INTERNATIONAL WELDING TECHNOLOGIES, INC.

STUD WELDING TECHNICAL GUIDE
For Weld Pins

PROCEDURE, MAINTAINENCE, AND TROUBLE SHOOTING

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INDEX

INTRODUCTION

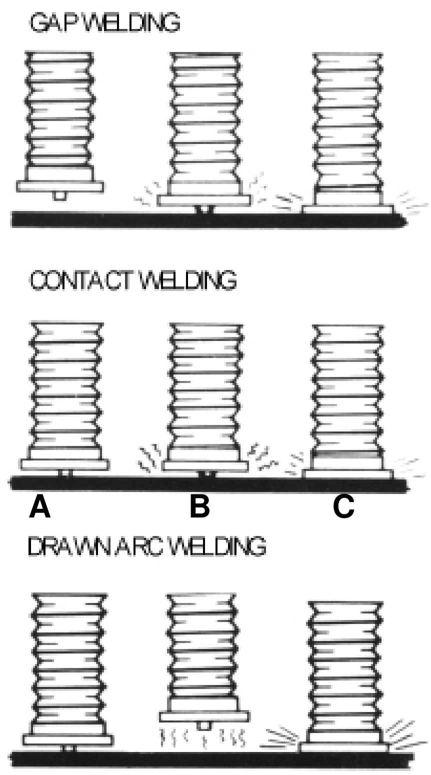
A careful study of this manual will enable you to understand how the welder operates to ensure proper performance under various conditions.

WELDING PROCESS

Capacitor discharge stud welding may be defined as a welding process wherein uniting is produced simultaneously over the entire area of abutting surfaces, by the heat obtained from an arc produced by a rapid discharge of stored electrical energy, with pressure applied during the electrical discharge.

Capacitor discharge stud welding uses a low-voltage electrostatic storage system as a power source in which the weld energy is stored at a low voltage in capacitors of high capacitance.

There are basically three different capacitor discharge stud welding systems - initial gap, initial contact, and drawn arc. These processes vary primarily in the manner of arc initiation. Initial contact system only will be discussed here.



PRINCIPLES OF OPERATION

Initial contact discharge stud welding utilizes studs having a small, specially engineered projection or tip on the weld end of the stud or fastener.

In initial contact capacitor stud welding the stud is first placed against the work as shown in 'A'.

The stored energy is next discharged through the projection at the base of the stud. The small projection presents a high resistance to the stored energy and rapidly disintegrates creating an arc that heats the surfaces to be joined ‘B’. During the arcing the pieces to be joined are in the process of being brought together by the action of the spring. When the two surfaces are in contact fusion takes place and a weld is produced between the stud and the work-piece ‘C’.

VOLTAGE CONTROL

A variable voltage control knob is mounted on the front panel of the unit. Before turning the power switch on, the voltage control knob should be turned to full counter clockwise position. When the equipment is completely connected, turn the power switch to the “ON“ position. The pilot light will glow, indicating power is supplied to the machine.--Slowly turn the voltage control knob clockwise to induce power and set according to the recommendations. (*On LYNX units this control is by push button*)

MATERIAL	FASTENER	VOLTAGE SETTING
Mild Steel	10 ga CD Nail	70 to 80
Galvanized Steel	10 ga CD Nail	80 to 100
Stainless Steel	10 ga CD Nail	70 to 90

NOTE: The above settings are approximate. They are based on a cross-section of applications. Local conditions and materials could alter the settings for any given applications. Test welds should be made before establishing final settings for your applications.

MATERIAL WELDABILITY

MATERIAL WELDABILITY	
BASE MATERIAL	**STUD MATERIAL**
Mild Steel	Mild Steel or Stainless Steel
Galvanized Steel	Mild Steel or Stainless Steel
Stainless Steel	Mild Steel or Stainless Steel

GUN SETUP

1. Insert fastener into chuck all the way until sealed firmly.
2. Position the footpiece squarely and firmly on base material.
3. Depress the trigger of the gun to complete the weld. Pull the welder **straight back** to remove the chuck from the stud and to prevent damaging the chuck.

