

APPLICATION

LINCOLN[®]
ELECTRIC
THE WELDING EXPERTS

WAVEFORM CONTROL TECHNOLOGY™

Power Wave AC/DC Submerged Arc

Welding Systems

The Power Wave AC/DC welding system is designed to provide superior results over a wide range of Submerged Arc applications. The system can be configured for single, tandem, or multi-arc applications with up to five arcs.

Experience the advantages of Waveform Control Technology™ in Submerged Arc Welding applications. Waveform selection provides the opportunity for greater deposition, as well as unparalleled control of heat input and penetration. This unique offering is the only system on the market that combines higher deposition, controlled heat input, and controlled penetration for single to multi-arc applications. The added flexibility and control enables the welder to perform in the most demanding applications that challenge older technologies.

What does this mean to you?

More flexibility.

Increased productivity.

Increased profitability.



a d v a n t a g e s

INCREASED TRAVEL SPEED

- High bandwidth digital controls give more stability and allow faster travel speeds. These speeds dramatically reduce cycle times, increasing the number of parts that can be made per day.

INCREASED DEPOSITION

- Fast-fill joints have achieved deposition increases of up to 30% over traditional technologies.

INCREASED FLEXIBILITY

- A system interface controls the phase relationship between the arcs, which allows up to five arcs to contribute to the same weld, without experiencing arc blow.
- A wider range of materials and joint geometries can be welded with the AC/DC system.

WIDER RANGE OF OPERATION

- Waveform Control Technology™ allows precise control of the waveform, producing greater stability over a wider range of operation.

Patented. This product is protected by one or more of the following United States patents: 6,809,292; 6,795,778; 6,700,097; 6,697,701; 6,683,278; 6,660,966; 6,600,134; 6,683,278; 6,596,570; 6,570,130; 6,536,660; 6,489,952; 6,472,634; 6,636,776; 6,486,439; 6,441,342; 6,365,874; 6,291,798; 6,207,929; 6,111,216; 4,927,041; 4,861,965 and other pending U.S. patents. Similar patents are maintained in other countries.

The future of welding is here.®

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Power Wave AC/DC Submerged Arc

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Welding Systems

Power Wave AC/DC 1000



The Power Wave AC/DC is the first power source to bring Waveform Control Technology™ to submerged arc welding. The Power Wave AC/DC 1000 is capable of producing a variable frequency and amplitude, AC output, a DC+ output, or a DC- output. This allows the welding procedure to be optimized for either high deposition, high penetration, or fast-follow applications.

The Power Wave AC/DC 1000 is a high performance, digitally controlled inverter power source capable of complex, high-speed waveform control. For multiple arc applications, the phase angle and frequency of different machines can be easily synchronized, which provides unprecedented welding performance in multi-arc applications.

For applications that require more than 1000 amps of continuous operation, the Power Wave AC/DC 1000 is a modular design that allows machines to be easily paralleled. This means that depending on the output, a welding arc may be driven by a single machine or multiple machines in parallel.

ADVANTAGES

Adjustable AC Waveforms

Waveform Control Technology allows unlimited control over an AC wave shape. The balance (percentage of time in the positive polarity portion of one cycle), and offset (positive and negative amplitudes) can all be independently controlled. This allows a waveform to be tailored for any application.

Stable Multi-Arc Welding

The Power Wave AC/DC is the only power source with an adjustable phase relationship and frequency. This allows the ability to set the machine and reduce arc interference, arc blow, etc. When welding arcs are in close proximity to each other, the arc's magnetic fields interact with each other (arc blow) and can become unstable. To reduce arc blow instability, the Power Wave AC/DC 1000 is the only power source with an adjustable phase relationship and frequency.

High Efficiency Inverter

An efficiency rating of 86% and a power factor of 95% gives the Power Wave AC/DC 1000 the highest efficiency and power factor rating of any submerged arc power source. The result is drastically reduced electricity costs, electrical capacity requirements and installation costs.

High Current Capabilities

A modular design provides the ability to easily parallel power sources. This enables multiple Power Wave AC/DC 1000 machines to deliver power, collectively, to one or more welding arcs.

Three-Phase Input

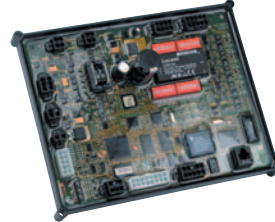
Unlike previous AC submerged arc power sources, the Power Wave AC/DC 1000 uses three phase power. This eliminates the load balancing problems associated with the high current, single phase requirements of other machines. The simple three phase input connection does not require special configurations like a cyclo-converter power source, nor does it require Scott connections.

