

# **GREAT DESIGNS IN STEEL**

## **AHSS REPAIRABILITY**

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# AUTO/STEEL PARTNERSHIP PROJECT TEAM MEMBERS

JPC Project Mentor: Jason Balzer, Ford Motor Company

Project Leader: Min Kuo, ArcelorMittal

Project Manager: Michael White, Auto/Steel Partnership

## Project Team Members:

- Sriram Sadagopan, ArcelorMittal
- Padma Durbha, ArcelorMittal
- Mike Palko, Ford Motor Company
- Gerry Bonnani, Ford Motor Company
- David Rigg, General Motors Co.
- Mark Szlachta, General Motors Co.
- Harminderpaul Grover, General Motors Co.
- Rob Kaminski, Nucor Corporation
- Dean Kanelos, Nucor Corporation
- Weiping Sun, Nucor Corporation
- Justin Hunt, Stellantis
- Hokook Lee, POSCO America

# PROJECT GOALS

The purpose of this project was to evaluate various weld repair processes and to provide joint test data for use by OEMs

An Auto/Steel Partnership Repairability Team Project

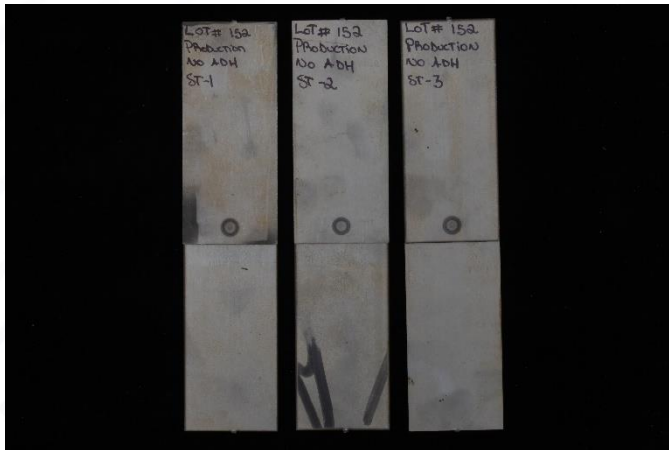
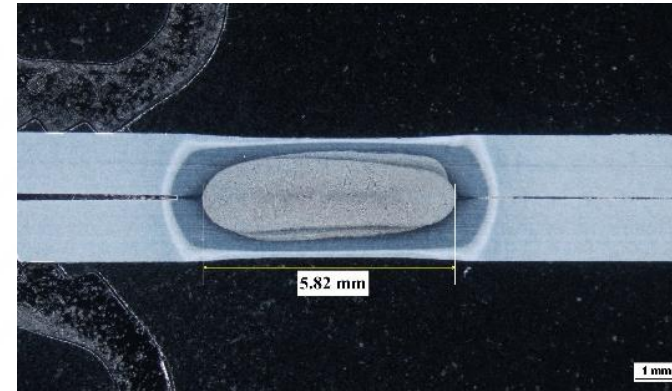
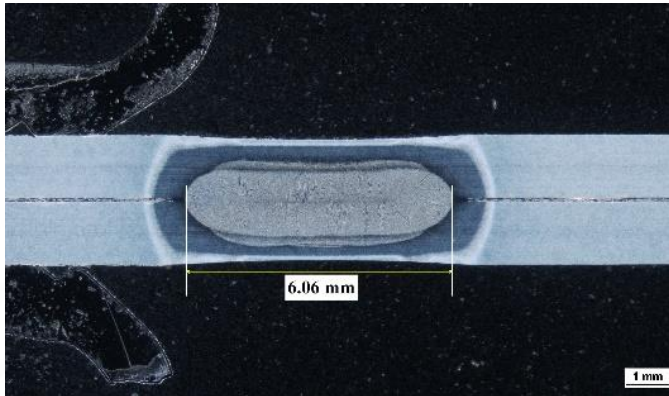
# PROJECT APPROACH

- Using coupon test assemblies fabricated from various grades of 3rd GEN AHSS, a variety of repair process joints were destructively tested. The resulting data can be used by OEMs to update repair process strategies
- 3rd GEN 980 uncoated, 3rd GEN 980 GI coated, and 3rd GEN 1180 GI were tested
- Repair processes investigated include: resistance spot welding (RSW), gas metal arc welding (GMAW), gas metal arc brazing (GMAB), and mechanical fastening
- Production and service adhesives were also tested
- Tests include shear tension and cross tension quasi-static, shear tension fatigue, cross-sections for microscopy and metallurgical analysis and cross-sections



# PROJECT RESULTS | TYPICAL JOINT AND CROSS-SECTION PHOTOS

1.4 mm 3rd Gen 980 - uncoated (Lot#152): RSW (Production)



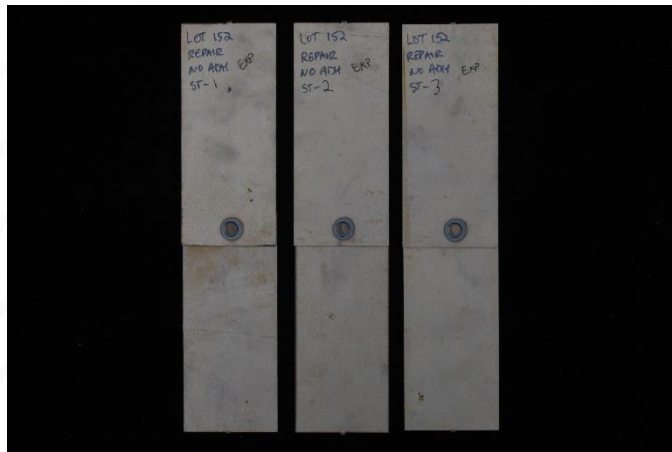
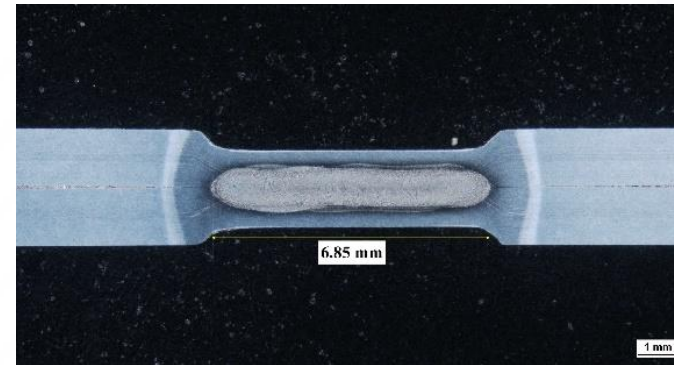
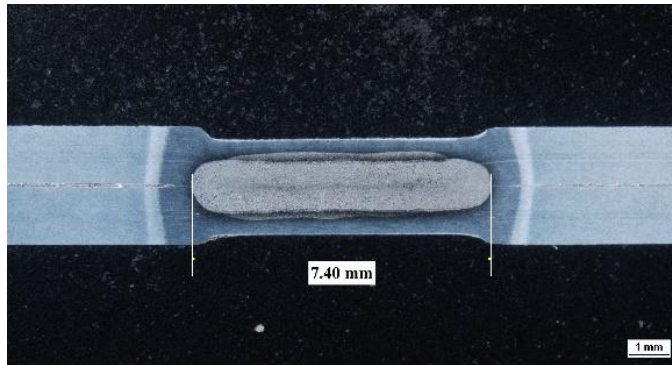
RSW  
(Production)



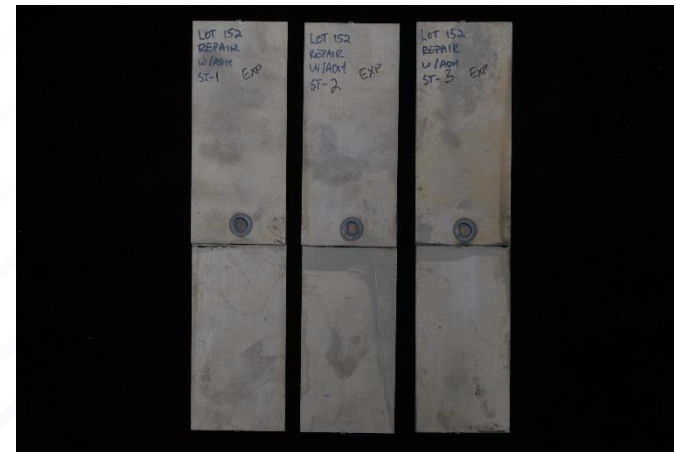
RSW (Production) with  
production adhesive

# PROJECT RESULTS | TYPICAL JOINT AND CROSS - SECTION PHOTOS

1.4 mm 3rd Gen 980 - uncoated (Lot#152): RSW (Service)



RSW  
(Service)

