Soldering Guide

©2013 McGraw-Hill

This document may be reproduced for instructors and students using relevant McGraw-Hill publications. A PowerPoint presentation is also available. The combination of this document and the PowerPoint presentation make an effective teaching and learning tool.

Introduction

Soldering is an evolving technology. The development of smaller and more efficient component packages and better assembly techniques have fostered new and improved methods of soldering, some of which create daunting repair issues. For example, IC packages called ball grid arrays (BGAs) have solder joints that are totally hidden from view. Environmental issues are also becoming more important and there is a need to reduce lead exposure, along certain other heavy metals.

Soldering is a specialty. Organizations, books, magazines, and various standards deal with its various issues. This document is an overview and will not address all of the details of this dynamic body of knowledge.

Soldering is both a manufacturing process and a repair process. The two have both common issues and unique issues. One very important thing that is common is *cleanliness*. It's just not possible to effectively solder dirty or heavily oxidized parts, connectors, wires, or circuit boards. Desoldering is typically a repair process. This document is mainly concerned with repair, but some manufacturing information is included.

The procedures described in this guide will vary according to the tools and equipment at hand. As always, refer to and follow manufacturer's recommendations. Also, there is some latitude according to the skill and knowledge of the worker. There is always more than one way to effectively desolder and resolder during a repair procedure.

The base process

Electronic hand soldering is typically accomplished by heating the metal parts to be joined while applying flux and solder to the mating surfaces. The flux is often supplied automatically by using wire shaped solder with a hollow core that contains the flux, which is normally rosin.

A finished solder joint is a metallurgical bond. Soldering forms both an electrical connection between the parts and a mechanical joint. Heat is supplied with a soldering iron or by other means. The flux is a chemical cleaner which prepares the hot surfaces for the molten solder by dissolving any oxide films on the metal parts. Also, and perhaps more importantly, the flux coats and prevents the heated base metals from oxidizing. The solder is a low melting point alloy of nonferrous metals. The melting point of electronic solder containing lead is approximately 370 °F (188 °C) and the iron tip temperature is around 650 °F (343°C), or more. Lead free solders melt at higher temperatures and might require higher tip temperatures.

A quick description of the process

First, a warning for beginners: Do not attempt to use a soldering iron to carry molten solder over to the solder joint. It won't work. Soldering is nothing like buttering bread. But, beginners sometimes try it.

Suppose a resistor is to be soldered onto a circuit board. We will assume that the circuit board pads are clean and shiny. If not, they can be buffed with a non-abrasive pencil eraser. If the resistor is relatively new and has clean leads, it can be inserted into the holes of the circuit board. If the resistor is old and its leads show discoloration or oxidation, the leads should first be cleaned by lightly scraping them with a knife. The soldering iron should be rated at approximately 20 watts and the tip should be about one to two times the diameter of the pads on the circuit board. A conical shaped tip is better for small pads and a chisel shaped tip is better for large pads. After the iron is turned on and comes up to temperature, it should be tinned by applying wire solder to the tip. After the tip is completely coated, wipe it on a damp sponge (special sponges are available). The tip should now have a bright, silvery appearance. The appearance will be duller for lead free solders. Touch the tip, at about a 45° angle, to one of the resistor leads where it exits the circuit board. The tip *must* be in contact with *both* the lead and the circuit board pad. Immediately apply wire solder with a flux core to both the wire and pad. Wait about 2 seconds and then remove the solder (by then, the solder should have melted and formed a joint). Then, immediately remove the iron. If the entire process takes longer than 3 seconds per solder joint, something is wrong:

1. The metal parts are not clean.
2. The solder or the flux is not the correct type.
3. The soldering tip is too small for the joint.
4. The iron was not up to temperature or its wattage rating is too small.

The joint should be shiny and the solder should show good wetting action (the solder forms a fillet that flows up the lead and flows to the edge of the pad). Lead free solders typically produce joints that are dull in appearance. If the solder looks like a ball or a blob sitting on the pad, something is wrong. If the iron was too hot, the joint will have overheated which produces a dull look. Also, the same thing can happen if the iron is applied for more than 3 seconds. If the iron was removed too quickly, then the solder might look like a ball instead of a filleted surface. Or, perhaps the iron was not in contact with both the wire and the pad. Or, the iron was not hot enough or the tip was too small. Finally, applying too much solder can make the joint look more like a ball. Excess solder can also cause a *solder bridge* which is an unwanted solder connection (short circuit) between two pads.

