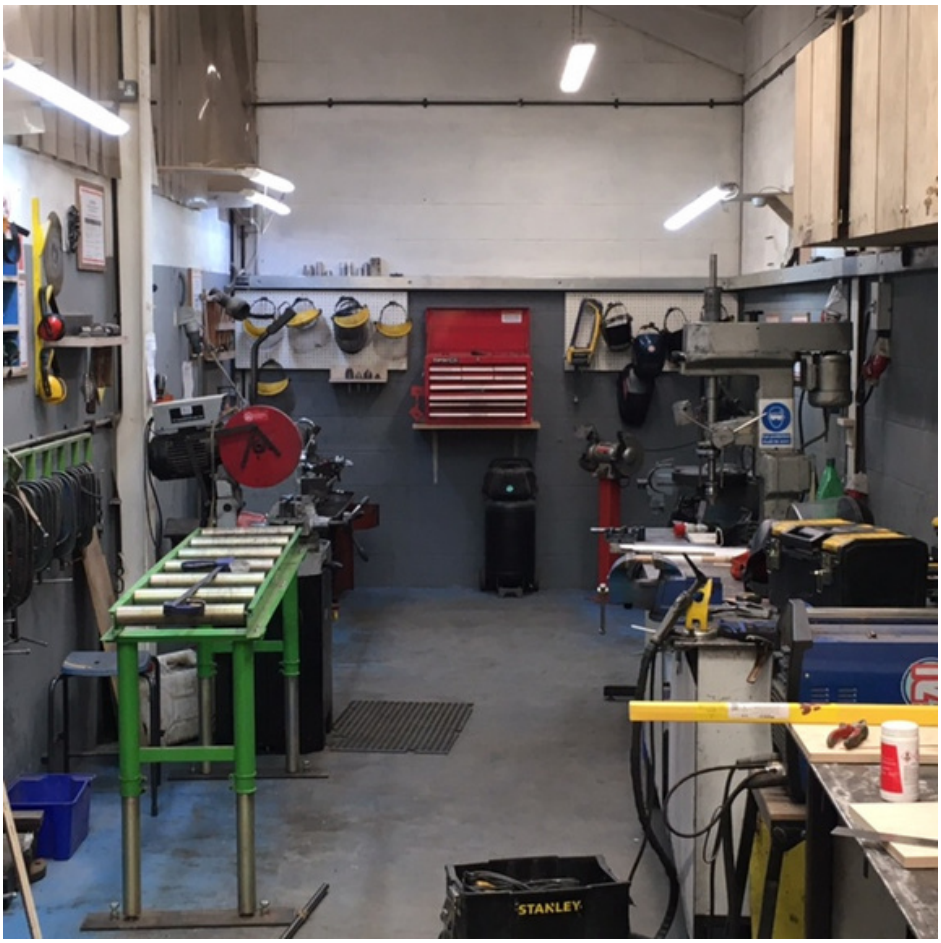
TECHNICAL HANDOUT

METALWORK

BLACKHORSE WORKSHOP

INTRODUCTION



Metals have played an important part in the story of humanity: the working of metals has been at the centre of all technological advances. From the Bronze Age to the Space Age, metals have played a constant and vital role in society due to their vastly different properties and ability to be formed, shaped, hardened, machined, cut, jointed and cast as a liquid.

The risk of injury from metalworking equipment and processes are considerable and varied, and so conscientious use of protective equipment and awareness of safe working practices is fundamental when working with these materials.

At the Workshop we are fortunate to have the equipment needed to tackle most metalworking tasks to various degrees. This handout gives a brief definition of the equipment introduced during the induction, accompanied by some key safety tips to help you work safely in the workshop.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

The numerous risks associated with metalworking are reduced significantly when safe working practices are followed.

These fall into two categories:

- Protection of yourself through the wearing of suitable Personal Protective Equipment (PPE)
- Protecting others through an awareness of risks and other people present in the workshop environment.

