

# PROCESS

## WAVEFORM CONTROL TECHNOLOGY®

# AC/DC Submerged Arc Welding

Improves Productivity, Quality and Safety

For over 50 years, Lincoln Electric has offered its Submerged Arc Welding (SAW) customers high deposition rates, reliable penetration, and smooth bead appearance.

Now, Lincoln brings you the first advance in SAW technology that provides the option of variable polarity. Changes in the balance of positive and negative polarity of the AC waveform enable the operator to change penetration and deposition, without changing the current or voltage settings.

Lincoln's AC/DC Submerged Arc process with the Power Wave power source gives the operator real-time control. Instead of making a weld, stopping and re-programming the new parameters, and running a test weld to make sure they worked, changing the face of a weld is as easy as turning a knob.



*The Power Wave® AC/DC 1000™ takes Submerged Arc Welding to the next level. In addition to conventional benefits of SAW, such as high deposition rates and good penetration, heightened control and faster responses to the arc are unique to the design of the Power Wave® AC/DC 1000™.*

## a d v a n t a g e s

### MODULAR

The Power Wave AC/DC1000 is designed for easy paralleling, overcoming the problems typically associated with synchronization of AC waveforms for increased amperage applications.

### MULTI-ARC

AC/DC welding is designed for applications that require up to five independently controlled welding arcs.

### EASY INTEGRATION

Digital Communications provide a simple solution for the integration of the welding power source to the motion controlling Programmable Logic Controller (PLC).

### INCREASED PROCESS CONTROL

Digital Communications also enable the use of software tools to record the actual welding values for each weld as well as monitoring the status of the welding system.

### WAVEFORM CONTROL TECHNOLOGY

The Power Wave AC/DC 1000 is equipped with factory-programmed procedures for fast setup.

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.®

# AC/DC Submerged Arc Welding

## What

### Is AC/DC Submerged Arc?

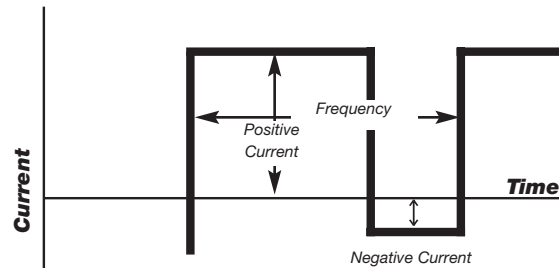
A Submerged Arc Welding (SAW) option that combined the advantages of AC and DC SAW welding was not possible until now.

A Lincoln inverter power source coupled with Waveform Control Technology provides control over the ratio of positive to negative amplitude, as well as the amount of time spent at each polarity.

The limiting factor for SAW AC welding has always been that it takes too long to cross from electrode positive (EP) to electrode negative (EN). This lag can cause arc instability, penetration, and deposition problems in certain applications.

The Lincoln Power Wave AC/DC 1000 with Waveform

## The AC/DC Submerged Arc Process



The above waveform represents the possible variations of an AC/DC waveform with Waveform Control Technology. Different parts of the waveform and wire feed speed may be modulated at varying rates to achieve a smooth, stable arc.

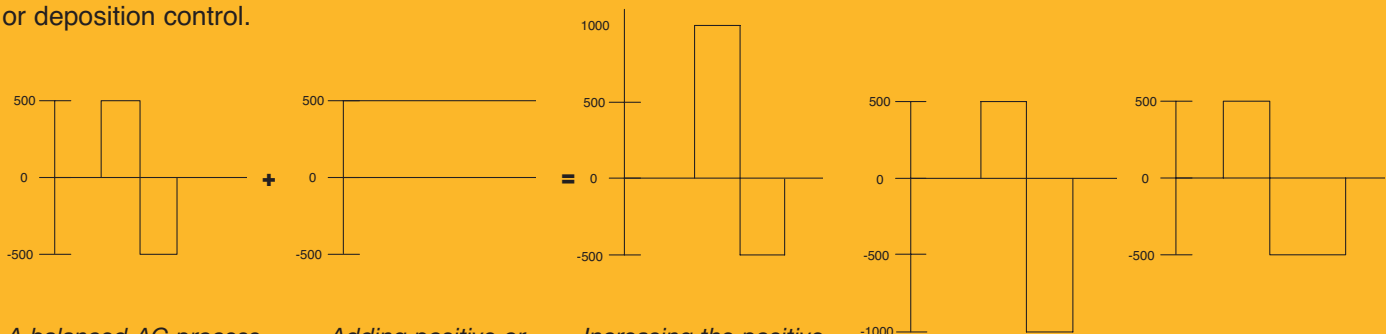
Control was designed specifically to solve this problem, allowing the operator to take full advantage of the reduction in arc blow experienced with AC, while maintaining the penetration advantages of DC positive and the advantageous deposition rate of DC negative. Using these controls, the shape of the output waveform is changed, and in turn the welding characteristics are controlled.

