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Industry's right hand

UEENEEE102A Fabricate, assemble and dismantle utilities industry components

Student Note

T2 – T12

Bracken Ridge Electrical

Version 4 – February 2013

Student Name: ________________________

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Table of Contents

UEE11 ELECTROTECHNOLOGY TRAINING PACKAGE (Version 4)
UEENEEE102A Fabricate, assemble and dismantle utilities industry components

Modification History
Not Applicable

Unit Descriptor
Unit Descriptor 1)
1.1) Descriptor
This unit covers basic fitting and fabrication techniques as they apply in the various utilities industry work functions. It encompasses the safe use of hand, fixed and portable power tools; cutting, shaping joining and fixing using metallic and non-metallic materials; dismantling and assembling equipment; basic mechanical measurement and marking-out and reading drawings/diagrams.

Application of the Unit
Not Applicable
Licensing/Regulatory Information 1.2)

License to practice
During Training: Competency development activities are subject to regulations directly related to licencing, occupational health and safety and where applicable contracts of training such as apprenticeships.

In the workplace: The application of the skills and knowledge described in this unit require a license to practice in the workplace where work is carried out on electrical equipment or installations which are designed to operate at voltages greater than 50 V a.c. or 120 V d.c.

Other conditions may apply under State and Territory legislative and regulatory requirements.

Pre-Requisites
Prerequisite Unit(s) 2)
2.1) Competencies
Granting competency in this unit shall be made only after competency in the following unit(s) has/have been confirmed.

UEENEEE101A Apply Occupational Health and Safety regulations, codes and practices in the workplace

2.2) Further Information:
For the full prerequisite chain details for this unit please refer to Table 2 in Volume 1, Part 2

Employability Skills Information
Employability Skills
3)
This unit contains Employability Skills
The required outcomes described in this unit of competency contain applicable facets of Employability Skills. The Employability Skills Summary of the qualification in which this unit of competency is packaged will assist in identifying Employability Skill requirements.

Application of the Unit 4)

4.1) General Application

This unit applies to persons entering work in utilities industry and may be used in school-based vocational programs.

4.2) Importation

RTOs wishing to import this unit into any qualification under the flexibility provisions of NQC Training Package Policy

Elements and Performance Criteria Pre-Content 6)

Elements describe the essential outcomes of a unit of competency

Performance criteria describe the required performance needed to demonstrate achievement of the Element. Assessment of performance is to be consistent with the evidence guide.

Elements and Performance Criteria

1 Prepare for dismantling, assembling and fabrication work.

1.1 OHS procedures for a given work area are obtained and understood through established routines and procedures.

1.2 Established OHS risk control measures and procedures in preparation for the work are followed.

1.3 Safety hazard not previously identified are reported and advice on risk control measures is sought from the work supervisor.

1.4 The nature of the work is obtained from documentation and from work supervisor to establish the scope of work to be undertaken.

1.5 Advice is sought from the work supervisor to ensure the work is coordinated effectively with others.

1.6 Materials required for the work are obtained in accordance with established routines and procedures.

1.7 Tools, equipment and measuring devices needed to carry out the work are obtained and checked for correct operation and safety.

1.8 Cutting tools such as drills and chisels are sharpened to suit the material on which they are to be used.

2 Dismantle and assemble utilities industry apparatus.

2.1 Established OHS risk control measures and procedures for carrying out the work are followed.

2.2 Circuits/machines/plant are checked as being isolated where necessary in strict accordance OHS requirements and procedures.

2.3 Appropriate tools are selected and used correctly and

2.4 Manufacturer apparatus dismantling and assembling guides are used where applicable.

2.5 Components are marked or tagged during the dismantling to help ensure correct and efficient reassembly.

2.6 Dismantled components and parts are stored to protect them against loss or damage.

2.7 Apparatus is dismantled and assembled efficiently without waste of materials and energy and/or damage to apparatus and the surrounding environment or services.

2.8 Procedures for referring non-routine events to immediate supervisor for directions are followed.

2.9 Routine quality checks are carried out in accordance with work instructions.

2.10 OHS risk control work completion measures and procedures are followed.

2.11 Work site is cleaned and made safe in accordance with established procedures.
2.12 Work supervisor is notified of the completion of the work in accordance with established procedures.

3 Fabricate utilities industry components.
3.1 Established OHS risk control measures and procedures for carrying out the work are followed.
3.2 Circuits/machines/plant are checked as being isolated where necessary in strict accordance OHS requirements and procedures.
3.3 Appropriate tools are selected and used correctly and safely in fabricating components.
3.4 Drawings and instruction for the fabrication of components are followed.
3.5 Component dimensions are determined directly or by calculation from information given in job drawings and instructions.
3.6 Components are fabricated efficiently without waste of materials and energy and/or damage to the surrounding environment or services.
3.7 Procedures for referring non-routine events to immediate supervisor for directions are followed.
3.8 Routine quality checks are carried out in accordance with work instructions.
3.9 OHS risk control work completion measures and procedures are followed.
3.10 Work site is cleaned and made safe in accordance with established procedures.
3.11 Work supervisor is notified of the completion of the work in accordance with established procedures.

Required Skills and Knowledge
REQUIRED SKILLS AND KNOWLEDGE 7)
This describes the essential skills and knowledge and their level, required for this unit.
Evidence shall show that knowledge has been acquired of safe working practices and fabricating, dismantling, assembling of utilities industry components.
The knowledge and skills shall be contextualised to current industry standards, technologies and practices.

KS01-EE102A Hand and power tools and their application
Evidence shall show an understanding of hand and power tools and their application to an extent indicated by the following aspects:

T1 Mechanical drawing interpretation and sketching encompassing:
- drawing standards and conventions used in drawings of mechanical components as specified in AS1100
- basic abbreviations and symbols used in drawing of mechanical components
- interpretation of mechanical drawings commonly used in the electrotechnology industry (orthogonal projection, third angle - detail and assembly drawings, pictorial views)
- laying out a drawing of mechanical components using engineering drawing convention.
- freehand drawings of mechanical components showing all information needed for its manufacture/fabrication

T2 Workshop planning and materials encompassing:
- methods used to work safely in an industrial work environment.
- typical non-electrical hazards in the workplace
- control measures for dealing with hazards identified.

- Conducting a risk assessment on a given work environment, documenting and assessing the risks identified
- type of metallic and non-metallic materials used in the electrotechnology industry and application of the common materials
- planning process

T3 Measuring and marking out encompassing:
- reasons for measuring and marking out
- tools used for marking out
- measuring and marking out a project accurately following correct procedures.
- sustainable energy work practices related to reducing waste when marking out.

T4 Holding and cutting encompassing:
- common tools for holding (bench vices, multi-grips, vice grips, wrenches).
- common tools for cutting metallic and non-metallic material (hacksaws, wood saws, chisels, pliers, files)
- procedure for using a range of tools for cutting, shaping, and finishing metallic and non-metallic materials
- safety procedures when using holding and cutting tools

T5 Drills and drilling encompassing:
- types of drills used in the electrotechnology industry
- sharpening twist drills
- drilling metallic and non-metallic components
- safe use of a bench drill

T6 Tapping and threading encompassing:
- type and size of commonly used threads used in electrotechnology work
- taps and tap wrenches
- tapping metallic and non-metallic components
- stock and die tools
- threading metallic and non-metallic components

T7 General Hand Tools encompassing:
- hammers used in electrotechnology work
- screwdrivers used in electrotechnology work
- spanners and sockets used in electrotechnology work
- pliers used in electrotechnology work
- assembling components applicable to electrotechnology industry using a variety of hand tools.

T8 Joining techniques encompassing:
- types of machine screws and nuts
- forms of welding (Oxy-acetylene, electric arc welding).
- forms of brazing and hard soldering
- process of soft soldering
- joining components using machine screws
- joining components using welding, brazing or soldering techniques

T9 Portable electric power tools encompassing:
- portable electric power tools (grinders, drills, jigsaws, saws)
- applications of portable electric power tools used in the electrotechnology work.
- using portable power tools.

- fabricating components using power tools (drills, grinders)

T10 Sheet metal work encompassing:
- types of sheet metal materials used in the electrotechnology work.
- names and applications of the types of fabrication materials.
- tools used with sheet metals in electrotechnology work (hacksaw, tinsnips, guillotines, punches, notching tools, folding machines)
- techniques used in fabricating sheet metal (cutting, bending, drilling/punching, joining, cutting mitres).
- marking out, cutting, bending, drilling and/or cutting and/or punching holes, joining and cutting mitred joints using sheet metal.
- sustainable energy work practices to reducing waste when fabricating using sheet metal.
- fabricating components using sheet metal and fabrication tools.

T11 Low tolerance measurement encompassing:
- tolerance
- techniques in using vernier callipers
- techniques in using micrometers.
- using vernier callipers to measure engineering components
- using micrometers to measuring engineering components

T12 Dismantling and assembly techniques encompassing:
- tools used in dismantling and assembling electrotechnology equipment (spanners, screwdrivers, bearing pullers, etc).
- procedures for ensuring the safe treatment of dismantled components.
- dismantling electrical, electronic, instrumentation or refrigeration/air conditioning piece of equipment using correct procedures.
- assembling electrical, electronic, instrumentation or refrigeration/air conditioning piece of equipment using correct procedures.

EVIDENCE GUIDE 9)
The evidence guide provides advice on assessment and must be read in conjunction with the Performance Criteria, Required Skills and Knowledge, the Range Statement and the Assessment Guidelines for this Training Package.

The Evidence Guide forms an integral part of this unit. It must be used in conjunction with all parts of the unit and performed in accordance with the Assessment Guidelines of this Training Package.

Overview of Assessment 9.1)
Longitudinal competency development approaches to assessment, such as Profiling, require data to be reliably gathered in a form that can be consistently interpreted over time. This approach is best utilised in Apprenticeship programs and reduces assessment intervention. It is the industry-preferred model for apprenticeships. However, where summative (or final) assessment is used it is to include the application of the competency in the normal work environment or, at a minimum, the application of the competency in a realistically simulated work environment. It is recognised that, in some circumstances, assessment in part or full can occur outside the workplace. However, it must be in accordance with industry and regulatory policy.

Methods chosen for a particular assessment will be influenced by various factors. These include the extent of the assessment, the most effective locations for the assessment activities to take place, access to physical resources, additional safety measures that may be required and the critical nature of the competencies being assessed.

The critical safety nature of working with electricity, electrical equipment, gas or any other hazardous substance/material carries risk in deeming a person competent. Sources of evidence need to be 'rich' in nature to minimise error in judgment.

Activities associated with normal everyday work have a bearing on the decision as to how much and how detailed the data gathered will contribute to its 'richness'. Some skills are more critical to safety and operational requirements while the same skills may be more or less frequently practised. These points are raised for the assessors to consider when choosing an assessment method and developing assessment instruments. Sample assessment instruments are included for Assessors in the Assessment Guidelines of this Training Package.

Critical aspects of evidence required to demonstrate competency in this unit 9.2)
Before the critical aspects of evidence are considered all prerequisites must be met.

Evidence for competence in this unit shall be considered holistically. Each element and associated performance criteria shall be demonstrated on at least two occasions in accordance with the 'Assessment Guidelines - UEE07'.

Evidence shall also comprise:

- A representative body of work performance demonstrated within the timeframes typically expected of the discipline, work function and industrial environment. In particular this shall incorporate evidence that shows a candidate is able to:
  - Implement Occupational Health and Safety workplace procedures and practices, including the use of risk control measures as specified in the performance criteria and range statement
  - Apply sustainable energy principles and practices as specified in the performance criteria and range statement
  - Demonstrate an understanding of the essential knowledge and associated skills as described in this unit. It may be required by some jurisdictions that RTOs provide a percentile graded result for the purpose of regulatory or licensing requirements.
  - Demonstrate an appropriate level of skills enabling employment
  - Conduct work observing the relevant Anti Discrimination legislation, regulations, polices and workplace procedures
- Demonstrated consistent performance across a representative range of contexts from the prescribed items below:
  - Fabricate, dismantle, assemble of utilities industry components as described in 8) and including:
    A Selecting and using hand tools appropriate to a task correctly and safely
    B Selecting and using power tools appropriate to a task correctly and safely
    C Sharpening at least two drill bits each for use different types of material.
    D Interpreting mechanical drawings/diagrams and instructions correctly.
    E Dismantle and assemble an apparatus relevant to utilities industry discipline in which competency is sought.

F Fabricate a component relevant to the utilities industry discipline in which competency is sought.
G Dealing with unplanned events

Context of and specific resources for assessment 9.3)
This unit should be assessed as it relates to normal work practice using procedures, information and resources typical of a workplace. This should include:

- OHS policy and work procedures and instructions.
- Suitable work environment, facilities, equipment and materials to undertake actual work as prescribed in this unit.

These should be used in the formal learning/assessment environment.

Note: Where simulation is considered a suitable strategy for assessment, conditions for assessment must be authentic and as far as possible reproduce and replicate the workplace and be consistent with the approved industry simulation policy.
The resources used for assessment should reflect current industry practices in relation to dismantling, assembling and fabricating utilities industry components.

Method of assessment 9.4)
This unit shall be assessed by methods given in Volume 1, Part 3 'Assessment Guidelines'.

Note: Competent performance with inherent safe working practices is expected in the Industry to which this unit applies. This requires that the specified essential knowledge and associated skills are assessed in a structured environment which is primarily intended for learning/assessment and incorporates all necessary equipment and facilities for learners to develop and demonstrate the essential knowledge and skills described in this unit.

Concurrent assessment and relationship with other units 9.5)
For optimisation of training and assessment effort, competency development in this unit may be arranged concurrently with unit:

Range Statement
RANGE STATEMENT 8)
This relates to the unit as a whole providing the range of contexts and conditions to which the performance criteria apply. It allows for different work environments and situations that will affect performance.

This unit shall be demonstrated in relation to installation, fault finding, maintenance, repair or development work functions in any of the following disciplines:

- Electrotechnology Disciplines
- Gas industry Disciplines
- ESI Transmission, Distribution and Rail Disciplines
- ESI Generation Disciplines

Generic terms used throughout this Vocational Standard shall be regarded as part of the Range Statement in which competency is demonstrated. The definition of these and other terms that apply are given in Volume 2, Part 2.1.

Unit Sector(s)
Not Applicable

Competency Field 2.3)
Literacy and numeracy skills
Participants are best equipped to achieve competency in this unit if they have reading, writing and numeracy skills indicated by the following scales. Description of each scale is given in Volume 2, Part 3 'Literacy and Numeracy'

Reading 3 Writing 3 Numeracy 3

2.3) Literacy and numeracy skills
Competency Field 5)
Utilities industry

Introduction
Tools are designed to make a job easier and enable you to work more efficiently and safely. Without the proper tools and the knowledge of how to use them, a tradesperson wastes time, reduces efficiency and may even cause themselves an injury.

The aim of this note is to explain the function, the correct and safe use and proper care of the tools you will use while working in the electrotechnology industry.

T2 Workshop planning and materials encompassing:

- Methods Used To Work Safely In An Industrial Work Environment.
- Typical Non-Electrical Hazards In The Workplace
- Control Measures For Dealing With Hazards Identified.
- Conducting A Risk Assessment On A Given Work Environment, Documenting And Assessing The Risks Identified
- Type Of Metallic And Non-Metallic Materials Used In The Electrotechnology Industry And Application Of The Common Materials
- Planning Process

Safety
The Workplace Health and Safety (WHS) Act 2011 requires the PCBU (Person conducting a business or undertaking) to ensure the health and safety of workers, so far as is "reasonably practicable". In addition, while at work, workers are required to take reasonable care for their own health and safety and that of others who may be affected by their actions or omissions. They must also cooperate with any reasonable instruction given by the PCBU and any reasonable policy or procedure of the PCBU to comply with the WHS Act 2011 and WHS Regulation 2011. This means that **you** have a responsibility to ensure that any decisions or actions on your part do not put yourself or others at risk. This means:

- Avoid unsafe practices,
- Follow your supervisor's instructions,
- Use correct methods.

Workplace injuries can be caused by many factors including:

- Poor design of factories, equipment and work areas.
- Poor management and organisational practice.
- Lack of instruction provided on safe use of equipment.
- Failing to provide or failure to use personal protective equipment (PPE).
- Using tools and equipment incorrectly.
- Distracting others from their work.
- Individual unsafe practices such as fooling around in workshop areas.

Hazards in the Workplace
"**Hazard**" is a term used to describe something that has the potential to cause harm, and a "**risk**" is a measure of the possibility of a specific harmful effect in given circumstances. It is important to know the difference between these two terms. Types of workplace hazards include:

Electrical: Exposure to electrical energy from, direct contact with exposed conductors or indirect contact with a faulty piece if equipment,

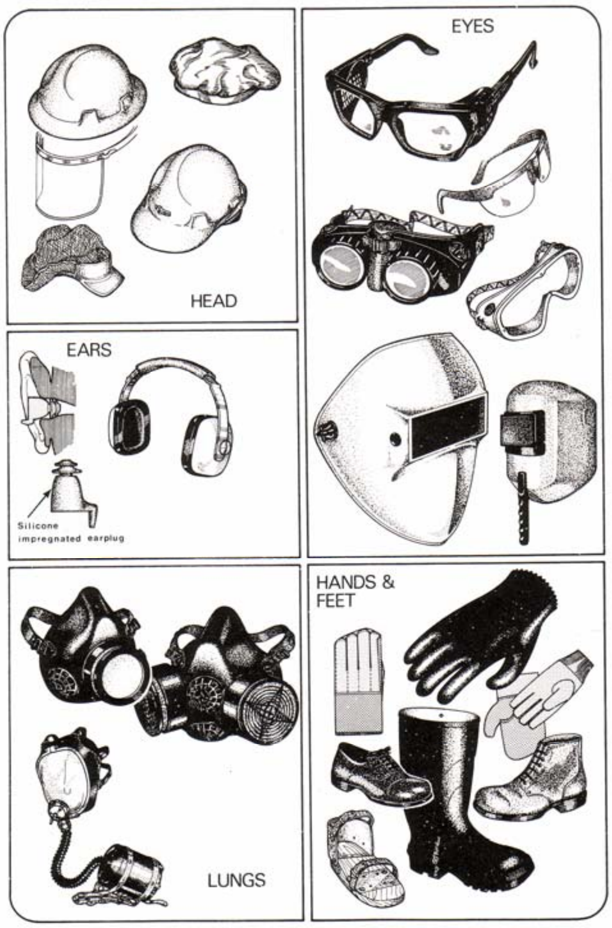
Gravity: Falls, trips and slips of a person, struck by falling objects,

Kinetic energy: Hitting objects with a part of the body or being hit by moving objects,

Radiation (ionising and non-ionising): Exposure to ultraviolet (UV) radiation, arc flashes, infrared radiation, microwaves and lasers etc

Vibration: Exposure to whole of body vibration or vibration to parts of the body only, such as hands,

Noise: Exposure to single, sudden sound or long term exposure to sound.



Chemical: Exposure to products such as solvents, glues, cleaning agents, thinners, etc.

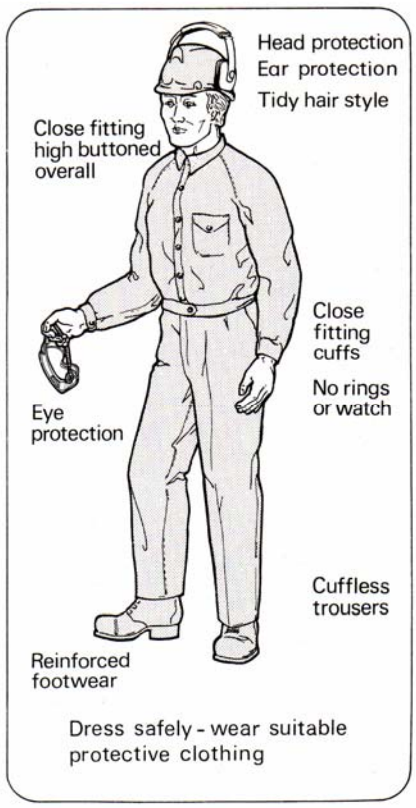
Body stressing: Muscular stress while lifting, carrying or putting down objects, muscular stress while handling objects other than lifting, carrying or putting down or muscular stress with no objects being handled, repetitive movement, low muscle loading,

Ergonomics: Fatigue or workplace design causing stress, causing errors,

Substances: Single contact with chemical or substance or long-term-contact with chemicals or substances, reptile, insect or spider bites and stings, other unspecified contact with chemical or substance, fire and explosion,

Airborne: Exposure to dusts eg. wood, asbestos, silica, gases eg. carbon monoxide, fumes eg. metal fume, vapours eg. Solvents, mists eg. acids, solvents

Skin contact: (absorption) Contact with eg. Pesticides, corrosive substances eg. acid, alkali, solvents; photosensitisation eg. Creosote; affected skin exposed to sunlight; allergic eg. nickel, epoxy,



Biological (microbial) substances: Exposure to bacterial, fungal, viral, parasitic

Mechanical: Refers to being caught between, struck by or against, mobile or fixed plant, and vehicles, powered equipment, tools and appliances, non-powered hand tools, appliances and equipment.

Psychological hazards: Those situations that cause stress to a worker. This kind of hazard troubles an individual to an extent that their general well-being is affected.

Identifying Workplace Hazards

- Study workplace injury and illness records,
- Stay current on WHS trends,
- Analyse all new work procedures for WHS,
- Investigate all workplace incidents and near misses,
- Conduct regular safety audits and inspections,
- Improve consultation and feedback procedures.

Hazard Control Measures to Reduce Risk

There are “five” categories of control measures:

“elimination”, “substitution”, “engineering controls”, “administrative controls” and “personal protective equipment”.

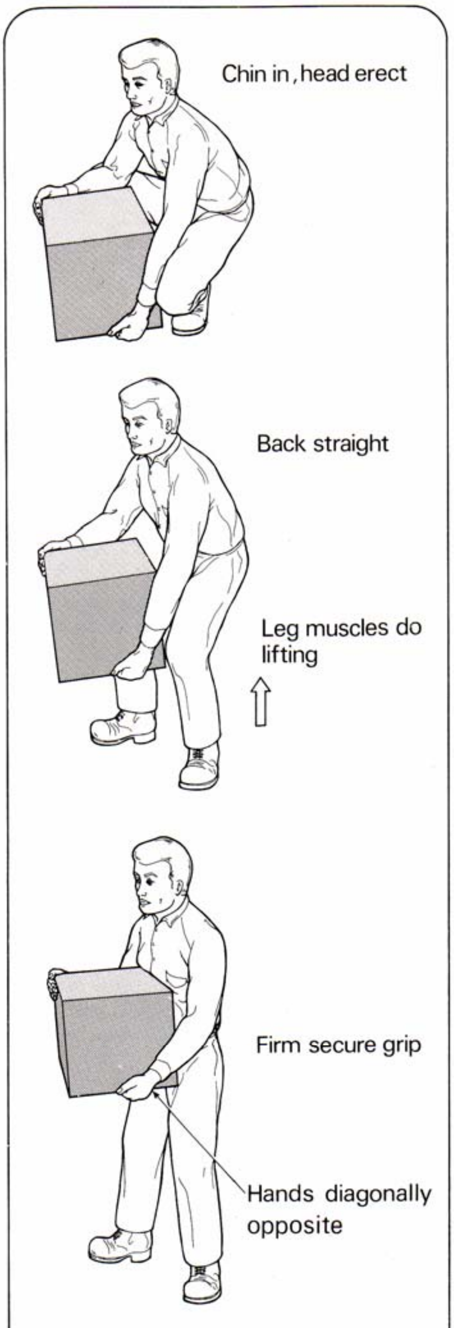
1. **Elimination** of the hazard is the most effective means of hazard control as it involves the physical removal of the hazard. Eg: If employees are required to work high above the ground, the hazard can be eliminated by moving the piece they are working on to "ground level" to eliminate the need to work at heights.

2. **Substitution** involves removing something that produces a hazard (similar to elimination) but replacing it with something that does not produce a hazard. An example of substitution is replacing an existing chemical cleaner with a less toxic type.

3. **Engineering controls** do not eliminate hazards, but rather keep people isolated from hazards. Examples are better guards on machines etc.

4. **Administrative controls** are changes to the way people work. Examples of administrative controls include procedure changes, employee training, and installation of signs and warning labels. Administrative controls do not remove hazards, rather limit or prevent people's exposure to the hazards. Eg: Completing a task out-of-hours when all electrical power can be isolated.

5. **Personal Protective Equipment** (PPE) is the least effective way to control hazards. PPE is the method of last resort because of the high potential for the PPE to become ineffective due to damage or aging etc.

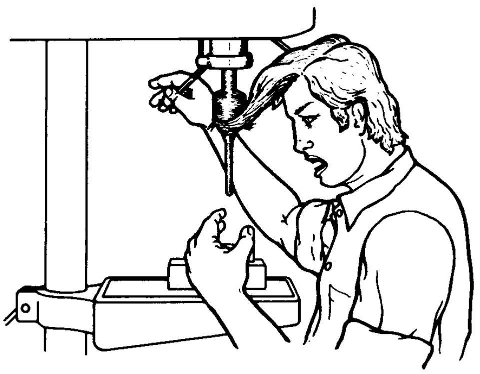


CORRECT LIFTING

Wear Appropriate PPE (Personal; Protective Equipment)
It is essential to safety that you always wear the appropriate personal protective equipment assigned to the task you are performing. This may include some of the following items:

- Suitable clothing
- Safety shoes or boots,
- Safety glasses,
- Goggles,
- Hair net or cap,
- Hearing protection,
- Gloves,
- Breathing apparatus.

Clothing
Suitable clothing should always be worn in the workshop. Loose sleeves and other loose clothing can easily catch on parts of a vehicle or tangle in


Hair and eyes unprotected

workshop equipment. Rotating parts, such as fans, belts and drills, are particularly dangerous as these could catch a loose sleeve and quickly pull a hand into a moving part. Long hair that is not under control can become tangled in rotating parts. This can cause severe personal injury. Always tie back long hair or wear a cap or other headgear such as a hair net.

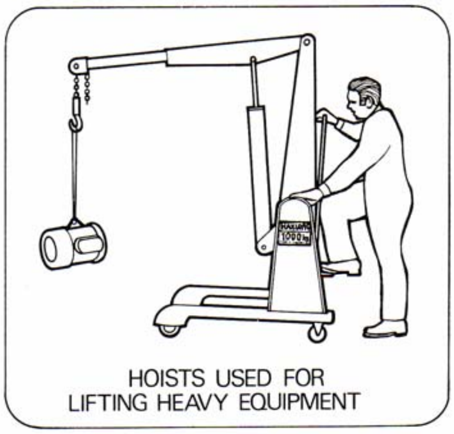
NB: An example of an unsafe work practice is an operator with "long hair" using rotating machinery without using some form of a hair protector.

Footwear
Boots and shoes should be of stout safety design. Safety footwear is designed with reinforced toecaps to provide some level of protection against some falling objects.

Safety glasses and shields
Eyes need special protection. Clear safety glasses should be worn when using a grinding wheel, or for any workshop job where dust or metal particles are prevalent.

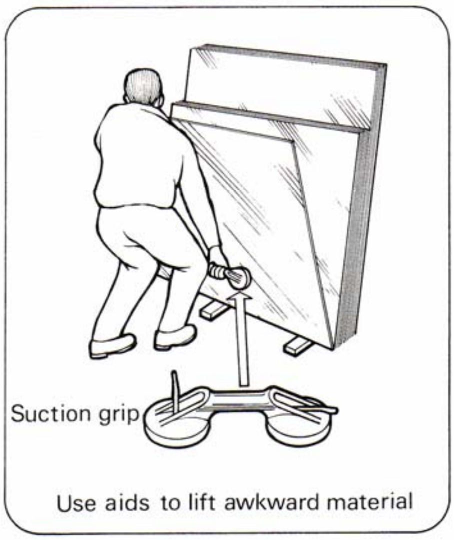
Manual Handling
Manual tasks can contribute to injuries affecting all parts of the body, particularly the back, shoulder and wrist. These are commonly called musculoskeletal disorders. Extra care is needed when performing manual tasks. If the task is beyond your capabilities, then either:

- Seek help,
- Use a mechanical lifting aid, (eg: bar)
- Use a mechanical lifting device (eg: Crane.)



Over time, damage can build up in your body through things such as:

- Handling loads - frequent lifting with the back bent and/or twisted, or pushing or pulling loads
- Repetitive work - using the hand or arm, or gripping tools or loads tightly
- Static work of the whole body - working in a fixed position with the back bent, continuous sitting or standing, or driving vehicles for long periods
- Static work of the upper limb - working with the neck, shoulders and arms in a fixed position (such as using tools and handling heavy loads)
- Vibration – using tools or coming into contact with vibrating surfaces while undertaking manual tasks (such as sitting on a large machine).



Safety and tools
Small hand tools should be kept clean and tidy. Always return hand tools back to their storage area when they are no longer required. They should be used correctly and maintained in good condition. Larger tools should be kept under control and not scattered about. Keep equipment out of aisles and working spaces where they would become a hazard.

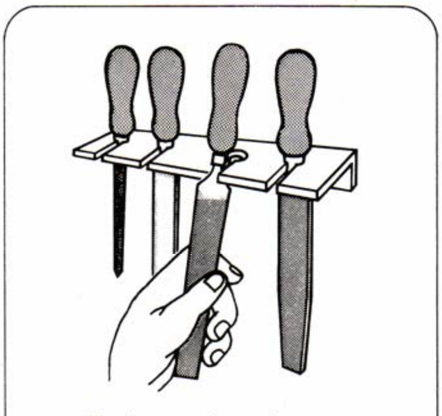
Use of machines
Before using any machine, know how it works. Always check the SOP (Standard Operating Procedure) for the machine which should be clearly displayed beside the machine.

It is important to carry out checks and minor maintenance **before** a machine is used so that it always remains in a serviceable condition. Always keep your hands away from moving parts.

When using a machine tool, **NEVER** attempt to “feel” the finished surface with the machine still in operation. Machines should be completely stopped **before** any checks or measurements are made.

Machine guards
Guards should be fitted to machines that have external moving parts. If the guard is missing from a machine, then it **MUST NOT** be used. The guards are there to protect the operator, who should make sure that the guards are correctly in place. Eg: Grinders should have covers over the grinding wheels to prevent grindings from being thrown towards the operator. The tool rests should always be adjusted close to the edges of grinding wheels. This will prevent an article that is being ground from jamming between the tool rest and the grinding wheel. This could easily injure the operator, damage the wheel, or ruin the article being ground.

Work Area
A clean and tidy area is safer than an untidy work area. Practice good housekeeping in your work area by keeping the area clean, ordered and tidy.
Always immediately report any damaged, worn or inoperative items or any unsafe conditions.


Replace each tool as you finish using it

Care in the Use of Hand Tools
Hand tools can cause injuries when an incorrect, improvised or defective tool is used. It is important to observe and carry out the following points:

- Make sure you select the correct type and size of tool for the job,
- Check the condition of any tool before you use it,
- Do not use tools that are worn out or damaged,
- Maintain tools in good condition and remember that cutting tools need to be sharp to be safe,
- Make sure that you use each tool in the correct manner,
- Store and carry your tools safely.


Put oily waste in bin

Risk Assessment
A risk assessment **must** be completed **before** commencing any practical task. Its purpose is to discover the "realistic" risks to be managed and then prioritize the risks inherent in the task. This usually involves walking around the intended work zone, imagining the task to be performed and determining what could be reasonably expected to cause harm.

Then, based on the level of risk, put control measures in place to reduce the risk level. The risk level is determined by the consequences if it does occur, and the probability that it will occur. A safe work plan means listing all of the control measures needed to either eliminate the identified hazards or at least, reduce the risk to an acceptable level.

Note:
Workshop and tool safety is such an important topic; some of the points discussed above will be reinforced in each of the topic areas.

Materials Used In The Electrotechnology Industry
Materials used in the electrotechnology industry can be grouped under three main categories:

- Electrical conductors
- Electrical insulators
- Equipment construction and support

Electrical Conductors
Most conductors are metals because they have a relatively low resistance to current flow. While "silver" and "gold" are the best conductors, their high cost makes them unsuitable for most practical applications. Copper, aluminium and brass are the most commonly used materials due to their good conductivity and cost. Copper and aluminium are used for both general circuit conductors and for large capacity busbars. Brass is used for its hardness when is used for neutral and earth links in switch boards.

Electrical Insulators
There are many insulating materials available that can be used as electrical insulators.
Electrical insulation is used in an electrical system to prevent unwanted flow of electric current to the earth or between phases. An insulating material must be mechanically strong, have a high dielectric strength to withstand the voltage stresses, high insulation resistance to prevent leakage current to the earth and it must also be free from unwanted impurities.
The physical as well as electrical properties must be independent of temperature changes.

There are many materials in common use including PVC (Polyvinyl Chloride), Nylon, Porcelain, Mica, Fibre glass, Perspex, Bakelite, Densified wood and Insulpanel (Phenolic resin impregnated paper base laminated sheet) used in switchboard construction.

Each material is application specific.

Equipment Construction and Support
Materials used for construction and support are extremely varied. Materials include steel (mild and stainless), aluminium, brass and copper are well as a full range of plastics etc.

Planning Process
Planning a job correctly involves coordinating all of the tasks from start to finish. Information can be derived from plans and specifications, quality assurance requirements and occupational health and safety requirements. This understanding enables problems to be avoided and also helps:

- Increase workplace safety,
- Reduce damage to tools and equipment,
- Reduce costly mistakes,
- Avoid processes which do not comply with the job plans or specifications, Australian Standards or codes of practice.

Planning:

- Helps ensure the safety of workers and equipment,
- Ensures that quality assurance requirements will be met,
- Ensures that the type of tools and equipment needed to complete the tasks are identified and are available,
- Ensures that the types of personal protective equipment needed for safe working are identified.

Task Scheduling

Time management and the amount of materials required for the job are key elements of the planning process. The practical difficulties of estimating times are considerable. The important point to consider is that the time allocated to each activity should be realistic rather than desirable. In practice, the estimation of times for each activity for a small job or a large project is derived from a person (or persons) with previous experience in performing or managing similar tasks. Alternatively, the duration of particular activities may be extracted from records concerning similar tasks carried out in the past.

Each individual task must be allocated an appropriate amount of time, suitable equipment and materials required and a work method statement and risk analysis.

Safe Work Method Statement

Work method statements detail how each work related activity can be carried out safely. They are required for all work related tasks - from the most basic task, such as using an electric drill to a more difficult task, such as the use of a lathe. Besides the process they also detail the Personal Protective Equipment (PPE) which will be required for each task. For example:

- safety helmets
- safety shoes
- safety glasses
- respirator
- gloves
- ear plugs / ear muffs
- wet weather gear
- sun protection
- fall arrest systems
- back braces etc

T3 Measuring and marking out encompassing:

- reasons for measuring and marking out
- tools used for marking out
- measuring and marking out a project accurately following correct procedures.
- sustainable energy work practices related to reducing waste when marking out.

Measurement
The system of measurement in use in Australia and in most countries of the world is the **SI (System International) Metric system**. The "**metre**" is the standard unit for length, with sub-divisions and multiples of the metre being based on the decimal system.

All engineering measurements, however, are made in millimetres, and all dimensions shown on engineering drawings are given in millimetres. There are 1000 (10^3) millimetres in a metre. The abbreviation for metres is the lower case "m" and the abbreviation for millimetres is lower case "mm".

Precision, Tolerance and Accuracy of Measurement
The "**precision**" of a measurement system, also called "**reproducibility**" is the degree to which repeated measurements under unchanged conditions show the same results. In practical terms, this equates to the minimum size "unit" being used to take a measurement. The smaller the "**unit**" used, the more "precise" the final measurement.

eg: If we attempt to go beyond the base unit of measurement and attempt to estimate by using just a part of the smallest graduation, then there is a high probability that the reading cannot be repeated. Ie: We have taken a "guess", which is "imprecise".

An engineering "**tolerance**" is the "predefined" permissible limit(s) of variation in a physical dimension etc. eg: The tolerance of a job may be given as, "±1mm" which means "1mm" more or "1mm" less than the originally set value. It is the "client" or the nature of the task which defines the tolerance to which you are to work. For example, if you are required to fit a bearing to the shaft of an electric motor, then the tolerance may be stated as "±0.01mm.

The "**accuracy**" of measuring equipment defines its ability to take an exact reading. The degree of closeness of the measurement to the quantity's actual (or true) value reflects the "accuracy" it can achieve. The bigger the "difference", the more "inaccurate" it is. The accuracy of measuring equipment is determined by the "**smallest unit**" available to it. Eg: The accuracy of a standard engineering ruler is "0.5mm" or "0.1mm"; a vernier "0.02mm" and a "micrometer "0.01mm".

Measuring Tools
The process of measuring is one of aligning an unknown physical quantity, the "work piece", against a known "standard", (ie: the measuring tool), and gauging the size.

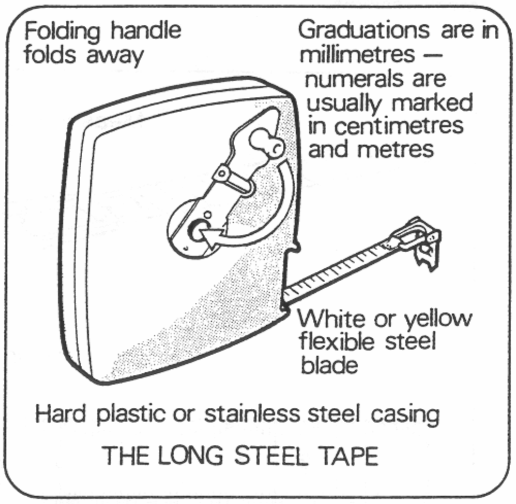
The graduated measuring instruments typically used by a tradesperson are a tape and steel rule and depth gauges. High precision measuring tools such a vernier and micrometer are covered in a later topic.

Care of Measuring Equipment
Measuring tools are precision instruments and are easily damaged. They should be stored in locations or containers where they will be protected from corrosion, dirt contact and also from harmful contact with heavier tools, such as hammers, chisels and files.

The best way to ensure they are not damaged is to return them to their protective cases when they are not in use. Also, never leave the jaws of the instrument firmly closed as they will stretch and loose accuracy. They should always be stored with the jaws slightly apart to allow for physical changes due to temperature variations. While the equipment is in use, you should always guard against:

- Dropping the instrument.
- Dropping other equipment onto the measuring instrument.
- Allowing it to come into contact with filings, grinding grit or dirt.
- Taking measurements whilst the machinery is still running.

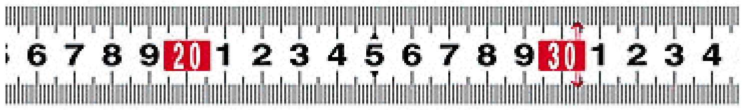
To protect instruments from corrosion, they should be cleaned and lightly coated with suitable oil at the completion of the day's work. At regular intervals these instruments should be dismantled, cleaned, checked and if necessary re-calibrated.



If contact surfaces are scored or burred; if spindles are bent, or if the frames are strained, then the accuracy of the instrument can be compromised and the continued use of the tool will result in faulty work.

Tape Rule or Tape Measure
A measuring tape consists of a flexible blade of steel housed in a metal or plastic case.

Long Tape
This instrument is used to measure very long lengths, typically up to30m but longer designs up to 50m are available. An application could be measuring the route length for a conduit or cable duct run.

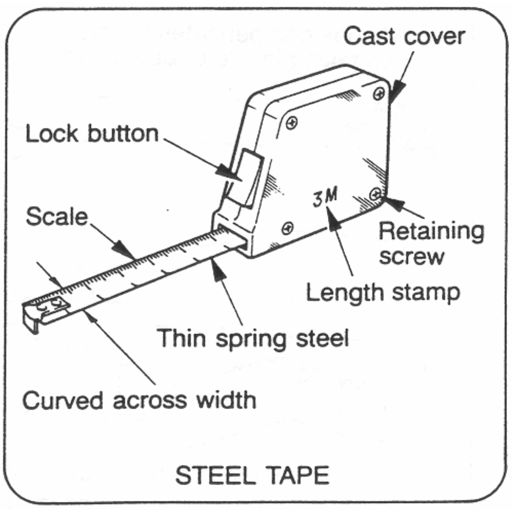


The "flexible" tape may be made of either nylon coated steel or fibre glass. The measuring tape is returned into the case by operating a turning mechanism with a handle as shown to the right. On some designs the handle can be folded away when not in use. An example is shown to the right.

Ref: http://www.surveyequipment.com

Steel Tape
This tape is used to measure shorter lengths up to about 8 to 10 metre lengths.

Tape rules have a power return spring which automatically returns the tape blade into the housing. Do not allow the tape to return in an uncontrolled fashion as the tip hook will break off. A lock button is usually included to secure the blade in the open position as well as slow its return into the case.



Danger
Because steel is an excellent conductor of electricity, **NEVER** use a "steel tape" in close proximity to live electrical terminals.

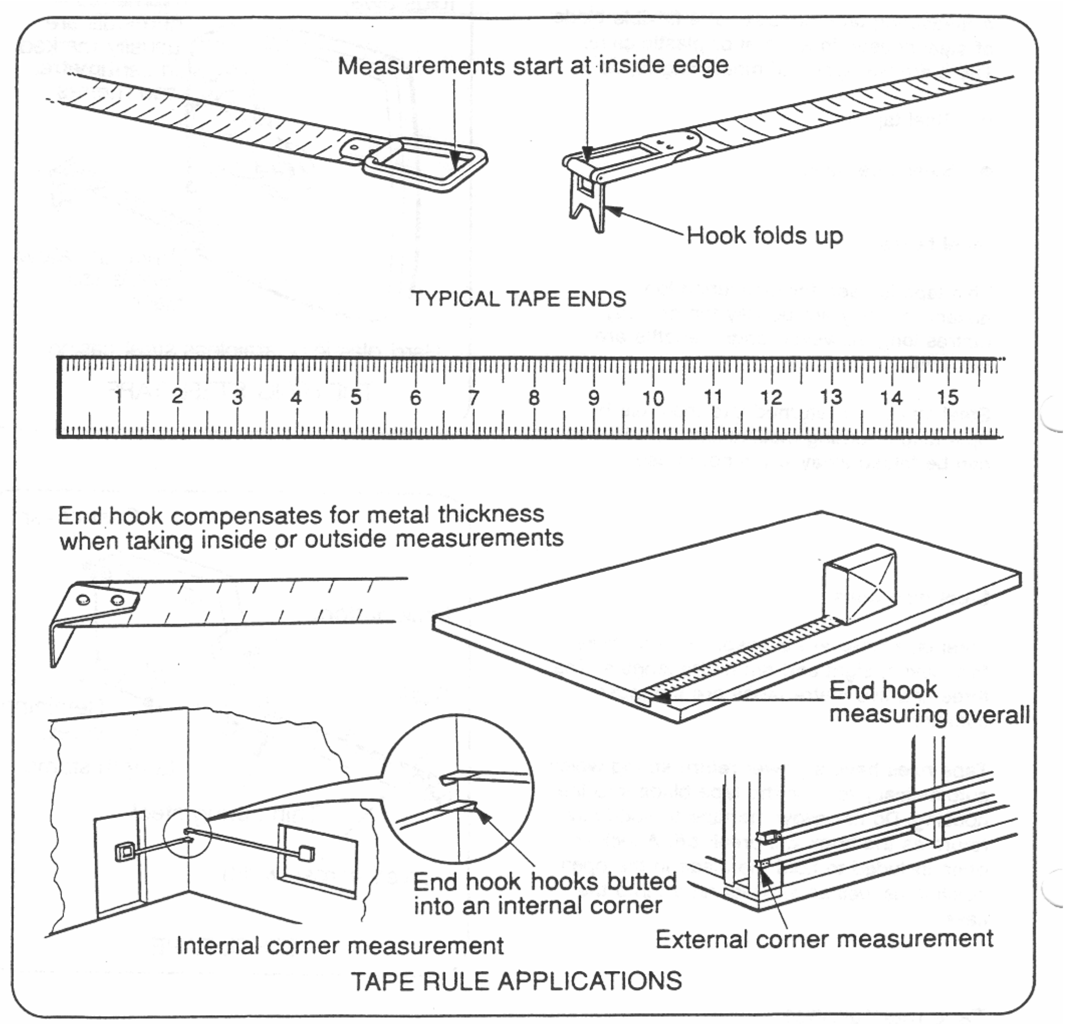
Tape Maintenance
Correctly maintained steel tapes and tape rules will last for many years. Follow these steps:

- Keep the blade free from grit and moisture.

- Slide the blade between a slightly oiled rag when returning it into the case.
- Avoid leaving the blade exposed to the direct rays of the sun as this can buckle it.

Using Tapes

Tapes can be graduated in either all metric or a combination of metric and imperial (feet and inches) measurements.



A steel tape can be used in most situations, but it is best used for on-site setting out and for taking on-site measurements.

The fixed end hook on a steel tape can move to compensate for the thickness of the metal when taking inside or outside measurements, so it is important to place it correctly in position.

The tape rule is used for all types of measuring and setting out tasks within its length. Its flexibility enables it to be used for measuring around curved surfaces.

Distance Measuring Wheel

Ref: http://www.laserlevel-tripod.com

A distance measuring wheel, (also called a surveyor's wheel) is an excellent tool for measuring longer distances with reasonable accuracy. They are ideal when measuring the route length of underground cable or aerial cable runs such as when estimating costs or cable quantities etc.

Each revolution of the wheel measures a specific distance, such as a "metre" and as the revolutions are automatically counted with a device attached to the wheel it measures the total distance directly.

The design will provide reasonable accuracy on a smooth surface, such as pavement, but on rough terrain, wheel slippage and bouncing can reduce the accuracy somewhat. Soft sandy or muddy soil can also affect the rolling of the wheel. As well, obstacles in the way of the path may have to be accounted for separately. When using keep track of any circumstance on the path that can influence the accuracy of the distance measured and either measure that portion with an alternative technique, such as a measuring tape, or make a reasonable estimate of the correction to apply.

To use the device, first reset the counter and locate the wheel at the point you want to start measuring, and roll in a straight direction to the stopping point, then read distance travelled directly off the counter.

Laser Range Meters

Ref: www.ehud-engel.co

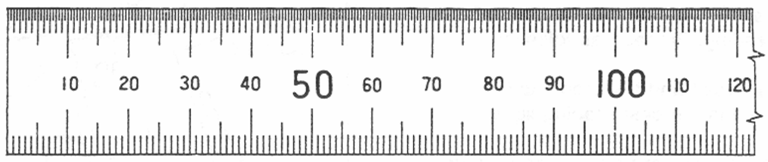
A laser distance meter uses a laser beam to determine the distance from a fixed starting point to another object. The distance is measured along a laser beam emitted by the tool to the point at which the beam strikes a reflective surface. The target from which the measurement is taken is clearly identified by the red laser measuring spot. The range of the tool depends on the reflectance and structure of the target surface from which measurements are taken. Measurements taken through glass or from plastic foam materials such as polystyrene foam or from highly reflective surfaces (mirrors, glass, etc.) may produce inaccurate results.

The most common form of laser meter operates on the "time-of-flight" principle by sending a laser pulse in a narrow beam towards the object and measuring the time taken by the pulse to be reflected off the target and returned to the sender. This measuring principle permits highly accurate and reliable measurement of distances to objects without need for special reflectors.

The specifications for these devices vary between manufacturers, but the **Hilti PD42** (as shown above) will measure from 0.05m to 200m with an accuracy of ± 1mm.

Laser Safety: Depending on the model purchased, generally these tools comply with Laser Class 2 in accordance with IEC825 -1:2003 / EN60825-1:2003 and may be used without need for further protective measures. The eyelid closure reflex protects the eyes when a person looks into the beam unintentionally for a brief moment. Nevertheless, as with the sun, one should not look directly into sources of bright light and **NEVER** direct the laser beam toward persons.

Steel Rule
(Engineer's Rule)
Steel rules are designed to accurately measure lengths in the range between 0 to 300mm to 2000mm. For lengths longer than 2m, then a steel tape is used. An example of a steel rule is shown below:



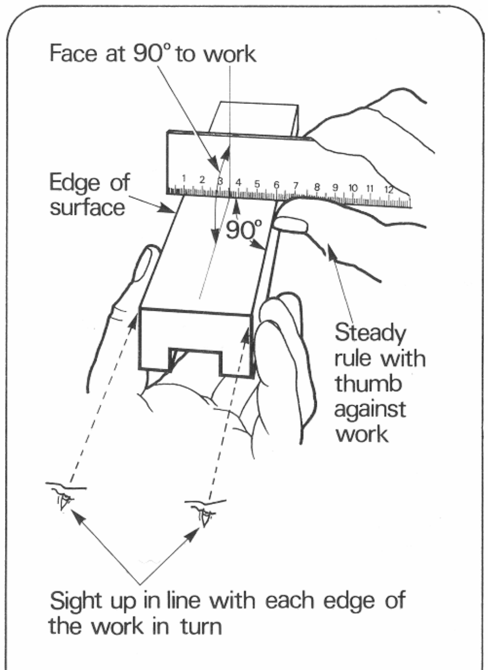
The ends and edges of the rule form important reference points, as it is from these surfaces that accurate measurements are to be taken. If the rule were to be used as a scraper, a screwdriver, a lever or as a piece of packing, then the resultant damage would make it unreliable as a reference tool for future accurate measuring.

"**Errors**" in measurement can occur from any or a combination of the following:

- Wear on the end of the rule,
- Graduation errors in the manufacture of the rule,
- Poor light conditions,
- Rule not held parallel or at right angles to the work piece,
- "Parallax error" which is a displacement or difference in the apparent, position of an object when viewed along two different lines of sight.

An engineer's rule is graduated in 1mm increments on one side and 0.5 mm increments on the other. This means its accuracy is "0.5mm".

To achieve reading accuracy and "reduce "**parallax error**" when reading this tool, always align the eye carefully with the point or edge of the work piece where the measurement is being taken, and then look closely at the rule graduations.



POSITIONING THE RULE

Positioning the Rule

- Correct use of steel rules is necessary for accurate reading. Proceed as follows: -
- Place yourself and the article to be measured in the best reading light.
- Position the rule at right angles to your line of sight.
- Make certain the rule that you use has fine clear graduations cut right to the edge.

Edge of Rule Method
If the steel rule is worn on the end then the following method is suggested.

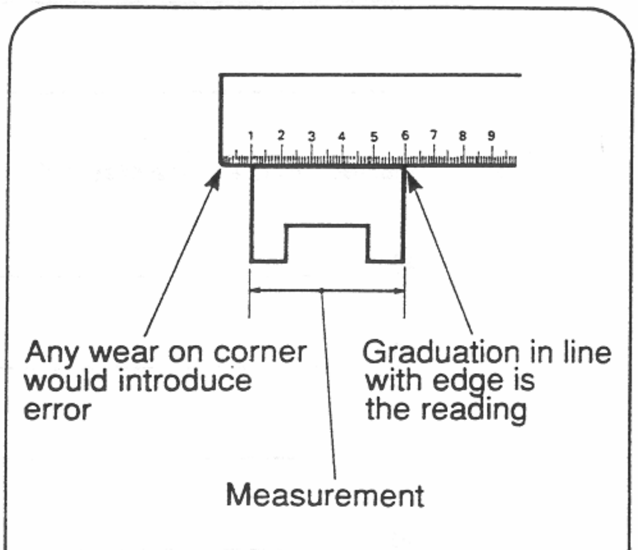
- Steady the work with your left hand.
- Hold the rule with your right hand and steady it with your right thumb against the work.
- Place the end of the rule on the surface so that the face of the rule is at right angles to the work.
- Place the edge of the rule on the surface so that the face of the rule is at right angles to the work and square across it.
- Sight up the first numbered graduation with the left hand edge of the work.
- Sight up the nearest graduation in line with the right hand edge of the work and take the reading.

NB: Remember to subtract the first number graduation from your final reading to obtain the accurate measurement required.

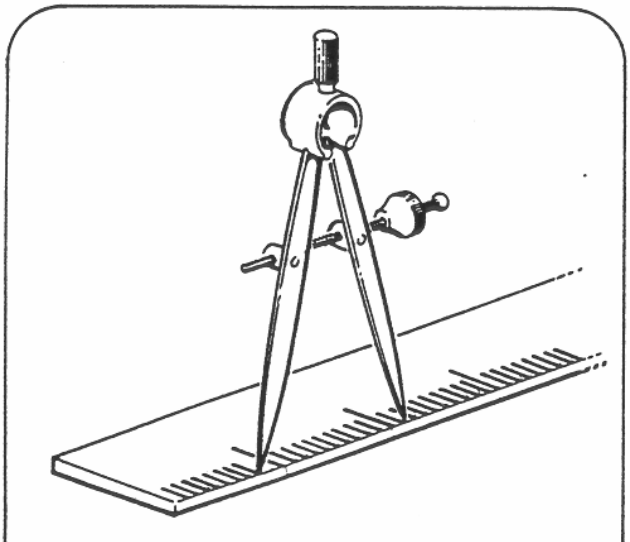
Other Uses for the Steel Rule
A steel rule can also be used as a:

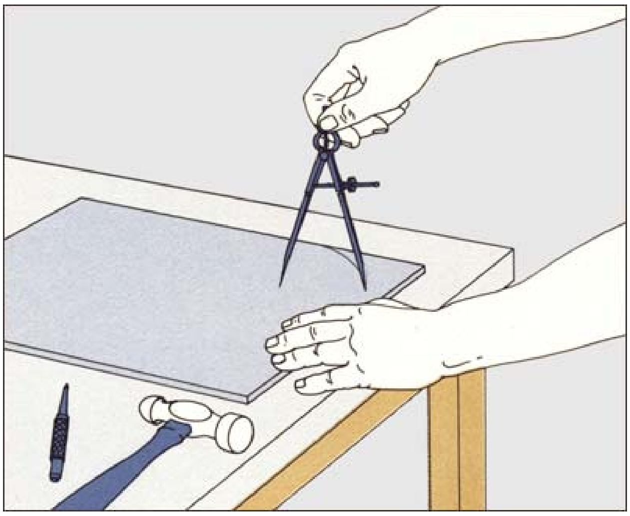
- Guide to draw or scribe a straight line
- Straight edge to test the accuracy of a flat surface
- Scale for setting dividers and other marking out tools

Ref:
http://www.tractorsupply.com



EDGE OF RULE

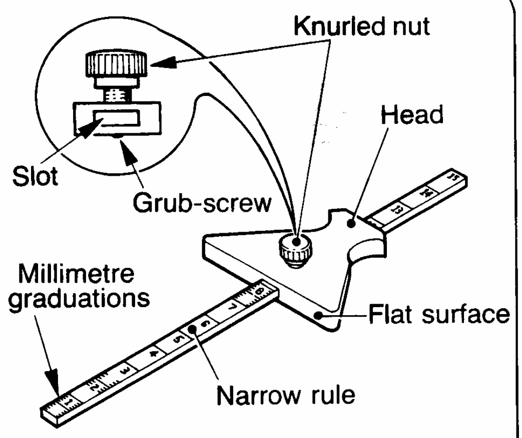

TRANSFERRING MEASUREMENTS



Rule Depth Gauge
A depth gauge is a measuring tool developed from a steel rule. Depth gauges are used to measure:

- Depths of holes
- Depths of recesses and slots
- Distances in from the edges of work

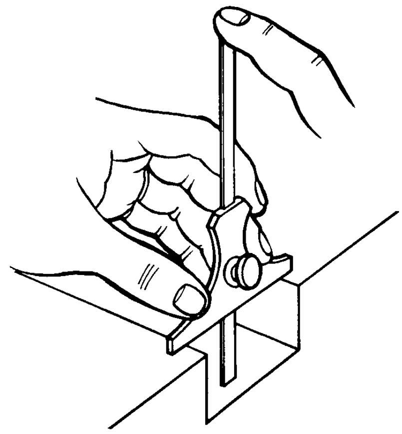
The depth gauge consists of a narrow graduated steel rule, fitted with a sliding frame that may be clamped along the rule.

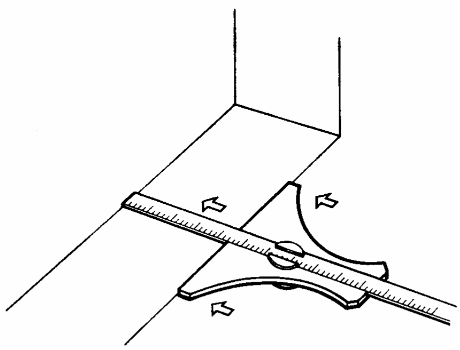


RULE DEPTH GAUGE

Using a Depth Gauge
Use a depth gauge to measure the depth of a recess as follows: -

- Hold the frame of the depth gauge between the thumb and finger of one hand.
- Loosen the locking screw with the thumb and first finger of your other hand.
- Hold the frame base firmly down on the surface across the recess of the work to be measured.
- Hold the gauge square to the work by steadying the rule with the first finger of one hand.
- Use the first finger of your other hand to press the sliding rule down until you feel the lower end touch against the bottom of the recess.
- Tighten the locking screw.
- Lift the gauge carefully out of the recess and away from the work.
- Turn the gauge into a position where you can read the depth of the recess directly from the rule scale.


MEASURING THE DEPTH OF A RECESS


MEASURING IN FROM AN EDGE

Marking Out Tools
Marking out is the preliminary work needed to establish the guide lines and centre marks required for cutting, drilling and machining. It is necessary to ensure that the finished job precisely meets the job specifications. For "manual tasks" an engineering drawing is typically provided which contains the details necessary for the tasks to follow.

For "automatic tasks", the marking-out is first created as a drawing using Computer Aided Drawing (CAD) software and the custom designed "program" is then used to direct appropriate machines to perform the engineering tasks to follow.

Marking Out Procedure
Marking out or lining is the process of placing accurate lines on metal surfaces in order to establish limits for the work. Ie: File, cut and drill etc. Marking out also establishes definitively if the work piece will accommodate the intended task.

Inspection of the Work Prior to Marking Out
Begin by checking:

- The physical size of the raw stock material to be certain that it will accommodate the finished size following all of the machining and filing that you will need to perform,
- The stock material itself for signs of cracks, flaws, surface defects, warps and twists etc,
- That this stock is the correct material for the job.

Marking Medium
To ensure scribed lines show up clearly on the work piece, the relevant area of the work should be pre-coated with a suitably coloured marking-off medium. Commonly used marking mediums include:

- Chalk
- Whitewash
- Copper sulphate solution
- Spirit-based metal marking dye
- White water-based acrylic paint

The marking-off medium selected should contrast in colour with the colour of the working surface.

- Chalk is ideal for small areas on rough surfaces of castings
- White water-based acrylic paint would be more effective on larger areas of rough surfaces of castings etc.
- Bright steel or machined steel is best suited to spirit-based marking dye. An alternative to the marking dye is copper sulphate solution.
- A dark permanent felt marking pen is also acceptable.

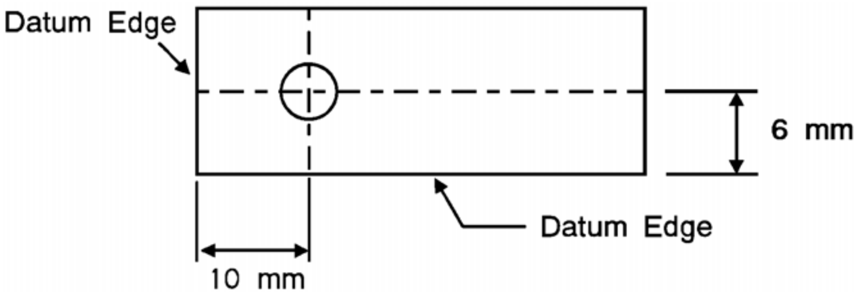
A thin coating is more preferable than a thick coat. Lines will show up sharp and clean with a thin coat.

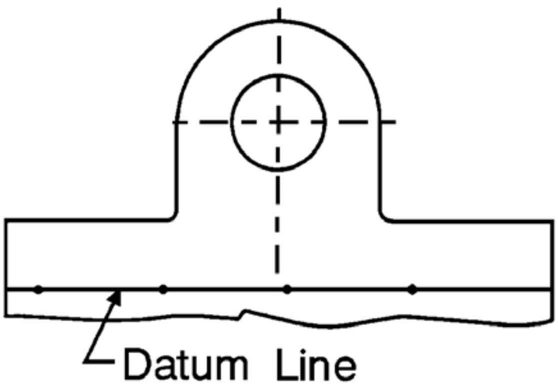
NB: For a small piece of stock material, it is easier to coat the entire job. For a large object, strategically coat only those areas that are to be worked on.

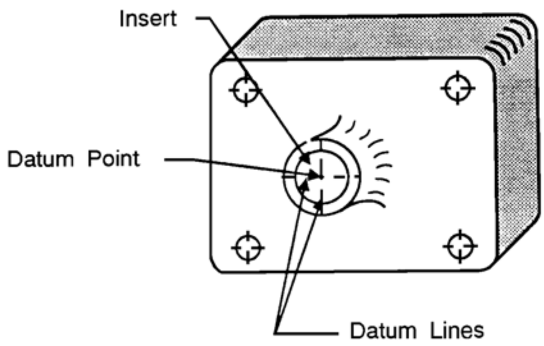
Types of Marking-out Lines
Datum Lines
The word "**datum**" is used to indicate a valid starting point such as line(s), edge(s) or surface(s).

A "**datum edge**" is a straight edge running the length of the material. It provides the starting or reference position to begin marking out. The marking out for a job can originate from one or more datum points, lines or surfaces. The datum may be a manufactured edge of the stock material or if the existing edges on the material are too rough, the datum may be scribed line(s) that are drawn near the edges. In some situations, the datum point may two intersecting lines established to locate an important feature such as a centre lines for a hole.

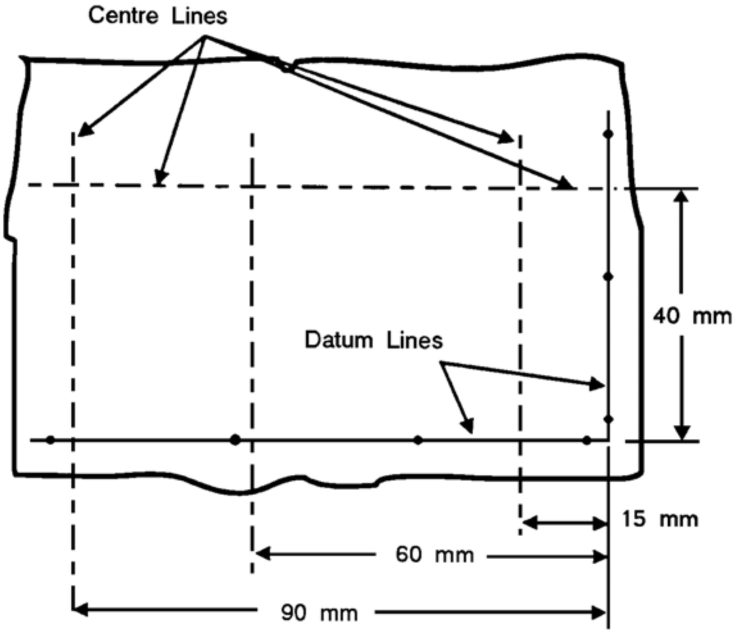
The images below show three examples of how a "datum" enables the marking out process to proceed.







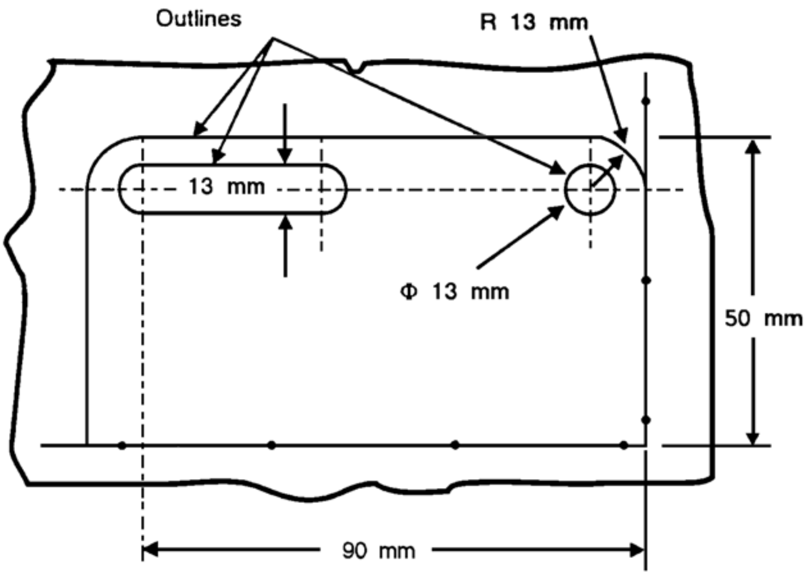
Centre Lines
Centre lines are often scribed at required distances from the datum features to establish the positions of holes, slots, radii, and other details. Holes and radii centres require two centre lines.



Outlines
Outlines show the dimensions of the work-piece and indicate the location and amount of metal to be removed. Lengths, widths, thicknesses, angles, diameters, and radii are outlines, which determine the finished shape.

Finally carefully check **all** dimensions against the drawing.
Remember, "**Measure twice and cut, <u>ONCE</u>!**"

NB: If an error in the marking out is found after the fitting operations have commenced, the probable consequences are wasted time and wasted material.



Marking Out from a Datum Edge
If the stock material supplied has an existing true edge which can be used as a datum then the development can proceed directly from this edge as shown to the right.

If there is no true edge, then:

- A datum edge may be a ruled line on the material as shown above, or,

- Create a true edge by, either:
    - Cutting a straight edge using tin snips for thin gauge sheet metal, or
    - Filing an edge straight for thicker materials.

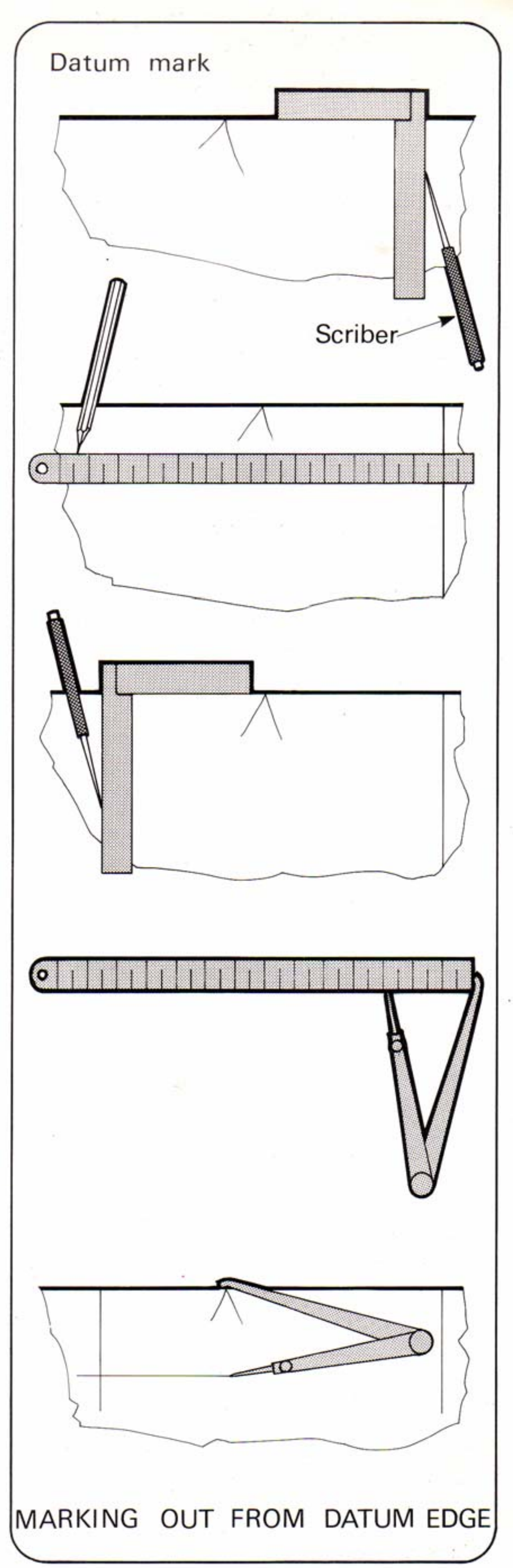
Once the datum has been established:

- An engineer's tri-square is used to project a "vertical datum line" line at right angles (90^{o}).
- A steel ruler is then used to develop from this scribed line.

- A Jenny calliper is used in the bottom sketch to develop parallel lines.

NB: The key point is that development of the work piece cannot proceed until firm datum edges or lines have been established.

NB: The "V" mark is typically used to denote the "datum line".



Permanent Outlines
Once the marking out and the checking of dimensions is complete, it is usually necessary to lightly prick punch fine “**witness marks”** to permanently indicate the position of the outlines, as they may become obliterated. Witness marks are especially important when the “marking medium” eventually rubs off due to handling.

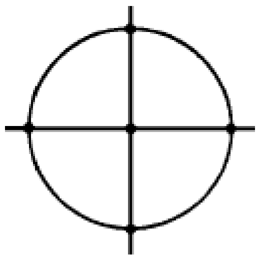
“**Witness marks”** are light, uniform indents made with a fine prick punch, and punched accurately on the line work indicating the outlines. When the required fitting or machining has been completed, only **one-half** of each witness mark should remain visible.

Once the “witness marks” have been completed, the “centre marks” used for drilling are deepened at this stage prior to commencing drilling operations.

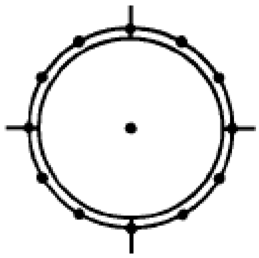
NB: Examples of the placing and spacing of witness marks are shown below.

Edge to be machined

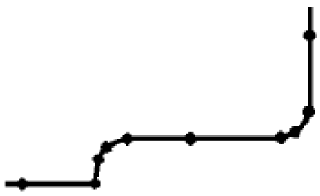
Edge to be filed



Hole to be drilled



Hole to be filed



At every change in direction

Spaced to accurately indicate the shape

Sustainable energy work practices related to reducing waste when marking out.
Stock materials are sold in standard sizes. Efficient ordering means purchasing stock sizes so as to obtain the maximum number of job pieces (blanks) out of a stock length. The key is to eliminate the amount of “off-cuts” which invariably is wasted. When performing the calculation on usage, always consider the “cut” wastage. For example, a guillotine has a “shear action” which has virtually no loss, but a saw will have a loss of about 2 mm for each cut. If the job pieces are small, and there are many “cuts” and this loss can be significant. If the job length is small, always pre-determine if the stock material can be safely secured after it has been reduced to a small size. That is, can you safely make the final cut or does this section become waste also.

The method used to mark out a sheet will depend on whether it is a one-off task or a production run. For a "one-off-task" always attempt to use up an off-cut from a previous job if possible and avoid cutting a "new" sheet. For a production run involving a full sheet, always consider how the sheet is to be cut. For example, a guillotine will only make complete cuts across the sheet, but a "gas", "water" or "laser" cutter can cut virtually any length or shape.

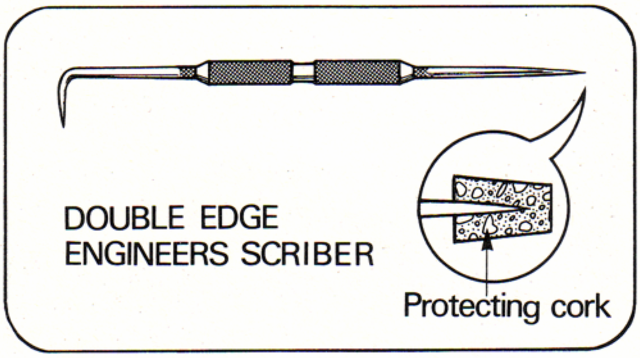
- If using a guillotine, common edge cutting is a more efficient method as the one action can produce a number of pieces. But it may also lead to wastage.
- Computer controlled machines are able to obtain the optimum cut from a sheet.
- Other techniques include, nesting small parts in cut-out holes and making use of suitable off-cuts where possible.
- Always re-check all marking out measurements prior to cutting to ensure no error wastage.

Tooling

The term "**tooling**" as applied to the engineering trades refers to any equipment that helps in the production of a product or any related activity. It ranges from the most fundamental type of hand tool such as a file to the very complex machine tools such as a computer controlled machines.

The basic hand tools include:

- Engineer's Scriber
- Tape measure and Steel rule
- Square, Protractor and Bevel gauge
- Combination square
- Dividers and Jenny callipers
- Scribing block
- Vernier height gauge
- Hammers
- Centre punch and prick punch



Engineer's Scriber

This tool is designed to scribe (scratch) very fine marking out lines on to a metal work piece in preparation for fitting tasks. It is made from hardened tool steel which has been ground to a needle sharp point. The scriber's point should be frequently restored so that all marking out lines are sharp and clear. When a grinding wheel is used to sharpen a scriber, care must be taken because if temper colours are raised due to overheating, the point will be softened.

It is better to use an oil stone to sharpen a scriber to avoid spoiling the hardness of the scriber's point. A scriber is generally used in combination with a rule, square or straight edge to draw a single, firm line.

Correct Use

The steps in the correct use of the scriber are as follows:

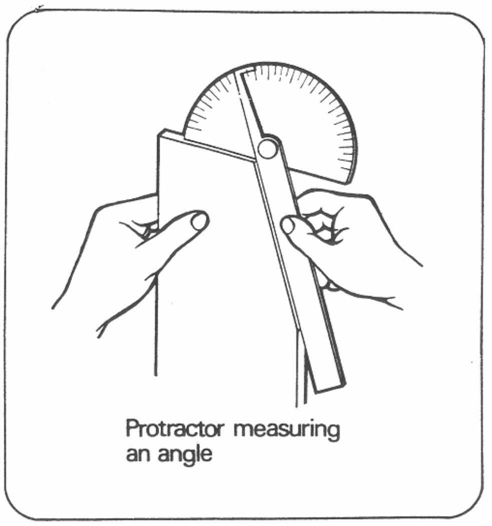
1. Hold the straight edge firmly in the required position (e.g. steel rule, square, etc.)
2. Incline the scriber away from the straight edge to bring the sharp tip as close to the straight edge as possible.
3. Incline the scriber slightly toward you in the direction of the stroke.
4. Draw the scriber toward you in **one** firm stroke.

Scriber Safety

- Never use a scriber as a substitute for a centre punch.
- Any hand tool which has sharp points or a sharp edge should be guarded when the tool is stored in the tool storage area. Use either a hardened pouch/sheath or a cork or similar soft object to protect both the tool and the person who retrieves it.

Protractor and Bevel Gauges

Angular measurement is closely associated with linear (straight line) measurement. Parts that are manufactured may have angles or tapers that are required to fit accurately into mating parts.



Various measuring tools have been designed to measure angles or tapers in degrees or even parts of a degree.

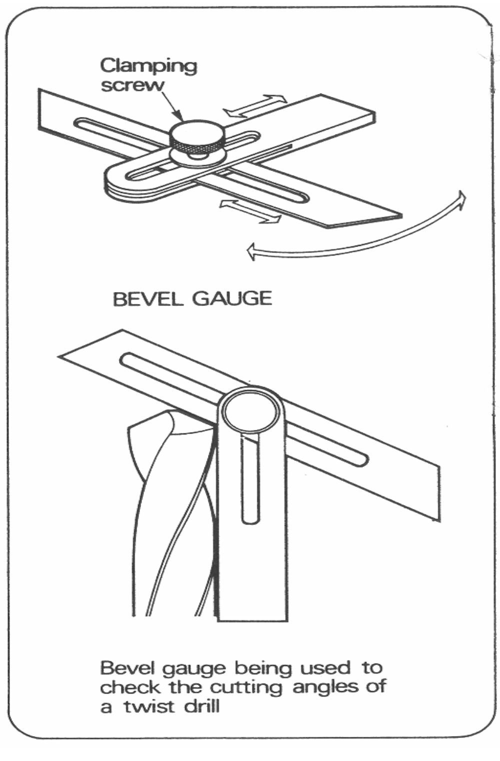
Protractors

Protractors have a dial face graduated in degrees, with a straight blade that can be swivelled to a specific angle, and then locked in position.

They are used for:

- Setting work to an angle
- Testing angles
- Marking out the position of holes

Because they are graduated only in degrees, protractors have limited accuracy.



Bevel Gauges

A bevel gauge consists of a body with an adjustable sliding blade that may be set and clamped at an angle to the body of the work piece.

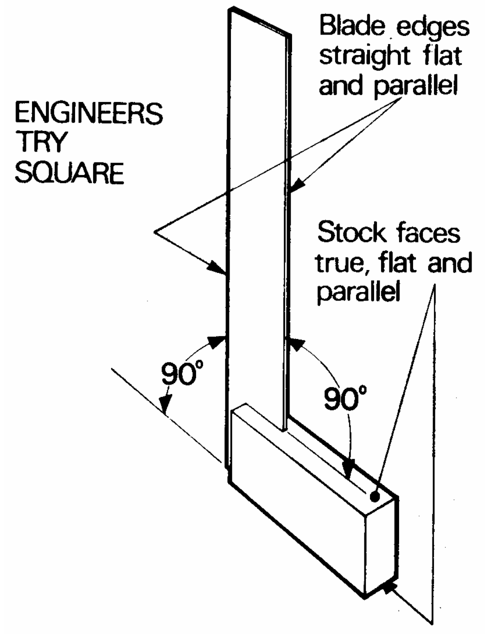
Use a bevel gauge as follows: -

- Set the blade of the gauge to the angle required
- Lock the blade to the body with the clamping screw
- Transfer the gauge on to the work
- Compare the setting of the gauge against the angle on the work

Bevel gauges are used mainly to transfer and to compare the angle from part to another.

Note how in the illustration above it is being used to compare the drill point angles.

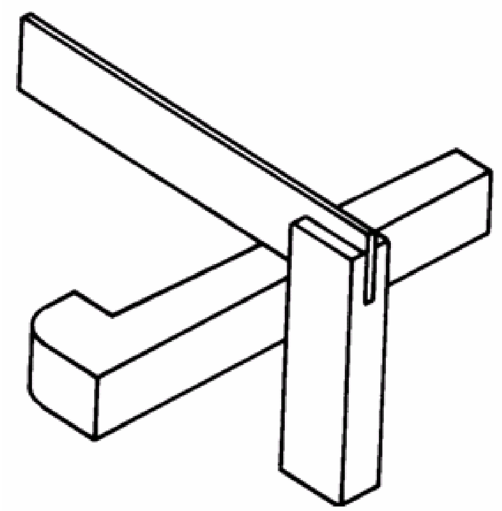
Engineer's Square or Tri-Square
This tool consists of a thick body called a "**stock"** and a "**blade**" set to a true right angle (90°) to the stock. The blade is straight, flat and has parallel edges.



Tri-Squares are used for:

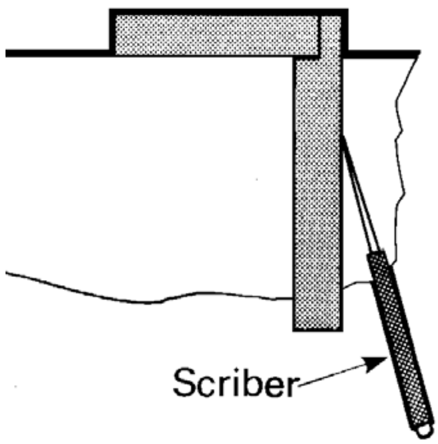
- Checking that surfaces are at right angles (90°) to each other,
- Setting up work square to another surface a guide when scribing lines at right angles.

Using a square
- Before using a square, it is important to remove any burrs from the work and ensure that the work surface and square are clean.
- Face towards a light source so the light will shine from behind the work.
- With your right hand, hold the inside of the stock of the square against one finished edge to be tested.
- Leave a light gap between blade and the other edge.
- Lower the stock carefully until the blade comes into contact with the edge of the work.
- If the surfaces are square all light will be excluded.

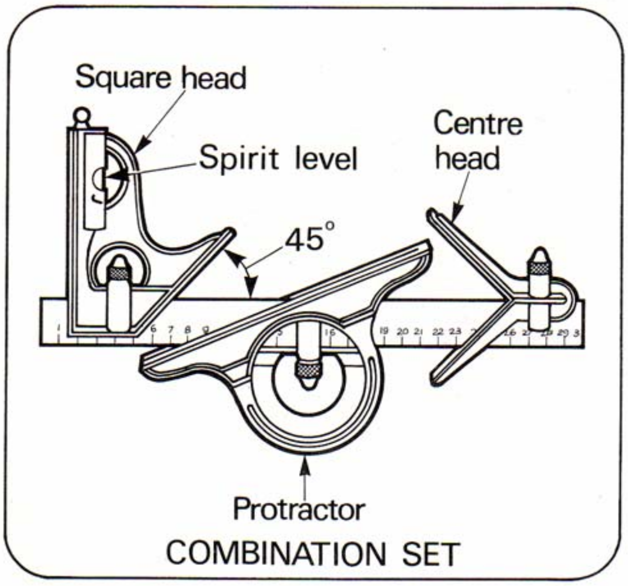


The adjacent illustration shows a tri-square being used to check the squareness of a face. This test should be also carried out frequently so that even during the roughing down stage the surfaces will be kept reasonably square with each other and you will maintain control of the work.

Practical Uses for a Tri-Square
(i) Guide a scriber when marking out lines at right-angles to the edge of work.
(ii) Determine if two surfaces are at right angles to each other.
(iii) Check the flatness of surfaces.



Combination Set
This is a multi function tool comprised of a "blade", a "square head", a "protractor head", and a "centre head".

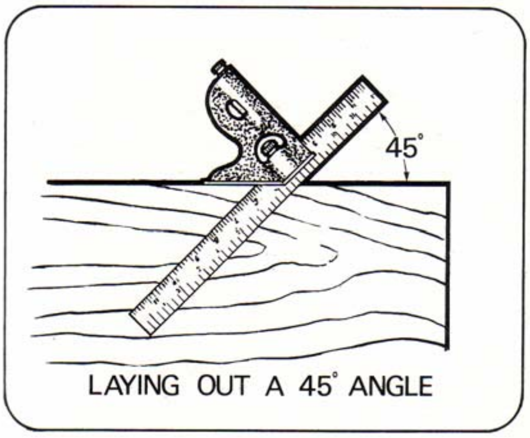


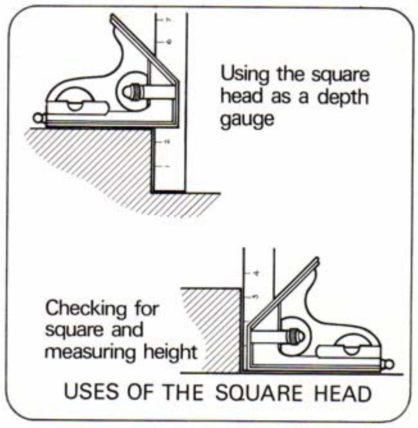
The "**square head**" has one face that forms a right angle (90°) with the blade and another face which forms a 45° angle with the blade. The square head and blade can be used as a:

- Depth gauge to measure from the square face to the end of the blade,
- Height gauge by setting the square face flush with the end of the blade,
- Square to set work at right angles,
- Bevel gauge to set work at 45°

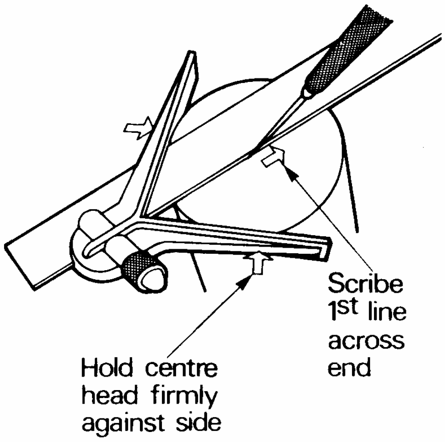
The **"protractor head"** allows the blade to be set at an angle to the flat face. It is used for setting up or measuring angles.

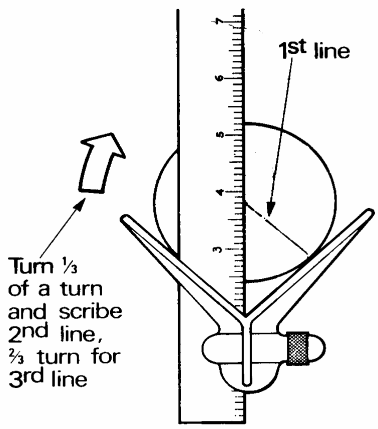
The **"centre head"** is designed to allow one edge of the blade to pass through the centre of two faces which are at right angles. It can also be used to find the centre of a round object or checking 45⁰ angles. The images below illustrate how the tool can be used in different applications.

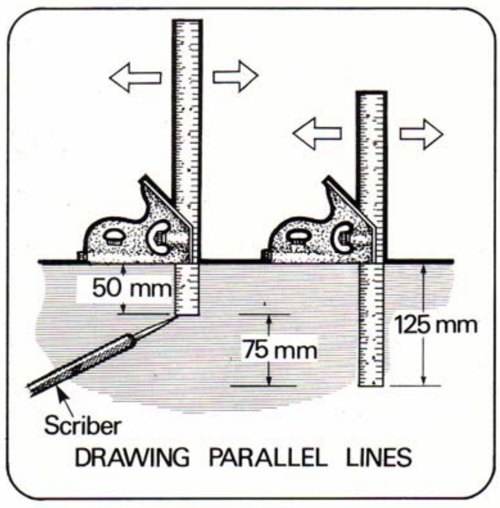




The examples below illustrate of how the "Centre head" can be used to create an accurate centre mark for a piece round stock bar. The intersection of the two lines is the "centre" of the bar.





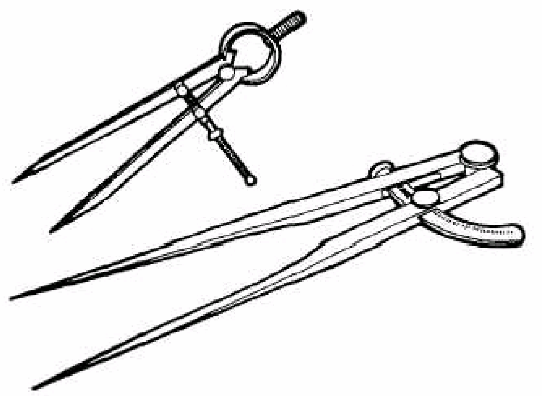


The illustration to the right shows how the tool can be used to draw parallel lines.

Combination Set Maintenance
A combination square set is an expensive, high precision tool and as such, requires commensurate care and protection from rough treatment and the environment. Individual parts should be regularly cleaned and returned to its case when not in use.

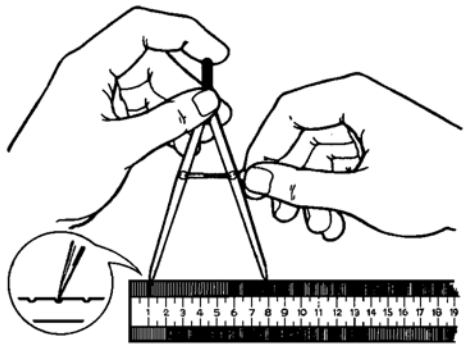
The ruler from the set should not be used as a generic measuring tool. Its real value is as part of the combination with the other parts.

Dividers
Spring Dividers and Wing Dividers
Dividers are tools used to scribe circles and arcs. They can also be used for marking-out geometrical tasks such as dividing circles and lines and creating angles etc. Another common use is to transfer and compare distances between two points.



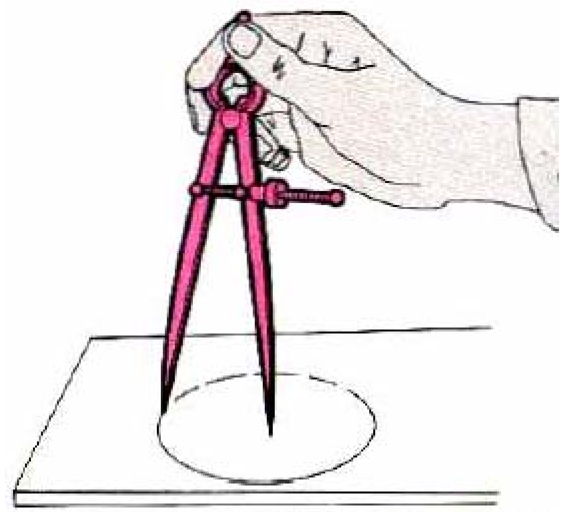
Commercially they are available in lengths ranging from 100mm up to about 300mm depending on the design. Smaller sizes are used for smaller dimensions.

A “**spring divider**” (upper image) consists of two sharp points at the end of straight legs, held apart by a spring and threaded rod and adjustment is by a knurled nut.



A “**wing-type**” divider (bottom image) has a steel bar that separates the legs, a lock nut for setting a rough measurement, and an adjustment screw for fine adjustments.

Use
- Set the desired radius on the dividers using the appropriate graduations on a rule.
- When setting dividers against a rule, the points should be kept parallel to the edge of the rule and set to the centre of the required graduation.
- When scribing a circle or arc, lean the dividers in the direction of movement and scribe the circle by revolving the dividers.



Maintenance
- Keep dividers clean and dry,
- Regularly oil to ensure that it does not rust,

- Protect the points against damage,
- Store dividers where they will not become bent or broken,
- Keep the hardened points sharp and care must be taken to keep the two legs at an equal length.

Jenny Calliper
(Also called odd-leg calliper)
This tool is commonly used to measure and scribe a development line onto a job surface from an adjacent edge.

It consists of one divider leg and one inside calliper leg designed to pivot about a point. The tightness of the two arms is set by a metal thread and flat nut. This is used to adjust tension the arms.

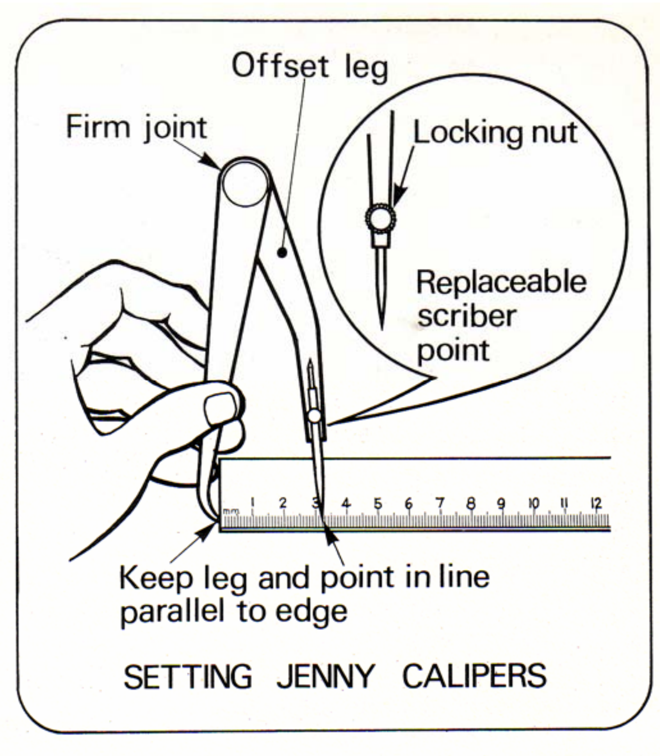
Practical Uses
(Examples are illustrated in the images below)

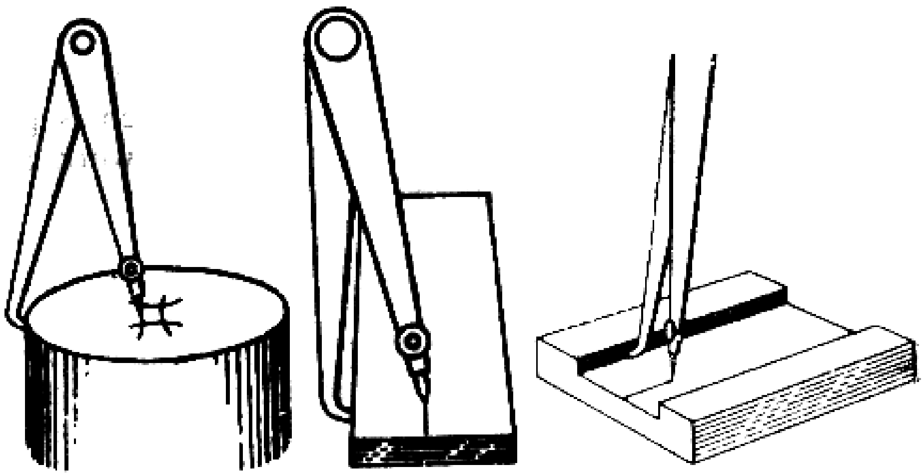
1. To set distances from an edge or shoulder,
2. For marking out lines parallel to an edge,
3. For finding the centre of circular work.

Setting up Jenny Callipers

1. Hold the inward curving leg with one hand and place it against the end of the rule,
2. With your other hand, position the scriber point in the required graduation,
3. Make sure the ends of both legs are at equal lengths.

Care:
Always keep the tool well oiled to prevent rust build-up and protect the needle point against damage.



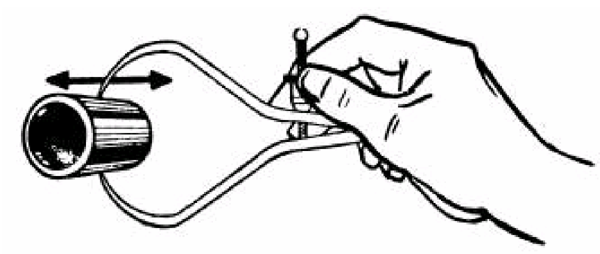


Marking or Scratch Gauge
Ref: http://toolboxes.flexiblelearning.net.au
Practical uses: To set distances from an edge or shoulder and marking out lines parallel to an edge.

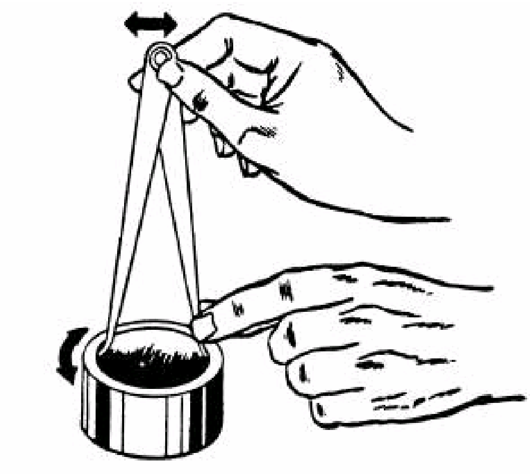
Using a marking gauge:
- ➢ Loosen the lock screw on the headstock.
- ➢ Hold the headstock with one hand against the end of the rule.
- ➢ Move the scriber point to the required graduation on the rule.
- ➢ Lock the screw on the headstock.
- ➢ Hold the headstock against the reference edge of the material.
- ➢ Draw the gauge along the edge to scribe a parallel line.

Outside and Inside Callipers
These are both precision measuring tools typically used for “fitting” type applications.

They are used in one of two ways:
- The calliper ends are preset to a definite measurement using a steel ruler as reference and then the calliper is compared to the work surface, or
- The calliper is set to the spacing of the work surfaces and then compared to the graduations on the ruler.



Use
To adjust a calliper to a scale dimension, first one leg of the calliper should be held firmly against one end of the ruler and the other leg adjusted to the desired dimension. To adjust a calliper to the work, open the legs wider than the work spacing and then bring them down to the work very gently.



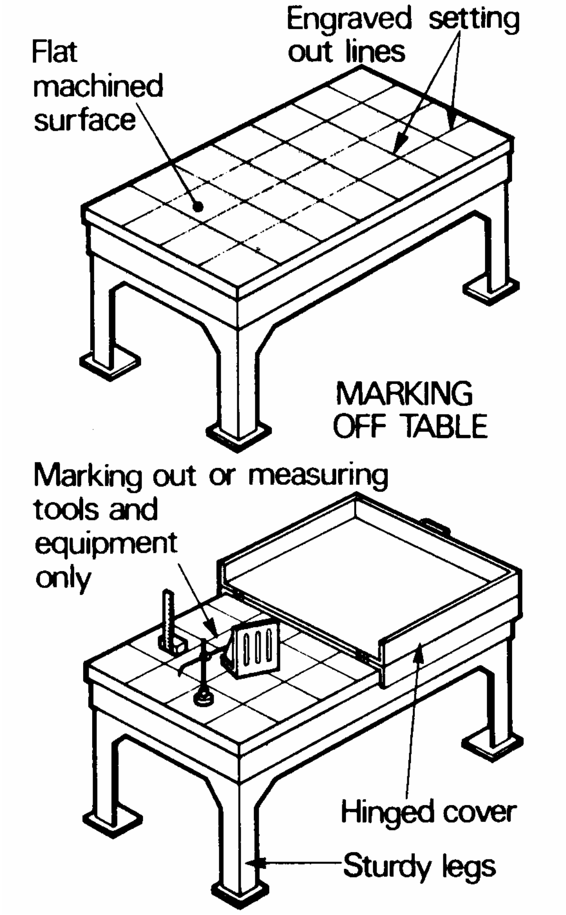
Caution
Never place a calliper on work that is revolving in a machine such as a lathe

Marking Out Equipment
The following basic equipment is used for marking out:

- The marking-off table
- Angle plates
- Clamps
- Vee blocks
- Parallel strips
- Marking medium

Care:
Always keep these tools well oiled to prevent rust build-up and protect the needle point against damage.

Marking-Off Table
The function of the table is to provide an accurate, flat surface that becomes a datum surface with respect to the work piece. It also supports the work at a convenient height for the person marking-out.



They are constructed from either heavy cast iron or granite which is then machined and ground perfectly flat.

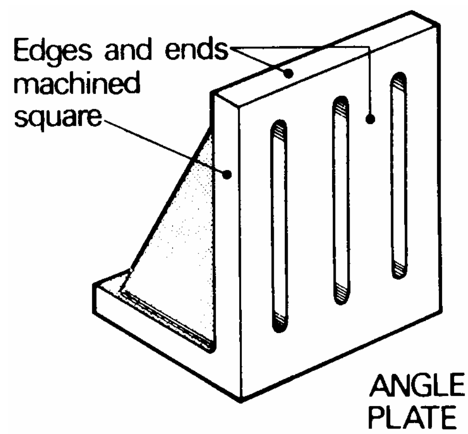
The table should be located so that there is adequate lighting and freedom from obstructions from all sides.

The marking-off table is used in conjunction with specialized marking-out equipment such as an “angle plate” , “vee blocks” or a “scribing block” to perform precision fitting work.

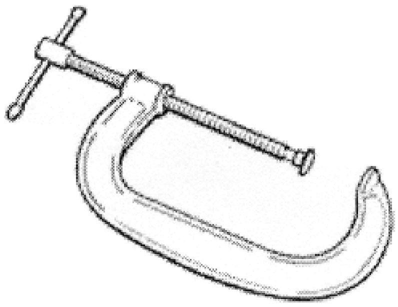
Care

- The table’s surface is to be used for precision work only and you should never use it for hammering or welding or any “rough” work etc.
- Replace the protective cover over the table when it is not in use.
- Always protect the surface of a metal table against rust.

Angle Plates: The working surface of angle plates are machined at right angles to their adjacent surfaces in order that work pieces may be held at right angles to the surface of a marking-off table. Cast iron is the most likely material from which angle plates are made.



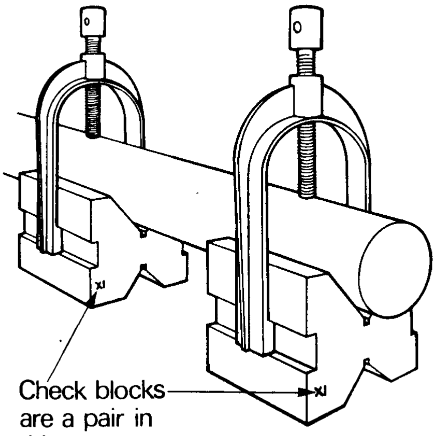
Clamps: To allow the marking out process to take place without any movement, clamps can be used to secure work to the angle plate. Light work may be clamped by using toolmaker’s clamps.



The size of the work piece determines whether to use one or more clamps. Only light clamping forces are normally required.

Nb: Magnetic clamps are also available for this task.

Vee Blocks: Vee blocks are used to hold circular work when marking out or setting up for machining. They are manufactured in pairs from cast iron or steel (hardened). A variety of sizes are available.

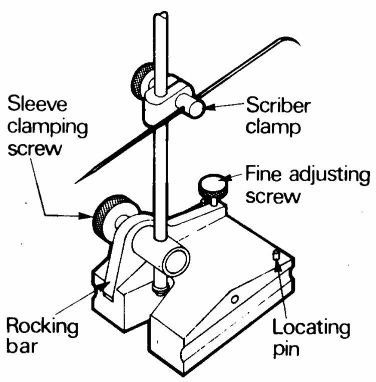


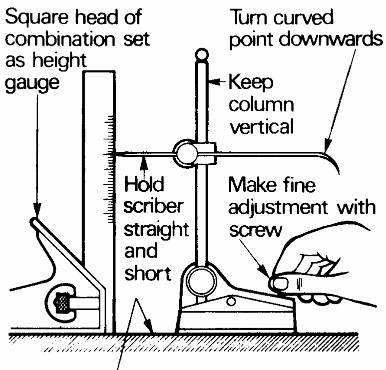
Vee blocks supporting a shaft for marking out and drilling

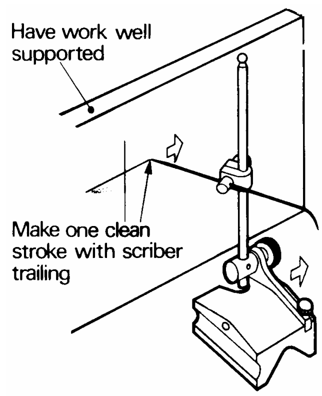
Some vee blocks are fitted with a clamp to hold work securely in position. There are also magnetic vee blocks where clamps are not required. These provide the option of securing flat plate at 90 degrees to working surface or locating round bar for marking out.

Scribing Block (Surface gauge)
This consists of a solid base, machined flat on the bottom. A vertical column attached to the base includes a scriber which is located in a moveable clamp. Its most common purpose on the marking-off table is to scribe lines on a work piece parallel to the table surface.

