



Welder's Guide to ARC Stud Welding

September 2003 Revision 2

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OTHER INFORMATION:

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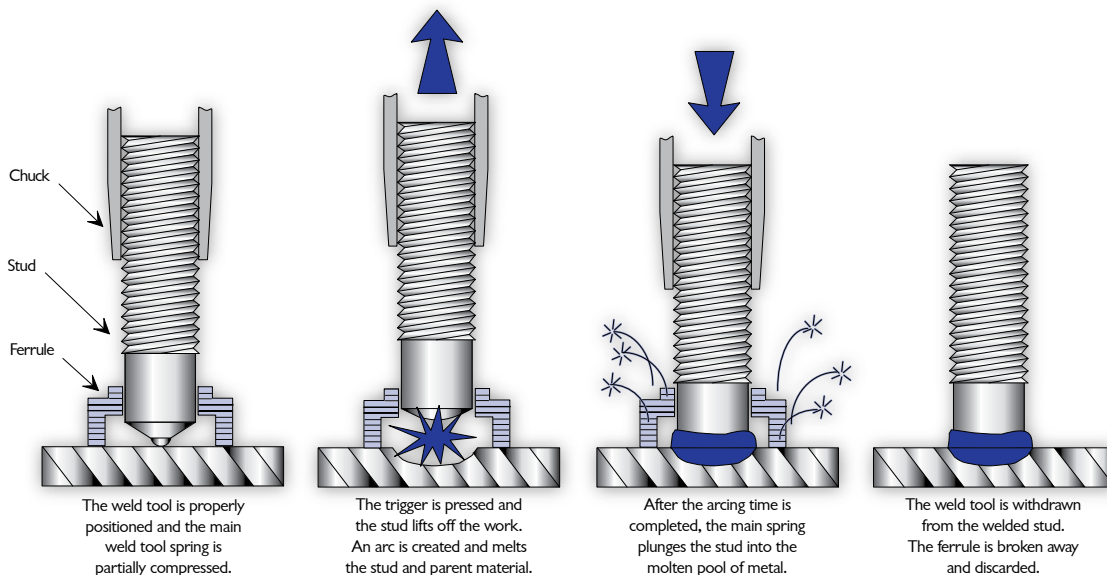
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Sequences of a Stud Weld



- 1.) The arc stud is loaded into the stud weld tool chuck.
- 2.) A ferrule is placed into the ferrule grip.
- 3.) The arc stud is positioned against the work surface to complete an electrical circuit.
- 4.) The operator initiates the weld cycle by pulling the weld tool trigger.
- 5.) The weld tool lifts the stud up from the work, drawing a pilot arc.
- 6.) The pilot arc establishes a path for the weld current which comes on after the stud is lifted.
- 7.) The stud remains lifted for the duration set on the controller. During this time the weld current is melting both the stud and the parent metal.
- 8.) When the time set on the controller has elapsed, the weld tool plunges the stud into the molten pool of parent material and the weld is completed.
- 9.) The ferrule is broken away and discarded.

Two concepts which require further discussion are “Plunge” and “Lift”.

What is Plunge? The amount of stud which protrudes beyond the ferrule when the stud weld tool is in its normal state. This represents the portion of the stud to be used in forming the weld fillet. Short plunge may cause incomplete fillet formation while too much plunge may cause excessive splatter which may also leave incomplete fillets or uneven fillet formation. The amount of plunge also determines the degree of spring pressure plunging the stud. Therefore, it is logical that too much plunge will “splatter” the weld, while too little will result in an incomplete fillet.

How Much Plunge? Typically the amount of plunge should be set at 1/8” excluding the flux ball. Vertical wall stud welding will typically require additional plunge for complete fillet formation (3/16”). See setting plunge in this booklet.

What is Lift? The Lifting motion is essential to the stud weld process since it creates a gap which the current must bridge. This air-gap increases the electrical circuit resistance and generates the heat necessary to melt the stud and parent material for the weld. If no gap exists there would be a direct short to the base material and sufficient heat would not develop.

How Much Lift? The lift, once set, should not usually require changing until the weld tool is disassembled and cleaned. Typical lift requirements are 1/16” to 3/32”. See setting lift in this booklet.