With the Power Wave AC/DC 1000, you get the best of both worlds: the speed, deposition rate, and penetration that DC SAW offers, and the resistance to arc blow that AC SAW offers. In single arc processes, the Power Wave AC/DC 1000 provides flexibility with Waveform Control Technology. In multiple arc processes, that same flexibility is achieved through control of phase shifting between arcs.

## How

### AC/DC Submerged Arc Works in a Single Arc Environment

Waveform Control Technology gives the operator the ability to change the positive and negative amplitude and time intervals independently of each other, to achieve the penetration and deposition rate that suits their application. In other words, if a weld requires greater penetration and reduced deposition, the operator would add a positive DC offset, forcing an imbalance in the waveform. Adding negative current results in higher deposition rates. Changing the balance of the positive or negative time intervals provides additional penetration or deposition control.



A balanced AC process uses a combination of DC positive and DC negative amperage.

Adding positive or negative DC offsets change the deposition and penetration characteristics.

Increasing the positive amplitude of the waveform increases penetration.

Increasing the amplitude or time balance of the negative amplitude increases deposition and decreases penetration.

# AC/DC Submerged Arc Welding

## Using AC/DC

The AC/DC SAW process is the ideal choice for high-deposition, high-speed welds that can be made in the 1G position. Whether your applications demands a single arc or up to five synchronized arcs, AC/DC SAW with the Power Wave will increase weld speeds and yield higher quality welds.

In multiple arc welding, as many as 5 arcs operate in a single weld puddle. The positive and negative polarity phases of the AC waveform can be independently adjusted, as well as the cycle balance. Changes to the combination of any of these values will change the deposition rate, penetration, and travel speed, without changing the voltage or current settings.

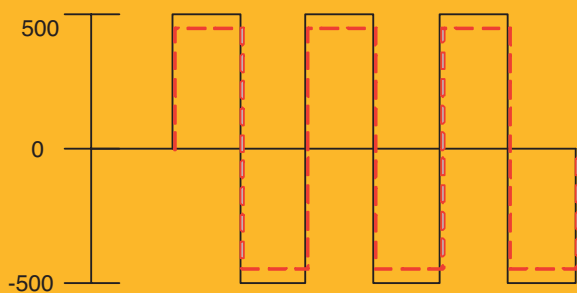
Typical DC-AC two-arc combinations can be replaced with AC/DC Power Waves for either AC/DC or AC/AC welding applications.



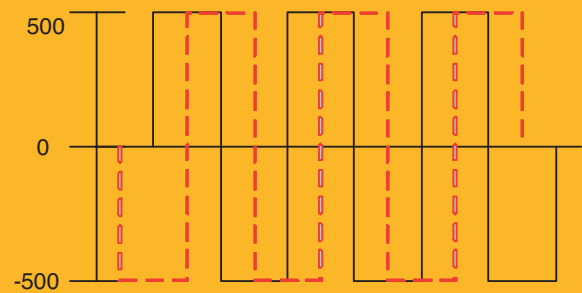
## How

### AC/DC Submerged Arc Works in a Multi-Arc Environment

When more than one arc is present, arc interaction plays an important role in the behavior of the weld. Two positive electrodes pull together because their magnetic fields attract each other. Two negative electrodes also pull together. One negative and one positive electrode repel or push against each other. By phase shifting the AC waveforms the amount of “push” and “pull” of the arc interaction can be balanced. This is the reason multi-arc processes use alternating current to minimize arc blow.



