ARC WELDING BASICS

In its most basic form, a welder is a device that melts two pieces of metal together using high amperage delivered at the end of an "electrode" (rod) into the work. Although the technology that makes this process happen is technical enough to fill hundreds of pages, I will deliver it to you in simple terms, the same way I learned it in the beginning. Like all new skills, practice will make you proficient, and welding is a skill that anyone can learn. If you have ever had the misfortune to see an electrical short, either from bad wiring, or some type of electrical equipment failure, you will have remembered the zapping sound, puff of smoke and burnt metal that usually follows. This is basically what a welder does, but in a controlled and expected manner.

The welder places a ground clamp onto one of the pieces of metal to be joined, then feeds a conductive electrode (rod) into the area or gap between the two pieces to be welded. Because the ground clamp and electrode are the two ends of a complete circuit carrying voltage and high amperage, a dead short happens at the end of the electrode, creating intense heat, melting both the electrode and surrounding area into a single fused piece.

This type of welding is called "arc welding." The rod is not actually touching the work (parts to be welded) during the welding process. It is held a small distance from the work so that a very hot arc (electrical spark) can form. This arc produces the heat to melt the metals together as shown in the photo above.

If the rod is pushed directly onto the work, a "dead short" occurs, and there won't be any heat to weld the metals since no arc will form. This is a common problem when you are learning to arc weld, known
as "sticking". Sticking occurs when the rod is pushed too hard into the joint to be welded, and causes the rod to stick to the work.

An arc welding rod is a thin metal rod coated in a material called "flux." This material is melted as the rod burns away, giving off a gas that protects the newly welded area from the effects of extreme heat and oxidization. The flux also helps to keep the arc perform smoothly, reducing sticking. If the rods were not coated in flux, the newly welded area would be damaged by the effects of oxidization, and would be prone to failure or fast deterioration. Some welders to not use flux-coated rod, but instead feed compressed gas into the weld area during the welding process. These types of welders are called "wire feed welders", but we will be only focusing on the basic arc welder here because it is the most basic type of welder to operate and the most affordable for most beginners.

Although welders fuse metals together using incredible amounts of amperage, it is almost impossible to be electrocuted by an arc welding machine. The reason is that inside a welder is a large transformer, a device that steps down the dangerous voltage in trade for higher "amperage." Amperage, the strength of a current of electricity, can seriously harm or kill, but only if a certain voltage is also present. A car battery can emit more than a hundred amps, which is much more than can be delivered from a standard wall outlet.

But, you can touch both terminals and not feel any electricity. How is this possible? Simply. Because there is not sufficient voltage to deliver the amperage to your body. Of course, don’t drop a metal object across a charged car battery’s terminals or you will have a smoke show you will never forget!

Using an arc welder requires a little practice and patience, but is far easier to learn than any other form of welding. The hardware can be purchased from most retail outlets for a few hundred dollars or less.
Anyone can learn to make a clean and strong weld with only a few nights of practice. There are a few different types of arc welders available, and it helps to understand some basic concepts before you buy.

An arc welder is easily identifiable among other welders because it looks like a box with a few knobs on the front, as shown in the photo. There will be no compressed gas cylinders, no spools of wire on top, no foot pedals or any other fancy options needed to make it work.

An arc welder may also be called a "stick welder," "rod welder," or "buzz box," depending on who you ask. When inquiring about an arc welder, you will usually be asked what level of "input voltage" and "amperage range" you want. Input voltage refers to the type of outlet you plan on plugging it into, either a standard 120V wall outlet or a 240V outlet (similar to your household dryer outlet). The amperage range refers to the welder's output power (in amps), and for the type of metal you will be welding, 100 amps would be more than enough.

The 120V (standard wall outlet) type of welders are the most inexpensive types, and will have enough power to weld almost any thickness of steel that would be used in bicycle construction. Another advantage of this type of welder besides the cost is its size. These welders are no bigger than a large microwave oven, and can be moved around by one person easily. The disadvantage of these welders is the output power. Although an arc welder is fine for bicycle frame building, it wouldn't be powerful enough for projects with larger steel components, such as a boat trailer frames or motorcycles.