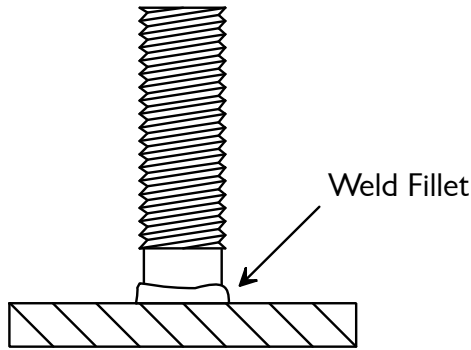


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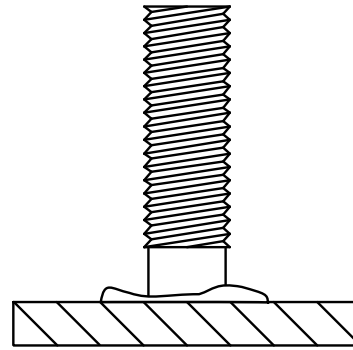
Visual Inspection of Weld Studs

The amount of stud metal melted and the appearance of the weld fillet can be related to the amount of power consumed in forming the weld. Visual inspection is dependent upon the interpretation of the appearance of the welded end of the stud and can be remarkably accurate if certain guidelines are followed. To assist you, the sketches and descriptions below show examples of various welds with the proper interpretation and corrective action.



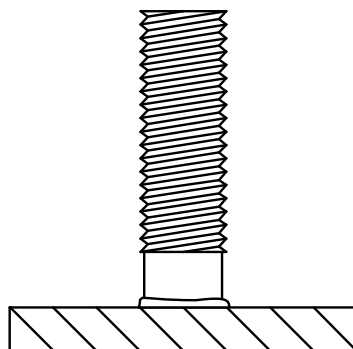
GOOD WELD

A good weld is characterized by a clean even fillet of good height all the way (360°) around the weld stud. The fillet should be bright and shiny with a bluish color and have a slight flow of metal into the base material from the bottom to the fillet. Another good indication of weld integrity is to check the burn-off. Place a stud next to one that has been welded, the welded one should be approximately 1/8" shorter.



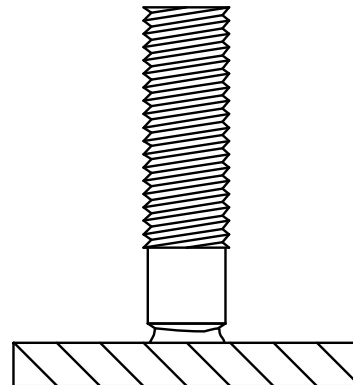
HOT WELD

A hot weld can be identified by a concave weld fillet that is close to the work surface (washed out fillet). Additionally, there may be excessive weld material spattered beyond the area contained by the ferrule. You may also be able to notice burn through on the base material. Corrective action is to decrease time, power or both.



COLD WELD

A cold weld is indicated if the weld fillet is not formed completely around the weld stud (360°) or there is low fillet height this may indicate a cold weld. NOTE: This may also be an indication of too little plunge. Verify the plunge setting first! Another sign of a cold weld is a dull grayish appearance and/or stringers ("spider legs") coming from the weld fillet. Corrective action is to increase time, power or both.



HANG UP

A hang up occurs when the stud base is partially melted away and the stud appears to be perched on a small portion of its base. This is caused by a bind in the weld tool that prevents the stud from plunging smoothly. A bind in the weld tool shaft will cause this, but most often it is caused by the stud rubbing the ferrule. For a good weld to occur consistently, it is extremely important that the stud be exactly centered in the ferrule. This is accomplished by adjusting the weld tool foot.

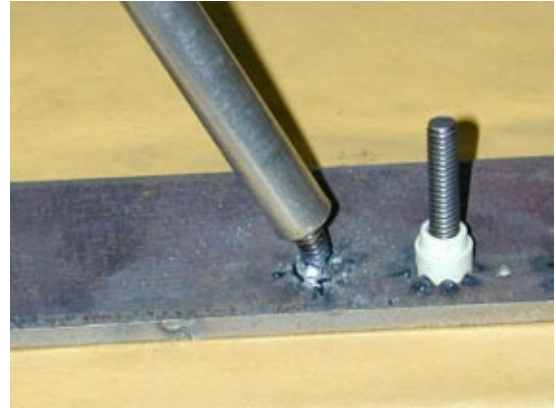
Physical Inspection of Weld Studs

Physical tests should be performed as part of the qualification procedure before beginning production welding to ensure the set-up parameters are correct. This should be done at the beginning of a new shift or after changing stud diameters or materials.

Physical tests are destructive and should be done only on test plates.

