orion

Safety Guide & Pulse Arc Welding Workbook

Read this guide to learn how to use your Orion welder safely and effectively.

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sunstone™

The Micro Welder Experts

LIMITATION OF LIABILITY

REVISION	DATE	VERSION NO.	DESCRIPTION OF CHANGES
1	08/2020	20200724	Production release.

Table of Contents

READ THIS GUIDE BEFORE WELDING

- The following safety notifications are generalized for all types of welding and are not inclusive. All operators should exercise reasonable caution while using this device.
- Read the owner's manual before using this welder.
- Only personnel trained and certified by the manufacturer should service the unit.
- Use only genuine replacement parts from the manufacturer.

IMPORTANT NOTICES

- The weld output is rated at an ambient temperature of 20°C and the welding time may be reduced at higher temperatures.
- Sunstone and Orion welding systems should not be used to thaw pipes. The welding power source should not be used in this manner.

SAFETY PRECAUTIONS FOR FIRE OR EXPLOSION

- A welding arc will create sparks. The flying sparks, hot workpiece, and hot equipment can cause fires and burns. Ensure your work area is clean and safe for welding. Do not weld where flying sparks can strike flammable material.
- Do not install or operate unit near combustible surfaces or near flammables.
- Do not overload your building's electrical wiring. Be sure the power distribution system is properly sized, rated, and protected to handle this unit.
- Remove all flammable materials from the welding area. If this is not possible, tightly cover them with approved covers.
- Protect yourself and others from flying sparks and hot metal.
- Watch for fire and keep a fire extinguisher nearby.
- Do not weld amid flammable dust, gas, or liquid vapors.
- Remove combustibles, such as butane lighters or matches, from your person before doing any welding.
- Do not exceed the equipment's rated capacity.
- Use only correct fuses or circuit breakers. Do not oversize or bypass them.

SAFETY PRECAUTIONS FOR ELECTRICAL SHOCK

Sunstone's Orion line of pulse arc micro welders are equipped with universal power supplies and can be used with 110- and 220-volt AC wall power. No voltage selection is required prior to powering the welder. The welder will detect the voltage and make the appropriate adjustments automatically. Touching live electrical parts can cause fatal shocks or severe burns.

The input power circuit and the internal circuits of the welder are live when the power switch is turned on. Additionally, the internal capacitors remain charged for a period of time after the welder is turned off and/or power is disconnected. Incorrectly installed or improperly grounded equipment is a hazard. Do not operate welder in a wet or damp environment.

- All welds are performed at low voltage for increased safety.
- Remove personal jewelry before welding (i.e. rings, watches, bracelets, etc.).
- Do not touch live electrical parts.
- Wear dry, hole-free insulating gloves and body protection.
- Properly install and ground this equipment according to this manual and national, state, and local codes.
- Do not weld with wet hands or wet clothing.
- Always verify the supply ground. Be sure the input power cord ground wire is properly connected to a ground terminal in the disconnect box or that the input power cord plug is connected to a properly grounded receptacle outlet. Do not remove or bypass the ground prong.
- Keep cords dry, free of oil and grease, and protected from hot metal and sparks.
- Frequently inspect the power cord and ground conductor for damage or bare wiring. Replace immediately if damaged. Check ground conductor for continuity.
- Turn off all equipment when not in use.
- Use only well-maintained equipment and repair or replace damaged parts at once.

PERSONAL PROTECTIVE EQUIPMENT RECOMMENDATIONS

Every person in the immediate work area must wear/utilize proper Personal Protection Equipment. Sparks often fly from the weld joint area Take precautions to avoid trapping a spark within your own clothing. Arc welding produces infrared and UV rays that can burn the retinal tissues within the eyes and cause burns to exposed skin, similar to a sun burn.

- The stereo microscope provides proper eye protection when pulse arc welding. No additional protection is necessary.
- Wear protective clothing, e.g., oil-free, flame-resistant leather gloves, heavy shirt, cuff-less trousers, high shoes, and a cap. Avoid synthetic fibers as they melt easily.
- Use an approved face shield or safety goggles with side shields when tack welding or when observing others performing pulse arc and tack welds.
- Use a sunscreen of SPF 30 or high if welding for extended periods of time.
- Use ear protection and button shirt collar. Wear complete body protection.
- Use the included weld shutter system.

SAFETY PRECAUTIONS FOR HOT METAL AND CABLES

- Welding material with high thermal conductivity will cause metal to heat rapidly.
- Be aware that repetitive welds in the same location can cause metal to become hot.
- Avoid touching weld spots immediately after the weld as they will be hot. Do not touch hot weld areas barehanded.
- Allow sufficient cooling time before handling welded pieces.
- Be aware of weld cables as they can become extremely hot after extended use.

SAFETY PRECAUTIONS FOR FUMES AND GASES

Welding produces fumes and gases that can be hazardous to your health. Sunstone welders produce minimal fumes and gases when compared to large-scale arc welders. Though not required, some form of ventilation is recommended.

- Do not breathe fumes.
- Use forced ventilation at the arc to remove welding fumes and gases.
- If ventilation is poor, wear an approved air-supplied respirator.
- Read and understand the Material Safety Data Sheets (MSDS) and the manufacturer's instructions for metals, consumables, coatings, cleaners, and degreasers.
- Welding in confined spaces requires good ventilation or an air-supplied respirator. Always have a trained watch person nearby. Welding fumes and gases can displace air and lower the oxygen level causing injury or death. Be sure the breathing air is safe.
- Do not weld in locations near degreasing, cleaning, or spraying operations. The heat and rays of the arc can react with vapors to form highly toxic and irritating gases.
- Do not weld on coated metals, such as galvanized, lead, or cadmium plated steel unless the coating is removed from the weld area, the area is well ventilated, and while wearing an air-supplied respirator. The coatings and any metals containing these elements can give off toxic fumes if welded.

SAFETY PRECAUTIONS FOR FALLING EQUIPMENT

- Use a working surface of adequate physical strength to support the welding unit during operation or storage.
- Secure welding unit during transport so that it cannot tip or fall.

SAFETY PRECAUTIONS FOR HIGH FREQUENCY PITCH AND VOLUME

- Welding with high frequency pulse agitation can produce loud, high-pitched sounds. It is recommended to use hearing protection when welding with agitation turned on.

MAGNETIC FIELDS CAN AFFECT IMPLANTED MEDICAL DEVICES

- Persons with pacemakers and other implanted medical devices should keep away.
- Persons with Implanted medical device should consult their doctor and the device manufacturer before going near arc welding, spot welding, gouging, plasma arc cutting, or induction heating operations.
- Never coil weld cables around your body.
- Route all welding cables together.

OVERUSE CAN CAUSE OVERHEATING

- Provide for a cooling period between strenuous welding schedules and follow rated duty cycle.
- If overheating occurs often, reduce duty cycle before starting to weld again.

OBSERVE ALL NECESSARY PRECAUTIONS ASSOCIATED WITH COMPRESSED GASES

- Use only compressed gas cylinders containing the correct shielding gas for the process used.
- Always keep cylinders in an upright position and secured to a fixed support.
- Cylinders should be located away from areas where they may be struck or subjected to physical damage and a safe distance from arc welding or cutting operations and any other source of heat, sparks, or flame.

CE TESTED AND CERTIFIED

Sunstone welders are tested for electrostatic discharge immunity up to 2kV for CE compliance.

Principal Safety Standards

- Safety in Welding, Cutting, and Allied Processes, ANSI Standard Z49.1,from Global Engineering Documents (phone: 1-877-413-5184, website:www.global.ihs.com).
- OSHA, Occupational Safety and Health Standards for General Industry, Title 29, Code of Federal Regulations (CFR), Part 1910, Subpart Q, and Part 1926, Subpart J, from U.S. Government Printing Office, Superintendent of Documents, P.O. Box 371954, Pittsburgh, PA 5250-7954 (phone: 1-866-512-1800) (there are 10 Regional Offices—phone for Region 5, Chicago, is 312-353-2220, website: www.osha.gov).
- National Electrical Code, NFPA Standard 70, from National Fire Protection Association, P.O. Box 9101, Quincy, MA 02269-9101 (phone: 617-770-3000, website: www.nfpa.org and www.sparky.org).
- Canadian Electrical Code Part 1, CSA Standard C22.1, from Canadian Standards Association, Standards Sales, 5060 Mississauga, Ontario,
- Canada L4W 5NS (phone: 800-463-6727 or in Toronto 416-747-4044, website: www.csa-international.org).
- Safe Practice For Occupational And Educational Eye And Face Protection, ANSI Standard Z87.1, from American National Standards Institute, 25 West 43rd Street, New York, NY 10036–8002 (phone: 212-642-4900, website: www.ansi.org).

Note: Sunstone's welder may or may not meet all of the standards proposed by the organizations listed above. Consult with your Sunstone sales representative if you have any questions.

Chapter 1: Pulse Arc Welding

Welding Basics

The Orion is a pulse arc welder and a capacitive discharge resistance welder in one. This combination of abilities allows for infinite creative possibilities. In its Resistance Welder Mode (Tack) the Orion can be used to temporarily position parts before welding or soldering. By increasing the energy output in Tack Mode it can also be used as a permanent fusion welder (resistance welder, spot welder). In its Pulse Arc Mode (Arc), the Orion can be used to perform permanent welds, add metal, and do a variety of other time-saving metal fusing applications.

WHAT IS A PULSE ARC WELDER?

A pulse arc welder is a specialized type of a Tungsten Inert Gas (TIG) welder. In TIG welding, a sharpened tungsten electrode is used in combination with electrical energy to start and sustain a high temperature plasma stream, or an arc. This plasma arc is used as a heat source to melt the workpiece metal. Filler metal can also be added to build up joints and create strong and reliable weld "beads", or weld seams.

TIG welders can use AC (alternating current) or DC (direct current) energy to initiate the pulse arc weld. The Orion uses industrial capacitive discharge technology to produce the pulse arc weld. Because AC wall voltage can vary up to 20% during the day, capacitive welders have the advantage over AC technologies of precisely storing energy before the welding process. Subsequently, your Orion welder will produce a repeatable weld independent of AC power fluctuations.

PULSE ARC WELDING FUNDAMENTALS

Pulse arc welding uses electrical energy to create a plasma discharge. The high temperature plasma in turn melts metal in a small spot. This process requires only milliseconds to complete. The process is clean, controllable, and perfect for intricate and minute welding applications.

Figure 7.1. The pulse arc welding process is a three-step process: 1. Using the electrode, the operator touches the surface of the workpiece; 2. The welder releases Argon gas; and 3. The welder retracts the electrode slightly while releasing energy to create the weld.

The Orion's welding process:

1. The user touches the electrode to the surface with very light pressure. See Figure 7.1 above.
2. The Orion releases argon as a shielding gas.
3. The Orion retracts the electrode and sends a burst of electrical energy, forming a plasma arc. Note that the weld is only made after the electrode lifts from the workpiece surface. Therefore, it is important to use very light pressure.

Remember that the weld is created only when the electrode lifts from the workpiece surface. This means that using too much pressure will prevent a weld from taking place and will also damage your electrode.

The penetration of your weld spot depends on many different factors. However, as a rule of thumb you can expect the penetration of the weld spot to be approximately ¼ of the diameter of the weld spot. Factors like electrode shape and condition also effect the weld penetration and will be discussed in more detail later.

PULSE ARC VS. LASER

Laser welding and pulse arc welding technologies are designed to create high quality welds in precious and non-precious metals. Laser welding uses collimated or focused light to add energy to the metal and melt it at a single location. See Figure 7.2. Pulse Arc welding uses electricity (specifically electrons) to add energy to the workpiece and melt the metal in a spot. Although laser welding devices are good welding tools, the Orion can

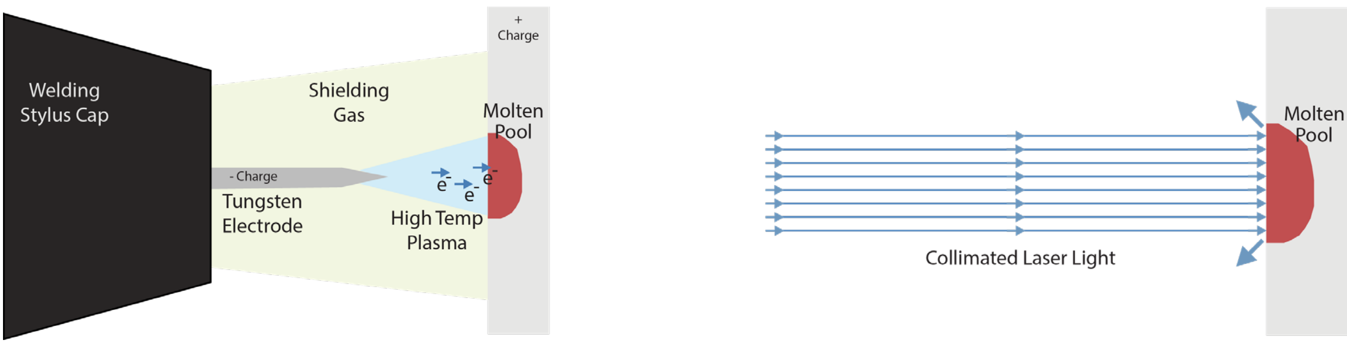


Figure 7.2. Pulse arc (left) and laser (right) welding differences.

perform many of the same functions of a laser and in some cases can even perform actions that lasers cannot. For example, welding silver is difficult for laser light because of silver's highly reflective properties. However, the Orion does not have this limitation because electrons are electrically attracted to the surface of silver. The Orion also has the advantage of only welding on metal. Lasers can strike precious stones or other nonmetals and can even crack or evaporate the target. Because the Orion is electrically driven it requires a conductor, such as a metal, to allow the welding process to take place.