It may also be used for:
- Setting up work for machining
- Checking work for parallel
- Finding the centre of work





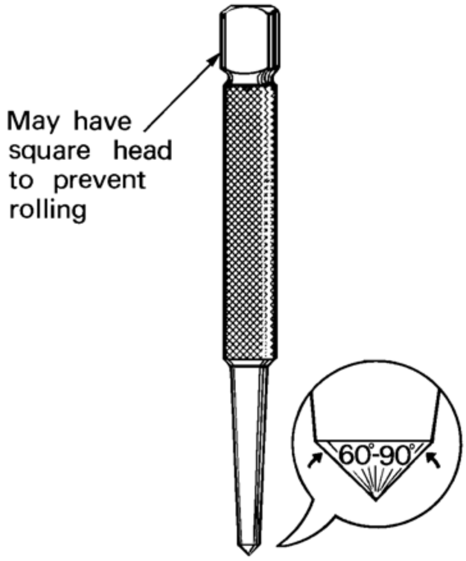


When using a surface gauge it is important to ensure:
- The scriber point is sharp,
- The scriber is held as short as possible against the column and always turn the bent end down for safety,
- The scriber is kept in a horizontal position as this will be more accurate,
- To make one clean stroke across the work after setting the correct height,

Safety
When finished with the surface gauge the scriber is clamped parallel to the column with the main point downward and the curved point inwards.

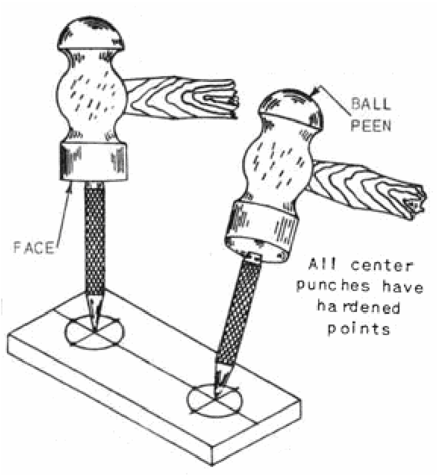
Punches
These are made from hardened tool steel.

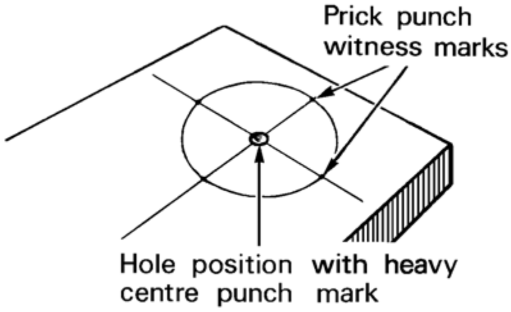
There are two main types of punches commonly used in marking out. A "c**entre punch**" and a "**prick (dot) punch"**.



Centre Punch
Centre punches are used to locate a centre position for a hole and make it easier to start a drill point cutting accurately at that position.

The centre punch has a point angle of between 60-90° and it is used for making an indent on a work piece to locate the drill point at start.



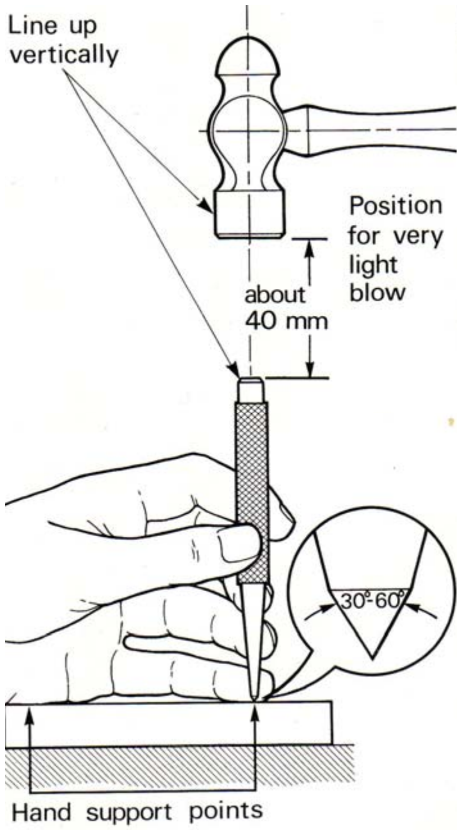


Prick Punch
Prick punches are used to make light (witness) marks to better identify scribed lines.

The prick punch makes it easier to:

- See marking out lines.
- Check the accuracy of centre positions before centre punching.
- Locate the pivot points of dividers for scribing circles of arcs.

Compared to the centre punch, a "prick punch" has a sharper point angle of 60° or less and it is used to make only small marks on a reference line or outline of a work piece.



Chalk Line
A chalk line is a piece of string or cord that is heavily coated with a coloured chalk. The line is stretched tightly between two points and then snapped to release a chalky line onto the target surface. The unit shown is a self-chalking line.

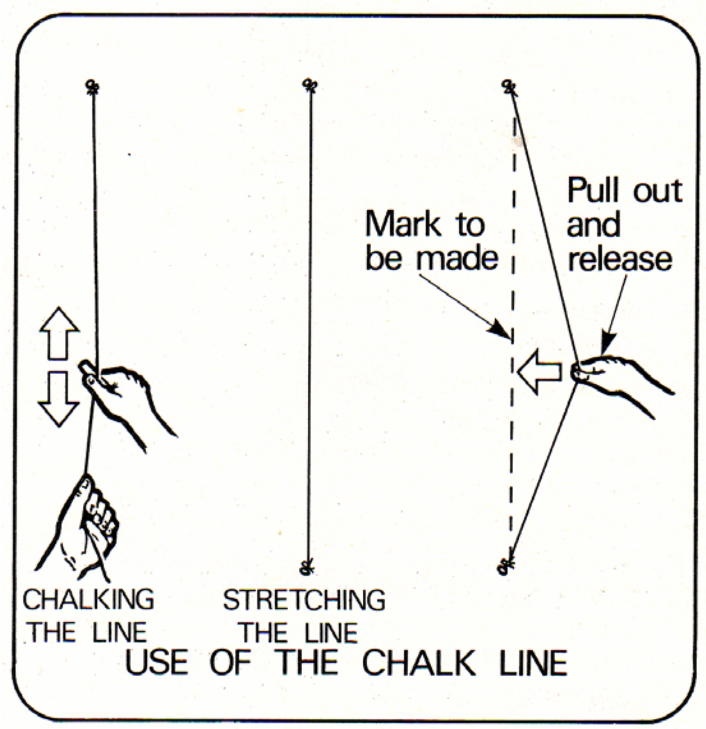
A mechanical self-chalking line is a container with the line on a reel. The container is filled with coloured chalk powder. The line is automatically chalked each time it is pulled out and can be 20 to 30m long.

Ref: http://www.toolstop.co.uk/stanley-0-47-681-fatmax-chalk-line-set-p42363

Application
This is a tool commonly used by an electrical mechanic during installation work.

Applications include:

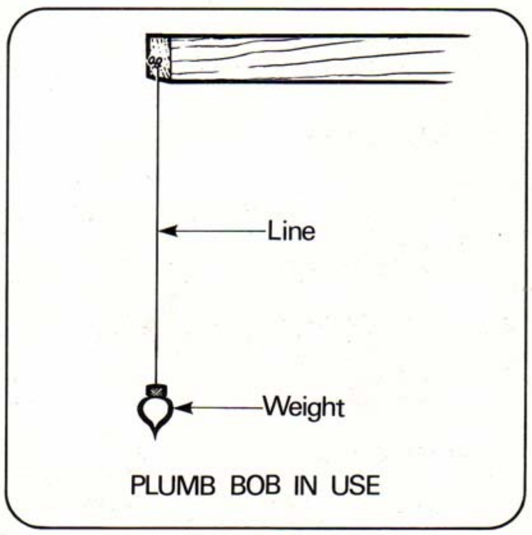
- Marking out fixing points for a cable run,
- A straight line guide when installing long rows of light fittings or;
- Levelling duct or cable tray.



Technique
- Stretch a taut string line between the ends of the proposed run by using suitable means of fastening, eg., nails or existing fixings. This ensures a straight line is produced.
- Pull the line perpendicular away from surface about 100mm and then release. This action should ensure a crisp line is produced.
- The chalk will gradually disappear.

Plumb Bob
This tool is used to vertically align two points in space. The tool is weighted object (commonly brass) with a pointed tip that is attached to a string line. The force of gravity causes the weighted line to hang vertically, or plumb. Plumb bobs are made in different weights. Always take care when using it outdoors as their accuracy is affected by the wind.

To mark a vertical line on a wall
- Hang a plumb bob from a chalk-coated string almost against the wall (ideally with a tiny gap). Secure the string at the top point, near the wall, with a nail.
- Steady the weight by hand until it stops swinging and twirling.
- Leave the weight to find its final position.
- Hold the weight against the wall and snap the string against the wall to create a vertical chalk line.
- Remove the chalk line when no longer needed.



Applications
There are many applications including:

- Vertical conduit runs
- The centring of lighting point to be located above a dining table.

Spirit Level

A spirit level or bubble level is an instrument designed to indicate whether a surface is horizontal (level) or vertical (plumb). Levels are made in many shapes, sizes and materials to suit the different trades.

They have in common, a small glass bulb filled with a liquid which has a small air bubble. When the bubble is located precisely between the two set marks then the surface is level or plumb.

Applications
The are countless applications including checking that switchboards, socket outlets or a conduit or ducting run is mounted level or vertical.

Sustainable work practice involves
- Maintaining and repairing tools and equipment so that it can operate at high efficiency and effectiveness,
- Reducing waste products,
- Re-using and recycling materials,
- Responsibly disposing of waste products.

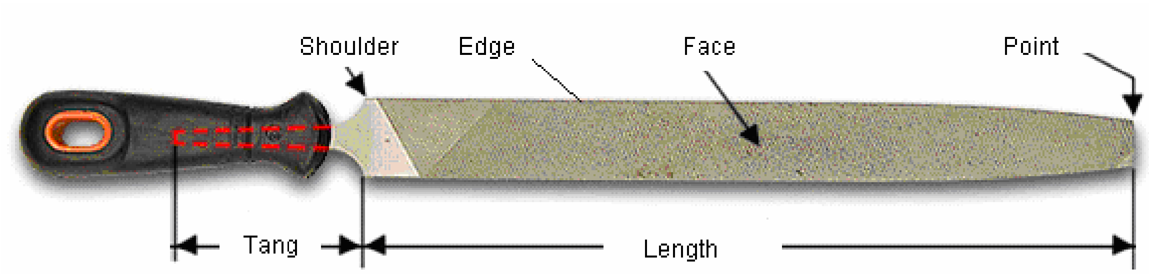
T4 Holding and cutting encompassing:

- common tools for holding (bench vices, multi-grips, vice grips, wrenches).
- common tools for cutting metallic and non-metallic material (hacksaws, wood saws, chisels, pliers, files)
- procedure for using a range of tools for cutting, shaping, and finishing metallic and non-metallic materials
- safety procedures when using holding and cutting tools

The electrotechnology industry covers a vast array of tasks and as such there are many types of hand and power tools that you are expected to recognize, know the characteristics, and use safely and efficiently. The tools shown in this note are the more common types, but, as you progress through the industry you will undoubtedly encounter many other specialized tools.

Files
Files are tools used to accurately shape materials by abrading away some part of its surface. This may be to make the stock match the measurements from an engineering drawing or to reduce the size of one metal part so that it will fit into or around another. Sometimes, filing is used to remove rough tool marks left by chipping or machining and produce a high quality finished surface. Files are made of high grade, carbon tool steel. There are many types in use with each suited to a specific application.

Parts of a File
The diagram below illustrates the principal parts of a file.
Ref:
https://www.dlsweb.rmit.edu.au/toolbox/electrotech/toolbox1204/resources/03workshop/05hand_tools/08files.htm



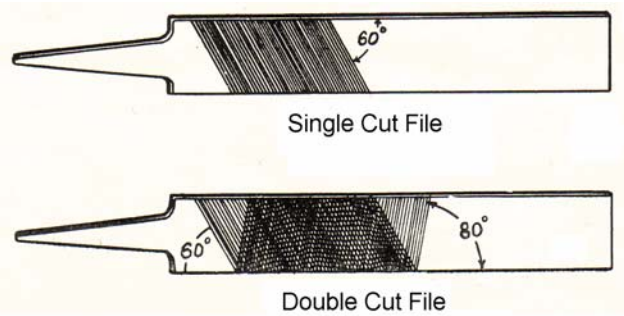
Classification of Files
Files are classified by the following features:

- Length
- Type of cut
- Grade of cut
- Longitudinal shape
- Cross-sectional shape
- Its most common use

Length of a File
This is measured from the "**point**" to the "**shoulder**" and does not include the tang which is inserted into the handle. (See image above). Common types are made in various lengths ranging from about 150mm up to about 300mm depending on the usage.

Cut Types

Single cut files have their teeth formed by a single set of parallel chisel cuts.

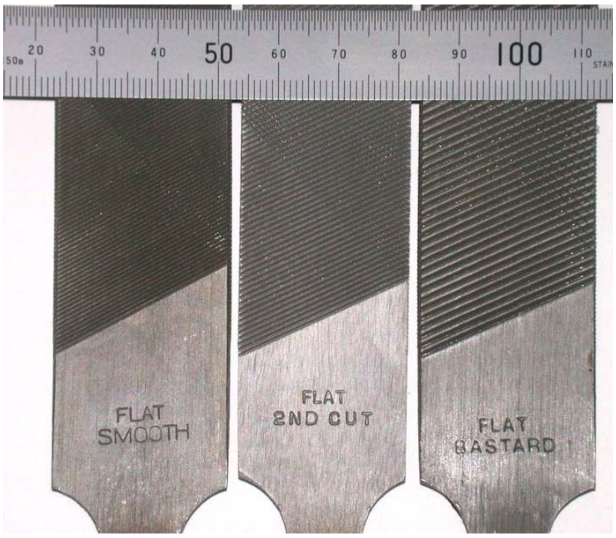


Each tooth runs the full width of the side of the file at an angle to its edge.

These files are used with lighter pressure than double-cut files and give a smoother finish.

Double cut files have their teeth formed by a double set of parallel chisel cuts that cross each other diagonally.

This gives a series of small diamond shaped teeth.



Dreadnought cut files have very coarse, curved teeth and are used for cutting soft metals such as aluminium, lead and fibre glass.

Grades of Cut

The grade of cut is indicated by the pitch or size of the file's teeth. The longer the file, the further the teeth are apart which means that longer files are coarser than short ones.

The common grades used are "**flat smooth**", **flat second cut**" and "**flat bastard**".

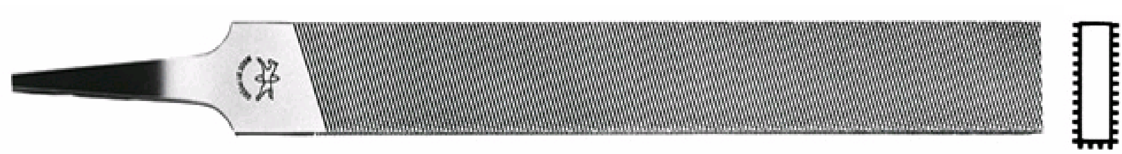
Note: A "**bastard file**" is a file whose teeth configuration is rougher than a **'second cut'** file and is ideal for quickly removing excess metal on a surface.

File Shapes

Ref: http://www.pferdusa.com/products/201a/201a15/201a1503P.html

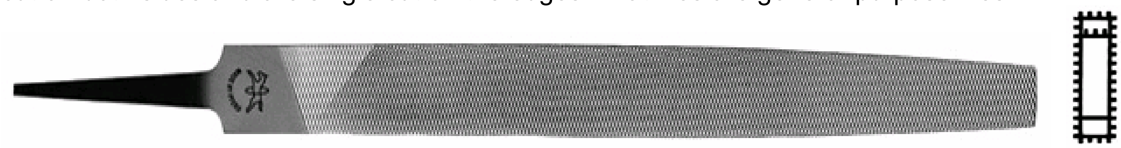
Hand file

The "**hand file**" has the same cross-sectional dimensions as the "flat file" (shown further below) but has a blunt end shape as the "flat file" has a tapered end. Hand files are parallel in width, but do taper in thickness to the end. They are somewhat thicker than flat files. This type is double cut, and normally has one "**safe edge**" (uncut) which permits filing one surface without affecting an adjoining one. They are used for general filing work.

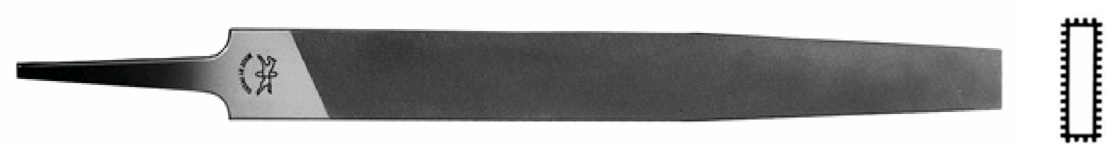


Flat File

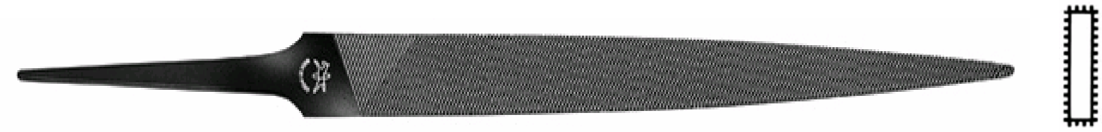
Tapered in width at the point and slightly tapered in thickness at the point. Flat files are double cut on both sides and are single cut on the edges. Flat files are general-purpose files.



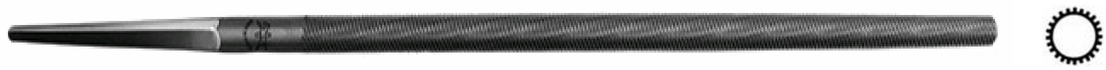
Mill File
This type has two square edges. Mill files are tapered in both width and thickness. One edge has no teeth. Ie. "Safe edge". Mill files are used for smoothing work, draw-filing, and other fine precision work. Mill files are always single-cut.



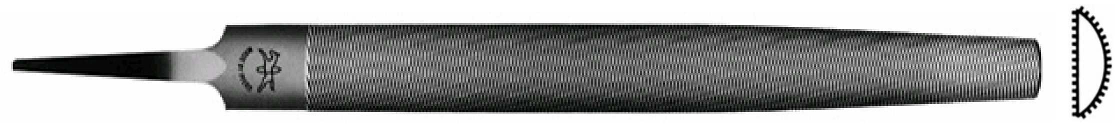
Warding File
This file can be used for narrow slotting and working on intricate shapes. It is double cut, parallel in thickness, tapered in width, and quite thin. Like a hand or flat file that comes to a point on the end. Used for flat filing work.



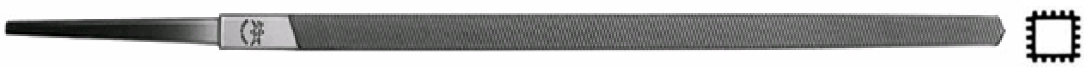
Round (Also called a Rat Tail file)
This file is used for enlarging circular holes or rounded grooves that are too small for a half round file. It tapers toward the point making it adaptable for use on various size holes. Round files are gradually tapered and are used for many tasks that require a round tool.



Half Round File
This file is used for filing out concave surfaces and crevices, and for rounding out holes. The spiral cut enables them to remove metal rapidly and leaves a smooth finish. Some half round files taper in width and thickness, coming to a point, and are narrower than a standard half round file.



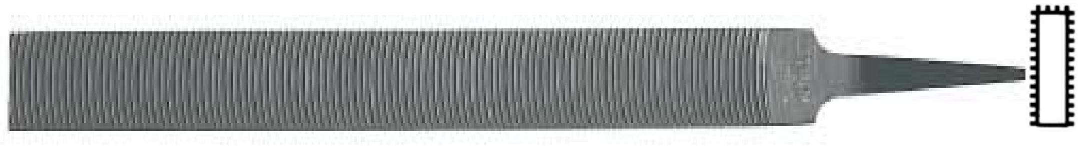
Square File
This file is used for filing slots, keyways, and rectangular as well as square holes and for surface work, this file has four equal sides. Double cut, it tapers toward the point.



Triangular (Three Square or Three Cornered) File
Three square files are triangular in cross-section and are double cut and have fairly sharp corners that are slightly set and cut. These files are used for filing internal angles more acute than the right angle. Three corner files (triangular) have a triangular cross-section, which gradually tapers. Some files taper all the way to a point (especially small ones). They are used for many cuts, such as cutting angles less than 90 degrees. They are often employed to sharpen the teeth of wood saws.

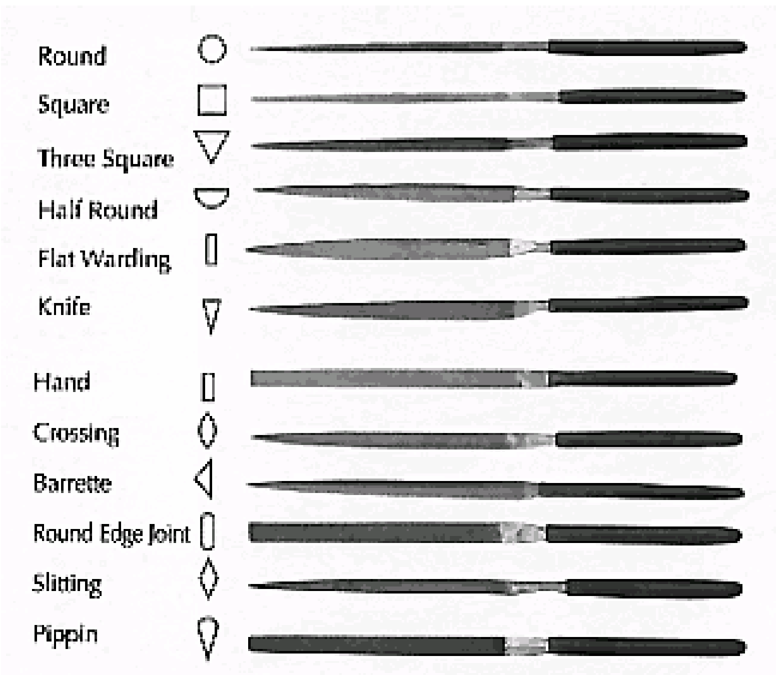
Rasp
Rasp files are tanged for blacksmith type work. They are flat with a rasp cut on one side (upstanding teeth arranged in rows with curved cutting edges of generally pyramidal shape and have a cutting face with a positive rake or slope) and a double cut file on the reverse side. They are used for removal of soft materials such as wood.

Dreadnought File
Dreadnought files typically have very coarse curved teeth. They are used for rapidly removing large quantities of material from thick aluminium alloy, copper or plastic epoxy filler materials.

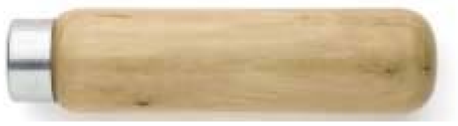


NB: A tradesperson’s toolkit is not complete unless it contains an assortment of file types.

Jeweller’s Files
Kits of small files, often called "Swiss Pattern" or "Jeweller’s" files, are used to fit parts of delicate mechanisms, and for filing work on instruments. Always handle these small files carefully because they break easily.

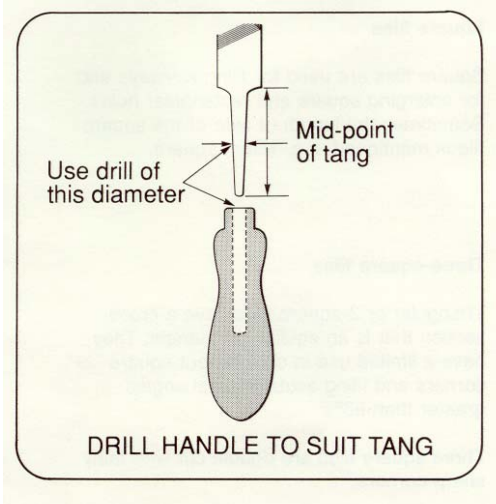


File Handles
The tang of a file is designed to fit tightly into a suitably sized file handle. It is designed as a tapered fit. The file handle is typically made of strong high-impact material, contoured to fit the hand for straight or draw filing.



Each file must be fitted with a handle for two reasons:

1. To prevent the sharp long tang from piercing the hand.
2. To give better control over the pressure and direction of the file.

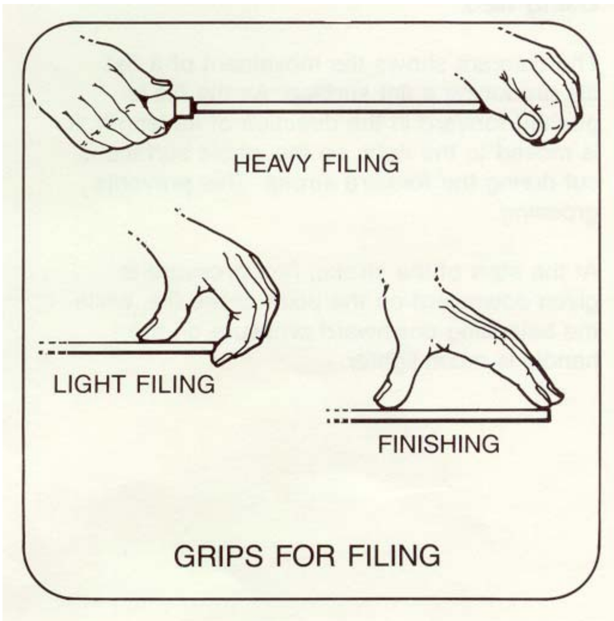


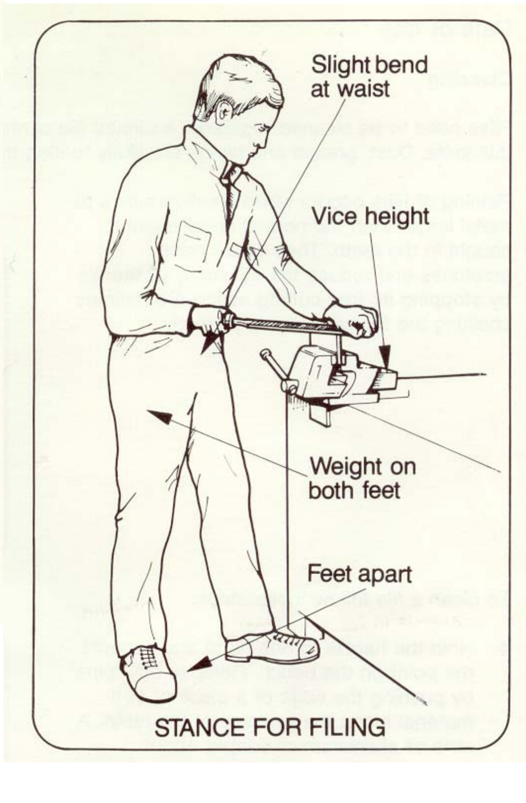
Both wooden handles and plastic handles are common. Long files require a long handle and vice versa. The handle must fit firmly onto the tang and must not be loose.

How to use a File
Cross filing. Use long steady strokes of medium pressure made at about 40 to 50 strokes per minute. If the pressure is too light, or the file speed too great, then the file tends to slip over the work without cutting. Slipping damages the file's teeth. Always use enough pressure so that you **"feel"** the file cutting.

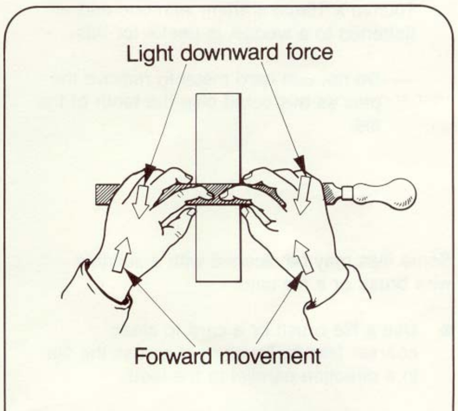
For heavy filing increase the pressure and decrease the speed of filing. If the work is very soft, or its surface very narrow, use less pressure and a greater speed of filing.

NB: A file with a "**safe edge**" is commonly used to ensure that material from an adjacent surface is not removed while filing close by.





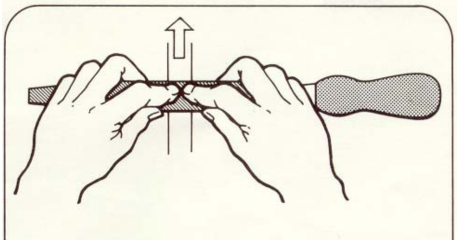
Draw Filing
Draw filing is a technique that can be used as a final finishing process on parts that are longer than they are wide. This method is only used when the work is nearly flat and close to its final size. It produces a smooth, even surface with all the file marks running in one direction.



DRAW FILING GRIP

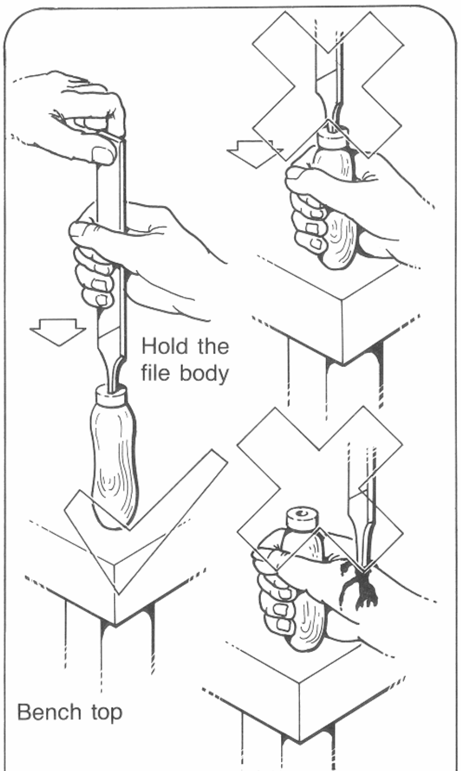
To "**draw file**" use the following procedure:

- Balance the file across the work at right angles to its length.
- Grip the file with both hands as close as possible to the work, with your thumbs on the rear edge and your fingers on the front edge.
- Make sure you keep the file level and move both hands at the same time.
- Make the cutting stroke by moving the file directly forward using light pressure.
- Don't use heavy pressure on the file on the return stroke.
- Continue at a speed suited to the job.


ALTERNATIVE POSITION

Fitting the File Handle
Two methods can be used when fitting wooden file handles: -

- An axial hole is first drilled in the handle with a drill that has a diameter equal to the width of the tang at its mid point.
- The tank is then inserted into the hole of the handle. With one hand hold the body with the file upright. Steady the file with the other hand.
- Bring down the handle sharply on a solid bench top.
- Alternatively, a small diameter pilot hole is drilled axially in the handle. Then the tang is heated while the blade is protected by a wet cloth.
- When the tip of the tang is red hot, it is pushed into the handle to a depth of three quarters of its length and then withdrawn.
- Once the tang is cool, it is reinserted into the hole and firmly fixed in the handle.



INSERTING THE
TANG IN THE HANDLE

Inserting a file in a plastic handle
- File three grooves in the tang
- Heat the tang until it is cherry red
- Push it into the plastic handle. The heat will melt the plastic into the grooves and solidify when it cools.

File Storing and Safety
Files are fine cutting tools. To cut well, they must be kept clean. Because they are tempered and hard, they are also very brittle and easily damaged.

To care for files ensure that you follow these rules

- Keep files clean and dry,
- Never put oil on the teeth of a file!,
- Never strike a file on a solid metal surface or strike it with a metal object, (it could shatter).
- Never bend a file or exert excessive pressure on it,
- Store files separately from each other and from other tools, (ie: Wrap in cloth or paper to protect cutting teeth)
- Make sure that file handles are sound and firmly fitted.

File Card

"**Pinning**" (Scratching) occurs when particles of metal or other material become wedged in between the teeth of a file. These particles stand higher than the teeth and cause scratches in the work surface. The effects of pinning can be minimized by rubbing soft teacher's chalk into the face of the file prior to starting filing.

Pinning commonly occurs when too much pressure is applied to a "new" file. If pinning is occurring, then the "pins" can be removed from the file's teeth by using a small stiff brush known as a "**file card**". Brush in a direction "parallel" with the teeth for best results.

Emery Paper

To achieve an extra-smooth finished surface after filing, place a piece of emery paper (abrasive cloth) length-ways under the file with its rough-side-out. Then use the file such that the work surface "grain" is directed in one direction. To finish, reverse the emery paper, (ie. smooth side out) and "burnish" (polish) the surface.

De-burring Tool

Ref: http://www.rapidonline.com/Tools-Equipment/Deburring-Tool-with-Spare-Blade-302092

The tool shown to the right is designed to "de-burr" the edge of a hole after filing or drilling. It has a solid carbide blade. The technique is to run the cutting edge of the tool along the edge of the work piece to form a small bevel and make the edge smooth. This model works equally well for curved surfaces.

File Safety

- Always wear eye protection when filing.
- Never use a file unless it is equipped with a tight-fitting handle. A file without a handle could result in the tang being driven into your hand. The file handle also will also give you better control and a more accurate cut.
- Never use a file with a loose handle as it may come off while in use.
- Never use a file as a lever or hammer. The hardened steel is very brittle and will snap and this could cause personal injury.

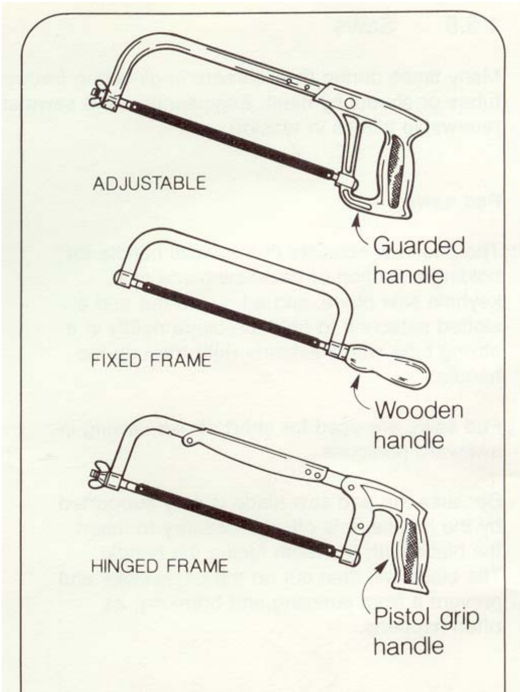
Handsaws
There are a number of different types of hand saws used in the electrotechnology industry. Listed below are the more common ones.

Hacksaw
The basic hacksaw is used to hand cut most solid materials including metals and other dense non-metallic materials. Eg: Plastics and Perspex, They are not effective when used to cut timber.

A hacksaw consists of a flexible hardened steel blade and an adjustable frame with the blade held under tension.

Saw blades are made of carbon steel or high speed molybdenum (more expensive). The teeth of the saw are hardened while the back of the blade is just annealed.

Parts of a hacksaw
Most hacksaws have an adjustable frame so it may accommodate blades of different lengths of blades. A set screw or catch allows the bow to be set in different positions in the handle.



TYPES OF HACKSAWS

Hacksaw blades
General purpose blades are made in lengths of 230mm, 250mm and 300mm.

The number of teeth per inch (25mm) also varies for each application. This ranges from 18 to 32 teeth per inch.

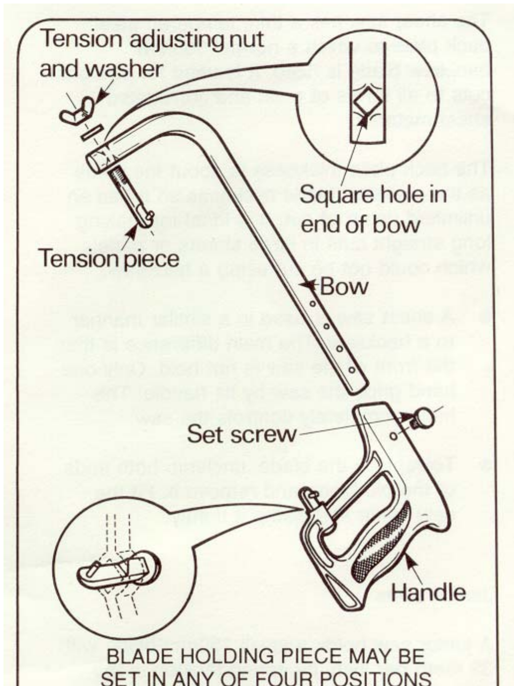
When choosing a blade for a task, as a rule of thumb, there should be at least "**two**" teeth in contact with the cut surface at all times.

When cutting, employ long steady slow strokes, using as many teeth as is possible to do the cutting. Short, fast strokes with uneven pressure will only result in a dulled or broken blade.

The cut is made on the forward stroke, only and **NOT** on the backward stroke.

Therefore, when cutting mild steel with a hand hacksaw, you should apply downward pressure on the forward stroke only.

Do not twist or bend the blade when cutting because this could cause it to break.



HACKSAW FRAME

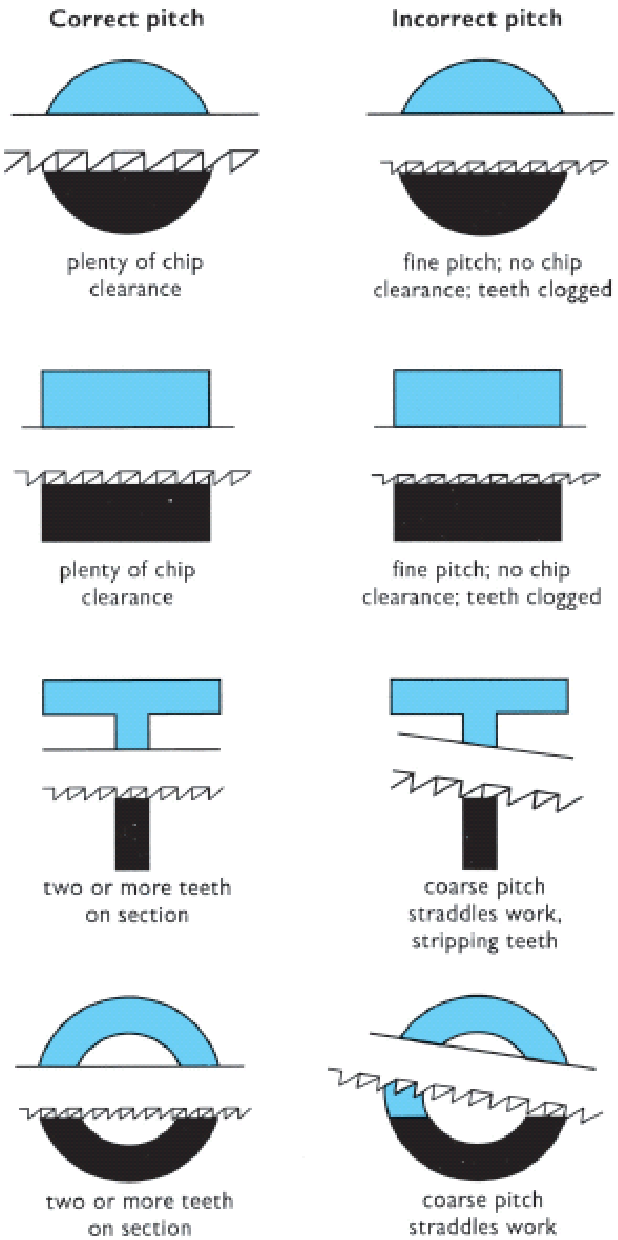
Selecting Blade Pitch

The blade “pitch” for different types of work is shown below. The blade’s teeth should be flat across the work. A blade with the correct number of teeth will provide chip clearance.

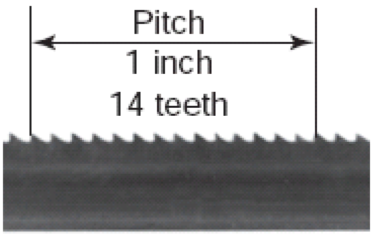
As general rule, “two-or-more” teeth should always be in contact with the work surface while cutting. If a coarse blade is used on a thin section, then the teeth will straddle the work making cutting difficult and cause the teeth to break. Eg: This is very common when cutting thin walled pipe.

But, if the tooth pitch is too fine then the blade cannot “clear” the material as it is removed. It will become clogged and will not cut efficiently.

Recommended Pitch Usage



NB: TPI (Teeth per Inch)



- **14 TPI** Use for machine, cold-rolled, or structural steel..
- **18 TPI** Use for solid stock, aluminium, tool steel, high-speed steel, cast iron, and the like.
- **24 TPI** Use for angle iron, brass, copper, iron pipes etc.
- **32 TPI** Use for conduit and other thin tubing and sheet metal work.

Hand hacksaw blades are generally 12mm wide and 0.7 mm thick. The “kerf” is wider than the blade’s thickness because of the set of the teeth.

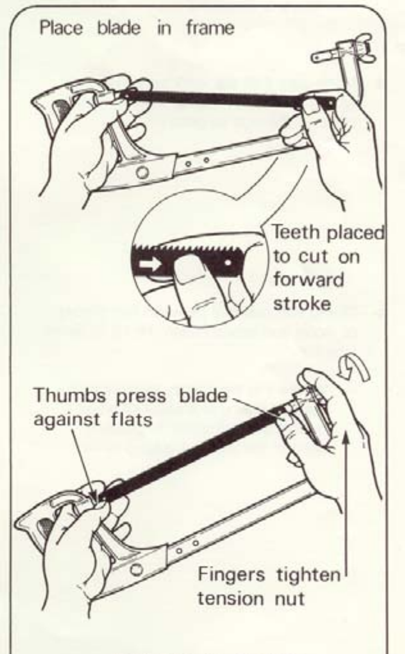
NB: The “**kerf**” is the width of cut, groove or incision made by the blade.

The “**set**” of a blade refers to the offset of teeth outward from the blade itself. Two kinds of sets are found on hand hacksaw blades; the “straight/alternate” set and the “wavy” set.

A wavy set is found on most fine-tooth hacksaw blades.

Fitting a blade

NB: A hacksaw blade should be inserted into the frame with its "teeth" points facing "forward" to enable it to cut on the forward stroke. Ie: Teeth point away from the handle.



FITTING A BLADE

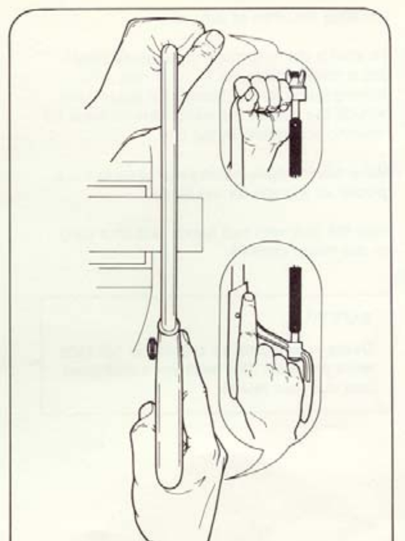
- Set the frame to the correct length to suit the blade.
- Hold the handle in one hand and check that both pins face the same direction.
- Hold the front of the blade in the other hand with the teeth facing towards the front of the frame.
- Fit the blade on the pin near the handle and steady it with your thumb then fit the blade on the other pin.
- Use your thumbs to press the blade hard against the flats of the blade holders and tension the blade with the wing nut. Take up the slack then give three full turns on the tensioning nut.
- Check the tension – the blade should "ring" sharply when the back of the blade is plucked with your thumb nail. If the blade flexes sideways when cutting, more tension is needed.
- The saw blade may break if it is too loose in the frame or if the work piece slips in the vice while sawing. Too much pressure may also cause the blade to break.
- A badly worn blade, one which the set has been worn down, will cut too narrow a kerf, which will cause binding and perhaps breakage of the blade.

NB: If you are forced to use a new blade to finish a cut, turn the work piece over and start with the new blade from the opposite side and make a cut to meet the first one. The set on the new blade will be wider. Forcing the new blade into an old cut will immediately ruin it by wearing the set down.

Cutting with a hacksaw

Holding the hacksaw

At all times control the hacksaw with both hands and keep it straight and upright. Do not allow the blade to twist or move sideways.


HOLDING THE HACKSAW

Stance

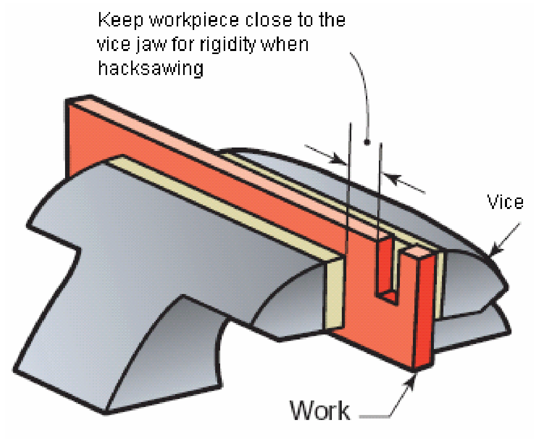
- Stand in a comfortable, well balanced position approximately 400 – 500mm behind the vice with the right foot perpendicular to the line of the cut.
- Allow the body to rock forward and back with each stroke keeping the right arm close to the body with the forearm in line with the blade.
- At the beginning of each stroke most of the pressure will be directed from the left hand.
- Gradually transfer the pressure to the right hand by the end of the stroke.


SAWING STANCE

NB: Both the type of material and the section to be cut are general factors to be considered in selecting the pitch of blade required.

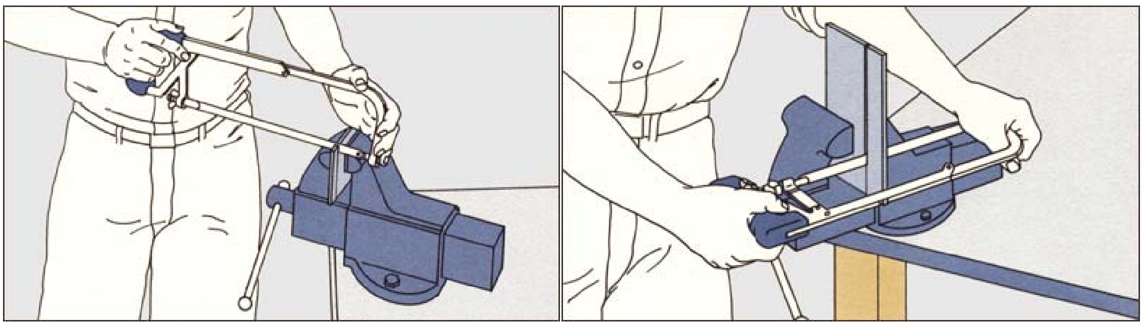
- **Soft material -** use a coarse pitch to give ample chip clearance.
- **Hard material -** use a fine pitch to give sufficient cutting points in contact with the work.
- **Thin sections -** use the finest pitch to ensure a minimum of three teeth in contact with the work.

Note: Blade manufacturers supply precise tables of the type and pitch of blade to suit specific materials.



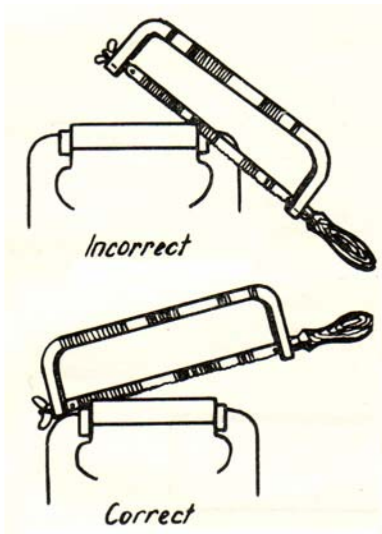
Cutting Techniques

- A cut on a work piece should be started with only light cutting pressure, with the thumb or fingers on one hand acting as a guide for the blade.
- Sometimes it helps to start a blade in a small vee-notch filed into the work piece.
- When a work piece is supported in a vice, make sure that the cutting is done close to the vice jaws for a rigid setup free of chatter.
- Work should be positioned in a vice so that the saw cut is vertical. This makes it easier for the saw to follow a straight line. At the end of a saw cut, just before the pieces are completely parted, reduce the cutting pressure or you may be caught off balance when the pieces come apart and cut your hands on the sharp edges of the work piece.
- To saw thin material, sandwich it between two pieces of wood for a straight cut.
- Avoid bending the saw blades, because they are likely to break, and when they do, they usually shatter in all directions and could injure you or others nearby.



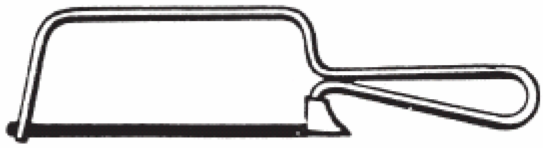
Blade/Tooth Breakage - Common causes

- Work insecurely clamped.
- Pitch of saw too coarse (too few teeth in contact with work).
- Incorrect tension on blade.
- Starting a cut on a corner.
- Pressure too great.
- Failure to reduce pressure at the finish of a cut.
- Twisty or jerky sawing action.
- Using new blade to finish a cut started with worn blade.

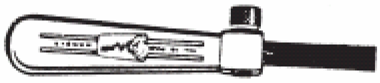


Safety Considerations

- Always wear safety glasses to avoid chips entering eyes.
- Ensure the blade is correctly tensioned and that the teeth point away from the handle.
- Clamp the job close to the saw line to avoid excessive vibration.
- Support the over-hang as the cut is nearly completed.
- When cutting, always have in your mind that the blade could shatter at any time and your balance is the only thing preventing your knuckles from injury.



Junior Hacksaw



Pad Handle

Junior hacksaw

A junior hacksaw is used to cut light gauge metal or rigid plastic such as PVC conduit etc. This is a small steel framed tool in which the spring tension of the frame itself holds the blade in place. The blade must be fitted with the points of the teeth facing (forward) away from the handle, so it will cut on the forward stroke.

Pad Handle

A pad handle is made of a light alloy or a rigid plastic and has a securing nut designed to hold a piece of a standard hacksaw blade. It is used to make a cut in tight confined spaces or situations where you are unable to access the space in behind the object to be cut.

A small section of hacksaw blade protruding from the handle is easier to control.

Coping Saw

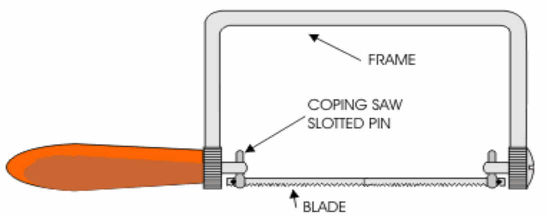
http://en.wikipedia.org/wiki/Coping_saw

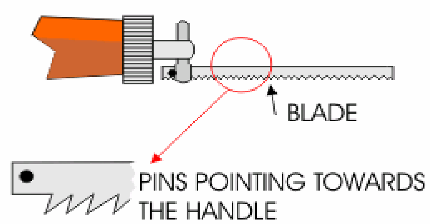
A coping saw is a type of hand saw used to cut intricate shapes in sheet materials. The blades are thicker and much coarser than a junior hacksaw blade.

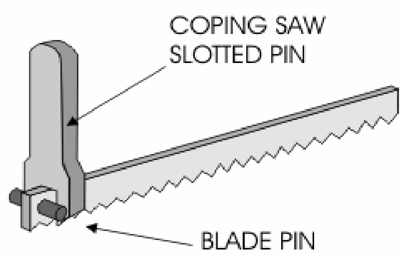
A coping saw consists of a thin, hardened steel blade, stretched between the ends of a square, "C"-shaped, springy-iron frame to which a handle is attached.

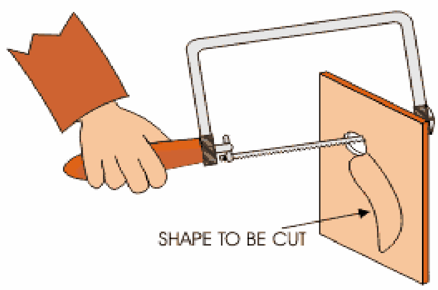
- A coping saw blade is removable by partially unscrewing the handle. Retightening the handle tensions the blade and locks it at the desired angle relative to the frame.

- The blade is prevented from rotating by means of the short, steady bar provided where the blade is attached.
- Loosening the handle also allows the blade to be rotated relative to the frame as desired.

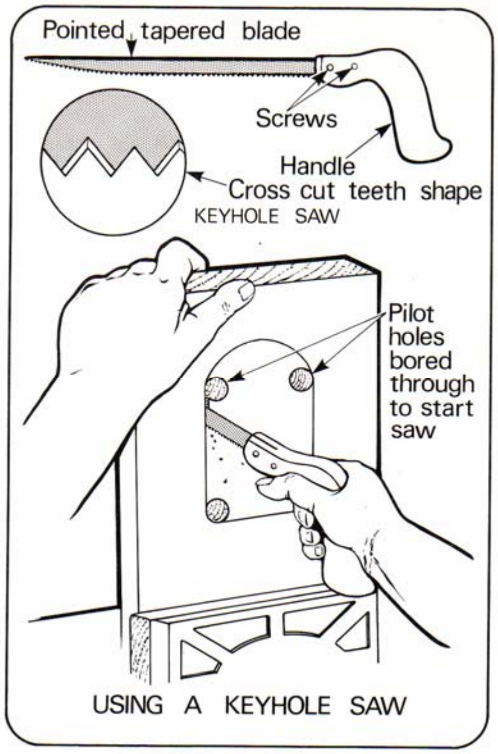








- Aligning the finger steady bars at the top and bottom of the blade ensures that the thin blade is straight and not twisted along its length.
- The direction of the cut is easy to change because of the thinness of the blade. Gentle curves are achieved by slowly turning the whole frame by means of the handle while continuing to cut steadily.
- The blade can also be rotated with respect to the frame to make sharper curves in the material being cut.
- The teeth on a coping saw blade should normally face the handle. (i.e." face backwards" as compared with most other hand saws); the action of pulling the coping saw allows the frame to remain in tension (and thus reduces blade breakages). This technique is opposite most other saws which cut on the "push" stroke.
- Coping saws are used for cutting a range of soft materials such as wood, acrylic, and aluminum.



Keyhole Saw
(Compass Saw or Plaster Saw)
This is a long, narrow and tapering rip saw designed to cut sections from boards or panels.

It is commonly used in the electrotechnology industry to cut small holes in plaster board to accommodate socket outlets and light switches.

It consists of a pointed 150 to 180mm tapered blade with rough pointed teeth usually with a wooden handle.

The point is usually sharp enough to penetrate soft plaster board directly without the need to pre-drill.

Safety: Use extreme caution when cutting plaster board on an existing house as there may be live conductors directly behind the plaster panel. Always turn off the power to the area before cutting. Also, plaster board dust could be a health hazard. Wear a "safety face mask" when performing this task.

Hand Saw (Wood)
(Cross-Cut or Rip Saw Types)
This type of hand tool is designed to cut mainly timber based products.

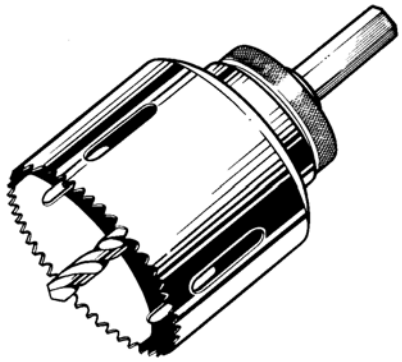
The teeth of "rip saws" are designed to cut timber of medium thickness with the grain and the teeth of "cross-cut" saws are designed to cut timber across the grain and also general cutting. Start a cut by slowly drawing the saw up a few times to make a notch. Once started the saw blade itself assists guiding the blade straight for the remainder of the cut.

Uses in the electrotechnology industry include cutting battens used for clipping cable, cutting out studs to mount air conditioners and making noggins to support ceiling mounted light fittings. Blade length: 550m to 700mm. Tooth size: Six points per 25mm is recommended for general-purpose applications.

Hand Saw Maintenance

- Keep the surface of the saw coated with a light lubricant to ensure that it does not rust.
- Ensure that the teeth do not contact other steel based tools as this will damage them.

Hole Saw



This tool is designed to cut neat round holes in variety materials of diameters larger than is possible with a normal twist drill. Typical sizes range from diameters of about 18mm up to about 75mm in diameter.

A hole saw is a circular shaped saw blade that is used in a powered drill. They typically have a pilot drill bit (approximately 6mm diameter) at their center to keep the saw teeth from walking during the cut. Sometimes there is a coil spring located around the drill bit to expel the core material from the saw after the hole is completed. Most hole saws have a fairly short aspect ratio of diameter to depth, which means they are used to cut through relatively thin work pieces.

Because of their high peripheral speed it is important to use a lubricant to stop the teeth from over-heating when cutting sheet metal.

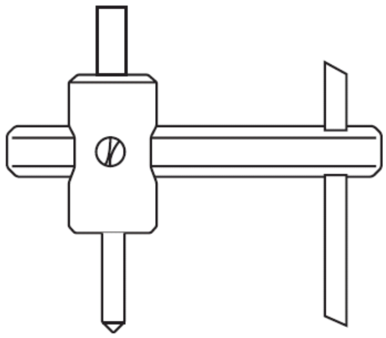
Safety

Always wear appropriate PPE, especially safety glasses.

Applications

They are many applications including mounting indicating lights, push buttons and instruments for switchboard panels. They are also used to cut large diameter holes in a variety of materials, to facilitate cable or conduit entry etc.

Fly Cutter
(Circle Cutter)



This tool is designed to cut very large diameter holes in flat materials such as sheet metal or plastic etc. It is ideal for hole sizes greater than can be cut using a hole saw.

A fly cutter is composed of a spindle, horizontal bar with a securing screw for a lathe tool bit. A clearance hole must be drilled to enable the spindle to rotate freely in the stock material.

As the entire unit rotates (extremely slowly) the tool bit takes a broad, shallow cut. The material to be drilled must be clamped flat and very secure and the spindle rotated at the slowest possible speed. This tool is often used with a “radial arm drill”.

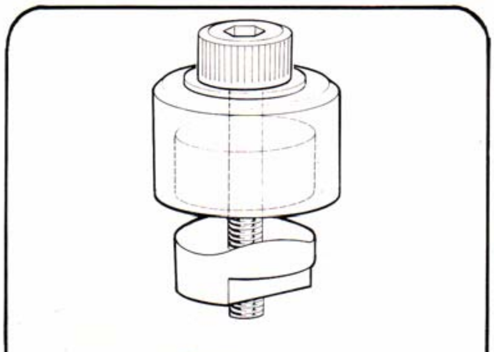
Wad Punch

Because the leading edge is very sharp, it enables this tool to cut neat holes in soft sheet material such as plastic, fibre, felt or lead. This makes it suitable for making “gaskets”.

Wad punches are produced with hole sizes ranging from 5mm to about 40mm using high grade steel.

To use a wad punch, first place a piece of soft timber as backing behind the sheet material and align it with the point of contact. Align the wad punch carefully with the centre line cross and strike the end of the punch cleanly with a hammer. If sharp, it should cleanly remove the centre section from the material.

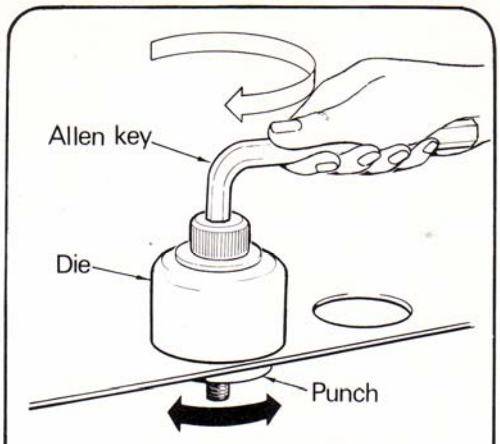
Metal Punch (Chassis Punch)
This tool is used to cut neat holes, up to about 40mm diameter in sheet metal or gasket material with a thickness not greater than 1.6mm.



METAL PUNCH

This tool is often used to cut conduit access holes in the sides of electrical switchboards. First drill a clearance hole for the bolt. Locate the cutting head on the inside and the recessed section on the outside. Thread the bolt through and begin to tighten using an “Allen Key” or ring spanner depending on the design.

When the cutting head passes through the metal it leaves very little burr. Because it produces little heat, it does not affect painted surfaces.



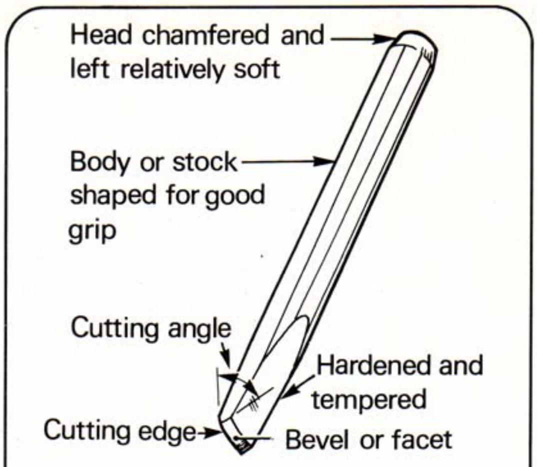
USING A METAL PUNCH

Cold Chisel
Cold chisels are designed to cut thick sections of metals such as steel, but it can also be used to cut products such as masonry bricks and concrete. They are made of carbon tool steel or of alloy tool steel. They are forged to the shape and size required, then hardened and tempered. They should be tough enough to withstand the impact of a heavy blow, yet sufficiently hard to maintain their sharp cutting edge.

A cold chisel could be used to chip away excess metal, or to split a piece of metal that can not be cut by hand with a saw or grinder.

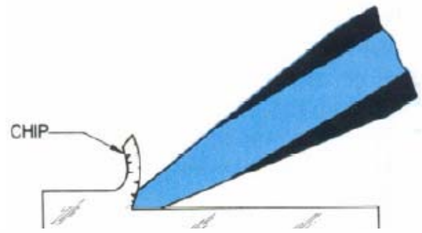
Common Types of Chisels
Chisels designed to cut metals are usually classified by the length of the stock, the width of the cutting edge, and the type.

Examples are: 180 x 25 mm, flat chisel and the 150 x 6 mm, cross cut chisel



COLD CHISEL

Types of "metal" chisels
The most common is the **flat chisel** which is used for chipping flat surfaces, trimming, cutting thin sections of metal. General applications include cutting off rivet heads and bolt heads and splitting nuts when dismantling machinery.

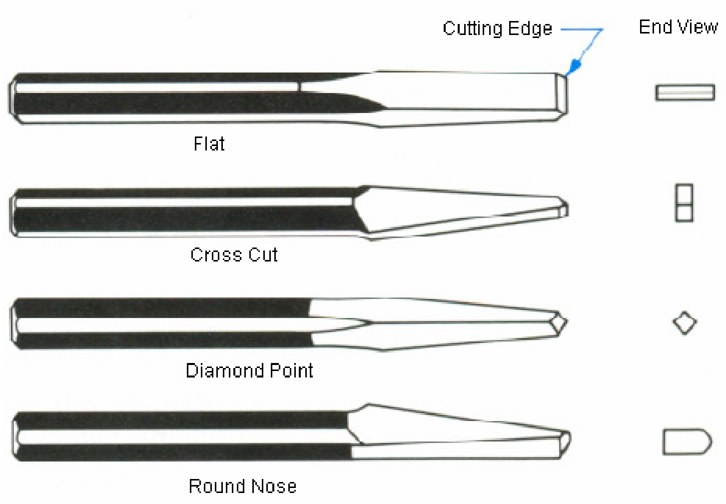


Less common chisel types include:
The **cross cut chisel** which is used for cutting key ways and grooves requiring a flat bottom and square walls.

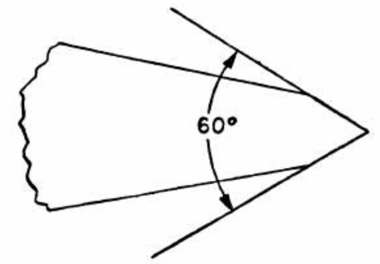
The **round nose chisel** which is used for cutting oil grooves in bearing surfaces, and also for drainage channels.

The **diamond point chisel** is used for cutting V shaped grooves and sharp corners, as well as for preparing cracked parts for welding.

Danger: Always wear safety glasses when using a metal chisel as pieces of metal can become projectiles.



Cutting Angle on "Flat" Chisels
The cutting angle (cutting edge) is usually formed by two bevels or facets equal in angle and width. The average cutting angle is 65°, but may be varied from 55° to 85° to suit the metal to be cut. The harder the metal to be cut, the stronger, and larger must be the cutting angle.



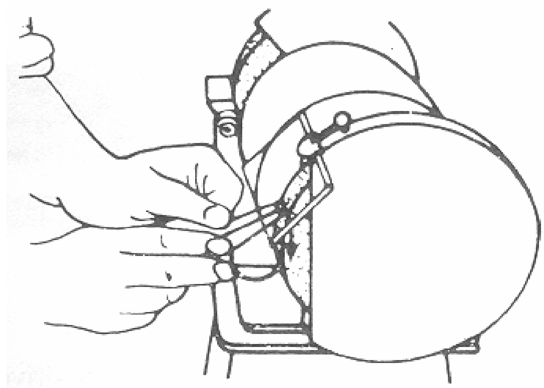
Commonly used cutting angles are:

Brass Mild	Steel	Cast Iron
50° - 60°	60° - 70°	70° - 80°

Sharpening a Chisel
A chisel made of **carbon tool steel** is normally sharpened on a grinding wheel. Care should be taken not to apply too much pressure, nor to keep it against the wheel for too long before cooling it. (eg. Water)

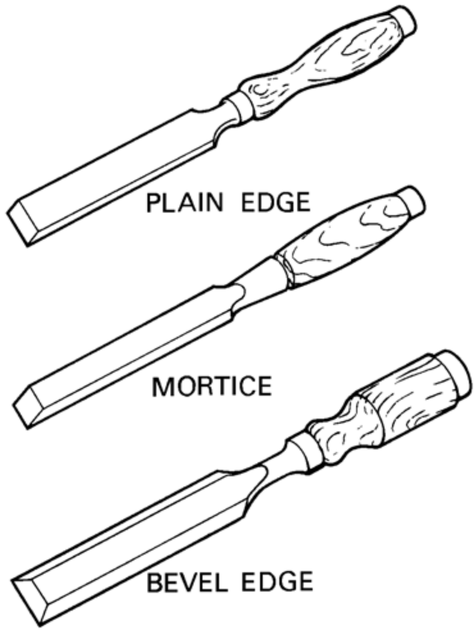
If the chisel is overheated (where its tip changes to a blue colour) then the temper of the steel will be drawn, and the chisel will be too soft to use.

Always wear safety glasses when using a grinder.



Chisels should be ground on the front face of the wheel. Always point the chisel facing upwards towards the wheel estimating the required angle.
The wheel should be fitted with a spark guard, and safety glasses must be worn.

Wood Chisels
These are designed to cut timber or other soft materials. These are made in a variety of types and sizes. They have either a wood or plastic handle (plastic being the more suitable material for use with a steel hammer).

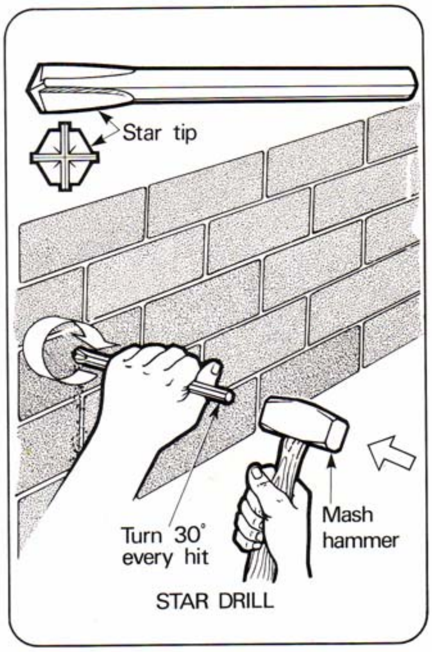


The blade has parallel sides and tapers in thickness. Blade widths from 6mm to 50mm are available. Some uses include:

- Cutting recesses for architrave dimmer switches.
- Cutting recesses in skirting for socket outlets etc.
- Cutting rebates in studs or noggings to accommodate cables.

Safety Precautions for Wood Chisels
- Replace cracked or split handles.
- Never use a wood chisel as a lever.
- Make sure the work is braced or supported.
- Never place your hand where it could be cut if the chisel slipped.
- Always cut away from your person.
- Use a sheath to protect the tip while it is being stored.

Bolster Chisel
A brick layers “bolster” chisel is designed to cut masonry bricks in two. It is commonly used in conjunction with a “lump hammer”. It has a blade 65mm wide.

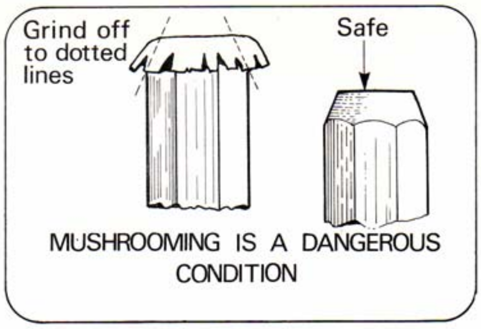


Star Drill
Classified as a chisel because of its impact cutting action when struck with a hammer, the star drill finds its main use in cutting round holes in concrete or brick work. Brackets supporting switchboards, motors and cable tray can be secured to fixing devices that have been inserted into the concrete or masonry etc.

It can be used in situations where a masonry drill is not available.

Chisel Safety Precautions

- Always wear safety glasses.
- Never chip towards yourself and protect others with screens.
- Do not use a chisel that has a crack or a flaw.
- Check that the hammer is in good condition.
- Make sure your hands, the chisel and hammer are clean and dry and free from grease.
- Watch the cutting edge of the chisel, not its head when hammering.
- Make sure that the size of the chisel and its cutting angle is correct for the job.
- Never use a chisel with a **mushroomed** head as it can easily chip and splinter and become a hazard. . The "mushroomed" section should be ground back using a bench grinder to an approximate shape as shown to the right.



Tin-Snips

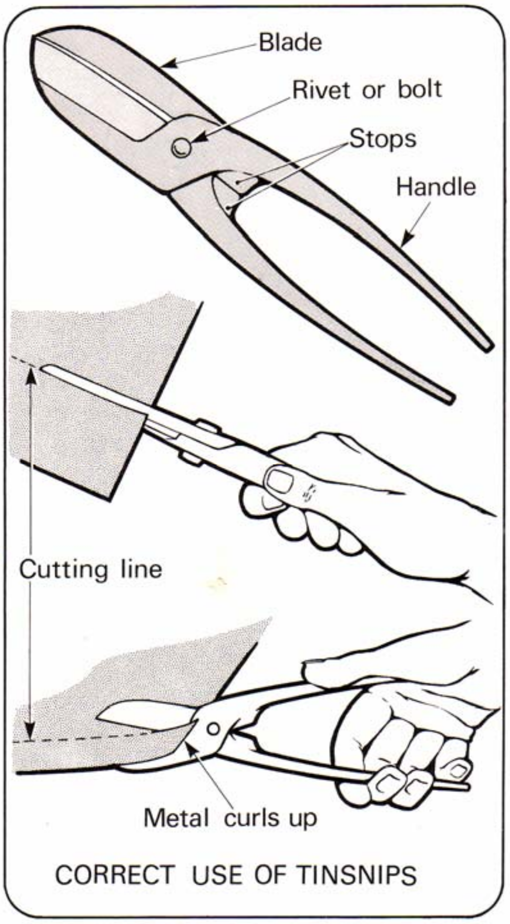
This tool is used for cutting "light-gauge" materials such as sheet metal. They are typically used in the electrotechnology industry for installing cable tray and metal duct.

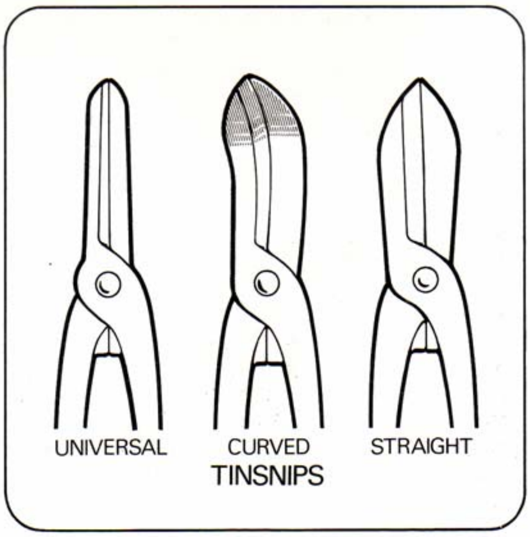
Tin snips will cut slightly heavier gauges of soft metals such as aluminium alloys or copper sheet. The linkage of compound-action type tin snips increases the mechanical advantage without increasing the length of the snips.

Tin snips are made with either "straight", "bent" or universal cutting jaws.

- "**Straight**" cutting snips are used to cut in a straight line and wide curves;
- "**Right**" snips will cut straight and in a tight curve to the right.
- "**Left**" snips will cut straight and in a tight curve to the left;
- "**Universal**" snips cut will cut in both directions.

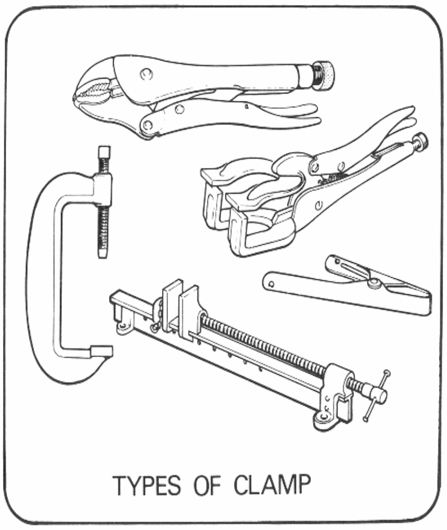
These different cutting styles are necessary because metal is stiff and heavy and does not move out of the way readily when cutting around a curve. The respective styles move the material out of the way when cutting in the direction they are designed for. The blades are usually serrated to prevent material slippage when cutting.





Use
Grip the handles between the thumb and the first finger and allow first and second fingers to curl around the lower handle. Place the third and small fingers between the handles, but rest them on top of the lower handle. This gives good control to open and close the cutting jaws..

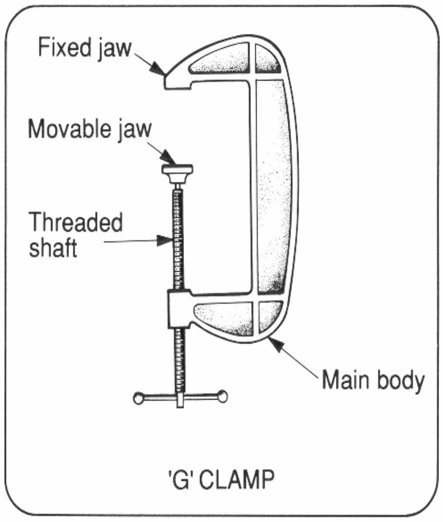
Application
Cutting large cable entry holes for switchboards, notching cable tray and cable duct during installation.



Clamps
A wide variety of clamping tools are used in a metal workshop. Each clamp has a variety of uses in situations which require the holding or aligning of materials in readiness for drilling, riveting, screwing or welding.

'G' Clamps
A 'G' clamp is designed to temporary clamp two or more objects together. Its main body is drop forged from high quality steel in the form of a 'G'.

The top of the 'G' forms the fixed upper jaw while the lower jaw is adjusted by turning the threaded shaft. Depending on the way it is turned, it will either increase or decrease the pressure between the jaws.



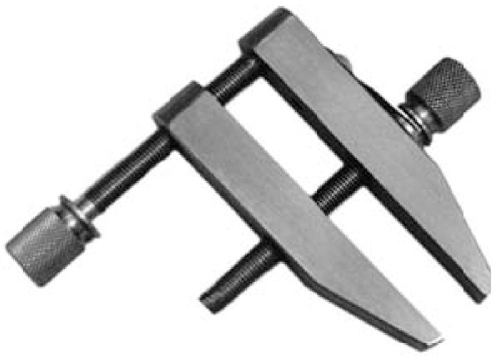
'G' clamps are available in a variety of sizes ranging from 50 mm to about 300 mm capacity. They are also made in different weights and strengths for general purpose, medium or heavy duty.

Warning
Do not increase the pressure between the jaws by applying a greater leverage than the clamp is designed to take, as this will distort and damage the clamp.

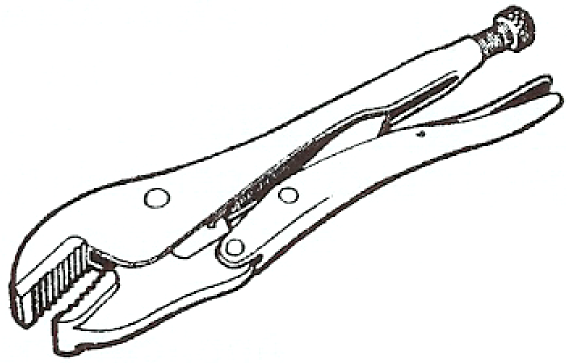
Other Types of Clamps
Apart from the "G" clamp, many other clamps are available, some designed for specific uses.

Below is a list of these clamps:

- Toolmaker's clamp (shown to the right)
- Sash clamps
- Spring clamps
- Adjustable Vice grips
    - Vice grip pliers
    - Vice grip welding clamps
    - Flat nose vice grips

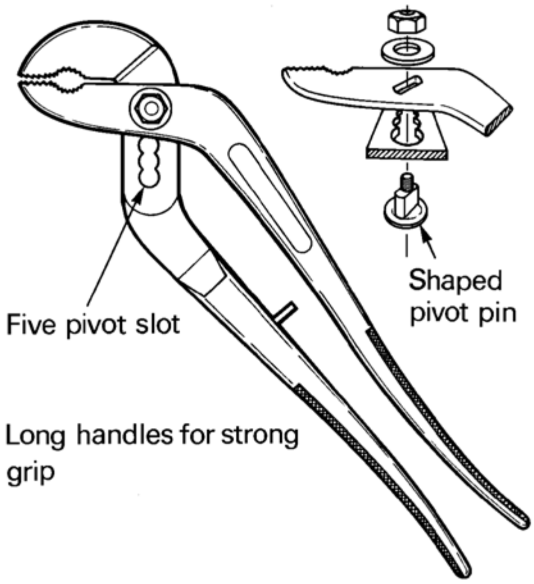


Adjustable Vice Grips
These pliers form an adjustable portable clamp with serrated jaws designed to hold narrow objects. It is adjusted by the knurled screw located at the end of the handles.



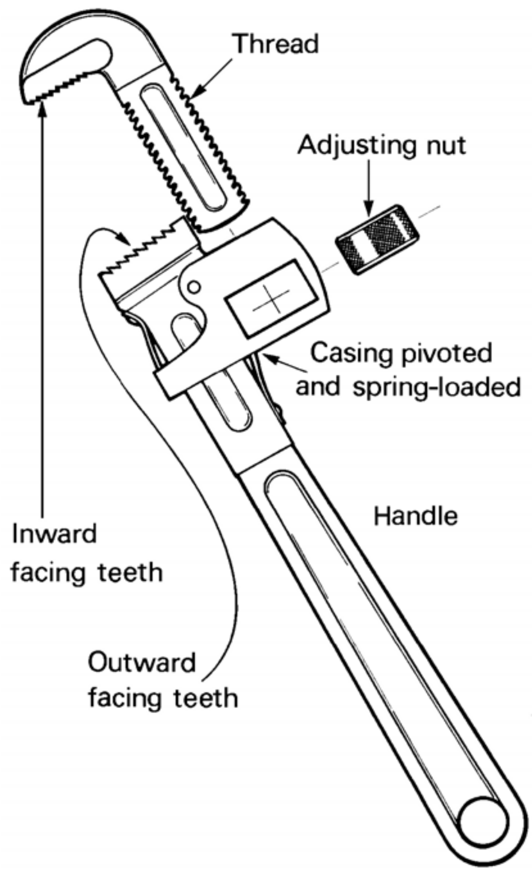
Application
This tool can be used as a temporary clamp, a wrench or a portable vice to hold items for drilling, grinding and welding etc.

Multi-Grip Pliers or Slip Joint Pliers
This tool is used as light duty pipe wrench and is ideal for assembling metal conduit work. They have a shaped pivot pin which can fit into two or more openings in the legs. This gives a range of jaw openings which allows parallel gripping by the jaws in a number of positions.



Multi-grips are designed to grip "round" objects such as rods and pipes and should <u>not</u> be used to turn hexagon headed bolts or nuts.

Stillson
(Also called Pipe Wrench)
This tool is used for gripping and turning metal pipes or conduits. It has much greater gripping force than can be provided by multi-grip pliers.



Fixed to the handle is a jaw with outward facing teeth. Attached to this handle by a pivot pin is a spring-loaded casing that carries a knurled adjusting nut. This engages with a thread on the adjustable arm of a jaw with inward facing teeth.
Once the jaws are adjusted, the spring loading keeps them in contact with the work and the toggle action causes the hardened serrations to bite into the work.

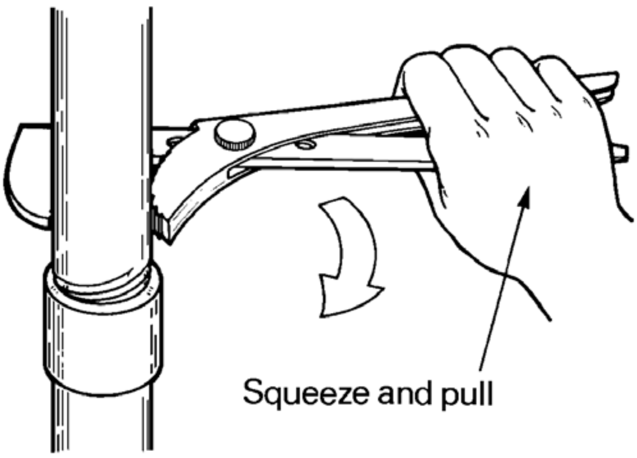
Footprint Pipe Wrench
This tool is used for gripping and turning pipes or conduits. It does not have the gripping force of Stillsons, but takes much less time to set up.

One folded steel handle has outward facing teeth cut in a convex jaw. The other solid steel handle has inward facing teeth cut into a straight jaw. Adjustment for differing diameters is made by fitting the removable pin in a hole that will allow the pipe to be gripped properly, without the two handles of the wrench being too far apart.

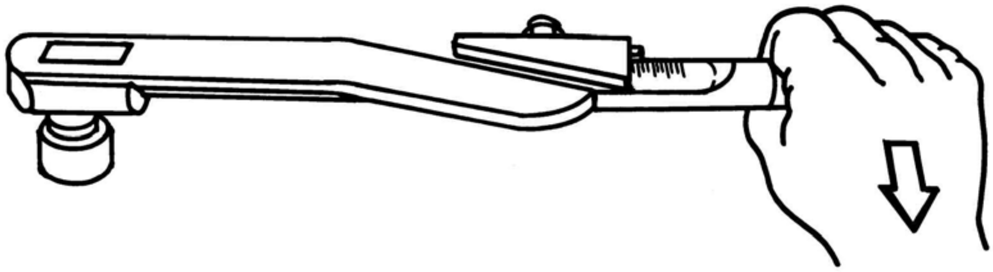
Application: Multi-grips, footprints and Stillsons are used for gripping and turning pipes or conduits.

Note: As pipe wrenches tend to `bite-in' they will invariably <u>mark</u> the surface on which they are used. Therefore, they should not be used on polished or plated surfaces (Here use a strap wrench).

Any burrs left on the surface should be filed off. Any damaged surface of galvanized metal conduit should be refurbished with paint to avoid the onset of rust.

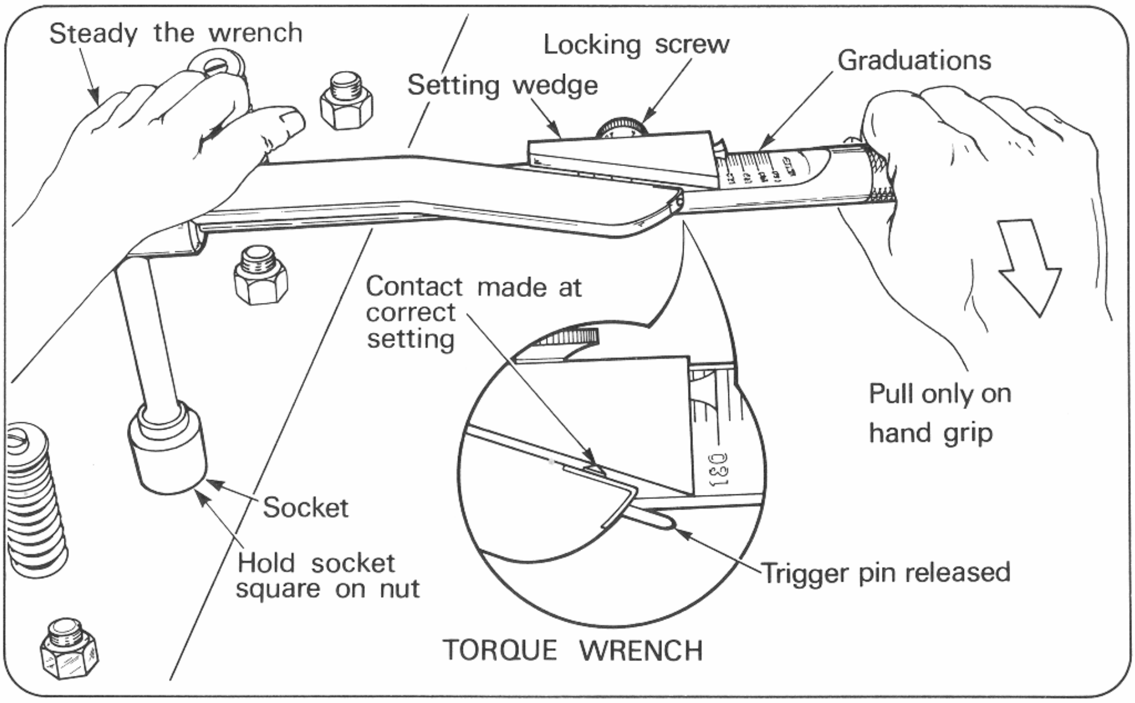


Torque Wrench (Tension Wrench)
A torque wrench is used in situations where a prescribed amount of torque (turning force) is specified for the final tightening of a fixing bolt. A torque wrench has a square drive which fits standard sockets and can be preset to release at a predetermined torque in “Newton/Metres” (Nm). In the electrotechnology industry, they are used to tension nuts on busbars, electric motors and machinery etc.



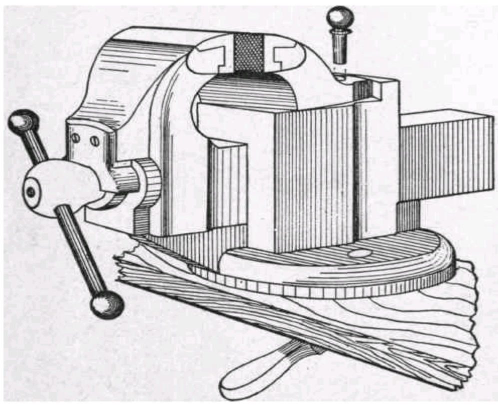
The amount of force required to turn a fastener is directly related to the tensile stress within the fastener. In Australia, torque is measured in Newton/ Metres, but for imported equipment, torque values may be given “psi” (Pound per square inch). A torque wrench should only be used for tightening operation and not to loosen nuts as this will affect its accuracy.

Common types of torque wrench include: “Beam”, “Deflecting beam”, “Click” and “Electronic”. The “Click” type torque wrench clicks a button when the selected torque is reached. This type is shown below.



Electronic Type Torque Wrench
Ref: http://www.google.com.au/imgres?
This design provides a digital readout of the torque being exerted.

Bench Vice

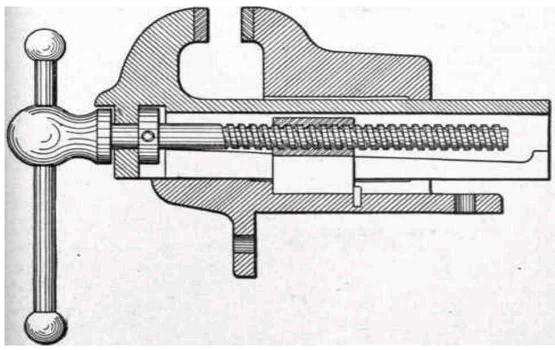


During disassembly work an engineer's "bench vice" can be used to hold parts while they are being processed.

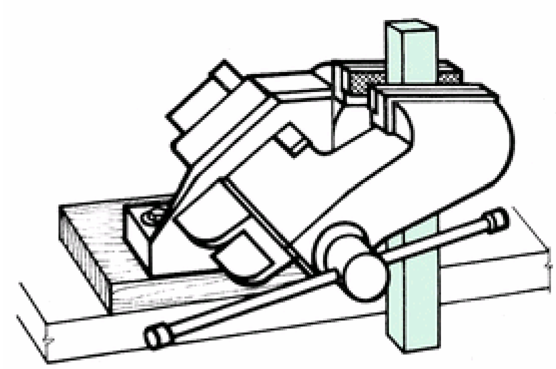
A bench "vice" is fabricated from steel or cast iron and consists of two jaws; one "fixed" or stationary and one moveable. These are fitted into a frame with a heavy screw apparatus operated by a lever which controls the moveable jaw, allowing the space between the jaws to be expanded or contracted to accommodate different-sized pieces of material.

The size of a vice is set by the width of the "jaws". Common sizes range from 75mm to 150mm and with jaw openings from 100mm to 200mm.

As shown to the right, some designs have "offset" jaws to enable them to hold long lengths of stock vertically.



Vice Jaws
"Hard jaws" are replaceable case hardened steel blocks fitted by two metal threads. The gripping faces of the jaws are serrated to provide excellent grip.

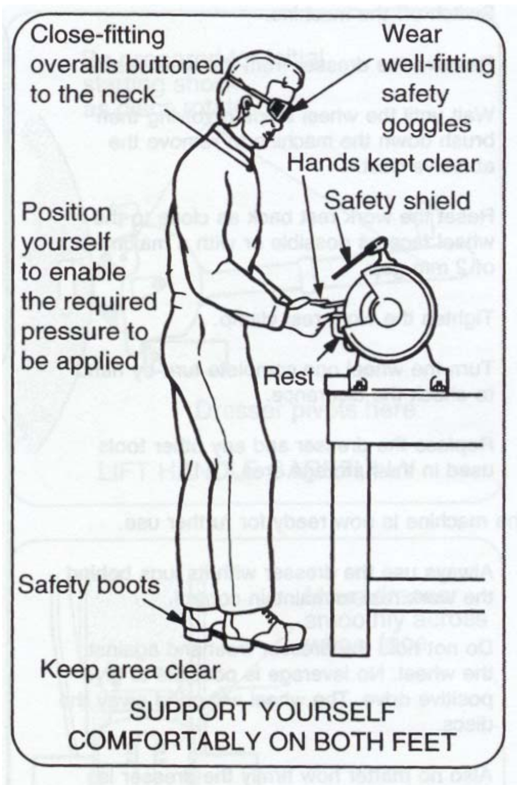


"Soft jaws" are made of plastic (polyurethane) or aluminium and have a magnetic strip to secure them in place over the steel jaws. Most workshops use soft jaws from bent "L" shaped inserts of aluminium. These help avoid damaging the surface of soft materials or threads etc.

Care and Use of a Vice

- Ensure that the vice is securely fixed to the work bench,
- Clamp the work piece evenly in the vice,
- Support the ends of long piece of material held in the vice,
- Do not use the vice as a hammering surface as it is not designed to function as an "anvil". The movable jaw is usually made of thin cast iron can easily crack.
- Heat should not be applied to work held in the jaws as the hardened insert jaws will become softened.
- The force of bending should be against the fixed jaw rather than the movable jaw of the vice.
- Bench vices should occasionally be taken apart so that the screw, nut, and thrust collars can be cleaned and lubricated. The screw and nut should be cleaned in
- Solvent and a heavy grease should be packed on the screw and thrust collars before reassembly.
- When it is not being used, partially close up the jaws, but, not fully tightened. NB: If a vice is left too tight, any expansion or contraction due to temperature change could crack the frame.

Workshop Equipment
A fixed machine tool refers to a power driven machine mounted in a permanent location. Most "fixed" workshop equipment is electric powered. Be aware; if an electric powered tool "stalls" for a length of time, then the current drawn by the motor will increase substantially. This may cause the motor to burn-out and it could cause a fire. Workshop tools function by:



- Holding the material to be cut,
- Holding the cutting tool or tools,
- Moving or rotating the work, the tool, or both, so that the parent material is removed.
- Controlling the speed, magnitude and rate of the cut.

The word "**machining**" means the cutting away of material by means of a power driven machine tool.

Typical fixed workshop machine tools include a:

- Pedestal or Bench grinder,
- Bench (Pedestal), Pillar or Radial fixed drilling machine,
- Metal Lathe,
- Abrasive saw,
- Cold saw,

- Vertical Band saw,
- Power hacksaw,

Safety
There are identifiable hazards associated with all machine tools as part of their operation and use. To reduce the level of risk it is essential that you:

- Are suitably trained in its correct use and that you **DO NOT** perform any task that is outside the scope of your training,
- Are supervised closely when new to a machine,
- Wear all PPE (Personal Protective Equipment) that is deemed necessary for the task,
- Strictly follow **ALL** of the safety guidelines.

Off-Hand Grinding
Off-hand grinding is the term used in engineering to describe the process where the work is held by hand and surplus material is removed using an abrasive grinding wheel.

This type of grinding is carried out in the workshop to:

- Dress metal,
- Rough shape parts,
- Remove excess metal,
- Prepare plates for welding,
- Smooth surfaces.

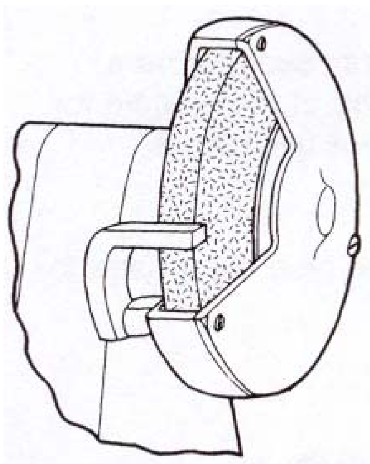
Off-hand grinding is also used for sharpening cutting tools such as:

- Twist drills,
- Chisels and scrapers,
- Punches and scribers,
- Lathe cutting tools.

Safety
Always wear safety goggles or an approved type of eye protection when performing any grinding operations.

Important: Leather gloves must **NOT** be worn when sharpening small tools such as drills or tool bits, where fingers and hands are in close proximity to the abrasive wheel. There is significant risk that the gloves may get caught in the spinning wheel which could cause severe injuries.

Safe Use of Grinding Wheels
Grinding wheels are fragile and they must be handled, mounted and used carefully and with adequate protection.



Australian Standards set the guidelines.
ASNZ1788.1_1987 Abrasive wheels - Design, construction, and safeguarding
ASNZ1788.2_1987 Abrasive wheels - Selection, care, and use

To safeguard the operator, always adhere to the following precautions

- Always handle and store the wheels correctly.
- A competent person should be assigned to the care, inspection and mounting of grinding wheels.
- Before mounting, check all wheels for possible damage in transit.
- Check maximum operating speed established for the wheel against machine's speed.
- Check the mounting flanges are at least one-third the diameter of the wheel and relieved around the hole.

- Use the mounting blotters supplied with the wheels. (NB: A "blotter" is a paper ring that helps buffer mounting pressures between the wheel and the flange.)
- Ensure that the work rest is correctly adjusted. On off-hand grinding machines, work rests must be kept within 2mm of the wheel face.
- Always use a guard covering at least one-half of the grinding wheel.
- Allow newly mounted grinding wheels to run at operating speed (with the guard in place) for at least one minute before commencing grinding.

- **When first turned, on always stand to one side of the machine and not directly in front of it in case the wheel shatters.**
- Always wear safety goggles or an approved type of eye protection when operating the grinding wheel.
- Do not use a wheel that has been dropped.
- Do not use mounting flanges on which the bearing surfaces are not equal, clean or flat.
- Do not excessively tighten the mounting nut.
- Do not start the machine when the wheel guard is not in place.
- Do not stand directly in front of the wheel when the grinder is started.
- Do not grind material for which the wheel is not designed.
- Do not wear gloves when working close to the wheel.

Care and Storage of Grinding Wheels
The following details must be observed so that a grinding wheel will function safely and efficiently.

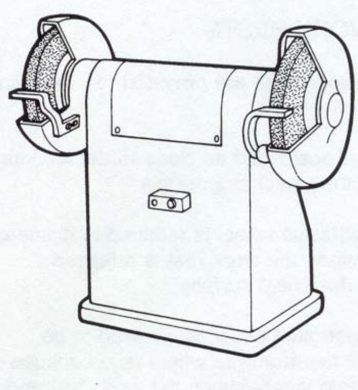
- During the handling, don't roll wheels or allow them to bump together. Keep them free from oil.
- Store wheels on edge, preferably in racks. They must be kept dry and not subjected to extreme pressure.
- Do not overload the wheel or repeatedly jab the wheel into the work.
- Do not make sudden or heavy loadings on the wheel, especially if the wheel is new or when starting work on a cold morning.
- Make sure that the wheel is dressed regularly. (Procedure shown below.)

Protective Equipment
- Wear suitable clothing such as close fitting overalls buttoned up to the neck.
- No loose sleeves or business ties.
- Safety goggles must be worn on all grinding operations.
- Wear safety boots/shoes.
- Wear hearing protection.

Types of Off Hand Grinding Machines
There are several types of machines used for off-hand grinding. Types include:

- Pedestal floor type
- Bench type
- Portable

Pedestal grinder
A pedestal or floor type grinder is a heavy duty machine grinder and consists of a heavy base supporting the drive motor. The main drive spindle is belt driven from the motor. There is usually an abrasive wheel mounted on each end of the spindle. The grinding wheels range up to around 300 mm diameter and 50 mm thick.

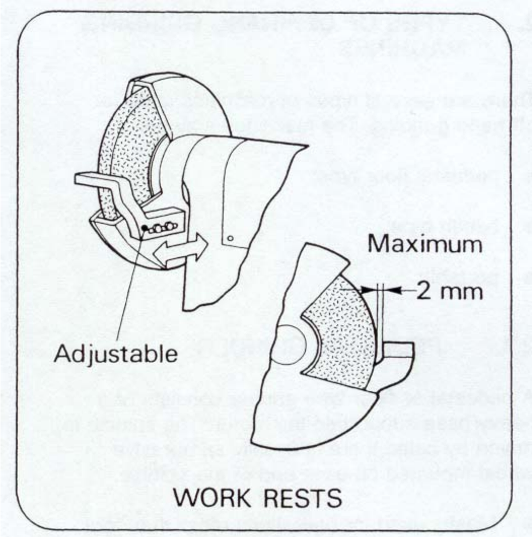


PEDESTAL TYPE GRINDER

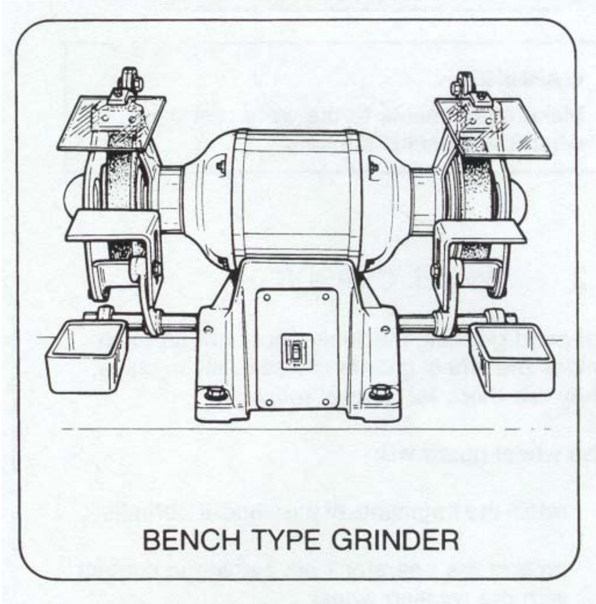
The machines have a roughing wheel at one end and a finer finishing wheel at the other end. The grit of the roughing wheel is larger than the grit of the finishing wheel, and the grade of the finishing wheel is usually a little softer.

Because the wheel must run at a surface speed of about 1700m/min there is always some risk of the wheel shattering. It is important, therefore, that the wheel be enclosed in a steel guard.

A pedestal grinder is mostly used for coarse operations rather than tool sharpening, although they can be used to sharpen larger tools such as drills etc.



Bench Grinder
A bench grinder is a light duty grinder which may be mounted directly on a work bench or on a vertical stand fixed to the floor. Abrasive wheels are fitted directly to the ends of the motor shaft. The grinding wheels range up to around 200 mm in diameter and about 25 mm thick. The bench grinder is mostly used for light grade tool sharpening.



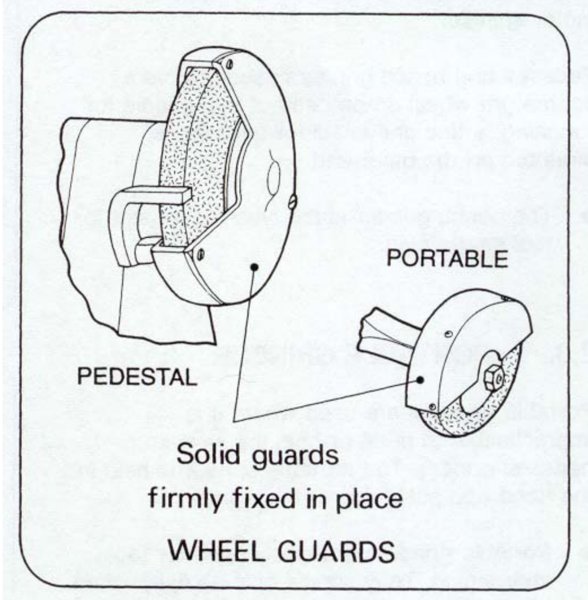
Grinder Work rests
Adjustable work rests are provided for steadying and guiding the work.

The “rest” should be positioned with a maximum gap **not more** than 2mm from the wheel surface. The top of the tool rest should be slightly **below** the horizontal centre line of the grinding wheel.

As an abrasive wheel is reduced in diameter due to wear, the work rest must be adjusted inwards towards the wheel surface.

Warning
Make adjustments to the work rest only when the wheel is stationary.

