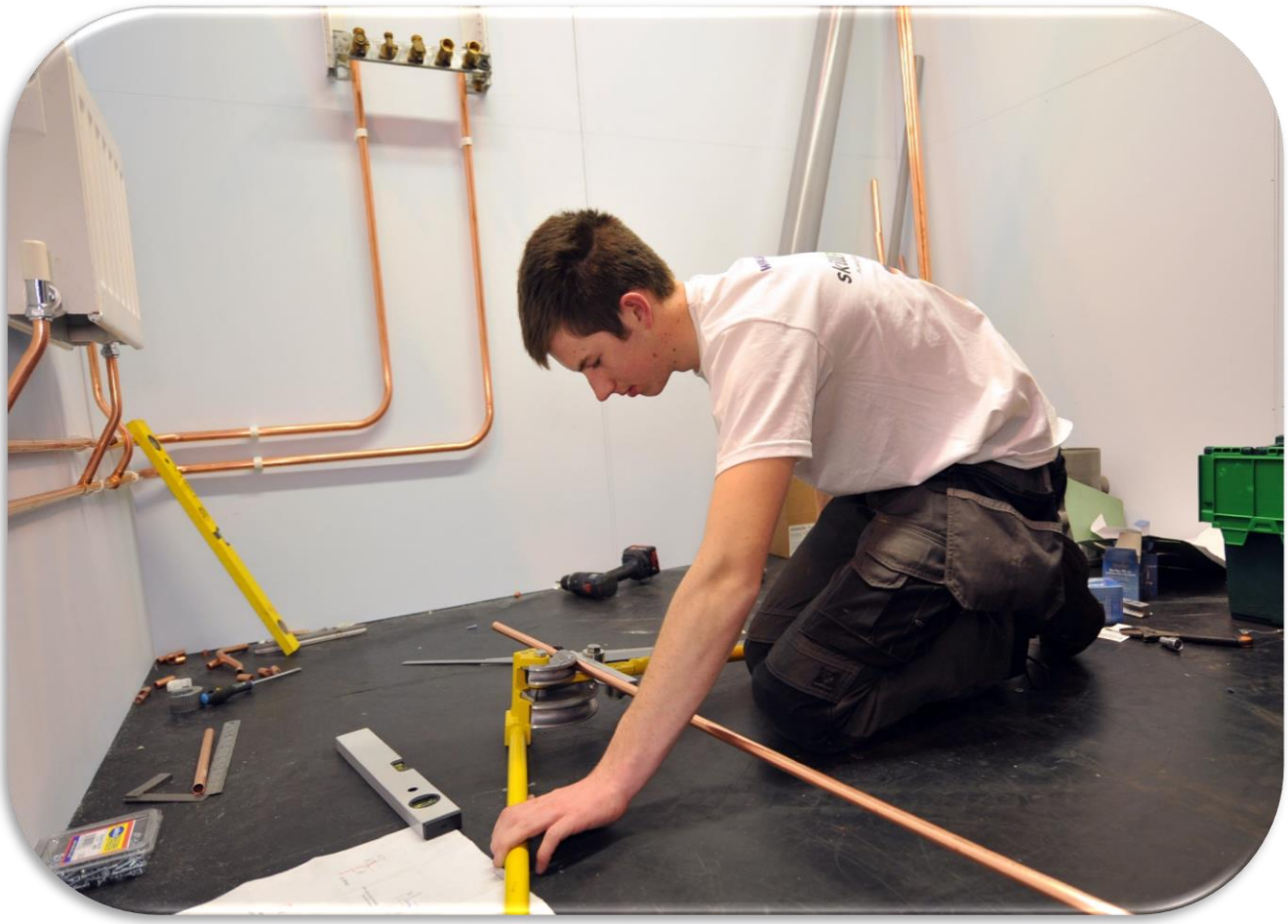
Essential Plumbing Skills Development for Copper Pipe Installation



2019 (Version 2)

Essential Plumbing Skills Development

For Copper Pipe Installation

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Introduction

The aim of this manual is to help new entrants to the plumbing industry improve their essential skills. It contains technical tips and advice to enable you to achieve your full potential. By working through this manual, with the support of your tutor, you'll be able to understand the techniques for measuring, bending and soldering copper pipe.

Tools

Remember, you should not use tools until you have been shown how to use them safely.

To accuratly complete the tasks described in this guide, you'll need the following tools:

(You can use the table below as a checklist)

Engineers square		Pipe cutting tool/reamer		Pipe cleaning material	
Measuring equipment		Pipe bender		Solder	
Aids for checking angles/ producing drawings		Blowtorch		Flux & brush	
Pencil or marker pen		Heat proof mat		Appropirate personal precedure equipment	

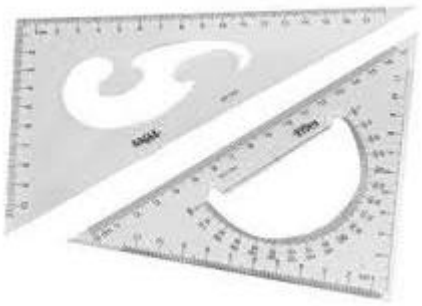
Small engineers square – Aids the accurate taking of measurements and used when bending copper pipe

Measuring equipment – The most accurate tools used for measuring are metric solid steel rulers or folding rulers, widely used by plumbers across Europe.

An alternative is to use a tape measure. The disadvantage of using a tape measure is that the end hook can become loose, reducing accuracy. When working to precise dimensions - plus or minus 2mm (± 2mm) - the use of a ruler is preferable.

Aids for checking angles and the setting out of drawings / templates –

60º/30º and 45º squares are good for producing setting out drawings because these angles are the most common angles used in construction. For more obscure angles a protractor can be used, sometimes these are incorporated in the square, (as in the picture of the 45º square.)



Engineers split rulers are good for checking angles when bending pipe; they can be set to the required angle and held adjacent to the pipe in the bender, to ensure bending is accurate.

Digital angle finders are superb for accuracy in both setting out and taking of angles from construction tasks, such as wall angles for setting out and checking of angles when bending. They are very expensive and delicate so care must be taken to avoid dropping them.

A pencil or marker pen is required for the production of setting out drawings / templates and marking pipework. For the marking of pipe the fine permanent marker is recommended, as it makes it easy to see the mark clearly when the pipe is in the pie bender. Remember to remove the marks from the pipe after fitting, because the customer will not wish to see these and it looks a lot more professional.