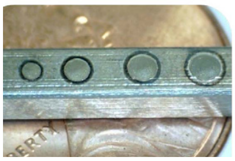
The Orion welder uses the same high temperature plasma that can be found on the surface of the sun. The sun creates this plasma via internal fusion reactions and the plasma temperature measures about 5,500 ºC at the sun's surface. The Orion creates it's plasma via electrical discharge and can generate temperatures of 5,500 – 8,000 ºC in very controlled, small bursts.

Start Welding

To become an expert and to really learn how to maximize the capabilities of the Orion, we recommend that you dedicate time for real hands-on experience. We recommend you read and complete the following sections while you are in front of the welder. Your Orion is easy to use and you will be making quality welds within minutes. The purpose of this section is to help you to better understand some of the fundamental welding principles, to utilize all of the functions of your Orion, and to adapt this knowledge to specific applications.

As you can see from this example, Orion welding machines offer a lot of energy. Higher energies are perfect for larger/thicker pieces, deeper weld penetration and for welding highly conductive metals like silver.

Hands On: Try welding on a flat plate with 30, 50, 75, 100, and 150 Ws of energy. Stay at max length, and make sure you have a sharp welding electrode. You should see results similar to the image at left. (Orion 150s was used here.)



Lower energy settings allow for welds on small parts and delicate features. Having both power and precision allows users to have maximum versatility. Selecting the proper weld setting is a matter of user preference and application necessity.

Hands On: Try welding at 3, 10, 25 Ws of energy. Stay at max length, and make sure you have a sharp welding electrode. You should see results similar to the image at left. (An Orion 150s was used here.)

WELD ENERGY VS. WELD LENGTH (OR TIME)

What happens if the length (time/duration) of the weld is adjusted? As can be seen in the figures below, the weld time controls the size of the pulse to a smaller extent than the energy. It also controls the smoothness of the weld puddle. Because the smoothness of the weld spot is also related to the internal stress of the weld joint, a smoother weld will have less stress. **It is recommended that the user keep the weld length at the max time for most applications.** See Figure 9.1: The top image was welded at 25 Ws with 3, 7, 11, and 15ms weld length. The bottom image was welded at 75 Ws with 20, 40, and 60ms weld length.

The two weld parameters (energy and length) can be understood with the following analogies. Consider your Orion welder to be like a water tower. See Figure 9.2. The amount of water in the tower is like the energy stored in the welder. Firing the welder is like opening a large valve to let water out. The length parameter in the welder can be thought of as how long the valve is left open. You can discharge a very small amount of water by only having the valve open a short time, or you can allow all of the water out of the tower by leaving the valve open for a longer period of time.

The actual weld puddle can be understood better using the following analogy. Think of the metal surface as a pool of water in its frozen state. Your welder's arc discharge impacts the "water" causing it to melt. The arc discharge also causes the now liquid "water" to ripple similar to when a stone has been thrown into a body of tranquil water, as illustrated in Figure 9.3. If the arc energy is removed quickly the "water" freezes instantly and the ripples remain frozen into the water's surface. If the arc heat is removed slowly, the ripples have a chance to dissipate and go away completely before the water's surface refreezes. This is why short weld length causes the weld spot to look rippled. Keeping the weld length at its max will leave the weld looking smooth and clean.

Using a more technical description, during the welding process the weld spot becomes a liquid pool of metal. The impact of the welding plasma causes vibrations on the molten pool's surface, much like a stone causes ripples on the surface of a still body of water. When in the arc screen, your Orion gives you the freedom to ramp down the weld energy at the length you desire. We recommend that when you are starting out that you keep the length at its max time for most welding applications. This gives the molten metal vibrations time to smooth out before the metal re-solidifies. After you feel comfortable welding, we suggest you experiment with different length settings.

In addition, a longer weld length will also help prevent cracking in some metals as the extended time and longer discharge curve allows the molten pool to cool slower. When the energy is cut off suddenly (by shortening the time setting) the liquid metal "freezes" in place. This rapid freezing can cause micro stresses in the weld spot and may make the metal more prone to cracks under additional stress such as hammering.

In most cases it is recommended to leave the weld length at max time with one important exception. If welding a very small part at less than 5 Ws of energy, it is very helpful to turn down the length. By turning down the length the arc will still ignite easily but the energy that the welder discharges during the weld is limited by the shorter amount of time.

Figure 9.1. The weld time controls the size of the pulse to a smaller extent than the energy. The top image was welded at 25 Ws with 3, 7, 11, 15ms weld length. The bottom image was welded at 75 Ws with 20, 40, 60ms weld length.

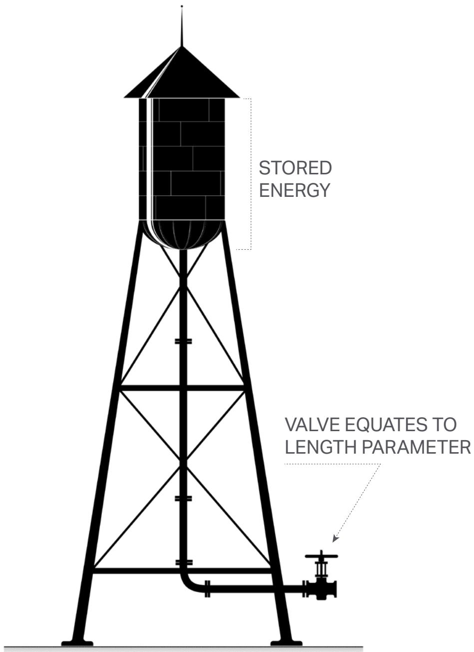


Figure 9.2. The amount of energy in your welder is akin to the amount of water in a tower. The valve represents the length parameter. You can discharge a very small amount of water by only having the valve open a short time, or you can allow all of the water out of the tower by leaving the valve open for a longer period of time.

Figure 9.3. A weld creates ripples, just like water.

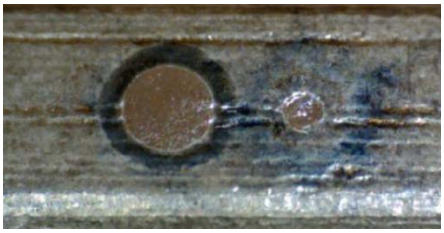


Figure 10.2. The impact of weld length can be seen here. Both welds used the same amount of energy but for different durations, the left at 15ms and the right at 3ms.

To illustrate the impact of weld length, consider that the larger weld in Figure 10.1 was done at 5 Ws for energy and 15ms for length. The smaller weld on the right was done at 5 Ws and 3ms. for length.

Alternatively, you can sharpen the welding tip to a very fine point to help ignite the welding arc at very low energy levels.

Hands On: Try making a small weld spot using 5 Ws of energy and maximum length, and then 5 Ws of energy and minimum length. Now, with a very sharp electrode, try making a weld spot at 1-3 Ws of energy and maximum length. You will see different results with each method. Take note of the results in order to help you when you begin work on your own applications.

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Chapter 2: Resistance Welding (Tack Mode)

This section applies to Orion welders that have the Tack welding feature. If you do not have the Tack feature this is still good welding knowledge to have.

What is Resistance Welding (Tack Welding)?

Resistance welding, often called tack welding, occurs when a large electrical current is passed through two workpieces to join them together. At the contact point between the two materials there is a resistance to the flow of the electrical current. As electrical current is passed through this contact point, resistive heating takes place. When enough current passes through the workpieces, the temperature (especially at the interface between the two pieces) can become hot enough to melt the metal in a spot. The terms “resistance welder” and “spot welder” are descriptive of this process.

If you limit the amount of energy and electrical current going into the weld you can create a temporary or weak weld called a “tack” weld. It provides the ability to temporarily position a part before permanent welding. This ability opens a multitude of creative possibilities. It also helps eliminate the need for complicated binding or clamping of parts before permanent welding or soldering. Tacking is especially useful in jewelry and orthodontic applications.

Because the heart of the Orion is an industrial capacitive resistance welder, everything from one-time custom pieces to production welding is possible.

As shown in Figure 11.1, a typical weld configuration requires a positive and negative electrode with pressure applied to the workpiece parts. As we zoom in on a cross sectional view of the workpiece parts, we can identify

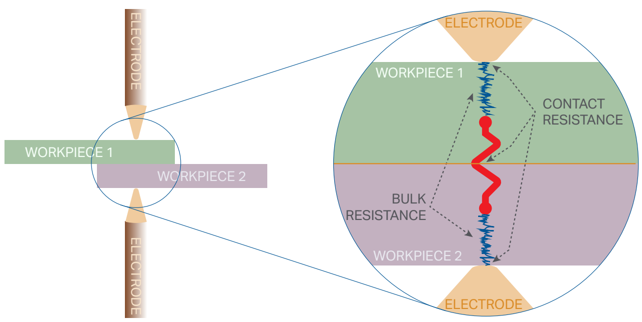


Figure 11.1. A typical (industrial) welding configuration on the left and a close-up zoom of the weld showing the electrical resistances that are used to create the weld spot.

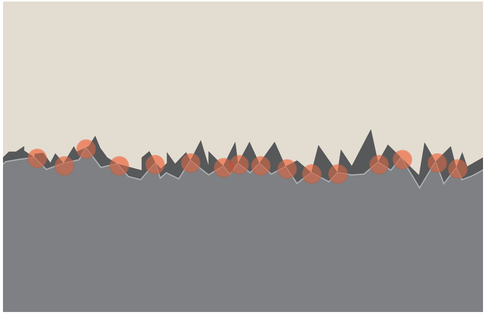


Figure 12.1. On the micro scale, all surfaces have a degree of surface roughness.

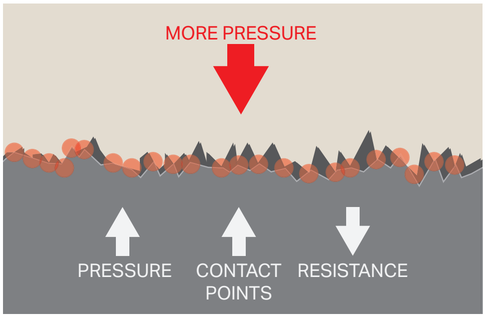


Figure 12.2. Applying more pressure will cause more surface contact, less resistance and less resistive heating.

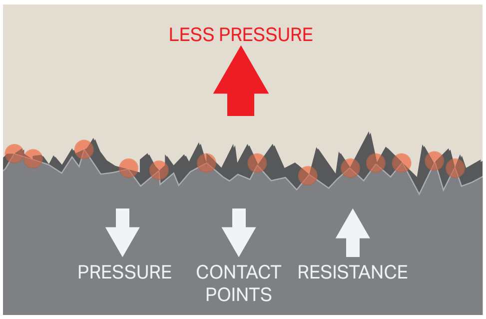


Figure 12.3. Applying less pressure will cause less surface contact, more resistance for better resistive heating.

the electrical resistance locations where heat is generated. For fine spot, or small scale resistance welding, most of the heat is generated at the contact point between the two workpieces. This has been identified on the figure as the largest resistance point. During the weld a large pulse of electrical current is dumped quickly through the workpiece causing rapid heating and melting at the electrode location.

On the micro scale, all surfaces have a degree of surface roughness, as illustrated in Figure 12.1. This roughness causes the workpieces to only contact in a limited number of locations. Applying more pressure will cause more surface contact, less resistance and less resistive heating, as seen in Figure 12.2. Applying less pressure will cause less surface contact, more resistance for better resistive heating, illustrated in Figure 12.3.

A resistance welder uses the resistance to the flow of electricity to heat and melt the part via a large electrical current. This contact point is where the highest heat is generated. Light pressure between the parts means less contact between the two surfaces, more resistance, and hence more heating and melting. Heavy pressure between the parts translates to more contact between the two surfaces, less resistance, and less heating.

Sometimes it can be helpful to focus the energy of a resistance weld for larger parts. This can be done by using a weldment, or bump between the parts to be welded. This bump forces the electrical current to pass through a concentrated point (especially important for thicker parts). The smaller the bump tip diameter the more heat that can be generated at that point. This technique is also very helpful for welding dissimilar, conductive metals. For example, resistance welding silver to gold can be difficult, however, if a gold weldment is placed on the silver part the gold to gold resistance weld becomes very simple.

To aid in welding difficult thicknesses or material combinations.

- Place a weldment or bump on one side to focus the energy.
- Use a simple electrode configuration that has as much contact area as possible on the outside of the parts.
- The weldment or bump will fuse into the other part making a resistance weld that cannot be seen on an edge. See Figure 13.1.

