scottish schools education research centre

Module 2

Engineering Skills - General Bench Skills

2020

CPD for technical teachers & support staff in schools

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2 Part 1 - Hand Tools

1 AIMS AND OBJECTIVES

1.1 Aims

To instruct teachers and technicians in the safe use of various metalwork hand tools and to highlight and demonstrate a number of general bench processes.

1.2 Objectives

1.2.1 Work with a range of basic metalwork hand tools.

1.2.2 Prepare and properly mark out metal.

1.2.3 Demonstrate how to cut metal using the most appropriate method.

1.2.4 Demonstrate how to shape and finish metal.

1.2.5 Set up and perform drilling operations safely.

1.2.5 Develop skills and knowledge of safe working practices.

2 PRACTICAL METALWORKING

The purpose of this booklet/course is to provide theroetical knowlegde of normal workshop practice found in the school metalwork room. It includes a range of tools and processes that are undertaken at the bench and embraces the standards required for the delivery of the SQA Practical Metal-work course, with emphasis on the Bench Skills Unit.

3 MEASURING & MARKING OUT TOOLS

3.1 Layout Ink

Layout ink or marking blue is a dye that is used to aid in the marking out of metal parts. The dye is used to stain the metal with a very thin layer of dye that can be scratched off using a scriber to produce a very narrow but bright line, making any marking out more visable. The dye is usually supplied in bottles and applied using a small paint brush.

3.2 Steel Rule

The steel rule is used to measure material such as wood, metal and plastics. It reads from zero to 300mm in 1mm steps. Rules are made from hardened and tempered tool steel in order to maintain their accuracy. They are often available in a satin or bright finish.

3.3 Scriber

A scriber is used to mark lines on metal or plastics. This is used instead of pencils as the marks from pencils can not be seen as clearly as scriber marks. It is made from hardened and tempered tool steel that has been sharpened to a point at one or both ends.

3.4 Engineers Square

An engineers square is similar to the try square but with a metal stock. It is used on both metal or plastic to check that the edges are square or to scribe lines at right angles to an edge. The groove in the stock prevents metal filings or burrs interfering with accurate testing. It is made from bright steel with a hardened and tempered blade.

3.5 Centre Punch

A center punch is used prior to driling holes in metal. When a twist drill is brought into contact with a flat metal surface it will have a tendency to wander on the surface until it gains sufficient purchase to start cutting the hole. A center punch forms a small dimple in which the tip of the twist drill (if it is small enough) will fit. A center punch usually has a tip, that when viewed on a profile, has sides at a 90 degree angle to one another.

3.6 Odd Leg Calipers

Odd leg or 'Jenny' calipers are used to scribe or mark parallel lines to the edge of a peice of metal. The bent leg is used to run along the workpiece edge while the scriber makes its mark at a preset distance. Made from tool steel.

3.7 Inside Calipers

Inside calipers are used for measuring internal diameter of holes and sizes of gaps and spaces in work pieces. They are manfactured from tool steel and available as either ‘spring’ or ‘firm joint’ .

3.8 Outside Calipers

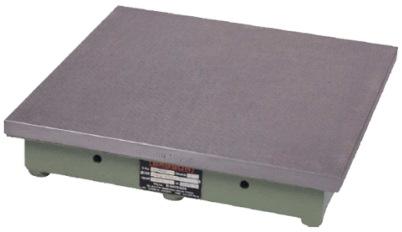
Outside calipers are used for measuring the diameter of round bars and the width and/or thickness of various metal sections. They are manufactured from tool steel and available as either ‘spring’ or ‘firm joint’

3.9 Spring Dividers

Spring dividers are used for marking out lengths into equal parts. The knurled finger grip enables the user to ‘walk’ the dividers along a line and at the same time strike an arc at each step. They are also useful to transfer lengths and in locating points with intersecting arcs.
They are manufactured from tool steel.

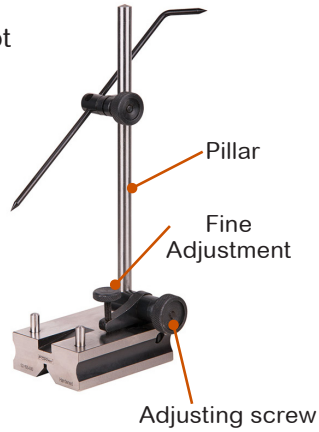
3.10 Surface Plate

Surface tables/plates provide a true plane of reference for testing other surfaces and for measuring and marking out procedures.
It is manufactured from fine grade cast iron, ribbed on the reverse side to prevent warping and usually has 3 small feet to stand on. This gives it stability and ensures no stresses are impossed on it when on uneven sur faces. These are available in a range of sizes, with larger sizes being fitted with legs and being floor standing, known as surface tables. It is important that surface plate is kept perfectly clean and protected with covers when not in use.



3.11 Surface Gauge

A surface gauge can be used to scribe lines at any height above and parallel to the surface table. The base of the surface gauge is heavy keeping it steady and only requiring light hand pressure to move it.
The scriber should be kept sharp in order to produce clean lines using a light stroking action.
Both scriber and the pillar are adjustable via the clamping mechanism. Fine adjustments can be made by turning the knurled screw which moves the rocker arm up or down.

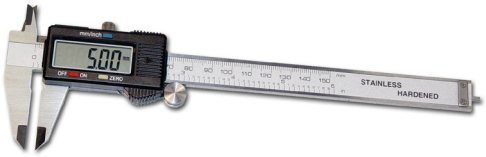


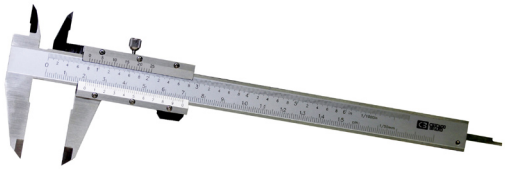
3.12 Vee Blocks

Vee blocks are manufactured from cast iron and accurately machined. They are made and sold in pairs. There are two different styles with one having clamps for holding bars in position for marking out, finding centres or for holding material in position for drilling.

3.13 Vernier Caliper

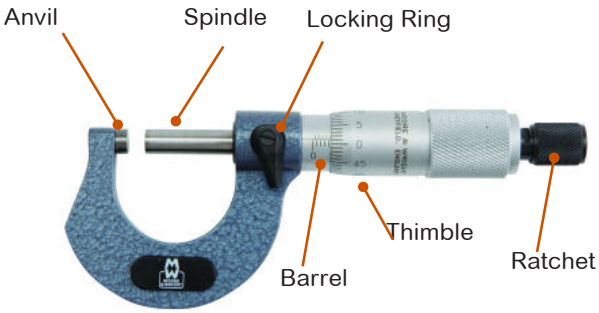
The vernier caliper or gauge is a precision instrument that used for measuring lengths, internal/external diameters or depths. It allows measurements to be taken down to a limit of 0.01mm. Digital vernier gauges have become a very popular measuring instrument within schools with the measurement reading been easily taken from the readout screen. However, tradtional “non digital”verniers are still available.





3.14 Micrometer

The micrometer is a high precision measuring instrument used for accurate measurement of external diameters or lengths.
Depandant on the micrometer this could be up to a limit of 0.001mm (i.e. a thousand of a millimetre)



3.14.1 Anvil

Made from hardened steel with an optically flat face.

3.14.2 Spindle

Made from hardened steel with an optically flat face. The spindle screw has a pitch 1/2mm, therefore the spindle moves lengths or longitudinally 0.5mm for each complete turn of the thimble.

3.14.3 Locking Ring

Locks spindle after measurement has been taken.

3.14.4 Barrel

The barrel is accurately divided (or graduated) into millimetres and half millimetres.

3.14.5 Thimble

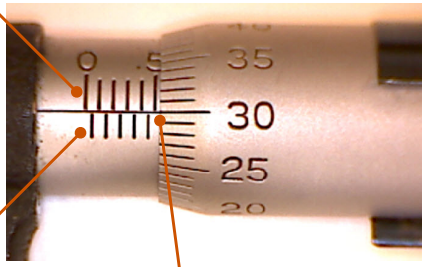
The thimble is accurately divided into 50 equal parts, therefore a movement of one division on the thimble causes a movement of 1/50th of a 1/2mm on the spindle;
i.e. 1/50th of ½ mm = 0.01mm

3.14.6 Ratchet

Prevents overtightening which could damage the threads on the spindle of the micrometer.