TEST WELDING

Before making your first weld check the ground clamp. It is essential that no power be lost through a poor connection. The surface under the clamp should be free from oil, scale, grease and rust. The test should be made on a piece of scrap material similar to the material you are going to use during actual production.

1. Examine the weld for quality. Hot welds show excessive splatter. Cold welds show little or no splatter and may have a void between stud flange and work-piece. A full strength weld is determined by bending the fastener back and forth. Failure should occur in the stud shank or in the base material. The weld should not fail.
2. It may be necessary to adjust the weld voltage up or down. **(SEE BELOW FOR TEST WELDS).** When adjusting voltage downward, e.g. from 100 to 80, it is sometimes necessary to switch the power off

depending on the unit. Then turn the voltage selector knob conterclockwise and put the switch back on.

3. To adjust the voltage upwards **(INCREASE WELD HEAT),** just turn the voltage selector knob clockwise in small increments. (*or push the down button on LYNX units*)
4. When weld quality is satisfactory continue welding.

CAUSES OF POOR OR ERRATIC WELDS

1. Loose chuck - does not grip stud tightly.
2. Faulty or loose ground connections.
3. Dirty base material (oil, grease, rust, etc.).
4. Voltage too high or too low.
5. Broken or loose cables.
6. Dirt in gun.
7. Leg and/or foot piece incorrectly set.
8. Use of center punch or deep scribe.
9. Cables too closely coiled.

NOTE: The gun welding and ground cables should be laid out in a straight line or large loops. Poor weld quality may result if welding cables are closely coiled.

I. BASIC ELECTRICAL CONCEPTS

CURRENT

The flow of electricity is referred to as current, and is expressed in amps. There are two basic types of current: alternating, (AC), and direct, (DC). Direct current always flows one way, from negative to positive. This is the type of current we use for stud welding. Alternating current, however, flows back and forth, and is the kind you get from the wall. We say DC is polarized, meaning there is a definite negative and positive connection. Conversely, AC is non-polarized -- you can reverse the connections and not alter anything. It should also be noted that because current is really an electron flow, the amount of current determines the size (or diameter) of the cable needed. The larger the cable, the more current it can carry.

VOLTAGE

Another name for voltage is potential difference, and that describes exactly what voltage is. It is the difference of electrical potential 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, we have AC voltage. This is the kind of voltage a generator would provide. Likewise, if one potential is always higher than the other, such as a battery, we have DC voltage.

For DC voltage, the higher potential is called positive, and the lower is called negative. This is why we call AC voltage non-polarized, and DC voltage polarized. Also, because of what voltage is, the type of insulation used is dependent on the level of voltage that is used.

RESISTANCE

Resistance in electrical terms is expressed in ohm' s. The more resistance to electric flow there is, the more ohm' s resistance there is. Also, resistance is a function of length. (For example, a 40-foot cable will have twice the resistance as a 20-foot cab of the same type.) Whenever electrical flow is impeded by resistance, heat develops. This is why stud welding works, as will be explained in more detail later.

GROUNDS

All equipment should be grounded, except in the case of double insulated types which are not required to be grounded. The reason for grounding is that the voltages used a 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. Also, if an extension cord is used, it must be a three wire type (the third wire is the ground path).

II. MECHANICS OF A BASIC C.D. WELDER

The unit is supplied with 115-volt AC. This voltage first passes through either a fuse and an on/off switch, or a circuit breaker whose purpose is to protect the other components from excessive current. These same 115 volts are then applied to the transformer. The transformer ' transforms' the voltage to usable levels: one low, for gun triggering, and one high, for welding current.

The higher voltage (welding) goes to a component called a charging rectifier whose purpose is to convert the AC voltage from the transformer to DC voltage. This DC voltage then goes through a switching device (either a relay or an SCR) before it goes to the capacitor bank. A switching device gives the operator the ability to control the welding voltage, which, in turn controls the welding heat. One side of the capacitor bank goes directly out of the unit (ground), the other side passes through another switching device before it, too, leaves the unit (gun). This switching device is either a weld SCR or a weld contactor.