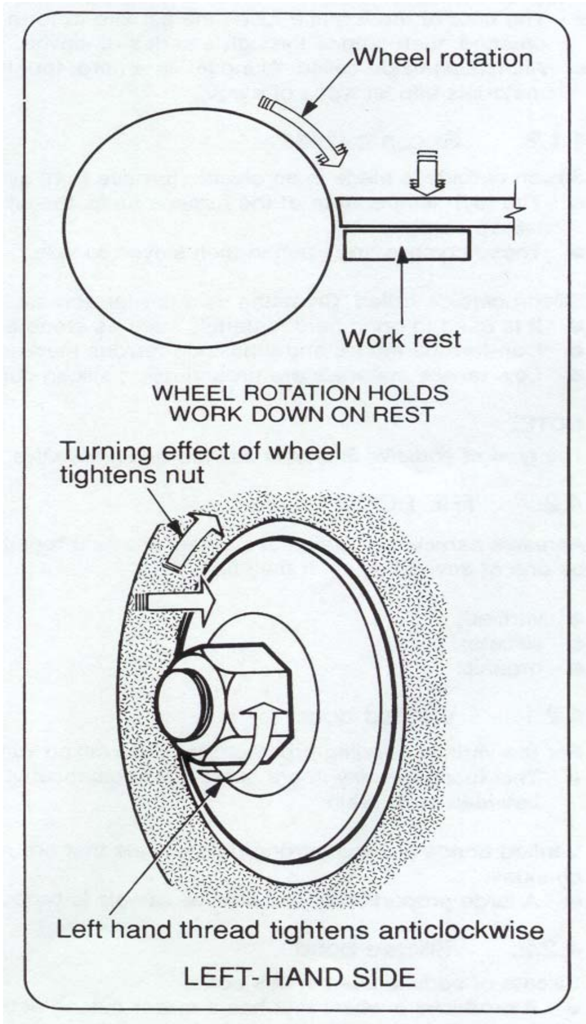
Wheel guards
Off-hand grinding machines must not be used unless the wheel guards are securely in place. They are there for several reasons, including:



- Retain the fragments of wheel if it breaks.
- Protect the operator from coming into contact with the rotating wheel.
- Prevent the fitting of a wheel that is to large for the machine’s capacity.
- Helps prevent accidental damage to a stationary wheel.

Wheel Speed
Manufacturers specify the **maximum** safe speed for all sizes of abrasive wheel. **Do not exceed this speed.**

Do not fit a wheel that is larger than the one designed to fit the machine nor increase the spindle speed. **This is** very **dangerous**. It will cause the wheel to run at a higher surface (peripheral) speed and it may fly apart.



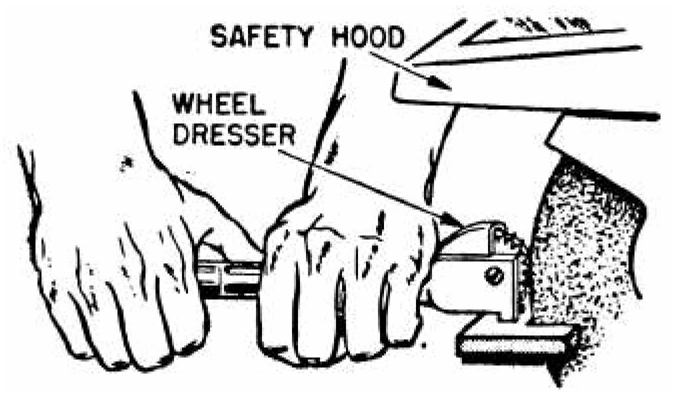
Wheel Rotation
The rotation of the grinding machine should be **downwards** towards the work rest.

The spindle rotation must always be such as to tighten the nuts holding the wheel. Stand facing the machine. The spindle on the left should have a left hand thread and the spindle on the right should have a right hand thread.
This will ensure that both nuts will be tightened by their respective blade rotation.

Truing and Dressing a Griding Wheel
Grinding wheels, like all other cutting tools, require frequent reconditioning of cutting surfaces to enable them to perform efficiently.

"**Dressing**" means to clean the periphery (front face) of grinding wheels. Cleaning breaks away any dull abrasive grains and smoothes the front face so that there are no grooves.

"**Truing**" means the removal of material from the cutting face of the wheel so that it runs "true" (rotates perfectly round) with the spindle axis.

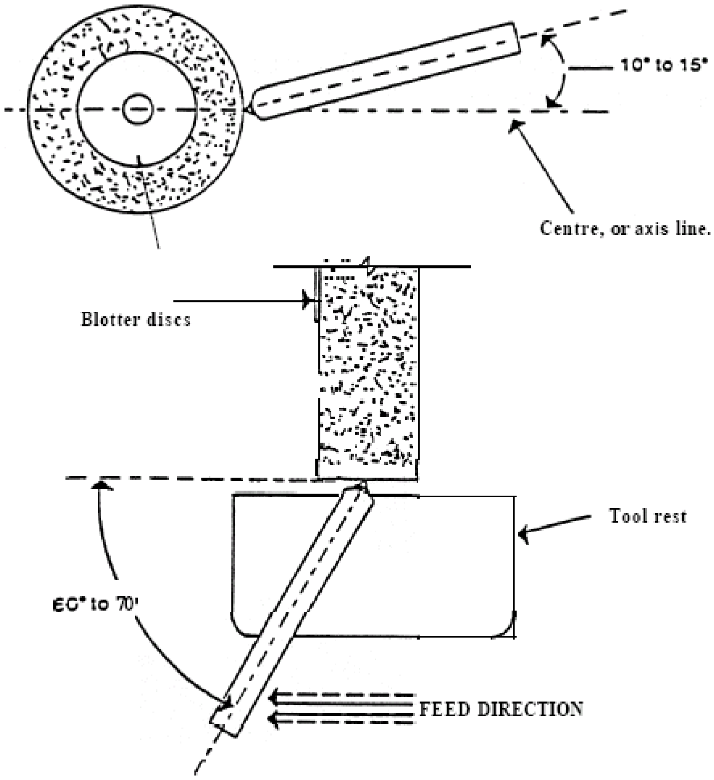


Dressing Tools
A "**revolving wheel**" type dresser is shown to the right.

To dress a wheel, run the grinder up to speed. Set the wheel dresser on the rest as shown and bring it in firm contact with the wheel. Move the dressing tool back and forth across the face of the wheel until the surface is clean and approximately square with the sides of the wheel.

A “**diamond dresser**” offers more precision than the revolving wheel type.

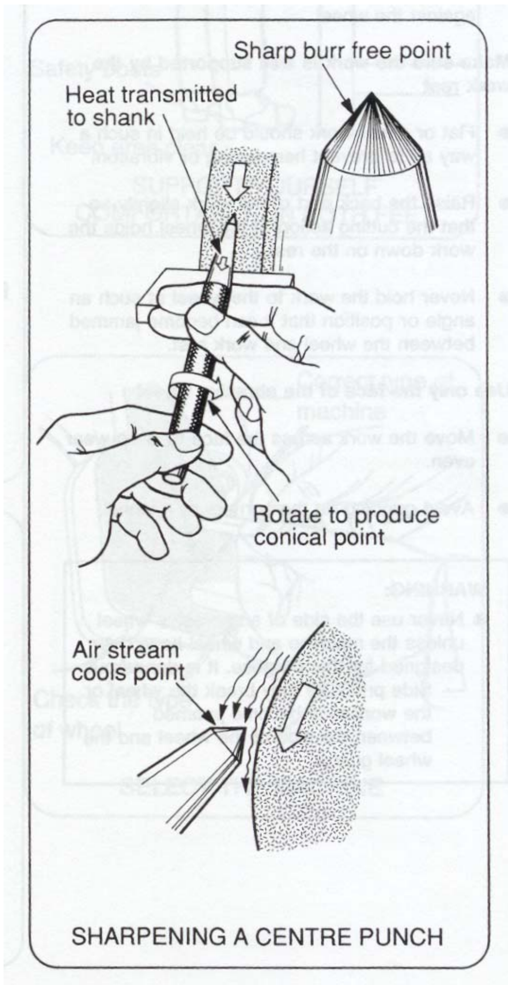
The wheel type dresser is normally pushed straight into the wheel to clear the face. In contrast, the diamond type dresser works best at a drag angle. When using the diamond dresser revolve it to retain its sharp point.



Hand Tool Maintenance
Tool sharpening is usually done on a smaller bench type grinder.

Safety Checks
- Visually check the condition of the wheel and work rest positions **before** starting the machine.
- Check all guards are fitted to the machine.
- Support yourself comfortably on both feet.

Sharpen Centre Punches and Scribers
- The grinding action of the wheel transmits any heat generated onto the solid part of the tool.
- Air flow carried around by the wheel is directed onto the cutting edge; this helps to prevent overheating.
- The grinding action is down onto the cutting edge to produce a burr free surface.

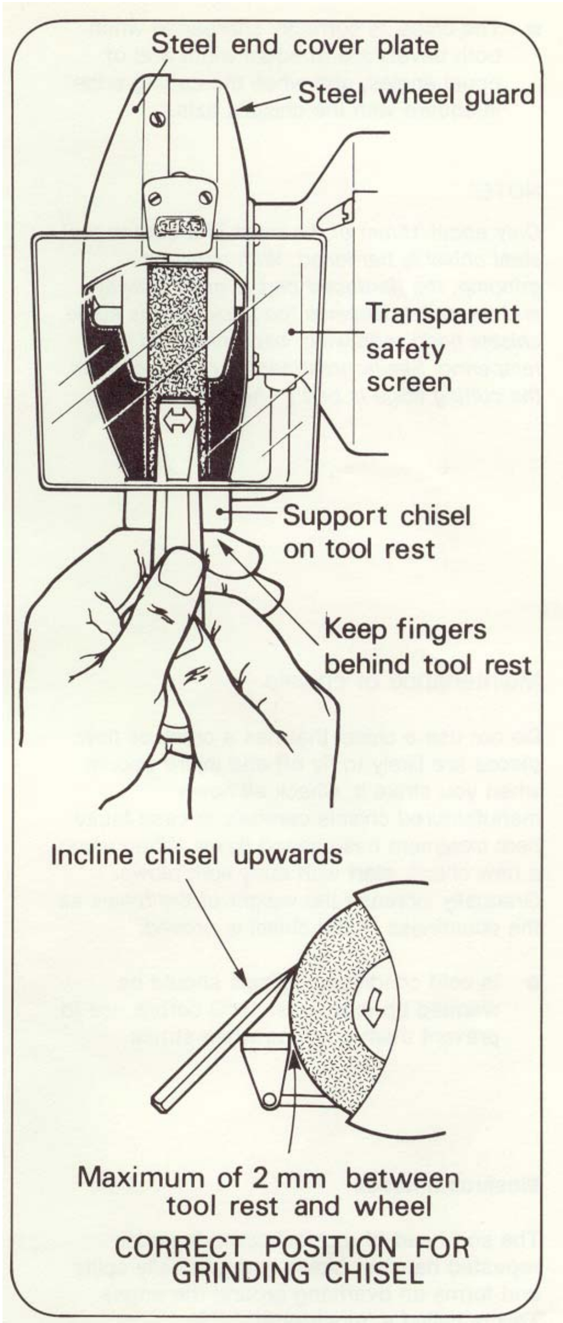


SHARPENING A CENTRE PUNCH

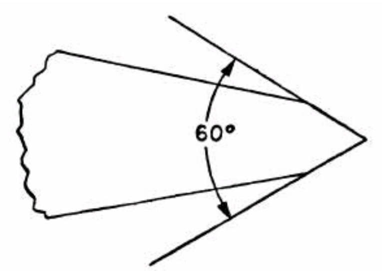
Sharpen Cold Chisels
Carbon tool steel chisels are normally sharpened by grinding. Care must be taken not to overheat the cutting edge or to remove more metal than is necessary.

Sharpen a cold chisel by grinding

- Wear a protective face shield or safety glasses and stand in a comfortable position to the front of the wheel.
- Hold the chisel firmly in both hands and lay it on the tool rest, keeping your fingers behind the tool rest.
- Incline the chisel upwards and bring it into contact with the grinding wheel to form an angle with the face of the wheel that is half the required cutting angle.
- Move the chisel slowly back and forth across the grinding wheel face. Quench the chisel in cool water when it becomes heated.
- Turn the chisel over and grind the second facet when the first is finished.



NB: The sketch below shows a general purpose cutting angle.



Safety: Off-Hand Grinder
DO NOT use this equipment unless you have been instructed in its safe use and operation and have been given permission.

PPE guidelines when working on a grinder


Safety glasses must be worn at all times in work areas.


Long and loose hair must be contained.


Hearing protection must be used.


Sturdy footwear must be worn at all times in work areas.


Close fitting/protective clothing must be worn.


Rings and jewellery must not be worn.

Pre-Operational Safety Checks
- Locate and ensure you are familiar with all machine operations and controls
- Ensure all guards are fitted, secure and functional. Do not operate if guards are missing or faulty.
- Check workspaces and walkways to ensure no slip/trip hazards are present.
- Ensure the wheels do not touch the work rest and that the gap between wheel and rest is no greater than 2mm.
- Check that the wheels are running true and are not glazed or loaded.
- Check for cracks in the wheel and report any you find.

Operational Safety Checks
- Stand to the side of the wheels when starting up.
- Let the wheels gain maximum speed before starting to grind.
- Only one person may operate this machine at any one time.
- Slowly move the work piece across the face of the wheel in a uniform manner.

Ending Operations and Cleaning Up
- Switch off the machine when work completed.
- Clean up and absorb any coolant spills immediately.
- Leave the machine in a safe, clean and tidy state.

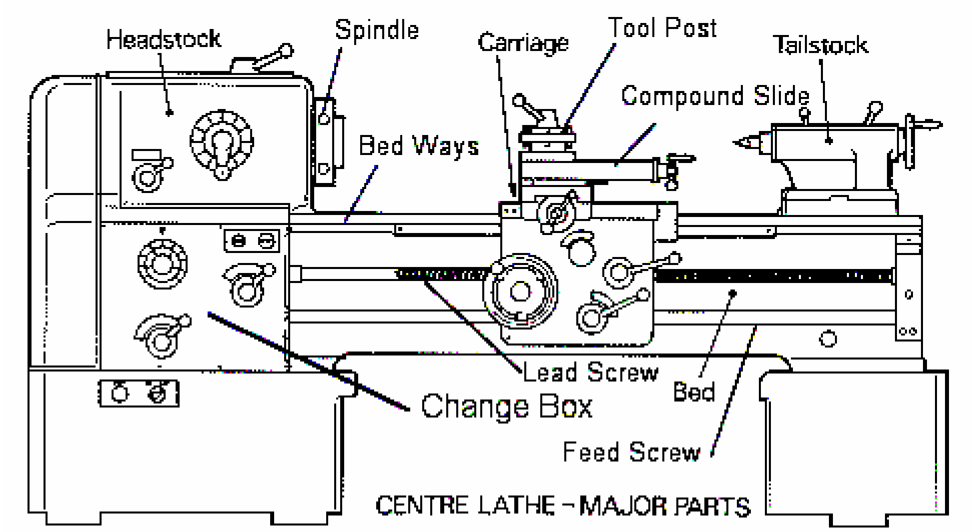
Potential Hazards and Injuries
- Hot metal.
- Sparks.
- Noise.
- Sharp edges and burrs.
- Hair/clothing getting caught in moving machine parts.
- Wheels ‘run on’ after switching off.
- Eye injuries.

Don’ts
- × Do not use faulty equipment. Immediately report any suspect machinery.
- × Do not hold work piece with gloves, cloth, apron or pliers.
- × Do not grind non-ferrous metals.
- × Do not grind on the side of the wheel.
- × Do not hold small objects by hand.
- × Never leave the machine running unattended.
- × Do not bend down near the machine while it is running.
- × Never force the work piece against a wheel.

Engineering Lathe
The main function of the engineering lathe is to hold and rotate the work piece to perform a machining operation. Machining operations include facing, turning, drilling, reaming, form threading, boring, knurling and more. The work material is securely held in an attachment to the rotating "spindle" such as a "chuck" or a "face plate". While the work piece is spinning a specially shaped cutting tool, which is attached to the "tool post", takes a precise cut across the surface of the work piece. In this way, the work piece is "machined" down to the required size.

This tool has many applications in the electrotechnology industry including "truing or skimming" the surface of a copper commutator or brass slip rings and also to machine electric motor shafts and bearings.

Main Parts of a Lathe
As shown in the image below, a lathe is comprised of a number of parts. The main parts that you should be aware of are listed below.



Bed: This is the base for the whole machine and supports the headstock, tailstock and carriage in alignment. The (normally) "Vee" shaped finely machined "tracks" on the bed are called the "ways" and these are used by the carriage and tailstock as a slide.

Headstock: This is clamped rigidly to the bed and holds all of the drive mechanisms (gears or pulleys) that turn the drive "spindle" and its attachments.

Headstock Spindle
This is the main drive line. The end of the headstock spindle is usually machined so that it can carry a faceplate, chuck, drive-plate, internal or external collets - or even special attachments designed for particular jobs. In turn, these attachments hold the work piece that is going to be machined.

Tailstock: This slides along the bed as required and holds a steel "centre" that supports the end of the rotating work piece.

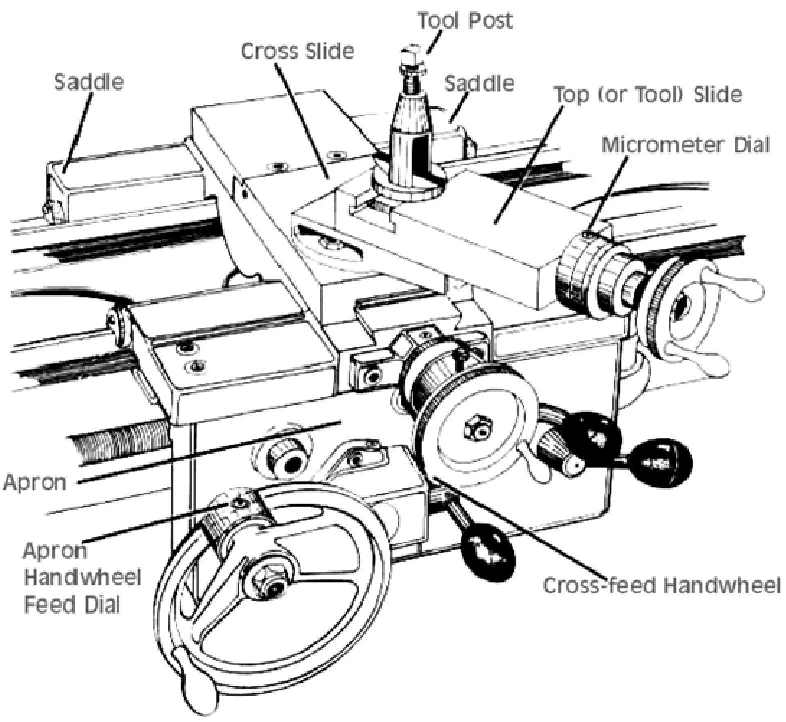
Carriage: The assembly of parts that slides up and back on the "ways". It is comprised of the "Saddle", front "Apron", "Top and Cross Slides". Carriage movement is controlled by the "lead screw". This is the threaded rod that runs the length of the lathe.

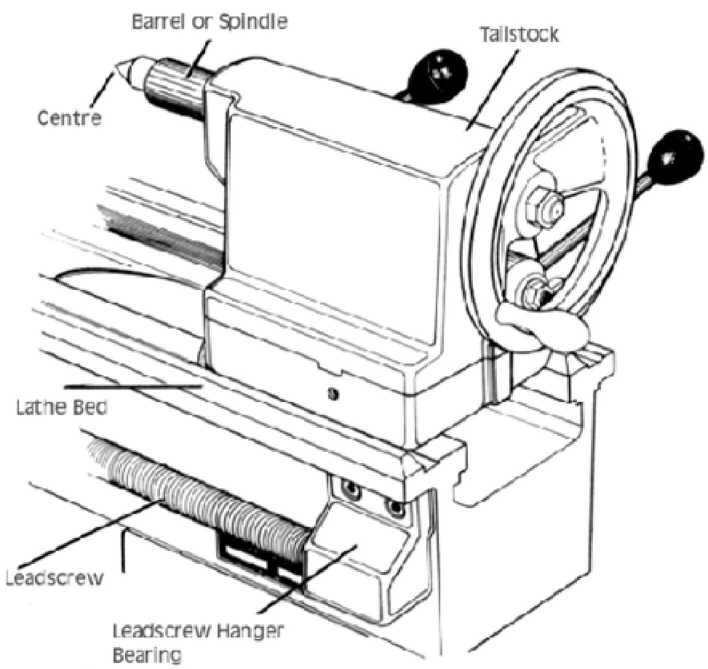
Saddle: This is the part of the "carriage" that fits onto the top of the bed and slides along on the "ways".

Compound Slide: Consists of the **Cross Slide** and **Top Slide.** The compound slide rest moves across the top of the "saddle" which in turns glides the length of the bed.

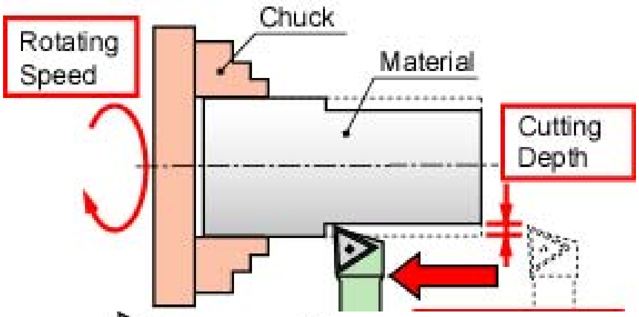
Tool Post: This is available in many designs and its role is to firmly hold the lathe cutting “tool”

Shown immediately below is a view of the “saddle”, “cross slide” and “tool slide”. The control wheels are used to accurately position the cutting tool against the work piece. The sketch at the bottom is of the “tailstock”. A “centre” inserted in the tailstock is used to support work material that extends a long distance out from the “spindle”.



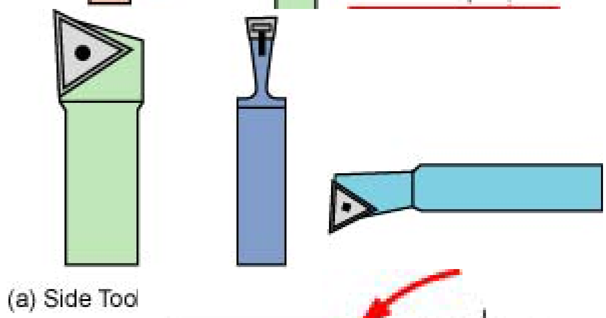


Basic Operation of a Lathe
The material to be machined is held in the "chuck" (three or four jaws) and rotated by the main drive motor which is threaded onto the "spindle". The rotational speed of the chuck is controlled either electronically or on older designs, by pulleys or gears.

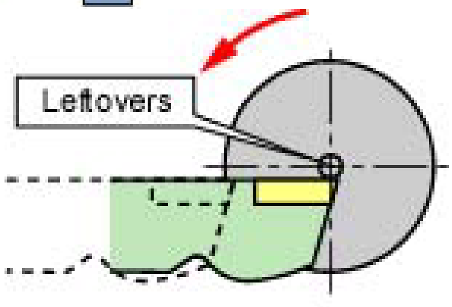


A specially shaped hardened steel "lathe tool" is held by the "tool post" which in mounted on the "top slide" mechanism. The "top slide" is in turn mounted onto the "cross slide" which in turn is mounted onto the "saddle".

Tools for a Lathe
There are various types of the cutting tools available. Three common types are shown to the right. (a) Side tool, (b) Cutting-off tool and (c) Boring bar.

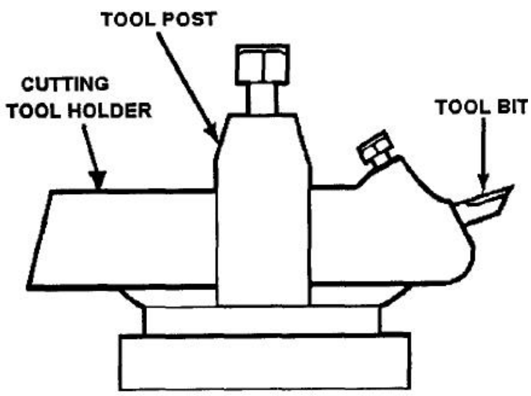


The lathe tool is adjusted so that the cutting tip is in line with the centre axis of material.



Cutting principle:

- The cutting edge is the intersection of two surfaces: the rake surface and the clearance surface.
- The rake surface is shaped and/or angled to provide an escape path which guides and forms the chip into a manageable shape as it leaves the cutting edge.
- The clearance surfaces enable the cutting edge to penetrate the work surface with a minimum of rubbing.



Tool Geometry
The shape of the cutting tool edge is an important factor in determining the cutting properties of a tool.

- The tool should be ground so that it is sharp enough to force its way into the work.
- It must also retain sufficient material behind the cutting edge to make the tool strong enough to withstand the pressure imposed upon it when cutting, and to dissipate the heat generated when cutting.
- The cutting operation the tool performs also determines its shape.
- The effectiveness of any metal cutting tool is determined by its normal rake and inclination.
- The tool or tool bit must be of the correct cross-section size to fit the tool holder you intend to use.

The material from which the tool bit is made is referred to as High Speed Steel. (HSS). Tool bits are usually produced in square section. Other shapes available are rectangle, round and come in a variety of sizes.

Lathe Safety
A lathe is potentially a very hazardous piece of machinery. It can rotate at a high speed, and due to its gearing, has a very high torque. The lathe operator is required to work very close to the cutting tip while the work piece is turning at high speed with few protective guards in place.

Safety: Metal Lathe
DO NOT use this equipment unless you have been instructed in its safe use and operation and have been given permission.

PPE guidelines when working on a Lathe


Safety glasses must be worn at all times in work areas.


Long and loose hair must be contained.


Sturdy footwear must be worn at all times in work areas.


Close fitting/protective clothing must be worn.


Rings and jewellery must not be worn.


Gloves must **not** be worn when using this machine.

Pre-Operational Safety Checks
1. Check workspaces and walkways to ensure no slip/trip hazards are present.
2. Locate and ensure you are familiar with the operation of the ON/OFF starter and Emergency Stop (if fitted).
3. Ensure all guards are in place.
4. Check that the job is clamped tight in the chuck.
5. Remove all tools from the bed and slides of the machine.
6. Ensure correct speed for machining process is selected.
7. Remove the chuck key **before** starting the lathe.
8. Do not try to lift chucks or face plates that are too heavy for you.
9. Faulty equipment must not be used. Immediately report suspect machinery.

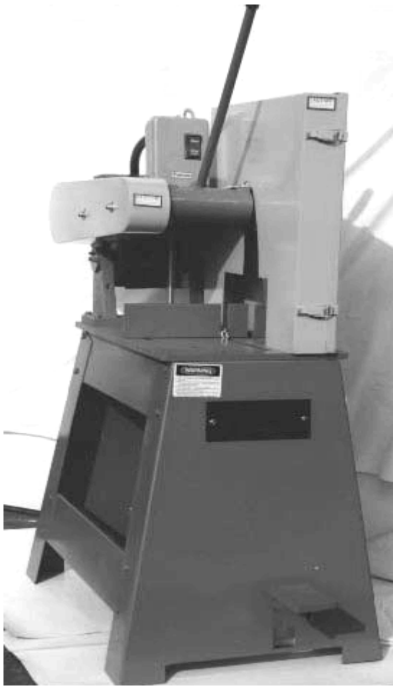
Operational Safety Checks
1. Never leave the lathe running unattended.
2. Before making adjustments or measurements switch off and bring the machine to a complete standstill.
3. Do not attempt to slow/stop the chuck or revolving work by hand.
4. Avoid letting swarf build up on the tool or job. Stop the machine and remove it.
5. Always remove the chuck key from the chuck.
6. Do not store tools and parts on top of the machine.

Lathe Maintenance
Switch off the machine and reset all guards to a fully closed position.
Leave the machine in a safe, clean and tidy state.

Potential Hazards
- Flying objects - chuck key left in chuck
- Cutting tool injury when cleaning, filing or polishing
- Rotating machine parts - entanglement
- Metal splinters/swarf
- Eye injuries

Don'ts
- × Do not use faulty equipment. Immediately report suspect machinery.
- × Do not try to lift chucks or face plates that are too heavy for you.

- ✗ Never leave the machine running unattended.
- ✗ Do not attempt to slow or stop the chuck or revolving work by hand.
- ✗ Do not attempt to "**feel**" the work piece while it is spinning.
- ✗ Do not leave equipment on top of the machine.



Abrasive Saw
An abrasive "cut-off: saw cuts material by means of a high-speed thin abrasive wheel. It can cut most materials to close tolerances including, glass, ceramics, and many metals (but not aluminium, zinc or other soft metals).

The blade makes straight cuts only and is used to "dock-off" stock materials.

The abrasive wheel on this type of machine is the same type that can be fitted to circular saws and angle grinders. This saw does not use liquid coolant.

Safety: Abrasive Saw
DO NOT use this equipment unless you have been instructed in its safe use and operation and have been given permission

PPE guidelines when working on an Abrasive Saw

Safety glasses must be worn at all times in work areas.

Long and loose hair must be contained.

Hearing protection must be worn.

Sturdy footwear must be worn at all times in work areas.

Close fitting/protective clothing must be worn.

Rings and jewellery must not be worn.

Pre-Operational Safety Checks

- Locate and ensure you are familiar with all machine operations and controls.
- Ensure all guards are fitted, secure and functional. Do not operate if guards are missing or faulty.
- Ensure the saw is properly secured to a worktable by bolts/clamps at approximately hip height.
- Ensure the saw is operated on an RCD (residual Current Device) protected circuit.
- Use abrasive cut off wheels with the correct size "arbor" hole.
- Use abrasive cut off wheels with a maximum safe operating speed greater than the "no load RPM" marked on the machine's nameplate.
- Inspect the cut off wheel for chips and cracks.
- Check workspaces and walkways to ensure no slip/trip-hazards are present.
- Ensure the depth stop is properly adjusted.
- Keep table and work area clear of all tools and off-cut material.

Operational Safety Checks

- Ensure all adjustments to machine are secure before making a cut.
- Use the vice to clamp the work and properly support the over-hanging portion of the work piece level with the base of the machine.
- Allow the machine to reach full speed before contacting the work piece.
- Ease the abrasive disc against the work piece when starting to cut.
- Keep hands away from the blade and cutting area.
- After finishing the cut, release the switch, hold the saw arm down and wait for the disc

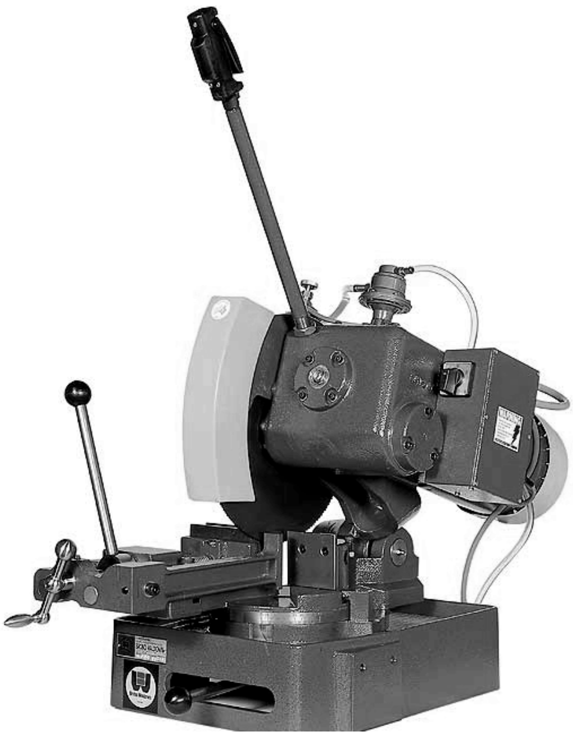
to stop before removing work or off-cut piece.
- Before making any adjustments, disconnect the plug from the power source and bring the machine to a complete standstill.

Cleaning Up
- Remove foreign material from in and around ventilation openings and switch levers.
- Leave the machine in a safe, clean and tidy state.

Potential Hazards and Injuries
- Metal sparks.
- Noise.
- Sharp metal burrs.
- Contact with rotating disc.
- Eye injuries.
- Burns from hot work pieces.

Don'ts
- ✗ Do not use faulty equipment. Immediately report suspect equipment.
- ✗ Do not grind on the side of abrasive cut off wheels.
- ✗ Do not cut wood or wood products.
- ✗ Do not hold a work piece by hand, as it will become very hot while being cut.
- ✗ Do not use a length stop on the free off-cut end of a clamped work piece.
- ✗ Do not have any part of your body in line with the path of the abrasive disc.
- ✗ Do not force the tool into a cut.
- ✗ Do not attempt to remove cut material while disc is moving.

Cold Saw
A cold saw cuts with a slow-speed blade. It is a true chip-forming action like a milling cutter unlike the high-speed abrasive saw above. Small machines use blades from 200mm diameter to cut light sections. Large machines are capable of cutting up to 600mm square stock.



They are of a swing frame type where the blade and drive is pivoted and manually pulled down into the work. Provision is sometimes made for the blade to be tilted or the vice swivelled, or both, for angular cutting.

The blade is sharpened to eliminate the jamming effect of the thickening chip in the cut. Alternate teeth are chamfered and the un-chamfered have a smaller diameter.

Liquid coolant is pumped through a hose and directed onto the blade when cutting takes place.

The blade makes straight cuts only and is used to "dock-off" stock materials.

Safety: Cold Saw
DO NOT use this equipment unless you have been instructed in its safe use and operation and have been given permission

PPE guidelines when working on a Cold Saw

 Safety glasses must be worn at all times in work areas.

 Long and loose hair must be contained.

 Hearing protection must be worn.

 Sturdy footwear must be worn at all times in work areas.

 Close fitting/protective clothing must be worn.

 Rings and jewellery must not be worn.

Pre-Operational Safety Checks

- Locate and ensure you are familiar with all machine operations and controls.
- Ensure all guards are fitted, secure and functional. Do not operate if guards are missing or faulty.
- Check workspaces and walkways to ensure no slip/trip hazards are present.
- Ensure saw blade is in good condition.
- Check the operation of the work vice.
- Check coolant delivery system to allow for sufficient flow of coolant.

Operational Safety Checks

- Ensure the work piece is securely held in the work vice.
- Support overhanging work. Signpost if it presents a hazard.
- Listen for any unusual noises during the sawing process.

Ending Operations and Cleaning Up

- Switch off the machine when work completed.
- Before making adjustments or before cleaning swarf accumulations, switch off and bring the machine to a complete standstill.
- Clean up and absorb any coolant spills immediately.
- Leave the machine in a safe, clean and tidy state.

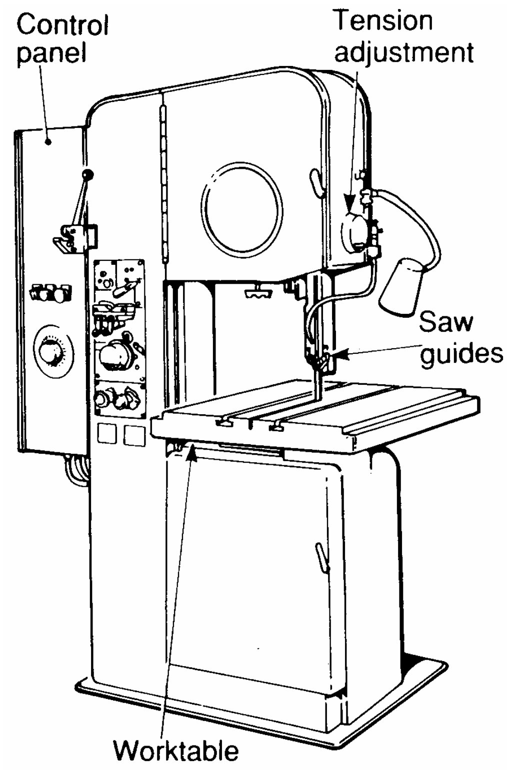
Potential Hazards and Injuries

- Possible skin irritation from coolants.
- Eye injuries.
- Sharp edges and burrs, metal splinters.
- Noise.

Don'ts

× Do not use faulty equipment. Immediately report suspect equipment.
× Do not cut very small items.
× Do not cut materials other than metal.
× Never leave the machine running unattended.
× Never force the saw into the work piece. Use a slow and even feed rate.

Vertical Band Saw



A vertical band saw can be used for docking off stock material, but its main use is in cutting curved shapes due to the narrow blades that can be fitted.

Each blade is one continuous piece. New replacement blade material is purchased in a roll. Each new blade must be custom-made. To form a new blade the material is first cut to length and the ends are tapered for joining. The two ends are then braised together by a special seam/butt welder. A custom designed “saw band welder” and a “blade grinder” is normally attached to the front side of the machine.

The table is horizontal and the blade is driven downwards forcing the material being cut, downwards onto the table surface. (ie: Blade teeth downwards.

The operator’s hands control the work piece and safety is a high priority when using this type of machine.

Safety: Band Saw
DO NOT use this equipment unless you have been instructed in its safe use and operation and have been given permission

PPE guidelines when working on a Band Saw

 Safety glasses must be worn at all times in work areas.

 Long and loose hair must be contained.

 Hearing protection may be required.

 Sturdy footwear must be worn at all times in work areas.

 Close fitting/protective clothing must be worn.

 Rings and jewellery must not be worn.

Pre-Operational Safety Checks

- Locate and ensure you are familiar with all machine operations and controls
- Ensure all guards are fitted, secure and functional. Do not operate if guards are missing or faulty.
- Check workspaces and walkways to ensure no slip/trip hazards are present.
- Ensure push stick is available.
- Lower the blade guide and guard to full effect.
- Start the dust extraction unit before using the machine.

Operational Safety Checks

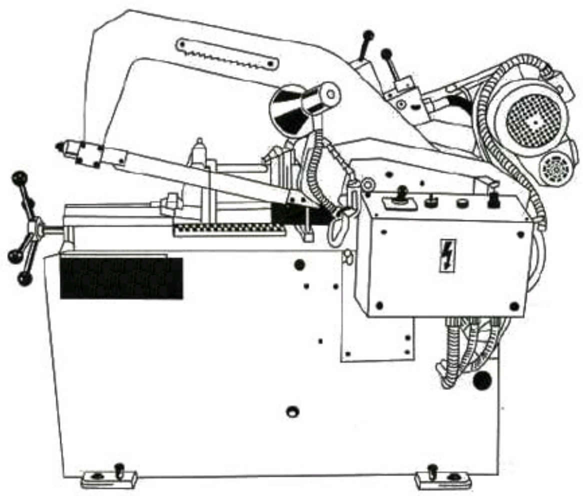
- Keep hands away from the blade and cutting area.
- Feed the work piece forward evenly and hold it firmly on the table to ensure effective control during cutting, while keeping hands in a safe position.
- Use a push stick when feeding material past the blade.
- Before making adjustments, switch off the saw and bring the machine to a complete standstill.
- Stop the machine before attempting to back the work away from the blade.
- Stop the saw immediately if the blade develops a ‘click’. Report it to your supervisor.

Ending Operations and Cleaning Up

- Switch off the machine when work completed.
- Reset all guards to a fully closed position.
- Leave the machine in a safe, clean and tidy state.

Don'ts

- ✗ Do not use faulty equipment. Immediately report suspect machinery.
- ✗ Attempt to cut very small items.
- ✗ Cut cylindrical or irregular stock.
- ✗ Never leave the machine running unattended.
- ✗ Do not force a wide blade on a cut of small radius. Use relief cuts when cutting sharp curves.

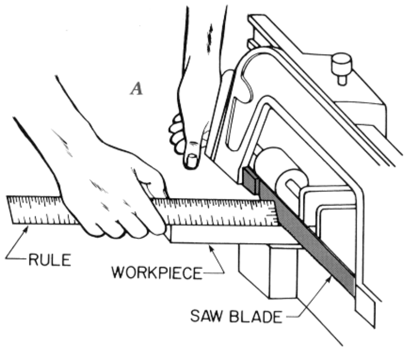


Power Hacksaw
Ref: http://www.itlind.co.in/hacksaw-machine.htm

Most power hacksaw machines are similar in design to that shown to the right. They are designed to cut heavy stock bar.

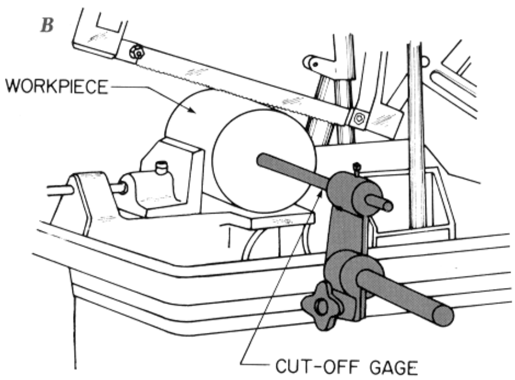
The base contains a coolant reservoir and a pump for conveying the coolant to the cutting surface. There is an adjustable vice (some designs can swivel) located on top of the base to secure the stock material.

The size of a power hacksaw is determined by the largest piece of stock material that can be held in the vice and sawed.



A heavy steel (cast) frame supports and tensions the hacksaw blade which contacts the work piece on the cutting stroke only. The frame "lifts" on the outwards stroke and cuts on the draw or back stroke. This design prevents unnecessary wear on the saw blade. The blades teeth should point forward on the cutting stroke.

Some machines feed by gravity, the saw frame having weights that can be shifted to give greater or less pressure on the blade. Other machines are power fed with the feed being adjustable. On these machines, the feed is usually stopped or reduced automatically when a hard spot is encountered in the material, thus allowing the blade to cut through the hard spot without breaking.



When cutting more than one work-piece it is possible to set a bar stop. The material is set to the stop saving the need to measure each part.

Blades
Power hacksaw blades differ from hand hacksaw blades in that they heavier, longer, and have fewer teeth per inch. Hacksaw blades are discarded when they become dull; sharpening is not practical.

Common pitches for power hacksaw blades range from 4 to 14 teeth per inch.

Soft materials require a coarser blade to provide adequate spaces between the teeth for removal of chips. Hard material requires a finer blade to distribute the cutting pressure to a greater number of teeth, thereby reducing wear to the blade. At least three teeth must be in contact with the work piece at all times or the blade will snag on the work piece and break teeth from the blade.

Safety: Power Hacksaw
DO NOT use this equipment unless you have been instructed in its safe use and operation and have been given permission

PPE guidelines when working on a Power Hacksaw


Safety glasses must be worn at all times in work areas.


Long and loose hair must be contained.


Hearing protection must be worn.


Sturdy footwear must be worn at all times in work areas.


Close fitting /protective clothing must be worn.


Rings and jewellery must not be worn.

Pre-Operational Safety Checks
- Locate and ensure you are familiar with all machine operations and controls.
- Ensure all guards are fitted, secure and functional. Do not operate if guards are missing or faulty.
- Check workspaces and walkways to ensure no slip/trip hazards are present.
- Ensure the material is tightly clamped in the work vice.
- Check coolant delivery system to allow for sufficient flow of coolant.

Operational Safety Checks
- Support overhanging work and signpost if it presents a hazard.
- Ensure no one stands in front of the saw when it is started.
- Keep clear of moving machine parts.
- Direct coolant onto blade before starting cut.

Ending Operations and Cleaning Up
- Switch off machine when work completed.
- Before making adjustments or before cleaning swarf accumulations, switch off and bring the machine to a complete standstill.
- Leave the machine and work area in a safe, clean and tidy state.

Potential Hazards and Injuries
- Reciprocating saw arm.
- Metal splinters.
- Sharp edges and burrs.
- Hair/clothing getting caught in moving machine parts.
- Eye injuries.

Don'ts
- × Do not use faulty equipment. Report suspect machinery immediately.
- × Do not cut very small items.
- × Do not cut material other than metal.
- × Never leave the machine running unattended.

Safety
Always report a faulty machine to your supervisor.
Remember to always isolate the machine before changing belts or blades etc.

T5 Drills and drilling encompassing:

- types of drills used in the electrotechnology industry
- sharpening twist drills
- drilling metallic and non-metallic components
- safe use of a bench drill

Drills and Drilling Techniques

Safety
No matter what kind of drilling machine you are about to use, your body must be protected from injury by using the following equipment:

- Safety glasses,
- Work type pants and shirt made from industrial quality material,
- Industrial quality work boots or shoes with steel toe caps,
- A hair net if you have long hair,
- Ear muffs if you are working in a high noise level area.

Hazards
Drilling machines can be dangerous so you must observe safety precautions and watch out for the following:

- sharp swarf particles,

NB: The term "**Swarf**" refers to the shavings and chips of metal debris resulting from metalworking operations. Also, the term "**Kerf**" refers to the width of the cut, groove or incision made by some type of saw or blade.

- the work piece spinning because there is not enough clamps used on the job for the size of the cutting forces,
- loose clothing or hair becoming entangled in the rotating spindle,
- dermatitis from the cutting fluids being used,
- burrs on drilled holes.

Additional advice to avoid injuries

- Do not wear gloves while using a drilling machine. The gloves may become caught and drag your hand into the cutter.
- Never try to remove tangled swarf from the cutting tool while it is still revolving. Always stop the machine and then use pliers to remove the swarf. **NOT YOU'RE HANDS.**
- When changing the spindle speed via the belt and pulley make sure that the machine cannot be suddenly started to avoid fingers getting nipped between belt and pulley.
- To avoid damage to the cutting tool and possible breakage, make sure that the work has a suitable clamping arrangement to prevent the work piece from coming loose.

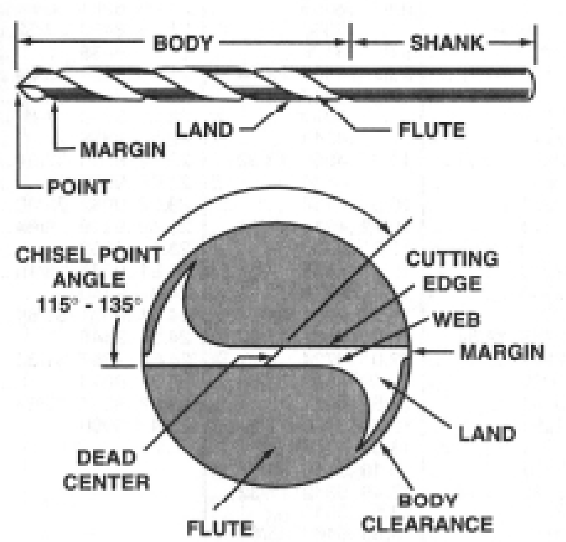
Twist Drill (or Drill Bit)
Drills and bits likely to be encountered in the electrotechnology industry are:

- Twist drill,
- Masonry drill,
- Auger bit,
- Spade bit.

A "**twist drill**" is a tool used to make cylindrical holes in solid materials. The word "drill" can be confusing as it may also refer to either the "**drilling machine**" itself or the "**drill bit**" which is inserted into the drilling machine.

A twist drill consists of a cylindrical piece of hardened steel with two spiral grooves called "**flutes**". The "**body**" is the penetration length of the drill.

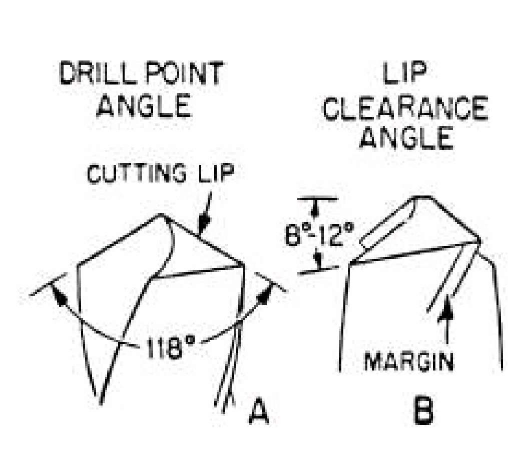
One end of the drill is pointed while the other end (called the shank) is shaped so that it may be secured tightly by the drilling machine.



The "**point**" of a drill is the entire cone-shaped surface at the end of the drill and the "**dead centre**" is the sharp edge at the extreme tip of the "point". This is formed by the intersection of the cone-shaped surfaces of the point and should always be in the exact centre of the axis of the drill.

The "**web**" is the metal wall, running the entire length of the body, which separates the flutes and forms the backbone of the drill. The web's thickness increases towards the shank end.

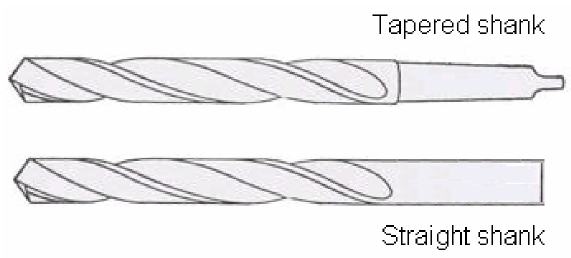
The two "**lips**" or cutting "**edges**" (one for each flute) are sharply ground. The "**lip clearance**" of a drill is the surface of the point that is ground away or relieved just back of the cutting edge.



The thin strip along the inner edge of the body is called the "**margin**". The distance across the two "margins" represents the full diameter of the drill and this extends the entire length of the flute. The diameter of the margin at the shank end of the drill is designed to be slightly smaller than the diameter at the point. This feature allows the drill to revolve without binding when drilling deep holes.

The "**shank**" is that part of the twist drill which fits into the "**spindle**", or "**chuck**" of the drilling machine or "**drill press**".

Different drill shank types are manufactured. "Straight" shank drill are used for diameters up to about12mm.



Straight shanked drills are normally held in a "drill chuck".

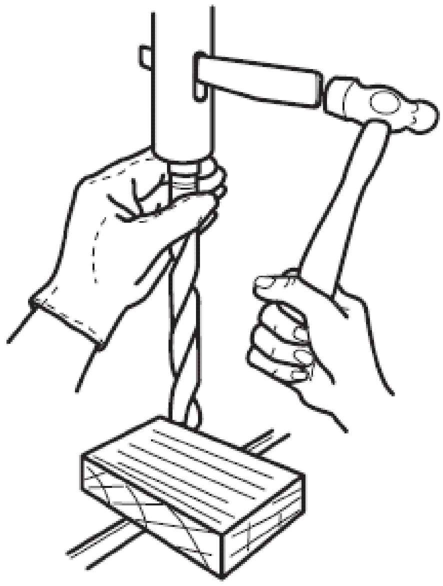
Standard three jaw chucks are tightened with a "chuck" key.

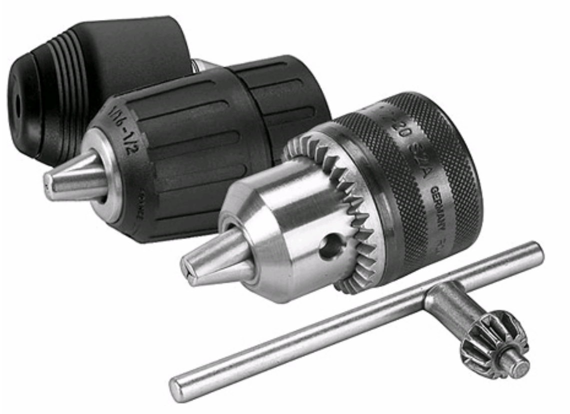
"Keyless chucks" are tightened by hand, requiring a "flick" of the wrist to tighten and undo.

Large diameter drills commonly have a standard "**Morse**" taper shank. The Morse taper fits into a matching taper inside the drilling machine's **spindle**.

The flattened section at the very bottom of the Morse taper is called the "**tang**". It is used to remove the drill from the spindle of the drill press. To insert a Morse taper drill bit, first place it into the spindle hole of the drilling machine, twisting and pushing upward until it is snug. Place a block of wood on the table and force the tapered bit point against the wood until the bit is firmly positioned into the spindle.

To remove the "tapered shank" drill from the spindle. Place a timber block under the drill so that it cannot fall too far. (No greater than 25mm) Then force a tapered steel bar through the spindle hole to wedge onto the tang. (Shown to the right)





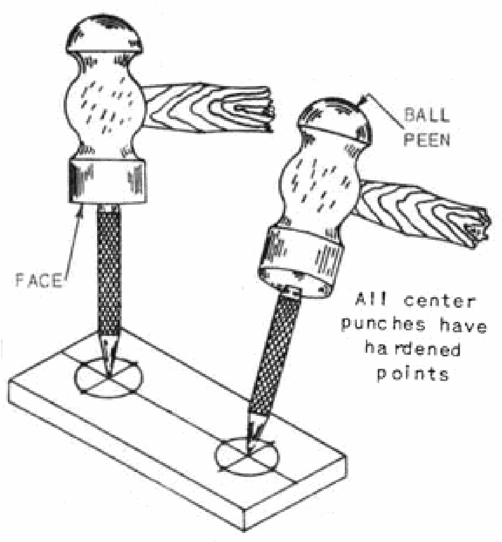
Drill Sizes
Twist drills are made in various sizes from about 1mm up to about 75mm in diameter.

They are manufactured using a range of materials depending on the substances to be drilled. High speed steel (HSS) drill types can be used to drill metal, hardwood, plastics etc.
Ref:
http://www.machinemart.co.uk/shop/product/details/cht383-19pce-cobalt-steel-drill-bit-se

Using Drill Bits
When drilling metals, there are several steps to be followed. First, always mark the exact location of the hole with a scribed **cross**. A marked "dot" will instantly disappear as the drill starts turning and you will have no way of knowing that you are still on course.

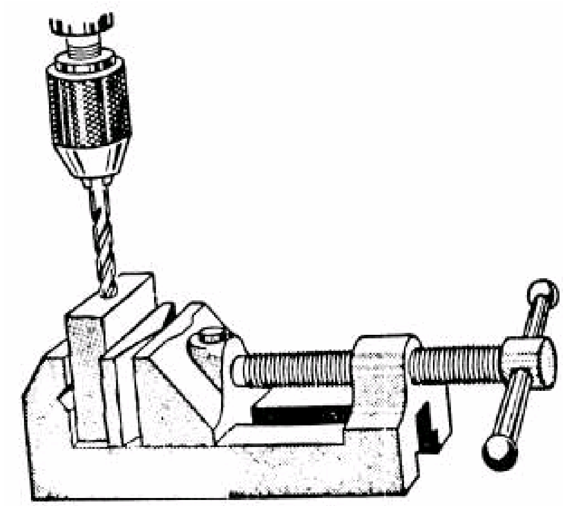
The crossing point is then marked with a centre punch indent. The punch mark forms a small seat to locate the drill point, thus ensuring accuracy.

Without the punch mark, the drill may have a tendency to "**wander off**" its intended location before it begins to cut.



Twist Drill Speed
Select the correct cutting speed and appropriate cutting "lubricant". The "Correct drilling speed is very important as it prevents the drill from over-heating. As shown in the table below, drilling speed criteria is based on the size of the drill and the type of work material. Generally, larger diameter drills require a lower cutting speed.

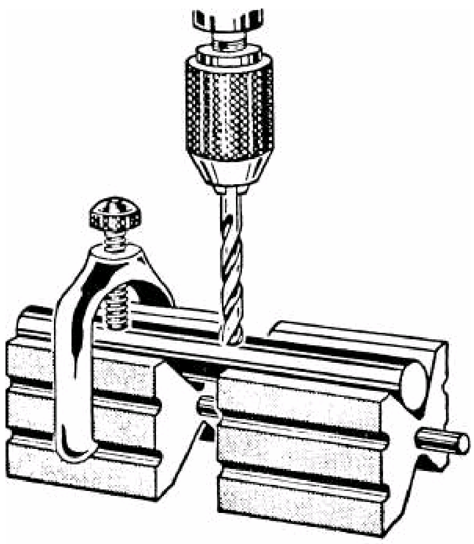
Operating speeds (RPM)							
Accessory	Softwood	Hardwood	Acrylic	Brass	Aluminium	Steel	Shop Notes
Twist drill bits*							
1mm - 5mm	3000	3000	2500	3000	3000	3000	Lubricate when cutting steel. Use centre punch on all holes to prevent drill from wandering.
6mm - 10mm	3000	1500	2000	1200	2500	1000	
11mm - 16mm	1500	750	1500	750	1500	600	
17mm - 25mm	750	500	NR	400	1000	350	

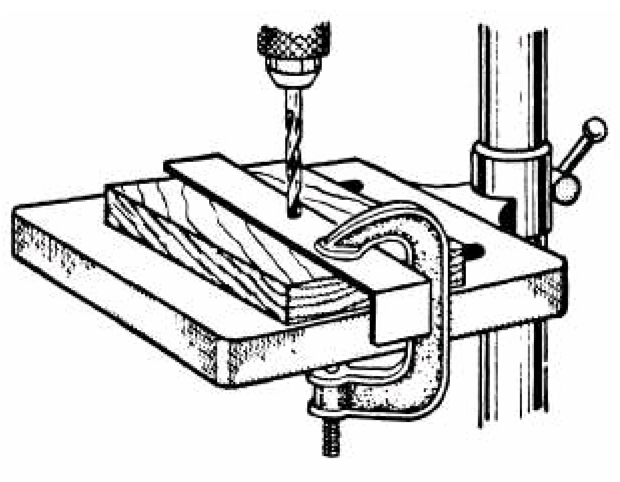


Holding the Work Piece
For safe drilling operation, the work piece must be held firmly by some mechanical means such as a machine vice, or "V" block and clamps. Be sure to also securely fasten the machine vice or v-block to the drill press table.

Pilot Holes
A "pilot hole" is a much smaller diameter initial hole, which is drilled prior to drilling the final hole. The advantage of a pilot hole is that it reduces drilling forces around the centre of the hole and it should also lead to a more accurately positioned hole.

The effectiveness of a pilot hole is dependant on the size of the pilot relative to the larger twist drill size that will follow. As a rule-of-thumb, the diameter of pilot hole should be about **one-quater** of the diameter of the final hole.





Drilling Process
The drilling process is pointless unless you have the “drill mark” in the correct position.
Always remember; “**measure twice and drill once**”.

1. Ensure you have correctly marked out the hole (with a cross). Now check it again!
2. Centre-punch the desired location of the hole.
3. Use dividers to scribe a circle inside the final size of the hole.
4. Set-up the job on the drill table.
5. Secure the job to the drill table or vice
6. Ensure neither the table nor the drill vice can move under the force of the drill.
7. Drill a pilot hole first. (Any drill size above about 6mm should have a pilot hole)

Note: The pilot hole is made to ensure that the final hole is on the “mark”. It is quite difficult to centre a large diameter drill bit on a small centre punch mark. The pilot hole also reduces the load on the drill bit. (For very large final drills, use staged pilot holes).

8. Ensure that the drilling speed is correctly set.
9. Gently lower the drill and allow the bit to cut. (If too much force is required, then the drill is not sharp enough).
10. Raise the drill and ensure that the cone drilled thus far is centred correctly. (If the cone is not centred then, using a chisel, place a groove on the side that the drill needs to be closer to. This process can be repeated).
11. Complete the hole, raising the bit as required to remove swarf.

Always apply pressure on a line which goes straight through the axis of the drill. (Side pressure will only enlarge the hole and can break the drill.) Keep the drill steady and apply enough pressure to keep it cutting. Too much pressure will overload the motor and too little pressure will merely cause the drill to "polish" instead of cut. This will quickly “dull” the cutting edges of the drill. You will know the pressure is correct when the drill “bites” continuously without overloading the drill motor.

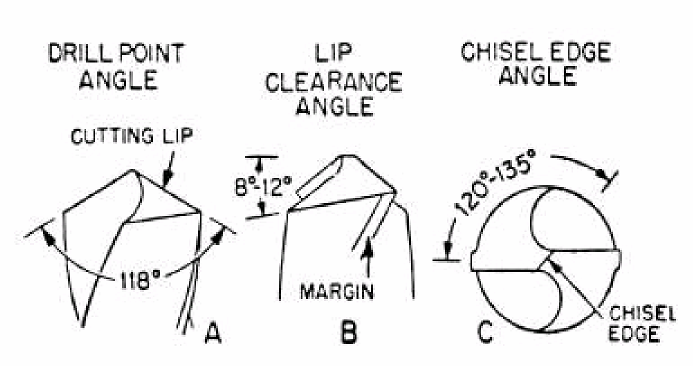
Lubricant and Cutting Fluids
Drilling generates heat and as a result, the drill tip may be overheated. (Blue point!) Lubrication is often required to reduce the friction caused by drilling. Excessive heat build up can cause distortion of the hole or the material being drilled and/or cause permanent damage to the cutting edges of the drill bit. Lubrication increases the life of the drill by preventing overheating. The cooling also prevents the work piece from warping due to over-heating. The coolant minimizes friction which reduces heat buildup and allows the heat to better flow away from the job and the drill bit. Cutting lubricants are typically needed for steel and wrought iron, but, cast iron, aluminium, brass and other soft metals may be drilled dry. The lubrication list below suggests suitable lubricants.

Lubrication Chart

Metal	**Fluids**
Aluminum Alloys	Kerosene, lard oil, soluble oil
Brass/Bronze	Dry/ Kerosene, lard oil, soluble oil for deep holes
Magnesium Alloys	Mineral lard oil, kerosene or dry
Copper	Mineral lard oil and kerosene, soluble oil or dry
Mild Steel	Mineral lard oil
High Tensile Steel	Soluble oil
Stainless Steel	Soluble oil
Titanium	Soluble oil
Plastics	Soapy water
Hard Rubber	Dry

Warning: Cutting fluids have been associated with skin rashes, dermatitis and some serious diseases. Care should be taken to avoid inhaling any vapours or mist resulting from the use of cutting fluids and precautions should be taken to avoid skin contact.

Sharpening a Twist Drill for Steel and Aluminium



All twist drills eventually become blunt after continued use. Therefore, it is necessary to sharpen the drill point and cutting lips.

To sharpening a twist drill, you will require a suitable bench grinder with a fine “flat” abrasive wheel. Access to coolant will ensure that the drill tip does not overheat and soften as it is sharpened.

Note the two key angles depicted in the illustration above.

- Drill point angle = 118^o
- Lip Clearance angle = 8 to 12^o

Manual sharpening in this way is an exacting technique to master and requires <u>much</u> practice.

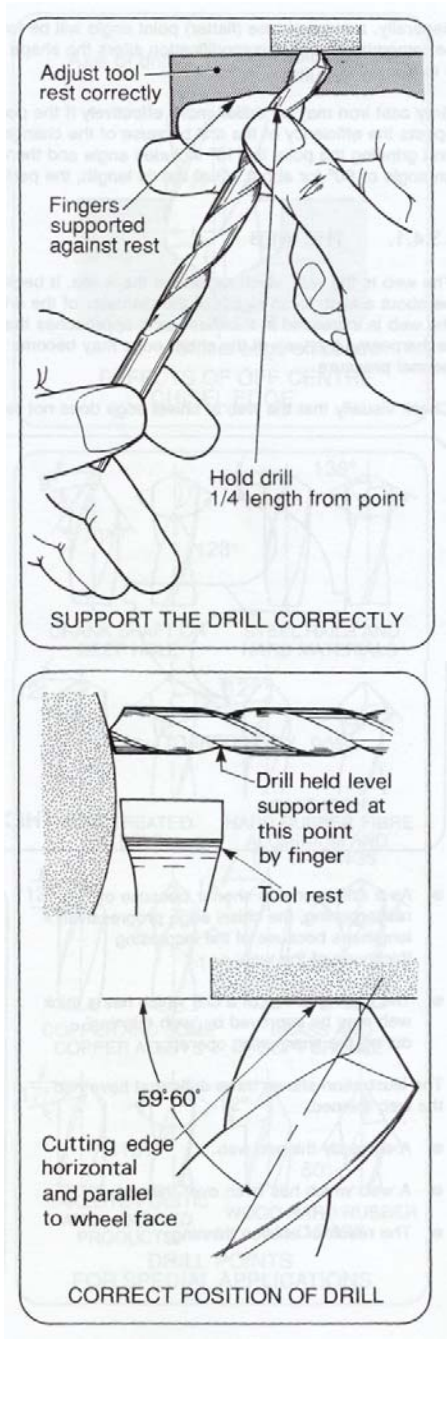
Drill diameters in the range from about 8 to 10mm are generally the easiest size bits to manipulate and you should select a drill bit in this range when practising the sharpening technique.

The following criteria are of greatest importance when grinding in twist-drills:

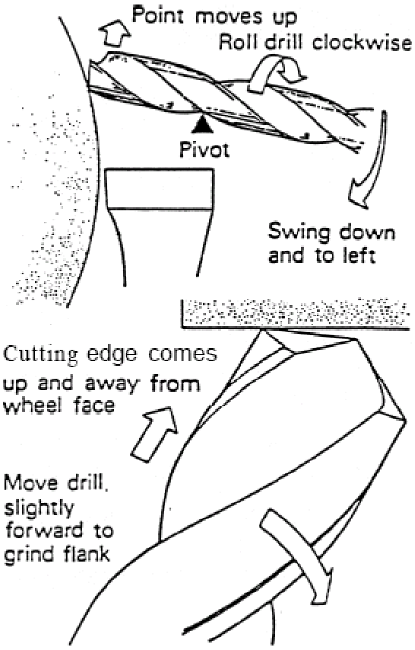
- Create equal and correctly sized drill-point angles,
- Create equal length cutting lips,
- Create correct clearance angle behind the cutting lips, and correct chisel-edge angle.

To successfully sharpen a twist drill on a bench grinder use the following method:

- Wear a well fitted pair of safety glasses.
- Stand in a comfortable position with the feet about 400mm apart. Stand in front of the machine and slightly left of the grinding wheel.
- Hold the drill at about one-quarter of its length from the point, between the thumb and first finger of the right hand.
- Support the hand on the tool rest with the other fingers.
- Hold the shank of the drill between the thumb and fingers of the left hand.
- Keep both elbows against your sides.
- Position yourself by moving your feet so that the drill makes an angle of 59º to 60º to the wheel face.

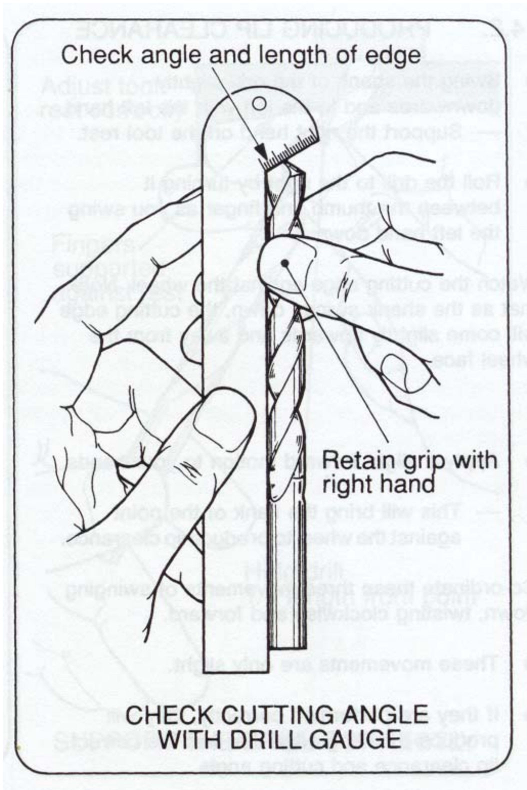


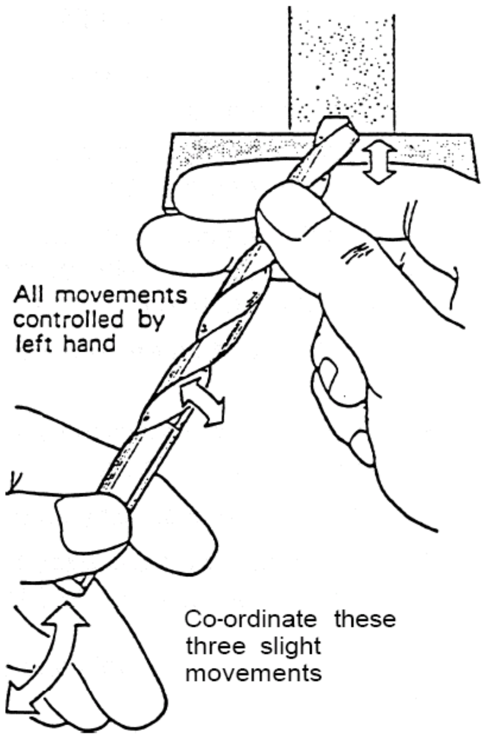
- Hold the drill level. Twist it until one cutting edge is horizontal and parallel to the wheel face.
- Swing the shank of the drill slightly downwards and to the left with the left hand. Support the right hand on the tool rest.
- Roll the drill to the right by turning it between the thumb and finger as you swing the left hand down.
- Watch the cutting edge against the wheel. Note that as the shank swings down, the cutting edge will come slightly upwards and away from the wheel face.
- Sharpen the second cutting edge using the same amount of drill movement as before.
- When these actions are carried out carefully, the drill will be sharpened with equal cutting angles.
- Check these angles with a drill gauge.



NB: The three key criteria to be used when "sharpening" twist drills are:

1. **"Equal drill-point angles,**
2. **Cutting lips of equal length,**
3. **Correct clearance behind the cutting lips".**

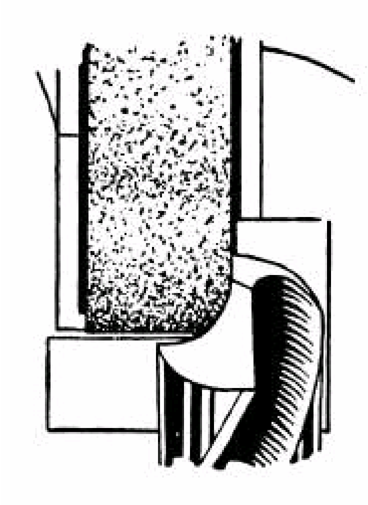




Sharpening a Twist Drill suitable for Drilling Brass or Perspex
Ref: http://www.listoftools.com/grinding_operations/sharpening_twist_drill_drilling_brass.html

If a drill bit that has been sharpened to cut "steel" is then used to drill "**brass**", it will tend to grab viciously and lock the spindle of the drilling machine. This can be very dangerous and could cause injury to the drill operator.

To prevent this, the cutting tips of the drill need to be modified slightly. To grind a drill tip suitable for drilling brass, hold the cutting lip against the right side of the wheel as shown in the sketch to the right.



NB: It is **not** normally recommended that the side of the "wheel" be used for grinding. But, for this application only, the pressure exerted on the wheel is so light, that it should not cause a problem.

Very gently grind the flute slightly flat, in line with the axis of the drill. This greatly reduces the included angle of the cutting lip. This will give the drill a scraping action, necessary for brass, rather than the cutting action used for steel. This scraping action will significantly reduce the likelihood of the drill grabbing when drilling brass stock.

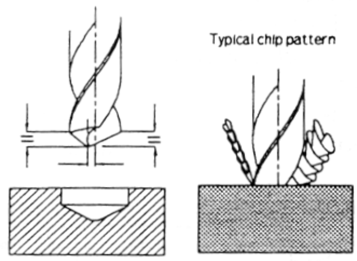
NB: Once the drill has been "backed off" in this fashion to suit "brass", it cannot be used to drill "mild steel" in this form. Typically, a small number of drill bits are sharpened in this fashion and are then retained solely for drilling "brass".

Drilling Perspex
The drill bit sharpened as above to suit "brass" can also be used to drill holes in "Perspex sheet". This material is very "brittle" and highly susceptible to grabbing and shattering.

A drill with the face "backed off" in this fashion scrape through the Perspex.

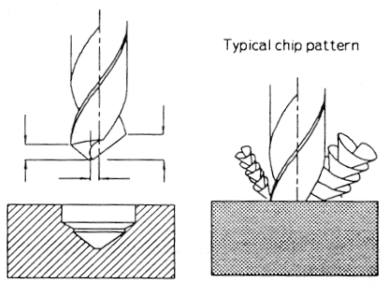
Important: To further reduce the probability that the drill will grab and crack when drilling "Perspex", always use a fresh piece of "timber" packing material immediately behind the Perspex and in line with the axis of the drill. When drilling multiple holes, always relocate the packing piece to a "fresh" area for **each** "new" hole to be drilled.

Possible Faults Due to Incorrect Drill Sharpening



- Lip lengths unequal, lip heights unequal, drill point off centre.

  Result: Oversize hole, uneven swarf from each flute, reduced cutting efficiency.

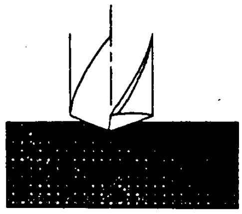


- Unequal angles (chisel edge off centre) lip heights equal.

  Result: Oversize hole, uneven swarf from each flute.

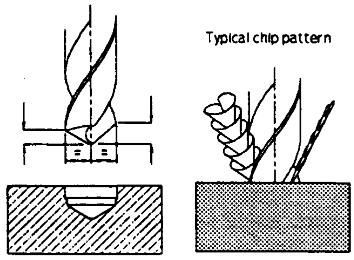
- Lip clearance insufficient

  Result: The drill will rub on the heel of the drill



- Lip clearance excessive.

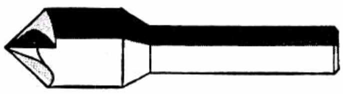
  Result: This will weaken the cutting edge



- Unequal angles, lip heights unequal

  Results: Hole oversize, stepped diameters, uneven swarf from the flutes.

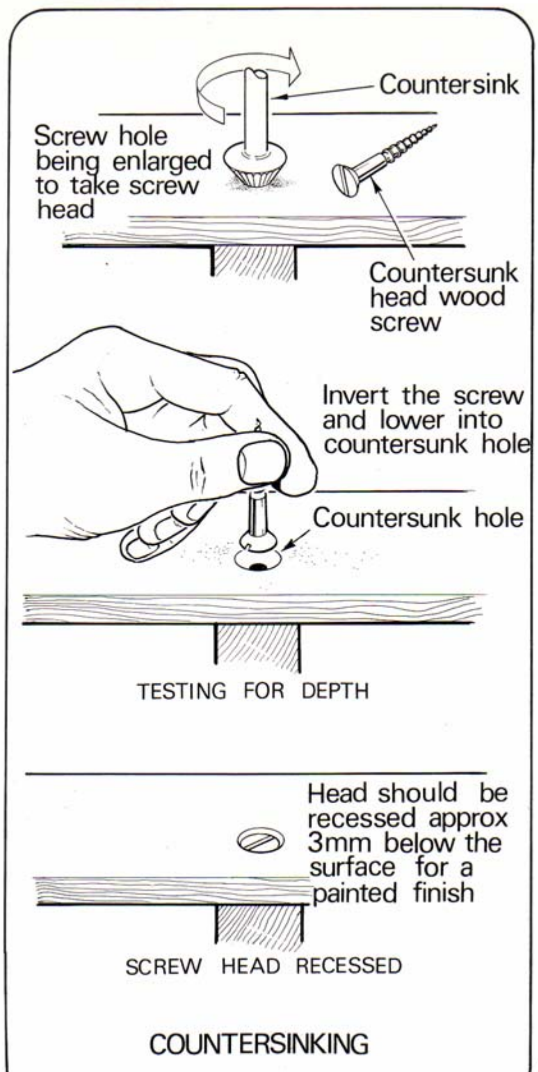
Countersink Bit
This tool is sometimes called a "rose drill" and is used to set a screw head flush or slightly below the surface of the materials being secured. The bits range in size from 10 to 25mm and they come in a variety of shank sizes.



Some types are suitable for timber only, while others can be used on either timber or metal. The bit shown is suitable for metal and has four cutting edges, which are taper ground, to the angle marked on the body.

When using this tool, remove only enough metal to set the screw or rivet head flush with the material. If you remove too much material the top of the hole will enlarge and weaken the work.

Preparing Work for Drilling
The location of a hole is marked by the intersection of two centre lines. To ensure that the hole is drilled in the prescribed position the intersection point of the centre lines is prick punched and a circle, equal in diameter to the required hole, is drawn with the point of intersection of the centre lines as its centre. Then mark with a prick punch the four points where the two centre lines cut through the circle. Finally, mark the centre of the circle more heavily with a centre punch so the drill point will have an easier starting spot.

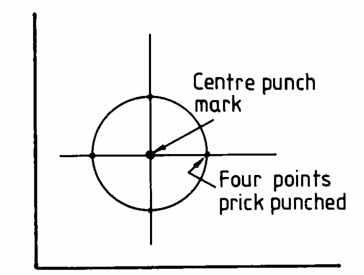


COUNTERSINKING

Centre Drill

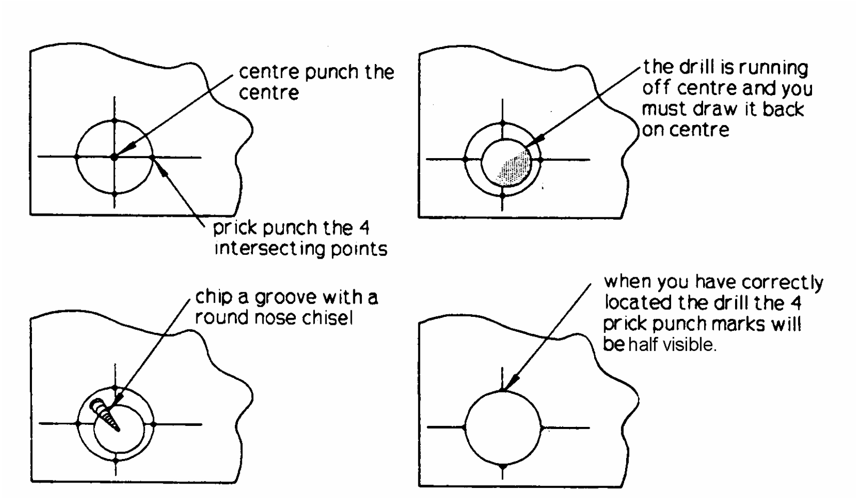
This specialised tool can create a very accurate starting centre hole in the face of a job. Centre drills are usually double ended types with a 60 degree stepped point.

Because of the stepped design they are very rigid and do not wander "off-centre" like a standard twist drill is prone to do. It is common practice to start a hole with a centre drill, and then use a pilot hole and then the final drill bit.



Drawing a Drill Back on Centre

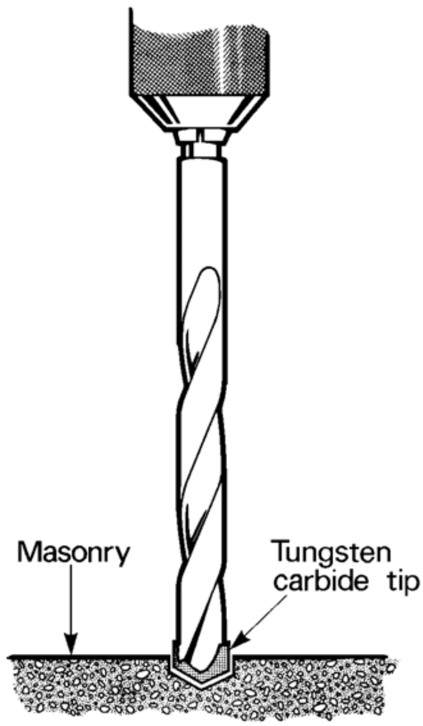
By taking care when setting up and by using correctly sharpened drills you can minimize the tendency for a drill to wander off centre. Nevertheless, surface hard spots and irregularities sometimes cause the hole to start off-centre.



If the drill has wandered, the fault can be corrected by chipping a groove on the side towards the direction the drill has to move with a round nose chisel, or even a centre punch can be used. The cutting force can now push the drill over into the groove and back on centre. It may be necessary to repeat this procedure several times.

This correction procedure should be started when the drill has entered about half way down the point. It must be finished **before** the body of the drill enters the work piece because once the drill is cutting to its full diameter it's not possible to make any further corrections.

Masonry Drill



These drills have a cutting tip of tungsten carbide that allows them to drill all forms of masonry materials.

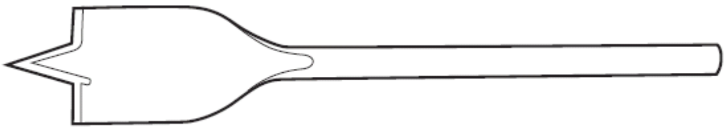
They are designed for use with a drilling machine equipped with a rotary impact/hammer drilling action.

Applications

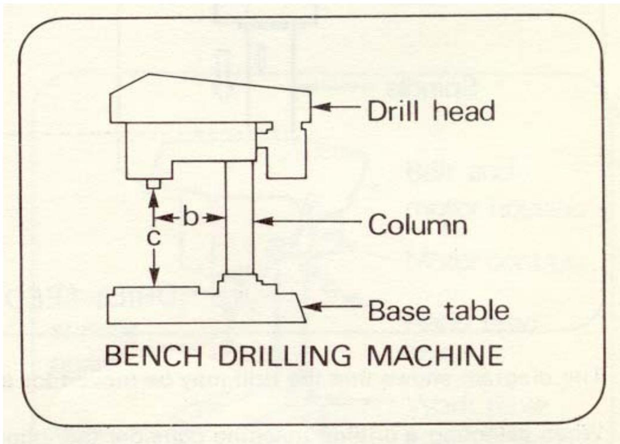
- Drilling ceramic tiles to secure a socket outlet.
- Drilling brickwork for plugs to secure an outside light fitting, weatherproof switch etc.
- Drilling concrete to secure motors or other machines.

Note: Do not use drills in the impact mode on hollow or brittle materials. eg. ceramic tiles.

Spade bit
A spade bit is commonly used by electricians to drill through parts of the timber frame of houses when roughing out. Sometimes long extension pieces are added to the spade bit to enable it to extend down from the top plate to drill through a "horizontal" noggin to enable a cable to be installed in a panelled wall. This type of bit has either a round or hexagonal shank and is used with an electric drill.

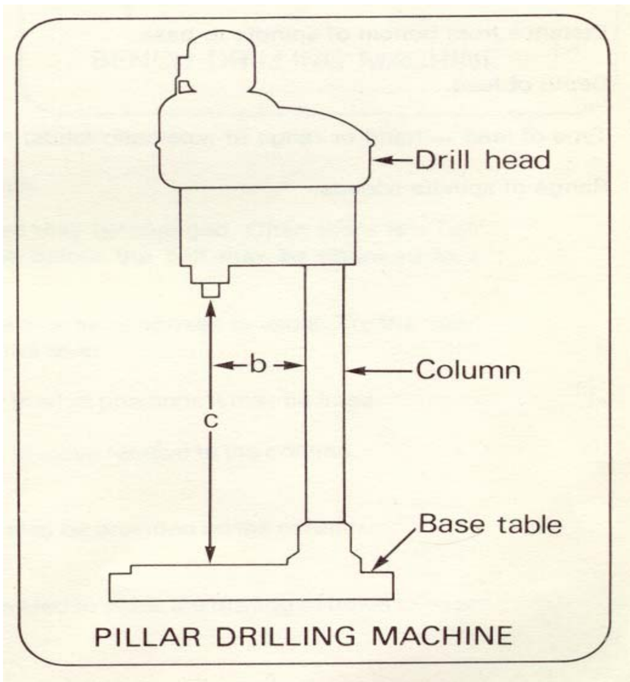


Fixed Drilling Machines
Workshops have various types of fixed drilling machines. The type of machine used for a job depends on the size of the drill to be used and the physical dimensions of the work piece to be drilled.



As shown to the right, key considerations are the throat depth measurement ("b") which limits the distance from the edge of the work piece to the centre of the hole and the vertical height measurement ("c") which limits the height of the object to be drilled plus the length of the drill bit.

Note that the main advantage of the "pillar" machine shown right is the drill height that it offers.

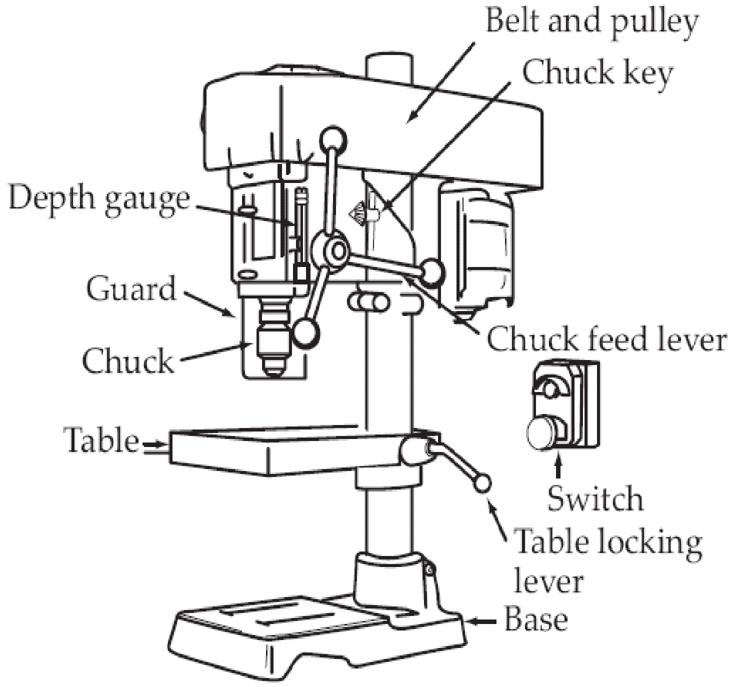


Common drilling machines available in workshops are:

- **Bench or Pedestal Drill**
- **Pillar Drill**
- **Radial Arm Drill**

Always select the most suitable drilling machine for a given task as it makes the task, much easier, more accurate and much safer!

Bench Drill
(Also called Pedestal Drill)
A typical pedestal drill is shown to the right. It is used for small scale drilling tasks. The size of the work piece is limited in both depth and height.

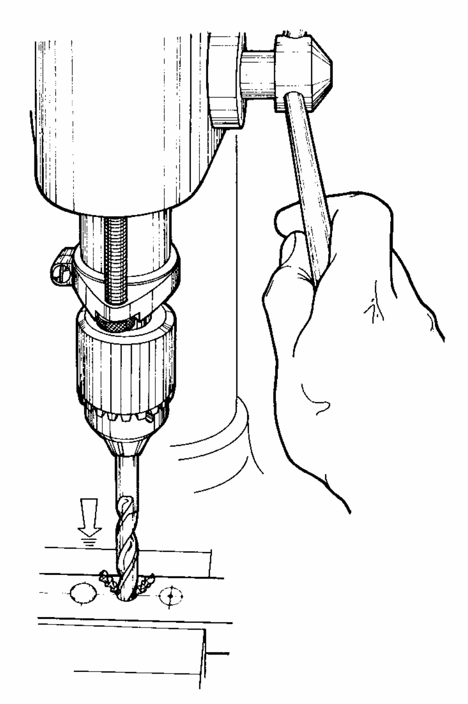


This design is usually belt driven via two pulleys. The spindle speed ranges from a few hundred revolutions per minute to a few thousand.

As a rule-of-thumb, the larger the drill bit diameter, the lower the rotational speed. If in doubt about a drill speed setting, always err on the low speed side.

This drilling machine is hand fed via the “chuck feed lever”. It is made more sensitive by balancing the weight of the spindle by means of a return spring.

The main advantage of a “fixed” drill over a portable drill is its ability to keep the drill bit “plumb” (right angle) to the material surface. This very difficult to achieve when using a portable drill.



Machine Characteristics
Motor Controls: Normally this type of machine is a simple “start-stop” push button control.

Full control details are given by standard **AS60204.1-2005 Safety of machinery - Electrical equipment of machines - General requirements**

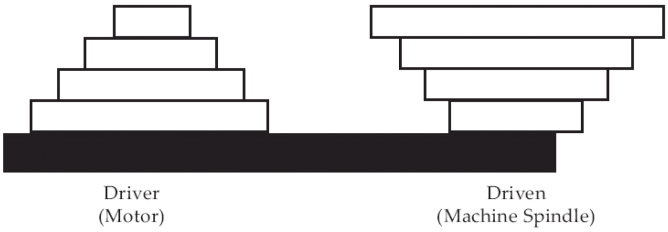
Safety Features: The design always includes a guard covering the drive belts and pulleys and emergency **mushroom** style stop button typically located in a position where it can be easily tripped.

Speed Control: Vertical drills mostly use stepped pulleys to alter the rotation speed of the bit. The required rotation speed is chosen by moving a V belt up or down on the pulleys.

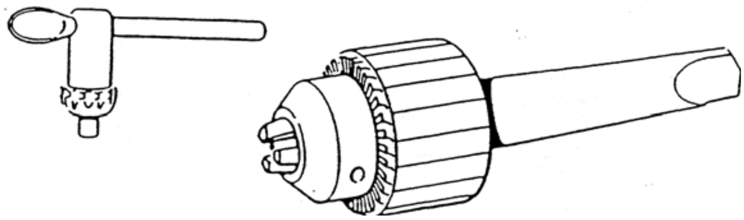
To obtain the slowest rotation speed, use the smallest pulley at the motor end and the largest pulley at the drill spindle end.

Changing Speeds

1. Ensure the power is isolated before commencing any speed adjustment.
2. Open the belt guard.
3. Unlock the belt tension knob, this usually allows the motor to move toward the spindle.
4. Shift the belts to obtain the required rotation speed. It is important to ensure the belts are running in line with the pulleys.
5. Move the motor away from the spindle to obtain the desired belt tension and lock the belt tension knob.
6. Close the belt guard.
7. Reinstate the power supply.
8. Test drill a hole in scrap material for correct rotation speed and correct belt tension.
9. If the speed is incorrect or if the belts are slipping repeat the above procedure.



Chucks: Most bench drills have as standard a three-jaw chuck secured by a "Morse" taper. To fit a straight shank drill bit, hand-tighten the chuck down to the bit size then use the chuck key to tighten it securely.



NB: The key only needs to be placed in <u>one</u> key hole only to tighten all three jaws.

Keyless Chuck: If frequent bit changing is necessary, a keyless chuck as shown right, is the preferred type to use. This design is tightened by hand and requires a flick of the wrist to undo. They tend to be hard to undo if they have been under load when driving a large bit.

Pedestal drill chucks have a straight shank drill bit capacity up to about 13mm, but, if the chuck is removed then the spindle itself will typically hold a larger diameter tapered shank drill.

But, never exceed the manufacturer's drill capacity size.

Ref: http://www.powertoolsdirect.com/rohm-keyless-chuck-rv-1-2inch-20-steel-single-sleeve

Holding the work
It is extremely important that the work piece is held securely to the machine table when drilling. There are various methods used including table stops, vice and direct clamping.

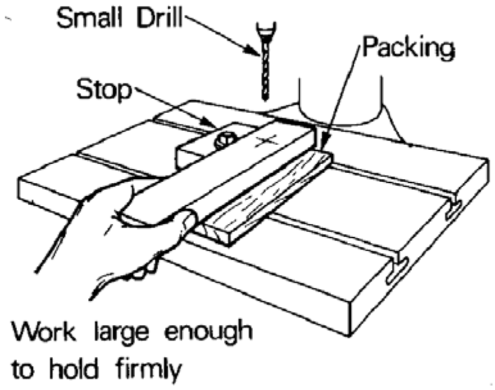
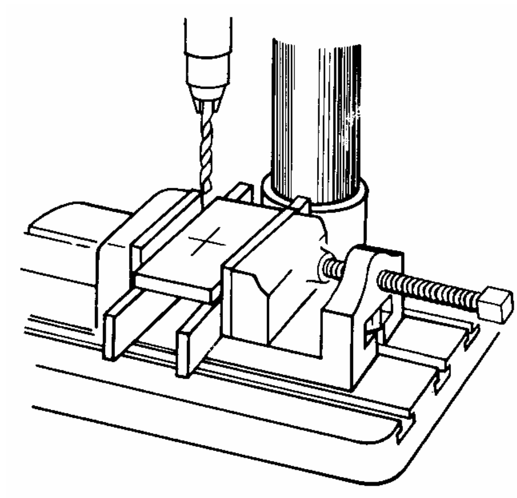
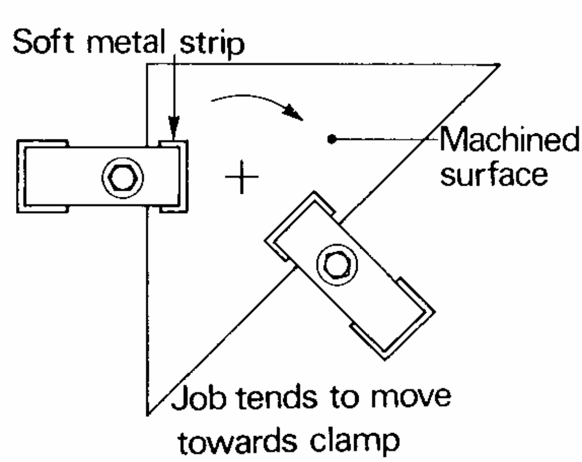


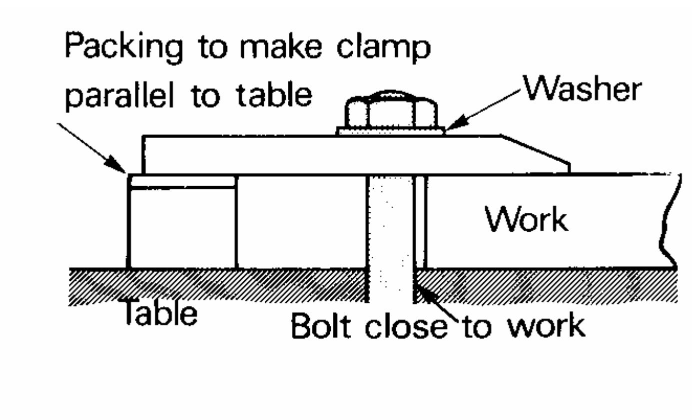
Table stops prevent the work from rotating but NOT from lifting. The drill turns clockwise so the work is prevented from turning in that direction. This method is only used for the drilling of small holes. It has a very quick turn over rate.

Flat work can be held in a vice; it is the simplest and most commonly used securing method. For larger drill sizes the vice itself must also be clamped or bolted to the table.

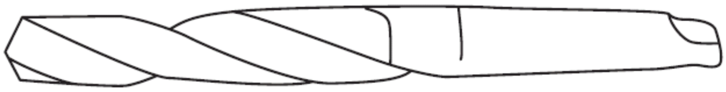


Direct clamping is ideal for large work. The work is clamped directly to the machine table. The packing must be the same height as the work or slightly higher. The clamping bolt should be as close to the work as possible.

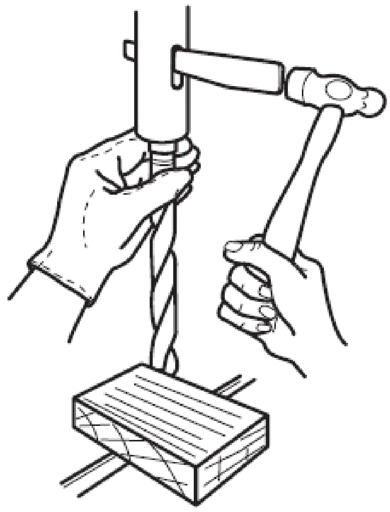




Tapered Shank: Drill bits can be purchased with a No 2 Morse taper shank to match the Morse taper in the machine spindle. A steel wedge is typically used to remove the drill bit from the spindle. This allows the fitting of bits without using a chuck. The shank of the drill and the hole in the driving shaft (sleeve) are identically tapered. The bit is pushed firmly into the sleeve. Drilling increases the pressure onto the taper thereby creating a more positive grip.



Safety: Ensure that the power to the drill is effectively isolated before changing the belt position. The pulleys are very sharp and could easily sever fingers.



NB: Some newer type pedestal drills are fitted with electronic variable speed controls.

Feed Control: A simple hand lever with two or more spokes is usual. If using a machine for the first time, gauge the "feel" and the range of movement of the lever.

Work Table: Note how it is adjusted and how it can be fixed. Some tables are controlled with the aid a windlass handle.

Depth Gauge: A depth gauge may be provided to allow the drilling of holes to precise depths. This allows accurate repetitive boring.

NB: Safety considerations when using a pedestal drilling machine are; (1) the shape of drill tip to be used; (2) that the drill bit fits securely in the spindle, (3) the use a suitable vice or clamps to secure the work piece and (4) the drill speed setting.

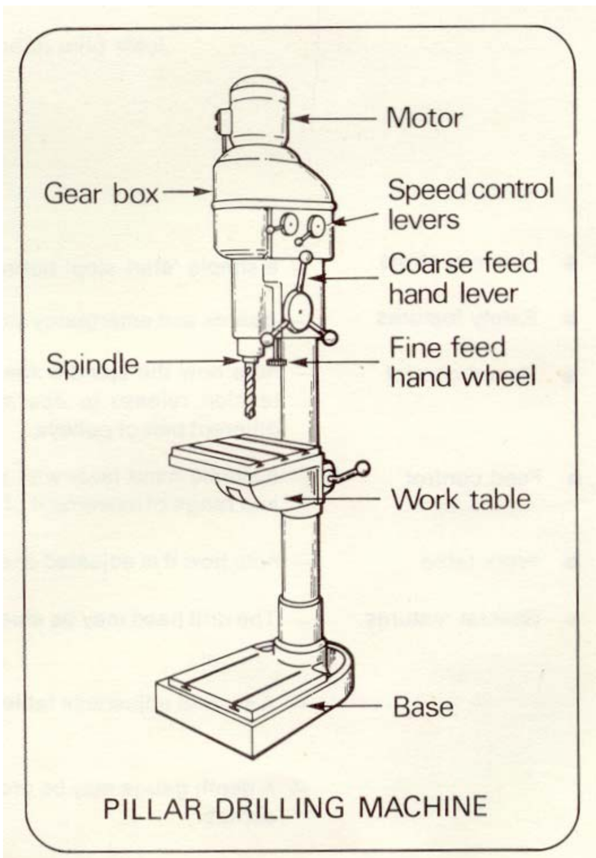
Pillar Drilling Machine
This is a heavier duty floor mounted drilling machine suitable for medium scale work. They have a drill capacity up to about 65mm and are either belt or gear driven.

This design greatly increases the potential vertical height thereby enabling larger objects to be drilled. The throat depth is generally not much more than that of a bench drill.

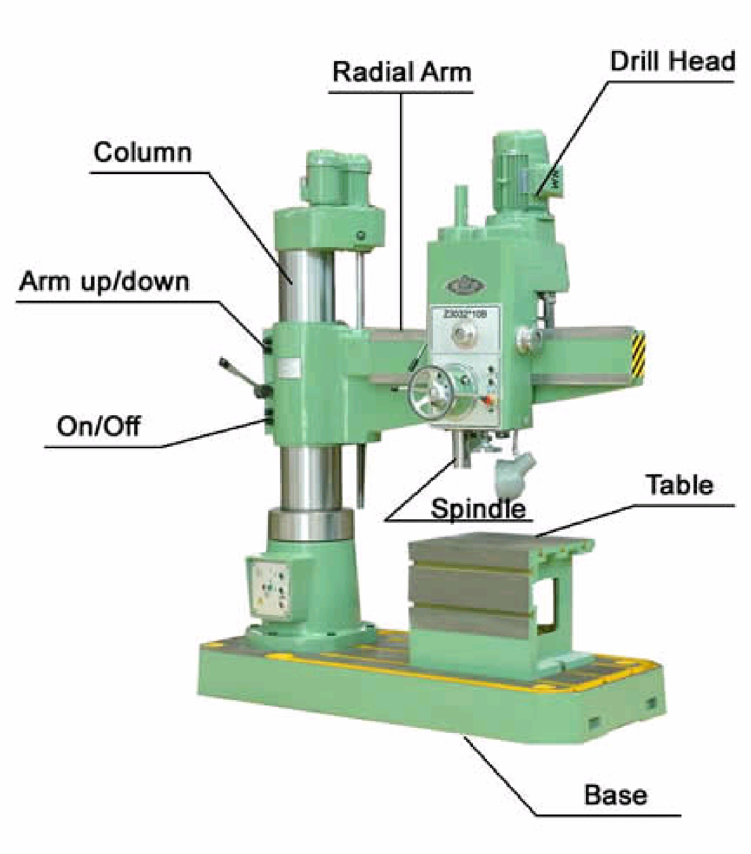
It has a very wide range of available spindle speeds. Dial or lever selection of speed is often provided.

A range of automatic feeds is often available in addition to both coarse and fine hand feeds.

Complex work tables that may swivel and tilt may be provided. In large machines the table may be operated by a separate elevating motor.



Radial Arm Drilling Machine
Ref: http://www.sundamachinetools.com



This design is suitable for very large diameter drills used on large sized work pieces. They are used in tool rooms and fabrication work shops for tasks that are too big for the previous types of drilling machines.

The radial arm can move pivoted horizontally and move vertically which gives it great flexibility to locate the drill head over the drill point.

Radial drilling machines have very low rotational speed settings which is very effective for large diameter drills and "fly-cutters".

Care of Drilling Machines
There are two main requirements for the continued efficient operation of drilling machines.

- They must be used correctly.
- They must be given regular cleaning, lubrication and maintenance to prevent rust build-up.

The main precautions to be observed in using a drilling machine are:

Do not overload the machine:
- By using drills of excessive diameter.
- By using feeds so heavy that the drilling head is deflected appreciably.

Do not subject the machine to shock:
- By ramming the drill into the work.
- By allowing the spindle to jar on the back stroke.

The following are indications that adjustments or repairs are necessary:

The spindle wobbles:
- The worn bearings need to be replaced.

The spindle has excessive end play:
- The feed mechanism must be adjusted to avoid backlash.

Holes are not being drilled at right angles to the work surface:
- The work table needs adjustment.

Safety: Vertical Drill
DO NOT use this equipment unless you have been instructed in its safe use and operation and have been given permission

PPE guidelines when working on a Vertical Drill


Safety glasses must be worn at all times in work areas.


Long and loose hair must be contained.


Gloves must not be worn.


Sturdy footwear must be worn at all times in work areas.


Close fitting/protective clothing must be worn.


Rings and jewellery must not be worn.

Pre-Operational Safety Checks
- Locate and ensure you are familiar with all machine operations and controls.
- Ensure all guards are fitted, secure and functional. Do not operate if guards are missing or faulty.
- Check workspaces and walkways to ensure no slip/trip hazards are present.
- Ensure the chuck key (if used) has been removed from the drill chuck.
- Follow correct clamping procedures to ensure work is secure.
- Erect a barricade if the job obstructs the walkway.
- Adjust the spindle speed to suit drill or cutter diameter.

Operational Safety Checks
- Before making adjustments or before cleaning swarf accumulations, switch off and bring the machine to a complete standstill.
- Feed downwards at a sufficient rate to keep the drill cutting.
- Feed with care as the drill breaks through the underside of the work.
- Use a safe working posture.

Ending Operations and Cleaning Up
- Switch off the machine when work completed.
- Leave the machine in a safe, clean and tidy state.

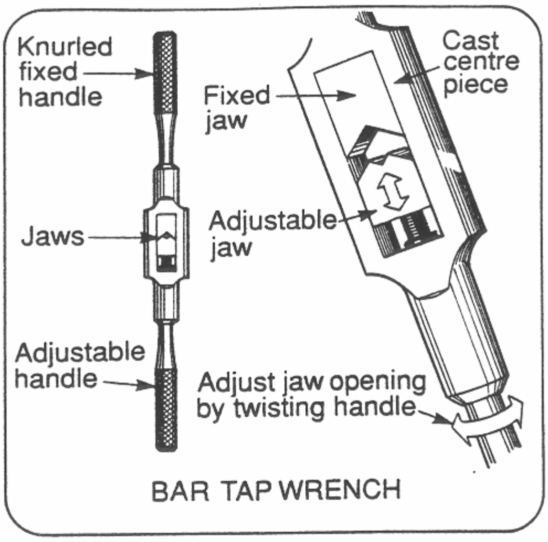
Potential Hazards and Injuries
- Hair/clothing getting caught in moving machine parts.
- Eye injuries.
- Flying swarf and chips.
- Sharp edges and burrs.