Example Reading

Each mark along the top equals 1 mm



Each mark along the bottom equals 0.5 mm

Take reading at this point

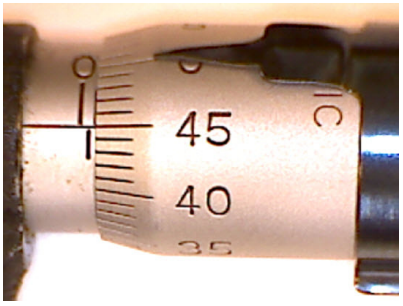
1. Count the number along the top (mm), in the picture above. At the reading point there are 5 whole mm

2. Does the 5.5 mark show along the bottom edge? No, so the reading lies between 5 and 5.5 mm.

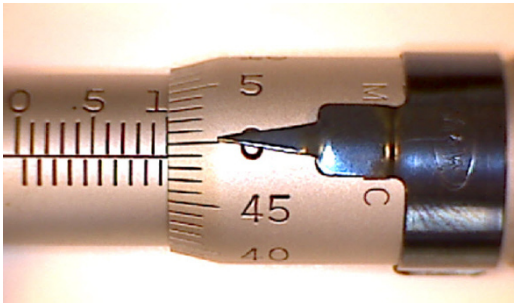
3. Take the reading ‘30’ which is 0.30 and add it to the number of whole mm (in 1 above)

Answer = 5 + 0.30 mm = 5.30 mm

3.15 Mircrometer Example Readings



Reading _____



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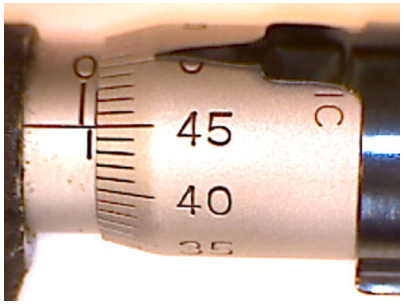

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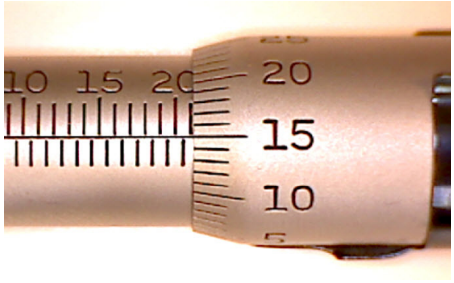

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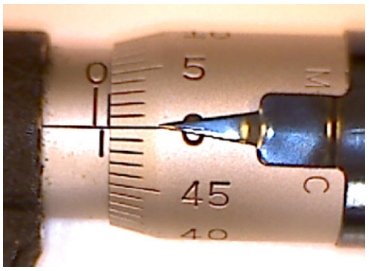

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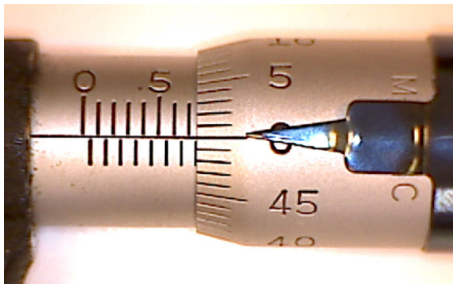

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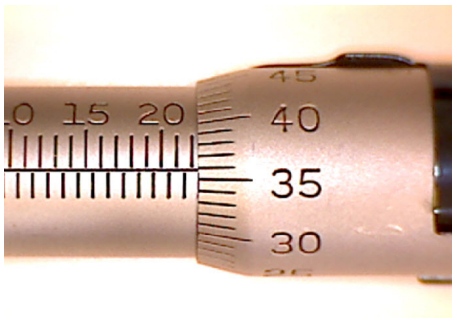

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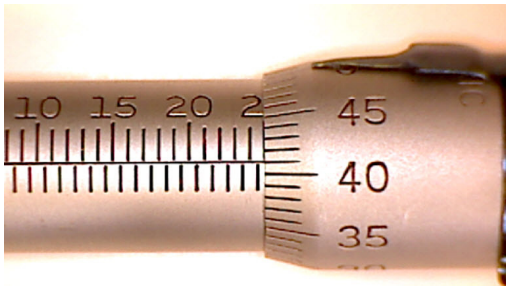


Reading _____

4 STRIKING TOOLS

4.1 Ball Pein Hammer

The ball pein hammer is the most commanly used hammer for metalwork. The head of the hammer is made from hardened and tempered carbon steel with the shaft usually being made from ash or hickery due to its natual springiness and shock absorbing propereties. The size of the hammer is classified by its weight, the most useful size for general bench work is between 0.45-0.5kg.

4.2 Soft Hammers

There are a number of different types of soft faced hammers. Copper, lead, hide and plastics are used in fitting work so that work faces will not be marked when assembling or adjusting component parts. They should be used with care and for delivering light blows only or they will be damaged or misshapen.

5 CUTTING TOOLS

5.1 Hacksaw

The hacksaw is the general purpose metalwork saw. It consists of a frame which can be rigid, or adjustable to take varying sizes of blades. The blade is inserted with the teeth pointing away from handle so that the saw cuts on the forward stroke only. Tooth sizes for the blade vary from 14 to 32 points per 25mm and the blade is made from specially hardened and tempered high speed steel. When cutting, there should be more than one tooth in action or each tooth in turn will be broken. For example, mild steel of suitable cross section, and 18T blade should be used. For tubing, hollow section and soft ferrous metals, an 32T blade should be used.

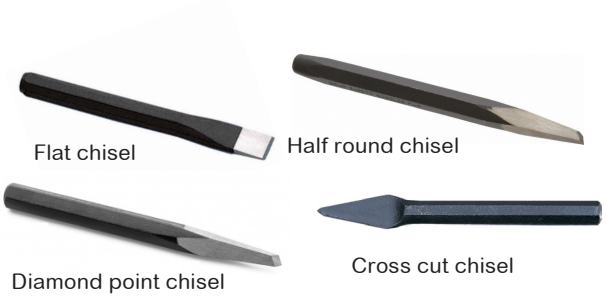
5.2 Junior Hacksaw

The junior hacksaw is used for light work in metal and plastics. Ideal for sawing rivets, screws and thin sections and cutting in a confined space. The chrome plated steel frame can be fitted with a rubber finger guard. Tooth sizes for the blade vary from 24 to 32 points per 25mm.

5.3 Cold Chisels

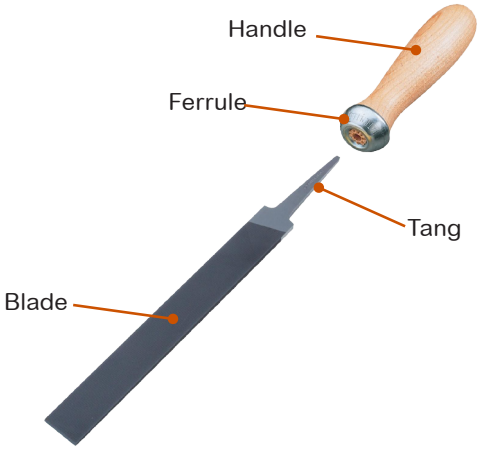
Cold chisels, usually made from one piece of octagonal carbon steel, are used for cutting metals. The chisel point is hardened and ground to form a cutting angle of 60˚. The head is chamfered to prevent burring over in a mushroom fashion from constant hammering. Four types of cold chisel are shown.

5.3.1 **Flat Chisel** - Used for cutting flat sheet, rivets, bolts, etc.
5.3.2 **Cross-Cut Chisel** - Useful for cleaning out grooves.
5.3.3 **Diamond-Pointed Chisel** - Useful for chipping out corners.
5.3.4 **Half-Round Chisel** -Useful for cutting rounded grooves.



5.4 Files

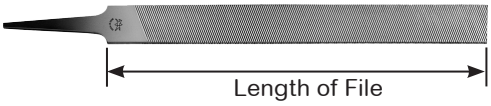
Files are made from high carbon steel (about 1.3% carbon) and are used for the removal and smoothing of metal and plastics. Due to the specialised heat treatment the blade is made very hard whilst the tang is left in a relatively soft state to prevent it from being easily broken.



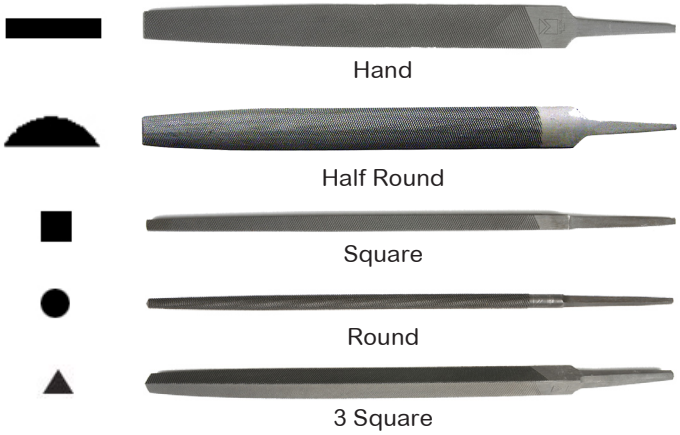
5.4.1 File Classification/Types

Files are classified by (1) length, (2) Section/shape and (3) cut.

(1) Length - this is measured along the blade, not including the tang or handle.

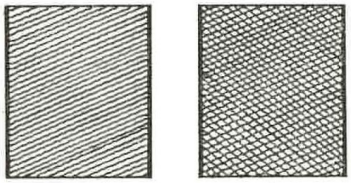


(2) Shape - Files come in a variety of shapes and sizes as shown.
An· enlarged cross section of each file is also shown.



(3) Cut - The teeth of files are shaped so that it cuts on the forward stoke only. There are number of different cut or tooth forms available which fall into two main groups, single or double cut.
If only one series of cuts are made across the file it is known as a single cut. Whilst single cut files are used on hard metals they are also necessary for the softer metals such as wrought iron, copper and aluminium.

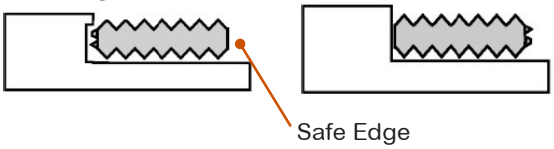
If a second series of cuts are made at an angle to the first, forming diamond shaped teeth the file is known as a double cut.



The grade of any cut is directly related to the size of the file. For example, the cut on a 300mm bastard file would be courser than that on a 200mm bastard file.
The following is a representation of a file 250mm long.

FILE	No. of teeth per 25mm
Rough cut	16
Bastard cut	26
Second cut	36
Smooth cut	60
Dead smooth cut	100

Some hand files have a safe edge or smooth edge. This means that a shoulder or corner can be filed without removing metal adjacent to the safe edge.



New files are best used on non-ferrous metals and then later for iron and steel. Files should always be used with a handle fitted for safety.

Warding files are special thin flexible files used for very fine and accurate work.

