scottish schools education research centre

Module 3

Engineering Skills - Fabrication

2021

CPD for technical teachers & support staff in schools

3 Contents

3 Part 1 - Hand Tools

1 AIMS AND OBJECTIVES

1.1 Aims

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

1.2 Objectives

1.2.1 Work with a range of basic sheet metalwork hand tools.

1.2.2 Prepare and properly mark out sheet metal.

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

1.2.4 Demonstrate how to form and shape sheet metal.

1.2.5 Demonstrate/understand various sheet metal joining techniques.

1.2.6 Develop skills and knowledge of safe working practices

2 SHEET METALWORK

The purpose of this booklet/course is to provide theoretical knowledge of normal workshop practice found in the school metalwork room. It includes a range of tools and processes that are undertaken when working with sheet metal. It also embraces the standards required for the delivery of the SQA Practical Metalwork course, with emphasis on the Fabrication and Thermal Joining Unit.

3 MARKING OUT

3.1 General Marking Out Tools

Marking out sheet metal is done when the metal is still in its flat form i.e. before any bends or forms have been produced. The tools required during the marking out of sheet metal are generally the same as used to mark out other engineering components.

A list of the following basic tools that will be required include;

1. Steel Rule
2. Scriber
3. Engineer's Square
4. Centre Punch
5. Odd leg Calipers
6. Spring Dividers

Further information on these tools can be found in "Module 1: Engineering Skills, General Bench Skills"

3.2 Specific Measuring Tools

Sheet metal is measured and sold according to its thickness. Traditionally this was done using British Standard Wire Gauge (or SWG). This is an imperial form of measurement.

This system of measurement was phased out with the introduction of the metric system in Britain (In Scotland, educational examinations from 1973 onwards used the metric system)

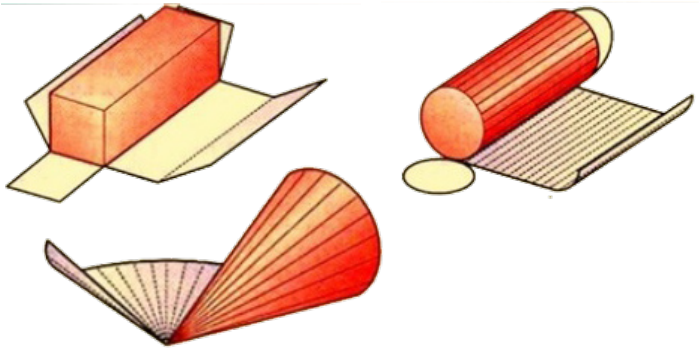
It is now sold and measured using millimetres (common thicknesses being 0.8mm, 1mm, 1.2mm etc.) Many technical departments may still have a British Standard Wire Gauge in storage or on display. These gauges are still available to buy, in both imperial and metric formats. They are often in either a round or rectangular shape with each different thickness (or gauge) notched out around the circumference. Made from hardened steel or stainless steel.

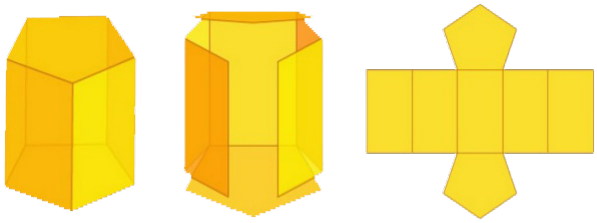
3.3 Developments

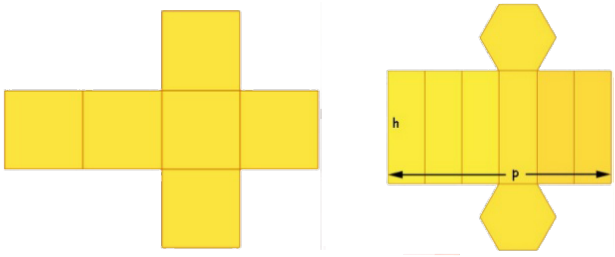
In most cases a "pattern" or "development" of the work is first worked out on paper or thin card. The term development is given to the flat shape required to produce a 3-dimensional object.

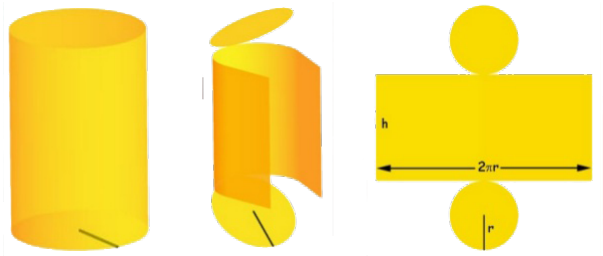
This requires a knowledge of geometry, and practice in drawing out layouts. It is these layout drawings that show true dimensions and angles that may be developed from basic geometrical shapes such as squares, cylindrical, pyramidal or prismatic. Once a development has be created, consideration has to then be taken to allow for bends or forms. Simple developments can often be marked directly onto the metal using the range of marking out tools. However, it is advised that the work would first be worked out on paper and then transferred. This allows for any errors to be rectified easily.

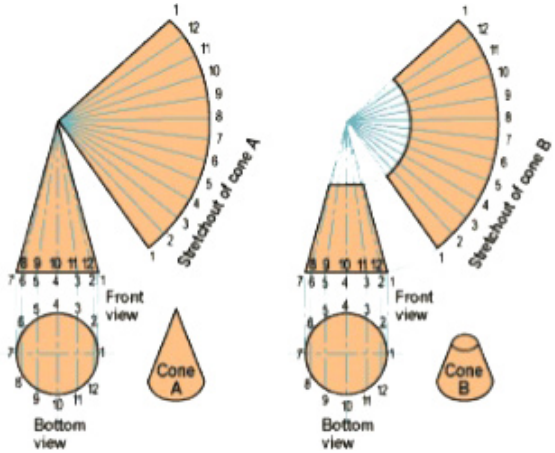
Below is a few examples of various sheet metal developments.











4 HAND CUTTING TOOLS

4.1 Hand Shears (TinSnips)

Hand shears or Tin snips are used to cut thin sheet metal. As the name implies, they are used to cut sheet tin, but they can also be used to cut through a variety of other metals in sheet form such as copper, brass, mild steel and aluminum. Tin Snips are easily identified by their long handle and short blades. They are manufactured from drop forged carbon steel and can cut between 24 and 16 gauge sheet, depending on the size of the blades.

There is a selection of different types of hand shears available and common sizes range from 180mm to 360mm. They can also be supplied for either right or left hand use.

4.1.2 Straight Hand Shears

These are used for general purpose cutting of straight lines or outside curves. As the cut is made it may be necessary to trim surplus metal away to allow manipulation of the handles to gain access to continue cutting.

4.1.3 Curved Hand Shears

These are used for cutting circles, irregular curved shapes or inside curves. Common sizes range from 200mm to 350mm.

4.1.4 Universal hand shears

These are designed to cut straight lines and both outside and inside curves.

4.1.5 Compound Action Shears

Also known as aviation snips due to their development in the aircraft industry to cut aluminum. However, they can cut other forms of sheet metal. Dependent on the size they generally can cut up to 18 gauge aluminum, mild steel up to 24 gauge or stainless steel up to 26 gauge. The popularity of this type of shear/snip has grown due to the linkage increasing the mechanical leverage without increasing the length of the snips handles. Again, theses snips are available in either straight or curved form dependent on the work undertaken.

4.2 Nibbler

An alternative to hand shears is a nibbler. There are two styles of nibbler available. One type operates with the use of a punch and die. As the handles of the nibbler are squeezed together the punch is pressed against the fixed dies and removes small amount of metal leaving a kerf approximately 3-6mm in width. The other method works similar to tin snips, but shears the metal along two parallel tracks 3-6m apart. As it cuts the waste material is rolled up into a tight spiral.
The main advantage to using nibblers is the fact that sheet metal can be cut with minimal distortion.

Nibbler attachments are also available for drills. These nibblers are mounted into a drill chuck and with the drill speed set to 1500 to 3000rpm are capable of cutting sheet steel up to 2mm. It works on the same principle as hand held nibblers, using a punch and dies set up. When using this type of nibbler cutting lubricants are recommend to prolong the life of the punch/die and aid in the clearing of waste metal during cutting.

5 STRIKING TOOLS

5.1 Raw Hide Mallet

The raw hide mallet is used for folding or forming curves in sheet metal. The head is made from a tightly rolled strip of animal hide. As the head of the mallet is made from hide, it prevents the surface of the metal from being damage. Various sizes of mallet heads are available and are usually classed with a number, e.g. No.0 to No.10 (smallest to largest). This dictates the diameter of the mallet head, with physical sizes ranging from 25 to 90mm. The shaft is generally made from Ash.

5.2 Bossing & Tinmans Mallet

Both of these types of mallet are used to shape and form sheet metal without damaging the surface. The heads of these mallets are usually made from boxwood with the shafts being made from either Ash or Cane. The bossing mallet, having rounded ends is used for hollowing work i.e. thinning metal to form a bowl shape. The tinmans mallet, having flat ends is used for forming straight bends or flattening out sheet metal.

Bossing Mallet

Tinmans Mallet

5.3 Raising Hammer

A raising hammer is used in conjunction with a raising stake. It has striking faces which are oblong and flat with the edges rounded. Some raising hammers are also made with one face for raising, the other being slightly convex so that it can be used for stretching.

5.4 Creasing Hammer

A creasing hammer is used to produce radial crimps or creases e.g. when closing down wire edge joints.

5.5 Hollowing Hammer

Hollowing (or blocking) hammers are used in the hollowing or sinking process. This is a process where sheet metal is thinned to form a bowel or tray shape.

5.6 Planishing

Planishing hammers are used to refine the outer surface of curved or flat forms in metal by removing the hammer marks introduced during initial forming (or raising) The faces can be round, square with a slight curve or completely flat. As this is a finishing hammer, the faces should be polished to a mirror finish.

Safety Note

Never use an unsafe hammer.
Before using, check for loose head or split shaft.
Inspect hammer faces for wear, dents or chips.