Don'ts
× Do not use faulty equipment. Immediately report suspect equipment.
× Never leave the machine running unattended.
× Do not hold the item being drilled with your hands. Use a clamp.

T6 Tapping and threading encompassing:

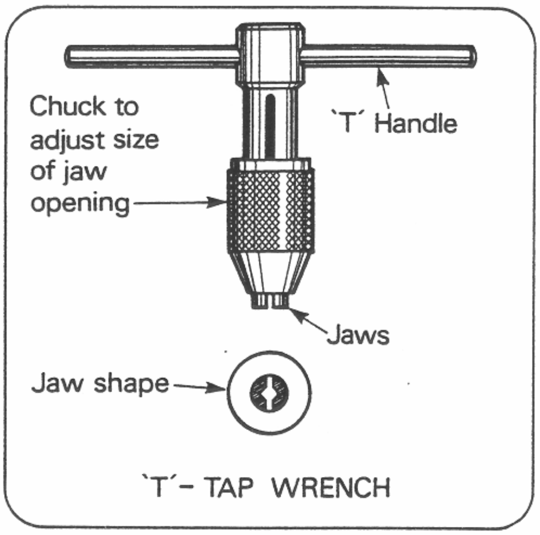
- type and size of commonly used threads used in electrotechnology work
- taps and tap wrenches
- tapping metallic and non-metallic components
- stock and die tools
- threading metallic and non-metallic components

Tapping and Tap Wrenches
A tap wrench is designed to securely hold and rotate a "thread" tap which is used to cut an internal thread in a pre-drilled hole. Always choose a suitably sized and type of tap wrench for the tap and the location. If a tap wrench is too large it will increase the probability of snapping the tap.



Types of Tap Wrenches
Bar Tap Wrenches
"Bar" tap wrenches have a flat centre section containing jaws shaped to grip the squared end of the tap. One sliding jaw is adjusted by a screw operated by turning one of the handles about its axis. The ends of the two handles are knurled.

Always choose the smallest capacity wrench that will grip the tap firmly. Check that the handles of the tap wrench can be turned without striking nearby parts.

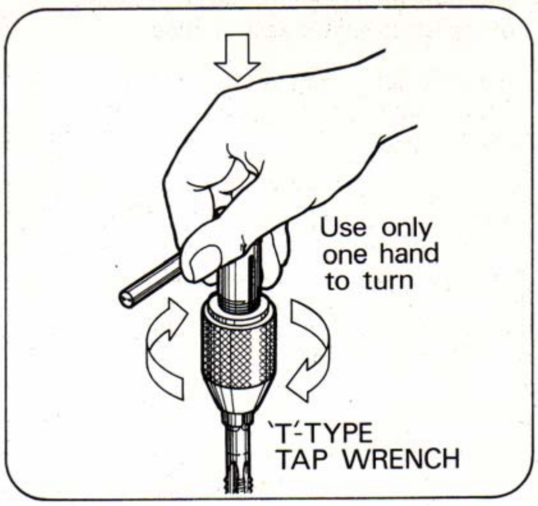


A small bar type tap wrench can hold taps ranging from 3mm to13 mm in size. There is a range of different capacity bar type wrenches available.

Tee Tap Wrenches
Tee ('T') tap wrenches are used for tasks where there is insufficient room to turn a bar type wrench. These wrenches have a small adjustable two jaw chuck on the end of a stem with a handle. There are different capacity tee ('T') type tap wrenches available. The largest capacity takes taps up to 13mm in size. NB: A large tap wrench fitted to a small tap significantly increases the chances of snapping the tap.

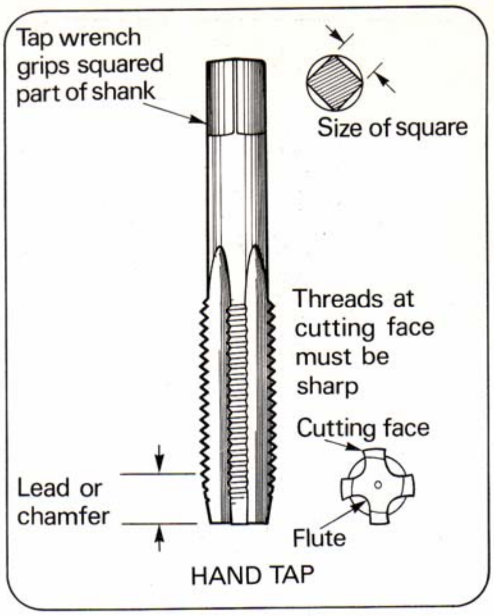
Hand Taps
Taps are normally used in sets of <u>three</u> to allow progressive cutting of the threads. There are many thread pitch types and tap sizes manufactured and this must exactly match the mating thread characteristics. Each tap "set" consists of a:

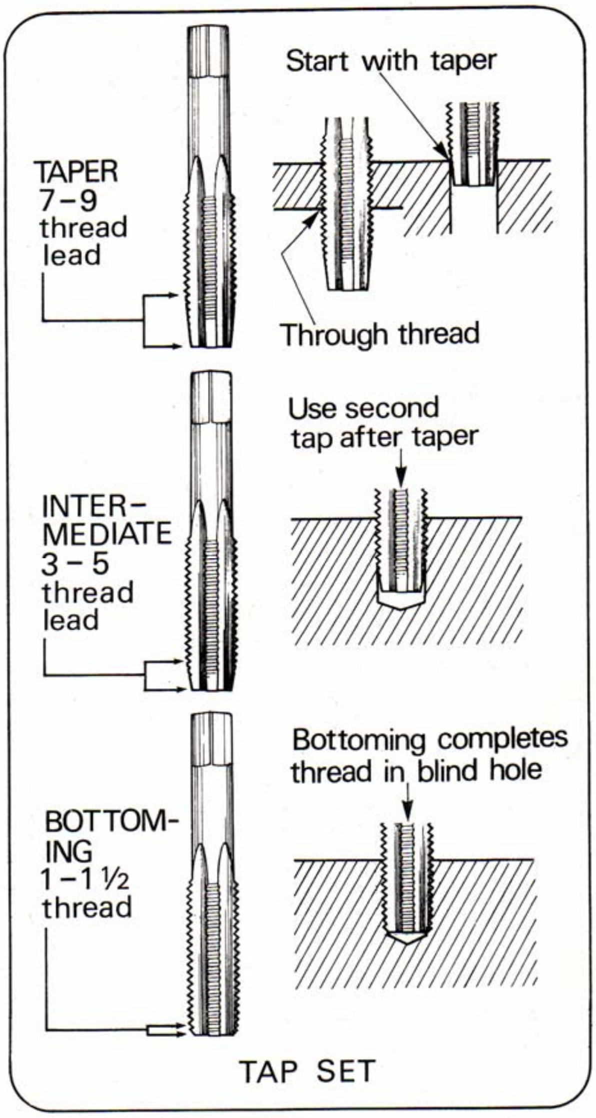
- Taper tap
- Intermediate tap
- Plug tap or bottoming tap



Each tap in a set has identical length and thread characteristics. Only their tapered leads are different. (See image over page)

The long taper of the “tapered” tap is designed to “start cutting” the thread. When tapping materials which are reasonably thin (approx. 6-12mm) and the hole passes completely through to the other side of the work material, then the tapered tap can also complete the cutting.





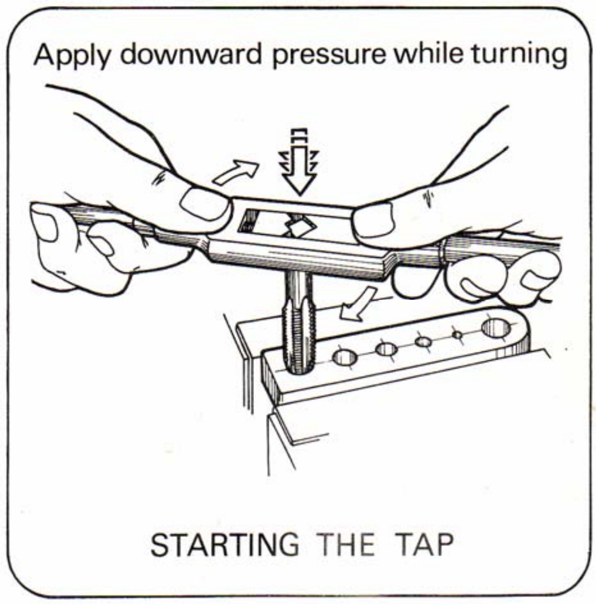
Using a Tap Wrench
First, the hand tap must be securely clamped in the jaws of a tap wrench.

NB: The pre-drilled drill hole size must always have a **smaller** diameter than the tap size. A comprehensive tapping chart is shown on the pages below.

It is important to stress that the “tap” and “tap wrench” must be matched in terms of physical size to reduce the probability of breaking the tap. If a large tap wrench is used with a small tap, then there is a good chance the tap will snap. Especially when tapping into copper!

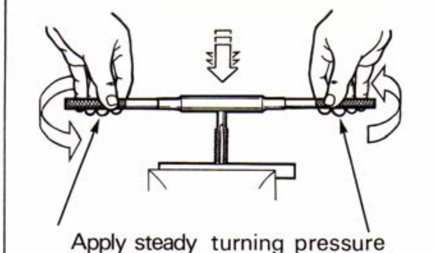
The tap wrench has two handles to provide a balanced driving force to control and reduce the chance of breaking the tap.

- The work should be firmly held in a vice or clamped from moving and the hole should be aligned to an upright position.
- Obtain a supply of suitable cutting lubricant and apply to the tap thread.
- Grip the tap in the wrench. The taper tap is used first because the taper lead allows the tap to better enter the hole. This helps to guide the tap and also

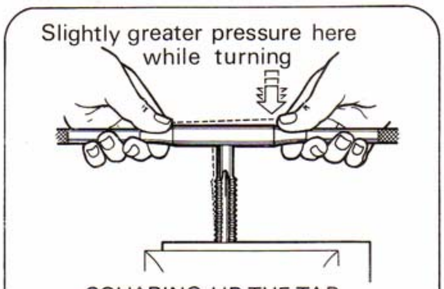


eases the cutting load by distributing the cutting action over several threads.

- Hold the tap wrench with both hands close to the centre of the tap wrench by pressing downwards and turning in a clockwise direction at the same time the tap will start to form a thread.
- After completing approximately one to two turns the "squareness" of the tap to the work surface must be checked. This is carried out by removing the tap wrench from the tap and placing the blade of a try-square against the tap checking in two positions at right angles to each other.
- Replace the tap wrench on the tap and continue to press down on the tap as it is turned. At the same time gently bear sideways, if it is necessary to correct any errors found via the check that was made. If strong resistance is felt, back the tap off (free it) a small amount to break the chip then continue to turn clockwise.



TURNING THE TAP

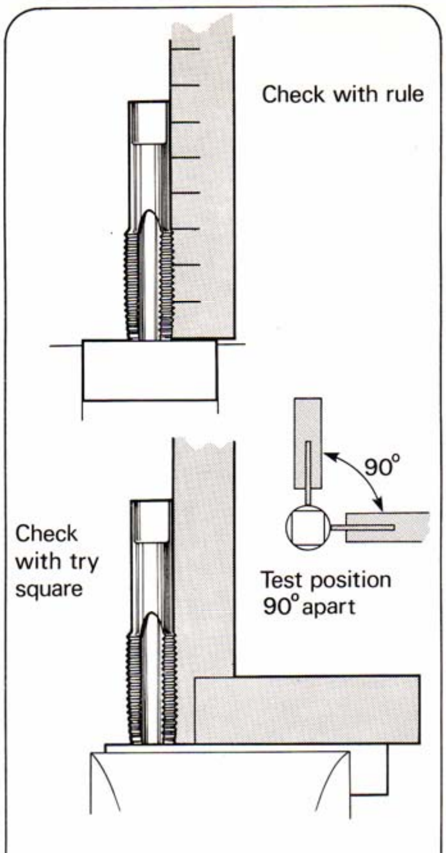


SQUARING UP THE TAP

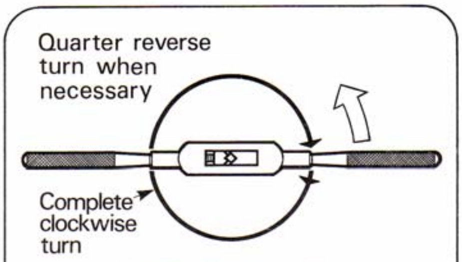
Tapping a Blind Hole

Ie. A "blind hole" is one that does not penetrate completely through to the other side of the material.

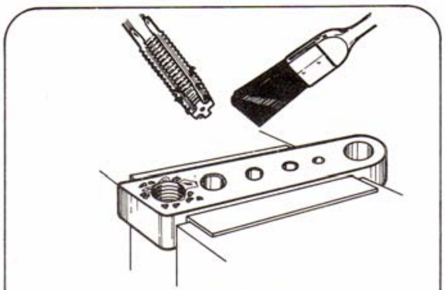
- The tapered tap is used to start cutting the thread in the hole.
- The intermediate tap is then used to consolidate the thread to a point where the plug tap may access enough threads for stability.
- The plug tap is used to cut the thread all the way to the bottom of the blind hole.
- By the time the tap has made 3 or 4 turns and its alignment has been corrected it will be firmly held by the thread it is cutting and will be automatically drawn deeper into the hole as it is turned.
- Every 2 or 3 turns, "free the tap", by reversing it for a "quater turn" and then continue cutting.
- Normally, a through hole can be completely cut with a taper tap, but if the cutting load becomes too heavy the taper tap should be reversed out of the hole for the intermediate tap to be substituted.
- Remember; taps are hard and brittle and are very <u>easily</u> broken. The user must learn to exercise good judgment with regards to the degree of force applied to the tap.
- Care must be taken to keep the blind hole clear of chips; otherwise the tap will be prevented from entering to the full depth. Be extra careful when the tap hits the bottom of the blind hole as this is when the tap is most likely to break.



CHECKING THE TAP IS SQUARE

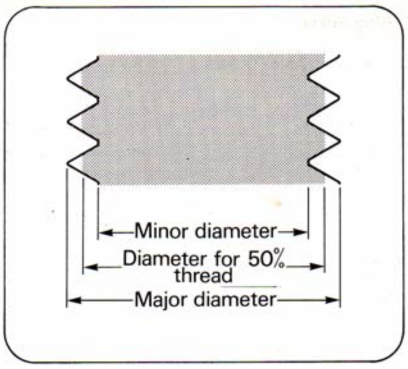


FREEING THE TAP

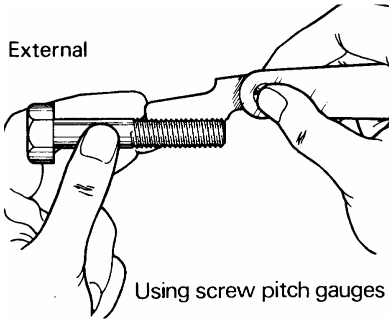

BRUSH CHIPS FROM TAP AND WORK

Threads and Terminology

A screw thread is helical ridge of uniform section formed on the surface of a cylinder or cone that advances uniformly along the length of the cylinder or cone. There are many thread types, but the most common is the “vee” thread” named because of its shape.

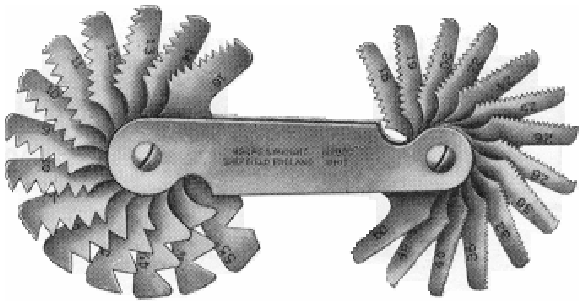


- Screw threads are used for general fastening purposes,
- They are uniform in diameter unlike a wood screw which is tapered,
- In some applications screw threads are used for the transmission of power and controlled motion.
- The “**thread pitch**” is the distance from one thread groove to the next. It is measured from “crest-to-crest”. (ie. Peak-to-peak.)



Commonly used Vee Threads

- “Metric” is currently the most commonly used thread form in the electrotechnology industry.
- British Standard Whitworth (BSW) thread form was once a widely used general purpose thread in Australia. There will still be remnants of these bolts and nuts in older switchboards and machines.
- Various other types of threads are used in imported machines.



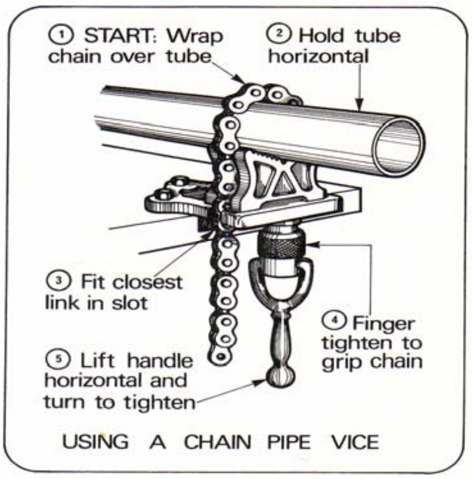
Thread Identification

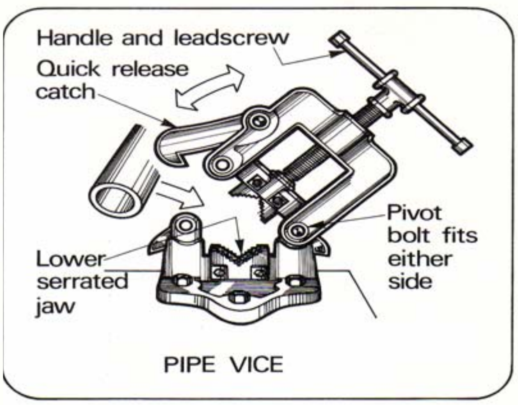
A tradesperson is frequently called upon to “mate” a “nut” with an existing “bolt”. Here, the type of thread and the pitch must be determined precisely. To make an accurate identification of a thread type, a tool known as a “**thread pitch gauge**” is used. The “graded” teeth of the gauge are placed into the teeth of the thread and this then identifies the “**pitch**” of the thread. Measure the “**major diameter**” of the bolt to determine the thread size.

Pipe Vice

(Sometimes spelt as Pipe Vise)

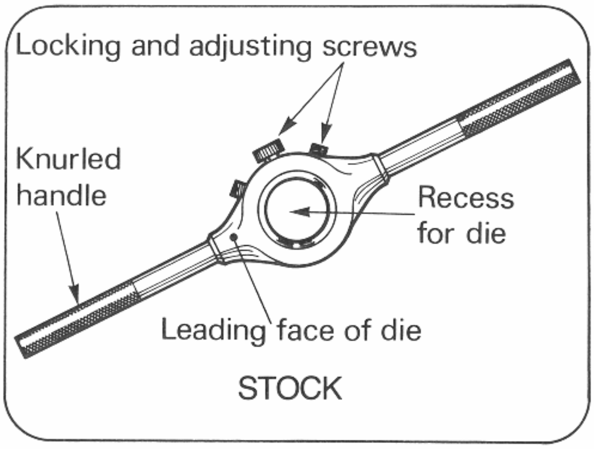
A pipe vice is a clamp used to securely hold round bar or pipe such as metal conduit or water pipe while it is being cut or threaded. There are a number of designs available, including the two types shown below. The “chain vice” on the left is very flexible and can accommodate large diameter cylindrical objects. The “bench yoke” vice on the right has a slightly faster locking action.





Cutting External Threads

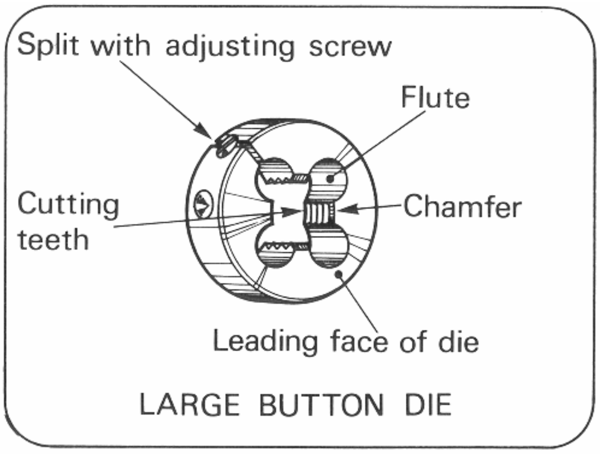
A cutting tool called a "die" is secured in a handle and frame known as a "stock" and rotated by hand in a clockwise direction to cut a "right hand" external thread. There are three main types of dies; adjustable half dies, button and die nuts. External threads are used on metal conduits, water pipes or solid fixing rods. There are many variations to the basic design for "stocks and dies.



Parts of a Stock

The stock is the tool used to hold and turn the die when making an external thread by hand.

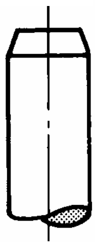
- The locking screws hold the die in position while the adjusting screw alters the size of thread to be cut
- Knurled handles hold and turn the die on the stud being threaded
- The recess houses the die and holds it against the leading face



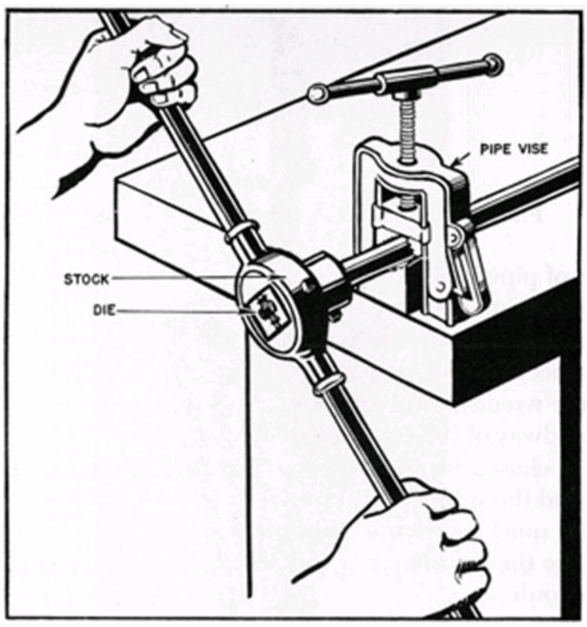
Parts of a Die

The die is a round or square block of hardened steel with a hole containing threads and flutes which are the cutting edges.

- The first few teeth of the die are chamfered to allow an easy start when turning a thread
- A split in some larger dies allows the die opening to be made larger or smaller by turning an adjustment screw



Before attempting to cut a thread by means of a die, the end of the work material requires some preparation. The end must be "squaring up" and a small "lead" chamfer, formed either by machining or filing. This "lead" surface will make it easier for the die to start cutting the thread.

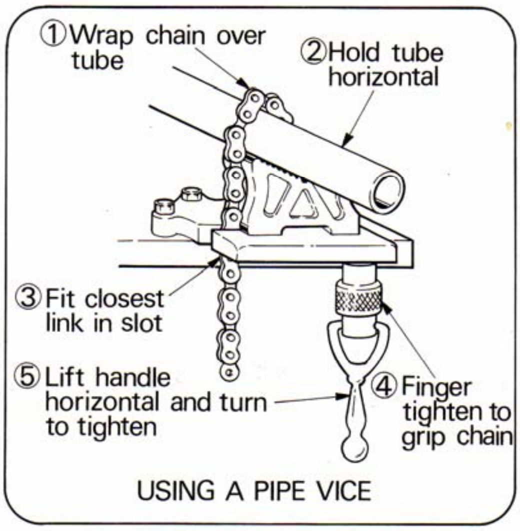


The following procedure should be followed for cutting an external thread:

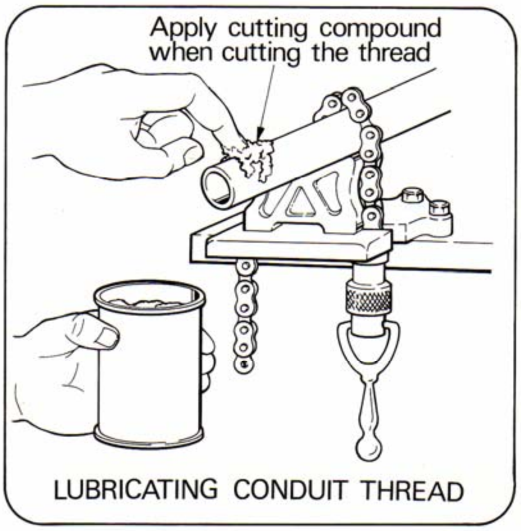
- Secure work appropriately in a bench vice and coat the surface where the thread will be cut with a suitable cutting compound.
- Hold the die holder near the centre with both hands and place the starting side of the die over the end of the rod. Then by firmly pressing the die onto the rod while turning it in a clockwise direction, the thread will start to be formed.

- If there is no guide in the die care must be taken to keep the die square with the work. Sighting from two positions at right angles to each other can check this. Bearing downwards on one side of the die makes corrections.
- Continue to turn the die, but when resistance builds up, back the die off a part of a turn (to break the chips) and then continue forward again.
- When the end of the work comes through the other side of the die, remove the die and check the size of the new thread with a nut. If necessary alter the setting of the button die to increase or reduce the size of the thread.
- Continue cutting for the full length of the thread.
- Remove any burrs with a file.

Applications
- Cutting external threads on conduits.
- Threading rod of circular bar for light drops or cable supports.



USING A PIPE VICE



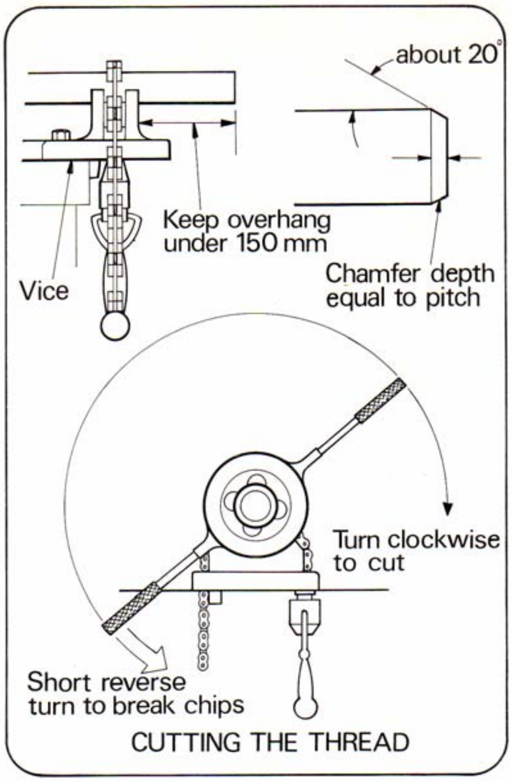
LUBRICATING CONDUIT THREAD

Thread Cutting Lubricants
A cutting lubricant is used for:
- Cooling
- Lubricating
- Chip removal

It must also be:
- Non-corrosive
- Non-injurious to the operator
- Non-inflammable at normal temperatures
- Reasonably cheap and in plentiful supply

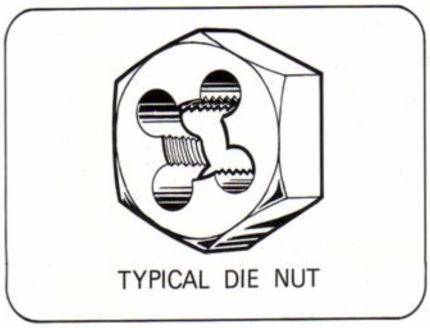
Examples:

Material	**Lubricant**
Steel	Neatsfoot oil or sulphur based oil
Stainless Steel.........	Neatsfoot oil or sulphur based oil
Brass and copper	Kerosene and lard oil
Cast iron	Kerosene or soluble oil
Aluminium................	Kerosene and light mineral oil
Plastics	Soap solution



CUTTING THE THREAD

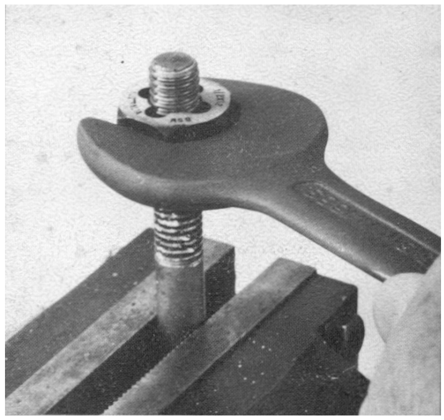
Die Nut



A "die-nut" has cutting teeth and relief holes to enable it to "clean" or "recondition" a damaged thread or to remove thick paint etc from inside a thread. A "die-nut" is not designed to create "new" threads as it has no guide.

The hexagonal shape of a "die nut" allows it to be rotated by means of a spanner or suitable socket.

Screw Extractor

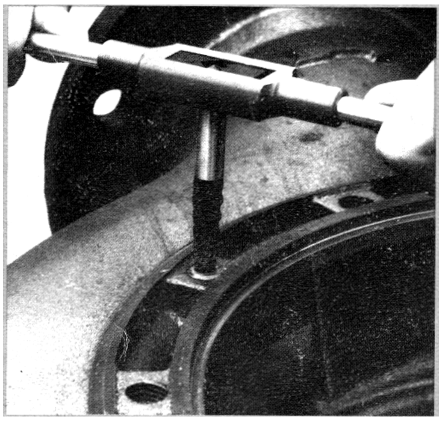


(Also called "Easy-outs")
Screw extractors are used to extract (remove) broken screws and studs from threaded holes.

To remove a broken screw or stud, first drill a hole to the recommended size in the exact centre of the broken end of the bolt. (This is not an easy task!)

Next, using a tap wrench to support the extractor bit, turn the extractor bit in an "anticlockwise" direction for right-hand screw threads.

The extractor does not have to be hammered in because it takes a quick and positive grip. It "feeds" itself into the predrilled hole and should start the most stubbornly embedded part and turn it out on its own threads, leaving the original thread in the hole undamaged.



A screw extractor should not be used to remove a screw with a left-hand thread, a broken press-fitted stud (ie. interference fit), a broken tap or a badly rusted screw.

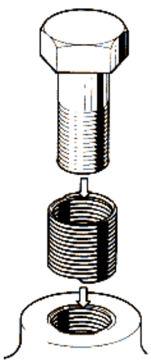
Be aware of how deep the broken screw or stud is drilled so as to avoid expanding the broken piece and become tighter in the hole.

NB: Extractors are very brittle and they can break very easily if too much force is applied.

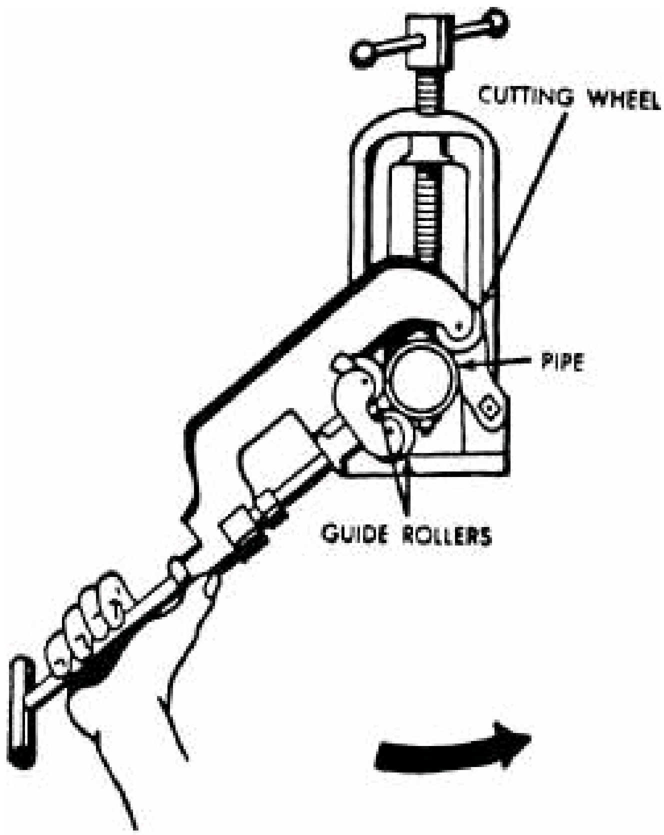
Thread Inserts

If an internal thread becomes damaged or "stripped", it can be repaired by the use of a thread insert kit. The damaged internal thread is drilled out and re-tapped to take a special high tensile spring of screw thread section.

This screw thread section known as the "insert" is then screwed into the tapped hole thereby restoring the original thread size.



Pipe Cutter or Tube Cutter
The main function of this tool is to neatly cut a pipe to a specific length. It is designed with a hardened steel cutting wheel and two rollers.



There are many sizes and designs of "pipe cutters" available to suit a large range of pipe sizes and material types.

To cut tubing, place the tube cutter with the cutting wheel exactly on the mark where the cut is to be made.

Move the cutting wheel into light contact with the tubing. Turn the cutter in the direction as shown on the diagram. As you rotate the handle you should feel the wheel cut a little for each revolution. Gradually screw in the adjustment as you turn.

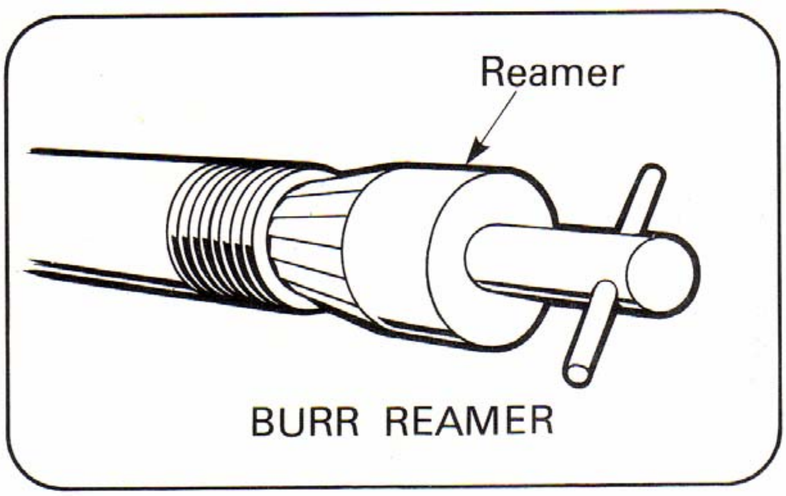
Different wall thicknesses, types of materials, and diameters of metallic tubing require different feeds. The feed pressure is correct when it keeps the wheel cutting, but does not flatten the tubing. Continue cutting until the tube is cut.

The final severing tends to happen suddenly so do not take your hand off the cutter during the process as it may fall.

Note: Pipe cutters produce a very sharp internal burr of the pipe and should **NEVER** be used for cutting metallic conduit.

For other types of pipes use a reamer or a file to remove the burr.

Burr Reamer
This is a tool used to remove the burrs from inside of a metal pipe so that the wires are not damaged when they are pulled through.



Tap / Drill Chart
Charts like the ones shown below are commonly displayed in most engineering workshops. It lists the standard thread types and sizes and the recommended drill size to suit.

Many styles of charts are in circulation and due to differences in how the information is arranged and thus read, it is suggested that you make yourself familiar with those in your work surrounds.

M — ISO METRIC COARSE (60º)

Tap Size	Pitch mm	Tapping Drill mm
M1.6	0.35	1.25
M2	0.4	1.6
M2.5	0.45	2.05
M3	0.5	2.5
M3.5	0.6	2.9
M4	0.7	3.3
M4.5	0.75	3.7
M5	0.8	4.2
M6	1.0	5.0
M8	1.25	6.8
M10	1.5	8.5
M12	1.75	10.2
M14	2.0	12.0
M16	2.0	14.0
M18	2.5	15.5
M20	2.5	17.5
M22	2.5	19.5
M24	3.0	21.0
M27	3.0	24.0
M30	3.5	26.5
M33	3.5	29.5
M36	4.0	32.0
M42	4.5	37.5
M45	4.5	40.5
M48	5.0	43.0
M52	5.0	47.0
M56	5.5	50.5

MF — ISO METRIC FINE (60º)

Tap Size	Pitch mm	Tapping Drill mm
M4	0.5	3.5
M5	0.5	4.5
M6	0.75	5.3
M8	1.0	7.0
M10**	1.0	9.0
M10	1.25	8.8
M12**	1.25	10.8
M12	1.5	10.5
M14**	1.25	12.8
M14	1.5	12.5
M16*	1.5	14.5
M18**	1.5	16.5
M20*	1.5	18.5
M22	1.5	20.5
M24	2.0	22.0
M25*	1.5	23.5
M32*	1.5	30.5
M40*	1.5	38.5
M50*	1.5	48.5

*Metric Conduit **Spark Plug

BSW — BRITISH STANDARD WHITWORTH (55º)

Tap Size	T.P.I.	Tapping Drill mm
1/16*	60	1.2
3/32*	48	1.85
1/8	40	2.55
5/32*	32	3.2
3/16	24	3.7
7/32*	24	4.5
1/4	20	5.1
5/16	18	6.5
3/8	16	7.9
7/16	14	9.3
1/2	12	10.5
9/16	12	12.1
5/8	11	13.5
3/4	10	16.25
7/8	9	19.25
1	8	22.0
1-1/8	7	24.75
1-1/4	7	28.0
1-1/2	6	33.5
1-3/4	5	39.0
2	4-1/2	44.5

*WHIT. Form

UNC — UNIFIED NATIONAL COARSE (60º)

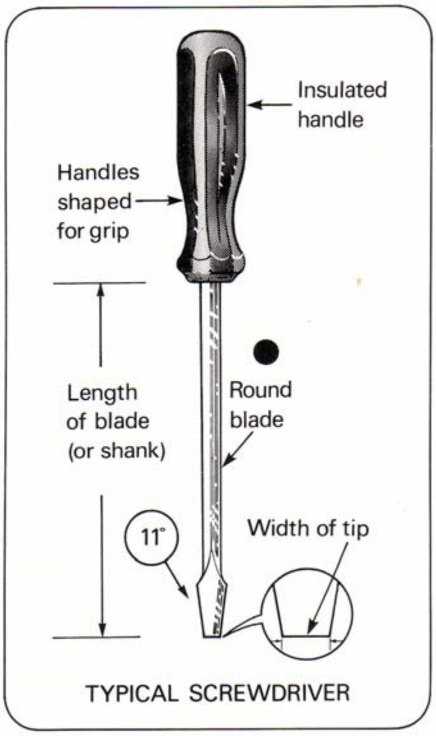
Tap Size	T.P.I.	Tapping Drill mm
#2 (.086)	56	1.85
#3 (.099)	48	2.1
#4 (.112)	40	2.3
#5 (.125)	40	2.6
#6 (.138)	32	2.8
#8 (.164)	32	3.4
#10 (.190)	24	3.8
#12 (.216)	24	4.5
1/4	20	5.1
5/16	18	6.6
3/8	16	8.0
7/16	14	9.4
1/2	13	10.8
9/16	12	12.2
5/8	11	13.5
3/4	10	16.5
7/8	9	19.5
1	8	22.2
1-1/8	7	25.0
1-1/4	7	28.0
1-3/8	6	31.0
1-1/2	6	34.0
1-3/4	5	39.5
2	4.5	45.0

Pg — STEEL CONDUIT (80º)

Tap Size	T.P.I.	Tapping Drill mm
Pg7	20	11.3
Pg9	18	13.9
Pg11	18	17.3
Pg13.5	18	19.1
Pg16	18	21.2
Pg21	15	26.8

T7 General Hand Tools encompassing:

- screwdrivers used in electrotechnology work
- hammers used in electrotechnology work
- spanners and sockets used in electrotechnology work
- pliers used in electrotechnology work
- assembling components applicable to electrotechnology industry using a variety of hand tools.



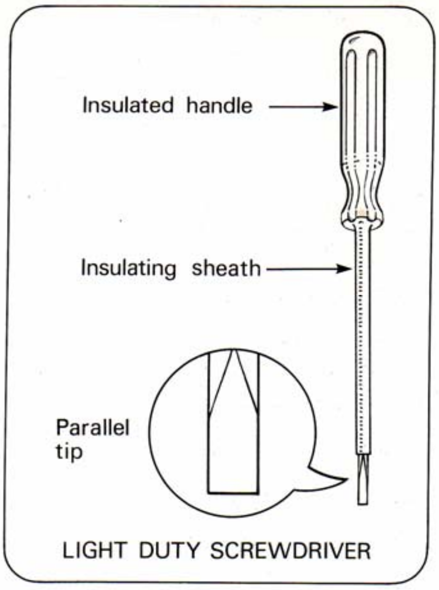
Screwdrivers
A screwdriver is a twisting tool with a long blade fitted to a handle and is designed to install screws and like. The tip of the blade is shaped to fit into the head of a screw and, when turned, will either tighten or loosen the screw.

There are two groups of hand-held screwdrivers; (a) Standard types with tips to slotted heads; and (b) Special types with tips to suit recessed headed screws.

NB: Screwdriver tips are made to be used in conjunction with drill braces and power tools etc.

Warning: A screwdriver should **NEVER** be used as a chisel or as a lever. This will damage the blade and could result in a hazardous situation.

Standard Screwdrivers
These are made with: (a) Round blades or square shanks (for use with spanners to loosen stubborn screws). (b) Handles made of metal, wood or molded plastic. (c) The thickness of the blade is based on the width of the "tip", and the blade length.



Standard screwdrivers are specified in size by length of shank/blade and width of the tip. eg. 200mm by 6mm. Variations of the standard screwdriver include:
(a) `Stumpy', `stubby' or `dumpy' screwdriver (which is about 40mm by 6mm) for use where there is limited room. (b) Light duty screwdrivers with small tips.
(c) Insulated screwdrivers (Rated to 1000v) are used by electricians as their blades are sheathed in insulation to avoid contact with `live' parts.

Selecting the Correct Size Screwdriver Tip
Various widths of tip are available and each width is available in different length blades. Thickness of a tip typically varies in proportion to the length of the blade.

Width of Tip
It is important to always select the size of tip carefully. The width of the tip should almost equal the length of the bottom of the slot.

- Too wide a tip could damage the work
- Tips that are too narrow exert their turning force too close to the screw axis. Check that the blade axis is lined up with the screw axis. The wrong alignment causes turning pressure to damage the tip and the screw rather than turn the screw.

Thickness of the Tip

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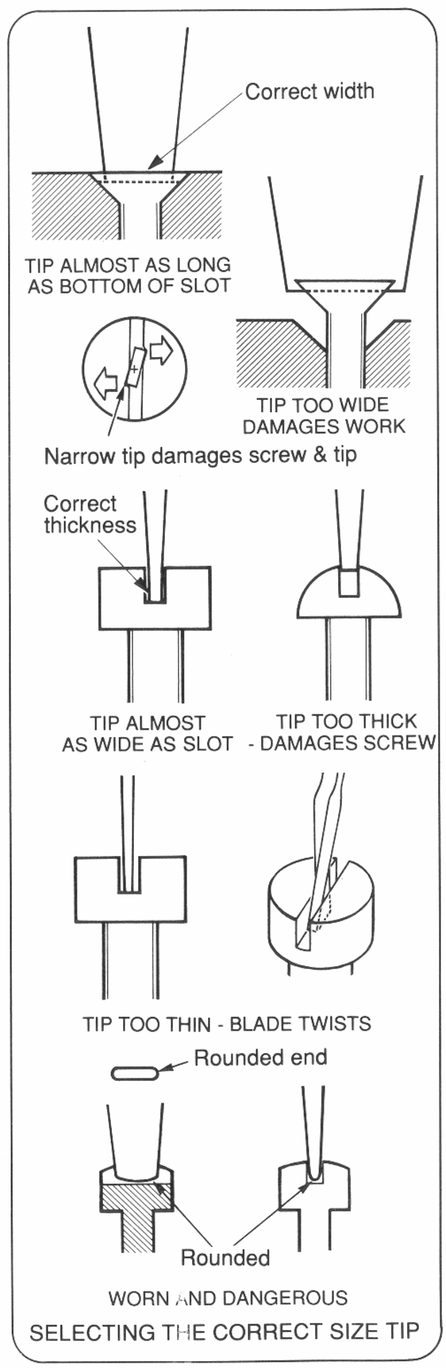


Shape of the Tip

The shape of the tip is also important. The tip edge must be straight. If the tip is badly worn (arc) or incorrectly ground, it will tend to jump out of the slot.

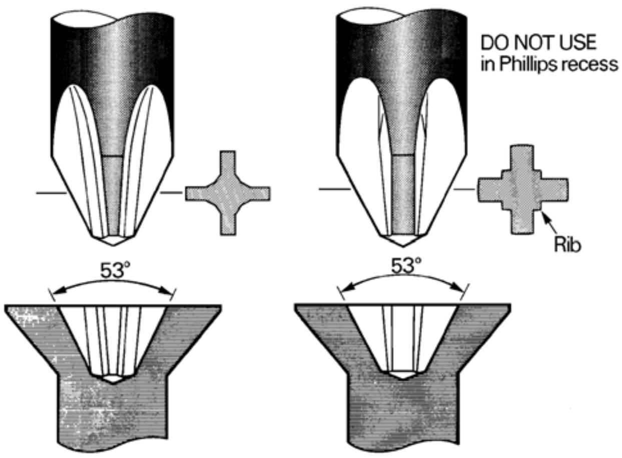
Safety when using a screwdriver

- Ensure the correct sized tool for the screw,
- Check the tool is in good working condition,
- Ensure the screwdriver fits correctly into the recess of the screw,
- Keep your hands free of the tip when operating as the screwdriver may slip and injure,
- Keep axis of shaft aligned with the screw.

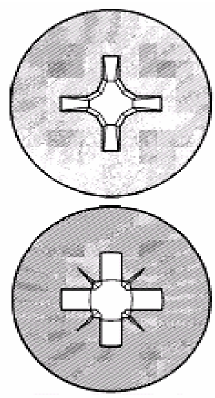
Screwdrivers for Recessed Head Screws

A wide variety of recessed head screws are used in the electrotechnology industry. These screws and their drivers (tips) are preferred over slotted screws because they are unlikely to slip and damage the work piece.

The image to the left is a “Phillips” head and the right side image is a “Pozidrive” head.



“Pozidriv” screwdrivers are similar to Phillips head screwdrivers, but they are made to fit Pozidriv screws which have a deeper recess.



NB: It **is not** recommended that Phillips head screwdrivers be used for Pozidriv screws (nor Pozidriv screwdrivers for Phillips head screws), since the recess is easily damaged.

Identification of recessed screws and screwdrivers
Because Pozidrive screwdrivers are unsuitable for use with Phillips recess fasteners, you should be able to identify both types of tip.

Comparing tips of the same size: Both types have 53^{o} end angles formed by the wings and there is a second taper that gives the extreme end a blunted appearance. The top image to the right is "Phillips" and at the bottom is "Pozidriv".

Their differences are listed below.

"**Phillips**" tips have:
- wings that taper.
- shallow two-faceted flutes between the wings

"**Pozidrive**" tips have:
- Wings that have straight sides.
- Small ribs or projecting flutes between the wings.

Screwdrivers Safety
- Select the correct type and size of screwdriver for the task,
- Check that the tip is in good condition and is a good fit in the screw slot or recess,
- For electricians, check that the handle is free of defects and that the handle is well insulated,
- Keep your hand away from where it could be injured by a slipping screwdriver blade,
- Keep the axis of the blade in line with the axis of the work,
- Never use a screwdriver as a chisel, lever, pry or punch bar.

Torx Driver
Torx (pronounced "torks") is a special type of screw head characterized by a 6-point star-shaped pattern.

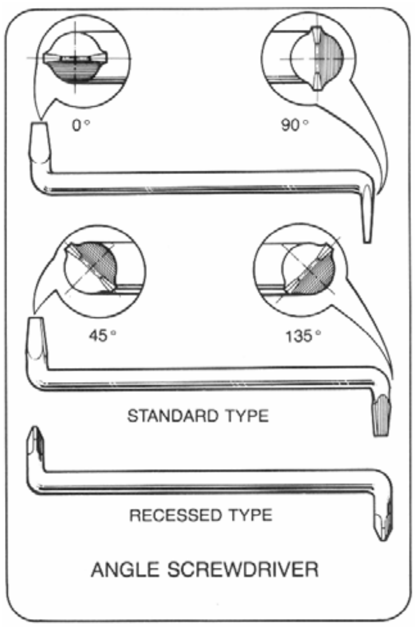
Torx screws are commonly found on electrical appliances. Because the screwdriver bits were not widely available, torx screws were used by manufacturers to reduce the level of tampering by non-professionals.

Access to a "Torx" screwdriver set, is essential when dismantling many types of electrical/electronics equipment.

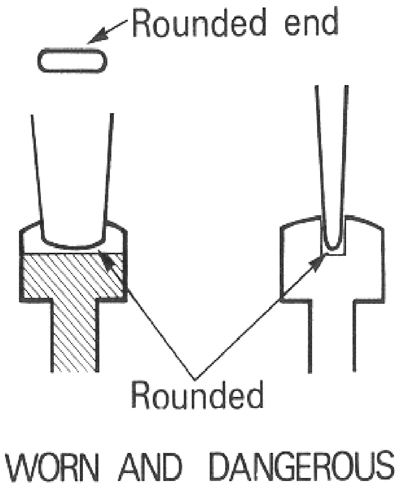
Angle Screwdrivers
An angle screwdriver is used to loosen and tighten screws located in very confined spaces. These cannot be accessed by a normal type screwdriver.

An angle, or offset screwdriver has its blades set at an angle to its shank.

The standard type may have its blades set at 0, 45, 90 or 135 degrees to a plane which is at right angles to the shank.



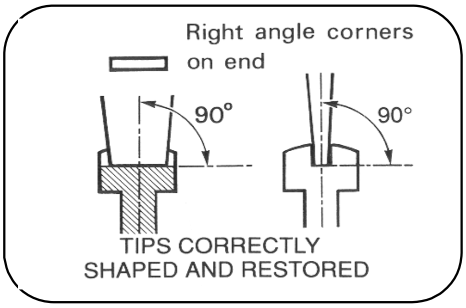
Maintenance of Screwdrivers
Screwdriver tips constantly wear with use. Worn tips tend to slip dangerously, so it is important to inspect screwdriver tips regularly.



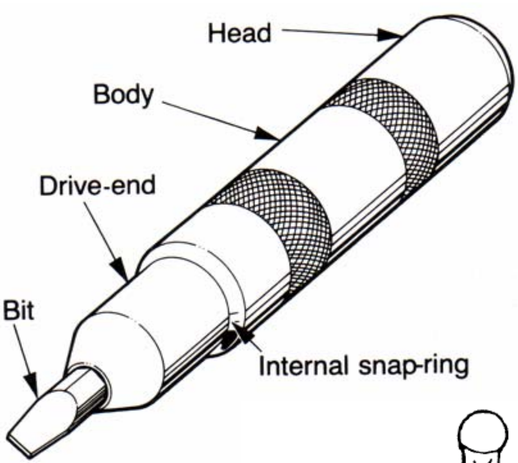
If a tip becomes worn or rounded, restore it to the correct shape by dressing it to shape with a file.

After dressing, the tip must be symmetrical about the axis of the blade. All corners must be square. The end must be at right angles to the axis in both planes. The tip thickness must be correct. The faces of the tip must be parallel for a distance equal to just over half the width of the tip.

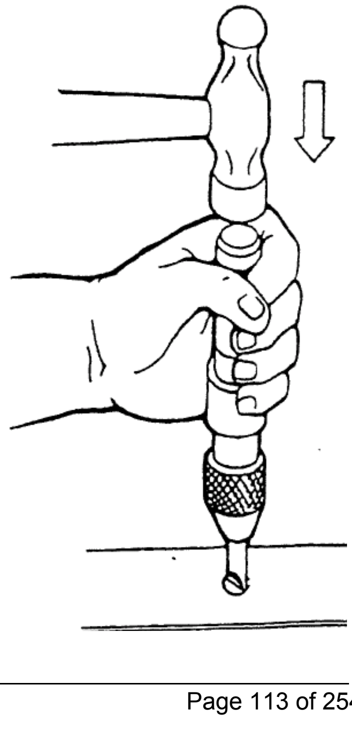
If it is necessary to grind the tip, take care not to overheat it. Grind only a little and then allow the tip to cool each time. An overheated tip will be too soft for use and would have to be hardened and tempered again.



Impact Screwdriver
This is a special heavy duty, screwdriver designed to remove very tight screws that will not turn when using a conventional screwdriver.



- Some designs have interchangeable bits to accommodate slotted or Phillips screws.
- Some designs also include a forward reverse rotation selector.
- The object/machine which contains the screw must first be securely held in place as the forces applied during the process are substantial.
- It may be necessary to spray a penetrating liquid onto the screw to assist with the process.
- Insert the screwdriver tip in the head of the screw and rotate the handle in the direct to loosen the screw to “load-up” the internal tapers.
- Use a heavy headed lump hammer to strike the end of the driver. The opposing tapers located on the drive train inside the driver’s head impart substantial torque on the screw.



Safety
Always wear safety glasses when using this tool as it probable that chips may fly. Also, it is advisable to wear a protective glove on the driver hand to protect it from slippage.

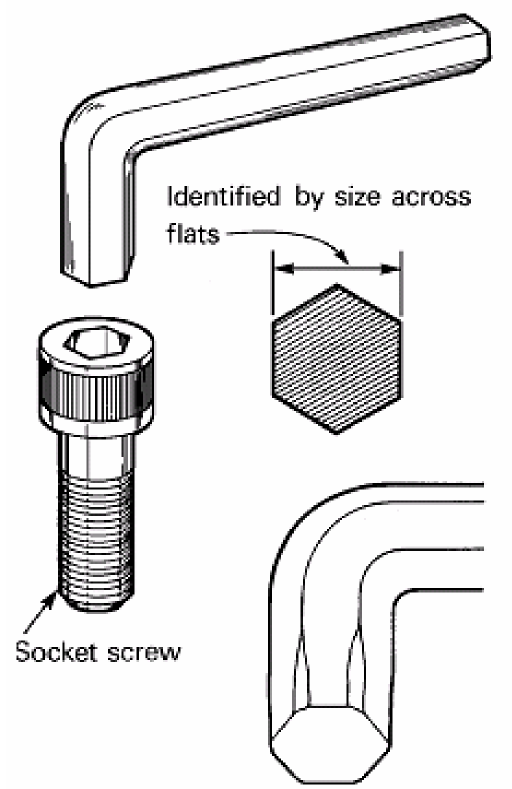
Hexagon Socket Wrench
These are more commonly known as "Allen keys" these are “**hexagonal**” bars of tool steel bent to an L-shape. They are designed to turn “hexagonal headed” fixing screws.

Allen keys are available in both “metric” “imperial” sizes.

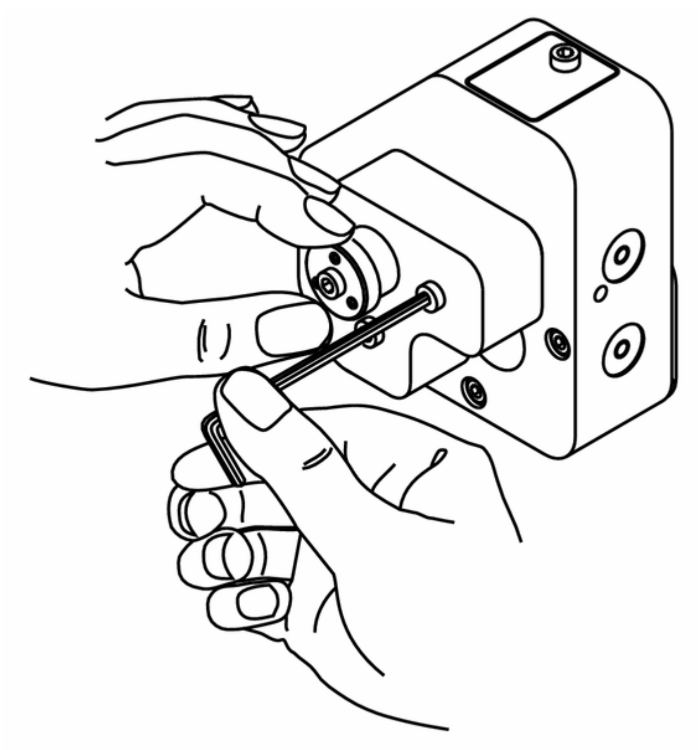
When using these keys:

(a) Make sure socket and keys are clean before use.
(b) Use the correct size.
(c) Insert to full depth.
(d) Do not attach an additional lever to the end of the key as this may cause it to strip or break.

Note: Discard a key if the ends become worn or rounded as shown in the image to the right, otherwise it is likely to slip under load.

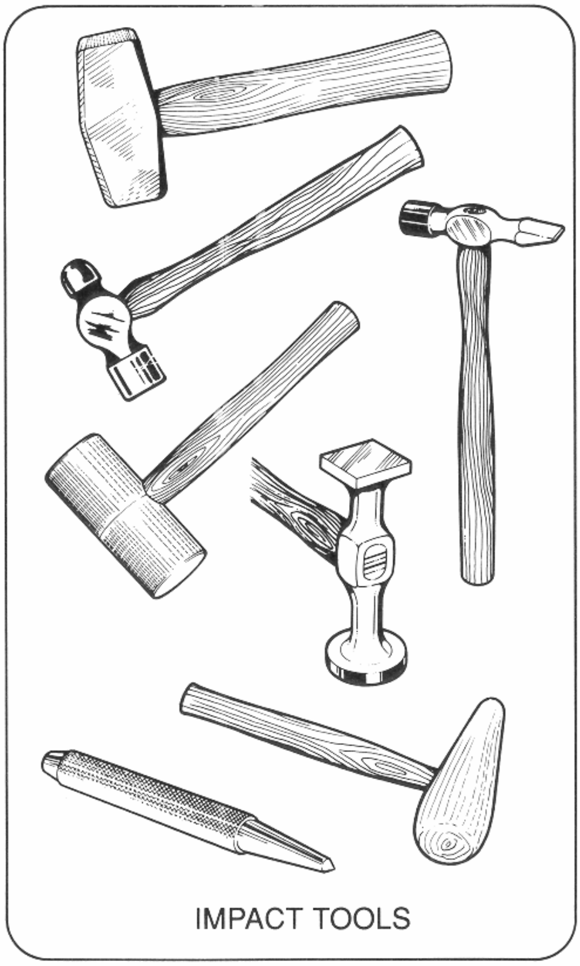


Shown below is an Allen key being used to fix a component.



Hammers

Hammers are heavy "impact tools" widely used by tradespeople. They impart a force, either directly through impact or indirectly through a punch or chisel, to change the shape or position of materials.



Hand hammers are manufacture in a wide variety of shapes and sizes. They are graded by the weight of their head.

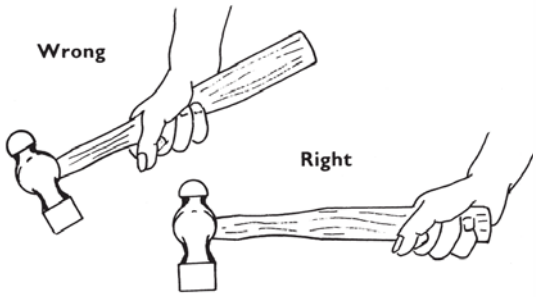
They have handles made of wood, steel, or fiberglass. The type of material used to construct the head classifies them into one of two groups – "Hard" or "Soft-face".

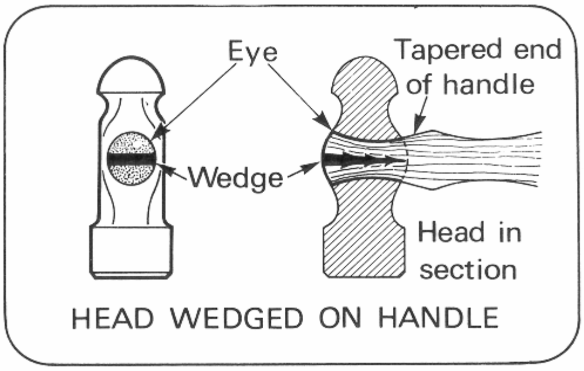
Hammer

A hard hammer has a steel head fastened to a handle which can be made of timber, fibreglass or steel. The head is held onto the handle by a metal "wedge" driven into the end of the handle after the head has been fitted.

The head of the hammer has both its "**face**" and "**pein**" end, hardened and tempered.

Hold the hammer handle near its end. Do not "choke" the hammer by placing your hand near the head as the "face" will be at the wrong angle to the work surface. It will allow you to apply more force.





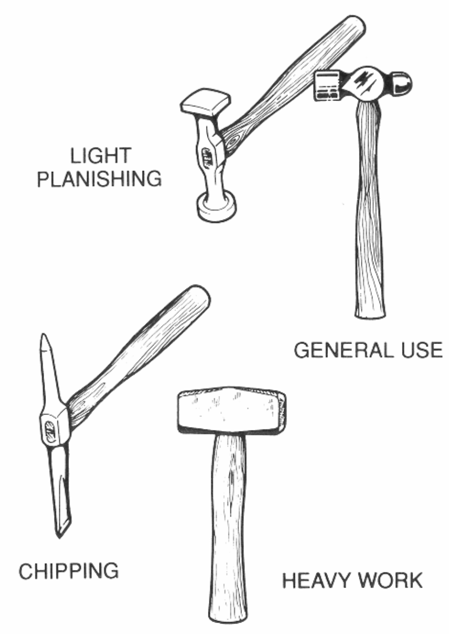
Safety

A moving hammer can concentrate a large amount of kinetic energy into a small area; where it can splinter material on impact and cause chips to fly off dangerously. Always wear goggles when hammering if there is a possibility of chips flying.

Selecting the Correct Hammer

Hammering varies from light tapping to hard striking. The heads of hammers can be swung with significant force. As it strikes an object, it changes the position or the shape of that object.

When a hammer is being selected, the mass of its head is as much a factor as the work piece. Light hammers are easy to control but are not suitable for applying heavy blows. Likewise, heavy hammers are tiring to use and it is difficult to strike light, accurate blows with them.



SELECTING THE CORRECT HAMMER

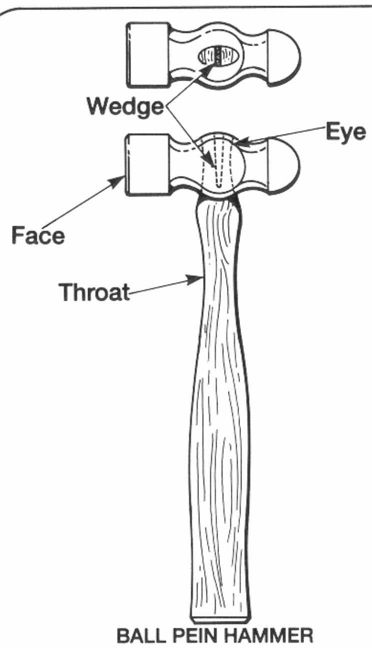
Handle Characteristics

- Length and shape of the handle,
- Material has good elasticity,
- Centre line of the handle should be at right angles to the head,
- Shape is important because it depends upon the feeling of flexibility and power which should go with each hammer blow,
- Most new hammers have a wooden wedge inserted lengthwise and a steel wedge inserted crosswise. This is to make sure that the handle end completely fills the head.

Head Shape

The shape and contour of the face must be suitable for the task.

- Marking off hammers usually have a flat face with slightly rounded edges
- Hard hammers and sledge hammers usually have a convex face so that they will not mark the plate severely.



FEATURES OF A HAMMER

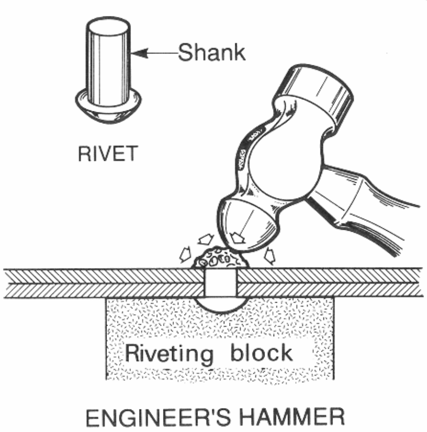
Types of Hammers
Ball Pein Hammer

This tool is most suitable for general bench fitting type work.

It has a flat or slightly convex (curved out) "face" for general work and a hemispherical "ball-pein" at the other end. They range in size from 100 grams to approximately 1.5 kilograms.

It is used to strike chisels, punches or the work piece itself, while the ball-pein is used for doming or shaping rivets.

An example is shown to the right.



ENGINEER'S HAMMER

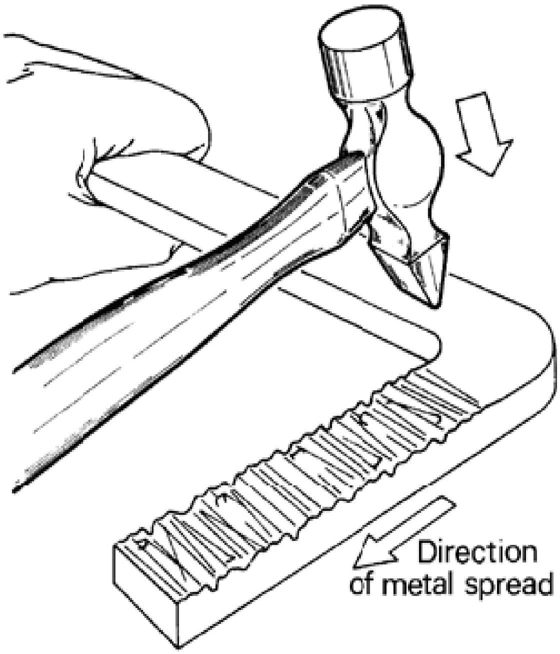
Peining Hammers

The two main types are the "**cross pein**" and "**straight pein**". A cross pein type is shown to the right and a "straight pein" type has its pein offset by 90 degrees.

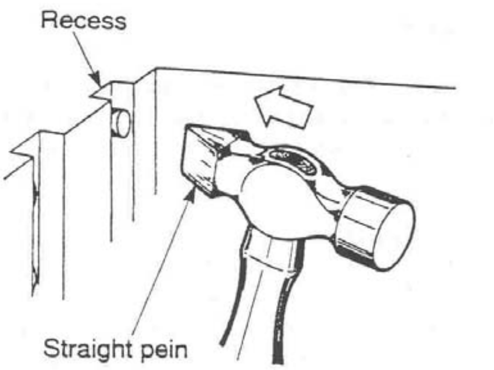
NB: "**Peining**" means to strike with the end of the hammer opposite to the face.

Cross-Pein Hammer
The pein end of this hammer can be used to stretch metal. By supplying a number of light sharp blows to the concave side of a bent bar it is possible to straighten the bar.

The pein end can also be used for working in confined spaces such as channels, corners and recesses where the striking face will not fit.



NB: The difference between a “cross pein” hammer and a ”straight pein” hammer is shown below.



Claw Hammer
This tool is used to either fix timber pieces together or nail accessories to timber (i.e. wall brackets, pin clips or nails etc). The claw end is used for removing nails from timber or for levering nails and galvanized iron roofing etc.

They are available in a range of head weights from 0.5kg to 1.25kg.

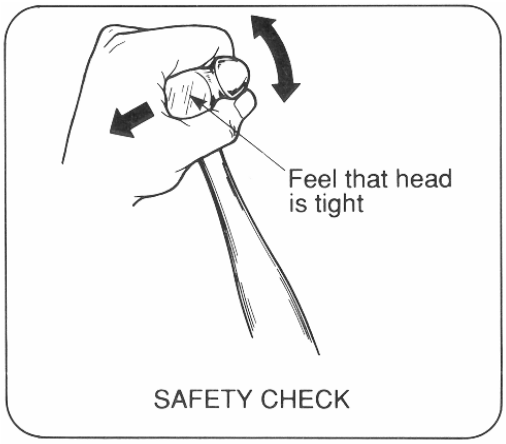
Note: Do not use a claw hammer general engineering work or for hitting hard objects such as masonry nails, cold chisels, etc. as the face is likely to chip.

Lump Hammer (Mash or Masons Club Hammer)
A lump hammer ranges in size from 1 to 2 kg but only a short handle. It is used in conjunction with the following tools strike:

- Bolster chisels for cutting bricks, concrete and pavers etc.
- Seaming, `coursing' or `plugging' chisels to remove bricks from walls etc.

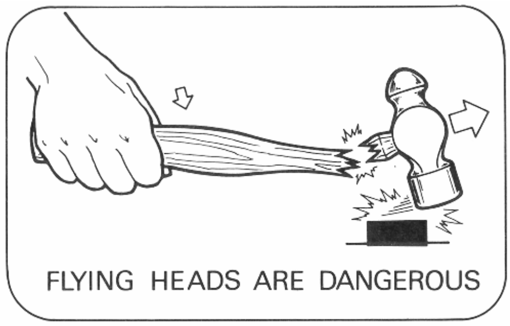
Sledge Hammer
This is the heaviest of the hammers with head weights from 3 to 10kg. They have a long wooden handle for extra leverage and are used for heavy duty tasks. Eg: Heavy steel work or smashing concrete etc.

Hammer Safety
Before using any hammer, use a clean dry cloth to wipe your hands, the handle and the head of the hammer. Oil, grease and dampness can cause the handle to slip from your hand or the striking face to slip from the work.



Feel if the head is firmly fixed to the handle and that the wedge is tight. Check that the head is square and in line with the handle. If the handle is loose, refit the head and have it re–wedged.

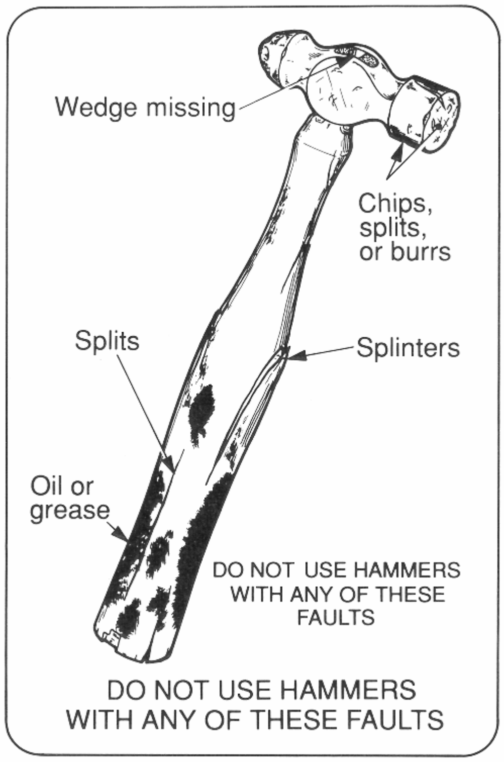
Caution
Hammer heads flying from poorly fitted or broken handles can inflict serious injuries.



Inspect the striking faces of the head and discard any split or badly chipped heads. Have any burrs or tiny chips ground off, making sure the faces are smooth, bright, clean and dry.

Inspect the handle and replace if it is cracked or split. Smooth any splinters with sandpaper and make sure that the handle is clean and dry, free from oil, grease or dampness.

Never hit two hammer faces together as the faces may split and chips would fly dangerously. Never hit any hardened metal directly. Always use a piece of soft metal between the hammer and hard steel to cushion the impact.



Soft Faced Mallet
Mallets or soft faced hammers are used to apply force to surfaces without damaging any soft or brittle parts. The force of the blow is distributed over a larger area than a "hard" hammer and any stretching or marking of the metal is reduced or even eliminated.

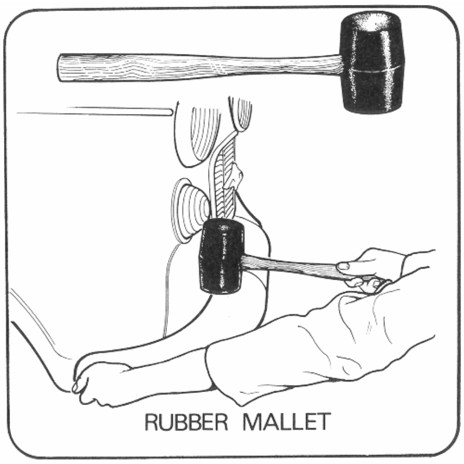
A blow from a steel hammer can damage or mark parts made of copper, aluminium or light alloys etc..

Mallets have wide flat heads which are made from materials like wood, rubber, soft metal and plastic.

Types of Soft Face Mallets

Rubber Mallets

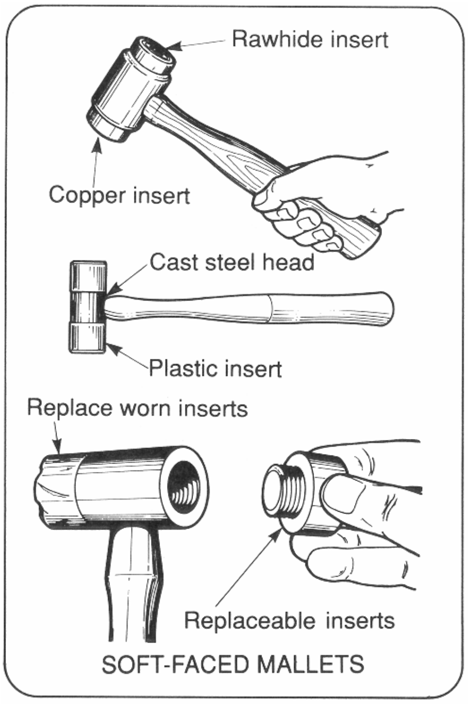
A rubber mallet has a cylindrical head made from solid rubber moulded to a wooden handle. Correct use of this mallet will prevent damage to surfaces which may have been painted, plated or finely machined.



Other Soft Faced Mallets

Materials used in the heads of soft-head hammers include brass, copper, aluminum, lead, wood, rubber, plastic and rawhide.

If possible, set the work piece in a vice as rebound can be a problem when using mallets.



For example, use:

- Copper to drive steel parts into position,
- Rawhide to seat insulated coils in an electric motor armature,
- Plastic to strike a finished metal surface,
- Lead to avoid damage due to rebound,
- Rubber to position MIMS cable in place.

Using Hammers Safely

To avoid injuries when using a hammer:

- Always wear appropriate PP when using hammers.
- Never use a hammer with a split, badly chipped or loose head,
- Replace any handle that is cracked or split,
- Make sure the handle and striking faces are clean and dry and free from grease,
- Never hit two hammer faces together,
- Use a piece of soft metal between a hammer and hard steel,
- Make sure it is clear, behind and above, before you swing a hammer,
- Strike the heads of chisels and punches etc. squarely.

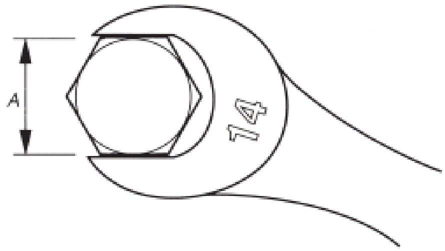
Maintenance and Storage

- Hammers should be selected carefully for the job in hand.
- Hammers fitted with wooden handles should be inspected prior to each use to ensure that the handle is tightly fitted full depth in the head and securely wedged.
- Hammers should be stored in a tool box or hung on a shadow board when not in use.

Spanner
Spanners are used to apply a twisting force (torque) to tighten or release a nut, bolt or threaded fastener. Spanners are made with "**jaws**" or openings that fit square or hexagonal shaped nuts and bolts. They are made of high tensile or alloy steel, drop-forged and heat treated for strength. They are given a smooth surface finish to make them easier to grip. The length of a spanner is designed to suit the strength of its jaws.

The following spanners are common to an engineering workshop:

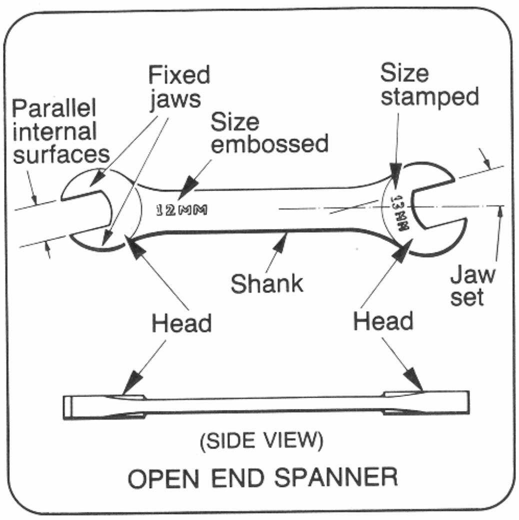
- Open end spanner
- Ring spanner
- Socket spanner
- Ratchet spanners
- Adjustable spanners
- Torque wrench
- Tube or Box Spanner



Most spanners are purchased as part of a set suitable for the bolt types and sizes likely to be encountered. Common set types include "metric", "BSW" and "AF".

Spanner Size
Both "Metric" and AF ("across flats") nuts and bolts, are measured across the flats (measurement "A" opposite) of the hexagon. In millimetres for metric and fractions of an inch for AF.

"BSW" (British Standard Whitworth) spanner sizes are based on the diameter of the bolt and **not** the dimension across the flats of the head. There are instances where different sizes of bolt, from different thread types, have the same size head and therefore fit the same spanner. **Never use a spanner from one thread system on another thread system.**



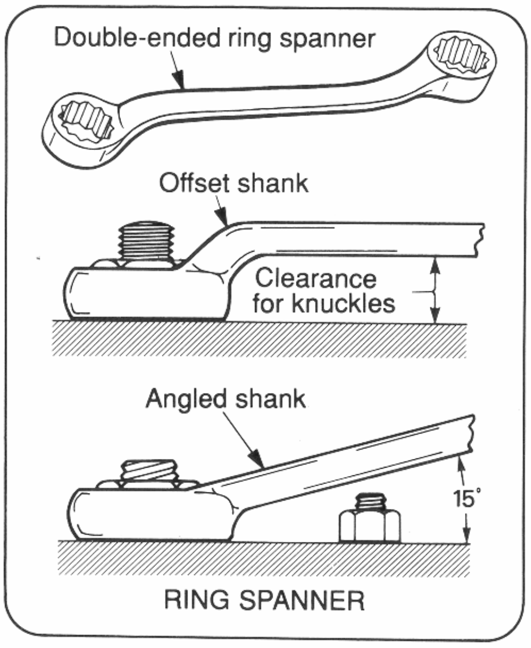
Open End Spanner
These spanners are open at both ends so they can be placed around nuts or bolts. They are very useful where you are unable to place the spanner over the bolt head or nut because something is in the way. Standard spanners have a length about ten times the width of the jaw. Extending this will strain the jaws of the spanner, strip the thread, shear the bolt or possibly cause an accident.

Maintenance and Storage
All spanners should be selected carefully for the application planned and inspected prior to use to ensure, where applicable:

- Jaws are square;
- Hexagon shoulders are not worn; and
- Moving parts are in good repair.
- All spanners, when not in use, should be cleaned and stored in a suitable roll or tool chest.

Ring Spanner
Ring spanners are available with offset or angled shanks. Because it is in the form of a ring, spreading of the spanner jaw cannot occur and greater force may be applied, making these spanners better for removing difficult or "frozen" heads.

The offset shank provides clearance for knuckles while the angled shank is to provide clearances above obstructions.

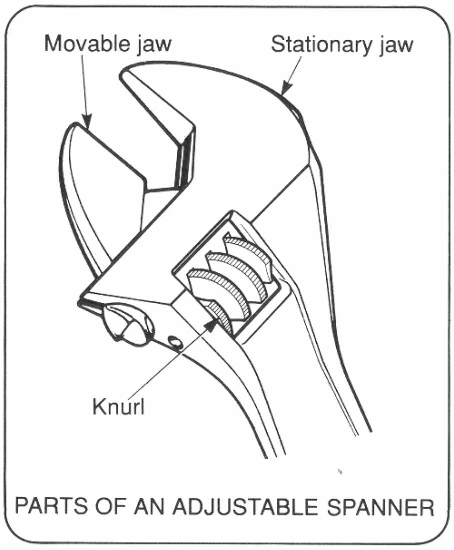


Combination Ring and Open End Spanner
When the combination ring and open end spanner is used, the ring spanner loosens the nut and the open end is then used to quickly undo the nut.

This spanner has open jaws at one end and a 12 point (double hexagon) ring at the other end.

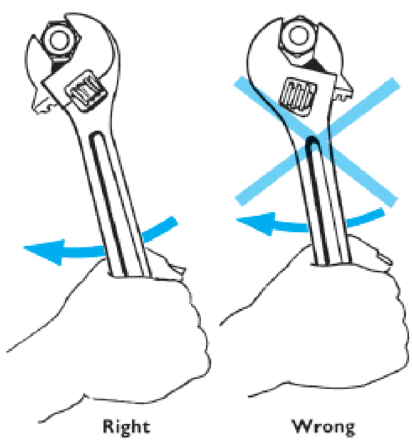
Adjustable Spanners
These are also called a "shifting spanner" or an adjustable wrench. Adjustable spanners are similar to open end spanners, but they have one moveable jaw. They tend to slip and are only used when a full kit of set spanners is not available.

Adjustable spanners range in length from 100mm to 760mm. The type illustrated has its jaws set at an angle to the handle.

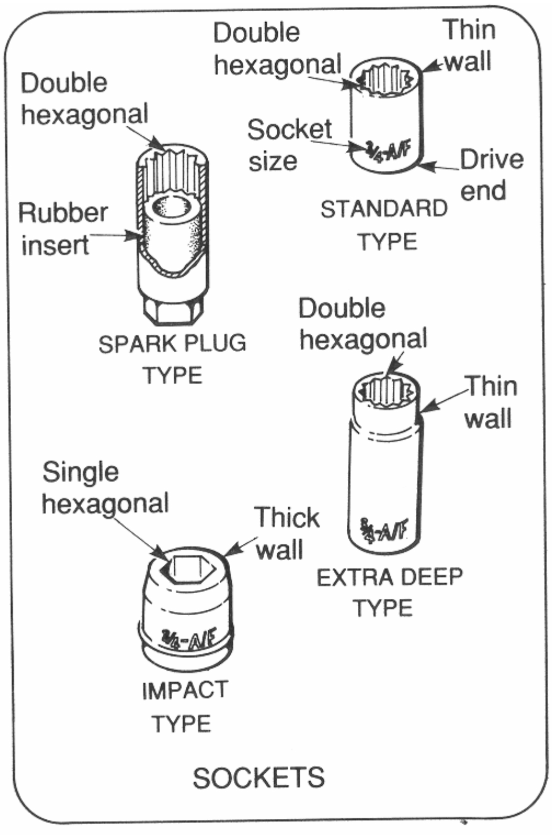


They are not meant to replace fixed spanners which are more suitable for heavy service. In general, adjustable spanners are **not** recommended in the metal industry.

It is important to keep adjustable spanners clean and moving parts should be lubricated regularly.



Socket Spanner
Socket spanner sets generally include a wide variety of handles, adapters, ratchets, breaker bar, speed handles, universal joints and extensions which significantly decrease the time taken to loosen or tighten nuts and bolts.



A socket is a cylindrical shaped tool made from chrome plated alloy steel. One of its ends has a square recess with an internal groove to accommodate a drive bar. Its other end is recessed to suit a particular nut or bolt head.

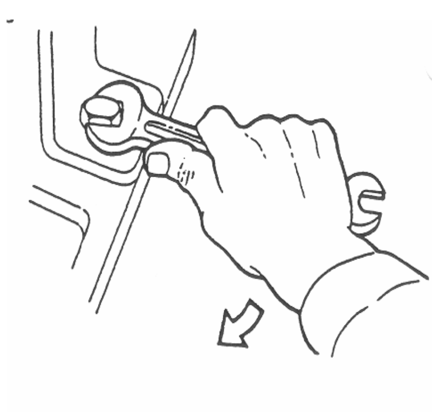
The dimension of the socket is measured across the flats of the square recess.

The nut or bolt head recess may have:

- Six (6) points and be a normal hexagonal shape. This is known as a “single hex” socket.
- Twelve (12) points and be a double hexagonal shape. This is known as a “double hex” socket.
- Sockets typically have a square drive hole at the other end.

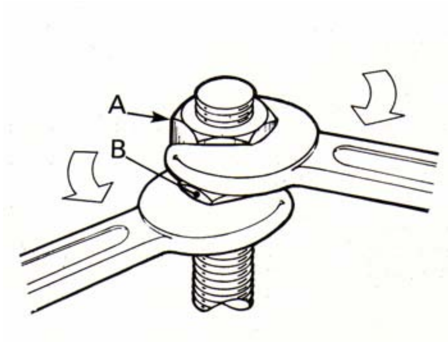
NB: Common socket spanner accessories include a: Speed brace, Extension bar, Universal joint, Handles, Adjustable offset handle, “L” bar handle, Sliding tee handle

Correctly using a spanner
1. The spanner must be the correct size for the nut or bolt head. If it is a loose fit, it may round off the corners of the nut or bolt head.
2. Do not use a “metric” spanner on an “imperial” bolt or vice versa.
3. If possible always “pull” the spanner towards your body. This way you are far more balanced then when pushing away. Pulling the spanner will also reduce the likelihood of the nut suddenly cracking open and injuring your knuckles.
4. If pushing the spanner is required, then use the heel of your palm to avoid hurting your knuckles.
5. Never use a spanner on moving machinery.
6. Do not hammer on to a spanner or extend the handle for additional leverage. Use a larger design of spanner.



7. The spanner must be in good condition with no cracks or worn jaws.
8. If you are working in an area where the spanner could be dropped into a hazardous position then use a wrist strap to secure it, (ie: Working over the top of an oiled filled transformer).
9. When requiring high torque on a fastener, always select a ring spanner rather than an open ended spanner.

Tightening Lock Nuts

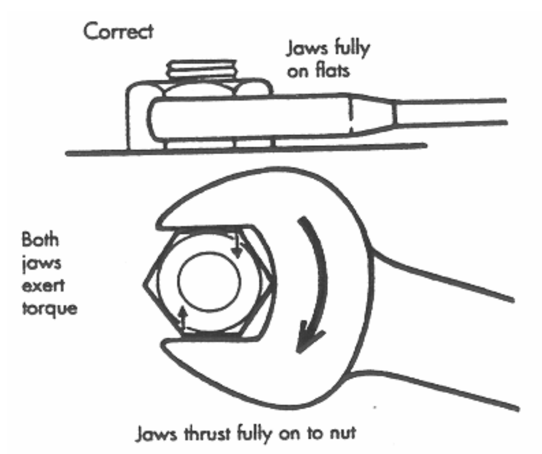


A “**locknut**” is a supplementary nut which is tightened upon the “primary nut” to prevent it from shaking loose.

This technique is commonly used in the electrotechnology industry to ensure “busbars” joints remain firmly connected.

To “**tighten**” a locknut bolting arrangement:

- First ensure the “primary” nut (Nut “B” in the illustration) is tightened to the required tension.
- Add the lock nut (Nut “A” in the illustration).
- Place an open end spanner on the primary nut and it hold firm.
- Use a “second” spanner to tighten the lock nut against the primary nut.
- When tighten to the required tension, remove both spanners.

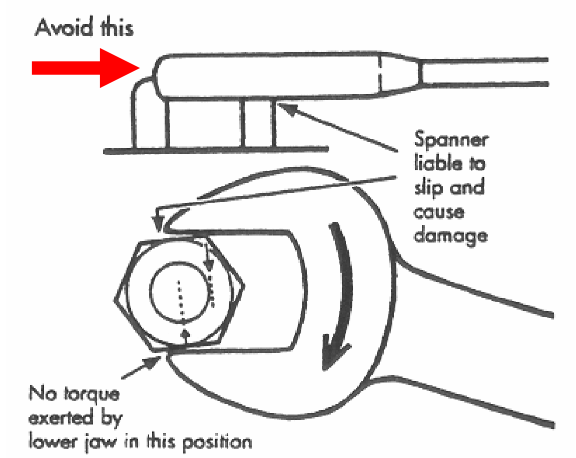


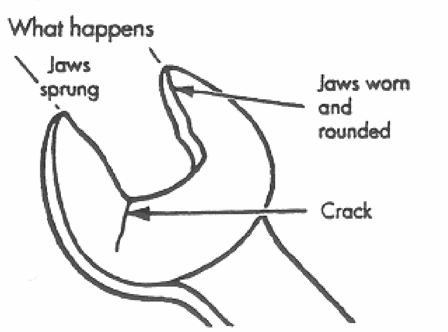
Care when using Spanners
It is important for spanner jaws to fit fully on the nut or bolt head. The jaws should also fit centrally on the hexagon flats as shown in the diagram, which also shows how a spanner will be damaged as a result of failure to fit it properly onto a nut.

Damage to both the spanner and nut can be avoided by correctly placing the spanner on the nut **before** applying any force.

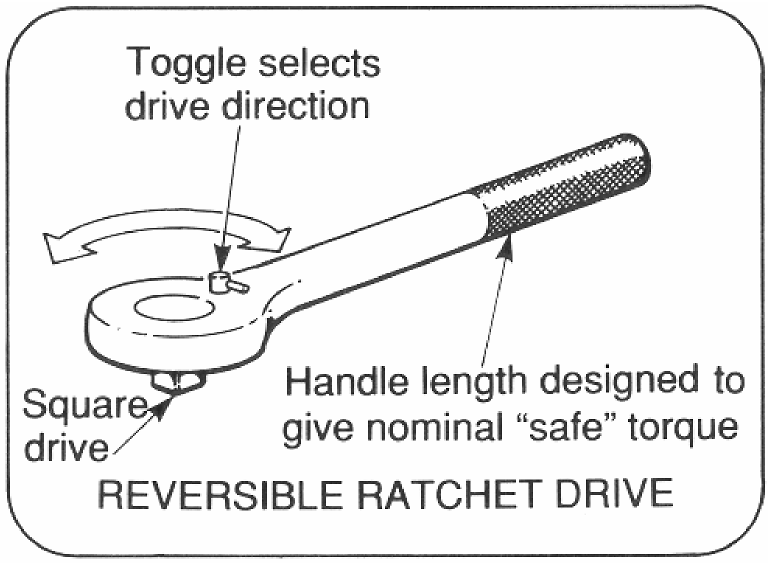
The handle length of an open ended spanner has been designed to enable a nut or bolt to be adequately tightened without spreading the jaws of the spanner.

__**Never**__ use a pipe or other device to increase leverage on the spanner.





Reversible Ratchet Spanner
A ratchet spanner is used in conjunction with sockets and variety of socket accessories. It significantly speeds up the turning motion when tightening and loosening nuts and bolts. It is also used in tight spots where the turning arc is small.



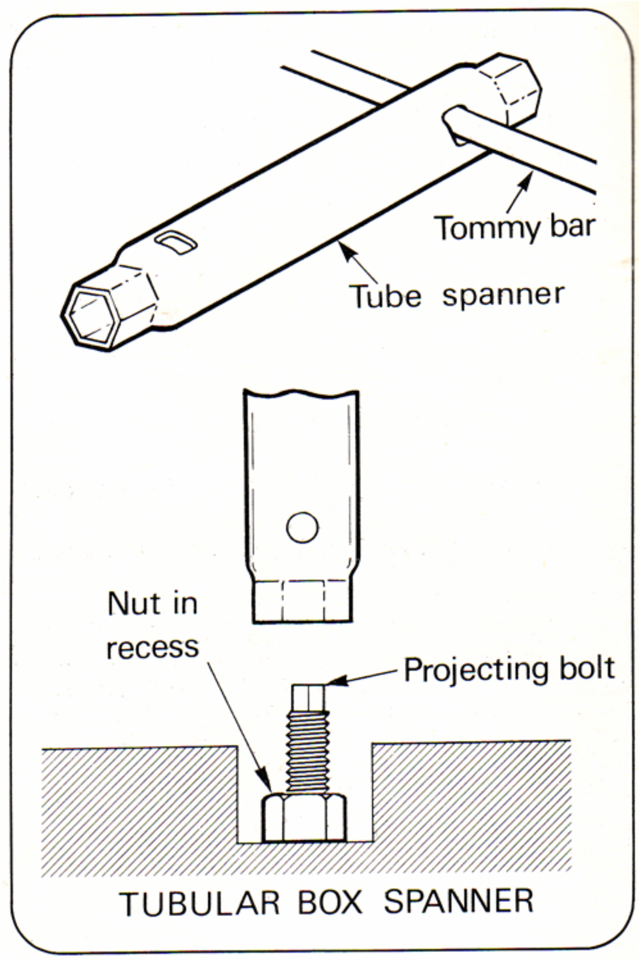
A socket drive is the "**square**" section that clips in to the top of the socket.

Common socket sets have drives sizes of either: ¼, ⅜, ½ or ¾ inch.

NB: The half-inch drive is a common general use size.

Unless the socket set is equipped with a drive converter, the drive dimensions mean that often, individual sockets are not interchangeable between sets.

Tube Spanner or Box Spanner
Tube or box spanners are used to tighten bolts and nuts that are located in deeply recessed or confined spaces.



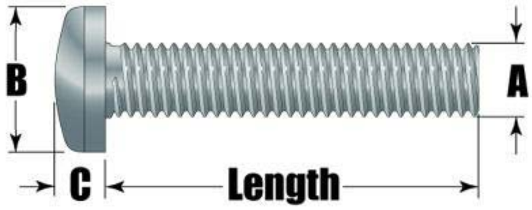
These tools are sold in sets with a range of sizes suitable most standard sized bolts. The lever or "Tommy" bar is used to provide additional torque.

T8 Joining techniques encompassing:

- types of machine screws and nuts
- joining components using machine screws
- forms of welding (Oxy-acetylene, electric arc welding).
- forms of brazing and hard soldering
- joining components using welding, brazing or soldering techniques
- process of soft soldering

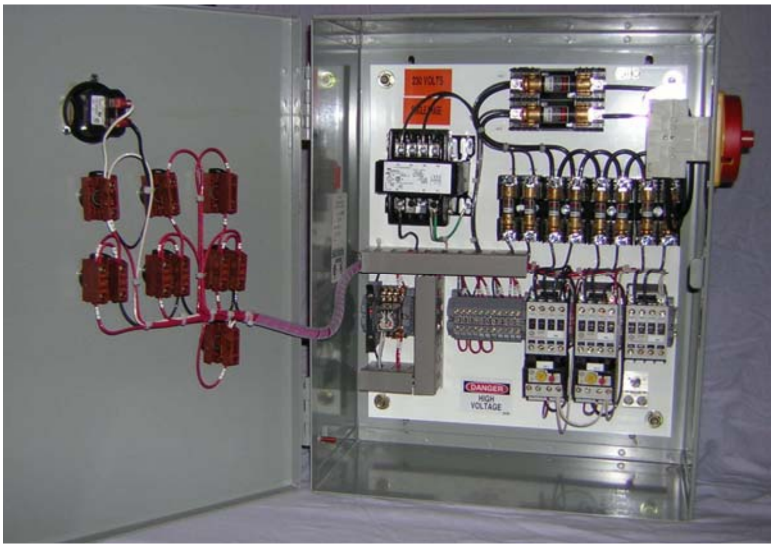
Types of Machine Screws and Nuts

There is no one fastener that is right for every application and selection from the vast array of shapes, sizes, materials available can be a daunting task. Consideration must be given to the application, orientation, ambient temperature, corrosion, vibration, fatigue and many other variables.

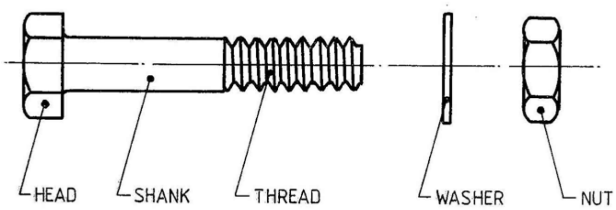


"Machine screws" (also called "metal threads" and "set screws") are uniformly threaded screws where the thread extends all of the way from the "tip" to the head. It has a nominal diameter (measured across the threads) and is made to be threaded into a matching nut or threaded hole for the purpose of assembling equipment. Uniform threads maintain the same diameter throughout the entire length of the threaded section as opposed to tapered threads which have a pointed end such as that used for "wood screws". Wood screws are designed to cut their way into the soft wood.

Machine screws are generally considered to be smaller than "bolts, although there is no hard-and-fast rule. Most machine screws are typically less than 10mm nominal diameter. A typical machine screw is shown below.



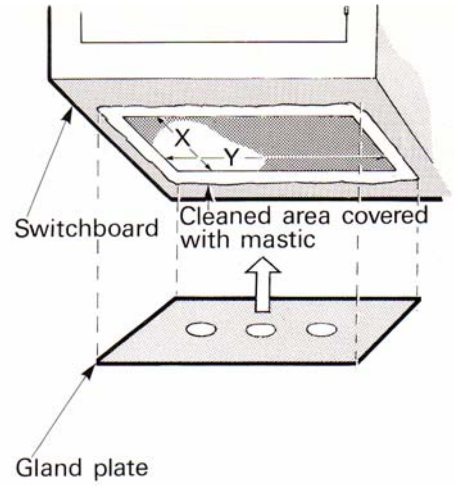
The main difference between a "machine screw" and a "bolt" (image shown to the right) is the primary tightening method. A machine screw is usually tensioned by turning the "head" of the screw as opposed to a bolt which is tensioned by turning the "nut" while holding the "head" stationary.



Compared to a "bolt" which has an unthreaded "shank" section, the uniform thread on a machine screw makes it more susceptible to "shear loads" (slicing across) for its size. A machine screw it about equivalent when taking "tension loads" (down the long axis).

Machine screws are available in a wide array of head configurations and sizes. When determining the “screw diameter” and the “number” of fixing screws required for a particular task it is best to follow the manufacturer’s pre-formed mounting holes as a guide. Manufacturer’s typically design a suitable safety margin into their product fixing arrangements and it is unwise to deviate from this. Eg: A large contactor may have four mounting holes available, a small contactor or relay may have two mounting holes and a fuse base may only have one mounting hole. The key point is to completely use all of the available fixing holes unless experience or circumstances suggests otherwise.

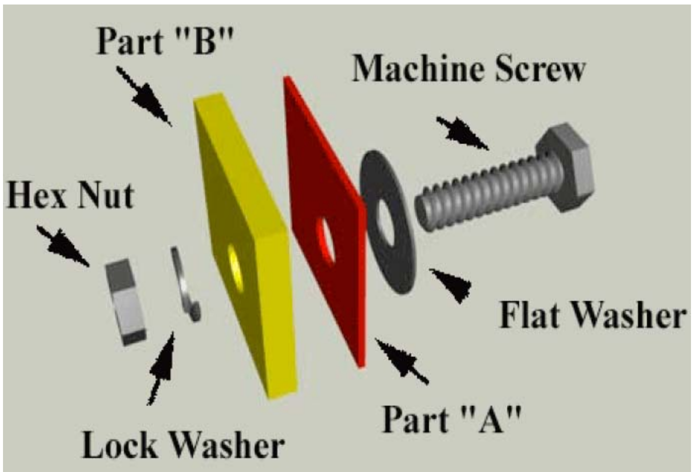
Machine Screw Applications
Machine screws are versatile in the number of types of joints they can secure. They can be used for fastening electrical accessories with through holes and a nut behind or into a tapped hole. They can be passed through two or more components and then threaded into the rearmost component, which acts as the securing nut for the joint. Machine screws can be threaded into metallic inserts cast into soft materials such as plastic or light alloy. Two opposing machine screws can be used with a “standoffs” to separate plates by set distances. Conductive machine screws (brass) can be used as part of an electrical connection (neutral or earth link) and nylon screws are commonly uses as insulators to separate panels which contain different potentials. Machine screws are commonly used to fasten electrical “gland plates” to switchboards and cableways to facilitate cable entry.



They are called “machine screws” because their primary role is to assemble machine components such as for tools, manufacturing equipment, electrical and electronic equipment of every description. In the electrotechnology industry, machine screws are used in switchboard construction to secure internal equipment such as contactors, relays and protective devices (fuses and circuit breakers) to back panels.

Machine screws are made using a variety of materials. Most are metallic; steel (including mild and stainless) or brass, but some exotic materials such as titanium are also used for special applications. Rigid nylon is used if an insulator is required. Each type of material has different characteristics of strength and corrosion resistance. The key is to select a screw type to fit the application and the environment. Always consider factors such as metal fatigue (due to vibration), and electrolytic corrosion if dissimilar metals are to be direct contact within a moist environment.

“Zinc plated” mild steel screws are used in benign environments such as a dwelling or factory etc. Stainless steel and brass are best used for outdoor applications and for corrosive marine environments where ordinary mild steel (even plated types) would quickly corrode. Brass is often used for its good electrical conductivity and nylon screws are used for their electrical insulating properties.

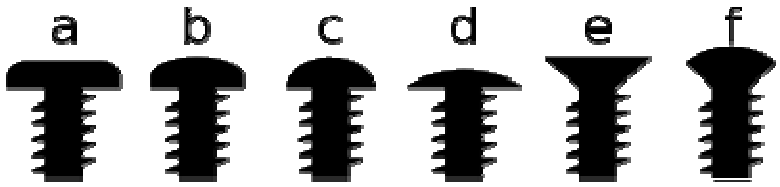


When choosing a machine screw, first consider the pieces to be joined and the thickness of the substrate and then select a screw that is long enough to pass completely through. The diameter of the screw should be thick enough to resist the forces that will attempt to separate the fixing and its load. Screw diameter is normally determined both by the material that the screw is made from and the stresses that it will encounter during its life. The length of the screw should be slightly longer than the conjoined pieces so as to ensure that a nut etc. can be secured to the end. The length of the fully tightened screw should be such that the screw tip should protrude beyond the securing thread or nut by at least two full threads.

There are many head types commercially available such as slotted, Phillips and Torx head. The head type must match the available tightening tools. Eg: Battery drill tip or hand screwdriver etc. Machine screws are prone to snapping if over tightened. A tool such as a screwdriver or battery drill and screw bit offer a large mechanical advantage to the user. Always match the size of the tightening tool to the size and type of screw. Nb: Brass screws tend to snap very easily and tend to give little warning that they are about to break.

Choosing between the different screw heads normally comes down to the tool available and whether you want a screw that has better torque (Phillips head) or more driving force (slotted head). Hex heads can take more stress than the slotted types and are better for heavy-duty projects. "Torx" heads are sometimes used to restrict unauthorised access to a part.

There are a number of different head profiles and shapes. The common machine screw head profiles are shown below. (e) A "flat" (countersunk) head has a completely flat top, and is normally used for projects where the screw head must be "flush" with the top of a surface. All of the other head types maintain a slightly higher profile to various degrees. The screw head shape is chosen to fit the application. Larger heads can be used to cover large mounting holes and spread the mechanical forces over a bigger area.



Profile Legend: (a) pan, (b) dome(button), (c) round, (d) truss(mushroom, tank), (e) flat (countersunk), (f) oval (raised head)

The "**advantages**" offered when joining materials using machine screws are:

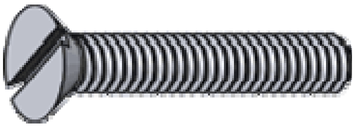
- Ease of disassembly,
- No heat distortion,
- No disruption to painted surfaces.