A 240V welder is a commonly used arc welder, and it is quite a bit larger with an amperage rating of at least 200 amps. This type of welder requires a special plug that is easy to install as long, but your building must have 240V wiring. They range in size from 2' to 4' tall or more. These welders cannot be easily moved around unless on wheels, and they weigh 100 lbs or more. The advantage of this type of welder is of course, power.

At 250 amps, you could weld steel plate thick enough to build a ship's hull. The 240V welder is the best unit to buy, as long as you have a place to put it and the proper electrical outlet to plug it into. This type of welder will produce a smoother weld, and will have enough power for any job you may want to do.

Another question you may be asked when purchasing a new arc welder is the output type — AC (alternating current) DC (direct current). AC is the type of current that comes from your wall outlet, whereas DC is the type of current that comes from batteries. Welders that output DC are usually more professional and also more expensive. A dedicated welder will usually prefer DC for most work because it can produce a smoother weld and use a larger assortment of different rods for specialty work.

An AC welder is the most basic type of arc welder, and for the hobbyist, all that is usually required. I have used both types of welders (AC and DC), but choose a basic AC 240V type for my shop, and this has been just fine for building just about anything. Although a DC welder can produce a slightly nicer final weld, a moderately skilled welder will be able to produce a much better weld on a simple AC machine than an unskilled welder could produce on an AC, DC or wire feed welder.
If you are new to all of this welding terminology, make your purchase at a welding supply house. The equipment is only marginally more expensive, but the quality of a brand name welder, combined with the advice of a knowledgeable salesperson is worth the extra cost.

A welder is a tool that will last for a long time, so choose the one that is suitable for your purposes. Besides a welder, you will need to purchase a few other small items before you can make the sparks fly. You will need some protective gear consisting of a welding helmet, welding gloves and safety glasses, as shown in the photo.

Although some welders sold in larger retail stores may include a welding helmet, it's a good idea to get some advice on the type of lens you will need for your work. Lenses come in different shades and are denoted by a number.

The higher the number, the darker the shade. All welding lenses protect your eyes from the damaging rays emitted from the welding arc such as ultra-violet. As your power level setting determines the intensity of the arc, darker shades will be needed as intensity increases. What does this mean to you?

Well, nothing if you don’t know much about setting the power level on your welder yet! To weld the light tubing that makes up most bicycle frames, amperage settings between 50 and 80 are commonly used, depending on your skill, and brand of welder. Therefore, a lens shade of 10 would be fine. Shade darkness is not set in stone, and a beginner may want to choose a shade 9 rather than a 10 just because it will be easier to see the work. Of course a shade 9 would be way too light if you had your amperage set at 500, and would feel like you were staring at the sun!

Welding gloves are heavy heat retardant gloves that cover a large area of your forearm, and this helps keep those hot sparks off your sleeves and out of the gloves. Although bicycle frame welding requires only requires a low power setting, there will still be sufficient heat produced to easily burn a standard pair of work gloves.
The hot sparks flying from the welding rod can find their way into areas such as your sleeves, open collars, and pockets, so at least having gloves that cover your work shirt sleeves can help reduce those painful experiences. A good pair of clear safety glasses or face shield will also be necessary.

After a weld is completed, there is a thin layer of hardened flux from the rod coating the top of the weld area. This flux is removed with a "chipping" hammer, and this process sends hot flakes of flux in all directions, so you must protect your eyes. Some welding helmets allow the dark shade lens to be lifted up, and have a clear glass shield behind the dark lens. This type of helmet will do the job of safety glasses during the chipping of a weld.

The last thing you will need is welding rods — a lot of them! If you are just starting out, you may want to buy a big box of rods, so you can practice making things stick together. It's a better deal to buy rods in bulk from a welding supply store, rather than in the small pack you will find on a department store shelf. Welding rods come in as many flavors as candy, and an entire chapter could be written on choosing the correct rod.

To keep things simple, we will use "6013" rod because it is fairly generic and sold in stores that also carry welding equipment. 6013 is a basic and inexpensive rod used by beginners or for general work. Most of the tubing you will be welding will be in the area of 1/16" thick, so a 3/32" 6013 welding rod will be fine. The outside of the box will have the rod type and size on a small label.