THE KEY ITEMS OF PPE

- Eye protection (safety spectacles/visors / wrap-around googles)
- Protective face mask (for welding only - see section below)
- Ear protection (defenders or plugs)
- Protective footwear (steel toe-capped shoes or boots)
- Protective gloves
- Respiratory protection (mask)

SAFETY TIPS

- Eye protection should be worn at all times where sparks, metal debris or UV light are being produced.
- Wear a welding helmet at all times when welding. This will protect your eyes and face from the UV light emitted by the welding process. Anti-glare goggles are necessary when carrying out HotWorks processes.
- Safety spectacles or a visor are suitable for processes such as drilling holes or cutting on the cold saw, while wrap-around goggles are essential for proper eye protection if sparks are being produced (e.g: when using an angle grinder).
- A full face visor is required when using wire wheels, as strands of wire often snap off and can be embedded in face or neck.

PERSONAL PROTECTIVE EQUIPMENT (PPE)

SAFETY TIPS (CONTINUED.)

- Ear protection is essential where excessive noise is being produced by a process, e.g: grinding
- Earplugs are advised to be worn underneath welding helmets to prevent damage to hearing from exposure to noise from the cold cut saw and outside grinding area.
- Metal is often hot, sharp or heavy. Steel toe capped footwear is essential during all use of the metalworking areas.
- Wear a leather apron to protect from sparks produced when welding or grinding. Avoidwearing non-synthetic clothing as this material can ignite if brought into contact with sparks.
- Wear leather gloves during all welding processes to protect your skin from UV light (sunburn) and burns from handling hot metal.
- Latex gloves also protect your hands from substances that might harm your skin (coolants, oil, grease etc).
- Cut resistant gloves are necessary when dealing with sheet metal, as sharp edges created during cutting processes, or stock that hasn't been deburred sufficiently can cause deep lacerations.
- Scarves, loose clothing, jewellery and long hair all present risks when using powered equipment.
- A mask is essential for respiratory protection when dust is being produced, e.g: grinding / cleaning of metal. To provide adequate protection this must be a P3 rated particle mask.

WORKSHOP ETIQUETTE

TIP DIP

When welding, please apply this to the shroud and tip of your MIG torch to prevent spatter build up and reduce the risk of the wire getting welded to the tip. Simply do this by dipping the hot shroud into the paste.

ANTI-SPATTER

Please spray a light coating of this over your workbench and any clamps that you are going to use and wipe off any excess with a cloth. This will prevent spatter build up on the benches and on the threads of the clamps.

Both Tip Dip and Anti-Spatter are supplied by the workshop and can be found in the COSHH cupboard.

GRINDING

- Grinding must be kept to the grinding bay only. Please refrain from tacking to bench unless absolutely necessary.
- If anything is tacked to the bench, please grind it down smooth after detaching.
- Workbench and grinding area must be swept down after use, as well as all machines that have been used.

THE COLD SAW

The cold saw is a powerful motor-driven machine used for cutting down metal lengths as large as 150 x 100mm in section. The machine has a hardened blade which is capable of cutting through most metals.the machine is fitted with a pump-fed coolant system to prevent damage to the blade, which activates when the motor is started by the switch on the handle. For safety, the blade is guarded and the workpiece is held securely in a vice while the material is being cut.

