Deep Penetration Laser-GMAW Welding

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NSRP Program Technical Representative: Jonathan Roberts (Ingalls)

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NSRP Welding Technology Panel Meeting

Project Team

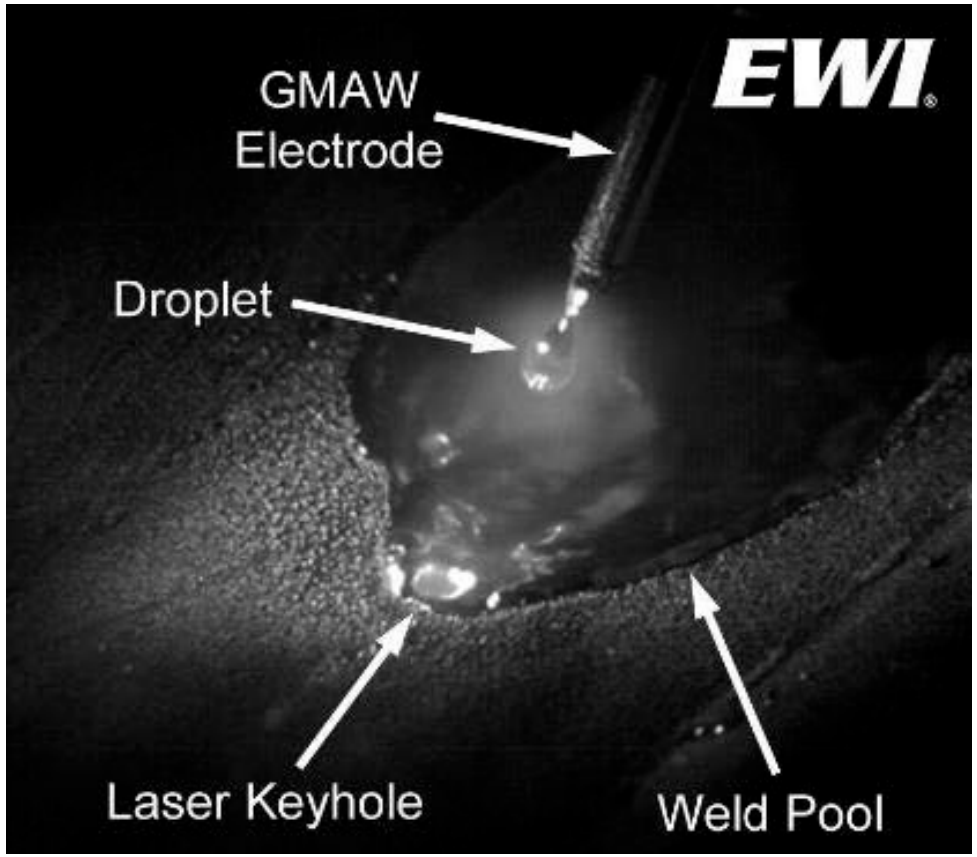
- EWI (prime)
  - Jake Hay (PI), Stan Ream (Principal Engineer), Dean Langenkamp (Engineer), Katie Hardin (PM)
- ATI PM
  - Ryan Schneider
- NSRP Program Technical Representative (PTR)
  - Jonathan Roberts (Ingalls)
- Participant
  - Cody Whiteley (NASSCO)
  - Kevin Roossinck (Ingalls)
  - James Marden (BAE)
  - Matt Sinfield & Dan Bechetti (NSWCCD)

Problem Statement

- Improve panel welding productivity and reduce distortion for Navy shipbuilding

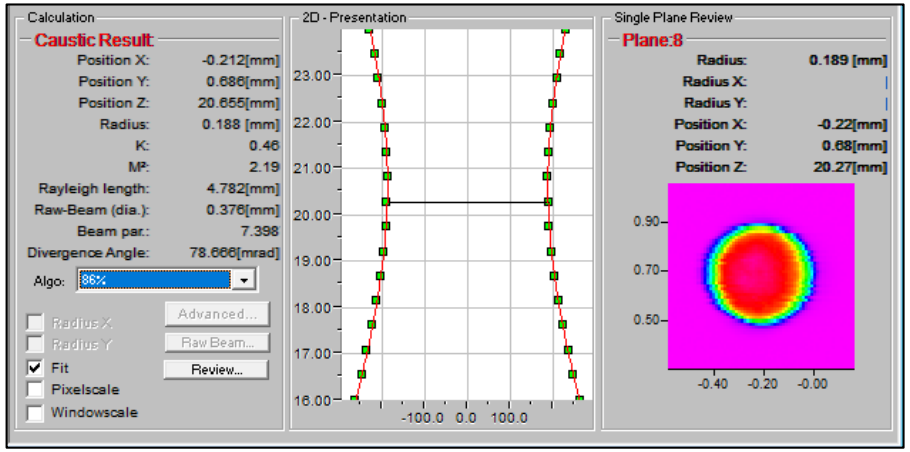
Solution/Approach

- Apply advanced hybrid laser/gas metal arc welding (GMAW) plus tandem GMAW process to accomplish deep penetration single-pass, panel fabrication