Figure 13.1. A weldment, or bump between parts to be welded, forces the electrical current to pass through a concentrated point (especially important for thicker parts). The smaller the bump tip diameter the more heat that can be generated at that point. This technique is also very helpful for welding dissimilar, conductive metals.

Resistance Welding Tips

Here are several different helpful recommendations to use when resistance (tack) welding:

- The pressure between the two parts is the most important variable in resistance welding; even the amount of energy being used for the weld plays (to a degree) a lesser role.
- Higher pressure creates a cool weld.
- Lighter pressure creates a hot weld.
- No pressure, or low pressure, will produce an arc.
- Placing a small bump or weldment between difficult to weld parts can simplify the welding process.

If using tools to hold the workpieces, remember that firm pressure between the tool and the workpiece is important to prevent welding the tool to the workpiece (e.g. jump ring pliers). Apply the correct pressure between the workpieces to achieve your weld.

Hands On: Try turning the Tack Mode energy to a middle setting and make a weld. Follow these steps:

- First weld with very firm pressure between the parts. The result may be little or no weld.
- Next clamp the parts firmly in the tool but apply virtually no pressure between the parts (make sure these are parts you no longer need). The result will be a very large spark, or at least a much better weld.
- Practice at different energies and pressures until you feel comfortable with the process and results.

The pressure between the tool holding the part is also very important. If insufficient pressure is applied between the tool and the part the weld may take place between the tool and the part. Always grip the part firmly in the tool to reduce the contact resistance between the tool and workpiece. Doing this will reduce the amount of heat created where the tool and part meet.

Resistance Welding Tools

It is always a good idea to have the resistance welding tool made from a material like copper (when welding more resistive parts such as steels). As noted earlier, if you're using a tool to hold the workpiece together use firm pressure between the tool and the workpiece to prevent welding the tool to the workpiece. This will help to ensure the resistance between the tool and the part is very low and no weld is made at this location.

Typically, steel is not used for resistance welding because of steel's high internal resistance. This high resistance means that a great deal of energy is dropped in the tool before even making it to the weld location. The tool can easily fuse to the workpiece. The exception to making a resistance welding tool from steel is when only a small amount of energy is needed. This may happen when only a light tack weld is needed before pulse arc welding.

Cables for Resistance Welding

A true resistance welding hand piece should transfer as much energy to the weld location as possible. The Orion is capable of transferring over 3000 amperes to the weld location. To enable this full energy transfer, the welding attachment should use 3.5ft (~1m) of 10AWG cable.

IMPORTANT: The cable should be no larger than 10 AWG or damage to the welder may occur (e.g. 8AWG is a larger cable).

Not all tack welds require this amount of energy. Smaller cabled pulse arc attachments can be used for simple tack welds that require lower energy.

Custom Resistance Welding Tools

It may be helpful to shape the tool for the application. Tools that clamp the parts (e.g. brass lined pliers) should have as much surface as possible in contact with the part to allow more energy to transfer to the weld location. Remember that the area between the workpieces should be small to focus the energy if a strong weld is desired. A weldment or bump can be used to help focus the energy, if desired.

If you are shaping an electrode to actually perform the weld then the tip should be as small as is reasonable for the desired weld size (e.g. 1mm spot size or less is typical). Remember that when using an electrode to perform the welding process, the pressure applied by the electrode tip determines the weld pressure and the heat generated. As noted earlier, a weldment or bump between the two parts to be welded can still be used to focus the energy. Place the electrode directly over the weldment location (remember the weldment is actually between the two sheets etc, not on the electrode).

Chapter 3: Tungsten Electrodes

The single most important variable in the welding process is the electrode. The Orion welder comes standard with (5) 0.5mm and (5) 1.0mm electrodes. The 1.0mm electrodes are a good all around electrode while the 0.5mm electrode is excellent for very small projects. The larger 1mm electrode allows more energy to come out at one time. The smaller 0.5mm electrode is better for applications where less energy is being used.

Hands On: Make a weld using 10 Ws and a sharp 1.0mm electrode. Now make a weld using the same settings with a sharp 0.5mm electrode.

In the 'Hands On' examples above, more energy was transferred from the Orion into the workpiece for the same setting using the 1mm electrode. For very small parts, using the small electrode is sufficient. This option reduces the peak weld current versus using the large electrode and can also allow for a smaller weld spot. For larger parts use the 1mm electrode. The 1mm electrode is used when needing additional weld current (more melting for same energy). The larger electrode is recommended for metals such as silver, due to higher welding energy requirements of such metals.

Note: The 0.5mm electrode will "burn" or oxidize at higher energy settings. As a general suggestion, the 1mm electrode is a good choice for most applications, even very small ones

As shown in Figure 15.1, using too much energy with the 0.5mm electrode will cause it to overheat and reduce its life. Using a 1.0mm electrode can weld at a variety of energies without overheating, as shown in Figure 15.2.

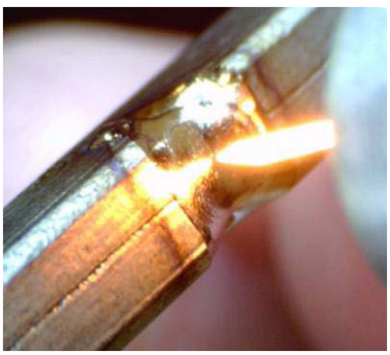


Figure 15.1. Using too much energy with the 0.5mm electrode will cause it to overheat and reduce its life.

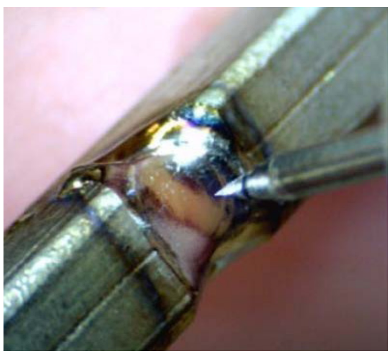


Figure 15.2. Using a 1.0mm electrode can weld at a variety of energies without overheating.

Why Use Tungsten Electrodes?

Tungsten is the ideal material for electrodes for the following reasons:

- **Hardness.** Tungsten is extremely hard and is therefore able to hold its shape during the welding process.
- **High Melting Point.** Tungsten's melting temperature is much higher than most other metals. This means the metals being welded will melt before the tungsten.

MELTING TEMPERATURES OF SELECTED METALS

The table below shows a variety of metals and their corresponding melting temperatures. Note that tungsten has a significantly higher melting temperature than the other metals. This is an important attribute of tungsten that aids the welding process. While welding, electrons from the weld plasma impact the workpiece and form a weld spot. At the same time, positively charged gas atoms impact the electrode. Both of these processes create heat. However, more heat is generated by the electrons impacting the workpiece than the atoms striking the electrode.

TYPE OF METAL	MELTING POINT (Cº)
Zinc	420
Aluminum	660
Silver	962
Gold	1064
Copper	1083
Stainless 304	1450
Carbon Steel	1500
Titanium	1660
Platinum	1772
Niobium	2468
Tungsten	3410

Electrode Shape

The electrode shape is a very important aspect to consider and has a significant impact when welding various metals. The shape of the electrode will greatly affect the welding plasma created during the arc. Poor electrode shape will lead to plasma arcs that are not repeatable while good electrode shape will help the plasma arc to discharge smoothly from the welding tip.

The grinding direction to sharpen the electrode is very important. When grinding, make sure that grind marks run parallel to the electrode shaft. See Figure 17.1. Parallel grind marks will allow the plasma to discharge uniformly and smoothly from the electrode. Grinding the electrode such that circular rings or marks show up will

Figure 17.1. When grinding, make sure that grind marks run parallel to the electrode shaft.

Figure 17.2. Grinding the electrode such that circular rings or marks show up will lead to poor weld quality.

Figure 17.3. The electrode should be ground so that the taper is approximately 2.5 times the diameter.

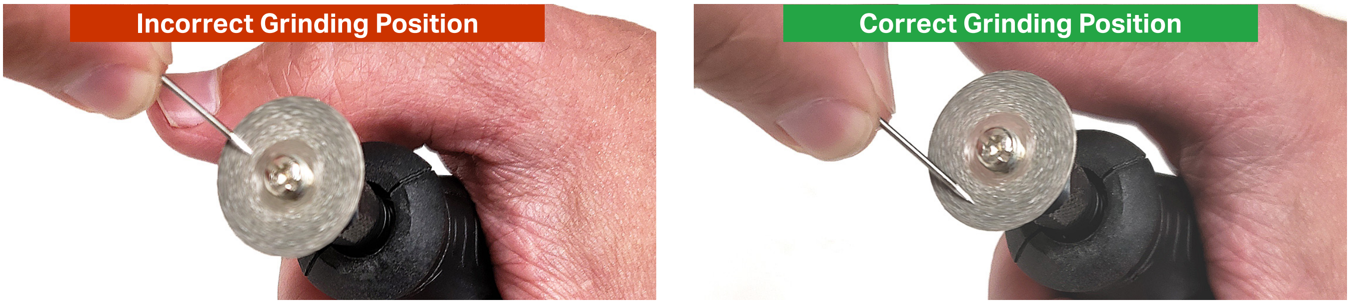


Figure 17.4. Always grind the welding electrode so that grind marks run parallel to the electrode shaft, as shown in the picture on the right.

lead to a poor plasma arc, affecting weld quality, as shown in Figure 17.2. The plasma will discharge inconsistently from the electrode ridges and may become unstable, oscillating in time. The weld spot will not be repeatable.

As a rule of thumb the electrode should be ground so that the taper is approximately 2.5 times the diameter. The resulting electrode shape is a good general shape for easy arc ignition and excellent weld spots. See Figure 17.3.

Always grind the welding electrode so that grind marks run parallel to the electrode shaft. See Figure 17.4 as an example. Placing the electrode incorrectly on the diamond wheel will produce circular grind marks and poor weld results.

Hands On: Grind your electrode so that grind marks run parallel to the electrode shaft. Verify by looking under the microscope. Try to produce a taper that is approximately 2.5 times the diameter of the electrode.

ELECTRODE SHAPING EFFECTS

There are three main electrode shape configurations that you should consider when preparing for a new project. **First, a sharp electrode is key for most applications and metals.** A sharp electrode is also the easiest to ignite and typically produces a good weld spot. A sharp electrode is especially important for small parts where fine control is essential.

Figure 18.1. The tip shape changes the energy focus and weld penetration, as shown above.

The tip shape changes the energy focus and weld penetration, as shown in Figure 18.1. The weld spot on the left was formed with a blunt electrode, while the spot on the right was made using a sharp electrode.

The shape of the electrode will influence the shape and penetration of the weld spot. There are advantages and disadvantages to each electrode shape.

As shown in Figure 18.2, the electrode shape greatly influences the weld spot's shape and penetration. The 15 degree electrode shape has the advantage of easy weld ignition at lower energy levels over any otther shape. In some situations it is advantageous to place a small flat surface on the end of the sharper tip, or truncate the weld tip. This has a stabilizing effect on the arc and also allows deeper weld penetration. Even a small flat surface on an otherwise sharp electrode can be helpful in making repeatable welds while still allowing easy arc ignition. For the smaller energy settings an extremely sharp electrode is essential. Remember the size of the truncated flat surface is related to the energy setting. Use smaller flat surfaces for lower energy, larger flat surfaces for high energy.

There are several considerations that can be helpful when selecting electrode shape (e.g. sharp, blunt, or a sharp tip with a small flatted end). The most helpful of these is to spend time on your Orion and experience how it responds to different electrode shapes and metals.

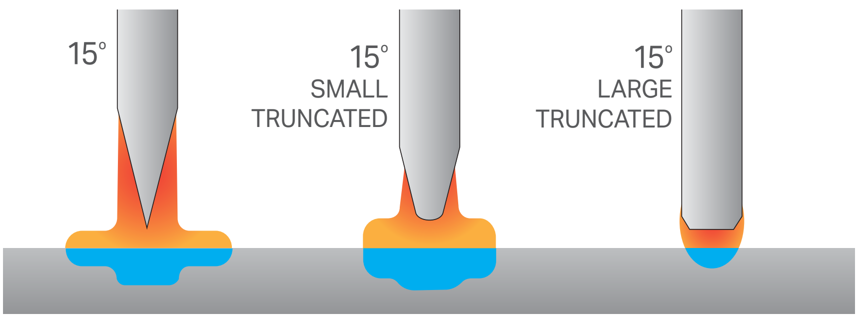


Figure 18.2. The shape of the electrode greatly influences the weld spot's shape and penetration, as can be seen above.

CONSIDERATIONS FOR ELECTRODE SHAPE:

- When welding very small features, less than 1mm, the electrode should be sharp to focus the weld energy.
- When welding with less than 20-30 Ws the electrode will typically be sharp.
- Some materials weld better with a sharp electrode (e.g. stainless steel).
- When welding at very low energy settings a sharp electrode will help ignite the arc more easily.
- Flattened tips provide arc stability at higher energies
- At high energies a sharp tip may melt off during the welding process and contaminate the workpiece.
- A large flat surface can be helpful on all metals depending on the desired weld puddle and the workpiece geometry.
- Truncating the electrode helps to un-focus the weld energy and prevents "burrowing" in mobile metals like silver.
- How large you make the tip flat (e.g. a very small flat vs. a completely blunt electrode) is determined by the amount of energy the Orion will deliver. At low energies no flat is needed, where at maximum energy the tip can (if desired) be completely blunt. Remember, the smaller the flat the easier the weld ignition.

