GLOBAL LEADER FOR SUBMERGED ARC WELDING
— 120 YEARS YOUNG, KNOWN WORLDWIDE
FOR QUALITY, PERFORMANCE AND PRODUCTIVITY

LOCATIONS
- Global Headquarters
- Solution Centers

Employees
10,000

Active in 160 countries
160

Manufacturing locations for consumables and equipment
48

Manufactured in 19 countries
19

Billion USD Revenue in 2015
2.5

SUBMERGED ARC WELDING
FOR EVERY INDUSTRY

HEAVY FABRICATION
OFFSHORE
PIPE MILL
POWER GENERATION
SHIPBUILDING
CHEMICAL PROCESSING
STRUCTURAL

TECHNICAL EXPERTISE • PRODUCTIVITY SOLUTIONS
GLOBAL APPLICATION SUPPORT

GO TO WEB PAGE

www.lincolnelectric.eu
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MOVING YOUR SUBMERGED ARC SOLUTION TO THE NEXT LEVEL

Lincoln Electric is the submerged arc process specialist. Together we will develop the best solution while maximizing your savings through highest deposition rates, highest quality and optimized parameters with your actual equipment and potential investments. Rate yourself on the next graph and let’s move together to the next step.

- High quality welding results
- Excellent bead appearance
- Highest deposition rates
- Deep penetration
- Increased productivity

**Deposition Rate (%) vs Single Electrode**

**Total Welding Amperage (A)**

<table>
<thead>
<tr>
<th>Single Wire</th>
<th>Tandem Arc</th>
<th>Tiny Twin Arc</th>
<th>Tandem Twin</th>
<th>Triple Arc</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>150</td>
<td>200</td>
<td>250</td>
<td>300</td>
</tr>
<tr>
<td>150</td>
<td>200</td>
<td>250</td>
<td>300</td>
<td>350</td>
</tr>
<tr>
<td>200</td>
<td>250</td>
<td>300</td>
<td>350</td>
<td>400</td>
</tr>
<tr>
<td>250</td>
<td>300</td>
<td>350</td>
<td>400</td>
<td></td>
</tr>
</tbody>
</table>

**Deposition Rate (kg/h)**

- Single Wire (Ø2.0 - 2.4)
- Tandem Arc (Ø3.2 - 4.0)
- Tiny Twin Arc (Ø2.0 - 2.4)
- Long Stick Out (Ø2.0 - 4.0)
- Tandem Long Stick Out (Ø3.2 - 4.0)
- Triple Arc (Ø3.2 - 4.0)
## MILD STEEL WIRE DEPOSITION RATES IN SUBMERGED ARC WELDING

### Average Deposition Rate in (kg/h)

*Improvement versus standard Single Arc in [%]*

<table>
<thead>
<tr>
<th>Single Arc</th>
<th>DC+</th>
<th>AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Wire 4.0 mm</td>
<td>6.5 kg/h</td>
<td>10.0 kg/h +54%</td>
</tr>
<tr>
<td>Tiny Twin Arc 2 x 2.0 mm</td>
<td>9.6 kg/h +48%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiple Arcs</td>
<td>DC+/AC</td>
<td>AC/AC</td>
</tr>
<tr>
<td>Tandem Arc 2 x 4.0 mm</td>
<td>18.7 kg/h +188%</td>
<td>23.5 kg/h +262%</td>
</tr>
<tr>
<td>Tandem Twin 4.0 + 2 x 2.0 mm</td>
<td>23.2 kg/h +256%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>AC/AC/AC</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Standard Stick Out</td>
<td></td>
</tr>
<tr>
<td>Triple Arc 3 x 4.0 mm</td>
<td>32.0 kg/h +392%</td>
<td></td>
</tr>
</tbody>
</table>

**Lincoln Electric supports you to select:**
- Optimum process
- Ideal parameters
- Consumables that guarantee the required mechanical properties customized to your application