Some additional troubleshooting tips follow.

1. The solder won't wet (take) because grease, corrosion or is dirt present … clean the parts, pads, wires and terminals.

2. The solder won't wet because the material is not suitable for soldering … a special solder and/or flux might be required.
3. The joint is dull or grainy looking because a part or a wire moved before freezing … physically stabilize the assembly in a holder or by other means.
4. The joint is dull or grainy looking because the joint was improperly heated or flux is lacking. Reminder: lead free solders do not produce shiny joints.
5. The solder joint has a spike because it was overheated and all the flux burned off … apply the iron for less time, use a smaller tip, or reduce the temperature of the iron.

Safety

Molten metal can splash and fly around. Eye protection is a must. Ordinary glasses are not adequate. Side shields are required and goggles are recommended. Also, after soldering, wire ends must sometimes be clipped off. These ends are sharp, and they can fly when clipped and can cause eye damage.

Soldering produces fumes, which should not be inhaled. Work in a well-ventilated area. Some people like to hold things in their mouth when they are working. This is a not a good practice. Wash your hands after you are done.

Don't touch hot objects. If you are burned:

1. Cool the affected area as soon as possible with cold water or ice. At least five minutes is suggested.
2. Thoroughly wash the area with soap and cold water.
3. Apply a sterile dressing.
4. Do not apply ointment or lotions.
5. Seek medical attention for serious burns.

Base metals and fluxes

A base metal is one that contacts the solder and forms an intermediate alloy. When attaching electronic components to a printed circuit board, the component's leads and the board's metal pads are the base metals that will become a part of the solder joint. Metals such as copper, bronze, silver, brass, and some steels readily alloy with solder to form strong chemical and physical bonds. Other metals, such as aluminum, high alloy steels, cast iron, and titanium, range from being difficult to impossible to solder.

The mass, composition, and cleanliness of the base material all determine the ability of solder to flow and adhere properly (wet) and provide a reliable connection. If the base material has surface contamination, this prevents the solder from wetting along the surface of the lead or the board material. Component leads are usually protected by a surface finish. The surface finishes can vary from plated tin to a solder-dipped coating.

Plating does not provide the same protection that a solder coating does because of the porosity of the plated finish.

There is an inverse relationship between the level of surface oxidation of a base metal and how readily solder will alloy with it. The more oxidation that is present, the weaker the solder bond will be. The fact that most metals oxidize at an accelerated rate when heated creates a problem since the chemical reactions associated with soldering require high temperatures.

Flux is the primary material used to overcome oxidation problems. Flux is often applied as a liquid to the surface of the base metals prior to soldering. Though flux actually has a number of purposes, the first and primary purpose of flux is to stop the base metals from oxidizing while they are being heated to the soldering temperature. The flux covers the surface to be soldered, shielding it from oxygen and thereby preventing oxidation during heating. Some fluxes have an acidic element that is used to remove any oxidation already present on the base metal.

Strong acids are damaging to electronic components and even mild acids leave a residue that continues to corrode after the soldering process is complete, leading to future failures. There is a trade-off between using a flux with a strong acid that removes a lot of oxidation and is very corrosive, and using a flux with a mild acid that is not as corrosive, but does not do as well for removing the oxidation layer. The need for acid flux is avoided in electronic soldering by using wires and printed circuit pads that are plated or coated with tin or solder.

Most flux used in electronic work is based on rosin. Rosin is generally considered non-corrosive and its residue can be left on solder joints without producing on-going corrosion. However, it is sticky and leads to an accumulation of particles that can become water absorbing and then later become somewhat conductive. For that reason, flux remover is generally used to remove residual rosin after the soldering is completed. Another problem with not removing flux is that “tin whiskers” (dendrites) can form later when lead free solders are used and these can cause short circuits.

