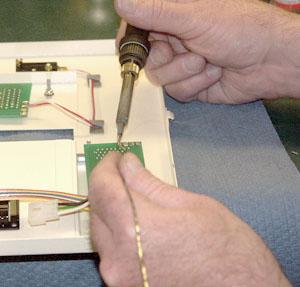
# Soldering Applications

## Objectives

* Describe hand soldering.
* Describe the role of the soldering technician.
* List the basic steps of hand soldering.
* List basic joint types.
* Explain how to choose a solder.
* Explain how to choose a flux.
* Explain how to choose a soldering iron.
* Explain how to choose a soldering iron tip.
* Explain how to prepare the soldering work area.
* Explain how to clean soldering materials.
* Explain the importance of tinning a soldering iron tip.
* Explain how to tin a soldering iron.
* Explain how to solder a joint.
* Explain how to solder a Western Union joint.
* Differentiate between a good joint and a bad joint.
* Explain how to desolder and resolder a joint.
* Explain how to clean up after soldering.

## Hand Soldering

|  |  |
| --- | --- |
| |  | | --- | | Although a number of products are made with sophisticated automated soldering equipment, technicians benefit from learning how to properly hand solder. **Hand soldering** is simply manual soldering with a soldering iron, as shown in Figure 1. It is typically used for small production runs, laboratory assembly work, space applications, rework and repair, or to add extra components to a machine soldered assembly, like the circuit board in Figure 2.  The advantage of hand soldering is that it allows the **soldering technician** a high degree of control over the process. The technician can monitor **joint** formation in real time and make immediate adjustments. However, whether you are connecting electrical wires or assembling a computer circuit board, quality hand soldering requires a level of skill that comes from training and experience.   In this class, you will learn how to choose soldering materials, operate and care for your soldering iron and tip, clean and solder a joint, inspect your work, and rework or repair a bad joint. | |



## The Role of the Soldering Technician

|  |  |
| --- | --- |
| |  | | --- | | As a **soldering technician**, you have a great deal of impact on the quality of the products you solder. It is up to you to use the right tools and materials and learn how to care for them. You have to set up your work area properly and learn basic safety procedures. Most importantly, you control every step of the soldering process. Like the technician in Figure 1, you must carefully monitor various factors while soldering the joint. From time to time, you may have to adjust:   * The temperature of your iron. * The amount of pressure you place on a joint. * The speed at which you are soldering.   You will also have to inspect the finished joints and correct any defects. Ultimately, your knowledge, skill, and consistency will be the key factors in doing high quality hand soldering. | |

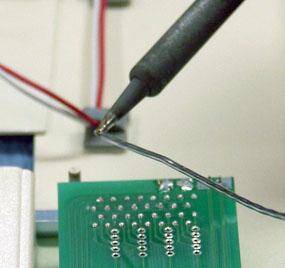
## The Basic Steps of Hand Soldering

While there are a variety of joints that you can create through manual soldering, the basic steps are the same for any joint:

* Select and prepare your soldering tools.
* Prepare your work area and materials.
* Tin your soldering iron (Figure 1).
* Solder the joint.
* Inspect the finished joint.
* Clean your work area.

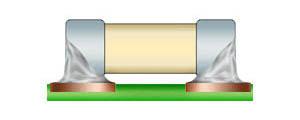
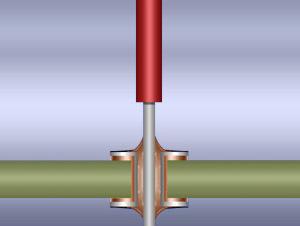
You should always follow these basic safety precautions as well:

* Never touch the tip of a hot soldering iron.
* Never leave a hot iron unattended.
* Never breathe in flux fumes.
* Always wear safety glasses.
* Always return the iron to its stand when not in use (Figure 2).
* Always wash your hands after using solder.

If you are burned by hot solder or a soldering iron, run cold water over the burn for at least 5 minutes, as shown in Figure 3. This prevents further damage to your skin after the initial burn. 

