GREAT DESIGNS IN STEEL

Repairability of AHSS: Zinc Removal and Hole Size Study

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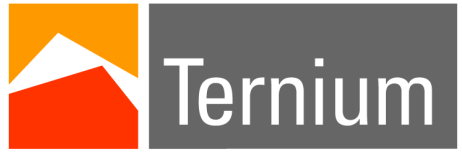
Materials Engineer - Welding

Stellantis

(Presenting for Auto/Steel Partnership)

Auto/Steel Partnership

Members



PROJECT TEAM MEMBERS

JPC Project Mentor: Dean Kanelos, Nucor
Project Leader: Justin Hunt, Stellantis
Project Manager: Michael White, A/SP

Project Team Members:

- Harminderpaul Grover, General Motors
- David Rigg, General Motors
- Mark Szlachta, General Motors
- Weiping Sun, Nucor
- Jackie Stachowski, Nucor
- Tim Rickard, Nucor
- Jiwoong Ha, POSCO America
- Lynn Rogers, Stellantis
- Joseph Beckham, Stellantis

Project Details

GDIS

Project Objective / Problem Statement:

- Assess zinc coating removal as a method to mitigate LME cracking in 980 3rd Generation steel GMAW plug joints.

- Determine the effects of GMAW plug joint hole diameter and filler metal grade on joint strength, relative to baseline resistance spot welding.

Project Details

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Goals:

- Determine if GMAW plug LME cracking in 980 3rd Generation GI steel can be mitigated by locally removing zinc prior to welding.
- Evaluate GMAW plug joint strength with 6 mm, 8 mm, and 10 mm hole diameters using ER70S-6 filler metal.
- Compare GMAW plug joint strength with commonly used ER70S-6 filler metal to the higher strength ER120S-G filler metal used in Project #5.
- Determine the minimum GMAW plug joint hole size required to produce joint strength equivalent to the baseline resistance spot weld for the selected steel grade and thickness.

Participants:

- AET Integration

Project Approach – Test Matrix

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Material	Surface Condition	Specimen Type	Baked before Joining	Before Testing Photo (Typical ST Specimen)	Visual Inspection (ST and CT Specimens with Closeup Images of Samples with Cracks)	After Testing Photo (Typical ST and CT Specimen(s) for each Fracture Location/Mode)	Fluorescent Liquid Penetrant Inspection (ST and CT Specimens with Closeup Images of Samples with Cracks)	Radiographic Inspection (ST and CT Specimens with Closeup Images of Samples with Cracks)	Metallurgical Examination	Quasi-Static Shear Tension (ST) (Peak Load Chart and Load Displacement Curves, Fracture Modes Identified)	Quasi-Static Cross Tension (CT) (Peak Load Chart and Load Displacement Curves, Fracture Modes Identified)
1.3 mm CR600Y980T-RA-GI (Lot# 192) (Same as Project #5)	"ALL ZINC" 	RSW (Production)	X	1	X	X			1	3	3
		GMAW Plug (8 mm hole) ER120S-G	X	1	X	X			1	3	3
		GMAW Plug (10 mm hole) ER70S-6	X	1	X	X	X	X	1	3	3
		GMAW Plug (8 mm hole) ER70S-6	X	1	X	X	X	X	1	3	3
		GMAW Plug (6 mm hole) ER70S-6	X	1	X	X	X	X	1	3	3
1.3 mm CR600Y980T-RA-GI (Lot# 192)	"BOTTOM SIDE ZINC" 	GMAW Plug (10 mm hole) ER70S-6	X	1	X	X	X	X	1	3	3
		GMAW Plug (8 mm hole) ER70S-6	X	1	X	X	X	X	1	3	3
		GMAW Plug (6 mm hole) ER70S-6	X	1	X	X	X	X	1	3	3
1.3 mm CR600Y980T-RA-GI (Lot# 192)	"NO ZINC" 	GMAW Plug (10 mm hole) ER70S-6	X	1	X	X	X	X	1	3	3
		GMAW Plug (8 mm hole) ER70S-6	X	1	X	X	X	X	1	3	3
		GMAW Plug (6 mm hole) ER70S-6	X	1	X	X	X	X	1	3	3