Fluxes are composed of two basic parts, chemicals and solvents. The chemical portion includes the active components, while the solvent is the carrying medium. The solvent determines the cleaning method that must be employed to remove the flux residue. While some fluxes can be removed with simple water treatments, many require other cleaning agents such as organic solvents, alcohol, or terpenes.

Solder

When an alloy such as solder is heated, it typically goes through three phases. It goes from a solid phase to a plastic phase (halfway between a liquid and a solid) and then to a liquid phase. Eutectic solder is an alloy with no plastic phase. The eutectic alloy for leaded solder is made up of 63% tin and 37% lead. The plastic phase is not desirable because additional heat is required to reach the liquid phase and the additional heat can damage parts and circuit boards. Eutectic tin/lead solder has the lowest possible melting temperature (361 °F). A second reason that the plastic phase is undesired is that any motion during cool down while the joint is in the plastic phase will cause an inferior joint

Eutectic solder changes to a liquid just above the melting point and, as it cools, it will transform directly into a solid. This makes it possible to *quickly* form superior solder joints. A 60% tin and 40% lead alloy can also be used. This alloy shows an almost eutectic change from solid to a liquid and has a melting range of 361 °F to 374 °F.

Another alloy is available that uses 62% tin, 36% lead and 2% silver. It has a melting range of 354 °F to 372 °F. It is sometimes preferred for surface mount chip components because it prevents silver from leeching from the components into the solder joints. (Some chip components use a silver coating on a ceramic body.)

Solder containing lead has been banned for some applications. 96.5% tin, 3% silver, 0.5% copper is a popular lead free alloy with a melting temperature range of 422 to 428 °F. Note that this is higher than for leaded solders. Workers using temperature controlled soldering stations usually set them for higher temperatures when working with lead free solder.

Most electronic soldering is accomplished with wire solder or with solder paste. Wire solder is available in several gages. A diameter of 0.025 inches is common for printed circuit board work. Wire solder usually has a hollow core filled with flux and consists of about 3.3% rosin (the flux).

Solder paste is used for surface mount components. It uses a eutectic alloy and typically has a *mesh size* of 25 to 40 microns (a micron is one-millionth of a meter … about 39 micro inches). Solder paste is often applied using screen printing during the SMT (surface mount technology) manufacturing process. The *mesh size* corresponds to the size of the openings in the screen. Solder paste can also be dispensed with a syringe, which generally occurs during the repair of SMT boards.

Soldering irons

The soldering iron tip transfers heat from the heater to the solder joint. Most tips have a base metal of copper because copper is an excellent heat conductor. Excellent heat conductivity means that the solder joint can be formed quickly, which minimizes component and circuit board damage. Nickel can be plated over the copper and then iron plated over that to increase the life of the tip.

Tip shape and size both determine a tip's performance. The size determines heat flow capability (thermal mass) while the shape controls how well heat is transferred from the tip to the joint (thermal resistance). The shape of the tip is important. It should be of a geometry that allows physical contact with the land and the component at the same time.

The size (wattage rating) of the heater is also important. Typical ratings range between 15 to 25 watts, or so, which is good for most work. A larger wattage rating does *not* mean that the iron runs hotter. It does mean that there is more thermal mass in reserve for coping with larger joints. A higher wattage iron won't cool as quickly and can therefore handle solder joints with a larger thermal mass.

The most basic and least expensive soldering irons don't have any form of temperature regulation. However, they tend to stay fairly constant in temperature because when the heater temperature drops, its resistance also drops so it draws more current. They are adequate for many circuit board repairs and interwiring jobs. However, most of them cannot handle big jobs such as soldering #12 wire.

Temperature-controlled irons cost more and use some form of regulation that maintains the tip temperature within fixed limits (perhaps 40 °F). Some use a simple bimetallic sensor and others use a thermocouple and a feedback controller in a bench-top unit. These are often digitally controlled and are generally called *soldering stations*. The lower the fixed limit (perhaps 10 °F), the more expensive the soldering equipment. The advantage of a controlled temperature soldering station is that the temperature can be optimized for the job at hand. Given an experienced worker, this provides fast and high-quality work and minimizes heat damage to components and circuit boards. Generally, the temperature should be increased for joints with a larger thermal mass and decreased for joints with a smaller thermal mass. However, it must be emphasized that the thermal mass of the tip must be appropriate … large joints require large tips,

Whether a basic soldering iron or a digital soldering station, a grounded tip is recommended. This minimizes the possibility of damage from electrostatic discharge (ESD). Wrist straps and other ESD measures are also recommended. This topic is covered in the 8th edition of ELECTRONICS: PRINCIPLES AND APPLICATIONS by Charles A. Schuler and in the PowerPoint presentation that was mentioned before.