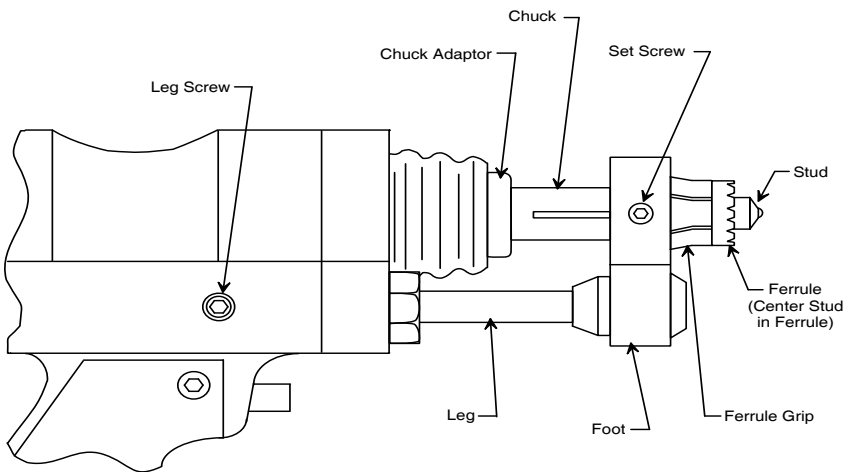
Suggested physical tests are as follows:

1. Bend Test The stud to be tested should be bent 15° away from its weld axis and back to 0° or until failure occurs. Bending can be done with a hammer or with the aid of a bending tool such as a tube or pipe. Failure should occur in the stud material itself or, on thin plate, a plug of base metal should be torn out.



2. Torque Test The stud should be torqued until a pre-specified load is attained or until the stud fails. Failure should occur in the stud material itself or, on thin plate, a plug of base metal should be torn out.

Adjusting Stud Weld Tool Plunge



1.) Place a chuck into the chuck adapter. Tap on the end lightly to make sure that the chuck is properly seated in the adapter. **NOTE: A different chuck is required for each different stud diameter.**

2.) Insert a ferrule grip into the foot and tighten the set screws on the foot. **NOTE: A different ferrule grip is required for different size ferrules.**

3.) Insert a stud into the chuck and a ferrule into the ferrule grip.

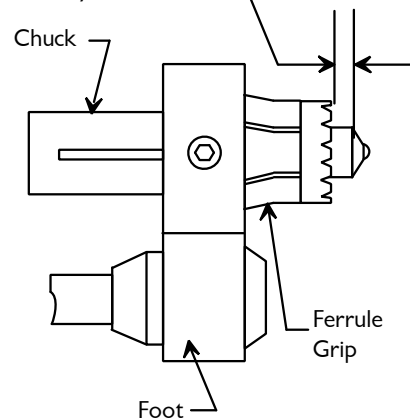
4.) Loosen the screws holding the FOOT and adjust the foot so the stud is centered in the ferrule. **THIS IS IMPORTANT** so there is no binding between the ferrule and the stud. This binding could cause improper welds (hang-up). A good rule of thumb is that you should be able to work the weld tool mechanism with the ferrule in place without knocking the ferrule out of the ferrule grip.

5.) Loosen the leg set screws (one on each side of the weld tool).

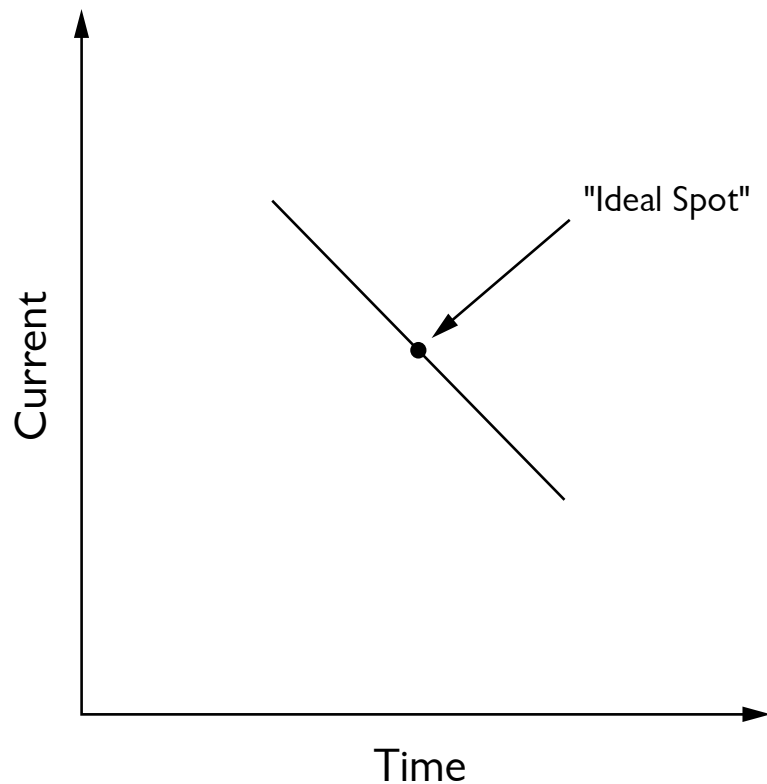
6.) Adjust the legs so that the stud extends 1/8" to 3/16" beyond the end of the ferrule.