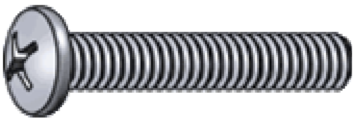
The main "**disadvantage**" of machine screw fixings it that they may become loose under severe vibration. This, however, can be overcome by using special locking nuts or washers or a chemical thread locker product such as "Loctite 243".

Ref: http://www.hirespares.com/sealants-adhesives-thread-lock-c-68_71.html

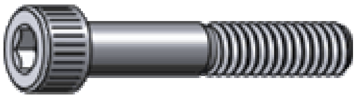
Overview of Machine Screws
http://www.boltdepot.com/fastener-information/Type-Chart.aspx

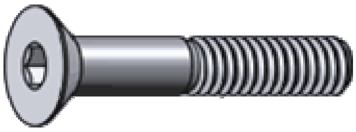
Machine Screws with uniform threads for use with a nut or a tapped hole.



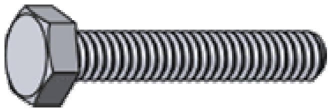


Socket Headed Machine Screws, also known as Allen head are fastened with a hex Allen wrench.



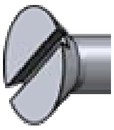


Hexagonal Headed Screw for use with a nut or tapped hole.

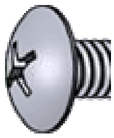


Common Screw Head Types:
There is a large number of screw heads available but the common types are shown below.

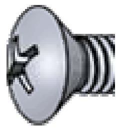
Slotted head



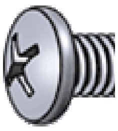
Truss (Tank)



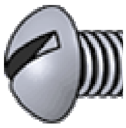
Oval head



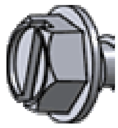
Pan head



Round head

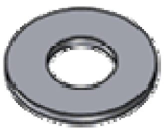


Slotted hex washer

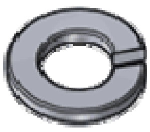


Washers and Nut Types

The “flat washer” is the most common style of washer used to prevent nuts and bolts from backing out and to spread the forces over a bigger area.



A spring (or split) washer with internal 'teeth' is used to prevent nuts and bolts from loosening.

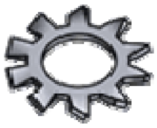
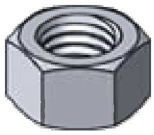
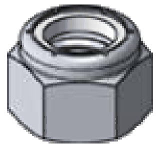


A “star” washer with internal 'teeth' is used to prevent nuts and screws, bolts from loosening.

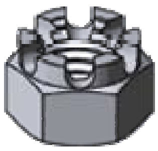
A “star” washer with external 'teeth' is used to prevent nuts and bolts from loosening. It is often used in switchboards to ensure a good electrical contact to a metal panel for earthing studs.

A six sided machine nut. Also referred to as a finished hexagonal nut.

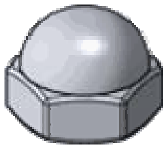
A “Nyloc” or “locking nut” which has a nylon insert and is used to prevent it loosening due to vibration.

"Castle" nuts are similar to slotted nuts but with the slots in a rounded section above the main nut. Used to prevent loosening.



An "acorn" nut with a domed top is used mainly for decorative purposes.

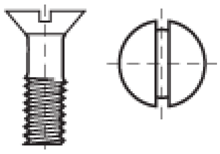
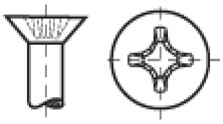
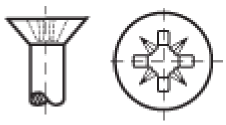
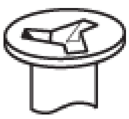


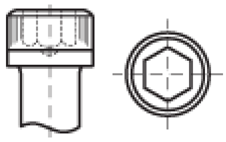
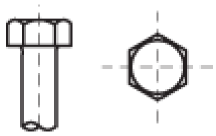
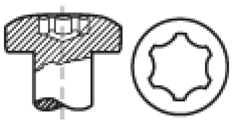
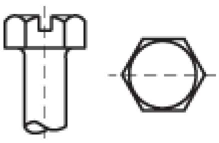
A "wing nut" is used for hand tightening and for quick removal by hand.

Head Driving Types
http://www.jamesglen.com.au/?DocPath=driving-methods/&

The drive type on a screw fastener is the feature through which rotational torque is applied. All threaded fasteners will have a drive feature or a retention feature to prevent rotation whilst the securing part is rotated - Eg: nut.

Machine screws are available in a wide assortment of driver head types, including standard slotted, Phillips head, hex socket head for use with Allen keys, Torx six-pointed star, square-drive socket head and security heads, which are easily driven in but very difficult to remove.

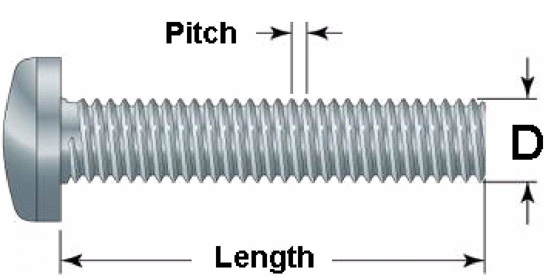
Sketch	Drive Type	Uses	Tightening Tool
	Slot	Commonly found on woodscrews and machine screws in domestic applications or where field retightening or removal may be required. Most suitable for hand operated tools. Oldest and simplest drive form.	Flat bladed common screwdriver.
	Phillips Recess (Type 1) (X-Recess) (Cross-Recess)	Commonly found on self tapping screws and machine screws, particularly where they can be power assembled eg: on a production line for domestic appliances.	Ideal for power operated tools and hand tools.
	POZIDRIVE RECESS (Type II Or IA) (X-Recess)	As above, but is less prone to 'cam out' when drive tools are worn.	Power operated Pozidrive Tools and Pozidrive hand tools.
	Tri-Wing	Security applications usually confined to screw products, particularly in aircraft, public transport fittings and electrical appliances where fieldwork should only be carried out by	Special 3-bladed drivers both power and hand.

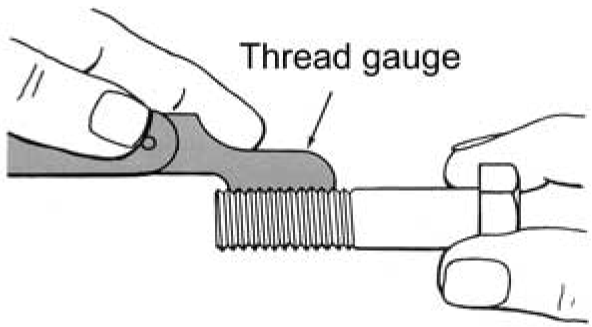
		authorized service personnel.	
	Hexagon Recess	Principally used in high torque applications such as automotive, heavy equipment, tool die sets. Commonly associated with cap screws.	Hexagon socket key (Allen key) and hexagon power drivers.
	Hexagon	The most common drive on bolt products - very versatile in drive torque range; economical to produce.	Hand driven ring and open ended spanners, hand or power driven with socket drivers.
	Internal Torx®	Gives very high driving torque capability with low risk of 'cam out'. Usually found in high production applications, particularly automotive and appliance industries. Usually restricted to screw products.	Normally power driven with special drive bits or hand driven with a Torx ® key.
	Hexagon Slot Combination	Usually associated with screw products. Is useful where it can be power driven on the assembly line and removed or adjusted in service with a blade screwdriver. Usually head is indent hex and sometimes x-recess is also added.	Power driven with hexagon socket. Hand adjusted with blade screwdriver.

Machine Screw Threads Types and Sizes
The most common machine screw thread type used in Australia is "**ISO-Metric**" (International Organization of Standardization), but "imperial sizes" (Ie: in inches) such as BSW (British Standard Whitworth), BA (British Association), UNC (Unified Coarse), UNF (Unified Fine) and BSF (British Standard Fine) may also be encountered in older types of equipment.

A screw size can be identified by measuring its "nominal diameter" and its thread type can be determined by using a "**thread gauge**" to measure its thread "**pitch**". The "thread pitch" is the distance from one thread groove to the next, measured from crest to crest.

Size	Minimum Length (mm)
M1.6	15
M2	16
M2.5	18
M3	19
M4	22
M5	25
M6	28
M8	34
M10	40
M12	46





ISO Metric Thread Designation

A metric ISO (International Standardization Organization) screw thread is designated by the letter "M" followed by the value of the nominal diameter "D" and the "pitch" which is expressed in millimetres and separated by the multiplication sign, "×" (e.g., M8 ×1.25). If the pitch is the common "coarse" pitch listed in ISO 261 or ISO 262, it can be omitted (e.g., M8).

Where the ISO metric thread pitch is the measured distance per thread in millimetres, "imperial" standards such as "BSW" are designated by how many threads occur per a given distance. Thus inch-based threads are defined in terms of "threads per inch" (TPI).

Right and Left Hand Threads

The vast majority of fixing screws are "**tightened**" by clockwise rotation, which is termed a "right-hand thread". A common mnemonic for remembering this when working with screws and bolts is; "**lefty-loosey, righty-tighty**." Screws or bolts with left-hand threads are mainly used for rotating parts to ensure that the forces do not cause the fastener to loosen. Eg: The securing bolt for the blade on a circular saw and screw securing fan blades etc are typically left hand threads.

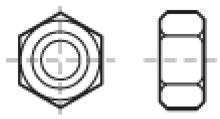
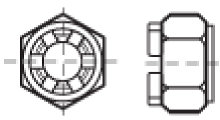
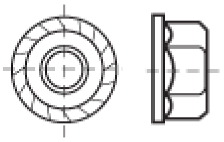
Machine Nuts

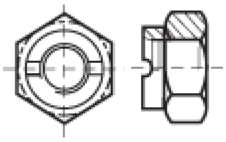
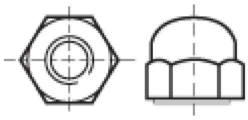
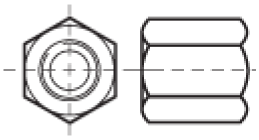
The primary function of the nut in a threaded assembly is to act as the instrument through which the "tension" is induced into the screw and to retain that tension by clamping the load to the assembly. The vast majority of nuts have hexagon drive faces although some "tank" screws often use nuts with "square drive faces.

The material used for the nut should be the same as that for the screw to avoid corrosion due to electrolytic action (Ie: dissimilar metals). Common materials range from carbon steels, stainless steels, brass, aluminium, nylon. Finishes would normally include plain, zinc, galvanized and chrome.

The correct combination of screw and nut should ensure that the nut is capable of tensioning the mating bolt to breaking point rather than the nut stripping; (NB: A broken screw is clearly evident, but a stripped nut may not be).

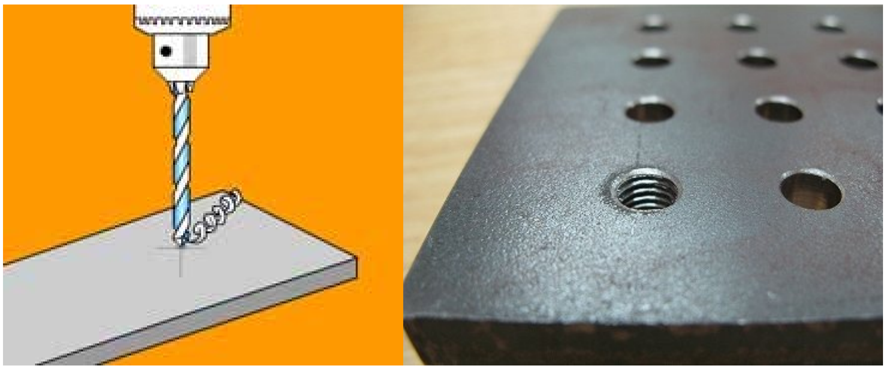
Various Nut Types

	Plain hexagon	The standard form general purpose nut and may be used with various washer types. Also available in a thin or (half) nut version. May also come with full bearing or washer face when machined.
	Hexagon castle	The "groove" is aligned with a small through hole in the screw to insert a cotter pin which is then spread to lock the nut.
	Hexagon flange serrated lock nut (whiz lock)	Special serrations on the flange face resist loosening in vibration applications. Also available as a plain flange to span a large hole or slot or spread the clamp load.

	Hexagon nylon insert lock nut	A nylon insert on top of the nut creates a prevailing torque, resists loosening and allows reuse after several removals without significant performance loss..
	Hexagon “acorn” or domed or cap nut	Either machined with a closed domed end or capped in a secondary process after tapping. Used in decorative applications, or for protection from protruding threads. Usually chromed or polished.
	Coupling nuts (joining)	Similar to the deep nut above except longer/deeper. Used for connecting lengths of all thread.

Machine Screws and Tapped Holes

It is common for electrical equipment to be mounted onto sheet metal backing plate within the switchboard. In many cases rear access behind this panel is not possible. This means that it is not possible to secure the components with a “clearance hole”, machine screw, washer and a nut. If the backing plate is made sufficiently thick it can be drilled and “tapped” with a suitable thread. The thickness of the backing plate should be such as to support at least “3” full threads. For electrical switchboards and motor control panels this is generally the fastest and cheapest method of mounting smaller sized electrical equipment.



Nut Inserts

http://www.mightyboyev.com/Nut%20insert%20tool.htm

If the backing plate material is too thin to successfully tap, then “nut inserts” provide a simple method of inserting a captive threaded “nut” into sheet-metal. Inserts also known under various trade names such as Blind Rivet-Nut, Nut-Inserts or Crimp Nuts and are designed to provide a strong threaded joint in relatively thin sheet-metal. They are called "Blind" as they can be installed from one side of the assembly even if there is no access from the backside. They should not damage the parent surface of previously finished [plated/coated] components, sub-assemblies.

Blind Nut-Inserts can be installed by means of a custom “crimp tool”. The technique is to drill a neat, correctly sized hole in the metal backing and the “insert” is placed into the hole with the custom tool (shown over page). The handle is squeezed to compress the back of the insert and lock it in place. (The action is similar to a pop-rivet gun.)

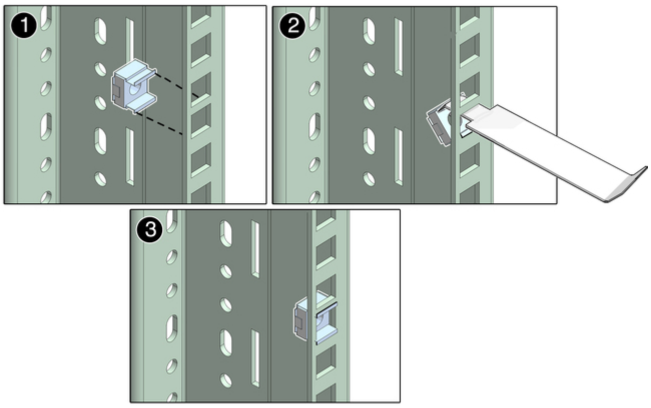
When installed, the Blind Nut-Insert body is designed to undergo controlled deformation, wherein the non-threaded portion crimps, creating a firm 360° rib which grips the underside of the mounting surface.

Cage Nut

http://docs.oracle.com/cd/E19657-01/E29153/z4000e8e1010292.html

A caged nut (also called a captive or clip nut) consists of a square nut in a spring steel cage which wraps around the nut. The cage has two wings that when compressed allow the cage to be inserted into a “standard” square hole in the equipment rack. When the wings are released they hold the nut in position behind the hole. (There is a small amount of movement to enable hole alignment.

Using cage nuts mounted in square holes provides several benefits over threaded holes directly in the cage. First, one has the flexibility to choose the size of nuts and bolts at a time after the cage is installed. They are easily replaceable. In contrast to a pre-threaded cage where if the threads are stripped it becomes more difficult to make use of the hole.

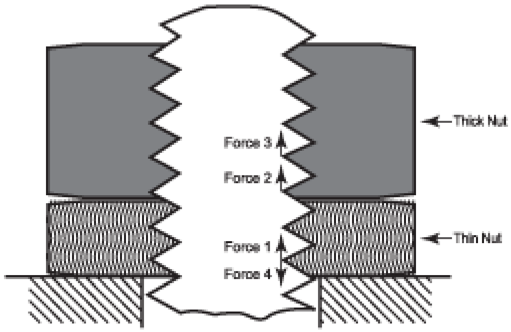


The nut is usually slightly loose in the cage to allow for minor adjustments in alignment. The gap between the two wings determines thickness of material that will hold nut in correct position without pulling it from the base material.

The size of square hole will also govern the position of nut. If size of hole is too large it will still pull out from base material.

Spring Steel Captive Nuts
http://export.rsdelivers.com/product/rs/r0504-525-082/znpt-spring-steel-captive-nut-m4/0525082.aspx
Captive nuts are manufactured from spring steel and are used for inaccessible areas where the securing nut is positioned close to a finished edge. (ie: <25mm) First a "clearance hole" for the screw is drilled or stamped in the sheet backing plate material and the captive nut is slid into place over the hole from the edge of the backing plate. The clip is held in place by spring action. They are relatively inexpensive and are commonly used in electrical switchboards for joining parts. They do not require special assembly tools and are easily replaceable.

Lock nuts
http://www.designworldonline.com/hard-lock-nuts-resist-loosening/
Locknuts are used in conjunction with a standard nut to prevent loosening due to vibration. If a full nut and a half nut are to be used then the "half" nut is installed first. This is shown in the diagram to the right.



- Tension the "half" nut to its set value.
- Next, apply the standard nut (thick) and tension it to snug tight.
- Next, hold the thin nut with a spanner to prevent rotation, and then tighten the standard nut against it to full design tension.

In effect, the two nuts are now working in opposite directions and are "locked" against each other. The amount of actual clamping force applied to the joint is set by the "inner" half nut. The outer "full" nut has to carry the combined load and therefore, has to be the thicker of the two. These nuts will remain locked even if tension in the assembly is lost.

Nylon Insert Locknut (Nyloc Nut)
http://www.weifeng-fastener.com/Nylon-Insert-Lock-Nut-76.html
A Nyloc nut or "nylon insert locknut" is a nut that includes a nylon insert. The insert is placed at the outer end of the nut and the insert's inner diameter is slightly smaller than the major diameter of the screw. The insert deforms elastically over the thread of the screw. (The thread is not cut into the nylon.) The nylon insert locks the nut in two ways. First, it forces the bottom face of the screw threads against the top face of the nut threads, increasing the friction between the two to prevent loosening. Second, the nylon applies a compressive force against the screw itself. It is used in applications where vibration can cause loosening.

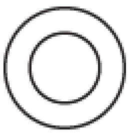
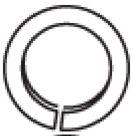
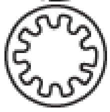
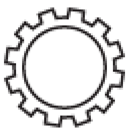
Serrated Flange Locknuts
http://www.apexfasteners.com/fasteners/nuts/locking-nuts
Fine thread serrated hex flange lock nuts have a built in washer with serrations on the bearing or mating surface. The angled serrations help to prevent the nut from loosening and will resist severe vibrations. The large flange has the added advantage of covering up oversized and messy drill holes. Serrated flange nuts actually require more torque to loosen the nut than is needed to tighten.

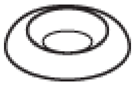
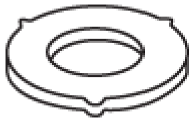
Washers
A washer is a thin plate (typically disk-shaped) with a hole (typically in the middle) that is normally used to distribute the load of a threaded fastener, such as a screw or nut. Other uses are as a spacer, spring (Belleville washer, wave washer), wear pad, preload indicating device, locking device, and to reduce vibration (rubber washer). Washers usually have an outer diameter (OD) about twice the width of their inner diameter (ID).

Washers are made of metal, plastic, rubber or fibre. Washers can be used to prevent galvanic corrosion such as insulating the steel screws from aluminium surfaces.

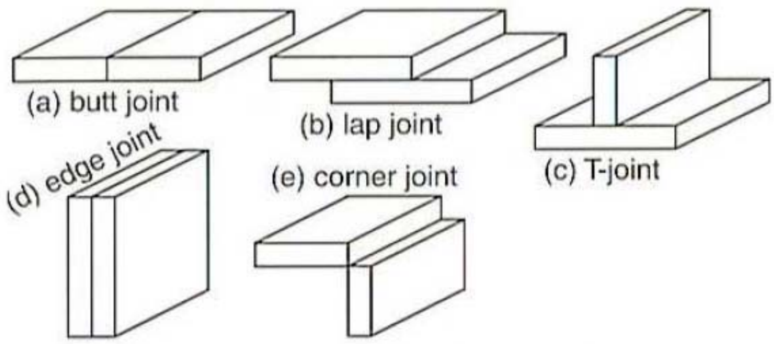
Washers are manufactured in a wide variety of designs, range of materials, dimensions and finishes. A washer size is designated by the diameter (size) of the fastener with which it is to be used.

Washer Applications
Washers have been designed to perform particular functions in particular types of applications. These may be locking, load spreading, decorative, tension indicating, sealing, or a combination of these functions. Some of the most common types of washers are shown in the charts following.

Sketch	Name	Uses
	Flat	Common general purpose basic washer can come in various dimensional standards, quality levels, materials, hardness grades and finishes. Often used in conjunction with a split spring washer.
	Split Spring	Common locking washer. Come in a variety of thicknesses and sectional ratios. Available in various materials throughout a wide size range. Used to resist vibration loosening. Will damage surfaces it contacts.
	Internal Tooth Lock Washer (Star washer)	Used with machine screws to resist vibration. Causes minimal damage to surface.
	External Tooth Lock Washer (Shake Proof)	Same as above except slightly more damaging to surface. Sometimes used to ensure electrical earth continuity between two joined metal surfaces.
	Wave	Available as full circle or split. Is used in place of spring washers where surface damage is to be avoided. Also used where some pressure is required on a free element of an assembly. Usually confined to small diameters. Similar products are crinkle washers.

	Curved	Generally confined to light applications similar to above, where only very light pressure is required.
	Screw Cup (Cup)	Used under a countersunk screw where a decorative or appealing finish is required. Normally would be nickel or chrome plated, or in stainless material.
	Structural	A hardened steel washer used in conjunction with structural bolts in heavy construction applications. The washer spreads the load. The three external tabs identify it as a structural washer.
	Load Indicating Washer (Coronet)	Used in the structural industry to provided evidence that the required tension has been achieved. The raised protrusions will crush in relation to the load applied, providing a permanent witness that required tension was achieved.

Machine Screw Joints
Machine screws are versatile in the number of types of joints they can fasten. Typically they are used to make "lap" and "T" joins and are generally not suitable for "butt" and "corner" joins.

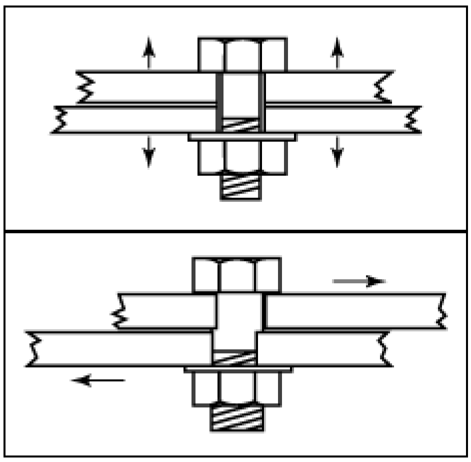


As shown, they can be used in combination with a securing nut or a threaded component.

Mechanical Properties
http://www.jamesglen.com.au/training-manual/
Most joining applications are designed to support or transmit some form of externally applied load. If "strength" is the only criteria then screws made of carbon steel are ideal. Nonferrous fasteners (brass, bronze, nylon) should be considered only when a special application is required.

Metals used in fastener manufacture are elastic materials which will stretch (elongate) under applied loads and return to their original shape when the load is removed. However, if sufficient load is applied, the material will stretch beyond its yield point and enter a plastic zone, losing its elasticity and becoming permanently stretched. Further increased load on the material will stretch it to its ultimate tensile strength at which point the material will fracture.

The major factor in determining the load a fastener can carry is its "**tensile strength**", which is related to its hardness.



Tensile Strength - is an expression of the maximum capacity of the material to stretch under tension load, prior to failure. It is normally expressed in kilo newtons (kn)

Yield Stress (Yield point) - is an expression of the theoretical point of stress (pressure) beyond which the material loses its elasticity and becomes permanently stretched. Realistically this is a range rather than a single point. It is expressed as: N/mm^2

Tensile Load (Top image previous page)
Where the load is acting to separate the fastened components along the shank length, it is referred to as a **tensile load**. Tensile loads try to elongate the fastener.

Shear Load (Bottom image previous page)
Where the load is acting to separate the fastened components across the shank diameter, it is referred to as a **shear load**. Shear loads try to "slice" the fastener in two. The load carrying capability of a fastener is somewhat less in shear than in tensile and will further vary if the shear plane is across the threads rather than the plane shank (ie: Bolt). Some applications will exert a combination of tensile and shear loads.

Selecting Fasteners
Calculating fixing sizes is beyond the level of this competency. Fortunately, manufacturers mostly provide engineering advice on the minimum fastener size when mounting their products. If this information is not available then (as a rule of thumb) select the largest fastener that will fit through the manufacturer's standard mounting hole. If replacing an existing fastener, then replace "like-with-like" unless there is an obvious reason not to. When choosing the length of fastener screws, after allowing for all intervening layers of materials, there should always be a minimum of two (2) full threads protruding out of the securing nut or tapped surface etc.

Dissimilar Metals
Choose the most appropriate type of sheet metal and jointing materials to comply with the job specification. Problems can arise when dissimilar metals are in direct contact. When two dissimilar metals are in contact with each other and moisture is present an action known as electrolysis or galvanic corrosion begins that can lead to rapid corrosion of one of the materials. This is due to a very small flow of current that is generated between the different materials when they are moist. This then leads to the decomposition of one of the materials. Some materials are more reactive than others. The list below shows the "reactivity" of common materials and is known as the 'Noble Scale'. **Ranking in sea water"** (Top of table is the most noble)

Most Noble

- Gold
- Silver
- Monel
- Nickel
- Copper
- Brass
- Tin
- Lead
- Active Stainless Steel (most common type)
- Cast Iron
- Steel
- Aluminum
- Zinc
- Magnesium

Least Noble

Those materials near the "bottom" (least noble) are the most reactive. If a material from near the bottom, eg zinc, is placed in direct contact with a material near the top eg copper and exposed to moisture, electrolysis will occur at a rapid rate. The less noble material is soon decomposed by the current flow that is generated, and as a result the zinc in this example would corrode away. Materials that are close to each other on this scale eg brass and copper will still create a reaction but any corrosion that occurs takes place so slow that the effects are almost unnoticeable.

If possible do not bring dissimilar meals in direct contact. When this is not practical, materials should be selected that will not create high levels of corrosion through electrolysis. Ie: Select materials that are close to each other on the Noble Scale.

Metallurgical Bonding Processes
The metallurgical attachment of one metal to another can be accomplished three basic ways: (1) Welding, (2) Brazing and (3) Soldering. The most significant difference between these methods is the process "temperature".

Welding
Welding is a process in which the base metal is melted during the joining process and the molten parts flow together and when allowed to cool they solidify to form a permanent bond. The process typically involves the bonding high-melting temperature metals such as steel-to-steel. The process can be performed with or without the addition of a filler metal. If a filler metal is used then it should have metallurgical properties that match the properties of the adjoining materials. The welding process requires very high heat which can be provided by an AC or DC arc-welder or an oxygen-acetylene gas torch.

Common types of welding processes include:

- MMAW (Manual Metal Arc Welding) (Was called "Stick Welding")
- MIG (Metal Inert Gas) welding also called GMAW (Gas Metal Arc Welding)
- TIG (Tungsten Inert Gas) welding also called GTAW (Gas Tungsten Arc Welding)
- Oxy-Acetylene Welding
- Spot welding (Resistance Welding)

Manual Metal Arc Welding (MMAW) (Also called Shielded Metal Arc Welding (SMAW) or "Stick Welding"
Ref: http://www.weldinginfocenter.org/basics/ba_05.html

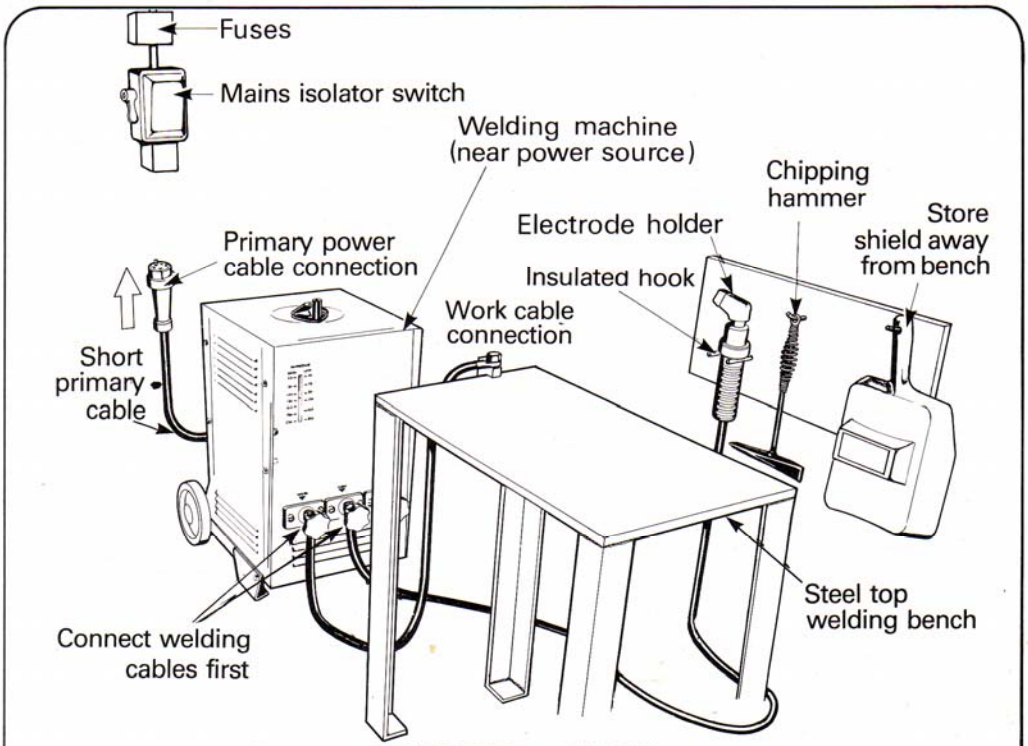
MMAW is one of several fusion processes for joining metals. By applying intense heat, a metal joint is melted and caused to intermix - directly, or more commonly, with an intermediate molten filler metal. Upon cooling and solidification, a bond is created. Since the joint is a mixture of metals, the final "weldment" potentially has the same strength as the metal of the original parts. This is in sharp contrast to non-fusion joining processes such as soldering and brazing etc. in which the mechanical and physical properties of the base materials cannot be duplicated at the joint.

Arc welding uses the intense heat produced by an electric arc to melt the base metals. The arc is virtually a "short circuit" arc as the circuit resistance is typically very low. The arc is formed between the actual work piece and an electrode (wire rod). Once the arc forms, the electrode must be manually guided along the seam of joint. The electrode used for welding is a specially prepared rod or wire that not only conducts the current but also melts (sacrificial) and supplies filler metal to the produce the joint.

The consumable electrode tip melts under the heat of the arc and molten droplets are detached and transported to the work through the arc column. Arc welding systems in which the electrode is melted off to become part of the weld are described as "metal-arc".

The open circuit voltage (ie: before the arc is struck) produced by a welding machine must be low enough so as not to be hazardous to the user. (Ie: Typically between 50 and 80 Volts.) But this open circuit welding voltage is then not high enough to cause a discharge when the electrode tip is held off the work. (Ie: The voltage is not high enough to arc across the normal air gap.) The arc must be established by first touching the electrode tip to the work (this produces a high current flow in the circuit) and then the operator must withdraw the electrode tip by a small distance as the contact zone becomes heated. An electric arc is then formed which ionizes the air which in turn enables the air to readily conduct current across the small gap. The key point is that an arc cannot form by passing a cold electrode over the work piece. (The arc must be ignited by the user.) Once the arc is struck, the welder design causes the terminal voltage to drop to between 17 and 40 volts, but at a constant current level (Ie: Up to hundreds of amps depending on the size of the welder and materials to be welded.).

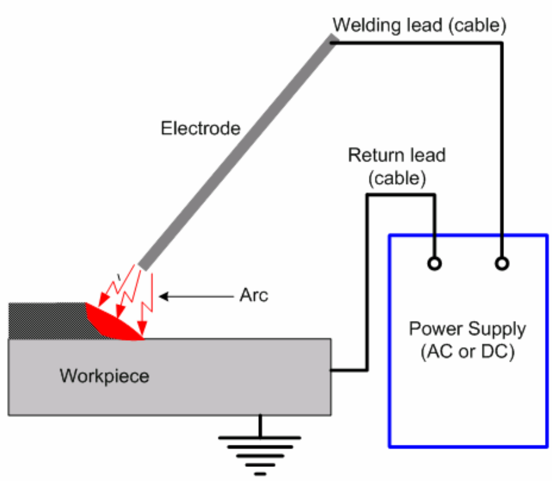
Arc welding uses the low voltage / high current (power) to produce the heat energy necessary to melt the parent metals and the filler rod. Arc welding may be performed using direct current (DC) with the electrode either positive or negative or alternating current (AC). The choice of current and polarity depends on the process, the type of electrode, the arc atmosphere, and the metal being welded.



EQUIPMENT – SET UP

Welding Circuit

A basic arc-welding circuit is illustrated to the right. The design uses a “low voltage / high current” power source which can be either AC or DC and is fitted with whatever controls may be needed to control the current. Basic AC welders typically use a step-down transformer which incorporates a “magnetic bridge” to create the conditions necessary for welding.



The welder’s output terminals are connected by the work cable to the “metal” work piece and by a second “welding” cable to the electrode holder which makes an electrical contact with the welding electrode.

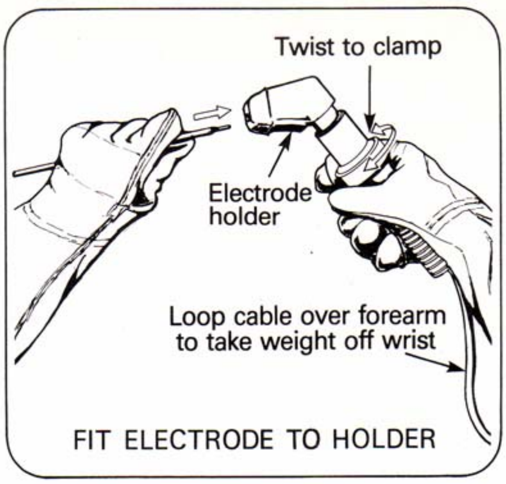
An arc is created across the gap when the energized circuit and the electrode tip touches the work piece and is slightly withdrawn.

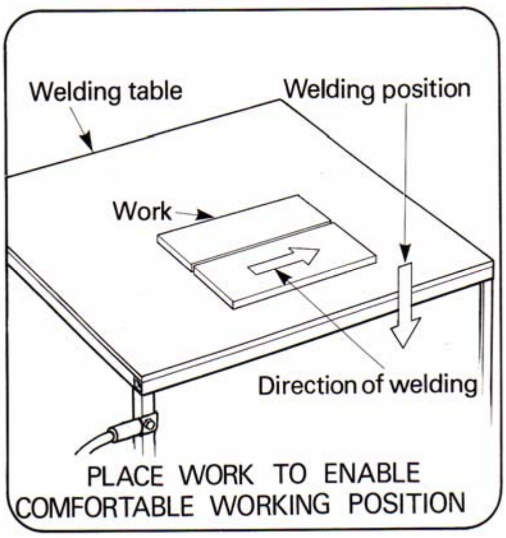
The current path is from the welder out through the welding lead and through the electrode holder, the “electrode” (rod) and into the work piece and then it returns back via the work lead to the welder.

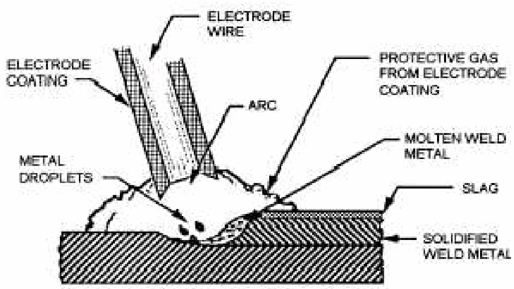
The electric arc produces a temperature of about 6500ºF at the tip which is sufficient to melt both the base metal and the rod electrode thereby producing a pool of molten metal sometimes called a "crater." The crater solidifies behind the electrode as it is manually moved along the joint. The result is a fusion bond.

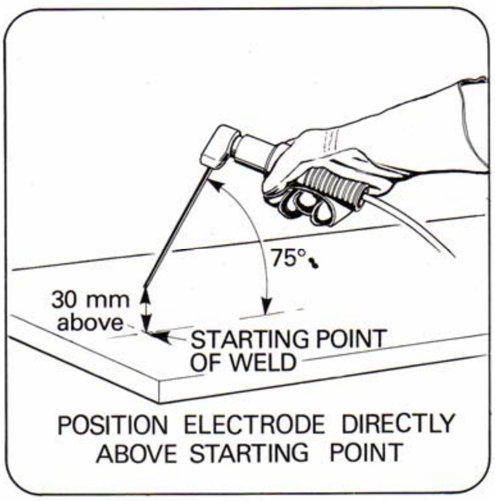
Basic arc welders consist of a variable transformer, earth clamp, insulated electrode holder attached to the electrode lead and a consumable (flux coated) welding electrode. Current settings and choice of welding electrodes depends on:

- The type and size of the material to be welded;
- The type and size of the welder to be used.









Process characteristics of "MMAW" welding:

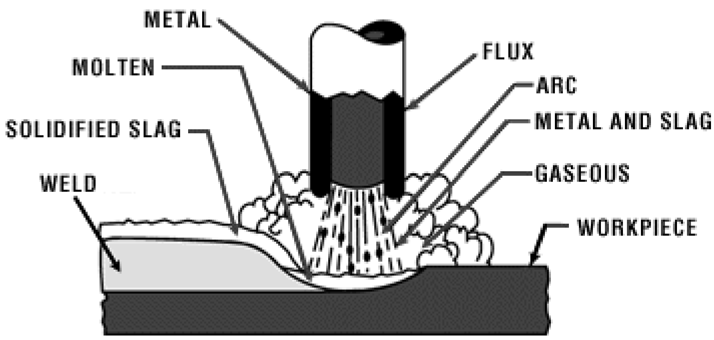
- Uses a electrode rod that is quickly consumed,
- Uses equipment that is simple, inexpensive, and highly portable,
- Uses an electrode that provides and regulates its own flux,
- Provides all position flexibility,
- Is less sensitive to wind or drafts,
- Yields a weld with a variable quality and appearance based on operator skill.

Electrodes and Flux

Ref: http://patelpowertools.com/viewmenus.php?id=26

The electrode is used to conduct current through to the work piece. It consists of a metal rod (of various diameters – gauge) which is covered by a flux coating of mineral or organic materials.

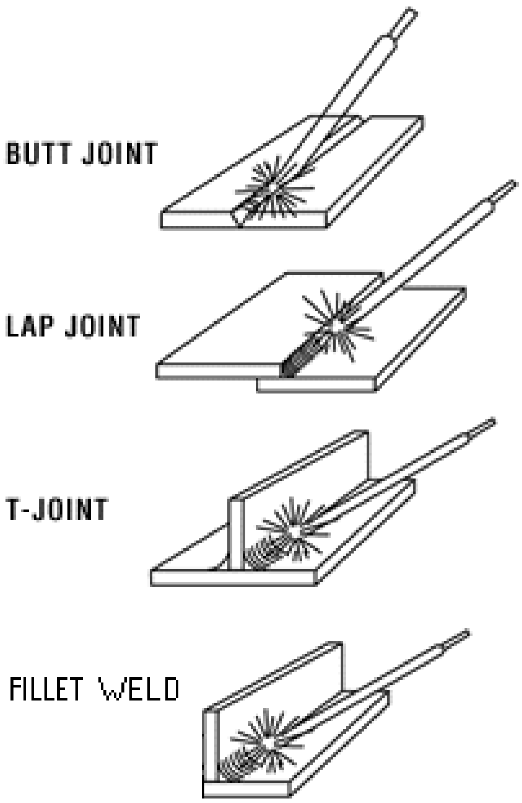
As the weld is laid, the flux coating of the electrode evaporates giving off vapors and a layer of "slag". The molten slag covers the filler metal as it travels from the electrode to the weld pool. Once part of the weld pool is formed, the slag floats on the surface and protects the weld from atmospheric contamination as it solidifies. Once hardened, the "slag" should be chipped away (using a chipping hammer) to reveal the finished weld.



Flux-coated electrodes are available in many core wire diameters and lengths. The electrode "core" must be matched to the properties of the base materials to be welded.

Commercial electrodes types include those suitable for mild steel, stainless steel, aluminum bronze, bronze, and nickel.

Typical manual welded joints are shown to the right. Manual welding is a process that requires a large amount of practice to achieve proficiency.



Nb: It is important to note that the welding of structural support members can only be done by a person suitably trained and certified.

Advantages

- Equipment is cheap, versatile, simple and portable;
- Can be used indoors or outdoors as it does not use shielding gas;

- ➢ Welds in any position;

Disadvantages

- ➢ Fumes are prejudicial to health;
- ➢ Electrode selection is crucial;
- ➢ The weld length is limited by the length of the fixed size electrode;
- ➢ Hydroscopic electrodes; (absorb moisture)
- ➢ Need to remove slag immediately after welding;
- ➢ Weld quality depends largely on the operator skill.

Safety

MMAW can be a dangerous and unhealthy practice if proper precautions are not taken. The open electric arc presents a risk of burns which are prevented by personal protective equipment in the form of heavy leather gloves and long sleeve jackets. Additionally, the brightness of the weld area can lead to a condition called “arc eye”, in which ultraviolet light causes inflammation of the cornea and can burn the retinas of the eyes.

Welding helmets (face mask) with dark face plates are worn to prevent this exposure, and in recent years, helmet models have been produced that feature a face plate that self-darkens upon exposure to high amounts of UV light. To protect bystanders, especially in industrial environments, translucent welding curtains should surround the welding area. These curtains, made of a polyvinyl chloride plastic film, shield nearby workers from exposure to the UV light from the electric arc, but should not be used to replace the filter glass used in helmets. In addition, the vaporizing metal and flux materials expose welders to dangerous gases and particulate matter. The smoke produced contains particles of various types of oxides. The size of the particles in question tends to influence the toxicity of the fumes, with smaller particles presenting a greater danger. Additionally, gases like carbon dioxide and ozone can form, which can prove dangerous if ventilation is inadequate. Some welding masks are fitted with an electric powered fan to help disperse harmful fumes.

Safety: Manual Metal Arc Welder

DO NOT use this equipment unless you have been instructed in its safe use and operation and have been given permission

PERSONAL PROTECTIVE EQUIPMENT

Safety glasses must be worn at all times in addition to welding mask.

Long and loose hair must be contained.

Oil free leather gloves must be worn.

Respiratory protection devices may be required.

A welding mask with correct grade lens for MMAW must be worn.

Close fitting/protective clothing to cover arms and legs must be worn.

Sturdy footwear with rubber soles must be worn.

Rings and jewellery must not be worn.

Pre-Operational Safety Checks

- Locate and ensure you are familiar with all machine operations and controls.
- Check workspaces and walkways to ensure no slip/trip hazards are present.
- Ensure the work area is clean and clear of grease, oil and any flammable materials.
- Keep the welding equipment, work area and your gloves dry to avoid electric shocks.
- Ensure electrode holder and work leads are in good condition.
- Start the fume extraction unit before beginning to weld.
- Ensure other people are protected from flashes by closing the curtain to the welding bay or by erecting screens.

Operational Safety Checks

- Keep welding leads as short as possible and coil them to minimise inductance.
- Ensure work return earth cables make firm contact to provide a good electrical connection.
- Ensure the electrode holder has no electrode in it before turning on the welding machine.
- Ensure current is correctly set according to electrode selection.

Ending Operations and Cleaning Up

- Switch off the machine and fume extraction unit when work is completed.
- Remove electrode stub from holder and switch off power source.
- Hang up electrode holder and welding cables. Leave the work area in a safe, clean and tidy state.

Potential Hazards

- Electric shock.
- Fumes.
- Radiation burns to eyes or body.
- Body burns due to hot or molten materials.
- Flying sparks.
- Fire.

Don't

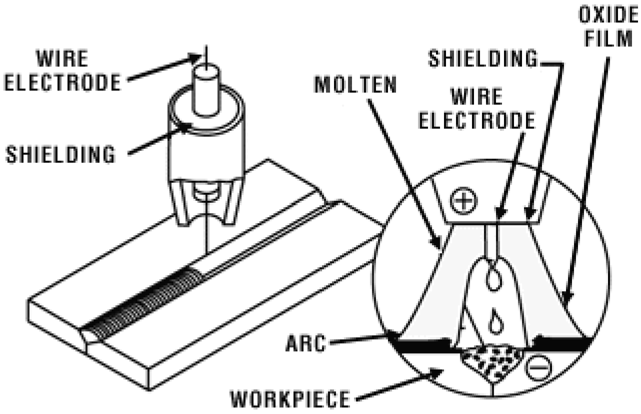
- ➢ Do not use faulty equipment. Immediately report suspect equipment.
- ➢ Do not use bare hands and never wrap electrode leads around yourself.

NB: This SOP does not necessarily cover all possible hazards associated with this equipment and should be used in conjunction with other references. It is designed as a guide to be used to compliment training and as a reminder to users prior to equipment use.

Arc Shielding

Joining metals requires more than moving an electrode along a joint. Metals at high temperatures tend to react chemically with elements in the air. Eg: Oxygen and Nitrogen. When metal in the molten pool comes into contact with air, oxides and nitrides form which destroy the strength and toughness of the weld joint. "Arc shielding" is a process of covering the arc and the molten pool with a protective shield of gas, vapour, or slag. This shielding prevents or minimizes contact of the molten metal with air.

MIG (Metal Inert Gas) or GMAW (Gas Metal Arc Welding)
http://www.advantagefabricatedmetals.com/brazing.html

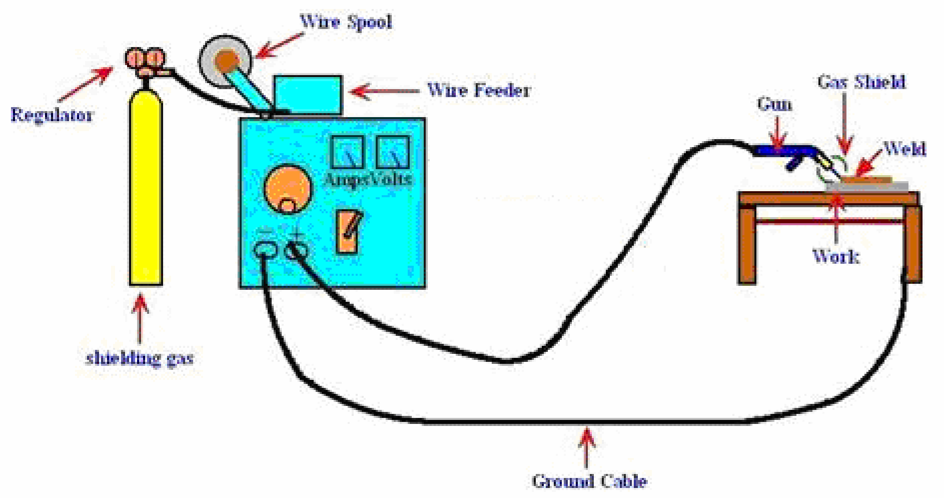


GMAW is a welding process in which an electric arc forms between a consumable "**wire** electrode and the metal work-piece(s) which heats the work-pieces (metals), causing them to melt together.

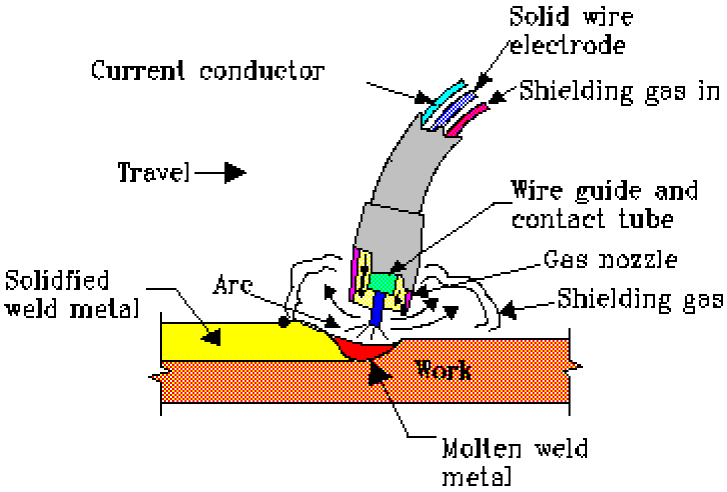
The "welding cable" (pipe) coming from the welder to the welding "gun" contains the continuous thin wire electrode, a shielding gas line and the control wires from the welding gun's "trigger switch". The trigger switch on/off controls the "power", "electrode feed rate" and the rate of gas flow. GMAW is generally a constant voltage, DC power source and the electrode flow rate through the gun sets the value of welding current. (The higher the wire feed rate, the higher the welding current.) (Nb: Constant current AC is also available on some GMAW welders). The shielding gas prevents atmospheric contamination for the weld and protects the weld during solidification. The shielding gas also assists with stabilizing the arc which provides a smooth transfer of metal from the weld wire to the molten weld pool. The process can be semi-automatic or fully automatic. There is different metal transfer processes available with GMAW depending on the type of welds required. Each method has its own advantages and disadvantages.

Characteristics of GMAW:

- Uses a continuous consumable wire electrode that is fed from a spool which makes it a very fast method of welding,
- Uses a shielding gas, usually – argon, argon - 1 to 5% oxygen, argon - 3 to 25% CO_2 and a combination argon/helium gas depending on the type of metal welded,
- Provides a uniform weld bead,
- Produces a slag-free weld bead which needs little cleanup.
- Produces less heat and distortion of the material being welded than MMAW,
- Allows welding in all positions,
- Requires less operator skill than TIG welding,
- Allows **long** welds to be made without starts or stops,
- The shielding "gas" system is not suited to outdoor applications in the wind.



The GMAW process is versatile and is capable of joining most types of metals and it can be performed in most positions. It is suitable for many metal types including aluminum, mild steel, cast iron, magnesium and stainless steel.



Ref: http://www.burnsstainless.com

During GMAW welding the thin wire electrode melts within the arc and becomes deposited as filler material. The wire "feed unit" supplies the continuous electrode to the work, driving it through the conduit (lead) and on to the contact tip. Basic models provide the wire at a constant feed rate only, but more advanced machines can vary the feed rate in response to the arc length and voltage setting. The "wire" feed rate sets the arc length and is one of the most important settings on a MIG welder needed to obtain quality welds.

Safety: Gas Metal Arc Welding
The shielding gases used for MIG welding do not support human life so it is very important that the welding area is well ventilated. Do not to weld in an enclosed space where you could become asphyxiated. **DO NOT** use this type of machine unless you have been instructed in its safe use and operation and have been given permission

Personal Protective Equipment


Safety glasses must be worn at all times in addition to welding mask.


A welding mask with correct grade lens for GMAW must be worn.


Oil free leather gloves and spats must be worn.


Sturdy footwear with rubber soles must be worn.


Long and loose hair must be contained.


Rings and jewellery must not be worn.


Respiratory protection devices may be required.


Close fitting/protective clothing to cover arms and legs must be worn.

Pre-Operational Safety Checks
- Locate and ensure you are familiar with all machine operations and controls.
- Check workspaces and walkways to ensure no slip/trip hazards are present.
- Ensure the work area is clean and clear of grease, oil and any flammable materials.
- Keep the welding equipment, work area and your gloves dry to avoid electric shocks.
- Ensure your gloves, welding gun and work leads are in good condition.
- Ensure other people are protected from flashes by closing the curtain to the welding bay or erecting screens.
- Start the fume extraction unit before beginning to weld.
- Ensure work leads do not create a tripping hazard.

Operational Safety Checks
- Ensure machine is correctly set up for current, voltage, wire feed and gas flow.
- Ensure work return earth cables make firm contact to provide a good electrical connection.
- Take care to avoid flashes.

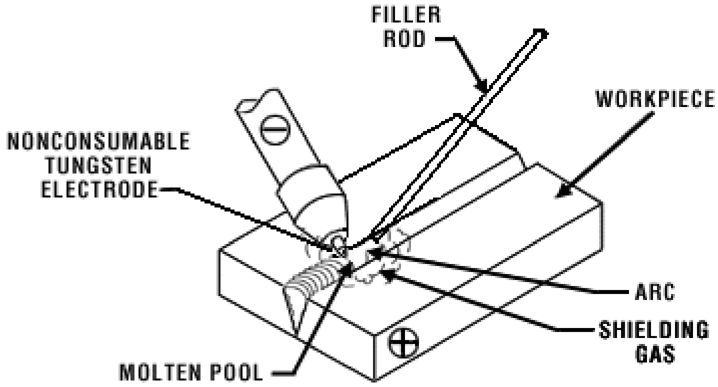
Ending Operations and Cleaning Up
- Switch off the machine and fume extraction unit when work completed.
- Close the gas cylinder valve.
- Hang up welding gun and welding cables.
- Leave the work area in a safe, clean and tidy state.

Potential Hazards
- Electric shock.
- Fumes.
- Radiation burns to eyes or body.
- Body burns due to hot or molten materials.
- Flying sparks.

Don't
- ➢ Do not use faulty equipment. Immediately report suspect equipment.
- ➢ Never leave the welder running unattended.

This SOP does not necessarily cover all possible hazards associated with this equipment and should be used in conjunction with other references. It is designed as a guide to be used to compliment training and as a reminder to users prior to equipment use.

TIG (Tungsten Inert Gas) or GTAW (Gas Tungsten Arc Welding)
This type of welding process uses a "**non-consumable**" **tungsten** electrode to establish an arc to the base metal. The heat of the arc melts the base metal and produces a weld pool. If filler wire is to be used, then it is added to the weld pool separately by the operator.



GTAW welding employs an inert gas similar to GMAW which shields the weld area to prevent oxidation of the tungsten electrode, the molten weld puddle, and the heat-affected zone adjacent to the weld bead.

Because GTAW welding uses an inert gas it means that its atomic structure does not allow it to chemically react with metals or other gases. Commonly used shielding gases include argon, helium, or an argon-helium mixture.

Ref:
http://www.advantagefabricatedmetals.com/tig-welding.html

http://www.streetchopperweb.com/

Argon operates at a higher arc voltage, which makes the arc start more easily, and is commonly used to weld mild steel, aluminum and titanium. Helium is generally added to increase heat input (increase welding speed or weld penetration) and is used for high speed welding of mild steel and titanium. Helium offers a smaller heat affected zone and therefore, penetrates metals deeply. It also can increase the welding speed. Helium is also commonly used to weld stainless steel and copper. The argon/helium combination gas is used for a hotter arc when welding aluminum and aluminum alloys.

GTAW welding is a high quality, precision welding process and is ideal for welding thin gauge metals. It requires higher operator skill than other forms of welding and is suitable for a range of metals including mild steel, stainless steel, titanium, aluminum and aluminum alloys. GTAW welding is a slower process than GMAW (MIG), but it produces a more precise weld and can be used at lower amperages for thinner gauge metal.

GTAW welding using "DC" creates an electrical circuit that flows only one-way. This leads to a constant polarity of arc charge. DC is used for welding ferrous metals such as stainless steels. GTAW welding using "high frequency AC" creates an arc which switches polarity in regular cycles. This polarity switching removes surface oxidation from the weld area and is used for welding aluminum.

TIG Summary

- Uses a non-consumable tungsten electrode during the welding process,
- Uses a number of shielding gases including helium (He) and argon (Ar),
- Can be applied to thin gauge materials,
- Produces very high-quality weld (dependant on operator skill),
- Welds can be made with or without filler metal,
- Provides precise control of welding variables (i.e. heat),
- Welding yields low distortion,
- Leaves no slag or splatter.

Safety: The clear atmosphere around the GTAW arc can cause up to twice the amount of infrared and UV rays compared to normal arc welding. Any exposed skin will be burned similar to extreme sunburn.

Safety: Gas Tungsten Arc Welding
DO NOT use this machine unless you have been instructed in its safe use and operation and have been given permission

Personal Protective Equipment


Safety glasses must be worn at all times in addition to welding mask.


Long and loose hair must be contained.


Oil free leather gloves and spats must be worn.


Sturdy footwear with rubber soles must be worn.


Close fitting/protective clothing to cover arms and legs must be worn.


Rings and jewellery must not be worn.


Respiratory protection devices may be required.


A welding mask with correct grade lens for GTAW must be worn.

Pre-Operational Safety Checks

- Locate and ensure you are familiar with all machine operations and controls.
- Check workspaces and walkways to ensure no slip/trip hazards are present.
- Ensure the work area is clean and clear of grease, oil and any flammable materials.
- Keep the welding equipment, work area and your gloves dry to avoid electric shocks.
- Ensure your gloves, welding torch and work leads are in good condition.
- Ensure other people are protected from flashes by closing the curtain to the welding bay or erecting screens.
- Start the fume extraction unit before beginning to weld.
- Ensure work leads do not create a tripping hazard.

Operational Safety Checks

- Ensure machine is correctly set up for current, voltage, and gas flow.
- Ensure work return earth cables make firm contact to provide a good electrical connection.
- Strike the arc before placing the tip of the filler wire in the weld zone.
- Turn off the power while changing tungsten electrodes.
- Take care to avoid flashes.

Ending Operations and Cleaning Up

- Switch off the machine and fume extraction unit when work completed.
- Close the gas cylinder valve.
- Hang up welding gun and leads.
- Leave the work area in a safe, clean and tidy state.

Potential Hazards

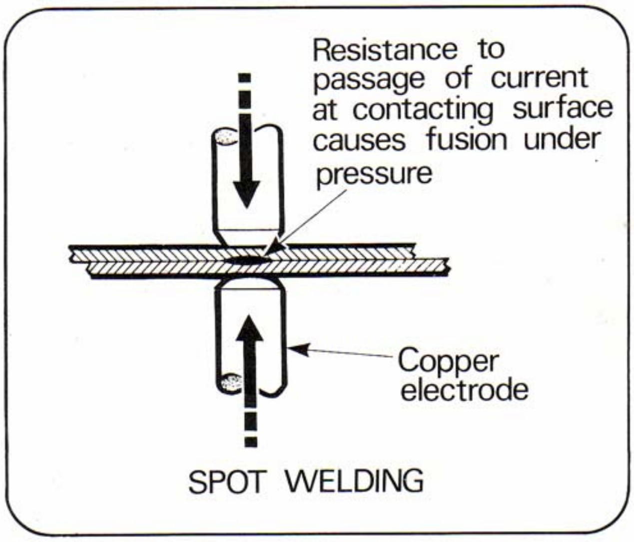
- Electric shock.
- Fumes.
- Radiation burns to eyes or body.
- Body burns due to hot or molten materials.
- Flying sparks.
- Fire.

Don't

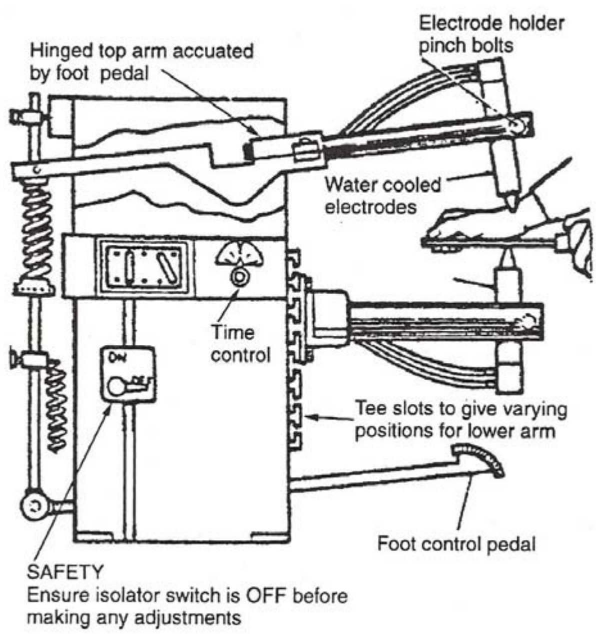
- ➢ Do not use faulty equipment. Immediately report suspect equipment
- ➢ Never leave the welder running unattended.

This SOP does not necessarily cover all possible hazards associated with this equipment and should be used in conjunction with other references. It is designed as a guide to be used to compliment training and as a reminder to users prior to equipment use.

Spot Welding (Resistance Welding)
Spot welding is a resistance welding method used to "join" overlapping metal sheets. Spot welding involves work-pieces being clamped together under pressure exerted by two heavy copper alloy electrodes.



The electrodes concentrate high welding current into a small "spot" while simultaneously holding the sheets together at the point of the weld. A large current is then passed through the spot thereby melting the contact metal area and forming the weld. As "current" is passed from one electrode to the other, metal clamped between them acts as a "low-value" resistor. This causes a build-up of heat that melts the two pieces of metal thus welding them together.



It is also known as "resistance spot welding", because the amount of heat delivered to the spot is directly related to the resistance between the electrodes, the amplitude of the current and the duration of the applied electric current.

The current required for such applications is produced by a "step-down" transformer which lowers the voltage and increases the current output. The voltage between the two electrodes rarely exceeds 1.5 volts, except for when there is no galvanic connection between the two, when the voltage increases to between 5-10 volts.

The electric current can reach very high values. (Ie: Hundreds of amps.) The spot welder electrodes and the work metal form the secondary circuit of the device.

Advantages

- Efficient energy use,
- Limited work piece deformation,
- High production rates,
- Easy automation,
- No filler materials required.

Disadvantage

If excessive heat is applied or applied too quickly, or if the force between the base materials is too low, or the coating is too thick or too conductive, then the molten area may extend to the exterior of the work pieces, escaping the containment force of the electrodes. This burst of molten metal is called “expulsion”, and when this occurs the metal will be thinner and have less strength than a weld with no expulsion. The common method of checking a weld's quality is a peel test.

Safety: Spot Welder

DO NOT use this machine unless you have been instructed in its safe use and operation and have been given permission

Personal Protective Equipment


Safety glasses must be worn at all times in work areas.


Long and loose hair must be contained.


Leather gloves must be worn when handling hot metal.


Sturdy footwear must be worn at all times in work areas.


Close fitting/protective clothing must be worn.


Rings and jewellery must not be worn.

Pre-Operational Safety Checks

- Check workspaces and walkways to ensure no slip/trip hazards are present.
- Check switchgear and cable are in sound condition.
- Check electrode points are in good condition and meet exactly.
- Ensure electrodes are securely mounted and clean from contaminants.
- Set pressure on clamps to hold work securely without damaging work.
- Preset weld time under your supervisor’s direction (if timer fitted).
- Use gloves to position and hold work.

Operational Safety Checks

- Ensure the spot welder has cooled before making any adjustments.
- Avoid prolonged use, as this can cause heat to build up in the electrodes and arms.
- When holding work, be aware of the heat created during welding process.
- Ensure work return earth cables make firm contact to provide a good electrical connection.

Ending Operations and Cleaning Up

- Switch off the machine when work completed.
- Leave the work area in a safe, clean and tidy state.

Potential Hazards

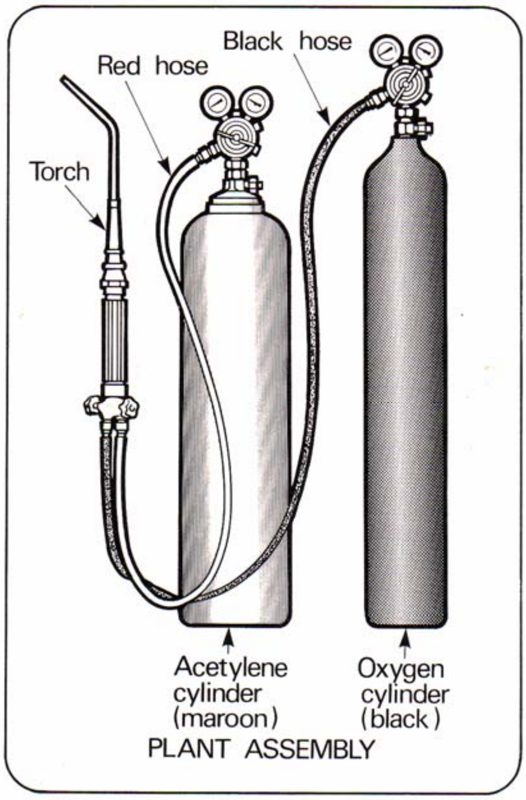
- Electrodes become hot with continued use.
- Burns.
- Hot metal.
- Spitting metal or flying sparks.
- Eye injuries.

Don't

- Do not use faulty equipment. Immediately report suspect machinery.

This SOP does not necessarily cover all possible hazards associated with this equipment and should be used in conjunction with other references. It is designed as a guide to be used to compliment training and as a reminder to users prior to equipment use.

Oxygen-Acetylene Welding
(Also called Oxy-Fuel Gas Welding)
This is a common welding process for sheet metal panels. The combination of oxygen and acetylene gases produces a flame that burns at up to about 3500°C which is hot enough to melt most commercial metals. To weld, the two metal work pieces are brought together with their edges touching and are melted by the flame with or without the addition of filler rod.

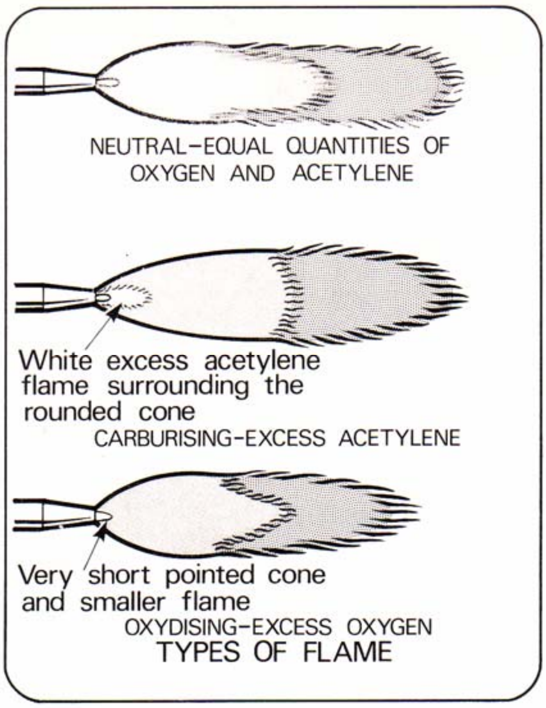


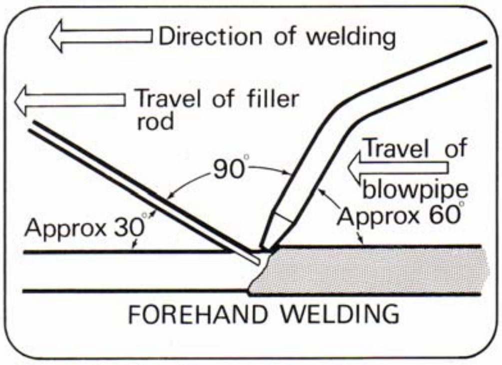
Characteristics of the process include:

- The use dual oxygen and acetylene gases stored under pressure in steel cylinders,
- Its ability to switch quickly to a cutting process, by changing the welding tip to a cutting tip,
- The high temperature the gas mixture attains,
- The use of regulators to control gas flow and reduce pressure on both the oxygen and acetylene tanks,
- The use of double line rubber hoses to conduct the gas from the tanks to the torch,
- Melting the materials to be welded together,
- The ability to regulate temperature by adjusting gas flow.

The welding tip is mounted on the end of the torch handle and the gas mixture passes through it to feed the flame.

"Welding" tips have only one hole while "cutting" tips have a centrally located hole with a number of smaller holes in a circular pattern.

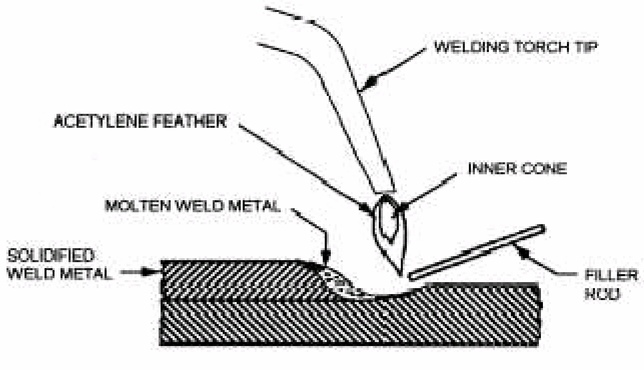




When welding, the flame produced by the combination of the gases melts the metal faces of the work pieces to be joined, causing them to flow together. A filler metal alloy is then normally added to fill the void.

Characteristics of the oxy-acetylene welding process include:

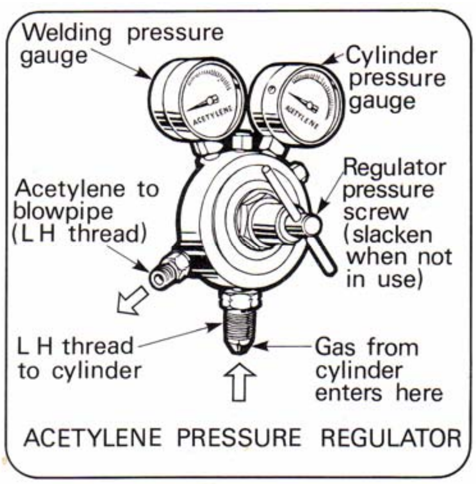
- The use dual oxygen and acetylene gases stored under pressure in steel cylinders,
- Its ability to switch quickly to a cutting process, by changing the welding tip to a cutting tip,
- The high temperature the gas mixture attains,
- The use of regulators to control gas flow and reduce pressure on both the oxygen and acetylene tanks,
- The use of double line rubber hoses to conduct the gas from the tanks to the torch,
- Melting the materials to be welded together,
- The ability to regulate temperature by adjusting gas flow.

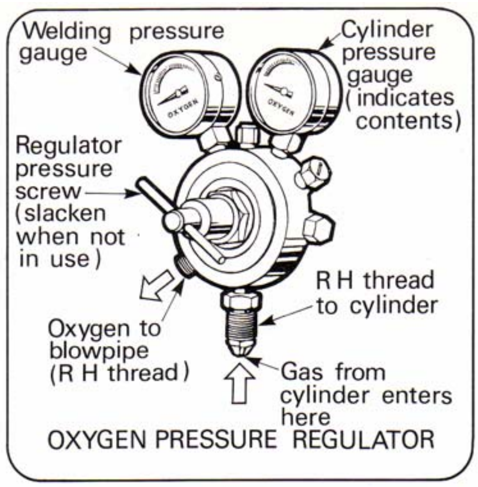


Safety

The molten metal has a tendency to pop and splatter as heat is applied and oxygen reacts with the superheated metal. It is critical when using this process that you wear suitable gloves and approved safety goggles or face shield. The goggles and/or face shield protect the eyes from sparks and flying hot metal particles. Also, the goggles or face shield use special lenses to protect the eyes from light damage. If protective eye shielding is not used, painful burns can occur on the surface of the eye, and could result in permanent eye damage.

The sketches below illustrate gas bottle gauges.





Safety: Oxy-Fuel Gas Welding Safety
DO NOT use this equipment unless you have been instructed in its safe use and operation and have been given permission.

Personal Protective Equipment


Welding goggles must be worn at all times in work areas.


Long and loose hair must be contained.


Oil free leather gloves must be worn.


Sturdy footwear must be worn at all times in work areas.


Close fitting/protective clothing must be worn.


Rings and jewellery must not be worn.

Pre-Operational Safety Checks

- Locate and ensure you are familiar with all machine operations and controls.
- Check workspaces and walkways to ensure no slip/trip hazards are present.
- Keep area clean and free of grease, oil and any flammable materials.
- Ensure gas hoses are in good condition and do not create a tripping hazard.
- Before lighting up, check all equipment for damage.
- Check that the area is well ventilated. Start the fume extraction unit before beginning to weld.
- Ensure the unit is fitted with working flashback arresters.
- Ensure work return earth cables make firm contact to provide a good electrical connection.

Pressure Setting

- Check that the oxygen and acetylene regulator adjusting knobs are loose.
- Check that both blowpipe valves are closed.
- Slowly open the cylinder valves on each cylinder for half a turn only.
- Screw in the regulator adjusting knobs slowly until the delivery pressure gauges register 70kPa.
- Purge and check for constant oxygen gas flow:
  - Open the oxygen blowpipe valve for 2 seconds and check the delivery gauge.
  - If necessary re-adjust the oxygen regulator to achieve a 70kPa pressure.
  - Close the oxygen blowpipe valve.
- Purge and check for constant acetylene gas flow:
  - Open the acetylene blowpipe valve for 2 seconds and check the delivery gauge.
  - If necessary re-adjust the acetylene regulator to achieve a 70kPa pressure.
  - Close the acetylene blowpipe valve.

Lighting Up

- Open the acetylene blowpipe valve slightly and light the blowpipe with a flint lighter.
- Continue to slowly open the acetylene valve until the flame no longer produces soot.
- Slowly open the oxygen blowpipe valve until a neutral flame is produced.

Shutting Off Blowpipe

- Close the acetylene blowpipe valve first.
- Then close the oxygen blowpipe valve.

Ending Operations

- Close down both cylinder valves.
- Open oxygen blowpipe valve to allow the gas to drain out.
- When oxygen gauges read zero, unscrew regulator-adjusting knob.
- Close oxygen blowpipe valve.
- Turn off acetylene cylinder valve.

- Open acetylene blowpipe valve and release gas.
- When acetylene gauges read zero, release regulator adjusting knob.
- Close acetylene blowpipe valve.

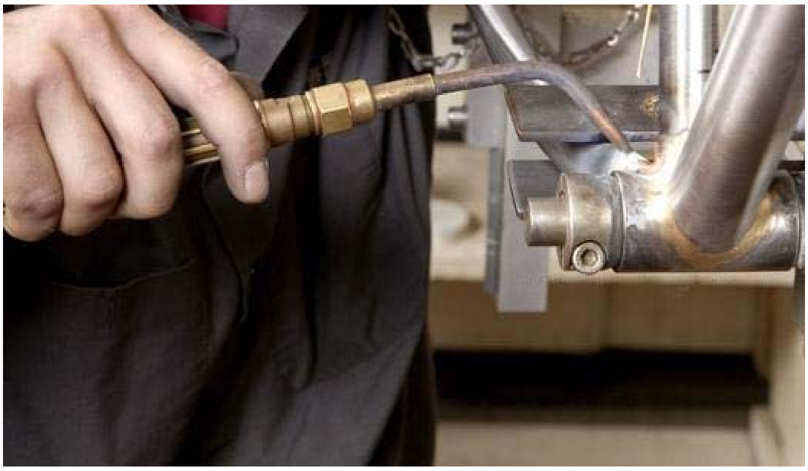
Cleaning Up
- Hang up welding blowpipe and hoses.
- Switch off the fume extraction unit.
- Leave the work area in a safe, clean and tidy state.

Potential Hazards
- Burns
- Radiation damage to eyes
- Flying sparks
- Combustible materials
- Fumes
- Explosion by gas leakage
- Flashbacks
- Oil and grease

Don't
- ➢ Do not use faulty equipment. Immediately report suspect equipment.
- ➢ Do not light the blowpipe with matches or lighters.
- ➢ Do not use oil, grease or other hydrocarbons.
- ➢ Do not use oxygen as a substitute for compressed air.

This SOP does not necessarily cover all possible hazards associated with this equipment and should be used in conjunction with other references. It is designed as a guide to be used to compliment training and as a reminder to users prior to equipment use.

Brazing
Brazing is a lower-temperature process than welding. It does not involve melting of the substrate surfaces, but rather depends on the formation of inter-metallics to provide adhesion. It uses a bronze or brass filler rod coated with flux together with an oxygen-acetylene gas torch to join the pieces of metal.



Ref: http://www.magnagroup.com/pressarea/Content2.asp?Uid=6

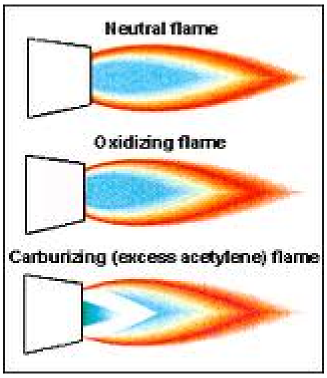
Brazing takes place at the melting temperature of the filler (e.g., 870°C to 980°C for bronze alloys) which is lower than the melting point of the base material (e.g.1600°C) for mild steel).

A bead of filler rod material reinforces the joint. Brazing fluxes are required to remove oxides from the filler material and mating pieces, and to promote good flow of the molten filler. Typically, brazing fluxes contain borates and fluorides and are considered "corrosive".

The joint area is heated above the melting point of the filler metal, but below the melting point of the work piece metals being joined. The molten filler metal flows into the gap between the other two metal pieces by "capillary action" and forms a strong metallurgical bond as it cools.

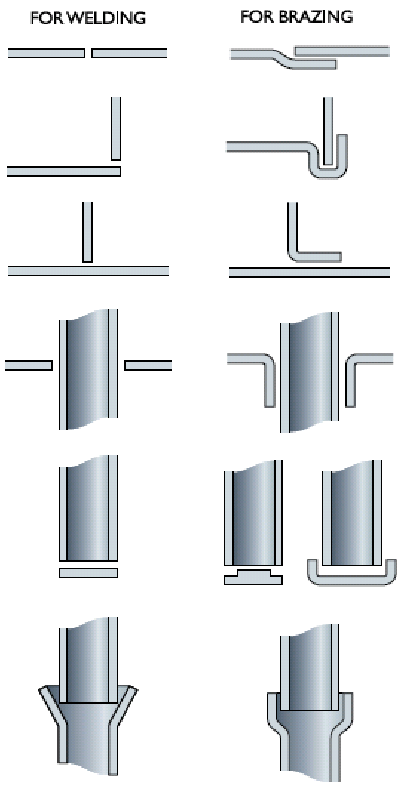
- Brazing is very versatile and the joints have great tensile strength and are often stronger than the two metals being bonded together. Brazed joints repel gas and liquid, withstand vibration and shock and are unaffected by normal changes in temperature. Because the metals to be joined are not themselves melted, they are not warped or otherwise distorted and retain their original metallurgical characteristics.
- Because brazed joints have a very clean, well-finished appearance, it is often the preferred bonding process for manufacturing plumbing fixtures, tools, heavy construction equipment and high-quality consumer products.
- The process is well-suited for joining dissimilar metals, which gives the assembly designer more material options.
- Complex assemblies can be manufactured in stages by using filler metals with progressively lower melting points.
- Brazing is relatively fast and economical, requires relatively low temperatures and is highly adaptable to automation and lean manufacturing initiatives.

In the electrotechnology industry, an oxy-Acetylene torch is used for brazing small assemblies and low-volume applications. A "**neutral**" flame with a bluish to orange tip, a well-defined bluish white inner cone and no acetylene feather works the best; a flame with a colorless tip can cause oxidation. The quality of the joint is largely dependent on operator skill and consistency is sometimes an issue, this technique requires only a small investment and is used extensively.
Ref: http://www.theiiwmumbai.8m.com/brazing4.html



The six fundamental points of brazing are: (1) Joint design; (2) Choice of filler metal; (3) Pre-cleaning of the parent materials; (4) Fluxing; (5) Removal of flux residues and (6) Heating the joint and applying the alloy

Types of Braze Joints
The best brazed joints are those which have a capillary joint (Ie: close fitting) gap into which the molten filler metal can flow. The most common type of joint used for brazing is the lap joint, or the sleeve joint in the case of tubular components. The main criteria for a lap joint are the joint gap and the degree of overlap. It is these two parameters that determine the ultimate joint strength, rather than the properties of the filler metal.



Safety
Brazing alloys and fluxes contain elements which, if overheated, produce fumes which may be harmful or dangerous to health. Brazing should be carried out in a well ventilated area with operators positioned so that any fume generated will not be inhaled. Adequate ventilation to prevent an accumulation of fumes and gases should be used.

Where fume levels cannot be controlled below the recognized exposure limits, use local exhaust to reduce fumes and gases. In confined spaces without adequate ventilation, an air fed breathing system should be used and outdoors a respirator may be required.

Special precautions for working in confined spaces should be observed. Apart from fume hazards, flux can be irritating to the skin and prolonged contact should be avoided. Before use, always read all the manufacturer's instructions. Refer to the warning labels on the packaging and always read the SDS for all chemical products.

Soldering
http://www.smex.net.au/Reference/SilverSoldering01.htm
"Soldering" is a process in which two or more parts are joined by melting a relatively low melting point filler metal into a joint. The bond established is not as strong as the base metal. The two main type of soldering are "soft soldering" and "silver soldering", also known as "hard" soldering.

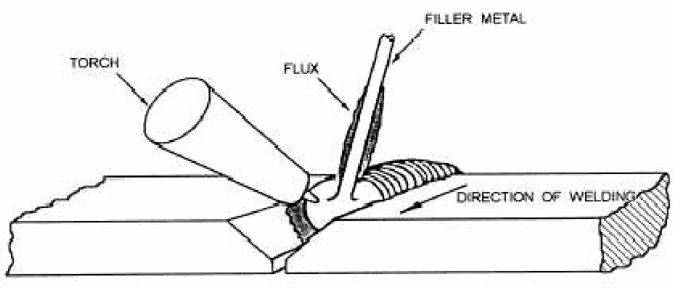
"Soft" soldering is a process in which two or more parts are joined by melting and flowing filler metal into the joint with the filler which has a relatively low melting point below approx 420°C. The bond between the materials is by "wetting" action. "Wetting" refers to the behaviour of a liquid when it contacts a solid surface. Liquids with poor wetting ability tend to form droplets, while liquids with good wetting ability tend to spread out evenly over the solid surface area. A good soft soldered joint has adequate strength, but good electrical conductivity, and is typically water-tight.

"Silver soldering", also known as "hard" soldering is a process in which two or more parts are joined by melting and flowing filler metal into the joint. The melting point of the filler metal is above 420°C and flows into the joint by "capillary action". Capillary attraction is the ability of a liquid to flow in narrow spaces without the assistance of, and in opposition to external forces like gravity. A silver soldered joint is a sandwich of different layers; each metallurgically linked to the surface of the joined parts, and is very strong. (Ie: Much stronger than soft soldering). It is called 'silver' soldering because the filler material often contains silver.

Although soft soldering and silver soldering both introduce a filler material (solder) into the joint, with soft soldering the solder only "adheres" (sticks) to the surface. With hard (silver) soldering, the metallurgy of the surface is changed and the joints are metallurgically linked and become part of the underlying metal surface. This is why a silver soldered joint is considered much stronger joint than one that is soft soldered.

Silver Solder
This is not a gap filling process. It does require a very small gap of about (0.001mm) for proper capillary action during joining of parts which means that items need to be matched to close tolerances for best effect. The best joint design is one where there is an overlap of the components in the form of a lap or sleeve join.

Silver solder will join most metals eg: brass, bronze, copper, steel, cast iron etc, but **not** aluminium.



A "flux" is used to clean the surface of the metals by removing oxides from the metals to be joined, and prevent further oxidization, during the heating process. Flux is an essential part of silver soldering, and usually applied as a thick paste. Too much flux will rarely cause any problems, but too little can ruin the work, as it prevents the capillary action of the solder into the joint, or fails to remove the oxides properly when heated.

Heating of the job should be done reasonably quickly to prevent exhausting the flux. A propane heating torch is suitable and provides gentler broader heating as compared to an oxy-acetylene flame which can be too hot and concentrated, and should be avoided unless skilled in it's use. Choose a burner of sufficient capacity for the job size. Heating should be even for the whole job, and ALL parts of the assembly should be at or about the same temperature.

Allow the joined parts to cool naturally to room temperature. Remember that some base materials may change their properties after being heated to the red heat required for silver soldering.

After soldering, always clean any accumulated flux from the job, and clean by “pickling” or emery paper. (Nb: “Pickling” means to use a liquid solution eg: water / acid etc. to clean surfaces of flux residues.) Check the joint from both sides where possible to ensure that all joints are soldered correctly. If not it is usually possible to re-flux the work and repeat the soldering process after cleaning. Make sure that the solder has fully penetrated the joint, and there is a small fillet of solder in the corners. Nb: A “fillet” is the rounded, concave section of the joint where the solder material bonds the component to a surface.

The key steps when making a silver soldered joint are: form the joint, clean it, flux it, apply heat and solder, cool it, clean and inspect.

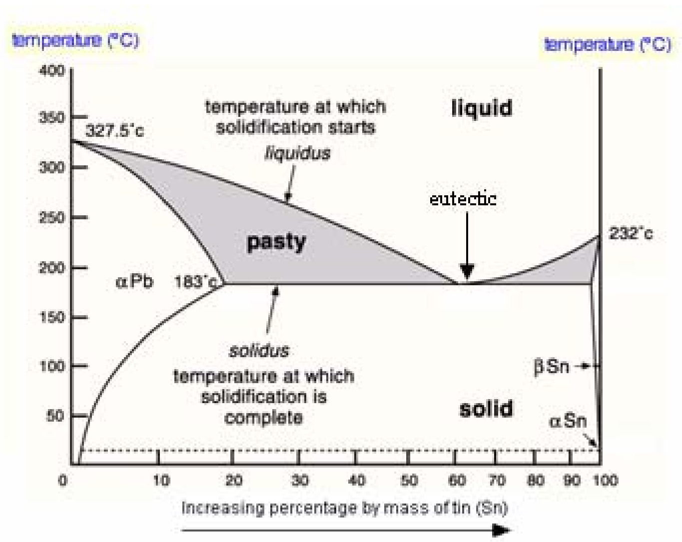
Silver Soldering Safety

- Silver soldering produces fumes, and you should avoid breathing these. A mask is preferred. Solder only in a ventilated area (but not so ventilated that the breeze cools the job!). Stand back from the work not over it.
- Goggles and gloves are essential. These parts get hot! Don't be tempted to touch anything even with gloves on unless you are sure it really is cold. Always lay down sticks of solder with the hot end away from you.
- Be careful of stray naked flame. It is very easy to concentrate on the job in hand in front of you and wave the flame elsewhere, and possibly set the workshop alight.
- Be careful with any of the chemicals involved, and thoughtful disposal of the pickle solution is recommended.
- The heat from soldering a large item can be overpowering and exhausting, so be aware and be careful. Dehydration and heat stress can and does occur.
- The propane torch should be complete, with a burst hose protector/flash back arrestor for connecting to the gas bottle.

Soft Soldering

Solder is a fusible metal alloy used to join together metal work pieces and having a melting point below that of the work piece(s). There are different types of solder used by industry including, bars, wires, and solder paste. Wire solder which has an internal “flux” core is typically used in the electrotechnology industry. The most common type of solder is an alloy of “tin” and “lead”. It is compatible with most types of fluxes and it has good corrosion resistance and excellent electrical properties. It can be used for joining most metals including copper wires.

By convention, the solder’s “tin” content percentage is always stated first. For example, electrical ”60/40” solder means it contains 60% tin and 40% lead. Plumber’s solder is normally 50/50 which means 50% lead and 50% tin. NB: The symbol for “tin” is “Sn” and for “lead” is “Pb”



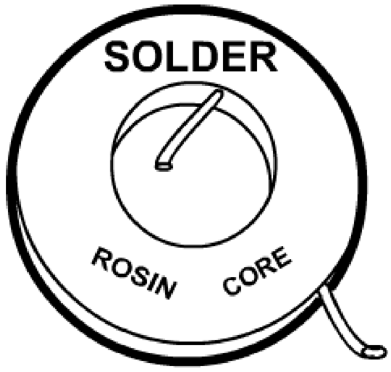
The ratio of “tin-to-lead” sets the solder’s melting characteristics. The greater the tin concentration, the greater the solder’s tensile and shear strength. Tin also increases the wetting ability and lowers the cracking potential of the solder.

Wetting produces an inter-metallic bond. Poor wetting tends to form droplets, while good wetting ability tends to spread out evenly over the solid surface area.

"60/40" (Tin/lead) solder is commonly used for soldering electrical connections. It melts at 188 C and it transitions between a liquid and a solid very quickly. Ie: It has very short "pasty" stage which means that the electrical joint is less likely to fail.

"Eutectic" solder is a 63%/37% (Tin/lead) combination transitions directly from a solid to liquid state at a temperature of **183 C**. (Ie: It has no plastic stage.) It is often used for soldering electronic components as it has the lowest melting point of all the tin/lead alloys.

NB: "Eutectic" is the proportion of constituents in an alloy that yields the lowest possible complete melting point. In all other proportions, the mixture will not have a uniform melting point; some of the mixture will remain solid and some liquid. At the eutectic, the "solidus" and "liquidus" temperatures are the same.



Flux
Rust and oxides form on most metal surfaces when exposed to air and any heating will only accelerate this formation. Solder will **not** adhere to or "**wet**" (flow over) the metal unless these pollutants are first removed.

"Fluxes" are special chemical compounds used to clean and maintain the metal surfaces during the soldering process. They also decrease the surface tension of the solder, making it a better wetting agent. Fluxes are manufactured in cake, paste, liquid, or powder form and are classified as either "**corrosive**" or "**non-corrosive**".

Corrosive fluxes are used when soldering large metal surfaces such as pipes and metal objects etc. Non-corrosive fluxes are used for soldering electrical/electronic connections and for other work that must be free of any trace of corrosive residue. "**Rosin**" is the most commonly used non-corrosive flux. In its solid state, rosin is inactive and non-corrosive. When heated, it melts and provides some fluxing action.

Rosin-core solder is a tubular (hollow) form of solder. The voids in the solder are filled with a non-corrosive rosin flux. This helps to keep the work piece clean during the soldering process and facilitates the bond between the metals and the solder. Rosin-core solder is the recommended solder when working with electrical wiring and metals, including copper and tin. This type of solder is available in different diameters for different purposes. Precise work with electronics is typically best suited for solder type with thinner diameter.

Other types of solder fluxes are listed in the table shown below:

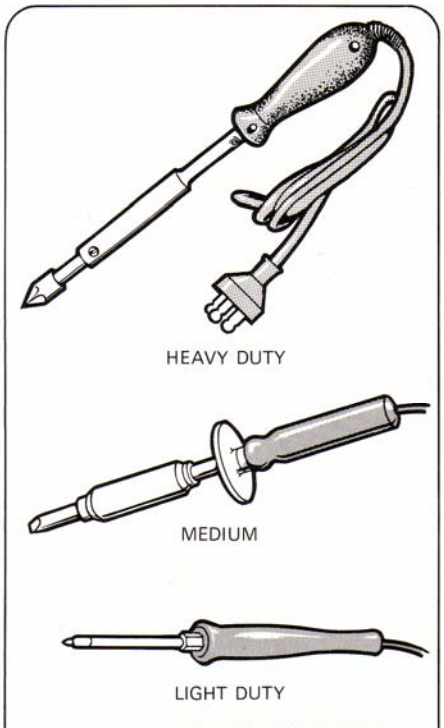
Metal	Fluxes
Brass, copper, tin	Rosin
Lead	Tallow, rosin
Iron, steel	Borax sal ammoniac
Stainless steel and other nickel alloys	Phosphenic acid
Galvanized iron	Zinc chloride
Zinc	Zinc chloride
Aluminum	Stearine, special flux

NB: When soldering is complete, always clean any remaining traces of the "flux" from the joint. Special alcohol based flux remover are available to remove surplus rosin flux as they leave no residue that could cause tracking.

Soldering Techniques
Soldering is normally achieved with the aid of either a "**gas torch**" or a "**soldering iron**".

A butane "**gas torch**" has its own gas supply and reaches correct soldering temperature very quickly. The unit shown is self-igniting through piezo ignition, light weight, portable and has an output temperature of 1300°C. Its disadvantage is that a naked flame can be very dangerous in some environments as it can burn electrical insulation and surrounding parts because it is difficult to localize the flame. Also, the flame is adversely affected by the wind. Despite this, electrical contractors typically use these types of units to make solder connections during installations.

Ref: http://www.getprice.com.au

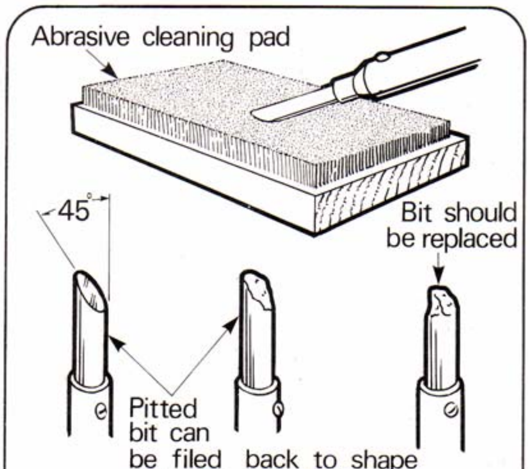


TYPES OF ELECTRIC SOLDERING IRONS

A "**soldering iron**" provides a more precise form of soldering. The heat energy can be directed to an exact location. A soldering iron must supply heat to melt the solder so that it can flow into the joint between the work pieces. It is comprised of a heated metal "tip" (normally copper) and an insulated handle. Heat energy is obtained by passing an electric current (supplied via an electrical cord or battery supply) through a resistive heating element in contact with the "tip". Some portable irons are heated by a gas flame.

Soldering irons are available in various ratings from 15W to a few hundred watts. The advantage of a high wattage iron is that it can provide sufficient heat energy to quickly solder a joint. This is important when there is a quite a large volume of metal to be heated. A smaller iron would take a longer time to heat the joint up to the correct temperature, during which time there is a danger of the electrical insulation becoming damaged. A small iron is used to make joints for miniature electronic components which are easily damaged by excess heat.

Temperature-controlled soldering irons operate at a "set" temperature. Temperature control can range from special magnetized soldering tip (based on the Curie point) and a magnetic switch to a highly sophisticated electronically controlled soldering station. These are used to solder "printed circuit boards".



CARE OF BITS

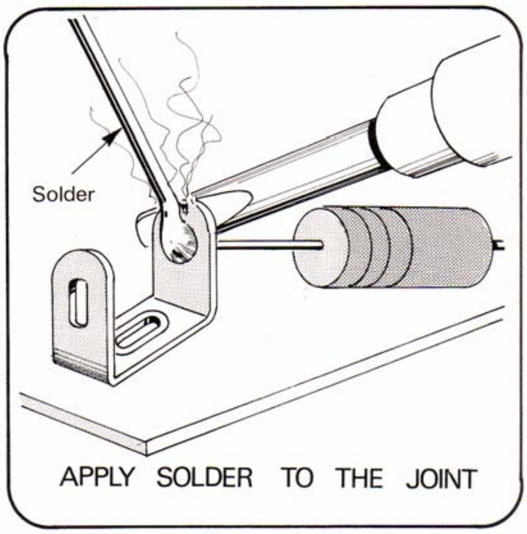
The soldering iron's heat capacity must always be matched to the size of the task. When heating large masses the temperature drops too quickly drops and does not melt the solder. But, too much heat capacity on very small jobs can affect the surrounding parts.

When soldering, the solder will flow evenly to make a good electrical and mechanical joint only if both parts of the joint are clean and at an equal high temperature. Sometimes, it may appear that there is direct metal-to-metal contact but there may a thin film of oxide on the surface that insulates the two parts. This will produce a “**dry joint**” which may have a high-resistance. This will then lead to system failure.

The surface of the soldering iron tip should always be clean and not pitted. Clean the tip surface by wiping it on the cleaning pad as shown above. A cleaning pad can be an abrasive “wire” type or a wet sponge is also suitable. (NB: After cleaning, always wait a few seconds for the soldering iron to reach its correct operating temperature before re-use.)

Technique
When the soldering iron is up-to-temperature:

- Apply some solder to the flattened working end at the end of the bit, and wipe it on a piece of damp cloth or sponge so that the solder forms a thin film on the bit. This is called “**tinning-the-bit**”.
- Melt a little more solder on to the tip of the soldering iron, and position the tip so it contacts **both** parts of the joint. It is the molten solder on the tip of the iron that allows the heat to flow quickly from the iron into both parts of the joint. If the iron has the correct amount of solder on it and is positioned correctly, then the two parts to be joined will reach the solder's melting temperature in a couple of seconds.
- Next, apply the end of the solder to the point where both parts of the joint and the soldering iron are all touching one another. The solder will melt immediately and flow around all the parts that are at, or over, the melting part temperature.
- After a few seconds remove the iron from the joint. Make sure that no parts of the joint move after the soldering iron is removed until the solder is completely solidified. This can take quite a few seconds with large joints. If the joint is disturbed during this “plastic” period it may become seriously weakened.



The finished surface of a properly made joint should have a smooth shiny appearance and if the wire is pulled it should not pull out of the joint. In a properly made joint the solder will bond the components very strongly.

It is important to use the correct amount of solder, both on the iron and on the joint. Too little solder on the iron will result in poor heat transfer to the joint. Too much will cause the solder to form strings as the iron is removed, causing splashes and bridges to other contacts. Too little solder applied to the joint will give the joint a half finished appearance: a good bond where the soldering iron has been, and no solder at all on the other part of the joint.

Safety: Soft Soldering
DO NOT use this equipment unless you have been instructed in its safe use and operation and have been given permission

Personal Protective Equipment


Approved safety glasses must be worn at all times.


Long and loose hair must be contained.


Appropriate footwear with substantial uppers must be worn.

Respiratory protection devices may be required.

Close fitting/protective clothing to cover arms and legs must be worn.

Rings and jewellery must not be worn.

Pre-Operational Safety Checks

- Examine the tools power lead and machine for obvious damage.
- Check condition of the soldering tip. Replace if damaged.
- Ensure tip is ‘tinned’ and free from waste build-up. Wipe tip on damp sponge to clean once iron has warmed-up.
- Ensure that the cord does not create a slip/trip hazard.
- Ensure the workspace is well ventilated. Use a fume extraction unit if available.
- Leave soldering iron in the stand when warming up.
- Never leave the soldering iron unattended when turned on or still hot. Leave unplugged when not in use.

Operational Safety Checks

- Never operate a faulty Power Tool. Always report faults to your supervisor.

Ending Operations and Cleaning Up

- Switch off the soldering tool and fume extraction unit when work is completed.
- Ensure soldering iron has sufficiently cooled before storing.

Potential Hazards

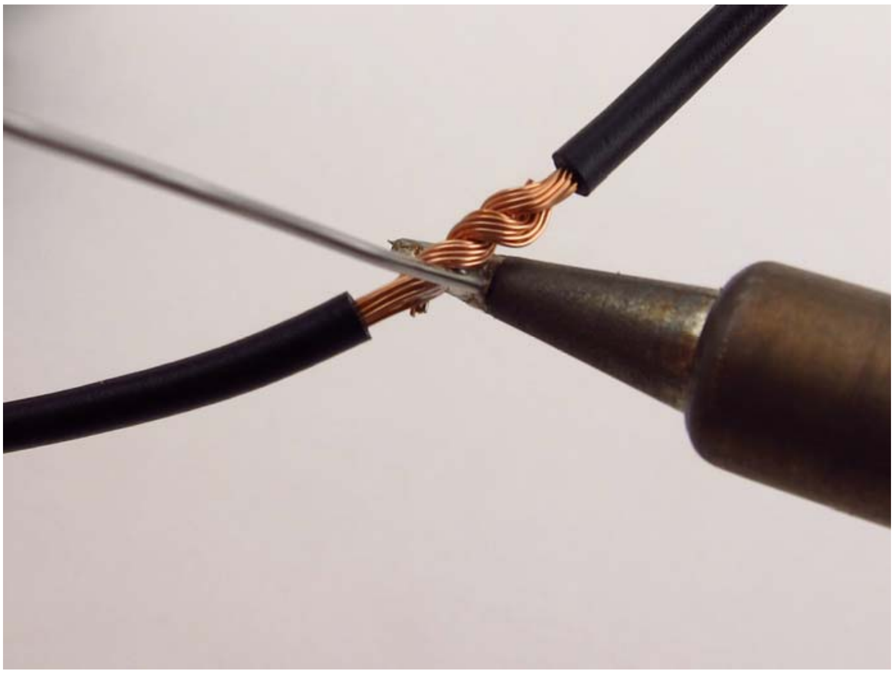
- Electric shock.
- Fumes.
- Body burns due to hot or molten materials.
- Fire.

Don’t

Do not use faulty equipment. Immediately report suspect equipment.

This SOP does not necessarily cover all possible hazards associated with this equipment and should be used in conjunction with other references. It is designed as a guide to be used to compliment training and as a reminder to users prior to equipment use.

Ref: http://bolty.net/wp-content/uploads/2010/11/solder_1.jpg



T9 Portable electric power tools encompassing:

- portable electric power tools (grinders, drills, jigsaws, saws)
- applications of portable electric power tools used in the electrotechnology work.
- using portable power tools.
- fabricating components using power tools (drills, grinders)

Portable Power Tools

Portable power equipment is essential to the electrotechnology industry both within the workshop and in the field. This section deals with the most commonly used portable electric hand tools.

- Pistol drill
- Hammer drill
- Angle grinder
- Disc sander
- Straight grinder
- Vertical grinder
- Die Grinder
- Jigsaw
- Sabre saw
- Circular saw
- Hand shear
- Nibbler
- Heat gun

Portable power tools can be operated using "**three**" types of power sources.

- Electrically "**mains**" operated via a power lead,
- Battery operated,
- Pneumatically (air) operated.

NB: Not every type of portable power tool is available in all three power modes.

Portable Tool Safety

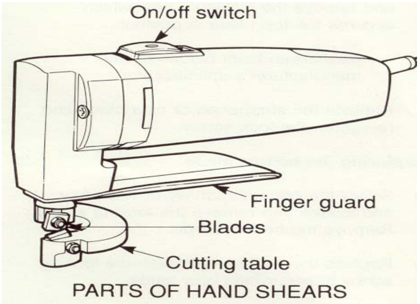
Safety when using power tools is very important. Always:

- Keep the work area clean. When not in use, store tools in dry, high or locked places.
- Use the right tool. Do not force a small tool to do the job of a heavy duty tool. It will do the job better and more safely at the rate for which it was designed.
- Wear protective clothing. Loose clothing or jewellery will get caught in moving parts. Rubber gloves and footwear are recommended for outdoor work.
- Your own equipment should include:
  - protective goggles
  - gloves
  - ear protection
  - protective clothing
- Avoid dangerous environments. In a gaseous or explosive atmosphere, sparks from an electric tool may ignite fumes. Do not expose tools to rain or wet conditions.
- Use the correct tool. Never carry the tool by the cord, or pull it to disconnect the plug. Make sure the tool is switched off before plugging in the cord.
- When using a tool at a long distance from the power source, an approved extension cord must be used for safety and to prevent loss of power and overheating.
  - Before using cords, inspect them for loose or exposed wires and damaged insulation. Have any necessary repairs done by a qualified electrician before using your power tool.

