

Ultralight Pulse Gas Metal Arc Welding System for Shipyard Applications

A Navy MANTECH Program



GENERAL DYNAMICS
Electric Boat

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CENTER for NAVAL SHIPBUILDING TECHNOLOGY



GENERAL DYNAMICS
Electric Boat

EB-200MP Ultralight Welding System
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Problem

- Many pipe hanger welds and other light welding normally accomplished with SMAW (stick) – relatively expensive
 - Pros
 - Offers good accessibility
 - Versatile
 - Minimum equipment (just welding lead) at immediate job area
 - Quick setup
 - Cons
 - Welding speed
 - Welding debris (slag, smoke, spatter, stubs, fume, etc.)
 - Remote location of power source necessitates leaving job area to make adjustments
 - Need to drag leads on and off the boat



Solution

- Substitute pulse gas metal arc (PGMA) welding
 - Pros
 - Welding speed
 - “Clean” process
 - Power source/feeder in vicinity of work area allows adjustments to be easily made
 - Cons
 - Conventional PGMAW equipment is heavy and cumbersome – difficult and inconvenient to move from small job to small job
 - Repositioning power supply requires 2 men
 - Accessibility and visibility concerns with welding torch
 - May not be able to weld entire hanger with PGMA. May need to weld partially with SMA.



Existing PGMA Equipment

Inverter, Wire Feeder,
Gas Cooled Torch, total
weight ~180 lb.



State of the Art 2002

Transformer-
Rectifier, Wire
Feeder, Water
Cooled Torch, total
weight ~600 lb.

State of the Art 1982



Goals

- Develop a man-portable welding system that supports PGMAW shipyard welding of hangers and other small applications.
 - Consists of a portable inverter power supply and integral wire feeder with a maximum total weight of 40 pounds.
 - System shall also be SMAW capable to support welding where PGMAW is not possible or recommended.
 - Wire feeder shall accept 2.5 and 12 pound spools of 0.035 in. diameter electrode for PGMAW.
 - System shall operate on 220V single-phase power versus 460V three-phase power.
 - Pulse welding current waveforms shall provide legacy calculated cooling rate versus weld metal yield strength performance with MIL-100S-1 electrode.



Goals

- Develop a man-portable welding system that supports PGMAW shipyard welding of hangers and other small applications.
 - Arc and puddle characteristics shall be comparable to those obtained using PGMAW equipment currently in use at Electric Boat.
 - The welding system shall be programmable and able to meet the requirements of various shipyards.
 - Develop a compact, light-weight GMAW torch to maximize the number of welds where use of the new welding system would be advantageous.
 - Transfer technology to other shipyards.



Benefits

- Reduction in fabrication costs for hangers and other small welding jobs.
 - Reduced equipment setup time and relocation labor.
 - Makes up a large part of the welding cost.
 - Allows one person to relocate and setup equipment versus two persons.
 - Allows the welding system to be easily moved on and off the boat and around the work area, something not easily done with present PGMAW systems.
 - Increased use of higher efficiency / higher throughput PGMAW welding in place of SMAW.
 - Compact size of equipment and torch allows PGMAW to be used in more space restricted areas compared to current PGMAW equipment.
 - Improved quality compared to SMAW.
 - Eliminates arc strikes on surrounding equipment.



Benefits

- Improved safety and working environment.
 - Less welding fume, spatter, and no debris from SMAW electrode stubs and slag.
 - Use of safer 220V single-phase power in lieu of 460V 3-phase power.
 - Eliminates need for electrician support to plug in equipment.
 - Eliminates clusters of SMAW weld leads on the boat.
 - Lighter equipment should reduce back strain injuries.
- System has SMAW capability.
 - Still the only option for some applications.
 - Allows hangers to be welded partially with PGMA and partially with SMAW, if necessary, without dragging separate SMAW leads onto the boat.



EB-200 MP “Ultralight” Welding System



EB-200 MP “Ultralight” Welding System



Weight: 40 pounds

Size: 15” H X 8.5” W X 22” D

Multi-process capability: PGMW, SMAW (GTAW, Spray GMA possible in other versions)

200 amps output rating

0.035” dia. electrode for PGMW

3/32” to 1/8” dia. electrode for SMAW

220 VAC / 30 A / 1-phase input rating

Power Factor > 98%

Efficiency >87%



EB-200 MP “Ultralight” Welding System – Front Panel Controls



SMAW Mode



PGMAW Mode

- Bright, legible display.
- Easy to change modes and make adjustments.