7.) After you have properly positioned the legs, tighten the leg set screws on both sides of the weld tool body. **NOTE: You must readjust the plunge setting whenever changing stud lengths.**

Adjust legs so that 1/8" - 3/16" of the Stud extends beyond Ferrule

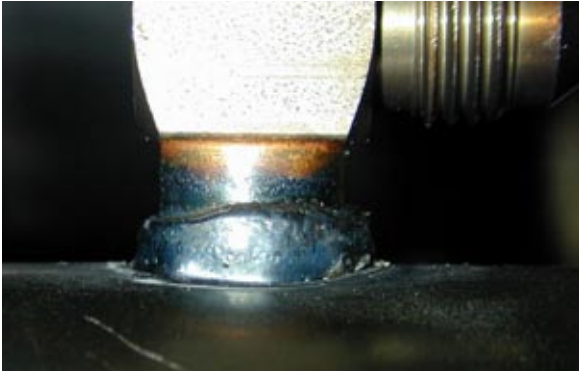


Relationship between Time and Current

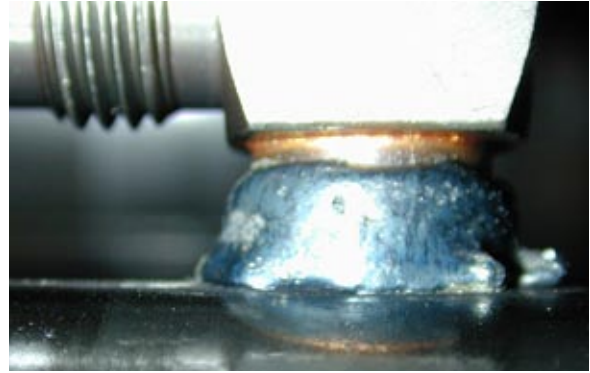


- For any diameter weld base there are many acceptable time and current combinations to achieve good weld results.
- As weld current goes up, the weld time must come down and vice versa
- Ideally, we weld near the center of the line. The relationship does not hold past a certain point. For example, you could not get good weld results using 1 amp for 100 seconds.