KEY FEATURES

- On-Off switch and blade feed
- Angle adjustment & scale
- Guard / function - to enclose as much blade as possible during cutting
- Vice clamp
- Workpiece support and adjustment of the stop

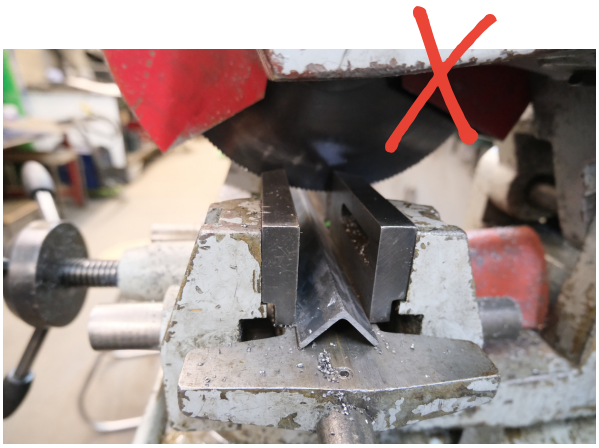
MOST COMMON USES:

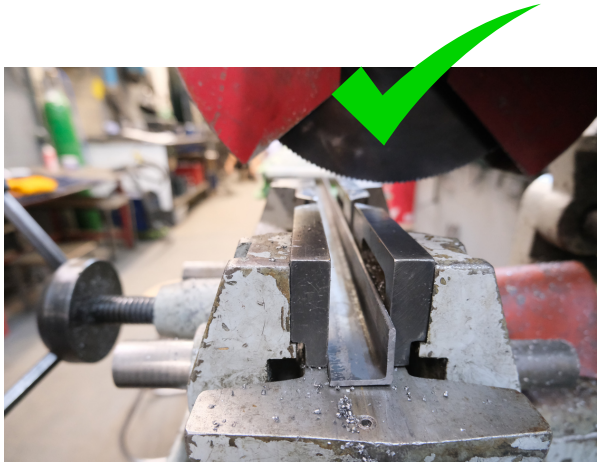
- Cutting down long lengths of solid or hollow section metal
- Cutting angles accurately

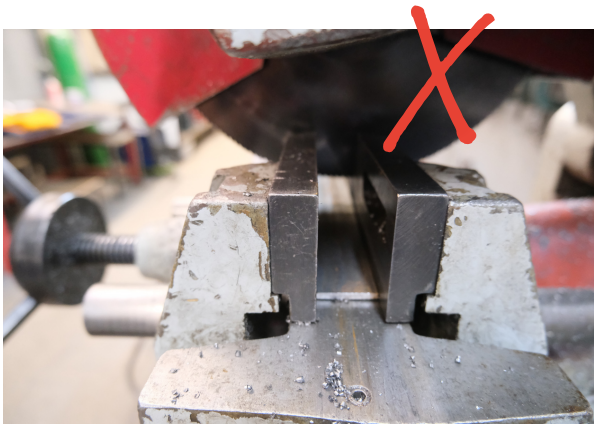
SAFETY TIPS

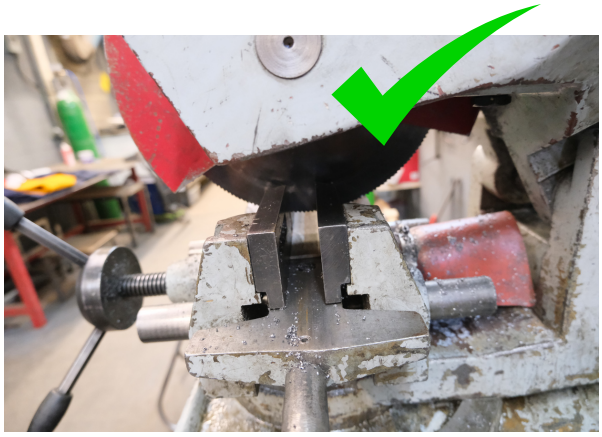
- Keep fingers at least 100mm away from moving blade at all times.
- Tightly secure all workpieces in the vice before starting to cut.
- Ensure both ends of material are adequately supported before making a cut.
- Ensure coolant is flowing onto the blade before starting to cut.
- Do not use with scarves, jewellery, long hair or loose clothing.
- Always wear eye and ear protection during use.
- Cut material of less than 5mm thickness on the flat to avoid damage to blade teeth
- When cutting angles, adjust vice jaws to prevent collision with moving blade.
- Allow saw time to cut - do not apply excessive force to blade during use.
- Do not cut material less than 150mm length
- There are two speed settings on the saw, when cutting stainless steel or thicker stock, set the speed to '1' rather than '2'.