Pipe cutting – Pipe cutters are the preferred tool for cutting pipe; hacksaws produce a lot of very fine copper filings that could be washed into the system and into the crevices of radiators leading to electrolytic corrosion. So where possible, pipe cutters should be used.

After cutting the pipe, always use a reamer to remove the burr inside as this can restrict flow, increase fluid noise and lead to the possible build-up of scale etc.

Pipe benders - The most popular type is the scissor bender shown here - they are portable and fairly cheap to purchase.

Upright stand benders are available and tend to be used for larger diameter pipes as they will bend up to 42mm pipe.

Bench or vice mounted benders are also available, these are very good and widely used in Europe. They are very expensive and have varied results on UK pipe, which has only a 0.6mm thick wall, compared to the common pipe around the world, which has a wall thickness of 1mm.

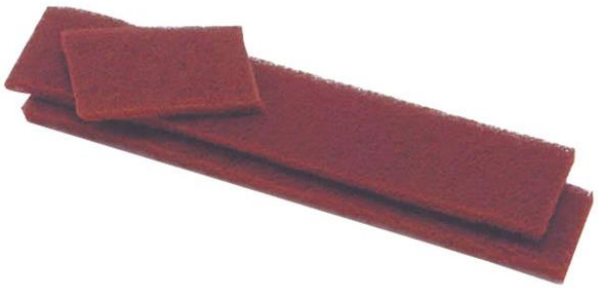
Soldering Equipment

Blowtorch and cylinder of gas - This is the most popular type of soldering blowtorch. Remember, for small diameter pipes butane is the best gas, as it provides a much cooler flame than that offered by the use of mapp gas (***m***ethyl***a***cetylene-***p***ropadiene ***p***ropane).

An alternative is a blowtorch kit (handle, burner head, hose and pressure regulator) connected to a larger type gas cylinder, usually propane. This style has various types of head for the flexibility, depending on the size of pipework to be soldered. This type is usually used by plumbers that work with larger diameter pipes.

Heat proof mat – This is used to protect the fabric of the building from damage by the flame when soldering. Care should be taken when using soldering equipment and the flame should be directed away from combustible materials. Mats should only be seen as an aid. DO NOT point the flame directly at the mat. Whilst they are called heat proof mats, in fact, they are heat resistant.

Pipe cleaning – Fibre cleaning strips can be used for cleaning copper pipe and fittings prior to soldering. Remember that cleanliness is a key part of good soldering. Steel wool was commonly used for cleaning copper pipe, however this type of cleaning material can enter the pipe and contaminate parts of the system containing different metals, leading to electrolytic corrosion.



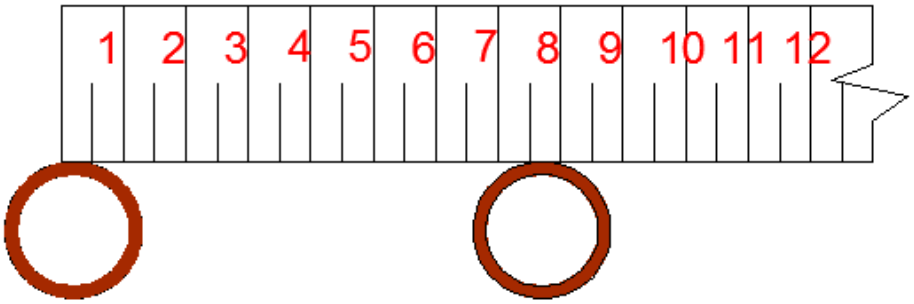
Solder and flux - Lead free solder is required for all potable water supplies.

Most fluxes used in the industry are of the self-cleaning variety. (Check for suitability for the type of system you are working on.) For best results, the pipe should be cleaned with a suitable pipe cleaner before the flux is applied.

Measuring Accurately

Taking accurate measurements is very important and can make a big difference to the quality of work. You should never try to guess. In this section we'll look at techniques that avoid guessing.

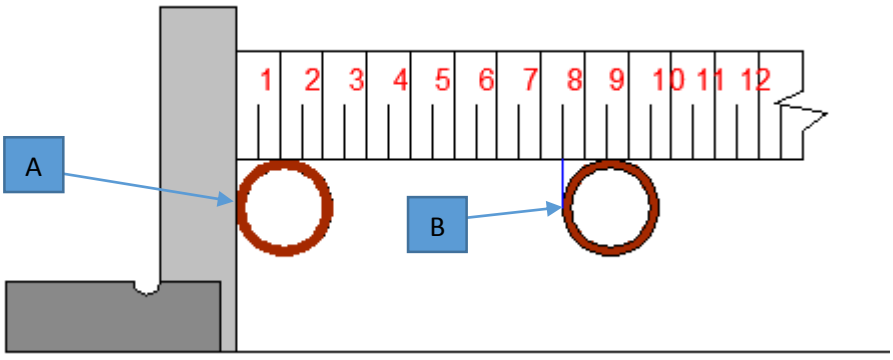
If you try to measure to the centre of a pipe, (as illustrated below), you'll struggle to be accurate.



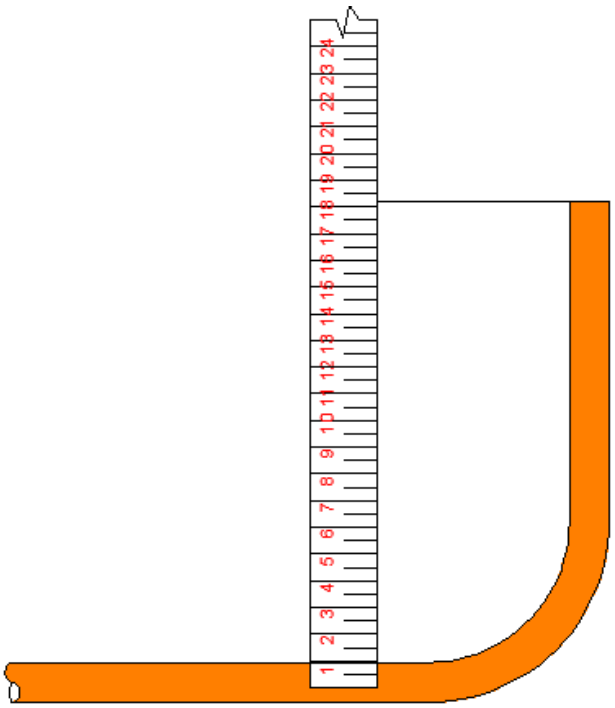
Using the above method is inaccurate because it relies on the user guessing the centres of the pipes - The measurement appears to be between 77mm and 79mm.