Plunge Material



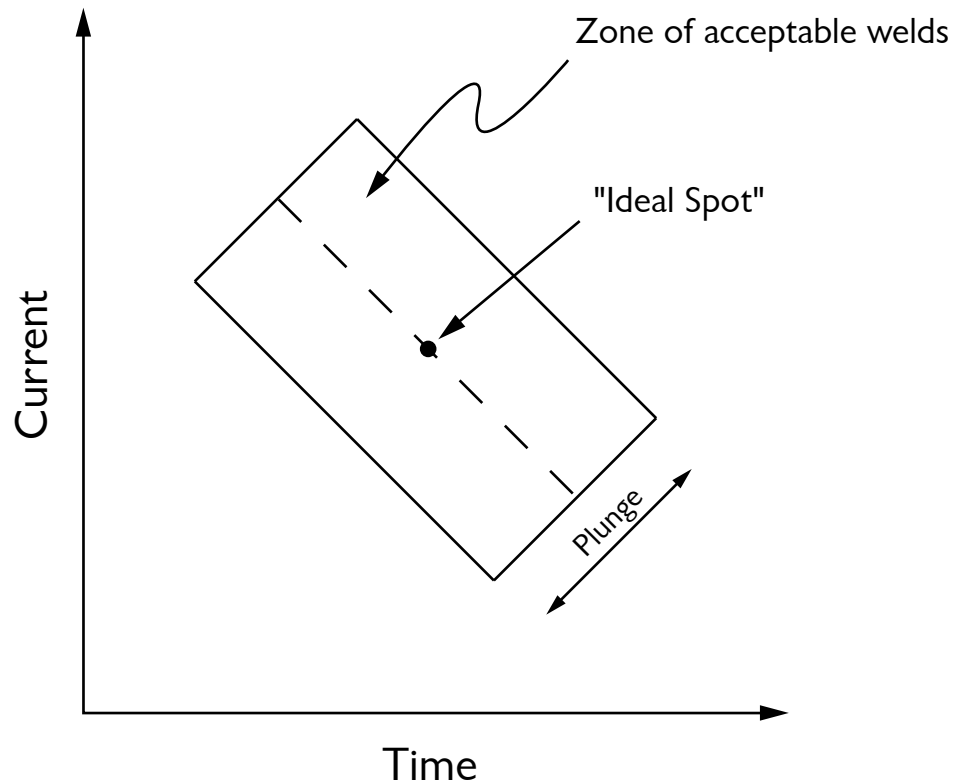
A



B

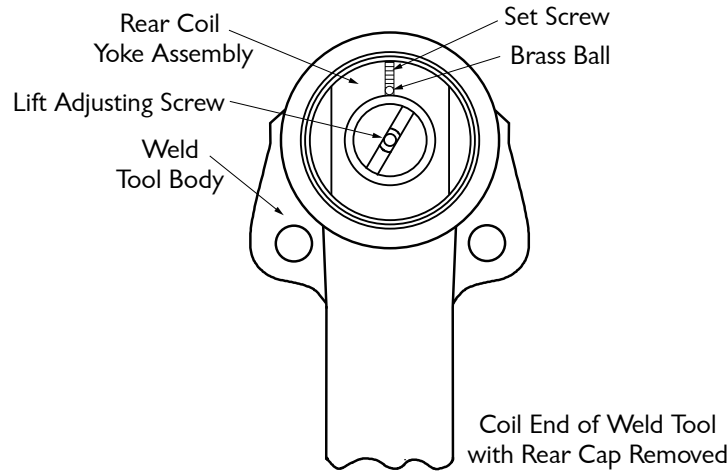
- Which set up had more plunge? B
- Was the ferrule in B full? Yes
- Which set up melted more metal? B
- Which set up will require more power to weld properly? B

Relationship between Time, Current and Plunge



- Plunge settings add another dimension to the time and current graph. As more plunge is added more weld energy is needed. This shifts the line up and to the right.
- The goal of set up is to be in the middle of the “zone”. The reason is so that small, natural process variations keep the results inside the acceptable weld zone.

Adjusting Stud Weld Tool Lift



LIFT DEFINED

Lift is the distance the weld tool will raise the stud above the base plate. This distance governs the power in the weld current arc. Lift that is not properly set will cause unsatisfactory welds.

For most current arc equipment it is not necessary to adjust lift for different size studs. Image equipment recommends setting lift at $3/32$ " or $.092$ " for all stud weld applications. This information is provided to understand lift and adjust older arc equipment.

MEASURING LIFT

- 1.) Turn on the power source.
- 2.) Set time knob to maximum time.
- 3.) If your unit has a "lift check" button, press it.
- 4.) Trigger the weld tool in the air.
- 5.) Measure the distance the chuck or stud moves from a fixed point on the weld tool.

ADJUSTING LIFT

- 1.) Remove the rear cap of the weld tool (see diagram above).
- 2.) Loosen the set screw which holds a nylon tipped set screw against the lift adjusting screw. (The nylon tip prevents the set screw from damaging the threads of the Lift Adjusting Screw.)
- 3.) To Increase lift - Turn the Lift Adjusting Screw counter clockwise.
To Decrease lift - Turn the Lift Adjusting Screw clockwise.
- 4.) Re-measure the lift as above.
- 5.) Once the lift has been set, tighten the set screw and replace the rear cap.

Recommended Lift Settings for Steel Studs	
Stud Diameter	Lift Setting
1/2" or less	1/16"
5/8" to 3/4"	3/32"
Larger than 3/4"	7/64" to 1/8"
Lift Settings for Aluminum Studs	
1/2" or less	3/32"

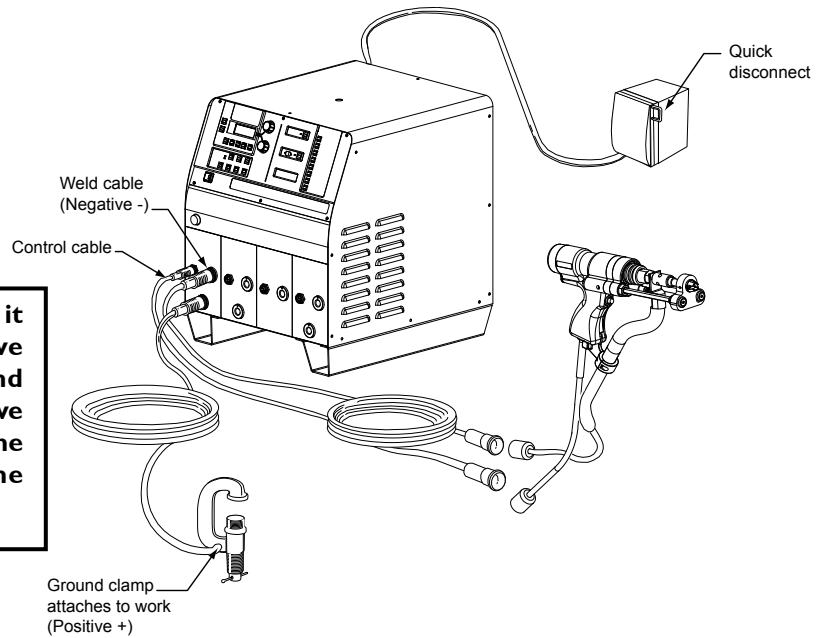


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Time and Current Settings for Arc-Stud Welders

Always follow the equipment manufacturer's suggested settings or the markings on the machine dials as the base line for setting time and current. Note: *The incoming power to the welding machine can effect the required settings.*

When setting up the power supply it is very important to have a positive ground. In other words, the ground cable should be connected to the positive terminal on the power supply and the weld cable should be hooked to the negative terminal.