NOTE 1: Data from highlighted rows are included from Project #5

Project Approach – Zinc Removal

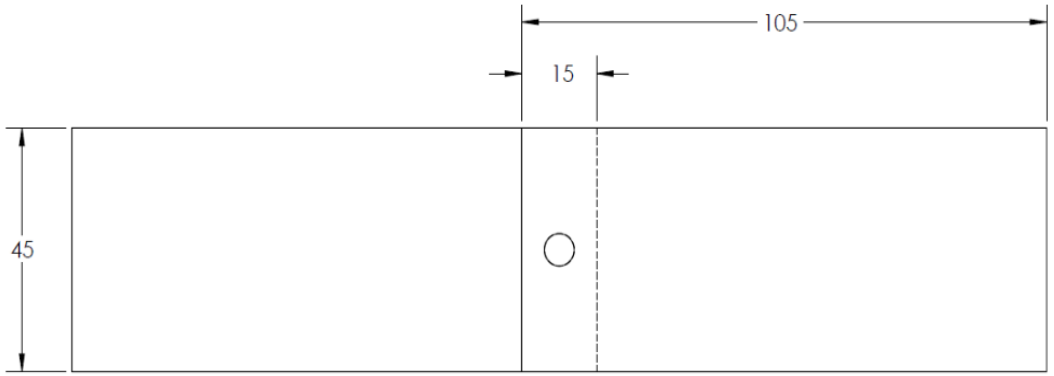
“ALL ZINC”

“BOTTOM SIDE ZINC”

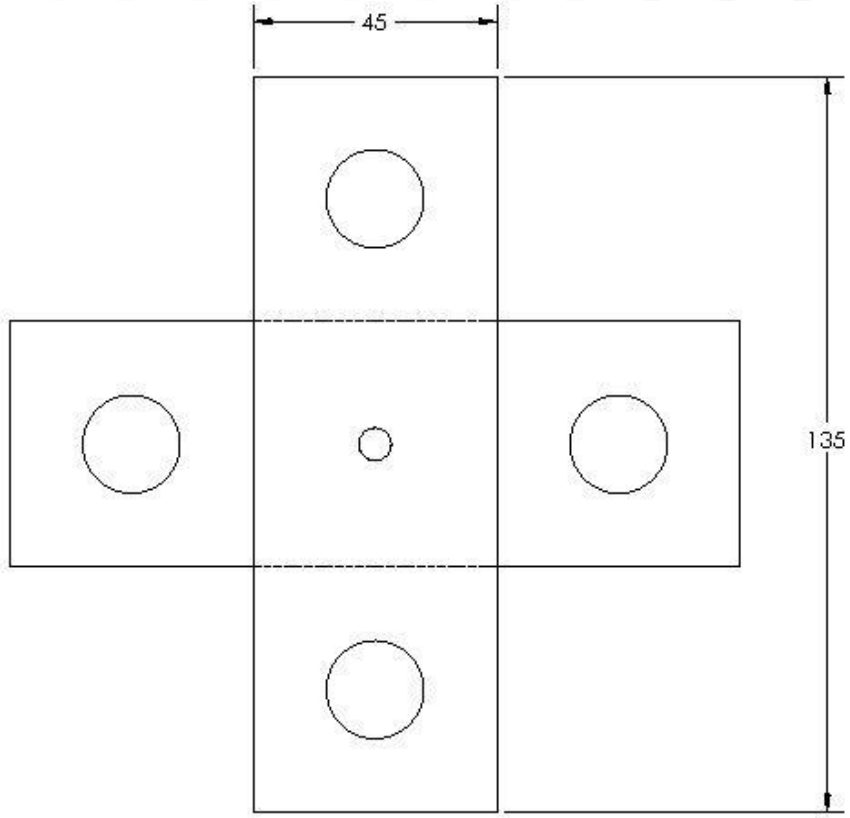
“NO ZINC”

Zinc was ground off the surfaces shown to represent repair scenarios where panel replacement allows zinc removal from the 980 3rd generation steel.

Project Approach – Test Specimen Dimensions



Shear Tension



Cross Tension

Dimensions in mm

Joining Process

- Gas Metal Arc Welding
  - 0.8 mm ER120S-G filler metal (Project #5)
  - 0.9 mm ER70S-6 filler metal (Project #6)
  - 90% Argon 10% CO_2 shielding gas