Using a square and accurately measuring makes a big difference, as can be seen in the diagram below; when measuring point A to point B, it can be seen that the more accurate method actually shows a centre to centre measurement of 75mm.

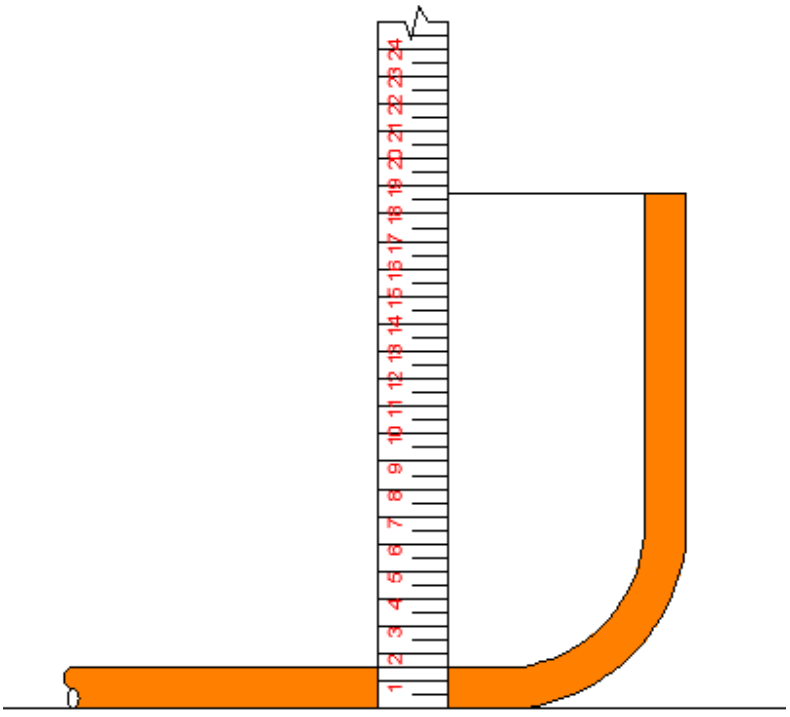
If you measure like this, then you are well within the ±2mm.



Another example is working from either a pipe end or a fixed point to the centre of a pipe.



In this example you can see that guessing the distance from the centre of the Horizontal pipe to the end of the vertical pipe or fixed point is around 182mm to 183mm.



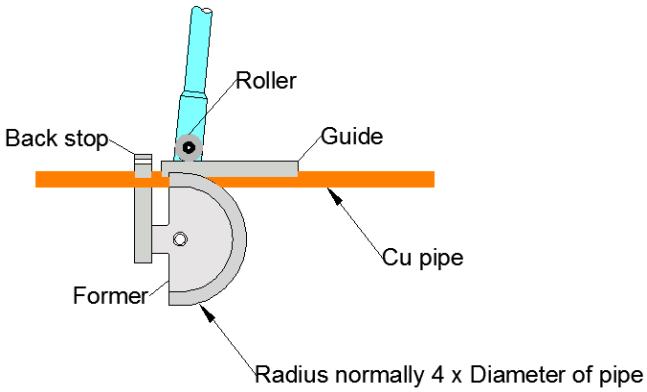
Here, you can see that the measurement is actually 187.5mm. Given that we are using 15mm pipe we take off 7.5mm making the final dimension 180mm.

If using pipe of a different diameter, all you need to do is take off ½ a pipe diameter to be 100% accurate.

Setting out for bends and bending

When bending pipe, it's important that you know the parts of the bender and the radius of the bend that it will produce.

Most benders bend at a radius of 4 x the diameter of the pipe so: -



For 15mm pipe it will be **15mm x 4 = 60mm radius to centre line**.

The outside radius will be **60mm + 7.5mm = 67.5mm.**

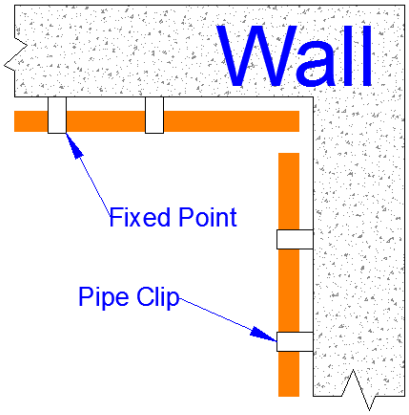
The inside radius (nearest the former) will be: - **60mm – 7.5mm (half the diameter) = 52.5mm.**

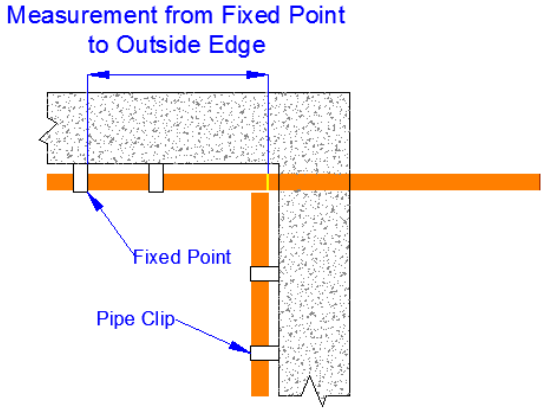
For 22mm it will be: - **4 x 22mm = 88mm to the centre line**. The inside radius (nearest the former) will be: - **88mm – 11mm (half the diameter) = 77mm** and the outside radius will be **88mm + 11mm = 99mm.**

Production of 90° bends

There is no need to produce a drawing for 90° bends, but the following will need to be considered:

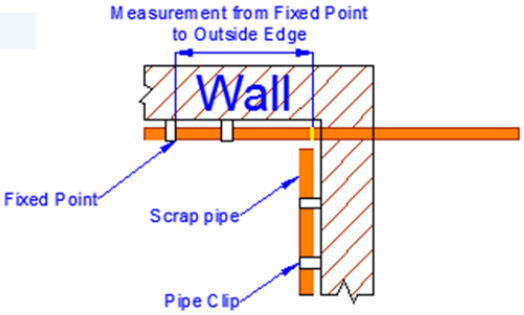
- The pipe will be fitted in pipe clips, so an allowance has to be made.
- A fixed point will need to be identified to determine the position of the mark on the pipe – The fixed point could be the end of the pipe, this eliminates the need to use long measurements. The fixed point is a pipe clip in the example.