Stud Diameter	Nelson TRI600/5000		SW I200	
	Weld Time	Current (Amps)	Weld Time	Current (Amps)
1/4"	0.17	425	0.25	350
5/16"	0.25	500	0.31	420
3/8"	0.33	550	0.38	530
1/2"	0.55	800	0.50	800
5/8"	0.67	1200	0.68	1000
3/4"	0.84	1400	0.75	1320

Stainless steel will require additional power. This can be achieved by using more weld current, weld time or a combination of both.

“Rules of Thumb” for Time and Current when Tables are not Available

The following are rules of thumb which can be used as a quick guideline for proper settings for a 1000 amp power supply. For example a 1/2" diameter stud by the rules of thumb would require 800 amps weld current and .5 seconds weld time. On a 500 amp stud welder (with 1/2" capacity) would not be able to be set according to these rules of thumb.

Weld Current Setting

The weld current can be set according to stud diameter. Use 100 amps of weld current for every 1/16" of stud diameter. So a 1/4" stud (4 x 1/16") would require 400 amps of weld current.

Weld Time

The weld time can also be set according to stud diameter. Use the decimal equivalent of the stud diameter. For example, a 1/2" stud would require approximately .50 seconds weld time.



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Maintenance of an Arc Stud Welding System

A majority of the maintenance of an arc stud welding system is in:

- 1.) Stud welding weld tool
- 2.) Welding cable
- 3.) Control cable

These items simply receive the most wear.

CABLE MAINTENANCE

When checking cables for continuity it is important to slightly pull on all the connectors so that if there is a break the wires will be pulled apart. The continuity check can be performed with a standard Ohm meter. All cables: ground, control and weld cables should be periodically inspected.

Also, the cables themselves should be closely inspected for any snags or kinks that could be causing a problem. Insulation around the cable should be periodically checked for wear to ensure proper safety. Finally, for operator convenience, the control cable and the weld cable should be fastened together (electrical tapes works well) to help movement of the weld tool.

WELD TOOL MAINTENANCE

The weld tool, since it carries out most of the welding functions, should be periodically (at least every 3 months) disassembled and cleaned. Special attention should be given to the lifting mechanism. This shaft must be absolutely free with no binding inside the weld tool and there should be no contact between the stud and the ferrule. Never lubricate the lifting mechanism. It should be cleaned with a dry cleaner such as electrical contact cleaner. Caution should also be exercised when reassembling the weld tool to be certain not to pinch wires or the weld cable. This could cause erratic welding problems which are usually difficult to isolate.

POWER SUPPLY MAINTENANCE

To check the power supply, you simply free-air trigger the weld tool at various time settings. If the amount of time that the weld tool stays lifted corresponds to the time you set on the unit, the timing module is usually good. *NOTE: If your unit has a "Lift Check" button on the controller this must be pressed in to check the timing functions.* On Image equipment the lift check function timing does not vary with the time on the display.

Typically, an annual blowing out of the power supply is all that is required. The power supply should be located away from sources of grinding sparks and other heavy contaminants.



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Personal Safety Precautions

- A) If the power source has a stick welding mode the output terminals and any tools connected are always electrically “hot”. In stud welding mode the output terminals are electrically “hot” only while welding. Use only the proper tool with the selected welding mode.
- B) **Always protect yourself from possible electric shock.**
- 1) Never allow contact between the electrically “hot” portions of the circuit and your bare skin or wet clothing. Wear dry, hole-free gloves to insulate your hands.
 - 2) Always insulate yourself from ground by using dry insulation when welding in damp locations or metal floors, gratings or scaffolds and particularly when large areas of your body can be in contact with possible grounds such as sitting or lying down.
 - 3) Maintain all the equipment such as stud weld tool, electrode holder, ground clamp, welding cable and welding machine in good, safe operating condition.
 - 4) NEVER dip the stud weld tool or electrode holder in water for cooling.
 - 5) If two welders are connected together, the open circuit voltage can be the sum of the two. Never touch the electrically hot portions of the circuit.
 - 6) If the welder is used as a power supply for automatic welding, there same precautions are applicable to the automatic unit.
- C) When working above floor level, protect yourself from a fall should you get a shock or startled. Never wrap the electrode cable around any part of your body.
- D) **Arc burn may be more severe than sunburn.**
- 1) When stud welding, safety goggles should be worn by the operator. A shaded No. 3 lens is suggested.
 - 2) When stick welding, arc-air gouging, or observing the same, use a head shield with the proper filter and cover plates to protect your face and eyes from sparks and the ultraviolet rays of an arc. The filter lens should conform to ANSI Z87.1 standards.
 - 3) Use suitable clothing to protect your skin and that of people around you from the arc rays and sparks.
 - 4) When stick welding or arc-air gouging, protect nearby personnel with suitable, non-flammable screening and warn them not to watch the arc or expose themselves to the arc rays, hot spatter or metal.
- E) Droplets of molten slag and metal are thrown or fall from the welding arc. Protect yourself with oil free protective garments such as leather gloves, heavy shirt, cuffless trousers, high shoes and a cap to cover your head. When welding out of position, or in confined areas, wear ear plugs.



