

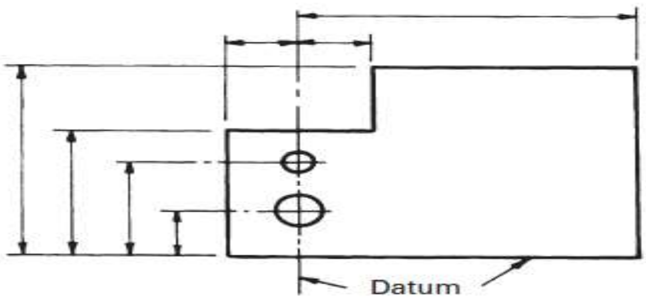
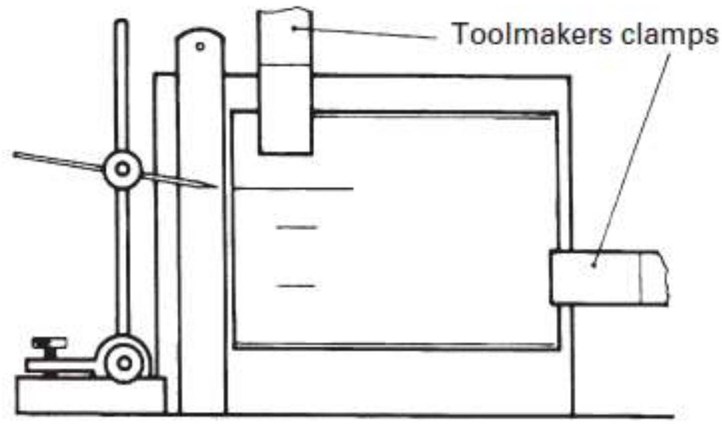
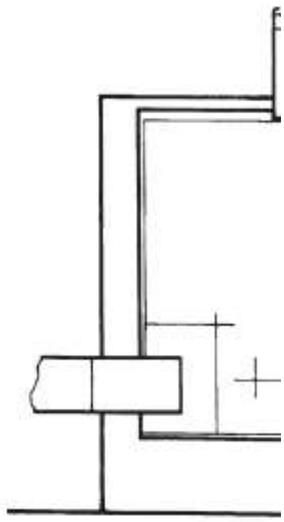


Figure 3.29 Component used in Example 3.3

Step 1: Clamp the plate to the face of an angle plate, ensuring that the clamps will not interfere with marking out. Use a scriber in a surface gauge and set the heights in conjunction with a precision steel rule. Scribe the datum line. Scribe each horizontal line the correct distance from the datum



Step 2: Without unclamping the plate, swing the angle plate on to its side (note the importance of clamp positions at step 1). This ensures that the lines about to be scribed are at right angles to those scribed in step 1, owing to the accuracy of the angle plate. Scribe the datum centre line. Scribe each horizontal line the correct distance from the datum to intersect the vertical lines.



3.4: Marking Out Profile of an Irregular Profile (Fig. 3.30)

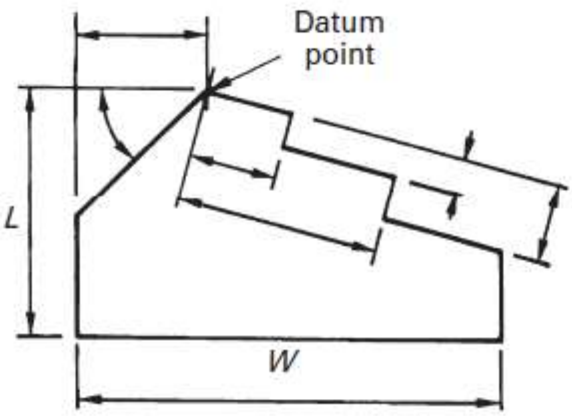
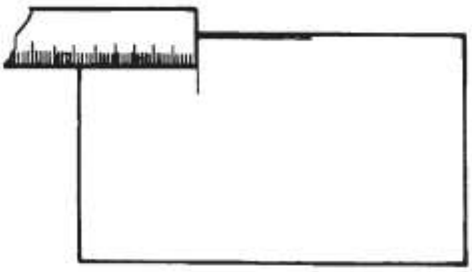


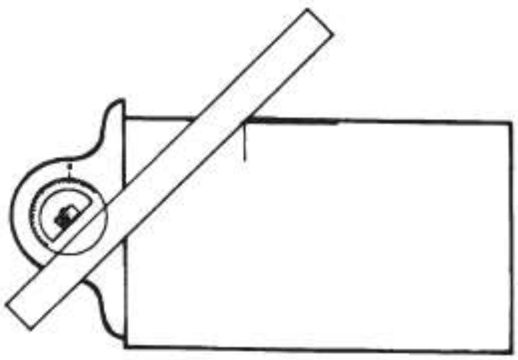
Figure 3.30 Component used in Example 3.4

The plate shown at step 1 is to be produced from the correct width (*W*) bright rolled strip and has been sawn 2 mm oversize on length (*L*). The base edge has been filed square to the ends and it is required to mark out the angled faces

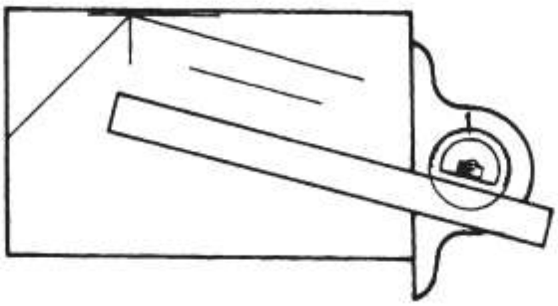
Step 1: Using a precision steel rule measure from two adjacent edges to determine the datum point. Centre dot the datum point



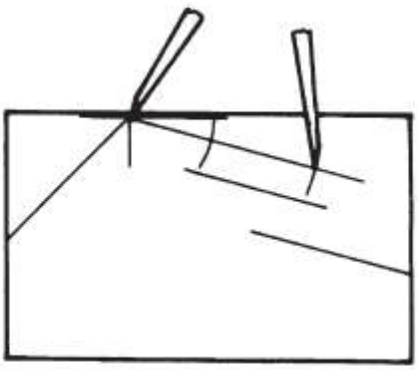
Step 2: Set protractor at required angle and scribe line through datum point



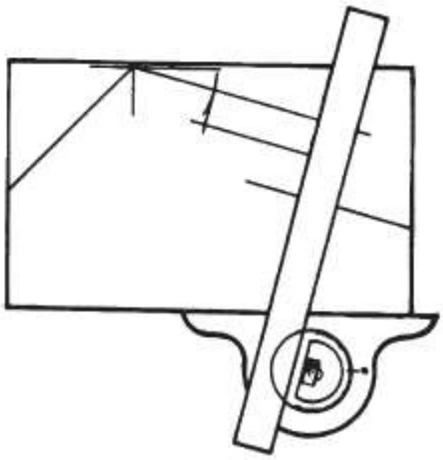
Step 3: Reset protractor at second angle and scribe one line through datum point. Scribe the remaining two lines parallel to and the correct distance from the first line using the protractor at the same setting.



Step 4: Set dividers at correct distances, locate in datum centre dot and mark positions along scribed line



Step 5: Reset protractor and scribe lines through marked positions



3.5: Marking Out Keyway on a Shaft (Fig. 3.31)

The shaft shown is to have a keyway cut along its centre line for a required length. Accurate machining is made possible by setting up the shaft relative to the marked out position.

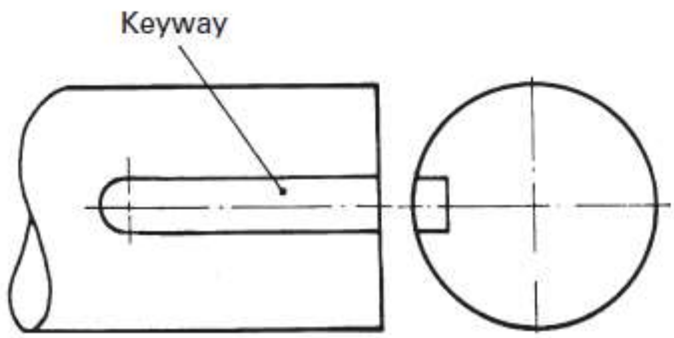
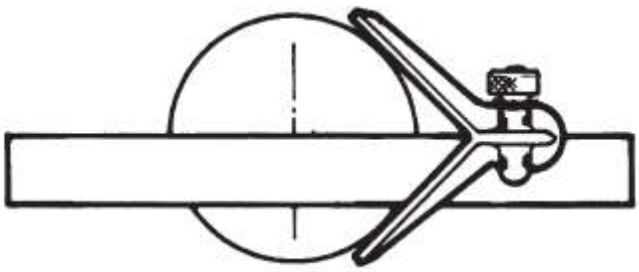
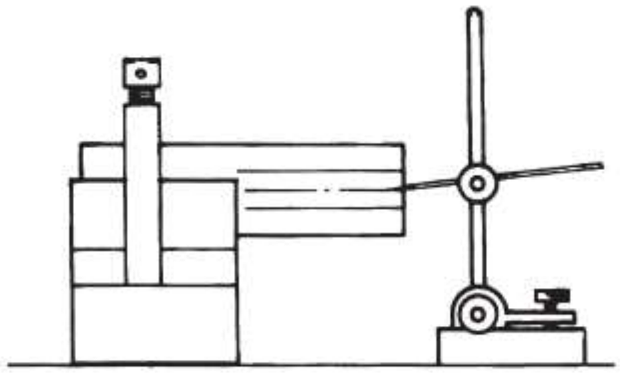


Figure 3.31 Component used in Example 3.5

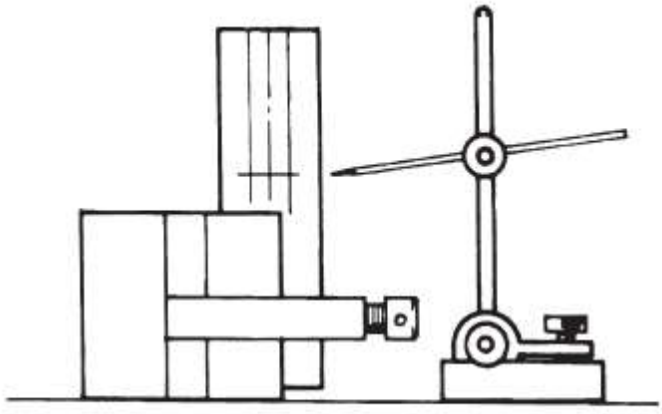
Step 1: Scribe line on the end face through the centre of the shaft using the centre head of a combination set (see Fig. 3.18).