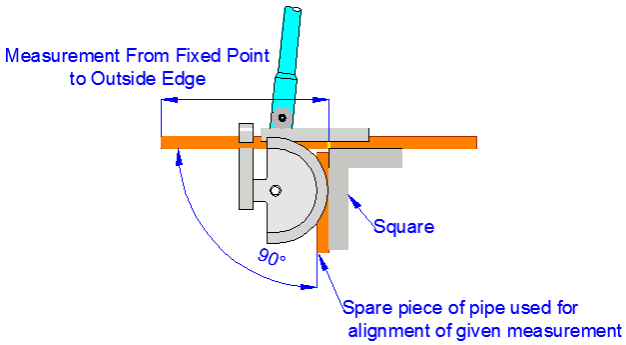




When copper pipe is to be bent, it is normal practice that all the marking out for the marking of the bending is done to the **outside edge.**

Measure the distance from the fixed point to the outside edge. A piece of scrap pipe can be used to determine where to mark the outside edge. Transfer this to the pipe to be bent and mark as shown (see yellow line in diagram).

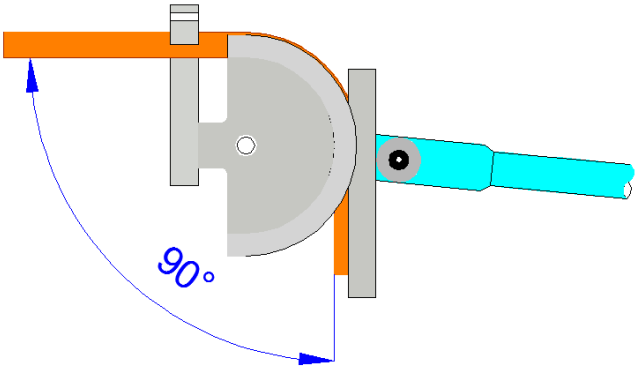


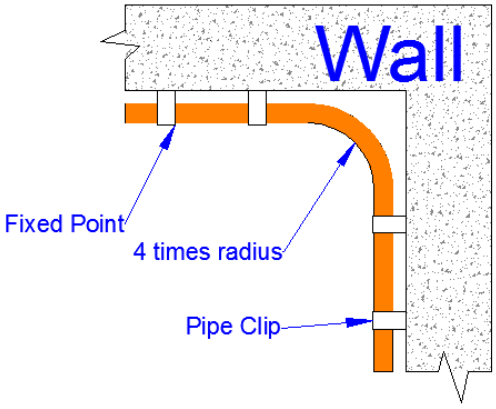


Place the pipe to the bender, ensuring the fixed point is behind the back stop. Use a scrap piece pipe and a square to ensure the mark on the pipe is aligned with the outside edge of the scrap pipe. Pull the bend to the correct angle.

Tip: It is much easier to bend accurately if your hands are free to hold squares etc. So in the early days of developing your skills consider mounting your bender either in a vice or a workbench for best results.

Check with either a square or an angle finder that the bend is 90°. Remember that the copper will spring back a little due to its elasticity, so release the pressure before checking the angle or your bend will not be accurate.



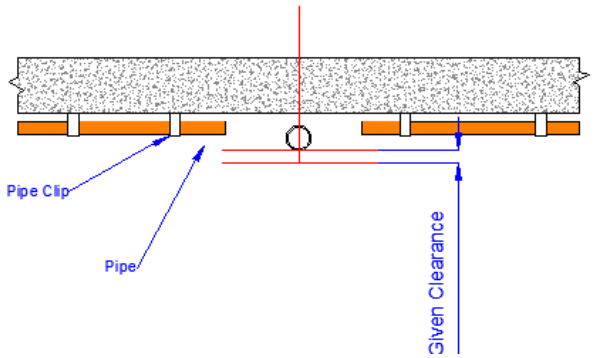


The pipe should fit in the clips without straining.

Note: do not make manual adjustments if the bend is not accurate as this will cause damage to the bend.

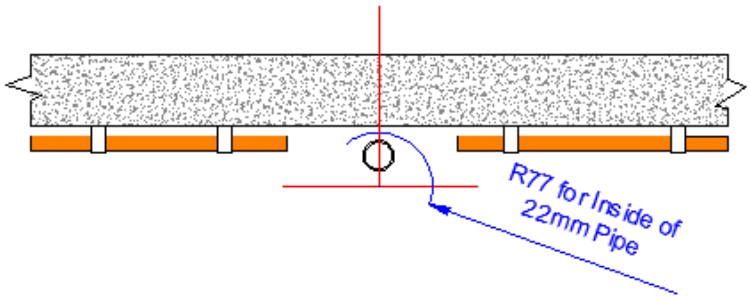
Passovers

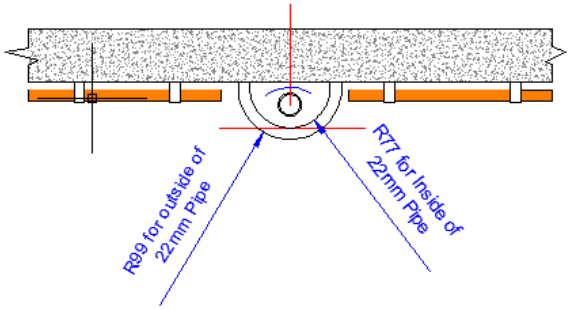
Passovers are much more complex and it's not unusual for two to be on the same piece of pipe, so setting out is very important.



This can be achieved by drawing the passover out. In this diagram, the object to be passed over and the clearance can be seen - This is the start of our setting out.

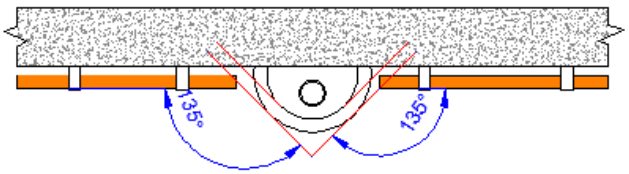
Strike an arc at a radius of 4 times the diameter of the inner edge, so **77mm for 22mm** pipe and **52.5mm for 15mm** pipe.