Inspection Methods

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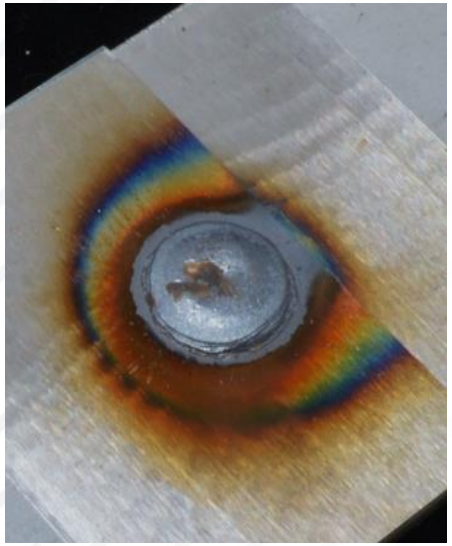
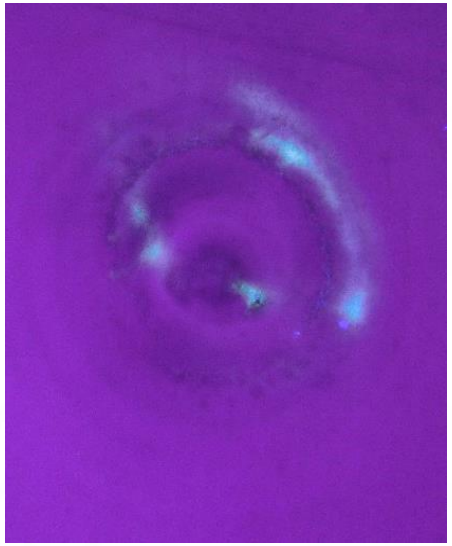
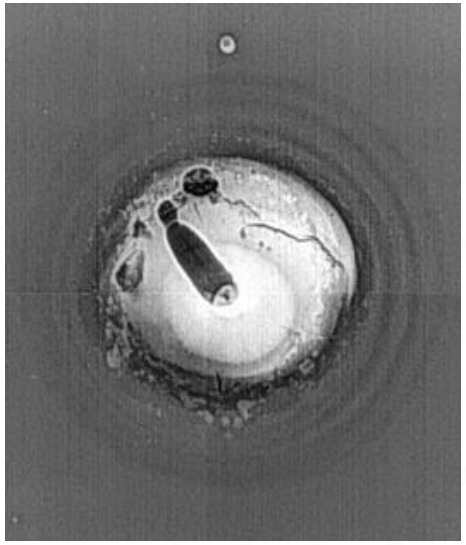