Step 2: Clamp shaft in a vee block ensuring that the line marked at step 1 is lying horizontal. This can be checked using a scriber in a surface gauge. Transfer the centre line along the required length of shaft. Scribe two further lines to indicate the width of slot.



Step 3: The required length of slot can be marked without removing it simply by turning the vee block on its end and scribing a horizontal line at the correct distance from the end of the shaft



Self Assessment Assignment

1. Describe in Details how you would go about Marking Out Hole Features on a Plate

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. State two uses of a centre punch when working out.
2. What our trammels used for?
3. Name the three heads which comprise a combination set and describe the use of each one.
4. When would a vee block be used during a marking out operation?

7.0 References

UNIT 5: STANDARDS AND MEASUREMENT

CONTENTS

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) List the various units of measurements
(ii) Discuss the need for dimensional accuracy
(iii) Enumerate the importance of calibration of measuring instruments

3.0 Main Body

3.1 Length

The universal standard of length is the metre, and the definition of this in terms of wavelength of light was agreed by all countries in 1960. The metre was defined at this time as 1 650 763.73 wavelengths of the orange radiation of the krypton-86 isotope in vacuo. At the same time the yard was defined as 0.9144 m, which gives an exact conversion of 1 inch = 25.4 mm.

It was also in 1960 that the first laser was constructed and by the mid-1970s lasers were being used as length standards. In 1983 the krypton-86 definition was replaced and the metre was defined as ‘the length of the path travelled by light in a vacuum during a time interval of 1/299 792 458 of a second’ and this is done at NPL by iodine-stabilised helium neon lasers.

The great advantage of using lasers as length standards is that it is constant, unlike material length standards where small changes in the length of metal bars can occur over periods of time. Also these laser standards can be directly transferred to a material standard in the form of an end gauge, e.g. gauge blocks, and to a line standard, i.e. a measuring scale such as a vernier scale, to a high degree of accuracy.

End standards of length used in the workshop are of two types : gauge blocks and length bars. These are calibrated and intended for use at 20°C.

Gauge blocks

Gauge blocks are made from a wear-resisting material – hardened and stabilised high-grade steel, tungsten carbide and ceramic and their dimensions and accuracy are covered by BS EN ISO 3650: 1999. Two uses for gauge blocks are recognised: (i) general use for precise measurement here accurate work sizes are required (ii) as standards of length used with high-magnification comparators to establish the sizes of gauge blocks in general use.

Each gauge block is of a rectangular section with the measuring faces finished by precision lapping to the required distance apart – known as the gauge length, Fig. 4.1 within the tolerances of length, flatness and parallelism set out in the standard. The measuring faces are of such a high degree of surface finish and flatness that gauge blocks will readily wring to each other, i.e. they will adhere when pressed and slid together. Thus a set of selected-size gauge blocks can be combined to give a very wide range of sizes, usually in steps of 0.001 mm.

Standard sets are available with differing numbers of pieces. A typical set is shown in Fig. 4.2. These sets are identified by a number indicating the number of pieces prefixed.

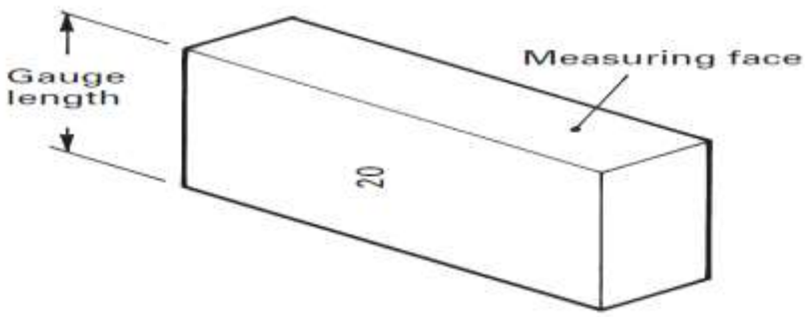


Figure 4.1: Gauge block

Figure 4.2: Set of gauge block

by the letter M, to indicate metric sizes, and followed by the number 1 or 2. This latter number refers to a 1 mm- or 2 mm-based series, this being the base gauge length of the smaller blocks. For example, an 88 piece set to a 1 mm base is designated M88/1 and contains the sizes shown in Table 4.1

An 88 piece set to a 2 mm base is designated M88/2 and contains the sizes shown in Table 4.2. The 2 mm-based series are recommended as they are less likely to suffer deterioration in flatness than the thinner 1 mm blocks. Four grades of accuracy are provided for in the British Standard: grades 0, 1, 2 with

Table 4.1:

Size (mm)	*Increment (mm)*	*Number of pieces*
1.0005	–	1
1.001 to 1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 9.5	0.5	19
10 to 100	10	10
		Total 88 pieces

Table 4.2:

Size (mm)	Increment (mm)	Number of pieces
1.0005	–	1
2.001 to 2.009	0.001	9
2.01 to 2.49	0.01	49
0.5 to 9.5	0.5	19
10 to 100	10	10
		Total 88 pieces

0 the finest, and calibration grade (K).

The choice of grade is solely dependent on the application.

Calibration-grade gauges should not be used for general inspection work: they are intended for calibrating other gauge blocks. This means that the actual gauge length is known, and this is obtained by referring to a calibration chart of the set, i.e. a chart showing the actual size of each block in the set. For this reason, relatively large tolerances on gauge length can be allowed, but calibration-grade gauges are required to have a high degree of accuracy of flatness and parallelism.

To build up a size combination, the smallest possible number of gauge blocks should be used. This can be done by taking care of the micrometres (0.001 mm) first, followed by hundredths (0.01 mm), tenths (0.1 mm) and whole millimetres; e.g. to determine the gauge blocks required for a size of 78.748mm using the M88/2 set previously listed:

78.748

Subtract 2.008 .... 1st gauge block

76.740

Subtract 2.24 . .. . 2nd gauge block

74.50

Subtract 4.50 . .. . 3rd gauge block

70.00 .... 4th gauge block

The 2.24 mm second gauge block is used as it conveniently leaves a 0.5 increment for the third gauge block.

In some instances protector gauge blocks, usually of 2 mm gauge length, are supplied with a set, while in other instances they have to be ordered separately. These are available in pairs, are marked with the letter P, and are placed one at each end of a buildup to prevent wear on the gauge blocks in the set. If wear takes place on the protector gauge blocks, then only these need be replaced. Allowance for these, if used, must be made in calculating the build-up.

Having established the sizes of gauge blocks required, the size combination can be built up. Select the required gauge blocks from the case and close the lid. It is important that the lid is kept closed at all times when not in actual use, to protect the gauge blocks from dust, dirt and moisture.

Clean the measuring faces of each gauge block with a clean chamois leather or a soft linen cloth and examine them for damage. Never attempt to use a gauge block which is damaged, as this will lead to damage of other gauge blocks. Damage is likely to occur on the edges through the gauge block being knocked or dropped, and, in the event of damage, it is preferable to return the gauge block to the manufacturer for the surface to be restored.

When two gauge blocks are pressed and slid together on their measuring surfaces, they will adhere and are said to 'wring' together. They will only do this if the measuring surfaces are clean, flat and free from damage.

Wring two gauge blocks by placing one on the top of the other as shown in Fig. 4.3 and sliding them into position with a rotary movement. Repeat this for all gauge blocks in the size combination, starting with the largest gauge blocks. Never wring gauge blocks together while holding them above an open case, as they could be accidentally dropped and cause damage

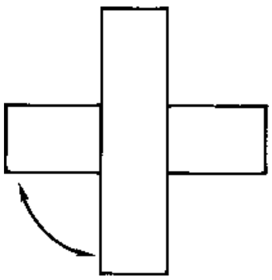


Figure 4.3 Position for wringing two gauge blocks

Do not finger the measuring faces, as this leads to the risk of tarnishing, and avoid unnecessary handling as this can lead to an increase in temperature and hence dimension.

Immediately after use, slide the gauge blocks apart, clean each one carefully, replace in the case and close the lid. Do not break the wringing joint but slide the blocks apart, and never leave the gauge blocks wrung together for any length of time.

Gauge blocks, separately or in combination, may be used for direct measurement as shown in Fig. 4.4(a) or for comparative measurement using a knife-edged straightedge or a dial indicator, Figs 4.4(b) and (c). The precise size of the gauge-block combination is usually arrived at by trial and error. The gauge-block combination is built up until the top of the work and the gauge blocks are the same height, this being so when no light is visible under the knife edge of the straightedge when it is placed simultaneously on both surfaces, Fig. 4.4(b), and viewed against a well-illuminated background. The same principle is employed using a dial indicator, the work and the gauge-block combination being the same height when the same reading is obtained on the dial indicator from each surface, Fig. 4.4(c).

Gauge blocks are also widely used in conjunction with sine bars and with calibrated steel balls and rollers, as well as for checking straightness and squareness. They are also used in conjunction with a range of accessories.

Gauge-block accessories: The use of gauge blocks for measuring can be extended by the use of a range of accessories. These are covered by BS 4311: part 2 1994. A typical set of gauge-block accessories is shown in Fig. 4.5 and consists of

(i) two pairs of jaws, type A and type B, which when combined with gauge blocks form an external or internal caliper, Figs 4.6(a) and (b);
(ii) a centre point and a scriber, used in combination with gauge blocks to scribe arcs of precise radius, Fig. 4.6(c);
(iii) ia robust base for converting a gauge-block combination together with the scriber into a height gauge, Fig. 4.6(d);
(iv) a knife-edged straightedge;
(v) holders for supporting the various combinations when in use.

