# ***All About Soldering***

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## How to choose the best soldering iron

There are several soldering irons available, in a variety of sizes and shapes. The soldering iron you choose depends on the projects you are planning, as well as how often you plan on using it.

The four main factors to consider when deciding on a soldering iron are:

- Wattage
- Type of soldering iron
- Temperature control
- Tip size and shape

**Wattage**

One of the most important factors of a soldering iron is the wattage. Most soldering irons used in electronics are in the range of 20-60 watts. Currently a 50 watt soldering iron will provide a sufficient amount of heat for most circuit board soldering projects. The higher the wattage doesn't mean there is more heat applied to the solder joint, it means a higher watt soldering iron has more power available to keep it hot longer. Lower wattage (20-30 watt) can lose heat faster than it can re-heat, which results in bad solder joints.

**Types of soldering irons**

Generally, there are 4 different types of soldering irons:

- Soldering pencil
- Soldering station
- Soldering systems (rework/repair stations)
- Soldering guns

**Soldering Pencil**

Soldering pencils are a very simple and inexpensive soldering tool that work great for simple do-it-yourself projects. They usually cost in the range of $10-$30, however, they aren't recommend for fine soldering projects since they do not provide any control of the temperature on the iron tip. Too much heat applied during soldering can damage components and peel off tracks on the circuit board.

**Soldering Stations**

Soldering stations consist of a soldering pencil that is attached to a power station. The power station gives you the option of using the controls to set the desired temperature on the tip of the soldering iron. Some soldering stations come with an electronic temperature control, which allows you to precisely set and maintain the temperature. Soldering stations range in price from $40-$150. They can handle most of your soldering projects including soldering of through-hole components, and very fine surface-mount components as small as .0603 and .0805.

**Rework/repair systems**

Rework/repair systems are more complex soldering systems that are mostly used in industry or high-volume manufacturing facilities. These systems usually consist of several extensions, including soldering iron, hot-air gun, desoldering gun, thermo-tweezers and more. These soldering systems cost between $150-$2500. (Check out Ebay for "Chinese soldering stations", there are lots to chose from for well under $100)

**Soldering guns**

The main part of a soldering gun is a transformer that converts 110 V AC to a lower voltage. A secondary winding of the transformer has only one turn. This allows the secondary of transformer to produce a very low voltage and several amperes of current. The current is routed through the copper tip of the soldering gun which results in the tip being heated quickly. Soldering guns are not recommended for intricate work on circuit boards since they can generate too much heat and damage them. They usually cost between $20-$70.

1. Most soldering "guns" are vastly overpowered for electronics soldering and can easily overheat components or expose them to harmful voltages. However, some people cleverly use them to solder multiple leads on surface mount devices. Soldering "guns" are for plumbing and much heavier duty applications, and are usually over 100 Watts. The "guns" work by passing high currents through the tips, and these currents can generate voltages that damage electronic components. Also, magnetic fields from guns with transformers can damage some electronics.By forming the heating element in the shape of of the chip, a soldering gun can be used to heat many leads simultaneously.

**How much wattage do you need for a particular application and how does wattage relate to tip temperature?**

A loose analogy: Imagine a car tire has a leak, but you're trying to keep it inflated by pumping air into the tire at the same time it's escaping out the leak. The bigger the leak, the more air you have to pump into it to keep the pressure up. If the tire pressure represents tip temperature and the air lost through the leak represents heat lost through the tip, then wattage represents the maximum amount of air your pump could supply. Once more air escapes through the leak than your pump can replace, the tire pressure (or tip temperature) starts to drop.

If you had a very small leak and a huge pump (say a 100 Watt iron equivalent), you might be afraid that the pump would cause the tire to explode since so much more air is going in and so little going out. But if you have a nozzle to regulate the pump's air, you could only allow just the right amount of air in to replace what's lost through the leak. This is how "temperature controlled" soldering irons work. As long as you aren't losing more heat out of the tip than the iron can replace (up to its rated wattage), it will automatically regulate just the right amount of heat into the tip to maintain the same temperature.

