

# GREAT DESIGNS IN **STEEL**

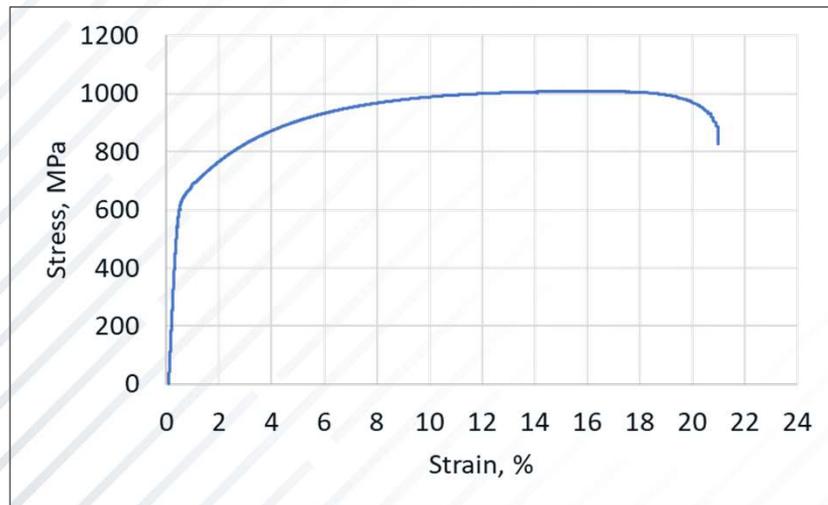
## **ON THE ADVANTAGES OF FORTIFORM® 980 GI - A 3<sup>RD</sup> GENERATION AHSS GRADE WITH SUPERIOR WELDABILITY**

Hassan Ghassemi-Armaki, Qaiser Khan, and Shri Aditya Varanasi  
ArcelorMittal Global R&D, East Chicago, IN, USA

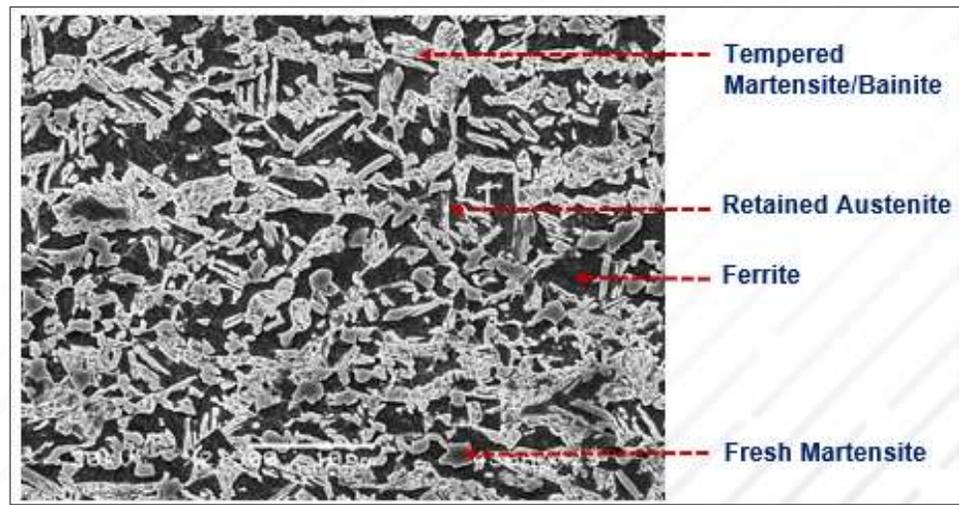
# FORTIFORM® 980 GI MECHANICAL PROPERTIES & MICROSTRUCTURE DESIGN

Engineered product - **Excellent mechanical properties with improved LME resistance**

	Targeted Mechanical Properties				Bendability
	YP (MPa)	TS (MPa)	TE (%)	HER (%)	
FORTIFORM® 980 GI	670	1005	22	23	V-bend < 2 r/t