The accessories other than the holders are made from high-quality steel, hardened and stabilised, with their wringing faces precision-lapped to give flatness, parallelism and surface finish to the same degree as gauge blocks, to which they are wrung to assemble any combination. Accessories can be purchased in sets as shown or as individual items

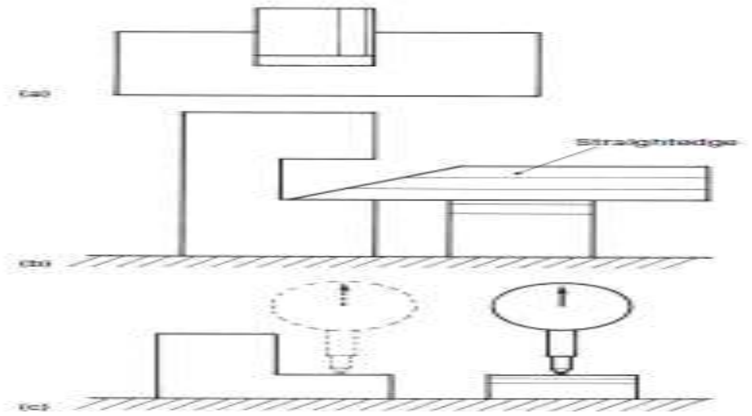


Figure 4.4 Gauge-block applications

Figure 4.5 Set of gauge-block accessories

Figure 4.6 Assembled gauge blocks and accessories

The sine bar

The measurement of angles can be simply carried out by using a protractor, but the degree of accuracy obtainable is, at best, 5 minutes using a vernier instrument. Greater accuracy can be obtained by using a sine bar in conjunction with gauge blocks.

A number of different designs of sine bar are available and are covered by BS 3064: 1978, which also specifies three lengths – 100, 200 and 300 mm – these being the distances between the roller axes. The more common type of sine bar is shown in Fig. 4.7 the body and rollers being made of high-quality steel, hardened and stabilised, with all surfaces finished by lapping or fine grinding to the tolerances specified in the British Standard.

The main requirements are:

(a) the mean diameters of the rollers shall be equal to each other within 0.0025 mm;
(b) the upper working surface shall be parallel to the plane tangential to the lower surface of the rollers within 0.002 mm;
(c) the distance between the roller axes shall be accurate to within

0.0025 mm for 100 mm bars, 0.005 mm for 200 mm bars, 0.008 mm for 300 mm bars.

In use, gauge blocks are placed under the setting roller with the hinge roller resting on a datum surface, e.g. a surface plate. The angle of inclination is then calculated from the length of the sine bar (*L*) and the height of the gauge-block combination (*h*), Fig. 4.8. Since the roller diameters are the same, we can consider triangle ABC, where AB = *L* and BC = *h*; thus

$$\sin\theta = \frac{BC}{AB} = \frac{h}{L}$$

If a known angle of inclination is required then the necessary gauge-block combination can be calculated from $h = L \sin\theta$. However, it is more usual to need to measure the angle

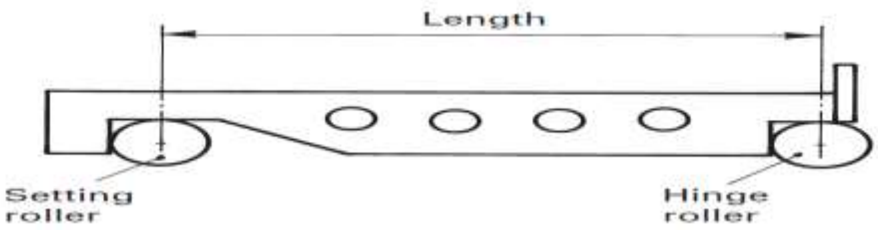


Figure 4.7 Sine bar

of inclination, and in this case the object to be measured is placed on the upper working surface of the sine bar and a gauge-block combination is made up by trial and error. This is done in conjunction with a dial indicator mounted in a surface gauge, the correct height of gauge blocks being established when the dial indicator gives the same reading at each end of the object being measured. The angle is then calculated from $\sin\theta = h/L$

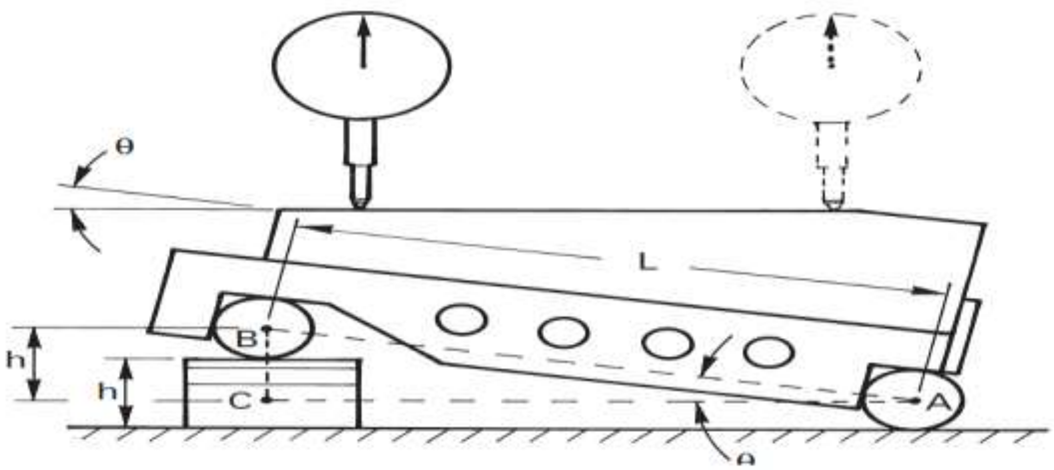


Figure 4.8 Sine-bar set-up

The degree of accuracy obtainable using a sine bar depends, among other factors, on the size of angle being checked. For example, using a 200 mm sine bar, the following gauge-block heights are required:

for an angle of 10° = 34.73 mm

for 10° 1' = 34.79 mm
for 60° = 173.20 mm
for 60° 1' = 173.23 mm

Thus for a 1' difference at 10° a variation in gauge-block height of 0.06 mm is required, while the same 1' difference at 60° requires a 0.03 mm variation.

This means, in theory at least, that if the smallest increment of gauge block available is 0.001 mm then, using a 200 mm sine bar, this represents an angular difference of 1 second at small angles and an angular difference of 2 seconds at around 60°. In practice, however, these accuracies would not be possible under workshop conditions, due to inaccuracies in gauge blocks, the sine bar, setting-up, and using the dial indicator; but it can be appreciated that this simple piece of workshop equipment is extremely accurate and capable of measuring angles within 1 minute.

It can be seen from the above that the larger angles cannot be measured to the same degree of accuracy as smaller angles. Because of this and the fact that the larger angles require a large gauge-block combination which makes the complete set-up unstable, it is recommended that for larger angles the complement of the angle be measured, i.e. 90° minus the required angle.

Other equipment based on the same principle is available – sine tables with a larger working surface and inclinable about a single axis for checking larger work, compound sine tables inclinable about two axes for checking compound angles, and sine centres which have centres in each end and are the most convenient for checking taper work.

Self-Assessment Exercise

3.2 Dimensional Deviation

Engineering workpieces cannot be consistently produced to an exact size. This is due to a number of reasons such as wear on cutting tools, errors in setting up, operator faults, temperature differences or variations in machine performance. Whatever the reason, allowance must be made for some error. The amount of error which can be

tolerated – known as the tolerance – depends on the manufacturing method and on the functional requirements of the workpiece. For example, a workpiece finished by grinding can be consistently made to finer tolerances than one produced on a centre lathe. In a similar way, a workpiece required for agricultural equipment would not require the same fine tolerance required for a wrist-watch part. In fact it would be expensive and pointless to produce parts to a greater accuracy than was necessary for the part to function. Establishing a tolerance for a dimension has the effect of creating two extremes of size, or limits – a maximum limit of size and a minimum limit of size within which the dimension must be maintained.

British Standard BS EN 20286-1 provides a comprehensive standardised system of limits and fits for engineering purposes. This British Standard relates to tolerances and limits of size for workpieces, and to the fit obtained when two workpieces are to be assembled.

BS EN 20286-1 is based on a series of tolerances graded to suit all classes of work covering a range of workpiece sizes up to 3150 mm. A series of qualities of tolerance – called tolerance grades – is provided, covering fine tolerances at one end to coarse tolerances at the other. The standard provides 18 tolerance grades, designated IT1, IT2, IT3, IT4, IT5, IT6, IT7, IT8, IT9, IT10, IT11, IT12, IT13, IT14, IT15, IT16, IT17, IT18 (IT stands for ISO series of tolerances.) The numerical values of these standard tolerances for nominal work sizes up to 500 mm are shown in Table 4.3. You can see from the table, that for a given tolerance grade the magnitude of the tolerance is related to the nominal size, e.g. for tolerance grade IT6 the tolerance for a nominal size of 3 mm is 0.006 mm while the tolerance for a 500 mm nominal size is 0.04 mm. This reflects both the practicalities of manufacture and of measuring

Terminology

Limits of size – the maximum and minimum sizes permitted for a feature. *Maximum limit of size* – the greater of the two limits of size.

Minimum limit of size – the smaller of the two limits of size.

Basic size – the size to which the two limits of size are fixed. The basic size is the same for both members of a fit and can be referred to as nominal size.

Upper deviation – the algebraic difference between the maximum limit of size and the corresponding basic size.

Lower deviation – the algebraic difference between the minimum limit of size and the corresponding basic size.

Tolerance – the difference between the maximum limit of size and the minimum limit of size (or, in other words, the algebraic difference between the upper deviation and lower deviation).

Mean size – the dimension which lies mid-way between the maximum limit of size and the minimum limit of size.

Maximum material condition – where most material remains on the workpiece, i.e. upper limit of a shaft or lower limit of a hole.

Minimum material condition – where least material remains on the workpiece, i.e. lower limit of a shaft or upper limit of a hole.

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. What is meant by tolerance?
2. What is the name of the calibration service within the UK?

