

## Automation Application Study



**Open-root Pulsed GMAW welding of Carbon Steel Pipe and Forged Flange Components  
Utilizing Lincoln Pulsed GMAW Waveform Technology with advanced AMET XM Weld Controls**

Customer: TD Williamson, Tulsa, OK

Prepared by: Jason Williams, AMET Inc.

**Contributors:**

Mike Armstrong, TD Williamson

Mike Phillips, TD Williamson

Keith Baldrige, TD Williamson

Joseph M. Murlin, Lincoln Electric Company, Tulsa, OK

Geoff Lipnevicius, Lincoln Electric Company, Cleveland, OH

Pete Goad, Airgas, Tulsa, OK

## Summary:

The automated, open root welding of Carbon Steel Pipe and Flange components using a precision welding lathe, AMET XM welding controls, and Lincoln Pulsed GMAW technology.

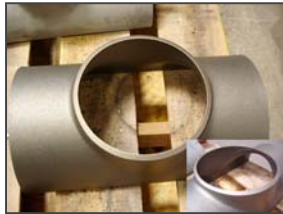
The customer was currently manually GMAW welding the parts in the following sequence:

- Parts were stacked on the floor, with spacers to set the gap.
- GMAW tacks were applied.
- Tacks were feathered using pneumatic grinding tools.
- Parts loaded onto a rotary positioner.
- GMAW root pass applied. Sometimes required grinding, cleaning, and GTAW repair.
- Subsequent Fill and Cap passes applied.

The existing welding equipment was Lincoln Power Wave 455, CV mode, with Lincoln SuperArc L56, .045 diameter wire.

A new Lean Manufacturing cell was designed by the customer to optimize the fabrication of 3 common sleeve to flange products. The lean cell scheme consisted of:

- Automated oven and press to heat, and press sleeve components out of steel plate.
- Wheelabrator cleaning booth.
- Automated Welding system to hold sleeve and flange, weld continuously from root to cap with a synchronized headstock and tailstock.
- Ultrasonic cleaning tank.
- Engraving station for labeling.
- Paint booth.



AMET was contracted to design and build the automated lathe welding station, based on our precision industrial lathe product line. Critical to the design, was the ability of AMET to fully integrate to existing Lincoln ArcLink technology, and provide a control solution that seamlessly melded the Lincoln Waveform GMAW technology with turn-key advanced controls of all welding equipment.

Geoff Lipnevicius of Lincoln's Automation Welding group provided process support, and design recommendations during the quotation and procurement process. AMET decided to integrate the Power Wave 455M / STT R, and Power Feeder 10R. Although not certain STT would be used, it was determined to be a cost effective value add-on, for potential weld development.

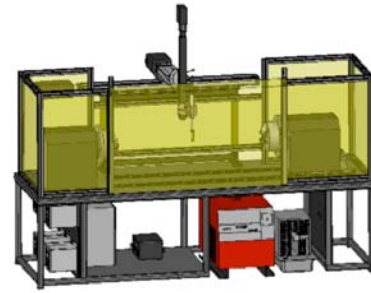
Procurement was 12 weeks to delivery, with factory acceptance testing performed at AMET prior to shipment. On-site installation was performed by AMET in April 2007. Lincoln local Representatives Joseph Murlin and Adam Ensminger, as well as Pete Goad from the local Airgas facility, provided materials support, and participated in Weld Development and production implementation.

Special thanks are given to Lincoln, for the on-site assistance of Senior Application Engineer Jeff Nadzam. Who provided weld development support, and instruction, specifically on the STT Mode welding.

**Equipment:**

AMET Precision Industrial Weld Lathe.

- Precision Torch X, Y, Z Linear axis.
- Precision harmonic drive Headstock and Tailstock.
  - Operator selectable synchronization for welding and manual clocking operations.
  - Tailstock mounted on adjustable precision rail base, with automated and manual pneumatic extension.
- Welding Safety Curtain.
- Lincoln Welding Package.
  - Lincoln Power Wave 455 STT R GMA power supply.
  - Lincoln Power Feed 10R wire feeder.
  - Lincoln Arclink integration with AMET XM Controls.
  - Tregaskiss ToughGun 500 amp water cooled GMA torch, LN4610-35-5.