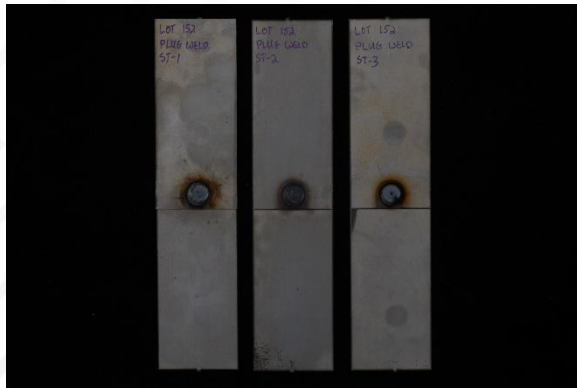
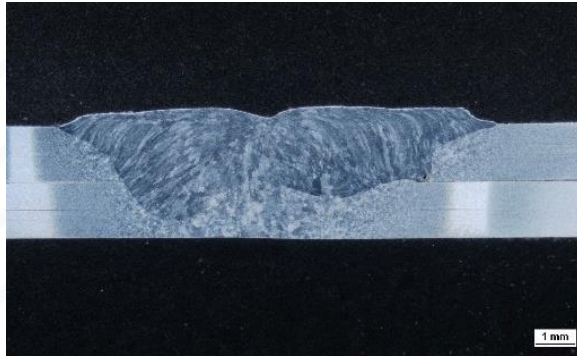


RSW (Service) with  
service adhesive

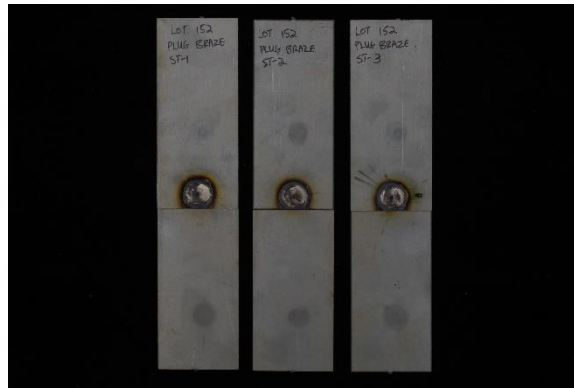


# PROJECT RESULTS | TYPICAL JOINT AND CROSS - SECTION PHOTOS

1.4 mm 3rd Gen 980 - uncoated (Lot#152): GMAW and GMAB



GMAW Plug



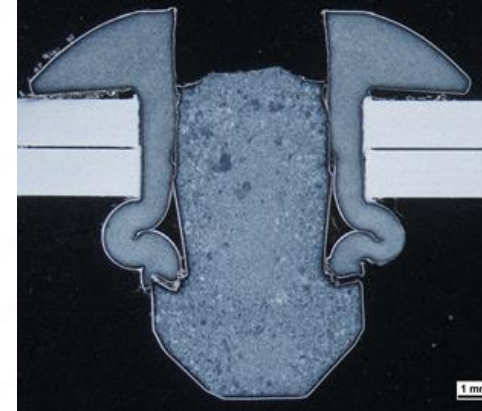
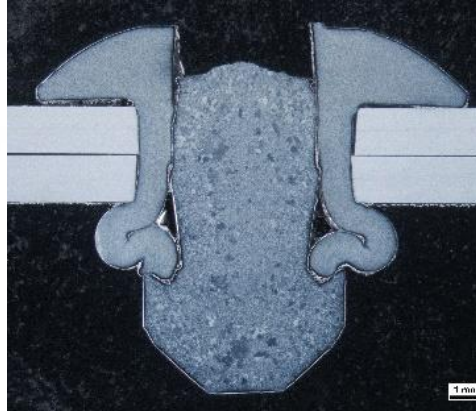
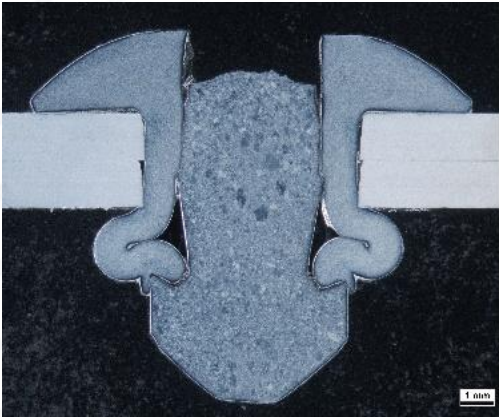
GMAB Plug



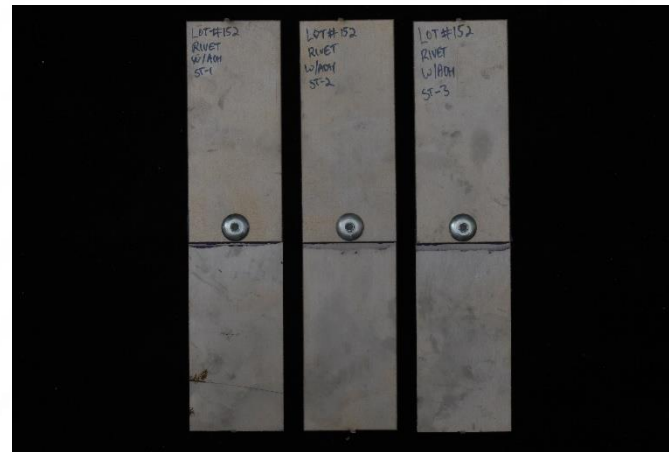
GMAB Slot

# PROJECT RESULTS | TYPICAL JOINT AND CROSS-SECTION PHOTOS

1.4 mm 3rd Gen 980 - uncoated (Lot#152): Hemlok Rivet



Hemlok Rivet



Hemlok Rivet with production adhesive

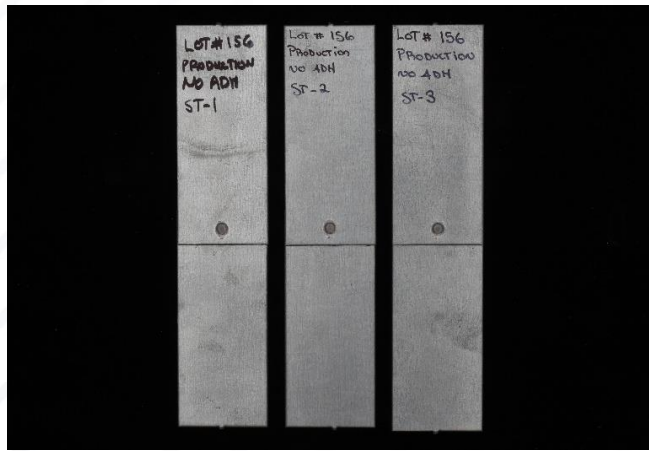
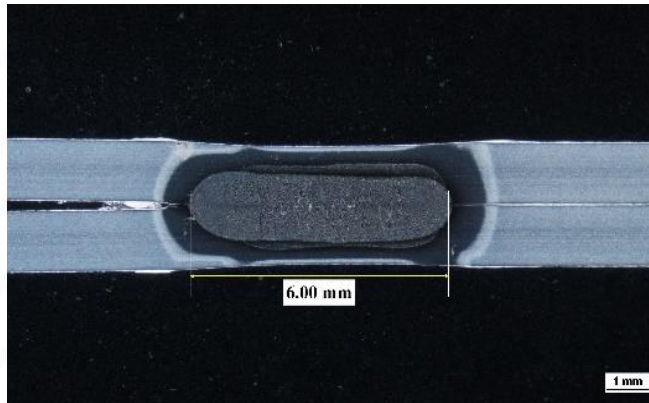


Hemlok Rivet with service adhesive

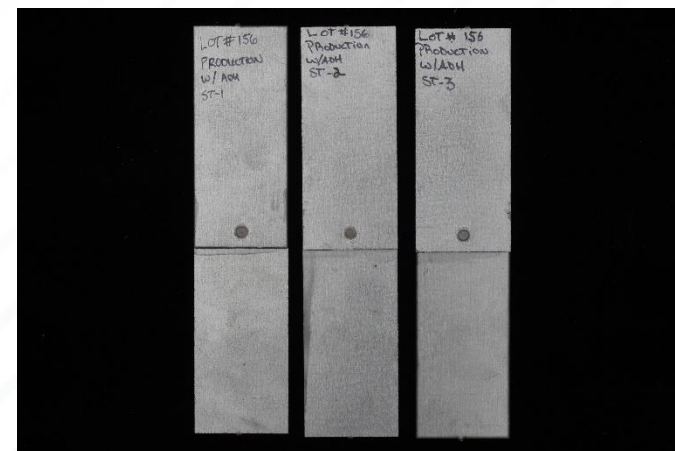
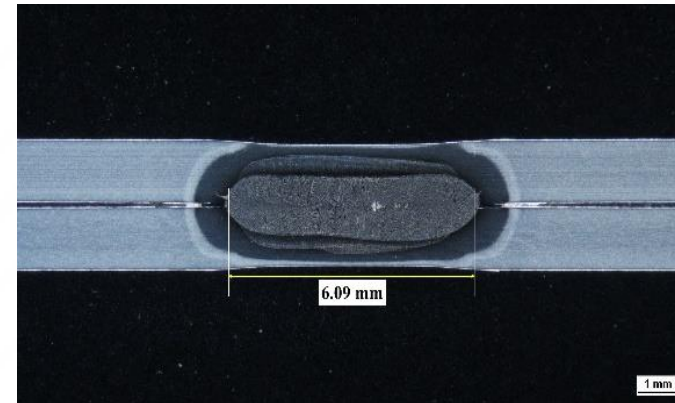