7.0 References

UNIT 1: PRINCIPLES OF GAUGING

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) Enumerate the principles of tolerance in dimensioning
(ii) Discuss dimensional accuracy and limits
(iii) Use the application of gauging systems

3.0 Main Body

3.1 Gauging

Establishing a tolerance on a manufactured workpiece results in two extremes of size for each dimension – a maximum limit of size and a minimum limit of size within which the final workpiece dimension must be maintained

Table 4.3 Standard tolerances

Basic size mm		Standard tolerance grades																	
		IT1	*IT2*	*IT3*	*IT4*	*IT5*	*IT6*	*IT7*	*IT8*	*IT9*	*IT10*	*IT11*	*IT12*	*IT13*	*IT14*	*IT15*	*IT16*	*IT17*	*IT18*
		Tolerances																	
Above	*Up to and including*	*µm*											*mm*						
–	3	0,8	1,2	2	3	4	6	10	14	25	40	60	0,1	0,14	0,25	0,4	0,6	1	1,4
3	6	1	1,5	2,5	4	5	8	12	18	30	48	75	0,12	0,18	0,3	0,48	0,75	1,2	1,8
6	10	1	1,5	2,5	4	6	9	15	22	36	58	90	0,15	0,22	0,36	0,58	0,9	1,5	2,2
10	18	1,2	2	3	5	8	11	18	27	43	70	110	0,18	0,27	0,43	0,7	1,1	1,8	2,7
18	30	1,5	2,5	4	6	9	13	21	33	52	84	130	0,21	0,33	0,52	0,84	1,3	2,1	3,3
30	50	1,5	2,5	4	7	11	16	25	39	62	100	160	0,25	0,39	0,62	1	1,6	2,5	3,9
50	80	2	3	5	8	13	19	30	46	74	120	190	0,3	0,46	0,74	1,2	1,9	3	4,6
80	120	2,5	4	6	10	15	22	35	54	87	140	220	0,35	0,54	0,87	1,4	2,2	3,5	5,4
120	180	3,5	5	8	12	18	25	40	63	100	160	250	0,4	0,63	1	1,6	2,5	4	6,3
180	250	4,5	7	10	14	20	29	46	72	115	185	290	0,46	0,72	1,15	1,85	2,9	4,6	7,2
250	315	6	8	12	16	23	32	52	81	130	210	320	0,52	0,81	1,3	2,1	3,2	5,2	8,1
315	400	7	9	13	18	25	36	57	89	140	230	360	0,57	0,89	1,4	2,3	3,6	5,7	8,9
400	500	8	10	15	20	27	40	63	97	155	250	400	0,63	0,97	1,55	2,5	4	6,3	9,7
500	630	9	11	16	22	32	44	70	110	175	280	440	0,7	1,1	1,75	2,8	4,4	7	11

This leads to the simpler and less expensive inspection technique of gauging during production, eliminating the need for more lengthy and expensive measuring techniques. Gauges used to check these maximum and minimum limits are known as limit gauges. The simplest forms of limit gauges are those used to check plain parallel holes and shafts with other types available for checking tapered and threaded holes and shafts.

Limit gauges are arranged so that the ‘GO’portion of the gauge checks the maximum material condition (i.e. the upper limit of the shaft or lower limit of the hole) while the ‘NOT GO’ portion of the gauge checks the minimum material condition (i.e. the lower limit of the shaft or upper limit of the hole).

In practice this means that if a workpiece is within its required limits of size, the ‘GO’ end should go into a hole or over a shaft while the ‘NOT GO’ end should not.

Self-Assessment Exercise

3.2 Plain Plug Gauges

These are used to check holes and are usually renewable-end types. The gauging member and the handle are manufactured separately, so that only the gauging member need be replaced when worn or damaged or when the workpiece limits are modified. The handle is made of a suitable plastics material which reduces weight and cost and avoids the risk of heat transference. A drift slot or hole is provided near one end of the handle to enable the gauging members to be removed when replacement is necessary.

The GO and NOT GO gauges may be in the form of separate ‘single-ended’ gauges or may be combined on one handle to form a ‘double-ended’ gauge, Fig. 4.9

Figure 4.9 Plug and ring gauges

Since the GO gauging member must enter the hole being checked, it is made longer than the NOT GO gauging member, which of course should never enter. Large gauges which are heavy and difficult to handle do not have a full diameter but are cut-away and are known as segmental cylindrical gauges, Fig. 4.10.

When checking a hole, the GO cylindrical plug gauge should enter the hole being inspected when applied by hand without the use of excessive force, and the hole should be checked throughout its length. A GO segmental gauge should be applied in at least two positions equally spaced around the circumference.

NOT GO plug gauges should not enter the hole when applied by hand without using excessive force.

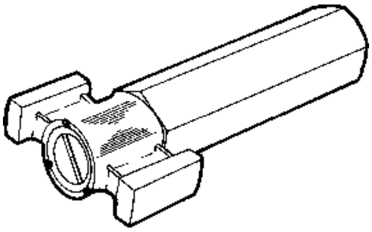


Figure 4.10 Segmental cylindrical gauge

Self-Assessment Exercise

3.3 Ring and Gap Gauges

These are used to check shafts. Plain ring gauges are ordinarily used only as GO gauges, Fig. 5.9, the use of gap gauges being recommended for the NOT GO gauge. The use of NOT GO gauges is confined to setting pneumatic comparators, and these gauges are identified by a groove around the outside diameter.

Plain gap gauges are produced from flat steel plate, suitably hardened, and may be made with a single gap or with both the GO and NOT GO gaps combined in the one gauge, Fig. 4.11

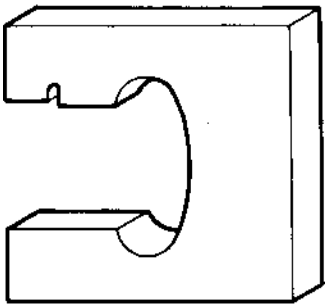


Figure 4.11 Solid gap gauge

Adjustable gap gauges, Fig. 4.12 consist of a horseshoe frame fitted with plain anvils the spacing of which can be adjusted to any particular limits required, within the range of the gauge. Setting to within 0.005 mm of a desired size is possible with well-made adjustable gauges.

When checking a shaft, the GO gap gauge should pass over the shaft, under its own weight when the axis of the shaft is horizontal or without the use of excessive force when the axis of the shaft is vertical. A cylindrical ring GO gauge should pass over the complete length of the shaft without the use of excessive force.

NOT GO gap gauges should not pass over the shaft and this check should be made at not less than four positions around and along the shaft.

Self-Assessment Exercise

3.4 Screw Thread Gauges

Limit gauges for checking internal and external threads are available in a similar form to those for plain holes and shafts but with threaded rather than plain diameters

Figure 4.12 Adjustable gap gauges

BS 3643: 1981 specifies four fundamental deviations and tolerances for internal threads and three for external threads resulting in a variety of different types of fit, with the most common 6H/6g for general engineering work, regarded as a medium fit.

For checking internal threads, e.g. nuts, a double-ended screw plug gauge, Fig. 4.13 may be used. This gauge has a 'GO' end which checks that the major and effective diameters are not too small (i.e. maximum material condition). It also checks for pitch and flank errors in the thread

Figure 4.13 Screw plug guage

The 'NOT GO' end checks only that the effective diameter is not too large (i.e. minimum material condition).

For checking external threads 'GO' and 'NOT GO' ring gauges, Fig. 4.14 or caliper gauges having 'GO' and 'NOT GO' anvils may be used. Wherever practical however, external threads should be checked using ring gauges as these provide a full functional check of all thread features, i.e. pitch, angle, thread form and size.

Self-Assessment Exercise

3.5 Taper Gauges

Taper gauges are used to check the male and female features of tapered workpieces. A taper ring gauge is used to check the male workpiece feature, i.e. a shaft; while a taper plug gauge is used to check the female workpiece feature, i.e. a hole – Fig. 4.15.

A taper gauge is used to check the correctness of the angle of taper of the workpiece and also to check the diameter at some point on the taper, usually the large diameter of a female feature and the small diameter of a male feature

Figure 4.14 Screw ring guage

Figure 4.15 Taper ring and plug gauges

The correctness of the angle of taper is determined by rocking the gauge, any error being indicated by the amount of ‘rock’ felt by the person doing the checking. The taper is correct if no ‘rock’can be detected. A positive indication of correctness of angle of taper can be achieved by smearing the taper portion of the gauge with engineer’s blue, offering the gauge to the workpiece, and rotating the gauge slightly. Complete transference of engineer’s blue from the gauge to the entire length of the workpiece surface indicates a perfect match of gauge and workpiece and therefore a correct angle of taper.

Checking the diameter at some point on the taper, usually at one end, is achieved by providing a step at the end of the gauge, giving two faces, equivalent to the GO and NOT GO limits of the diameter being checked. A correct workpiece is indicated by the diameter being checked passing the gauge face equivalent to the GO limit and not reaching the gauge face equivalent to the NOT GO limit, i.e. the workpiece surface must lie somewhere between the two gauge faces, Fig. 4.16. (This may require scratching the workpiece surface with a finger-nail to determine whether or not it protrudes.)

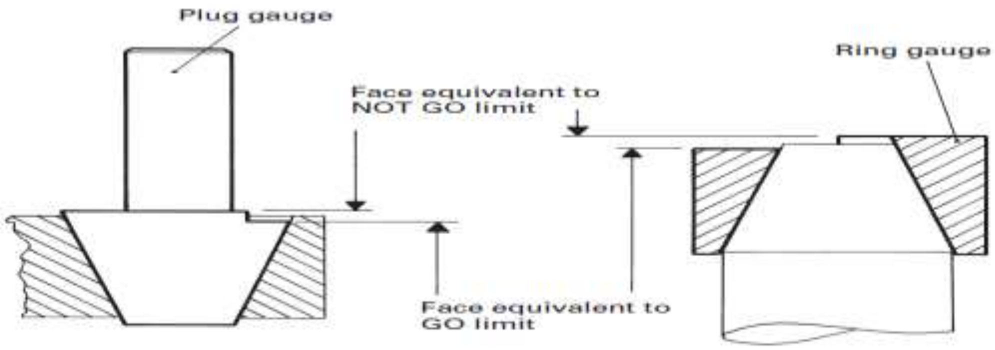


Figure 4.16 Use of taper gauges

Self-Assessment Exercise

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. State two recognized uses of gauge blocks
2. At what temperature are gauges blocks calibrated and intended for use?

7.0 References

UNIT 2: MEASUREMENT OF SURFACE PROPERTIES

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) List the various surface properties
(ii) Compare surfaces
(iii) Explain the principle of surface finishing

3.0 Main Body

3.1 Straightness

The workshop standard against which the straightness of a line on a surface is compared is the straightedge. An error in straightness of a feature may be stated as the distance separating two parallel straight lines between which the surface of the feature, in that position, will just lie. Three types of straightedge are available: toolmaker's straightedges, cast-iron straightedges and steel or granite straightedges of rectangular section.