5.4.2 Care of files

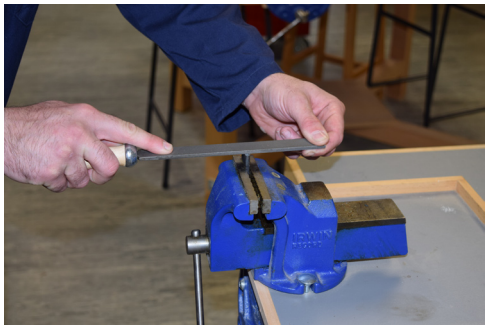
As files are very hard and thus brittle. The blade and teeth can be easily damaged through improper use or storage. They should never be rubbed together or thrown down on benches. They should be stored laid side by side to prevent damage.

When particles of metal clog the teeth of the file this is known as 'pinning'. Using chalk rubbed onto the file blade will help prevent clogging, however when they do appear they should be cleared using a file card (a short wire type brush) by brushing in the direction of the teeth. Files should never be used without a handle, as holding the tang could lead to serious injury. If any file handle is found to be spilt or damaged it should be replaced immediately.

Safety Note
Never use a file without a handle fitted.

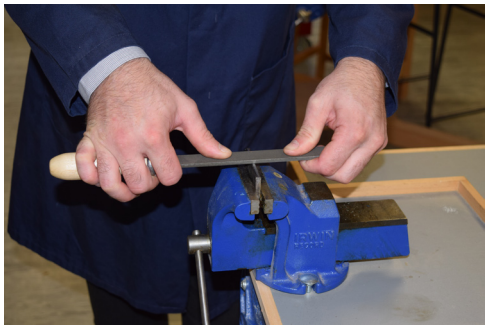
5.4.3 Cross Filing

Cross filing is a technique used to quickly remove waste metal and for filing to a line.
The file is moved across the work piece using the full length of the blade. This technique however, does not produce a smooth surface. It is important that a good stance is adapted while filing and that the workpiece is set low in the vice to prevent vibration noise.



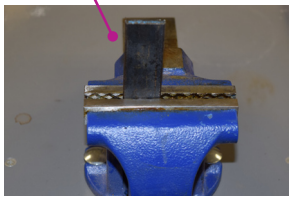
5.4.4 Draw Filing

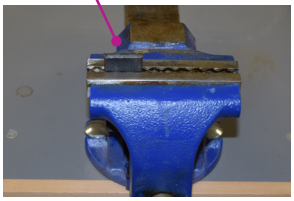
Draw filing is a finishing process that is used after cross filing to produce a smooth, fine surface.
For this the file is gripped around the blade with both hands and balanced across the work piece. The file is then moved back and forwards along the work piece.



Wrong position - Work-piece set to high in vice.

Right position - Workpiece set low in vice to provide maximum support.



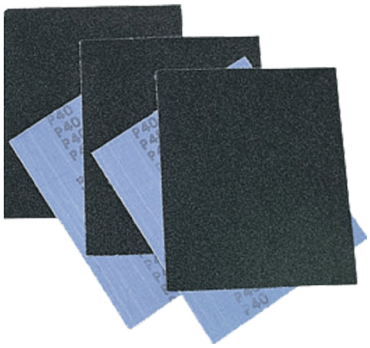


Check out the video links!
http://www.sserc.org.uk/images/Technology/Video clips/General Bench Skills/draw filing.mp4
http://www.sserc.org.uk/images/Technology/Video clips/General Bench Skills/cross filing.mp4

6 ABRASIVES

6.1 Emery Cloth

Emery cloth is a type of coated abrasive that has emery glued to a cloth backing. Emery is a dark granular rock which largely consists of the mineral corundum. It is crushed in to different grit sizes to make a range of coarseness. The grade is printed on the back of each sheet in the form of a number.
For example P220, P150, P120, P100,P80, etc. The greater the number the finer the grit. In finishing filed sur faces a course grit (i.e. P80) would be used first. The scratches
from this grade would then be removed by using a finer grade (i.e. P120) and so on until the scratches are so fine they are no longer visible.



6.2 Wet & Dry Paper

Wet/Dry paper is an abrasive paper that has a waterproof backing on it. It is used almost always wet using water with a little soap added to prevent the paper from clogging up. It also comes in various grades. Most commonly P100, P320, P400, P600, P800, P1200, P2000. These very fine grades make it suitable for polishing and also rubbing down paintwork.

6.3 Steel Wool

Steel wool is used as an abrasive material in finishing work, such as polishing and cleaning.
It is made from low carbon steel in a process where heavy steel wire is pulled through a toothed die that removes thin, sharp wire shavings.
Steel wool is available in various grades. It is graded in a numerical system from extra course (grade 4) through to super fine (grade 0000)

Part 2 - Pillar Drill

2

1 AIMS AND OBJECTIVES

1.1 Aims

To instruct teaching and technician staff in the safe use of the Ambassador Drill and to highlight and demonstrate any functional changes in the new machines.

1.2 Objectives

1.2.1 Know and understand the hazards associated with use of the drill.

1.2.2 To outline the safety precautions necessary for the safe operation of the drill.

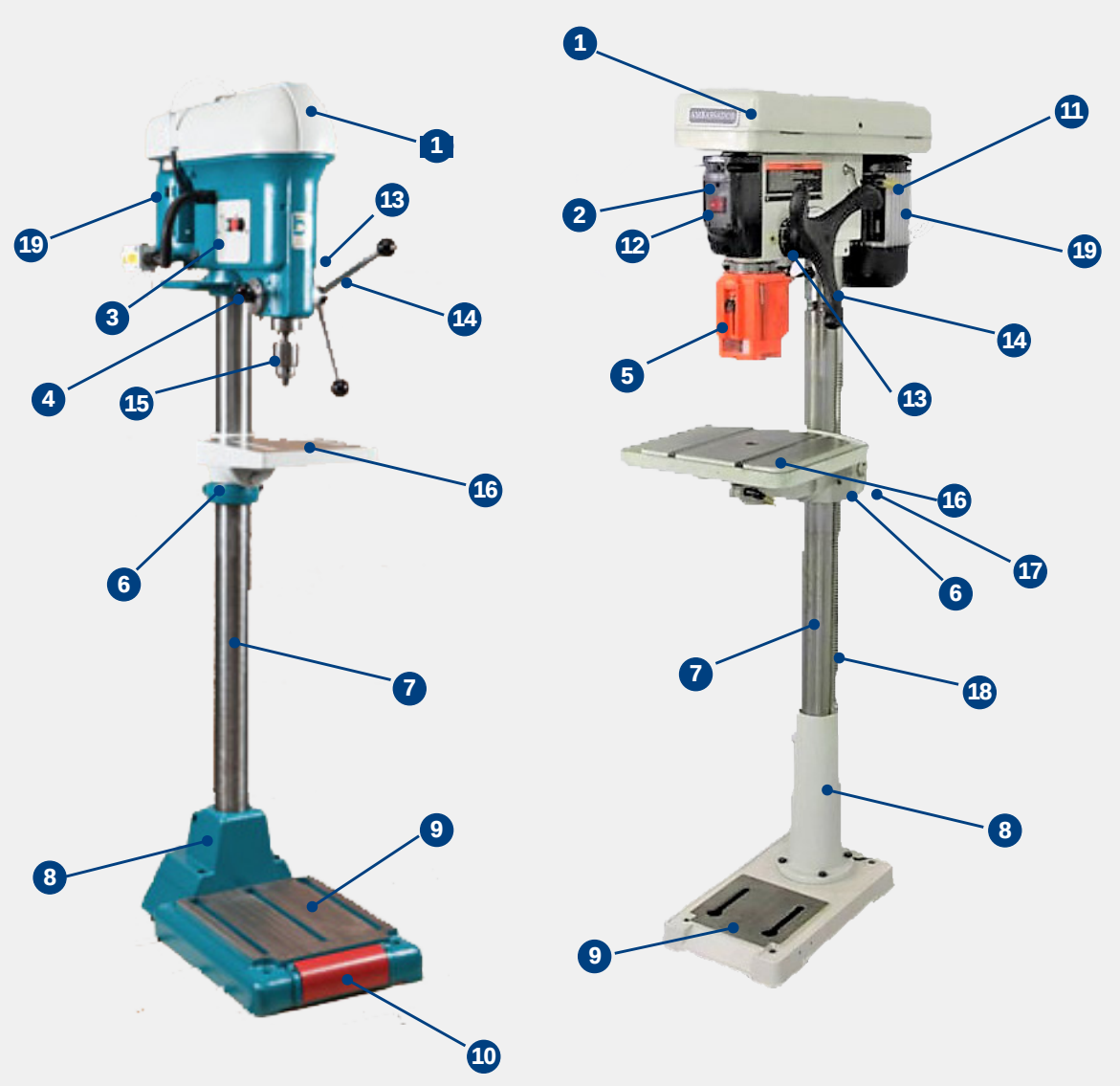
1.2.3 To demonstrate the functions of the guards and safety devices.

1.2.4 Become familiar with the parts of the drill and their functions.

1.2.5 To demonstrate how to set the tools and prepare the drill for safe use.

1.2.6 To demonstrate how to operate the drill to carry out its functions safely.

2 TYPICAL PILLAR DRILL



1) Belt Guard
2) Lamp Switch
3) Stop/Start Controls
4) Return Spring
5) Adjustable Drill Chuck Guard
6) Table Support/Lock
7) Column
8) Column Support
9) Base
10) Emergency Stop
11) Belt Tension/Locking Handles
12) Drill NVR Switch
13) Depth Scale/Lock
14) Feed Wheel
15) Chuck
16) Work Table
17) Table Adjustment Handle
18) Rack
19) Motor

*Note - The 2 pillar drills above give a general comparison between typical older machines and newer machines found in schools, not all features may be present. Irrespective of age of machine all pillar drills should be fitted with emergency foot stops, chuck guards and belt guard only accessable via a fixture requiring a tool to remove.