It's a good idea to have a selection of various soldering iron tips available with different diameters and shapes. Conical shapes lend themselves to work with small pads and devices such as integrated circuits. Chisel shapes lend themselves to work with larger pads and wires and also to interwiring soldering. However, it should be mentioned that some people simply prefer a certain shape (and even size) and have developed the skill required to use it effectively over a wide range of applications. Generally, larger tips are better for larger jobs and smaller tips are better for smaller jobs.

For field soldering, a gas-powered soldering iron that uses butane and a catalytic element might be viable. These are used mostly for occasional or quick repairs and are not often used at repair benches or in assembly areas.

Bench soldering irons should be placed in a heat-resistant holder. Soldering stations include the holder.

Soldering guns are based on a low-voltage transformer and quickly come up to temperature after the trigger switch is closed. They are not useful for printed circuit work but can be used to apply terminals to large wires and tasks of that nature. However, they are usually not appropriate in a production environment because of their low duty cycle (on time to off time) and their tendency to produce inferior joints.

Soldering iron tips

The best soldering iron tip is one that was recently cleaned and tinned. Beginners must understand the importance of a clean, freshly tinned tip. Not only is it necessary to produce good solder joints, frequent tinning extends tip life.

1. Iron coated tips are usually the best because they last longer and stay tinned longer.
2. Do not use anti-seize compounds (unless the tips are threaded). These compounds can introduce thermal resistance and make it difficult to obtain a good joint in 3 seconds or less.
3. If a tip does seize in its heater, use pliers to remove it *after* the tip has reached operating temperature.
4. Clean and re-tin the tip often to maintain a clean, shiny look.
5. If the tip deteriorates rapidly, the temperature might be too high or the solder/flux might be inferior.
6. When using small diameter wire solder, there might not be enough flux in the core to properly tin the tip. Use separate flux or larger diameter flux core solder.
7. If a tip becomes difficult to tin, apply just flux to the tip and then wipe the tip on a damp sponge. Attempt to tin the tip again. Repeat, if necessary.
8. If the tip still won't tin, try cleaning it with flux remover. If that doesn't work, emery cloth may be used to lightly wipe away oxidation while the tip is hot. The tip must then be *immediately* re-tinned to prevent further oxidation. Tips may also be cleaned using a soft steel brush along with an active flux. Again, *immediate* re-tinning of the tip is essential. Limit the use of emery cloth and steel brushes because they shorten tip life.
9. Don't wipe a tip and then turn the iron off. Solder helps prevent oxidation. Apply a liberal coating of solder immediately before turning the iron off.
10. Distilled water is recommended for dampening the cleaning sponge.

Other tools and accessories

A circuit board holder is a valuable accessory. A lighted magnifier is often required for fine pitch work. Brushes, tweezers, dental picks, swabs, an assortment of pliers, and an assortment of solvents and fluxes are also often needed.

The circuit board holder makes it easier to keep the assembly motion free until the joint becomes solid. Any motion during the freezing phase can destroy the integrity of a solder joint. Also, do not blow on solder joints to speed cooling. Do not apply a wet finger or a damp object. Rapid cooling will ruin the joint.

Solder joints can be tested with a dental pick to insure that they are mechanically solid. Angled, diagonal cutting pliers are used to clip off excess leads after soldering on a printed circuit board. Clipped leads fly! Eye protection is a must.

Interwiring sometimes requires that loops be formed after a wire passes through a terminal. Needle nose pliers work well. The loop makes the joint mechanically sound *before* it is soldered. This is especially important if there is any motion or vibration along the wire during the soldering process. Also, joints that are subject to mechanical stress should not rely on solder alone to maintain joint integrity.