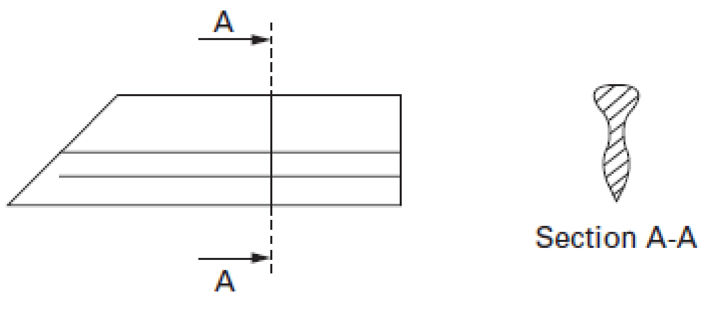


Figure 4.17 Toolmaker's straightedge

Toolmaker's straightedges, covered by BS 852: 1939(1959), are of short length up to300 mm and are intended for very accurate work. They are made from high-quality steel, hardened and suitably stabilised, and have the working edge ground and lapped to a 'knife edge' as shown in the typical cross-section in Fig. 4.17. Above 25 mm length, one end is finished at an angle. This type of straightedge is used by placing the knife edge on the work and viewing against a well-illuminated background. If the work is perfectly straight at that position, then no white light should be visible at any point along the length of the straightedge. It is claimed that this type of test is sensitive to within 1 pam.

Cast-iron straightedges, of bow-shaped (Fig. 4.18(a)) and I-section design (Fig. 4.18(b)), are covered by BS 5204-1:1975. Two grades of accuracy are provided for each type – grade A and grade B – with grade A the more accurate. The straightedges are made from close-grained plain or alloy cast iron, sound and free from blowholes and porosity. The working surfaces of grade A are finished by scraping, and those of grade B by scraping or by smooth machining. The recommended lengths for the bow-shaped type are 300, 500, 1000, 2000, 4000, 6000 and 8000 mm and for the I-section type 300, 500, 1000, 2000, 3000, 4000 and 5000 mm

Steel and granite straightedges of rectangular section are covered by BS 5204- 2:1977. Two grades of accuracy are provided: grade A and grade B. Grade-A steel straightedges are made from high-quality steel with the working faces hardened. Grade-B steel straightedges may be supplied hardened or unhardened. Grade-A and grade-B straightedges may be made of close-grained granite of uniform texture, free

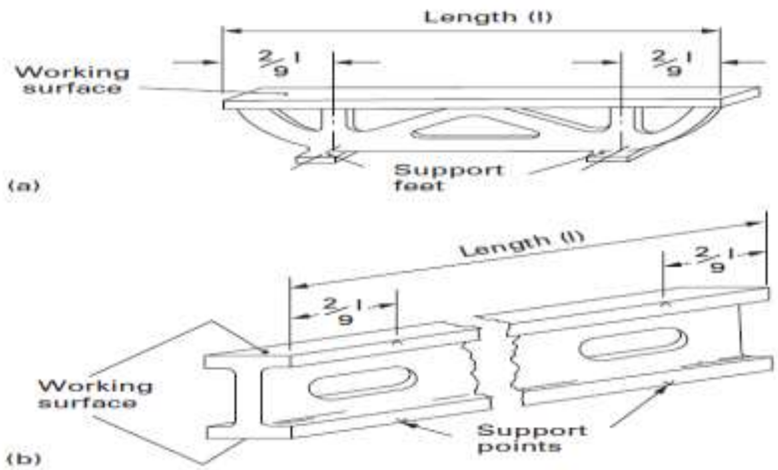


Figure 4.18 Cast-iron straightedges

from defects. The working faces are finished by grinding or lapping. The recommended lengths for rectangular-section straightedges are 300, 500, 1000, 1500 and 2000 mm.

When a straightedge is used on edge, it is likely to deflect under its own weight. The amount of deflection depends on the number and position of supports along the length of the straightedge. For minimum deflection, a straightedge must be supported at two points located two-ninths of its length from each end, Fig. 4.18 – i.e. at supports symmetrically spaced five-ninths (0.555) of its length apart. For this reason, rectangular and I-section straightedges have arrows together with the word 'support' engraved on their side faces to indicate the points at which the straightedge should be supported for minimum deflection under its own weight.

If a rectangular or I-section straightedge is used on edge, it should not be placed directly on the surface being checked – it should be supported off the surface on two equal-size gauge blocks placed under the arrows marked 'support'. The straightness of the surface being checked is then established by determining the width of gap under the working face of the straightedge at various points along its length, using gauge blocks. Alternatively a dial indicator held in a surface gauge can be traversed along the surface being checked while in contact with the straightedge. Since the straightedge is straight, any deviation shown on the dial indicator will show the error of straightness of the surface.

Straightedges – especially the bow-shaped type – are used extensively to check the straightness of machine-tool slides and slideways. This is done by smearing a thin even layer of engineer's blue on the working surface of the straightedge, placing the straightedge on the surface to be checked, and sliding it slightly backwards and forwards a few times. Engineer's blue from the straightedge is transferred to the surface, giving an indication of straightness by the amount of blue present. Due to the width of the working face of the straightedge, an indication of flatness is also given.

Self-Assessment Exercise

3.2 Flatness

The workshop standard against which the flatness of a surface is compared is the surface plate or table. The error in flatness of a feature may be stated as the distance separating two parallel planes between which the surface of the feature will just lie. Thus flatness is concerned with the complete area of a surface, whereas straightness is concerned with a line at a position on a surface; e.g. lines AB, BC, CD and DA in Fig. 4.19 may all be straight but the surface is not flat, it is twisted.

For high-precision work, such as precision tooling and gauge work, toolmaker's flats and high-precision surface plates are available and are covered by BS 869: 1978. This standard recommends four sizes of toolmaker's flat – 63, 100, 160 and 200 mm diameter – made from high-quality steel hardened and stabilized or from close-grained granite of uniform texture, free from defects. Two sizes of high-precision flat are recommended – 250 and 400 mm diameter – made from plain or alloy cast iron or from granite. The working surface of flats and plates are finished by high-grade lapping and must be free from noticeable scratches and flat within 0.5 pLm for flats up to 200 mm diameter, 0.8 pLm for 250 mm diameter plates and 1.0 iim for 400 mm diameter plates.

Surface plates and tables are covered by BS 817: 1988 which specifies the requirements for rectangular and square surface plates ranging from 160 mm X 100 mm to 2500 mm X 1600 mm in four grades of accuracy – 0, 1, 2, 3 – with grade 0 the most accurate. The accuracy relates to the degree of flatness of the working surface

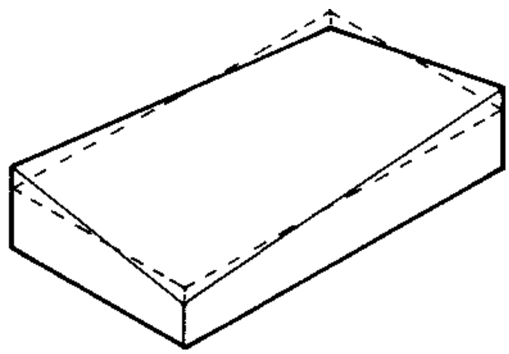


Figure 4.19 Error in flatness of a surface

The highest accuracy grade 0 plates and tables are used for inspection purposes, grade 1 for general purpose use, grade 2 for marking out while grade 3 for low grade marking out and as a general support plate.

The plates may be made from good-quality close-grained plain or alloy cast iron, sound and free from blowholes and porosity, and must have adequate ribbing on the underside to resist deflection. Alternatively, plates may be made of close-grained granite of uniform texture, free from defects and of sufficient thickness to resist deflection. The working surface must have a smooth finish.

The smaller sizes of plates may be used on a bench; the larger ones are usually mounted on a stand and are then known as surface tables.

The simplest method of checking the flatness of a surface is to compare it with a surface of known accuracy, i.e. a surface plate. This is done by smearing a thin even layer of engineer's blue on one surface, placing the surface to be checked on the surface plate, and moving it slightly from side to side a few times. Engineer's blue will be transferred from one surface to the other, the amount of blue present and its position giving an indication of the degree of flatness.

The main use of surface plates and tables is as a reference or datum surface upon which inspection and marking-out equipment are used.

Self-Assessment Exercise

3.3 Squareness

Two surfaces are square when they are at right angles to each other. Thus the determination of squareness is one of angular measurement. There is no absolute standard for angular measurement in the same way as there is for linear measurement, since the requirement is simply to divide a circle into a number of equal parts. The checking of right angles is a common requirement, and the workshop standard against which they are compared is the engineer's square, of which there are a number of types. BS 939: 1977 specifies the requirements for engineer's try-squares (Fig. 4.20(a)), cylindrical squares. (Fig. 4.20(b)), and block squares of solid (Fig. 4.20(c)) or open form (Fig. 4.20(d)).

Engineer's try-squares consist of a stock and a blade and are designated by a size which is the length from the tip of the blade to the inner working face of the stock. Recommended sizes are 50, 75, 100, 150, 200, 300, 450, 600, 800 and 1000 mm. Three grades of accuracy are specified –AA,A, and B – with grade AA the most accurate. Try-squares are made of good-quality steel with the working surfaces of grades AA and A hardened and stabilised

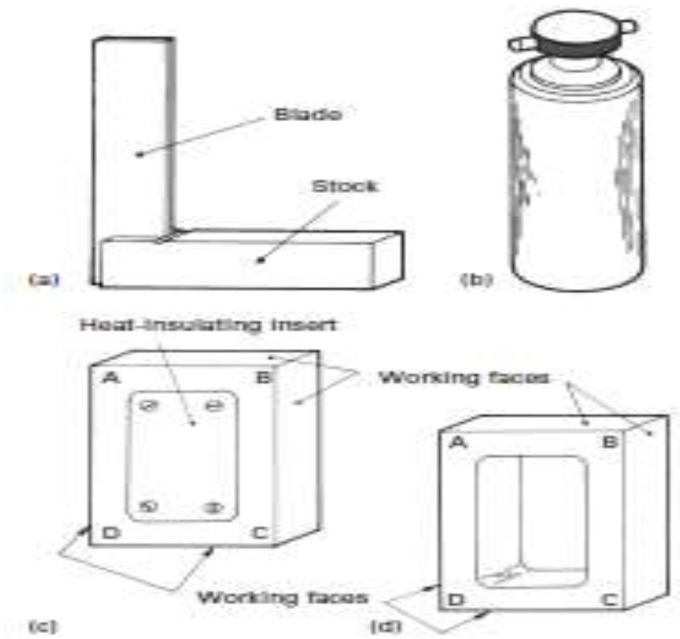


Figure 4.20 Types of square

Grade AA try-squares have the inner and outer edges of the blade bevelled. All working surfaces of the blade and stock are lapped, finely ground or polished to the accuracy specified for each grade.