3 USAGE

Used for drilling softwood, hardwood, composite materials, plastics and metal.

4 HAZARDS

4.1 Work pieces jamming, spinning can cause hand injuries.

4.2 Electric shock.

4.3 Drill bit breaking, swarf can be ejected into the room.

4.4 Sharp edges on drill, work pieces and swarf can cause cuts.

4.5 Hands and fingers can contact the drill, gearing and pulleys.

4.6 Entanglement: clothing, long hair and loose jewellery can become entangled.

4.7 Environmental: keep area around machinery clear of surplus materials, wood waste and other tripping or slipping hazards.

4.8 Inadvertent starting/stopping of the machine.

4.9 Unauthorised persons using the machine.

5 CONTROL MEASURES

5.1 Safety Signs

Blue - Mandatory Instructions

Red - Prohibitory

Yellow - Warning

5.2 Personal Protective Equipment (PPE)

5.2.1 Goggles (BSEN-166-349B)

5.2.2 Loose clothing must be secured and long hair tied back.

5.3 Emergency Stop Systems

5.3.1 Room Emergency Stop System – various sites around the room.

5.3.2 Mushroom Headed Footstop – situated at the base of the drill.

5.4 Guards

HSE: Drilling machines: guarding of spindles and attachments – Guidance Note PM83

12 "Effective guarding of spindles and chucks presents no real difficulty. It is often claimed that guarding of the drill itself is impracticable because it would obstruct the view of the workpiece, slow down the process of changing drills, or otherwise interfere with production. However, most accidents occur at the tip of the drill when it is in its top most position and the operator is removing the drilled workpiece or securing the next. Guarding is therefore necessary and, with careful design, can provide a high standard of protection without interfering with production."

16 "During drilling work it is essential that the guard should be below the tip of the drill when it is in its raised position."

25 "Drive mechanisms of drilling machines can be dangerous. Where access is infrequent (e.g. for maintenance), only a fixed guard or cover plate requiring a tool for its removal should be fitted. If access is regular (e.g. for changing speed by means of a multi-step pulley and belt), then the guards or cover should electrically interlock the power to the motor driving the pulley."

5.4.1 **Chuck Guard**
Silvaflame fully adjustable telescopic guard; secured to the depth stop collar with an integral clamp. It is of aluminium construction with 2 polycarbonate visor sections which allow visibility for the operator and telescope on contact with the

workpiece, guarding all rotating parts during all stages of the drilling process – from fully raised to fully lowered.

5.4.2 **Belt Guard**
This is a fixed guard restricting access to the drive belts and pulleys. The guard has a micro switch fitted which cuts the power to the motor when the guard is open. It is fixed using tamper proof screws and should only be re moved to adjust or replace the drive belts or alter the speed of the drill.

Only competent technicians and technical teaching staff trained in this process should access this area.

6 SAFETY CHECKS BEFORE USE

6.1 Clear Working Area
Before use, ensure that the area around the drill is clear of surplus waste materials, wood waste products and/or models that may hinder the safe use of the drill.

6.2 Ensure the Pillar Drill is Isolated
Before carrying out any safety checks the drill must be isolated from the power supply. Check the machine isolator is in the "off" position.

6.3 Drill Speed
The correct spindle speed must be selected and set before operating the drill. To calculate the spindle speed required the following factors should be considered:

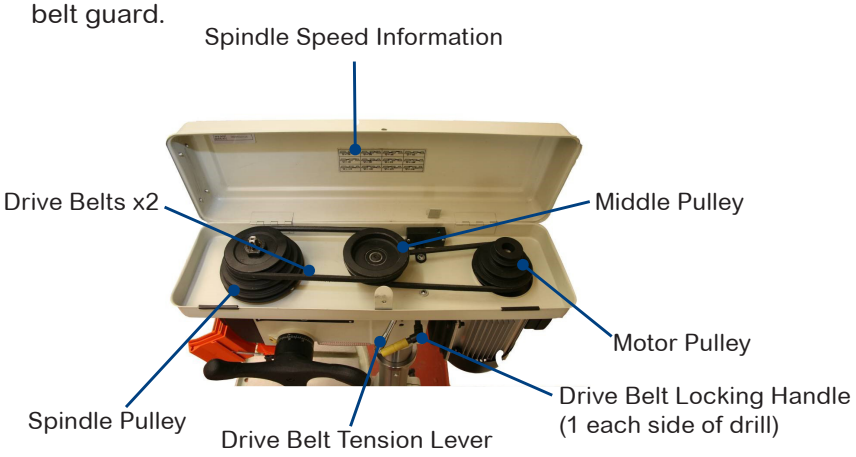
6.3.1 Type of material being drilled (plastic, metal, wood, hard, soft, thick, thin etc.)

6.3.2 Type of drill / cutter to be used.

6.3.3 Size of hole to be cut.

7 ADJUSTING SPINDLE SPEED

The Ambassador Drill is controlled by 2 drive belts and 3 sets of pulley wheels and can be adjusted to 12 different speeds ranging from 180 RPM to 2740 RPM. The positioning of the drive belts on the pulleys determines the speed of the spindle as shown below. This diagram can be found on the underside of the belt guard.



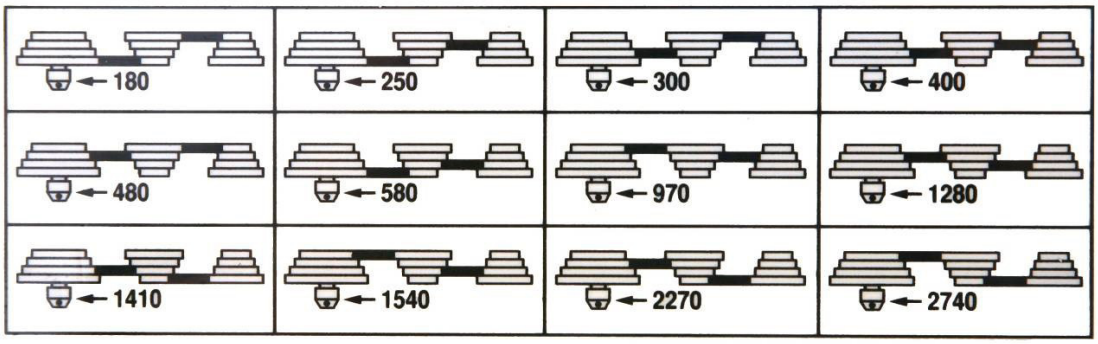
To change the spindle speed work as follows:

7.1 Ensure that the drill is isolated from the power supply and that the power isolator is locked – off with the yellow maintenance padlock, retain the key.

7.2 Remove the tamper proof screw from the belt guard and open to expose the drive belts and pulleys.

7.3 Select the required speed from the information on the inside of the guard.

7.4 Loosen the drive belt locking handles located on each side of the machine head.



7.5 Release the tension on the belts by pulling the tension lever forward (toward the front of the machine).

7.6 Position the drive belts on the pulleys as advised by the information guide.

7.7 Re-tension the drive belts by pushing the tension lever back (toward the back of the machine) until the desired tension is reached.

7.8 Lock the drive belts in position using the locking handles.

7.9 Close the belt guard and replace the tamper proof screw.

7.10 Remove the padlock from the isolator and energise the machine.

8 POWERING THE PILLAR DRILL

8.1 Energise the Ambassador Drill

8.1.1 Switch on the 3-phase power supply to the work room, this may be controlled by a keyswitch.

8.1.2 Switch the machine isolator to the "on" position (situated on the wall, close to the machine).

8.1.3 Switch on the drill NVR power switch on the front panel.

8.1.4 With the drill guard in place press the green start button, the chuck will turn.

8.1.5 Press the red stop button to stop.

8.2 Testing the Stopping Systems

8.2.1 With the drill guard in place, press the green start button, the machine will start and the chuck will turn, press the Red Stop Button on the control panel, the drill will come to a complete stop.

8.2.2 Press the green start button, the machine will start, depress the Red Emergency Stop Button on the control panel, the drill will come to a complete stop. To reset the emergency stop button; turn to the right to unlock and the button will reset.

8.2.3 Press the green start button, the machine will start, depress the Mush room Headed Footstop, the drill will come to a complete stop.

8.2.4 Reset the Mushroom Headed Footstop by pulling the mushroom head out until you hear it "click" back into position.

The Mushroom Headed Footstop is essentially part of the emergency stopping system and should not be routinely used to stop the drill.

The Emergency Stopping System will be tested regularly by the School Technicians as part of the routine maintenance of the machine tools.

The drill is now ready for use.

9 CLAMPING METHODS

It is essential to ensure that when drilling material, the workpiece is fixed securely to the table using clamps, vices or custom made jigs.

HSE: Drilling machines: guarding of spindles and attachments – Guidance Note PM83

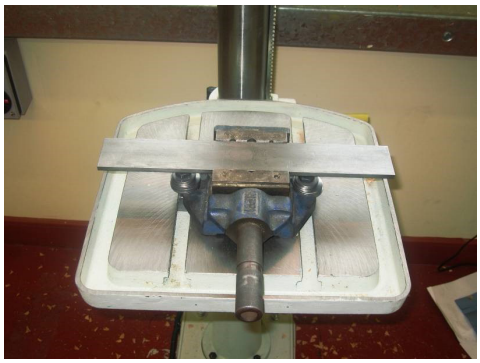
17 "Many severe accidents have been caused by the workpiece revolving violently under the action of the drill through failure to securely clamp the workpiece to the table. It is necessary not only to have good clamping arrangements, but also to use them correctly"

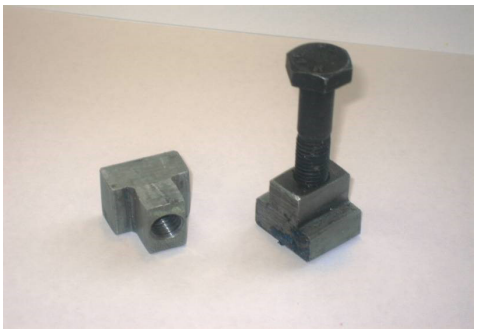
9.1 Clamp

Material can be fixed to the drilling table using G clamps.