Cutting Tools
Among the range of portable power tools available are cutting tools. Each type of cutting tool relies on a different cutting action.

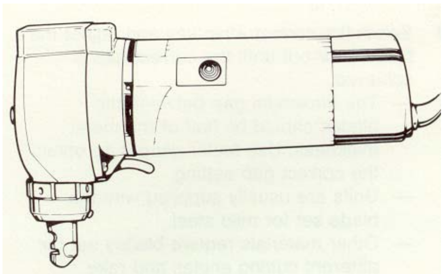
Types of Cutting Actions

Shearing action: The metal is cut in a similar way to tinsnips. The blades slice, but no metal is removed. An electric hand shear tool is shown below.



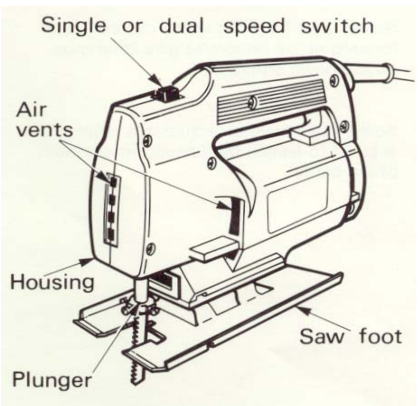
PARTS OF HAND SHEARS

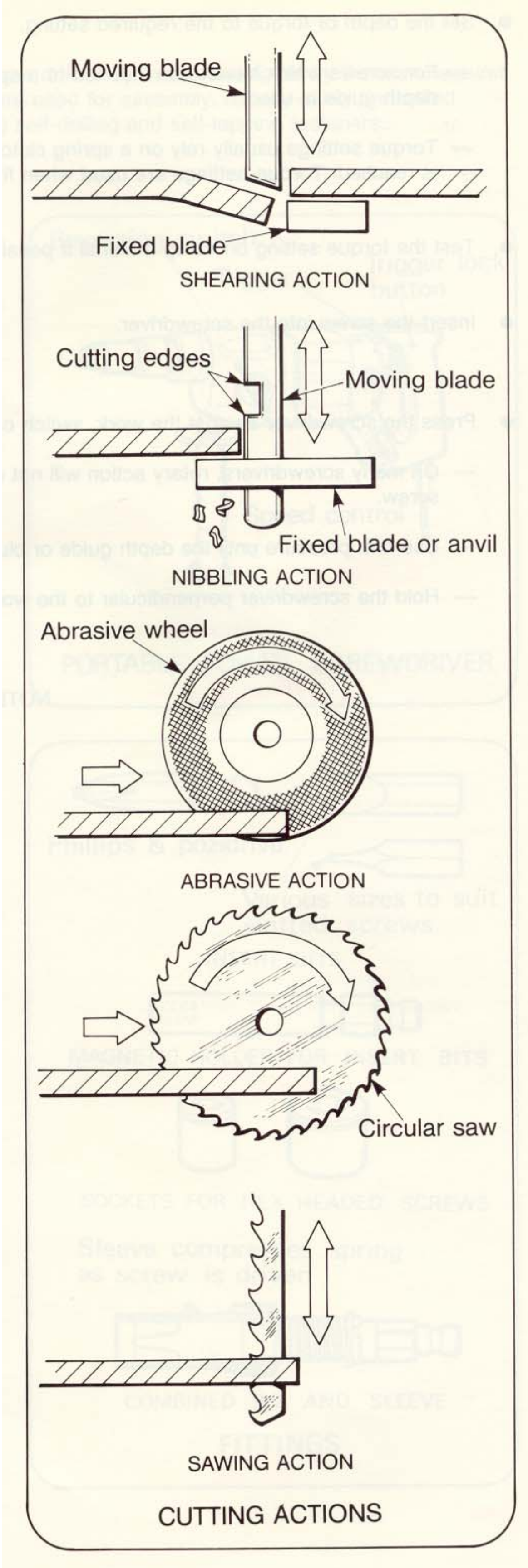
Nibbling action: The metal is punched out in a "half-moon" shape. The kerf is much wider than that produced by a saw blade.



Abrasive action: The metal is cut in a similar way to a grinding action.

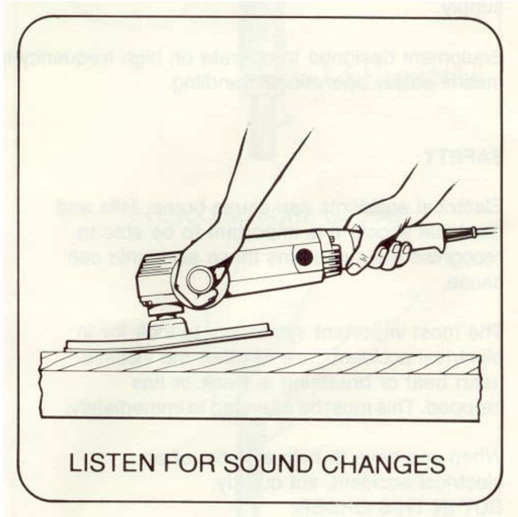
Sawing action: The metal is cut with a round blade in a "Circular saw" or a straight blade such as in a "Jig saw" or "Sabre Saw".





CUTTING ACTIONS

Using Portable Tools
To get the best results from any portable tool:



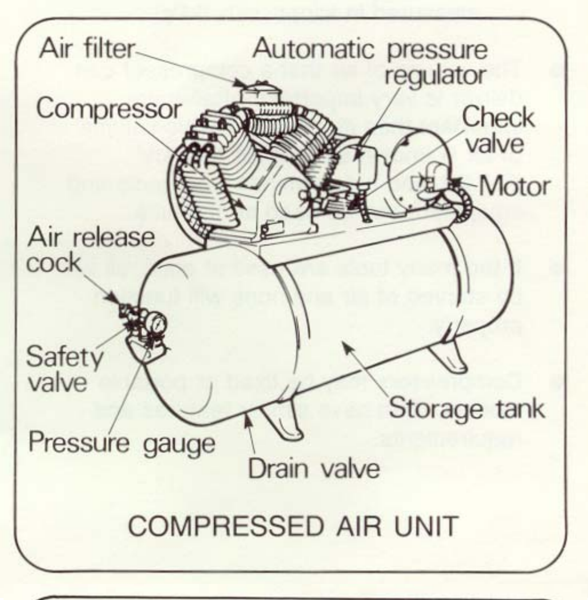
- Clamp the material down to prevent it from moving or falling.
- Always allow the tool to reach full speed before bringing it to the job. This prevents overloading the motor and serious damage.
- Lift tools such as grinders clear of the work before switching the machine off.
- Stopping tools under load (that is when they are still working on the job) is not good for the motor.
- Jig saws may need to be switched off while on the job.
- Keep the cutting edges of tools sharp. Dull or damaged cutting edges give a poor finish and overload tools.
- If the tool must be forced through the work the cutting edges need sharpening.
- Listen to the sound of the motor for changes in pitch or tone. Most tools must run at full speed for top efficiency. A droning or slowing motor sound means an overloaded tool. If this occurs, sharpen the cutters or readjust the depth of cut.
- NEVER use a tool's cutting to perform a task that it was not designed for.
  eg: A circular saw with timber "rip-cut blade" must <u>NOT</u> be used to cut masonry products.

  Special brick cutting blades are manufactured to fit circular saws. The two saw blades below are both designed to fit a circular saw but the products differs significantly.

The saw blade below is suitable for cutting Wood (Engineered Wood Products - Hardboard, Chipboard / Particle Board, Plywood, Softwoods, Hardwoods, Picture Frames, Timber Planks, and Weather Board)

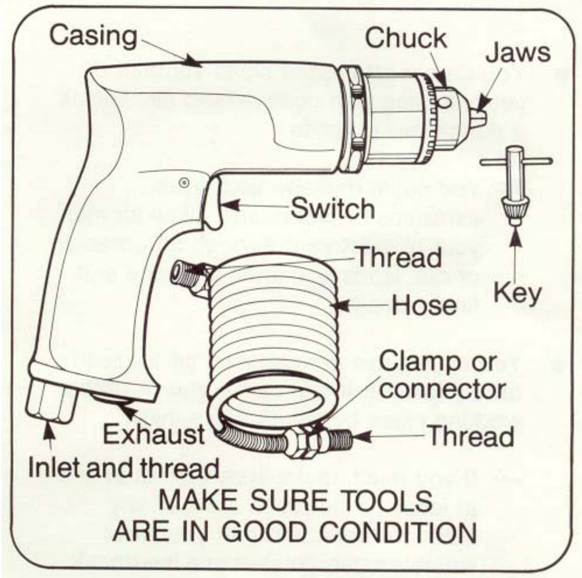
The saw blade below is suitable for cutting Ceramic (Bricks, Pipes, Floor & Wall Tiles, Terracotta, Roof Tiles), Clay and Mud Products, Concrete (Blocks / Bricks, Pavement, Pavers, Pipes),

Pneumatic Power Tools
A pneumatic tool is one operated by compressed air. This makes safer than electrically powered in many applications. (ie: Damp) Each tool is somewhat lighter than the equivalent powered by an electric motor. Unlike an electrically powered tool, they are not damaged when stalled.



Air compressor
An air compressor is a machine that pumps and stores air at a pressure which is high enough to operate pneumatic tools and equipment.

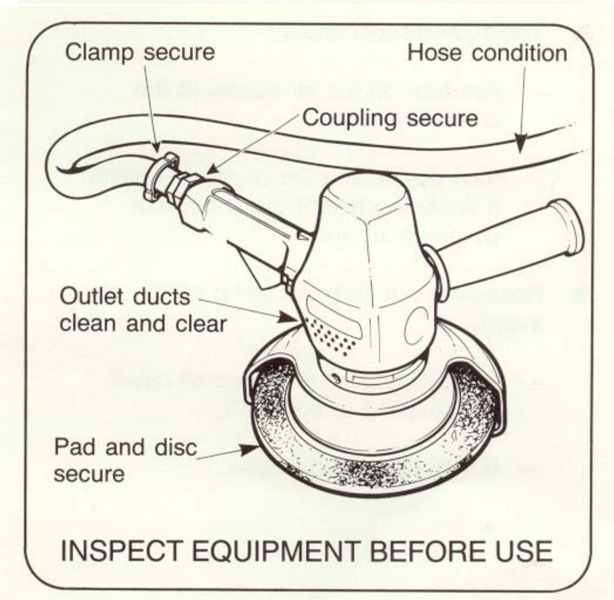
Most compressors are fitted with a "regulator" to control the correct pressure in the "storage" tank, a "filter" to remove impurities from the air, and a "drain valve" to remove water that has condensed inside the storage tank.



It is essential that all impurities are removed from the compressed air and the pressure controlled if pneumatic tools are to operate efficiently and effectively.

Points To Remember When Using Compressed Air
Compressed air is widely used in engineering to operate pneumatic tools such as torque wrenches, drills, grinders, sanders and other equipment.

Compressed air is piped around many work areas. Australian Standard **ASNZ1345_1995 Identification of the contents of pipes, conduits and ducts** (Table 1**)** sets the colour coding of pipes supplying "compressed air" as **"Light Blue".**



Safety: Air Compressor

DO NOT use this equipment unless you have been instructed in its safe use and operation and have been given permission

PPE guidelines when working with a Compressor

Safety glasses must be worn at all times in work areas.

Long and loose hair must be contained.

Appropriate footwear with substantial uppers must be worn.

Close fitting/protective clothing must be worn.

Rings and jewellery must not be worn.

Ensure all flammable materials are safely stored.

Pre-Operational Safety Checks

- Ensure no slip/trip hazards are present in workspaces and walkways.
- Locate the compressor in a suitable location for safe operation.
- Lock the wheels on the base of the compressor to prevent movement.
- Check that all fittings and connections are in good condition prior to starting.
- Check all fittings are securely connected prior to being pressurised.
- Faulty equipment must not be used. Immediately report suspect machinery.
- Locate and ensure you are familiar with the operation of the ON/OFF starter.

Operational Safety Checks

- Start the compressor noting pressure increase and cut-out/cut-in pressure.
- Listen for any air leaks from any flexible airlines and immediately report if any leaks are observed.
- Adjust pressure regulator to suit work requirements.
- Check the compressor at regular intervals.

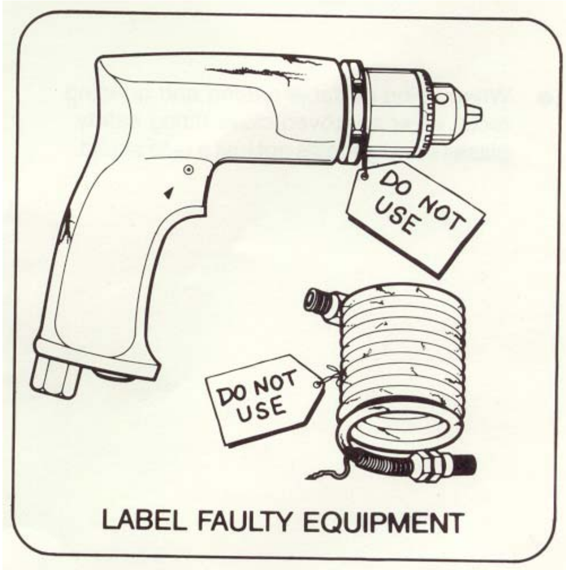
Ending Operations and Cleaning Up

- Switch off machine.
- Leave the machine, hose and work area in a safe, clean and tidy state.

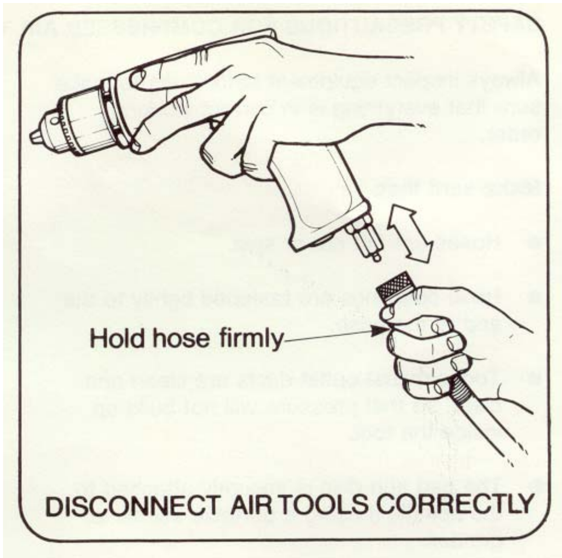
Potential Hazards

- × Unsecured hoses whipping under pressure
- × Compressed air is very dangerous when used for anything but the correct purpose. Pressures of 690 kilopascals (kPa) or more are quite common.

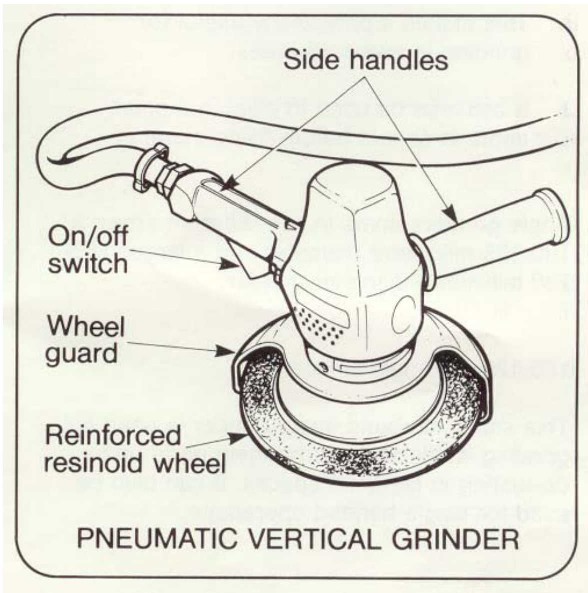
Safety Precautions for Compressed Air Tools
Always inspect equipment before use to make sure that everything is in correct working order.



Before use, make sure that:
- Hoses are not cut or split.
- Hose couplings are fastened tightly to the end of the hose.
- Tool exhaust outlet ducts are clean and clear, so that pressure will not build up inside the tool.
- The pad and disc is securely attached to the spindle if using a portable sander or grinder.
- The machine is in good working order. If not, report it:
  - Label the tool stating its fault and send it out for repairs.
- Only the correct working pressures as specified by the manufacturer are used for the equipment:
  - Incorrect pressures can cause serious injury, and also damage the equipment.



When using, make sure that:
- Tools are used as directed by the manufacturer:
- Use the correct stance and grip; you will know if you are standing correctly if you feel well balanced and comfortable.
- You take care not to damage anything or injure yourself.
- **When using portable cutting and grinding tools, you must wear approved eye protection.**
- You do not play around with compressed air.
- Do not point the hose at anyone, it can cause serious injuries.

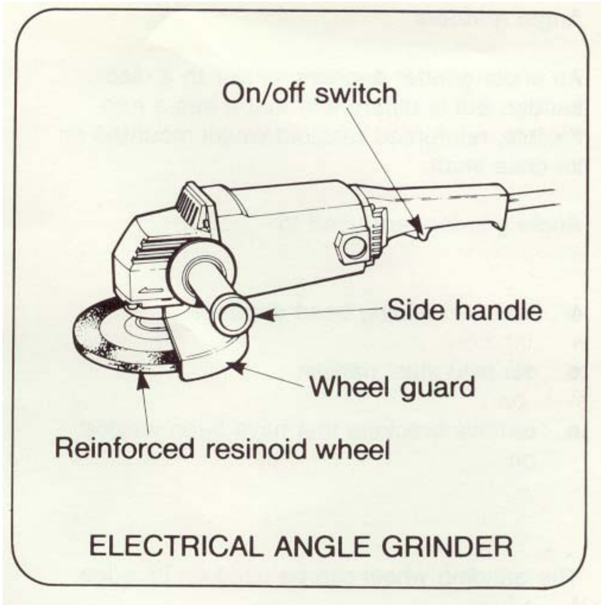


Warning
Remember, air under pressure is dangerous; many lives have been lost through thoughtless and careless acts with compressed air.

After use, make sure that:
Tools are disconnected:
  - first turn off the air supply at the control valve;
  - Then disconnect the coupling, holding it firmly to prevent the hose from whipping around.

Hoses are not kinked, cutting off the air supply:
  - This is dangerous and could cause the coupling to come off.
  - It may damage the hose.
- The tool is clean.

- Do not attempt to clean yourself or your clothing with compressed air. This is a dangerous practice.
- Do not use compressed air to clean off equipment. It can cause you or other workers near by, serious eye injury.
- When finished, ensure that the tool and leads are packed away in a safe place for protection.

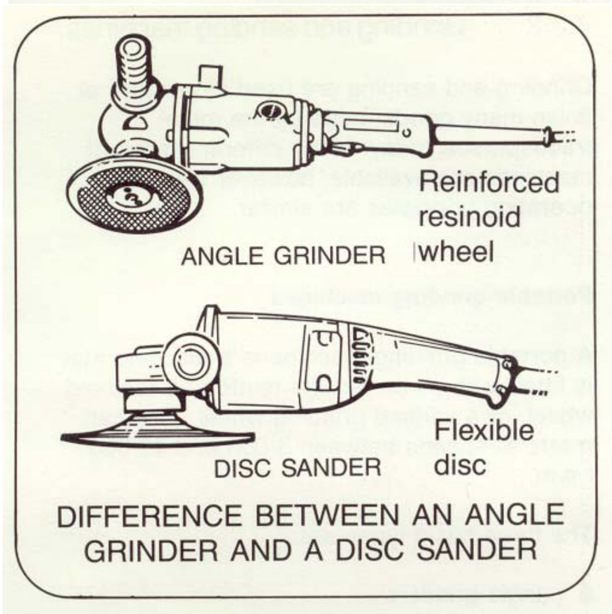


Electric Powered Tools
When using an electrically power tools there is always the inherent risk of receiving an electric shock. As a result there must be very strict safety checks. These are discussed later. If an electric powered tool "stalls" for a length of time then the current drawn by the motor will increase substantially. This may cause the motor to burn-out and it could cause a fire.

Grinding and Sanding Machines
Grinding and sanding operations are used to prepare or finish many goods. Many different types of machines are available; however their operating principles are similar.

Portable grinding machines
A portable grinding machine is a machine that is fitted with a non-flexible reinforced abrasive wheel. This can rotate at speeds between3000 and 48000 rpm.

The three basic types are:



Angle Grinders
An angle grinder appears similar to a disc sander, but is different in that it has a non-flexible, reinforced grinding wheel mounted on its drive shaft.

Angle grinders are for heavy duty grinding which includes:
- Remove welding bead deposits;
- Cut mild steel panels;
- Remove brackets that have been welded on etc.

The grinding wheel can be used on its edge.
- This makes it particularly useful for grinding in awkward areas.
- It can also be used to clean out small dents in sheets before filling them.

Applications:
• Cutting off metal strips, tube and angle iron.
• Chasing concrete and brickwork.
• Grinding welded joints flat.

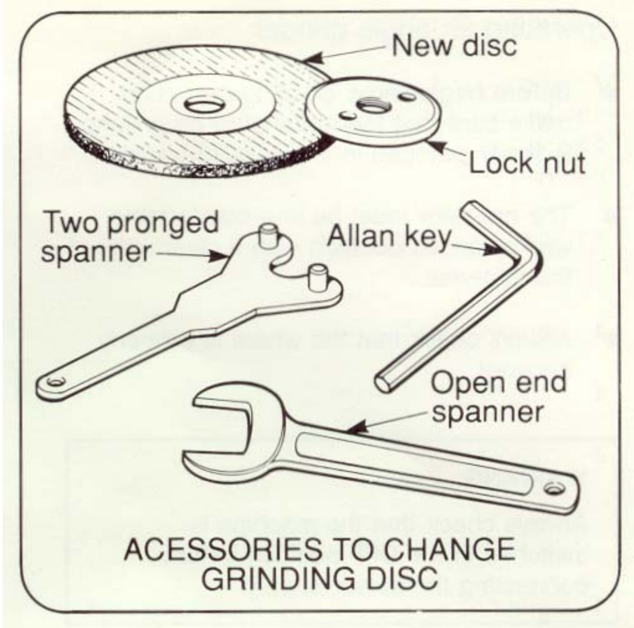
Changing Grinding Discs
The method of changing a grinding disc on either sized angle grinder is very similar. On most grinders the grinding disc is secured by a locknut. The removal of the disc requires a two pronged spanner and, for large grinders, an open end spanner, or for small grinders, an Allen key to remove the locknut.

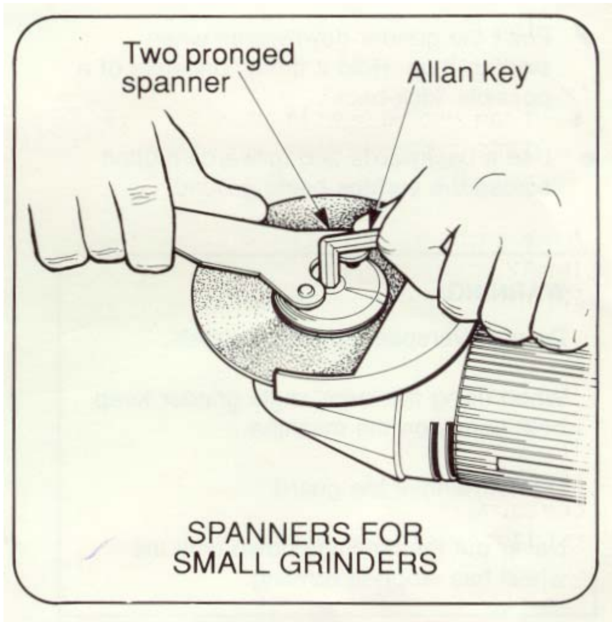
To change a grinding disc on either angle grinder, the procedure is as follows:

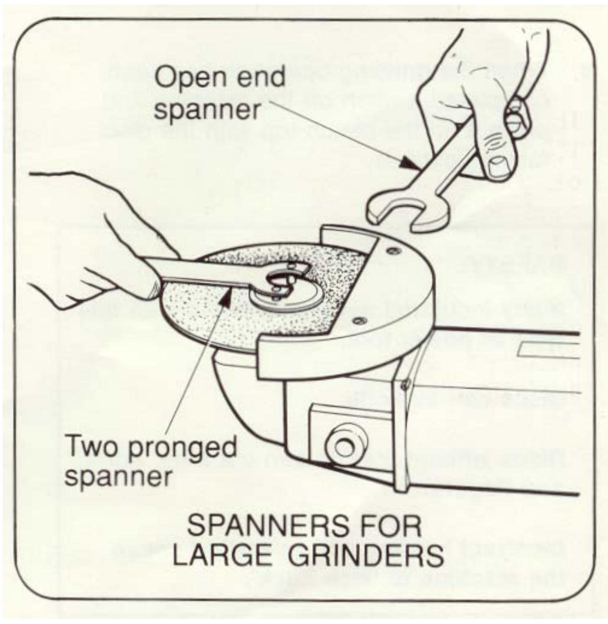
Safety
Turn off the power supply and remove the plug from the power point.

- Select the correct spanners to loosen the locking nut: The Allen key and two pronged spanner for the small grinder, and the open end spanner and two pronged spanner for the large grinder.
- Position the Allen key in the centre of the drive shaft of the small grinder or the open end spanner below the grinding disc holding the drive shaft on the large grinder.
- Place the two pronged spanner into the holes of the locking nut and turn anti clockwise to loosen it.
- Remove the old grinding disc. Place the new disc in position, then replace the locking nut, putting the two pronged spanner into the locking nut holes. Tighten in a clockwise direction to fasten the grinding disc in position.
- Plug the lead into the socket and switch on. The grinder is now ready to use.

Note: Using a small grinder to do work that is too large or requires too much pressure will end up in burning-out the motor.







Operating an Angle Grinder

- Before beginning a grinding operation make sure that the material to be ground is firmly clamped in a vice or to a bench.
- The operator must be in a comfortable, well balanced position with a clear view of the material.
- Always check that the wheel is properly secured.

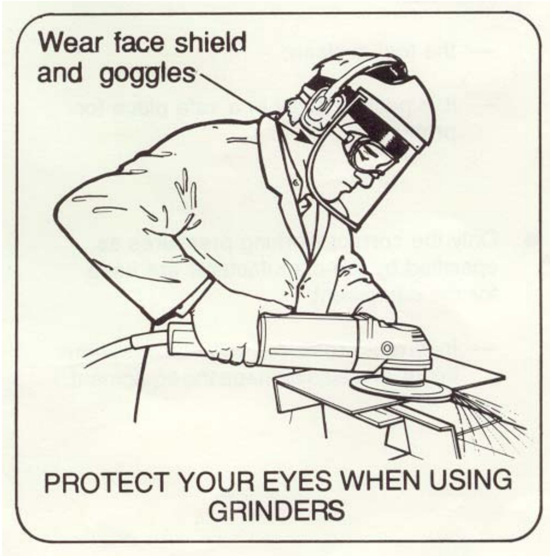
Warning
Always check that the machine is switched in the OFF position before connecting the power supply.

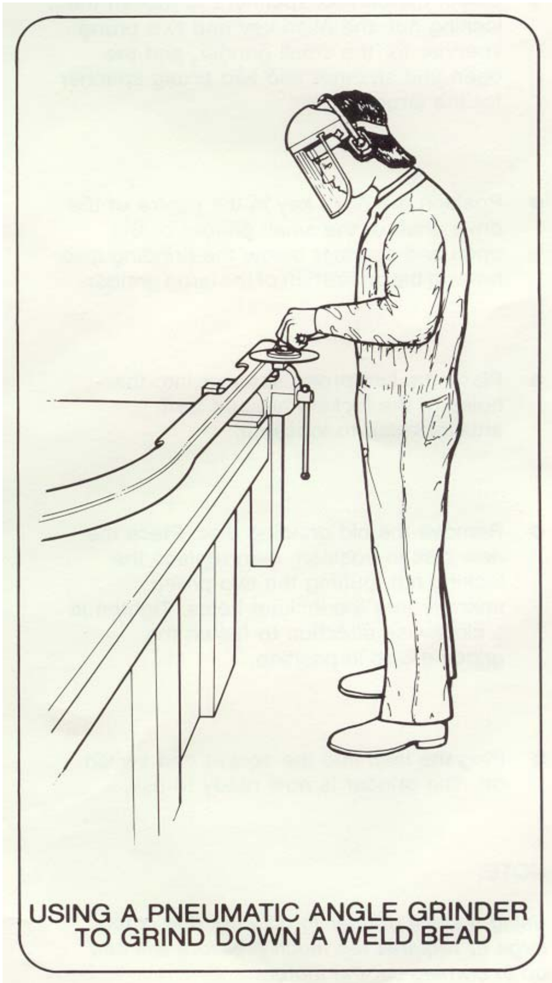
- Point the grinder downwards when starting it up. Hold it firmly, because of a possible "kick-back".
- Use a backwards and forwards motion across the surface being ground.

Warning

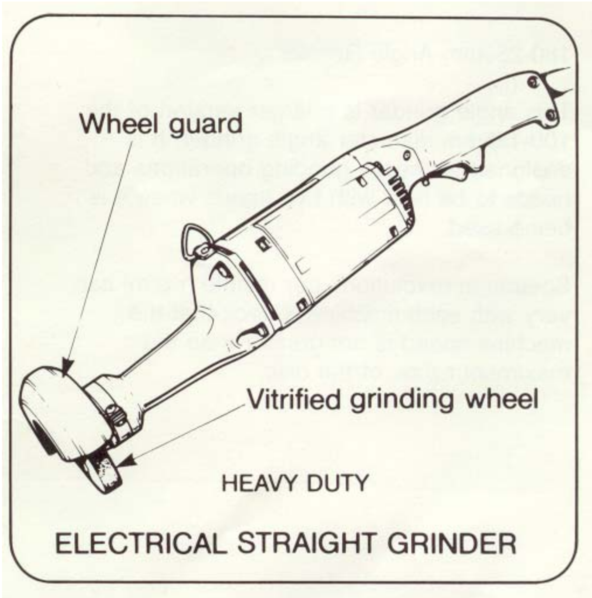
- **Do not over speed grinding wheels.**
- **When using the angle grinder keep both hands on the machine.**
- **Do not remove the guard.**
- **Never put the machine down until the wheel has stopped rotating.**
- When the grinding operation has been completed, switch off the machine and place it on the bench top with the disc facing upwards.

Safety
Many industrial accidents occur with this type of power tool. Discs can explode, Beware of hot work.





Straight Grinder
Straight grinders are portable, hand held machines designed for industrial level grinding. They have long, thin bodies with the grinding wheel fitted on the end of the drive shaft. There are two types of straight grinders; light or heavy duty. They may be electrically or pneumatically powered.
Small versions are sometimes called “die grinders”.



Die Grinder
(Also called a Pencil Grinder)
This tool is used for finishing operations to grind and polish contours in metals, plastic or wood. The grinding wheels are cemented to a shank, commonly called “mounted points”. The shank then fits into a “collet” in the grinder.

NB: A “collet” is a holding device that forms a collar around the object to be held and exerts a strong clamping force on the object when it is tightened, usually via a tapered outer collar.

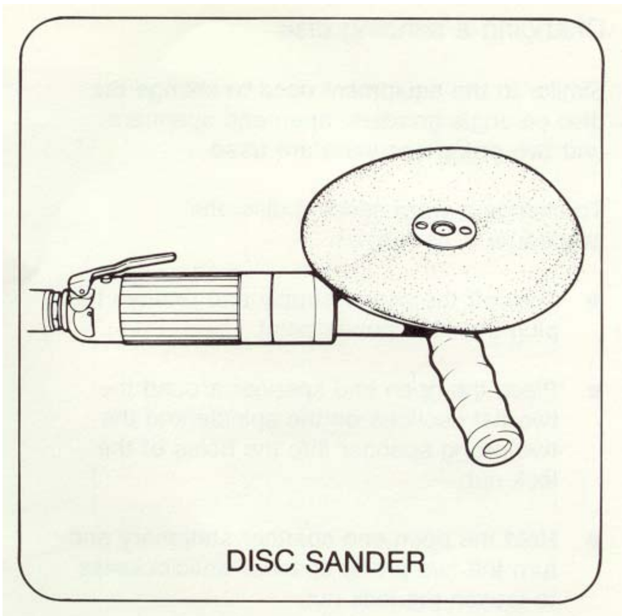
A die grinder operates at very high-speed and there is a wide selection of point abrasive wheels available to suit different applications.

Sanding Machines
When the coarser grinding operation is completed and a smoother finish is required, the work must be sanded.

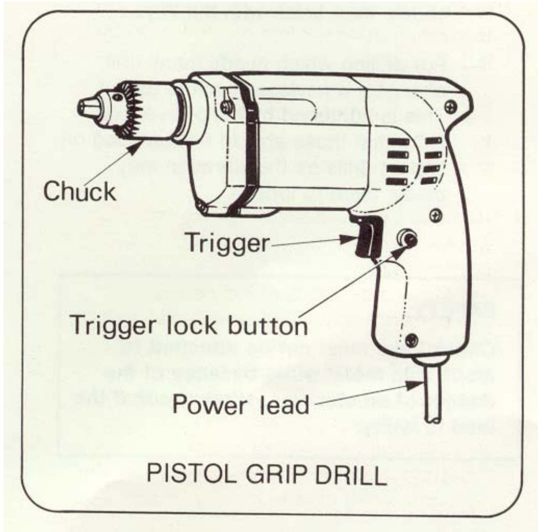
The most popular types of sanding machines are the disc sander and the belt sander.

Polishing Buffs can also be fitted to an angle grinder.

A “buff” is used to give the surface of paint work a high shine.



Portable Mains Powered Drill
Portable drills are used in the electrotechnology industry for drilling holes when installing equipment. These are pistol grip, rotary action drills designed for light duty operation. Some models have selectable "hammer" action for light duty, masonry drilling. Some models have variable speed control.



PISTOL GRIP DRILL

Pistol grip drills are designed for single hand operation and are mainly used for drilling small diameter holes.

The size of a portable drill is established by the maximum twist drill diameter that its chuck will accommodate. For portable drills, sizes range from 6.5, 10 to 13mm. Eg: A 10mm drill will take up to a 10mm twist drill.

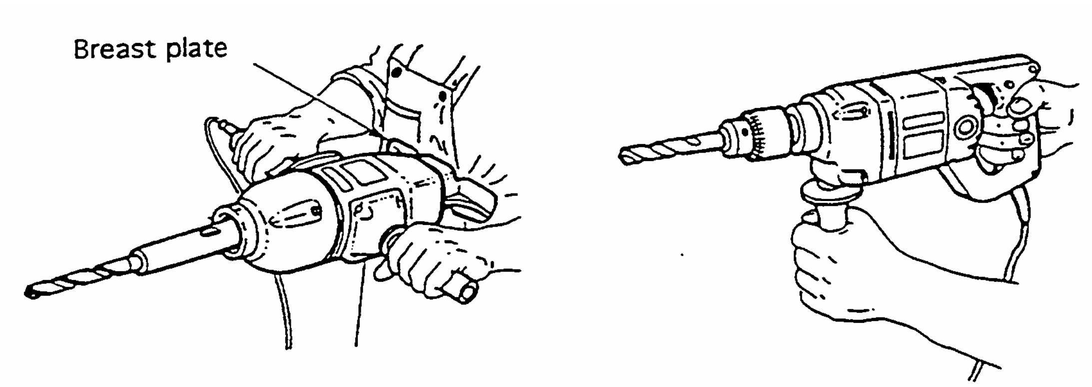
When using a portable electric drill always wear suitable "eye protection" and ensure that drill test tag indicates that it has been tested to verify that it is in safe working order.

Cordless Drill
These use a rechargeable battery as energy source. They are used as a drill and as a power screwdriver if they have a reversing switch fitted. The cordless design offers increased flexibility of movement. Some models have drill bit capacities up to 12mm, hammer action and variable speed.

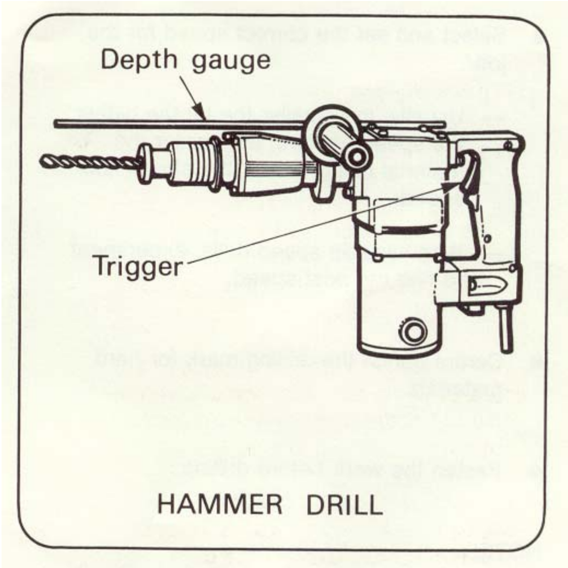
There is a range of rechargeable battery types available with 18V "Lithium-ion" types commonly used trade model. They weigh up to about 2kg.

Variable speed allows you to match the speed with the size of the drill bit. It also allows you to start drilling slowly then increase the speed as required without burning-out the motor.

Heavy Duty Drill
These are used for drilling larger diameter holes. The side handle prevents injury to the operator if the drill bit jams. Some have closed "D" pistol grip handles or breastplate or both and additional side handles for extra grip and pressure. As a general guide, drill bit diameters over 8mm should be used in a machine with the additional side handle. These tools have large chuck capacity with heavy duty motor and bearings. They usually have a dual function and can be switched to operate as impact drills for masonry or concrete work.



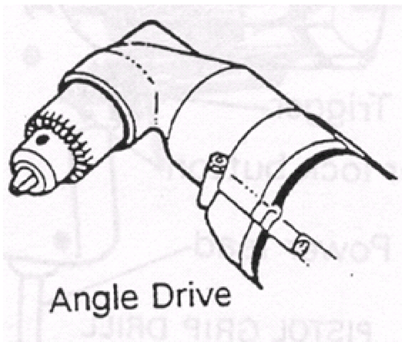
Hammer drills
A hammer drill has a spring or pneumatically driven floating hammer, which adds percussive force to the rotary action. This offers the advantages of faster drilling and reduced operator fatigue.



Hammer drills are more efficient than impact drills when drilling into masonry or concrete. Mostly are used in rotary plus hammer mode, but can be switched to rotary mode only.

The hammer action must not be used to drill products such as timber of steel. Never use hammer action on ceramic tiles as it may cause them to crack.

Angle Head Drill
Ideal for drilling in tight corners or in confined spaces. It has a small chuck capacity.



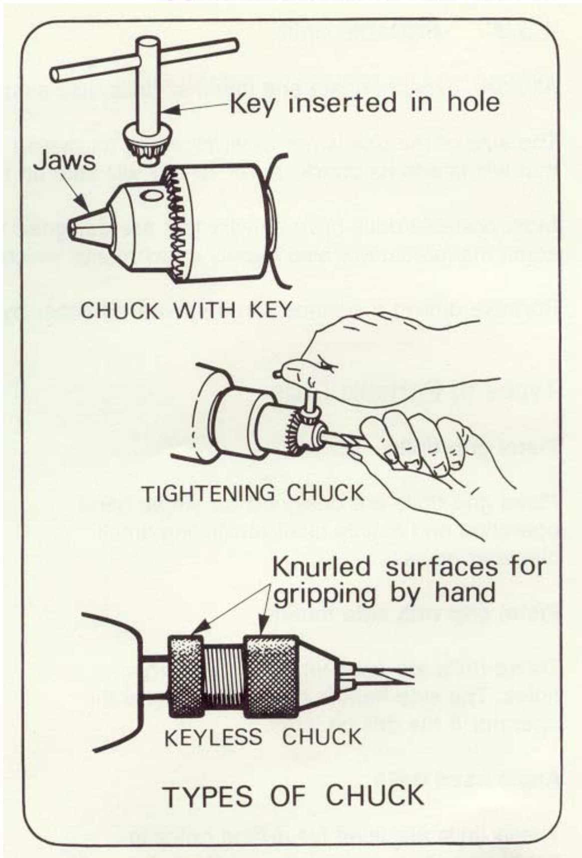
Operating a Drill

- Select the correct drill bit
  - Carbide tipped bits are used for stone, concrete, brickwork, ceramic tile and fibrous cement. They need slow speed and high feed pressure.

- Insert the drill bit:

  - Most drills have a three jaw, key tightening chuck. Hand tighten the chuck and then finish with the key.

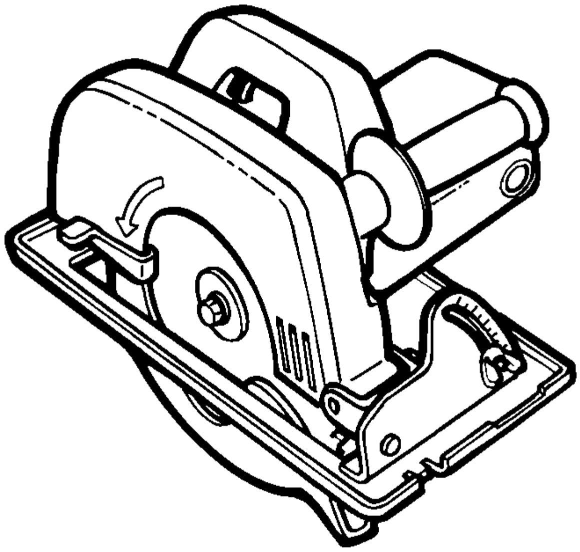
  - For drilling which needs many drill changes, a keyless chuck is useful. This is tightened by hand pressure.



Safety
NB: Chuck keys must not be attached to leads with metal wires because of the danger of an electrical short circuit if the lead is faulty.

Never lower any portable tool such as a portable drill or saw etc to the ground from a height via its power lead as this could cause a hazard.

Power Saw (Circular Saw)
This is a rotary saw originally designed to cut timber. With the introduction of special blades or discs it is now capable of efficiently cutting a wide variety of materials.



Note the arrow direction on the drawing to the right. A circular saw's blade typically turns counter-clockwise as you face the blade side of the saw. The saw blade's teeth (except in rare instances) always point in the direction of blade rotation.

The securing bolt should be unscrewed in the direction "**opposite**" of the blade's rotation. For the majority of saw brands, this makes it a "**left hand thread**".

Applications
Electricians commonly use a circular saw, fitted with a carbide type blade, to make parallel cuts in masonry walls for the purpose of running conduits inside the wall render etc. This technique is known as "**chasing**".

Safety When Changing a Saw Blade
(Always follow manufacturer's instruction if they are available on how to change a blade.) If instructions not available, then follow the guide below:

- **Always** turn off the saw's power switch and remove the power cord's plug from the mains socket outlet. Bring the plug end of the saw's lead very close to you so that it cannot be accidentally reinserted into an outlet while you are changing the blade.
- Slide up the protective blade guard to expose the blade and lay the saw down on a sturdy bench top.
- Note which way the saw's teeth are pointing prior to removal.
- Most circular saw models are equipped with a blade lock feature that can be employed to stop blade movement.
- Attach the supplied spanner or socket to the circular saw blade retaining bolt in the centre of the blade. This bolt attaches the blade to the saw's spindle.
- NB: This bolt will undo in the **opposite** direction to the saw's rotation. (**Most probable it will be a "left hand thread".)** Remove the bolt and set aside.
- Remove the saw blade and place the new blade with the teeth direction as before in its place.
- Replace the blade bolt and tighten securely to the saw.

Heat Gun
Ref: http://www.productreview.com.au

A heat gun is a tool used to emit a stream of hot air. They are superficially similar in shape and construction to a hair dryer, though they run at **much** higher temperatures.

They are used in the electrotechnology industry to apply heat shrink tubing to colour code electrical conductors. Other uses include rapidly drying paint and in the electronics field to de-solder circuit board components.

Output air temperatures range from 100 - 550°C with some hotter models running around 760°C.

Heat guns can have nozzles which deflect the air flow for various purposes. Most have a heating element based on electrical resistance and a fan increases and focuses the air flow for convection heating. Other devices used for similar purposes include focused infrared heaters.

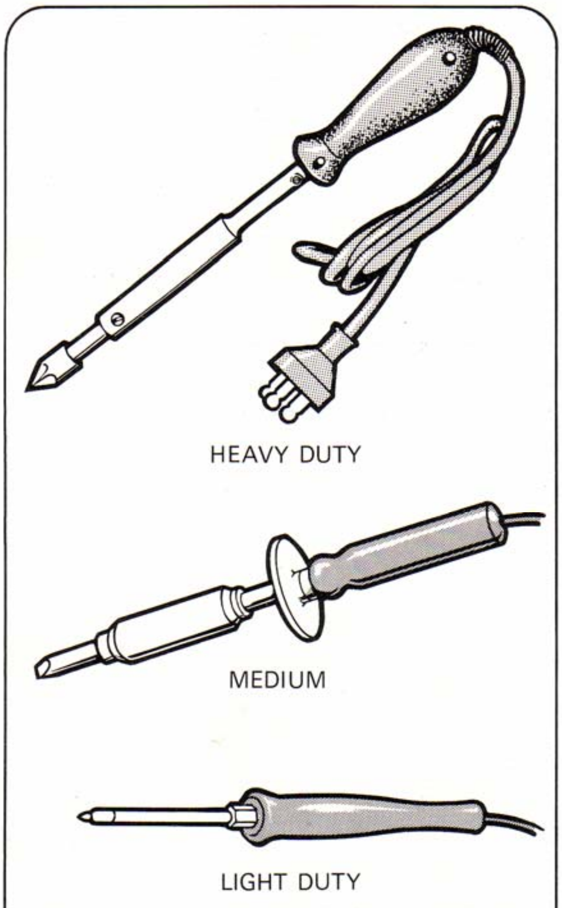
Electric Soldering Iron
These tools come in many sizes and wattage ratings. Some have almost instantaneous heat while others require some time to reach correct temperature. Some are temperature controlled.

Application

- Joining electrical conductive wires.
- Soldering small conductors to circuit boards.

Safety
The main soldering iron hazards are receiving personal burns and setting fire to combustible materials.

Never leave a soldering iron unattended. If the iron must be left on for a protracted period, to retain heat, place a guard around the hot areas to prevent accidents.



TYPES OF ELECTRIC SOLDERING IRONS

Portable Power Tool Safety

- **Never** use any power tool with the manufacturer's guard removed.
- Before using any power tool read the operating instructions carefully.
- Always wear safety glasses when using power tools.
- Use a face or dust mask if the cutting operation is dusty.
- Wear ear protection for noisy operations.
- Do not use power tools in explosive atmospheres.
- Never carry a tool by the cord or tug the cord to disconnect it.
- Protect cords from heat, oil and sharp edges
- Do not expose power tools to rain.
- Do not force a small tool or an attachment to do the job of a heavy duty tool.
- Disconnect tools when not in use, before servicing, or when changing accessories such as blades.
- Maintain tools with care. Keep tools sharp and clean at all times for best and safest performance. Follow instructions on lubricating and changing accessories.
- Avoid accidental starting. Do not carry a plugged-in tool with a finger on the switch. Be sure the switch is off before plugging in.
- When using the tool at a considerable distance from the power source, an extension cord of adequate size must be used for safety and to prevent loss of power and overheating.
- Before using cords inspect them for loose or exposed wires and damaged insulation.
- Ensure any needed repairs are made or replacement before using your power tool.

Care and Maintenance Portable Power Tools

A maintenance programme integrates workplace health and safety, inspection, reporting and record keeping procedures.

A key part of the maintenance program is maintaining a "log" for each power tool recording full manufacturer and an accompanying list of the parts needed for normal service and major repairs. Eg: Bearing and brushes etc. The maintenance program will establish the frequency of inspections for each tool in addition to the mandated electrical "test and tag" program set Australian standards. This is discussed in the next section.

Portable tools must be checked:

- Before the tool is put into use for the first time
- After servicing and changing parts
- At regular intervals appropriate for each tool.

Checks include tests for:

- Less than normal output,
- Malfunctioning safety devices such as on/off switches, emergency buttons, protective covers, or guards, etc.
- Over temperature,
- Severe noise or vibration,
- Cracked or broken grinding wheels or faulty cutting blades,
- Cracked or broken case, overt flaws in the power lead,
- Faulty electrical insulation or faulty earthing system.

Constant care and adequate maintenance and storage are essential for the safe use of portable tools in the workplace. In practice, this involves visual inspections aimed at detecting signs of possible fault. Early detection may be able to correct a small problem before it becomes a major problem. Items requiring attention should be reported and recorded in the maintenance log.

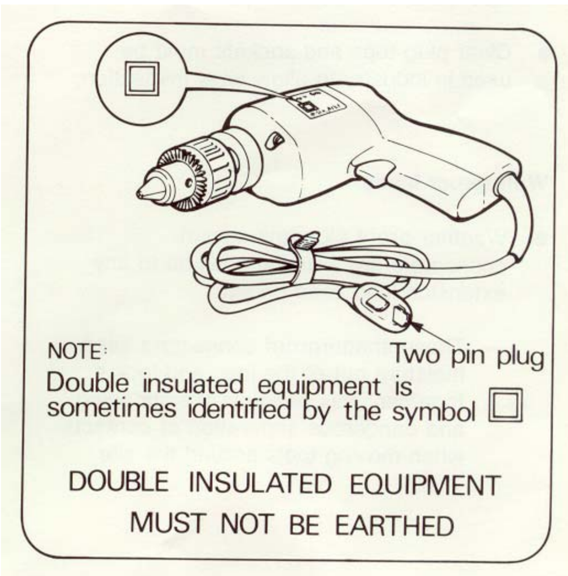
Some basic procedures to prevent hazards associated with the use of hand and power tools are:

- ✓ Examine each tool for visual signs of damage before use
- ✓ Check that the guards are present and secure
- ✓ Check the wheels and blades for cracks
- ✓ Visually check electrical cords and plugs,
- ✓ All portable tools that are damaged should be removed from use and tagged “Do Not Use”
- ✓ Keep tools sharp and clean
- ✓ Follow instructions given in the user’s manual for lubricating and changing accessories.
- ✓ Maintain tools according to the manufacturer’s specifications.
- ✓ Replace vibration mountings before they are worn out
- ✓ Check rotating parts for balance and replace them if necessary

Hazards
Hazards associated with portable electric tools used on a construction site include:

- Electric shock, electrocution, burns;
- Heat, sparks (fire);
- Cuts, abrasions, punctures;
- Dust/flying particles/arc flash (eyes);
- Entrapment of clothing, etc.;
- Sprains and strains (wrist, hand, arm, shoulder);
- Noise (hearing);
- Vibration.

Portable Power Tool Insulation
Electric shock is the most significant of the potential hazards listed above. Electric shock caused by “indirect contact” is typically due to by insulation failure. An appliance in a “safe” condition is expected to have a very high insulation resistance (ie. > 1MΩ) between its active conductors and any exposed external conductive surface. But, if the insulation resistance was to decrease due to a failure of the insulation then this could result in an electric shock.



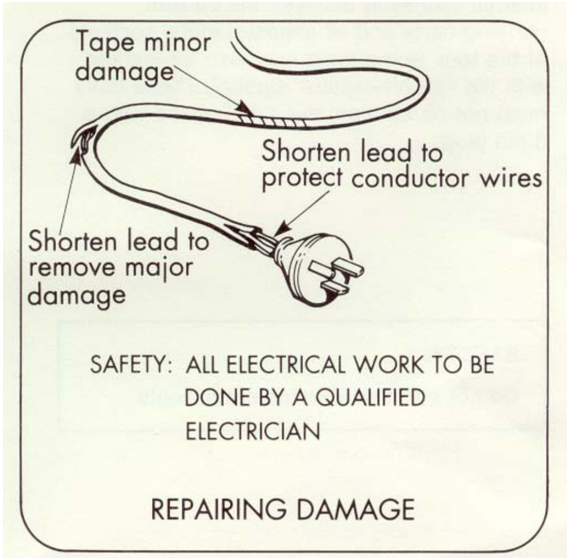
Safety: When using mains (230V) powered equipment, **always** perform a visual inspection just prior to use to ensure that there are no overt signs of faults to the tool’s case, power lead or plug. In the workplace you should also check the test date marked on the “test tag” affixed to the power lead. This date ensures that the tool is not past mandatory test date.

Australian Standard AS/NZ 3000 Wiring Rules introduces classes of electrical equipment based on the type of protection that they employ: For portable tools the two most important are Class I and II.

Single Insulated (Class I) Equipment
Class I equipment employs a protective earth (PE) conductor. The basic means of protection is the insulation between live parts and exposed conductive parts such as the metal enclosure. In the event of a fault, that would otherwise cause an exposed conductive part to become live, the supplementary protection (i.e. the protective earth) comes into effect.

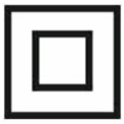
Additional protection is also provided for Class I equipment when it is plugged into a "socket outlet" via a mandatory RCD (Residual Current Device). If an insulation failure (ie: drop in resistance) causes the leakage current flowing to earth to exceed 30mA, then the RCD will trip and de-energizing the circuit.

Double Insulated (Class II) Equipment
Class II equipment is either "**double insulation**" or "**reinforced insulation**". With double insulated equipment, the basic protection is afforded by the first layer of insulation. If the basic protection fails then supplementary protection is provided by a second layer of insulation preventing contact with live parts.



NB: Class II equipment is <u>NOT</u> earthed.
Ie: It has no PE connection.

The symbol for Class II equipment consists of two concentric squares is shown to the right.



Legislative Requirements
A workplace is a much harsher environment than a domestic environment. In addition, it is normal that staff share access to the organisation's tools and equipment. To ensure that each portable tool is maintained there is a strict standards of inspection and testing. While these regulations do not extend to private domestic appliances, individual house owners may request a similar level of inspection and testing.

Legislative framework for in-service safety inspection and testing of electrical equipment.
The **Electrical Safety Act** 2002 and **Electrical Regulation 2013**, provides the legislative framework in Queensland for prescribing and regulating the requirements for in-service safety inspection and testing of electrical equipment.

Type of electrical equipment to be inspected and tested includes:

1. **Portable equipment** – mains operated portable appliances connected to supply by flexible cords.
2. **Cord extension** sets and electrical portable outlet devices.
3. **Portable and Non-portable Residual Current Devices (RCD's)**, including electrical portable outlet devices incorporating RCD's.

Construction Work
The Electrical Safety Regulation 2013, Subdivision 3 requires that all electrical portable equipment used for "**Construction work**" must comply with the requirements of Australian standard: **AS/NZS 3012-2010 Electrical Installations – Construction and demolitions site**.

AS/NZS 3012_2010, in turn references Australian Standard "**ASNZS 3760-2010 - In-service safety inspection and testing of electrical equipment"** to define the test procedures for inspecting electrical equipment to be used for construction work.

AS/NZS 3760_2010 – In-service safety inspection and testing of electrical equipment.
This standard specifies the procedures for safety inspection and testing of electrical equipment, operated by single or polyphase low voltage supply, and which is entered into service for the first time, or which is already in-service or is available for hire or resale. The scope of the standard is outlined in Section 1 as well as the type of electrical equipment the procedures

cover and definitions that apply to wording in the document.

Procedures for Inspection and Testing
Section 2 of AS3760 outlines the frequency of inspection and testing, types of inspection and tests to be undertaken, required test results, actions to occur as a result of the test results and required documentation. In Queensland the requirement of the Electrical Safety Act and Regulation 2013 takes precedence over the requirements of AS/NZS 3760. What this means is that you **must** firstly ensure you meet the requirements of electrical safety legislation. If the standard has additional requirements then they can be addressed as an add-on.

Extracts from:
AS/NZS 3012:2010 Electrical installations - Construction and demolition sites

Section 3 – Verification and Testing
Construction wiring and electrical equipment shall be inspected and tested as follows:

(a) For new equipment, prior to the initial introduction into service.
(b) Before return to service after a repair or servicing which could have affected the electrical safety.
(c) For hire equipment, inspection prior to each hire and testing at not greater than monthly intervals. If hire equipment remains on site then Table 3 applies.
(d) At intervals not exceeding those specified in Table 3.

3.5 RCDS
RCDs shall—
(a) be successfully operated by means of their in-built test facility (push-button); **and**
(b) be subject to and comply with a test for operating time of RCDs in accordance with AS/NZS3760.

3.6 Other Electrical Equipment on Site
3.6.1 General
All other electrical equipment on site, including power tools, flexible cords, cord extension sets and portable socket-outlet assemblies, shall be tested in accordance with Clauses 3.6.2 and 3.6.3, as appropriate, and inspected in accordance with the methods of AS/NZS 3760, before being put into service and thereafter at intervals not exceeding those listed in Table 3 of this Standard.

TABLE 3
PERIODIC VERIFICATION INTERVALS

1	2	3	4	5	6	7
Environment	**Transportable structures, Class I (earthed conductive parts) and Class II (doubled insulated) electrical equipment**		**Residual current devices (RCDs)**			
	Transportable structures[1], fixed and transportable equipment[2] and construction wiring[3] including switchboards	**Portable equipment[4]**	**Pushbutton test (by user)**		**Operating time (RCD tester)**	
			Portable[5]	**Non-portable fixed[6]**	**Portable[5,7]**	**Non-portable fixed[6]**
Construction and demolition sites in accordance with Clause 1.1	6 months	3 months	After connection to a socket or before connection of equipment, and at least once every day in use.	1 month	3 months	12 months

3.8.2 Non-compliant equipment

Where inspection or testing identifies equipment that fails to comply with the criteria given in this Standard, the equipment shall be—

- **(a) withdrawn from service immediately, have a label attached to it warning against further use; and**
- **(b) sent for repair, disposal or destruction by an authorized repair agent or service personnel.**

3.8.3 Compliant equipment

New equipment, after inspection and tests **shall be fitted with a durable, non-reusable, non-metallic tag**. Construction wiring, switchboards, fixed RCDs, fixed and transportable electrical equipment need not be tagged.

3.10 Documentation

Records of inspection and tests shall be kept. All the following should be recorded:

(a) A register of all equipment.
(b) A record of formal inspection and tests.
(c) A repair register.
(d) A record of all faulty equipment.
(e) For construction wiring:
  (i) Visual inspection—date, checklist (as per AS/NZS 3000 checklist).
  (ii) Continuity of earthing system—values obtained for main earth, bonding earth and protective earth.
  (iii) Insulation resistance value.
  (iv) Polarity—checklist.
  (v) Correct circuit connections—checklist.
  (vi) RCD—values for trip time.

Extract from:

AS/NZS 3760_ 2010– In-service safety inspection and testing of electrical equipment.

SECTION 2 – INSPECTION AND TESTS

2.3.3 Testing

The purpose of testing is to detect the unobservable faults not found by the visual inspection process, and forms an integral part of the inspection/testing process.

2.3.3.1 Earthing continuity

To confirm that the resistance of the protective earth circuit is sufficiently low to ensure correct operation of the circuit protecting device, the continuity of the protective earthing conductor from the plug earth pin to accessible earthed parts of Class I equipment shall be checked.

The continuity of the protective earth conductor between the earth pin of the plug and the earth contact and every outlet(s) of cord sets, cord extension sets, EPODs and PRCDs (“portable residual current device”) shall be checked. Such equipment shall be tested in accordance with Appendix D and shall have a measured resistance of the protective earth circuit, or the protective earthing conductor which does not exceed **1Ω.**

2.3.3.2 Testing of insulation

Insulation shall be subject to a leakage current test or an insulation resistance test in accordance with Appendix E. When an insulation resistance test is performed in accordance with Appendix E, the insulation resistance values obtained shall be not less than those specified in Table 2. (Partial extract shown below)

TABLE 2 – Insulation resistance limits

Equipment	Insulation test	Minimum insulation resistance MΩ
Class I	Measure between **live parts** and **accessible earthed parts**	1.0
Class II	Measure between **live parts** and any accessible metal parts	1.0
PRCDs with FE	Measure between **live parts** and the functional earthing conductor	0.05
Cord extension sets, **cord sets**, **EPODs** and **PRCDs**	Measure between **live parts** and the protective earthing conductor	1.0

Ref: http://www.haineselectrical.com.au

Summary
The testing requirements for equipment to be used on a "construction" site in terms of "frequency" of tests must be in accordance with: ASNZ3012_2010 as this standard is directly referenced in the Queensland **Electrical Safety Regulation 2013**.

ASNZ3012_2010 in tun directly references standard ASNZ3760 for electrical specifications for the tests.

Sample "tags" are shown to the right. Note that the "test date" and the date of the next test are both listed.

Note: Prior to use always inspect the "tool's tag" and if the "Test Due" date has passed, then this item **MUST NOT** be used under any circumstances. Any faulty equipment should be tagged with a suitable "danger tag" and reported to the supervisor.

T10 Sheet metal work encompassing:

- types of sheet metal materials used in the electrotechnology work.
- names and applications of the types of fabrication materials.
- tools used with sheet metals in electrotechnology work (hacksaw, tinsnips, guillotines, punches, notching tools, folding machines)
- techniques used in fabricating sheet metal (cutting, bending, drilling/punching, joining, cutting mitres).
- marking out, cutting, bending, drilling and/or cutting and/or punching holes, joining and cutting mitred joints using sheet metal.
- sustainable energy work practices to reducing waste when fabricating using sheet metal.
- fabricating components using sheet metal and fabrication tools.

Introduction

Sheet Metal work (or Metal Fabrication) is the working of metal by cutting, bending, and assembling processes:

- Cutting is done by sawing, shearing, or chiselling (all with manual and powered variants); torching with handheld torches (such as oxy-fuel torches or plasma torches); and via CNC (Computer Numerical Control) cutters (using a laser, mill bits, torch, or water jet).
- Bending is done by hammering (manual or powered) or via a pan brake, press brake or similar tools.
- Assembling (joining of the pieces) is done by welding, binding with adhesives, riveting, threaded fasteners, or even yet more bending in the form of a crimped seam. Structural steel and sheet metal are the usual starting materials for fabrication, along with the welding wire, flux, and fasteners that will join the cut pieces. As with other manufacturing processes, both human labour and automation are commonly used.

Fabrication tasks overlap the various metalworking specialties. Eg: Fabrication shops and metal machine shops have overlapping capabilities, but fabrication shops generally concentrate on metal preparation and assembly as described above. By comparison, machine shops also cut metal, but they are more concerned with the machining of parts using machine tools such as a lathe or a milling machine.

Sheet Metal Work Safety

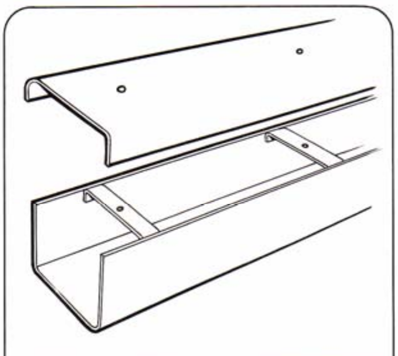
Sheet metal work has a number of inherent hazards. The metal has very sharp edges (especially thin gauge) and the associated machines and tools all present a different set of hazards. Never operate any tool or machine unless you have been specifically trained in its use and have been given permission to use it. Always follow the SOP (Safe Operating Procedure) list which must be situated adjacent to the machine. Ensure all machine guards are in place and there are no visible signs of machine defects before use. Always wear appropriate personal protective equipment (PPE) as directed by the SOP. Eg:

- Appropriate clothing,
- Eye protection,
- Feet protection,
- Hands,
- Ears

Good housekeeping is an important element in accident prevention and begins with planning. As stated above, edges of sheet metal can be very sharp and represent a significant hazard in the work area. All materials especially sheet metal should be neatly stacked and off-cuts placed in storage bins. Any spillages of oil or grease should be cleaned up immediately. Each person should pay attention to their own work area. Always think safety.

Sheet Metal Characteristics
Sheet metal refers to material types such as steel, stainless steel, aluminium, brass, copper etc. produced as standard sized flat sheets or as coiled a strip of metal. The major feature of sheet metal is called "gauge" which refers to the thickness of the metal sheet. Standard gauges may vary from about "3" (6.073mm) to "38" (0.152mm). Note that the higher the gauge number, the thinner the metal. Today sheet identification is by "thickness" in (mm) rather than by a gauge number.

Typical sheet thickness range from a thin 0.4mm to about 3mm depending on the metal type. Commonly available thicknesses are 0.4 mm, 0.55 mm, (0.75/0.70 mm), (0.90/0.95 mm), (1.15/1.20 mm), (1.55/1.60 mm), 1.95 mm, 2.5 mm and 3.0 mm. Available sheet sizes depend on the "gauge" and material. Common sheet steel sizes in "mm" include "900x1800", "900x2400", "1200x1800", "1200x2400", "1200x3000" and "1500x2400".

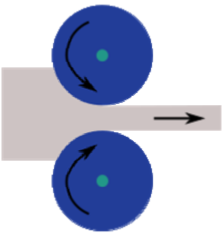

TYPICAL METAL CABLE TROUGHING

Electrotechnology applications for sheet metal are extensive as it can be cut and bent into a variety of different shapes. Common applications in the electrotechnology industry include electrical switchboards, busways, connection boxes, cable tray and cable duct (trough). Images of "cable troughing" and an electrical "busway" are shown.

Ref: Busway: http://exportservices.com.au/bus_ducts.php

Types of Sheet Material used in Electrotechnology
Steel is an ideal material because it is strong, easily worked, relatively cheap and is available with special coatings suitable for various environments. Sheet metal is "rolled" into thin and flat pieces. It is the main sheet material used and can be cut and bent into a variety of different shapes. Countless objects associated with electrotechnology are constructed of the material.

Thicknesses can vary significantly, although extremely thin thicknesses are considered as foil or leaf, and pieces thicker than 6mm are considered to be "plate".



Sheet steel is made in both "coated" or "uncoated" form. Uncoated ferrous (iron based) sheets are susceptible to rust and corrosion and are not commonly used. Coating of various types are applied to either to prevent corrosion or for aesthetics (appearance). "Coated" sheets include "galvanized" and "zincalume" while stainless steel, aluminium, brass or copper are referred to as "solid" sheets. Individual sheet types can be identified by visual appearance or by manufacturer's marks.

Galvanized Steel
This has a zinc coating and can be recognized by its typical spangled appearance. A zinc coating is highly resistant to corrosion as long as it remains intact on the sheet. However, if the surface coating is damaged in any way by welding, grinding or bending then the underlying steel will be exposed to the environment and the sheet will rust very quickly.

Galvanized metal can be bent without the zinc peeling away. Also, it solders well but welding is complicated by the fact that the zinc gives off toxic fumes and a residue which makes the weld more difficult. In addition, welding destroys the coating on the sheet, and for this reason it is rarely used where welding applications are required. Because of the zinc coating, galvanized sheets will measure slightly thicker than uncoated sheets. The difference is so slight that the gauge numbers for the sheet remain the same as for the solid sheets. Electrical cable tray and cable duct are generally constructed of galvanized steel.

Zincalume® (Trademark BlueScope) This is steel sheeting protected against corrosion by an aluminium-zinc coating. Typical uses include electrical appliances (white goods), switchboards etc. Zincalume sheets are often painted using a special process in which the painted finish is baked onto the surface. This is commonly known by the trade name 'Colorbond'. Many colours are available.

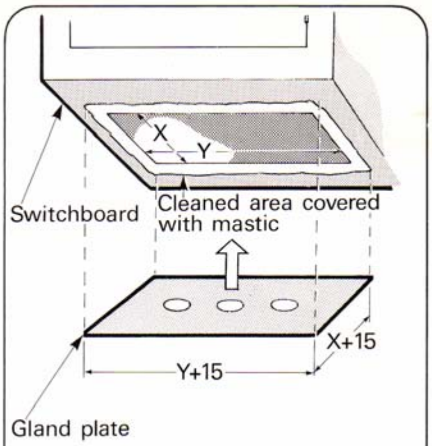
"Solid" Sheet Metal (Un-coated)

Stainless steel –The term "Stainless Steel" refers to a general class of metals rather than to one particular type and there are a number of different types of stainless steels available. Each type is designed to meet a particular need. Some are extremely resistant to corrosion, while others are not. Some will resist certain chemicals better than others. Others are designed for special qualities i.e. weld ability, ease of machining and work hardening. A small change in one of the constituent alloys will change the characteristics of the steel. Stainless steel is classed by type number e.g. type 304. There are a large number of grades of stainless steel available, and full details can be found in a metal handbook. Eg: Type 304 is used for applications where possible corrosion is mild. Type 316 is used in highly corrosive environments such as electrical fittings located in marine or toxic environments such as chemical plants etc.. Both "304" and "316" grade stainless steels are termed "austenitic" meaning they are "non-magnetic".

Aluminium – Is light weight, non-magnetic and highly corrosion resistant. Sheet aluminium weighs approximately one-third as much as sheet steel and is just as strong and can be folded and welded effectively. It is however, more expensive than steel. Aluminium is used in place of steel for many outdoor applications such as electrical switchboards and connection boxes etc. Because "aluminium" is so low in the "Noble" table, it is highly susceptible to galvanic corrosion if it is placed in direct contact with a metal of another type.

Copper – Is easily recognized by its reddish colour. It offers high resistance to corrosion and good electrical conductivity. Copper sheet is expensive, costing about three times the price of galvanized iron. Copper that has been work-hardened can be annealed by heating to a cherry red and then cooling in water or leaving to cool in the open air. Sheet copper has some applications in electrotechnology due to its "malleability". (Ie: It is able to be hammered or pressed permanently out of shape without breaking or cracking.) Eg: Capping for wooden power poles.

Brass – Sheet brass is commonly used for electrical cable "earthing gland plates" mounted on electrical switch boards and connection boxes. Brass sheet is used for its strength and for its good electrical conductivity.



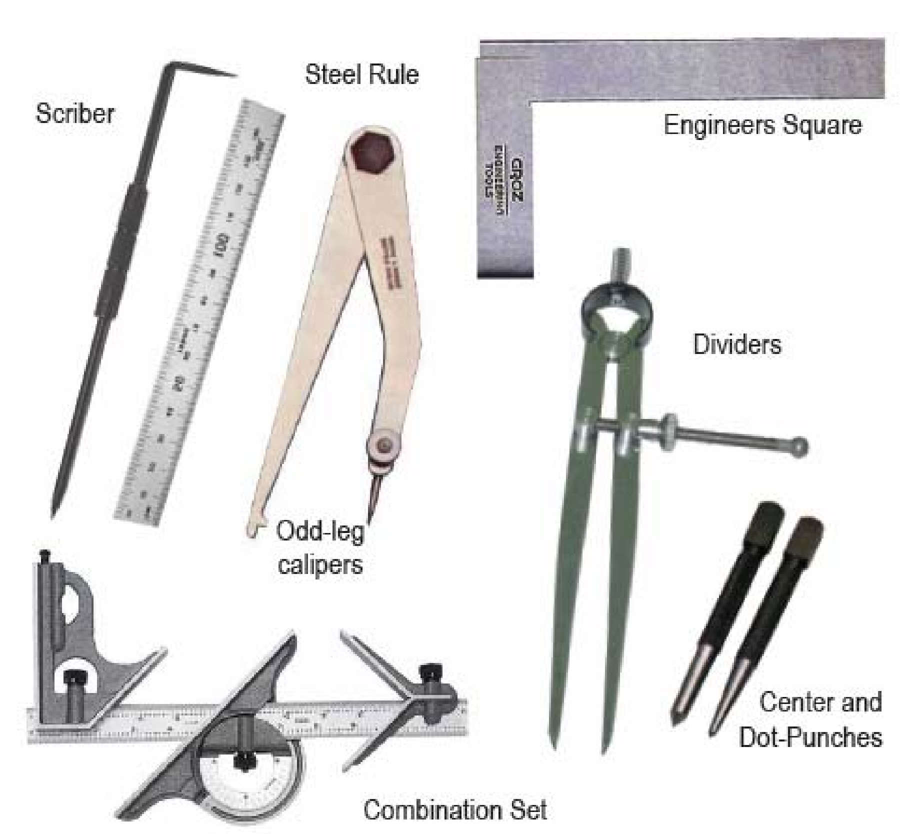
FIXING A GLAND PLATE

Electrotechnology Sheet Metal Tasks

Small electrical switchboards and connection boxes etc. are generally mass produced and the metal work used to construct large switchboards is typically done by specialized sheet metal workers. The main type of sheet metal work performed by electrical workers is cutting cable access holes in switchboards and the installation of metal cable tray, cable troughing or duct. The main focus of this note is therefore directed towards developing the techniques needed to install metallic cable ways. But, it is important to understand that the sheet metal skills developed here are transferable to other sheet metal working tasks.

Sheet Metal Work Hand Tools
Quality tools must be used with care and for the correct purpose where they will provide years of useful service, requiring only minor attention, such as sharpening. Tools used incorrectly or for the wrong application, or handled carelessly, quickly become blunt, damaged or broken. Sheet metal work tasks for electrotechnology will typically require the use of the tools listed below. Full details of the tools are explained elsewhere in this note.

Steel rule – Used for measuring, ruling straight lines, testing for straight edges and flat surfaces.
En**gineer's square** and **Combination square** - Used for marking lines at specific angles to an edge and for testing right angles.
Scriber - Used for marking of lines.
Centre punch - Used for marking the centre of holes prior to drilling.
Dividers - Used for marking circles and curves, stepping off equal divisions along a line, transferring measurements.
Odd-leg (Jenny) callipers – Used for marking lines parallel to an edge.
Malle**t - Wooden or rubber**, can be used to bend and shape sheet metal.
Ball Pein Hammer – Used for general work.
Snips (Tin snips)- They are used mainly for "notching" metal sections prior to bending. Available in straight, right- or left-hand versions.
Soldering iron – Can be used for general soldering applications such as joining of metals or electrical cable joints.
Pliers - Can be used to fold or twist metal into shape. Use in preliminary work only.
Pop Rivet Tool – Used to quickly join then gauge sheet metal.
Hand saws - Hacksaws to cut most metals and junior hacksaws to cut lighter gauge materials.
http://www.graysonline.com



Snips

"Tin snips" or "snips" are used to cut sheet metal. There are many designs of snips in use. The ones shown below are quite common. The main problem when using snips is that the material on one side of the cut deforms (curls). The cut should be arranged so that the deformed section is the "off cut" and not needed for the finished product.

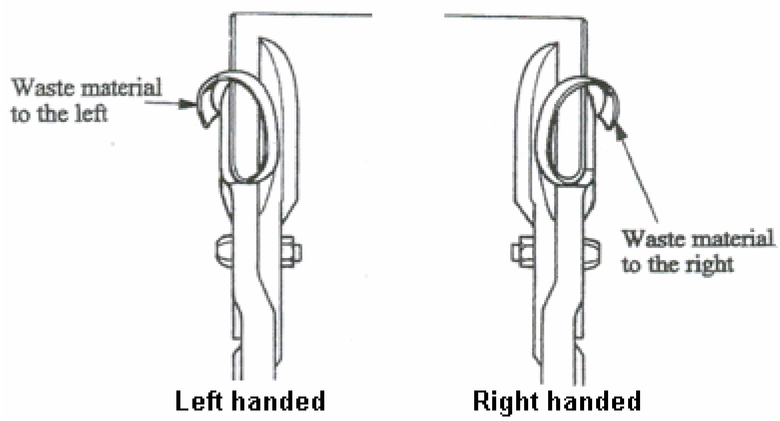
They are manufactured in a variety of styles for different cutting operations. The two main types are: "Universal" (Top image) and "Aviation" (Bottom). The type of snip required for a task depends on the thickness of metal, type of metal and the type of cut (e.g. straight line, curved or notch). Straight snips can have a combination blade or straight back blade. The handle on these snips are set in line with the blade. (Not cranked) They are used for straight line cutting, notching and outside curves. "Cranked" snips have their handle set at an angle to the blade. This enables the operator's hand to clear the sheet for safe and easier operation.

Ref: http://www.toolstop.co.uk
Ref: http://www.powertoolsdirect.com

Aviation Snips

This design has a "compound action", universal blade and the cutting edge is serrated to prevent slipping. Tin snips are designed to cut curves in one direction only.

There are three cutting styles: straight cutting, left cutting, and right cutting. Straight cutting snips (generally have yellow coloured soft grips) cut in a straight line and wide curves; left cutting snips (usually red) will cut straight and in a tight curve to the left; right cutting snips (usually green) will cut straight and in a tight curve to the right.

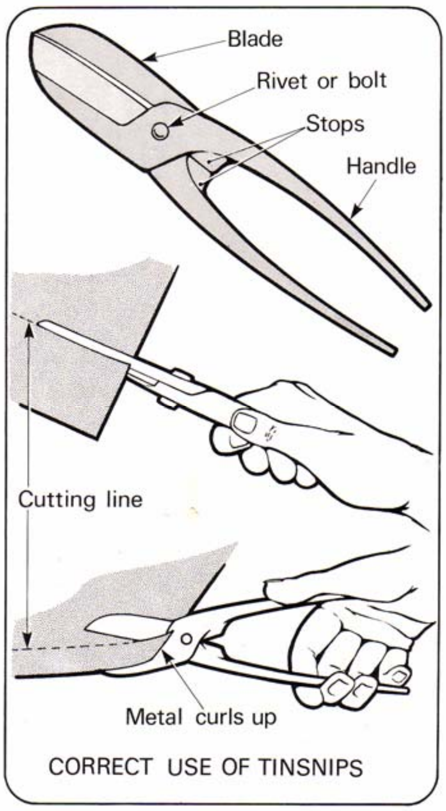


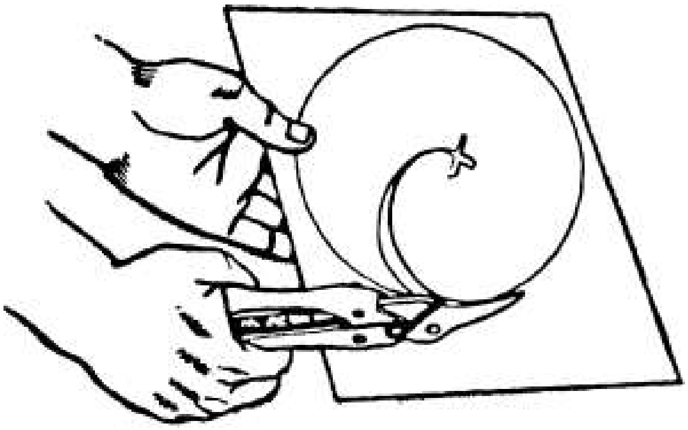
Care of snips

- Only use snips for the material they were designed to cut.
- Never use snips to cut wire as the cutting edge will be nicked and further clean cuts will be impossible to make.
- Keep the cutting edges in good condition by lightly honing with an abrasive stone or by re-grinding on a bench grinder.
- The pivot point should be kept lightly oiled and in good adjustment so that the faces of the blades slide together firmly with minimum clearance.

Correct Use of Snips

- Grip the handles between thumb and first finger and allow first and second fingers to curl around the lower handle.
- Place the third and small fingers between the handles, but rest them on top of the lower handle.
- Squeeze the hand closed and note that handles and blade close.
- Open the hand and note that the handles part and the blades open, ready for cutting.
- Place the sheet metal to be cut into the blades with the junction of the blades on the marking line.
- Squeeze the hand closed and note the cutting action.
- Open the hand and move more metal into the blades.
- Alternatively, push the snips further into the metal.
- Repeat the steps above until the cut is complete.
- Avoid closing the blades completely as this causes distortion of the metal immediately ahead of the snips.



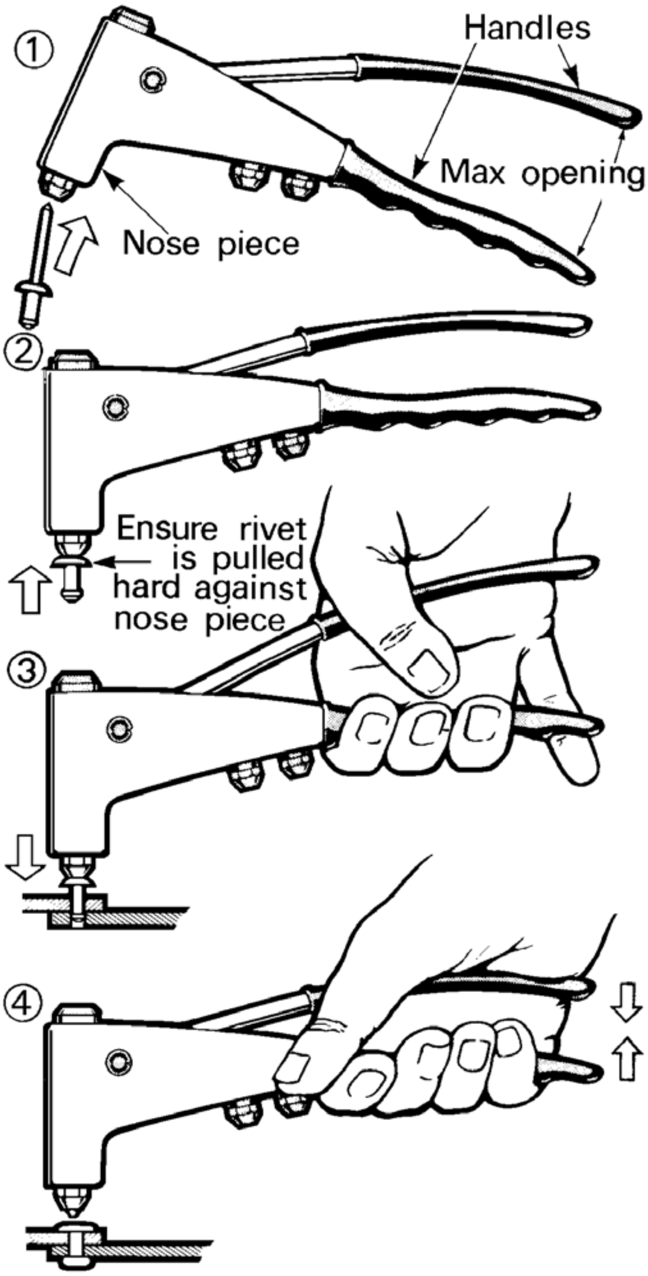


Pop Rivet Tool (Gun)

This tool is used to install a fixing rivet in a pre-drilled hole located within thin materials such as sheet metal for the purpose of joining. Pop rivets are manufactured from aluminium alloy, mild steel or copper alloy.

http://www.htsalescompany.com

They are supplied with a domed or countersunk head in diameters of 2.8mm, 3.2mm, 4.0mm, 4.8mm and 6.0mm. Rivets are made in various lengths to accommodate different thicknesses of materials. The hole size to be pre-drilled is typically the nominal size of the rivet. (NB: Always check manufacturer's details.)

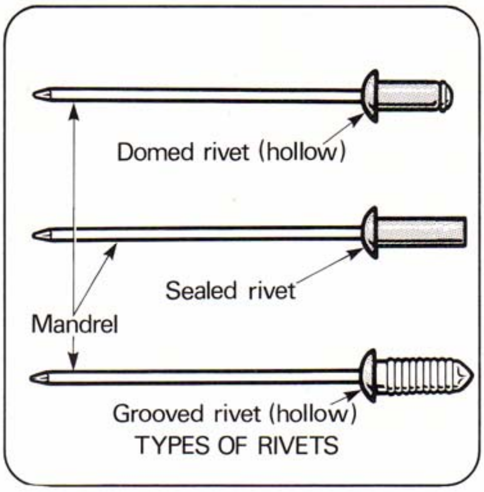


Riveting Tool
A typical hand-riveting tool with grip handles is shown above,
This tool is supplied with interchangeable jaws to suit different diameter rivets,
This tool automatically severs the mandrill from the rivet when the set tension point is reached,
When selecting a suitable rivet for a task, always be sure to replace like-with-like,
Common rivets are made of aluminium, but stainless steel types are also made for harsh environments.

Installation Process

- Pre-drill a hole to the specified diameter at the precise location for the rivet,
- Ensure that the rivet tool's jaws are suitable for the size of rivets to be used NB: The jaws are interchangeable. (Hex head spanner.),
- Insert the mandrill in the jaws of the riveting tool,
- Using the rivet tool as support, force the head of the rivet through the predrilled hole until the rivet head is seated flush,
- Squeeze the riveting tool's handles together, which causes the mandrill to pull through the head causing the rear of the rivet to flare out.
- At a predetermined point the mandrill will sever leaving the rivet clamping the two surfaces tightly together.

Pop River Characteristics
Pop rivets are installed from one side of a work piece in one simple operation without damage or distortion to the structure. This is very useful when you cannot access the rear section.



To remove a pop rivet, use a drilling machine with a twist drill the same size as was used to install originally. This means that a new rivet can be re-installed back in the same hole with no loss of integrity.

Range of Riveting Tools
http://www.rivetwise.co.uk/productrange/tools.asp?section=popset_rivet_hand_tools_278

A hand small hand riveter is suitable for small jobs only. For tasks where many rivets are to be installed, larger tools are available. A selection of manually operated tools are shown below.

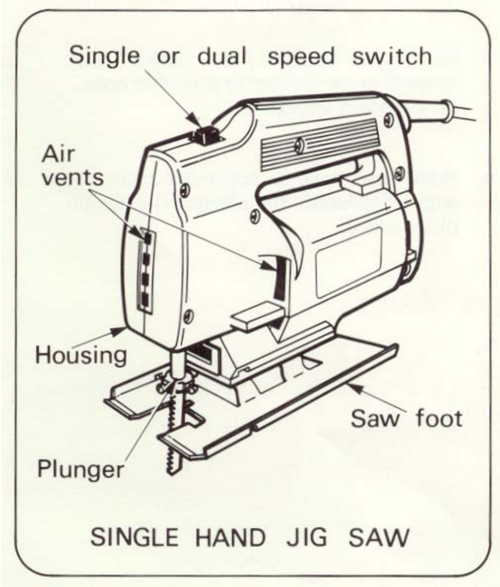
Sheet Metal Work Power Tools
There are a number of hand held power tools suitable for sheet metal work. The more common types are as shown below. Safety when using power tools is very important.

Keep the work area clean.
- Always wear appropriate protective clothing for the task. Never wear loose clothing or jewellery as they may get caught in moving parts.
- Always inspect the tool prior to use to ensure there are no visible defects.
- When not in use store tools in dry, high or locked places.
- Use the right tool.
- Do not force a small tool to do a task for which it was not designed. If the task is too heavy for this tool then a heavy duty tool will do the job better and more safely at the rate for which it was designed.

Ref:
http://www.jalopyjournal.com/forum/showthread.php?t=381458

Jig Saw
This is a portable reciprocating saw which means it cuts with an alternating back-and-forth blade movement. This tool is used to cut-out holes and openings in sheet metal, timber or plaster board etc. It is ideal for curved work in the field where band-saws are unavailable.

By selecting a suitable type blade it can be used to cut most thin materials from cardboard to steel. Always allow the tool to reach full speed before bringing its cutting surface to the job. This prevents overloading of the motor and serious damage.



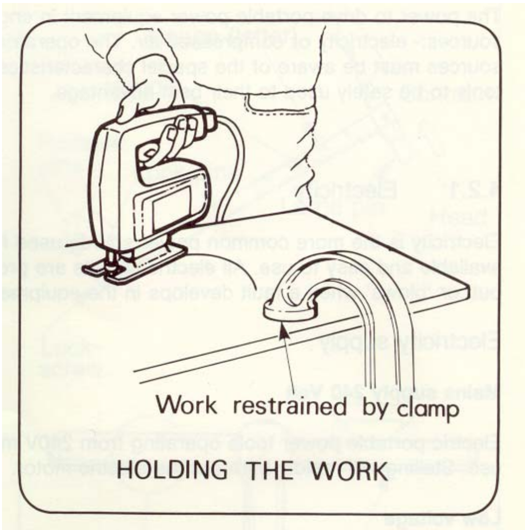
SINGLE HAND JIG SAW

Single Hand Jig Saw
If the tool has multi-speed control then use the “low” setting when cutting sheet steel and the “high” setting for wood or aluminium.

Circles may be cut by:

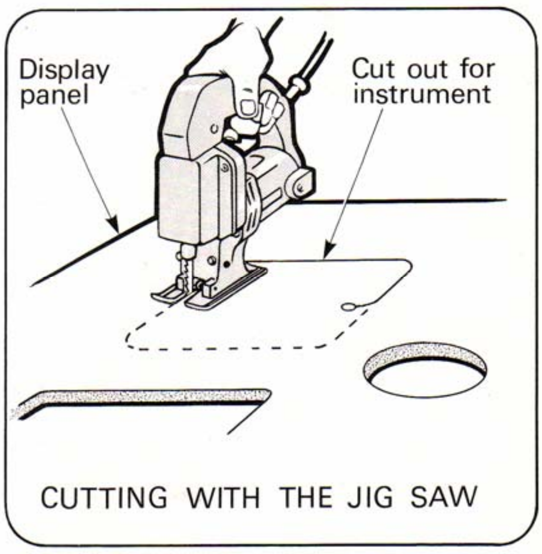
- Guiding the saw freehand.
- Using a circle guide which is ideal for repeating work.

Cutting Action
Cutting is done on the up stroke only. Most jig saws have reciprocating (up and down) action only. This tends to cause drag on the down stroke. Some saws have the blade canted forward at the bottom to give clearance on the down stroke; and some saws have an adjustable roller support to lessen the unsupported length of the blade.

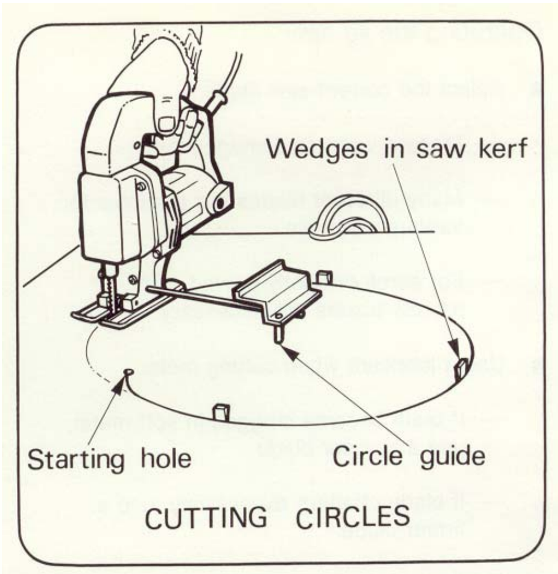


HOLDING THE WORK

Always keep the base plate in contact with the work. Never exceed the capacity of the saw. The blade must have sufficient clearance below the work to prevent fouling.



CUTTING WITH THE JIG SAW



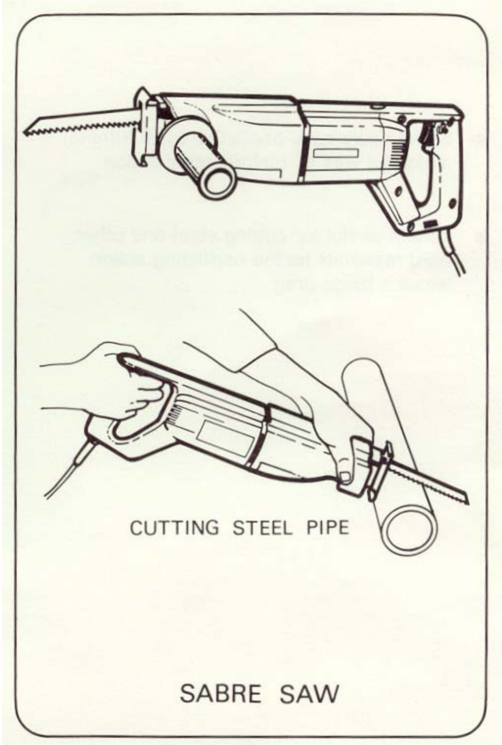
CUTTING CIRCLES

The “Kerf” refers to the width of the “cut”. It is the slot made by a cutting tool when parting material. For a jig saw this is the width of the blade plus the “set” of the teeth. The kerf width is “lost” when a cut is made and should always be considered especially when determining the number of “blanks” that can be cut from a stock sheet. The “kerf” for a “jig saw” is always much less than that for a nibbler. A jigsaw kerf is approximately 2mm whereas the kerf of a typical hand held nibbler is about 6 mm.

Safety
Always wear appropriate PPE and clamp the material down securely to prevent it from moving or falling while cutting. Also, carefully control the position of the tool’s power lead to ensure that it is not accidentally cut.

Two Handed Jig Saw (Sabre Saw)
This is a portable jig saw designed for two handed operation. It is designed for heavy duty use. When in use, it is usually pulled towards the operator. Cutting is usually done on the “up” stroke but some are designed to cut on the “down” stroke also. (Always check with the manual.)

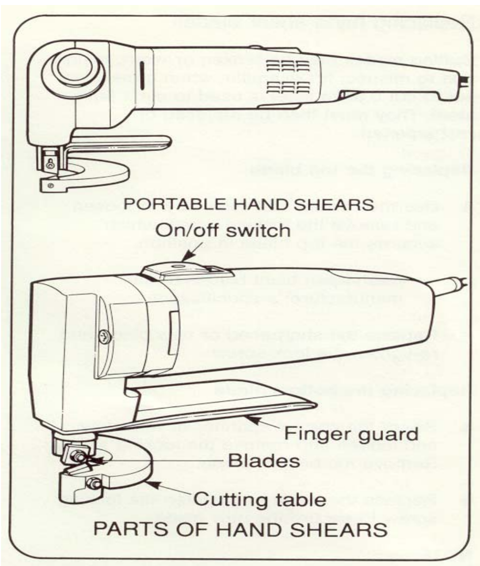
It can be used to cut steel pipe or heavier gauge sheet metal.



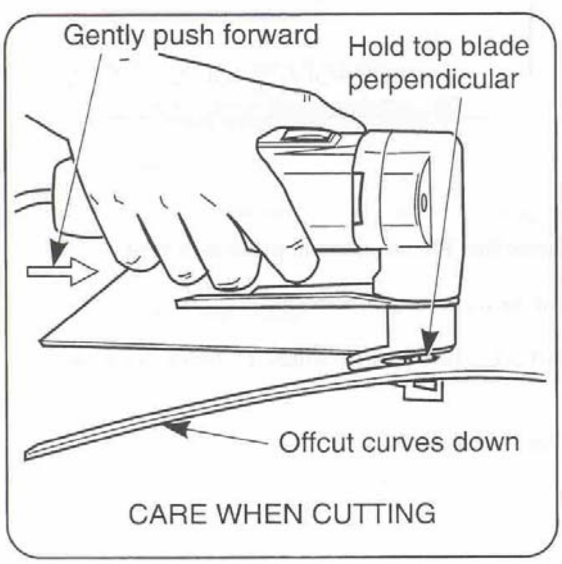
SABRE SAW

Hand Shear
Portable hand shears are a time-saving machine because they quickly cut along lengths of sheet metal. (They are faster than jig saws.) They are can be used to cut larger diameter curves. Shears can replace hand snips, but they are only suitable for cutting sheet metal to a maximum thickness of 1.6mm. They cut with a shearing action similar to a guillotine. This means that the “kerf” thickness is almost zero. The lower cutting blade is fixed while the top blade moves up and down to cut the material. It should be noted that the material on one side of the cut becomes distorted as it is cleared to make the cut.

Note: Do not use shears beyond their “cut capacity”. (Ie: Material thickness.) Most shears have their maximum capacity written on the body.

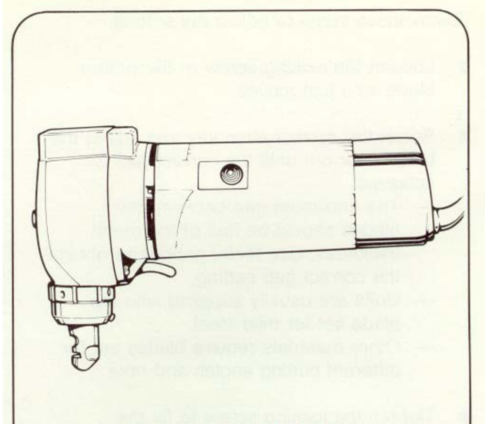


PARTS OF HAND SHEARS



CARE WHEN CUTTING

Hand Nibbler
A nibbler is a tool for cutting sheet metal with minimal distortion. (Much less than hand shears) One type operates much like a punch and die, with a blade that moves in a linear fashion against a fixed die, removing small bits of metal and leaving a kerf approximately 6 mm wide.

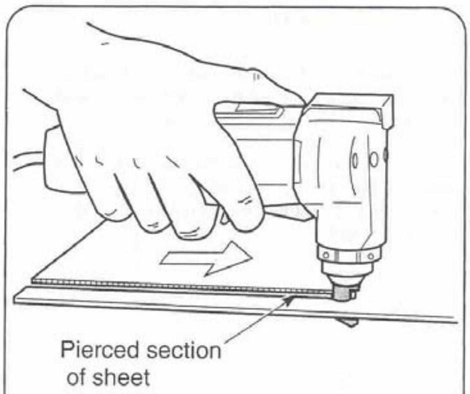

ELECTRIC NIBBLER

While the shear cuts the metal with a scissor cutting action, the nibbler punches a narrow slot in the metal. The "swarf" (section removed) is in the form of small half moon sections (called a "slug") and these are forced out through the top of the tool.

An advantage of the nibbler is that it will cut tighter bends than can be achieved by shears and it does not distort the material either side of the cut. The disadvantage is the very wide "kerf".

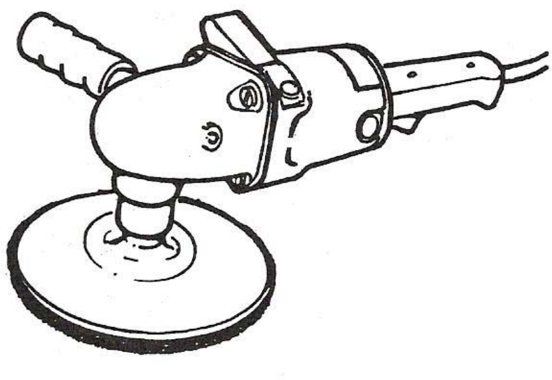
NB: Nibblers are designed to suit a maximum material thickness. Do not use a tool on material that is thicker than the machine's capacity. Always refer to the manufacturer's instructions prior to use.

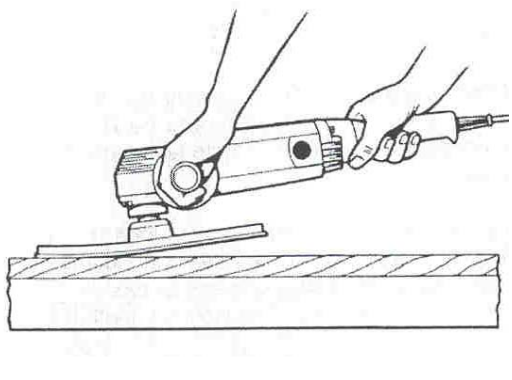
NB: Sheet metal workshops often have a fixed "nibbler".



NIBBLING

Sanding Machine
This hand held machine can be either electrical or air powered. It has a flexible rubber pad onto which the abrasive sanding disc is fastened by means of a centre nut. This tool is used in a sheet metal workshop for weld removal on metal panels, cabinet corners etc. prior to painting.





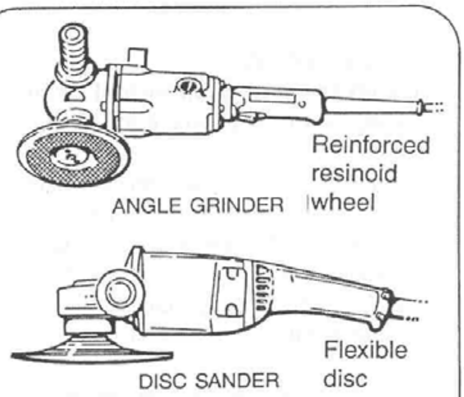
Electric Angle Grinder
The main use of an angle grinder in the sheet metal shop is for removing excess weld metal on welded joints, flanges, frames and general fabrication work prior to painting. With the aid of a cutting disc, sheets, angles, flat bar etc. can be cut to size. It is a heavier duty than a "sander".

PROTECT YOUR EYES WHEN USING GRINDERS

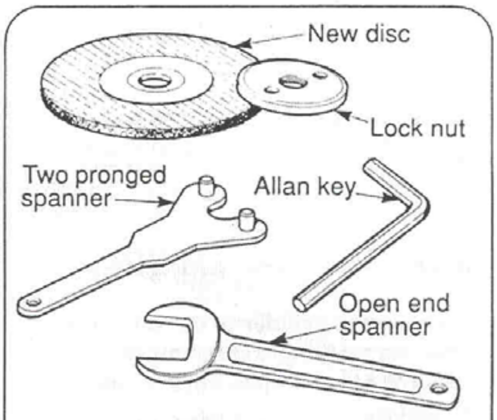
Changing Grinding Discs
The method of changing a grinding disc on the different sizes of angle grinder is very similar. On most grinders the grinding disc is secured by a locknut. The removal of the disc requires a two pronged spanner and an open end spanner for a large grinder. For smaller type grinders an Allen key and a spanner is used to remove the locknut.

Operating an Angle Grinder
Before beginning a grinding operation make sure that the material to be ground is firmly clamped in a vice or to a bench. The operator must be in a comfortable, well balanced position with a clear view of the material. Always check that the wheel is properly secured and not damaged prior to use.

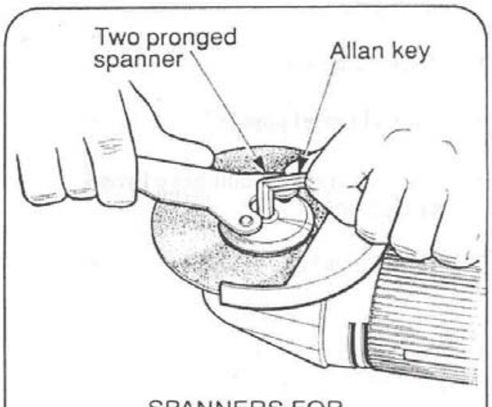
Safety: Always wear appropriate PPE when operating this tool as it can be extremely dangerous.



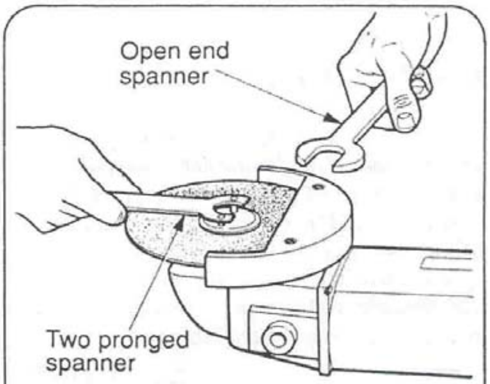
DIFFERENCE BETWEEN AN ANGLE GRINDER AND A DISC SANDER



ACESSORIES TO CHANGE GRINDING DISC

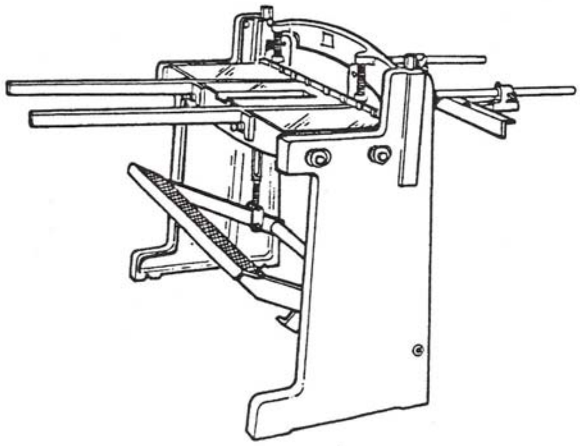


SPANNERS FOR SMALL GRINDERS



SPANNERS FOR LARGE GRINDERS

Treadle Guillotine



A guillotine is a device for cutting or trimming sheet material, such as sheet metal. It consists of a hardened steel blade inclined at a small angle such that that it descends onto the sheet with a shearing action. A "treadle" type guillotine is small manually powered (foot operated) tool for "straight line" cutting or trimming of sheet material. The maximum width of the cut is given by its "bed" (base cutting area) size measurement.