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Personal Safety Precautions (Continued)

- F) When in a welding area, always wear safety glasses. Safety glasses with side shields are a must when near a slag chipping area.
- G) Move fire hazards to a place safely away from the welding area. Welding sparks and hot materials generated at the welding arc will go through small cracks and openings into adjacent areas.
- H) When not manual arc welding, place the welding tool where it is insulated from the ground system. Accidental grounding can cause overheating and create a fire hazard.
- I) Connect the ground cable as close to the welding area as practical. Ground cables connected to the building framework or other locations some distance from the welding area increase the possibility of the welding current passing through lifting chains, crane cables or other alternate circuits. This creates fire hazards. Overheating of lifting chains or cable can cause them to fall.
- J) Welding can produce hazardous fumes and gasses. Use adequate ventilation and avoid breathing these fumes and gasses. Welding on galvanized, lead or cadmium plates produces toxic fumes.
- K) No welding should be done in locations near chlorinated hydrocarbon vapors such as degreasing and painting stations. The heat and rays of the arc can react with the solvent vapors to form phosgene, a highly toxic gas, and other irritating by-products.
- L) Do not heat, weld or cut tanks, drums or containers until the necessary steps have been followed to insure that no flammable, irritating or toxic vapors can be formed by the residue.
- M) Vent hollow castings or containers before heating, cutting or welding. A pressure build up may cause it to explode.
- N) For more detailed safety information, consult the pamphlet, "Welding Safety", published by the U.S. Department of Health, Education and Welfare, DHEW (NIOSH), Publication No. 77-131. It is also recommended that you purchase, read and follow the directions of "Safety in Welding & Cutting, ANSI Standard Z49.1" for \$5.00 from the American Welding Society, Miami, Florida, 33125.

Power Supply Safety Precautions

- A) Always connect the frame of the power supply to ground in accordance with the National Electrical Code and the manufacturer's recommendations.
- B) Installation, servicing or trouble shooting should only be done by qualified personnel trained to work on this type of equipment.
- C) Before servicing any piece of equipment, turn off the disconnect switch at the fuse box.
- D) When operating, all covers must be on the equipment.



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Definition of Stud Welding Terms

- Amperage** See Current
- Arc-Blow** The effect where the weld fillet runs away from the ground connection. The electric fields generated during the weld repel the fillet material away from the location of the ground. If this is a concern, it can frequently be addressed through the use of double grounds.
- Bellows** This is the rubber boot that slides over the chuck adapter. This helps to keep dirt, weld spatter and other foreign contaminants from entering the internal weld tool mechanism.
- Burn-Off** The amount of stud consumed during the weld. This “burn-off” material forms the weld fillet.
- Burn Through** A condition where the weld excessively distorts or actually melts through the base material. This is caused by an excessively hot weld or by using base material that is too thin.
- Chuck** The device that holds the weld stud during the welding process. It fits into the chuck adapter. This is a consumable component and should be replaced when worn.
- Chuck Adapter** This component of the stud weld tool holds the chuck and connects to the internal lifting mechanisms. The weld current flows from the weld cable to the lifting mechanism to the chuck adapter to the chuck and finally into the stud.
- Control Cable** This is the thin cable that connects the stud weld tool to the controller. This cable carries the trigger signal from the weld tool to the controller and the lifting voltage back from the controller to the weld tool.
- Controller** The controller initiates the pilot arc, sends the lift signal to the stud weld tool, starts the weld current at the right instant, and controls the duration of the weld. The controller can be a separate “box” or an internal component as in self contained units.
- Current** The flow of electricity is referred to as current and is expressed in Amperes (Amps). There are two types of current: Alternating Current (AC) and Direct Current (DC). Direct current always flows one way: from negative to positive. DC is polarized which means there is a definite negative and positive connection. Alternating current (the type you get from a wall socket) flows back and forth. AC is non-polarized, you can reverse the connections and not alter anything. Stud Welding uses DC current.
- It should be noted that current is an electron flow. The amount of current required determines the size (diameter) of the cable needed. The larger the cable the more current it can carry. See *Resistance*.
- Ferrule** A ceramic shield used in arc stud welding. The purpose of the ferrule is to contain sparks, heat and molten metal in the weld zone while keeping gasses and impurities out.
- Ferrule Grip** Holds the ferrule during the weld sequence. This is a consumable item and should be replaced when worn.