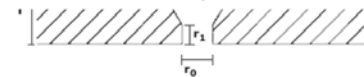


**Base Materials:** A105N Carbon Steel.

**Joint Preparation:** Finished with beveling tool.

Sleeve and Flange parts welded are nominally 4, 6, and 8 inch pipe sizes.

a (wall angle)	22-28.5 Degrees
T (Thickness)	See Schedule below
r <sub>0</sub> (root gap)	1/16 - 3/32 "
r <sub>1</sub> (land height)	1/8"



Pipe Size	OD	Schedule											
		5	10	20	30	40 (Standard)	60	80 (Extra Heavy)	100	120	140	160	2X Heavy
1/8	.405	.035	.049	-	-	.068	-	.095	-	-	-	-	-
1/4	.540	.049	.065	-	-	.088	-	.119	-	-	-	-	-
3/8	.675	.065	.065	-	-	.091	-	.126	-	-	-	-	-
1/2	.840	.065	.083	-	-	.109	-	.147	-	-	-	.187	.294
3/4	1.050	.065	.083	-	-	.113	-	.154	-	-	-	.218	.308
1	1.315	.065	.109	-	-	.133	-	.179	-	-	-	.250	.358
1-1/4	1.66	.065	.109	-	-	.140	-	.191	-	-	-	.250	.382
1-1/2	1.9	.065	.109	-	-	.145	-	.2	-	-	-	.281	.4
2	2.375	.065	.109	-	-	.154	-	.218	-	-	-	.343	.436
2-1/2	2.875	.083	.12	-	-	.203	-	.276	-	-	-	.375	.552
3	3.5	.083	.12	-	-	.216	-	.3	-	-	-	.437	.6
3-1/2	4	.083	.12	-	-	.226	-	.318	-	-	-	-	.636
4	4.5	.083	.12	-	-	.237	.281	.337	-	.437	-	.531	.674
4-1/2	5	-	-	-	-	2.47	-	.355	-	-	-	-	.710
5	5.563	.109	.134	-	-	.258	-	.375	-	.500	-	.625	.75
6	6.625	.109	.134	-	-	.280	-	.432	-	.562	-	.718	.864
7	7.625	-	-	-	-	.301	-	.5	-	-	-	-	.875
8	8.625	.109	.148	.250	.277	.322	.406	.5	.593	.718	.812	.906	.875
9	9.625	-	-	-	-	.342	-	.5	-	-	-	-	-

**Weld Parameters:**

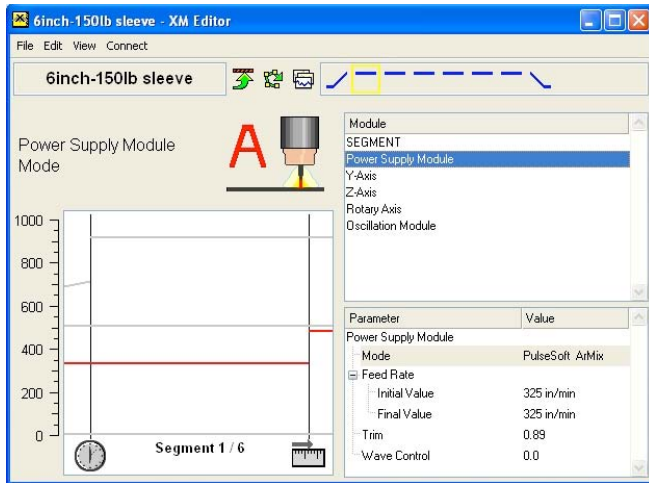
Pass	Wire Feed Rate	Trim	Wave Control	Electrode Lincoln SuperArc L-56,	Gas Flow Rate (90% Argon – 10% CO2)	Travel Rate	CTWD
root	325	.89	0.0	.045" (1.1mm)	50 scfh	16 ipm	.75"
Hot	325	.89	0.0	.045" (1.1mm)	50 scfh	16 ipm	.75"
Fill	325	.97	0.0	.045" (1.1mm)	50 scfh	16 ipm	.75"
Cap $\text{¥}$	350	.97	0.0	.045" (1.1mm)	50 scfh	16 ipm	.75"