Figure 19.1. A blunt electrode tip can be helpful when making more powerful welds in silver to help overcome silver's high liquid mobility by "un-focusing" the plasma over the entire flattened area.

Figure 19.2. A sharp electrode will help place the weld into tight geometries, a blunt electrode can spread the energy and prevent weld formation.

As seen in Figures 19.1 and 19.2, the shape of the electrode assists in certain types of welding. A blunt electrode tip can be helpful when making more powerful welds in silver to help overcome silver's high liquid mobility by "un-focusing" the plasma over the entire flattened area. A sharp electrode will help place the weld into tight geometries, a blunt electrode can spread the energy and prevent weld formation.

As discussed above, silver is really the major exception to having a sharp tip. Because of silver's high liquid mobility, a sharp electrode with a focused arc (at the very tip) can actually burrow a hole in the center of the weld spot at higher energies. **However, for most welds a sharp tip is still recommended in silver.** By using a blunted or truncated tip the energy is effectively spread over the weld area and both the burrowing hole and the thin silver blow-through can be largely avoided.

Troubleshooting the Electrode

Poor weld results are most often traced back to electrode condition and shape. Because the electrode condition is very important, the following information will help troubleshoot problems quickly.

- **During the ignition process the electrode is touching the workpiece surface when the weld current begins to flow.** The metal contaminate may form a liquid metal electrical conduction bridge. During the weld ignition process the electrode will retract and this may lead to the vaporization of the liquid metal bridge as it is necked down during the electrode retraction process. This vaporization process can be explosive (on a very small scale) and leaves a crater in the metal's surface. The result will be a small "pockmark" in the metal's surface. The electrode must be reground before reliable welding can continue at this setting. At lower energies this resurfacing/re-tipping may be very important to get the welder to ignite reliably. At higher energies the welding process may proceed virtually unhindered even with a metal contaminated electrode. To remove the small crater, weld over the crater with a newly ground electrode.
- **The electrode may stick to the metal's surface.** This happens as the liquid metal bridge cools before the electrode tip has retracted sufficiently to leave the surface of the workpiece. A now solid metal to metal weld has taken place at the electrode tip preventing retraction and arc ignition. This is often referred to as electrode "sticking".
- **What can be done if the weld spot doesn't look good, asymmetric for example?** This may mean the electrode may be damaged (sharp tips or jagged edges or strange shape due to contamination). Poor tip condition can also lead to porosity (small holes in the workpiece).

In the table below you'll see that trouble igniting the arc can be caused by several different reasons. If the workpiece's metal contaminates the welding electrode the following may occur:

SYMPTOM	POSSIBLE PROBLEM	POSSIBLE SOLUTION
Trouble Igniting the Arc	• Contaminated electrode • Electrode shape not conducive to ignition at low energy • Broken electrode or jagged edges	• Re-grind the electrode to remove contamination • Shape the electrode to the desired shape • Re-grind the electrode to the desired shape
Cratering of the Weld	• Electrode contamination leading to a metal bridge explosion • Sharp electrode in a mobile metal such as silver	• Re-grind the electrode • Truncate the end of the electrode to help "un-focus" the weld energy
Weld Spot Symmetrical	• Damaged or jagged electrode	• Re-grind the electrode

SYMPTOM	POSSIBLE PROBLEM	POSSIBLE SOLUTION
Porosity in the Workpiece	• Damaged electrode with jagged tips • Metal may contain zinc and "boil" during the welding process (such as white gold and brass) • Sharp electrode in a mobile metal such as silver	• Re-grind the electrode • Often welding over the same location two or three times will smooth the weld • Truncate the end of the electrode to help "un-focus" the weld energy

As electrodes wear, they will become dull and result in lower quality and less attractive welds. Sharpening or changing them out periodically is important to maintain weld consistency.

The Orion's electrodes are made of lanthanated tungsten. The small amounts of lanthinum found in the electrodes help the tips stay sharp and help improve weld performance. The electrodes are also double ended, meaning that either end can be used for welding.

Warning: *When swapping electrodes, use caution when touching any part internal to the stylus. With extensive use, the internal parts and especially the electrode will be hot. Allow them to cool before attempting to change electrodes. As an added safety precaution, it is recommended to put the Orion in Pause Mode.*

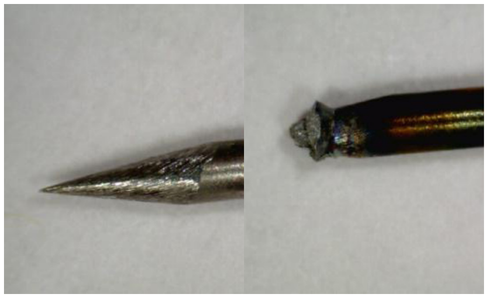


Figure 21.1. A perfect electrode at left, and an electrode in poor condition with metal contamination at right.

Figure 21.2. Electrode contamination can lead to small "explosions" that create craters in the workpiece.

Electrode condition greatly affects energy transfer and also weld properties (see above discussions). In Figure 21.1, the left electrode is in perfect shape. The right electrode is in poor condition with metal contamination.

Electrode contamination can lead to small "explosions" that create craters in the workpiece, as seen in Figure 21.2. All four welds were made at the same setting. Metal contamination on the electrode caused one weld to create a crater.

It is recommended that you pay close attention to the electrode condition. A contaminated electrode can lead to inconsistent welds and poor arc starting. Only light pressure is needed to start the welding process, too much pressure will interfere with the welding process, leading to electrode metal contamination and will shorten the amount of time you can weld before re-sharpening or replacing the electrode.

Chapter 4: Techniques, Tips, and Tricks

Adding Material

Typically material is added with a small “laser wire”, one weld at a time. However, there are many additional options to add material. For example, instead of using small “laser wire” the Orion can weld a much larger wire or rod to fill in more metal in a single weld. Common wire sizes are 26 AWG, 28 AWG, and 30 AWG.

There are several methods to aid in the addition of fill wire, which are mentioned below. The placement of the electrode relative to the wire is very important and will influence how the material behaves during the addition process.

SIDE PLACEMENT

Placing the electrode on the side of the wire is generally the best method of adding fill wire. As shown in Figure 23.1, place the electrode at an approximate 45 degree angle between the wire and the base material. As the electrode pulls away from the base material and the arc ignition happens, the base material will melt first and then the wire will be melted and pushed or pulled (by surface tension) into the base material. This is an excellent method to produce a uniform molten pool of metal and ensure the proper mixing of the base material and the fill wire. The electrode may also be placed at a 45-degree angle in front of the wire. However, less material will be added with every weld, and a portion of the wire will typically ball-up in the process.

Remember that for a larger fill wire the energy must be increased to completely melt the wire. If there is insufficient energy there may only be partial melting of the wire, as illustrated in Figure 23.2. However, in some situations this may be advantageous.

Hands On: Try adding fill wire using the side placement method. Build up a small mound of material.

TOP PLACEMENT

With top placement the material addition process will depend a great deal on the wire size and the weld energy. If the wire is very small, the results will be similar to the side placement discussed above. For a small wire welded with high weld energy (relative to the wire size) the weld plasma powers through the wire. This technique melts the base metal and joins the melted wire to the base plane. However, if the wire is larger or the energy is set to produce only a small spot size, the wire will typically fail to be added to the base material. Instead the wire will

Side Placement of the Electrode

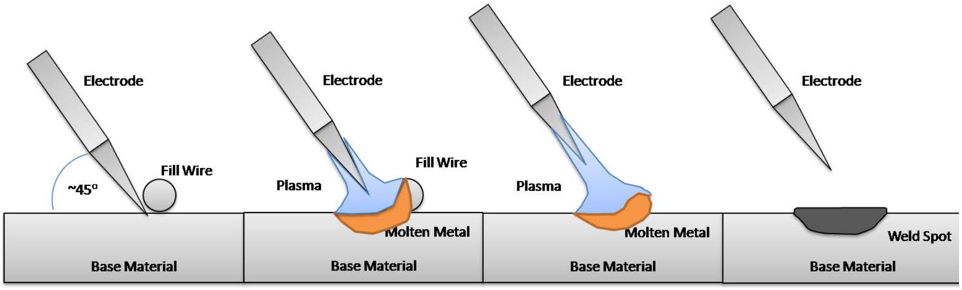


Figure 23.1. Side Placement example.

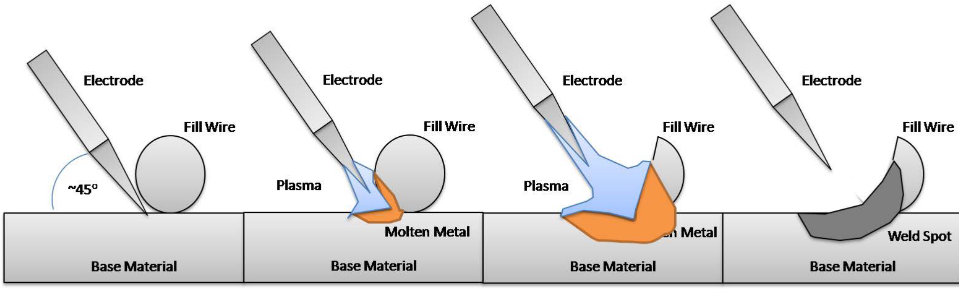


Figure 23.2. Side Placement example with large fill wire.

Top Placement of the Electrode

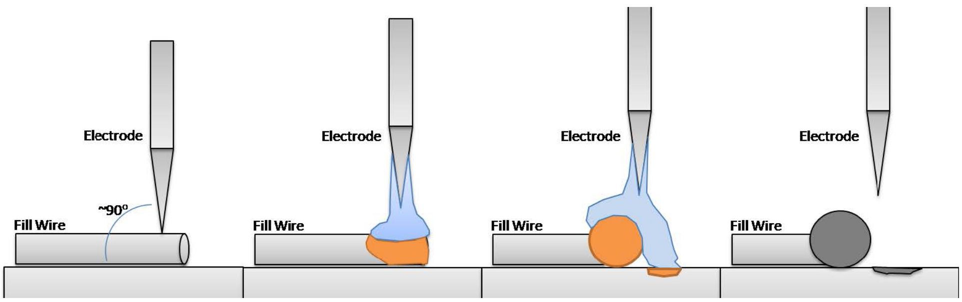


Figure 23.3. Top Placement example.

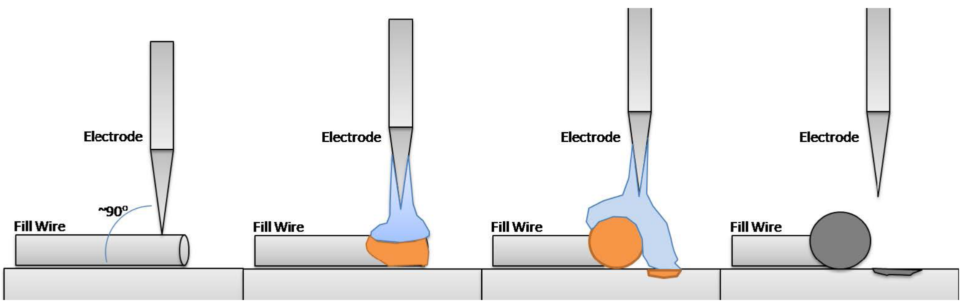


Figure 23.4. Top Placement example with large fill wire.

ball and some melting of the base material will occur, which is insufficient to add the wire. See Figure 23.3.

Placing the weld electrode on top of the fill wire at a 90-degree angle from the base material surface is typically not the preferred method of adding material, as shown in Figure 23.4. If the wire is large compared to the energy setting, the wire will ball due to surface tension and will not be added to the base material.

A top electrode placement can work if the wire diameter is small compared to the energy setting. In this case there is enough plasma pressure to force the molten wire onto the base material. Placement of the electrode directly on top of the fill wire can melt the wire into the base if the energy is sufficient, or the wire is very small. Alternatively, it may only melt the wire causing it to ball as shown here.

A final scenario can occur when the electrode is placed on top of a large wire being welded to a base material at a high weld energy setting. In this case the plasma can push the wire metal down to the base metal surface but there may be no penetration into the base material.

Hands On: Try adding fill wire using the top placement method. Build up a small mound of material.

As a rule of thumb it is always best to use the side electrode placement. This is especially true of larger fill wire diameters. If it is essential for a top placement weld, the process will be improved by using very fine laser wire to ensure full wire melting, as shown in Figure 24.1. Choosing the correct wire gauge for your application is very important. For example, on micro-scale applications, it is important to select the smallest fill wire available.

If a wire is selected that is similar in size to the base metal, there is a good chance that the energy setting required to melt the wire will also melt the base metal. See Figure 24.2. Alternatively, if the wire is small relative to the base metal, the wire can be melted adding material to the base metal without any damage or warping to the base metal.

For larger features, select a wire size that will allow you to perform your task efficiently. For example, filling a large hole should not be done with ultra-fine wire, but instead with wire of approximately the same diameter as the hole, as shown in Figure 24.3.