6 FORMING TOOLS

6.1 Bench Stakes

To support work and for bending purposes when working with sheet metal a number of bench stakes are used. Bench stakes are manufactured from wrought iron faced with steel. Bench stakes are held in either special bench sockets, in square holes or in the hardie hole of the anvil. The following types of bench stakes are usually found in the school workshop.

6.1.1 Hatchet Stake

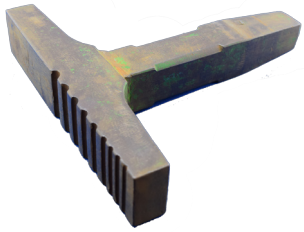
Used to bend edges beyond 90˚, the hatchet stake is used for straight edges.

6.1.2 Half Moon Stake

Used as per hatchet stake, although for edges on circular work.

6.1.3 Creasing Iron

Creasing irons are primarily used for making curved bends, wiring edges and grooving. Caution must be taken to avoid damaging the work surface on the groove edges.



6.1.4 Funnel Stake

For bending cylindrical and conical shapes

6.1.5 Round Bottom Stake

Round bottom stakes are used for forming cylinder bottoms. These are available in various diameters.

6.2 Folding Bar

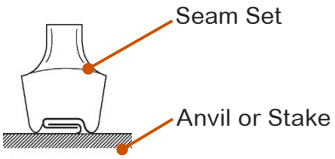
For bending small scale work or thin sheet metal at the work bench folding bars are used. Folding bars are manufacture from mild steel and forged to shape with a loop on the end. This provides a slight spring action when opening and closing the blades. This springing action enable the sheet metal to be firmly gripped when inserted to make ready for final securing within the vice. These are available in a range of sizes from 150mm to 550mm. Folding bars for lager work can be easily made using lengths of angle iron bolted together.

6.3 Sand Bag

The sand bag is made from thick leather and filled with sand. These are used for supporting work or tools primarily when performing sinking, doming, raising and engraving techniques on sheet metal. The bag should be kept away from sharp edges/objects to prevent the bag from being punctured through use. The more the bag is used the softer and more supple it becomes. They are generally available in a range of sizes ranging from 150mm to 230mm.

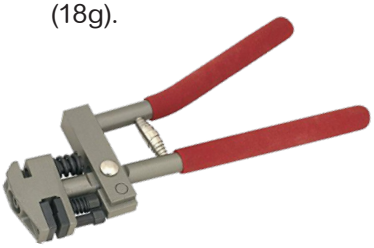
6.4 Seaming Tool

A seam set is used to set down a folded seam (see sheetmetal joints) Care must be taken to avoid damage to the sheet metal (tinplate) on either side of the joint. This joint presents a surface which is smooth and unbroken on one side. The correct size of seam set must be used to avoid damage to the joint



6.5 Joggler Pliers

Joggler pliers or edge jogglers is a forming tool that allows sheet metal to be joined together, with one side of the joint being flush. The stepped jaws form a shallow stepped edge so that an adjacent overlapping sheet sits flush. The Joggler jaws sets down a 12mm wide step along the sheet edge in mild steel up to 1mm (18g).

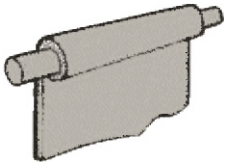


Check out the video link!
http://www.sserc.org.uk/images/Technology/Video clips/Fabrication Skills/Joggler.mp4

7 SHEETMETAL JOINTS/EDGES

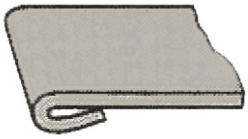
7.1 Wire Edge

A wired edge produces a more robust edge to metal by adding reinforcement via a wire. The allowance of the metal to make a wired edge is two and half times the diameter of the wire used. Having marked off this allowance, the edge is tapped over using folding bars, preferably having round edges to preserve the curve. With wire being placed in the groove produced then metal can then be tapped down, finishing with a creasing iron.



7.2 Safe Edge

This is the simplest method of treating an edge and providing strength, safety and good appearance. The edge is first bent over to form a right angled bend using either a folder or using folding bars and a hide mallet. The edge is then folded further on a hatchet stake (or using the gabro pressed down using the clamp bar) If using the hatchet stake the edge is finally formed on a bench and tapped further down until the main body of the metal touches. Care needs to be taken not to hit the curved bead.

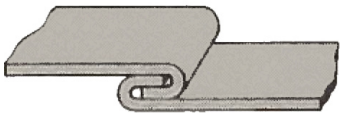


7.3 Joggling

Joggling is a process whereby a lap joint can be produced which has one smooth face (i.e. one side is flat and flush) the process involves offsetting one edge of metal down the thickness of the metal. This is often done using joggling pliers.
(See joggling pliers)

7.4 Folded Seam

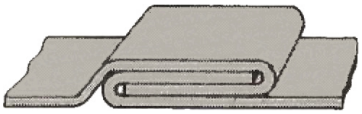
A folded seam provides a joint that is stronger to that of basic butt or lap joints. This joint is made by allowing the width of the joint on one piece of metal and twice the joint width on the other piece. The two edges are hooked over, joined and tapped down to make a tight joint. This can then be soldered if required to be air or watertight.



7.5 Grooved and Seamed

This type of joint is the same as a folded seam except that it is made to lie flush on the one side by means of a seam set. When setting out folded seam joints, the allowances must be 'bare' owing to the thickness of metal when folding.

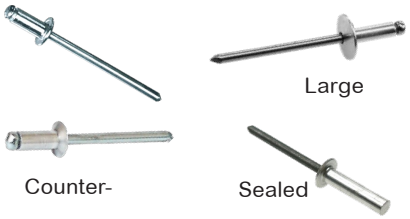
(See seaming tool)



7.6 Riveting

Further information on the process of traditional riveting can be found in "Module 1: Engineering Skills, General Bench Skills, Part 4)

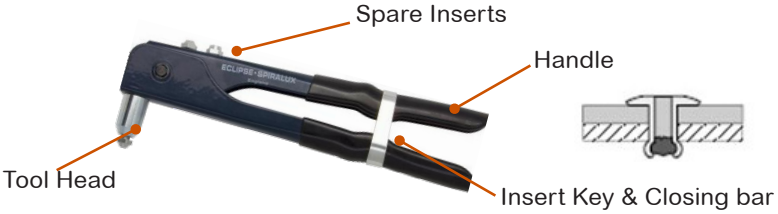
The traditional method of using a ball pein hammer and rivet set (set/Snap) to rivet material can be problematic if access was restricted. In these situations, where it is impossible to get access to one end of a rivet with a hammer or rivet set, a special hollow type of rivet can be used. this was orginally developed by the aircraft industry. This type of rivet is known as a pop rivet.



Pop rivets are mainly used for joining thin sheet metal, but can be used for other thin materials. Washers can be put onto the rivets to enable soft materials such as leather and rubber to be riveted.

The rivet is fitted into a drilled hole and a special pop riveting gun or pliers is then used to pull through the inner core. When the correct pressure is reached the head "pops" or breaks off in the end of the hollow rivet and completes the joint.

This type of rivet allows for a very speedy process of making permanent joints in sheet metal. They can only be removed by breaking the head of the rivet off with a cold chisel or by drilling them out.



Part 2 - Guillotine & Notcher

3

1 AIMS AND OBJECTIVES

1.1 Aims

To instruct teaching and technician staff in the safe use of the Gabro Notcher and the “Keetona” style Bench Guillotine.

1.2 Objectives

1.2.1 Know and understand the hazards associated with the use of guillotines and notchers.

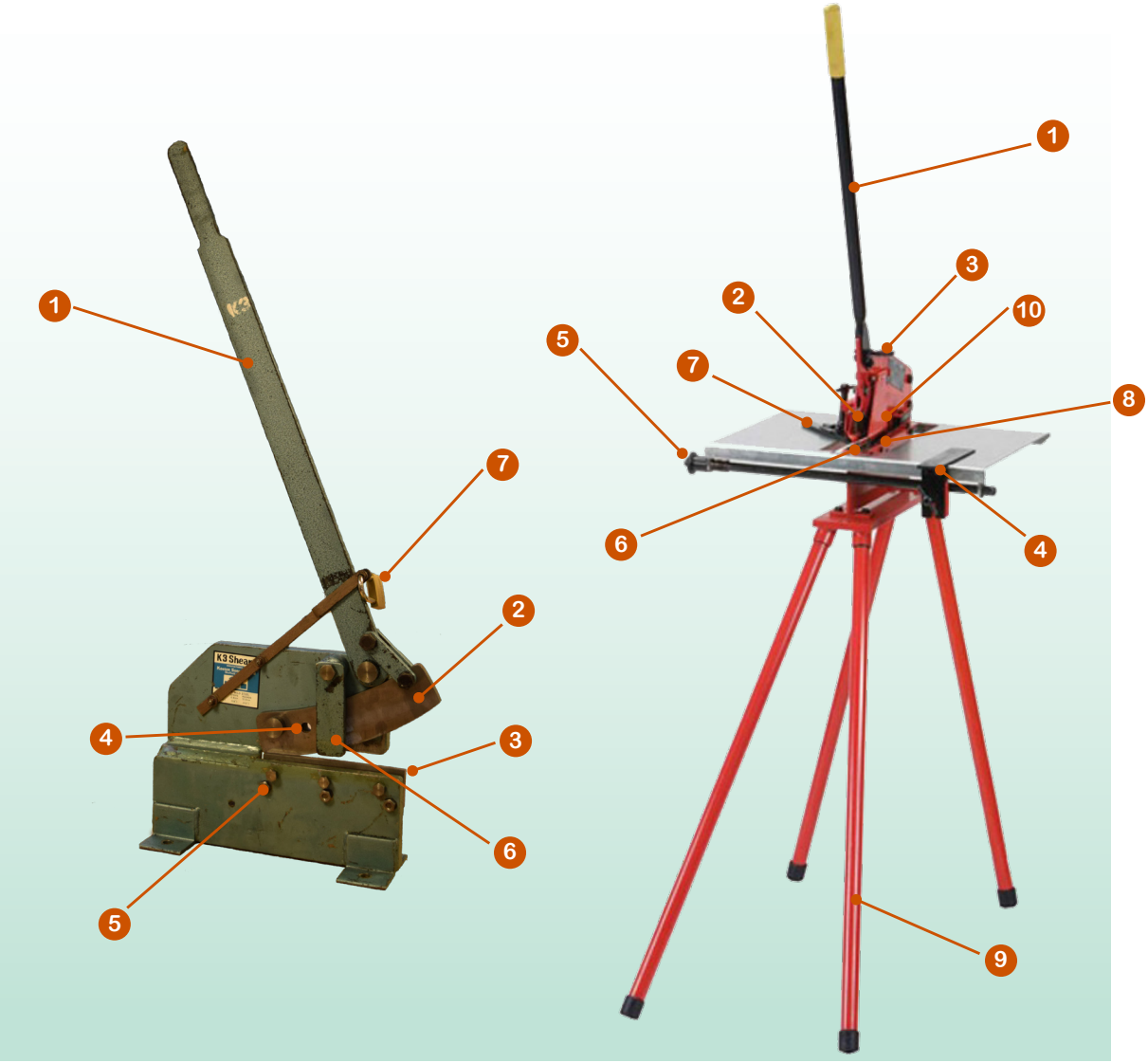
1.2.2 To outline the safety precautions necessary for safe operation.