However, typical plug-in irons have no such regulation. A 15 Watt iron always delivers 15 Watts of heat to the tip, and the tip temperature stops increasing only when 15 Watts of heat escape through the air. When the tip touches a part, its temperature drops, and if the part you're soldering can dissipate enough heat, the temperature will keep dropping until it won't melt solder any more. After the iron is pulled away from the joint, the temperature will climb again. There is some amount of natural regulation: as the tip gets hotter, it dissipates more heat, and as it gets cooler, it dissipates less.

Usually, the bigger the component the more heat it can absorb and dissipate, so the general rule is that you need more wattage for larger parts. If you're just soldering small resistors and ICs, 15 Watts will probably suffice, but you may have to wait a bit in between joints for the tip to recover. If you're soldering larger components, especially ones with heat sinks (like voltage regulators), or doing a lot of soldering, you'll probably want a 25 or 30 Watt iron. For soldering larger things like 10 gauge copper wire, motor casings, or large heat sinks, you may need upwards of a 50 Watt iron or more. The following video shows what happens to tip temperature as 15, 25, and 40 Watt irons solder various sizes of wires and components. For cheap irons, higher wattage does indeed mean higher temperatures!

1. **What Watts, What?** A short article about how much wattage is needed. From the article: "Power doesn't do it. Temperature control does. All you need is enough power to keep the tip hot. Anything more than that is a waste."

- What is the difference between cheap RadioShack® irons and more expensive ones like Wellers®? What do $100+ and $400+ soldering "stations" have over the cheaper kinds that plug straight into the wall? Among the irons that plug straight into a wall and don't have a separate station, the dirt cheap kinds will work satisfactorily for many applications. From personal experience, the tips on RadioShack® irons often come loose and sometimes can be impossible to remove. The irons can also get uncomfortably hot to hold after several hours of use. The more professional Weller (or other) lines are made for longer, continuous use and have insulation on the handles that keeps them cooler. They can also take a wider variety of tips.
  Soldering iron "stations" usually provide some control over the heat being supplied to the iron tip. Ones that are temperature controlled automatically control the amount of heat delivered to the tip so that it remains at a set temperature. In every iron, when the tip touches a component, some heat is lost and the temperature drops. One measure of quality is the time needed for the tip to regain its temperature. A nice feature of many soldering stations is that the tip heats up in seconds after you turn it on.
  Many stations also allow you to hot-swap the iron tip, which can be very helpful if you're alternating between surface mount joints and larger components.
- If standard tin-lead solder melts below 400 °F (and lead free below 500 °F), why do most soldering irons have tip temperatures between 600 and 800 °F? Just what is the right soldering temperature? The basic reason that tips are so much hotter than solder's melting point is because that difference helps to transfer heat faster to the joint. What is the "correct" temperature is a debatable topic, but a common rule of thumb is to start off at 600 °F and increase from there until acceptable results are achieved. Typical Kester (a solder manufacturer) recommend 600-700 °F for lead-based solder, and 700-800 °F for lead-free solder. "No-clean" or "low solids" fluxes will burn off before a joint can be made with higher temperatures, so low temperatures (below 700) may be essential for these fluxes. From Kester's hand-soldering. "When hand soldering with a rosin flux such as the Kester #44 or the # 285 the recommended iron tip temperature is 750°F. If you are soldering with a low residue no clean solder such as the #245 or # 275 we recommend a tip temperature of 600-650°F.
  What are acceptable results? The goal is to heat up the parts enough so that solder will

adhere to them and form a good bond. The higher the iron temperature, the faster it will heat up the parts, so why not set it extremely high to work faster?
Besides the obvious increased risk of overheating components and the board, higher temperatures cause the iron tip to oxidize faster and can significantly reduce its life. Some claim a 10 °C rise reduces tip life by half. For occasional use, though, tip life may not be much of a factor, especially if the tip is kept covered with solder at all times.