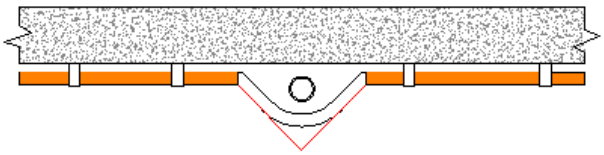




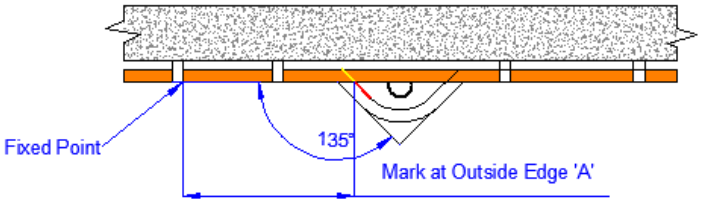
Striking through the two arcs – one at **52.5mm and 67.5mm if using 15mm** pipe, or **77mm and 99mm for 22mm** pipe as shown.

Using squares or angle finder set at (in this case) 135°, draw a line from the tangent of each of the arcs as shown.



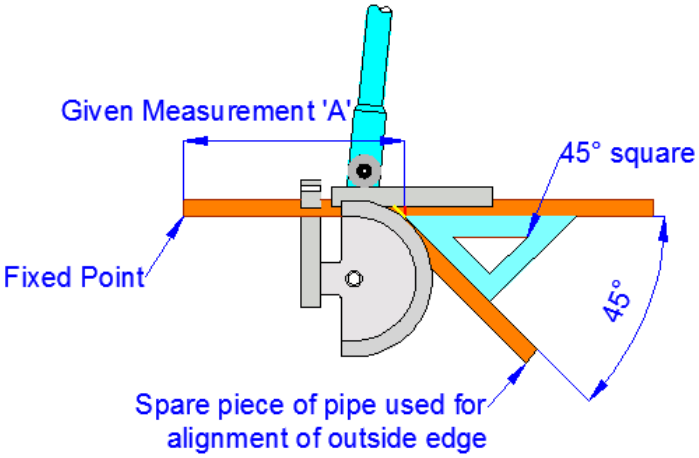


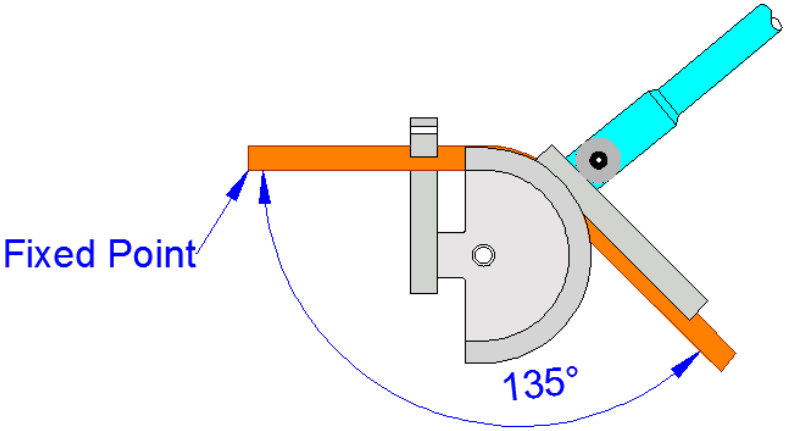
The final set out drawing should look like the drawing shown. That completes the setting out.



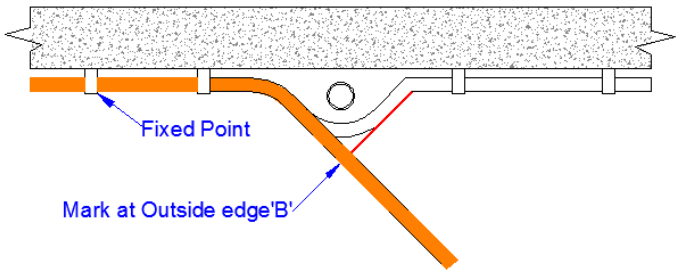
Use the drawing as a template, decide on a fixed point, which can be a pipe clip, a fitting or something else. The pipe should be marked on the outside edge of the first bend (yellow line).

Place the pipe in the bender and, using the square and a piece of scrap pipe, line up your mark as shown - remembering to keep the fixed point behind the machine.



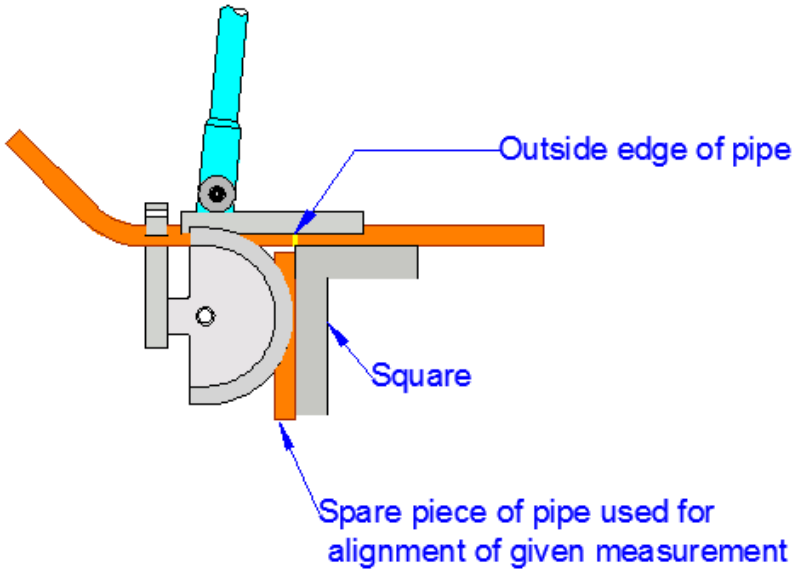


Pull the bend to the required angle. Using a split rule set at the angle (or an angle finder), check that your bend is accurate before removing from the bending machine. Remember to allow for the spring back when releasing the pressure on the arm.



The pipe can now be returned to the drawing and should fit perfectly without any adjustment by pulling etc., which will that distort the bend and detract from the quality of the finished job.

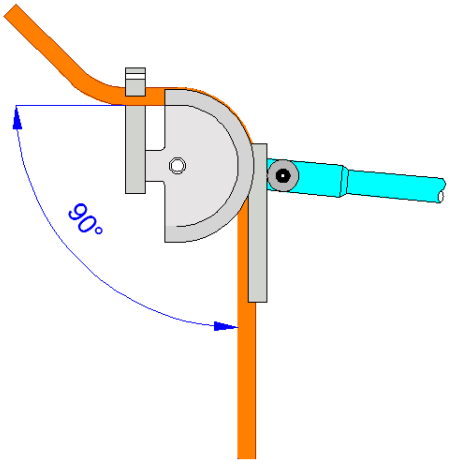
The second bend can be marked in line with the outside edge using the drawing as a template. In the diagram the 135° (45°) bend will mean that this bend is a straightforward 90° bend.