# PROJECT RESULTS | TYPICAL JOINT AND CROSS-SECTION PHOTOS

1.4 mm 3rd Gen 980 - HDGI (Lot#156): RSW (Production)



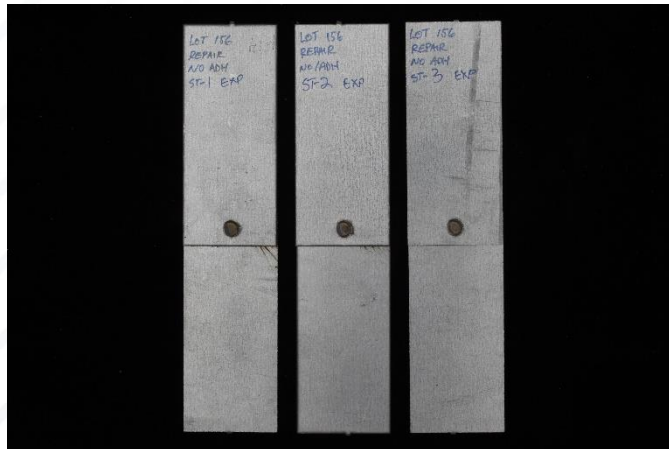
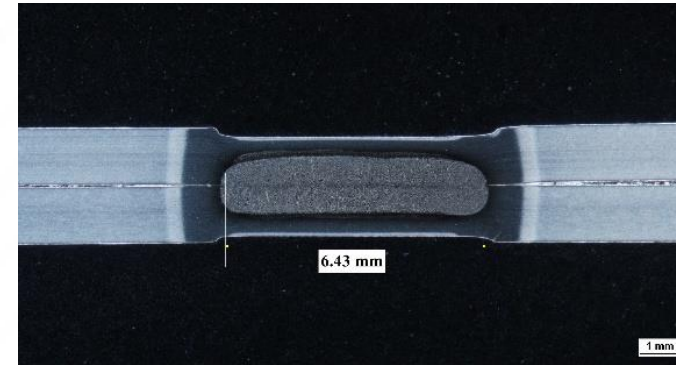
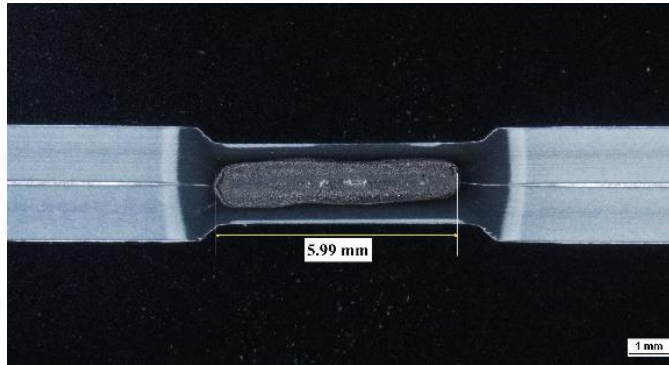
RSW (Production)



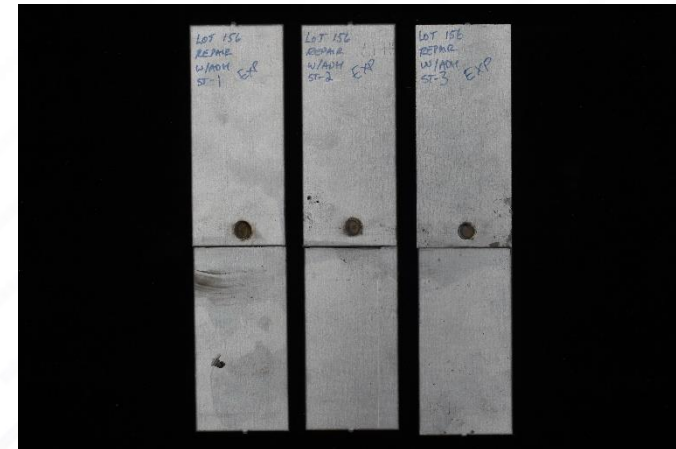
RSW (Production) with production adhesive

# PROJECT RESULTS | TYPICAL JOINT AND CROSS-SECTION PHOTOS

1.4 mm 3rd Gen 980 - HDGI (Lot#156) : RSW (Service)



RSW  
(Service)

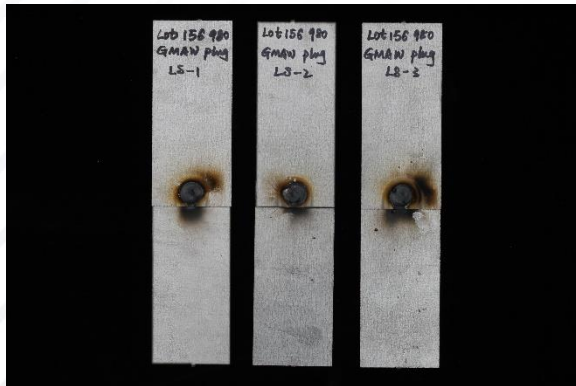
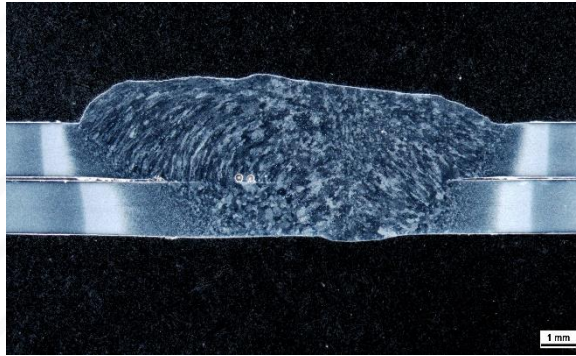