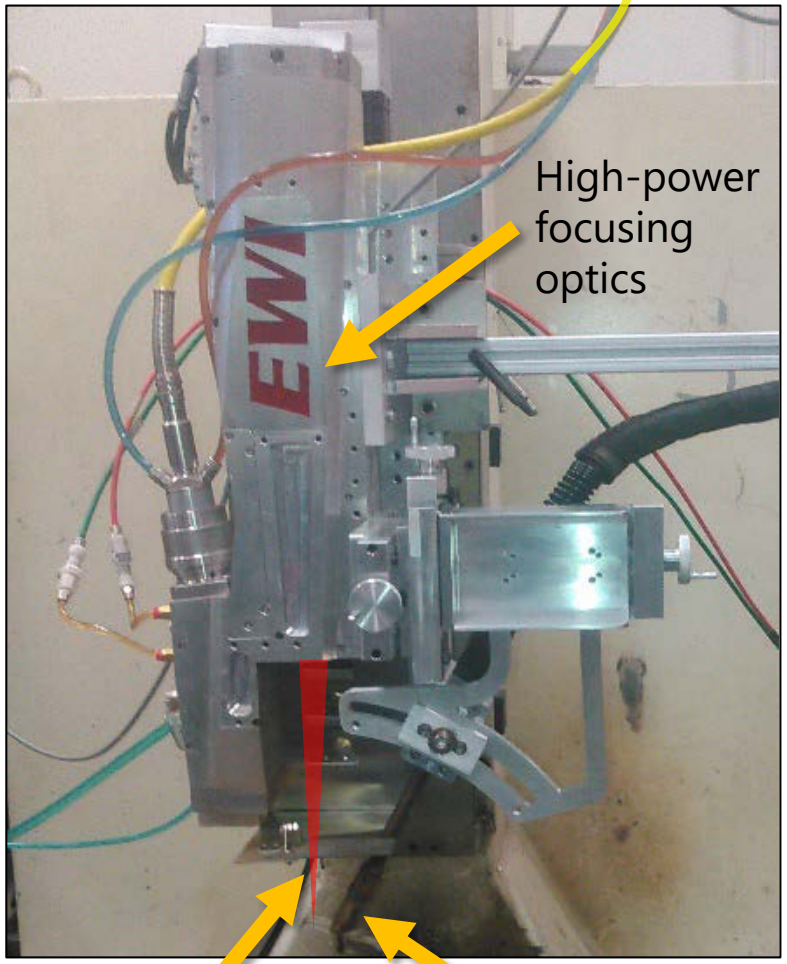


Hybrid Laser Arc Welding (HLAW) Setup - Laser

Laser	IPG YLS-20000
Optics	EWI Custom B3
Fiber Diameter	200 µm
Focal Length	800 mm
Theoretical Spot Size	400 µm
Laser Beam Angle	0 Degree (normal)



- The measured spot size (376 micron) agreed with the theoretical value.
- The beam quality was within specification for the 200-micron fiber.

