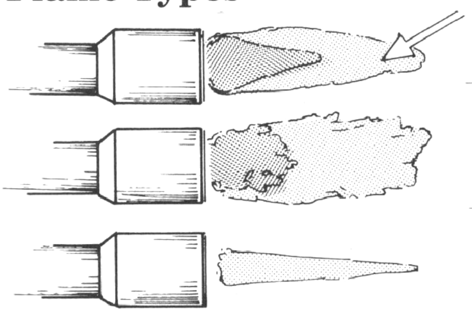
Silver Soldering

A matter of terminology
The process of joining metal parts through the use of heat and a filler metal is commonly called “soldering” by manufacturing jewellers and silversmiths. Actually, this term is incorrect by today’s definitions. The joining of metals in the temperature range of 593° C to 871° C is properly called brazing. (The term “soldering” is used to describe metal-joining operations at temperatures below 427° C.
However, the term “soldering” is so firmly established in the industry that we will use it in the discussion that follows, rather than the more technically exact term “brazing:” No harm will be done, as long as it is understood that when we talk about soldering we are talking about metal joining operations in the range 593° to 871° C.

General outline
Soldering is the joining together of two or more parts of the same metal through the fusion of heated alloys called solders which melt at a lower temperature than the melting point of the metal being joined.
The solder alloy melts, but there is no melting of the metals or alloys being joined. The solder flows between these parts, drawn by capillary attraction. The base metal is not fused, but the solder diffuses into the base metal, it makes a surface alloy with the base.
A soldered joint in a sense “makes itself” Capillary action does the work, drawing the molten solder completely through the joint. But even a properly designed soldered joint can turn out imperfectly unless the correct soldering procedures are followed. These procedures can be boiled down to six basic steps. They’re generally simple to perform (some take only a few seconds), but every one of them is essential to the completion of a strong, clean soldered joint.

Soldering
Technique
Silver soldering cannot be accomplished without using flux. The joining surfaces are first cleaned mechanically and then coated with a flux, usually of borax or soldering powders such as Easy Flo or Tenacity No.5 (both Johnson Matthey fluxes). Borax flux is only suitable for very small joints and has been superseded by the more modern powder fluxes. The joint should be carefully checked for closeness and fit and carefully cleaned before soldering begins so that edges meet without gaps. The joint may need to be joined together with binding wire to hold it together. The pieces to be soldered should be placed carefully in position on heatproof board or blocks for support (not asbestos). It should then be heated until the melting point of the solder is reached. The solder should then be applied to the work until it runs along the joint. This is achieved by capillary attraction. The soldered piece should then be allowed to cool. It should then be cleaned in dilute Sulphuric acid or safety pickle until all traces of flux and oxide have been removed. The piece is now ready to be filed or finished as required.
Note: silver does not show red in normal daylight, therefore it is best to solder in subdued light.

Flame Types



Neutral	Sharp point, gentle hiss, medium blue color. All gas is being ignited. Hottest point is at the arrow.
Reducing	Bushy, pulsing flame, deep blue color. This fuel-rich flame absorbs oxides and is best for soldering.
Oxidizing	Thin cone, angry hiss, pale lavender. This fuel-starved flame has no advantages when soldering.

Good fit and proper clearance
As we’ve noted, soldering operates on the principle of capillary action. And capillary works best where there are close clearances between the metals being joined. How close? The strongest joints are made at clearances of .0015”-about half the thickness of this page.

However, soldering is a “forgiving” process, and clearances ranging from .001” to .005” will still produce high-strength joints. In actual shop practice, an easy slip fit between two tubular parts, or simply resting one flat part on top of the other is all the clearance you’ll usually need. The average mill finish of the metals imparts enough surface roughness to create capillary paths for the flow of the molten solder.

Cleaning the metals

Capillary action works properly only when the surfaces of the metals are clean. If the parts you’re soldering are factory-fresh they’ll require no cleaning. But if the metal surfaces bear contaminants-oil, grease, scale or dirt-those contaminants have to be removed, or they’ll form a barrier between the metal surfaces and the soldering alloy. You should remove the oil and grease first, using a degreasing solvent. Scale and dirt can then be removed chemically, with an acid pickle treatment, or mechanically.

Assembly for soldering

Once the parts are cleaned and fluxed, they are ready for soldering. Now you have to hold them in correct alignment during the heating and cooling cycles, so that capillary action can do its job.
The easiest way to hold parts together, if their shape and joint conformations permit, is by gravity -simply resting one part on the other. You can even add additional weight to give gravity a helping hand. Or you can use any clamping or supporting device-spring clamp, vice or pliers-that holds the parts together long enough to complete the soldering operation.
If you have a number of identical assemblies to solder, it may pay to make a supporting jig. The jig should be designed for minimum contact with the parts, so heat is not conducted away from the joint area. Materials used for the jig should be poor heat conductors (like stainless steel or ceramics) that won’t draw heat away from the joint, rather than good conductors like aluminium or copper.