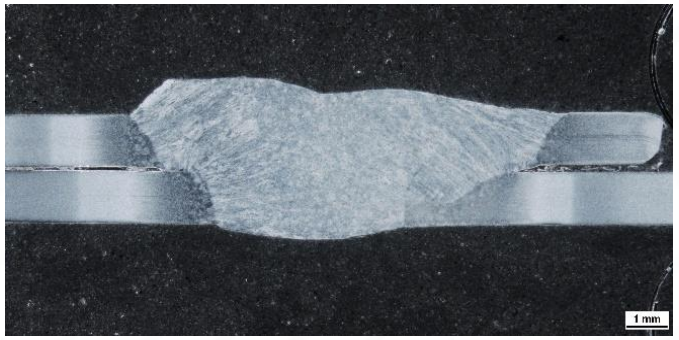
Visual



Fluorescent liquid penetrant

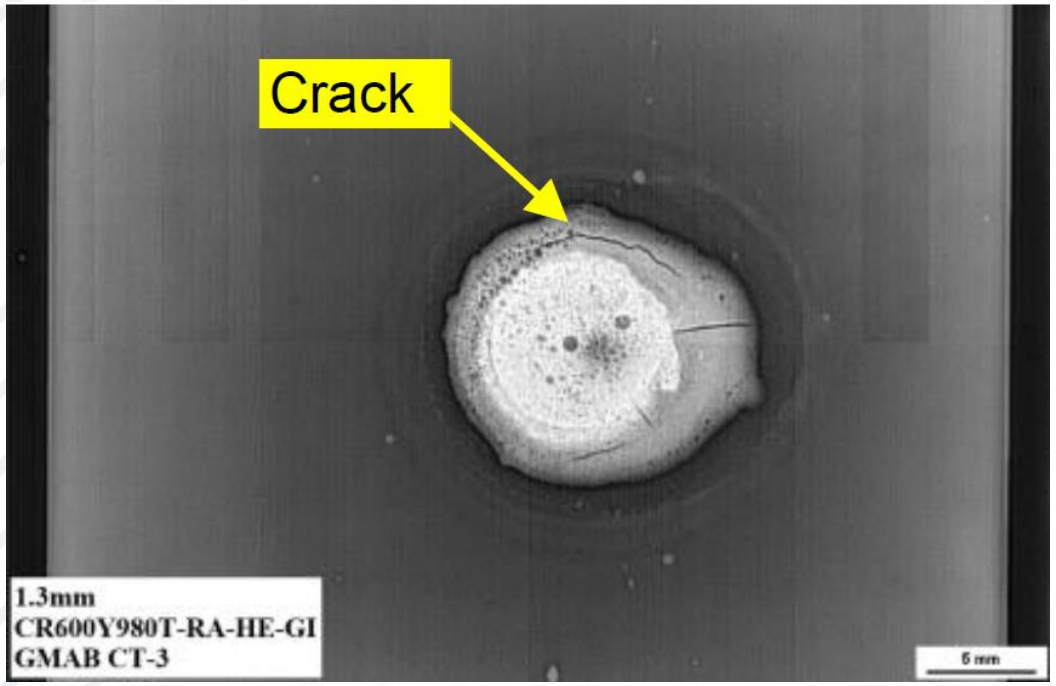


Radiographic

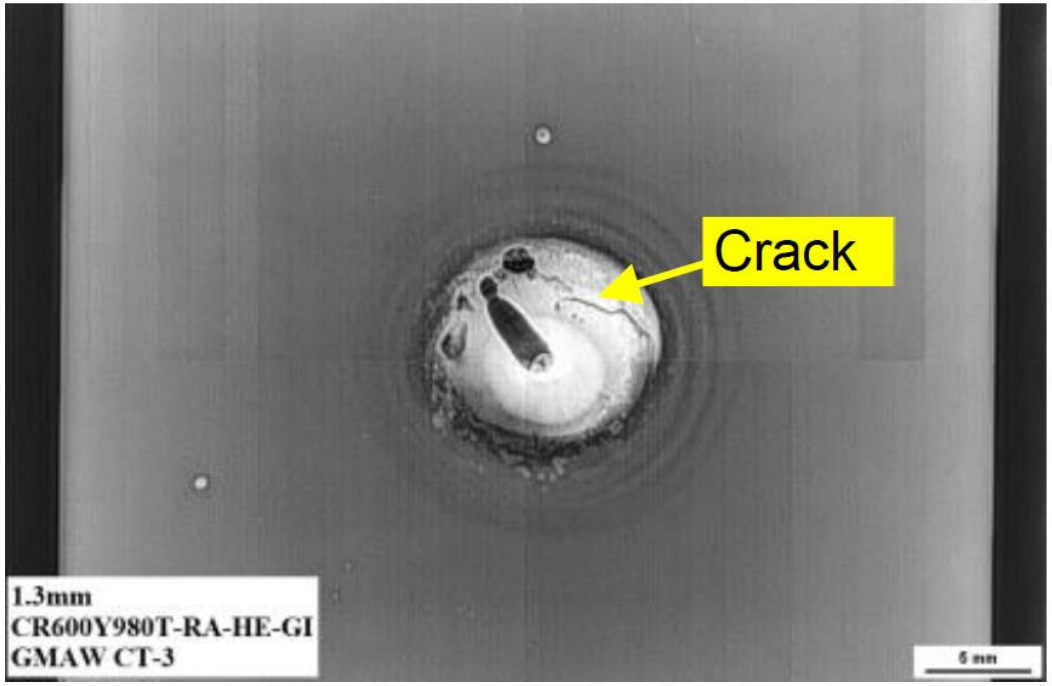


Metallographic

Project Results – Radiographic Inspection – Project #5



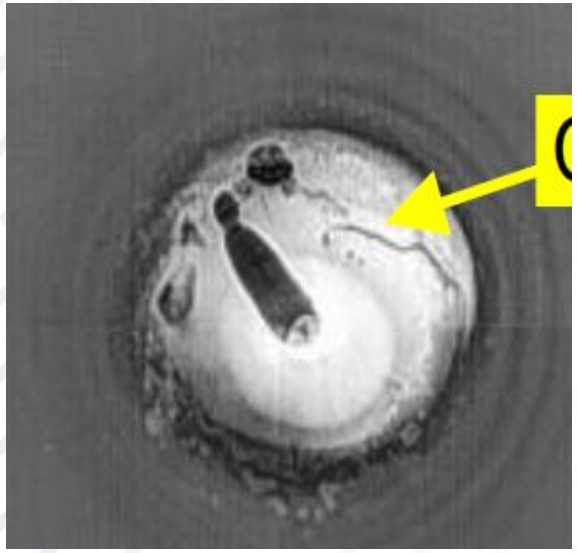
1.3 mm CR600Y980T-RA-HE-GI (Lot 192)
GMAB Plug (8 mm Hole ERCuSi-A)
Cracks present in 6 of 6 samples

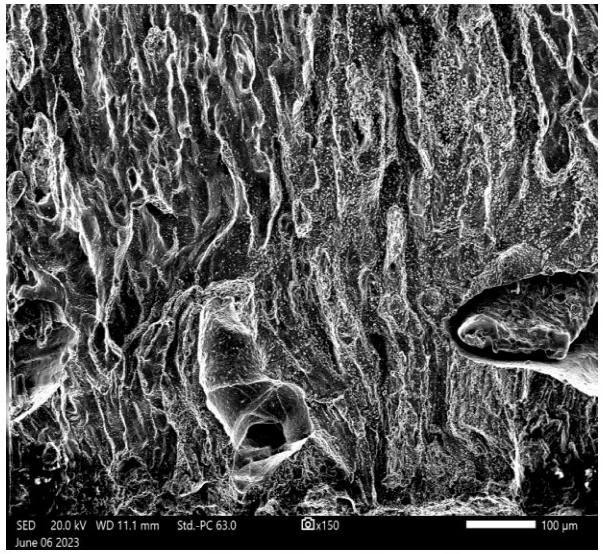


1.3 mm CR600Y980T-RA-HE-GI (Lot 192)
GMAW Plug (8 mm Hole ER120S-G)
Cracks present in 5 of 6 samples