$\text{¥}$  Cap pass includes Mechanical Oscillation



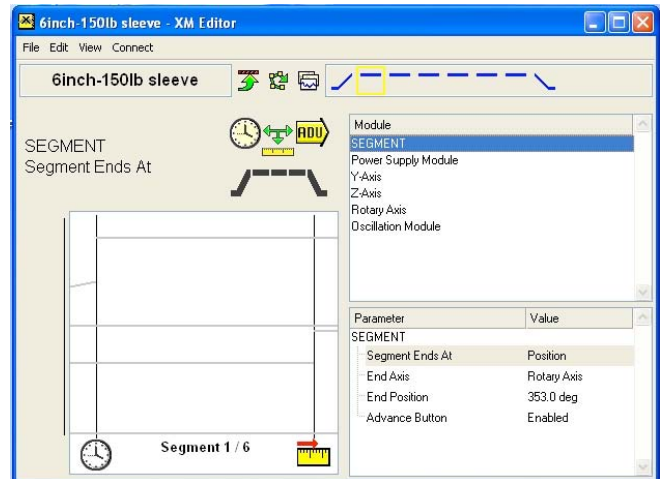
**XM Controller**

Weld Programs created on the XM Controller provide end-user, menu based programming interface to command all welding equipment, peripheral devices, and torch motion, with integrated data acquisition and real time tolerance checking.



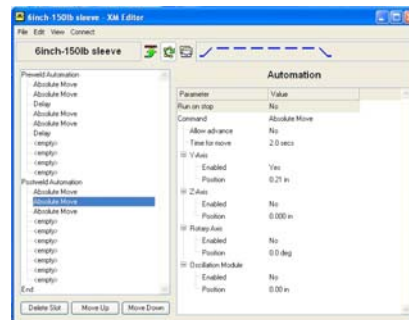
**Weld Program settings – Power Supply**

Mode: select Power Wave mode (001-255).  
 Mode 19 (PulseSoft Ar/Mix) shown.  
 Trim: Specific to each mode.  
 Wave Control: Specific to each mode.  
 Note: Feed Rate, trim and Wave Control are selectable for override during weld.



**Weld Program settings – Segments**

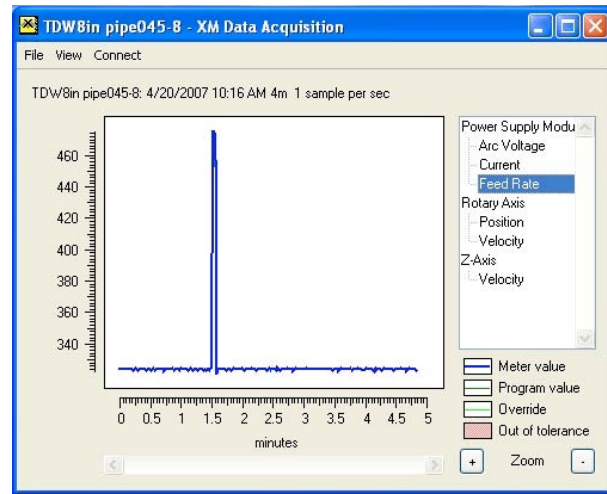
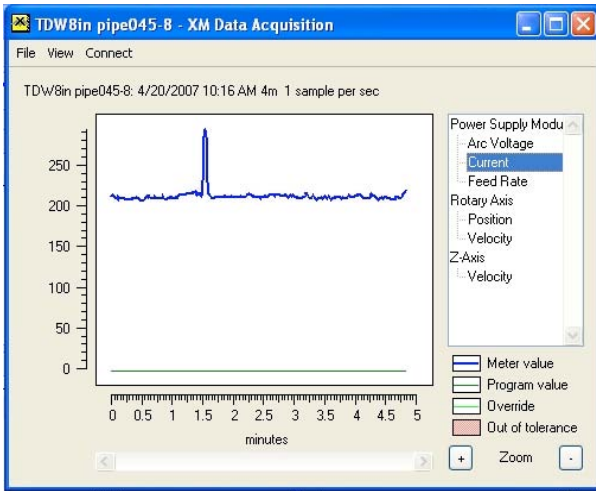
Segment: Up to 30 segments can be programmed standard.  
 Time or Position defined duration