9.2 Vice

A metal nippy vice can be used to securely hold a small workpiece while drilling. The nippy vice should be secured to the table using the square bolts and clamps as shown below.





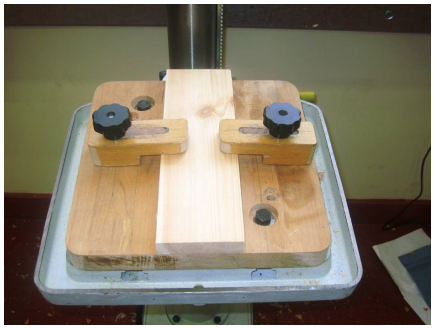
The T – bolts are designed to fit into the grooves of the drill table, the nippy vice is then held in place by securing the bolts.

9.3 Clamping Jigs

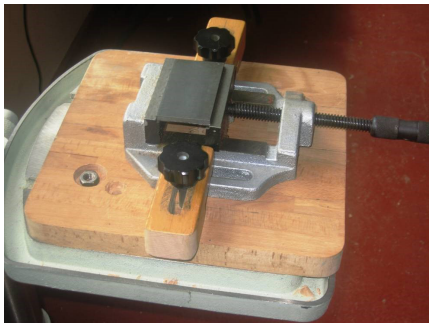
Clamping jigs can be produced for specific drilling processes, these clamps are particularly useful for pupil exercises

The jig shown below is basically a wooden board that is clamped to the drill table using T-shaped clamping bolts.

A small workpiece can then be clamped and secured to the jig using the adjust able side arms.



This jig can also be used along with the nippy vice as shown below



10 SELECTING CORRECT CUTTER

It is essential that the cutter selected is suitable for the type material to be cut;

10.1 Twist Drill

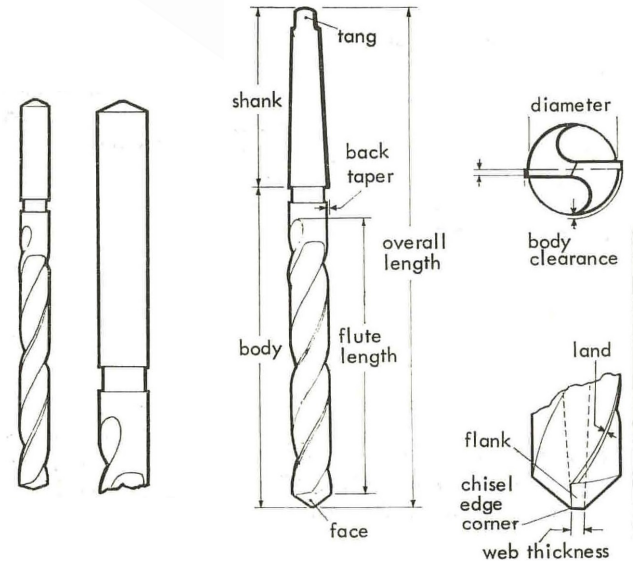
Twist Drills are manufactured from high speed steel (H.S.S.) or carbon steel and are used for drilling circular holes in metal, wood and plastics.
Twist drills have three basic parts, a point, a parallel body and a shank that can either be parallel or “morse” tapered.

In use, twist drills with parallel shanks are securely held in an adjustable chuck. Drills with tapered shanks fit directly into lathe tailstock barrels and drilling machine spindles.

The parallel body of the twist drill is cut away to form two spiral or helical flutes. This allows lubricant to reach the cutting edges quickly and swarf (waste material) to exit easily. To reduce friction during drilling the body of the twist drill is made with a slightly reduced diameter but leaving a thin band of metal at the leading edges of the flutes.

These thin bands are known as LANDS and are ground cylindrically true to form the drill diameter.

Twist drills are manufactured in a wide range of sizes, straight shanked drills from 0.3mm diameter to 13mm diameter and morse-taper shank drills from 10mm diameter to 100mm diameter.



10.2 Spur Point Bit

Also known as a wood or dowel bit, they have a central point and two raised spurs that help keep the bit drilling straight. The bit cuts timber very fast when used in a power drill and leaves a clean sided hole.
They are ideal for drilling holes for dowels as the sides of the holes are clean and parallel. Sizes range from 3 to 10mm. Spur point bits should only be used for drilling wood or some plastics.

10.3 Countersink

A countersink drill is used to counter sink holes in wood, metal and plastics to accommodate countersunk screw heads.

10.4 Hole Saw

A hole saw is used at slow speeds with powered drills to cut holes, ranging in size from 20mm to 80+mm diameter, in thin metal, plastics or wood. It has a circular saw blade fixed to the body of the drill as shown. The drill makes a pilot hole whilst the blade cuts a circular groove.

10.5 Fostner Bit

A fostner bit bores a clean flat bottomed hole without the depression formed by the centre point of a twist drill or centre bit. This type of bit is used for boring out waste wood in a recess or housing. Sizes vary from 6mm to 50+mm.

Note:
The above information on cutter/drill types is provided to assist the operator in selecting the correct type of cutter for a specific exercise.

Operators should note that the drill guard must be in place for all cutting exercises and this will limit the size of certain cutters e.g. Forstner bit, Flatwood bit and Hole Saw etc.

10.6 Local Restrictions

The use of sanding bobbins is strictly prohibited as recommended in the Glasgow City Council Health & Safety Department report on the Installation of new Pillar Drills:

"Sanding bobbins should NOT be used in pillar drills as they cannot be guarded to protect the operator. "

As well as the guarding issue, Control of Substances Hazardous to Health Regulations 2002 (COSHH) requires that the production of wood dust should be managed.

The pressure applied to the bobbin when in use, will eventually damage the bearings in the spindle shaft due to the exessive side loading. This can lead to a costly repair which would not be covered by the warranty as this operation is strictly prohibited.

10.7 Selecting the correct drill speed

It is essential when selecting the drill speed that consideration is given to the material to be cut and the type of cutter / drill being used; refer to the Pillar Dril Speed Chart, Appendix A.

10.8 Take - Off

The pillar drill is designed to be used by only one person at a time; therefore there should only ever be one operator at the machine. The only other person who could be in the vicinity of the drill operator would be the class teacher in a supervisory capacity.

11 DRILLING MATERIAL

11.1 Using the depth stop

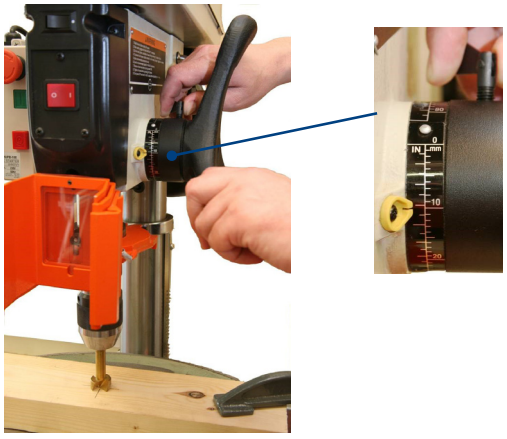
11.1.1 Position the workpiece and clamp securely to the drill table.

11.1.2 Set the drill table to a suitable working height; unlock the table by releasing the table lock at the rear. Using the crank handle raise or lower the table to reach the appropriate working height and lock in position.

11.1.3 Using the feed wheel, lower the drill/ cutter to the top of the workpiece and hold in position.

11.1.4 Release the depth stop lock and ad just to the required cut depth (e.g. 10mm)

11.1.5 Lock the depth stop, the cutter can now only travel a distance of 10mm through the workpiece.



11.1.6 Lower the drill guard adjust and lock in position. Ensuring that the cutter and rotating parts are guarded from fully raised to fully lowered.

11.1.7 When drilling a through hole it is advis able to use a waste packer to protect the table, this is a waste piece of wood clamped beneath the workpiece.

11.2 Feed Speed

The force at which the drill is fed through the material is dependant upon the following factors:

- Type of material being cut
- Type of cutter/drill being used
- Size of the hole to be cut

Sharp drills or cutters should work through the material without the need to impose excessive force. It may be necessary to step the drilling process; drill the workpiece in stages. This allows the shavings and swarf to be cleared, prevents heat build up and for acrylics provides a cleaner cut (less likely to crack or splinter).

11.3 Swarf / Wood Chippings

Swarf, also known as turnings, chips, or filings, are shavings and chippings of metal, the debris or waste resulting from metalworking operations. The chips can be extremely sharp, and this creates a safety problem, as they can cause severe injuries if not handled correctly. Swarf/wood chippings should never be removed when the drill is in operation.

12 POWERING DOWN THE PILLAR DRILL

12.1 Press the red stop button on the control panel to stop the pillar drill, the chuck should come to a complete stop.

12.2 If the ambassador model is used switch off the NVR power button on the front panel.

12.3 Switch off the pillar drill isolator at the wall.

Note
Operators **must never leave** the pillar drill after use so that it can be readily powered-up and used by unauthorised users.

13 LEAVING THE PILLAR DRILL SAFE FOR THE NEXT USER

13.1 Clear the drill table and surrounding area of all debris/dust, using a Hepa Filter Vacuum Cleaner as appropriate.

13.2 Remove any drills or cutters.

13.3 Leave the chuck guard in place

14 FAULT REPORTING

If any fault or damage is found when using the Pillar Drill, the user should:

- Switch the pillar drill off.
- Isolate and lock-off the power using the padlock.
- Report any faults, defects or damage immediately to the appropriate school technician or the principal/senior technician who will arrange for any necessary maintenance or repairs to be carried out.