## Joint Types

## In **electronics fabrication**, two types of **joints** are used. The first is a **through-hole** joint. As you can see in Figure 1, a **component** with protruding wires is placed on top of a **PCB**. The wires are inserted through holes in the PCB and soldered into joints underneath. The second type of joint is a **surface mount**. Figure 2 illustrates this joint type. An **SMD** or surface mount device is a tiny component that is used to create powerful circuits on PCBs. Some SMDs have protruding **leads**, which are soldered to pads on top of the PCB. The number of leads can vary from 2-3 leads to 50 or even 60. However, not all SMDs have leads. Some types simply lie flat on top of the PCB. In **electrical work**, there are several methods of joining wires together. The decision to use a **pigtail wrap**, **fixture splice**, **tap splice**, or **Western Union splice** depends on how strong the joint needs to be, and whether it will be stressed by movement or kept immobile. However, of these four joints, the Western Union joint shown in Figure 3 is the most common.



## Choosing a Solder

|  |  |
| --- | --- |
| |  | | --- | | When choosing a solder, there are many variables for you to consider. First, you must decide which **alloy** to use. For most electrical connections, **60/40 SnPb** is the most common. Figure 1 shows a spool of 60/40 SnPb **solder wire**. However, despite its reliability, melted 60/40 SnPb solder goes through a **plastic phase**, in which the solder has a pasty consistency. During this time, the joint must be kept absolutely still or defects will occur.  Because 60/40 SnPb melts unevenly, **63/37 SnPb** solder is becoming the preferred alloy for hand soldering electrical connections. It goes directly from liquid to solid and therefore is easier to work with and less prone to defects.  Another aspect to consider in choosing solder is the **diameter** of your solder wire. For soldering most types of electrical connections, a diameter of 0.031 in. to 0.040 in. is recommended, but you can go larger or smaller than that depending on your preference. Just keep in mind that thinner wire is easier to manipulate, but thicker wire applies more solder, making the job go faster. | |

## Choosing a Flux

|  |  |
| --- | --- |
| |  | | --- | | **Flux** is an important part of soldering. It cleans the area to be soldered, enhances conduction of heat from the iron tip to the joint, and ensures that the solder flows evenly.   For electrical connections, you will typically use solder wire with a flux core. As you can see from the illustration in Figure 1, **flux-cored solder** is filled with flux at the center. It can be **single core** (1 flux channel) as shown in Figure 1, or **three core** (3 flux channels) as shown in Figure 2. The percentage of flux within the solder can be normal, medium, or low. The flux you choose should be rosin-based, type **R** or **RMA**. In general, rosin-based fluxes are milder than other types of fluxes. Figure 3 shows the different categories of flux. Never use an **acid flux**, **corrosive flux**, or **conductive flux** for electrical work, as it will damage electrical parts.   Some fluxes are sticky and may leave behind a **residue**. Therefore, you may need a **flux cleaner** as well. There are many commercial flux cleaners available, although **isopropyl alcohol** is usually adequate.  http://www.toolingu.com/multi_media/images/660_72.jpghttp://www.toolingu.com/multi_media/images/660_10.gif | |
|  |
|  |

## Choosing a Soldering Iron

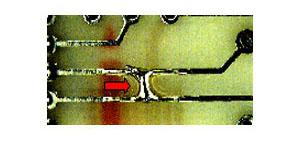
|  |  |
| --- | --- |
| |  | | --- | | Soldering irons come in three varieties: wands, guns, and torches. For electrical work, you will use a **soldering wand**. A soldering wand resembles a large pen. They can be powered by battery (Figure 1), gas, wall outlet (Figure 2), or **soldering station** (Figure 3).  Soldering stations are most often the best choice, as they usually have adjustable **wattage** and a digital display that lets you monitor and control the temperature of your soldering iron. Some stations offer features like fast start, thermal recovery, sleep mode, auto-off, or static protection, and come with accessories such as iron stands and fume extractors.   If you do not have an adjustable soldering iron, the iron you use should be 15 watts to 30 watts, although you may go up to 50 watts for larger components. The wattage range of the soldering iron does not indicate how hot the iron can get, but rather how much heat can be stored in the tip and transferred to the joint before the tip cools.  Generally speaking, higher wattage soldering irons are better for soldering multiple joints, as they retain heat better. When choosing a soldering iron, look for one that is lightweight, comfortable to hold, heats up quickly, and has good heat recovery. | |