*In this example, both electrodes are either always positive, or always negative, causing a constant “pull”. Constant “pulling” will lead to arc blow, penetration, and bead appearance problems.*



*Similar to the way a single arc process allows operator flexibility through manipulation of the waveform, the dual arc process is controlled by shifting the phase of the waveform.*

*In the above waveform, the amount of time that both electrodes are positive is balanced with the amount of time that one is positive and one is negative.*

# AC/DC Submerged Arc Welding

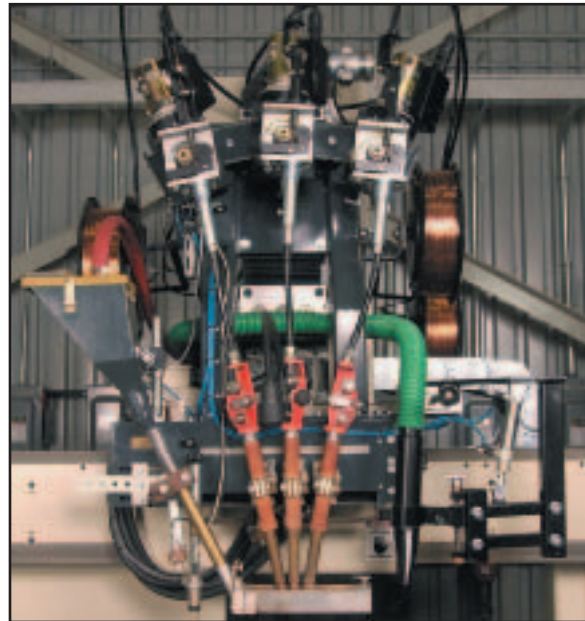
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## Using AC/DC

Power Wave® AC/DC 1000™ multi-arc welding is being used for:

- Longitudinal and spiral pipe mills
- Mold rebuilding
- Structural material for bridges and offshore platforms
- Pressure vessels
- Shipbuilding

The Power Wave AC/DC 1000 is designed to be easily paralleled for welding applications that require higher amperage. Each Power Wave AC/DC 1000 provides 1000 amps of AC or DC output at 100% duty cycle and can be paralleled to any desired capacity.



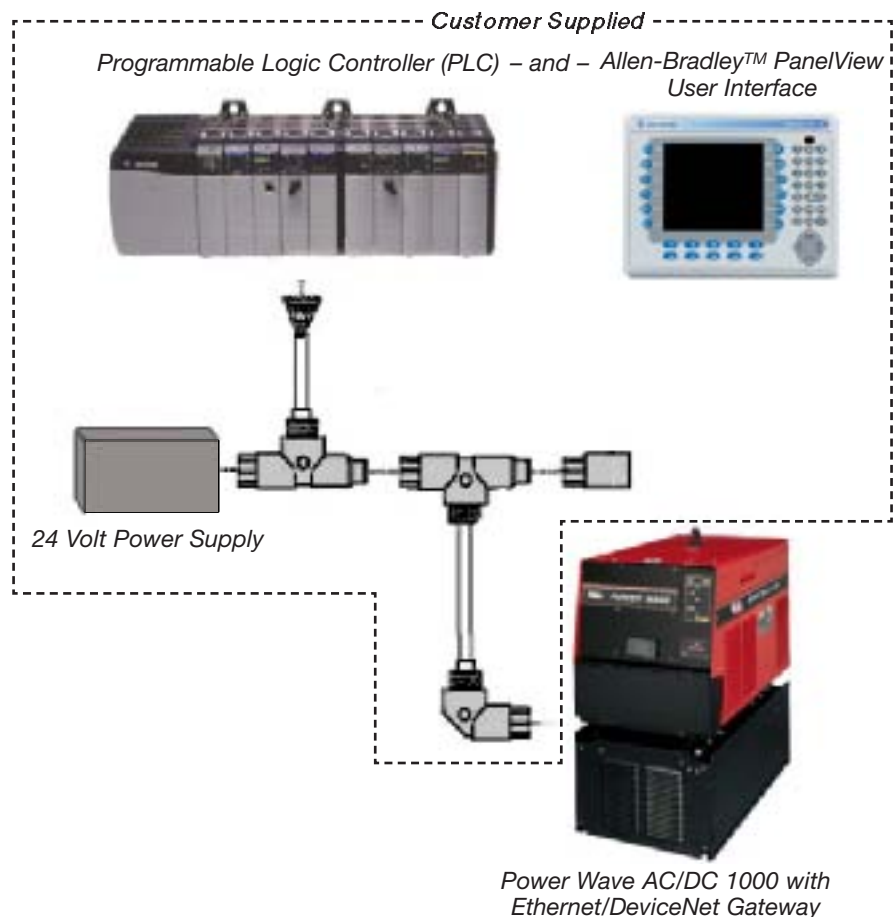
Three-Arc Power Wave AC/DC 1000 Submerged Arc welding system controlled by a PLC

## Interfacing

with Power Wave AC/DC 1000

### Hard Automation

For repeatable, high-deposition, quality welds, the Power Wave AC/DC 1000 coupled with a PLC provides a reliable hard automation welding solution. The Power Wave AC/DC 1000 can easily be connected to a PLC with the standard Ethernet/DeviceNet gateway board (which is included in the Power Wave AC/DC 1000). The Ethernet/DeviceNet gateway board also allows the system to be tracked and monitored from a remote location, over a network.