**GO FOR NEXT STEP**
DEPOSITION RATES – SINGLE POWER SOURCE

The single power source configuration panel

- Standard platform
- Easy to upgrade
- Deposition rate up to 10 kg/h

1 – Power source
1 – Wire feeder
1 – Wire

- Low additional investment
- To be used over 700 A
- High deposition rate and high speed weld
- To be used on fillet or filling weld
- Reduced penetration
- Deposition rate up to 20 kg/h

1 – Power source
1 – Wire feeder
2 – Wire
1 – Drive roll kit

Very low additional investment
High deposition rate
Low heat input (less distortion)
Flux / wire ratio reduction
Deposition rate up to 30 kg/h
Recommended with Power Wave® AC/DC 1000® SD

1 – Power source
1 – Wire feeder
1 – Wire
1 – Long Stick Out kit

TYPICAL STANDARD DEPOSITION RATES FOR SINGLE POWER SOURCE

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</tr>
<tr>
<td>Deposition Rate</td>
<td>6.5 kg/h</td>
<td>10.0 kg/h</td>
<td>9.6 kg/h</td>
</tr>
<tr>
<td>Improvement vs. Single Wire 4.0 mm</td>
<td>100%</td>
<td>154%</td>
<td>148%</td>
</tr>
</tbody>
</table>

DC+
50 Hz
20% balance
-25% offset

AC
50 Hz
20% balance
-25% offset

+54%
+48%
+23%
+130%
+112%
DEPOSITION RATES – MULTIPLE POWER SOURCES

The tandem and triple arc configuration panel

- **Tandem**
  - High productivity
  - High welding speed
  - High deposition rate up to 35 kg/h
  - Versatile process with Power Wave® AC/DC 1000® SD

- **Tandem Tiny Twin**
  - High productivity and high speed weld
  - High deposition rate up to 30 kg/h

- **Triple Arc**
  - Power source
  - Wire feeder
  - Wire

- **Favourable weld geometry pass/cap pass**
- **Long stick out option with all benefits on demand**

**TYPICAL STANDARD DEPOSITION RATES FOR MULTIPLE POWER SOURCES**

<table>
<thead>
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<th>AC/AC</th>
<th>AC/AC/AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single wire 4.0 mm</td>
<td>Tandem Arc</td>
<td>Tandem Tiny Twin</td>
<td>Tandem Arc + Long Stick Out</td>
</tr>
<tr>
<td>Typical Deposition Rate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.5 kg/h</td>
<td>18.7 kg/h</td>
<td>23.2 kg/h</td>
<td>23.5 kg/h</td>
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<tr>
<td>Improvement vs. Single Wire 4.0 mm</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>100%</td>
<td>288%</td>
<td>356%</td>
<td>362%</td>
</tr>
</tbody>
</table>

**Graph showing productivity improvement percentage:**
- **DC+**
- **AC/AC**
  - 50 Hz
  - 25% balance
  - -25% offset
- **AC/AC/AC**
  - 50 Hz
  - 25% balance
  - -25% offset
THE SUBMERGED ARC WELDING PROCESS

The arc being shielded and hidden under the flux, high current density can be considered with the following benefit:

- Operator protection from arc ray and heat radiation
- High deposition rate and high quality welds
- Versatile welding process with combination of wire diameter, flux type, single or multiple electrodes, welding current wave shape and welding mode

WELDING PARAMETERS (VARIABLES)

WIRE DIAMETER/AMPERAGE

The submerged arc wire standard portfolio includes different wire sizes, mainly between 2.0 and 4.0 mm wire diameter. The choice of wire size is made in accordance with the welding procedure parameters in order to maximize the current density and increase the melt off rate, without exceeding the wire current carrying capacity as shown in the following table.