Power Wave AC/DC Submerged Arc

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Welding Systems

Power Wave AC/DC 1000 Features



PC Boards are potted in protective trays. All electrical connections are sealed against dust and water.



All Power Wave AC/DC machines come standard with an **Ethernet/DeviceNet Gateway Module**. This allows the Power Wave to be accessed easily for remote viewing and operation, or for factory automation integration. This versatility offers the user the option to streamline configuration and commissioning of the system. In addition, diagnostics and software capabilities ease troubleshooting and future upgrades.



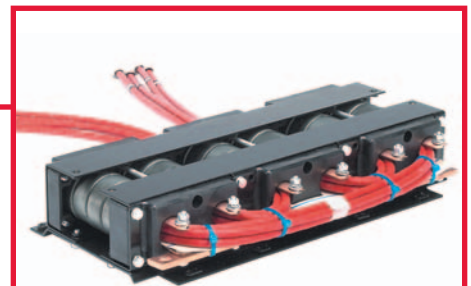
Impeller Cooling Technology™

The impeller fan creates a high-pressure chamber, which forces airflow across the heated components in the machine. This technology improves airflow 200-300% over conventional fans.



Copper Heat Sinks

Highly conductive copper removes the heat given off by the machine. The larger surface area increases the heat transfer, which keeps the machine operating within a normal temperature range. Cooler operation improves machine performance and reliability.



Coaxial Transformer Technology™

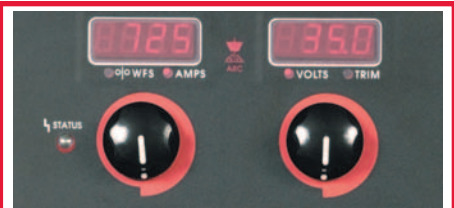
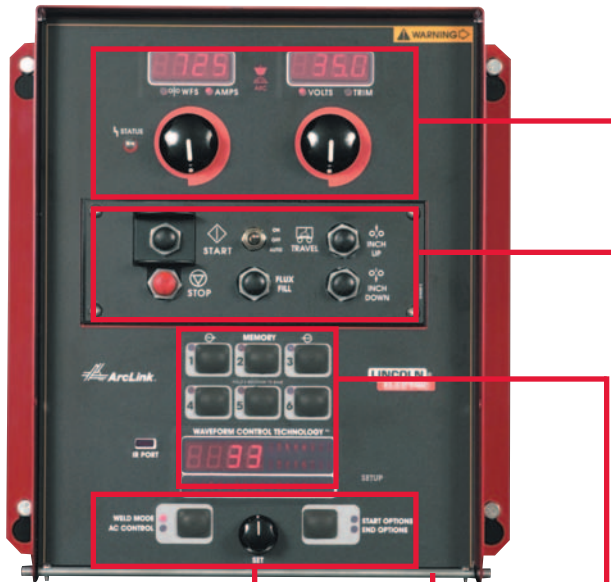
provides the highest inverter power capabilities on the market. A high efficiency rating delivers reduced energy costs, and reduced stress on components.

Power Wave AC/DC Submerged Arc

Welding Systems

Power Feed 10A Features

The Power Feed 10A is based on the traditional NA-5 and Power Feed 10 user interface. Now, all controls are accessible from one station, and are displayed on the digital readout. The Power Feed 10A communicates using ArcLink, and can easily integrate with custom controls and PLCs, in multiple configurations.



Two **control knobs** can increase or decrease Wire Feed Speed (WFS), Voltage, and Amps. Any of these adjustments can be made “on-the-fly”.



The **switch panel** can also be used as a remote pendant. From here, start and stop the weld, inch the electrode wire, activate the flux hopper, and control travel.



Memory panel can store up to six welding procedures.

Limits are set from the memory panel.

On-the-fly procedure changes can be made.

ADVANTAGES

One Location for all Operator Controls

Weld Mode, Current, Voltage, Wire Feed Speed, and Waveform Control are all accessible from the Power Feed 10A.

Security

For procedure security, operator limits can be set from the Power Feed 10A memory panel and passcode protected through the PC Lockout application.

Memory Panel

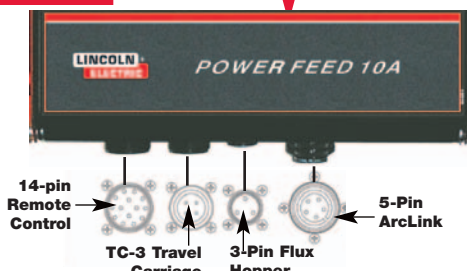
Each of the six memory panel buttons can store a weld procedure.