1.2.3 Become familiar with the component parts and their function.

1.2.4 Demonstrate how to adjust and set the guillotine/notcher.

1.2.5 Demonstrate how to operate the guillotine/notcher to carry out its function safely.

2 TYPICAL GUILLOTINE & NOTCHER



Keetona Guillotine

1) Handle
2) Top Shear
3) Bottom Shear
4) Round Bar Shear
5) Bottom Shear Adjustment Bolts
6) Material Foot
7) Locking Bar

Gabro Notcher

1) Handle
2) Top Blade
3) Handle Return Spring
4) Fence
5) Fence Adjustment (Fine)
6) Bottom Die
7) Angle Guide
8) Line Guide
9) Stand
10) Stripper Plate/Guard

*Note - The 2 Guillotine/Notcher above give a general comparison between typical machines found in school workshops - When not in use, the machine should be made safe by locking the action and, if possible removing the operating handle.

3 USAGE

For cutting sheet metal to lengths or sizes. Notchers are designed to prevent any distortion during cutting unlike traditional bench guillotines/ shears which usually end up with one edge of the cut distorted. This is the advantage of using the Gabro Notcher when cutting sheet metal.
A complete strip of thin metal is removed to produce clean edges on both sides of the cut. The main advantage to traditional bench shears (Keetona shears) is the fact it has the capability to cut heavier flat bar, sheet, and round bar to lengths. Maximum machine capacities must not be exceeded.

4 HAZARDS

4.1 Closing movement between surfaces and other parts can result in trapping and serious injury.

4.2 Sharp edges on materials can cause cuts.

4.3 Lack of space around the machine can lead to the operator being pushed by passers-by.

4.4 Slippery floor surfaces or loose items around the machine can cause slips that result in contact with moving parts.

4.5 Manual handling of sheet materials and operating levers can present a hazard.

4.6 Entanglement of long hair, loose clothing, etc., in moving parts can present a hazard.

4.7 Unauthorised persons using the machine.

5 CONTROL MEASURES

5.1 Safety Signs

Blue - Mandatory Instructions

Red - Prohibitory

5.2 Personal Protective Equipment (PPE)

5.2.1 Googles – Appropriate eye protectio should be worn by users. (BSEN-166-349B)

5.2.3 Protective Garments - industrial type gloves should be worn to handle sheet materials.

5.2.4 Long hair and loose clothing should be secured so as not to come into contact with moving parts. Jewellery should be removed.

5.3 Environment

5.3.1 Only one person should operate the machine at any time.

5.3.2 These machines should be secured to a bench or stand specifically designed for the purpose.

5.3.3 There should be sufficient space around the machine to prevent the operator from being accidentally pushed by passers-by.

5.3.4 The floor surface should not be slippery and should be kept free of loose items.

5.4 Equipment Conditions

5.4.1 When the machine is not in use, it should be made safe by locking the action.

Example of locking Attachment

5.4.2 Only one person should operate the machine at any time, pupils should be under direct supervision.

5.4.3 Only material within the capacity of the machine should be cut, to minimize physical effort and to prevent damage.

5.4.4 Material should be properly supported during cutting.

5.4.5 Manual handling tasks associated with moving materials should be assessed and measures implemented as appropriate to minimize risks (e.g. team lifts, correct lifting

techniques, care of passers-by).

5.4.5 These machines should be included in a planned maintenance programme.

6 NOTCHER OPERATING PROCEDURES

6.1 General Procedures

Gabro style notcher's work by taking a small piece of material completely out with each cut, so with progressive cuts the machine is capable of cutting across any sheet size as long as its thickness is within the maximum capacity.

Always keep the stripper plates in place, i.e down. This prevents the material from jamming by pushing it down and away from the top blade. It also protects fingers from entering the blade area. Adjustments, should they become loose are made at the pivot by tightening the nuts.

The machine produces a small piece of scrap with each cut which must be on the waste side of the material.

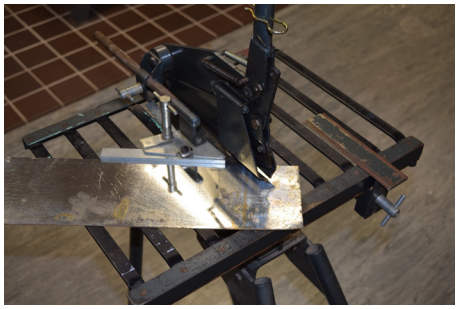
When cutting to maximum capacity with one side of the top blade only, keep about half of the top blade in the bottom die to prevent damage to dies or material becoming wedged.

Cutting using the fence, set fence roughly with the tommy nut and all fine adjustments can be made with the handwheel on the fence bar.

If cutting with the line guide always make a small cut first approx. 6mm and align it with the lug on the top blade. Once the line guide is aligned, cut along the marked line making progressive cuts until completed. When not in use it can be swung out of the way.

6.2 Cutting at an Angle

To make angled cuts, set the angle guide and backstop to the required angle and make the cut. For cuts longer than one stroke, lift the guide after first cut and feed the sheet beneath it, the friction washer should hold the guide up above the sheet.



6.3 Taking out Corners and V Notches

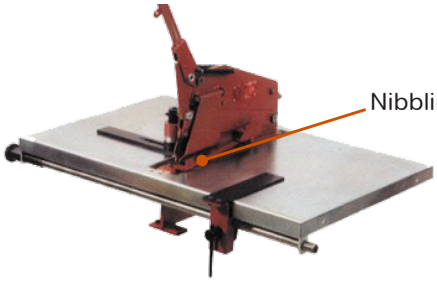
Set the Fence to the width of the notch (ensuring that the kerf is in the waste) and set the Angle guide/Backstop to the depth, make the cut and then turn material over and make second cut.

6.4 Nibbling

Where a gap has to be cut in the side/end of a sheet of material. This is done by setting depth of cut with the Angle Guide/ Backstop and cutting by moving material left or right just the width of the Top Blade each stroke until gap is wide enough.

6.5 Nibbling Shapes

Nibbling shapes is done in the same manner as ordinary nibbling. However, nibble to lines or use the Nibbling Steady. First remove the Angle Guide/Backstop from the clamp and then insert the nibbling steady and line it up with the front of the top blade with slight pressure against the blade. This can then be used as a guide.



6.6 Cutting Angle

Make one cut for each leg of the material, cut up to root on first cut turn around material and lift strippers just enough to pass the angle under and make second cut.

7 MAINTENANCE & ADJUSTMENTS

7.1 General Maintenance

It is important to keep all loops and pivots well oiled and this should be done regularly. Keep all blades well-adjusted and set to the correct clearance when cutting.

The top blade can be ground on the front and bottom edge on the standard bench grinder. When doing this it is important to set the centre of the grinding wheel through the centre of the blade in order to grind a concave profile. This profile aids in the cutting process.

The stripper plate must be kept in good working order, should they become loose they can be tightened via the nuts on the pivot.

Should the machine not crop at the front of the blade, to the rear of the blade carriers, there is an eccentric pivot. By slacking the nut and turning the bolt left or right will move the top blade forward or back. Once set the nut should be retightened, holding the bolt with a spanner to prevent movement from setting. The keyway in the bolt should always be facing downwards.

7.2 Difficulty in cutting Near Upper Limit

Undue difficulty in cutting near the machines upper limits may be due to the blade and/or die being blunt, or insufficient die clearance. Should the material stick to the top blade and not strip when in contact with the strippers, this is due to not enough die clearance.

7.3 Difficulty with Feeding Material

This is very likely to happen and will occur only if the upward stop, which limits the upward travel of the top blade has become badly misplaced. To adjust, first loosen the nut and turn the eccentric stop so the ground concave part of the lug on the top blade is central with the bottom dies, when set retighten the nut.

8 NOTCHER CAPACITIES

8.1 Gabro Model 2M2

Max Mild Steel 1.6mm
Max Stainless Steel 1.4mm
Max Non-Ferrous Metals 3.2mm
Without Die Adjustment 0.25mm
Blade/Die Clearance Each Side 0.05mm
Standard Blade Thickness 3.3mm
Max. Length of Cut - One Stroke 70mm

8.2 Gabro Model 3M2

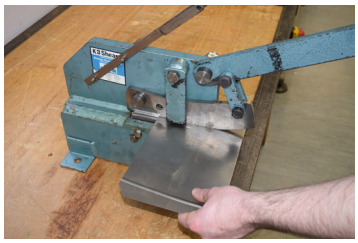
Max Mild Steel 3.2mm
Max Stainless Steel 1.8mm
Max Non-Ferrous Metals 4.0mm
Without Die Adjustment 0.3mm
Blade/Die Clearance Each Side 0.08mm
Standard Blade Thickness 4.5mm
Max. Length of Cut - One Stroke 108mm

9 GUILLOTINE OPERATING PROCEDURE

9.1 Cutting Sheet Metal

9.1.1 Position the material to be cut between the cutting blades from the left hand side, ensuring the material foot is just touching the top of the workpiece.

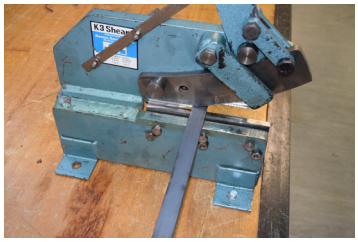
9.1.2 For straight cuts, keep the metal stationary and flat as the handle is pulled forward and downward.