Cylindrical squares, of circular section, are designated by their length. Recommended lengths are 75, 150, 220, 300, 450, 600 and 750 mm. One grade of accuracy is specified: grade AA. Cylindrical squares are made of high-quality steel, hardened and stabilised; close-grained plain or alloy cast iron, sound and free from blowholes and porosity; or close-grained granite of uniform texture, free from defects. Granite is particularly suitable for the larger sizes, as its mass is approximately half that of the equivalent size in steel or cast iron. In order to reduce weight, it is recommended that steel or cast-iron cylindrical squares 300 mm long and above are of hollow section. All external surfaces are finished by lapping or fine grinding.

Solid-form block squares are designated by their length and width and are available in sizes from 50 mm X 40 mm up to and including 1000 mm X 1000 mm. Two grades of accuracy are specified:AA and A. Solid-form block gauges are made of high-quality steel, cast iron, or granite – the same as cylindrical squares. Again, granite is recommended due to its lower mass. The front and back surfaces of each solid-form steel block square are recessed and fitted with a heat-insulating material, to avoid heat transfer and hence expansion when handled. The working faces of the solid-form steel block square are finished by lapping, and those made of cast iron or granite are finished by lapping or fine grinding.

Open-form block squares are designated by their length and width and are available in sizes from 150 mm X 100 mm up to and including 600 mm X 400 mm. Two grades of accuracy are specified – A and B – grade A being the more accurate. They are made of close-grained plain or alloy cast iron, sound and free from blowholes and porosity, and may be hardened or unhardened. All external surfaces are finished by lapping or fine grinding.

Use of Squares

Grade AA engineer’s try-squares have the inner and outer edges of the blade bevelled to produce a ‘knife edge’. This increases the sensitivity of the square in use. If, however, the square is used with its blade slightly out of normal to the surface being checked, an incorrect result may be obtained. For this reason, try-squares with bevelled-edge blades are unsuitable for checking cylindrical surfaces. For this purpose a try-square with a square edge or a block square should be used, since the cylindrical surface itself will provide the necessary sensitivity by means of line contact.

Cylindrical squares are ideal for checking the squareness of try-squares and block squares and for work with flat faces, since line contact by the cylindrical surface gives greater sensitivity.

To check the squareness of two surfaces of a workpiece using a try-square, the stock is placed on one face and the edge of the blade is rested on the other. Any error in squareness can be seen by the amount of light between the surface and the underside of the blade. This type of check only tells whether or not the surfaces are square to each other, however, and it is difficult to judge the magnitude of any error.

When accurate results are required, the workpiece and square may be placed on a surface plate and the square slid gently into contact with the surface to be checked. The point of contact can then be viewed against a well-illuminated background. If a tapering slit of light can be seen, the magnitude of the error present can be checked using gauge blocks at the top and bottom of the surface, Fig. 4.21, the difference between the two gauge blocks being the total error of squareness.

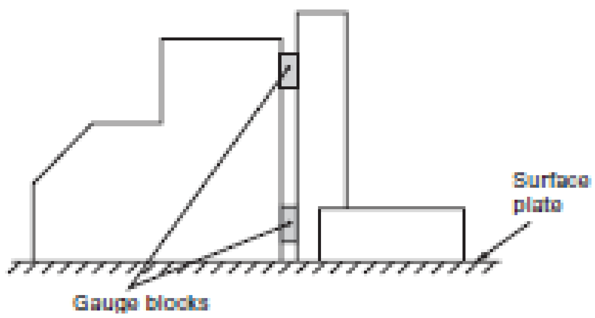


Figure 4.21 Checking squareness with square and gauge blocks

Self-Assessment Exercise

3.4 Roundness

There are a number of workshop tests which are used to determine the roundness of a part; however, not all of these give a precisely true indication. A part is round when all points on its circumference are equidistant from its axis but, as a result of different methods and of machine tools used in the production of cylindrical parts, errors in roundness can occur.

The simplest check for roundness is to measure directly at a number of diametrically opposite points around the circumference of a part, using a measuring instrument such as a micrometer or vernier caliper. Any difference in reading will give an indication of the out-of-roundness of the part. However it is possible, when using this method, for errors in roundness to go undetected. For example, an incorrect set-up on a centreless grinding machine can produce a tri-lobed shape such as is shown exaggerated in Fig. 4.22. Measuring at diametrically opposite points will give identical readings, but the part is not round.

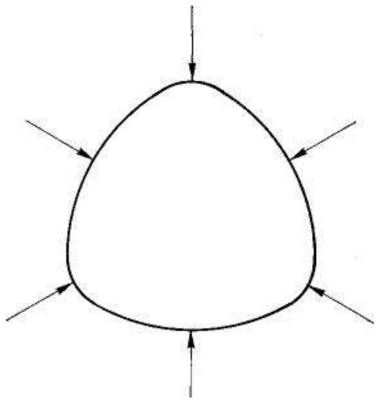


Figure 4.22 Tri-lobed shape

Alternatively, a part which contains centres at each end may be checked for roundness by mounting between bench centres and rotating the part under a dial indicator, Fig. 4.23. An error reading on the dial indicator would show the part to be not round. However this method can also be misleading, since the centres in the part themselves may not be round or may not be the central axis of the part and it may be these errors which are represented on the dial indicator and not the error in roundness of the part.

A part with a plain bore may be loaded on to a mandrel before being placed between the bench centres. In this case, since a mandrel is accurately ground between true centres, it can be assumed that the centres are on the true central axis. A constant reading on the dial indicator would show the part to be round. It is also an indication that both the bore and the outside diameter lie on the same axis – a condition known as concentricity. An error reading on the dial indicator could therefore be an error in concentricity and the part be perfectly round.

The ideal workshop test which overcomes the problems already outlined is to rotate the part under a dial indicator with the part supported in a vee block. Because the points of support in the vee block are not diametrically opposite the plunger of the dial indicator, errors in roundness will be identified. For example, the tri-lobed condition undetected by direct measurement would be detected by this method, as shown in Fig. 4.24.

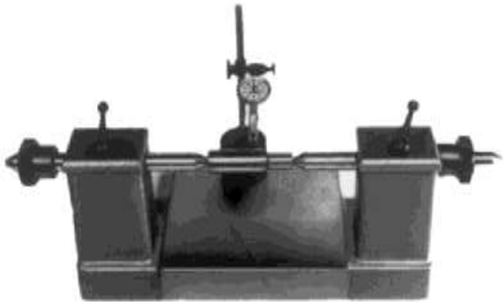


Figure 4.23 Checking work between centres

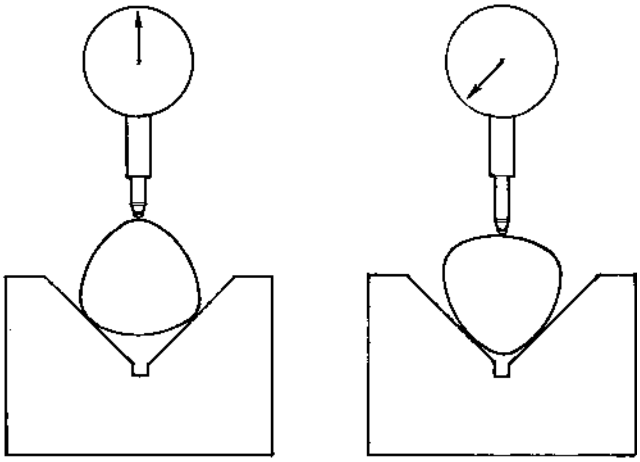


Figure 4.24 Checking work in a vee block

Self-Assessment Exercise

3.5 Surface Roughness

No manufactured surface however it may appear to the naked eye is absolutely perfect. The degree of smoothness or roughness of a surface depends on the height and width of a series of peaks and valleys which give the surface a certain texture. This surface texture is characteristic of the method used to produce it. For example, surfaces produced by cutting tools have tool marks in well-defined directions controlled by the method of cutting, and equally spaced according to the feed rates used.

The control of surface texture is necessary to obtain a surface of known type and roughness value which experience has shown to be the most suitable to give long life, fatigue resistance, maximum efficiency and interchangeability at the lowest cost for a particular application. This is not necessarily achieved by the finest surface. For example, two surfaces required to slide over each other would not function if finished to the same high degree as the surface of a gauge block – they would not slide but simply wring together. At the opposite extreme, the same two sliding surfaces with a very poor texture would wear quickly. The cost of producing these extremes of surface would also vary greatly.

The measurement of roughness is taken as the average of the peaks and valleys over a given length. This roughness average is denoted by R_a and the values expressed in pm

The R_a values specified should be selected from a range of preferred values contained in BS 1134-1: 1988 shown in Table 5.4. The values are given as ‘preferred’ in order to discourage unnecessary variation of the values expressed on drawings. Where a single value is stated on a drawing it is understood that work with any value from zero to the stated value is acceptable.

The method of assessing surface roughness is either by sophisticated stylus type equipment, although pocket size instruments with digital readouts are available for rapid on the spot measuring, or simply by surface roughness comparison specimens, Fig. 4.25.