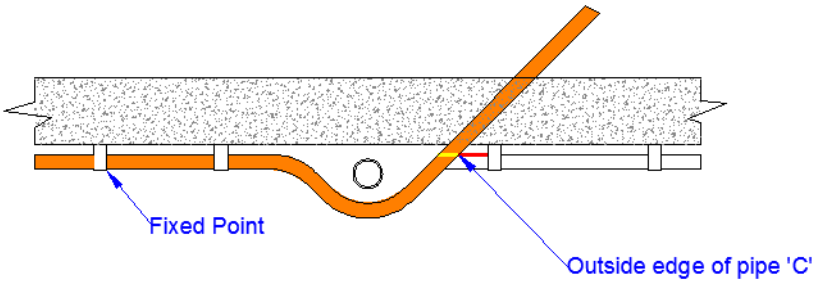


Return the pipe to the bending machine with the use of a square and a scrap piece of pipe, as shown. Remember the fixed point still needs to be inserted behind the bending machine.

Tip: Before bending look across the pipe bender to ensure that the pipe is not twisted in the machine.

Pull the bend to the required angle and check with a square to confirm it is correct, before removing from the bending machine.

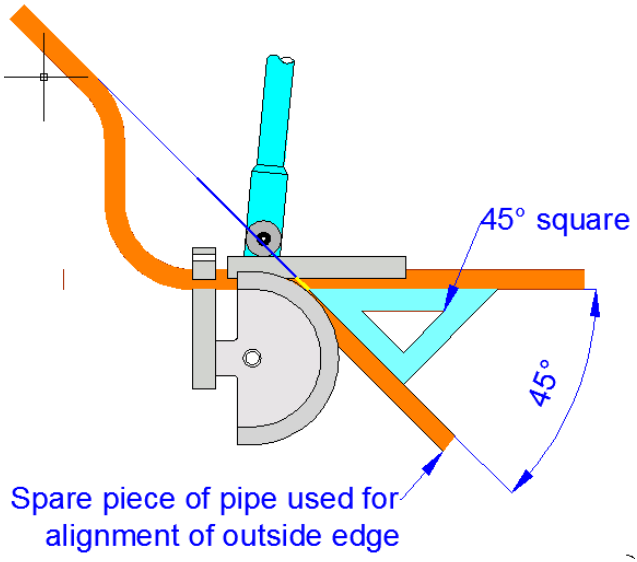


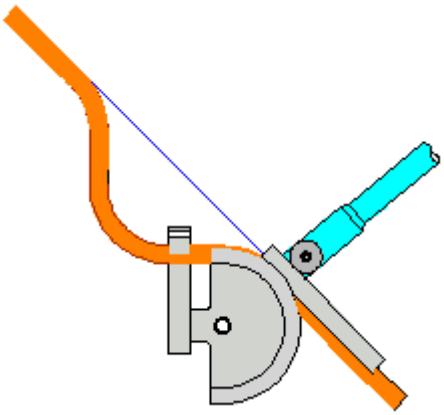


The pipe should now fit the drawing without any tweaking, as shown.

The last bend can now be marked out on the outside edge.

Now place the pipe in the machine and if it has been set out correctly it will look like it does in the diagram. Accuracy can be checked by ensuring the two legs of the bend are aligned, as shown by the blue line.

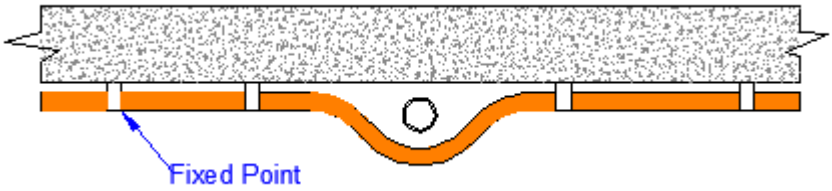




When checking, use a long steel rule to ensure that the passover is in line.

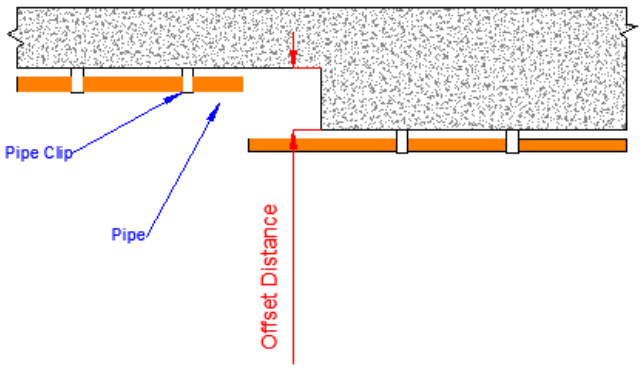
Then return to the drawing and it should match 100%. Check that the clearance is correct – remember that the industry accepted tolerance is $\pm$ 2mm

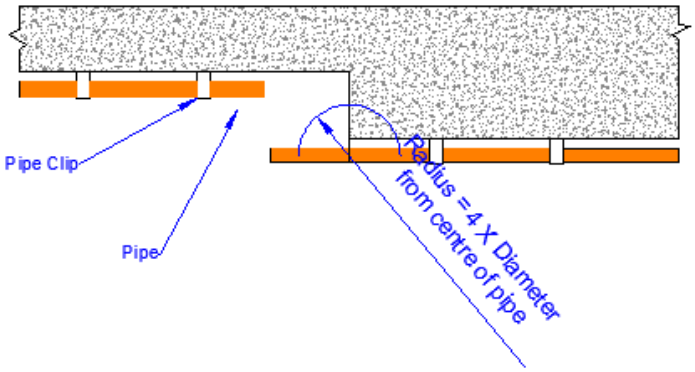
Then fit to pipe clips and it should fit without the need for adjustment or forcing it to fit.