Versatility

Various configuration options are possible with the remote pendant feature, and I/O capability.

Reliability

Designed for a rugged environment, the potted PC boards are water-tight and dust resistant.



Left Pushbutton:

- Selects **Weld Mode** based on weld procedure and wire diameter
- Sets **AC Control: Balance, DC Offset, Frequency**

Right Pushbutton:

- Sets **Start Options: Strike WFS and Volts, Start WFS, Volts, Time Start Arc Force Upslope Time**
- Sets **End Options: Downslope Time Crater WFS/Amps, Volts, Time, Arc Force Burnback Time**

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Welding Systems

Power Wave AC/DC and Power Feed 10A

Configuration Options

Accessories

Power Feed 10S (K2370-1)

(3/32 to 7/32 in. solid wire)

The Power Feed 10S includes:

- wire feeder head with straightener for solid wire
- flux hopper with automatic valve
- head mounting
- cross seam adjuster

This package does not include control box or wire reel brake and mounting.

Power Feed 10SF (K2312-1)

(3/32 to 7/32 in. solid wire)

Use the Power Feed 10SF for machinery and fixture builders. The fixture mount wire drive assembly includes:

- motor
- gearbox
- drive rolls
- guide tubes
- straightener for solid wire

This package does not include head mounting, electrode cables, cross seam adjuster, flux hopper or pointer.

TC-3 (K325x)

The self-propelled travel carriage carries the wire feed head and Power Feed 10A in either direction on a beam. It can operate automatically with the weld controls, or manually. The TC-3 comes in two speed ranges (S and F) in standard or high capacity (HC) models. The standard carriage is equipped for one wire feed head, and the high capacity carriage is for multi-head systems.

- S: 5-75 ipm (0.1-1.9 m)
- F: 15-270 ipm (0.4-6.9 m)

Programmable Logic Controller (PLC)

The Power Wave AC/DC 1000 and Power Feed 10A can easily integrate into a customer-supplied PLC system. Motion of the TC-3 can be controlled from the PLC, while individual weld controls such as mode selection, amperage, and voltage are still controlled from the Power Feed 10A.

System Interface (K2282-1)

This external controller is required for multi-arc applications. The arc-to-arc interaction is controlled by offsetting the phase relationship, as each arc is added.

Power Feed 10SM MotorConversion Kit

This ArcLink motor retrofit kit is to be used with the NA Series Gear Head. It replaces the existing motor on the NA3/4 or the NA5 wire feed head.



System Interface (K2282-1)



Power Feed 10SM MotorConversion Kit

Power Wave AC/DC Submerged Arc

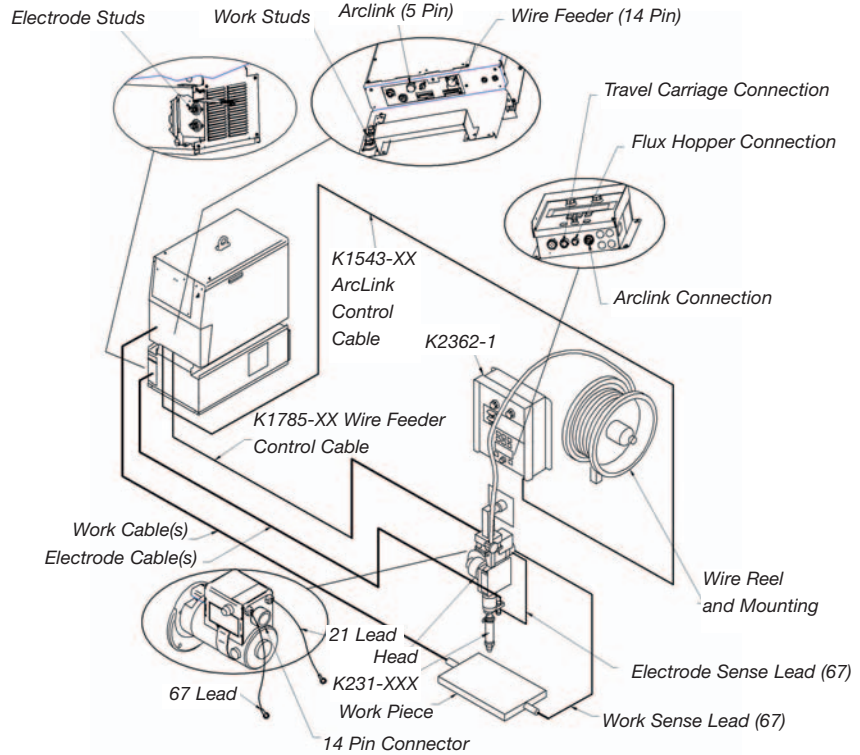
Welding Systems

AC/DC Submerged Arc — Single Arc Configuration

Typical AC/DC Submerged Arc Example

The Power Wave AC/DC 1000 combined with the Power Feed 10 SF Head and Power Feed 10A Controller provide up to 1000 amps for single arc applications.