RSW (Service) with  
service adhesive

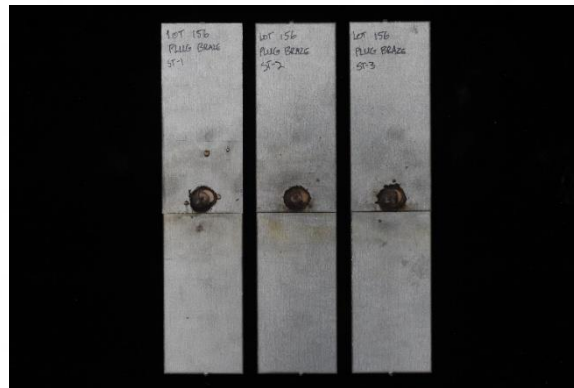


# PROJECT RESULTS | TYPICAL JOINT AND CROSS - SECTION PHOTOS

1.4 mm 3rd Gen 980 - HDGI (Lot#156) : GMAW and GMAB



GMAW Plug



GMAB Plug

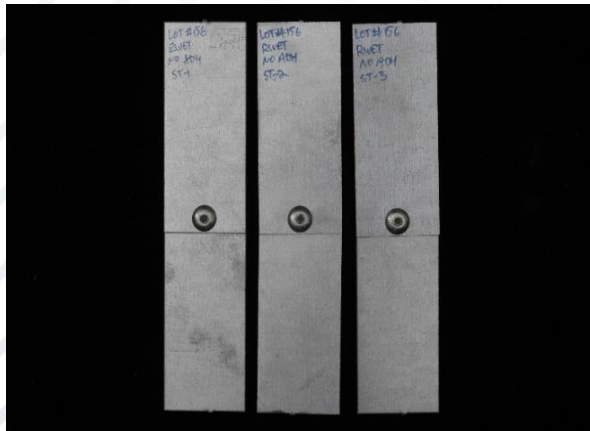
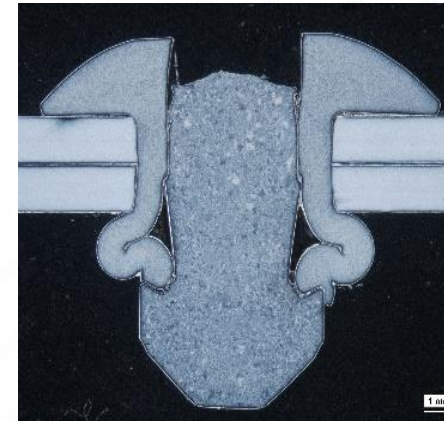
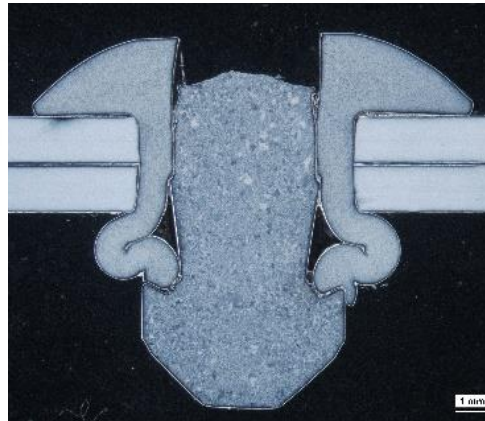
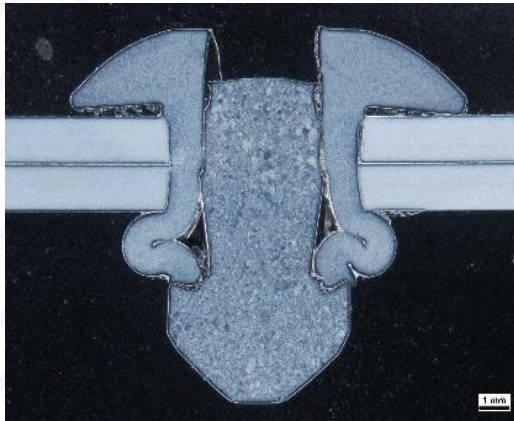


GMAB Slot

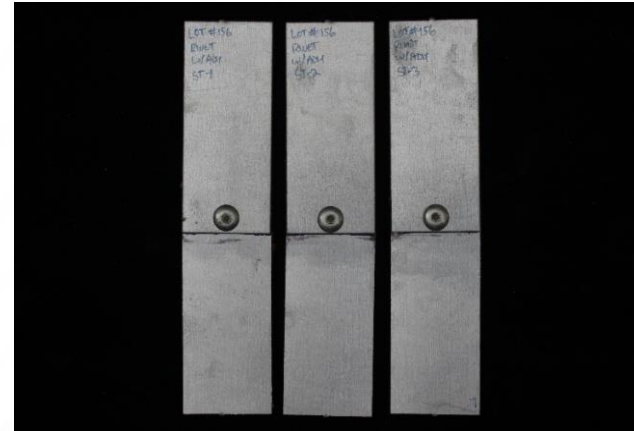


# PROJECT RESULTS | TYPICAL JOINT AND CROSS - SECTION PHOTOS

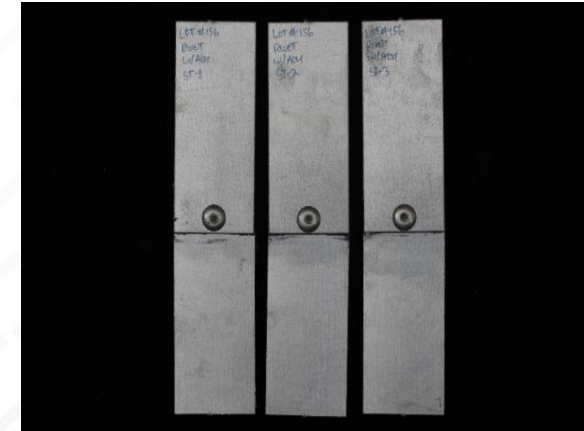
1.4 mm 3rd Gen 980 - HDGI (Lot#156): Hemlok Rivet



Hemlok Rivet



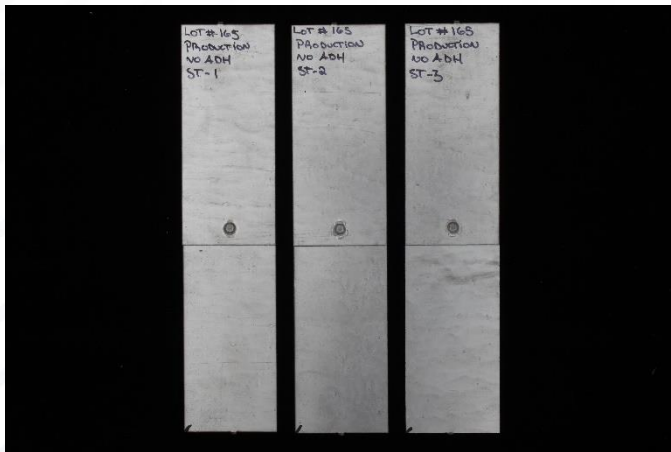
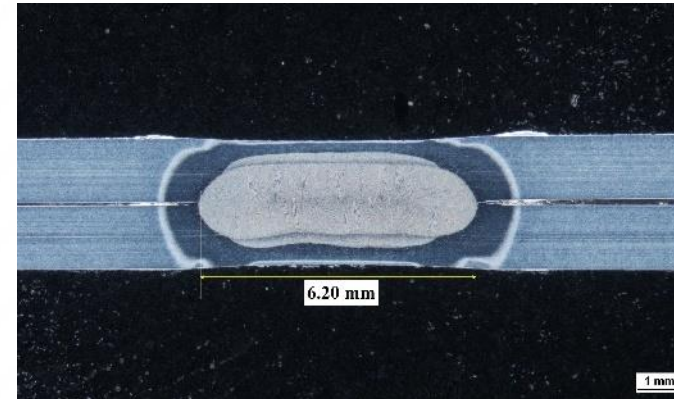
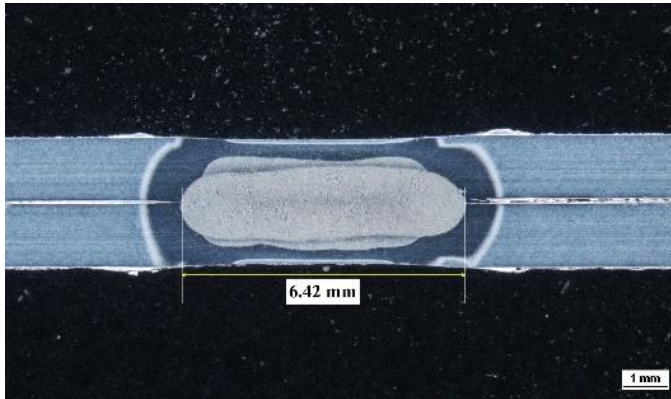
Hemlok Rivet with production adhesive



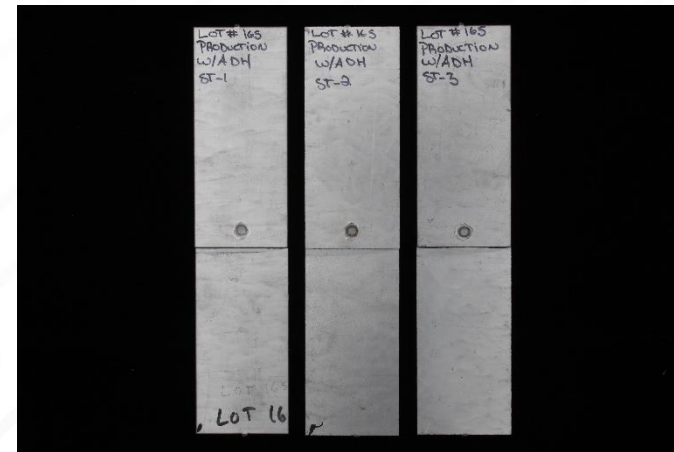
Hemlok Rivet with service adhesive

# PROJECT RESULTS | TYPICAL JOINT AND CROSS - SECTION PHOTOS

1.4 mm 3rd GEN 1180 - HDGI (Lot#165): RSW (Production)



RSW  
(Production)