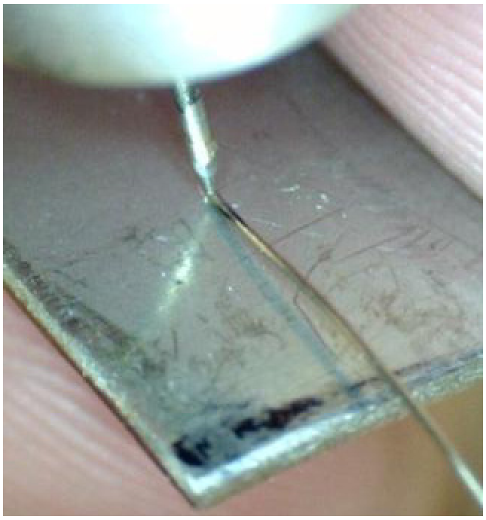


Figure 24.1.

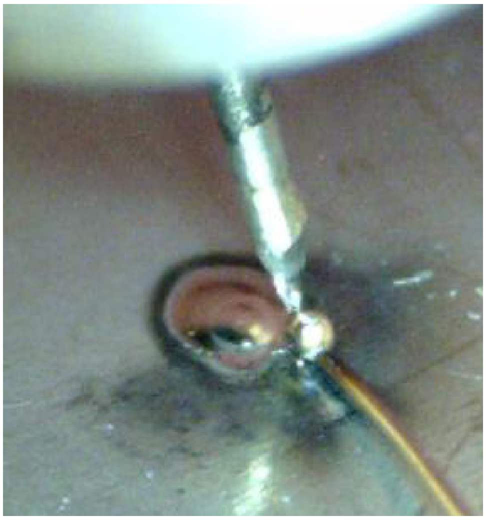


Figure 24.2.

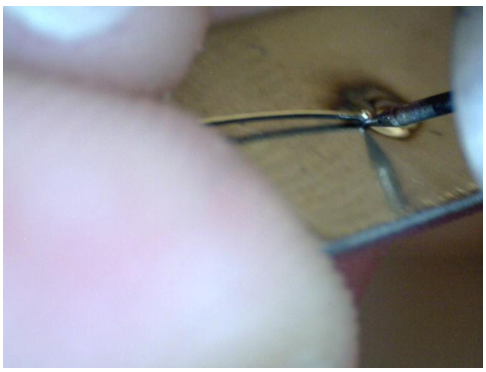


Figure 24.3.

In this case the repair can be accomplished in literally one weld. In comparison, with the ultra-fine wire, the repair would take many welds.

Note: Common wire sizes for pulse arc welding are 26 AWG, 28 AWG, and 30 AWG.

Pushing Metal

There are two competing forces at work during the pulse arc welding process. The first is the surface tension of the molten metal. Surface tension is a force between the metal atoms that is pulling the molten pool of metal flat during the metal's liquid phase. The Second is the electrons from the plasma pushing the molten metal in the direction the electrode tip points. The plasma tries to push the molten metal, while the surface tension tries to keep it in place.

This means:

Some metals with lower surface tension (e.g. silver) are easier to "push" around than metals with high surface tension (e.g. stainless).

- Surface tension itself can be used to move metals around. By placing the electrode between a high and low spot, the melting process will try and "flatten" the two, stealing material from the high and moving it toward the low. See Figure 25.2.
- Pushing metal is accomplished by placing the electrode at a 90 degree angle from the workpiece surface with the electrode tip on the edge or slightly interior to the edge of the metal mound. The welding process will then take material from the mound and spread it into the surrounding material. One should repeat this process until the proper spread of material is achieved. See Figure 25.1

Hands On: Use your electrode with several different materials to push metal around, or to use surface tension to smooth a metal mound out. See Figure 26.1.

Please note that various metals will react differently to pushing and surface tension smoothing. For example, silver has a relatively low surface tension while in a liquid state. This means

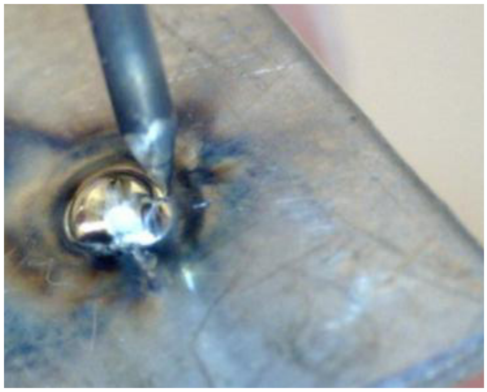


Figure 25.1. By placing the electrode between a high and low spot, the melting process will try and "flatten" the two, taking material from the high area and moving it toward the low area.

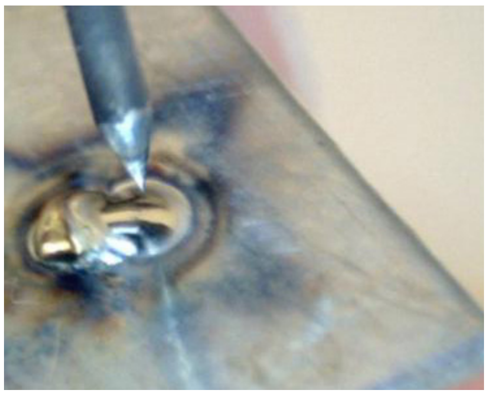


Figure 25.2. Placing the weld electrode on the edge of a bump will smooth away the bump as surface tension spreads the metal over the molten base material.

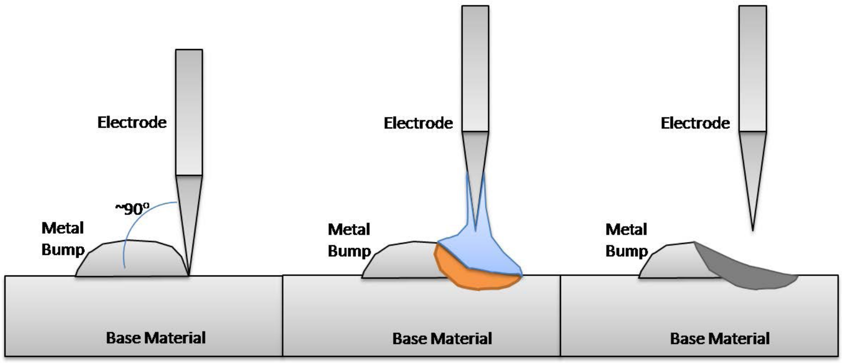


Figure 26.1. Place the electrode in different spots to move the metal around.

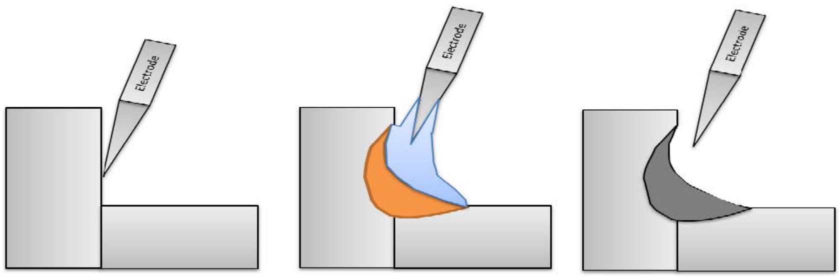


Figure 26.2. Place the electrode in different spots to move the metal around.

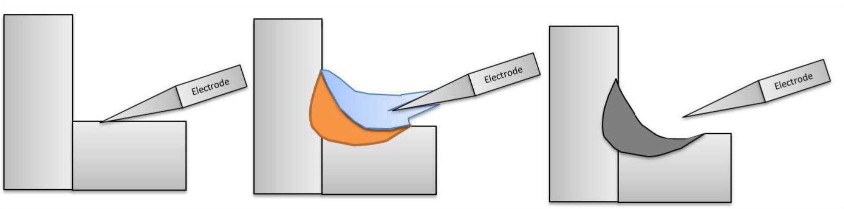


Figure 26.3. Place the electrode in different spots to move the metal around.

that the plasma push method may be more successful than it would be with stainless steel (with a much higher surface tension). On the other hand, because of the high surface tension of stainless steel, the surface tension smoothing method will proceed quickly.

Pushing metal is especially helpful if one of the parts to be joined is heat sensitive. In the example in Figure 26.2, the horizontal member is more heat sensitive or is thinner than the vertical member. Material is pushed from the vertical member onto the horizontal member to prevent part damage.

In the example in Figure 26.3, the vertical member is more heat sensitive or is thinner than the horizontal member. Material is pushed from the horizontal member onto the vertical member to prevent part damage.

Weld Cracking

Some materials are prone to crack because of their metal properties. For example, high carbon steel, palladium, and some silver alloys. Why does the cracking take place? With some metals it is the new crystal structure

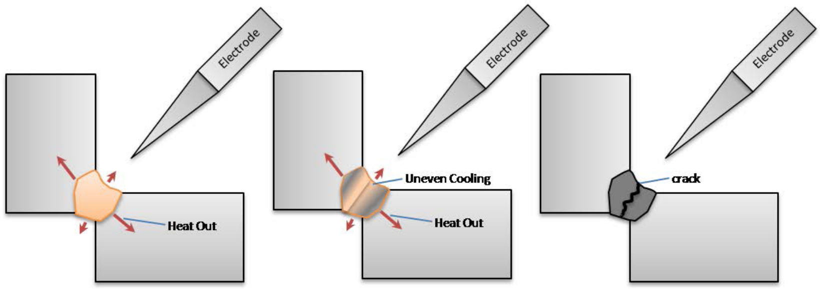


Figure 27.1. Improper joint preparation or geometry can lead to uneven weld puddle cooling.

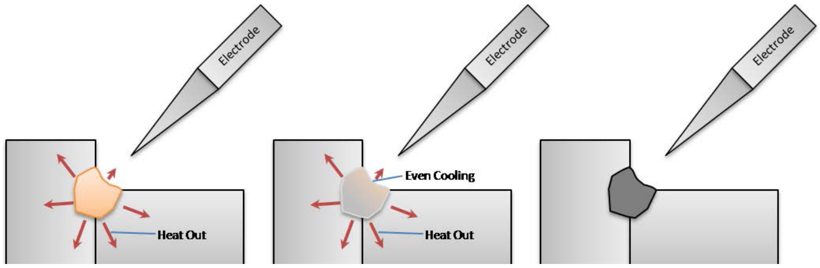


Figure 27.2. A proper weld joint will help the weld puddle cool uniformly.

created during the welding process e.g. palladium and high carbon steel. However, another cracking process often called "hot cracking" can occur when the cooling process and the resulting thermal shrinkage create high stresses in the workpiece. Hot cracking is very geometry dependent and can be avoided by carefully considering the weld joint before welding.

Ideas to overcome hot cracking:

- Keep joint gaps as small as possible.
- Keep the weld length/time at its max length setting to help ramp down the heat more gradually.

Improper joint preparation or geometry can lead to uneven weld puddle cooling, as shown in Figure 27.1. If the puddle cools in such a way to create a hot center section the hot section will be pulled apart by the stresses from the cooling out metal.

A proper weld joint will help the weld puddle cool uniformly, as shown in Figure 27.2 This will allow even stresses within the weld puddle and prevent weld cracking.

Palladium and high carbon steel cracking is a special case and is difficult to overcome with laser or pulse arc welding. If only one weld spot is made, cracking will typically not occur unless the weld joint is stressed by hammering etc. This means that welding over porosity in a palladium piece can be accomplished with the Orion to help clean up a ring during the finishing process. However, welding more than one overlapping weld will inevitably lead to cracking.

Palladium cracking can be thought of as a combination of hot cracking and a new weld puddle crystal structure problem. After a weld the molten palladium re-crystallizes, typically forming a large and weak metal grain structure. When welds overlap the new crystal structure in the previous weld, the new puddle will be weak compared to the original metal. See Figure 28.1.

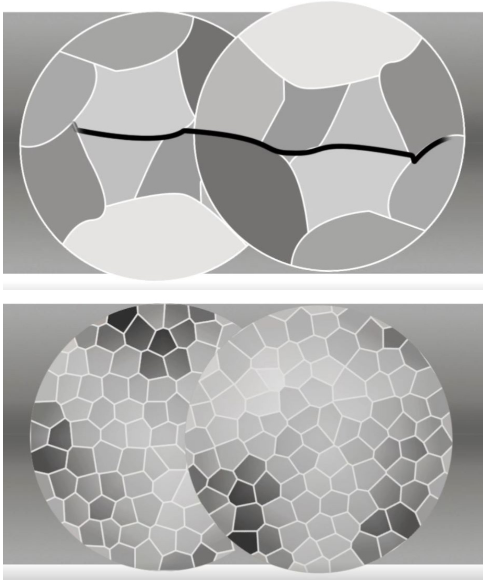


Figure 28.1. Cracking occurs when the joints of two or more overlapping welds give way to stress (see top illustration). Agitation prevents joints from aligning during the cooling process, which strengthens the weld (see bottom illustration).