- Tip size and shape: a basic guide is to pick a tip that's slightly smaller than the pad you're soldering to. From there, you want a tip with a large thermal mass and short stroke (why?) In most soldering irons, the tip is not actually the heater, but sits in between your work and the heater. You can think of it like a heat bucket that empties into your work and gets filled again by the heater. Typically touching a component empties heat out of the tip much faster than the iron can replace it, and if you have a small bucket (tip), the temperature will quickly drop to an ineffective level.
  Especially if you have a small wattage iron (15 Watts or less), the temperature will drop before you can heat up a larger part, or you'll have to wait a bit in between joints for the tip temperature to recover. With a bigger bucket (tip), you can handle larger joints with smaller wattage, but eventually you'll need to step up the wattage.
  The "stroke", or length of the tip should be minimized to get the heater closer to the work; it takes some time for heat to transfer through the tip. This is balanced with the need to get into tight places where you need a longer tip.

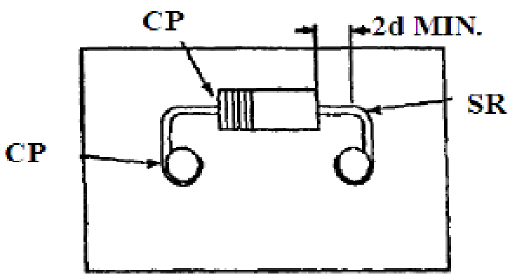
## Tips

Screwdriver, spade, and conical are some of the more common tip shapes. Personal preference is the biggest factor when choosing a tip, but the goal is to get as much surface area contact between the tip and work as possible. Chisel and spade tips have more surface area at their ends, and also "hold" solder at their tips more readily than conical tips, which have a tendency to draw solder away. Even for fine pitch surface mount soldering, having a small flat at the end can be helpful.

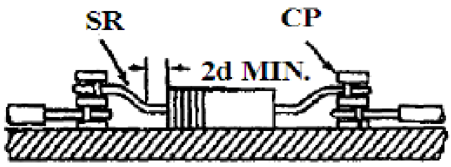
To preserve tip life, the number one thing you can do is reduce the tip temperature (if your iron allows this). After that, ALWAYS keep a layer of solder on the tip to prevent the tip itself from oxidizing, and clean it in between uses. Put a glob of solder whenever you put it back in the stand, and before you turn it off. When heating up a new tip for the first time, hold solder against it so the tip can be covered as soon as the iron gets hot enough.
The longer flux residues and oxides are left on the tip, the harder they are to clean off. They also can drastically reduce the tip's ability to heat up a part, and prevent solder from "wetting" the tip. Regular cleaning of the tip before use is one of the best ways to prolong tip life and make soldering easier. It's important that solder "wet" or cling to the surface of the iron--without solder in between the tip and work the tip's ability to heat is drastically reduced.