9.1.3 As the 1st cut has been done and the upper blade has reached the low point, raise the handle then move the material forward placing the uncut area once again at the blade intersection point.

9.2 Cutting Flat Material

9.2.1 With the Handle in the full up position, place flat stock as far back into blade intersection as feasible.

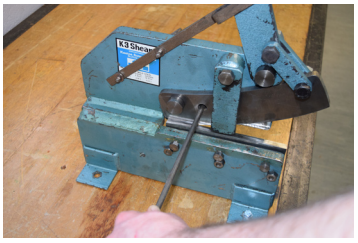


9.2.2 Pull Handle firmly forward and down to cut material.

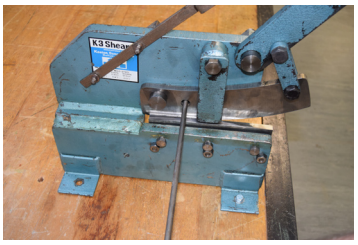
9.2.3 Raise Handle and withdraw cut pieces.

9.3 Cutting Round Material

9.3.1 With the handle in the full up position, insert round material to be cut into the round bar shear in the upper blade and main body.



9.3.2 Pull Handle firmly forward and down to shear material.



Check out the video link!
http://www.sserc.org.uk/images/Technology/Videoclips/Fabrication Skills/Guillotine.mp4

9.3.3 Raise Handle and withdraw cut round stock.

10 MAINTENANCE & ADJUSTMENTS

10.1 All pivots, for the operating lever and linkage should be checked for side movements and adjustments made to eliminate any excess play. All nuts should be checked for tightness. Lubricate all pivot points periodically with a medium bodied lubricating oil.

10.2 The blades should be inspected regularly for damage and ground as necessary. The blades should be adjusted as follows, with the top blade fully lowered and the bottom blade assembled use the adjustment screws to bring the bottom blade into light contact with the lowered top blade. Then tighten the bottom blade with the nuts on the 3 securing bolts.

11 GUILLOTINE CAPACITIES

The keetona Bench Guillotine was manufactured in 6 models, each having a varying degree of cutting capacity.

K1 - Blade 112mm, 3mm sheet, 4mm strip, 9.5mm rounds

K2 - Blade 158mm, 4mm sheet, 5mm strip, 11mm rounds

K3 - Blade 203mm, 5mm sheet, 6.5mm strip, 12.5mm rounds

K4 - Blade 152mm, 9.5mm sheet, 12.5x50mm strip, 19mm rounds

K5 - Blade 304mm, 3mm sheet, 5mm strip, 12.5mm rounds

K6 - Blade 203mm, 6mm sheet, 8mm strip, 14mm rounds

11 LEAVING THE GUILLOTINE/ NOTCHER SAFE FOR THE NEXT USER

11.1 Clear the bench/stand and the surrounding area of all debris and metal off cuts. Dispose of these off cuts in the appropriate manner, i.e purpose bins, not general waste.

11.2 Ensure all guards are in place.

11.3 Secure operating handle in upwards postion with a padalock to prevent unauthorised use.

12 FAULT REPORTING

If any fault or damage is found when using either the Guillotine or Notcher, the user should:

- Lock off the action, i.e use a padlock to secure the handle to prevent the guillotine/notcher from being operated.
- 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 either the Guillotine/Notcher is reported, the following action should be taken by the appropriate school technician:

- Ensure that the guillotine/notcher has been locked-off using a padlock and retain the key.
- Label the guillotine/notcher - "**Do Not Use - Under Repair**".
- Advise the necessary staff that the guillotine/notcher 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 guillotine/notcher, or as a direct result of any person using the guillotine/notcher then it must be reported using the Local Authorities Incidents Report Form; recording all the details of the incident.

13 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.
- RMT - Gabro Guillotine/Notcher– Operation and Maintenance Instructions Model 2M2/3M2
- Technical Education - A Code of Practice 1995. (Glasgow)
- SSERC Draft Risk Assesessments

Part 3 - Box Pan Folder

3

1 AIMS AND OBJECTIVES

1.1 Aims

To instruct teaching and technician staff in the safe use of the Gabro Box Pan and general purpose folder.

1.2 Objectives

1.2.1 Know and understand the hazards associated with the use of Gabro folder.

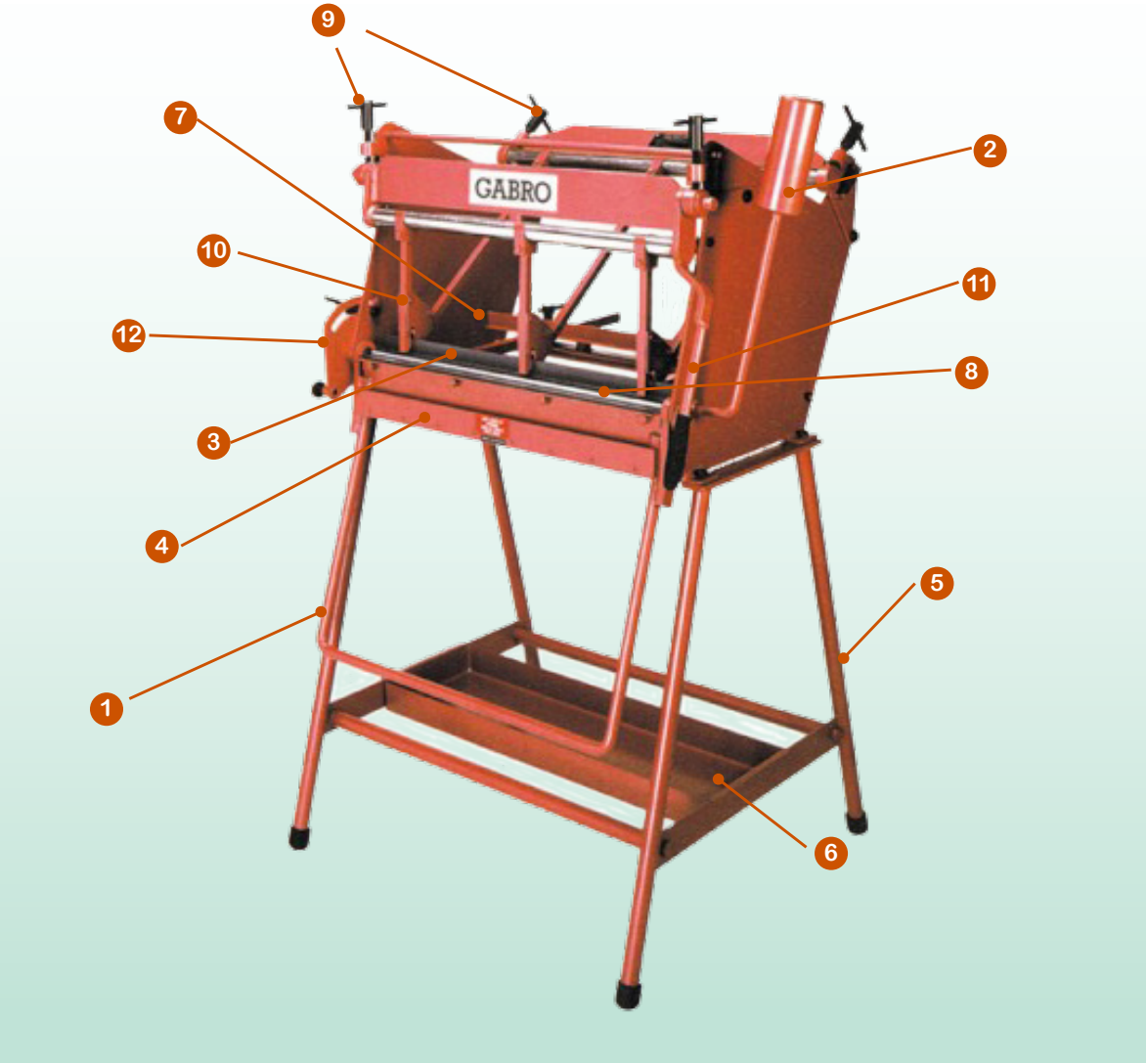
1.2.2 To outline the safety precautions necessary for safe operation.

1.2.3 Become familiar with the component parts and their function.

1.2.4 Demonstrate how to adjust and set the Gabro Folder

1.2.5 Demonstrate how to operate the Gabro Folder to carry out its function safely.

2 TYPICAL BOX FOLDER



1) Handle
2) Counter Weight
3) Clamp Bar
4) Fold Bar
5) Frame
6) Tool Tray
7) Back Stop
8) Bed
9) Adjuster Screw
10) Back Strut
11) Clamp
12) Stop Quadrant

*Note - The Gabro Box Pan Folder above gives a general comparison between typical machines found in school workshops (some models may vary slightly)- When not in use, the machine should be made safe by locking the action.

3 USAGE

For bending sheet metal to form various angles and shapes. The top portion is made/cut into sections as required so that completed box and pan shapes can be formed from one flat sheet. Maximum machine capacities must not be exceeded.

4 HAZARDS

4.1 Closing movement between surfaces and other parts can result in trapping and serious injury.

4.2 Sharp edges on cut materials can cause cuts.

4.3 Lack of space around the machine can lead to the operator being pushed by passers-by.

4.4 Slippery floor surfaces or loose items around the machine can cause slips that result in contact with moving parts.

4.5 Manual handling of sheet materials and operating levers can present a hazard.

4.6 Entanglement of long hair, loose clothing, etc., in moving parts can present a hazard.

4.7 Unauthorised persons using the machine.

5 CONTROL MEASURES

5.1 Safety Signs

Blue - Mandatory Instructions

Red - Prohibitory

5.2 Personal Protective Equipment (PPE)

5.2.1 Googles – Appropriate eye protection should be worn by users.

5.2.3 Protective Garments - industrial type gloves should be worn to handle sheet materials.

5.2.4 Long hair and loose clothing should be secured so as not to come into contact with moving parts. Jewellery should be removed.