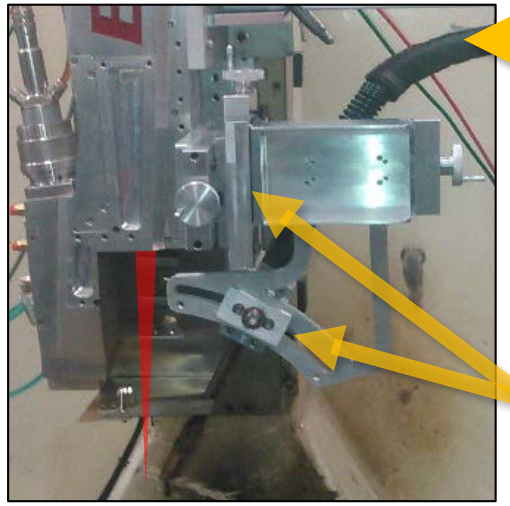


HLAW Setup - GMAW

Control panel

Power supply

Wire feeder



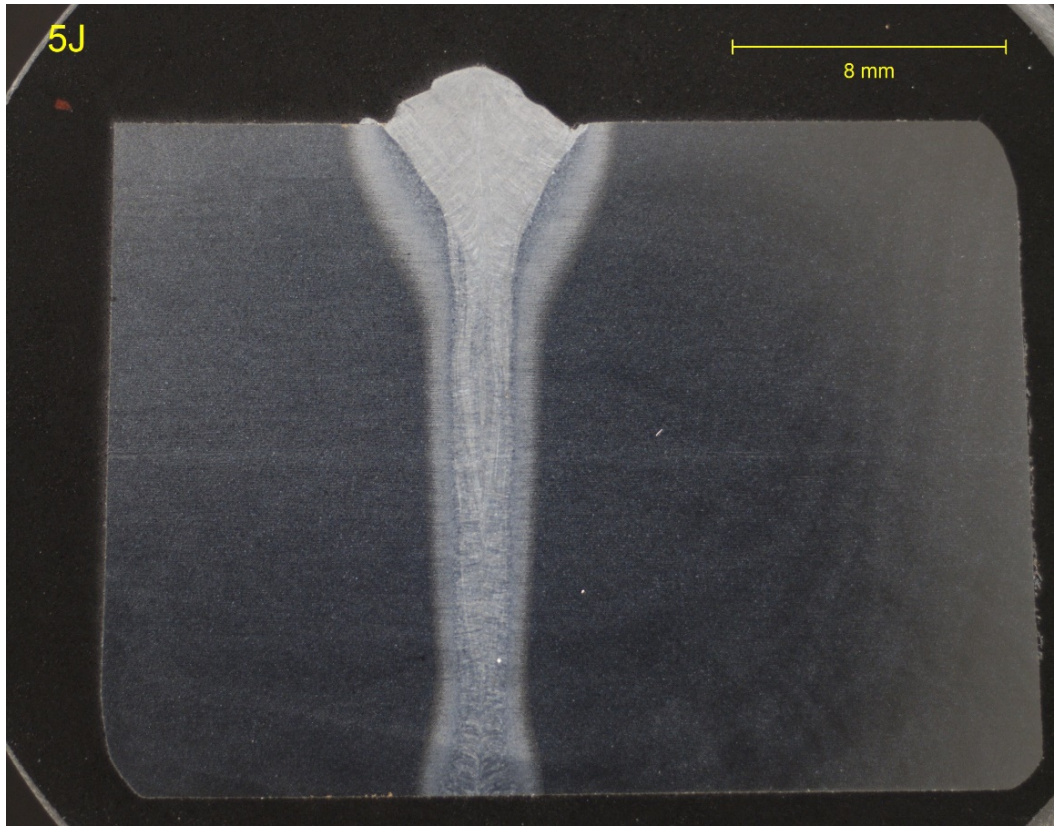
GMAW torch

GMAW alignment relative to laser

Results - HLAW Bead on Plate (BOP)

- 107 BOP trials were conducted with varying visual inspection results.
- Parameter set 5J resulted in acceptable top and back side results for this point in the development process.

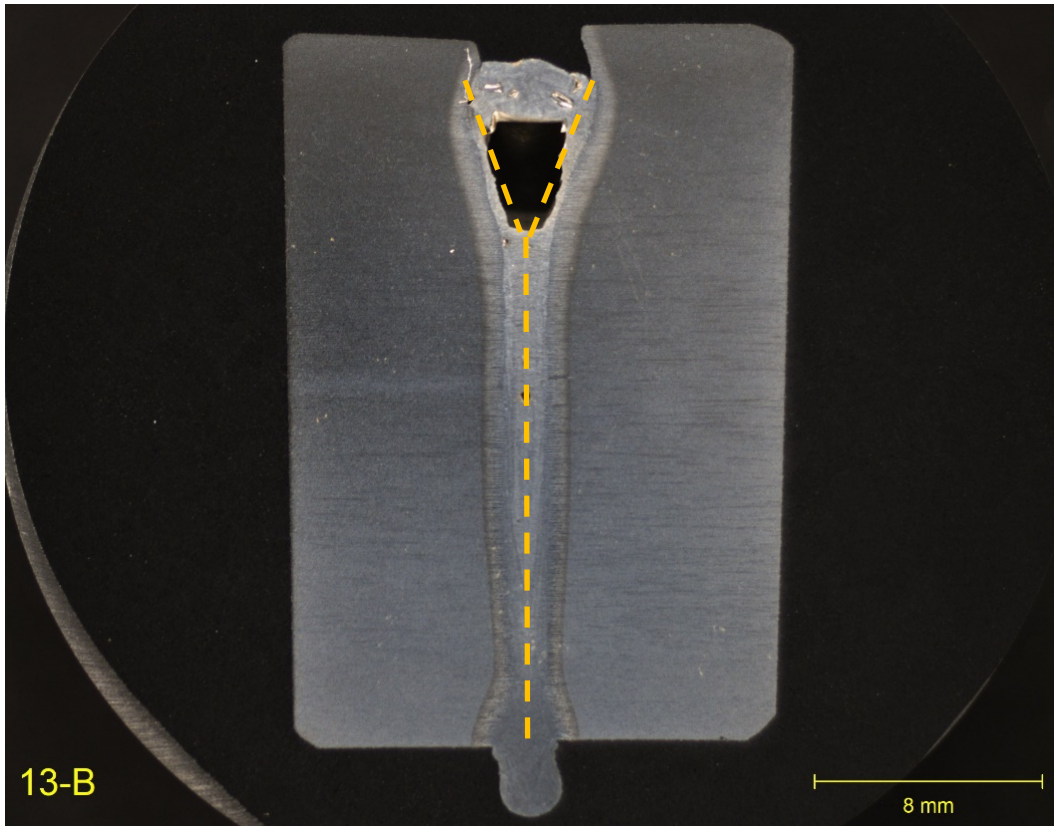
Laser Power (kW)	20
Travel Speed (IPM)	65
GMAW WFS (IPM)	500
GMAW Trim	1.00
GMAW Wire Stick Out (in)	0.5
Beam To Wire (mm)	2