When replacing devices with terminals, such as a potentiometer, it might be quicker and easier to cut the wires at the terminals of the defective part and then remove about ¼ inch of insulation before soldering the wires to the new part. It's often a matter of judgment.

Desoldering

Desoldering is usually a repair issue. The defective device must be desoldered before removal. Desoldering must be done in such a way that damage to circuit boards and other non-defective parts is avoided.

This section deals with the *removal of solder*, which is the usual definition of desoldering. It's also possible to use thermal tweezers or hot air to melt device joints for device removal. These techniques are covered later.

There are three major methods of desoldering: (1) desoldering braid, (2) vacuum pumps and (3) vacuum desoldering stations. Desoldering braid is the least expensive but sometimes works the best of the three (especially for printed circuits).

Desoldering braid is braided, fine copper wire that is coated with flux. It is "solder-hungry" and wicks up solder much as a paper towel absorbs a spill. It is easy to use. The braid is laid against the joint to be desoldered and then the soldering iron tip is applied to press the braid to the joint. When the braid becomes saturated with solder, it is moved along to a fresh section and the process repeated until no additional solder can be removed. The saturated section of braid is cut off with diagonal pliers and discarded.

Vacuum pumps are spring-loaded plungers in tubes that produce a partial vacuum when their plungers are released. They can be tricky to use and require some practice. The plunger is pressed in until it locks. The soldering iron tip is applied to the joint for about 2 seconds, the pump nozzle is applied to the joint and then the plunger's trigger is released. When the spring drives the plunger to the other end of the pump, a partial vacuum is created and the molten solder is sucked into the nozzle.

Vacuum pumps are tricky to use because it's often difficult to position both the soldering iron tip and the nozzle in such a way that effective solder removal results. Several attempts might be needed. It's sometimes necessary to add fresh flux and solder to a joint *before* it is desoldered. A fresh joint is easier to desolder and the additional solder can create a mass flow of molten material that results in less solder remaining at the site.

The most expensive desoldering tool is the vacuum desoldering station. These are easier to use than vacuum pumps because the heat is applied by the same nozzle that provides the vacuum. There is no tricky positioning problem. To use a station, the tip is applied to the joint for about 2 seconds and then a switch (often foot activated) turns on the vacuum. As with vacuum pumps, it might be necessary to add fresh solder and flux to the joint before desoldering.

Surface mount technology rework

The tool of choice for removing chip components (like resistors, capacitors, transistors, etc.) is thermal tweezers. These come with interchangeable tips. The advantage of tweezers is that they apply heat only where needed and they simultaneously heat both ends of the device. Other methods, such as soldering irons, can't accomplish this and often cause lifting of chip pads and damage to nearby solder joints. Thermal tweezers are available in both analog and digital temperature control versions. The digital versions are more expensive but often do a better job.

The usual method of using thermal tweezers is to first place a dot of no-clean solder paste to each of the joints before removal. The fresh solder will aid in heat transfer. Tweezers can also be used to remove small outline integrated circuits (SOICs). In this case, a bead of solder paste is applied to the joints before removal.

Time for removal varies with the circuit board. For example, a single layer board might require 1 second before the joints melt. The same component on an 8 layer board can take as long as 12 seconds. This is an example of the importance of operator knowledge and experience. There is a tendency for impatience and the use of excessive twisting force on the tweezers when things don't seem to be progressing as they should. Excess force can tear the pads from the circuit board.

The removal of many leaded devices such as quad flatpacks (QFPs) requires the use of hot air. A hand-held hot air delivery system is one possibility. A dental pick is positioned so as to apply some lifting force to the device. Then, hot air is delivered through an appropriate nozzle. Uniform heating is the key. Generally the nozzle must be moved around the device to accomplish this. Or, the nozzle must be shaped and sized such that it heats all of the leads at the same time from the same position. It's important to not heat surrounding devices and joints any more than can be helped.