5.3 Environment

5.3.1 Only one person should operate the machine at any time.

5.3.2 These machines should be secured to a bench or stand specifically designed for the purpose.

5.3.3 There should be sufficient space around the machine to prevent the operator from being accidentally pushed by passers-by.

5.3.4 The floor surface should not be slippery and should be kept free of loose items.

5.4 Equipment Conditions

5.4.1 When the machine is not in use, it should be made safe by locking the action.

5.4.2 Only one person should operate the machine at any time, pupils should be under direct supervision.

5.4.3 Only material within the capacity of the machine should be folded, to minimize physical effort and to prevent damage to the machine.

5.4.4 Sheet material should be properly supported during folding.

5.4.5 Manual handling tasks associated with moving materials should be assessed and measures implemented as appropriate.

6 SETTING PROCEDURES

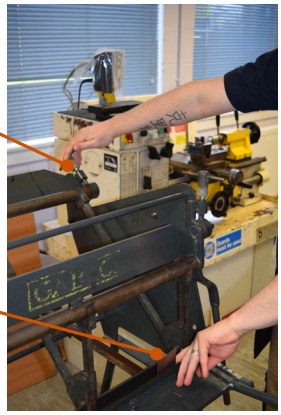
6.1 Move the two outer struts to their widest position and fit the bevelled edge clamp bar into the stung loaded struts. The

bevelled clamp bar is meant to be kept uncut, the plain edged bar should be kept for cutting into length for box and pan forming.

6.2 Turn the back four top adjuster screws so that the clamp bar is well back from the fold bar and well clear of the bed.

6.3 Raise the fold bar to the horizontal position and secure it by adjusting the stop quadrant on the left of the machine and turn the knurled headed screw into the hole provided.

6.4 Tighten the four adjuster screws a little at a time in turn until the correct metal gauge is pressed firmly into the corner formed by the bed and fold bar.



6.5 When setting the front edge of the fold bar to a line or measurement it is good practice to release the front adjuster screws one half turn so that the workpiece can be easily moved when the clamp bar is down.

6.6 Retighten the adjuster screws one half turn before bending the workpiece.

Note - not alot of pressure is required for clamping, using too much pressure will result in damaging the folder.

7 FOLDING PROCEDURES

7.1 Vertical Sides

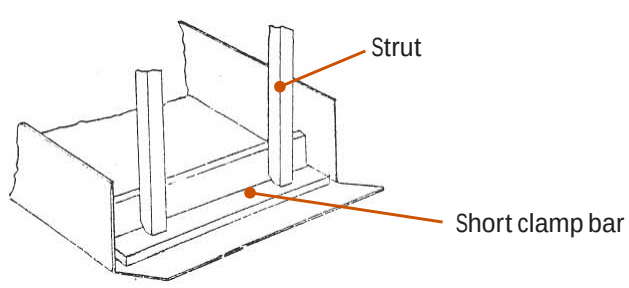
7.1.1 With the clamp bar fully adjusted to accommodate the gauge of metal being folded (as per the setting procedures) folding the long sides first, clamp the metal and raise the folding bar handle up to the required angle.

Note, if a 90˚ bend is required it is some times necessary to raise the folding bar handle slightly beyond this angle. As the folding bar handle is lowered the metal can very slightly spring back.

7.1.2 With the use of a short piece of clamp bar (cut from the plain edged bar) insert into the sprung loaded struts and position centrally along the bed of the folder. Clamp the material down and raise the

folding bar handle to achieve the required angle

Note, the short clamp bar can be up to 25mm shorter that the edge to be folded. However, it should clamp centrally.



7.2 Lapped Corners

To produce corners that are lapped as fig. 1 the sheet metal blank will probably be similar to that of fig. 2 with the folding being a little more complicated. This is due to side 'E' being required to be bent back one gauge thickness further then lap 'D'. the procedure to bend this would be to bend side E and laps 'D' first with a piece of one gauge thickness packing under side 'E', after the first few degrees of the bend (see fig. 3)

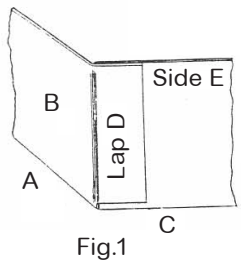


Fig.1

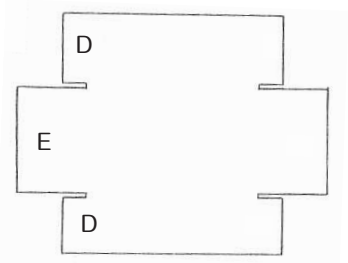


Fig.2

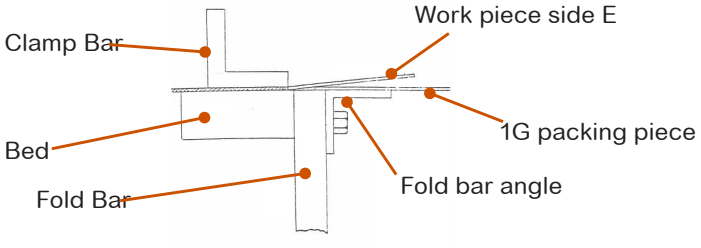


Fig.3

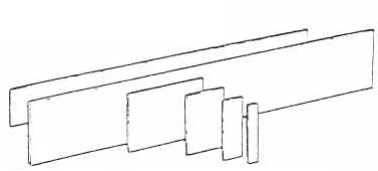
When the bend is made the packing will force the side back one gauge thickness, but of course it must be allowed to slip right down as the bending proceeds. The opposite side is bent next and then the other two.

7.3 Boxes/Trays with Sloping Sides

7.3.1 When bending boxes/trays with 2 sloping sides, the 2 sloping sides should be bent first.

7.3.2 When all 4 sides a tapered, remove the folding bar angle, fit the bed raising plate and place a bending plate of appropriate

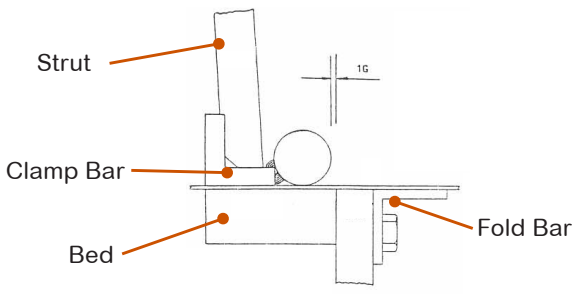
length into the fold bar channel. The side of the blank are necessarily dovetail shaped and the length of the bending plate is somewhat shorter than the root length.
Particularly for thin gauge materials and so that the bending plate applies the folding force as near to the line of the fold as possible, place the packing piece in the fold bar channel, in front of the bending plate.



7.4 Radius Bends

7.4.1 Producing bend with a large radius i.e. 10mm can be achieved by welding a length of 20mm diameter bar to the clamp bar (a piece of 25x25x6mm angle should be used)

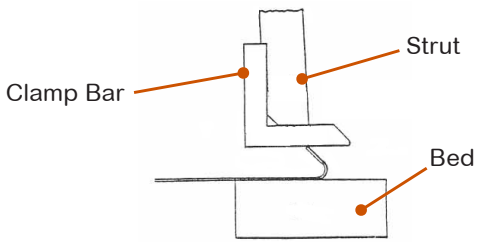
7.4.2 As per the diagram the rod should be set back from the bed edge by the gauge of the sheet metal being formed.



7.5 Bends over 90˚

7.5.1 In normal use the fold bar can be turned up to 20˚ beyond the right angle, depending on the position of the clamp bar, and up to 60˚ with the bevelled edged clamp bar installed. However, the fold bar angle should be removed prior to making such angled bends.

7.5.2 Safe edges can be produced by folding the material as far as possible using the folding handle. The material can then be removed and placed directly over the clamping bar. Once in position the clamping bar can be closed down, pressing the metal down to close the bend.



7.6 Repetition Work

7.6.1 The function of the back stop can be set and used for repetitive work. With the clamp and fold bar properly adjusted the distance can be set using a steel rule from the folding edge to the backs stop. Loosen the back stop securing screws and slide into the required position.

7.6.2 Folding thicker gauges of metal can apply considerable pressure, therefore the back stop must be well secured to prevent movement. This can be overcome by dropping the bed raising plate in front of it and removing before folding up the material.

7.7 Roll Forming

7.7.1 To form rolls on the machine a piece of appropriate tubing should be slide over the clamp bar and then positioned between the two strut assembles centrally on the machine.

7.7.2 Set and lock into position the fold bar clamp to an angle of 30˚ using the side quadrant and fold bar stop.

7.7.3 Feed the sheet material under the tube whilst at the same time applying a repetitive clamping action. The size of the roll is dependent on the material thickness, size of tube and angle at which the fold bar is set.

8 ADJUSTMENTS & MAINTENANCE

8.1 If necessary, adjustments likely to be required are those of the lock nuts which hold the clamping bar handle and the eccentric stop which set the “just over centre clamping position”

8.2 The pivots and adjusting screws should be oiled or greased routinely and all bolts check for tightness.

Note, do not oil the clamp frame pivots. These pivots have a fibre washer installed to provide friction in order to hold the clamp bar up while moving material in or out of the machine.

For bending sheet metal to form various angles gloves should be worn to handle sheet materials.

9 MACHINE CAPACITIES

The following table shows the maximum depth of boxes of a given length and width that can be produced (these apply to 18g (1.2mm) mild steel. The second table indicates the maximum gauge of material that can be bend for different materials.

mm	25	50	100	150	200	250	300	350	400	450	500	550
600	6	20	64	100	150	175	150	125	100	75	50	25
550	25	25	64	100	150	175	150	125	100	75	50	25
500	50	50	64	100	150	175	150	125	100	75	50	
450	76	76	76	100	150	175	150	125	100	75		
400	100	100	100	100	150	175	150	125	100			
350	130	130	130	130	150	175	150	125				
300	152	152	152	152	152	175	150					
250	180	180	180	180	180	180						
200	152	152	152	152	152							
150	100	100	100	100								
100	64	64	64									
50	20	20										
25	6											

10 LEAVING THE FOLDER SAFE FOR THE NEXT USER

10.1 Clear the stand and the surrounding area of all debris. Dispose of unused material in the appropriate manner, i.e purpose bins, not general waste. Excess material should be recycled where possible.