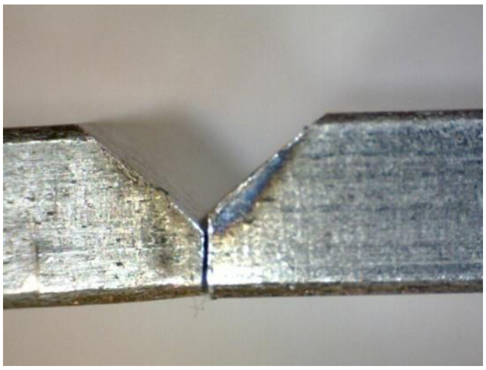


Figure 28.2.

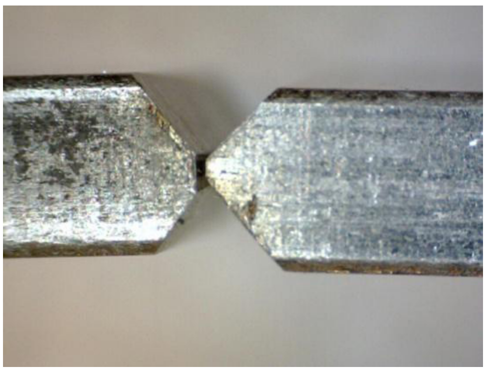


Figure 28.3.

The resulting crack from the weld will start at the edge of the new weld where it overlaps with the old weld joint. The crack will then run along the middle of the weld puddle in the direction of the overlapping joints, as seen in Figure 28.1. This is due to the stresses created during the weld puddle cooling process as described above with hot cracking.

However, this time, instead of geometry causing cracking, a rip starts in the old crystal structure and propagates during the cooling process, much like ripping a piece of paper. The result: Palldium is difficult to weld successfully without breakage. Typically, with palladium, single spots of porosity can be welded and fixed but overlapping welds will crack.

Joint Preparation

Your Orion pulse arc welder can be adjusted to a weld penetration of up to approximately 0.66 to 1 mm in depth (depending on the material and the Orion model being used). However, deeper penetration usually also means large spot size around 2 to 3 mm.

When deep penetration is desired but the weld spot size needs to remain small or the workpiece thickness is very thick, additional weld joint preparation may be necessary.

The Y joint is the simplest joint to prepare. See Figure 28.2. Use fill wire of an appropriate diameter to build up material in the joint. Weld with no fill material for the first pass to increase the weld penetration into the joint. Then add fill wire to build up material in the top of the Y until the material is flush with the top surface.

Other joint preparations, like X, V, etc. (see Figure 28.3), are possible and the welding procedure is similar.

Warping

In some specialized applications, precise positioning of the workpiece relative to a model is very important. However, during the melting process the weld pool will expand and shrink asymmetrically, meaning that the expansion during melting is less than the shrinkage during cooling. This asymmetric expansion can warp the workpiece.

The warping can be used to one's advantage if done correctly. Often the user can simply observe the natural warp in the workpiece and place welds to warp the part back into proper alignment. Even if warping is not desired there are steps to avoid this problem.

To do this, start with lower energy settings. This will minimize the initial warping as you stabilize the workpiece. Always alternate sides during the welding process; several welds in a row on one side can exaggerate the warping, while alternating welds will pull the part back and forth eliminating most warping. After the smaller stabilizing welds have been placed you can turn up the energy and make the larger welds, alternating sides as done with the lower energy welds.

Weld Cleaning

For many applications the weld joint will require very little preparation. Keep the weld area clean and free from debris. Remember that finger oils, and other surface contaminants will cause blackening around the weld spot. This blackening can easily be wiped away with a clean rag or taken off with a glass brush (one is included with your Orion welder), sand blaster or steam cleaner.

During the welding process small amounts of metal will be vaporized from the weld joint and can be deposited elsewhere on the workpiece. Typically, this thin film of metal will look black and can easily be cleaned off with a glass brush, ultrasonic cleaner, or other type cleaner If the welds themselves look black or discolored, it may be an indication of oxidation and can come as a result of too little or too much argon gas flow. If the part is too hot, some metals will readily react with oxygen to form oxide layers. If gas flow is insufficient the weld spot may be poorly covered and oxygen may be present during the weld. On the other hand, if the protective gas flow is too high, the gas may exit the stylus nozzle in a turbulent state. When the gas flow is turbulent it will "grab" oxygen and other atmospheric gases and bring them inside the protective argon gas shield. This will also lead to the molten weld puddle being exposed to oxygen.

Protective Gas Rules of Thumb

- 5 - 10 PSI is a good shielding gas rate.
- The shorter the electrode, the less argon required.
- Gas flow may need to be increased if the electrode is lengthened.

Any discolorations that shows in titanium is an indication of poor shield gas coverage. For this reason it may be helpful to practice on titanium to make sure your gas flow is correct. Adjust your gas to ensure no discoloration in a small titanium weld spot. This will give you confidence of proper argon shielding for other materials.

Chapter 5: Metals

Weldability of Common Metals

One very important aspect of pulse arc welding is a working knowledge of material properties. This knowledge will help you understand why various metals will react differently during the welding process. Shown below is a table of properties of some common metals. These metals have been arranged by melting temperature for convenience. Each of the properties listed below will have an effect of the weldability of the metals.

	Zinc	Aluminum	Silver	Gold	Copper	Palladium*	Cobalt Chrome*	Stainless 304*	Carbon Steel	Titanium	Platinum	Niobium	Tungsten
Melting Point	420	660	962	1064	1083	1200	1300	1450	1500	1660	1772	2468	3410
Boiling Point	607	2467	2212	3080	2567	3100	2800	3000	3000	3287	3827	4742	5660
Specific Heat	388	900	237	129	385	244	10	500	500	523	129	268	133
Electrical Resistivity	6	2.7	1.6	2.2	10.6	10.8	475	70	60	54	10.6	16	5.4
Density	7.1	2.7	10.5	19.3	9	11	8.3	7.9	7.8	4.5	21.5	8.6	19.3
Thermal Expansion	31	23.5	19.1	14.1	17	11	10	18	12	8.9	9	7.2	4.5
Thermal Conductivity	116	237	429	318	401	71	100	16.3	50	22	71.6	54	173

**Some Values may be approximate*

Definitions:

Melting Point: The temperature at which the metal will begin to melt. The molten metal of the weld pool will be at this temperature during the welding process.

Boiling Point: If enough energy is added to the weld joint (and heat is removed slowly by the surrounding solid metal) the weld puddle can begin to boil. Liquid metal will be turned into gaseous metal.

Specific Heat: The energy required to raise the temperature of the metal (per unit mass). Think of this number as how much metal will melt for a given weld energy (melting point also is important). A larger specific heat means more energy is required to melt the metal.

Electrical Resistivity: This number represents the resistance to the flow of electrons in a metal. This property is especially important during a resistance or "tack" weld. The more resistive the metal is the more easily it will resistance weld (e.g. stainless steels), the smaller this number is the more difficult it will be to weld the material (e.g. silver), especially in "tack" mode.

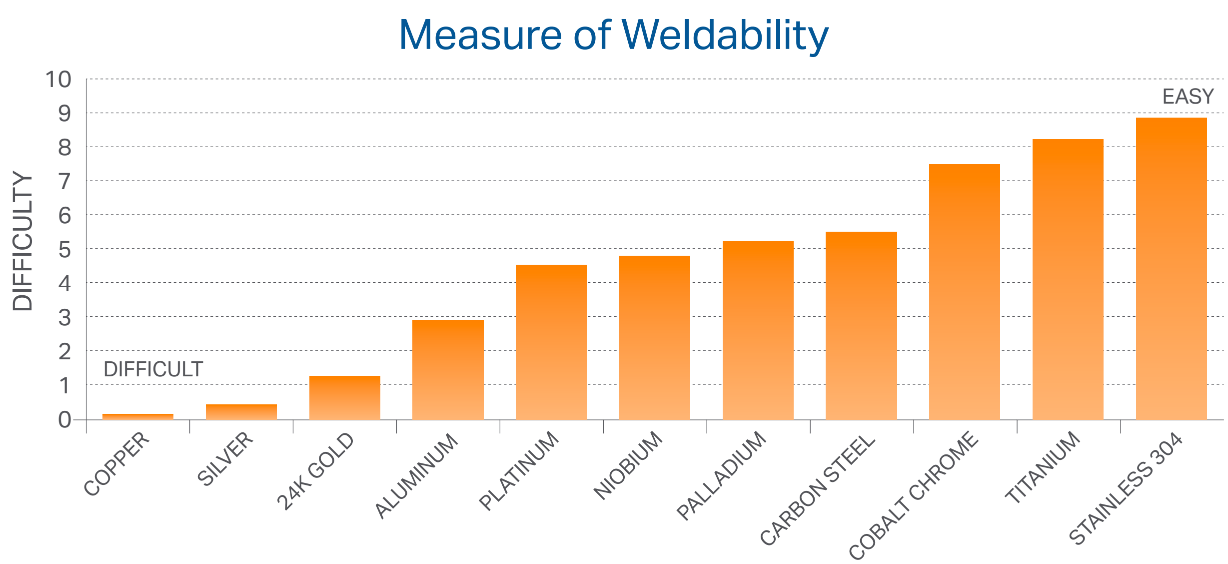
Density: Density is the measure of how much of the metal (atoms / mass) is in a given volume of space. This property will also influence how large the weld spot is for a given metal. All other things being equal, a lower density metal will have a larger weld spot than a higher density metal for the same weld energy.

Thermal Expansion: When a metal is heated it will expand, or elongate slightly. In some situations, especially during resistance welding, metal can expand quickly and spill out of the weld joint.

Thermal Conductivity: This is a measure of how fast the metal conducts heat. Metals that are good conductors of heat (e.g. copper) will dispel the heat away from the weld location quickly during the welding process. This action reduces the size of the weld spot. Metals that are poor conductors of heat (e.g. titanium) are slow to conduct heat away from the weld location and the weld energy has a greater affect on the weld size, etc.

Measure of Weldability

This measure of weldability comes from properties of the metal, such as melting point, thermal conductivity, density, etc., and is intended as a relative reference between the different metals. It can be thought of as how much spot size and penetration a given amount of weld energy will have on the metal. Please note that some metals may have properties not accounted for in the chart below that may make welding more difficult than indicated (e.g. palladium).



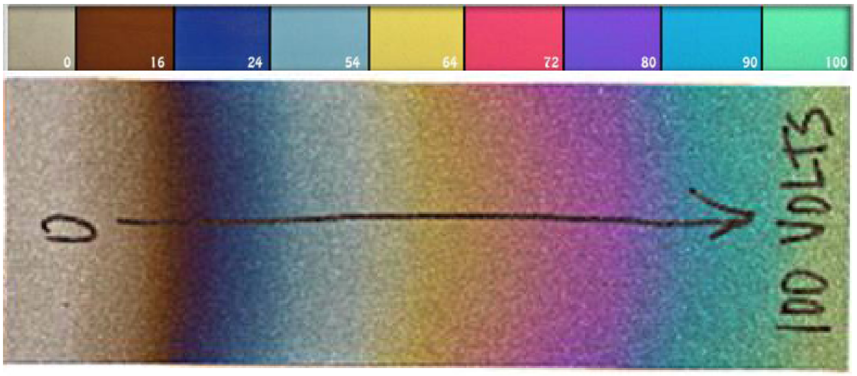


Figure 32.1. Titanium and niobium metals will oxidize readily at elevated temperatures and voltages,

TITANIUM AND NIOBIUM

Some metals may react easily with oxygen and even other gases like nitrogen. Titanium (Ti) reacts with both oxygen and nitrogen at elevated temperatures. Titanium burns to form titanium dioxide in air at 1200 ºC. Titanium will also burn in pure nitorgen gas at 800 ºC to form titanium nitride, which is inherently brittle and creates a weak weld joint. Very light reaction (mostly shielded) may just include slight discoloration. However, a heavy reaction will cause absorption of gas and will cause a dark gray and porous result. If the reaction is too heavy the weld location will become very weak and porous.

Niobium reacts with both oxygen and nitrogen gas. Niobium will oxidize (react with oxygen) at 200 ºC. The reaction with nitrogen starts at 400 ºC. As you can see, niobium is even more reactive than titanium. This means that greater care must be taken when welding niobium to ensure proper gas shielding and clean welds. For thin parts this is particularly difficult as heat is easily conducted to the opposite weld side (the underside of the sheet for example). This heat on the underside causes the niobium to absorb oxygen and nitrogen gases resulting in brittle welds.

For both titanium and niobium, the level of oxidation can be observed visually. Heavy oxidation will cause a gray porous surface; oxidation (or nitrogen absorption) in smaller degrees will cause the surface of the metal to color. This principle can be used to actually “paint” on oxide in different colors on titanium and niobium parts.

Titanium and niobium metals will oxidize readily at elevated temperatures and voltages, as shown in Figure 32.1. The figure shows titanium and niobium “painting” with electricity (showing the voltage at which the color will appear). However, similar colors will appear due to heat if welding without sufficient shield gas. These colors during welding need to be avoided. (Picture courtesy of Reactive Metals.)

To avoid oxide and nitride formation (these will work for other metals as well), the use of argon coming from the welding stylus completely covers the molten weld pool and prevents oxidation. However, in some situations this is not the case. For example, when welding on a thin material, the back of the material is unshielded from oxygen and the exposed metal will react with oxygen.