Results – V-Groove Joint Design – 13B

- 17 trials were conducted on V-Groove joint prep.
- All samples exhibited back side humping and most showed evidence of process instability.

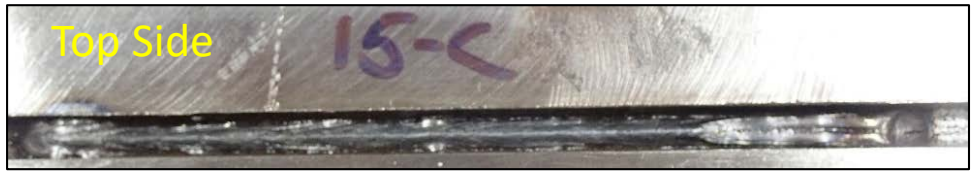
Laser Power (kW)	20
Travel Speed (IPM)	72
GMAW WFS (IPM)	500
GMAW Trim	1.05
GMAW Wire Stick Out (in)	0.5
Beam To Wire (mm)	2

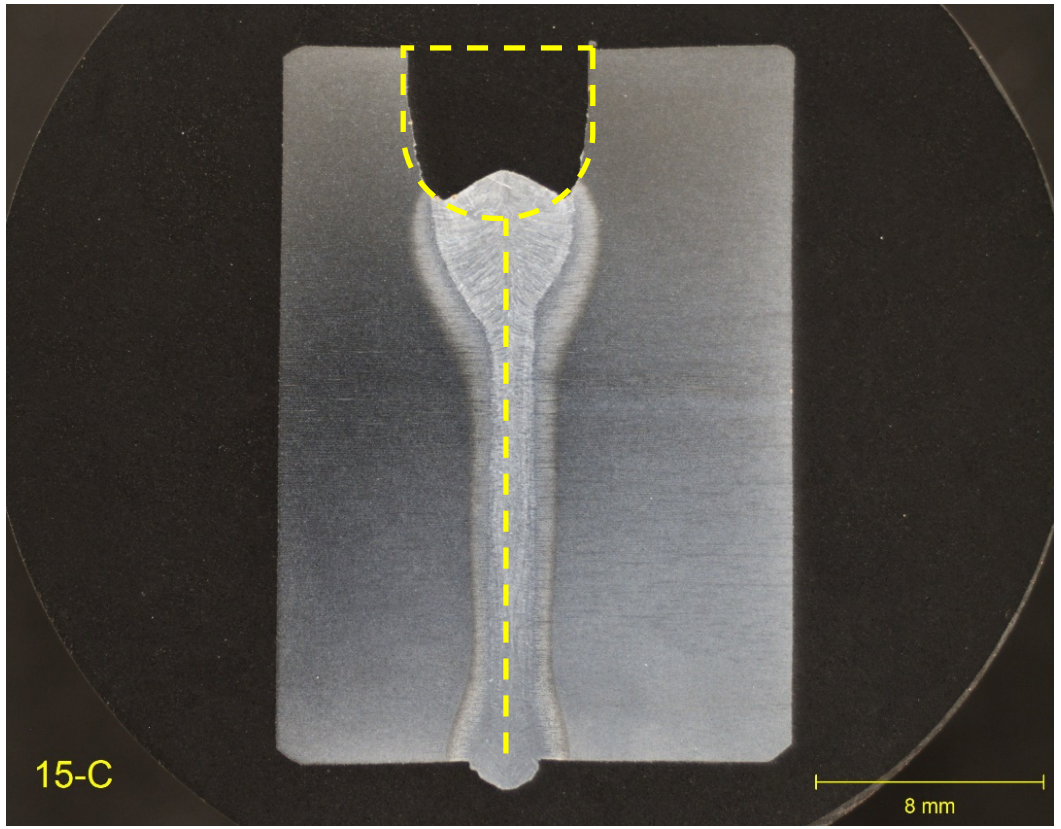


Results – U-Groove Joint Design – 15C

- Six trials have been conducted on U-Groove joint preparation.
- All U-Groove joints have shown significant improvement in weld quality and process stability.