## Choosing a Tip for Your Iron

When you select a soldering iron **tip**, it should be similar in size and shape to the part you are soldering, as demonstrated in Figure 1. Soldering iron tips come in chisel shapes and cone shapes and are available in many different sizes. Figure 2 illustrates some common soldering iron tip shapes.  
  
Different tip shapes provide a range of properties. Thick, short tips store heat better and provide more efficient heat transfer than long, pointed tips. However, longer and thinner tips allow you to do more delicate work and offer better versatility. Be careful not to choose a tip that is too big, as it may touch more than one joint and cause solder **bridging**, as shown in Figure 3. By creating an unintended connection between two joints, solder bridging can cause an electrical short circuit.   
  
If the tip you are using is not brand new, make sure that it is clean. It should be bright silver, with no residue or black spots.





## Preparing Your Work Area

Once you have selected the proper tools and materials for your soldering project, the next step is preparing your work area. Set up a work bench or table in a spot with good ventilation and lighting, like the work table shown in Figure 1. You may also need a clamp to hold the object you are soldering.   
  
Make sure you have a soldering iron stand and tip cleaner on your work table. Figure 2 shows a highly effective type of tip cleaner that comes in coiled wire form. You can clean your iron tip by simply plunging it into the wire. However, if you do not have access to a commercial tip cleaner, a wet sponge will suffice. The sponge should be clean and swell back to its normal size when you press down on it. Place the sponge in a sponge dock, or in a small, clean dish, and keep it soaked in **distilled water**. Avoid tap water if possible, as it contains **minerals** that may contaminate your soldering iron tip. Make sure that neither the sponge nor the sponge holder is made from plastic, as the heat from your soldering iron will cause it to melt.   
  
Another good practice is to check your soldering iron to make sure that the tip is securely mounted. A loose tip will prevent heat transfer and result in a bad joint.



## Cleaning Your Materials

If you are attaching an **integrated circuit** or electronic **component** onto a circuit board, you should clean the area to be soldered with a flux pen or some isopropyl alcohol. Figure 1 shows a technician using a **flux pen**. On the other hand, if you are soldering two wires, remove about one inch of insulation from each end with a wire stripper, and clean the ends of the wires.  
  
Clean the tip of your soldering iron by wiping it with a cotton swab, **emery cloth**, coiled wire, or commercial **solder cleaning paste**. Figures 2 and 3 show examples of coiled wire and paste used for tip cleaning. Never file or scrape your iron tip, as this will remove the protective plating and cause the tip to corrode. Make sure that no debris is left on the tip. A dirty tip will contaminate the solder and create an unreliable joint.





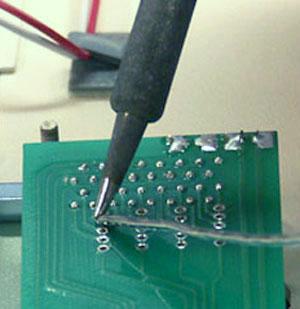
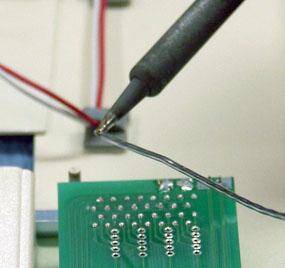
## The Importance of Tinning

Before you begin soldering, plug in or turn on your iron and wait a few seconds or a few minutes for it to heat up, depending on the iron. Ideally, the iron should reach a temperature of about 700°F to 750°F. Once the iron is hot, you are ready to begin tinning.  
  