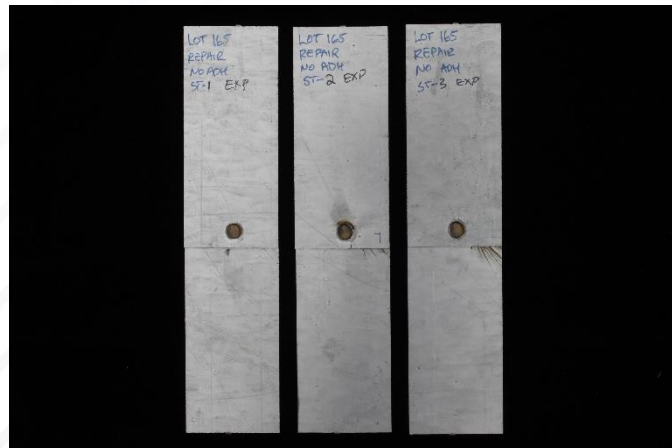
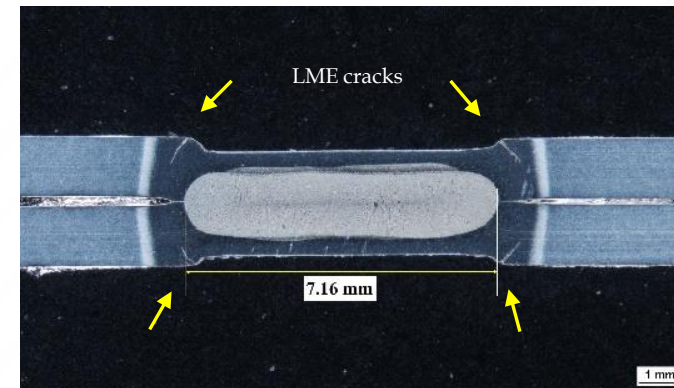
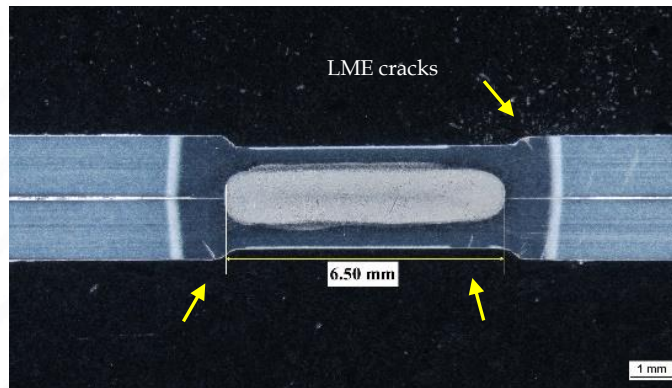


RSW (Production) with  
production adhesive

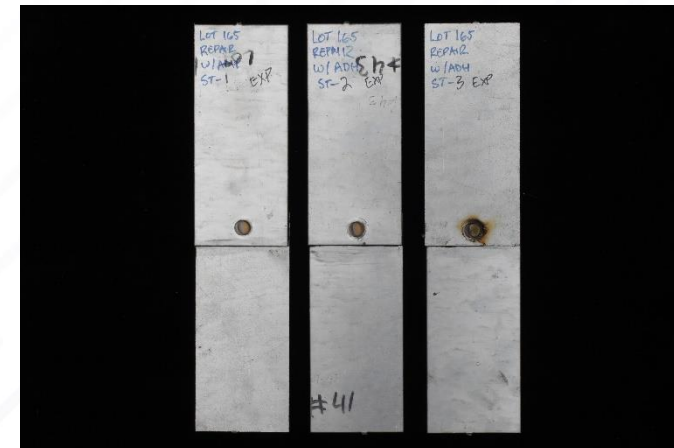


# PROJECT RESULTS | TYPICAL JOINT AND CROSS-SECTION PHOTOS

1.4 mm 3rd GEN 1180 - HDGI (Lot#165): RSW (Service)



RSW (Service)

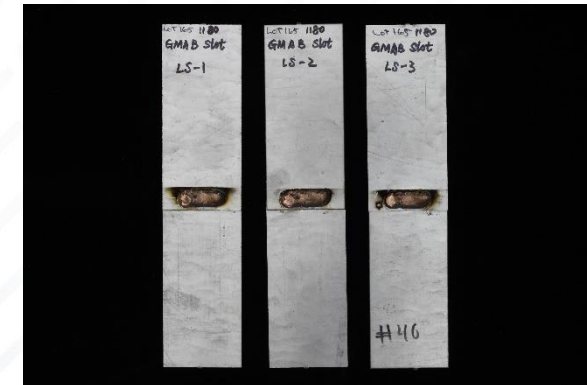
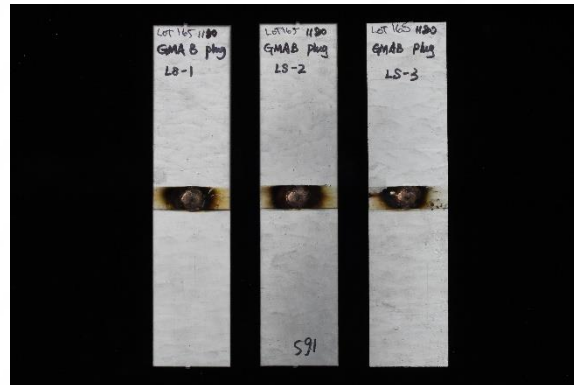
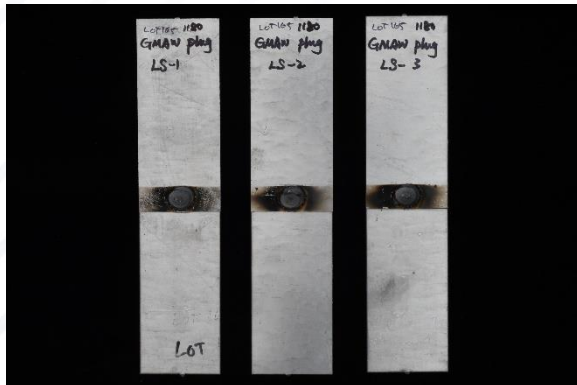
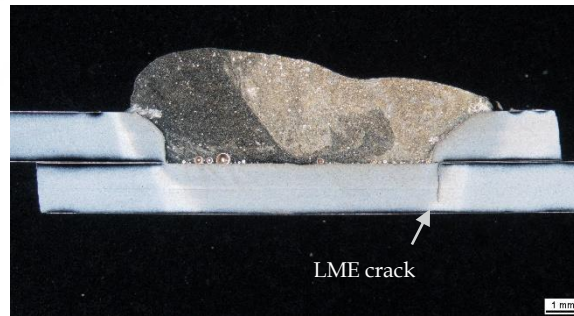
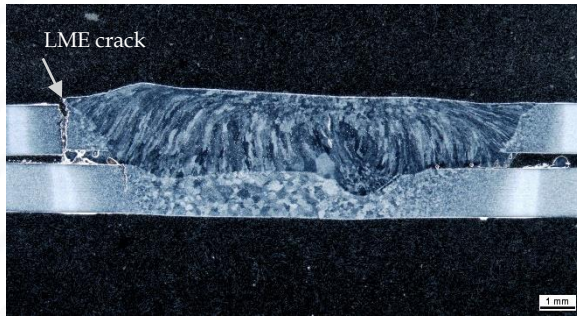


RSW (Service) with service adhesive



# PROJECT RESULTS | TYPICAL JOINT AND CROSS - SECTION PHOTOS

1.4 mm 3rd GEN 1180 - HDGI (Lot#165): RSW (Service)



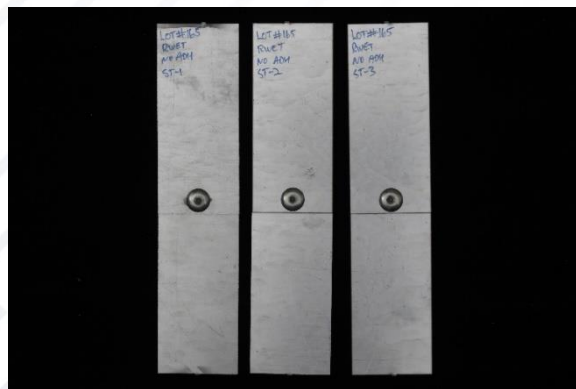
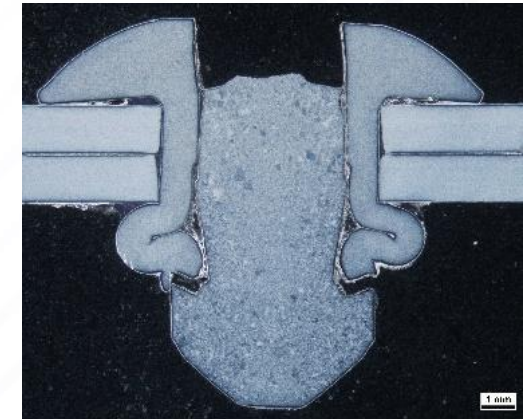
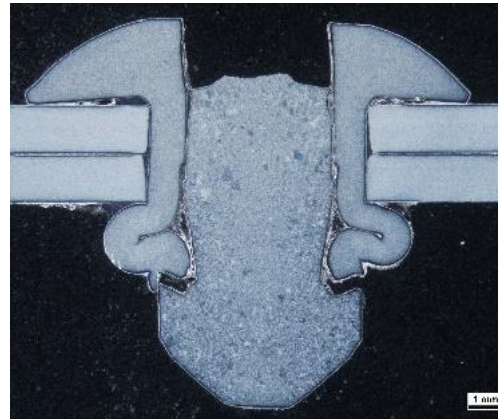
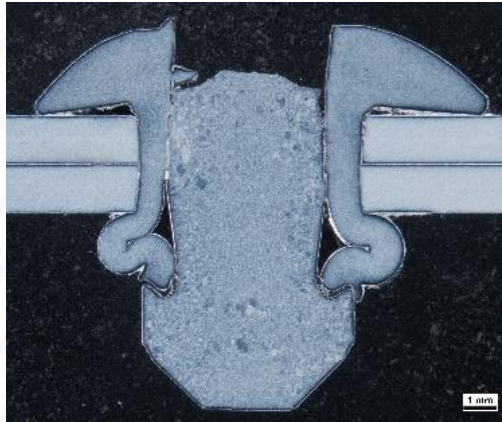
GMAW Plug