Meanwhile, the lower voltage from the transformer also goes to a rectifier. One side of the DC voltage then goes through the gun trigger switch to a small control relay, and to one of the weld cable receptacles on the side of the unit. The other side of the DC voltage goes to the other weld cable receptacle. Thus, to get current to flow through the control relay, the gun trigger must be closed and the gun must be on the welding ground (this connects the two weld cable receptacles). When the control relay is activated, it signals the weld switch (either contactor or SCR) to conduct so the weld current can flow. The result is that the capacitor bank is discharged through the gun and the stud to the ground. This is all that is necessary for a C.D. weld to happen.

III. MECHANICS OF A C.D. GUN

From an electrical standpoint, the gun has two different functions. The trigger circuit, being the first function, consists of the trigger switch and the control cable. The trig, current (from the welder) comes up one wire in the control cable to the trigger switch. When the switch is activated, the current travels back down the control cable through another wire signaling the welder to fire (if all other conditions are met).

The second electrical function is to conduct the welding current. This consists of the weld cable, gun shaft, and sometimes there is a small pigtail cable between the / weld cable and the shaft. This portion of the circuit carries the welding current from the welder to the stud (via the collet).

Likewise, there are two mechanical functions to the gun: the trigger button and the shaft. The button is merely a means to activate the switch; the shaft, however, is a much more integral part of the welding system. It' s function is to hold the piece to be welded, and when complete, to give it enough pressure to bond the pieces together. It is extremely important that this shaft be able to move freely. If there is any bind or restriction in the movement at all, it will affect the weld adversely.

IV. TROUBLE SHOOTING A C.D. WELDER

There are five basic rules to follow when servicing any C.D. welding system. They are as follows:

(1) When approaching a welder that "isn' t working," stand back a moment and look at the entire situation. More often than not the problem will be something simple, such as wrong polarity, bad ground, coiled cables, etc.

(2) After you have determined that the welder has everything it needs externally to work, examine the cables. This is the part of the welder that receives the most wear and naturally is most subjected to failure. If possible, switch the cables and use a set that you are certain is good.

(3) Only after you are certain that the trouble is in the "box", unplug the ground and gun cables before proceeding. It is possible for a defective cable to keep the unit from charging up its capacitor bank.

(4) When making resistance or continuity readings, unplug the modules and P.C. Board, first making sure

the welder is unplugged. Not observing this rule could cost you a meter.

(5) Be logical. For example, when making voltage readings, start at the 120 VAC input. Then follow the voltage in the following sequence: to the transformer, through the charging section and to the capacitors.

Another point to be aware of before actually trouble shooting the system is that it' s a common misconception that whenever the welds, C.D. or ARC, are inconsistent, it is the fault of a defective control unit. This is rarely the case -- if the welder is defective, it will very seldom fire at all.

Usually when inconsistency occurs, it means that the set-up is marginal, or there may be a problem in the parent metal. This would account for the differences in the welds.

If the problem cannot be corrected by adjustments on the control, look at the gun. Is the stud rubbing the ferrule? Is there enough engagement on the stud with the collet or chuck as the case might be? If nothing is apparent on the outside of the gun, check it internally. Is it able to move back and forth freely in the bearing? Very seldom is the problem in the control. Almost the only thing that could cause inconsistency in the control unit would be a loose connection that would be readily apparent, such as arcing on the capacitor buss bars or at the cam-lok connections.

Remember, before suspecting the equipment, step back and look at the whole situation. Often it isn' t anything that cannot readily be corrected by proper set-up.

If, after observing all of the preliminary pointers, it is obvious there is a defect within the system, one or more of the following symptoms would occur. Below each symptom is listed a series of tests and solutions.

(1) The unit either blows a fuse or trips a circuit breaker as soon as it is turned on.