Single arc AC welding increases productivity over single arc DC+ polarity welding, with increased resistance to arc blow.



Recommended Equipment

System Identifier	Part No.	Description	Qty. Required
Power Source	K2344-1 or K2344-2	Power Wave AC/DC 1000 Power Source	1
Head	K2370-1 or K2312-1	Power Feed 10S Head for 3/32 to 7/32 in. solid wire (includes hopper, wire straightener, cross seam adjuster, and head mounting hardware) or Power Feed 10 SF Head for 3/32 to 7/32 in. solid wire Fixture Builders Head (Insulators not included)	1
Control Box	K2362-1	Power Feed 10A Controller	1
ArcLink Digital Communication Cable	K1543-xx	ArcLink Cables (5-pin) from Power Feed 10A Controller to Power Source	1
Welding Cables	K2163-xx or K1842-xx	Weld Power Cables from the Power Source to the contact Nozzle and from the Power Source to the Work	2
Power Source to Head Control Cable	K1785-xx	Feeder Control Cable (14-pin) from the Head to the Power Source	1
Torch	K231-xx	Submerged Arc Contact Nozzle Assembly	1

Optional Equipment

System Component
PLC (customer supplied)
Ethernet Switch (customer supplied). Required for arcs > 1000A or with use of the Submerged Arc Software Suite.
Computer (customer supplied). Required for use of the Submerged Arc Software Suite.
K325-x TC-3 Travel Carriage
K96 Horizontal Lift Adjuster
K29 Vertical Lift Adjuster
K299-1 Wire Reel Assembly

Descriptions in **BOLD** are as they appear in the Lincoln Electric Price Book.

The Work Sense Leads are not Lincoln Electric orderable parts. Customers must extend appropriate sensing leads from the power source to the work.

XX is a placeholder for the length of the cable. Based on the distance between welding power supplies, the values for XX could be 12, 25, 50, etc. Cables can be connected end to end to create longer lengths.

XXX is a placeholder for the wire diameter of the application.

Power Wave AC/DC Submerged Arc

Welding Systems

AC/DC Submerged Arc — Tandem Arc Configuration

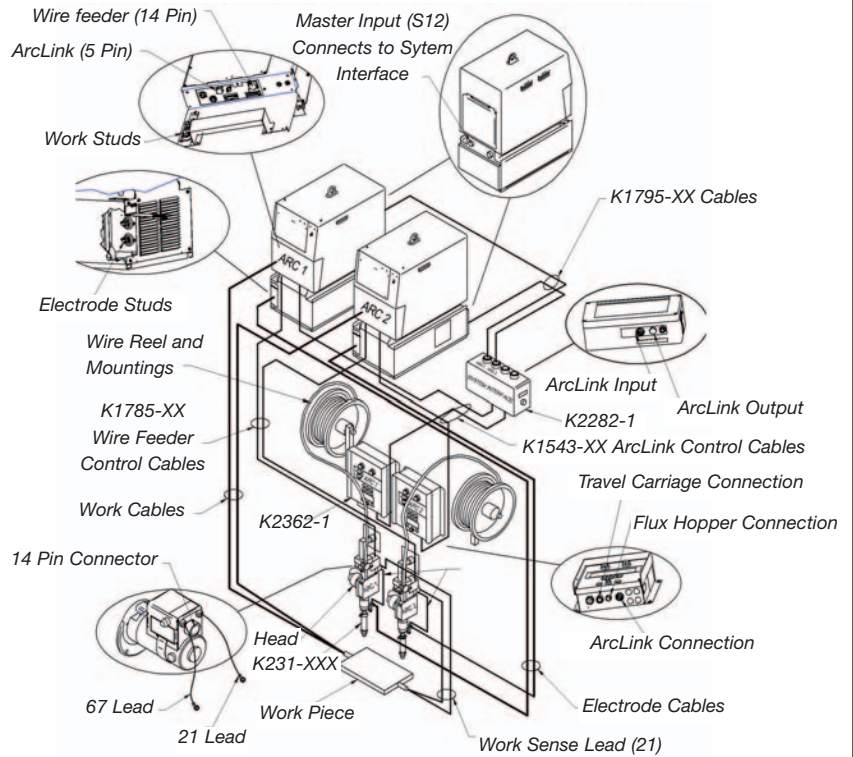
Typical AC/DC Submerged Arc Example

The Tandem arc system provides two 1000A arcs, which can be configured as an AC/DC or and AC/AC system.