# <u>How to install components on pc boards</u>

SR = STRESS RELIEF BEND
CP = CONSTRAINT POINT

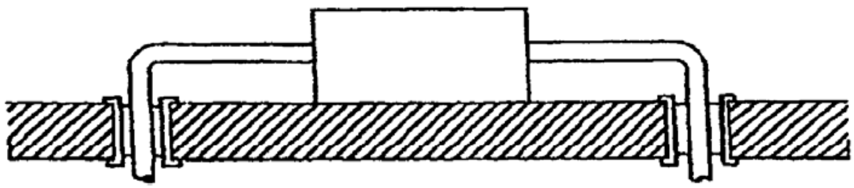


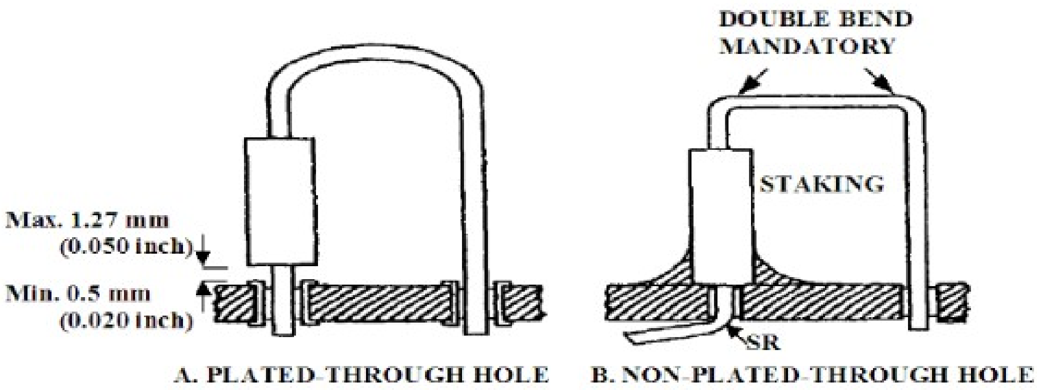

A. OFFSET MOUNTING

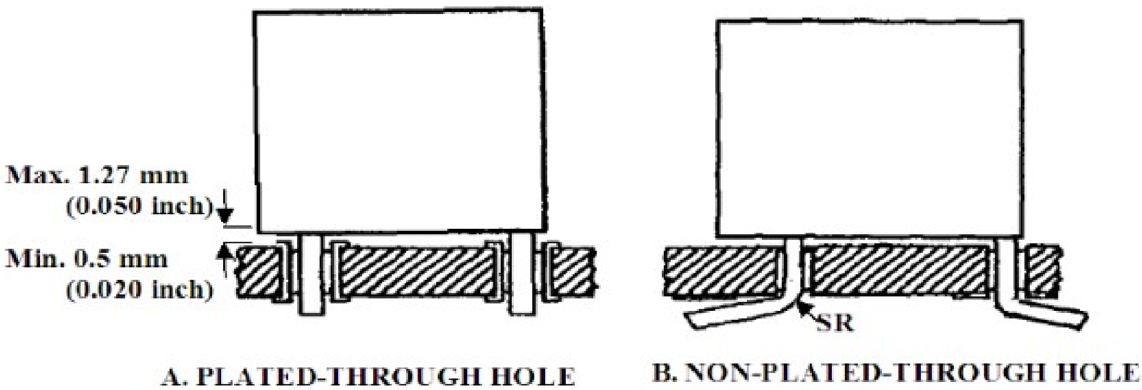


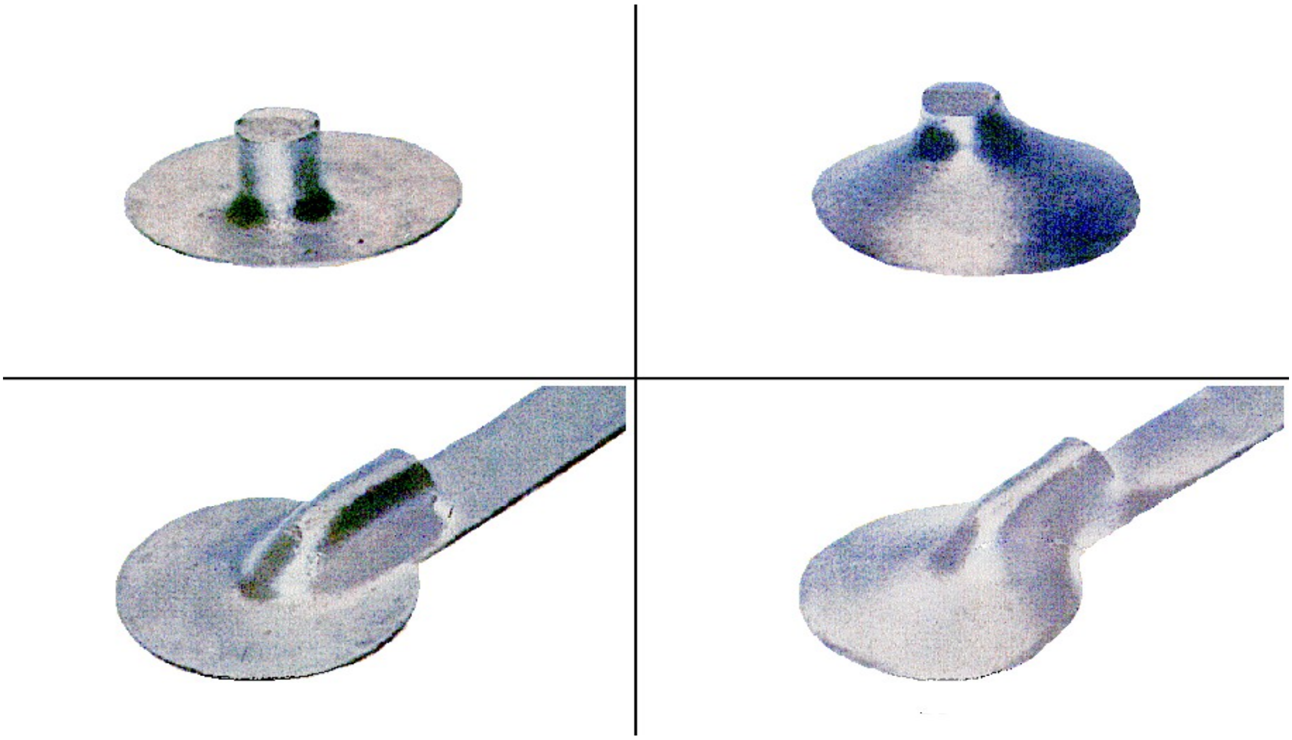

B. IN-LINE VERTICAL
(VERTICAL PLANE)