GMAB Plug

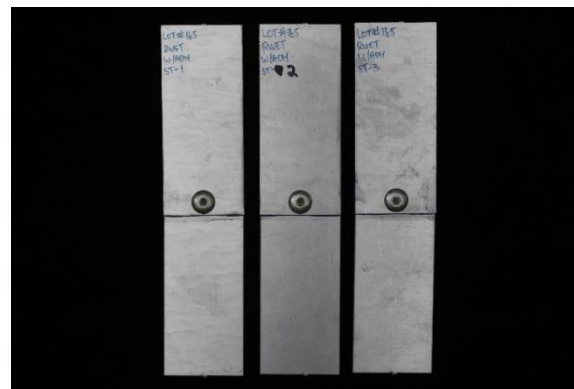
GMAB Slot

# PROJECT RESULTS | TYPICAL JOINT AND CROSS - SECTION PHOTOS

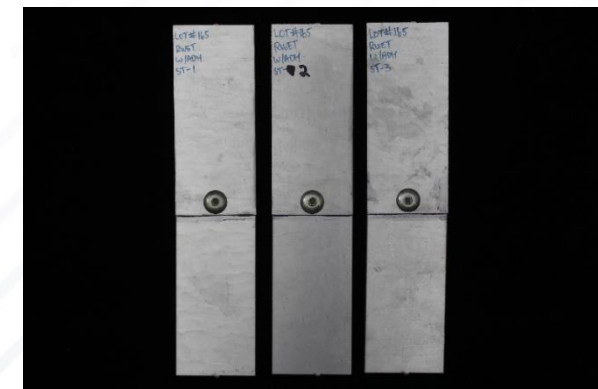
1.4 mm 3rd GEN 1180 - HDGI (Lot#165): Hemlok Rivet