Welding is a skill learned by practice. No amount of theory or information will make you into a good welder, only hands-on experience. I will present you with just the basic information needed to make a good weld, but you must put in the time, and learn it yourself. If you want to become a professional, there are many good courses offered at colleges or night school. You will not only learn how to arc weld, but also how to use a cutting torch and all of the welder theory you will ever need.
Before you start welding bicycle tubing together, it’s a good idea to practice on thicker steel because the thinner the tubing, the harder it is to make a good weld without burning through. A few pieces of scrap 1/8” plate or angle iron will make a good surface to test your welder with. Put a welding rod into the handle, set your welder’s amperage dial to around 80 or so, then place the ground clamp onto the part you will be welding.

The hardest part of learning to weld is getting an arc going without having the welding rod stick to the metal. False starts and "sticking" is going to be the most frustrating part of the learning experience, and will take some time to get past. Even a seasoned welder will have a few false starts every once in awhile, and you will certainly have your share in the beginning.

When the rod sticks, it will basically weld to your work area and require you to bend it back and forth in order to free it from the material as fast as you can to avoid melting the entire rod. Doing this usually breaks away the flux coating, making it even more difficult to restart the weld, so be prepared to curse a little while you are just starting out! Imagine that the rod is a stick match, and that you will be striking it along the work to light it.

Hold the handle at a 45-degree angle with the electrode trailing your hand, as shown in Figure 6, then quickly strike the tip of the electrode along the metal using wrist action so an arc can form. If you push too hard, or your welder’s amperage dial is set to low, the electrode tip will stick to the metal, and your will have to pry it back and forth to free it. Welders call this a “false start”. A brand new welding rod will be easier to start an arc with than a used rod as well due to the way the flux is filed away at the end of a new rod.
Once the rod has been used to weld a few inches, the flux will harden around the end of the rod, requiring you to strike with a bit more initial force than with a new rod. You almost have to peck at the work with a used rod at times, so keep this in mind while practicing the starting and stopping motions. If you had to pry the electrode back and forth, the protective flux may have come off the end of the rod, exposing the bare rod.

It is very hard to get a bare rod to form a good arc, so you may want to cut the bare end off or get a new rod. Once you are more experienced, starting a bare rod will be possible, but for now, don’t make things harder than they need to be.

If you managed to get an arc started without much difficulty, you will notice that there is a range of about one inch that you can move the rod away from the work and still maintain the arc. Try to keep the rod as close to the work as possible without pushing it onto the surface, as this may cause a stick. With the rod held at a 45-degree angle, and a good close arc going, drag the tip along the metal for about five seconds traveling about one inch in a straight line. If all went well, you will have a "bead" of weld that looks like the one in the photo.

Don’t forget to chip away the top layer of flux coating with a chipping hammer after you are done welding so you inspect your work. The weld on the left is a nice clean bead of weld with good penetration into the metal, but the weld the right is lumpy and rough, a sure sign that either you had the electrode tip too far from the metal, or the amperage setting is too low.

Experiment with the amperage setting on your welder as you practice drawing beads of weld on your scrap metal. When the amperage is too low, you will get a lot of sticking and false starts. Also, the flux
will seem harder to chip from the weld. When the amperage is too high, you will burn a hole into the metal after a few seconds. A good amperage setting allows you to weld continuously along the top of your metal without burning a hole or sticking to the work. Adjusting your amperage setting controls the amount of heat that is put into the work, and this is what makes a good welder. All the theory in the world won’t teach you to instinctively control your heat, only a lot of practice.

Keep laying beads of weld from along the top of your work in a smooth straight line from one end to the other, and then start a new line along the last one, until you have created a raised surface on your practice piece. Have you noticed that the more you weld, the hotter the metal gets? Don’t touch it to find out, just trust me here!

Once you are able to weld the thin bicycle tubing together, you will have to make frequent starts and stops in order to stop from burning a hole through the steel, this is because the tubing is so thin that it gets red hot in just a few seconds. Keep practicing on your heavier metal until you can lay down rows of beads, as shown in the photo. Don’t get discouraged if it takes a while to get good at striking an arc. The hardest part is learning to set your amperage properly and getting that arc going without sticking. This may take you all day.

Once you are able to strike up an arc and lay some weld for an inch or two, it’s time to move on and actually try to make two pieces stick together. Find two flat pieces of metal of equal thickness, and clamp them together so there is a gap in between each piece about equal to the thickness of a welding rod.
Ensure that the ground clamp is connected either to one of the plates or to the clamp, or you will be striking all day with no arc starting. Also, don’t weld too close to your clamp — you may hit it with the electrode or weld the work to it. Strike an arc anywhere on the work, and then bring the electrode into the joint between the plates, laying a slow, steady bead as you hold the electrode at a 45 degree angle from the work.