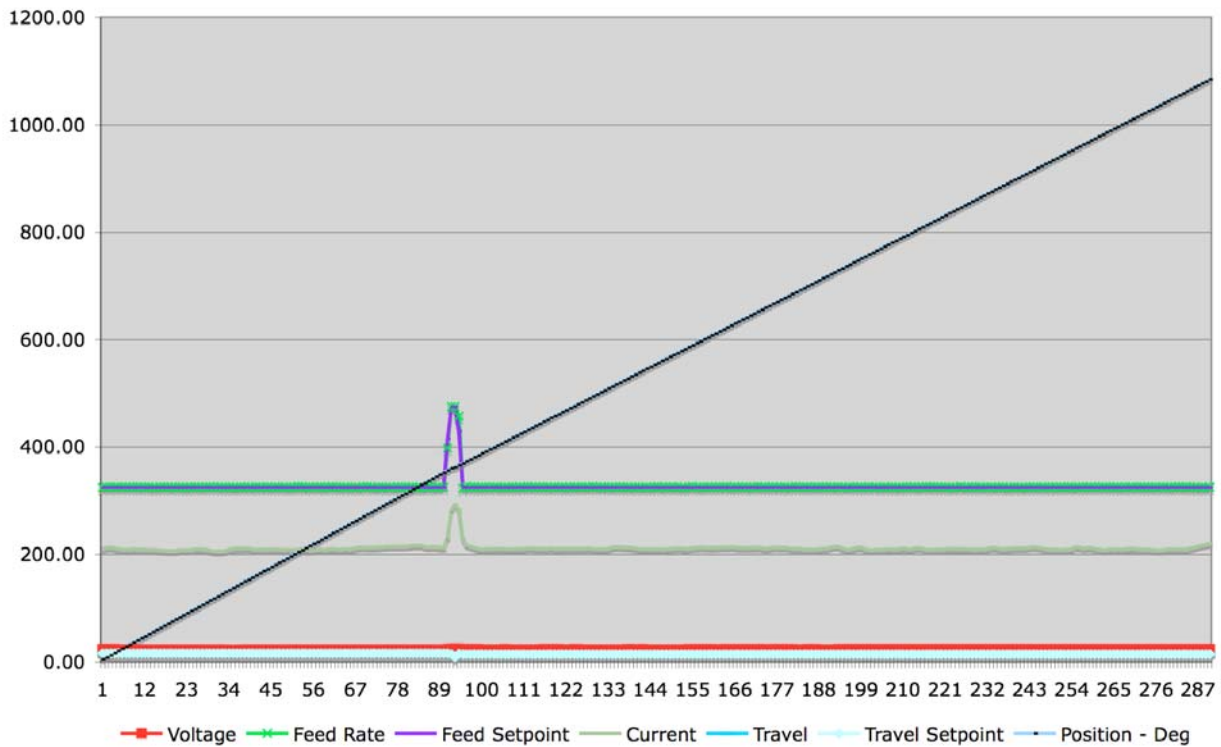
**Weld Program settings – Automation**

Define up to 10 Pre-weld and 10 Post-weld events, including torch motion, delays, purging, etc.

**Data**



**Exported Weld Data**

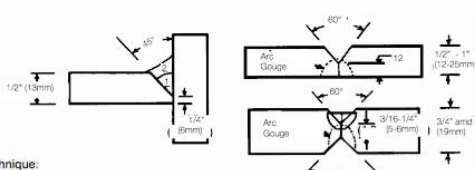


## Weld Development

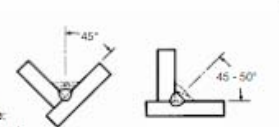
The Lincoln “GMA Welding guide” was the basis for developing weld parameters.

**Welding Guidelines for Carbon and Low Alloy Steel**  
**Axial Spray Transfer — Flat Butt Joints**

CTWD<sup>(1)</sup>: 5/8”-3/4” (16-19mm)  
 Gas: 90% Argon, 10% CO<sub>2</sub>  
 Gas flow: 40 to 45 cfh  
 (19 to 21 L/min.)