Hemlok Rivet



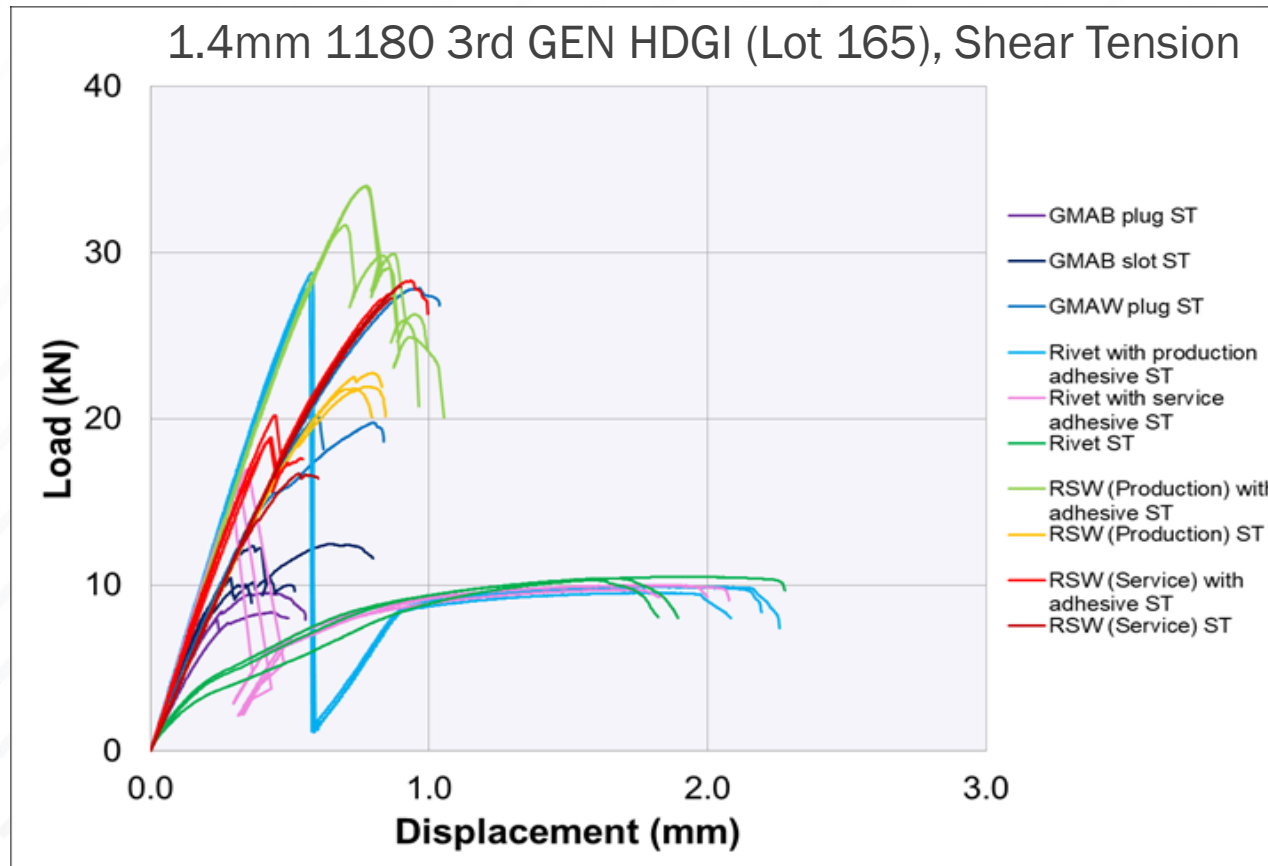
Hemlok Rivet with production adhesive



Hemlok Rivet with service adhesive

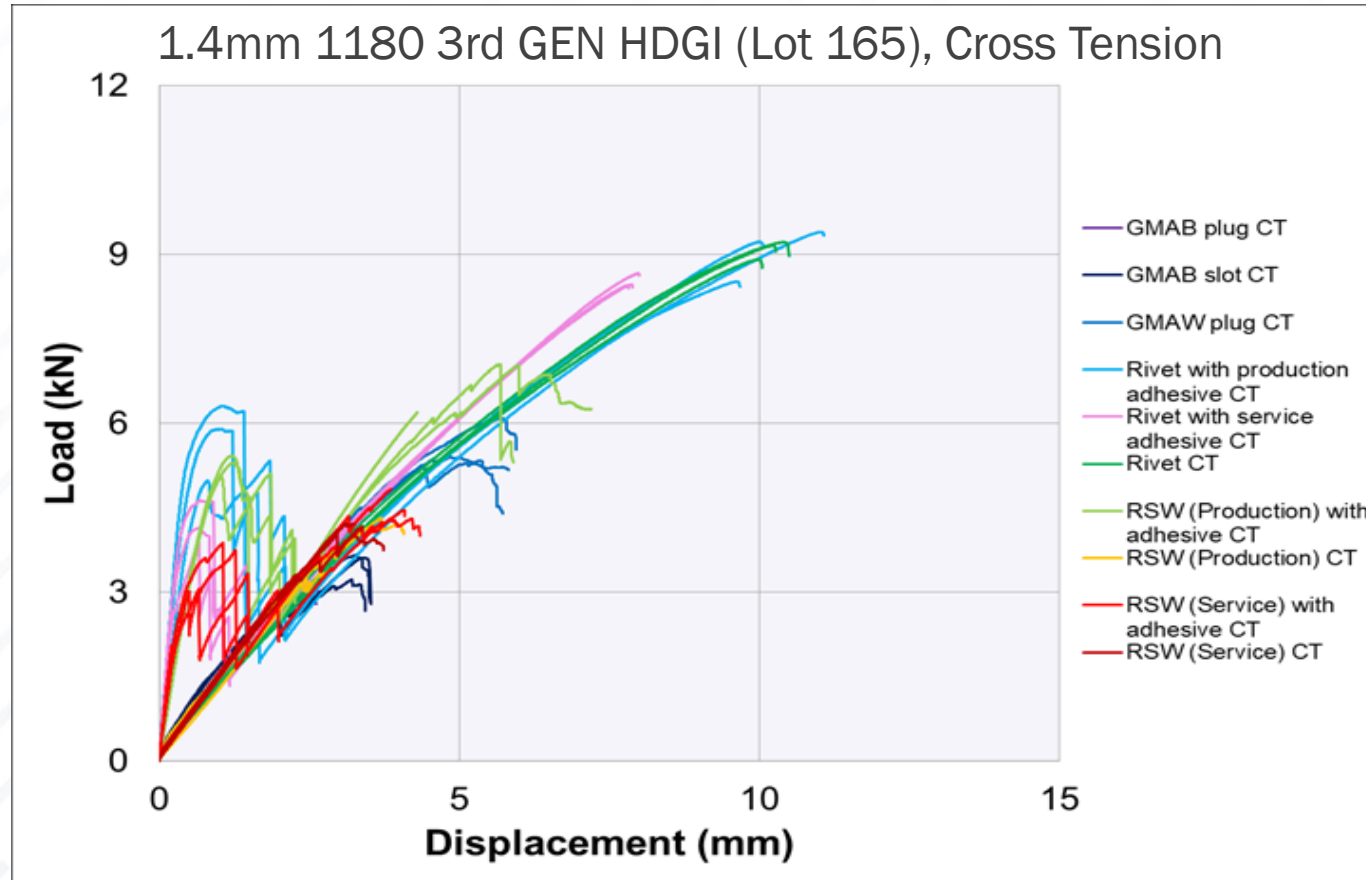


# PROJECT RESULTS | JOINT PEAK LOAD DISPLACEMENT PLOTS



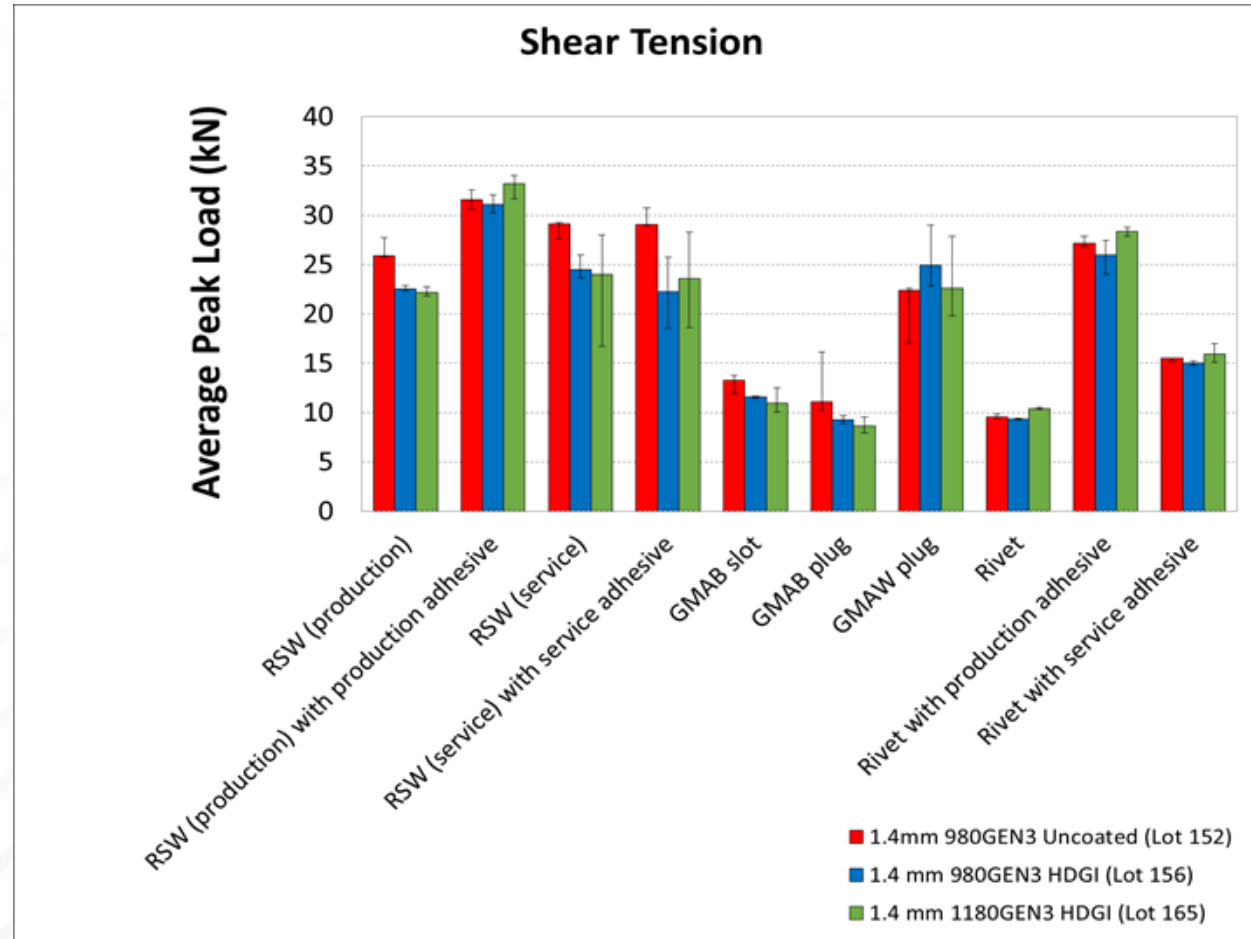


# PROJECT RESULTS | JOINT PEAK LOAD DISPLACEMENT PLOTS



# PROJECT RESULTS | JOINT PEAK LOAD COMPARISON BAR CHART

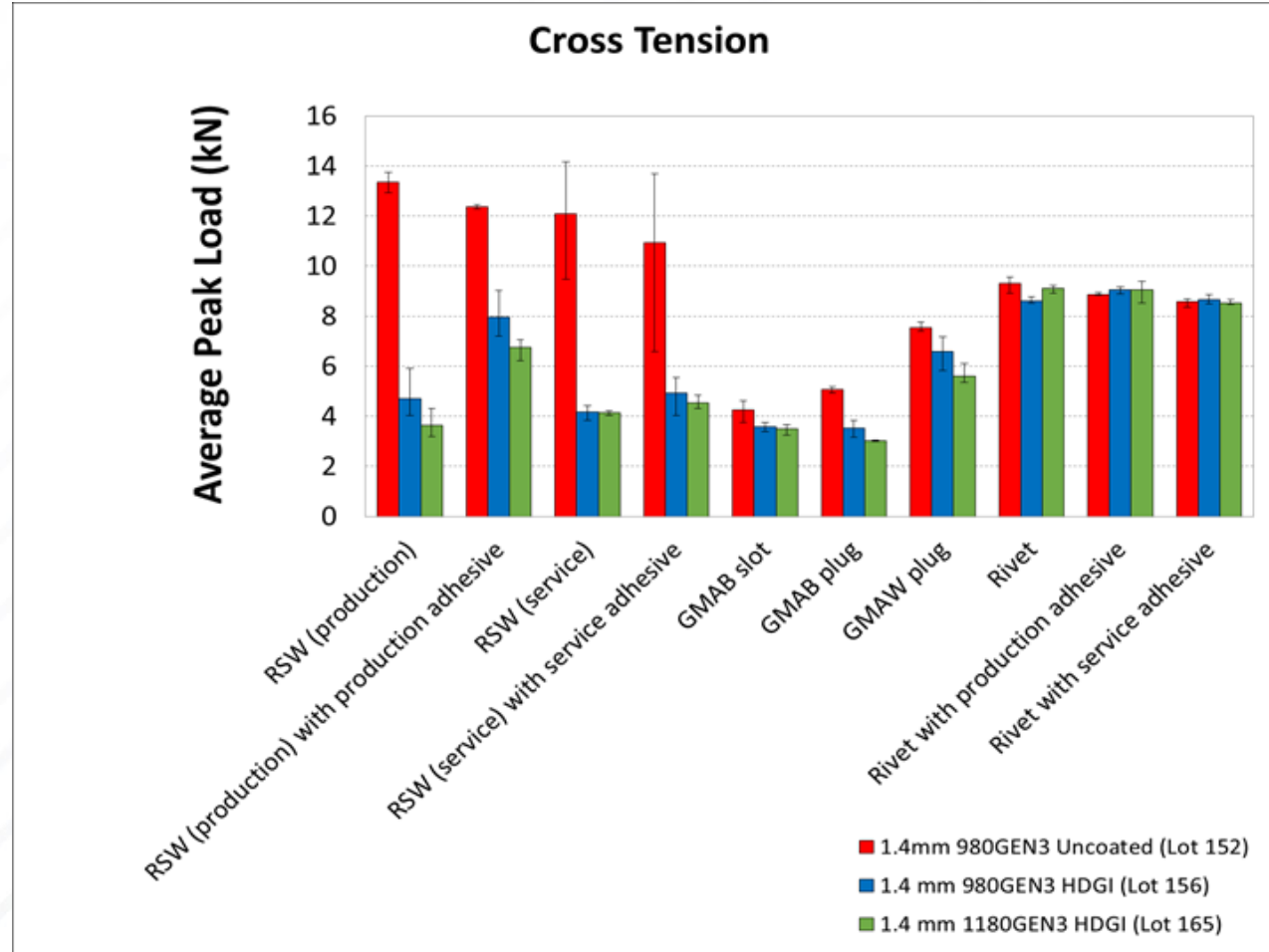
Shear Tension Comparison For All Types



Error bars indicate minimum and maximum peak loads for each group

# PROJECT RESULTS | JOINT PEAK LOAD COMPARISON BAR CHART

Cross Tension Comparison For All Types

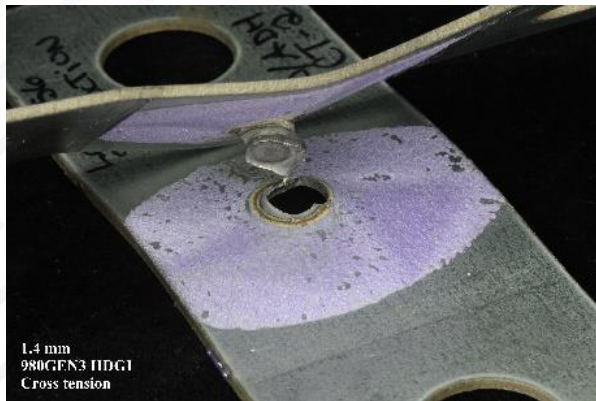


Error bars indicate minimum and maximum peak loads for each group



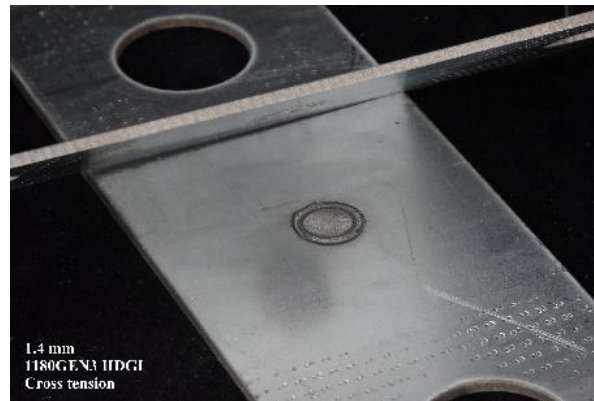
# PROJECT RESULTS | TYPICAL FRACTURE PHOTOS

980 3rd GEN HDGI (Lot 156), CT



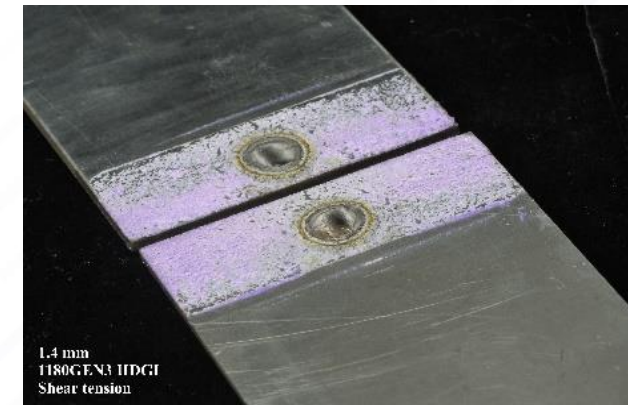
button pull – both sheets/cohesive separation

1180 3rd GEN HDGI (Lot 165), CT



interfacial

1180 3rd GEN HDGI (Lot 165), ST



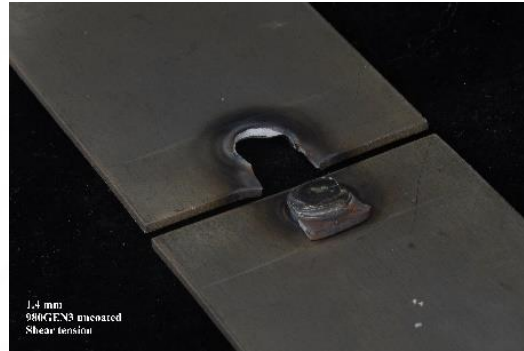
interfacial/cohesive separation

RSW (Production)

# PROJECT RESULTS | TYPICAL FRACTURE PHOTOS – SHEAR & CROSS TENSION

GMAW

980 3rd GEN Uncoated (Lot 152), ST



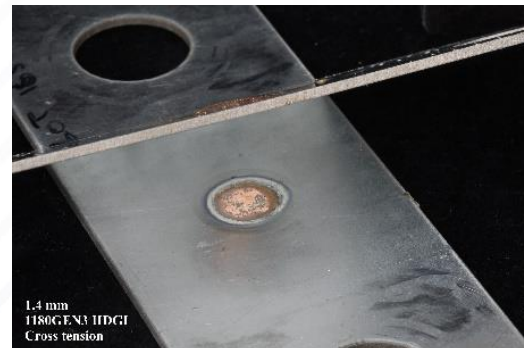
weld pullout – top sheet