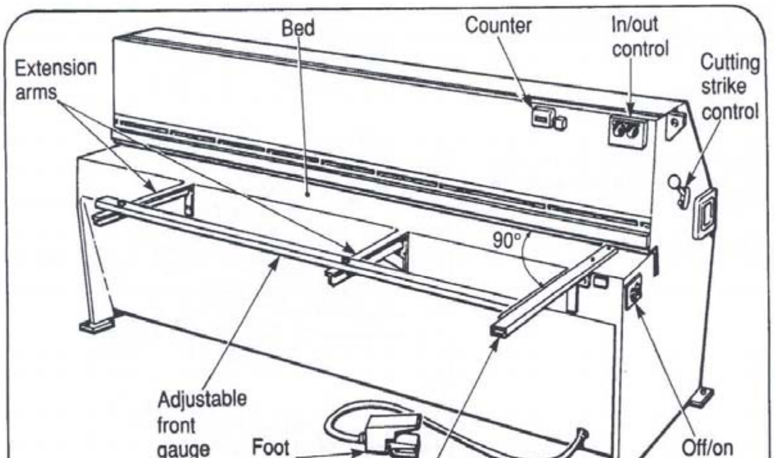
A treadle guillotine, (sometimes called a foot-operated squaring shear) is common to most workshops as they are ideal for cutting light gauge metal (up to 1.2mm thickness and about 1.2 metres in length). Because of the shearing action the "kerf" of the cut is normally zero.

Some of these machines do not have sheet clamps. If the machine does not have sheet clamps then to achieve optimum accuracy always cut with the edge of the metal against the left or right-hand side-squaring gauge of the guillotine.

Safety

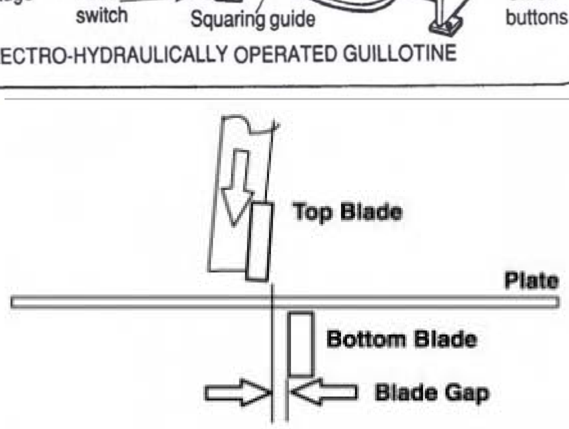
- Ensure nearby people are clear of foot pedals.
- Do not over-exert when trying to cut metal.
- Do not exceed the capacity of machine.
- Ensure your own feet and legs are clear of the foot pedals.
- Take care when handling the sheet itself.
- Only one sheet should be cut at a given time.
- Never cut wires, rods or seams etc.

Power Guillotine



Guillotines vary in shape and size from the small treadle (foot operated) type shown above which is ideal for cutting light gauge sheet metal to the heavy duty mechanical or hydraulic powered types (shown to the right) which can be used to cut heavy gauge steel plate to a length of about 3 metres.

A popular commercial guillotine is the hydraulic powered design which has a variable cutting length. With these machines it is possible to adjust the rake angle and the clearance gap as well as being able to set front and back stops.



NB: Due to their blade design, guillotines are designed for "straight-line cutting" only. Also, they cannot be used to cut half way along a piece of metal. It must be a full cut or no cut.

The principle of operation is that an upper blade which is offset slightly from the horizontal plane descends vertically towards a fixed bottom blade which is fitted to the bed of the machine, thus shearing off the metal along a line where the two blades pass. The distance between the cutting edges of top and bottom blades is termed the “blade gap” or “clearance gap” and this distance should be adjusted to suit the thickness of metal being cut using feeler gauges.

Safety: Metal Cutting Guillotine
A guillotine is potentially a very hazardous piece of machinery. **DO NOT** use this machine unless you have been instructed in its safe use and operation and you have been given permission. Only one person may operate this machine at any one time.


Safety glasses must be worn at all times in work areas.


Long and loose hair must be contained.


Sturdy footwear must be worn at all times in work areas.


Close fitting/protective clothing must be worn.


Rings and jewellery must not be worn.


Gloves must not be worn when using this machine.

Pre-Operational Safety Checks

1. Ensure fixed guards are in place to prevent hands or other parts of the body from entering the trapping space.
2. Guards or safety devices must never be removed or adjusted, except by an authorized person for maintenance purposes.
3. Working parts should be well lubricated and free of rust and dirt.
4. The area around the machine must be adequately lit and kept free of materials, which might cause slips or trips.
5. Be aware of other personnel in the immediate vicinity and ensure the area is clear before using equipment.
6. Familiarize yourself with and check all machine operations and controls.
7. Ensure cutting table is clear of scrap and tools.
8. Faulty equipment must not be used. Immediately report suspect machinery.

Operational Safety Checks

1. Do not attempt to cut material beyond the capacity of the machine.
2. Never attempt to cut rod, strap or wire with this machine.
3. Use correct lifting procedures when handling large sheets of material.
4. Take extreme care during the initial feeding of the work piece into the machine.
5. The work piece should always be held sufficiently far back from the edge being fed into the guillotine.
6. Ensure fingers and limbs are clear **before** actuating the guillotine.
7. Hold material firmly to prevent inaccurate cutting due to creep.
8. When cutting ensure feet are positioned to avoid contact with the foot operated lever.

Housekeeping
Remove all off cuts and place them in either in the storage rack or waste bin.
Leave the work area in a safe, clean and tidy state.

Potential Hazards

- Sharp edges and burrs
- Crush and pinch points
- Manual handling sheets

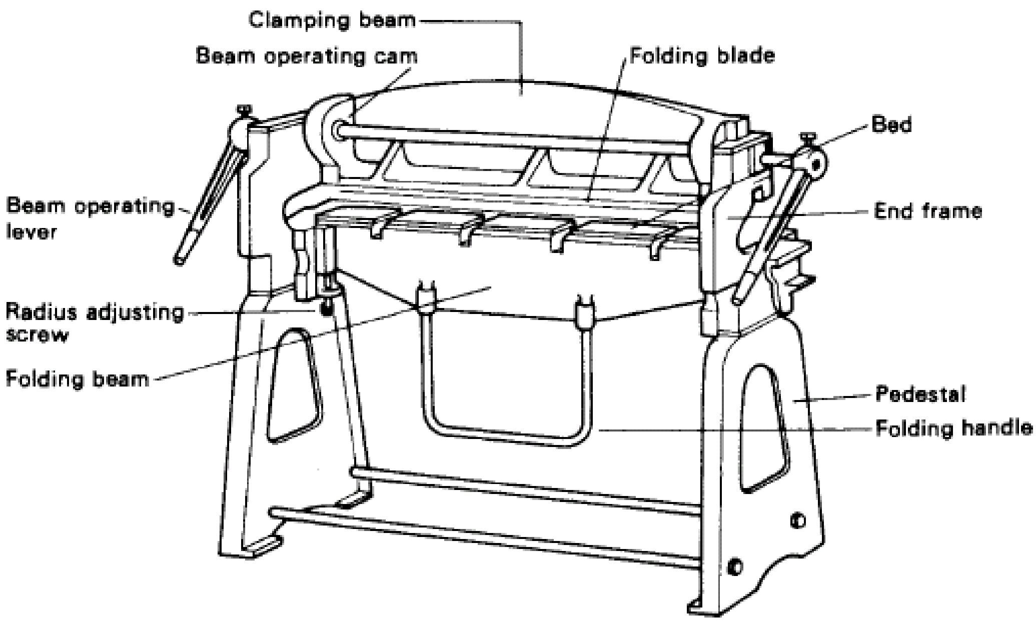
Pan Brake Folder

There are a number of different types of commercial folding machines available. A pan brake is a manually operated tool used for bending thin gauge sheet metal. It consists of a clamping bar to hold the material firmly during the bending process. This clamping bar has removable fingers / blocks to enable the bending of box shapes or partially formed pieces. The bending is preformed by a bending beam which is hinged at the front of the equipment. Some pan brakes utilize a counterweight to assist with the bending action.

A pan brake can be used for sheet thicknesses up to approximately 1.62 mm in thickness. A typical manually operated folding machine is shown below. The smallest width of bending is 8 to 10 times the material thickness and the minimum inside corner radius of the bend is about 1.5 times the metal thickness.

Characteristics of a sheet metal folding machine:

1. Clamping . In clamping, the amount of lift of the clamping beam is important. It should be sufficient to allow the fitting and use of special clamping blades (fingers) and to give adequate clearance for previous folds.
2. Folding . Care must be taken to ensure that the folding beam will clear the work. Particularly when making second or third folds for a piece of metal. Some folding machines are designed to fold radii above the minimum, either by fitting a radius bar or by adjustment of the folding beam.
3. Removal of work . Care must be taken when folding to ensure that the work can be easily removed on completion of the final bend. (Get this wrong and the material becomes trapped inside the folder.) The sequence of folding must be carefully planned. The lift of the clamping beam is important when removing the work. Some folding machines, known as universal folders, have swing beams. Here, the work may be folded completely around the beam, which is swung out to facilitate removal of the work.



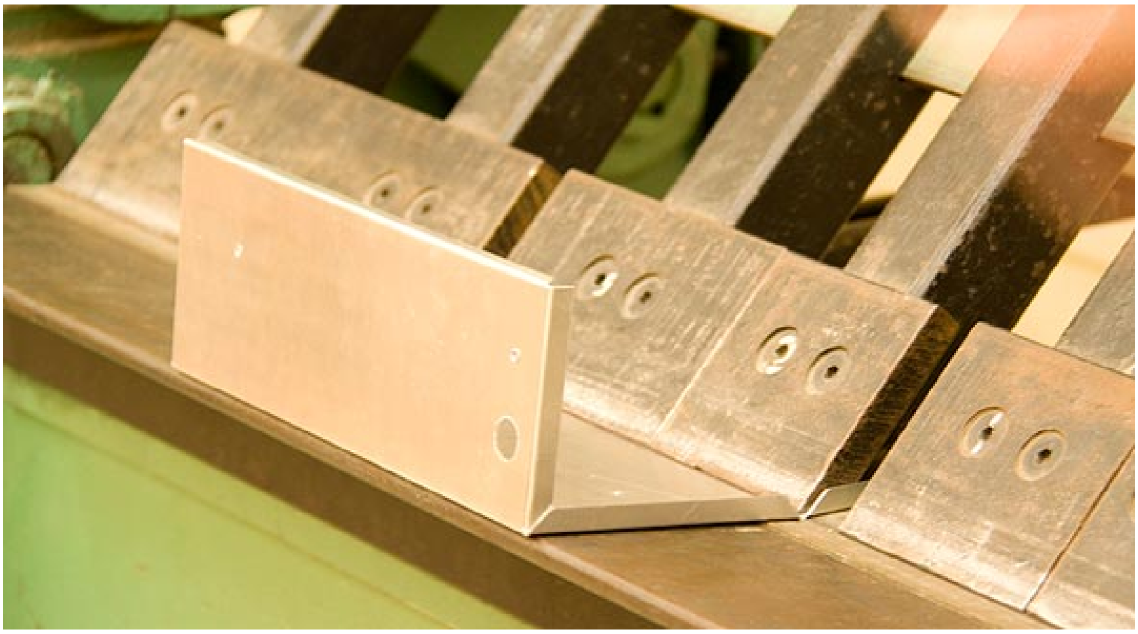
The folding action of the tool is illustrated in the images shown below. The brake consists of a flat surface onto which the material is placed and a clamping bar (fingers) which are forced down on the bend line to hold the material firmly in place during the bend. This clamping action may be manual, automatic or operated using a foot pedal. The “folding beam” is the front, gate-like, cast plate of the tool and is hinged. It is controlled by a handle which is lifted to force (roll) the sheet around the edge of the fingers to form the bend.

The bends can be to any angle up to a practical limit of about 120 degrees.

Folding: A metal bending machine can be used to form bends or folds in sheet metal. It consists of two jaws to clamp the sheet metal in place and a hand operated bending leaf.

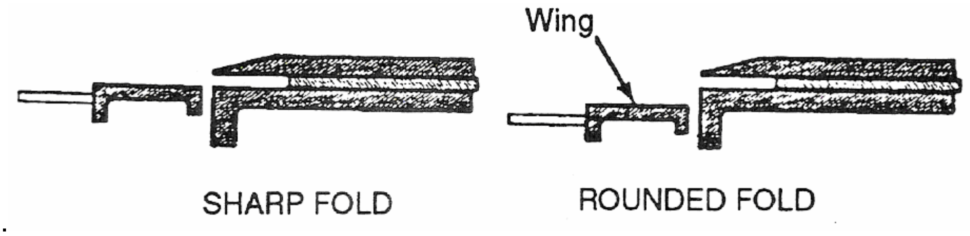
To use the bending machine:

- Clamp the metal in place with the fold line aligned with the outer edge of the top jaw
- Lift the bending wind (leaf) up until the desired angle of fold is achieved
- Lower the bending leaf to its starting position
- Release the jaws and remove the metal. (Check angle.)



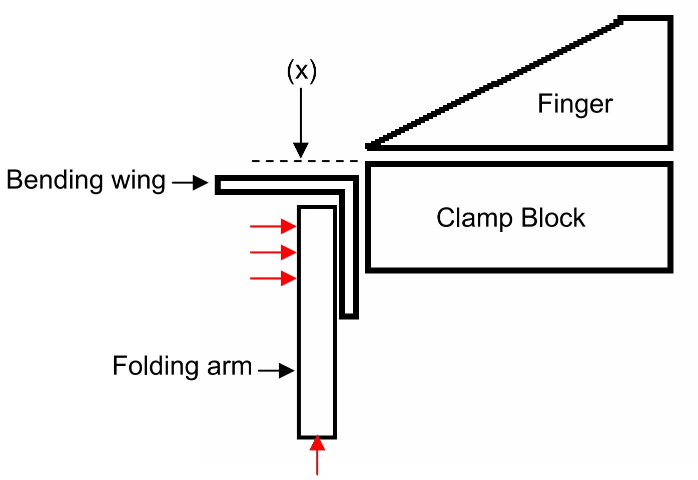
Ref:
http://toolboxes.flexiblelearning.net.au/demosites/series12/12_04/toolbox1204/resources/03workshop/10sheet_metal/05folding.htm

Adjusting the Bend Radius on a Pan Brake Folder
The bend radius of the folded edge is controlled by lowering or raising the "bending wing" in relation to the top of the "clamp bar". If the radius is too tight it will "crush" the metal and possibly weaken it. The cross-section view of the bar folder illustrated below (left side) shows the wing raised to produce a very "sharp" fold and on the (right side) it is lowered to suit thicker gauge material which needs a larger bend radius. As a rule-of-thumb, the "wing" should be set to a minimum of "one material thickness" below the top of the "clamp block". This is measurement "x" in the lower sketch. To adjust the bender in "our" workshop there are "six" bolts (3 either side) which can be loosened "slightly". Two further lower bolts then act as "grub" screws to enable fine adjustment of the wing. When the setup is complete, re-tighten the six wing bolts.



NB: Clamp pressure can be adjusted by turning the two "lower" knurled nuts on the clamp adjustment bolts. (Located towards the top of the bender). The top two knurled nuts are to lock the setting.

Also, the "fingers" can be spaced to suit the task.



A restriction with a "pan brake" style of folder is the minimum distance it requires between folds. There must always be sufficient clearance to enable the previous fold to fit so that it does to come it contact with the finger/clamping mechanism. The "brake press" style of bender shown below can create bends much closer together.

Safety: Using a Pan Brake Folder
A "pan brake" folder is potentially a very hazardous piece of machinery. **DO NOT** use this machine unless you have been instructed in its safe use and operation and you have given permission. Beware of swinging counter-balance weights and bottom leaf (bed) of machine. Do not use improper manual handling techniques when using machine or moving metal in or out of benders. This machine can put great strain on your back. Beware of blade crush when using machine or especially changing blade.

NB: Only one person at a time should control this machine. Never use another person to operate the clamp while you attempt to align the fold line. This action will result in "pinched fingers". (Yours!!!)

PPE

Safety glasses must be worn at all times in work areas.

Long and loose hair must be contained.

Sturdy footwear must be worn at all times in work areas.

Close fitting/protective clothing must be worn.

Rings and jewellery must not be worn.

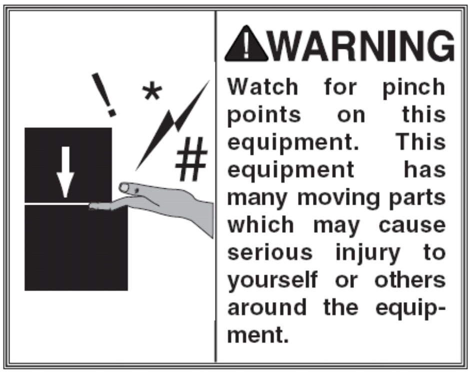
Gloves must <u>not</u> be worn when using this machine.

Pre-Operational Safety Checks

1. Guards or safety devices shall never be removed or adjusted, except by an authorized person for maintenance purposes.
2. Working parts should be well lubricated and the jaws and fingers free of rust and dirt.
3. Ensure no slip/trip hazards are present in workspaces and walkways.
4. Be aware of other personnel in the immediate vicinity and ensure the area is clear before using equipment.
5. Familiarise yourself with and check all machine operations and controls.
6. Faulty equipment must not be used. Immediately report suspect machinery.

Operational Safety Checks

1. Never use pan brakes for bending metal that is beyond the machine's capacity with respect to thickness, shape, or type.
2. Never attempt to bend rod, wire, strap, or spring steel sheets in a pan brake.
3. Remove the pan brake fingers that are in the way - use only the pan brake fingers required to make the bend.
4. Ensure the pan brake fingers that are not removed for an operation are securely seated and firmly tightened before the machine is used.
5. Ensure fingers and limbs are clear before operating the pan brake.
6. Lower finger clamps to work - do not drop.
7. Check work piece is secure.
8. Keep clear of moving counterweight (where fitted).



Housekeeping

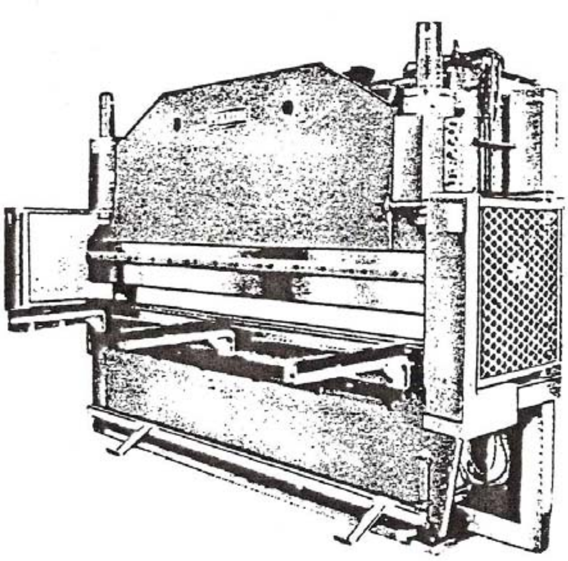
1. Lower finger clamps to a safe position.
2. Return all accessories to storage racks.
3. Leave the work area in a safe, clean and tidy state.

Potential Hazards

- Sharp edges and burrs
- Squash/crush and pinch points
- Impact from counterweight (Not on some types)

Brake Press Folding Machine

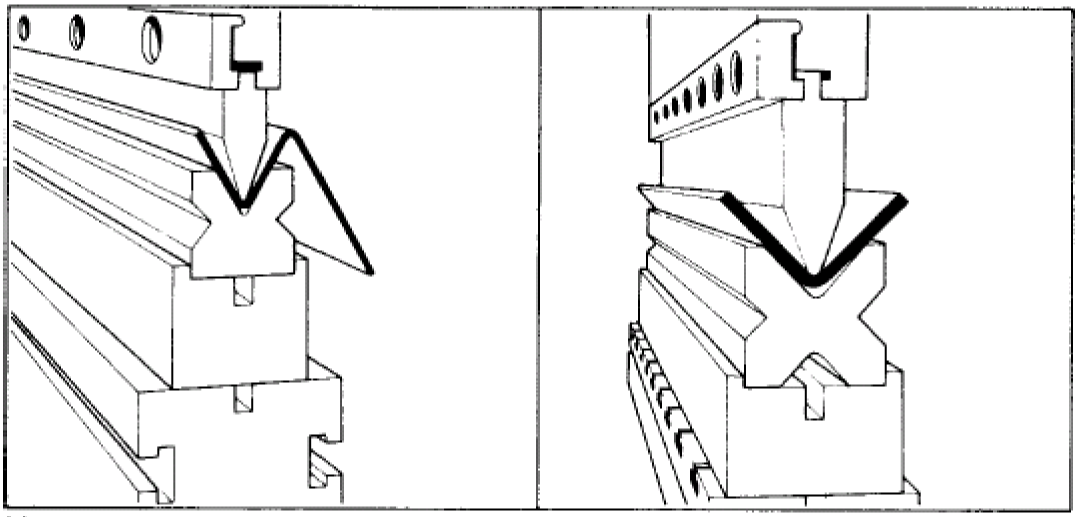
This is much larger type of machine for bending sheet metal. This operation of this machine is quite different from the "Pan Brake" folder because it bends and forms the metal by pressing it into a specially shaped "V" die. The size of the die of the press brake can be changed to suit the task. Ie: Gauge and type of metal.



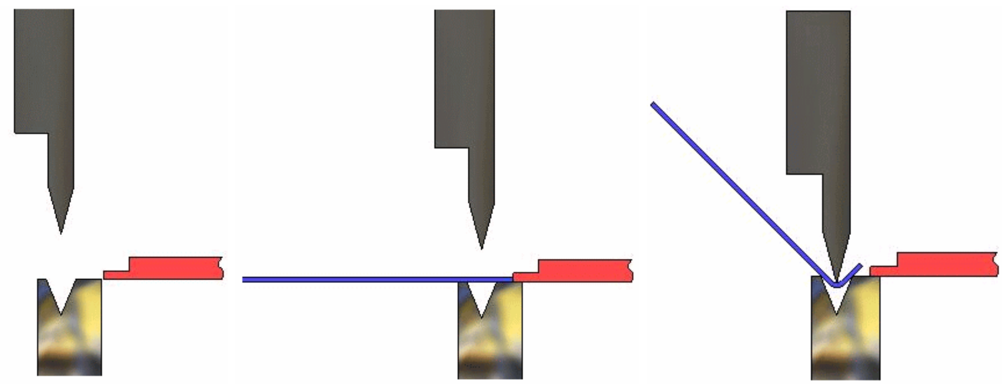
The press brake is a high volume production machine. That is, it is better suited to doing a large number of repetitive operations rather than doing many different operations.

Generally, machine stops are set to suit the task and then the process can be repeated exactly many times over for a production run.

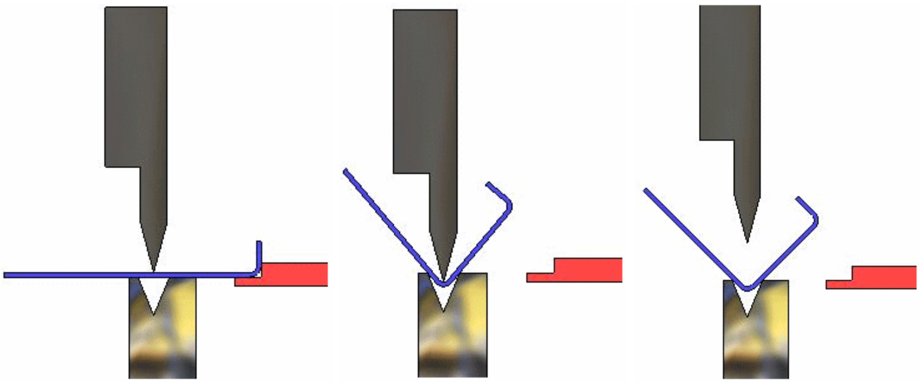
Press brakes are made in various sizes, with a 3 metre (wide) bed model being common.



NB: Typically a knife edged shape blade is forced down onto the sheet forcing it into a "V" shaped die. This produces a folding action on the metal. The distance that the blade travels vertically downwards creates the bend angle.



NB: This type of folder can produce multiple folds very close together if required. Unlike the "pan brake" folder, the "gain" or "stretch" which occurs during the bend is distributed either side of the fold line.



Ref: http://en.wikipedia.org/wiki/File:Biegeanimation_2D.gif

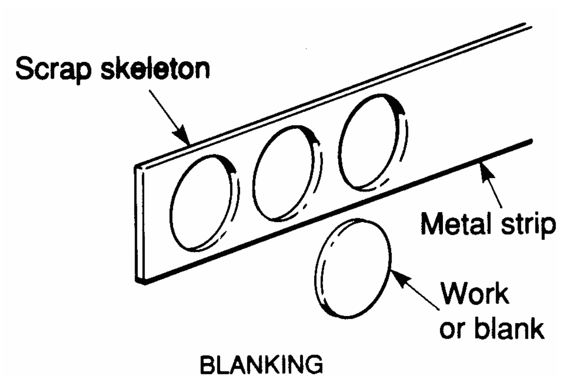
Safety

- Always wear appropriate PPE as designated in the SOP when using this machine.
- Always ensure that all guards are in place prior to use as your hands may get squashed between top and bottom tooling. Also, fingers may get trapped between machine and work piece
- The work piece may fly up when bending and strike operator.
- Always use correct manual lifting techniques when operating this machine.

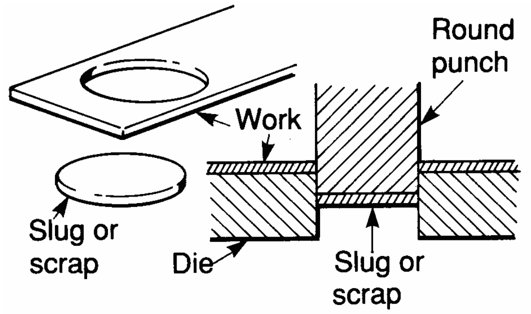
Sheet Metal Hydraulic Punch
http://www.stainelec.com.au/2.html
This tool uses an hydraulic ram action and a hardened steel "punch" and "die" combination to quickly and accurately produce "holes" and "cut outs" in sheet metal. Each punched shape and size requires a dedicated "punch" and "die" combination. If the edges on the "die set" are "sharp" then the hole produced by the punch is virtually free from any "burrs" on the reverse side. This greatly speeds up high volume processing.

NB: A "burr" is the leftover sharp, hazardous ridge caused by a cutting process. De-burring is the process of removing burrs.

"**Blanking**" is the term used when cutting a "work-piece" from a stock sheet in one operation. The cut out piece (which is wanted) is called the "blank" or "work-piece" and the material left behind is then the scrap.

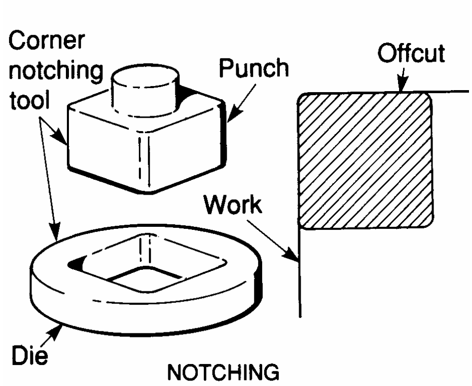


The term "**Piercing**" is similar to "blanking", but here the cut out piece (called the slug) is punched from the work-piece and becomes the scrap. The "work" is the sheet with the holes in it.



PIERCING

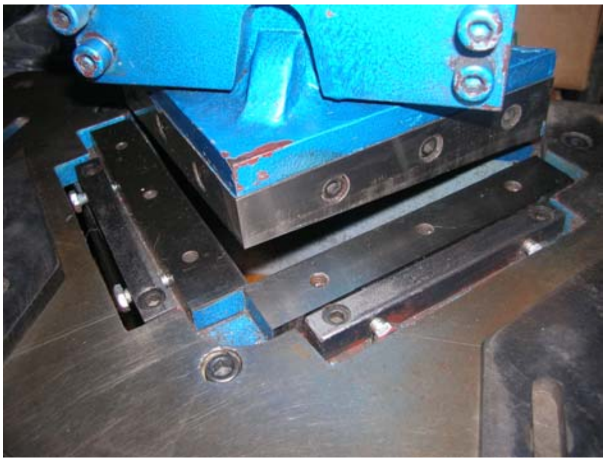
The process of "**Notching**" involves cutting out a shaped section typically in the form of a "V" from the work-piece. This is usually done prior to folding. "Notching" can be done by hand using "snips" but is much easier and faster when using a specialized tool called a "notcher". (Hand type shown below).



NOTCHING

Hand Operated Sheet Metal Corner Notcher
This is typically a hand operated bench or floor mounted tool with a capacity of about 100mm x 100mm x 90° fixed angle cut for sheet up to about 1.0 mm. It has a set sized cutting blade and die and is designed to cut a perfect 90° "V" section out of a piece of thin sheet metal. Typically this is done usually prior to folding. If necessary, a second cut can be made into the "V" for angles greater than a right angle. A hand "notching" tool has a long handle to give the operator sufficient leverage to force the blades through the metal. Power operated notchers are also available and are used for larger production runs.

Ref: http://www.advancecutting.com



Sheet Metal Work - Plan Activities
Careful planning of work activities is essential when performing sheet metal tasks safely and effectively. It is important to think a job through **before** starting work. Factors such as:

- Joint design – Welding, screws or rivets
- Type of material – Thickness and type of finish
- Cutting efficiency to avoid wastage,
- Cut lengths and bend lines.

Always consider the bend sequence, the order of work (consideration must be given to drilling or punching any holes prior to bending. Task sequencing is important. The piece that is made first should always be the piece that is wanted now and not in six weeks.

When planning a job it is important to minimise the amount of scrap. Careful consideration as to how “blanks” (work pieces) are arranged may increase the amount produced per sheet. If a saving on metal means extra working time involved – one aspect must be weighed against the other in the final analysis.

Plans or Specifications
Before starting a project it is important to understand the specifications of the task. The plans are drawings used to specify the finished job. Some complex sheet metal tasks will use a series of drawings to depict the object from a number of different angles.

Plans are usually drawn to a scale to allow a large area to be shown on a single plan page. The “scale” of the plan is shown as a ratio such as 1:10. This means that the drawing is 1/10th of full size. Something drawn with the size of "1" would have a size of "10". A measurement of 150mm on the drawing would really be 1500mm.

Many of the important measurements are written on the plan. These written measurements always take precedence over a measurement that you may scale off yourself. Some plans are not drawn to scale (NTS), and the key measurements are given in written form. In Australia, the dimensions will be given using the ISO (International Standards Organization) measurement system. This means that all dimensions are in millimetres (mm) or metres (m).

A “**specification**” provides details of a job that are not found on the plan. Some of the things detailed in the specification may include:

- Materials type including “type” eg steel, zinc, aluminium, “grade”, eg Grade 316 Stainless steel, G250 steel, “sheet thickness”, “finish coatings”, Eg Galvanised, Zincalume or Colorbond etc.
- Joining methods such as welded, screwed or riveted,
- Fastener types and spacing,
- Sealing methods and types sealant types eg solder, silicone, mastic and sealant specifications.

NB: Always check the SDS (Safety Data Sheets) before using any chemical sealants.

Safe Handling of Materials
When moving heavy or awkward loads the safety of workers in the area must be ensured. Sheet metal materials are often slippery due to oil coatings applied during manufacture. If a sheet slips through your hands it can cause serious cuts. Two people working as a team should move full sheets of metal. Large bundles of sheets need to be moved with a forklift or other lifting devices.

If materials become jammed in equipment such as folders or guillotines etc. you should never pull at it to remove it. If it is stuck, then your hands may slip along the edges and cause serious cuts. Always find out why it is jammed and free it without pulling with your hands. If the sheet needs to be pulled to free it use locking pliers or similar tools to grip the sheet instead of your hands.

Marking Out
Sheet metal must be correctly and accurately marked out according to the job specifications. In workshop situations, marking out is best done with a scriber and steel rule. A metal blade tape measure can be used for larger jobs. Marking gauges designed for metal work are useful for marking small measurements which need to be repeated such as folding allowances for seams or laps. A range of engineering squares and adjustable bevels are available that will help when marking out sheet metal materials.

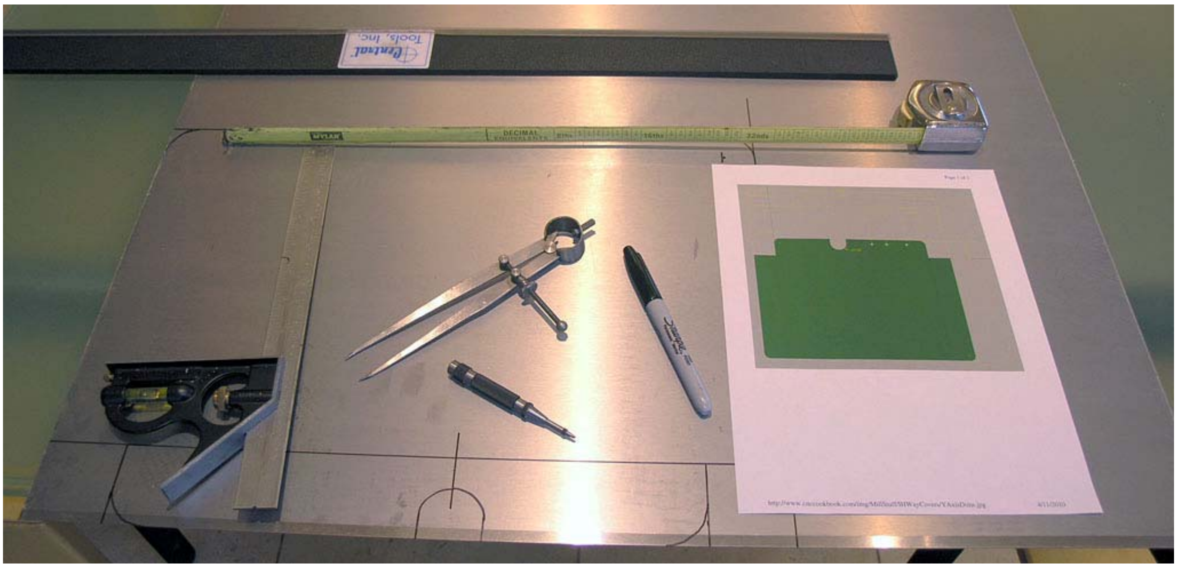
The use of pencils, ball point pens or felt tip markers is <u>not</u> recommended for sheet metal work as these produce lines that are too wide for accuracy. Also, the marks made by these methods are sometimes difficult to see on the shiny surface of the sheets, or rub off during handling of the material.

When pre-finished materials like Colorbond are being used, a fine line felt tip pen could be used to eliminate the scratches left by scribers. These pens should not be used for marking out after the tip has been worn to the point where it leaves wide lines on the material. Pens of this type have a limited life as marking instruments for sheet metal and so their use should be restricted to those tasks where they are the only viable option.

NB:Black lead pencils are made from a mixture of graphite and clay. Graphite (carbon) in contact with metals and exposed to moisture creates an electrolytic (galvanic) reaction leading to corrosion of the metal. For this reason black lead pencils should <u>never</u> be used for marking out on metals exposed to the weather.

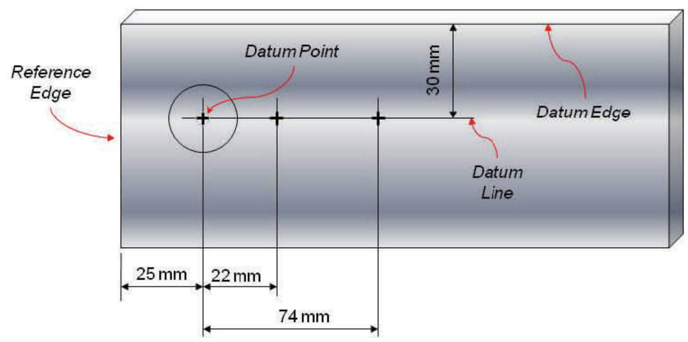
When working “on-site” (ie: on-the-job) marking out will invariably require the use of tools capable of measuring much greater distance without loosing accuracy. Tape rulers and a chalked string line can be useful when marking long lines on sheet metal. Eg Marking fixing lines on the tops of large switch boards. This method leaves a line that is easy to see, is easily removed and leaves the sheets undamaged.

Ref: http://www.cnccookbook.com/CCMillWayCovers.htm

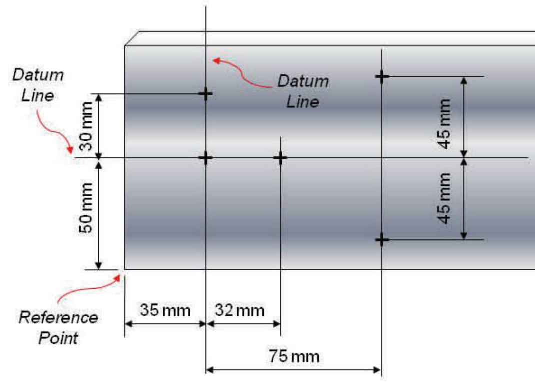


Marking Out From a Datum Edge or Datum Line
It is difficult to achieve a high level of accuracy when cutting metal from a large sheet. To overcome this, the piece of metal should be marked out and cut slightly oversize. This will allow the metal to be accurately marked to size from a "**datum edge**" or "**datum line**".

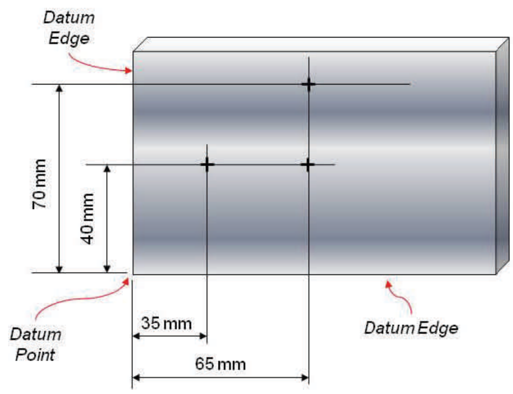
A datum edge is a perfectly **straight** edge to be used as a measurement reference. It should run down the full length of the piece of metal and is used to mark out the job. A second "datum line" should then be drawn at right angles to this datum edge which can also be used as a side reference. All job dimensions should then be measured and drawn from these two references.



NB: Sometimes unsuitable stock material can be prepared for a datum edge as follows:
- Rule a straight line with a rule and a scriber.
- Carefully cut along the line with tin snips or a guillotine.
- Test for straightness with a rule (straight edge).
- Mark the edge with a datum edge mark.



If the metal is too thick to be cut with snips:
- Scribe a straight line close to the edge of the metal.
- Carefully file down to the line.
- Draw file the edge and test for straightness with a rule.
- Mark with a datum edge mark. (ie: "V")



NB: If it is not possible to form a datum edge on the stock material an alternative method is to draw a straight "datum line" down the full length of the material (usually close to the bottom edge) and mark this as a datum ("V" mark). Near the bottom left hand side of the stock draw a second datum line at right angles to the first which will also be used as a dimension reference.

When marking to size, all markings should be made from the two datum edge as follows:

- Place the stock of the try square firmly against the datum edge.
- Scribe a line close to the edge of the metal.
- Use a rule and a scriber to mark off the length of the job.
- Hold the stock of a try square firmly against the datum edge and scribe a line through the mark and square to the datum edge.
- Set odd-leg callipers to the required width.
- Mark to the required width by moving the odd-leg callipers along the datum line.

Cutting Sheet Metal
To form the job, the sheet metal needs to be cut accurately using appropriate cutting tools and in accordance with safety requirements. In workshop situations large sheets typically need to be cut into smaller pieces (blanks) to produce the required components for fabrication. This is typically done with a guillotine. As shown above, large guillotines are usually power driven while smaller types are manually operated, usually by a foot pedal or bar.

All guillotines have limits with respect to the type and thickness of materials they can cut. Always read the SOP to obtain user instructions for the safe and correct use of a guillotine before starting. Never exceed the rated capacity of the guillotine. This could result in expensive damage to the machine or injuries to workers.

In addition to a guillotine there are a number of hand held power tools available that can be used for cutting sheet metal although non will achieve the same level of precision as a guillotine. The hand held tools include:

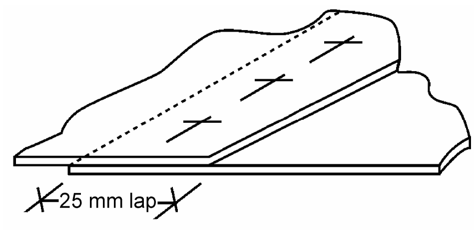
- Power shears
- Nibblers
- Circular saws (fitted with metal cutting blades)
- Angle grinders (fitted with metal cut off discs).

Always read and follow the instructions given in the SOP for each tool and wear the PPE as specified in the SOP. Most powered tools are very noisy and noise protection is recommended, especially if a large amount of cutting is required. Chips and sparks from these tools can cause eye damage if safety glasses or face shields are not worn. Only operate these tools if you have had instruction in their safe use.

Some tools such as saws and grinders may leave a burred edge which are sharp and can make the blanks dangerous to handle. Also the burred edge of mild steel materials will corrode badly if exposed to weather. The burr can be removed with a suitable file.

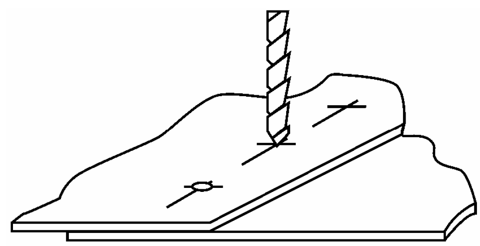
Unsightly rust stains and corrosion of the sheet will result if fine chips (known as swarf) are left in contact with the sheet surface and then exposed to weather. Swarf from nibblers and dust from jig saws etc must be completely removed from the surfaces when cleaning up. Angle grinders produce very hot chips of metal that can burn into the surface of materials like Colorbond.

Making a Lap Joint
A "lap joint" is an overlapping joint between two pieces of metal. It must be made using appropriate tools and equipment.



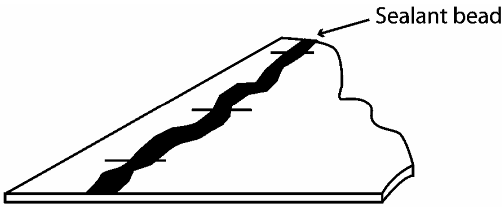
"Lap" joints can be fastened by welding, rivets or even self-tapping screws.

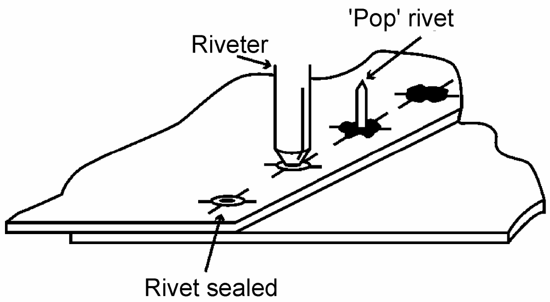
If using screws or rivets for the join, first cut the material to size after allowing for a "lap" of about 25 mm. Next, ensure that surfaces are clean, dry and free of contaminants. Mark laps on material to help with alignment.

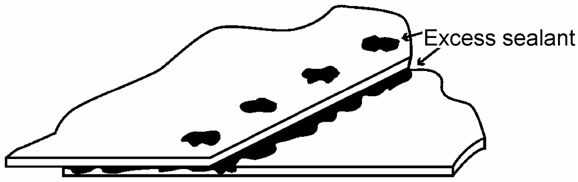


Lap the materials and cramp them with locking pliers, "G"-cramps or similar. Drill holes for fasteners at a suitable spacing. Remove cramps, clean up swarf from drilling.

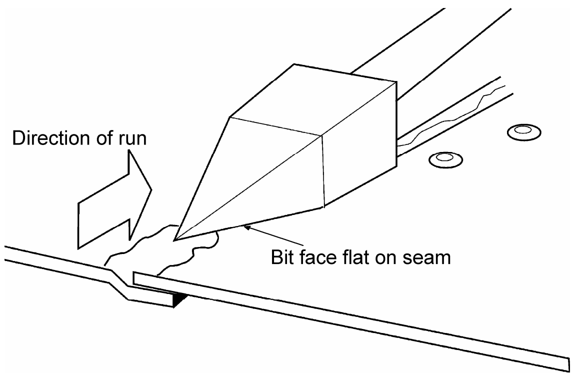
If water proofing is required for a joint apply a continuous narrow bead of sealant over the centre line of the drill holes. Re-form the lap then insert the fasteners. Apply additional sealant to fasteners to seal them. Wipe off excess sealant squeezed from the joint.







Joints by Soldering
Soldering can be used to join some sheet metals. Solder is an "alloy" that can be melted and then it solidifies after cooling thereby bonding the two materials together. For effective jointing the solder must have a melting point lower than the materials to be joined. Sometimes the joints to be soldered should be fastened with rivets prior to sealing with the solder.



Soldering cannot be used to join all sheet metal types. The common materials that can be soldered include zinc (galvanised) steel , zinc sheet as well as copper and brass sheets. Joints in materials such as Zincalume, Colorbond and aluminium must be screwed, riveted or joined with a sealant such as silicone.

When soldering sheet metal the preferred type of solder is "50/50". It is an alloy containing 50% lead and 50% tin that melts at a temperature of approximately 220ºC.

Solder can be applied to the joint with a soldering iron. The working part of a soldering iron is a copper 'bit', which is usually square in cross section and tapered to a point. The bit is heated by a gas flame or by an electrical element to a temperature hot enough to melt the solder. The heat energy stored in the bit is then transferred to the materials being joined by direct contact. The materials are raised to a temperature that allows the molten solder to adhere.

Prior to use, a soldering iron needs to be 'tinned'. This is a process that allows a coating of solder to be applied to the copper bit of the soldering iron. To "tin" a soldering iron it should be heated, filed to a bright, smooth finish and have solder applied while the hot iron is rubbed in flux. The flux normally used for tinning soldering irons is a block of "sal ammoniac" or similar.

After heating, the soldering iron it should be cleaned before applying solder to the joints. This can be done by quickly dipping the iron into a pot containing water with a small amount of soldering flux added, or by quickly wiping the surface on a cloth. If the surface of the iron becomes oxidised by overheating, re-tinning will be necessary.

The materials to be soldered must be thoroughly cleaned of oil, grease, dirt and corrosion prior to starting as these contaminants prevent good adhesion of the solder to the surfaces being joined. The joints need to be chemically cleaned with a ‘flux’ to remove any surface oxide layer from the material. The flux also prevents the formation of oxides while the molten solder is flowing into the joint.

A range of commercial fluxes are available. These are normally identified by the manufacturer’s trade name on the container. Instructions on the container explain the suitability of these fluxes for particular applications. Most fluxes are corrosive. Take care when handling and working with fluxes. Read the manufacturer’s SDS for the product prior to starting work. Always use appropriate PPE and work in well ventilated areas. After soldering, the flux residue must be removed from the affected surfaces with a clean, wet cloth. If this is not done, corrosion of the joints and or the surrounding areas will occur.

Other materials which can be soldered include: copper, brass, stainless steel and tinplate. Each material requires its own special flux.

Joining with Sealants
Due to the difficulty of soldering some metal products, alternative methods of joint sealing have been developed. Chemical sealants such as “silicone” are now in common use. Many different types of sealants are available from trade suppliers and specialist adhesive manufacturers. It is important to select an appropriate sealants for the task. Sometimes sealants may be specified for the job and this information is typically in the plans or specification for the job. A common type of sealant is shown to the right.

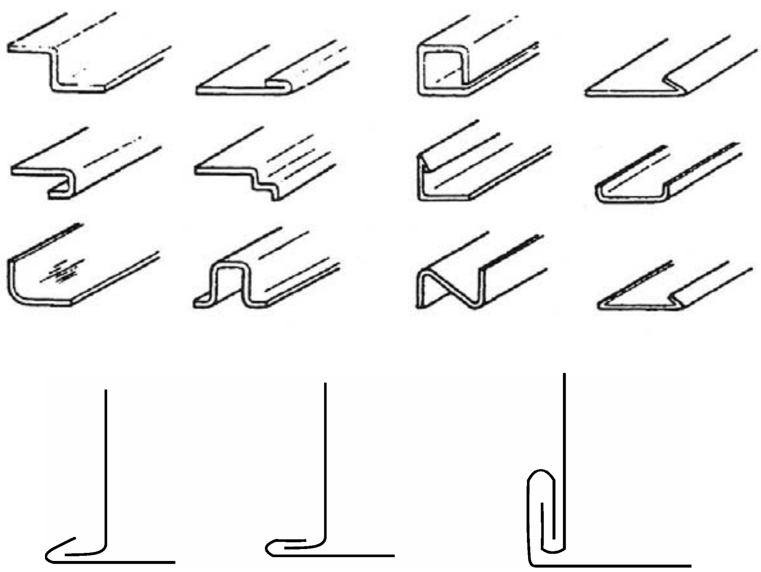
Ref: http://www.bunnings.com.au

NB: Always check the **SDS** (Safety Data Sheets) before using any chemical sealants.

Electrolysis or Galvanic Corrosion
As shown earlier corrosion can occur when dissimilar metals are placed in direct contact with each other in the presence of moisture. Electrolysis or galvanic corrosion can then lead to rapid corrosion of one (the least Noble) of the materials. This is due to a very small flow of electric current that is generated between the different materials when they are wet. This current flow leads to the decomposition of one of the materials. Some materials are more reactive than others in this type of situation. Galvanic corrosion can be overcome by the use of chemical sealants as they form an insulating barrier between the two metals.

Folding Sheet Metal
Folding or bending is one of the most fundamental sheet metal work tasks. Folding is used to fabricate products and also to make joints between associated pieces.

While folding can be achieved manually with the aid of a hammer and a straight edge, it is generally best done with the aid of a purpose built machine such as the “Pan Brake” folder or the larger “Brake Press” discussed earlier.

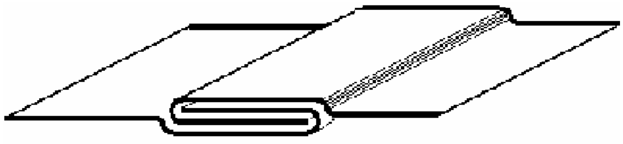


Accurate folding is a fairly complex task and every folder exhibits different characteristics. In addition, the bending characteristics will always change slightly as the machine and its edges begin to wear. Before attempting any "new" bending task always use a piece of scrap material to determine the current bending characteristics of the machine to be used. This will ensure the best accuracy and the least amount of material waste.

When using a metal folder, it is important to:

- Set the machine to suit the metal thickness to be bent.
- Never bend beyond the capacity of the machine as this strains the machine and will shorten it life-span and reduce the quality of the folds produced.
- Never bend materials for which it was not designed.

When removing or inserting the fingers (of the machine) take care not to get your own hand or fingers squashed. Always follow the SOP for the machine.

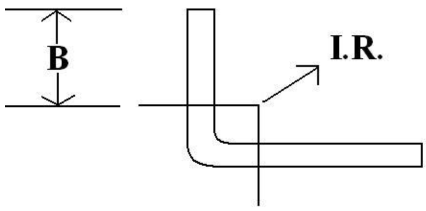


Grooved seam

The main specifications of folding machines are as follows:

1. The maximum length and thickness to be bent. For example, the capacity of the machine may be 1.5 m times 1.62 mm. This means that the machine is capable of folding a metal sheet 1.5 m wide and of 1.62 mm thick.

2. The lift and shape of the clamping beam. The smallest width "B" (in the sketch below) of bend is typically 8 to 10 times the metal thickness. The minimum inside corner radius of the bend is typically 1½ times the metal thickness.



NB: Dimension "B" refers to the smallest width which will clamp securely in the machine. If "B" is smaller than 8 to 10 times metal thickness it may slip out from under the clamp.

The three main steps in folding work are: (These are repeated from earlier in the note.)

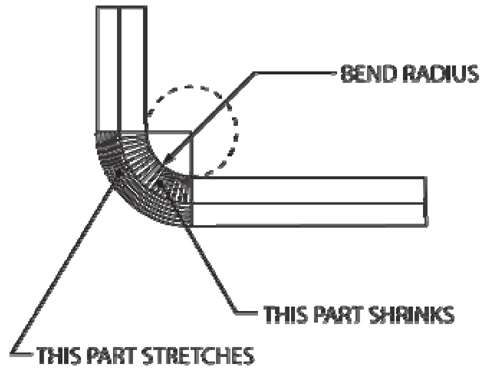
1. **Clamping**: In clamping, the amount of lift of the clamping beam is important. It should be sufficient to allow the fitting and use of special clamping blades, or to give adequate clearance for previous folds.

2. **Folding**: Care must be taken to see that the folding beam will clear the work, particularly when making second or third folds. Some folding machines are designed to fold radii above the minimum, either by the fitting of a radius bar or by adjustment of the folding beam.

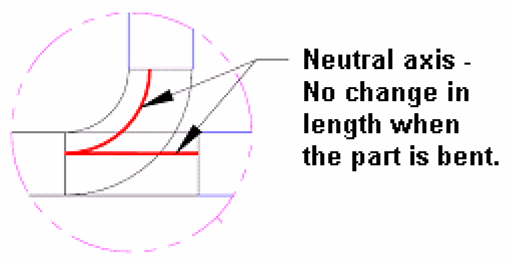
3. **Removal of the work**: Care must be taken in folding to ensure that the work may be easily removed on completion of the final bend. The sequence of folding must be carefully studied. The lift of the clamping beam is important here. Some folding machines known as universal folders have a swing beam. The work may be completely folded around this beam, which is then swung out to allow removal of the work.

Metal Folding

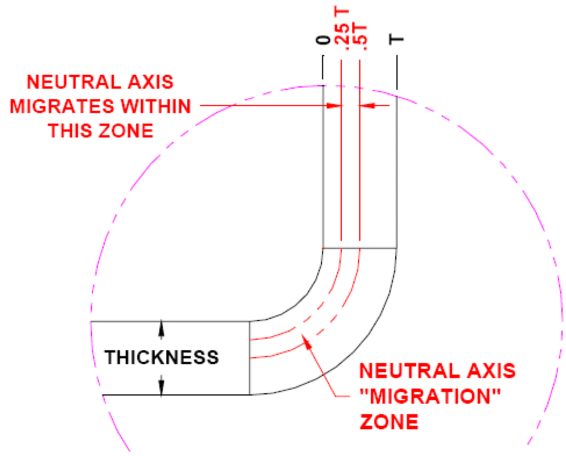
When metal is folded, the bending action stresses the sheet. The folding force compresses the material on the "inside" of the curve, and "stretches" the material on the outside of the curve. However, at some distance between these two there is a space which is not affected by either force. This area is known as the "Neutral Line" or "Neutral Axis". The position of the neutral axis is not fixed and will vary with material type, its thickness, the bend radius and even the characteristics of the folder itself.



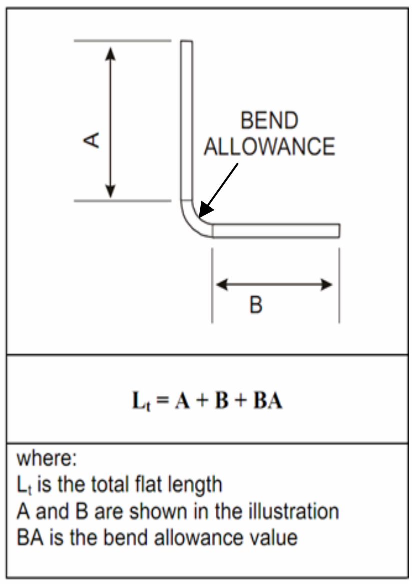
The action of some folders will stretch the metal in only one direction from the fold line, while other folder types stretch the metal equidistant either side of the fold line. This stretching causes small variations in the finished size of the bent parts. To achieve the desired accuracy, allowances must then be made for every bend to ensure the final measurements are accurate.



There are two approaches that can be adopted to determine the precise position of the fold line. A theoretical design based on a calculation involving the position of the "neutral axis" and the second is an approximation based on "inside" measurements and material thickness.



The theoretical approach is based on the fact that the measured "length" along the "neutral axis" will **NOT** change as a result of bending as there is no stretch or compression at this point. The problem is that the position of the neutral axis difficult to fix as there are many variables. The neutral axis is located near the centre of the metal for a gradual bend and closer to the inside edge for a tight bend. The position of the "neutral axis" with respect to the material thickness is known as the "K" factor. In practice, "K" is between 0.25 and 0.50. The length of the "bend" measured along the line of the neutral axis" is called the "bend allowance". The cut length of the material becomes the length of the two "flat" sections plus the "bend allowance".



The "Bend Allowance" can be calculated from the following formula.

$$BA = \frac{2\pi A\,(R+KT)}{360}$$

Where:

$BA = Length\ of\ bend\ allowance$

$A = Angle\ in\ degrees$

$R = Bend\ radius\,(mm)$

$K = Neutral\ axis\ offset\ (K - Factor)$

$T = Thickness\ of\ material\ (mm)$

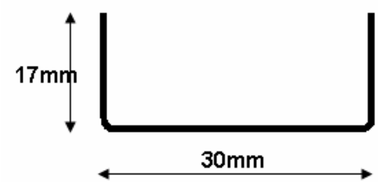
The problem with the theoretical approach is that "K" and the "bend allowance" calculation is **NOT** an exact science and for critical tasks the best method is to always use a trial piece of material in the same bender and then accurately measure the amount of stretch and in which direction from the fold line that it occurs. This "trial-and-error" should determine the current bending characteristics for this folder on this gauge and type of metal.

Working with "Inside" Measurements

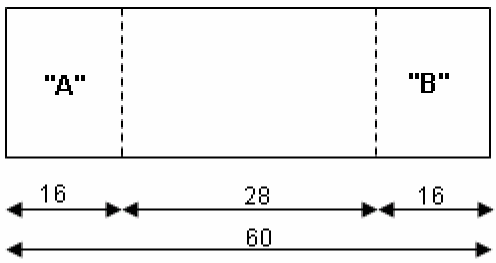
Before marking out, always establish the level of accuracy needed for the assembled work. For relatively simple low level tasks determine "cut" and "fold" measurements based on "inside" measurements is normally sufficient. If in doubt, fold small a trial piece and test the amount of stretch and make minor adjustments if necessary.

Inside measurements example:

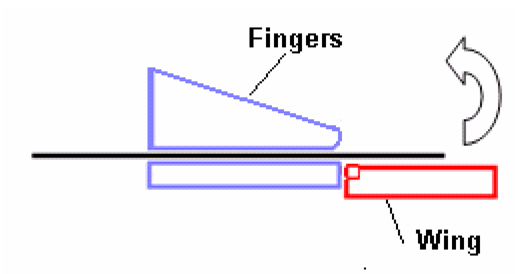
Consider the "U" shaped task to the right for a material which has a nominal thickness of 1mm. The dimensions given are "outside" dimensions which is typically given in drawings.



Note that around the "outside" face the total length is 17 + 17 + 30 = 64 mm. The "inside" measurements are then "16mm" for each of the two side walls and "28mm" for the base for a total cut length of "60mm". The difference to the outer surface is made up as the metal is stretched by the bender for each of the two 90 degree bends.

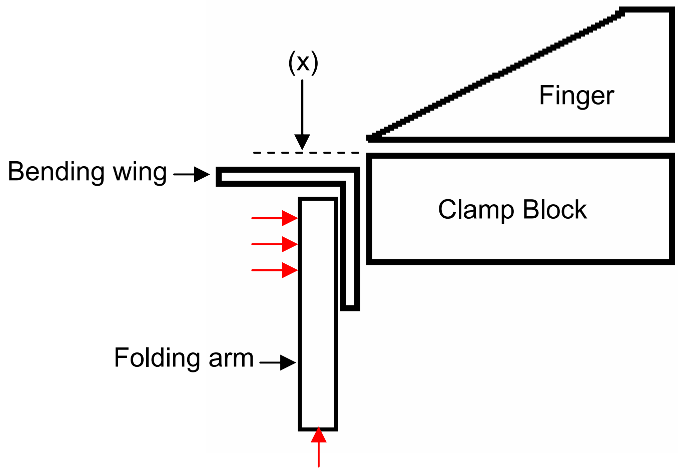


As explained earlier, each type of folder will stretch in different directions and by different amounts. A "pan brake" folder (such as that to be used in the practical exercise) will stretch the metal in "one" direction only. The metal under the "clamp" should not stretch, but the section under the "wing" will stretch as it is rolled around the radius at the front of the fingers.



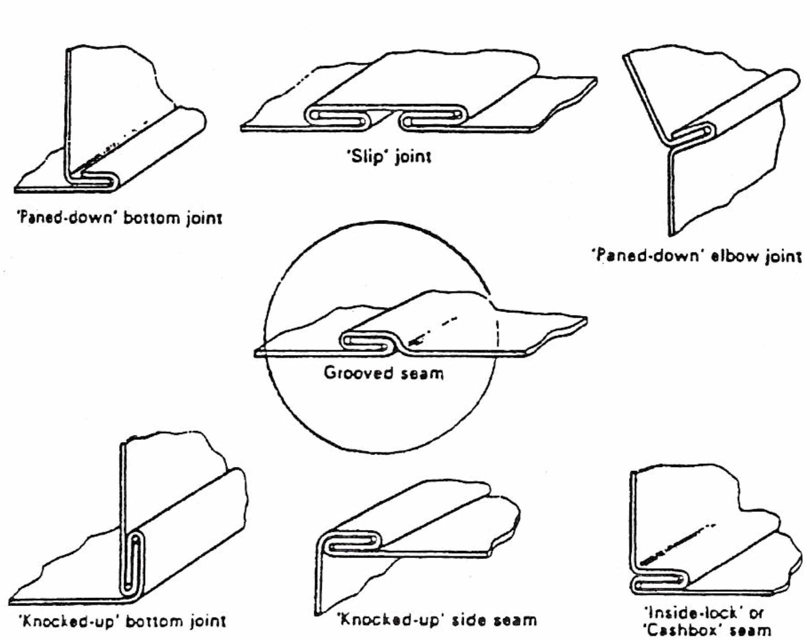
This means that when folding a "U" section shown, it is important that the "base" section is under the clamp when making both bends. That is, parts "A" and "B" will protrude over the wings. This will ensure that the stretch in the two walls is equal and the two side walls will be equal in length. Just how accumulate it will be can be determined by a small test piece.

The radius of the bend created by a "pan brake" folder can be adjusted by setting the height of the "wing". The amount of gap required between the clamp block and the clamp fingers determines the bend radius. If the wing is raised to it highest point where it is flush then the bend will be very sharp (small radius). When the wing is lowered it created a bigger bend arc and the radius is greater.



Self-Secured Joints

These joints are formed by folding and interlocking thin sheet metal edges together in such a manner that they are made secure without the aid of any additional jointing process.



Their use is confined to fabrications or components constructed with light gauge sheet metal less than 1.6 mm thick. A selection of these joints is shown. Of these the following are the most widely used are:

- The grooved seam
- The paned-down joint
- The knocked-up joint

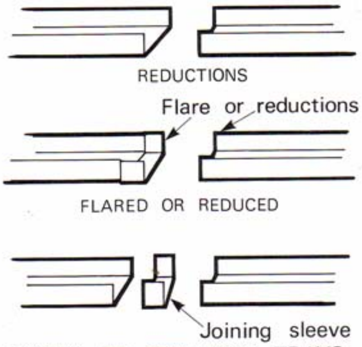
Job Inspection

- Finished joints need to be cleaned and inspected to ensure that the materials are correctly aligned and sealed.
- When inspecting completed joints check that all laps have been completely closed by the joining method. When using fasteners like rivets or screws, check the spacing between fasteners to ensure that they meet the job specifications.
- Check the sealant in the joint to ensure that it has completely sealed any gaps and that leaks will not occur. Check all open style rivets to make sure that the sealant has been applied in a way that ensures that they will be watertight if necessary.
- When checking soldered joints ensure that all areas of the joint have been effectively sealed and that rivets have been sealed with solder. Check that all traces of flux have been removed.
- If joints are meant to be watertight it is normal to expose them to water and check for leaks. Inspections should be done carefully as leaking installations will require repairs later on. This is both expensive and embarrassing.
- If faults are discovered during inspections use appropriate techniques to fix any problems. This may involve additional fasteners, sealant or solder and check the joints again.

Clean up

- Always allow clean-up time. Cleaning up includes clearing the work site of debris and unused materials and stacking materials to aid good site management.
- Sheet metal off cuts will result from cutting and joining of these materials. Off-cuts that are large enough to be used for other projects should be stored for future use. In workshops, storage racks are usually provided to contain part sheets and large off cuts. This material should be stored as soon as possible to keep work areas clear and prevent damage to the material. If working on-site locate suitable storage areas for this material.
- Smaller off-cuts should be disposed of as soon as practicable. Sharp edges make this material dangerous to handle. Gloves should be worn to protect workers' hands during disposal operations.

- In some organisations small sheet metal off-cuts are separated from other waste material and sent to recyclers. Check the operating procedures in the workplace before disposing of waste.
- All off-cuts, swarf from drilling or cutting operations, rivet stems, etc must be cleaned up at the end of each day. If this material is left on a finished surface it will stain and can lead to corrosion.
- Tools and equipment used during the installation should be cleaned to remove oil, grease, dirt, sealant etc. After cleaning they should be checked for damage or wear. If tools require maintenance, report this to the work supervisor. Tools requiring maintenance should be tagged to prevent other workers using them before repairs are carried out.

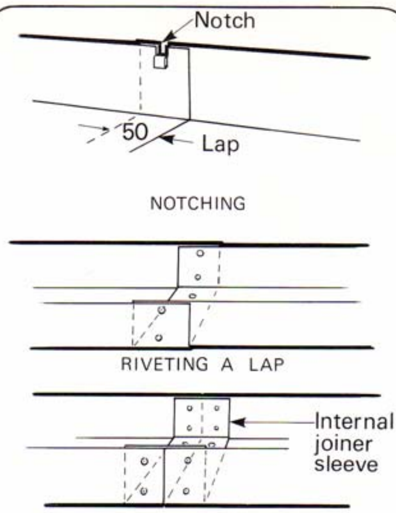


TYPES OF STRAIGHT TRAYS

Cable duct is a common cabling system used in both industrial and commercial applications.

Joining Lengths of Cable Duct
There are three types of cable trays:

- Straight tray –Tapered with reductions.
- Straight tray - Flared at one end.
- Straight tray - No reductions, but with joining sleeves.



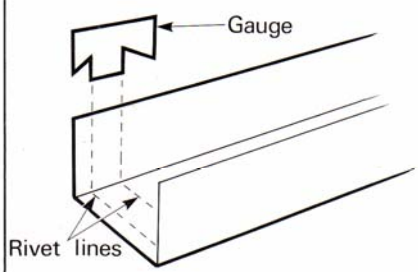
JOINING TRAYS WITHOUT REDUCTIONS

Straight Tray with Reduction
- Generally, there is a difference of 1.5 mm between one end of the tray and the other.
- Slide the narrow end into the larger one of the next tray for approximately a 50 mm lap.
- Either notch or rivet the ends together.
- Mount the assembled length on the brackets or on the wall.

Straight Tray - Reduced or Flared
- At one end of the cable tray, a step inwards or outwards is made during production.
- Slide the narrow end into the manufactured end.
- Notch or rivet together to secure the parts.

Straight Tray – with Joining Sleeves
- Depending on manufacture, sleeves are mounted inside or outside the tray.

- Butt the ends of the cable tray together.
- Place the joiner either inside or outside the join.
- Align the joiner centrally on the join and mark its rivet hole positions.
- Clamp the joiner to the tray ends to avoid misalignment of parts during drilling.
- Drill the holes and rivet joiner sleeve and tray ends together.

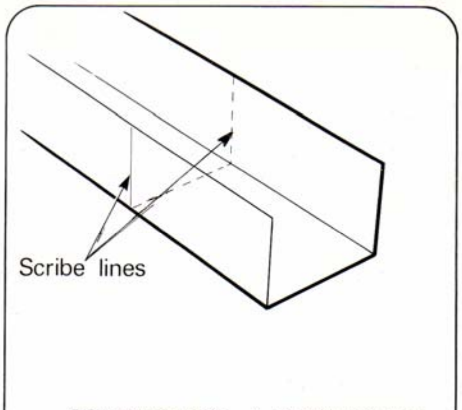


RIVET GAUGE

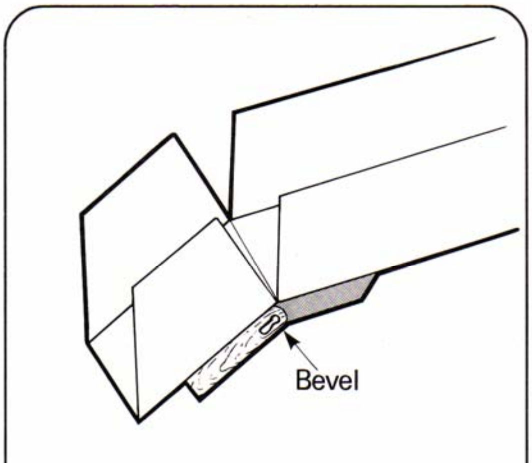
NB: The use of a rivet gauge is helpful in achieving a neat and consistent appearance of each joint. See illustration.

Making a Turn Down
A change of direction.

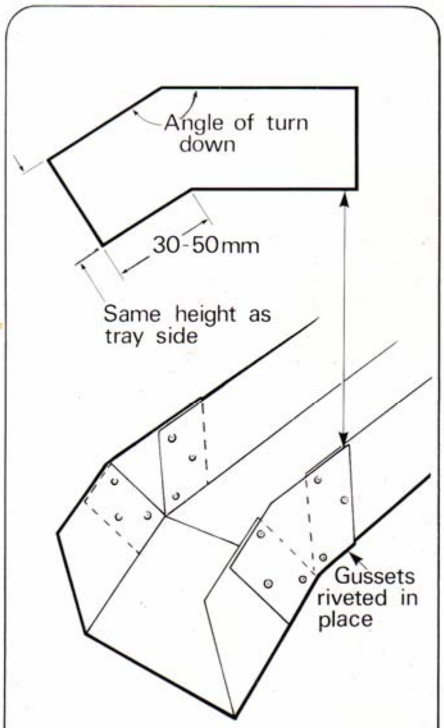
- Place the tray in position.
- Scribe vertical lines on the sides of the gutter at the points where the turn down is to be made.
- Cut along the scribe lines using a hacksaw and tinsnips.
- Bend the gutter down to the required angle and check with a bevel.



SCRIBING FOR A TURN DOWN



CHECKING THE ANGLE OF BEND



FINISHED TURN DOWN

- Make a template from paper or from cardboard in the shape and to the size of the gussets required.
- Cut a pair of gussets from scrap material to cover the gaps in the sides of the tray.
- Insert the gussets to the sides of the tray and secure them temporarily with clamps.
- Check the angle again, then drill and rivet the joints.

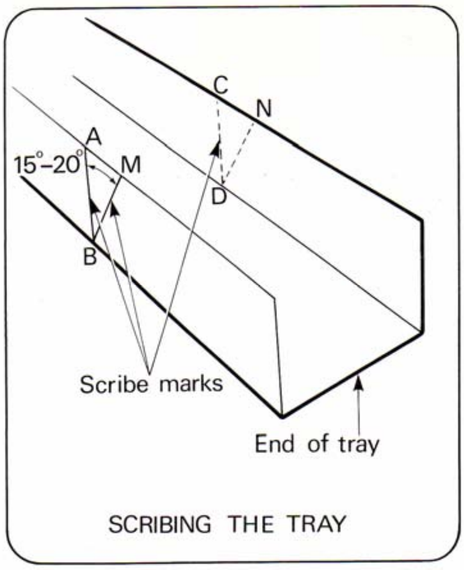
NB: A “gusset” is this case is a small specially shaped piece of metal used to strengthen a joint.

Make a Stop end

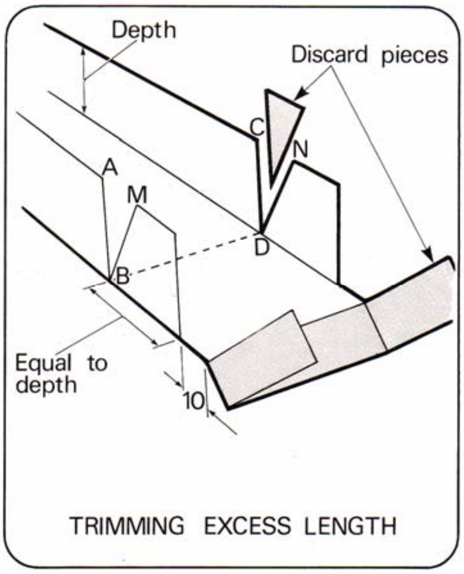
To make a stop end:

- Scribe a vertical line at each side of the tray where it is to be turned up.
- (lines A-B and C-D).
- If possible, this should be done with the tray temporarily positioned.

- From points B and D, scribe two lines angled at about 15°-20° from the vertical marks and towards the end of the tray. (lines B-M and D-N).



SCRIBING THE TRAY



TRIMMING EXCESS LENGTH

- Check that the distance from points B and D to the end of the tray is equal to the depth of the tray.

- If this distance is greater than the depth of the tray, trim off the excess length.
- Leave the bottom piece projecting by approximately 10 mm if a reinforcing top edge is required.

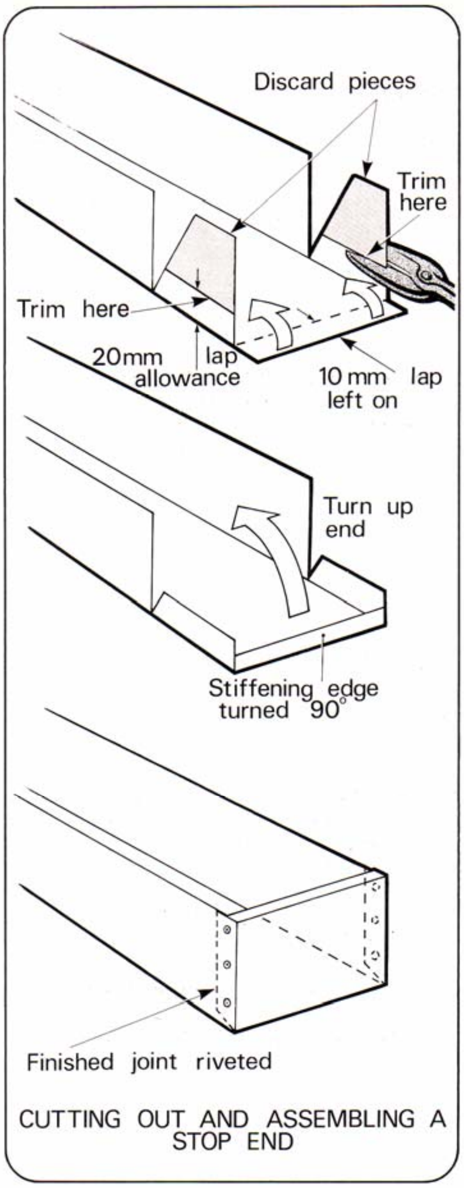
- Trim off the top of the tray sides between points M and N and the end, leaving a 20 mm lap.

- Turn the 10 mm allowance on the bottom piece up at 90° to form a stiffening fold if so required.

- Turn up the end of the tray vertically.

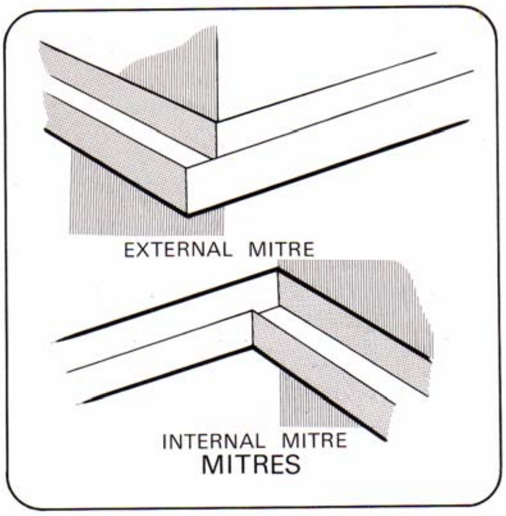
- The lapping allowances should be on the inside of the tray sides.

- Drill and rivet into position.



CUTTING OUT AND ASSEMBLING A STOP END

Mitres or Angle Joints
Mitres or single joints are required at corners and are:
External mitres for external corners.
Internal mitres for internal corners.



External Mitres (Right-Angled)

- If commercially produced mitres are not available, it will be necessary to make them to suit the job.
- To make a right-angled mitre:

- Measure the distance, against the wall, between the cable tray end and the edge of the wall corner.

- Transfer this measurement to the cable tray to the side that will be against the wall and mark the spot with a scriber. (A)

- Place the tray upside down for the marking, but take care to identify which side goes towards the wall before marking. Remember you are marking upside down.

- Measure the width of the base of the cable tray, e.g. 100 mm.

- Mark on the wall side of the cable tray 100 mm from the corner mark (B) and 200 mm from corner mark (C).

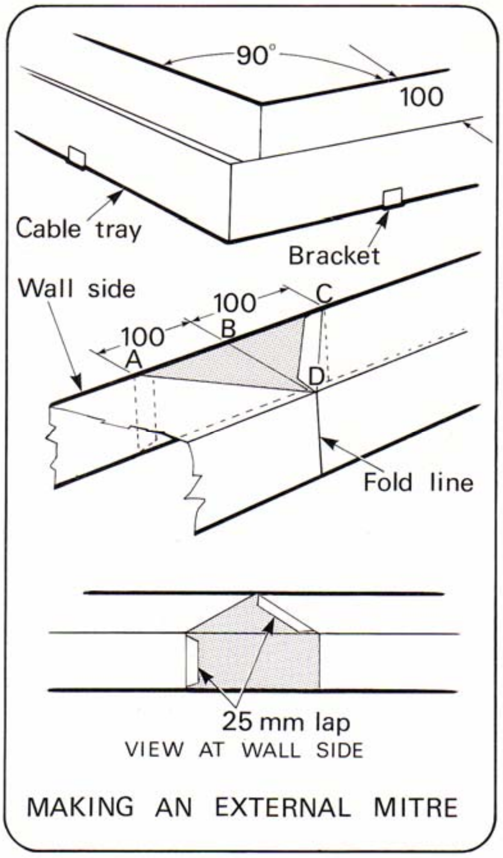
- Place the stock of a try square against the tray wall side.

- Draw from mark B a line across the base of the tray with a scriber to D.

- Draw lines from A and C and D using ruler and scriber.
- This forms a triangle with a top angle of 90° at D.

- Allow for a 25 mm lap as shown.

- Cut away excess metal with tinsnips.

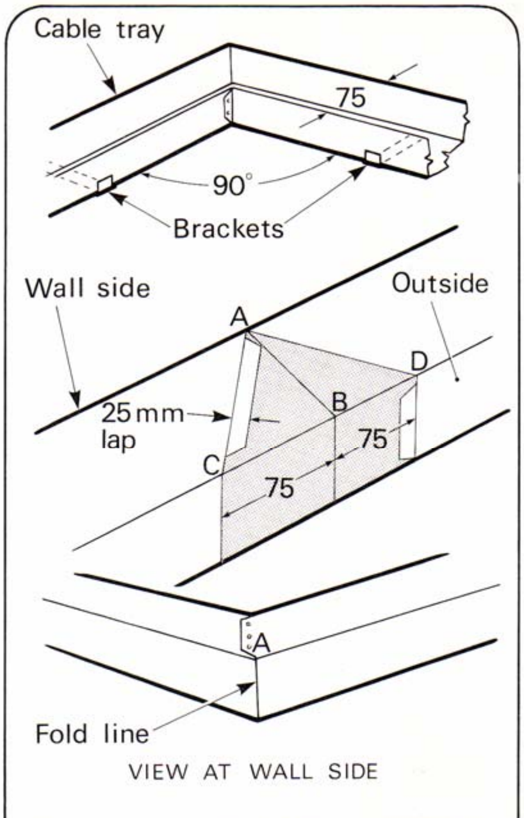


- Fold the tray along the fold line and ensure the lap is inside the base.

- Clamp together, then drill and rivet the tray together.

- Fix the tray securely to the wall.

Internal Mitres (Right-Angled)
If commercially produced mitres are not available, it will be necessary to make them to suit.



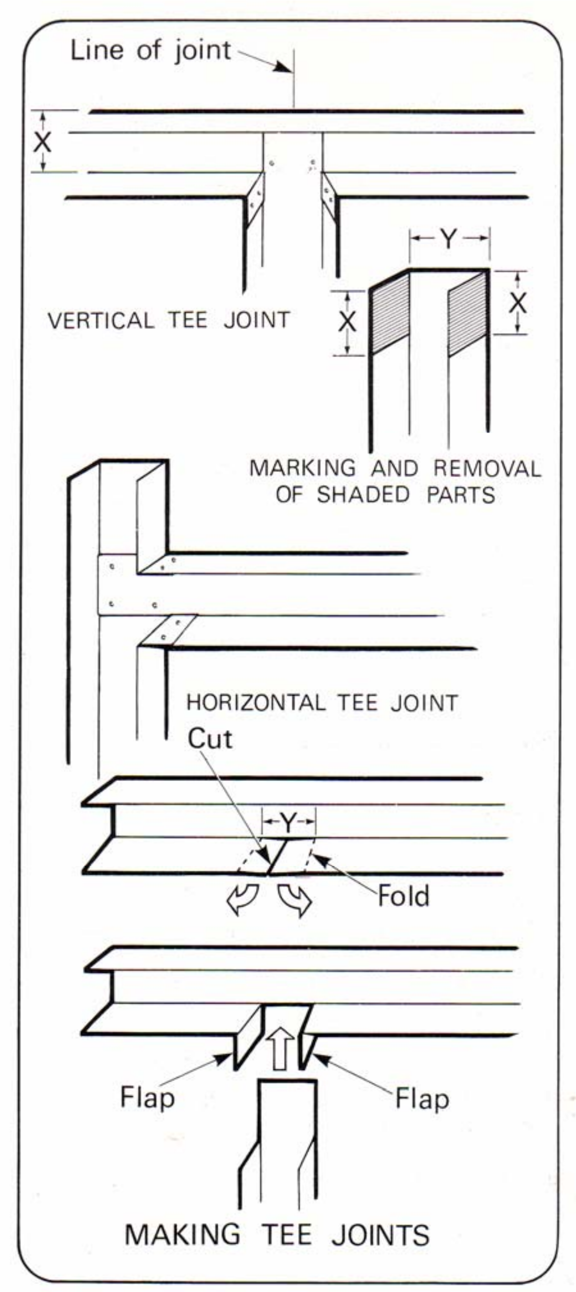
MAKING AN INTERNAL MITRE

To make a right-angled internal mitre:

- Measure the distance against the wall between the cable tray end and the internal corner.
- Transfer this measurement to the cable tray to the side that will be against the wall and mark the spot with a scriber. (A)
- Place the tray upside down for the marking. Remember that right is now left and vice versa.
- Using a try square and a scriber, draw a line from that mark to the outer edge of the tray. (B)
- Measure the width of the base of the tray, 2.g. 75 mm.
- Mark off 75 mm on each side of B, giving points C and D.
- Join C and D to A to complete the right-angled triangle.
- Mark the 25 mm laps for the base and on the side opposite the fold line.
- Cut away excess metal with tinsnips (shaded areas).
- Clamp, drill and rivet the tray edges together.
- Fix the tray securely to the wall.

Cable Tray Covers
The general procedure for making external and internal mitres (right-angled) is the same as for the trays, except that what is right and left on trays is reversed for covers. Only the lap on top of covers is required.

Making Tee-Joints
If commercial tees are not available, it is relatively simple to make them. Note that the end of one tray is made to fit into the side of the other.

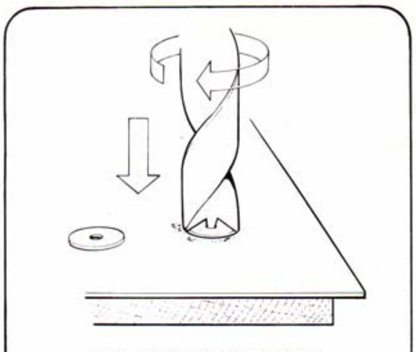


To make such a tee-joint:

- Mark the spot where the joint is to be made.
- Measure the width X of the cable tray base.
- Transfer this measurement to the sides of the end of the tray piece that will form the branch.
- Mark off the measurements with a scriber.
- Cut away the sides but leave the base as shown.
- Remove any burrs with a file.
- Slide the tray end under the base of the other tray where the branch is to fit and mark the outline of the branch tray on the side of the other tray.
- Remove the branch tray, then halve the distance between the two marks just made and mark this centre with a scribed line.
- Cut through this centre line and along the back of the tray sides to the two lines that mark the outline of the branch t ray.
- Fold down each flap at 90° along the marked lines.
- Remove burrs and sharp edges.
- Slide the branch tray into the gap made in the other tray.
- Clamp, drill and rivet the two parts together.

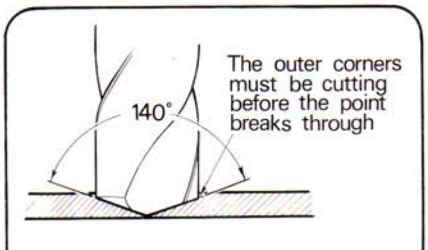
Drilling and Cutting Holes In Sheet Metal
Making holes in sheet metal can be done with:

- Drills,
- Hole saws,
- Metal punches,
- Fly cutters.


DRILLING THIN METAL WITH A DOWELLING DRILL

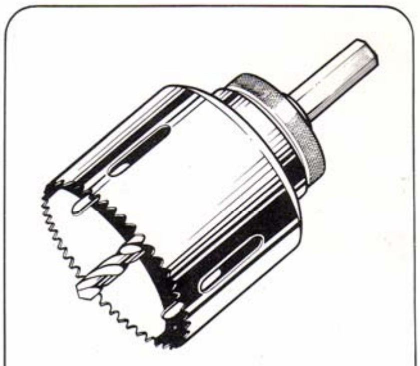
Drills
To drill thin metal below 1.6 mm in thickness, it is best to use a specially prepared sheet metal drill for holes over 6 mm in diameter. Such a drill resembles the dowelling drill used by carpenters and joiners. Drills with a 140° point angle can also be used satisfactorily to drill thin sheet metal.

Standard drills (120° point angle) are satisfactory for use on thicker material. Holes drilled with these drills are suitable for bolts and for entry of cables.



DRILLING THIN METAL

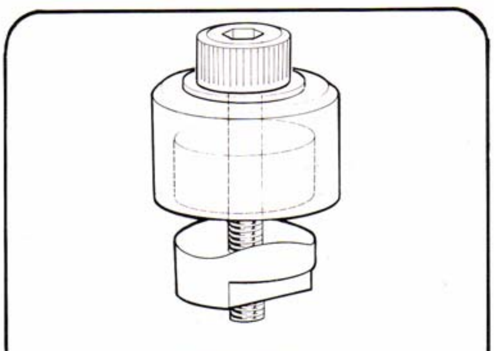
Hole Saws
These can be used to cut larger holes in sheet metal. Their sizes range from 15 to 150 mm in 2 mm diameter increments. When using a hole saw, make sure to use an adequate supply of cutting fluid to cool the blade and to reduce friction. Holes made with hole saws are suitable for meters and gland fittings etc.

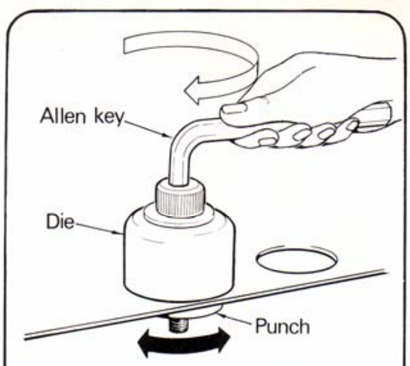

HOLE SAW

Metal Punches
The punches for smaller holes, 6 to 15 mm in diameter, are usually pushed or punched through the metal. For holes of 16 mm and larger, the matched punches and dies are pressed through the metal. A pilot hole to accommodate the punch spindle is drilled first and then punch and die are assembled to the spindle.

By tightening the nut on the spindle the punch and die are gradually pressed together until the hole is clearly punched through.

Holes made with these punches are suitable for fixing meters, gland fittings and light sockets etc.


METAL PUNCH



USING A METAL PUNCH

Fly Cutter
A fly cutter consists of a lathe cutting tool secured to an adjustable arm. This in turn is secured to a holder, the spindle of which is clamped into a drill chuck.

Very large diameter holes can be cut with this tool and the cutting is done at the lowest speed possible. Large radial drilling machines are typically used as they offer accurate control and very low rotational speeds.
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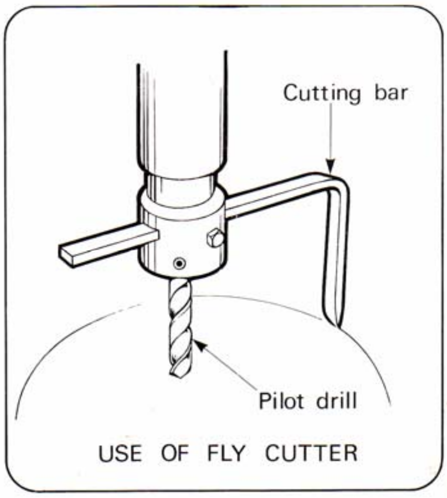
The plate or sheet to be cut with this process must be clamped very securely against rotation and held absolutely flat on the work table. Suitable cutting fluid must be provided during the cutting operation.



Cutting a "Rectangular" opening
To cut out a rectangular opening in an electrical switchboard:

- Mark out the cut-out outline with a ruler, scriber and try square etc. (NB: If the switchboard is already painted then it is best to use masking tape to shield the cut-out area against scratches and mark the cut-out on the masking tape with a pen or pencil.
- Drill a clearance hole suitable for the saw blade to be used in diagonally opposite (inside) corners of the cut-out area. Make sure to stay well within the marked outline.
- Cut from a drilled hole through the material to the next corner with a jig saw, sabre saw or a hacksaw blade and pad handle. Use the saw to trim close but not to the line.
- File the rough edges to the marked outline and remove sharp edges and burrs. Finally, remove the masking tape and paint edges to protect metal.
- Thin material can be cut with tin snips.

Sustainable Energy Work Practices
Sustainable work practices involve:

- Working safely with electro technology.
- Reduce energy usage where possible but switch off electrical systems when not in use.
- Maintaining and repairing tools and equipment.
- Reducing waste products.
- Reusing and recycling materials.
- Responsibly disposing of waste products

All waste whether it is the materials or energy represents loss of resources and loss of money. Reducing waste can help:

- Reduce operating costs,
- Reduce waste disposal costs,
- Reduce long-term liability,
- Help sustain environmental quality,
- Project a positive public image for an organization.

Sheet metal stock materials are sold in standard sizes. This means "set lengths" for bars, rods and pipes and set length and breadth for sheet materials. Efficient ordering means purchasing stock sizes so as to obtain the maximum number of job pieces (blanks) out of a stock length or sheet area. The key is to eliminate the amount of "off-cuts" which invariably is wasted. When performing the calculation on usage, always consider the "cut" wastage ("kerf"). For example, a guillotine has a "shear action" which has virtually no loss, but a saw will have a loss of about 2-3mm for each cut. If the job pieces are small, and there are many "cuts" to be made then this loss can be significant. If the job length is small, always pre-determine if the stock material can be safely secured after it has been reduced to a small size. That is, can you safely make the final cut(s) or does this section become waste also.

The method used to mark out a sheet will depend on whether it is a one-off task or a large production run. For a "one-off-task" always attempt to use up an off-cut from a previous job if possible and avoid cutting a "new" sheet. For a production run involving a full sheet, always consider how the sheet is to be cut. For example, a guillotine will only make complete cuts across the sheet, but a "gas" cutter or "laser" cutter can cut virtually any length or shape.

If using a guillotine, common edge cutting is a more efficient method as the one action can produce a number of pieces. But it may also lead to wastage. Computer controlled machines are able to obtain the optimum cut from a sheet. Other techniques include, nesting small parts in cut-out holes and making use of suitable off-cuts where possible.

Always re-check all marking out measurements prior to cutting to ensure no error wastage. Always remember the saying "measure **twice** and cut **ONCE**".

T11 Low tolerance measurement encompassing:

- tolerance
- techniques in using vernier callipers
- techniques in using micrometers.
- using vernier callipers to measure engineering components
- using micrometers to measuring engineering components

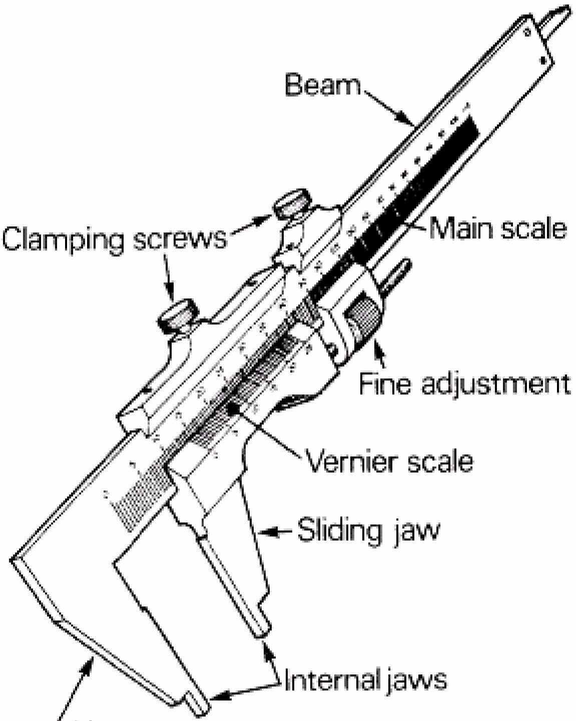
Tolerance
Engineering "tolerance" is the maximum permissible limit or limits of variation in a physical dimension, a measured value.

Eg: It could be the space between a bolt and a hole, etc..

Dimensions, properties, or conditions may vary within certain practical limits without significantly affecting functioning of equipment or a process. Tolerances are specified to allow reasonable leeway for imperfections and inherent variability without compromising performance.

A variation beyond the tolerance is said to be non-compliant, rejected, or exceeding the tolerance (regardless of if this breach was of the lower or the upper bound). If the tolerance is set too restrictive, resulting in most objects being rejected, it is said to be intolerant.

A primary concern is to determine how wide the tolerances may be without affecting other factors or the outcome of a process.



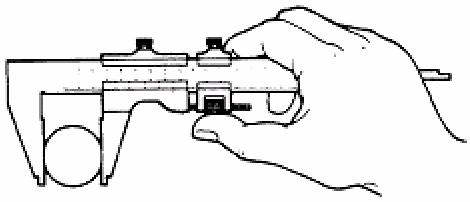
VERNIER CALIPER

Vernier Calliper (Vernier Gauge)
NB; A "**calliper**" is an instrument designed to measure the distance between two points.

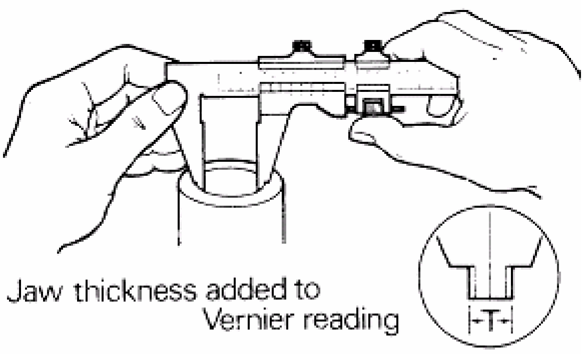
A "**vernier calliper**" is a precision tool used to obtain very accurate measurements for machined components.

A "vernier" is a small movable graduated scale used in combination with a fixed "main scale" to obtain high precision.

Eg: A "vernier gauge" can be used to accurately measure a motor shaft and housing diameter to identify a suitable bearing type.



Measuring an outside diameter



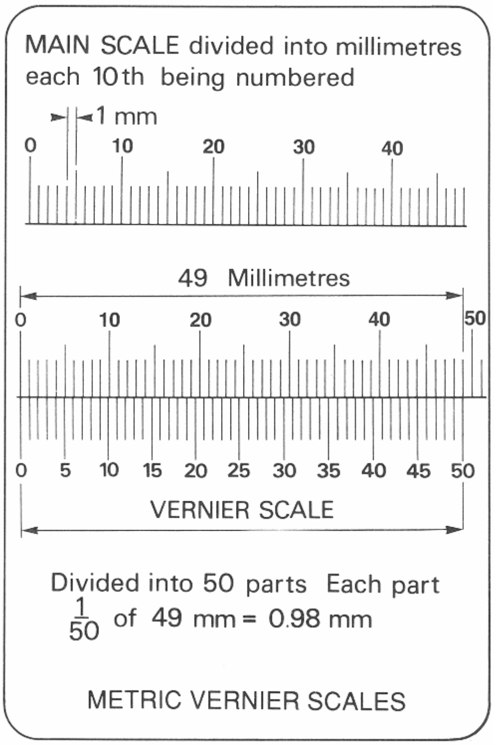
Measuring an internal diameter

A vernier gauge consists of two scales:

- **Main scale**
- **Vernier scale.**

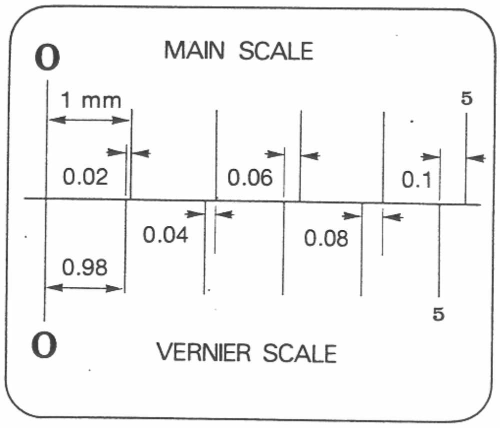
The base tool is designed in such a way that the one instrument is able to take "external", "internal" and "depth" measurements, and can be used in locations such as narrow slots that are inaccessible to micrometers.

A vernier is an expensive high precision instrument and as such requires great care. When not being used, it is essential that it is wiped clean, very lightly oiled with suitable protective oil and stored in its protective case.



Principle of the Metric Vernier
The principle of a standard metric vernier with an "accuracy" of "**0.02mm**" is as follows:

- The main scale is graduated into millimetres, with each tenth millimetre being numbered.
- The vernier scale is made **49** millimetres long and divided into **50** equal parts.
- The length of each division is therefore one fiftieth of the total length of 49 millimetres.
- 1/50 of 49 mm – 0.98 of a millimetre
- The main scale divisions are one millimetre long. The vernier scale divisions are 0.98 of a millimetre long. This means that the vernier scale divisions are 0.02 of a millimetre shorter than the main scale divisions.
  - 1 mm – 0.98 mm = 0.02 mm
- From the sketch, note that each vernier division is progressively displaced by 0.02 of a millimetre from its corresponding main scale division.

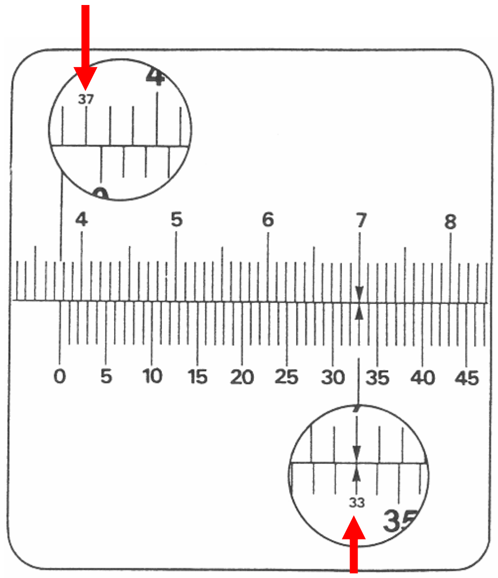


NB: The key reading is the point where the two scales become aligned.

Reading a Metric Vernier
Read a metric vernier with an accuracy of 0.02mm as follows:

- Read the main scale to the left of zero of the vernier in millimetres
- Now look at the vernier scale
- Note which <u>one</u> of the vernier divisions is opposite a line on the main scale
- Each of the lines on the vernier scale represents a division that is 0.02 of a millimetre shorter than those of the main scale. Multiply the number of the line on the vernier scale by 0.02 and add the result to the reading of the main scale.
- The sketch shows the reading on a vernier.
- There are "**37**" full divisions on the main scale to the left of the zero. This equals 37 millimetres.

- The thirty third line on the vernier scale is opposite a line on the main scale giving:
    - **33 x 0.02 which equals 0.66 mm**
- Now add 0.66 mm to the main sale reading of 37 mm to give a total reading of **37.66 mm**.



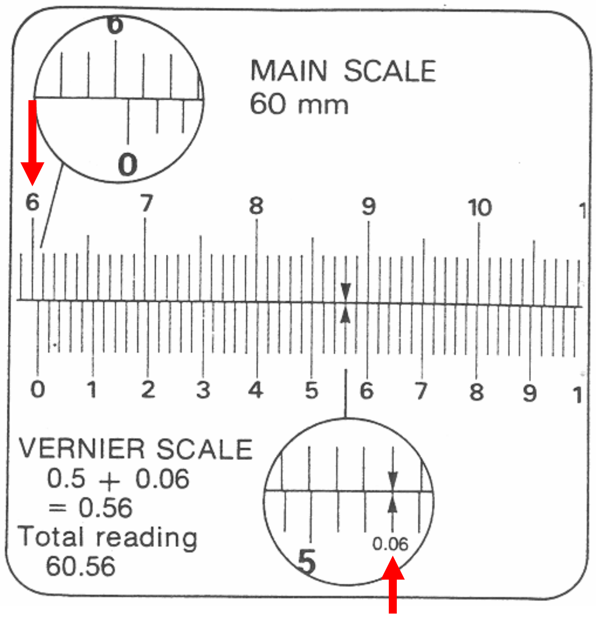
Note:
Another type of vernier scale is commonly used apart from the one shown in the above example.