Keep your eye on the arc as you move along the joint, and watch if it is connecting to both plates. You may need to manipulate the welding rods back and forth slightly to get the arc to travel to both plates if it seems to favor only one side. Don’t travel too fast along the joint, or the final weld will be lacking sufficient filler metal from the rod.

If you travel too slowly, a large crater will form between the plates similar to the many holes you burnt through the metal as you were practicing laying beads. When you are done welding the entire length of the joint, remove the work, and chip the flux. You may also want to use a wire brush to clean the weld and surrounding area to get a better look at it.

The weld on the left is clean and solid, with adequate metal filling the joint. The weld on the right is lumpy, and full of gaps where the arc stayed to only one side of the joint due to lack of heat or improper electrode angle. Keep trying this exercise until you can make a smooth and solid weld between the two plates without gaps or holes. Remember, the key to making a good weld is to learn to control your heat by setting the amperage, and dragging the electrode at the appropriate speed. Are you running out of welding rods yet?

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If you have learned to strike an arc and weld two plates together, then it’s time to take the final step, and join some thin walled bicycle tubing together. This exercise will require some patience and practice to get it right. Not only is round tubing the hardest joint to weld, it is also very thin, and this only adds to the complexity. Once you have mastered this next step, you will be a fairly good welder, but don’t expect to get it right on your first attempt, or even on the first day.

Find a length of 1” thin walled round tube without rust or paint covering it. A length of electrical conduit would be perfect, but any clean steel tube will do. Using a pipe cutter, or grinder disk, cut the tube into several two or three inch lengths. Don’t be too critical about measuring each cut, as you will only be using the metal for practice welding here.

Take two sections of tube, and grind the end of one of them, so they will fit together, as shown in the photo. Again, don’t be too critical about making a perfect fit with the two pieces, as this will not always be possible, and a good welder can fill in the odd small gap. Remember to set up your ground clamp on either on one of the tube sections before you try to strike up.

When you have a small bead of weld joining the two sections, flip the work over and do the same thing on the top of the other side. Now the two pieces can be welded all around. Each time, only weld a small
section no longer than half an inch, or you will burn through the tubing wall. Also, don’t attempt to weld in any other position than from the top just yet, as this is something that takes a lot of skill to do properly. When you weld a small length then stop, it is a good idea to chip the flux, so you can begin your new bead of weld slightly over top of where you last left off to avoid leaving a small hole in between the start and stop.

Keep turning the work around, welding small lengths at a time until you have made a complete joint, as shown in the photo. Don’t worry about the appearance of the bead at this point. Try to avoid burning holes and leaving voids where you start and stop. Remember to hold your electrode so that it is at an equal angle between the two sections of tubing, not favoring one side or the other, or you will end up with weld only one side of the joint. Remember, this is the hardest weld you will ever have to make, so take your time and practice until you get it right.

If you practice these basic exercises, you will learn to make a clean and strong weld.

Once you start welding your projects for real, it’s a good idea to get into the habit of grinding finished welds. Not only does this make for a professional-looking job, but it reveals areas that may need to be filled due to inadequate weld metal in the joint. Take a look at the two welds in this photo. Although both are equally as strong, the weld on the left is rough looking due to many starts and stops and holes that needed to be filled. The one on the right was done very smoothly on the first attempt.
Looking at the two welds in the next photo, can you tell them apart? A weld does not have to be pretty to be strong, and once cleaned up with a grinder, even the roughest-looking weld looks good. When grinding a weld, avoid taking too much off the material off or you will weaken the joint. A ground weld should be flush or slightly higher than the material around it. If you accidentally take too much off, add more weld to the joint.

If you would like to explore welding beyond the very basics I have covered here, check with your local college about the courses available. A welding course will teach you many other aspects of welding such as "all position" welding, welding specialized metals such as chromoly, cast iron and aluminum, TIG welding, MIG welding to name a few.

With patience and practice you will learn to make a good weld, even if you know very little about the technology and terminology, so get at it, and burn some rod! See you in the Builders Forum.
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