<table>
<thead>
<tr>
<th>Wire Diameter</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>600</th>
<th>700</th>
<th>800</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 mm kg/h</td>
<td>1.9</td>
<td>3.0</td>
<td>4.5</td>
<td>6.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4 mm kg/h</td>
<td>2.9</td>
<td>4.4</td>
<td>5.9</td>
<td>8.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2 mm kg/h</td>
<td>2.5</td>
<td>3.8</td>
<td>5.2</td>
<td>6.7</td>
<td>8.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.0 mm kg/h</td>
<td>3.5</td>
<td></td>
<td>5.0</td>
<td>6.5</td>
<td>8.3</td>
<td>10.0</td>
<td></td>
</tr>
</tbody>
</table>

![Graph showing deposition rate vs. amperage used]
POLARITY

In most of the submerged arc applications it is possible to work in DC current with the electrode being either positive or negative.

Thanks to Lincoln Electric Waveform Control Technology® embedded in the new Power Wave® AC/DC 1000® SD power source and the new MAXsa® Controllers and Feeders, we can now take over the full area between DC+ and DC-.

<table>
<thead>
<tr>
<th>DC+</th>
<th>DC-</th>
<th>AC</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Most common mode</td>
<td>• Deep penetration and stable arc</td>
<td>• A compromise between the two DC modes</td>
</tr>
<tr>
<td>• Improves deposition rate (25%)</td>
<td>• Limits penetration</td>
<td>• The optimum choice with Power Wave® AC/DC 1000® SD</td>
</tr>
<tr>
<td>• Limited arc stability</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Waveform Control Technology® capability provides precise control over:

- Frequency (Number of switch per second from positive to negative polarity)
- Balance (Percentage of time in the positive polarity portion of one cycle)
- Offset (Positive/Negative Amplitude)

Offset : Positive Current Level = Penetration

Offset : Negative Current Level = Deposition

Cycle Balance = Penetration/Deposition

AC Frequency
ELECTRICAL STICK OUT

Electrical Stick Out setting:
The electrical stick out or CTWD (contact tip to work distance) is the distance set between the contact tip end and the work piece. The stick out needs to be kept constant along the weld if consistent results are expected for the welding behavior and penetration.

The Long Stick Out variant:
Taking benefit of the Power Wave® technology, the long stick out variant is now a reliable option for a number of applications.

<table>
<thead>
<tr>
<th>Unmatched Productivity Increase</th>
<th>Complete Control</th>
<th>Enabled by State-of-the-Art Equipment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Increase deposition rate without changing the process</td>
<td>• Power Wave® technology eliminates arc striking issues by allowing complete tailoring of the arc start characteristics</td>
<td>• Power Wave® AC/DC 1000® SD</td>
</tr>
<tr>
<td>• Significant reduction of heat input possible</td>
<td>• Precise control over the input of energy into the weld</td>
<td>• MAXsa® 10 Controller</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• MAXsa® 22 Automatic Feeder</td>
</tr>
</tbody>
</table>

HEAT INPUT

$$HI = 0.06 \times \frac{A \times V}{V}$$

The heat input will affect the mechanical properties of the deposited metal as well as the base material in the heat affected zone. It is also a key parameter for the distortion of the weld assembly. As an example, a target at 20 kJ/cm for single arc procedure on non and low alloy grade is a good start.

With the Power Wave® AC/DC 1000® SD, the heat input can be optimized and tailored as needed.
LINCOLN SUPPORT IN PRODUCTIVITY IMPROVEMENT

As per our previous parameters setting range description, the submerged arc process offers a lot of opportunities for productivity improvements. From the procedure adjustment to the hard automation investment, it is our philosophy to partner with the customer to achieve the highest savings combined with an optimum ROI (return on investment).