- This design still has a vernier scale 49 mm long but each fifth graduation of the vernier scale is numbered from 1 to 10.

  (ie: There are still "50" minor division as before.)

- Because each division on the vernier scale still represents 0.02 mm, then the fifth line representing: 5 x 0.02 which equals 0.1 mm is actually marked number 1.

  Ie: "1" corresponds with 0.1mm and "2" corresponds with 0.2mm and so on.

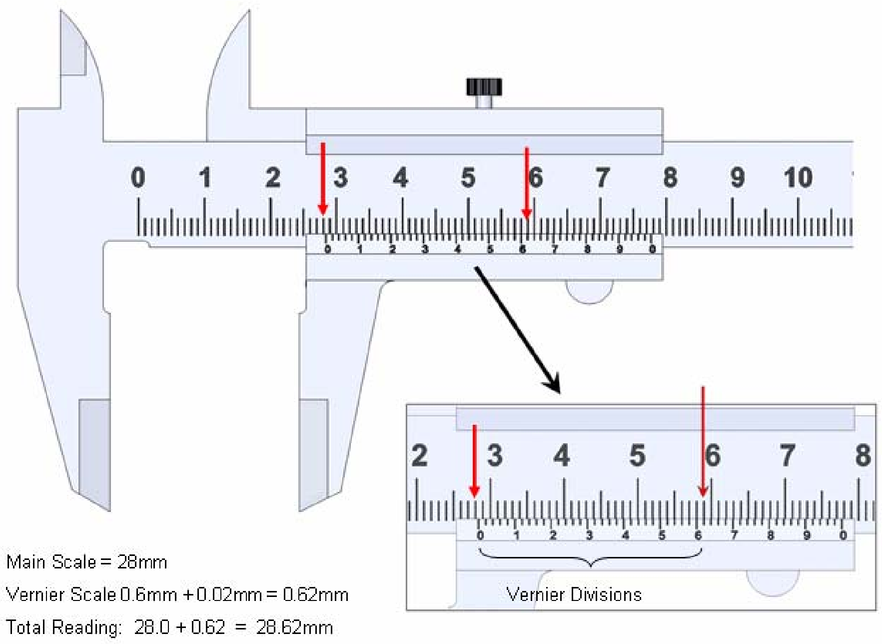


- This makes it easier to read as you do not have to multiply as shown earlier. You can directly read the decimal fraction off the vernier scale.
- In the example to the right, the whole millimetres from the main scale are "60mm" and the decimal fraction from the vernier scale is "0.56mm", giving a total of.

  60 + 0.56 = 60.56mm

Ie: The principle is identical to that shown earlier as it still has "50" divisions, but, the renumbering of the vernier scale means the user does not have to multiply to get the reading.

Example 2

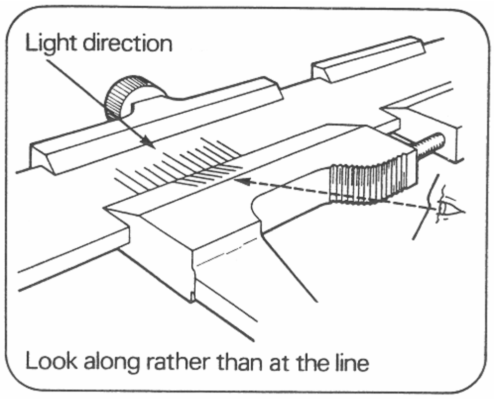


NB: In this example the vernier scale is graduated from "0 to 10" which means you can use a direct vernier scale reading.

- In the sketch above, the number of whole millimetres of the main scale immediately to the left of the vernier scale's "0" point is "**28mm".**
- Next, the division of the vernier scale which aligns best with a main scale graduation is "**62**" meaning that the decimal fraction component is 0.62mm.
- Therefore, the full reading is becomes: **28mm + 0.62mm = 28.62mm**

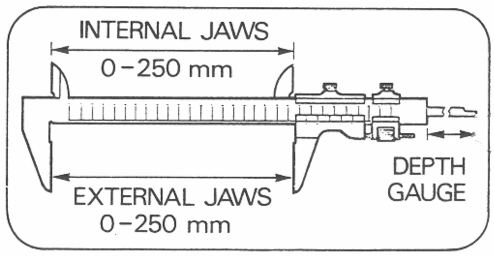
Using a Vernier Calliper

The procedure for using a vernier calliper is as follows:



1. Move the sliding jaw to the approximate position required,
2. Lightly tighten the locking screw on the fine adjustment clamp.
3. Adjust the sliding jaw by means of the knurled fine adjustment nut until; with the instrument square to the work piece, the jaws contact the work piece with a sensitive feel.
4. Lightly tighten the locking screw on the sliding jaw.
5. In general, the precautions against strain, misuse and faulty storage applying to micrometers (given below) are also essential for vernier callipers.
6. The next task is to determine which division of the "vernier scale" aligns best with a division on the "main scale".
7. A good magnifying glass is helpful when reading a vernier, but, when one is not available, hold the vernier so that you are looking at the scale at an angle and in line with the graduated line. (As shown to the right.)
8. Move into a position where the light strikes from the back of the vernier scale at about the same angle as your line of sight.

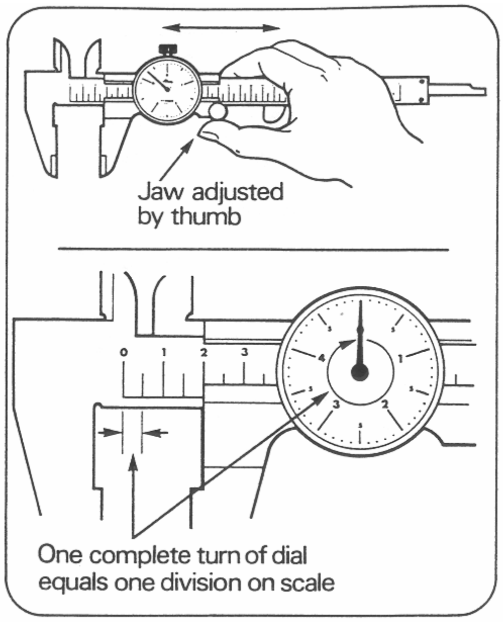
Characteristics of a Vernier Calliper
An advantage of a vernier calliper over a micrometer is that the standard tool may measure from zero up to the length of the main scale, often 250 millimetres or more.



Also, the base tool can measure both outside, inside and depth readings.

The disadvantage of a "vernier" is its accuracy is only "0.02mm" compared to a micrometer's accuracy of "0.01mm".

Dial Type Vernier Callipers
This design of calliper has an attached dial face reading device which replaces the vernier scale. They will measure to the same accuracy as other verniers. The dial gives the advantage of quick and easy reading.



The dial is graduated to represent a proportion of the main scale division.

One complete turn of the pointer around the dial represents a distance of one main division on the main scale.

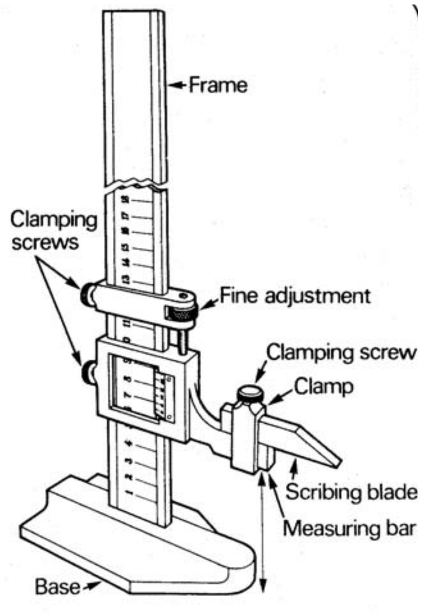
NB: Verniers which incorporate a digital readout are also manufactured.

Vernier Height Gauge
The vernier height gauge is a development of the standard vernier calliper. The graduated frame is held in a vertical position by being attached to an accurately ground base.

The base is commonly a "magnetic" design to enable it to firmly attach to a magnetic surface.

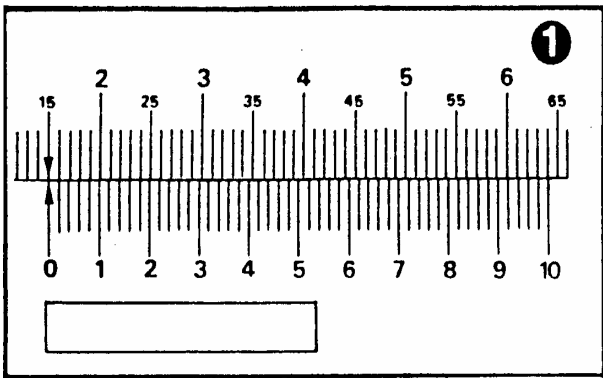
The vernier is read in the same way as the standard vernier calliper, except in this case, the reading is taken from the movable jaw to the base.

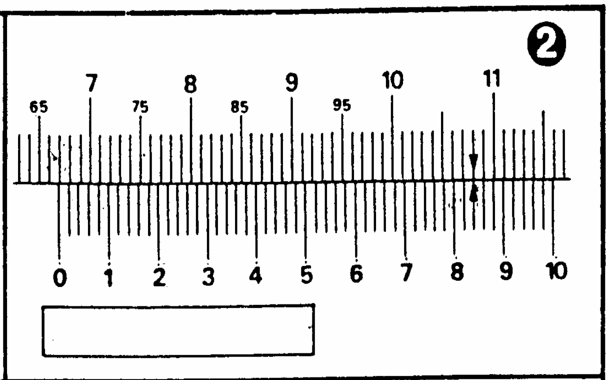
This tool is commonly used in conjunction with a surface plate or table and is designed for accurate marking out or checking heights.

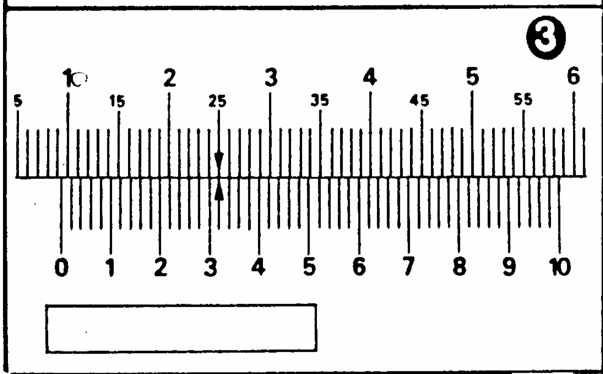


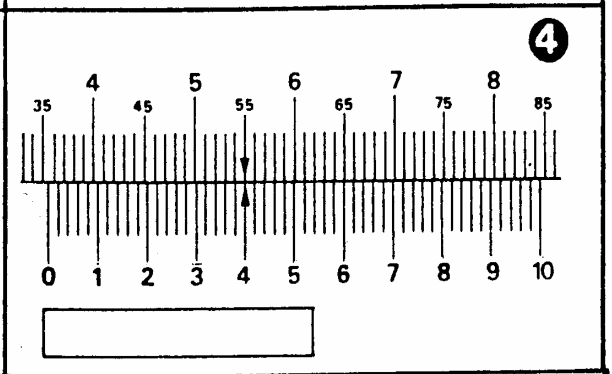
VERNIER HEIGHT GAUGE

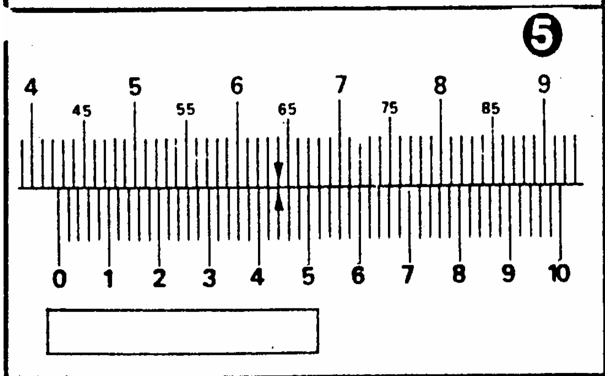
Metric Vernier Reading - Class Exercise
Determine the readings for the following positions and record in the box provided:

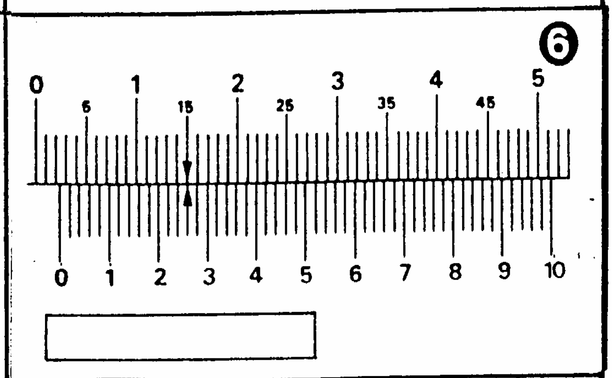


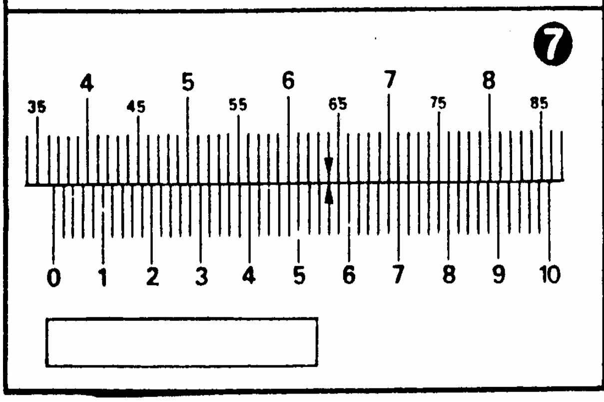


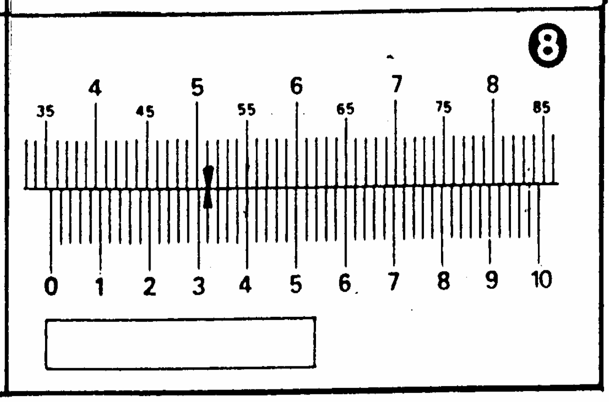




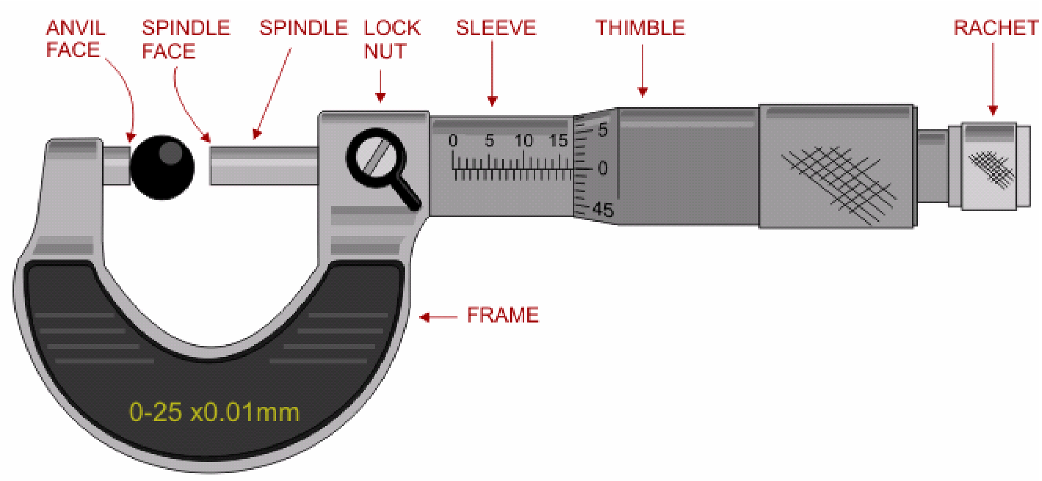




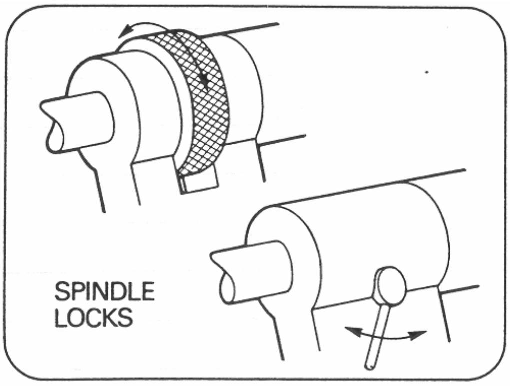




Outside Micrometer
An "outside micrometer" is a high precision measuring tool used to obtain accurate measurements of machined parts. The principle of the micrometer is based on the movement of a precision-cut screw rotating through a mating nut. The scales on the micrometer provide a means of counting the revolutions of the screw and converting them into a length measurement.



Metric micrometers measure to an accuracy of "**0.01mm**". They are available in various frame sizes including 0-25mm, 25-50mm, 50-75mm, 75-100mm, 100-125mm, 125-150mm and beyond.



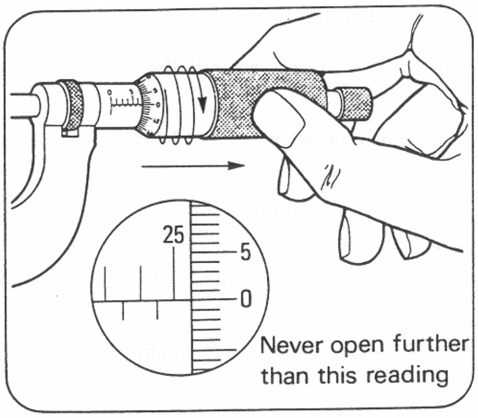
Metric models have a 0 - 25mm measuring range which is limited by the length of the thread on the spindle. While larger frame sizes enable sizes enable them to measure longer lengths, the measurement range does not increase.

The principal parts of the micrometer are:

- **Frame** – manufactured from drop forged steel to minimise distortion and determines the size of the micrometer.
- **Spindle** – made with an accurate screw thread one end, hardened, ground and lapped.
- **Lock Nut** – in which the spindle thread turns.
- **Sleeve** – Accurately graduated and clearly marked.
- **Thimble** – provides equally marked divisions and is fixed to the spindle.
- **Ratchet** – to ensure even pressure of the spindle so as to provide exact repetitive readings.
- **Anvil** – built into the frame in exact alignment with spindle

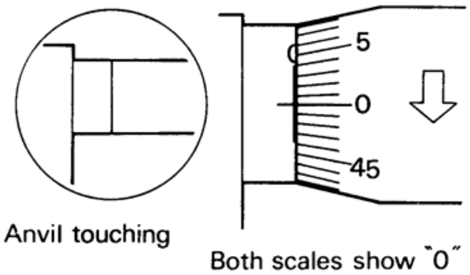
Principle of a Micrometer

A standard metric micrometer measures to an accuracy of 0.01mm. This is achieved through the combination of two scales. The “**sleeve or barrel**” scale which is graduated into millimetre and half millimetre graduations and the “**thimble scale**” which is graduated into 50 equal parts.



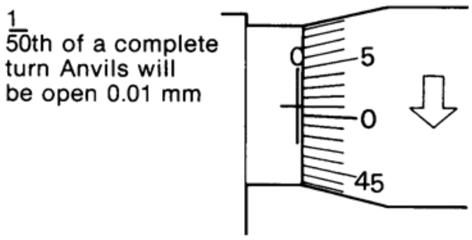
If the anvils are cleaned and then adjusted to touch each other, both scales should show "0".

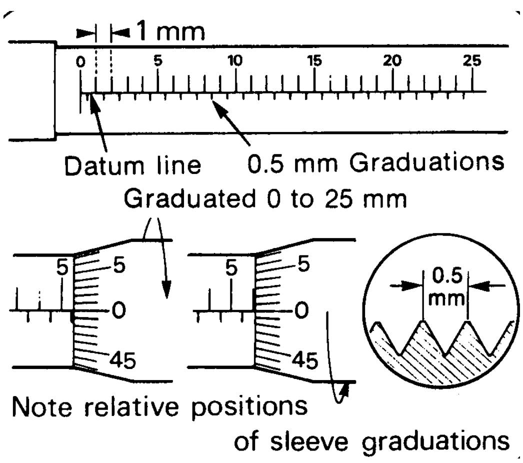
This action is referred to “**zeroing**” the micrometer and is always carried out just prior to use to ensure the accuracy of measurement.

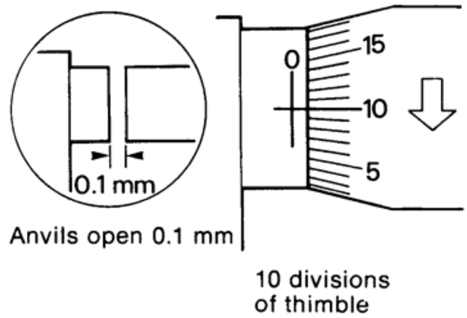


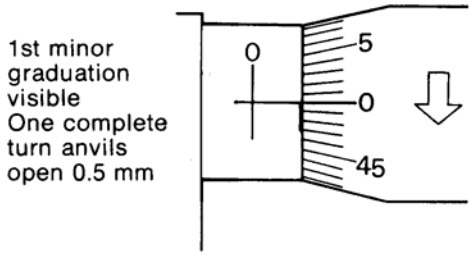
If the scales do not “zero”, then the barrel needs to be adjusted with the supplied "C" spanner.

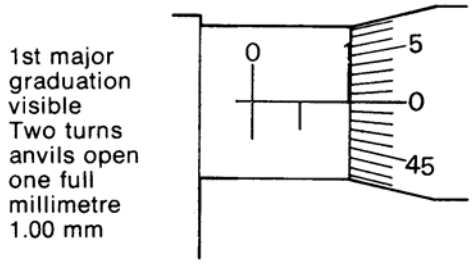
For micrometers larger than 0 - 25mm an appropriate test piece is used between the anvils so the specific micrometer can be checked “zero”.











Note the micrometer below with its “C” spanner adjusting tool.

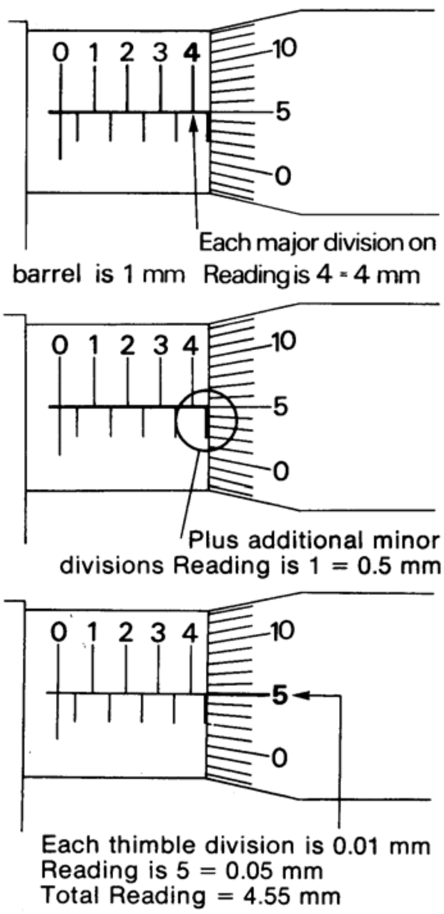
Reading a Metric Micrometer

1. Read from the sleeve or barrel scale, the number of “whole” millimetres that are completely visible. In the sketch to the right this is “**4mm**”.

2. Add any “**half millimetres**” that are “completely visible” on the sleeve.

NB: The key words are “completely visible” Here you must be careful as some instruments begin to partially display a “sleeve” scale graduation even though the thimble scale has not rotated past the zero point. If in doubt about a sleeve scale graduation, take a lead from the position of the “**thimble**” scale. In the example to the right, the half scale does show, and this adds “0.5mm” to the total.

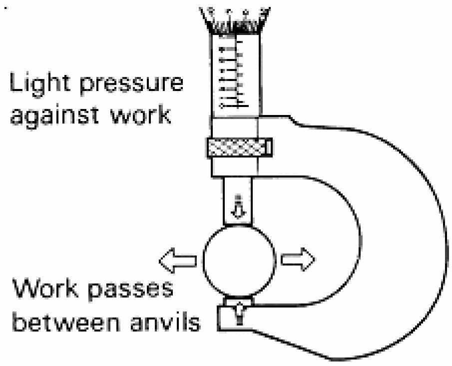
3. Note the number of graduations on the thimble scale that is level with the datum line and add to the previous values. In this example this adds a further “0.05mm”.

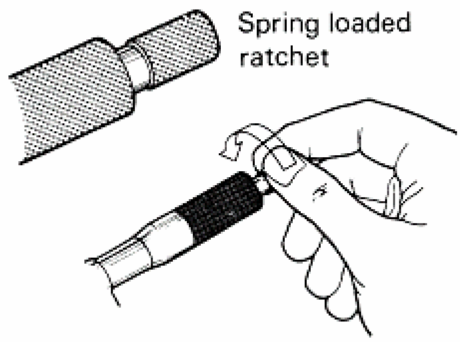


The total reading is **4mm + 0.5mm + 0.05mm = 4.55mm**

Using Outside Micrometers
Excessive pressure during adjustment will give inaccurate readings and cause strain on the thread and possibly distort the frame. To avoid this, micrometers are fitted with a spring-loaded ratchet that will ensure constant adjusting pressure on the component being measured provided the micrometer is kept square to the work.

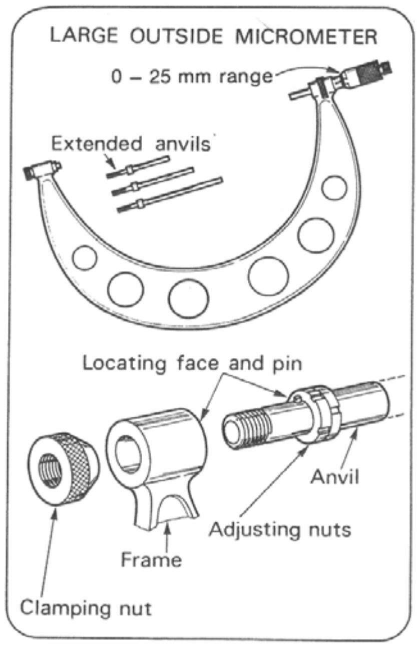
When using the micrometer, try as much as possible to have the graduations on the “barrel” scale towards you. If the frame cannot be supported by the left hand and only one hand can be used to hold the micrometer, support the frame on the lower centre of your palm using the little finger to hold the frame to the palm. Keep the first finger and thumb free to adjust the knurled thimble.





Micrometer Advantages
The main advantage of the micrometer over a base level vernier or other measuring instruments is the accuracy of 0.01mm.

Its disadvantage is the inherently low “range” that it has. Eg: As stated earlier, the range is typically only 25mm. The scope of measurements can be extended by using larger frames and extended anvils as shown below. These enable it to measure from 0mm up to about 100mm, but for every 25mm block, the anvil must be changed.



Large Purpose Micrometers
This tool is used to obtain very accurate and precise measurements of objects which are larger than can be accommodated by a standard micrometer.

- Large outside micrometers with interchangeable extended anvils make it possible to measure over a range of sizes.

- The micrometer consists of the normal barrel, spindle and thimble with a larger frame.

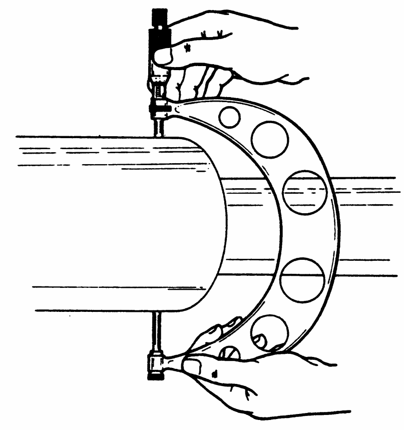
- The anvil in the frame can be removed by undoing a clamping nut that holds it in position.

- By selecting suitable anvils it is possible to take measurements progressively larger from zero to the maximum range of the micrometer frame.

- Care must be taken when changing anvils.

- Make sure the locating face on the frame and the collar on the extended anvil are clean and free from grit.

- Test bars are supplied with the micrometer. Always make a test reading with a test bar between the anvils before you measure with the micrometer.



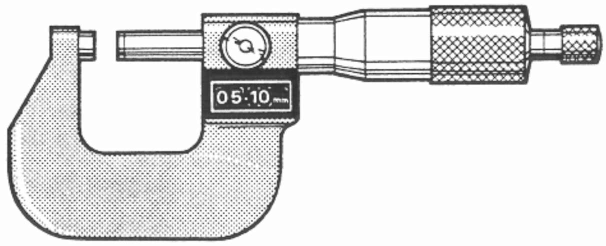
Large micrometer supported by both hands

Digital Micrometers
This tool operates on a similar principle to other micrometers but gives a direct numerical reading of size on a dial in the frame. The figures on the dial: -

- Make the micrometer quick and easy to read

- Ensure accurate measurement of size

- Help eliminate reading errors



DIGITAL MICROMETER

Metric Micrometer Reading -Class Exercise
Determine the readings for the following positions and record in the box provided:

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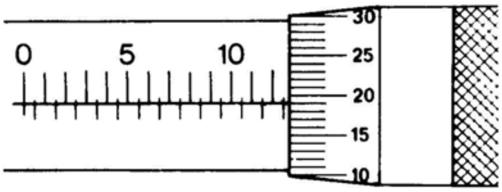

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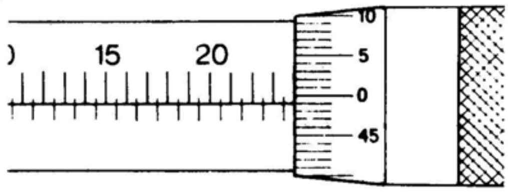

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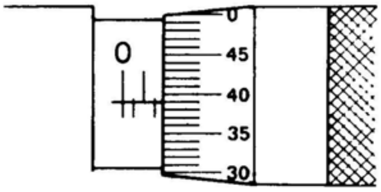

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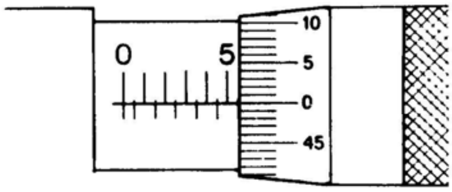

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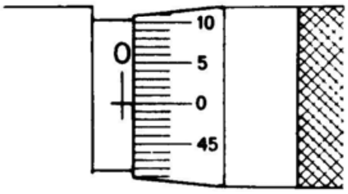

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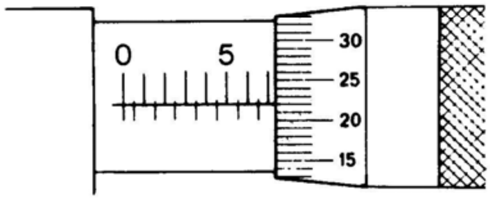

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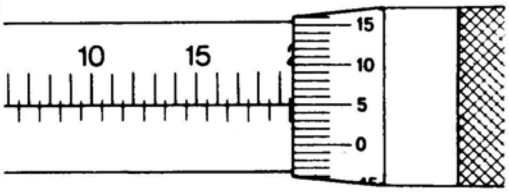

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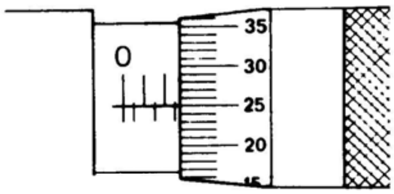

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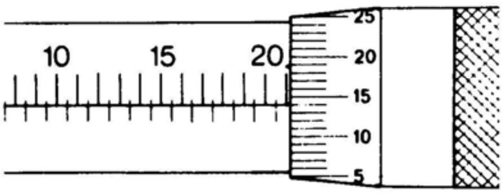

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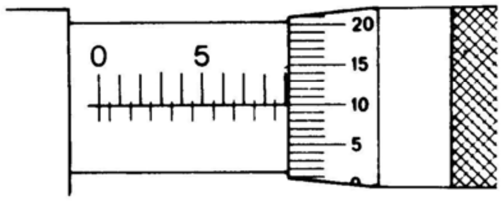
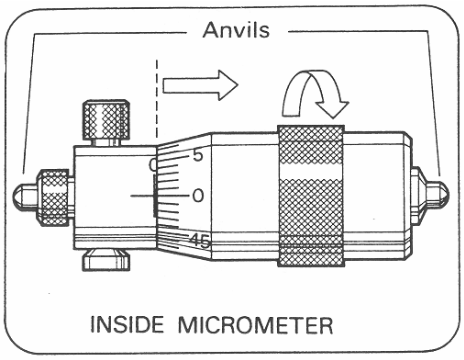


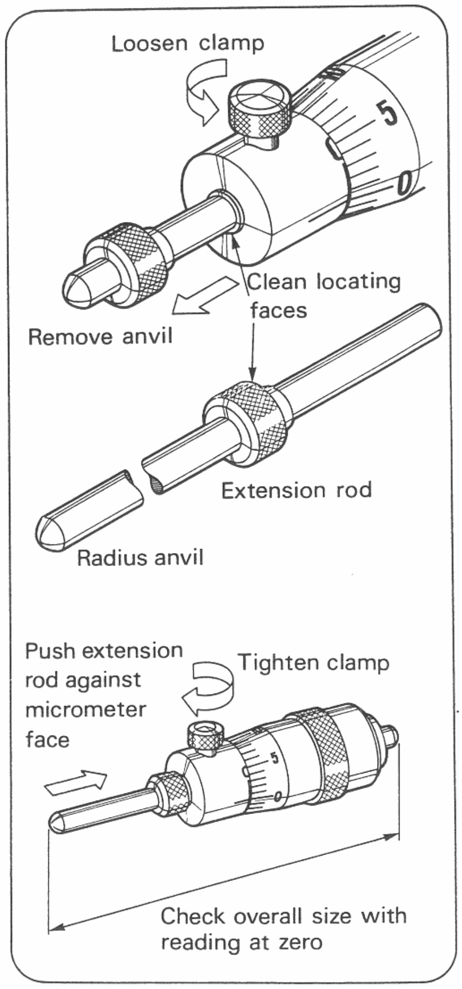
Inside Micrometer
Inside micrometers are used to measure:

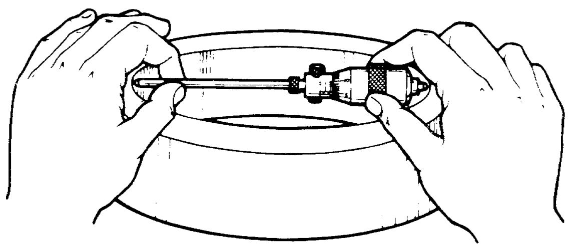
- Inside diameters of holes
- Distances between internal parallel surfaces
- Other inside dimensions
- Inside micrometers are provided with a series of extension rods to measure a range of sizes.



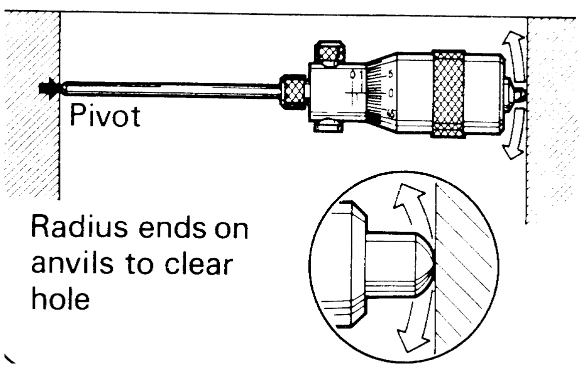
Fit an extension rod to an inside micrometer as follows:

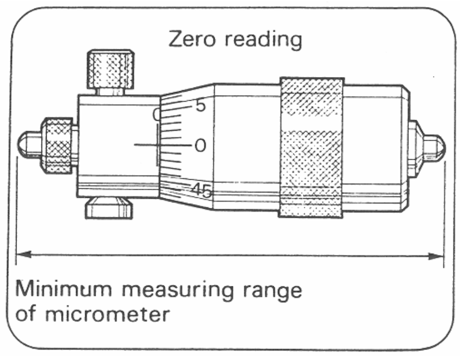
- Select an extension rod suitable to cover the range required
- Loosen the clamping screw on the sleeve
- Remove the existing extension rod and place it in its protective box
- Wipe the locating faces on the new rod and micrometer
- Insert the rod into the body of the micrometer with the curved anvil outwards
- Press the locating face against the end of the micrometer
- Tighten the clamping screw to hold the rod in position
- Check the zero setting of the inside micrometer by measuring it with an outside micrometer of the same size.





Measuring a large bore using an Inside Micrometer with an extension rod fitted



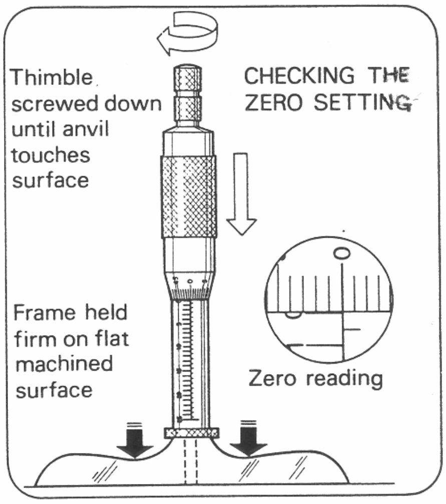


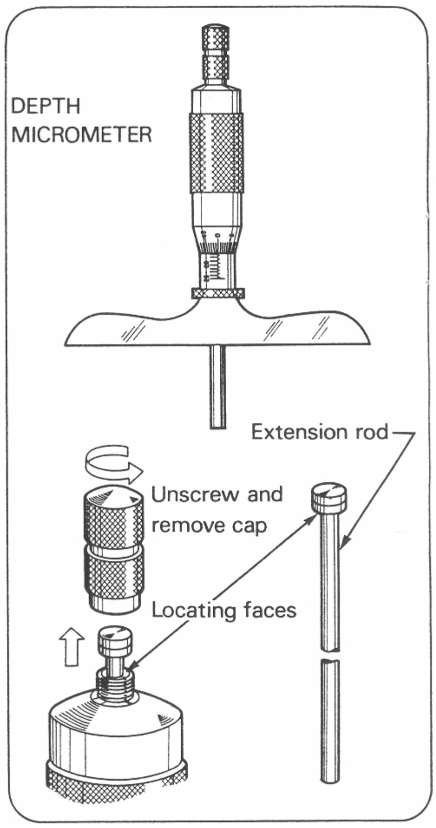
Depth Micrometer
Depth micrometers are special micrometers used to measure:

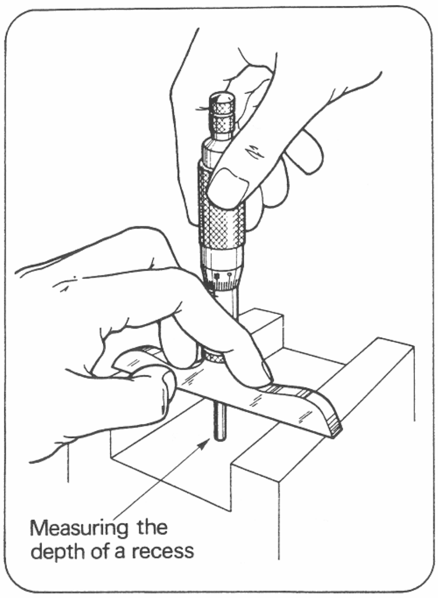
- Depths of holes
- Depths of grooves or recesses
- Heights of shoulders or projections
- The measuring range of depth micrometers can be increased by using interchangeable extension rods.

Change the extension rod of a depth micrometer as follows:

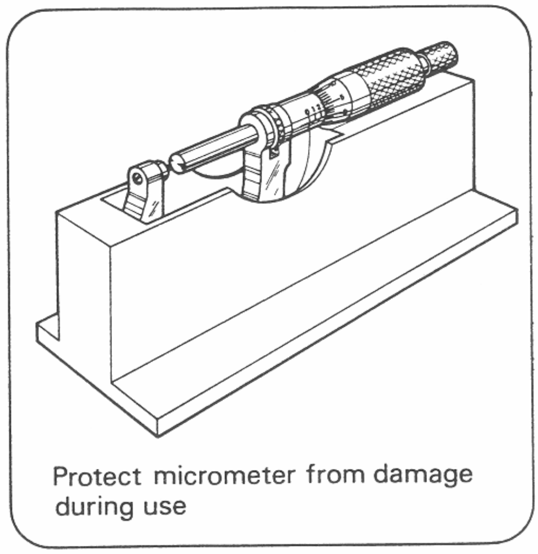
- Hold the lower portion of the knurl on the thimble firmly between the thumb and first finger of your left hand.
- Use the thumb and finger of your right hand to loosen the knurled clamp by turning it anti clockwise
- Unscrew the clamp completely from the thimble
- Remove the existing rod by pulling it completely out of the thimble and place it in the protective box
- Select a suitable length extension rod for the work to be measured
- Check carefully that the locating face on the end of the thimble and the shoulder of the extension rods are clean
- Insert the rod into the thimble and push it down to the locating face
- Replace the knurled clamping cap
- Tighten the clamp to a firm finger tight pressure





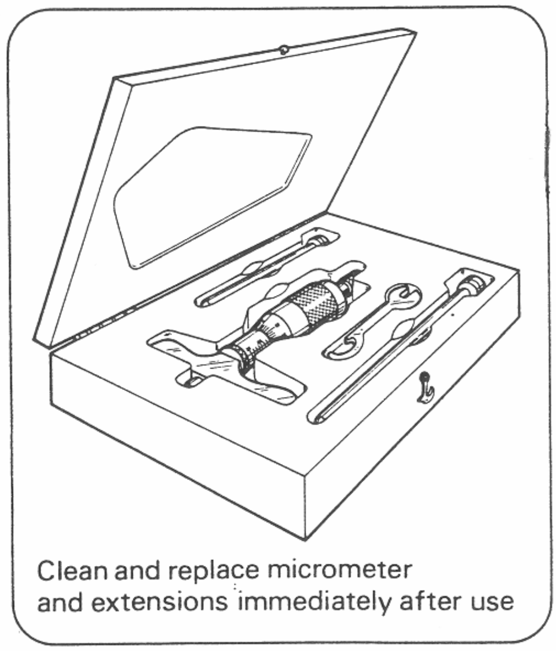


Care of Micrometers
Micrometers are precision instruments. Their accuracy depends upon the way they are used and stored. Some points to be considered when using micrometers are:



Protect micrometer from damage during use

- Clean the face of the spindle and anvil before using the micrometer
- Check the zero reading
- See that the work is clean and dry before measuring
- Do not attempt to measure over rough surfaces
- Make sure the work is stationary before attempting to take a reading
- Make sure the spindle clamp has been loosened before turning the thimble
- Do not screw the spindle beyond the barrel scale
- Never place the micrometer where it can come in contact with dirt or cutting fluids
- Handle the micrometer as little as possible and never allow it to be exposed to heat
- Keep the micrometer square to the work during readings
- Never apply excessive force to the thimble
- Endeavour to develop a light constant ‘feel’
- Do not put a micrometer down in a position where it could be knocked or dropped
- Replace any attachments, such as extension rods, in their box immediately after they have been used
- Do not attempt to make adjustments to micrometers unless you have been trained to do this
- Have micrometers checked regularly over their range of size
- When you have finished using the micrometer, it must be wiped clean, oiled with suitable protective oil and stored in a protective box.

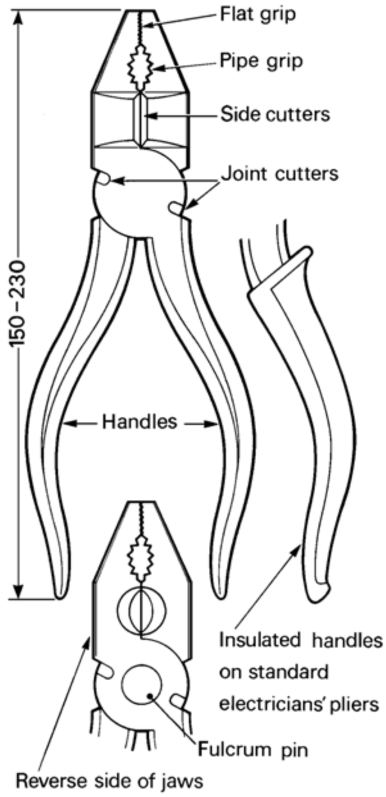


Clean and replace micrometer and extensions immediately after use

Maintenance and Storage Measuring Tools
All measuring tools should be cleaned free of dust and grit after use. If damp they should be dried with a clean rag and the blade returned into the case passing through an oil saturated cloth. This equipment should be carefully stored in a tool box or drawer.

T12 Dismantling and assembly techniques encompassing:

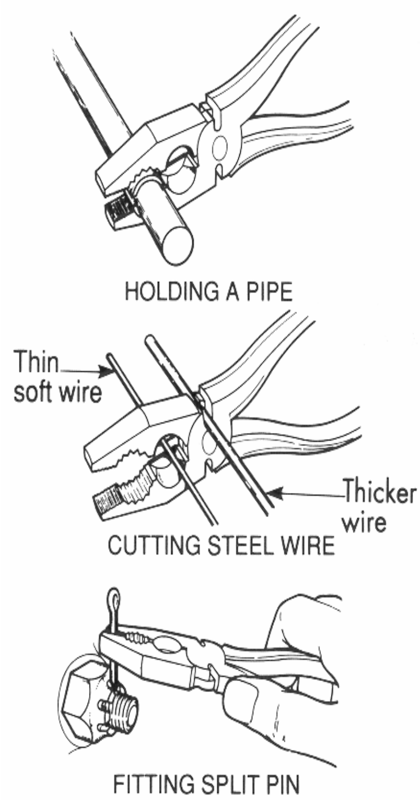
- tools used in dismantling and assembling electrotechnology equipment (spanners, screwdrivers, bearing pullers, etc).
- procedures for ensuring the safe treatment of dismantled components.
- dismantling electrical, electronic, instrumentation or refrigeration/air conditioning piece of equipment using correct procedures.
- assembling electrical, electronic, instrumentation or refrigeration/air conditioning piece of equipment using correct procedures.



Dismantle and Assembly
A common task that an electrician is expected to perform is dismantling and reassembling electrical/electronic equipment and accessories. Because there are innumerable variations to these products, an electrician must always include a range of suitable tools in the kit. The following are some of the more commonly used tools needed to perform this task.

Pliers
Pliers are gripping tools used to hold small components that would otherwise be difficult to grasp and control. Pliers are also used for shaping and bending light sheet metal as well as bending, twisting and cutting small diameter wires.

Combination Pliers
Standard engineers' pliers are also called combination pliers because of their versatility. These pliers combine the function of a number of types of pliers and therefore have a wide variety of uses in the electrotechnology industry. Combination pliers are available in sizes from 150 to 230mm.



USING PLIERS

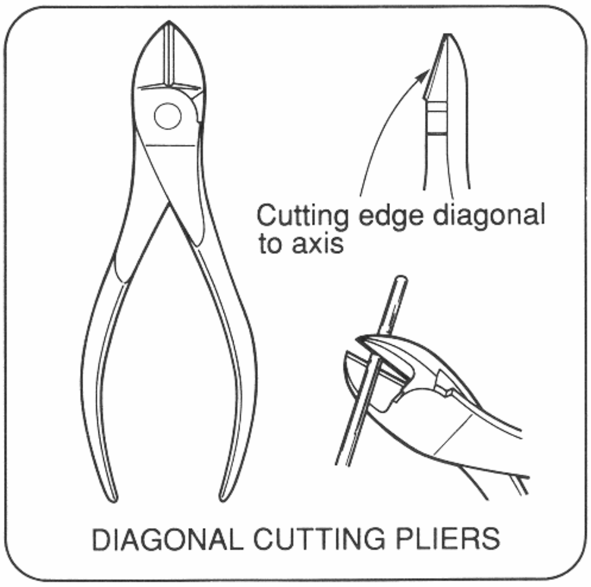
Applications:
- The flat jaw tips are serrated for general gripping, bending and twisting etc.
- The pipe grip is serrated for gripping cylindrical objects.
- Two joints cutters are provided for shearing off steel wires.
- Side cutting jaws are for cutting softer wires, e.g. copper etc or stripping cables.

Note: Stripping electrical cables with this tool so as not to damage the copper conductors requires a great deal of practice.

- To cut harder steel wires, use only the joint cutters. These have strong 90° shearing edges and are placed to have greater mechanical advantage than the side cutting jaws.
- To cut, open the pliers wide until the cutter grooves in adjacent jaws line up. Insert the wire with the short end facing away. Squeeze to cut.

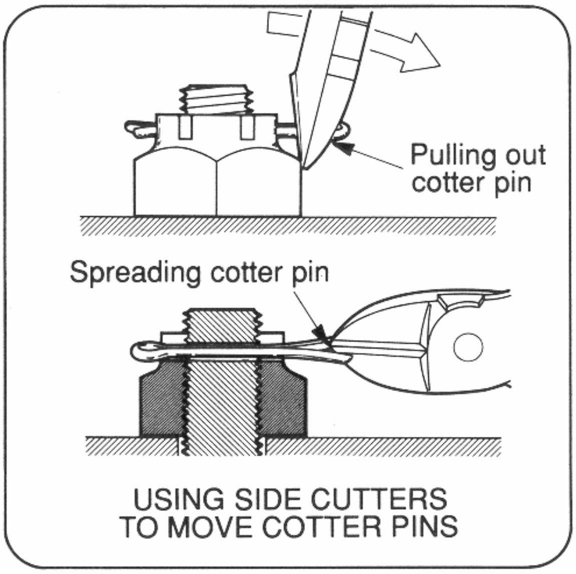
Warning

- Never cut wires that are under tension until you have made sure that the ends cannot fly dangerously. Always wear safety glasses for this type of application.
- Grip small round objects at right angles to the flat jaws for greatest control.



Diagonal Cutting Pliers
This tool is designed to neatly cut wires. They are especially useful for cutting copper wires.

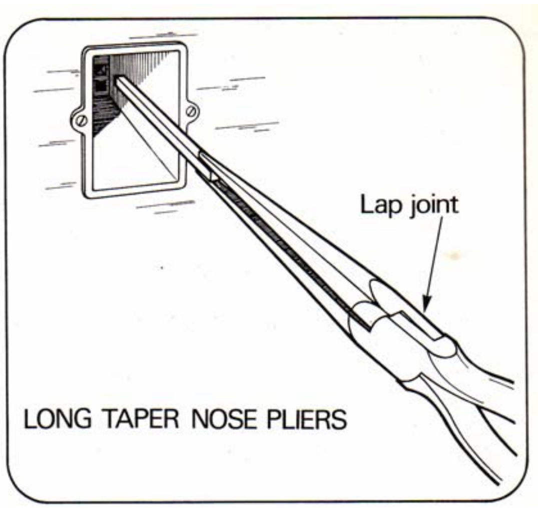
Another name for diagonal cutting pliers is '**side cutters**'. These cutters are made with the jaws cranked, or offset. That is, they are set at an angle which allows wire to be cut close to a surface or in confined spaces. They are also available with insulated handles for electrical work.



Note: Never cut electrical wires unless you are certain that the electrical power has been first disconnected.

NB: If in doubt, always use an electrical tester (multimeter) device to confirm that the cable is de-energized prior to cutting. If you are working near the middle section of a cable which cannot be traced out, use a "non-contact" electrical tester to confirm that the cable is de-energized. Remember: Always "prove-test-prove" when using an electrical tester to test for de-energization.

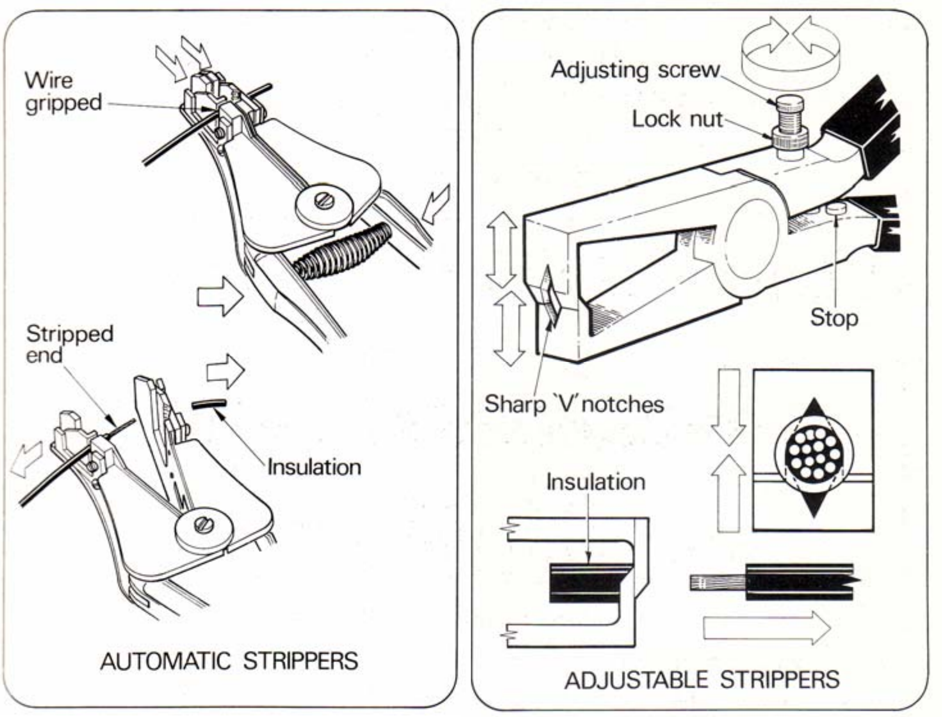
Warning
Short ends of wire, particularly steel wire, are liable to fly considerable distances when cut. Guard against this. Cut with the free end of the wire pointing away from you and aimed into a closed receptacle such as a bin. Always wear goggles or safety glasses.



Long Nose Pliers (Long Taper Nose)
Long-nosed pliers are sometimes called "needle-nose" pliers. This tool is useful for holding small objects and reaching into confined spaces and for making delicate adjustments to equipment.

Wire Strippers
This tool is used to cut back the insulation from electrical wire without damaging (nicking) the copper wire strands. When using this type of tool, always make sure that it is correctly adjusted before attempting to strip the insulation.

Once the adjustment is made, a steady squeezing and pulling action will strip a wire. There are a number of designs made including the three are shown below.



Ref: http://www.sparksdirectsupplies.co.uk/products/item/kew-technik--automatic-wire-stripper-ws-250/

Maintenance and Storage
Moving parts of tools should be tight and kept oiled and cutting edges free of gaps and sharp. Tools should be stored in a suitable container or on a shadow board.

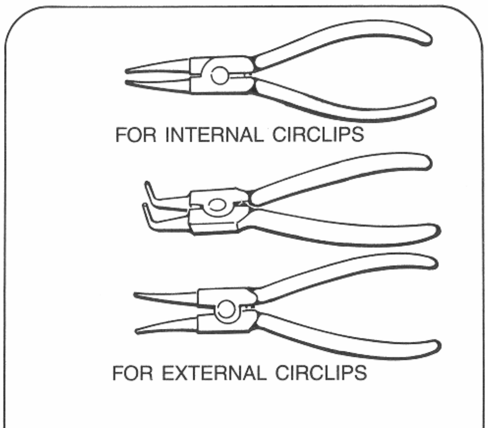
Tools will begin to rust very quickly if exposed to the weather.

Circlip Pliers
Circlip or “snap ring” pliers are designed to install and remove “external” or “internal” circlips. A “circlip” is a form of spring used as a fastener. The ring is elastically deformed, put in place, and allowed to snap back toward its unstressed position into a groove or recess.

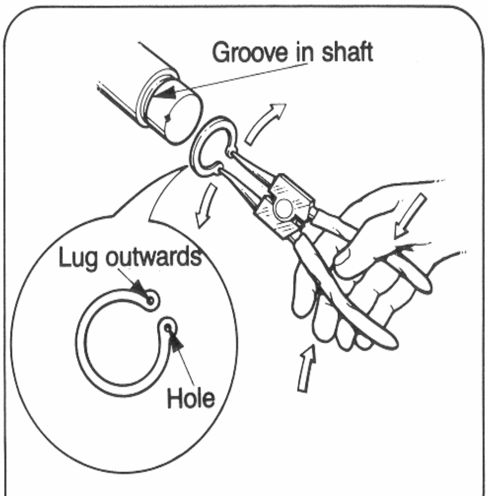
Applications
Circlips are used to secure fans onto motor shafts and locate bearings in end housings etc.

The size and type of circlip will dictate the tips needed on the jaws on the pliers.

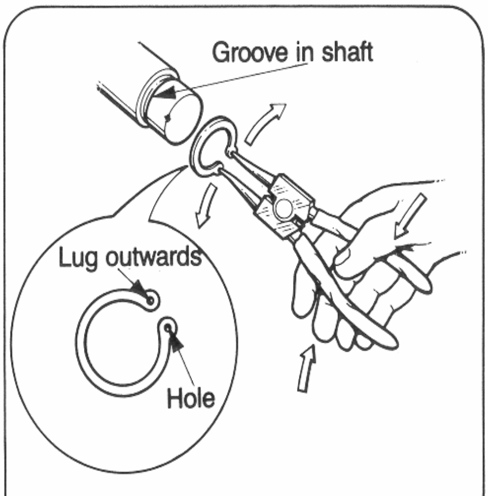
Circlips with a small hole at each end require round jaws and those with a slight bevel at each end require flat jaws.



CIRCLIP PLIERS



EXPANDING EXTERNAL CIRCLIP



EXPANDING EXTERNAL CIRCLIP

NB: Where there is limited space in front of the circlip, pliers with angled jaws can be used. An external circlip is expanded with a pair of external circlip pliers to remove or install it. An internal circlip is contracted using a pair of internal circlip pliers to remove or install it.

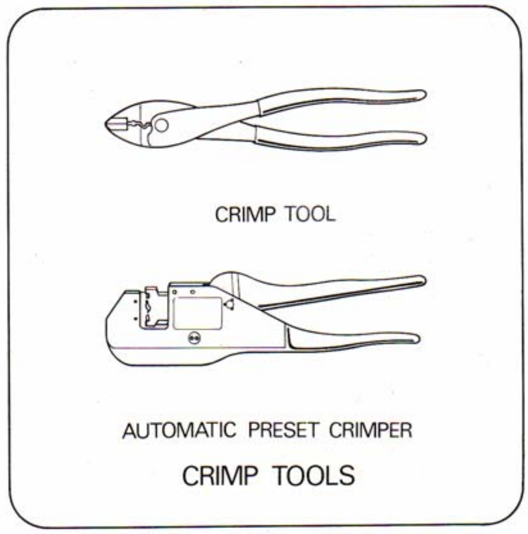
Care
This is a specialized tool and should be kept in a protected location. It should not normally be grouped with the common tools as the fine tips will get damaged.

Crimping Tool
Crimping tools are used to crimp (deform) a wide variety of cable “lugs” and “connectors” used terminate electrical conductors.

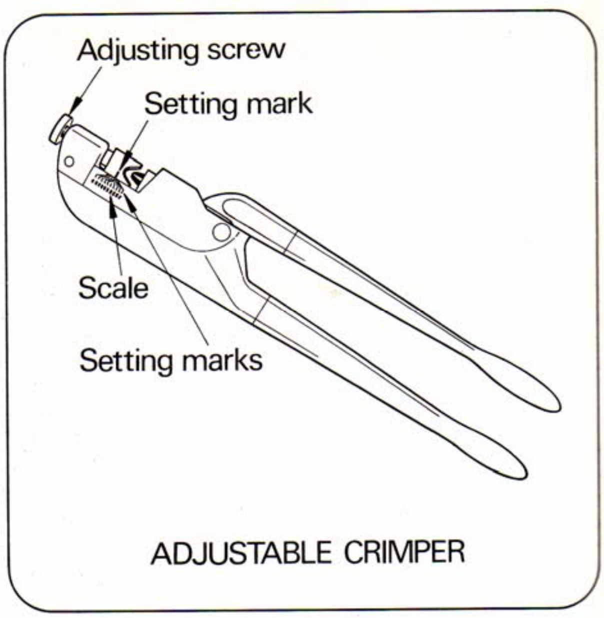
They use compressive force to constrict or deform a specially designed connector or cable lug.

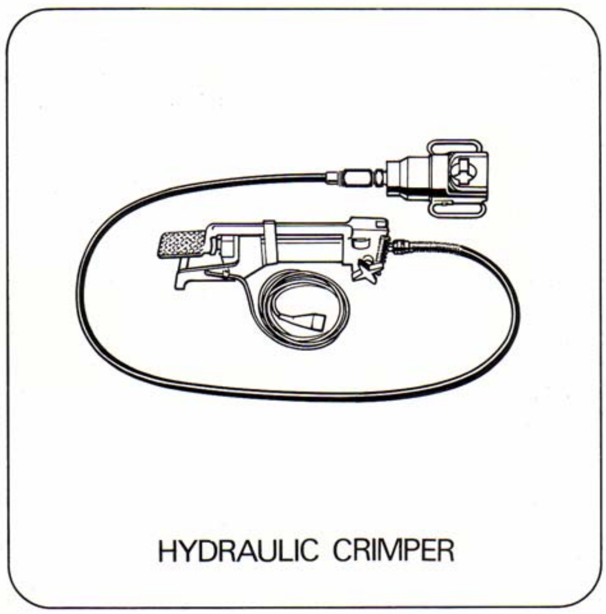
Crimping tools fall into two basic categories, small “hand operated” types for smaller sizes and large “hydraulic powered” types for very large high-current electrical connections.

NB: The automatic crimping tool to the right is a hand operated tool for small cable lugs. It is purpose built where the different cable lug sizes are colour matched to the jaw position.



The tool shown at the bottom right is a hydraulic crimper typically used to crimp very large cable lugs and connectors.





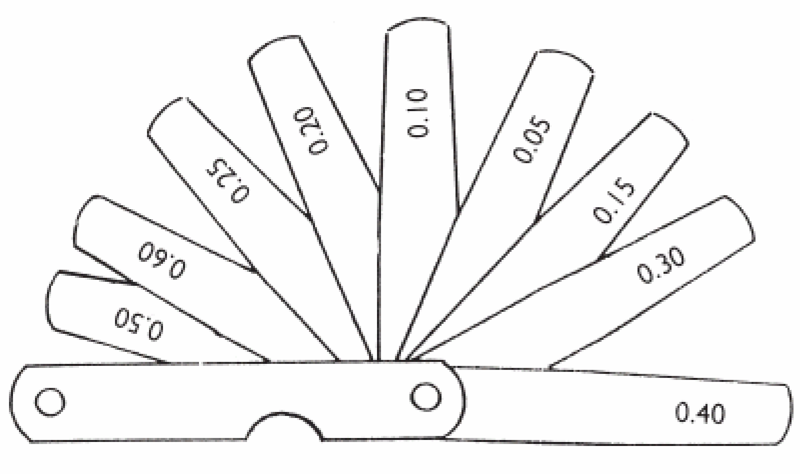
Parallel Pin Punches
Pin punches are made from hardened steel and are often used as a "drift" to remove or insert locking pins, dowels and rivets etc during assembly and disassembly.

Nb: A hand made "copper" or "brass" drift is often substituted in situations where the machine part being disassembled could get damaged by a "hardened steel" drift.

Safety
As for all punches, always keep the head of the punch free from burrs and ensure that the punch is squarely struck with the hammer.

NB: Wear eye protection when using punches as chips may fly and keep you fingers away from the striking and point areas.

Feeler Gauge
A "feeler gauge" is a fine measuring tool with a handle (similar to a multi-bladed pen knife) which holds multiple blades of hardened steel that are ground or rolled to an accurate and constant thickness.



- Each individual blade is stamped with its thickness measurement in millimetres.

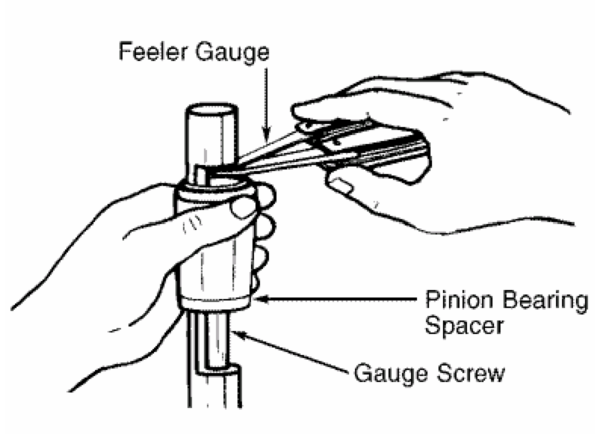
- The blades can be used singly, or in combination to accurately measure the spacing between two surfaces or points.

- Feeler gauges are only used to measure very "small" clearances.

- With the correct clearance, the feeler gauge should slide snugly between the two parts with a slight resistance.

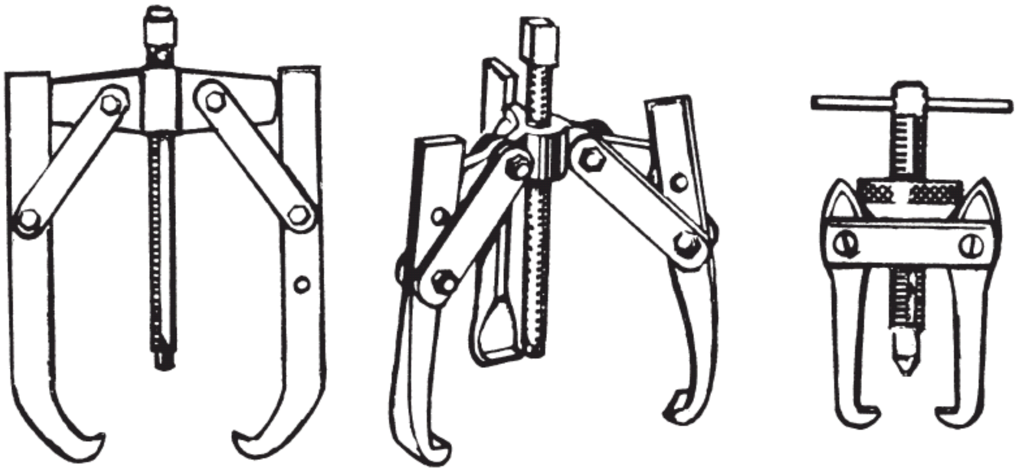
- The drawing above illustrates a set of metric feeler gauges ranging from 0.05 mm to 0.60 mm

- The sketch shows a feeler gauge being used to measure clearance.



Bearing Puller

This tools main function is to remove components, such as a “gear”, “pulley” or “bearing” etc from a drive shaft.



When first assembled these components would have been “press” or “shrink” fitted” to secure them to their drive shaft and it typically requires considerable force to remove them during disassembly. Bearing puller “sets” are made up of a range of interchangeable parts of various sizes and shapes, all designed for perform specific applications. They consist of three main parts:

- Jaws
- Cross Arm
- Forcing Bolt

Normally there will be “two” or “three” jaws in the set that can be used on a puller. They are designed to work either externally around a pulley, or internally. The forcing bolt has a very long very fine “vee” thread and is directed to the center of the drive shaft. When the forcing bolt is rotated with the aid of a spanner, its very fine screw action enables the puller to exert great force between the end of the shaft and the object to draw it off the shaft.

Safety check

- Always wear eye protection when using a bearing puller.
- Make sure that the puller is located correctly on the work piece. If the jaws cannot be fitted correctly on the part, then select a more appropriate puller.
- Do not use a puller that does not fit the job.

Process

1. Examine the puller you have selected for the job. Identify the jaws – there may be two or three of them, and they must fit the part you want to remove. The cross-arm enables you to adjust the diameter of the jaws. The forcing bolt should fit snugly onto the part you’re removing. Finally, select the right size spanner to fit the nut on the end of the forcing bolt.
2. Adjust the jaws and cross-arms of the puller so that it fits tightly around the part to be removed. The arms of the jaws should be pulling against the component at close to right angles.
3. Use the appropriate spanner to run the forcing bolt down to touch the shaft. Check that the point of the forcing bolt is centered on the shaft. If not, adjust the jaws and cross-arms until the point is in the center of the shaft.
4. Tighten the forcing bolt slowly and carefully onto the shaft. Check that the puller is not going to slip off center or off the pulley. Readjust the puller if necessary.
5. If the forcing bolt and puller jaws remain in the correct position, tighten the forcing bolt

and pull the part off the shaft.

Ref: http://www.forums.woodnet.net

The image below illustrates a three limb bearing puller being used to remove a bearing from the "rotor" of an electric motor.

Care and Maintenance of Hand Tools
All tools should be serviced as part of a routine maintenance plan. All regulatory requirements for testing and calibration of instruments must be met. Summary of hand tool maintenance requirements:

Inspect:

- All tools, especially hammer handles for signs of defects.
- Never put a tool back into store or in a toolbox if it requires repair.
- Faulty tools should be tagged or marked so they are not used while faulty.
- The insulation of tools used by electricians. (eg: Pliers and screwdrivers).
- PPE for signs of defects.

Clean:

- All tools to ensure that dirt and grease is not affecting their effectiveness and safety.

Sharpen / Grind:

- Scribers and caliper points.
- Chisels and screwdrivers.
- Saw blades (where possible).
- Drills.
- The heads of chisels and punches etc for signs of mushrooming.
- Other cutting tools.

Lubricate:

- The surfaces of metal tools to ensure that they do not rust.
- All hinged joints of tools to ensure that they move freely.

Recondition:

- Any part of a tool where the safety or efficiency has been impaired through use. eg: Hammer handles.

Calibrate:

- Measuring tools such as Tapes and rules, verniers and micrometers.
- Ensure the accuracy of squares and protractors.

- Tension wrenches to ensure indicators are valid.

Storage:

- Ensure that all tools stored will not be damaged by their proximity to other tools and or they will not harm workers when they are retrieved.
- Ensure all tools which have pointed tips or sharp edges are well guarded when placed in storage.
- Ensure that before being stored tools are stripped down to their base form. Ie: Remove taps from its tap-wrench, the die from the stock and even the blade from a hack saw etc.
- Ensure that the jaws of tools are not stored fully closed as this can cause strain and long term damage.

Discard:

- All tools that are beyond repair must be discarded to ensure that they are not accidentally used. But, before disposal, render them totally unusable to ensure that they are not salvaged by an unsuspecting person.

Log:

- Maintain records for hand tools such as the brand, supplier, purchase date, disposal date and other relevant details etc. This data will ensure that future tool purchases are more reliable.

Assemble and Dismantle Machines

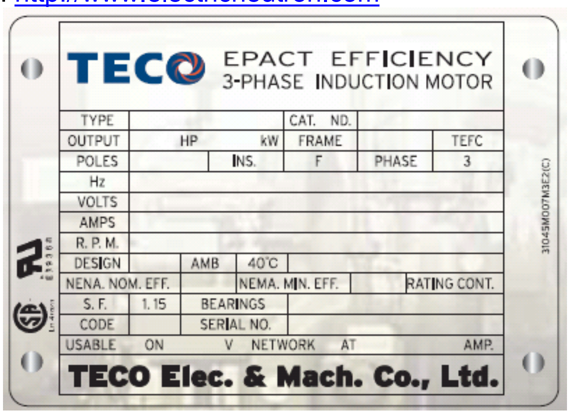
Electrical equipment must be dismantled for a variety of reasons including, routine maintenance, fault finding and repair, and sometimes during the initial installation phase.

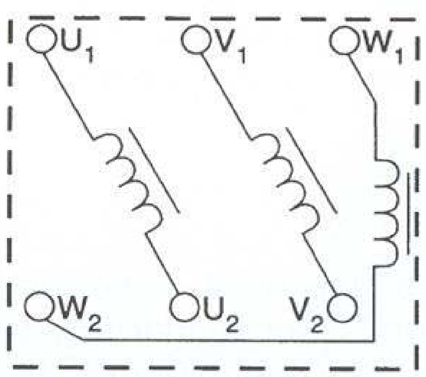
Preparation

Always attempt to obtain all available information regarding the machine prior to dismantling. This can be obtained from the machine's nameplate, product manuals, maintenance logs, form other maintenance staff and the operator. In particular you are looking for recurring faults or locations where persistent wear may occur.

A three phase motor is a piece of equipment that an electrotechnology tradesperson is required to both assemble and disassemble. A typical motor name plate and winding connections are shown below.

Ref: http://www.electricneutron.com





When dismantling a machine, the two possible approaches are:

1. Completely disassemble it without any detailed component inspection and then make a full diagnosis when all parts have been removed. This is a very quick disassembly.
2. Inspect and diagnose each component and only remove the faulty bits or those components needed to gain access to the faulty bits. This approach reduces the amount of unnecessary work.

<u>Considerations</u> before starting dismantling

1. Analyse the results of a "Risk Analysis".
2. Possibility that hazardous substances may be present within the machine and the need for suitable personal protective equipment (PPE).
3. Analysis of Safety Data Sheets (SDS). Possible environmental, fire or a health hazard to humans. Eg. Depending on its chemical composition, the oil stored within a transformer tank or a large capacitor can be toxic.
4. Warranty status. Once manufacturer's seals are broken, a machine's warranty may become void (ie. Invalid or not legally binding).
5. Inconclusive electrical tests and you are uncertain as to the precise status of the machine.
6. Prior machine history of the machine.
7. Possible Electrostatic Discharge Damage (ESD) issues.
8. The availability and quality of any support documentation.
9. Personal experience with similar machines.
10. Time frame available to complete the task.
11. Availability and cost of a replacement machine, compared to service costs,
12. Location where the machine is to be disassembled (eg: In situ, or workshop.)
13. Priority in terms of costs while the machine is out-of-service.
14. Interval time between the disassembly and reassembly.
15. Overt signs that the machine may be beyond repair, eg: Burn odour, peripheral case burning or overt physical damage.
16. Recovery value of possible salvageable parts.

Disassembly Sequencing

This is a detailed step-by-step approach to disassembly. Typically, the sequence may give the precise order that is to be followed and could be supported by detailed "assembly" drawing or images.

Criteria used to establish such a sequence is:

1. Worker safety,
2. Reducing the risk of any potential environmental damage due to spillage, or gas leaks etc,
3. Elimination of damage to the components during the disassembly process,
4. Fastest approach which reduces the disassembly time,
5. Component separation where one component must pass beside or through another component,
6. A sequence which will give service personnel access to the zones which have a high probability of component failure without the need to completely disassemble the entire machine. Eg: For a washing machine this may include the main controller area, the valves and the electric motor etc.

Example Sequence: Dismantle and Assemble Electrical Equipment and Removal of the Electric Motor

A disconnection procedure is as follows:

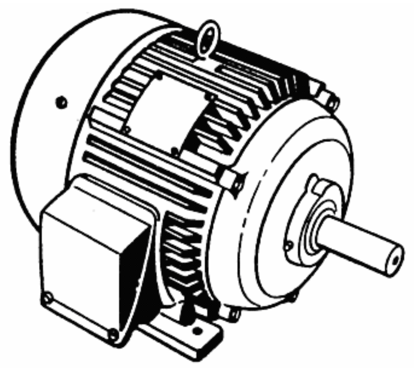
1. Notify all concerned persons of the isolation and removal of the motor.
2. Find an effective earthing point within the electrical system.
3. From this point, check that the frame of the motor is not LIVE
4. Check the direction of rotation of the motor if possible (and record details).
5. Locate the circuit isolator and isolate the power supply to the motor via the circuit break and motor isolator.
6. Pre-test the test device, test the terminals of the motor and then retest the test device on a known supply.
7. Attach a personal danger tag and lock out the isolating switch to prevent accidental reconnection of supply to the motor.
8. Disconnect the live conductors carefully marking and recording their position for reconnection. Disconnect the earth conductor last. Make the conductors safe both

mechanically and electrically.
9. Record all motor nameplate details.
10. Remove all holding bolts and nuts on the motor base, coupling etc.
11. Remove the motor from its mounting using safe lifting procedures.

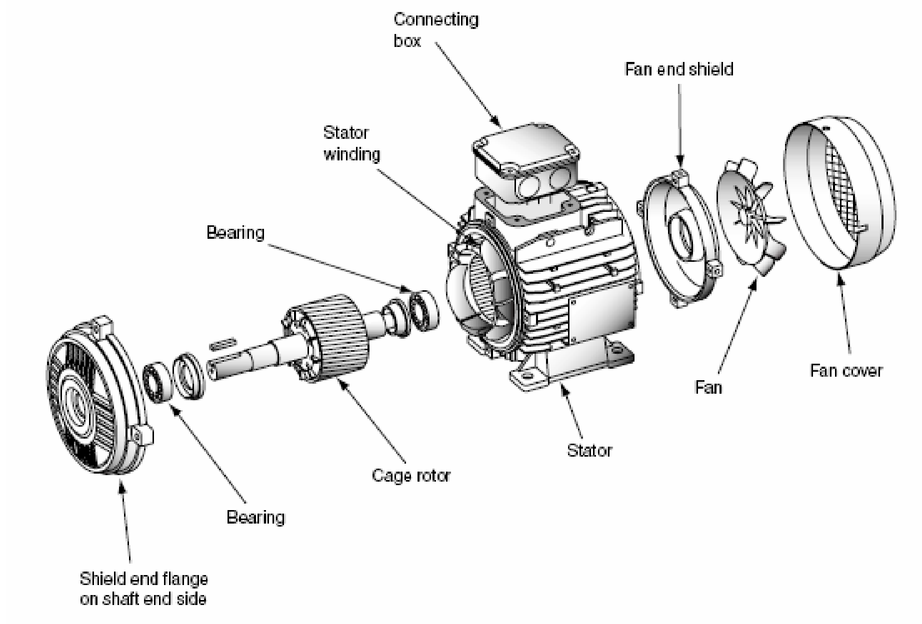
    Ie: **Manual method** – straight back, bent knees etc.

12. If using **mechanical lifting** devices, care must be taken to use the correct size sling.

Disassembly of an Electric Motor



1. Place the motor on a sturdy, clean bench.
2. Witness-mark both the stator and the end shield for accurate realignment on reassembly. A common method is to use a centre punch.
   NB: Witness marks are explained in Part (c) below.
3. Undo the central bearing cover metal threads.
4. Carefully lever the end of shield from two positions on opposite sides of the motor to evenly space the pressure on the bearing taking care not to damage the windings.
5. To remove bearings, you must use the correct bearing puller, which will evenly distribute the pressure around the bearing.
6. Store ALL parts to ensure they are not lost.



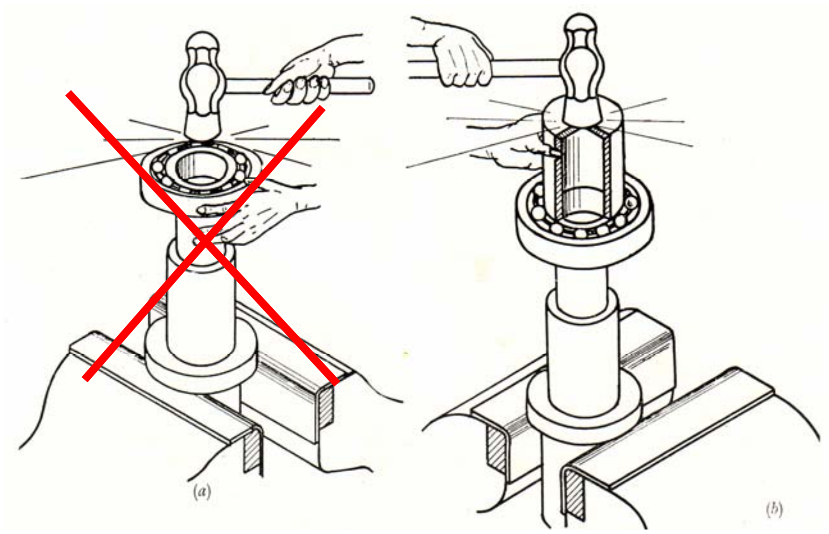
Replacement or Repair
A common question when a machine fails is; should it be “replaced” or should it be “repaired”? This decision is sometimes difficult to make. Considerations include:

- Is a suitable replacement available and what will be the cost and time frame for both options?
- Will the repaired machine be as reliable and efficient as a “new” one?
  NB: Rewound electric motors are not required to meet government MEPS (Minimum Energy Performance Standards).
- Age of the machine?
- How long will the repairs take?
- Will a repaired item void any warranty considerations?

Reassembly of a Motor

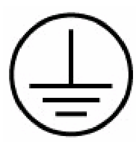
1. When installing new bearings, absolute cleanliness is essential. Ensure that the inner bearing cap is in place before fitting a new bearing.
2. Most bearings are now of the sealed type which are pre-lubricated. The use of a hydraulic press is recommended. If no other means are available, the bearing may be driven onto the shaft by gentle taps with a hammer or mallet. A piece of tubing of metal or brass called a “drift” should be used a mounting sleeve of a shaft. The drift must only contact the “inner race” of the bearing so that no stress is placed on the bearings. Contact with the “outer race” would destroy the bearing.

NB: This is illustrated below.



3. If the motor has open bearings, they may be evenly heated in an oil bath to between 80ºC and 90ºC and then the expanded bearing may be carefully slipped over the shaft. An open bearing needs to be packed up to 50% full of grease but no more.
4. Place the rotor within the stator taking care not to damage the windings. Place a piece of copper wire into an inner bearing cap thread hole, so that you may easily locate the other holes later.
5. Screw an end shield on to the stator evenly tightening the bolts.
6. Place the other end shield on the shaft and evenly tightening the bolts, this will evenly pull the end shield over the bearings.
7. If there is a need to force the end shields over the bearing, always use a soft faced mallet and never a steel ball pein hammer as this tool would damage the end shields.
8. You should now be able to rotate the motor shaft by hand.
9. After repairs on a motor, always perform an “**Insulation Resistance**” and “**Earth Continuity” Test** on the motor.

   a. Join all live conductors together, set **Insulation Resistance and Earth Continuity Tester** to the **500V** scale, place one lead on the joined actives and the other probe on the metal frame of the motor. Test result must be **1 Megohm** or greater. Disconnect the active conductors.
   b. For a three phase 400 Volt motor: Set **Insulation Resistance and Earth Continuity Tester** to the **1000V** scale. Check the insulation resistance <u>between</u> each phase winding and the other two windings. Test result must be **1 Megohm** or greater.
   c. Set Insulation Resistance and Earth Continuity Tester onto the **OHM** scale, one probe to the motor’s earth terminal and the other probe to the metal frame in few a few positions. Test result must be less that **0.1Ω** on the fixed part of the frame or



less than **1Ω** for moving parts of the frame.

10. Bench test the motor on full voltage in the workshop before re-installing it. Check the no-load current against the name plate current. Typically, the no load current is between 60% rated current on very small machines and 20% of rated current on large machines.
11. Before reconnecting the motor, it is essential to check that all circuit breakers and switches and danger tags are still in place.
12. If it is safe to continue, inform all concerned persons that you are going to re-install the motor. Bolt the motor to its mountings taking care to align the couplings or belts.
13. Test **all** of the conductors for **LIVE** with a non-contact circuit tester and then test your tester on a known voltage source.
14. Take the tape off the conductors, treating them as if they were alive. Once bare, test the conductors, using a pre-tested voltmeter and the effective earth as a reference. Always, retest the tester against a known voltage source.
15. Reconnect the conductors as per the diagram. Always connect the earth conductor first.
16. Having warned all relevant persons remove **your** lock and danger tag etc; turn the circuit breaker and isolating switch on. Test the motor for operation and correct rotation.

Importance of marking/labelling and storing parts

Marking or labelling each component as it is removed from a complex machine is critical. Especially when you are not familiar with this machine or if no servicing documentation is available. While you may easily recall the correct reassembly sequence at the time of disassembly, you may be compelled to wait for an extended period of time for replacement parts and in the interim you will soon forget the sequence.

It is quite common that a different staff member may be required to reassemble machine at a later time and only detailed documentation and comprehensive labelling will ensure a smooth reverse process.

There are a number of documentation techniques that you should consider:

1. Take high resolution digital still images showing the key views, before each component is removed. Focus mainly on any orientation aspects such as cable colours, cable connections, pin/plug orientations, physical orientation, physical alignments, clearances, direction of rotation. Ie. Anything that could go back more than one way.
2. If photos are not possible, then make suitable sketches showing key details before removal. Just as for digital images sketch any aspect which will assist with correct assembly.
3. Create “witness” or alignment marks with a felt tip pen in positions where they will not show on the final assembled product.
4. Label each wire that is to be removed if it is possible to swap them during reassembly,
5. Group fixing screws from each area under a piece of adhesive tape to ensure that they are returned to the precise locations from where they originated.
6. If the machine is slot mounted which could give a slight variation to the position, trace feet outlines or witness mark it to ensure that it is returned to its original position.
7. Record DOR (direction of rotation) prior to removal.
8. If mounting bolts may have been tensioned and machine documentation is not available, record each bolt’s tension as it is removed.
9. Measure and record the precise position of any fans, pulleys on motor shafts.

Storing Parts during Disassembly

1. Store all parts in suitable containers so that they are not lost or damaged. Parts should **NEVER** be left on the floor or loose on a work bench. The fragility and cost of each component will dictate the security level of its storage.
2. If possible, attempt to stack the parts in an order which will expedite the reassembly

process.

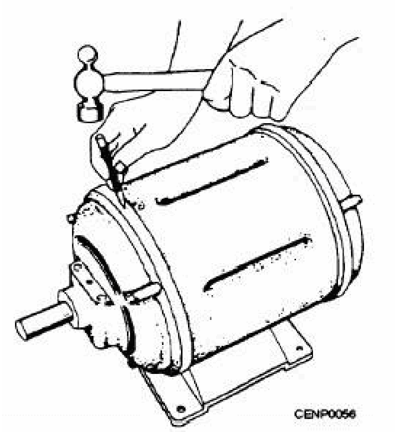
3. Store fixing screws with their own part.
4. Serviceable bearings should be stored such that they are not affected by dirt etc. If they are open or partially open types then cover them with a plastic bag to ensure that are safe.
5. An idle electric motor should be rotated by hand approximately 10^{o} for each calendar month to ensure that the bearings are not affected by “false brinelling”.
6. Link sub-assemblies temporarily together to better protect components. Eg: Electronic circuit cards are susceptible to ESD (Electrostatic Discharge) and are safer if they are reinserted back in their connecting slots. Surface Mounted Devices (SMDs) are less likely to suffer mechanical damage if the cards are relocated back in their slots.
7. Store electronic circuit boards in specially designed “anti-static” bags.

NB: One of the keys to successful disassembly and assemble is to always be patient and methodical.

Machines with Close Fitting Parts
As manufacturers of electrical equipment are forced to meet government Minimum Energy Performance Standards (MEPS), they are engineering their products to much closer tolerances. Appliances such as electric motors etc have much reduced air gaps and spacings. Eg: Electric pumps which require seals to prevent liquid leaks also operate on very fine tolerances.

Other equipment which has close fitting parts includes those rated for “flame proof” or “explosion proof” operation.

Witness Marks
Due to the fine tolerances there may be rotational clearance only when the machine is assembled in one of the possible ways. Key alignment marks called “witness marks” should be placed on adjacent sections prior to dismantling.



For an electric motor, “**witness**” marks are best made with a centre punch on <u>both</u> end shields and the frame. Typically, “one” mark at the drive end and “two” marks at the non-drive end.

“**Polling**” means that the motor’s revolving “rotor” is rubbing against the stationary “stator” core. On a closely fitted motor, polling could be as a result of either worn bearings or a misalignment of the motor’s end shields during reassembly. Polling is synonymous with a machine which has close fitting parts.

For many other machines, witness marks could simply be a “mark” from a permanent felt marker drawn across a key joint such that the two pieces can be realigned precisely as before.

Fine Tolerances
Gaps between close fitting parts may need to be adjusted to within tolerance through the use of feeler gauges. This tool, discussed earlier can accurately measure very small clearance gaps. Therefore, when disassembling certain types of equipment it may be necessary to measure and record air gaps.

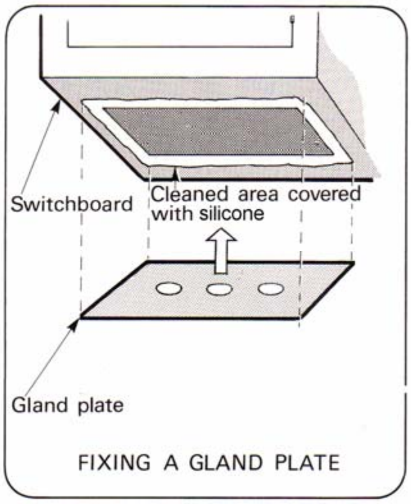
Temperature Variations
Machine parts undergo physical changes due to ambient temperature variations. This should be taken into account during reassembly. For example, a bearing may not fit on to a motor’s shaft if the temperature of the shaft to too high. The shaft may need to be cooled with compressed air or a refrigerant spray prior to assembly. Alternatively, a motor’s end housings may need to be placed in an oven to expand them to a point where they can accommodate the bearing.

Seals and Gaskets

The word "**seal**" used as "verb" can mean to "seal-something-in" thereby preventing something from escaping or to "seal-something-off" thereby isolating the area.

As a "noun", a "**seal**" is a device or substance that is used to join two things together so as to prevent them either from coming apart or to prevent something seeping between them. Eg: This could be the passage of solids, liquids or gases etc.

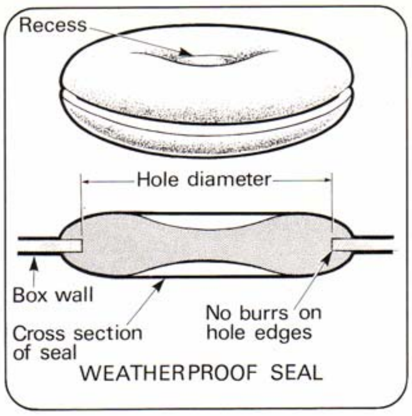
A "**sealant**" is a material (compound) which has both the "adhesive" and "cohesive" properties necessary to form a seal. NB: "Adhesive" means to ability to "adhere" (stick to) some surface and "cohesive" means its ability to hold together and not dissolve.



There are countless substances available that can be used as sealants with "silicone" and "polymers" being common. The sealant is selected on the characteristics of what is to be resisted, the surface in contact with the sealant (eg: metal, ceramic, wood, plastic etc.), the environmental conditions such as pressure and temperature range etc and whether the sealant is required to "cure" or be "non-curing". NB: "Cure" means to set-hard, whereas "non-curing" means remains flexible which allows for expansion and contraction.

NB: When preparing to use a sealant, always carefully read the **Safety Data Sheet** for the product and use all recommended PPE.

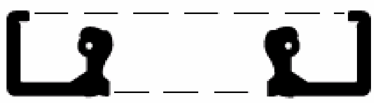
Weatherproofing is a typical application for sealants in the electrotechnology industry. Outdoor items such as switchboard cable entry, junction boxes and light fittings etc must be made waterproof if the electrical system is to be made reliable. The "cable gland plate" shown to the right is a typical example.



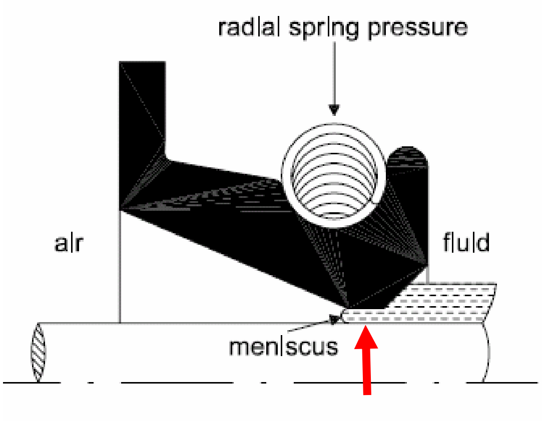
A "**mechanical seal**" is a physical "**device**" which helps join systems or mechanisms together by preventing leakage.

A "**static weatherproof seal**" is shown to the right. It is made of rubber or plastic and is designed to fit into standard sized holes in sheet materials ranging from 12.5mm up to about 50mm. It can be inserted or removed with the aid of screwdriver and is typically to "seal-off" spare cable or conduit entries into switchboards.

A "**rotary shaft seal**" is a more complex design and is commonly used to seal between a moving surface (eg: motor shaft) and a fixed surface (eg: motor end housing). It can be used to prevent water, chemicals, oil or grease etc, passing from one side of the seal to the other.



A common shape is shown to the right. The design is pressure energising. This means that the compression load on the seal is initially just sufficient to resist low pressure, but when machine is operating, the inherent pressure within the system increases its sealing properties.



They are constructed from an "elastomer" compound and typically have an internal metal "radial or garter spring" which helps the sealing lip compensate for lip wear and elastomer changes. The sealing lip has a point contact with the shaft formed by two angles, with the air side angle usually less than the liquid side angle.

The garter spring is positioned such that axially the centre line of the spring is biased to the air side of the lip contact point.

Installation

The "**sealing lip**" is critical and it should be closely inspected to make sure there are no nicks or tears at any point around its circumference. Ensure that the lip is not turned back as a torn or turned lip will quickly fail in-service.

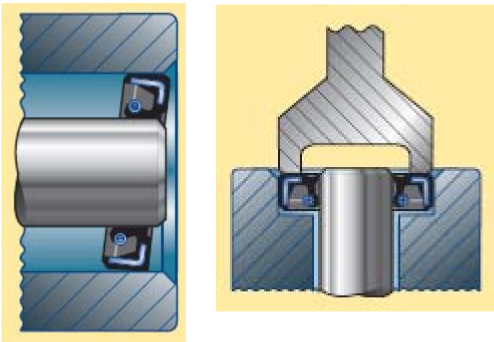
Make sure that the "garter spring" has not been displaced out of its groove as a result of handling and the seal's outside diameter should be free of damage such as cuts, dents, or scores.

If there is any sign of damage then do not use it.

New seals should be wiped clean prior to installation. The shaft surface should be inspected to ensure there are no nicks or burrs which could damage the seal lip.

Ref: http://www.bargroup.com.au/hollow_shaft_parts.html

Both the seal lip and the shaft should be lubricated (typically with the same oil or grease that is being sealed) prior to installation of the seal. This makes installation easier and less damaging to the seal. It also helps protect the seal during the initial break-in period. Continued lubrication minimizes wear and maximizes service life of the seal. Running a machine with the seal "dry" can quickly ruin the seal.



Care must be taken to install the seal facing the correct direction. When replacing an existing seal, always note the direction in which the old seal faced.

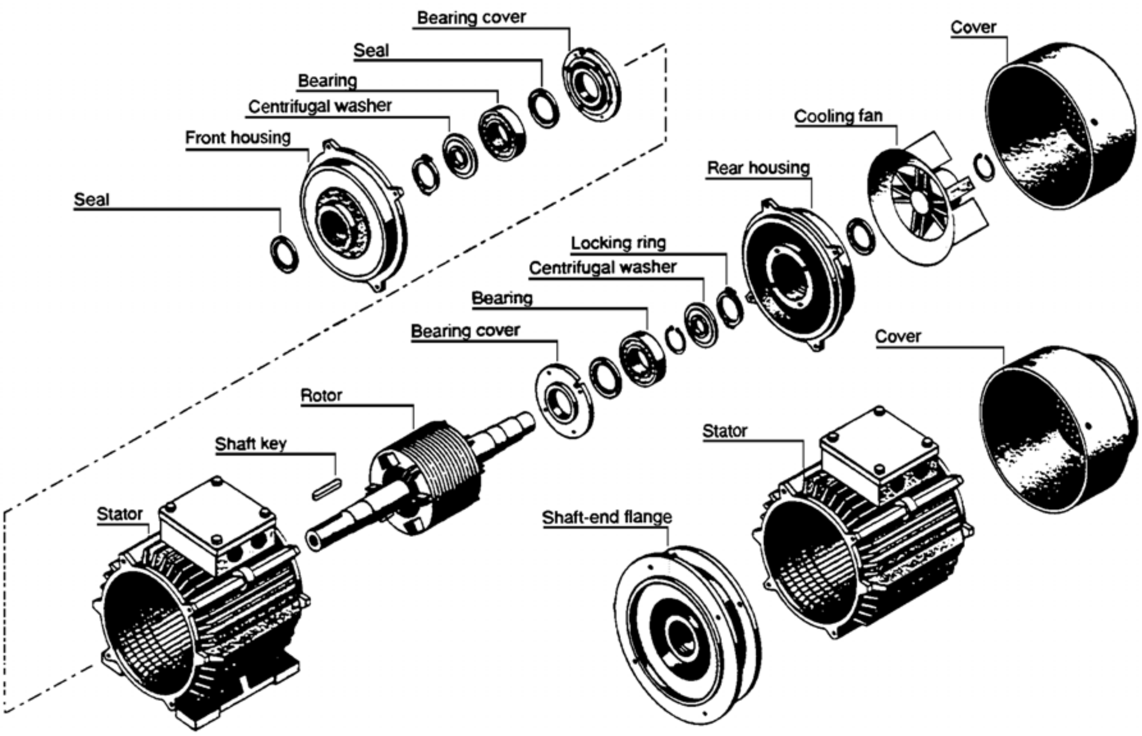
Ensure that the seal is installed straight and not skewed such as that shown in the image. Use a suitable "drift" to ensure it is inserted straight in the housing.

Seal Installation Checklist

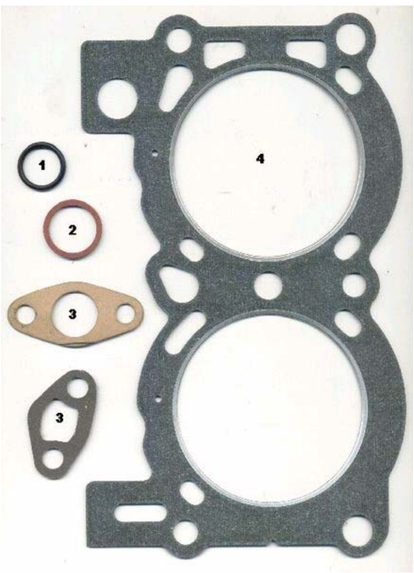
- ☑ Is the seal in good condition?
- ☑ Is the spring properly in place, or has it been displaced during handling?
- ☑ Have you carefully wiped the seal clean (so as not to damage it)?
- ☑ Have you made sure there are no nicks, scratches, or spiral grooves on the shaft surface?
- ☑ Have you pre-lubricated the seal's lip for initial break-in?

☑ Are you installing the seal with the lip facing in the right direction?
☑ Are you installing the seal at a right angle to the centerlines of the bore and shaft?
☑ Have you taken measures to keep the lip from being damaged when passing it over splines, threads, or burrs on the shaft?
☑ Have you inspected the bore to make sure there are no burrs or scratches?
☑ Have you ensured proper protection for the seal during painting or cleaning operations?
☑ Is adequate ventilation provided for internal pressure in the seal area?
☑ Have you made sure that assembly components do not rub and that any vents are not clogged?

NB: The "assembly drawing" shown below illustrates the parts for an AC (Alternating Current) electric motor. Both bearings have a "seal" located either side to prevent grease seeping into the motor stator and to prevent contaminants from the outside affecting the bearing.



Gasket
Ref: http://en.wikipedia.org/wiki/Gasket



A "**gasket**" is a flat static mechanical seal which fills the voids (spaces) between two or more mating surfaces, generally to prevent leakage from or into the joined objects while under compression.

Gaskets allow "less-than-perfect" mating surfaces to form a seal as it compresses to can fill the irregularities. They are commonly produced by cutting a specific "shape" from a sheet. Complex gaskets are typically commercially made but simple shapes can be custom made. A custom gasket is cut using a sharp knife and wad punches are used to create internal holes.

The gasket is made from a material that is "yielding" so it can deform and tightly fill the voids. Eg: Rubber, neoprene, cork etc. The gasket material must be compatible with the substances being contained. Ie: Temperature, pressure, acidity etc. Some gaskets require an additional liquid or paste sealant to enhance its sealing properties. Always check with manufacturer's specifications before using unknown sealants.

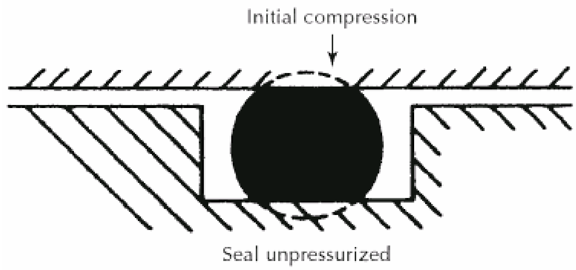
When installing, the "gasket:" is clamped between two solid surfaces with sufficient force so that the pressure is resisted by the stored energy within the gasket. A gasket has to react to the forces generated by the bolts, and therefore, the work and energy imparted to the bolted joint becomes "stored" within the gasket itself.

Installing a New Gasket

- Remove all foreign material and debris from the seating surfaces, fasteners (bolts or studs), nuts, and washers.
- Examine flange surfaces for warping, radial scores, heavy tool marks, or anything prohibiting proper gasket seating. Replace components if found to be defective. If in doubt, seek advice.
- Examine the gasket to ensure it is free of defects.
- Carefully insert gasket between flanges.
- Do not use jointing compounds or release agents on the gasket or seating surfaces unless it is specified by the gasket manufacturer.
- Bring flanges together, ensuring the gasket isn't pinched or damaged.
- Lubricate load-bearing surfaces, but use only specified or approved lubricants.
- Apply lubricant uniformly to all thread, nut, and washer load-bearing surfaces.
- Ensure lubricant doesn't contaminate either flange or the gasket face.
- When tightening always use proper tools such as a calibrated torque wrench or other controlled tensioning device.
- Always torque nuts in a cross-bolt tightening pattern.
- Tighten the nuts in multiple steps:

    - Step 1 – Tighten all nuts initially by hand. (Larger bolts may require a spanner.)
    - Step 2 – Torque each nut to approximately 30% of full torque.
    - Step 3 – Torque the nuts to approximately 60% of full torque.
    - Step 4 – Torque each nut to full torque, again using the cross-bolt tightening pattern. (NB: Large-diameter flanges may require additional tightening passes.)
    - Step 5 – Apply at least one final full torque to all nuts in a clockwise direction until all torque is uniform. (Large-diameter flanges may require additional tightening passes.)

"**O ring**" This is a gasket consisting of a ring of rubber or plastic; used to seal a joint against pressure. It is a static seal designed to provide compression on the seal across one axis.



They are often used on outdoor luminaires to prevent the ingress of water. They are inexpensive, easy to install and are fairly reliable. They can seal high pressure areas if required.

Safety

Gaskets used in the past for high pressure steam systems and like may contain asbestos. If the presence of asbestos is suspected, **DO NOT** access this existing gasket, but immediately seek expert advice and assistance on its safe removal and disposal.

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