THE COLD SAW





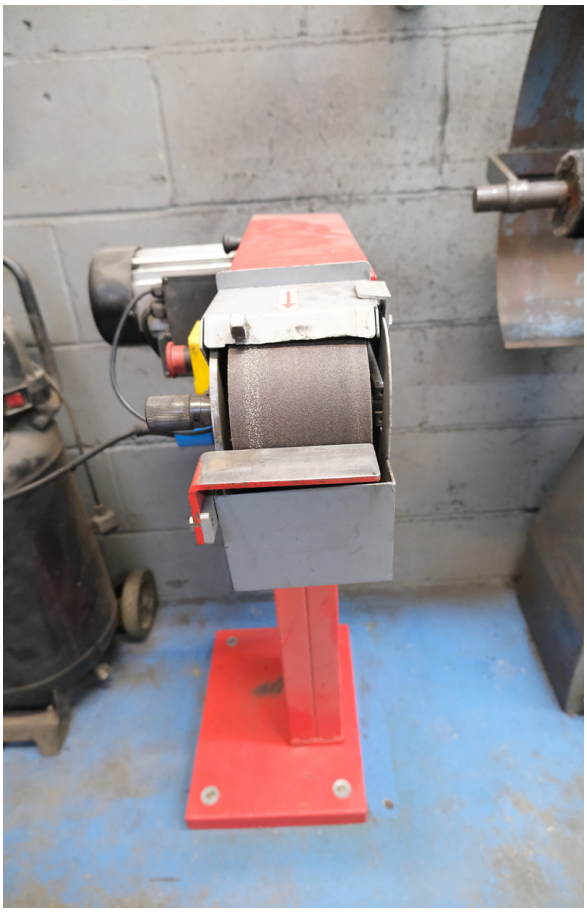




SAFETY TIPS

- Keep fingers at least 100mm away from moving blade at all times.
- Tightly secure all workpieces in the vice before starting to cut.
- Ensure both ends of material are adequately supported before making a cut.
- Ensure coolant is flowing onto the blade before starting to cut.
- Do not use with scarves, jewellery, long hair or loose clothing.
- Always wear eye and ear protection during use.
- Cut material of less than 5mm thickness on the flat to avoid damage to blade teeth
- When cutting angles, adjust vice jaws to prevent collision with moving blade.
- Allow saw time to cut - do not apply excessive force to blade during use.
- Do not cut material less than 150mm length
- There are two speed settings on the saw, when cutting stainless steel or thicker stock, set the speed to '1' rather than '2'.
- Check. the locking mechanism during your cut to ensure the vibrations aren't causing it to loosen.

THE BELT LINISHER



The Belt Linisher is commonly used for grinding and preparing the surface of metals. It has a flat sanding belt which can be used to flatten surfaces or remove the 'burrs' or sharp edges ofetn left after cutting on the co ldsaw.

KEY FEATURES

- On-off switch
- Guards and rests: purpose & adjustment
- Internals - belt tension & tracking / rollers / motor

MOST COMMON USES

- Removing 'burrs' and sharp edges on materials
- Shaping of small components
- Prepairing materials for welding
- Flattening off welds and small surfaes

SAFETY TIPS

- Always lower the guard on whichever part of the linisher you are not using
- Always wear wrap-aroun goggles to protect your eyes from sparks produced
- Keep fingers well away from the moving belt at all times
- Hold small workpeices with locking pliers as protection from het build-up, sharp edges or in case of 'snatching' by the belt.
- Quench small workpeices frequently in water to prevent heat buld-up
- Keep workpieces moving side to side across belt to reduce friction and wear on the belt

THE BENCH GRINDER AND POLISHING WHEEL

These are used for sharpening of tools and cleaning/polishing of metal surfaces. The bench grinder is fitted with an abrasive wheel which is used for sharpening hardened tools such a drill bits and lathe tools, as well as precision grinding of tube joints for brazing or welding. The bench grinder also has a wire wheel which is used for removal of paints and rust from surfaces, as well as cleaning of bolt threads ect.