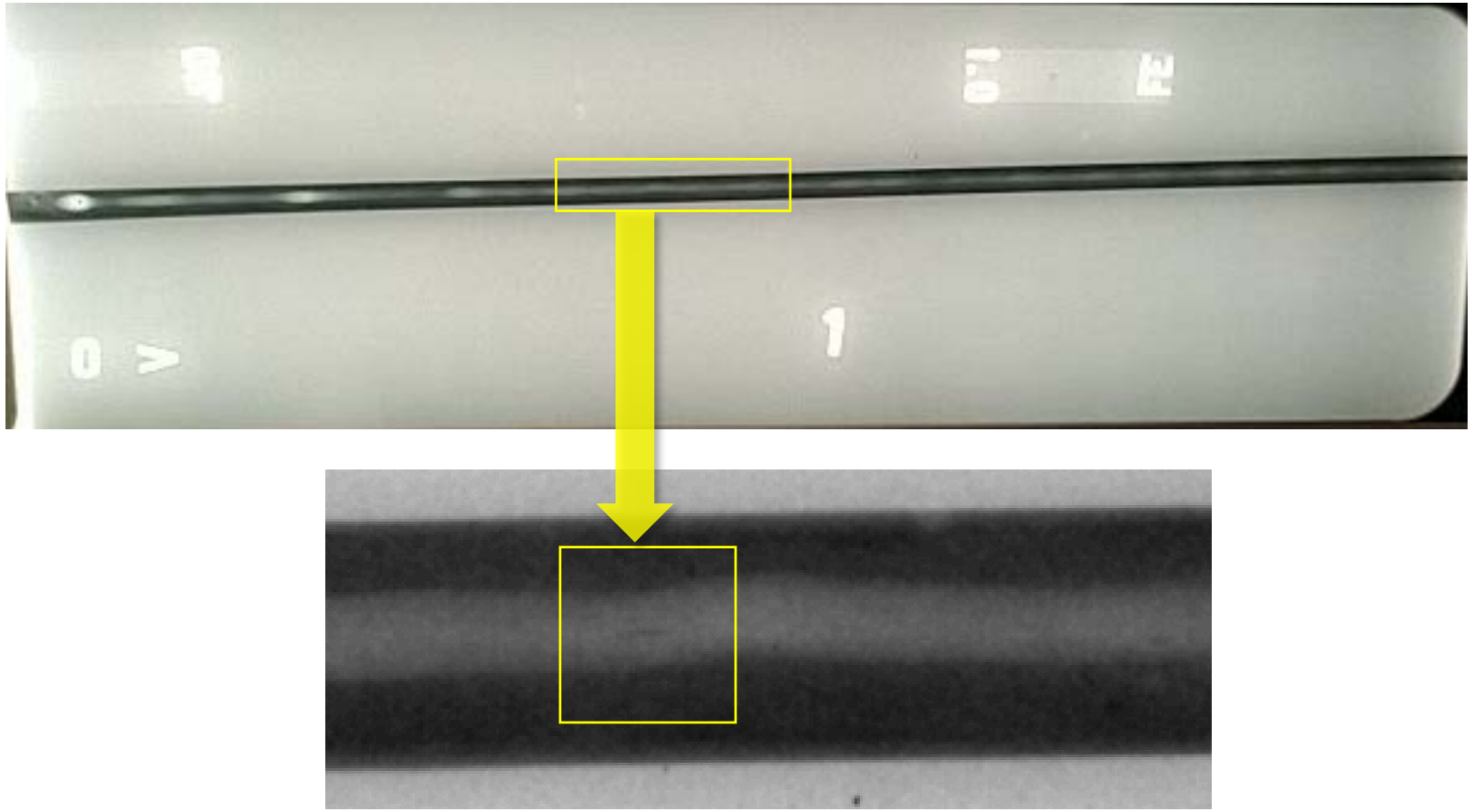
Laser Power (kW)	19
Travel Speed (IPM)	65
GMAW WFS (IPM)	500
GMAW Trim	1.05
GMAW Wire Stick Out (in)	0.5
Beam To Wire (mm)	2