If any fault or damage to the Pillar Drill is reported, the following action should be taken by the appropriate school technician:

- Ensure that the pillar drill has been isolated from the power supply and that the power is locked-off using the padlock and retain the key.
- Label the pillar drill **"Do Not Use - Under Repair".**
- Advise the necessary staff that the pillar drill cannot be used.
- If appropriate, carry out necessary repair or maintenance.
- If necessary, contact your Technician Support Service (if appropriate) to arrange for repair.
- If any injury or near miss occurs to any person using the pillar drill, or as a direct result of any person using the pillar drill, then it must be reported using the Local Authorities Incidents Report Form; recording all the details of the incident.

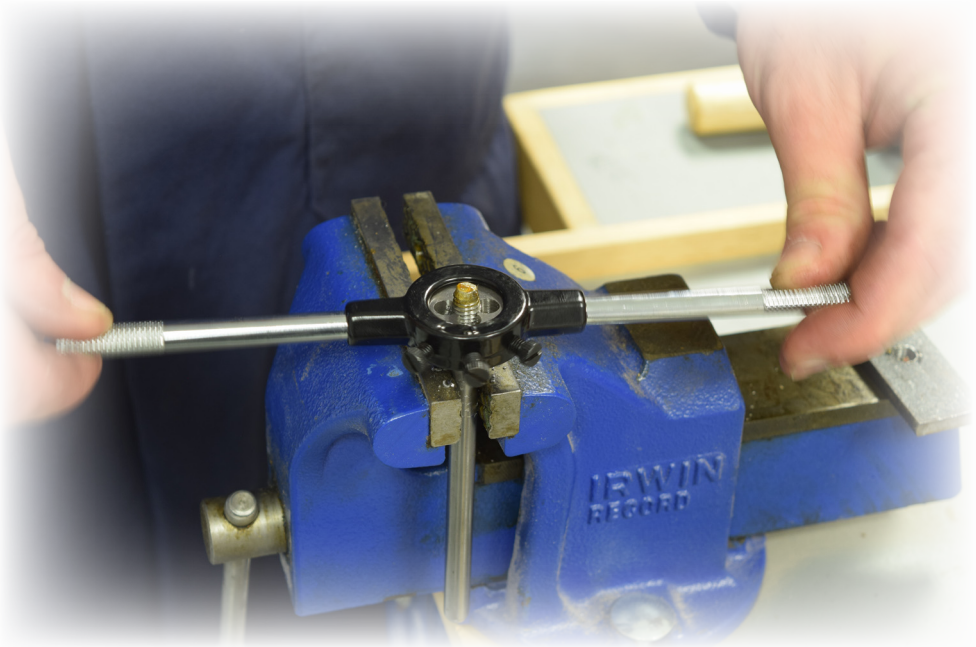
15 REFERENCE MATERIAL

This section was compiled with reference made to the following material:

- BS 4163:2014 Health and Safety for Design and Technology in Schools and similar establishments - Code of Practice.
- HSE: Drilling machines: guarding of spindles and attachments – Guidance Note PM3
- Ambassador Drill – Operation and Maintenance Instructions 2003
- Technical Education - A Code of Practice 1995. (Glasgow)
- Glasgow City Council - Technical Support Services (T.S.S)
- SSERC Draft Risk Assesessments

Part 3 - Screwcutting

2



1 AIMS AND OBJECTIVES

1.1 Aims

To instruct teaching and technician staff in the safe use of screwcutting tools and demonstrate the processes of cutting internal and external threads by hand.

1.2 Objectives

1.2.1 Know and understand screwthread terminology and types of thread forms.

1.2.2 Undertand the different types of screwcutting tooling and how to set it up.

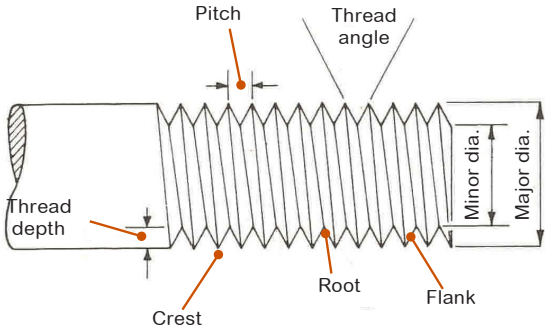
1.2.3 To demonstrate how to prepare material to be threaded.

1.2.4 To demonstrate screwcutting procedures and techniques.

2 SCREWTHREAD

The screwthread is a very important detail in engineering. It is used to hold parts together (eg. bolt and nut) and to transmit power (eg. vice screw). A screwthread is really a helical spiral and is specified by:-

I. The name or type of thread system;
2. The size of thread major diameter;
3. The series; (coarse pitch, fine pitch,etc)



3 SCREW THREAD FORMS

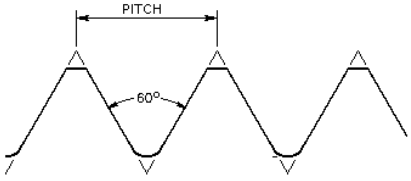
3.1 ISO Metric Screw Threads

International Standards Organisation (ISO) metric screwthreads are a range of threads that have been approved by the British standards Institution. ISO metric threads may be either Coarse or Fine series (or pitch). The ISO metric coarse range of threads covers most of the work undertaken in industrial and school workshops and, as such, is called “ISO Metric”. This range is designated by the letter M followed by the nominal diameter and the pitch (both in millimetres)

e.g. M6 x 0.75 i.e. nominal diameter 6mm and pitch, 0.75mm

e.g. M6 x 1 i.e. nominal diameter 6mm and pitch, 1mm

When a course thread is intended it is usual for the pitch not be indicated. Thus M6 x 1 can be shown simply as M6.



3.2 Other Thread Forms

There are a number of other thread forms available. ISO Unified Threads are also recognised by the British Standards Institution and like ISO Metric threads, have a range of both coarse and fine pitches.
Unified Threads are based on imperial dimensions and are designated by a fraction of an inch followed by UNF (Unified Fine) or UNC (Unified Coarse). For example, 1/4” UNF or 3/8” UNC.

Older thread forms such as BSW (British Standard Whitworth, BSF (British Standard Fine) and BA (British Association) have been superseded by the ISO Metric and ISO Unified threads. However, as many of these threads exist on various equipment and machinery they are still available.

4 HAND SCREW-CUTTING

4.1 Taps

An internal screwthread is cut, in a previously drilled hole, using a tap. Taps are made from high speed steel screwthreaded and fluted to form cutting edges. The ends of their shanks are square to enable the tap to be held securely in a tap wrench.

Taps are available in sets of three and are used in the following order:-

Taper tap 2nd tap Plug tap

4.2 Tapping an Internal Thread

For example, to tap an M8 thread a core hole must be drilled using a 6.8 or 6.9mm diameter tapping drill.

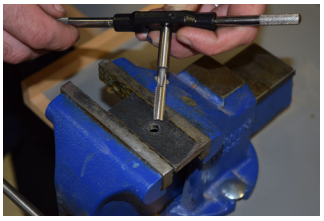
The taper tap must then be started with its axis parallel to the centre line of the hole; if not a “drunken” thread will result. As soon as the tap cuts it should be checked for alignment with an engineers square.

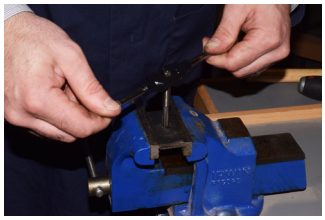
This is followed by a second or intermediate tap which is tapered for the first few threads only.

Finally the plug or bottoming tap is used to cut the full thread.

The tap should be turned clockwise half a revolution to cut the thread and back a quarter turn to clear the swarf.

A cutting oil or coumpound should be used to lubricate the work as the thread is being cut. This will prolong the life of the tap and allow for an efficent cutting action, which in turn produces better quality threads.





Check out the video link!
http://www.sserc.org.uk/images/Technology/Videoclips/General Bench Skills/internal threading.mp4

4.3 Tapping Sizes

The table shown below gives all the information required when tapping a metric hole from M2 to M12.

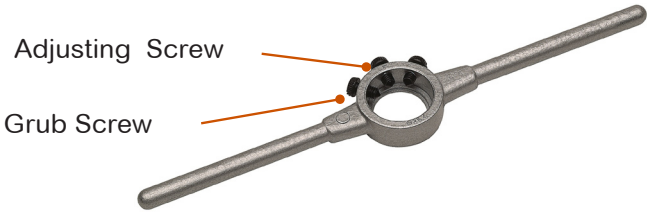
ISO METRIC COARSE PITCH THREADS		
DIAMETER	TAPPING	CLEARANCE
2	1.6	2.2
2.5	2.1	2.7
3	2.5	3.2
3.5	2.9	3.7
4	3.1	4.3
4.5	3.8	4.8
5	4.2	5.3
6	5.0	6.4
8	6.8	8.4
10	8.5	10.5
12	10.2	13

4.4 Broken Taps

Broken taps always present a problem as there is rarely enough tap left protruding for easy extraction with pliers.
A tap extractor, as shown could be used. However if this fails then other means must be found. For example, it is sometimes possible to punch the tap out from the other side, or it may become loose enough for extraction when heated. The tap could be annealed by heating after which it might be possible to drill it out.

4.5 Dies

An external thread is cut on a cylindrical bar or tube by means of a die which is securely held in an instrument called a stock or die holder.



Dies are made from high speed steel (HSS) and come in various forms, the main ones being;

Circular Split Die

Die Nut

The circular split die is more common in the school workshop.