Typical Hard Automation Welding System Configuration



# AC/DC Submerged Arc Welding

## Benefits

of Power Wave® AC/DC 1000™

### Power Electronics

Power Wave AC/DC 1000 uses inverter technology, not SCR or cyclo-conversion, which limits control options.

### Control

Choice of AC frequency (from 10 Hz to 100 Hz) standard, balance of positive and negative half-cycles, and amplitudes.

### Efficiency

Inverter power sources operate at 87% efficiency and a power factor of 95%.

### Stability

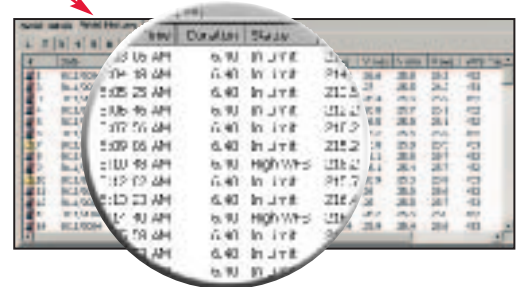
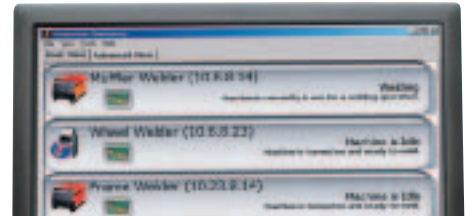
Increased stability of phase-shifting of multiple arcs due to the capability of any degree of shift to create equal ratios of magnetic push and pull.

### Waveform Control

Waveform Control and infinite phase shifting stabilize imbalanced waveforms. The operator achieves full control of penetration and deposition without changing heat input levels.



Power Wave AC/DC 1000



Communications between ArcLink and Ethernet enable equipment tracking via Lincoln Electric's Production Monitoring™ software utility.

## Productivity

of Dual Arc SAW

Fill Productivity	Process	Current (Amps)	Voltage (Volts)	Travel Speed (IPM)	Total Kj/in.	Wire Feed Speed (IPM)	Electrode Diameter (in.)	Deposit Rate (Lbs/Hr)	Total Lbs/Hr	Area/pass (sq. in.)
100%	DC/AC	650/650	30/34	31	80.5	45/55	5/32	15/18	32.66	0.0620
109%	AC Balanced	650/650	30/34	31	80.5	54/55	5/32	17.5/18	35.59	0.0676
130%	AC 25% DCEP Balanced	650/650	30/34	31	80.5	64.5/65.7	5/32	21/21.4	42.39	0.0805
135%	AC 25% DCEP 25% DC Offset	650/650	30/34	31	80.5	68/67	5/32	22/22	44	0.0836

# AC/DC Submerged Arc Welding

## Lincoln Welding Systems featuring AC/DC

### Power Wave® AC/DC 1000™

The Power Wave AC/DC 1000 is equipped with Waveform Control Technology and Inverter Power Source design, to provide the highest reliability and weld quality the welding industry has to offer.

Power Wave AC/DC 1000 operates at a 95% power factor with low harmonic distortion, and is 87% efficient. It draws equally matched currents from a three-phase line and can produce both sine and square waves, for compatibility with older equipment or better penetration and greater deposition with new processes.



### Power Feed™ 10A Controller

The Power Feed 10A Controller is the next generation in automatic submerged arc feeding. Designed for use with the Power Wave AC/DC 1000 power source, the Power Feed 10A eliminates the need for a separate AC and DC controller, making this powerful hard automation system controllable, adaptable and easy to use. The user-friendly control panel offers a single-point of control over the entire welding cell, including the

Power Wave's Waveform Control Technology™, delivering an unprecedented level of control over wave balance, amplitude and

#### 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](http://www.lincolnelectric.com) for any updated information.

#### WHAT IS NEXTWELD?

The challenges facing industrial fabricators today are growing in number and complexity. Rising labor, material and energy costs, intense domestic and global competition, a dwindling pool of skilled workers, more stringent and specific quality demands all contribute to a more difficult welding environment today.

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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**ELECTRIC**

THE WELDING EXPERTS<sup>SM</sup>

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