(a) A defective logic center (either P.C. Board or logic box) could cause this problem to occur. Before proceeding, replace it with one that you know is good, leaving it there until you have determined what the complete problem is. _ then do you replace the original to determine if it is good. The reasoning behind this is that it is impossible to determine if the logic module is good or bad if an additional component is defective. Be replacing it, you have assured yourself that it is good.

(b) Disconnect one of the AC leads from the charging rectifier, or unplug the charge module, and turn the unit on. If it still blows the breaker or trips the fuse, the problem has to be on the AC side. It could be a defective breaker, shorted transformer, shorted pilot light assembly, or even a short in the wiring harness.

Whatever, it would have to be in the circuit before the transformer, or in the transformer itself. If the problem doesn1t occur with the AC leads disconnected! turn the unit off, reconnect them, and proceed to step (c).

(c) With the welder off, disconnect **all** the wires going to the positive buss bar on the capacitor bank. Position the wires so they don' t touch anything, and turn the unit on. If it blows the fuse or trips the breaker now, it is a shorted charging rectifier. If the problem doesn' t occur, it is a bad capacitor.

If there is no sign of damage or rupturing of any of the capacitors, reconnect all the wires to the positive buss bar and begin isolating capacitors. To do this, remove either one of the two capacitor screws and slide an insulator, such as cardboard, between the cap, terminal, and the buss bar. As each cap is isolated, turn the welder on and see if it stays on. At the point the unit stays energized, the defective capacitor or capacitors are isolated. Begin replacing the other caps until only the defective ones are isolated. It is possible to operate the welder with the defective capacitor isolated; however, the power is reduced proportionately.

(2) The unit turns on, but doesn' t charge the capacitors. To check the charge on the capacitors, set your meter to read a high enough DC voltage (200-250) and connect the appropriate leads to the capacitor buss bars.

(a) Change the logic center. Even if this doesn' t solve the problem, leave it in until you determine exactly what the problem is.

(b) Change the charging circuit, both the rectifier and the regulator (either SCR or relay).

(c) If that doesn' t work, and the unit has a weld SCR, disconnect the cable that goes from the SCR to the weld cable receptacle. Disconnect it from the SCR if possible **--** if it isn' t, disconnect it at the receptacle. If the cap bank charges with this cable disconnected, the weld SCR is bad and must be replaced.

(d) If the problem still hasn' t been located, check the following items:

1. All the gun and ground cables are unplugged from the control unit.

2. Check the control receptacle to see if the connections to it are shorted together.

3. Check all the wires going to the charge circuit and make sure they are making good electrical contact.

4. Check the complete welder harness for breaks or bare spots.

(3) The unit charges the capacitors, but will not fire.

(a) Make sure the problem isn' t in the gun or cables. If possible, use another set that you know is good. If this isn' t possible, refer to the gun servicing section.

(b) Change the logic center (board or box), and even if the gun still doesn' t fire, leave it in until you determine exactly what the problem is.

(c) Change the weld SCR if there is one. If the unit has a welding contactor, check to see if its coil is receiving voltage. If it is, but doesn' t activate, it is defective. If there is a relay to activate the welding contactor, check it to be sure it is also working properly.

(d) Check the control receptacle and make sure the electrical connections are good.

(e) Make sure you have a good welding ground and that your pin or stud is making good contact with the work.

(4) The unit either blows the fuse or trips the breaker when a weld is made.

(a) Change the P.C. board or logic center.

(b) Change the charging circuit. (c) Check the capacitors.

(5) The unit charges to maximum voltage.

(a) Change the P.C. board or logic center.

(b) Change the voltage potentiometer.

(c) Change the charging circuit.

(6) The unit fires as soon as the gun touches the work.

(a) Unplug the control wire from the unit. With the welder on, and only the gun and ground weld cables plugged into the unit, touch the gun to the work as if you are going to make a weld. If the weld occurs, the problem is inside the control unit. If the gun doesn' t fire, refer to the gun servicing section. If it does fire, proceed with the next step.

(b) Change the P.C. board or logic center.

(c) Check the control receptacle for shorted connections.