C. HORIZONTAL PLANE

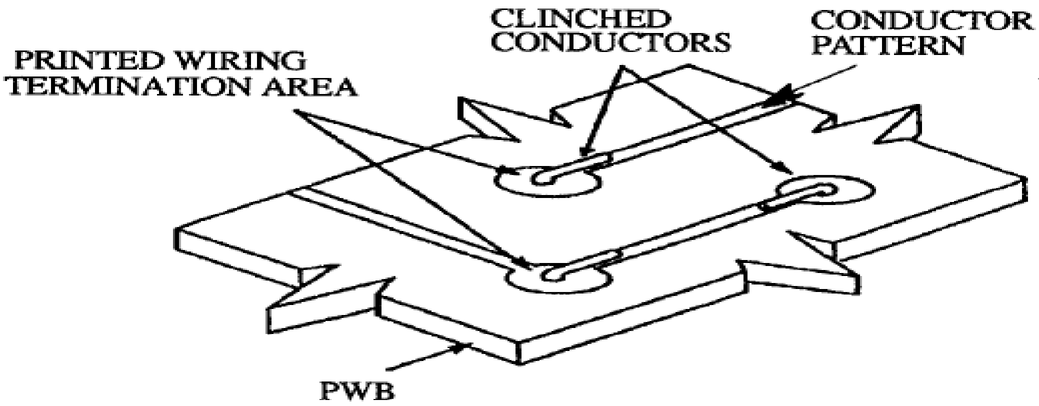



DOUBLE BEND
MANDATORY
STAKING
Max. 1.27 mm
(0.050 inch)
Min. 0.5 mm
(0.020 inch)
SR
A. PLATED-THROUGH HOLE
B. NON-PLATED-THROUGH HOLE


Max. 1.27 mm
(0.050 inch)
Min. 0.5 mm
(0.020 inch)
SR
A. PLATED-THROUGH HOLE
B. NON-PLATED-THROUGH HOLE