4.6 Cutting an External Thread

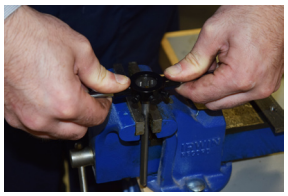
To cut an external thread on a rod the die is placed in the stock with the tapered end outwards. This also has the details of the size and thread stamped on it.

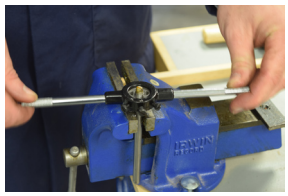
The stock is flanged at the opposite side to enable the die to be correctly located and also to enable positive pressure to be applied to the die when in use.

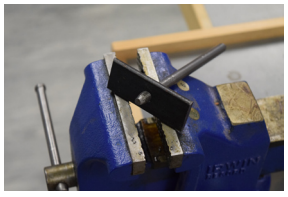
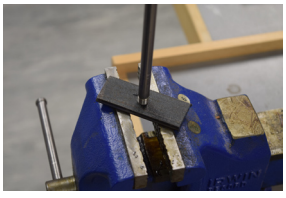
To take the first cut, the die must be opened wide. This is done by screwing the adjustment screw as far as it will go into the V groove. The grub screws are then tightened to secure the die. The rod to be threaded must have a taper filed on one end as an aid to starting the die. Just as for tapping, the stock and die must be pressed down on the rod and rotated clockwise, pausing to check the "squareness" of the stock and die to the rod from front and side If the stock and die are not square with the rod a "drunken" thread will result. Once cutting has started the die should be turned half a revolution forward, then back a quarter turn to break off and clear the swarf. Once the cut has been-completed the stock and die is wound back up the rod and the die is removed and adjusted before taking a further cut. Cutting oil should be used throughout the process.

It should be noted that taps cut an internal thread to a fixed size and no adjustment is possible. Dies, however, can be adjusted to cut a little metal at a time thereby making the thread on the bolt to the desired fit.

For this reason the internal thread on the nut must always be cut first. The external thread on the bolt is then cut to fit it.

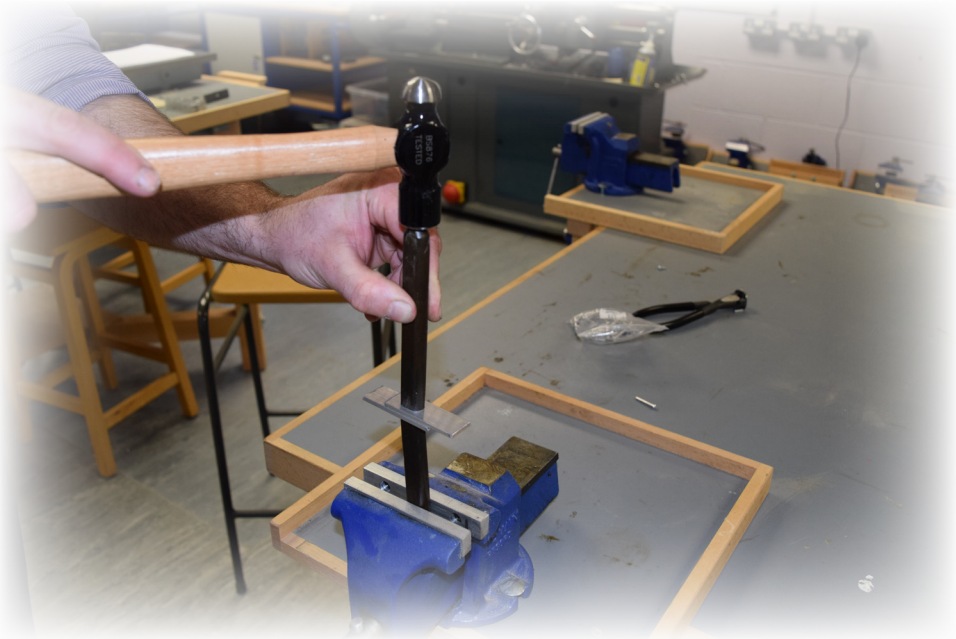



Check out the video link!
http://www.sserc.org.uk/images/Technology/Video clips/General Bench Skills/external threading.mp4

Part 4 - Riveting

2



1 AIMS AND OBJECTIVES

1.1 Aims

To instruct teaching and technician staff on how to safely use traditional hand riveting techniques to join metal.

1.2 Objectives

1.2.1 Know and understand the types of rivets available and how they are specified

1.2.2 To demonstrate how to prepare material to be riveted.

1.2.3 To demonstrate how to use the tools correctly and safety to rivet material.

2 RIVETING

Riveting is the process where two or more pieces of metal are permanently joined together using metal fasteners or plugs known as “rivets”.

Rivets are classified by their;

1. Shape of head,
2. Diameter and length.

Riveting is now regarded as ‘old fashioned’ as various welding processes such as spot welding are now more commonly used in joining metal.

However, it can still be a very useful process to use for certain applications. Riveting was used extensively in past for the construction of ships, bridges and other large structures.

2.1 Rivet Materials

Rivets are made in most types of metal; e.g. mild steel, stainless steel, copper, brass and aluminium. To prevent corrosion and discolouration it is usual to use rivets of the same material as the parts being joined.

2.2 Types of Rivets

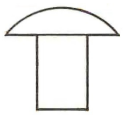
2.2.1 Snap or round head rivets are used for general purposes where a flush finish is not important and countersinking would weaken the job.

2.2.2 Countersunk head rivets are used for general purposes where a flush surface is needed. They are the most commonly used type

2.2.3 Flat head rivets are used for joining thin plates which cannot be countersunk.

2.2.4 Pan head rivets are used instead of snap heads and for more decorative work.

2.2.5 Mushroom head rivets are used for decorative work, it gives little projection of the head.



2.3 Riveting Tools

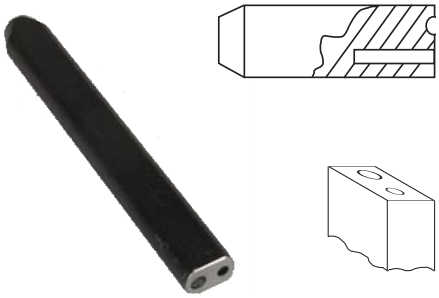
2.3.1 Rivet Set

The rivet set is used for setting or pressing together metal plates and making sure that the rivet is pulled all the way into the hole.
The hole in the set is the same as the rivet diameter.

2.3.2 Rivet Snap

The rivet snap (or dolly) is used to support the head of a round head rivet while riveting, and to finish a round head rivet to the correct shape (snap). It has a concave hole the same size and shape as the rivet head, and two are needed to complete a round head rivet.

A rivet set and snap are commonly combined into one tool and are available in several sizes to fit different rivet diameters.

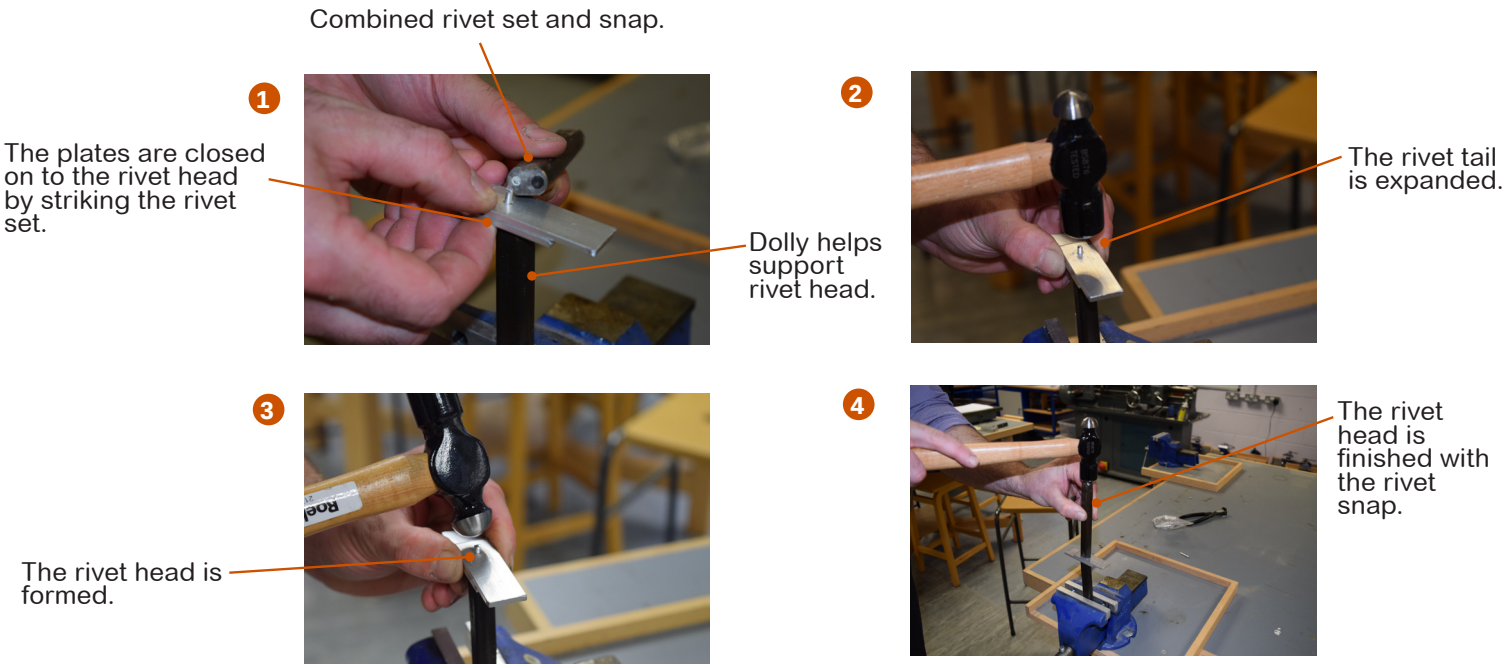


2.4 Riveting Process

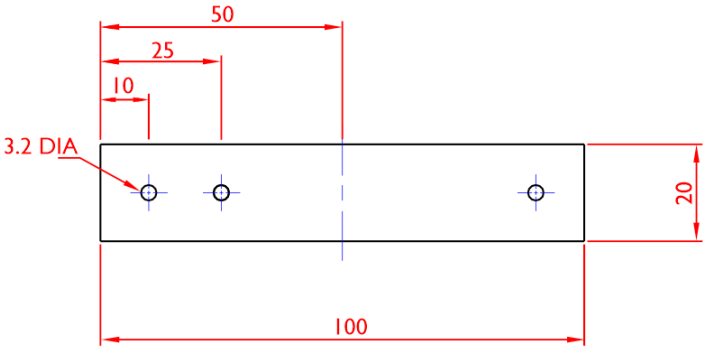
Component parts that are to be joined by a number of rivets should be clamped and drilled together and all rivets inserted before any riveting is done.
It is sometimes more convenient to complete one rivet to fix the joint, then drill and rivet the rest.