EB-200 MP “Ultralight” Welding System – Tweco “Mini” - Based Torch



Tweco “Mini” - based Ultralight GMA torch

Flexible gooseneck

Uses Tweco front-end parts



EB-200 MP “Ultralight” Welding System Lincoln “Magnum” - Based Torch



200A OXO AP20
Torch

Lincoln Ultralight
Torch

Lincoln “Magnum” - based Ultralight GMA torch
Fixed gooseneck
Uses Tweco front-end parts



Ultralight GMA Torches

- Both Small in Size and Light Weight
 - Fixed gooseneck
 - Flexible gooseneck
 - Common front-end parts (gas diffuser, gas cups, contact tips)
 - Gas cooled
 - Inexpensive
 - Very good accessibility
 - High welder appeal for the intended applications

EB-200 MP “Ultralight” Welding System – Lenco – Based SMAW Stinger



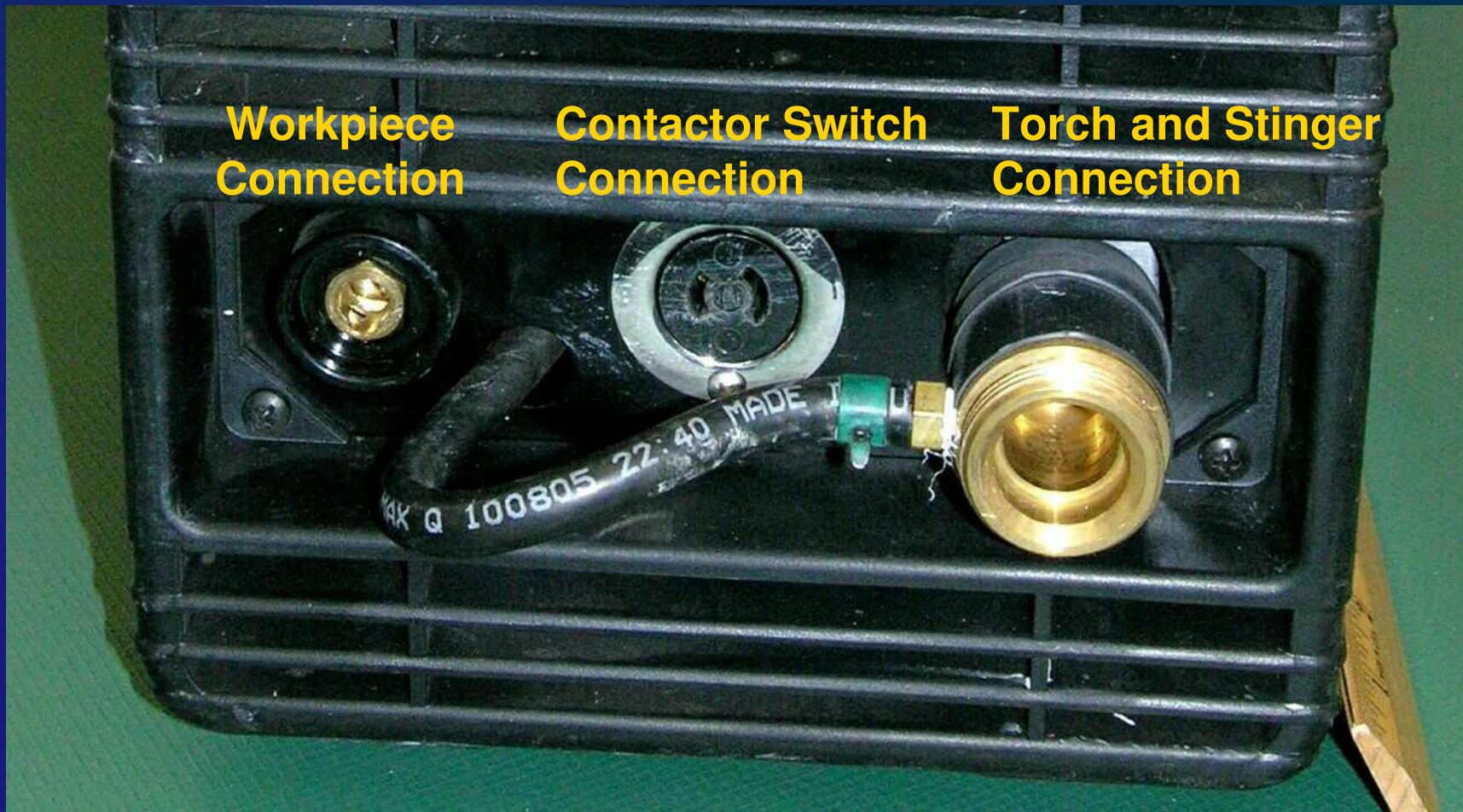
Lenco – based SMAW Stinger With Contactor Switch