Offsets

These bends are often found in two or three pipes that run parallel in an installation: consistent, accurate bending is the key to aesthetics (looking good). It is best practice to set out to ensure consistency of offset quality, to keep the pipes aligned (identical / straight)



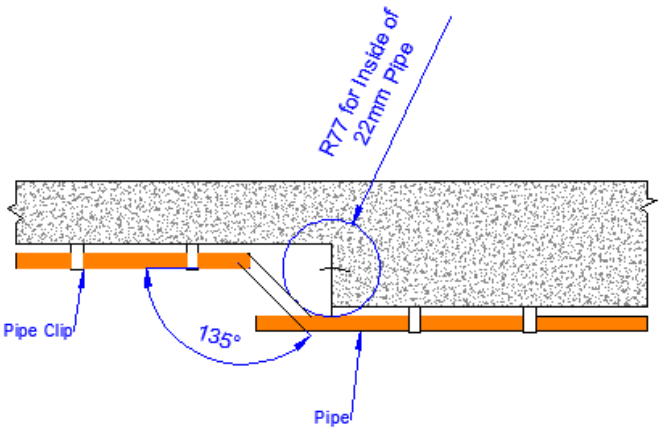


To set out, start as above then strike an arc from the centre of the pipe at 4 times the diameter as the radius, as shown:

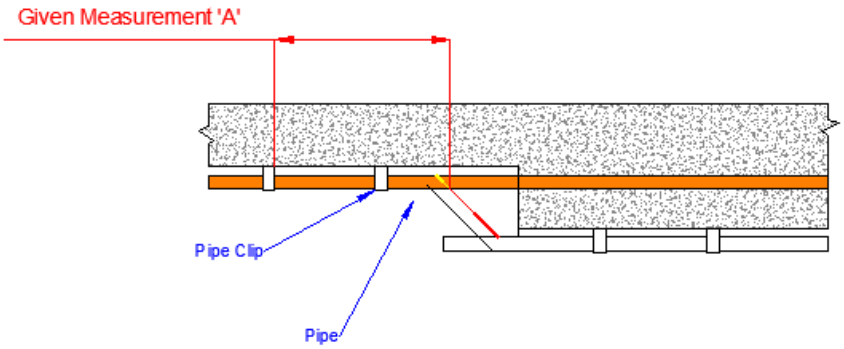
For 22mm 4 X dia = 88mm

For 15mm 4 X dia = 60mm

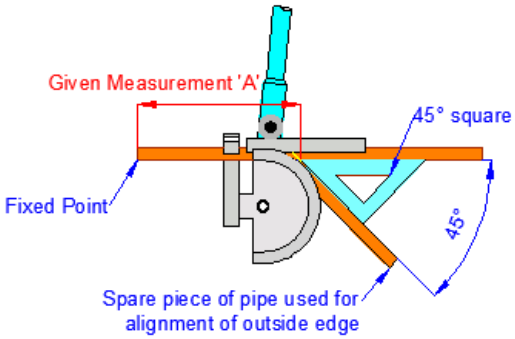
Draw a circle as shown, and draw a line from the tangent of the circle at the required angle of the offset. To obtain the outside edge, draw a line parallel to the first line at a distance that matches the diameter of the tube used. That completes the setting out.

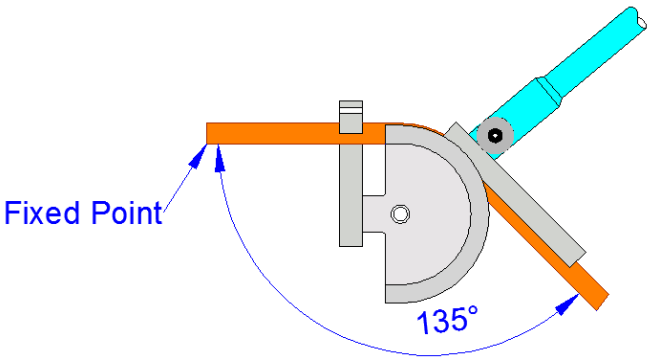


Use the drawing as a template, and decide on a fixed point, which can be a pipe clip, a fitting or something else. The pipe should be marked for bending on the outside of the first bend as shown:



Place the pipe in the bender and using the square and a piece scrap of pipe, line up the mark as shown - Remember to keep the fixed point behind the machine.

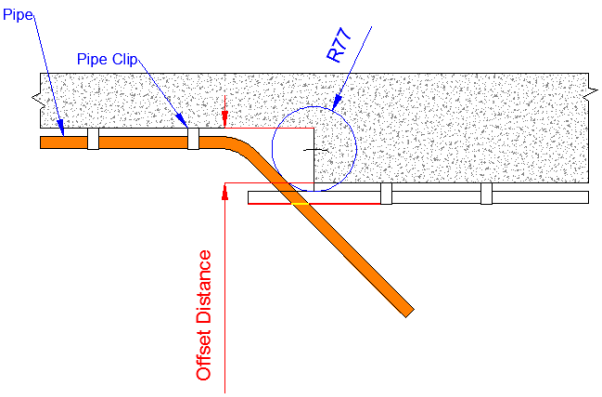


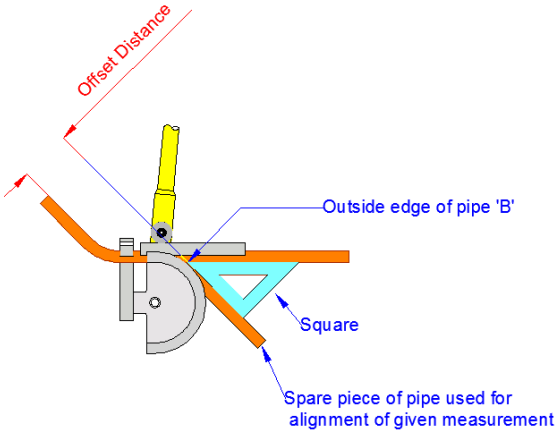


Pull the bend to the required angle and using a split rule set at the angle, or an angle finder, check that the bend is accurate before removing from the bending machine. Remember to allow for the 'spring back' when releasing the pressure on the arm.

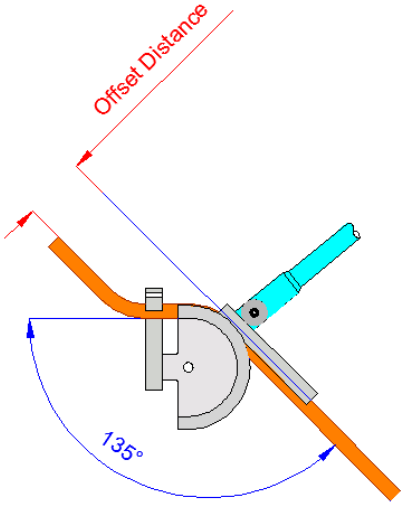
The pipe can now be returned to the drawing and should fit perfectly without any adjustment by pulling etc. which will distort the bend and detract from the quality of the finished.

Use the drawing as a template to mark out the second bend, in line the outside edge as shown.