Improving productivity in the workshop should be considered from many aspects:

WELD PREPARATION

V, X and K Joint

- The included angle ranges between 45° and 60°
  The narrower angle is used when the top of the preparation can be reached in one pass

Heavy plates

- Combined preparation also called a compound bevel is used to limit the groove area and guarantee penetration
  - 60° angle at the bottom
  - 5° to 15° above as soon as the bevel side distance exceed 12 mm
  - Machining and seam tracking system is mandatory

Double side welds

- Symmetric preparations are always more effective than asymmetric grooves
- Up to 25 mm, it is possible to use the two run technique (1 pass each side in tandem)
**WELD COST STUDY - SINGLE POWER SOURCE EXAMPLE**

**APPLICATION**

Labour cost*: 60 €/h  
Weld length: 10 000 m  
Consumables: Lincolnweld® 860 / L-61 wire combination

---

**PROCESS**

<table>
<thead>
<tr>
<th>Electrical parameters</th>
<th>DC+</th>
<th>AC**</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Single Wire</td>
<td>Tiny Twin Arc</td>
</tr>
<tr>
<td></td>
<td>30 mm Stick Out</td>
<td>25 mm Stick Out</td>
</tr>
<tr>
<td>Amperage</td>
<td>550</td>
<td>550</td>
</tr>
<tr>
<td>Voltage</td>
<td>29</td>
<td>29</td>
</tr>
<tr>
<td>Deposition rate [kg/h]</td>
<td>6.5</td>
<td>10.0</td>
</tr>
<tr>
<td>Welding speed [cm/min]</td>
<td>42</td>
<td>65</td>
</tr>
<tr>
<td>Heat input [kJ/cm]</td>
<td>23.0</td>
<td>15.0</td>
</tr>
</tbody>
</table>

---

**COST STUDY FOR 10 000 METERS OF WELD**

<table>
<thead>
<tr>
<th>CONSUMABLE COST</th>
<th>Weld metal cost [€]</th>
<th>187 000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Welding time [h]</td>
<td>6 692</td>
<td>4 350</td>
</tr>
<tr>
<td>Time saving [h]</td>
<td>-2 342</td>
<td>-2 161</td>
</tr>
<tr>
<td>Labour cost* [€]</td>
<td>401 538</td>
<td>261 000</td>
</tr>
<tr>
<td>Labour saving [€]</td>
<td>-140 538</td>
<td>-129 663</td>
</tr>
<tr>
<td>Total cost [€]</td>
<td>588 588</td>
<td>448 050</td>
</tr>
</tbody>
</table>

**TOTAL COST**

| Total cost saving       | -24% | -22% | -13% | -39% | -36% |

---

* Machine cost including one operator  
** AC = 50 Hz, 25% balance, -25% offset

---

Total Welding Cost for 10 000 m of Weld

**Consumable Cost**

- Weld metal per m = 4.35 kg  
- Consumable cost per m = 18.70 €

**Production Cost**

- Welding time: 6 692 h, 4 350 h, 4 531 h, 5 438 h, 2 900 h, 3 152 h
- Time saving: -2 342 h, -2 161 h, -1 255 h, -3 792 h, -3 540 h
- Labour cost*: 401 538 €, 261 000 €, 271 875 €, 326 250 €, 174 000 €, 189 130 €
- Labour saving: -140 538 €, -129 663 €, -75 288 €, -227 538 €, -212 408 €
- Total cost: 588 588 €, 448 050 €, 458 925 €, 513 300 €, 361 050 €, 376 180 €

**Total cost saving**

-24%, -22%, -13%, -39%, -36%
## WELD COST STUDY – MULTIPLE POWER SOURCE EXAMPLE

### APPLICATION

- **Labour cost**: 60 €/h
- **Weld length**: 10 000 m
- **Consumables**: Lincolnweld® 860 / L-61 wire combination

### PROCESS

<table>
<thead>
<tr>
<th>DC+</th>
<th>DC+/AC*</th>
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</tr>
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<tbody>
<tr>
<td>Single Wire</td>
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<td>Tandem Tiny Twin</td>
</tr>
<tr>
<td>30 mm Stick Out</td>
<td>30 mm Stick Out</td>
<td>25 mm Stick Out</td>
</tr>
</tbody>
</table>