Fluxing the parts

Flux is a chemical compound applied to the joint surfaces before soldering. A coating of flux shields the metal surfaces from the air and prevents the formation of oxides; this would interfere with the bonding action of the soldering alloy. Flux can be applied as a paste to the joint and applied with a brush to the metal surfaces. Flux can also be applied mixed with methylated spirit to remove any contamination from the metal surface. It should be applied generously, as insurance against oxidation, and the joint should be soldered as soon as possible after the flux is applied.
General purpose fluxes such as Easy Flo or Tenacity No.5 (both Johnson Matthey fluxes) will cover most applications. Both these fluxes become liquid at soldering temperatures thereby protecting the work from oxidisation.

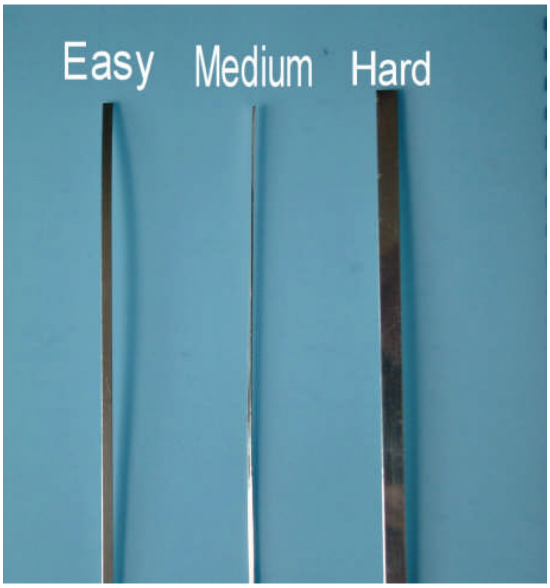
Soldering the assembly

The actual soldering operation involves heating the assembly to soldering temperature (hot enough to melt the solder but below the melting point of the metals) and flowing the solder through the joint.
The most common method of heating is the hand-held torch fuelled by natural gas or propane and compressed air. Light the torch and apply heat to the joint area, working broadly and keeping the torch in constant motion. In heating pieces of unequal mass, favour the heavier piece to avoid overheating the lighter member. In joining two different kinds of metal, favour the metal that is the more rapid heat conductor.
If you’ve used Easy Flo or Tenacity No 5 to flux the parts, the point at which the flux becomes clear indicates that the joint area has reached (or is near) soldering temperature. At this point you simply touch the solder rod (or wire) to the joint line. The heated assembly will melt off a portion of the solder, which will instantly be drawn by capillary action through the entire joint area, forming a strong, permanent bond.

Application of flux and solder

First decide which type or grade of solder you are going to use. If the piece of work has been soldered already, consider if resoldering will melt the previous joint. If this is the case, decide on which grade of solder to use (see below,) make sure that the area to be soldered is clean and close fitting. Mix sufficient flux in a small pot to a smooth paste. Bind joint together with iron binding wire if needed to keep joint together. Apply flux to joint and surrounding area with a soft brush. Position the work carefully on the hearth and apply heat from the torch. The diagram above shows the hottest part of the flame. Do not hold the flame to far away or too near to the work. Either will not produce satisfactory work. Heat the work to the required temperature and apply the solder being careful not to apply to much. Solder will run along the joint by capillary attraction. Use the heat from the torch to draw solder to the required part of the joint. Always solder silver in subdued light. Due to the colour produced during heating silver, it is difficult to see the red colour of

silver in bright light. When soldering is finished, allow the work to cool. When cool, put work into acid (pickle) to clean. Never put work into the acid hot, dangerous fumes are created. When all flux and oxide is removed from the work, remove from acid and wash thoroughly in clean water. If you are concerned about using Sulphuric acid, you can use safety pickle.
Solders can be divided into three main types. Hard solder, for silver solder, Easy Flo solder, for soldering base metals such as brass, copper, steel. Soft solder, a tin or lead based alloy used in electronics.
Generally, hard solder is used for silver. The major ingredient is silver; the other metals in the alloy are copper and zinc. There are five different types of solder used in silver soldering, they are as follows:



Extra Easy Solder Strip 2mm x 0.45mm 5g.
Melts between 667°C- 709°C

Easy Silver Solder Strip 3 x 0.5mm 9g.
Melts between 705°C- 723°C

Medium Silver Solder Strip 1.5 x 0.7mm 6g
Melts between 720°C- 765°C

Hard Silver Solder Strip 6mm x 0.6mm 18gms
Melts between 745°C- 778°C

Enamelling Silver Solder Strip 1.0mm x 1.5mm 9gm
Melts between 730°C- 800°C

All hallmarking silver solders is sold in 600mm lengths

The photo shows the most popular silver solders

Silver solder is also available as paste in hard, medium and easy as a paste in a syringe. This is particularly useful if you need an exact amount soldering small joints such as jump rings or small findings for jewellery. Silver melts at about 962° C (about 1764° F). As you can see from the melting points of the silver solders shown above, they are designed to melt at various temperatures in relation to the melting point of silver. The soldering work should be carefully planned so that the highest melting point solder is used first, and the lowest melting point last.

Chip or pallion. A small piece of solder is cut from the strip (usually 2 to 4mm wide). This is placed on or very near to the joint. The joint is fluxed and the whole is heated gently until the solder melts and runs into the joint.
Sweating or tinning: Solder is usually applied to one surface to be soldered. The other surface is then applied to it and heated until the solder runs. This will keep solder out of sight when doing overlay work.
Probe or pick: Small pieces of solder are cut in the same way as for pallions. This is particularly useful for jump ring soldering or butt soldering very small pieces of work. The work is fluxed and gently heated. The small cut pieces are laid near the work. One piece at a time is lifted in tweezers and placed on the joint until the solder melts.
Stick: This is suitable for larger work that cannot be heated all at once. The work is prepared in the normal way. As the work is heated, the solder stick is applied to the joint. The heat from the gas torch will melt the solder into the joint. The torch should be used to guide the solder along the joint by capillary attraction.
Paste: This usually comes ready prepared in a syringe. This method is commonly used for assembly line soldering. Good for delicate work such as filigree and wire. A small amount of the paste is squeezed onto the joint. No separate flux is needed. The whole joint is then heated until the solder melts.
Clean the soldered joint after soldering in the normal way.
This is available in easy, medium and hard.

Firestain, firescale or fire.

Firestain occurs when the copper contained in silver alloys is oxidised during annealing or soldering. It will appear on a polished surface as a grey dull film on the surface of the silver spoiling the bright white finish that should be the hallmark of polished silver.
Light firestaining can usually be polished out, or may respond to pickling in a bath of 10% sulphuric acid or another proprietary pickle.

If a protective atmosphere is not available to carry out annealing operations, the following steps can be taken:
Avoid prolonged heating wherever possible. Ensure that a large enough flame is used to get soldering and annealing jobs completed in the minimum amount of time.
The entire workpiece can be coated with a flux or Argotect[i] which will form a glassy coat on the metal, protecting it from the atmosphere.
Use a large, bushy flame when annealing, which allows the job to be completed quickly and provides a slightly reducing atmosphere.
Filing, polishing, electroplating or electro stripping can remove or hide firestain. There are now various silver alloys available that claim to tackle the problem of firestain such as Argentium[ii] or Brilliante[iii] silver.

Troubleshooting:

1. **Ventilate confined areas.** Use ventilating fans and exhaust hoods to carry all fumes away from work and air supplied respirators as required.
2. **Clean metals thoroughly.** A surface contaminant of unknown composition on metals may add to fume hazard and may cause a too-rapid breakdown of flux, leading to overheating and fuming.
3. **Use sufficient flux.** Flux protects the metals being joined during the heating cycle. Full flux coverage reduces the chance of fumes.
4. **Heat metals broadly.** Heat the metals broadly and uniformly. Intense localized heating uses up flux, increases danger of fuming. Apply heat only to metals being joined, not to filler metal. (Direct flame on filler metals causes overheating and fuming.)
5. **Know your metals.** Be especially careful not to overheat assembly when using filler metals that contain cadmium. Consult the Material Safety Data Sheet for maximum recommended brazing temperature of a specific filler metal. The filler metal carries a warning label. Be sure to look for it and follow instructions carefully**.**

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[i] **ARGOTECT –** used to protect silver when annealing or as a brazing flux.

[ii] Argentium Silver's protective germanium oxide

The germanium in Argentium Silver oxidises preferentially to the copper and silver to form a transparent germanium oxide surface layer. This oxide forms in the presence of air/oxygen and is able to replenish itself at ambient temperatures through the migration of germanium atoms to the surface. Argentium silver is only available in the USA at present.

iii

A general purpose alloy suitable for casting and wrought work (rolling, drawing, spinning and pressing), highly tarnish resistant, less susceptible to firestaining than Sterling or Britannia Silvers. Age hardenable and can to be reworked more than Sterling Silver.