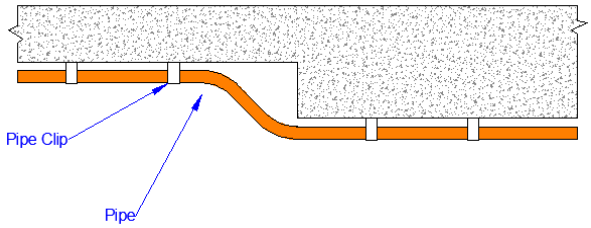




Place the pipe in the machine and if it has been set out correctly, the pipe will sit in the bending machine as shown. It can be checked for accuracy by ensuring the two legs of the bend are in line, as shown by the blue line, to give the correct offset distance.



To check that the offset is in-line and parallel use a long steel rule. Then return to the drawing and it should match 100%. Check that the clearance is correct – The accepted industry tolerance is $^{+}/_{-}$ 2mm.



The pipe should now fit the drawing without any tweaking, as shown.

Soldering of joints on Copper Pipe

The quality of soldered joints is greatly influenced by your work processes. Therefore, it is worth visiting the method of preparing a soldered joint and the quality of the finished product.

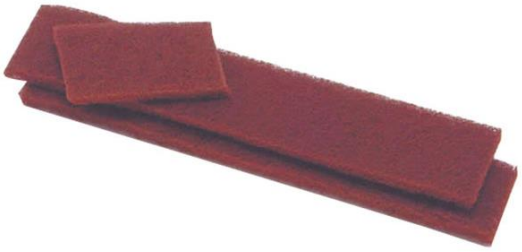
Preparation

The pipe needs to be cut correctly and at the correct length to ensure full insertion into the fitting.

When cutting copper pipe, it is best to use wheeled pipe cutters where possible. Cutting pipe with a hacksaw produces lots of very fine copper filings that could go inside the pipe and end up circulating to parts of the system that would result in electrolytic corrosion.

In some cases, you have no alternative for access reasons to cut pipe with a hacksaw, but make sure the pipe is cut square.

After cutting the pipe it is important to ensure that the pipe burr is reamed out to maintain the full bore of the pipe. If the burr is left in place this will reduce the flow inside the pipe and also create unusual flow patterns which will create noise. In hard water areas scale will build up much easier where burrs are left on the pipe.



Cleaning the pipe and fitting is also important for good results. Most plumbers use self-cleaning fluxes and in the majority of cases these do a great job. However, if you look at fitting manufacturer's literature they always say 'clean the pipe and fitting.' This means that their guarantee will be good, should it be needed in the future. The cleaning process should be completed using a suitable pipe cleaning pad to remove all the surface oxides from the copper tube from its exposure to the atmosphere. Cleaning these surface oxides off the pipe also assists the solder in doing its job and flows more easily and adhere to the pipe / fitting.

Choice of Flux is also very important. Most manufacturers prefer the use of the traditional type fluxes that are not self-cleaning. Self-cleaning fluxes tend to be corrosive, so it is important that they are used correctly and used sparingly. For water pipes, the flux can be removed from inside the pipe by flushing with water. However, for gas pipes this is not possible and the corrosion process will continue over a long period of time during temperature changes. If used sparingly, this can be avoided. Remember, the purpose of the flux is to reduce the surface tension and viscosity of fused solder, improving its wettability (fluidity) and preventing metal from being re-oxidized in the soldering process.

When applying flux, apply sparingly with a small brush to both the inside of the fitting and the pipe. Wipe off any excess prior to soldering. **NOTE**: Check that the flux you are using is suitable for the type of system you are working on, as some are not suitable for gas installations.

Jointing

Once the joint is prepared, it is ready for soldering.

The finished joint needs to look professional and an excellent joint will look like that pictured with a ring of solder clearly visible and the joint not burnt by the over application of heat.

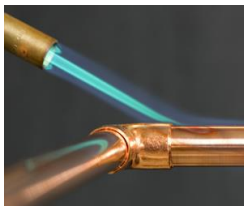
A joint that is still acceptable in the workplace may well look very similar with maybe a slight over application of solder. Again, note that the fitting is not burnt.

Joints that are not acceptable look as pictured - very untidy and unprofessional. They might not leak, but they look no better than a DIY attemt.

The secret to quality soldering is the flame. The flame needs to be hot enough for the solder to flow into the joint, but not enough to burn the fitting.

If the flame is too intense then the fitting and pipe are likely to burn very quickly and the application of solder will be virtually impossible. Also, it is more likely that you will burn the fabric of the building, as the flame is not controlled.

The flame needs to be well defined and provide sufficient heat. (The flame is more controlable and less likely to burn the fitting.) The hottest part of the flame is at the tip of the cone of the inner flame and this needs to be located close to where you require the heat. Practice will determine the size of flame that you require.



When soldering the pipe, the inside of the fiiting needs to be heated as well,so a good tip is to warm the pipe up slightly first, so that the heat on the pipe conducts inside the fitting.

Then move the flame on to the fitting, so that both the pipe and the fitting are heated to a temperature where the solder will flow. Experience / practice will determine this point

Apply the solder at the face of the joint with one touch point for 15mm and 22mm joints and two touch points for 28mm.

Do not over apply solder. A good tip is bend your solder at 15mm for a 15mm fitting and 22mm for a 22mm joint. This should be sufficient solder for the joint and will aid your practice in getting the quantity correct.

In this picture you can see the solder flowing and the pipe is not burnt using a reasonable flame. Apply solder so that a solder-ring is visible all round.

Once soldered, allow to cool naturally. DO NOT wipe with a rag, as this will diturb the solder as it soldifies and could lead to a leak in the future through movement during the cooling process.

Also, wiping will spread the solder whilst in liquid form all over the pipe and fitting which again, looks unprofesional. The need to wipe the solder off is due to over application of solder. If you apply the correct amount of solder this will not be necessary.

Once cooled and prior to handing the work over to the customer, remove any remains of the flux from the pipe by cleaning with a wet cloth.

If flux is not removed, the pipe will start to look unsightly and if it is a self cleaning flux, the flux could continue to be active when heat passes through or near the pipe leading to corrosion over time.

We hope that this guide was useful and supports your development as a plumber.

Some sources of information on soldering are:-

http://www.pegleryorkshire.co.uk/EN/literature/brochures

http://copperplumbing.org.uk/education

Note:

BPEC would like to thank Paul Dodds (the WorldSkills plumbing expert and SkillPLUMB lead judge) for compiling the information and guidance contained within this document.