The following tips can help reduce oxide formation on the back of the workpiece:

- **Argon flood on both sides of the workpiece during the welding process.** This is the best method but can use a lot of gas and requires additional setup.

- **Solder flux.** A thick layer of solder flux can help reduce oxide formation. Place the flux on the back side of the workpiece. The flux should be as viscous and thick as possible. Some fluxes may work better than others.

Despite the aforementioned, it should be noted that titanium is very simple to weld. With proper gas shielding, the weld looks bright and clean. Titanium to titanium welds are simple to perform and are strong. Titanium welded to other metals can have a variety of results. For example, titanium to gold results in a clean looking but brittle weld. Copper to titanium has similar results. Silver to titanium is relatively strong. When welding titanium to other materials remember to test the weld strength with scrap pieces before welding the final workpiece.

One important consideration when welding niobium is it's high boiling temperature (4742 ºC) relative to tungsten's melting temperature (3410 º C). What this means: If the tungsten electrode is contaminated with niobium metal the niobium may superheat and start to boil right on the electrode. This boiling of the niobium will in turn melt the tungsten electrode causing it to lose its sharp shape.

GOLD

Yellow gold is a relatively simple material to weld. Typically, it will produce a strong and symmetric weld spot and resulting welds are smooth and require little cleanup. This is true for even lower karat golds; however, please note that weld results will improve with higher gold content. Typically, the different metals added to gold are used to change its wear characteristics and color. The more additional metal added (not gold) the lower the karat value. Lower karat golds that contain copper and silver, etc. can produce a black coating around the weld's surface. This can easily be steam cleaned, wiped off with a clean rag, or taken off with a glass brush.

Sometimes during the welding process a small amount of the welded metal will evaporate. Different metals will evaporate at different rates from the weld pool. The evaporated metal can deposit around the weld location in a very thin layer that can look black. This type of deposit can typically be removed by steam cleaning, wiping with a clean rag or with a glass brush.

Gold alloys can contain small amounts of zinc (0.5-1.0%). This zinc addition is used as a deoxidizer during casting, and can improve the fluidity of the molten metal. As discussed above, zinc can cause porosity and will contribute to a black film that must be removed via glass brush or clean rag.

- **Yellow Gold** (one example of its physical properties and composition): 58-75% gold, 12-27% silver, 9-15% copper and some zinc
- **White Gold:** White gold is also a relatively simple metal to work with. There are two main types of white golds – palladium-white gold and nickel-white gold.
- **Palladium White Gold** (one possible composition): 58.5% gold, 10% palladium, 28.5% silver, 2.5% (copper, nickel, zinc)
- **Nickel White Gold 14k** (one possible composition): 58.5% gold, 25.8 % copper, 15.3% nickel, 0.4% zinc

White gold can contain higher levels of zinc content and can lead to weld defects like porosity, etc. as the zinc boils out of the weld joint. Please see the previous discussion on overcoming porosity. In short, welding over the location with porosity again will help remove the porosity. A fresh, sharp electrode will help with this process. Sometimes adding pure laser wire will also help in removing porosity.

In general, gold welds easily. Here are some tips when working with gold:

- Typically a sharp electrode is preferred when welding gold.
- Gold can easily accept small or large weld spots
- It is often typical that gold will look black surrounding the weld location. This black layer is easily removed with steam cleaning, clean rag, or a small glass brush.
- Gold can easily be added to almost any other metal.
- Very interesting welding combinations are possible.

PLATINUM

Platinum has a melting temperature that is similar to stainless steel, but a density that is three times higher. In addition, the specific heat of platinum is lower by a factor of 4 than stainless steel. This means that it takes less energy to raise the temperature of platinum to its melting temperature. The end result is that platinum is a little more difficult than stainless steel to weld but very similar in overall behavior.

One important consideration when welding platinum is its high boiling temperature (3827 ºC) relative to tungsten's melting temperature (3410 ºC). What this means: If the tungsten electrode is contaminated with platinum metal the platinum may superheat and start to boil right on the electrode. Boiling platinum will in turn melt the tungsten electrode causing it to lose its sharp shape.

PALLADIUM

Palladium is a white lustrous metal that is typically a much lower cost than platinum. Palladium is also much lighter, having a density ½ that of platinum. It would seem that palladium is the perfect metal. Unfortunately, palladium is generally difficult to work with and is somewhat difficult to weld. This is mainly due to palladium cracking during the welding process.

Palladium can be welded using the Orion welder, however, cracking can occur. Palladium cracking is an especially difficult phenomenon to overcome with laser or pulse arc welding. If only one weld spot is made, cracking will typically not occur unless the weld joint is stressed by hammering, etc. This means that welding over porosity in a pallaidum piece can be accomplished with the Orion to help clean up the metal during the finishing process. However, welding more than one overlapping weld will inevitably lead to cracking.

As discussed earlier, similarly, palladium cracking can be thought of as a combination of hot cracking and new weld puddle crystal structure problems. After a weld, the molten palladium re-crystallizes, typically forming a large and weak metal grain structure. When welds overlap, the new crystal structure in the last weld puddle is weak compared to the original metal. The result: A crack will start at the edge of the new weld where it overlaps with the old weld joint as the new weld cools and is stressed. The crack will then run along the middle of the weld puddle in the direction of the overlapping joints. This cracking is due to the stresses created during the weld puddle cooling process as described above with hot cracking. However, this time instead of geometry causing the cracking, a rip starts in the old crystal structure and propagates during the cooling process, much like ripping a piece of paper. The result: Palladium is difficult to weld successfully without breakage. Typically, single spots of porosity can be welded and fixed but overlapping welds will crack. There is a welding solution that can stop this cracking process. The addition of gold fill wire to the weld joint creates a new alloy and stronger crystal structure. The gold can discolor the weld joint. However, by welding over the joint several times the gold will diffuse into the palladium. Another possible solution is to use a high gold content white-gold palladium alloy laser wire.

SILVER

Silver is an interesting metal with several properties that must be considered during the welding process. First, silver is highly reflective over a large range of light wavelengths. This metal characteristic makes welding silver difficult for a laser, but poses no problems for a pulse arc welder. Second, silver is a very mobile metal when in a liquid state and has low surface tension when compared to other metals. Because of these properties, how the weld energy is applied to silver is important.

When welding silver it is important to understand the concentration of your weld energy relative to the size of the silver being welded. For very small welds, a sharp electrode poses no problem. This means that in the Orion's arc mode, silver will typically behave well even with a concentrated, focused beam of energy (i.e. a very sharp electrode tip point). However, as the desired spot size gets larger (bigger arc mode welds and almost all pulse arc mode welds) the liquid silver is easily pushed around by the welding pulse. This will lead to large blobs of material being displaced from the weld site resulting in a noticeable hole. To avoid this problem, simply un-focus the weld energy by creating a truncated electrode tip flat. The size of the flat depends on the size of the weld. For relatively small welds a small flat is all that is required. For very high energy welds the electrode may be completely flat (1mm diameter).

Resistance welding silver in tack mode is very difficult because of silver's high electrical conductivity. Sterling silver has a high electrical conductivity very similar to that of copper. However, Argentium silver is approximately 30% less conductive. This means that more heat can be generated during the spot welding process due to the additional material resistance. Use Argentium silver if your application requires spot welding as opposed to pulse arc welding. Even while pulse arc welding it may be desirable to use Argentium silver because of its superior tarnish resistance. Thin Argentium silver parts can be welded directly using copper electrodes. Thicker silver parts may require a weld projection or "bump" to focus the weld current. This welding strategy is discussed in detail in Chapter 4.

ALUMINUM

Aluminum behaves very much like silver during the pulse arc welding process. Aluminum has a very low melting temperature (660 ºC) and is very mobile when in a liquid phase. This means that the same principles that apply to welding silver also apply to aluminum. Aluminum also has one additional complication that may make it difficult to work with in some situations. This metal is very susceptible to hot cracking. On occasion the weld parameters or geometry may be such that a crack may appear in the weld. Always perform test welds for strength verification. In general, pulse arc welding in aluminum will produce a weaker weld than with other metals.

STAINLESS STEEL

Stainless steels are relatively simple to weld. The weld puddle looks smooth and joins easily and the resulting weld joint is strong. Because of the low thermal conductivity of stainless steel, it is easy to hold the workpiece in hand while welding without weld heat immediately making the workpiece too hot to hold. Use only stainless steel fill wire when welding. If regular low carbon steel is used, the weld joint will eventually rust over time.

Austenitic stainless steels, (304 for example) weld easily. However, hot cracking is a possibility with this material. To help avoid any cracking it is helpful to weld using an alloy that will produce a small amount of ferritic crystal structure in the weld joint. The addition of the ferritic crystal structure will help suppress cracking. For example, when welding 304 stainless, a 308 stainless fill wire can be used. Not all situations will require crack suppression techniques. Smaller parts, like those typically welded using the Orion, do not require these procedures (for the following types of stainless steel: 201, 202, 205, 216, 301, 302, 303, 304, 305, 308, 309, 310, 312, 314, 316, 317, 321, 329, 330, 332, 347, 348, 384, 385).

Martensitic stainless steels (410 for example) have a high carbon content. This high carbon content increases the risk of cracking. To decrease the risk of cracking it may be helpful to increase the workpiece temperature to between 200 – 300 ºC. Often material thinner than 3mm can be welded successfully without heat treatment provided that pure argon is used during the welding process (for the following types of stainless steel: 403, 410, 414, 416, 418, 420, 422, 431, 440, 501, 502, 503, 504).

LOW CARBON STEELS (MILD STEEL)

Low carbon steels typically weld easily with no major cautions. Please be advised that low carbon steel will rust and will often come with a coating of zinc. The zinc coating will cause the metal to appear more white or lustrous than typical steel. As discussed above, welding on zinc is problematic. The zinc will evaporate quickly from the weld area causing a black coat to spread to the surrounding metal (including the welding stylus). The zinc evaporation may also cause strange weld behavior, etc. For best results select a low carbon steel without a zinc coating. Make sure the steel is free from other contaminates such as rust or oil. Remember that if using the Orion to produce welds in very thick pieces the weld joint may need to be prepared as discussed previously.

HIGH CARBON STEELS (SPRING STEEL / TOOL STEEL)

High carbon steel welds easily but may become brittle after the welding process. To avoid weld failure the part must be heat treated after the welding process.

COBALT CHROME ALLOYS

Cobalt Chrome is very sensitive to oxygen contamination. If there is insufficient argon coverage or oxygen present in the argon gas this alloy will crack. Once oxygen embrittlement has occurred the weld area must be removed (via grinding etc) to prevent future cracking over the same area.

COPPER

Copper is one of the more difficult alloys to weld because of its high heat capacity and high thermal conductivity. These factors make it even more difficult to weld than silver. Copper also requires more energy than silver for the weld to take place (about 30% more). Thin copper, however, welds very easily and lower energy is typically sufficient to produce very strong welds. For thicker copper similar techniques as those employed to weld silver must be used.

BRASS

Brass is a material that contains a large amount of zinc, 30-37% zinc by composition. The remaining material is copper.

As discussed previously, zinc is a hard metal to pulse arc weld or resistance weld because of its low melting and boiling temperature (420 ºC, 907 ºC). During the melting process the low temperature zinc evaporates/boils out of the brass alloy.

For low energies this simply coats the surrounding material in a black zinc film that can easily be removed with a glass brush. For larger pulse arc weld energies the black coat can cover larger areas and porosity can develop at the weld location as zinc boils from the weld.

Joining Different Metals

Welding different metals together will produce a new alloy at the weld location. The new alloy will have different properties (although in many cases similar properties) to the base metals. Some metals combine well, forming a strong and useful new alloy. Other metal combinations are weak and brittle.

Helpful Hints for Combining Different Metals

- Check the new alloy strength with scrap material to ensure the joint will turn out as expected.
- You may need to weld over the joint location several times to get complete mixing of the weld pool and a uniform new alloy. In most cases this is not necessary for a strong joint and the first weld will be sufficient.
- Some material combinations may benefit from a third metal at the joint which forms a better/stronger alloy with the two primary metals.

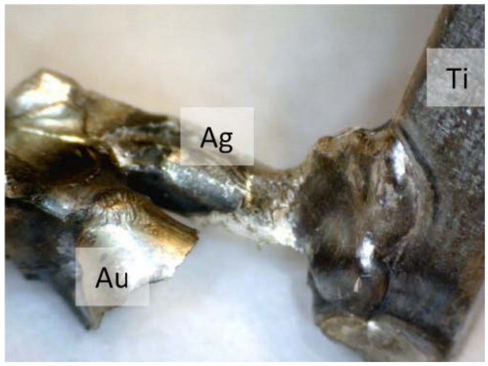


Figure 37.1. An example of titanium welded to gold and silver. The gold to titanium weld looks clean but is brittle. The silver to titanium weld also looks good and is strong.

Chapter 6: Operational Resources

Frequently Asked Questions

Can I use any attachment while in Tack Mode?

No. The pulse arc welding stylus should never be used while the Orion is in Tack Mode. However, any other attachment can be used. Attachments sold as "tack" welding attachments have been designed to transfer more energy to the weld. These attachments help the Orion work as not only a tack welder, but as a permanent fusion resistance welder.