Engineering Stress-Strain Curve



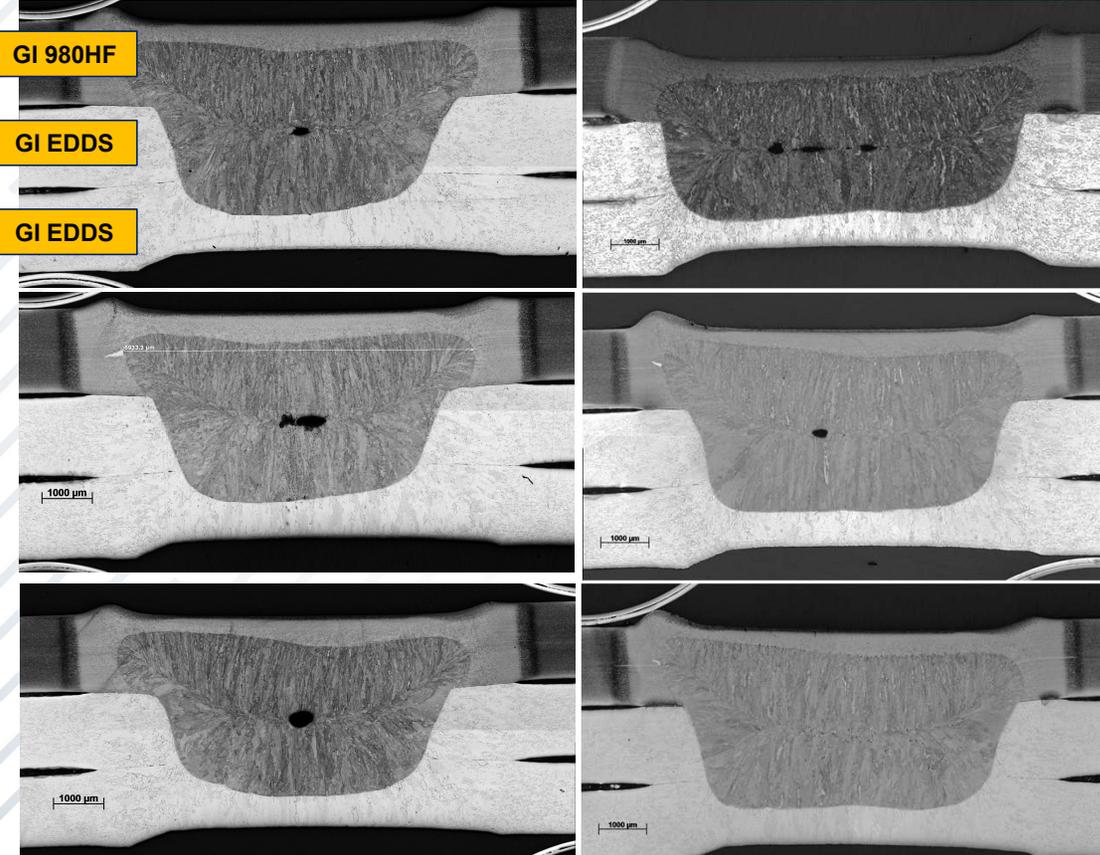
Microstructure

# WELDABILITY SPOT WELDING

Stackup: 1.6mm GI980HF / 1.5 mm GI EDDS / 1.5mm GI EDDS  
Welding Condition: SEP1220-2

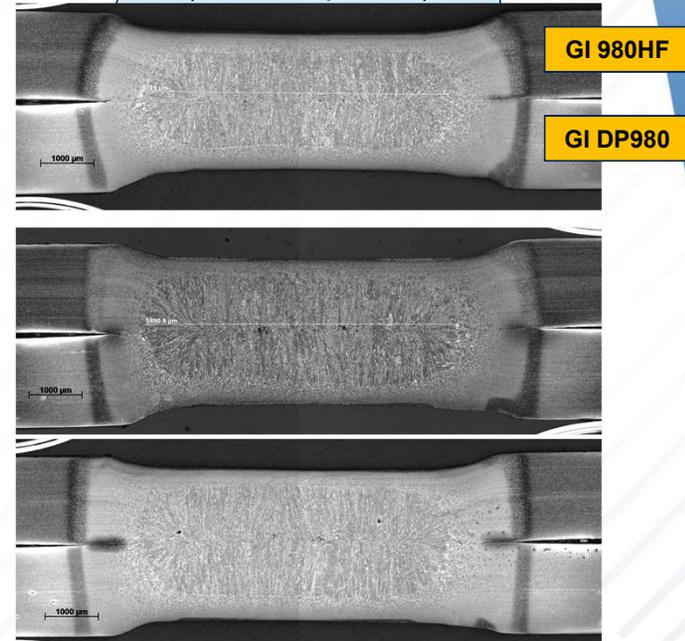
Max. Welding Current ( $I_{max}$ );  
Just Below Expulsion

10% Above  $I_{max}$   
(Above Expulsion)