980 3rd GEN Uncoated (Lot 152), CT



weld pullout – both sheets

1180 3rd GEN HDGI (Lot 165), CT



braze fracture

980 3rd GEN HDGI (Lot 156), ST



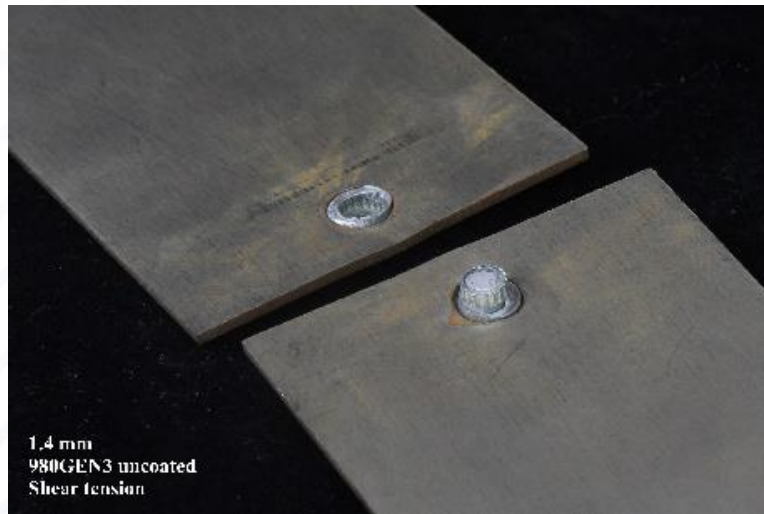
braze fracture/braze pullout – top sheet

GMAB

# PROJECT RESULTS | TYPICAL FRACTURE PHOTOS

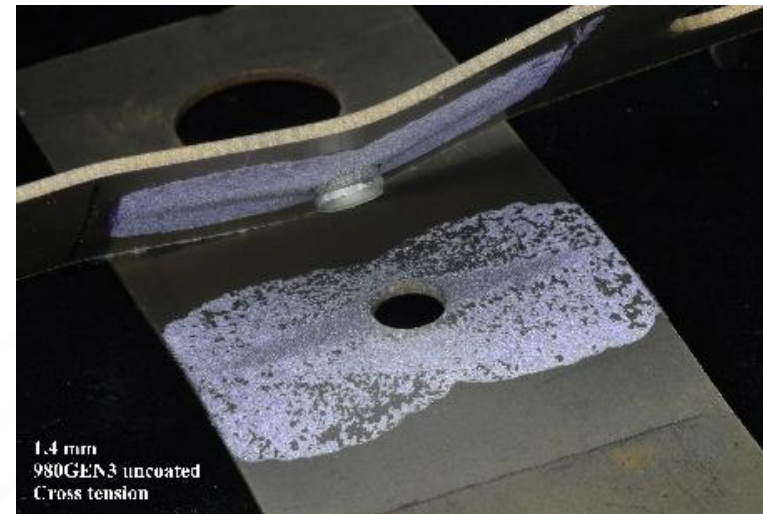
## Structural Mechanical Rivet

980 3rd GEN Uncoated (Lot 152), ST



rivet separation

980 3rd GEN Uncoated (Lot 152), CT



rivet separation/cohesive separation



# PROJECT CONCLUSIONS AND RECOMMENDATIONS

- For materials evaluated in this project, appropriate repair methods can be selected
- Adhesive increased shear tension peak loads but had little effect on cross-tension peak loads
- Production adhesive joints had higher peak loads compared to service adhesive joints for both shear tension and cross tension
- LME cracking was observed in the 3rd GEN 1180 spot welds, both production and repair welder
- LME observed in the 3rd GEN 980 - HDGI service spot welds
- Significant LME cracking was observed in the GMAW plug and GMAB slot joint configurations:
  - 1.4 mm 3rd GEN 980 - HDGI (Lot#152) GMAW plug
  - 1.4 mm 3rd GEN 1180 - HDGI (Lot#165) GMAW plug, GMAB plug and GMAB slot

# FOR MORE INFORMATION

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