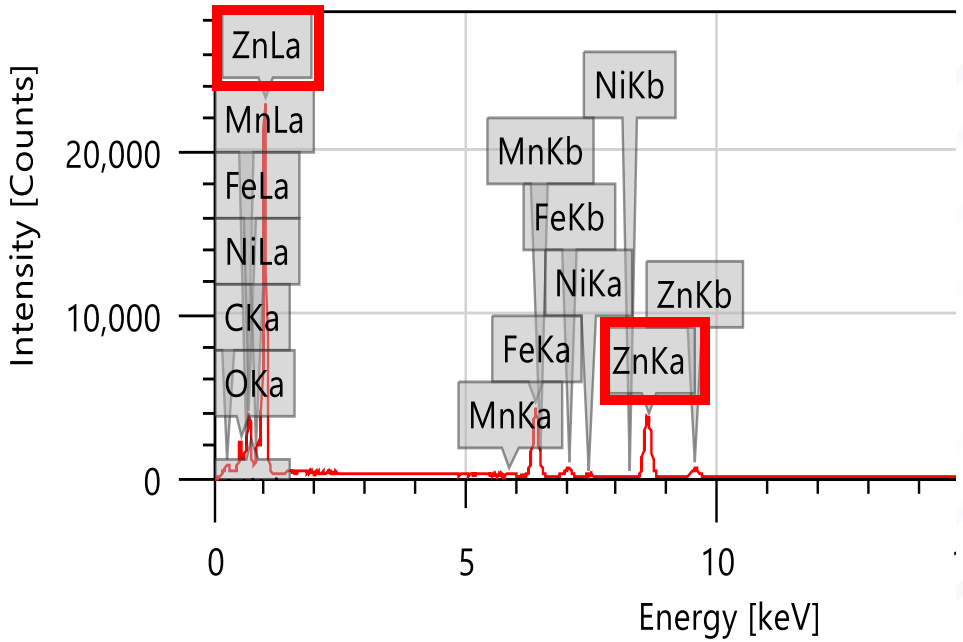
Project #5 GMAB and GMAW plug joints exhibited “internal” cracking believed to be LME.

Project Results – Crack Inspection – Project #5





1.3 mm CR600Y980T-RA-HE-GI (Lot 192)
GMAW Plug (8 mm Hole ER120S-G)



The Project #5 sample evaluated had zinc on the fracture surface, indicating potential LME.

Project Results – Radiographic Inspection Summary – Project #6

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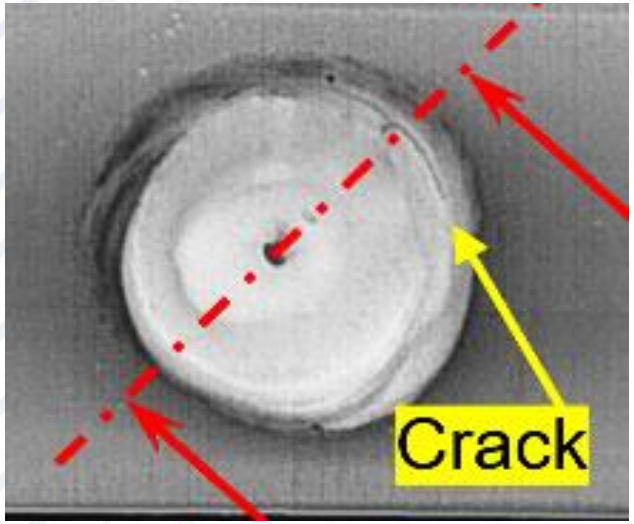
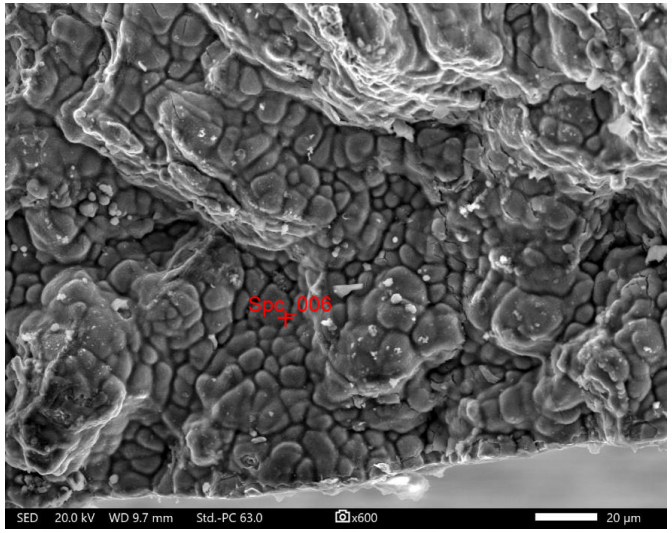
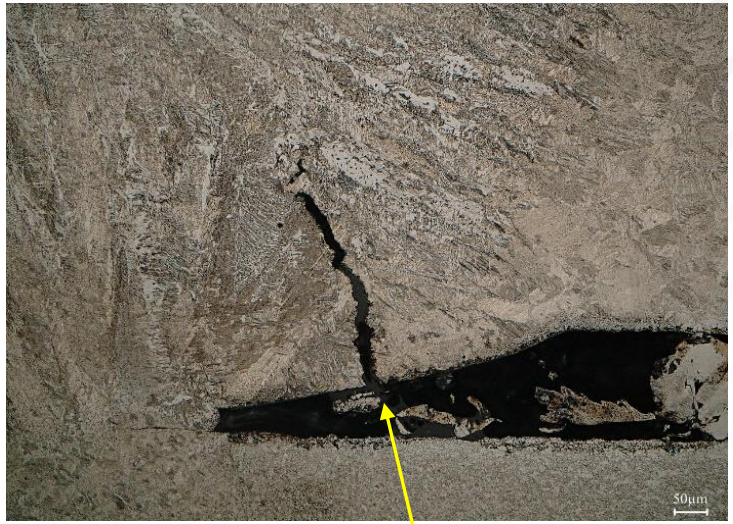
Repair Process	1.3 mm CR600Y980T-RA-HE-GI (Lot#192) "All Zinc"		1.3 mm CR600Y980T-RA-HE-GI (Lot#192) "Bottom Side Zinc"		1.3 mm CR600Y980T-RA-HE-GI (Lot#192) "No Zinc"	
	Radiographic Inspection Cracking Observed?					
	Shear Tension	Cross Tension	Shear Tension	Cross Tension	Shear Tension	Cross Tension
GMAW Plug ER70S-6 (10 mm Hole)	1 of 3	0 of 3	3 of 3	0 of 3	3 of 3	0 of 3
GMAW Plug ER120S-G (8 mm Hole)	2 of 3	3 of 3	Not tested	Not tested	Not tested	Not tested
GMAW Plug ER70S-6 (8 mm Hole)	0 of 3	0 of 3	3 of 3	0 of 3	1 of 3	0 of 3
GMAW Plug ER70S-6 (6 mm Hole)	0 of 3	0 of 3	0 of 3	0 of 3	0 of 3	0 of 3