**Tinning** involves coating the tip of your soldering iron with a thin layer of solder, as shown in Figure 1. Tinning accomplishes two things. First, it forms a protective coating on your iron tip that keeps it from **oxidizing** like the tip shown in Figure 2. Second, it provides a buffer that rapidly and efficiently transfers heat from the soldering iron tip to the joint.   
  
Some iron tips are pre-tinned by the manufacturer before you ever use them. However, you should still tin the tip of your iron before any soldering job. In addition, you should always leave some solder on the iron tip when you are not using it or when you have finished soldering. This extends the tip life by protecting against oxidation and preventing **corrosion**.



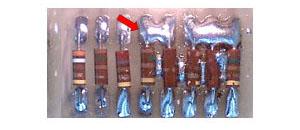
## Tinning the Tip of Your Iron

To tin your iron tip, let the iron heat up first. Unwind a few inches of wire from your **solder spool**, cut a few millimeters off the end and discard that piece. Then lightly touch the end of wire to the hot iron tip while rotating the iron to cover the entire tip surface. Figure 1 shows this tinning process. If you are soldering two electrical wires together, tin the ends of the wires as well.  
  
A well-tinned tip should have a chrome-like appearance, like the tip shown in Figure 2. The surface should be flat and shiny, not dripping with a blob of solder. Make sure that the soldering iron tip does not turn black. A blackened tip means your iron is too hot, and the flux has activated too quickly. If this happens, lower the temperature of your soldering iron, clean the tip, and try again.



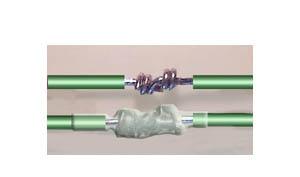
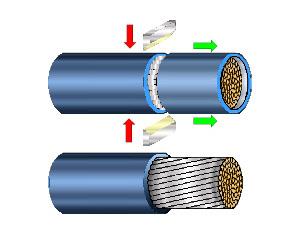
## Applying Solder to the Joint

Once you have tinned your soldering iron, touch or wipe the tip on a wet sponge to remove any impurities. Then, hold the soldering iron in your dominant hand and touch it to the joint. At the same time, use your other hand to touch the end of the solder wire to the joint at a 45° angle. The iron tip and solder wire should be right next to each other, with the joint sandwiched in between, as shown in Figure 1.  
  
When manually soldering, note that the iron does not directly contact the solder. Heat from the iron is transferred to the joint, which in turn melts the solder. You will see a thin puff of smoke rise up from the joint as the flux is activated. Do NOT breathe in these fumes. They are poisonous.  
  
The heated joint will cause solder to melt almost immediately and flow around the joint. The solder should liquefy easily and completely after a few seconds. If the solder melts slowly, you may want to raise the temperature of your iron, or give the iron a few more minutes to warm up. If the solder burns like the soldered joint in Figure 2, turn your iron off, wait about 20 seconds, then turn it on again.  
  
Be careful not to apply too much solder, which is shown in Figure 3. This is a mistake often made by beginners. You should use just enough solder to cover the joint. Once solder has completely surrounded the joint, remove your iron and let the joint cool.



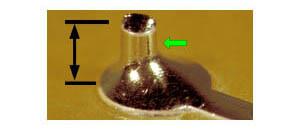
## Creating a Western Union Joint

Western Union joints form extremely secure and reliable connections. Figure 1 shows this joint type. To create a Western Union joint, you must first **splice** the two wires that are to be soldered. Using a wire stripper, remove one to two inches of insulation from the end of each wire, as shown in Figure 2. Cross the bare ends of wire together to form an "X," so that they create a 90° angle in the middle. Twist the wire ends tightly together with your fingers until they are completely flat, with no ends sticking up.   
  