**Electrical parameters**

- **Amperage**: 550 / 750 / 650 / 850 / 750 / 650 / 750 / 650
- **Voltage**: 29 / 30 / 32 / 32 / 33 / 30 / 32 / 32 / 34 / 33 / 34 / 32 / 34

**Deposition rate** [kg/h]

- Single Wire: 6.5
- Tandem Arc: 18.7
- Tandem Tiny Twin: 23.2
- Tandem Arc + Long Stick Out: 23.5

**Welding speed** [cm/min]

- Single Wire: 42
- Tandem Arc: 100.0
- Tandem Tiny Twin: 130.0
- Tandem Arc + Long Stick Out: 120.0

**Heat input** [kJ/cm]

- Single Wire: 23.0
- Tandem Arc: 26.0
- Tandem Tiny Twin: 24.0
- Tandem Arc + Long Stick Out: 21.0

### COST STUDY FOR 10 000 METERS OF WELD

#### CONSUMABLE COST

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<td>-4 366</td>
</tr>
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<td>Total cost [€]</td>
<td>588 588</td>
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**Total cost saving**

-45% -49% -49% -47% -51% -53%

* Machine cost including one operator

** AC = 50 Hz, 25% balance, -25% offset

### Total Welding Cost for 10 000 m of Weld

<table>
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**APPLICATION**

- Labour cost*: 60 €/h
- Weld length: 10 000 m
- Consumables: Lincolnweld® 860 / L-61 wire combination

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SUBMERGED ARC EQUIPMENT

Digital Power Source

Power Wave® AC/DC 1000® SD

Increase Productivity, Quality and Flexibility

Digital Wire Feeders

MAXsa® 10 Controller

ArcLink® enabled Controller for Power Wave® AC/DC 1000® SD Systems

MAXsa® 22 Feed Head

Submerged Arc Hard Automation Wire Drive for Power Wave® AC/DC 1000® SD Systems
**Idealarc® AC-1200**
Automatic Submerged Arc Welding Power Source

**Idealarc® DC-1000**
**Idealarc® DC-1500**
Industrial DC Multi-Process Welders

**NA-3, NA-4 & NA-5**
Control & Heads
Automatic Welding Systems
SUBMERGED ARC CONSUMABLES

Lincoln Electric is proud to offer a complete solution of equipment and consumables in order to deliver the best quality and most economical weld for any application. Ask your Lincoln Electric representative for the next step.

<table>
<thead>
<tr>
<th>Application</th>
<th>Fluxes</th>
<th>Wires</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild Steel</td>
<td>761, 780, 781, 782, 839, 842-H</td>
<td>L-60, L-61, LNS 135, L-50M</td>
</tr>
<tr>
<td>Low Alloy</td>
<td>8500, 860, 888, 960, 980, P230, P240</td>
<td>LNS 140A, LNS 150, LNS 151, LNS 160, LNS 162, LNS 163, LNS 164, LNS 165, LNS 168</td>
</tr>
</tbody>
</table>

PACKAGING

SUBMERGED ARC FLUX AND WIRES

35 kg Spool  
VCI packaging for optimum corrosion protection during transportation and storage

100 kg Coil  
High capacity packaging for column/boom applications, optimum for multi-wire applications (tandem/triple arc)

300 kg Spool  
Wooden reel

1000 kg Coil  
Liftable

Speed-Feed® Drum
Accu-Trak® / Speed-Feed® Drums  
600 kg / 1000 kg

25 kg Bag  
- Standard plastic  
- Moisture resistant Sahara ReadyBag™

1000 kg Bulk Bag

OTHER PACKAGING AVAILABLE ON REQUEST
CHECKPOINT™

With the Power Wave® AC/DC 1000® SD, store your weld data in the cloud and access it on almost any device.