- Fluorescent liquid penetrant inspection did not detect cracks in any samples.
- Radiographic inspection detected cracks in samples of all surface conditions, including no zinc. This indicates cracking was not likely LME related.

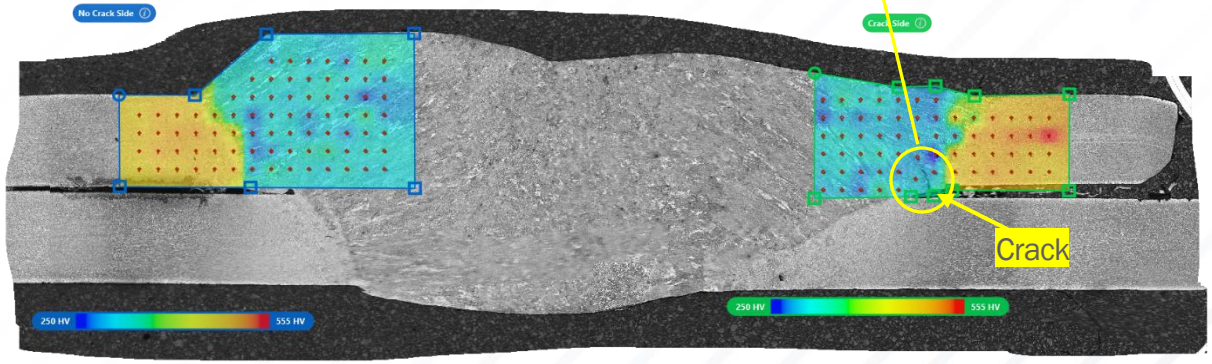
Project Results – Crack Inspection – Project #6