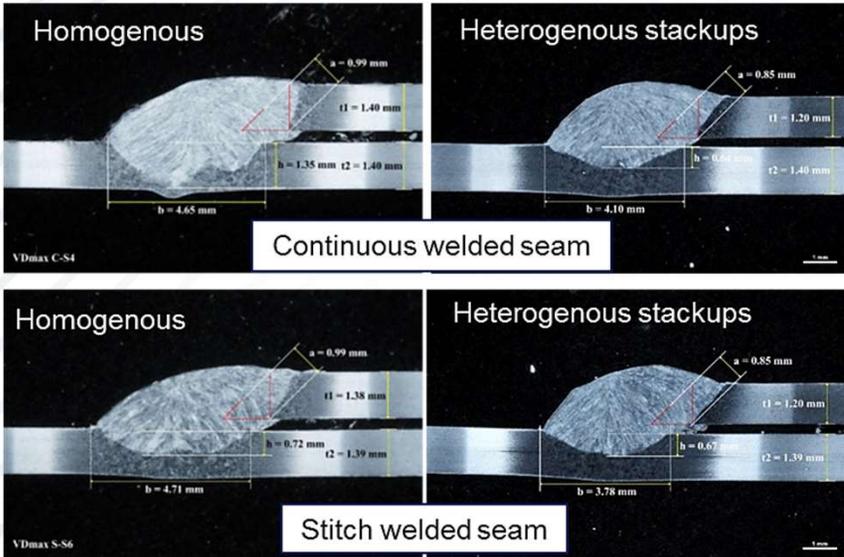
Stackup: 1.6mm GI980HF / 1.6 mm DP980GI  
Welding Condition: SEP1220-2

10% Above  $I_{max}$   
(Above Expulsion)

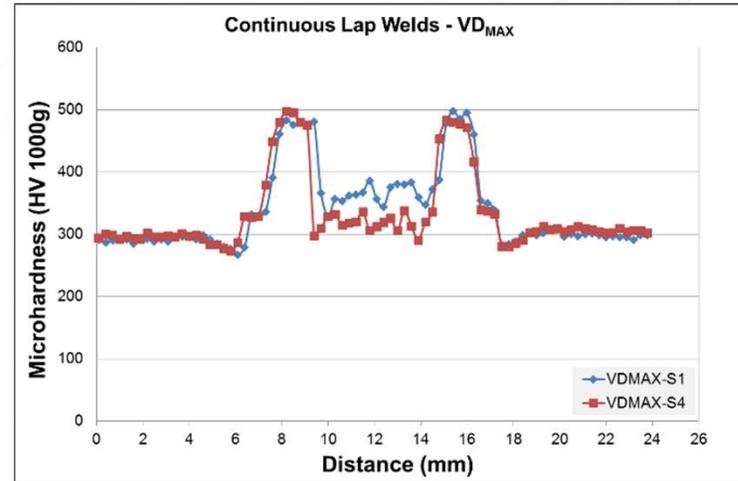


**No surface cracking in high thickness heterogenous stackups with mild steel; even at Expulsion**

# WELDABILITY GAS METAL ARC WELDING (GMAW)

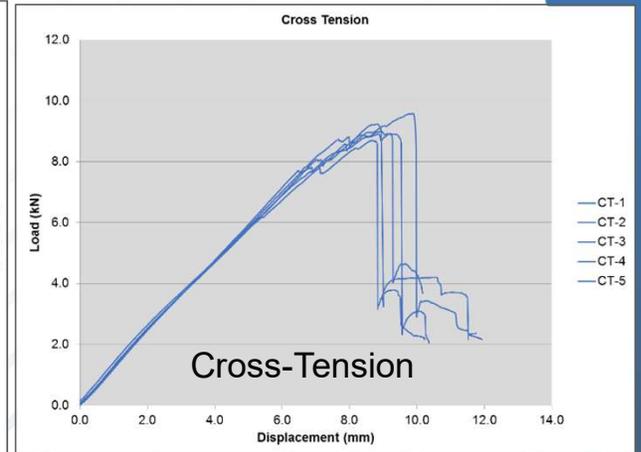
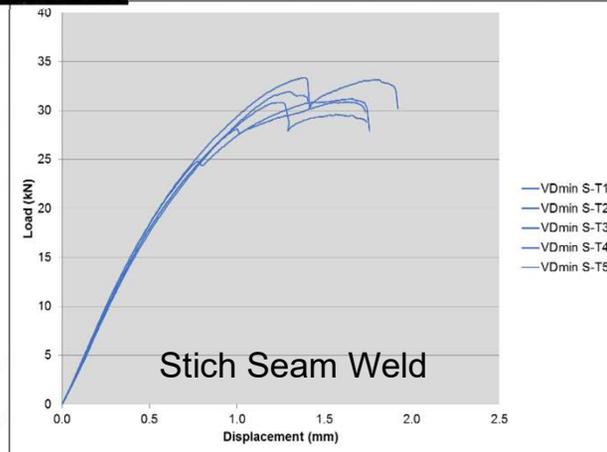