(d) Change the weld SCR or check the welding contactor and change the contacts if they are sticking.

SERVICING THE CONTACT C.D. WELD GUN

(1) The gun shaft must always move freely. Any binding with either the spring or the bearing will cause erratic weld results. If there is a bind, its cause must be found and eliminated: **Under no circumstances** should the gun be lubricated, as this will attract dirt to the bearing surfaces and it will also cause the bearing to swell and restrict the gun shaft' s movement.

(2) The weld cable should read continuity from the Cam-lok to the gun shaft. When taking this reading, pullan the weld cable and move the gun shaft to make certain there are no breaks in the circuit.

(3) Check continuity between the two trigger pins in the control plug. This should only read continuity when the trigger is pressed. If there is any deviation in this reading, check the trigger switch **--** two

pins should read continuity when the trigger is squeezed, and open when the trigger is in its normal position. If the switch is okay, check the wires that go from the switch to the trigger pins in control plug for continuity. Remember to pull and wiggle the wires when checking them for continuity.

(4) Check that the trigger pins and the weld cable don't read continuity to each other or to anything else, such as the handle screws, etc. If they do read anywhere else, the problem must be found and eliminated in order for the gun to operate safely.

V. THE C.D. WELD

In order for a weld to be good, it should have an even fillet completely around it. Any voids at all indicate a weakness in the weld zone that could only cause weld failure later. Also, the stud or pin should appear to penetrate the parent material -- it should never appear to be 'sitting on top' of the weld.

What actually happens during a contact C. D. weld? The work (or ground) is connected to one side of the capacitor bank. The stud, through the collet, gun, and a switching device (SCR or weld contactor) is connected to the other side of the capacitor bank. When the stud is placed against the work, only the tip touches. When the trigger is squeezed, the switching device conducts, and the capacitor bank is shorted out through the tip of the stud. Because of the high welding current, the tip disintegrates and an arc is established. The arc melts the interface surfaces, and the spring pressure of the gun pushes the stud into the parent material to complete the weld. The whole process lasts about 1/1000 of a second.

Therefore, to make a good weld occur, two things are needed: **heat and pressure.** You must have sufficient heat to melt the weld zone, and if you don't have enough pressure, you won't have good fusion.

In a C.D. welding system, heat is easily regulated by the voltage on the capacitor bank. Of course, the length of weld cable used also affects the heat. It should be noted however, that you should always use at least 10' of cable, otherwise the weld arc is too hot and erratic. Pressure is largely controlled by protrusion; that is, the amount of stud that extends beyond the gun's foot. Some systems, such as ours, also have an assortment or gun springs that make regulating the pressure easier. It should be mentioned that the more pressure the weld has, the shorter the weld time will be. This will result in a cooler weld with less penetration. However, the heat can be turned up to compensate.

Besides heat and pressure, some of the other aspects of C.D. welding should be mentioned. Grounding is very important. Of course, the ground connection must be clean and tight, but it must also be positioned properly. Whenever the weld consistently "blows" one way, the ground is inadequate. Sometimes this can be compensated for by turning up the voltage. If this doesn't work, the grounding must be changed.

Another important subject is polarity. Straight polarity is when the work is positive and the gun is negative. Whenever the work is clean, straight polarity is used. On the other hand, reverse polarity (work is negative) is used whenever plating, rust, paint or other impurities are present.

One other point should be mentioned. Whenever possible, a flanged stud should be used instead of a non-flanged stud. With a flanged stud, there is approximately twice the area of contact as a non-flanged stud, and naturally this gives much more welding power.

By inspecting a stud that failed, can we tell why it failed? Most of the time we can. If there is any un-melted material on the base of the stud, there obviously wasn't enough heat. If the stud is all melted, but shiny, there wasn't enough pressure. What happens was the molten metal in the two surfaces started to harden before the gun spring could punch them together. Too much pressure, or not enough heat, usually results in the tip not being fully burned away. Most of the time, a close examination of the stud will give a good indication of why it failed.