The polishing machine is used to 'buff' the surface of metal to remove scratche and abrasions left by other machines. A combination of polishing and buffing wheels (mops) and abrasive compounds are used to create a surface of the desired brightness and colour .

KEY FEATURES

- On- Off switch / emergency stop
- Fitting and removing of wheels
- Guards and rests
- Safe usage

MOST COMMON USES

- Bench grinder: sharpening of toos, sharpening of joints and cleaning of small metal items
- Ploishing wheel: Applying fine surface finishes to metal

SAFETY TIPS

- Only use the bench grinde when guards and rests are in place and correctly adjusted
- Always wear wrap-around goggles to protect your eyes from sparks and flying debris
- Do not wear loose gloves - tight fitting rubber or latex gloves are safer
- Keep fingers well away from moving wheels at all times
- Hold small workpeices with locking pliers or gloves to protect from heat buil-up, sharp shrp edges or in case of ' snatching' by the wheel.
- Quench small workpieces frequently in water to prevent heat build-up
- Use ferrous metal only on grinding wheels

THE BANDSAW

The Bandsaw is used for detail cutting of thin sheet material only. It's blade is suitable for non-ferrous materials only (i.e. brass, copper and aluminium) and can cut up to a thickness of 2mm.

KEY FEATURES

- On-Off switch / emergency stop
- Adjustment and purpose of guard / blade guides

MOST COMMON USES

- Small scale cutting or non-ferrous sheet metal

SAFETY TIPS

- Ensure the blade guard is properly adjusted before use - i.e. as close to the surface of the workpeice as possible.
- Always wear eye proteion to protect your eyes rom flying debris
- Keep fingers well away from the moving blade at all times
- Apply gentle pressure to te blade and do not twist the blade when cutting tight curves
- Non-ferrous metal only to be cut (no steel / stainless steel)

THE PILLAR DRILL

Pillar Drills (or drill presses) provide a more accurate and safer means of drilling holes than a hend-held drill. They are also more powerful and so better suited to drilling larger diameter holes. Workpeices can easily be clamped to their adjustble bed or held in a vice, allowing for greater control over the drilling process.

The machine consists of a large diameter metal post (the pillar) mounted on a heavy base with a motor attached at the top. This rotates a chuck into which the drill bits are fitted. The adjustable table can be raised and lowered, as well as providing a surface to which the workpeice can be secured while drilling.

KEY FEATURES

- On-Off switch / emergency stop
- Motor and drive belt system
- Speed change
- Chuck & drill bits
- Feed handle
- Guard use & purpose
- Table rise/fall
- Depth stop

SAFETY TIPS

- Keep fingers min 100mm away from the moving drill bit at all times
- Workpeices MUST be secure to the table by clamps or in a vice in case of drill jams in the workpeice.
- Never use with scarves, loose clothing, jewellery or long hair
- Always remove the chuck key (on a key chuck)
- after fitting or removing a drill bit
- Safety guard should be lowered during all use
- Slower speeds should be used for larger diameter drill bits
- Eye protection is essential for all drilling
- Don not apply excessive pressure upon drill bits - the bit may need sharpeningor coolant may need to be used if the it is ot cutting
- Depth stop or table height should be adjusted to prevent drilling into the table of the machine
- For deep holes, drill bit should be periodically raised to clear waste and prevent heat build-up
- It is advisable that cutting paste is applied to the drill bit in order to reduce friction and heat.
- Never move the bd whilst the drill is in operation.