Ultralight SMA Stinger

- Standard Stinger With Added Contactor Switch
 - Allows welder to engage contactor after positioning the electrode at the intended starting position
 - Avoids possibility of an inadvertent arc strike with a live electrode while positioning the electrode in a space restricted area
 - High welder appeal for the intended applications
 - *As configured, the contactor switch is not ergonomically optimized. A revised configuration will be necessary.*

EB-200 MP “Ultralight” Welding System – Front Connections



EB-200 MP “Ultralight” Welding System – Front Connections

- The Ultralight GMA Torches and the Ultralight Stinger Both Attach to the Same Front Panel Connector
 - Changeover from GMA to SMA takes about 2 minutes.
 - Disconnect contactor wire plug.
 - Unscrew conduit from torch connector and slightly retract.
 - Cut wire in front of torch connector. Remove torch and conduit from area. (Wire is left mounted on machine with wire still threaded through the drive rolls.)
 - Place SMA cable connector on torch connector and secure.
 - Attach contactor wire plug.
 - Change program mode.
 - No need to drag in separate leads to support SMAW.
 - No reason to not use the best process for the job.



Duty Cycle - PGMAW

Wire Feed Speed (ipm)	Current, Average (Amps)	Current, RMS (Amps)	Duty Cycle (%)
150	70	121	100
200	90	145	70
250	100	165	50
300	110	180	40
350	120	190	30

} Typical operating range

- Duty cycle is very satisfactory for the intended applications and welding conditions.



Duty Cycle - SMAW

Current, Average (Amps)	Voltage, Average (Volts)	Duty Cycle (%)
70	22.8	100
80	23.2	100
90	23.6	100
100	24.0	100
110	24.4	75
120	24.8	65
130	25.2	55
140	25.6	45
150	26.0	35
160	26.4	30

- Duty cycle is very satisfactory for the intended applications and welding conditions.



Laboratory Testing / Production Experience – General Comments

- Controls and power supply connections were easy to operate and user friendly.
- Positive comments about the light weight of the machine.
- Sufficiently wide range of adjustments to accommodate variations in electrode, operator preference, etc.
- Positive comments about the deposited weld quality and bead appearance.
- All welders liked the ease with which the equipment could be switched from pulse GMA to SMA. Comments that time was saved since it was no longer necessary to drag stick leads through an area to do incidental SMA welding either on the assigned job or just in the general work area.



Laboratory Testing / Production Experience – Comments Specific to PGMAW

- The arc characteristics were judged to be excellent overall and fully suitable for the intended applications.
- Consistently short arc lengths, and a very stable arc.
- Transitions during welding from vertical to horizontal, overhead to vertical, etc. were smooth. The arc length was maintained even when the tip to work distance varied during the transition.
- The puddle was always controllable.
- Positive comments about the reduction in welding time required to complete a joint (comparing PGMAW to standard SMAW).
- Housekeeping concerns were greatly reduced with the Ultralight as less cover up of adjacent areas and clean up time are required (comparing PGMAW to standard SMAW).



Laboratory Testing / Production Experience – Comments Specific to SMAW

- The arc characteristics were judged to be excellent overall and very smooth.
- Many welders commented that the Ultralight was one of the best SMA machines they had ever used.
- All welders liked the inclusion of a remote contactor switch on the SMA stinger.



Estimated Level of Cost Savings

- Approximately \$312K in the first year after implementation costs and equipment acquisition.
- Approximately \$358K in the second year, and \$398K per year in the out years.
 - 42% of the estimated labor savings comes from a reduction in the number of required SMA lead removals, and forming and repair of SMA lead clusters.
 - Approximately \$100K per year savings in replacing SMA leads and SMA power distribution systems.



Summary

- Lincoln EB-200 MP “Ultralight” Welding System Provides:
 - 40 lb. welding system package.
 - Ability to substitute PGMA for SMA for many shipboard applications without bulky equipment.
 - Easily moveable.
 - Good accessibility and welder appeal with Ultralight torches.
 - Improved safety with 220V single-phase power.
 - Elimination of significant fume and debris compared to SMAW.
 - Excellent quality welds and high welder appeal.
 - No need to drag in separate leads to support SMAW.
 - Elimination of inadvertent arc strikes with both PGMA and SMA.



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