10.2 Secure operating handle in downwards postion with a padalock to prevent unauthorised use.

12 FAULT REPORTING

If any fault or damage is found when using the box pan folder, the user should:

- Lock off the action, i.e use a padlock to secure the fold bar the box pan folder from being operated.
- 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 box pan folder is reported, the following action should be taken by the appropriate school technician:

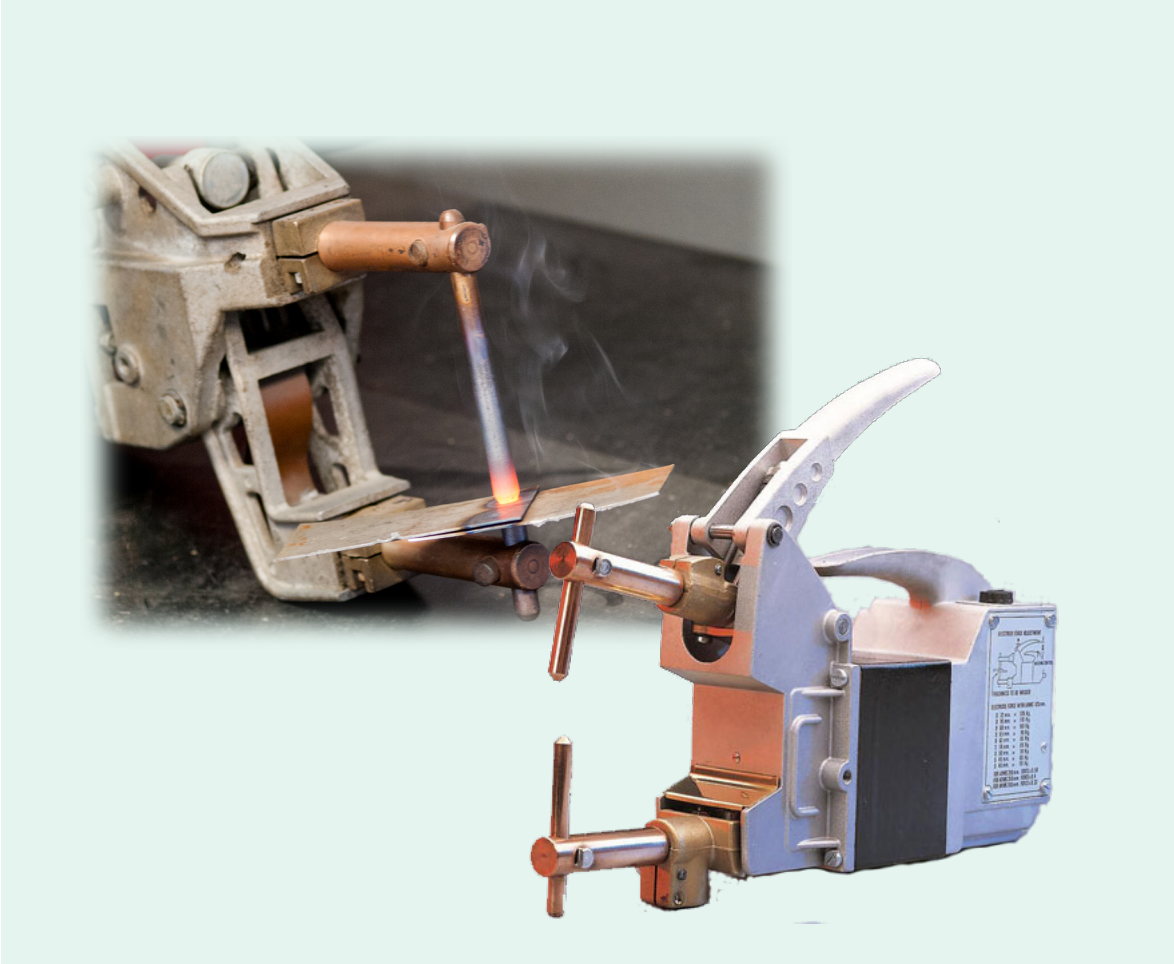
- Ensure that the box pan folder has been locked-off using a padlock and retain the key.
- Label the box pan folder - "**Do Not Use - Under Repair**".
- Advise the necessary staff that the box pan folder cannot be used.
- If appropriate, carry out necessary repair or maintenance.
- If necessary, contact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

13 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.
- RMT - Gabro Box Pan and General Purpose Folders Operation and Maintenance Instructions Model BF100/BF620-2
- Technical Education - A Code of Practice 1995. (Glasgow)
- SSERC Draft Risk Assesessments

3 Part 4 - Resistance Spot Welding



1 AIMS AND OBJECTIVES

1.1 Aims

To instruct teaching and technician staff in the safe use of the -
SIP Spotmatic Spot Welder.

1.2 Objectives

1.2.1 Know and understand the hazards associated with the use of the spot welder.

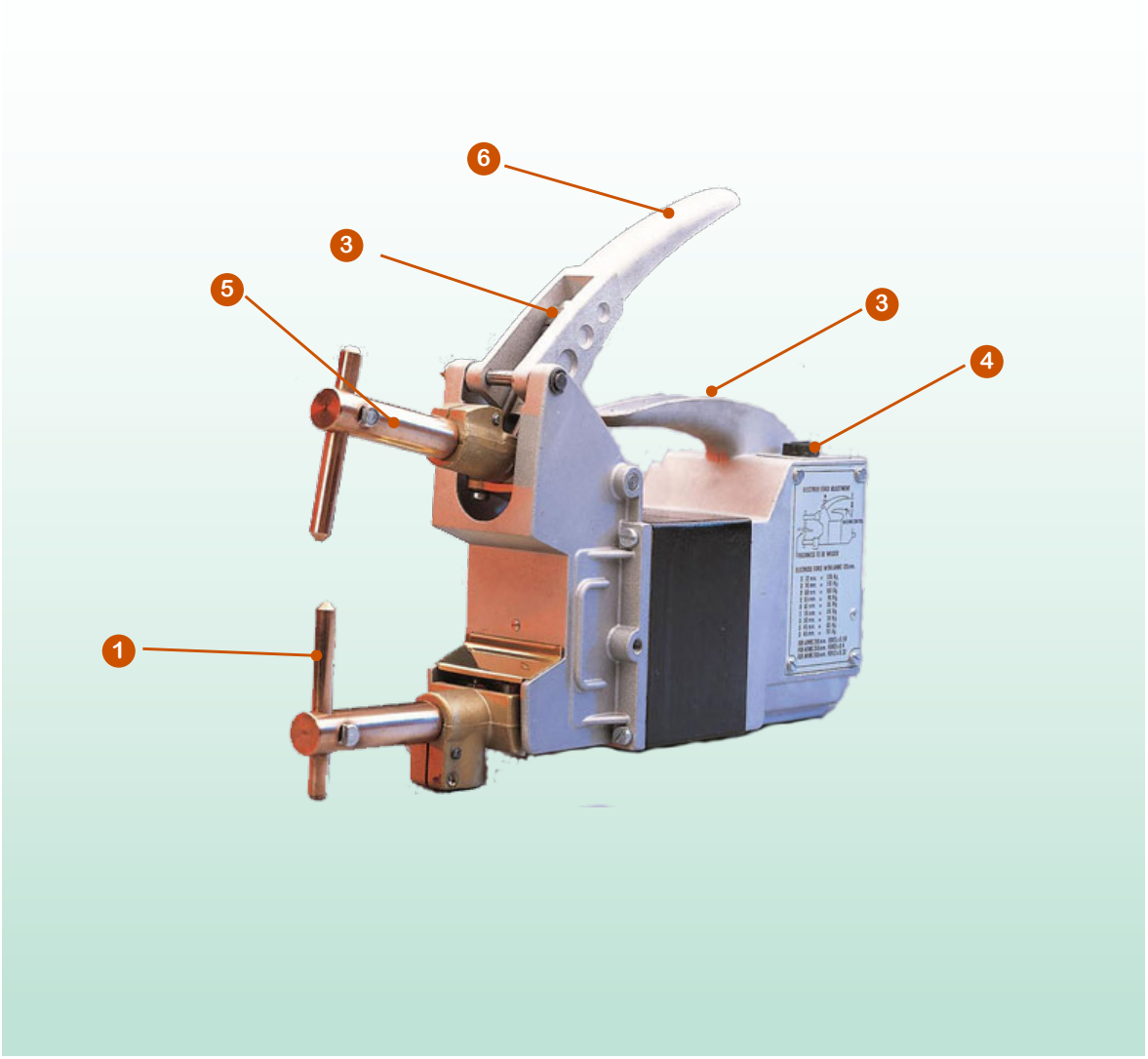
1.2.2 To outline the safety precautions necessary for safe operation.

1.2.3 Become familiar with the component parts and their function.

1.2.4 Demonstrate how to adjust and set weld times and pressures.

1.2.5 Demonstrate how to operate the spot welder to carry out its function safely.

2 TYPICAL RESISTANCE SPOT WELDER



1) Electrodes
2) Handle
3) Pressure Adjustment
4) Timer
5) Electrode Arms
6) Clamping Arm

3 USAGE

Resistance spot welding, usually referred to as spot welding, is a process that is widely used for joining thin sheet metal. Overlapping sheet metal is clamped between copper electrodes, which have reduced diameter tips to produce welds that are usually between 1.6mm and 12.5mm in diameter. A powerful current is then passed through the work for a pre-set time, the higher electrical resistance causes local heating, sufficient to melt the metal. The pressure from the electrodes unites the molten metal once cool. This combination of heat, pressure and time is how each weld is produced. This is usually repeated multiple times along the length of the metal.

4 HAZARDS

4.1 Contact with the electric arc.

4.2 Electric Shock.

4.3 Burns: Contact with hot metal and sparks.

4.4 Eye injuries from sparks.

4.5 Tripping hazards from power cables.

4.6 Environmental: keep area around welder clear of surplus material, waste and other tripping hazards.

4.7 Fire: possibilities of fire resulting from hot material and/or stray sparks.

4.8 Unauthorised persons using the machine.

5 CONTROL MEASURES

5.1 Safety Signs

Blue - Mandatory Instructions

Yellow - Warning

5.2 Personal Protective Equipment (PPE)

5.2.1 Googles – Appropriate eye protection should be worn by users.

5.2.1 Leather Gauntlets

5.2.3 Protective Garments

5.2.4 Users should remove all personal jewellery (especially rings, bracelets and metallic watchstraps) before carrying out any welding.