HEAVY DUTY BAR BENDER

KEY FEATURES

- Hand crank
- Lower rollers and adjustment
- Upper roller adjustment

SAFETY TIPS

- Keep fingers away from the moving rollers to prevent cruching or pinching them
- Max solid metal section 25mm x 25mm
- Max hollow section 50mm x 50mm
- Take care not to hit yourself or others when using the crank or roller adjustment bar

This hand-operated machineis used for curving and bending sections of solid and hollow metal sections. It has a pair of rollers which need to be adjusted to the width of material being bent before use. It works by forcing the top roller down onto the workpeice, which rests upon two lower lollers. The top roller is then rotated with a hand-crank to feed the work throughthe machine, bending it as it passes through the rollers.

THE ANGLE GRINDER

The angle grinder is one of the most commonly used in metalwork, and is used for cutting and trimming metal, dressing down welds and prepairing joints prior to welding. Despite it's small size, there are numerous risks of injury when using an angle grinder, and so it is essential to ensure you are using it safely at all times.

The type of disc or wheel fitted will depend upon the task in hand - and these are described as follows:

CUTTING DISC - for cutting metal. 1mm thick disk for thinner materials / 3mm for thicker sections. Thinner discs wear down more quickly, so do not apply too much pressure during cutting.

GRINDING DISC - a 5mm thick solid resin-bonded grinding wheel - for grinding down of welds and shaping of metal

SANDING DISCS AND FLAP WHEELS / WIRE WHEELS - for smoothing down and cleaning of surfaces before finishing.

KEY FEATURES

- Motor and On-Off switch
- Handle and user position during use
- Fitting & removal of discs
- Types of disc
- Guard

SAFETY TIPS

- Aways wear wrap-around goggles during any grinder use
- Never use a grinder with the guard removed
- Inspect discs for damage before use and ensure tightly secured to the tool with a spanner
- Never apply side pressure to a 1mm cutting disc during use (this can cause it to crack or shatter)
- Do not use with scarves, loose clothing, jewellery or long hair
- Workpeices should always be secured in a vice or clamped to a bench unless large or heavy
- Cutting discs can become pinched during cutting, causing the disc to shatter or cause a kickback. Always cut in a straight line and support any offcuts where necessary to prevent this occuring
- Grinding produces sparks. Check your work area for other people and presence of flammable liquids, materials or other fire risks before starting work
- Wear a eather apron to protect yourself, as sparks from grinding can easily ignite clothing
- Check the power cable for damage before use and direct the cable away from grinding area during use. Keep moving disks well away from live power cables
- Ensure that the locking nut is the correct way around for the particular wheel that you are using
- Never change the wheel with the grinder plugged in
- Be aware that the friction between the metal on the disc / wheel will cause heat to build up on the workpeice. Do not pick up and cut peices without leather gloves as there is a risk of burns to skin.

SHEET METALWORKING EQUIPMENT

THE GUILLOTINE

The guillotine is used for stright 'shear' cuts on sheet metal. It is foot-operated and can cut up to the following thickness - aluminium (1.5mm), mild steel and copper (1.5mm) and stainless steels (0.9mm). It's maximum width of cut is 1300mm. Full sheets can be unweildy and heavy, so please ask for assistance if necessary. Two people are sometimes needed to push the oot tread dow on long cuts. An adjustable stop can be fitted for cutting multiple components of the same dimension.

KEY FEATURE:

- Blade and pressure plate
- Foot treadle
- Adjustable stop

SLIP ROLLERS AND BOX / PAN FOLDER

This machine has to functions - the 'slip' rollers (on top) and a folder (below) which can both accommodate sheet metal of up to 1000mm in width.

The rollers consist of three solid round bars of metal. The two front rollers feed the material towards a third adjustable roller behind, which deflects the material upwards to produce a curve of the desired radius. The rollers are adjustable in height and should be used incrementally until the desired curve is achieved.