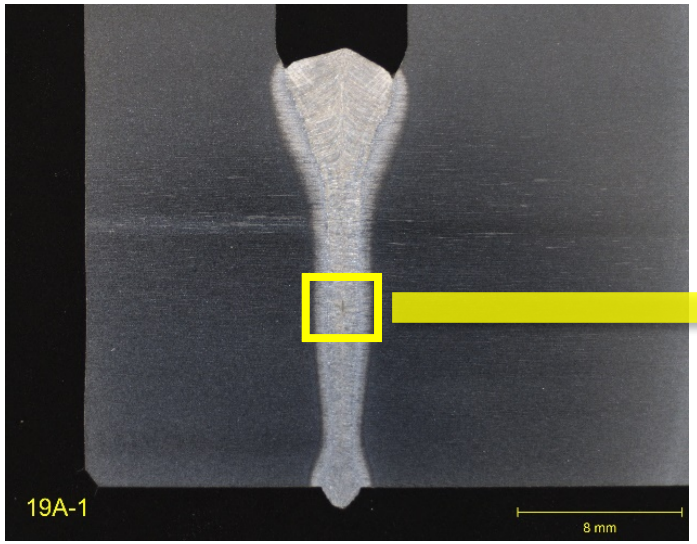


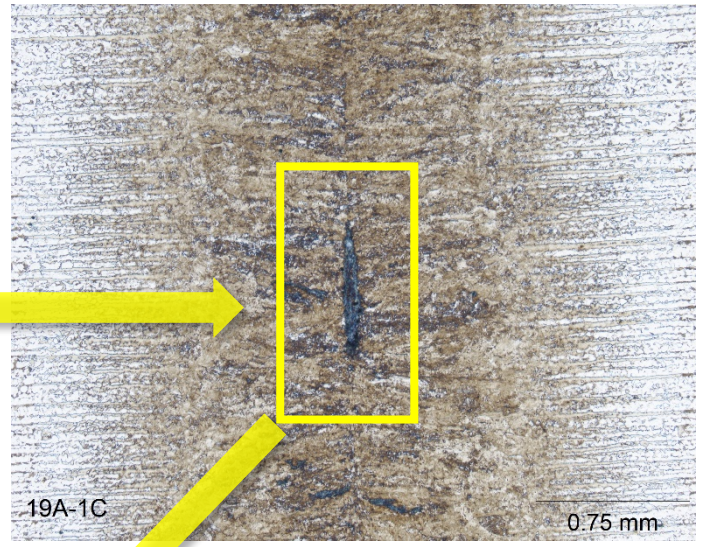
Results –19A – Radiography

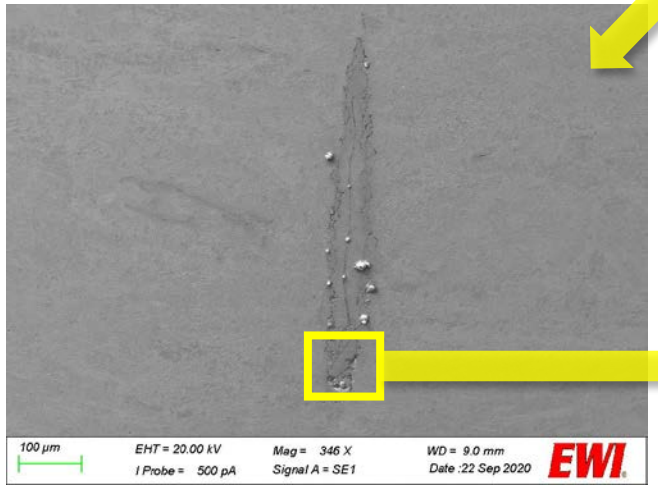
- A full-length weld was completed using parameters from 15C.
- Lack of fusion (LOF) defects found.