Technique:  
Use push angle

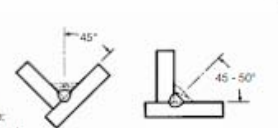


Technique:  
Use push angle

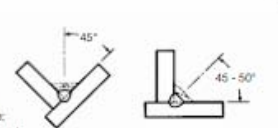
Electrode Dia. - in. (mm)	0.035 (0.9)	0.045 (1.1)	0.052 (1.3)	1/16 (1.6)
WFS - in./min (M/min.)	500 - 600 (12.7 - 15.2)	375 - 500 (9.5 - 12.7)	300 - 485 (7.6 - 12.3)	210 - 290 (5.3 - 7.4)
Amps (Approximate)	230 - 275	300 - 340	300 - 430	325 - 430
Travel Speed - in./min (M/min.)	10 - 15 (0.25 - 0.38)	12 - 18 (0.30 - 0.45)	14 - 24 (0.35 - 0.60)	14 - 23 (0.35 - 0.58)
Voltage (DC+)	29 - 30	29 - 30	30 - 32	25 - 28
Deposit Rate - lb/hr (kg/hr)	8.0 - 9.6 (3.6 - 4.4)	9.9 - 13.2 (4.5 - 6.0)	10.6 - 17.1 (4.8 - 7.8)	10.7 - 14.8 (4.8 - 6.7)

**Welding Guidelines for Carbon and Low Alloy Steel**  
**Pulsed Spray Transfer — Flat or Horizontal Fillets**

CTWD<sup>(1)</sup>: 5/8”-3/4” (16-19mm)  
 Gas: See below  
 Gas flow: 30 to 40 cfh  
 (17 to 19 L/min.)



Technique:  
Use push angle



Technique:  
Use push angle

Electrode Dia. - in. (mm)	0.045 (1.1)		
Plate Thickness - in. (mm)	1/4 (6)	5/16 (8)	3/8 (10)
Log Size - in. (mm)	3/16 (4.8)	1/4 (6.4)	5/16 (7.9)
WFS - in./min (M/min.)	300 (7.6)	325 (8.3)	375 (9.5)
Travel Speed - in./min (M/min.)	13 - 14 (0.33 - 0.36)	14 - 15 (0.35 - 0.38)	10 - 11 (0.25 - 0.28)
Voltage (DC+)	95% Ar/5% CO <sub>2</sub> <sup>(2)</sup> 24 - 24	90% Ar/10% CO <sub>2</sub> <sup>(2)</sup> 24.5 - 25.5	75-80%Ar/25-20% CO <sub>2</sub> 25.5 - 26.5
Deposit Rate - lb/hr (kg/hr)	28 - 29	28.5 - 30	30 - 31
	8.1 (3.6)	8.8 (4.0)	10.1 (4.5)

<sup>(1)</sup> Contact Tip to Work Distance

<sup>(2)</sup> For use on descaled plate only.

Several manufacturing requirements were important factors in the weld development.

1. A finished under-bead crown limit of 1/16 inch. Any crown above this would require grinding.
2. A continuous welding process, no stopping between passes for grinding, cleaning, or repairing. This was to conform to timelines established in a Lean manufacturing scheme being implemented.
3. Open root joint configuration. Although limited development showed successful welding with a butt joint preparation, open root welding was required to conform to the customers existing certification process.

Welding was started with 300 ipm wire feed, and experimentation was done with the Pulsed Soft, Pulse Crisp, and Pulse Rapid modes. Pulse Soft was selected based on stability and weld finish.

Experimentation was done with the STT Argon CO<sub>2</sub> mode used on the root pass. Root pass STT parameters were easily developed, producing low heat input, quality welds. Weld testing was performed at 125-150 ipm wire feed rate, with consistent sidewall wetting, and underbead geometry.

Subsequent hot, fill, and cap passes were welded with the Pulse Soft mode. Problems were encountered in maintaining penetration during the tie-in.

Experimentation was done utilizing pauses, and eventually switching to Pulse Soft mode at approximately 355 degrees, and maintaining penetration with both an increase in wire feed rate, and travel pause of 1 to 1.5 seconds.



Shield cup modifications were recommended for the STT mode, specifically, reducing the length of the shield cup by 5/16 inch. Thus effectively extruding the contact tip from the shield cup. This allowed welding with a lower CTWD, and improved the STT root process by reducing spatter, and arc light.

This modification could not be used, due to porosity problems during the fill and cap passes in pulse soft mode. Extra time was not taken to experiment with trailing shields, the decision was made to return to welding the root in the Pulse Soft Mode.