Microhardness plots



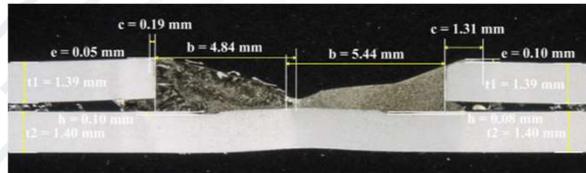
Cross-section Images at Maximum Penetration

No Surface Cracks for all the different welded geometries studied

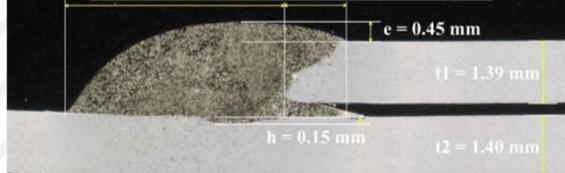


# WELDABILITY MIG BRAZING AND LASER WELDING

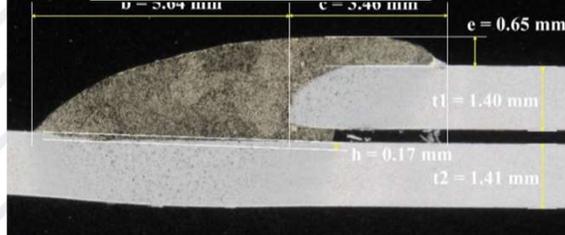
Stitch brazed cross tension, VD<sub>MIN</sub>