After twisting the wires, tin your soldering iron and apply solder to the joint as you normally would. Draw melted solder along the entire connection, but be careful not to use too much solder. Once the joint has cooled, inspect it. Your joint should appear smooth and sleek. Protect the finished joint by wrapping it in **electrical tape** or a **heat shrink**, like the bottom wire in Figure 3.



## Inspecting the Joint

|  |  |
| --- | --- |
| |  | | --- | | After your soldered joint has cooled, you should inspect it. A **good joint** should be shiny, smooth, and evenly covered, like the one shown in Figure 1. You may see some flux residue. This residue will appear as a brown or clear layer surrounding the joint, as you can see in Figure 2. If there is any flux residue, you may need to clean it, depending on the flux type. Some fluxes do not require cleaning.   If the joint appears dull or lumpy or is not completely covered in solder, it is considered a **bad joint**. Typically, bad joints are caused by a cool iron, poor contact between the iron tip and part, or poor solder **wetting**. Figure 3 shows an example of poor wetting. You may have to experiment with raising your iron temperature, adjusting the contact time of the iron or the angle of the solder, or you may need to use a more active flux. | |



## How to Desolder and Resolder a Joint

|  |  |
| --- | --- |
| |  | | --- | | Sometimes a soldered component or wire must be repaired. In such cases, you must **desolder** the joint by reheating it with a soldering iron and removing the melted solder with either a pump or a braid, which are shown in Figures 1 and 2.  To use a **desoldering pump**, wait until the solder melts, and then activate the plunger on your pump to suck the solder into the pump’s reservoir. To use a **desoldering braid**, lay the braid across the joint while applying gentle pressure with your soldering iron tip to melt and absorb the solder. If the braid stops absorbing, switch to an unused portion of the braid. Always make sure to choose a braid that matches the width of the joint. If you wish, you may combine both desoldering methods by using the pump to remove large amounts of solder, then using the braid to remove any remaining solder.  You also have the option of using a **desoldering iron**, which is a hybrid of a soldering iron and desoldering pump. Figure 3 shows desoldering irons. These tools heat the joint and allow you to suction the liquid solder into the iron’s hollow tip. Once you have removed all the old solder, create a new joint as you normally would.  http://www.toolingu.com/multi_media/images/660_54.jpghttp://www.toolingu.com/multi_media/images/660_53.jpghttp://www.toolingu.com/multi_media/images/660_76.jpg | |

## Cleaning Up

|  |  |
| --- | --- |
| |  | | --- | | When you have finished soldering, you should clean your work area and properly store your tools. Before turning off the soldering iron, remember to coat the tip with a little blob of solder. This will protect the tip from corrosion and make it last longer.  Unplug any electrical equipment and tightly close any open containers. Remove any solder scraps or spills with a moistened cloth or paper towel and isopropyl or **ethyl alcohol**. As you can see in Figure 1, if you must clean the floor, use a damp mop instead of dry sweeping.  Throw out any used solder braid or contaminated cleaning rags in designated waste containers. Remember that lead-based solder is toxic, so you should wash your hands thoroughly after you leave your work area (Figure 2). If possible, change out of your work clothes and put on fresh, clean clothes to prevent contaminating your home with lead. | |

## Summary

Hand soldering is manual soldering with a soldering iron. With training and experience, a soldering technician can exercise a high degree of control over the soldering process and make a positive impact on the finished product.   
  
As a skilled soldering technician, you should have some ability to choose the proper solder and flux for your work. 60/40 SnPb solder is the most common, but 63/37 SnPb is preferred for many applications because it melts directly into a liquid. For any electrical work, you should use only R or RMA flux.  
  
For professional soldering, an adjustable soldering iron is recommended. The soldering iron tip you use should be clean, and it should match the size and shape of the joint. Before you begin soldering, you should always tin your soldering iron. Solder the joint by holding the iron in one hand and the solder spool in the other, touching both to the joint until liquid solder flows. When the joint cools, it should be smooth and shiny. If the joint is defective, you can easily repair it by desoldering and resoldering.