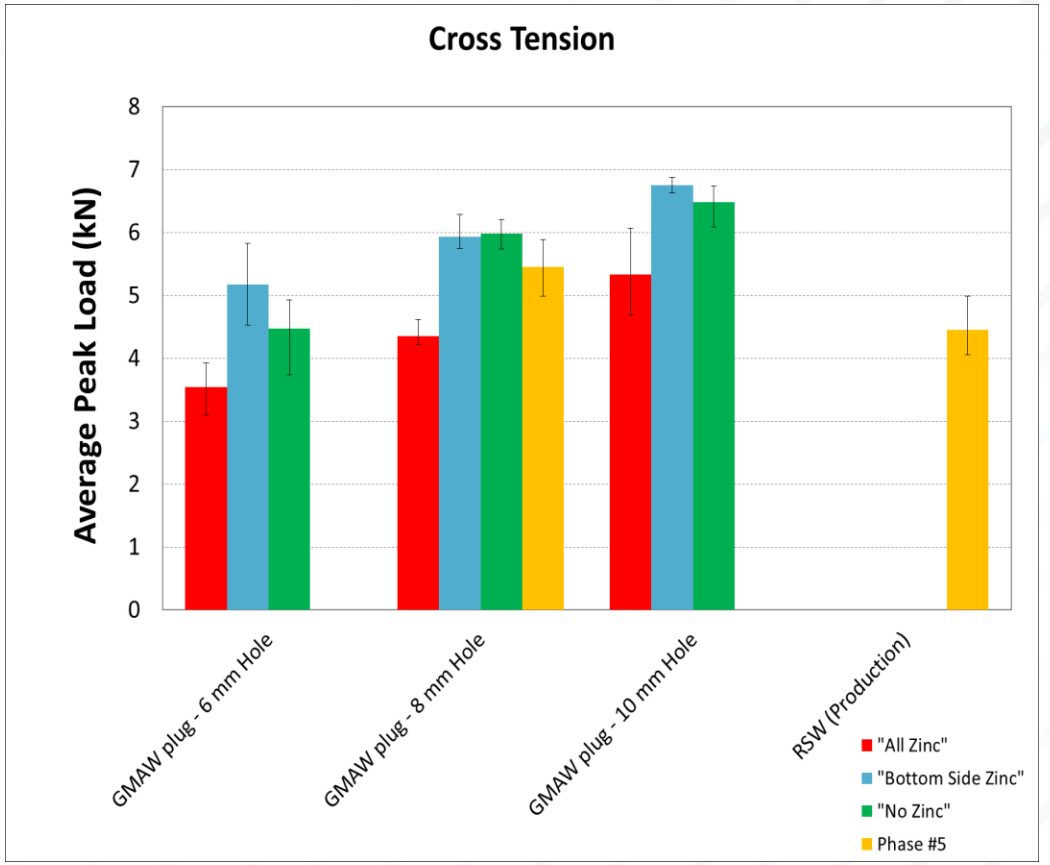


1.3 mm CR600Y980T-RA-HE-GI (Lot 192)
GMAW Plug (8 mm Hole ER70S-6)



The Project #6 sample evaluated exhibited a crack in the weld metal with no zinc detected on the fracture surface. Dendritic structures were observed on the fracture surface. This is characteristic of hot cracking occurring during solidification, unrelated to LME.

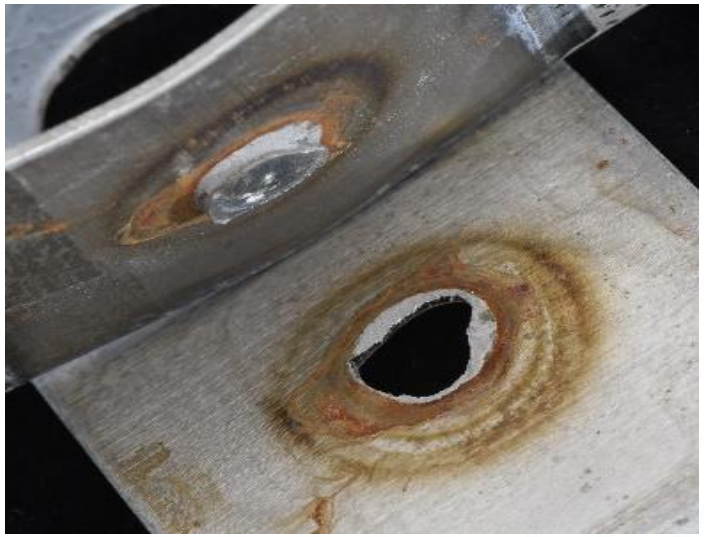
Project Results – Average Quasi-static Peak Load



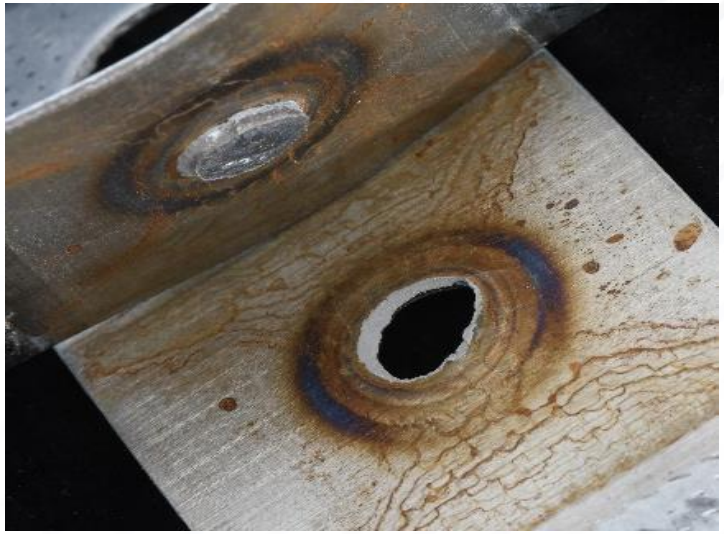
- Peak loads were lower in the “all zinc” surface condition samples. This may be due to the presence of porosity at the fusion boundary.
- Peak loads were higher in the ER120S-G (Phase #5 - 8 mm hole) samples compared to the ER70S-6 (8 mm hole “all zinc”) filler metal samples.