The advantage of the Power Wave AC/DC 1000 tandem and multi-arc systems is the control over the phase relationship.

When two welding arcs are running close together, an anomaly known as “arc blow” occurs as the magnetic fields created by the high currents repel each other and actually blow molten metal out of the weld puddle.

The Power Wave has the ability to synchronize the phase relationships between multiple arcs allowing unprecedented control over arc blow. Conventional welding equipment is limited to a 1 or 2 phase relationship. The Power Wave AC/DC is the only machine where the phase relationship can be controlled from zero to 360 degrees.



Recommended Equipment

Optional Equipment

System Identifier	Part No.	Description	Qty. Required
Power Source	K2344-1 or K2344-2	Power Wave AC/DC 1000 Power Source	2
Mounting for Heads	K387	Tandem Arc Framework	1
Head	K2312-1	Power Feed 10S Head for 3/32 to 7/32 in. solid wire (Includes hopper, wire straightener, cross seam adjuster, head mounting hardware) or Power Feed 10SF Head for 3/32 to 7/32 in. solid wire Fixture Builders Head (Insulators not included)	2
Control Box	K2362-1	Power Feed 10A Controller	2
Phase Control	K2282-1	System Interface	1
ArcLink Digital Communication Cable	K1543-xx	ArcLink Cables (5-pin) (1) Lead Arc: Power Source to System Interface (2): System Interface to User Interface (3) Trail Arc: Power Source to User Interface	3
Welding Cables	K2163-xx or K1842-110	Welding Power Cables from the Power Source to the contact Nozzle and from the Power Source to the Work	4 Per Machine
Power Source to Head Control Cable	K1785-xx	Feeder Cable (14-pin) from the Head to the Power Source	2
Torch	K231-xxx	Submerged Arc Contact Nozzle Assembly	2
System Interface to Power Source Cable	K1795-xx	Control Cable (22 pin) from each Power Wave AC/DC 1000 to Systems Interface	2

System Component
PLC (customer supplied)
* Ethernet Switch (customer supplied). Required for arcs > 1000A or with use of the Submerged Arc Software Suite.
Computer (customer supplied). Required for use of the Submerged Arc Software Suite.
K325-x TC-3 Travel Carriage
K96 Horizontal Lift Adjuster
K29 Vertical Lift Adjuster
K299-1 Wire Reel Assembly
K390 Two Wire Reel Mounting for TC-3
K389 Flux Hopper for K387 Mountings

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Power Wave AC/DC Submerged Arc

Welding Systems

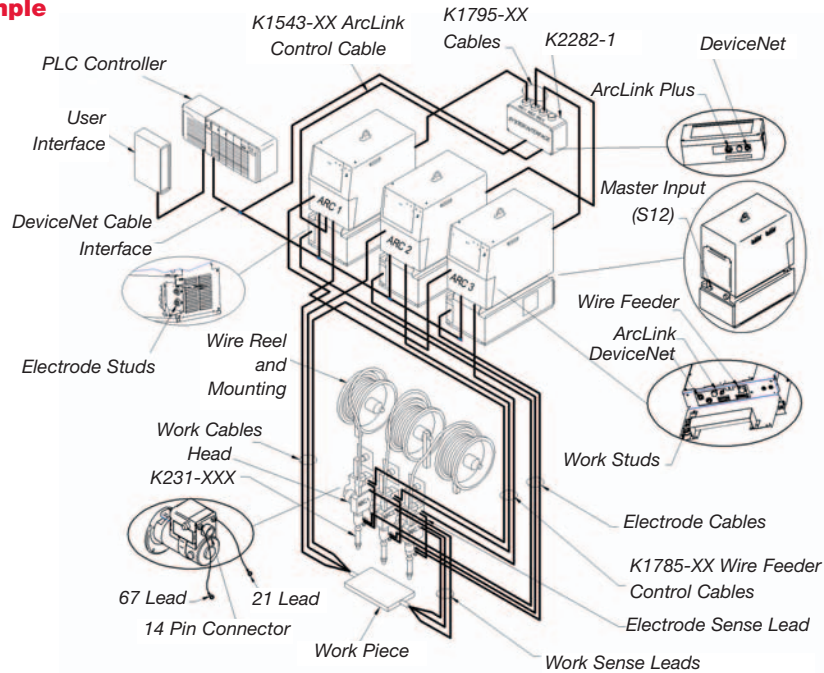
AC/DC Submerged Arc — Multi-Arc Configuration

Typical AC/DC Submerged Arc Example

The Power Wave AC/DC 1000 may be used with a Programmable Logic Controller (PLC) for multiple arc applications up to five arcs.