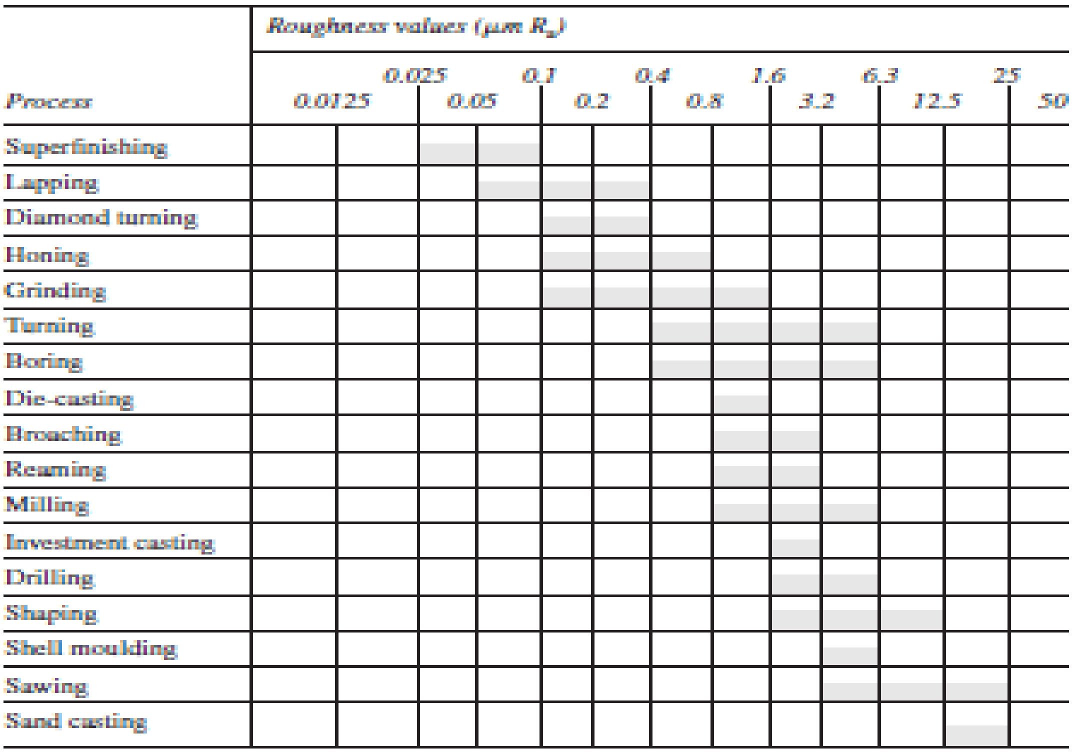
Comparison specimens are used to give draughtsmen/women and machine operators an idea of the relation of the feel and appearance of common machined surfaces to their numerical roughness value. By visual examination and by scratching the surface with a finger nail, a comparison can be made between the specimen and the workpiece surface being considered. Some average surface roughness values obtainable from common production processes are shown in Table 4.5

Table 4.4: Preferred surface-roughness values

Nominal R_a values (μm)
50
25
12.5
6.3
3.2
1.6
0.8
0.4
0.2
0.1
0.05
0.025
0.0125

Figure 4.25: Surface roughness comparison specimens

Table 4.5: Average surface-roughness values obtained by various processes



Self-Assessment Exercise

1. British standard numbers are often prefixed BS EN ISO. What do these prefixes mean
2. What do you understand by the term surface roughness?

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. Name three materials from which straightedges are made.
2. A 200mm sine bar is used to check an angle of 30^{o} 12'. Calculate the size of gauge blocks necessary. (ans. 10^{o}.604 mm).
3. By means of a sketch show the GO and NOT GO arrangement of a taper plug gauge.

7.0 References

UNIT 3: SHEET METAL WORKS

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) Itemize the various operations involved in sheet metal operations
(ii) Carry out bending operations on sheet metal
(iii) Explain the operation of sheet metal bending machines

3.0 Main Body

3.1 Cutting and Bending Sheet Metal

Light-gauge metal can be easily cut using snips. These may have straight or curved blades, Fig. 5.1, the latter being used to cut around a curved profile. Lengths of handle vary from 200 mm to 300 mm, the longer handle giving greater leverage for cutting

Figure 5.1 Straight- and curved-blade snips

Figure 5.2 Hand-lever shears

Figure 5.3 Treadle guillotine

heavier gauge material. For cutting thicker metals, up to 1.5 mm, hand-lever shears are available, usually bench-mounted, Fig. 3.2. The length of the lever and the linkage to the moving shear blade ensure adequate leverage to cut the thicker metals

Where larger sheets are required to be cut with straight edges, the guillotine is used. Sheet widths of 600 mm X 2 mm thick and up to 1200 mm X 1.6 mm thick can be accommodated in treadle-operated guillotines, Fig. 3.3. These have a moving top blade, which is operated by a foot treadle, and a spring which returns the blade to the top of its stroke. The table is provided with guides, to maintain the cut edges square, and adjustable stops to provide a constant size over a number of components. When the treadle is operated, a clamp descends to hold the work in position while cutting takes place, and this also acts as a guard to prevent injury. *These machines can be extremely dangerous if not used correctly, so take great care*.

When holes are to be cut in sheet metal, this can be done simply and effectively using ‘Q-Max’ cutters as shown in Fig. 5.4. A pilot hole is drilled in the correct position, the screw is inserted with the punch and die on either side of the sheet, and the screw is tightened. The metal is sheared giving a correct size and shape of hole in the required position

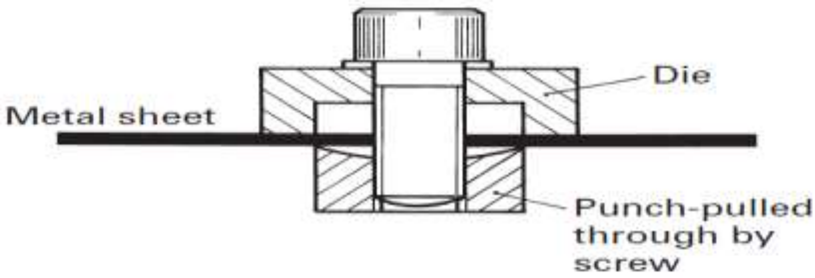


Figure 5.4 ‘Q-Max’ cutter

Where a number of components require the same size hole in the same position, it may be economical to manufacture a punch and die for the operation. The operation is carried out on a fly press, Fig. 5.5, with the punch, which is the size and shape of the

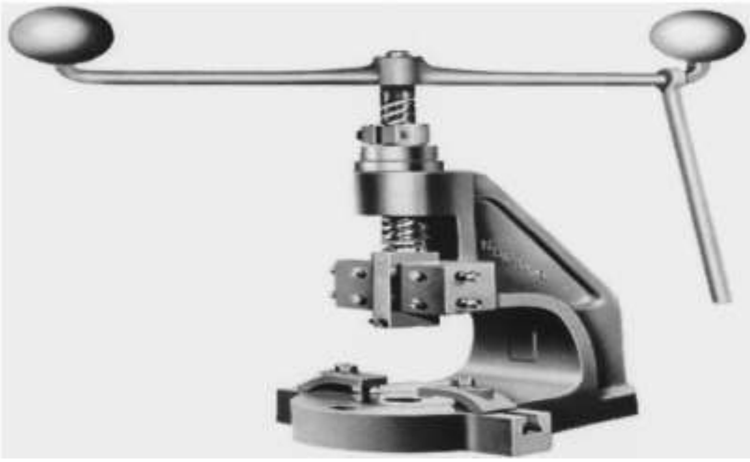


Figure 5.5 Fly press

hole required, fitted in the moving part of the press. The die, which contains a hole the same shape as the punch, but slightly larger to give clearance, is clamped to the table directly in line with the punch. When the handle of the fly press is rotated, the punch descends and a sheet of metal inserted between the punch and die will have a piece removed the same shape as the punch, Fig. 5.6

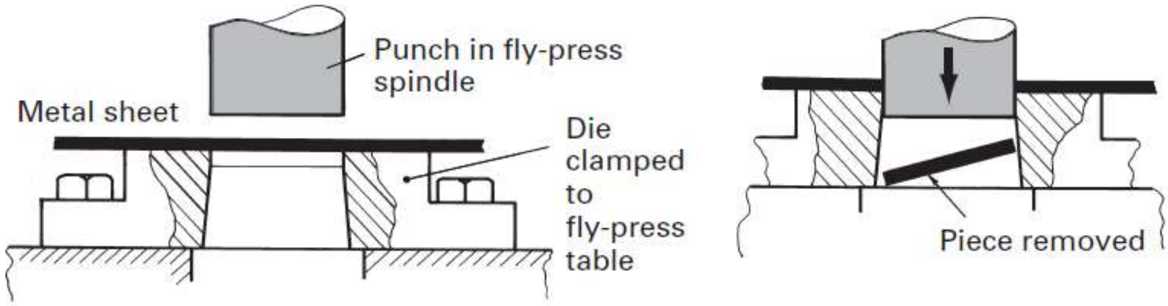


Figure 5.6 Punch and die in fly press

With the use of simple tools, the fly press can also be used for bending small components, Fig. 5.7. The top tool is fixed to the moving part and the bottom tool, correctly positioned under the top tool, is fixed to the table of the press. Metal bent in this way will spring back slightly, and to allow for this the angle of the tool is made less than 90°. In the case of mild steel, an angle of 88° is sufficient for the component to spring back to 90°

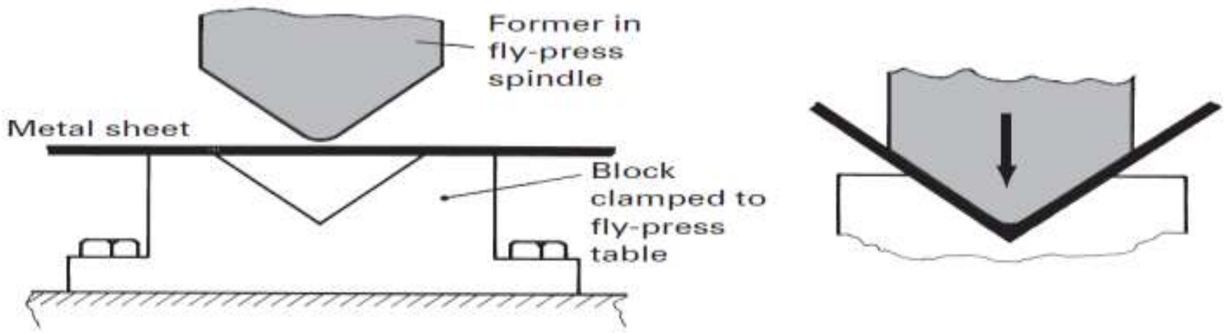


Figure 5.7 Bending tool in fly press

The simplest bends can be produced by holding the component in a vice and bending it over using a soft hammer. If the component is wider than the vice jaws, it can be clamped between metal bars. Unless a radius is put on one of the bars, this method produces a sharp inside corner, which may not always be desirable.