**Pictures of through-hole terminations showing minimum and maximum solder.**



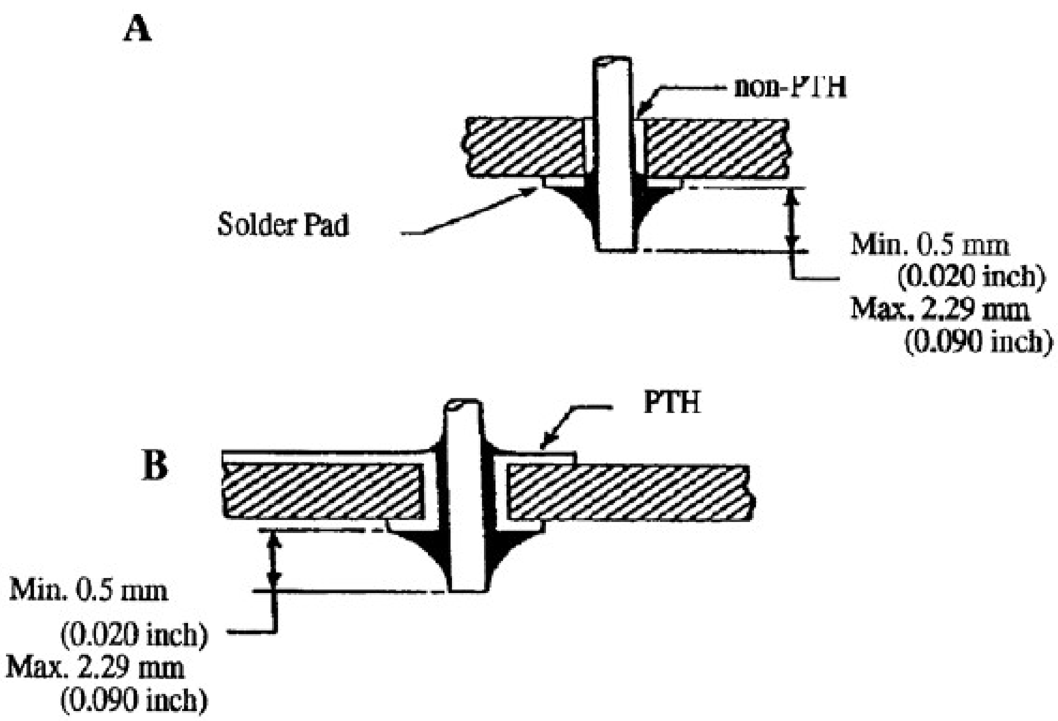
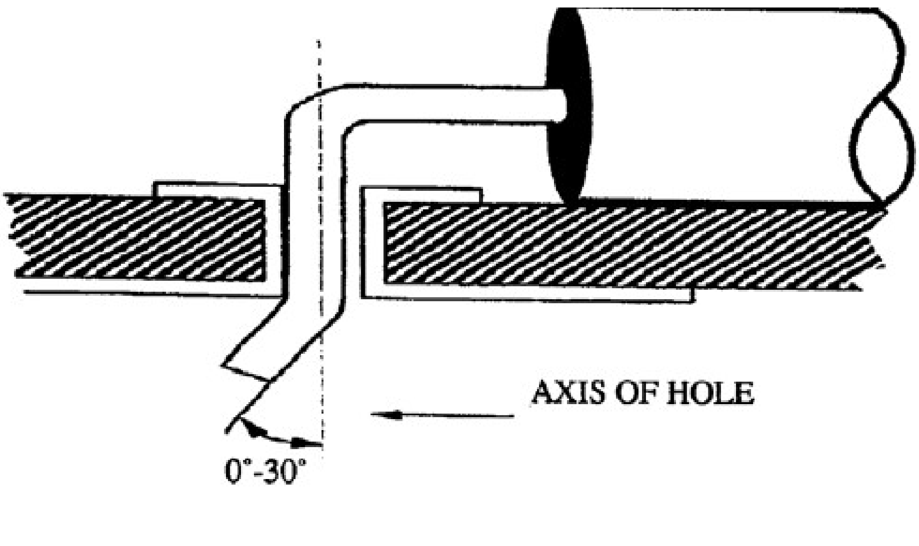



**Figure 8-18. Straight-Through Termination**



# SOLDERS

## What kind of solder (rosin cored, etc. lead-free)? What is flux and when is it necessary?

As a starting place, for most small electronics soldering, 1/32 inch (.03) rosin-cored, 60/40 (tin-lead) or 63/37 solder should work fine. Rosin-cored lead-free is fine, too. Unless you have reason otherwise, don't use "no-clean" solder--it's very likely that you don't need to clean the regular rosin-cored solder. The solder should be thin enough to prevent accidentally applying too much (and causing a solder bridge), but thick enough so that more doesn't have to be gathered from the coil too often.