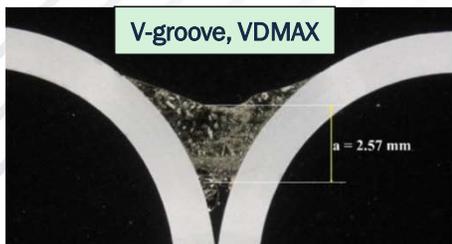
Continuous brazed seam, VDMAX



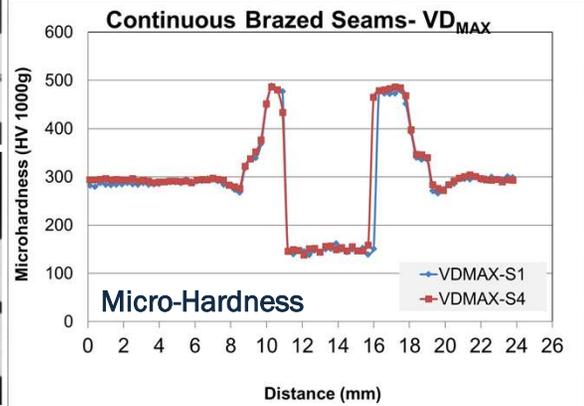
Stitch brazed seam, VDMAX



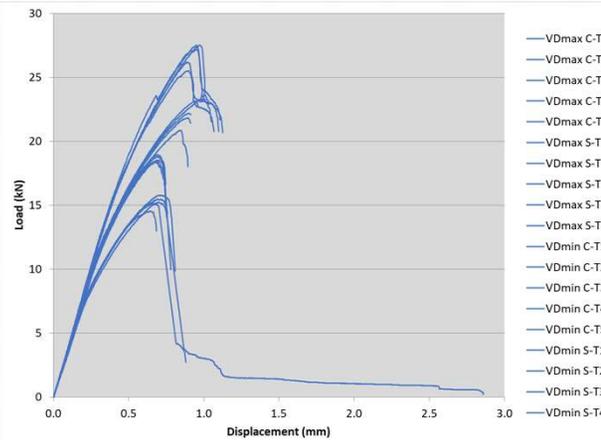
V-groove, VDMAX



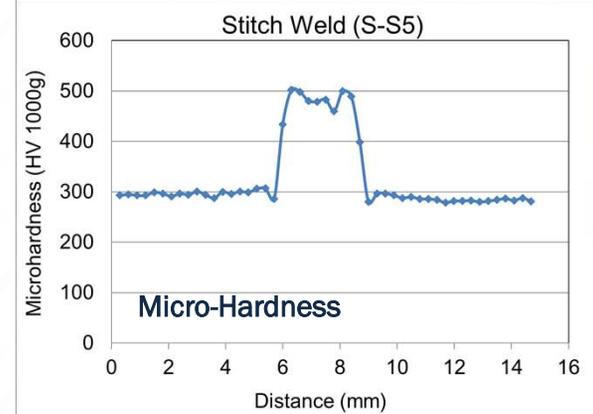
MIG Brazing



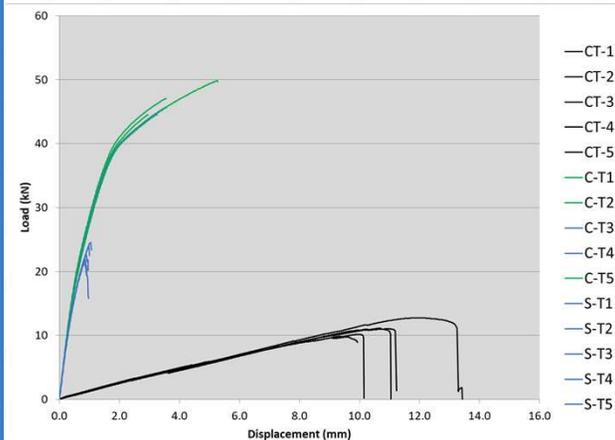
Load-Displ.; continuous, stich seam and CT