Folding machines, Fig. 5.8, are used with larger work of thicker gauges and for folding box sections. The top clamping beam, is adjustable to allow for various thicknesses of material and can be made up in sections known as fingers to accommodate a previous fold. Slots between the fingers allow a previous fold not to interfere with further folds, as in the case of a box section where four sides have to be folded. The front folding beam, pivoted at each end, is operated by a handle which folds the metal past the clamping blade, Fig. 5.9

Figure 5.8 Folding machine

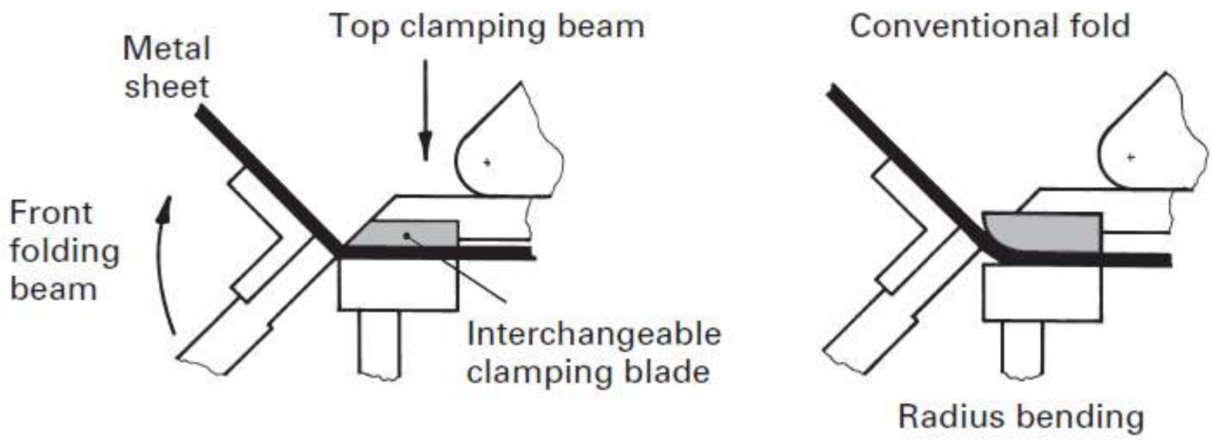


Figure 5.9 Folding operations

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. How is the thickness of sheet metal identified?
2. Describe two methods of producing a hole in sheet metal

7.0 References

UNIT 4: DEVELOPMENT OF SIMPLE SHAPES

CONTENT

1.0 Introduction

2.0 Objectives

At the end of this Unit, you should be able to:

(i) Explain the development of surfaces in sheet metal works
(ii) Explain the development of simple shapes encountered in sheet metal works
(iii) Calculate developed lengths in sheet metal works

3.1 Development

The development of sheet-metal components ranges from the simple to the extremely complex. Let us consider three simple shapes: a cylinder, a cone and a rectangular tray.

If a cylinder is unfolded, like unrolling a carpet, the length of the development is equal to the circumference, Fig. 5.10.

If a cone is unfolded while pivoting about the apex *O*, the development is a segment of a circle of radius *Oa* whose arc *ab* is equal in length to the circumference of the base, Fig. 5.11. To find the length of arc *ab*, the base diameter is equally divided into 12 parts. The 12 small arcs 1–2, 2–3, etc. are transferred to the arc with point 12 giving the position of point *b*. A part cone (frustum) is developed in exactly the same way, with the arc representing the small diameter having a radius *Oc*, Fig. 5.12.

In practice, the circumference must take account of the material thickness. Any metal which is bent will stretch on the outside of the bend and be compressed on the inside.
Unless the metal is of very light gauge, an allowance must be made for this. The allowance is calculated on the assumption that, since the outside of the bend stretches and the inside is compressed, the length at a distance half way between the inside and outside diameters, i.e. the mean diameter, will remain unchanged

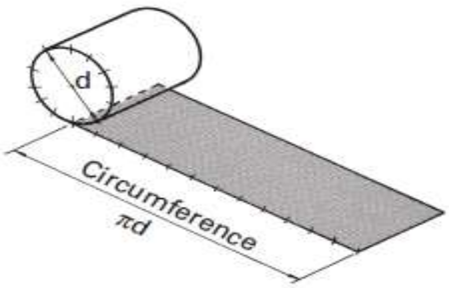


Figure 5.10 Development of a cylinder

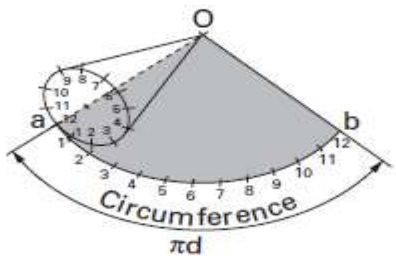


Figure 5.11 Development of cone

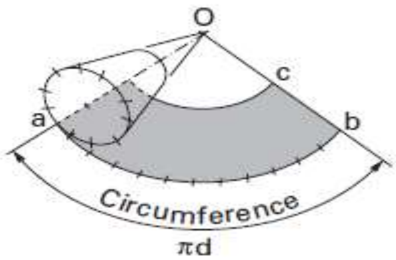


Figure 5.12 Development of part cone

Example 5.1 Development of cylinder

The cylinder shown in Fig. 5.13 has an outside diameter of 150 mm and is made from 19 SWG (1 mm thick) sheet. Since the outside diameter is 150 mm and the thickness 1 mm

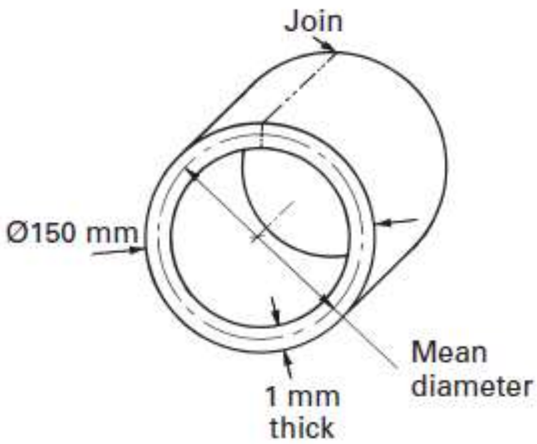


Figure 5.13 Cylinder

mean diameter = 150 – 1 = 149mm

Given

mean circumference = π x 149 = 468 mm

The circumference at the outside of the cylinder is π x 150 = 471 mm

Thus a blank cut to a length of 468 mm will stretch to a length of 471 mm at the outside and give a component of true 150 mm diameter.

Self-Assessment Exercise

3.2 Development of Rectangular Tray

The development of a rectangular tray is simply the article with the sides and ends folded down, Fig. 5.14(a). The development would be as shown in Fig. 5.14(b), the dotted lines indicating the position of the bend. If sharp inside corners are permissible, the bend lines are the inside dimensions of the tray. If the tray is dimensioned to the outside, you must remember to deduct twice the metal thickness for length and for width

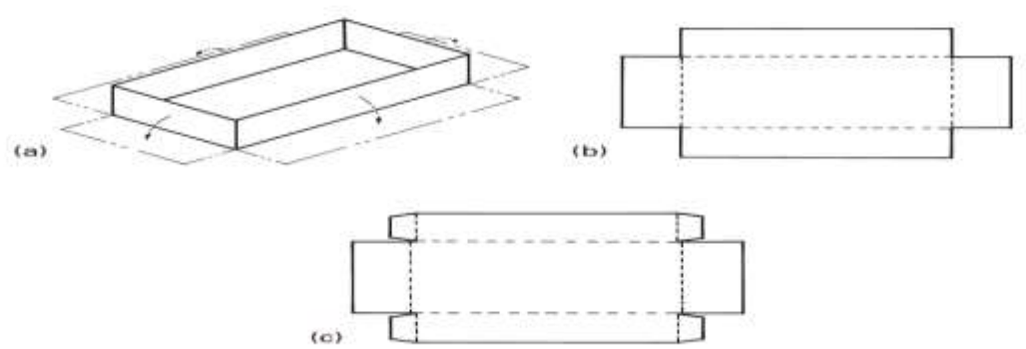


Figure 5.14 Development of rectangular tray

A tray which is to be joined by spot welding or soldering requires a tab, and in this case the tab bend line must allow for the metal thickness so that the tab fits against the inside face of the tray, Fig. 5.14(c). Sharp inside corners for bends are not always possible or desirable, and as a general rule an inside radius is made, equal to twice the thickness of the metal used.

To find the development length on the flat sheet, it is necessary to find the length of the mean line by calculating the lengths of the flat portions and the bends separately. The stretched-out length of the bend is called the bend allowance and for a 90° bend is found by multiplying the mean radius by 1.57 (i.e. $\pi/2$)

Example 5.3 Development of a bracket

Figure 5.15 shows a right-angled bracket made from 1 mm thick material. To obtain the development, first find

length *ab* = 60 — inside radius — metal thickness = 60 — 2 — 1

= 57 mm

next

length *cd* = 80 — 2 — 1

= 77 mm

finally

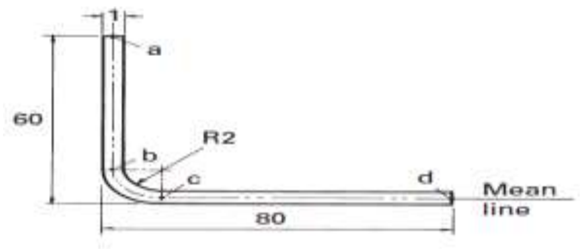
length *bc* = mean radius x 1.57

= (inside radius + ½ metal thickness) x 1.57 = (2 + 0.5) x 1.57

= 2.5 X 1.57

= 3.9, say 4 mm

∴ total length of development = 57 + 77 + 4 = 138mm



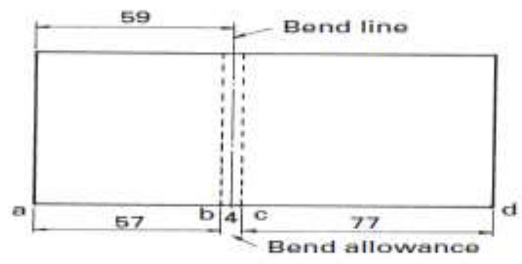


Figure 5.15 Right-angled bracket

Figure 5.16 Development of right-angled bracket

It can be seen that the development of the bracket shown in Fig. 5.15 is made up of a 57 mm straight length plus a bend allowance of 4 mm plus a further straight length of 77 mm, as shown in Fig. 5.16. The bend is half way across the bend allowance, and therefore the bend line must be 57 + 2 = 59 mm from one edge.

Self-Assessment Exercise

1. Why is it necessary to overbend material during a bending operation?

2. Under what circumstances would it be more appropriate to use a folding machine rather than a vice when bending sheet metal?

3. Why is it necessary to calculate the developed length of sheet metal components using the mean line

4.0 Conclusion

5.0 Summary

6.0 Tutor-Marked Assignment

1. Calculate the cut length of blank required to produce a plane cylinder of 180 mm finished diameter from 14 SWG (2 mm) sheet (ans. 559.2 mm).

2. A right angle bracket has leg lengths of 90 and 50 mm with a 3 mm corner radius and is made from 14 SWG (2 mm) sheet. Calculate the developed length (ans. 138.3).

3. State the restrictions in using hand snips to cut sheet metal.

7.0 References