Can attachments labeled "tack" be used with the pulse-arc welding stylus?

Yes. The pulse arc welding stylus requires an electrical contact to the workpiece. Tack welding attachments can be used for this purpose.

Please note that tack welding attachments will also transfer more energy to the arc when used for Pulse Arc Mode. This means that you should use lower energy settings than you would need with pulse-arc attachments.

I want to get the most power possible out of the Orion. What can I do?

The Orion is designed to deliver a tremendous amount of energy in Tack Mode. You can use up to 10AWG cabling to deliver more energy to the work area.

NOTE: Using larger cabling (ex. 8 AWG or larger) may damage the welder and will void your warranty.

Can I make my own welding attachments?

Yes, the Orion welder is very versatile. You are welcome to make your own pulse arc and tack/fusion welding attachments.

NOTE: 10 AWG is the largest cable that should be used with your Orion welder. The 10 AWG cable should not be shorter than 3.5 feet (1m).

Can I make permanent welds in Tack Mode?

Yes, the Orion has been designed with Sunstone Engineering's industrial spot welding (resistance welding) technology. By turning up the energy, and using tack welding attachments, the Orion is a fully fledged resistance welder, often called a fusion welder. Alternatively, by using low energy, or small cabling, the Orion will act as a temporary tack welder. This temporary tacking allows positioning of a weld piece before permanent welding in Pulse Arc Mode.

What materials can you weld with the Orion?

The Orion can weld a wide variety of materials. Some examples include gold, silver, platinum, steel, stainless steel, titanium and virtually all other precious metals. In addition, cobalt alloys, aluminum, tin, brass, and even copper can be welded with the Orion. Even with an ideal welder, some materials and alloys will be difficult to weld. Furthermore, some materials such as zinc should not be welded because they may produce fumes that will make the welding technician sick. Pulse arc welding of solder is also not advised because of its low melting temperature. Solder will vaporize easily and leave your workpiece looking blackened or burnt.

Can I build-up or add material to a weld location?

Yes, the Orion is very versatile. In Pulse Arc Mode, filler wire can be used to add metal to a weld location. In Tack Mode, filler wire or sheet filler can be permanently affixed to a location. Wire sizes up to and greater than 1mm in diameter can be added. However, the operator should select wire diameters that match the size of the feature being welded. Operators should also select wire with similar material to that of their workpiece. For example: when re-tipping a gold ring, 0.25mm gold filler wire is an excellent choice. If filling a large gap in a steel workpiece, 1mm steel wire may be more suitable. The Orion has the energy and versatility to weld both of these, and many more applications with ease.

Can the Orion weld silver?

Yes, the Orion has been specifically designed with the more difficult-to-weld materials in mind. Silver requires appreciable energy for a sustained period of time. The Orion has enough energy and capacity to make quick work of your silver applications.

Can I weld different (dissimilar) metals together?

Yes, in many instances different metals can be welded easily together with the Orion. In pulse arc welding the weld spot location becomes a new alloy of the two primary metals (this new alloy will adopt new properties that may be better or worse than the primary materials). Dissimilar metals can also be joined in Tack Mode. Again, weld strength and properties will depend on alloy properties.

How do I determine the best energy settings for my application?

In Pulse Arc Mode, metals will weld according to thermal conductivity and melting point. For example, a metal with lower thermal conductivity (e.g. stainless steel, titanium, cobalt alloys) will weld easily because the weld heat stays concentrated in the spot. Therefore, less energy is required to weld one of these metals than other metals of the same thickness that have a higher thermal conductivity.

Metals with higher thermal conductivity (e.g. copper, silver, gold) will require more energy to create the same spot because much of the heat is conducted away quickly.

The melting temperature of the metal is also very important when determining the necessary energy setting for a weld. Knowing the approximate, or relative, melting temperature of your working metal will enable you to estimate the amount of energy required to create a spot. High melting temperature translates to a large amount of energy required. Low melting temperature translates into a smaller amount of energy required to make the weld.

In Tack Mode, energy is important but there are two other important factors that need to be remembered. These factors are electrical conductivity and contact pressure. In Tack Mode the Orion is a full-fledged resistance welder. This means that the Orion uses a metal's electrical resistance to create the weld heat. Metals that conduct electricity well (e.g. copper) are more difficult to weld in Tack Mode and require special Tack attachments to obtain a proper weld.

The second important factor when in Tack Mode is the weld contact pressure. The weld contact pressure can be controlled by how much force you apply to the two pieces that are being welded together. The harder you push the pieces together the lower you make the electrical contact resistance between them and the lower the created heat. Conversely, light pressure will result in high contact resistance and high heat.

For all welds, the size and thickness of the metal will play a significant role in the energy settings that you choose. Orion recommends that users start at a low energy, and work upwards until an appropriate energy setting is found.

Will I contaminate my base material with the tungsten electrode?

There is a possibility of tungsten contamination when the Orion user forces the welding electrode into the weld material. However, with proper practice using the pulse-arc welding stylus contamination is very unlikely.

Do I need to use argon to weld?

Argon is necessary to produce a clean and repeatable pulse-arc weld. Without protective argon, oxygen may combine with the weld metal to produce brittle and porous welds. In Tack Mode, however, protective argon is not necessary. Other protective gases can also be used, such as pure nitrogen. You can purchase Sunstone pure argon directly from Sunstone by calling or texting +1-801-658-0015.

How do I control weld spot size and weld depth?

Simplified answer: Energy adjusts your spot size while your weld time controls penetration. In reality both of these factors (energy and time) influence both welding characteristics (spot size and weld depth). However, the above rule-of-thumb will allow good and intuitive control of your welding parameters. It is also important to keep your tungsten electrode sharp to maintain precise control over the characteristics of the weld spot size and weld depth.

How much heat is added to my workpiece?

The Orion is capable of extremely fine welds. In low energy settings, small amounts of energy are added and cause virtually no heat to be added to the workpiece. During small welds involving little energy it is possible to hold the workpiece in hand. For applications that require higher energy, your Orion (depending on the model) is capable of adding up to 250 Joules (Ws) of energy to a weld. Until the user is familiar with the welding characteristics of the Orion, we recommend holding all parts with the pulse arc attachments (e.g. alligator clip) and not with your fingers.

What is the smallest and largest spot size achievable?

The answer to this question depends greatly on the material being welded. However, spot sizes of down to 0.75 mm and up to 3.5 mm are typical and simple to implement.

How deep can my pulse-arc weld penetrate?

Depends on the material being welded, however, spot depth of down to 1 mm can be achieved.

How long will electrodes last?

Under normal use electrodes will last for approximately 8,000 welds. To ensure that you get the most life out of your electrodes use argon gas for pulse-arc welding and maintain a sharpened electrode tip during the welding process.

Are there special joint preparations needed when pulse-arc welding?

Pulse-arc joint preparation is very similar to that of general "tungsten inert gas," or TIG, welding. Some different types of weld preparation include the simple "I" seam (but joint), X, Y and V joints (named for the way they look). The "I" seam may require no filler material, while the X, Y and V require filler material and may require successive layers of material to be added to the joint. For joints were the Orion can penetrate approximately ½ to ¾ of the way through the material an "I" seam may be appropriate. The weld location should be cleared of solder as this will reduce weld quality.

Are there special joint preparations needed with tack/fusion welding?

Just as in pulse-arc welding, all solder should be removed if a strong metal to metal tack/fusion weld is desired. Tacking can be used to weld solder in place, or to temporarily tack a workpiece to a solder layer.

Can I use Tack Mode to place solder granules or pieces before a soldering torch is used?

Yes, this is a very simple process. A variety of hand pieces are available.

Trouble Shooting

Problem	Solution
My welder won't turn on.	• Verify that the power cord is plugged into the rear panel of the Orion and also into a power outlet. • Do NOT use an extension cord with the Orion. • Check the circuit breaker for that particular power receptacle. • Check and replace any blown fuses in the Orion's Fuse Bay.
My electrode keeps sticking before I even weld.	• Clean the workpiece at the weld site. • Clean or sharpen the electrode. • Increase the energy slightly to add more energy to the arc.
I can trigger a weld, but it always aborts and does nothing.	• Hold the stylus steady so that the electrode continuously contacts the workpiece. If contact is lost, even for an instant, the weld will abort. • Verify that the attachment plugged into the + terminal is making constant contact with the workpiece. • Clean the surface of the workpiece at the weld site. Oil, carbon deposits, and other residue can cause continuity to be lost. • Verify that the electrode is sharp and not deformed at its tip. Replace or sharpen the electrode as necessary.
My electrode keeps sticking when I weld.	• Verify that the current mode is not Tack Mode. • Hold the stylus so that there is less pressure on the electrode. Very low energy settings will require extremely little pressure on the electrode. • Increase the energy slightly to add more energy to the arc.
I'm set to Auto Trigger (Touch Detect) but nothing ever happens when I touch the electrode to my workpiece.	• Verify that the workpiece is clipped to, or touching, an attachment that is securely plugged into the + Arc terminal. • Verify that the play button is green. • Verify that the stylus connector is completely inserted into the stylus receiver on the front panel. Disconnect and reconnect it following the procedure given in the Setup Instructions. • The workpiece is not conductive and cannot be arc-welded with the Orion.

Problem	Solution
My welds look dirty or blackened.	• Change the flow rate of the shielding gas. Between 5 -10 PSI is recommended. • Decrease the length of exposed electrode to bring the workpiece closer to the stylus nozzle. • Verify that there are no gas leaks at the gas receiver on the rear panel of the Orion and also at the stylus connector on the front panel. Note: Gas cannot leak from the stylus connector except during a weld. • Increase your gas post flow to ensure that welds will look cleaner.
The Orion indicates I have gas connected even after I've turned my tank off.	• Even though the tank's valve has been shut, there may still be residual pressure in the gas tube. After the pressure is released, the Orion will display the gas connectivity status correctly.

Glossary

Capacitive Discharge (CD): An effective resistance welding technology that stores energy in capacitors in order to release a consistent amount of energy in every weld. Orion uses this technology to produce clean and smooth welds.

Custom Setting: The available "slots" for settings that a user may customize and then save.

Factory Preset Setting: Refers to the settings that have been pre-programmed into the Orion.

Hand Attachment: The Orion comes with a variety of hand attachments that can serve as a positive or negative electrode depending on the circumstances.

Joule: See Watt Second.

Liters Per Minute (lpm): Used to reference a gas flow rate for shielding gas (argon).

Millisecond (Ms): One thousandth of a second (.001). Used to reference the Weld Time or length of a weld pulse.

Plasma: Plasma is an ionized, high temperature gas, in which a certain proportion of electrons are free rather than being bound to an atom or molecule. The ability of the positive and negative charges to move somewhat independently makes the plasma electrically conductive. The Orion's pulsed arc uses this high temperature plasma to create a weld.

Pulse Arc Welder: Arc welding uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point; Pulse refers to the intermittent nature of the weld arc produced.

Resistance Welding: A process that uses the electrical resistance properties of a metal as a method of welding.

Shielding Gas: Argon, or other inert gas, is used while welding to displace the regular atmosphere from the weld location. This drastically reduces oxidation and carbonization of the metals increasing the weld quality.

Stylus: On the Orion, the stylus is the main hand piece used for arc welding. It safely encloses the electrode and directs the shielding gas to the weld area.

Tack / Fusion Welding: Tack welding can refer to a semi-permanent weld to place parts prior to permanent pulse arc welding. Fusion welding can also refer to a permanent resistance weld. See Resistance Welding.

TIG Welding: Also known as Tungsten Inert Gas Welding; an arc welding process that uses a non consumable tungsten electrode to produce a weld. The weld area is protected from atmospheric contamination by an inert gas such as argon.

Trigger: When using the Orion welder the term trigger is used to denote what method the operator is using to initiate the welding cycle. When the trigger is set to “Automatic” the Orion will automatically detect the contact between the tungsten electrode and the workpiece. Once contact is made the weld sequence will initiate automatically. When the trigger is set to “Foot Pedal” the Orion will not initiate the weld sequence until the foot pedal is depressed and there is contact between the tungsten electrode and the workpiece.

Watt Second (Ws): The reference for weld energy. A Watt second is the same as a Joule. 1 Ws = 1 J.

Workpiece: In this manual, workpiece refers to anything being welded or worked on.

Chapter 7: Cleaning

Workpieces

The included fiberglass brush can be used to clean off weld debris and discoloration from weld areas. The bristles are extended and retracted by twisting the top.

General Cleaning Guidelines

Be sure to only perform cleaning on the Orion when it is switched off and unplugged. Never use abrasive cleaning implements on any part of the Orion. Do not blow compressed air into any part of the Orion as this may damage the internal components. Never use any chemicals besides mild detergents on any part of the Orion. Always clean the Orion's parts indirectly by moistening or spraying a soft cloth first, and then use only the cloth to perform the cleaning.

Stylus and Hand Attachments

If discoloration appears at the end of the stylus or hand attachment, it can be wiped off using a moistened cloth.

Cables and Cords

Detach cables and cords from the Orion and wipe them off using a moistened cloth.

Orion's Case and LCD Screen

Wipe gently with a moistened cloth being careful not to let any moisture into the air vents.

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