The importance of the phase relationship grows with each additional arc. Keeping arc interaction at a minimum is imperative, and it is in this role that the multi-arc AC/DC shines.

Because the operator has independent control of each arc, the variability of the waveform is infinite. This gives the operator ample opportunity to vary amplitude, time balance, and frequency to meet the demands of the application.



Recommended Equipment

System Identifier	Part No.	Description	Qty. Required
Ethernet Network Equipment	Customer Supplied	Ethernet Switch, Cables, etc. required for arcs >1000A or for use with Power Wave Submerged Arc Utilities software package	1
Personal Computer	Customer Supplied	IBM Compatible PC (Windows NT SP6, Windows 2000, Windows XP or greater) required for use with Power Wave Submerged Arc Utilities software package	1
Controls	Customer Supplied	Programmable Logic Controller	1
DeviceNet Cables	Automation Department or Customer Supplied	DeviceNet Cables from the Power Source to PLC and System Interface to PLC	4+
Ethernet Switch	Customer Supplied	Ethernet Switch	1
Power Source	K2344-1	Power Wave AC/DC 1000 Power Source	3+
Head	K2312-1	Power Feed 10 SF Head	3+
Phase Control	K2282-1	System Interface	1
Welding Cables	K2163-xx or K1842-xx	Welding Power Cables from the Power Source to the contact Nozzle and from the Power Source to the Work	4 Per Machine
Power Source to Head Control Cable	K1785-xx	Feeder Cable (14-pin) from the Head to the Power Source	3+
Torch	K231-xxx	Submerged Arc Contact Nozzle Assembly	3+
System Interface to Power Source Cable	K1795-xx	Control Cable (22 pin) from each power Wave AC/DC 1000 to Systems Interface	3+

NOTE: Although a PLC is shown in the three arc system illustrated, the Power Feed 10A user interface can be used in system configurations of up to four arcs. If this is the desired setup, it will be necessary to purchase the same number of Power Feed 10As as there are arcs. Also, additional ArcLink control cables will need to be purchased.

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Power Wave AC/DC Submerged Arc

Welding Systems

AC/DC Submerged Arc — Digital Communications



ArcLink



DeviceNet



Ethernet

AC/DC Submerged Arc Utilities

The Power Wave AC/DC includes software to assist with installation and operation of the equipment. From an intelligent configuration utility to a high-level monitoring and data logging tool, these packages are designed for ease of use.

NetSet

Utility used to assign the Ethernet address properties of the welding equipment as well as security settings for administrative access.

Network Cell Setup

An installation tool to assist with configuration, Network Cell Setup generates a file to store this configuration, and prepares the cell for use with Command Center.

Command Center

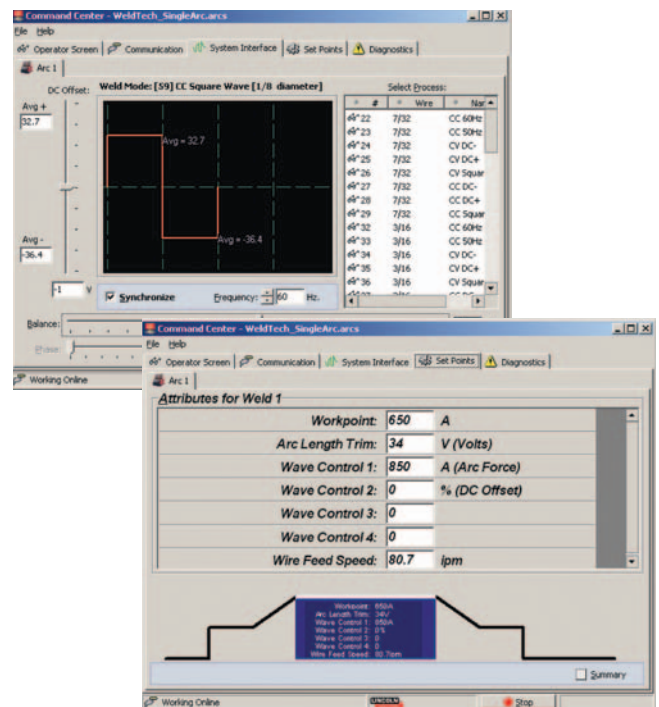
Provides monitoring and control of each arc in a multiple arc system, presenting master/slave relationship and configuration of the arc in the system. Weld mode selection, parameters of weld states, and diagnostics are also available here.