Laser Welding



Load-Displ.; continuous, stich seam and CT

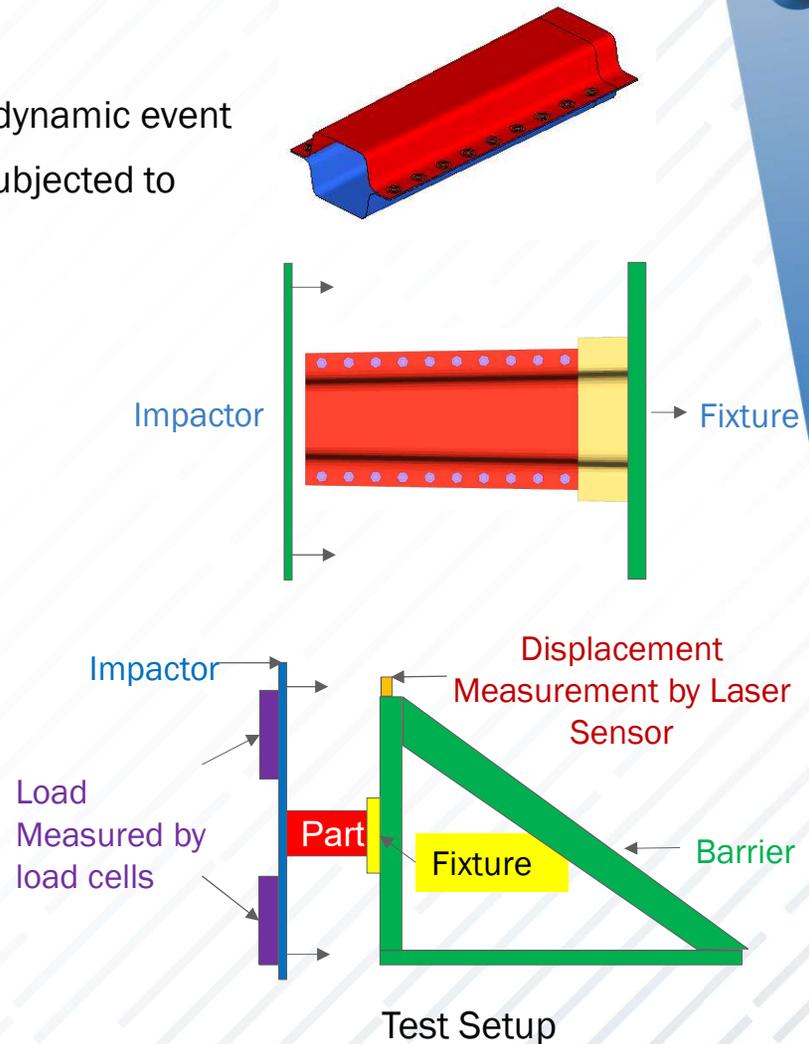


# EVALUATION OF SPOT WELDABILITY AXIAL CRUSH TEST

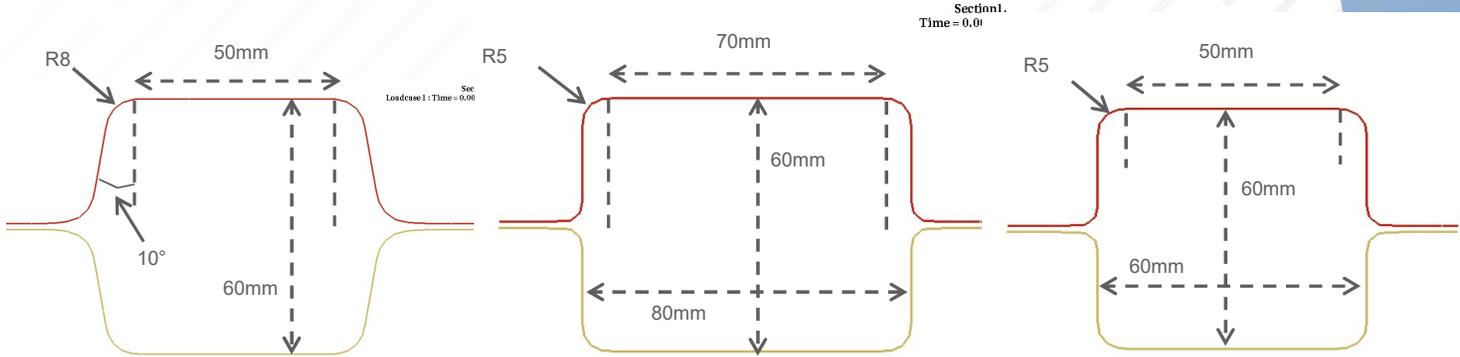
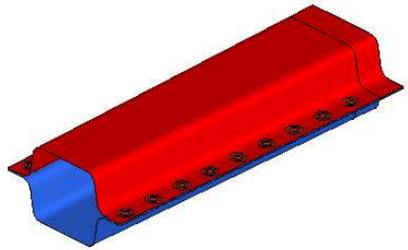
To assess the Resistance Spot Weld (RSW) performance in a dynamic event

- A double hat section was used to ensure spot welds are subjected to peel loading mode
- 3 gauges tested - 1.4mm , 1.6mm and 1.2mm
- Parts baked at 180° C for 27 mins
- Weld pitch - 25mm & 20mm
- Test Speed of 9.0 mph & a target energy of 15kJ

Welding Schedule	Welding - RE#452
	Welding Mode: MFDC
	Weld force: 5.5 KN
	Tip Face Diameter: 7 mm
	Welding Schedule(cycles): W/T-12, SQZ-70, H/T-10, Cool-2, Pulse-2
	Nugget Size: 6.2 mm
	Welding Current: 7.85 K.A.
	Weld pitch: 25 mm



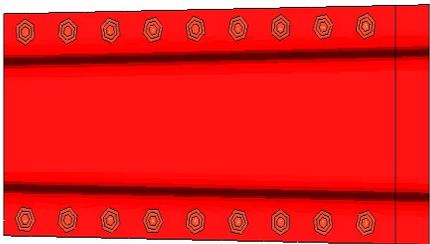
# AXIAL CRUSH TEST GEOMETRY SELECTION



Geometry 1

Geometry 2

Geometry 3



300 mm



Geometry 1 selected to ensure repeatability

# AXIAL CRUSH TEST SUMMARY

Sample Thickness	Sample Configuration	Weld Nugget Size	Weld Pitch	Observations
1.4mm	Unbaked	6.2mm	25mm	<ul style="list-style-type: none"> <li>Exhibited mainly HAZ &amp; base metal failure</li> <li>Effect of baking is not significant</li> </ul>
	Baked			
1.4mm <i>Effect of Weld Pitch vs Nugget Size</i>	Baked	5.0mm	20mm	<ul style="list-style-type: none"> <li>Crush performance of 20mm weld pitch with 5mm weld nugget size is <u>GREATER THAN</u> 25mm weld pitch, 6.2mm weld nugget size</li> </ul>
1.6mm	Unbaked	6.7mm	25mm	<ul style="list-style-type: none"> <li>Exhibited mainly HAZ failure on the welds</li> <li>Effect of baking is not very significant</li> </ul>
	Baked			
1.2mm	Unbaked	5.3mm	25mm	<ul style="list-style-type: none"> <li>Effect of baking on lower gage (1.2mm thickness) is more pronounced on weld toughness</li> <li>Unbaked samples showed failures - interfacial &amp; HAZ</li> </ul>
	Baked			