Project Results – Fracture Modes

“All zinc”



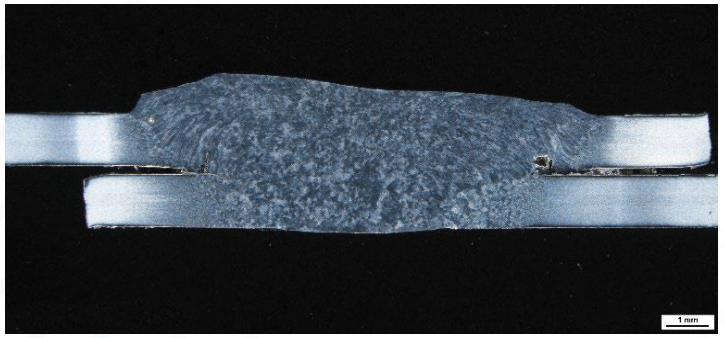
“Bottom side zinc”

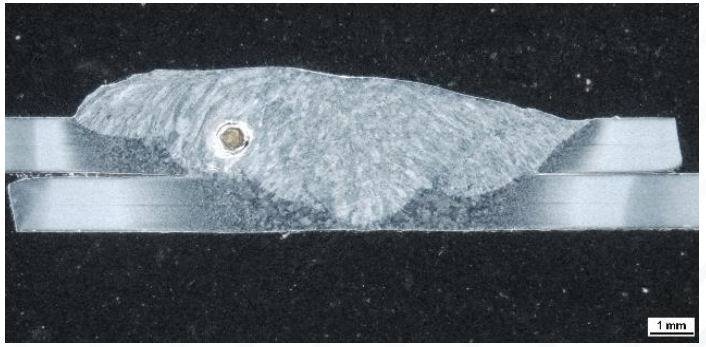


“No zinc”

- Evidence of porosity is observed on the “all zinc” fracture surface which may have reduced peak loads.

Project Results – Fracture Modes





ER120S-G “all zinc”

ER70S-6 “all zinc”

- ER120S-G joints were typically higher strength than ER70S-6 joints

Project Results – Quasi-static Peak Load Comparison to RSW

Repair Process	1.3 mm CR600Y980T-RA-HE-GI (Lot#192) "All Zinc"		1.3 mm CR600Y980T-RA-HE-GI (Lot#192) "Bottom Side Zinc"		1.3 mm CR600Y980T-RA-HE-GI (Lot#192) "No Zinc"	
	Repair Process Average Quasi-static Peak Load Meets or Exceeds RSW Production Average Quasi-static Peak Load?					
	Shear Tension	Cross Tension	Shear Tension	Cross Tension	Shear Tension	Cross Tension
GMAW Plug ER70S-6 (10 mm Hole)	YES	YES	YES	YES	YES	YES
GMAW Plug ER120S-G (8 mm Hole)	YES	YES	Not tested	Not tested	Not tested	Not tested
GMAW Plug ER70S-6 (8 mm Hole)	NO	NO	YES	YES	YES	YES
GMAW Plug ER70S-6 (6 mm Hole)	NO	NO	NO	YES	NO	YES

- Pre-test cracks were not detected in the test specimen configurations that failed to meet or exceed the average quasi-static peak load of the RSW production process.

Project Summary / Conclusion

- Cracks observed in Project #6 samples appear to be hot cracks in the weld metal with no clear indication of LME.
- Cracks were not observed in any of the 6 mm hole diameter test samples.
- Removal of zinc generally increased quasi-static peak loads, possibly due to reduced weld metal porosity.
- ER120S-G filler metal produced higher peak loads than ER70S-6 filler metal.
- 10 mm hole diameter plug joints exceeded resistance spot weld peak loads for all surface coating conditions and both filler metals tested.
- 8 mm hole diameter plug joints exceeded resistance spot weld peak loads for ER70S-6 filler metal only when zinc was removed from the faying surface.
- 6 mm hole diameter plug joint shear tension peak loads were lower than resistance spot weld peak loads for all surface/coating conditions.

Value Proposition

- Project results will assist OEMs in defining appropriate GMAW plug joint repair strategies for 980 3rd Gen AHSSs

- Common procedures used in this study allow for comparison to other A/SP Joining projects and with prior Repairability Team testing of other AHSS grades

Next Steps

- The team is currently scoping the Repairability, R#7 Project for 3rd Gen Steels
  - Project Purpose
    - Evaluate various weld repair processes and provide joint performance test data for use by OEMs in determining appropriate repair strategies for 3rd Gen steels. Implement liquid metal embrittlement (LME) mitigation techniques developed in P#6 for the GMAW and GMAB repair welding processes used in the study.

For More Information

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