Power Feed 10A Lockout

Utility to turn on and off lockouts and set a pass code for the Power Feed 10A control box.

Diagnostic Utility

Provides ability to remote monitor, track machine status, test sense leads, calibrate, and read system information.



Command Center was designed exclusively for Submerged Arc applications. The phase relationships between each arc can be controlled from this application.

Power Wave AC/DC Submerged Arc

Welding Systems

Using AC/DC Submerged Arc

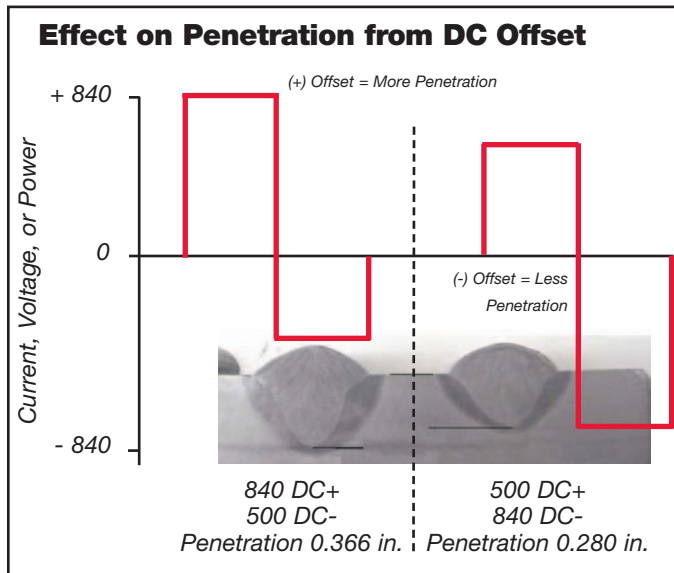
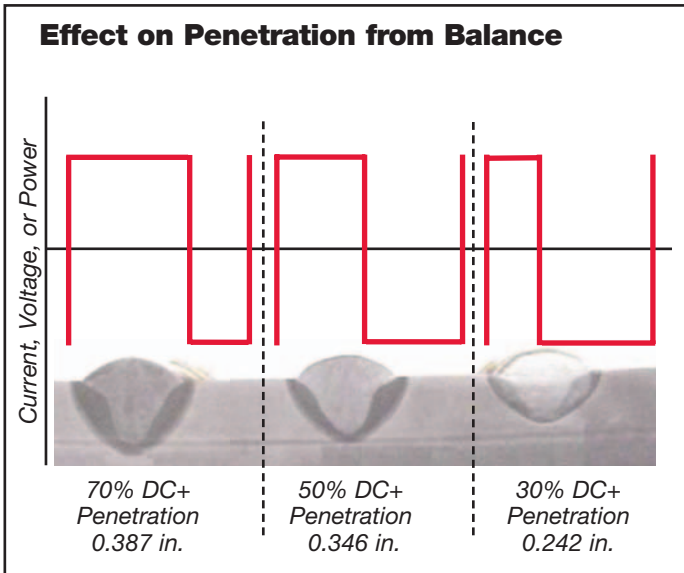
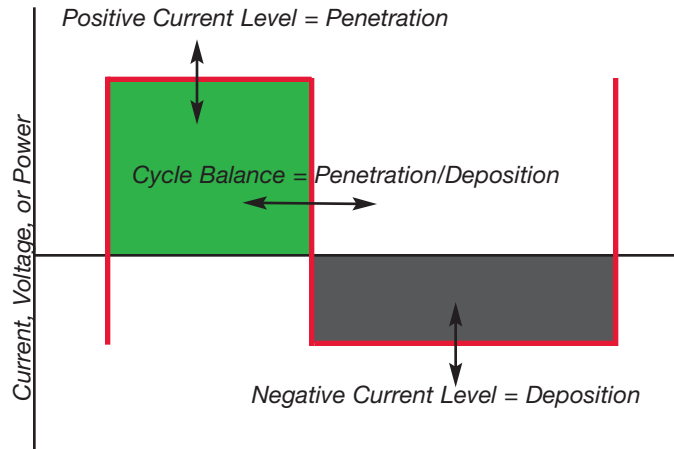
Waveform Control Technology

The waveform may be varied to:

- control penetration
- control bead shape
- eliminate arc interactions which can cause arc blow.