# FORTIFORM® 980 GI 1.4MM SAMPLES

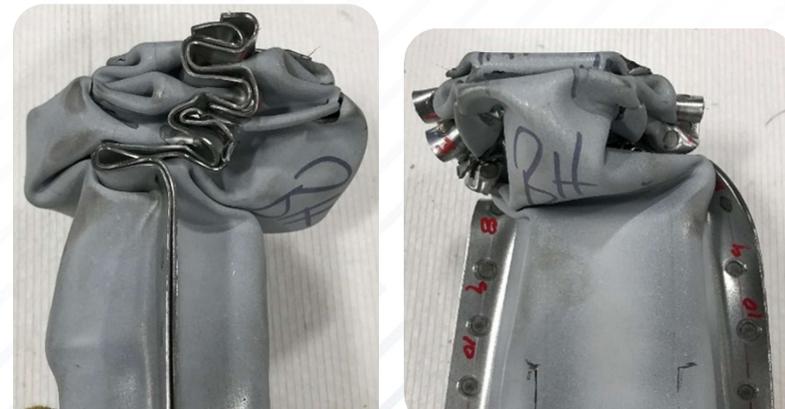
Un-Baked Sample  
25mm Weld Pitch, 6.2mm Nugget Size

Baked Sample  
25mm Weld Pitch, 6.2mm Nugget Size

Sample 1



Sample 2



Test provided repeatable crush pattern. Effect of Baking is not significant at 1.4mm thickness

# FORTIFORM® 980 GI 1.4MM SAMPLES

## Effect of Weld Pitch vs Nugget Size

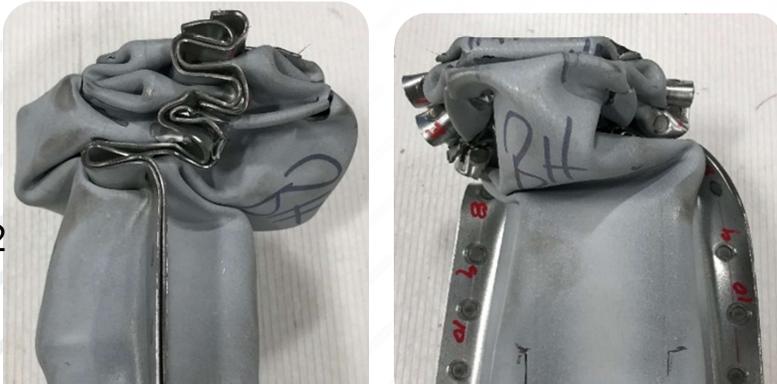
Baked Sample  
25mm Weld Pitch, 6.2mm Nugget Size

Baked Sample  
20mm Weld Pitch, 5.0mm Nugget Size

Sample 1



Sample 2



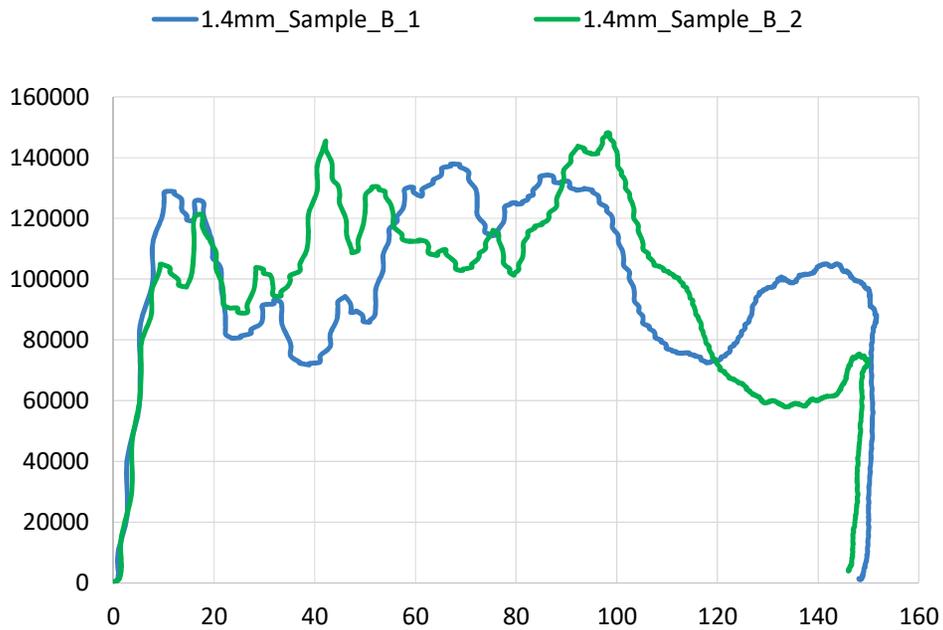
Effect of weld pitch is higher than the weld nugget size