5.2.5 Wearers of vital electronic medical equipment (e.g. pacemakers) should consult their physician before beginning any arc welding, cutting, gouging or spot welding operations.

5.3 Electricity Supply

A suitably qualified electrician should be consulted to ensure that the electrical supply will be able to cope with the current demands of the equipment.

5.4 Environment

5.4.1 Welding should be carried out in dry surroundings with dry equipment.

5.4.2 Welding should be carried out in areas that are non-reflective and are curtained or screened off.

5.4.3 Risk assessments should be carried out to assess the risk from fumes and suitable extraction equipment should provided where required.

Note: Any coatings on the metal, such as paint or surface contamination will give rise to fumes. There is a particular risk of fumes if galvanised steel is welded. This this should not be welded.

6 SAFETY CHECKS BEFORE USE

6.1 Clear Working Area

Before use, ensure that the area around the spot welder is clear of surplus waste

materials, flammables and/or models that may hinder the safe use of the spot welder.

6.2 Ensure the Spot Welder is Isolated

Before carrying out any safety checks the spot welder must be isolated from the power supply. Check that the welder is unplugged.

6.3 Equipment Functionality Checks

6.3.1 Check all cables are in good, safe condition.

6.3.2 Check electrodes are clean and properly faced (see section 8, Electrode Angles)

7 ADJUSTING WELD TIMER & PRESSURE

7.1 Pressure

7.1.1 The amount of pressure that is applied to the weld is an important factor in producing quality welds. If too little pressure is applied, the joining area will be small and weak. If too much pressure is applied, then cracking can occur in the weld because of the quenching effect of the welding tips.

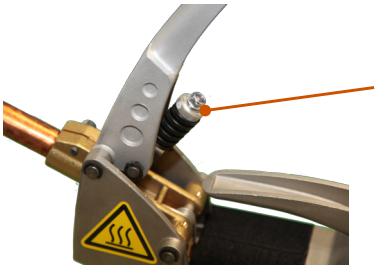
7.1.2 High pressure can also cause thinning of the metal and cause a weakness. The depth of the depression on the sheet surfaces caused by welding electrodes should never exceed 25 percent of the sheet metal thickness.

7.1.3 The primary purpose of pressure is to hold the parts to be welded in close contact at the joint. This action assures consistent electrical resistance and conductivity at the point of the weld. The electrode tips should NOT be used to pull the workpieces together. The spot welding machines are not designed as an electrical “C” clamp. The parts to be welded should be in close contact before any pressure is applied.

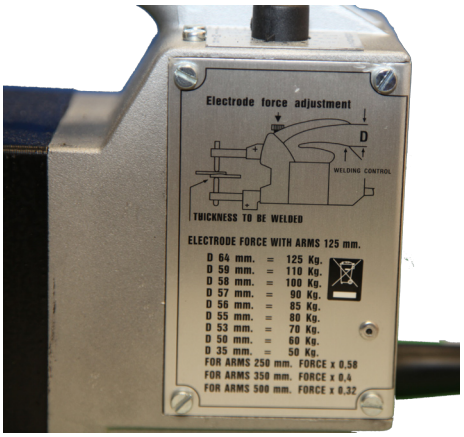
7.1.4 Investigations have shown that high pressures exerted on the weld joint decreases the resistance at the point of contact between the electrode tip and the workpiece surface. The greater the pressure the lower the resistance factor.

7.1.5 Proper pressures, with close contact of the electrode tip and the base metal, will tend to conduct heat away from the weld. Higher currents are necessary with greater pressures and, conversely, lower pressures require less amperage from the resistance spot welding machine.

7.1.6 The pressure on SIP Spotmatic welders can be adjust by turning the thumbscrew, situated directly behind the electrode arms.



Turning this thumbscrew clockwise will increase the pressure, anti-clockwise to decrease the pressure.



The table on the side of the transformer should be used to determine the pressure force required.

7.2 Weld Timer

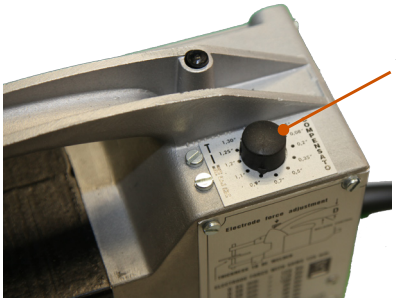
7.2.1 The weld timer controls the amount of time the current flows into the welding transformer. In most cases several thousand amperes are used in making the spot weld.

7.2.2 Such amperage values, flowing through a relatively high resistance, will create a lot of heat in a short time. To make good

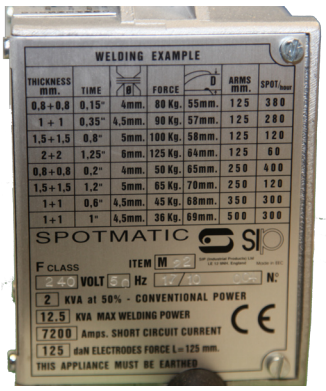
resistance spot welds, it is necessary to have close control of the time the current is flowing.

7.2.3 Most resistance spot welds are made in very short time periods. Since alternating current is normally used for the welding process, procedures may be based on a 60 cycle time (sixty cycles = 1 second).

7.2.4 Control of time is important in that if the time element is too long, the base metal in the joint may exceed the melting point of the material. This could cause faulty welds due to gas porosity. There is also the possibility of expulsion of molten metal from the weld joint, which could decrease the cross section of the joint weakening the weld. Shorter weld times also decrease the possibility of excessive heat transfer in the base metal. Distortion of the welded parts is minimized, and the heat affected zone around the weld nugget is substantially smaller.



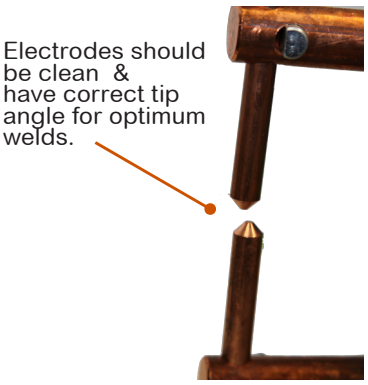
7.2.5 With regards to the SIP Spotmatic range of spot welders, the time the current flows is control by setting the black control knob at the rear of the transformer. The pointer can be turned to match up with the required time. Information on how long weld times should be, are found on the table at the side of the welder.

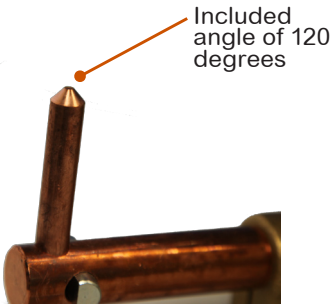


8 ELECTRODE ANGLES

8.1 Angle

As the spot welder is used the electrode tips, which are manufactured from chromium/copper alloy, will eventually wear and require refacing. Obtaining the correct angle (an included angle of 120 degrees) on the electrode is important in achieving good weld penetration and thus weld quality.



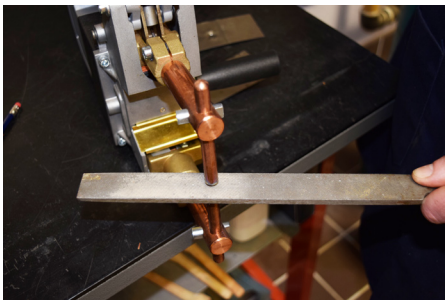


8.2 Angle Cutting

There are a number of methods of achieving/maintaining this angle. The easiest and most convenient way is to purchase a purpose made tool as shown.

This small tool/cutter is used by fitting it into the chuck of a small power drill. It is then inserted over the electrode and spun at a slow speed. As the electrode must fit inside the profile cutter before any metal is cut it results in an accurate angle being achieved.

Another method of refacing the electrode tips is with the use of a specially adapted file, but this method requires some skill. You must hold the file at the correct level and angle, working back and forth around the tip's circumference, alternatively an ordinary hand file will produce similar results, if used with care.



Whichever method is employed an included angle of 120 must be achieved.

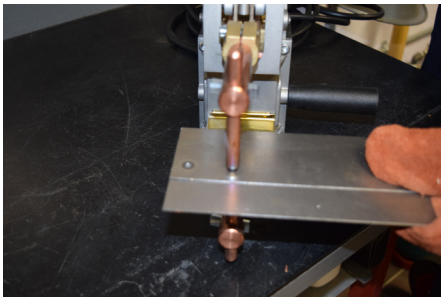
9 MATERIAL PREPARATION

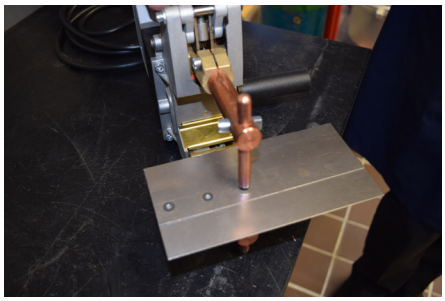
To achieve good quality welds, it is essential that the metal to be welded is cleaned to a bare, shiny surface. Electrical current will take the shortest route of least resistance, therefore it is important that good flow paths are created by sanding/cleaning the metal with an abrasive such as emery cloth or a wire brush.

One of the main difficulties with this form of welding is the difficulty in protecting the metal between the joint from corrosion once they have been welded. One method of overcoming this problem is to use products such as weld-through primer. These are painted on before the metal is joined together

10 WELD SPACING

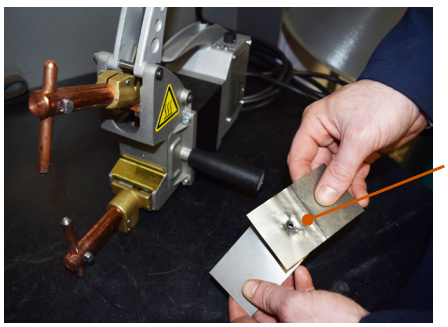
The distance between each spot weld is of paramount importance if consistently good quality welds are to be expected. It should be not less than 25mm. Spot welds produced at intervals closer than this are likely to be affected by a condition known as shunt, which can weaken then weld considerably.