WELD GUN HEAT & PRESSURE

There are two basic requirements necessary to make a good weld -- **heat and pressure.** Lack of one or the other and weld quality will suffer. This requirement is necessary not only in CD stud welding but in arc as well. Even resistance or spot welding requires heat and pressure.

Heat, or current, can pretty well be controlled and even monitored. Circuits are available to compensate for line voltage fluctuations. Voltmeters and ammeters are available to watch over and even inform an operator when a condition becomes critical. We know how much current we need, we know how much current we have; it's cut and dried.

Now, how about pressure? Just as important as heat, ---too much or too little will seriously affect the weld quality. We don't have instrumentation to tell us what is right or wrong, we are on our own! Remember, pressure is a mechanical function and therefore is subject to all the evils of mechanical devices. Rust, dirt, grime, weld berries, friction, etc. all contribute to variations in pressure. Pressure, therefore, is one extreme variable in all welding processes. New guns operate under optimum conditions, but from the first weld on, it's downhill all the way. For this reason alone, it is very important that a good preventative maintenance program be initiated and adhered to. Don't wait until weld failures occur--prevent them from happening.

"WHY REVERSE POLARITY"

"What polarity?", a question frequently asked when setting up C.D. welders. The reasons for using one or the other are quite simple.

It is a known fact that, in all types of arc welding, the positive electrode runs hotter than the negative electrode. This increase in temperature, approximately 20%, is caused by the electron bombardment on the positive electrode. Current flows from negative to positive.

Normally, straight polarity is used in stud welding. The work positive and the stud negative. Using this polarity will concentrate the heat on the work and give maximum penetration into the base material.

When welding a high temperature alloy stud, such as stainless steel, to a low temperature material, such as copper, reverse polarity is advantageous. The concentration of heat will now be on the stud, which has the higher melting point. This set-up will insure complete melting of the stud tip without penetrating too deeply into the base material.

Reverse polarity is always used when welding to plated or coated surfaces, such as galvanized steel, even though the melting points are similar. Why? -- the current flowing from the work to the stud has a tendency to lift off and expel impurities of contaminants from the work surface. These impurities must be removed if good welds are to be expected.

Arc stud welding, with the longer burn time, is always done with straight polarity. The exception is when welding aluminum, for reasons stated above.

"Get the Point?"

Tips, projections, points, conical, cylindrical, nibs, spuds, teats, etc.; many names, but all serve one purpose --- to initiate an arc.

Why are conical tips better than cylindrical tips? Other than being more expensive, look at them as if they were fuses. The conical like a 10 amp fuse and the cylindrical like a 50 amp fuse. Naturally, the 10 amp will blow more readily than the 50 amp. This is exactly what we are looking for. The mass of a conical tip is about one-third of the comparable cylindrical tip.

Contact welding is a different story. As the name implies, the stud is preloaded against the work before it is fired. A conical tip may collapse from the preload, or imbed itself in the soft base material causing erratic welding. A cylindrical tip will normally take this preload without distorting.

Whenever considering applications on light gauge aluminum, where reverse side marking is of some concern, always recommend the gap process and studs with conical tips. The additional cost of conical tips will more than be offset by the quality and consistency of the welds.

<u>LIGHT RUST OR LIGHT PAINT ON VINYL CLAD STEEL</u>

C.D. stud welding on all contact type welders through rust preventative or light paint used on vinyl clad steel.

Higher than normal voltages are required to initiate an arc. Capacitors should be removed to reduce heat rather than lowering the voltage. Gun should be connected in reverse polarity. Suggested voltages for #6, 8 and 10's would be around 140 to 150, depending on the thickness of the coating. Use 20' cable extensions, black spring and ¼" plunge.

Mini-flanged studs must be used on these applications. Standard size flanged studs have a tendency to lift off the work during the weld. This repulsion is due to the vaporization of the various impurities in the weld zone.

Since just about all vinyl coated steel has some sort of coating on it, this technique will eliminate grinding prior to welding. As, in all unusual applications, always test prior to making commitments.