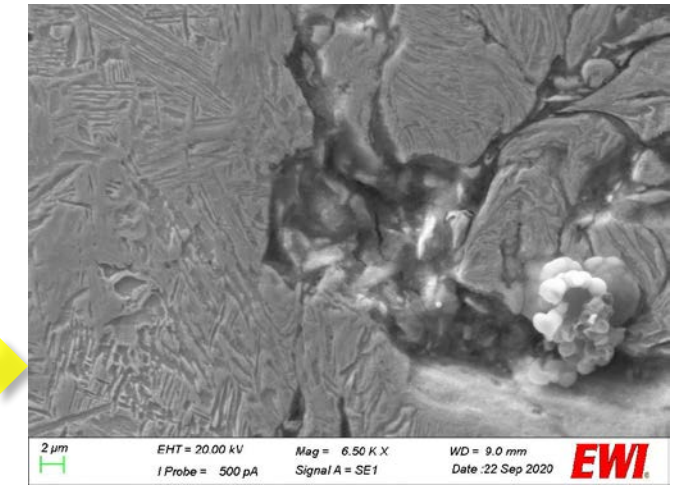


Results –19A – SEM/EDS Analysis





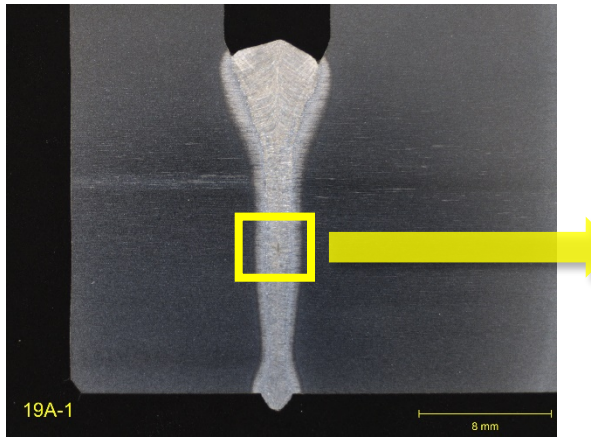


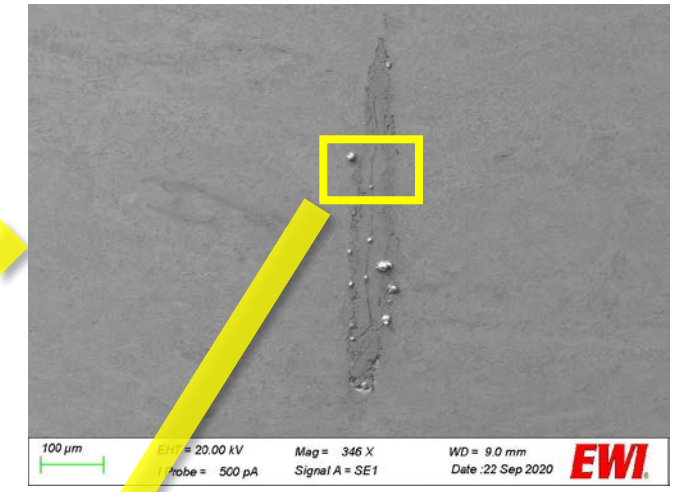


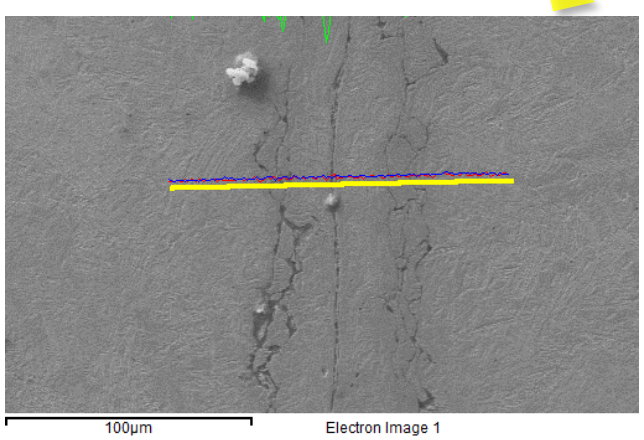
- Further metallographic and scanning electron microscopy/energy dispersive spectroscopy (SEM/EDS) analysis of LOF defect indication from radiography

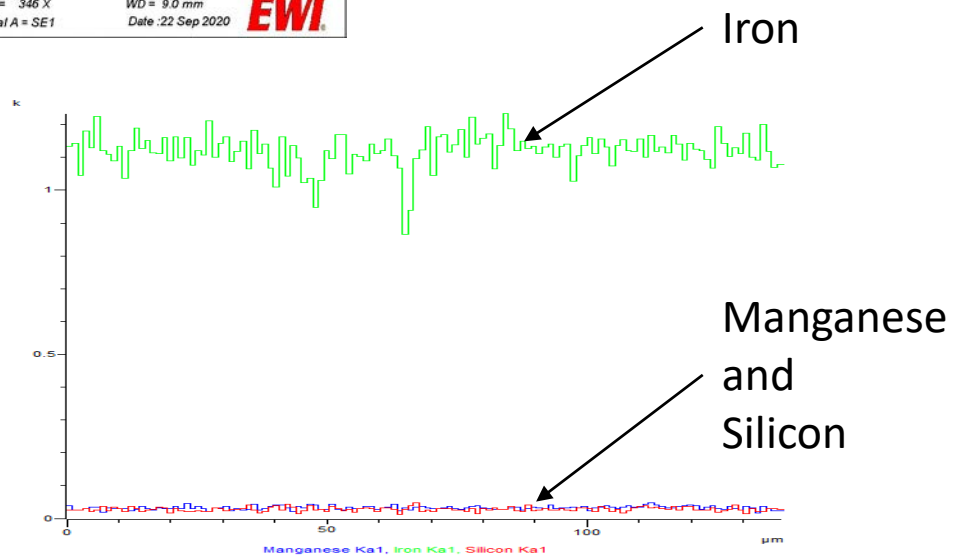
Results –19A – SEM/EDS Analysis

- Further metallographic and SEM/EDS analysis of LOF defect indication from radiography