Hot air rework stations are expensive but do the best job. They are perhaps the only viable way to replace fine pitch devices and ball grid array devices. They have interchangeable nozzles and confine the delivery of hot air to the device being removed. After selecting the correct nozzle and installing it, an appropriate temperature profile is entered into the controller. Next, a bead of no-clean flux paste is applied over all of the pins of the device to be removed. The circuit board is now mounted in the holder and the component is centered under the nozzle and should be about 1/8 inch below it. A foot switch activates the heat cycle and a digital display will register the temperature of the heated air as it ramps up. The vacuum is turned on and the pickup assembly is lowered to contact the device. After an appropriate time, the device will lift off of the circuit board. The heating cycle is now terminated and the time for reflow is recorded. This information is important for installation of the new device. Removal of a BGA device is a similar procedure but the area under the chip is flooded with wetting solution before removal.

After removal, the printed circuit pads must be prepared. For BGAs, the pads are cleaned with a soldering iron and desoldering braid. If the pads are rough or show any solder whiskers, they must be leveled with hot air. This is accomplished by coating them with wetting solution and then using the hot air rework station to heat them. Once the pads are all level and shiny, they are coated with no-clean flux paste. The replacement device is now placed on the circuit board. With BGAs, there are registration marks on the board and the device must be positioned as accurately as possible. The board is now placed in the holder and the device is aligned under the nozzle as it was for removal. Hot air is applied for a period equal to the removal time plus 30 seconds.

BGA devices can popcorn (pop apart) during the reflow soldering process. This happens because moisture enters the plastic package and then turns to steam. BGA devices should not be removed from their sealed carriers until it is time to install them. If they have been exposed, a baking process can be used to slowly and safely drive the moisture out.

For QFP replacement, the circuit board pads are lightly coated with flux and then leveled using hot air. The solder should appear smooth with a slightly rounded pillow shape. The board is now removed from the holder and the area is cleaned with the appropriate solvent. Paste flux is applied in a thin bead and then brushed to form an even coating. Too much flux can cause the device to float off position during reflow. The new device is placed in position and will be held by the flux. A hand magnifier and a probe are used to carefully nudge the device until all of the pins are accurately placed on the pads. The board is now placed in the holder and the device is aligned under the nozzle as it was for removal. The hot air is applied for a period equal to the removal time plus 20 seconds.

Wave soldering

Wave soldering is a manufacturing process. Liquid solder is pumped up through a nozzle. Gravity causes the solder to fall back down, creating a parabolic shaped wave. The printed circuit board, with the electronic components inserted, travels over the apex of the wave. As the wave of solder comes in contact with the bottom side of the board, the flux coated base metals alloy with the solder.

Wave soldering is easily automated with the use of a conveyor system to move the boards. Conveyor systems can move boards on flat pallets or by the use of finger conveyors. In either case, the conveyor system is constructed of a material that does not bond with solder. The conveyor moves the board into the fluxing area, from the fluxing area through a preheating process, and then over the solder wave.

Circuit boards, along with their parts, are preheated to raise the base metals to soldering temperature. This minimizes the amount of time that the solder fountain must be in contact with the board and provides superior solder joints. Heating the board up at a slow, steady rate minimizes the thermal shock to the board and its parts. Subjecting a room temperature circuit board to a wave of liquid solder can cause extensive warping and cracking.

Flux can be applied with a flux wave. A flux wave operates like a solder wave. The nozzle that the flux is pumped through contains a screen to minimize ripples as the flux is propelled upwards. Flux is applied as the board travels over the apex of the wave. An air knife is then used to blow off the excess flux as the board leaves the wave. Although this method is an effective way of applying flux, it requires continual cleaning and maintenance.

The flux can also be sprayed on using a compressed gas process similar that of paint sprayers. The amount of flux applied can be accurately controlled. However, most of the excess flux is not recoverable when a compressed gas sprayer is used.

The most common way of applying flux for wave soldering is foam fluxing. The flux is aerated with fine bubbles of compressed gasses, causing it to foam. The foam climbs up a channel and spills out at the top, creating a foam head. The printed circuit board moves across the top of the foam head, picking up some of the flux. An air knife removes the excess foam as the board exits.

Reflow soldering in manufacturing

Surface mount technology has led to the development of other soldering methods. While surface mount components can be wave soldered, they must first be attached to the circuit board with some type of adhesive in order to hold them in place during soldering. This introduces another step in the assembly process. Since the whole surface mount component is immersed in the wave, it must be constructed in such a manner to withstand the high temperature of the liquid solder. There is also a problem with gasses becoming trapped between the component and the board. Because of these difficulties with wave soldering, reflow soldering is the preferred method of soldering surface mount components.