Maximum thicknesses on this machine as follows:
Mild steel 1mm / non-ferrous 1.2mm.
Attempting to bend thicker material is likely to damage the machine.

The smallest diameter of roll that can be achieved is 42mm, with the top roller being removable to allow the workpeice to be removed from the machine. Grooves on the right-hand end of the rollers also allow the bending of 6mm, 8mm and 10mm solid round bar.

The folder consists of a 'V' blade which is lowered into a corresponding 'V' block. This can be used to put a 90 degree bend in sheet metal. Removing part of the blade allows the workpeice to be rotated in order to fold up the sides of a box without the blade interfering with a previous fold.

KEY FEATURES

- Rollers and adjustments
- Handle and adjustment
- Operation of folder
- Removal of blade segments

SAFETY TIPS

- Keep fingers min 100mm away from moving parts at all times
- Beware sharp edges on sheet metal - wear gloves if necessary
- Do not use with scarves, loose clothing, jewellery or long hair
- Wear eye protection to protect eyes from shards of metal

WELDING PROCESSES AND HOT WORKS

MIG WELDING

Metal inert Gas (MiG) welding, is an electric- arc welding process that uses a motor fed consumable wire as both the electrode and the filler rod to produce the weld. To prevent the metal from burning, the weld area and electrode is protected from the presence of oxygen by an inert shielding gas (we use argon). This produces electrical energy, which is conducted across the arc through a column of highly ionized gas. With the correct power setting, this melts the surface of the work (the workpiece) in a very controlled manner. As the electrode and filler are the same thing, it is a one-handed operation. MiG welding grants the operator easier control over the weld than TiG welding, the drawback being it is a weaker, lower quality weld than that of a TiG weld as it does not have the same penetration of the workpiece. Welds should ideally not be ground flat for aesthetic reasons as this will significantly weaken the joint.

Troubleshooting Guide if the welder does not work or performs poorly:

- Check the earth lead. Make sure the lead is connected to the bench or workpiece.
- It is important to ensure that extraction is on , and that the adjustable arms have been directed over the workpiece.

- Check the gun. The gun has several removable consumable items. If the tip is blocked, it will need replacing. There is also a metal shroud to direct the gas. This can become clogged with 'spatter' (molten metal coming back from the weld) which solidifies in the shroud resulting in a poor contaminated weld. This can be removed with a sharp object or pliers. If the shroud is bent or damaged, it will need replacing. Ask the duty technician to do this.

- Check the gas. There are two dials attached to the top of the gas bottle. The left one is remaining gas level. Check that the dial needle is not on zero. The right one is gas pressure. Only adjust this if it is on zero while there is still a reading on the left dial. Only technicians are permitted to change gas bottles, so please ask if you find a bottle is empty of gas.

KEY FEATURES

- On-Off switch (machine and gun)
- Wire speed & feed
- Current adjustment
- Earth lead
- Gun internals - tip / shroud
- Gas bottle / supply

WELDING PROCESSES AND HOT WORKS

TIG WELDING

Tungsten inert gas (TIG) welding is an electric arc welding process that uses a non-consumable tungsten electrode to produce the weld. To prevent the metal from burning, the weld area and electrode is protected from oxygen being present by an inert shielding gas (we use argon). A constant-current (variable) power supply produces electrical energy, which is conducted across the arc through a column of highly ionized gas. With the correct power setting, this melts the surface of the work (the workpiece) in a very controlled manner. A filler metal is then introduced by hand, meaning it is a two-handed operation. TiG welding grants the operator greater control over the weld than processes such as MiG welding, allowing for stronger, higher quality welds. It is also significantly slower than most other welding techniques, so allow time for practice. By changing the machine's power from direct current (DC) to alternating current (AC), non-ferrous metals such as aluminium, copper and its alloys and magnesium can be welded, but the use of these materials are comparatively more complex and difficult to master.