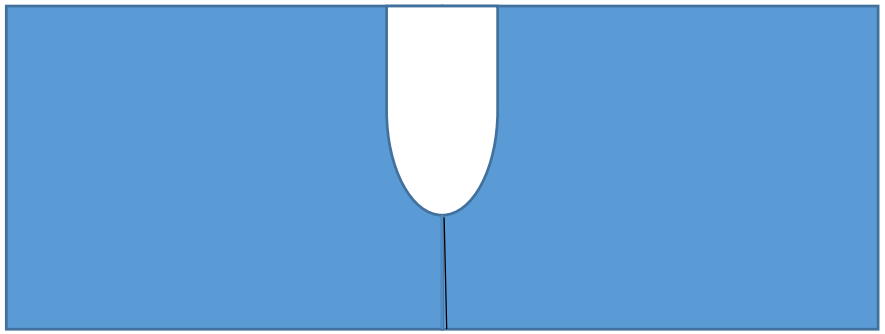




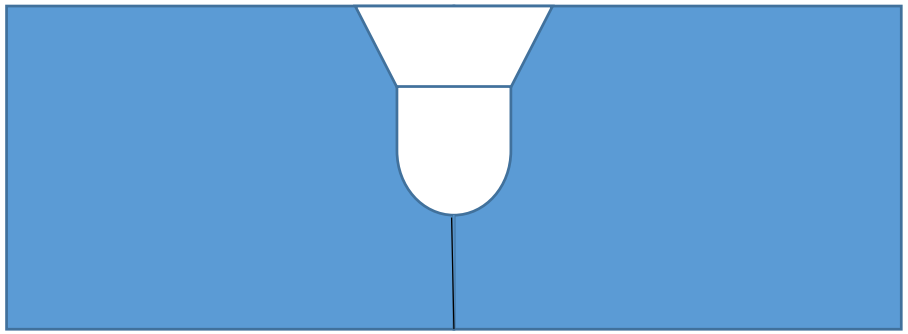
Next Steps

- Investigate LOF defect found in radiography
- Complete hardness traverses
- Complete tensile and Charpy testing
- Move to Task 3 – Tandem GMAW fill pass development
- If Tandem GMAW fill LOF is an issue, joint design will be modified to

U-Joint Design



Modified U-Joint Design

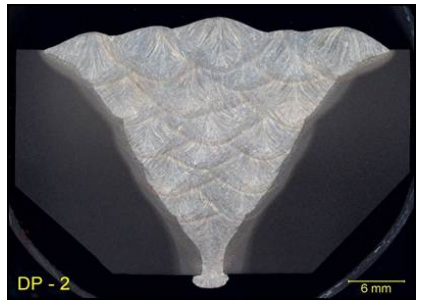


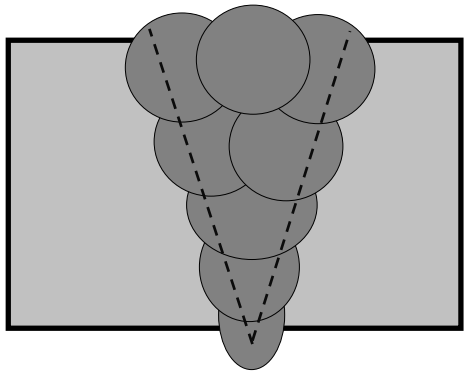
Tandem GMAW

- Tandem system planned for task 3

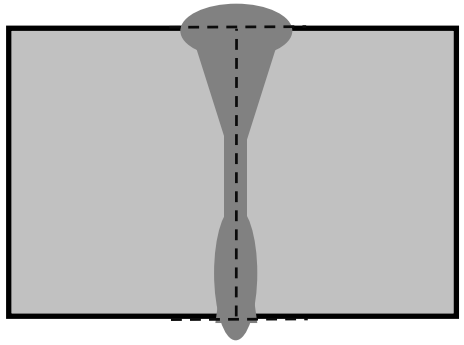
Project Benefits

- Reduced panel manufacturing costs
  - Improved productivity
    - Single pass full penetration weld
    - 40 to 80 ipm welding travel speeds
  - Reduced panel distortion and straightening requirements
- Improved ship performance





Conventional GMAW
Multi-pass



HLAW
Single pass

Questions?