In a reflow process, solder paste is put on the component sites of the printed circuit board and the components are put on the board on top of the solder paste. Sometimes, a separate adhesive is used to hold the device in place until soldering takes place. The board and components are then heated to activate the flux, elevate the temperature of the base metals, and melt (reflow) the solder.

There is more than one way to apply the solder paste to the circuit board. One way is to dispense it through the end of a tube. This is similar to the operation of a syringe. This method has several advantages over other methods. First, it uses a closed container of solder paste that eliminates solder contamination and delays deterioration. Second, the syringe can reach into odd places, which is of particular use in reflow soldering surface mount components onto a board after the through-hole components have already been soldered. Third, it's a relatively inexpensive process. One disadvantage is that it is very difficult to control the precise amount of solder paste that is applied to the board. A second disadvantage is that the paste application takes place one pad at a time, making this method relatively slow.

Screen printing is the more common way of placing the solder paste onto the circuit board. A screen stencil is placed above the board, and a squeegee is manually drawn over the stencil, forcing solder paste through the screen openings and onto the board. The amount of solder deposited can be accurately controlled with the density (mesh) of the screen and the shape of the squeegee. The alignment between the board and the screen is very important. If the either moves even slightly, or if the alignment is off, the solder paste will not be deposited in the right place.

The board and its components are uniformly heated to a predetermined temperature. They are held at this temperature to allow the solvents in the solder paste to evaporate. This is the same temperature that the flux becomes active, and begins to clean the base metals. After a sufficient time at this temperature, the temperature is raised above the melting point of the solder and is held for about thirty to sixty seconds. The board is then slowly cooled at a continuous rate. Cooling the board quickly results in strong solder bonds but rapid cooling introduces stresses into the board and warping can result.

Heating is accomplished with a convection process, or a radiation process, or a combination of the two. One type of convection heating is vapor phase heating. A liquid is boiled, causing some of it to vaporize and saturate the air within the vapor chamber. When the board is inserted into the chamber, the vapor condenses onto it. Energy is transferred from the vapor to the board during condensation, causing the board to heat up. This heats the board to the boiling point of the liquid. This is a very fast heating method and also provides a very uniform temperature increase. Another advantage of this method is that it is performed in a closed vapor chamber where no oxygen is present. With no oxygen, oxidation cannot occur. This permits the use of a mild flux in the solder paste. Sometimes the flux is so mild that cleaning is not required.

Radiation heating allows the assembly to be heated using electromagnetic waves. Either infrared or laser light is used. Radiation heating allows precise control of the amount and placement of the transferred energy. The disadvantage is the slow rate at which radiation heats up the board.

Glossary

Ag	silver
BGA	ball grid array
Bi	bismuth
Bumped	solder sphere contacts on a BGA or flip chip
BQFP	bumpered quad flat pack (corner bumpers)
CBGA	ceramic ball grid array
CCBGA	column ceramic ball grid array
Column	non eutectic solder CBGA connections
Cu	copper
DIP	dual inline package
ESD	electrostatic discharge
Eutectic	alloy of lowest possible solidification temperature
Flip Chip	die technology with bumped contacts
Flux	chemical agent to retard/remove oxidation during soldering
Gull wing	wing shaped SMT device leads
IC	integrated circuit
JLEAD	PLCC leads with J shape
LCC	leadless chip carrier
Pb	lead
PCB	printed circuit board
Pitch	center to center spacing of IC leads
PLCC	plastic leaded chip carrier
QFP	quad flat pack
Reflow	heating solder paste to its liquid state
Rework	the removal and replacement of electronic devices
Through-hole	device leads go through holes in the circuit board
Sb	antimony
SMT	surface mount technology
Sn	tin
SOIC	small outline integrated circuit
Solder	low melting point alloy used to join metals
SOP	small outline package
SOT	small outline transistor
Surface mount	devices soldered on component side of circuit board
Tin	apply a coat of solder to an iron, PCB pad, or a lead (also the metallic element)
TSOP	thin small outline package
Wet	alloy solder to a base metal (similar to *tin* or *tinning*)