Waveform Control Technology capability provides precise control over:

- AC Frequency
- Balance (Percentage of time in the positive polarity portion of one Cycle)
- Offset (Negative Amplitude)



Balance & Offset versus Deposition Rate

Polarity	Balance (DC+)	Offset	Wire Feed Speed	Percent Increase in Deposition
100% DC+ (highest penetration)			48	0
AC	75%	0	51	6%
	65%	7	53	10%
	50%	0	58	21%
	35%	-7	64	33%
	25%	0	65	35%
	30%	-20	68	42%
100% DC- (highest deposition)	NA	NA	71	48%

These results are specific to a single wire, 5/32" diameter, and solid steel electrode. Assuming a 5/16" leg fillet weld. Changes in current voltage, travel speed and joint configuration will affect results.

Power Wave AC/DC Submerged Arc

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Welding Systems

Using AC/DC Submerged Arc

Single Arc

Seam Welding on Sheet Metal

The customer increased travel speed from 115 to 150 IPM (42% increase). Waveform Control Technology enhanced productivity and deposition without negative effects of heat input.

Mold Rebuilding

By using Wave Form Control technology the deposition rate was increased from 14.6 lbs/per hour to 19.9 lbs./per hour with the same heat input.

- Mold rebuild time dropped from 11 days to 6 or 7 days (36% reduction in welding time)
- Total mold stock reduced by 6 million dollars

Tandem

Pressure Vessels

Deep groove welds on 165 mm thick plate were taken from 56 minutes to 45 minutes in welding time. Lincoln Electric devised a two arc AC/AC submerged arc solution.

- 23% reduction in heat input
- 20% less welding time

Offshore Structures

Conventional DC/AC deposition was yielding 33 lbs/hr (15 kg/hr) deposition. By using the two arc AC/AC submerged arc process, deposition increased to 44 lbs/hr (20 kg/hr).

- 33% increase in deposition rate.

Four Arc

Pipe Mills

ID welding of longitudinal pipes was taking too long, and inhibiting production. Conversion of a 3-arc system to a 4-arc system increased travel speeds and productivity by 35%.

- Travel speed of 1.7 m/m increased to 2.3 m/m
- 33% gain in productivity)
- Weld bead profile and mechanical properties remained the same quality



Offshore Structures



Longitudinal Pipe Mill

Power Wave AC/DC Submerged Arc

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Welding Systems

Lincoln Submerged Arc Consumables

Submerged Arc Fluxes

Lincoln Electric offers a wide variety of fluxes to be used in a submerged arc welding environment. Depending on the application, the choice of flux will vary. Please refer to the Submerged Arc Welding guide for assistance in selecting the right flux for you.



Submerged Arc Electrodes

Selection of the appropriate wire electrode is application dependent. Please refer to the Submerged Arc Welding guide for assistance in selecting the right electrode for your application.



Customer Assistance Policy

The business of The Lincoln Electric Company is manufacturing and selling high quality welding equipment, consumables, and cutting equipment. Our challenge is to meet the needs of our customer and to exceed their expectations. On occasion, purchasers may ask Lincoln Electric for advice or information about their use of our products. We respond to our customers based on the best information in our possession at that time. Lincoln Electric is not in a position to warrant or guarantee such advice, and assumes no liability, with respect to such information or advice. We expressly disclaim any warranty of any kind, including any warranty of fitness for any customer's particular purpose, with respect to such information or advice. As a matter of practical consideration, we also cannot assume any responsibility for updating or correcting any such information or advice once it has been given, nor does the provision of information or advice create, expand or alter any warranty with respect to the sale of our products.

Lincoln Electric is a responsive manufacturer, but the selection and use of specific products sold by Lincoln Electric is solely within the control of, and remains the sole responsibility of the customer. Many variables beyond the control of Lincoln Electric affect the results obtained in applying these types of fabrication methods and service requirement.

Subject to change - This information is accurate to the best of our knowledge at the time of printing. Please refer to www.lincolnelectric.com for any updated information.

WHAT IS NEXTWELD?

The challenges facing industrial fabricators today are increasingly difficult. Rising labor, material, and energy costs, intense domestic and global competition, a dwindling pool of skilled workers, more stringent and specific quality demands.

Through our commitment to extensive research and investments in product development, Lincoln Electric has established an industry benchmark for applying technology to improve the quality, lower the cost and enhance the performance of arc welding processes. Advancements in power electronics, digital communications and Waveform Control Technology™ are the foundation for many of the improvements.

NEXTWELD brings you a series of Process, Technology, Application and Success Story documents like this one. NEXTWELD explains how technologies, products, processes and applications are linked together to answer the important questions that all businesses face:

- How can we work faster, smarter, more efficiently?
- How can we get equipment and people to perform in ways they've never had to before?
- How do we stay competitive?

NEXTWELD is the future of welding but its benefits are available to you today. Ask your Lincoln Electric representative how to improve the flexibility, efficiency and quality of your welding operations to reduce your cost of fabrication.

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