Troubleshooting guide if the welder does not work:

- Check the earth lead. Make sure the lead is connected to the bench or workpieced.
- Check the gun. The gun has several removable consumable items. If the tungsten tip is worn, it will need sharpening. Use the linisher for this.
- Check the gas. There is a flowmeter attached to the argon gas bottle. This should be around centre height (8-12 litres per minute). Check that the dial needle is not on zero.

KEY FEATURES

- On/Off Switch (machine and gun)
- Filler rod
- Current adjustment
- Earth lead
- Gun internals - electrode / ceramic shroud
- Gas bottle / supply

WELDING PROCESSES AND HOT WORKS

TIG WELDING SAFETY TIPS

- Welding helmets must always be worn during welding to protect your eyes and face from the harmful UV light produced during welding processes.

- Leather welding gloves and apron are essential to protect exposed skin and clothing from UV Light and sparks produced during the welding process. Avoid wearing non-synthetic clothing that might ignite upon contact with sparks or hot metal.

- Metal becomes very hot during welding. Use protective gloves and pliers or tongs to handle metal that has recentlty been welded.

- Protect other workshop users from UV light by use of welding curtains and the foldable welding doors provided.

- Keep any combustible or flammable materials well away from the welding area. Live power cables should also be moved away from the immediate area before welding.

- Galvanised steel must not be welded in the workshop without adequate precautions being taken.

BRAZING, SOLDERING AND THE BRAZING HEARTH

A brazing hearth is a self-contained unit consisting of a rigid metal structure with the bench part made of heat-resistant bricks. It has an extraction hood and a flexible extraction arm to eliminate smoke and fumes. The heat is provided by oxygen and propane gases. Propane itself is a highly flammable gas, although without the addition of oxygen it wouldn't be hot enough for most industrial purposes. The bottles should be opened prior to use, but check the torch valves are closed prior to this. The propane bottle has a rotating valve on the top. The oxygen requires the use of a key. The hand torches have two rotating valves to release the gas and are colour coded red and blue. Red it the propane and should be turned on first before introducing the oxygen (blue).

Brazing is the joining of metal parts by heating them to a certain temperature (depending on the material) usually until it glows red, then applying a brazing rod to the joint. The rod is made up of various copper and zinc based alloys, so will melt at a lower temperature than most metals (steel for example) and will form a semi-molten liquid. This is then built up along the joint between both metal parts. It differs from welding in that it doesn't involve melting the parent metal and so allows different metals to be joined (steel to copper, copper to brass etc.) There is also less distortion than welding due to the uniformity of heat as opposed to localised heat.

Brazing and soldering both require the use of a flux: a liquid which is designed to keep the join free from oxygen and allow the filler to flow freely in the required areas.Flux comes in powder form and needs to be mixed with clean water. Brazing flux should be mixed to a thick paste which will help it stay in place, whereas soldering flux needs to be a milky consistency to allow for gap filling.

HOT WORKS SAFETY TIPS

KEY FEATURES

- Gas bottle open / lighting of torch
- Nozzle type / changing
- Gas bottle shut off / purging of hoses
- Brazing hearth use / fume extraction
- flux / brazing rod / solder

SAFETY TIPS

- Use of hot work equipment is not covered in any detail in the induction, so please ask a technician for help when you use this for the firsts time.
- Protective goggles should be worn at all times during hot works to protect eyes from the glare of hot flux.
- Surrounding environment should be clear of flammable substances and combustible materials before starting work.
- No sparks from grinding are being produced in the immediate area
- Users know the location of the nearest fire extinguisher and the procedure to follow in case of a fire before starting work.
- Wear a leather apron to protect from sparks and burns produced when carrying out Hot Works processes.
- Wear leather gloves and use pliers or tongs to protect your hands from burns when handling hot metal
- The fluxes used for brazing and soldering will give off acidic fumes, so maximise the use of the extraction
- Do not leave any flammable materials in the direction of the flame. This includes lighters or matches.