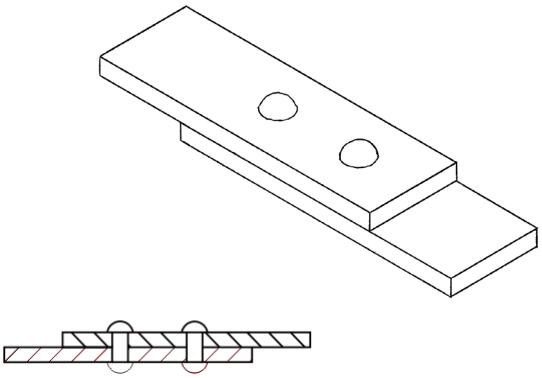
Avoid leaving to much tail to rivet over; for a snap head rivet 1.25 x diameter is usually about right and for a countersunk rivet allow an amount equal to the shank diameter.

A riveted joint is a PERMANENT JOINT and cannot be dismantled without some part or parts of the joint being damaged.



3 RIVETING EXERCISE



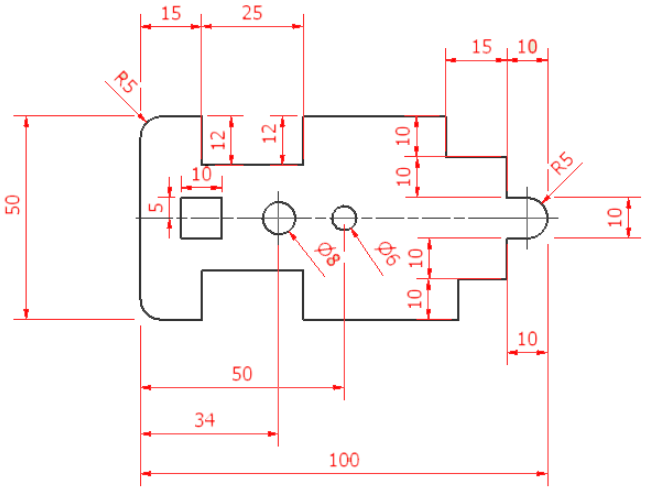


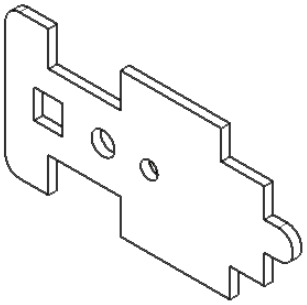
3.1 Sequence of Operation

1. Cut one piece of aluminium to the given size.
2. File both ends straight and square.
3. Mark out the position of the holes by using the odd leg calipers to find the centre, and an engineers square to mark to the correct distance. Centre punch positions.
4. Drill the 3 holes using the pillar drill and a 3.2mm twist drill.
5. Cut aluminium in half and square the cut ends.
6. Assemble the two pieces of metal and insert a rivet through the hole. If necessary snip the rivet off to the correct length using rivet snips/ junior hacksaw.
7. Select a rivet set and snap of suit able size to take the rivet head. Fasten the set and snap vertically in the vice and, using the set part close both the plates together with a sharp blow from a hammer.
8. Spread the rivet tail with a few hammer blows.
9. Using the ball pein part of the hammer, work around the edge of the rivet roughly forming a semi circular head.
10. Finish off with the snap part of the rivet tool.
11. Drill through the remaining hole and rivet as above.

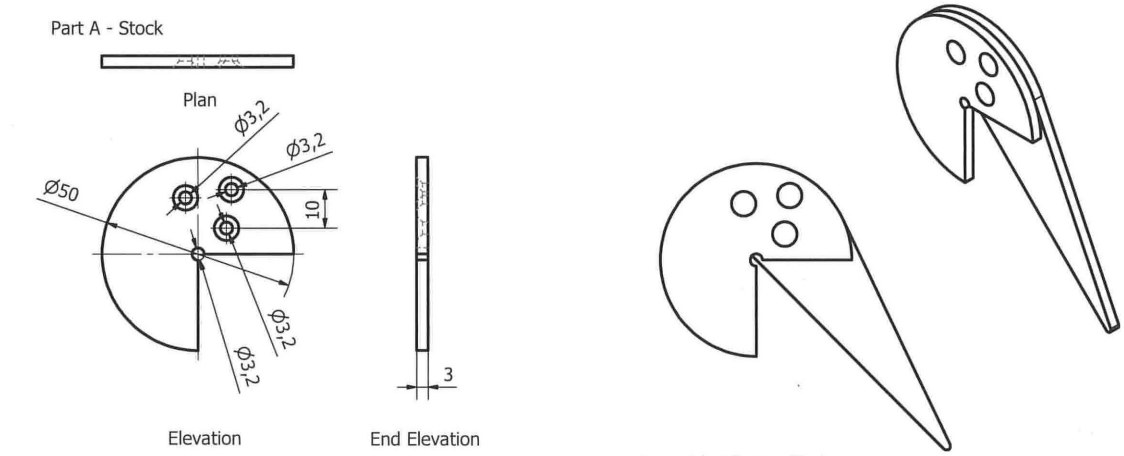
2 Part 5 - Project Exercise

1 MARKING OUT EXCERCISE





2 CENTRE FINDER WORKING DRAWING



Pillar Drill Speed Chart

Recommended Drilling Speeds (RPM)							
Drill Type	**Softwood**	**Hardwood**	**Acrylic**	**Brass**	**Aluminium**	**Steel**	**Notes**
Twist Drills							
1 mm - 5 mm	3000	3000	2500	3000	3000	3000	Lubricate drill with cutting oil when drilling steel 3mm of thicker. Use centre punch on all holes to prevent drill from wandering.
6 mm - 10 mm	3000	1500	2000	1200	2500	1000	
11 mm - 15 mm	1500	750	1500	750	1500	600	
16 mm - 25 mm	750	500	N/R	400	1000	350	
Brad Point Drills							
3 mm	1800	1200	1500	N/R	N/R	N/R	Raise 6 mm and smaller bits often to clear shavings and prevent heat build up.
6 mm	1800	1000	1500	N/R	N/R	N/R	
10 mm	1800	750	1500	N/R	N/R	N/R	
12 mm	1800	750	1000	N/R	N/R	N/R	
15 mm	1800	500	750	N/R	N/R	N/R	
19 mm	1400	250	750	N/R	N/R	N/R	
22 mm	1200	250	500	N/R	N/R	N/R	
25 mm	1000	250	250	N/R	N/R	N/R	
Forstner Bits							
6 mm - 10 mm	2400	700	N/R	N/R	N/R	N/R	Raise 6 mm - 10mm bits often to clear shavings and prevent heat build up. Make several shallow passes with larger bits; allow bit to cool between passes.
13 mm - 16 mm	2400	500	250	N/R	N/R	N/R	
19 mm - 25 mm	1500	500	250	N/R	N/R	N/R	
28 mm - 32 mm	1000	250	250	N/R	N/R	N/R	
35 mm - 50 mm	500	250	N/R	N/R	N/R	N/R	
Hole Saws							
25 mm - 38 mm	500	350	N/R	250	250	N/R	Do not use with brass or aluminium thicker than 1.5 mm. Avoid dense hardwoods.
40 mm - 50 mm	500	250	N/R	150	250	N/R	
53 mm - 64 mm	250-500	N/R	N/R	150	250	N/R	
Flat Bits							
6 mm - 13 mm	2000	1500	N/R	N/R	N/R	N/R	Clamp to work table to improve quality of hole.
15 mm - 25 mm	1750	1500	N/R	N/R	N/R	N/R	
28 mm - 38 mm	1500	1000	N/R	N/R	N/R	N/R	
Tank Cutter							
6 mm - 13 mm	500	250	250	N/R	N/R	N/R	Drill one side, flip material, place centre bit in its hole and resume.
15 mm - 25 mm	250	250	250	N/R	N/R	N/R	
Countersinks							
2 flute	1400	1400	N/R	N/R	N/R	N/R	Raise and lower frequently for quicker cutting.
5 flute	1000	750	750	250	250	250	
Countersink Screw Pilot Bits							
All Sizes	1500	1000	500	500	N/R	N/R	Clear twist drill often.
Plug Cutters							
All Sizes	1000	500	N/R	N/R	N/R	N/R	Cut to full depth so bit chamfers plug

NR - Not Recommended

- Recommendations are based on visual and tactile tests under workshop conditions. Drilling faster than recommended can cause overheating. Speeds slower than recommended may cause poor quality holes.
- All wood testing done on face grain. Reduce speeds when drilling end grain.
- Speeds based on new bits.

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