11 WELD QUALITY TEST

The only way to ensure a series of welds is likely to be of high quality is to carry out a peel test. This should always be done with new equipment or in unknown situations. For example, to obtain the same degree of strength when welding two pieces of 0.9mm (20 swg) metal, as opposed to three, a different time setting is required. When carrying out the test you will need a number of metal offcuts to use as test pieces.



Metal peeled apart, hole left in one plate indicating good quality weld.

12 WELD DEFECTS/REMEDIES

Compared to other forms of welding, few defects can be expected with resistance spot welding. However, faults that commonly occur are due to overheating, blowing holes, incomplete fusion and deformed metal surface. Most of these common faults can be attributed to improper adjustment of the spot welder.

The following table specifically refers to faults/ remedies when welding low carbon steel, though it can provide useful reference of other applications.

DEFECTS	REMEDIES
Blow-holes Overheating Lack of fusion	Lack of pressure between electrodes and workpiece, causing too much resistance on the outer surface of parent metals rather than between them where the weld nugget should be formed.
Overheating	Time setting for each weld is too long.
Incomplete fusion	Time setting for each weld is too short.
Metal deformed or rough	Poor tip shape, incorrect angle, tips out of alignment, or electrode holder pivot points badly worn.
Metal falls apart	Insufficent weld time, or pressure, or dirty material, therefore no contact.

13 POWERING DOWN THE SPOT WELDER

13.1 Once the welding process is complete the welder will automatically switch off after the pre-set time has been reached. This switching off action can often be heard.

13.2 Caution should be given to accidently re-engaging the welding process by re- closing the arms. This will cause the automatic switch to re-energize the welder.

13.3 Switch off the spot welder at the wall socket and remove the plug

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

14 LEAVING THE SPOT WELDER SAFE FOR THE NEXT USER

14.1 Clear the surrounding area of all debris and unused material.

14.2 Ensure electrodes are in good condition.

15 FAULT REPORTING

If any fault or damage is found when using the Spot Welder, the user should:

- Switch the Spot Welder off.
- Isolate and lock-off the power using a 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 spot welder is reported, the following action should be taken by the appropriate school technician:

- Ensure that the Spot Welder has been isolated from the power supply. If the Spot Welder is hard wired into an isolator this should be switched off and locked-off using a padlock and the key retained. If not hard wired the plug should be removed from the electrical socket and the Spot Welder removed from class workshop.
- Label the box pan folder - "**Do Not Use - Under Repair**".
- Advise the necessary staff that the spot welder 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 misses occur to any person using the Spot Welder, or as a direct result of any person using it, 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.

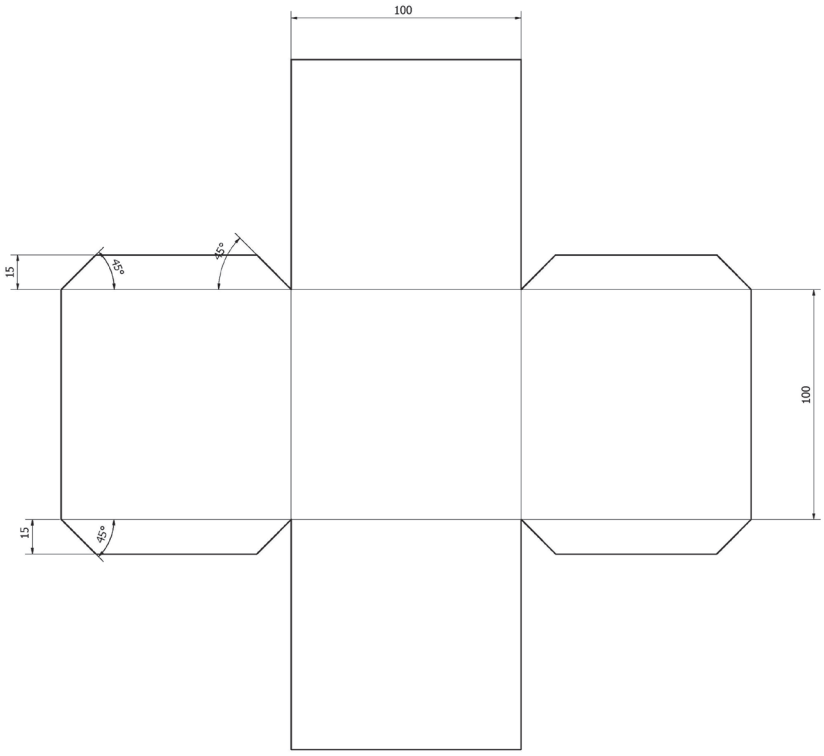
• SIP Spotmatic – Operation and Maintenance Instruction manual.

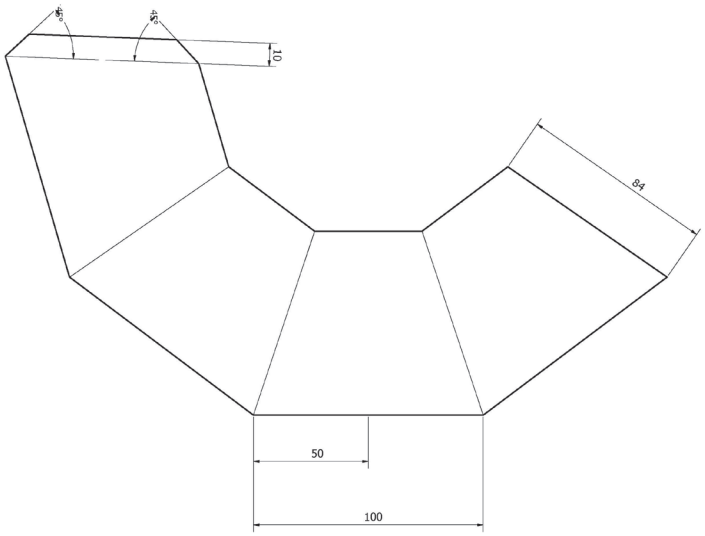
• Technical Education - A Code of Practice 1995. (Glasgow)

• SSERC Draft Risk Assessments.

3 Part 5 - Project Exercise

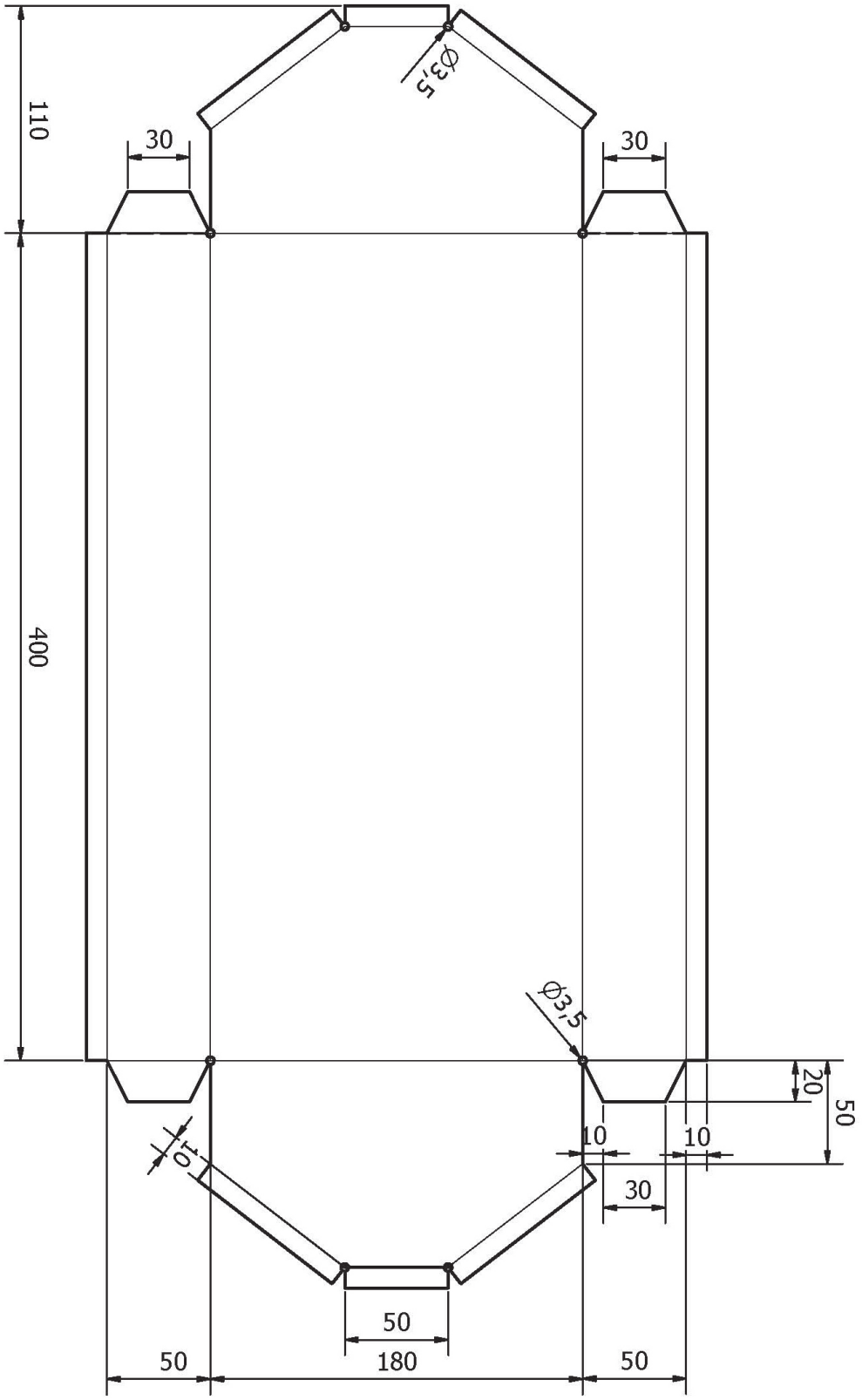
1 CUTTING & FOLDING EXERCISES





Extra - Plot out development and manufacture a 125mm cylinder 200mm long.
* Remember to create a tab for either spot welding or pop riveting

2 TOOL TRAY WORKING DRAWING



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