- **Benefits**
  - **Traceability/Scanning**
    Use the CheckPoint™ mobile app to scan barcodes for operator, consumable ID and part serial numbers. All scans are correlated with the weld data transmitted by the welder. Includes Bluetooth integration for industrial barcode scanners.
  - **Simple System Management**
    Determine who is authorized to view the data, analysis, documents and manuals specific to each welder through desktop and mobile devices.
  - **Cloud API**
    Using the industry standard protocol O Data, CheckPoint™ delivers secure access to data by enterprise ERP systems, plant OEE systems, and maintenance applications.
  - **Graphical Interface**
    View data in an intuitive dashboard view that provides a Pulse™ on your welding operations at a glance.
  - **Security you can count on**
    Your data is protected with physical security, encryption, user authentication and more.
  - **Data aggregation**
    With a global view of all of your welding equipment, you can benchmark your facilities.
  - **Exporting**
    Export data and reports in various formats for offline analysis.
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  - **Data aggregation**
    With a global view of all of your welding equipment, you can benchmark your facilities.
  - **Exporting**
    Export data and reports in various formats for offline analysis.
  - **Mobile device compatibility**
    View on smart phones, tablets, laptops or desktops with any browser.

- **Alerts**
  Receive email notifications based on equipment conditions and wire consumption.

- **Production Monitoring**
  View live status of each welder and weld details.

- **Traceability**
  Satisfy reporting requirements by capturing audit trail data.

With the Power Wave® AC/DC 1000® SD, store your weld data in the cloud and access it on almost any device.
TOTAL SOLUTION FOR SUBMERGED ARC WELDING

WELDING CONSUMABLES

AUTOMATION

POWER SOURCES, WIRE FEEDERS & CONTROLLERS

R&D and SOLUTION CENTERS ALL OVER THE WORLD

GLOBAL SOLUTION

SOLUTIONS FROM ONE HAND

PipeMills
Multi Arc, Sub Arc Technology
Global Leader in Longitudinal Pipe Welding and Leading Position in Spiral Pipe Welding

Critical Process Equipment
Strip Cladding complete solution
Narrow Gap Welding complete solution

Uhrhan & Schwill
SCHWEISSTECHNIK
A Lincoln Electric Company

Lincoln Electric
Cleveland, USA

Lincoln Smith weld
Nijmegen, The Netherlands

Uhrhan & Schwill
Essen, Germany

Lincoln Electric
Rouen, France

Lincoln Electric
Essen, Germany
70% Time and 40% Cost Saving
- Always Single Layer Solution
- High Speed Cladding Process

Homogeneous and Cleaner Chemistry
- <5% Fe in Ni-625
- Improved Quality

Full Process Control
- State-of-the-Art Digital Hybrid 3D Z5 Controller
- Real Time Data Logging and Traceability

First Proven Single Layer High Speed Solution with Neutral Flux
- <5% Fe in Ni-625
- Required Undiluted AWS Chemistry for Stainless Steel

Reduction in Working Capital
- Single Stainless Steel Strip for All Austenitic SS Grades
- Faster Delivery of MCW and Full Control of Delivery Time

Instant Technical Service to Customer

DOWNLOAD BROCHURE
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 customers and to exceed their expectations. On occasion, purchasers may ask Lincoln Electric for information or advice about their use of our products. Our employees respond to inquiries to the best of their ability based on information provided to them by the customers and the knowledge they may have concerning the application. Our employees, however, are not in a position to verify the information provided or to evaluate the engineering requirements for the particular weldment. Accordingly, Lincoln Electric does not warrant or guarantee or assume any liability with respect to such information or advice. Moreover, the provision of such information or advice does not create, expand, or alter any warranty on our products. Any express or implied warranty that might arise from the information or advice, including any implied warranty of merchantability or any warranty of fitness for any customers’ particular purpose is specifically disclaimed.

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