### **Alloy:** 60/40, 63/37

- **Standard lead-based solder**is made of tin and lead. When you see 60/40 or 63/37, it means 60% tin by weight, 40% lead. Either once of these alloys should be fine for typical small electronics soldering. 63/37 in bulk is slightly more expensive because of additional tin, but has the special property of being a "eutectic" alloy, which transitions from liquid to solid at one temperature (like water) instead of range of temperatures. Basically, in non-eutectic alloys like 60/40, there is a "pasty" region of temperature where portions of the solder are frozen and other portions are liquid. What does this mean for soldering and is 63/37 really that much better?

  Alloy metals have some interesting properties that are different from the metals comprising them. In tin-lead solder, the mixture has a lower melting point than either lead or tin alone, and the melting point varies depending on the portions. The mixture that yields the lowest melting point is called eutectic. This is also the only mix where all the constituents melt and freeze at the same temperature.

  If the tin-lead alloy isn't eutectic (ie, if it is not 63% tin), it will go through a "pasty" phase while it freezes. Unlike water, which freezes entirely at 0 °C, some parts of a non-eutectic mixture of tin-lead freeze at higher temperatures than other parts. For a somewhat simplified explanation, if you held the temperature of 60/40 slightly above 361 °F, the "extra lead" would solidify and be floating in a liquid 63/37 eutectic mix.

**Lead-free Solder:** As of July 1st, 2006, European laws mandated that new electronics be almost entirely lead free. As of yet, there are no US laws (outside CA) mandating the removal of lead, but most manufacturers are switching over for competitive reasons. More on RoHS, WEEE, and lead risks:

The European Union passed directives in 2003 stating that no equipment sold in Europe should, by July 2006, have more than .1% lead in any homogenous component (like a solder joint). The directives are known as the WEEE (Waste Electrical and Electronic Equipment) and RoHS (Restriction of Hazardous Substances). There are corresponding laws in China, Korea, and California. Japan manufacturers actually voluntarily begin switching to lead free years before RoHS or WEEE for competitive reasons.

Although only .5% of lead used in the US gets embedded in electronics (verses 80% in batteries), there is concern that the lead from those electronics will leach into ground water supplies from landfills. Why the concern over solder joints when batteries contain so much more lead? For the most part, lead containing batteries are recycled and regulated, whereas electronics are routinely just thrown away. The EPA claims that 1% of municipal waste is electronics. Interestingly, according to this publication by IPC, no studies have found any evidence of lead getting into the ground water from landfills.

**Lead health risks:** Lead does not get absorbed through the skin, and is actually not present in solder fumes to any appreciable degree (fumes are still bad for you, see fumes section below). The greatest risk of hand soldering with lead comes from ingesting lead by eating or smoking without first washing. Health risks include increased blood pressure, fertility problems, nerve disorders, muscle and joint pain, irritability, and memory or concentration problems. The latest health data indicates that there is no amount of lead that will not be detrimental to health.

# Basic Tutorial on the Soldering

**http://www.youtube.com/watch?v=BxASFu19bLU**

# IPC Standards

**http://www.youtube.com/watch?v=v2FrnC_xNDc**

**Web sites with videos on how to select the best soldering station:**

**http://www.youtube.com/watch?v=EGo46KFXGV4**

# Video on more professional soldering, lesson 1, 2, 3 etc.

**http://www.youtube.com/watch?v=vIT4ra6Mo0s**

**http://www.youtube.com/watch?v=Mrhg5A1a1mU**