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Definition of Stud Welding Terms

Fillet	The ring of weld metal that surrounds the stud after welding.
Flux Ball	The flux load press into the end of most weld studs. During the weld process the flux load vaporizes and consumes the oxygen at the weld site. This helps to eliminate contaminates in the weld itself.
Foot	This stud welding component is attached to the legs and it holds the ferrule grip. The combination of the legs, foot and ferrule grip determine plunge.
Ground	All equipment should be grounded (the exception is double insulated equipment). The reason for grounding is that the voltages used are always at a potential level different from the ground, and if a good conduction path is established between the equipment and the ground there can be no potential difference developed between the equipment and anyone who is standing on the ground. Thus, if any voltage is leaked it will be conducted away through the ground path rather than through the operator. For the equipment to be properly grounded you must be able to read continuity (no resistance between the ground pin on the plug and any conductive surface on the equipment).
Hang Up	A condition where the stud weld tool does not plunge the stud into the weld pool properly and only a partial weld occurs. This can be caused by the internal mechanisms binding or more commonly by the stud hitting the ferrule. Remedy by adjusting the foot.
Lift	This motion is essential to the stud weld process since it creates a gap which the current must bridge. This air-gap increases the electrical circuit resistance and generates the heat necessary to melt the stud and parent material for the weld. If no gap exists there would be a direct short to the base material and sufficient heat would not develop. Short lift may cause molten metal to bridge the arc gap and seriously hamper weld quality. Excessive lift may result in the arc being interrupted and inconsistent which can cause poor weld results. See resistance.
Pilot Arc	This is the initiating arc which is first formed while the stud is being lifted off the work. It establishes the path for the weld current.
Plunge	The amount of stud, typically 1/8", which protrudes beyond the ferrule when the stud weld tool is in its normal state. This represents the portion of the stud to be used in forming the weld fillet. Short plunge may cause incomplete fillet formation while too much plunge may cause excessive splatter which may also leave incomplete fillets or uneven fillet formation.
Plunge Damper	A device which slows the rate which a stud plunges into the weld pool. This reduces the amount of splash from the molten metal and helps to form a uniform weld fillet. This typically is only necessary for stud diameters over 1/2".



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Definition of Stud Welding Terms

- Power Supply** The power supply can be external, such as a generator or a transformer-rectifier. Ideally, it should have an open-circuit DC voltage in the 70-120 volt range. The current required depends on the stud diameter to be welded. A general rule of thumb is 100 amps for every 1/16" diameter. For example: a 1/4" stud will require 400 amps of weld current. A power supply can also be internal and are call self contained units. Smaller units (1/2" diameter stud capacity) usually hook up to 220 or 440 volt single phase power. Larger units require 220 or 440 volt three phase power.
- Protrusion** See plunge.
- Resistance** This is the opposition to current flow and is expressed in Ohms. The more resistance the more Ohms. Whenever electrical flow is impeded by resistance heat is generated (it is this heat that allows stud welding to work). For example, a 40 foot cable will have twice the resistance of a 20 foot cable of the same type.
- Time** This is the duration of the weld. The general rule is that as the stud diameter increases, the weld time is increased. In cases where there is limited base material thickness, shorter than normal weld time is used and the amperage is increased to give sufficient heat to the weld.
- Voltage** Is the electrical potential difference from one point to another. Electrical current flow is the result of an electrical path (such as a wire) being established between two points of different potential, or voltage levels. If the potentials are continually interchanging and the current flows back and forth, it is AC voltage. This is the type of voltage a generator would provide. On the other hand, if one potential is always higher than the other, such as a battery, it is DC voltage. In DC the higher potential is called positive and the lower potential is called negative.
- Weld Cable** This is the large diameter cable which carries the power for the pilot arc and the welding current to the arc stud.
- Weld Tool** This is the unit the operator holds. It is connected to the controller via the control cable and to the power supply via the weld cable. Besides holding the stud, the weld tool handles the lift, plunge and trigger functions. In other words, the weld tool tells the controller when to begin the weld cycle, the it executes all the weld functions from the controller to complete the cycle.



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