# FORTIFORM® 980 GI 1.4MM SAMPLES

Effect of Weld Pitch vs Nugget Size

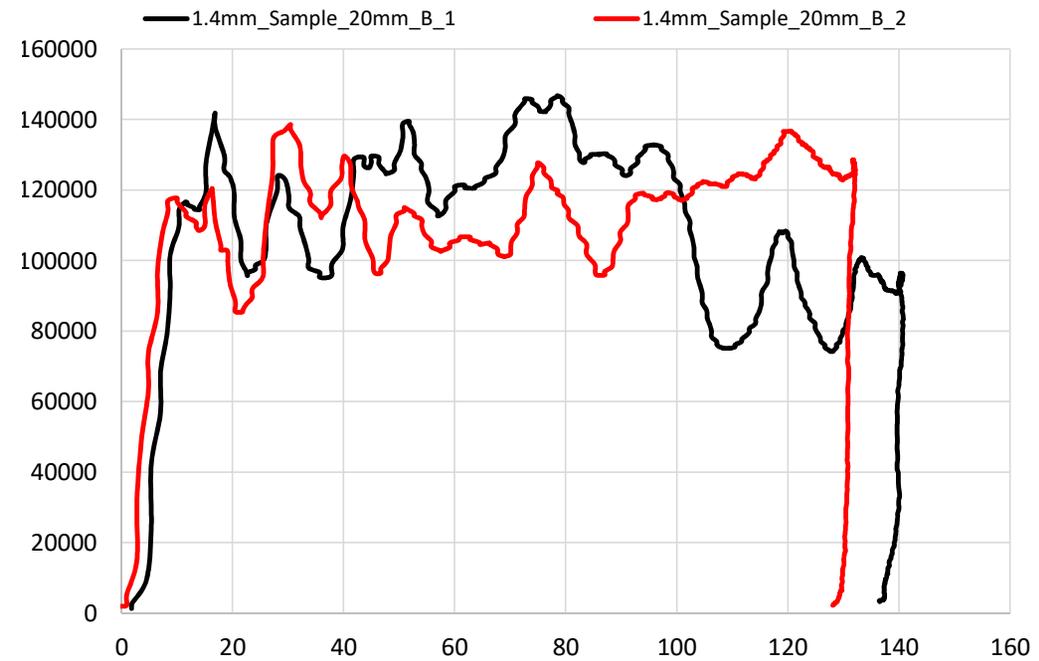


### Force(N) vs Displacement(mm)



25mm Weld Pitch samples

### Force (N) vs Displacement(mm)



20mm Weld Pitch samples

Samples with 20mm pitch, even at a lower nugget size, maintain consistent average force

# FORTIFORM® 980 GI 1.6MM SAMPLES

Un-Baked Sample  
25mm Weld Pitch, 6.7mm Nugget Size

Baked Sample  
25mm Weld Pitch, 6.7mm Nugget Size

Sample 1

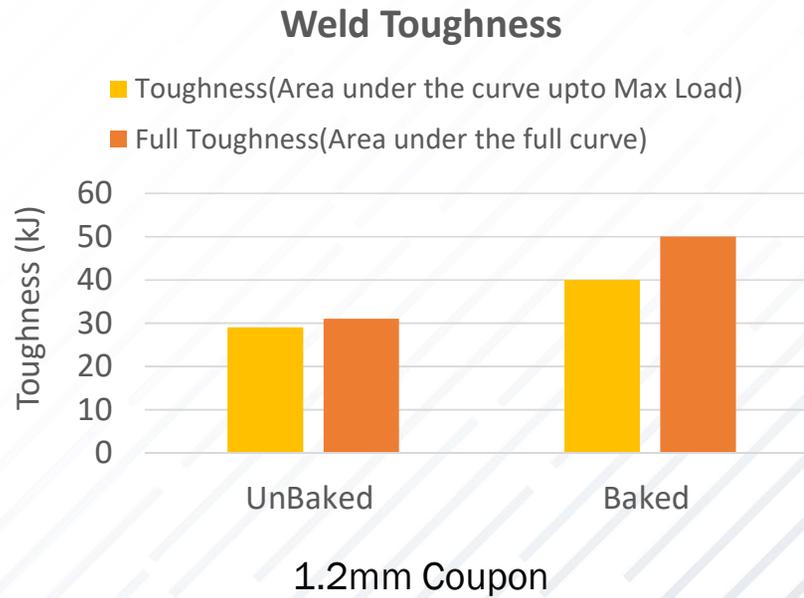
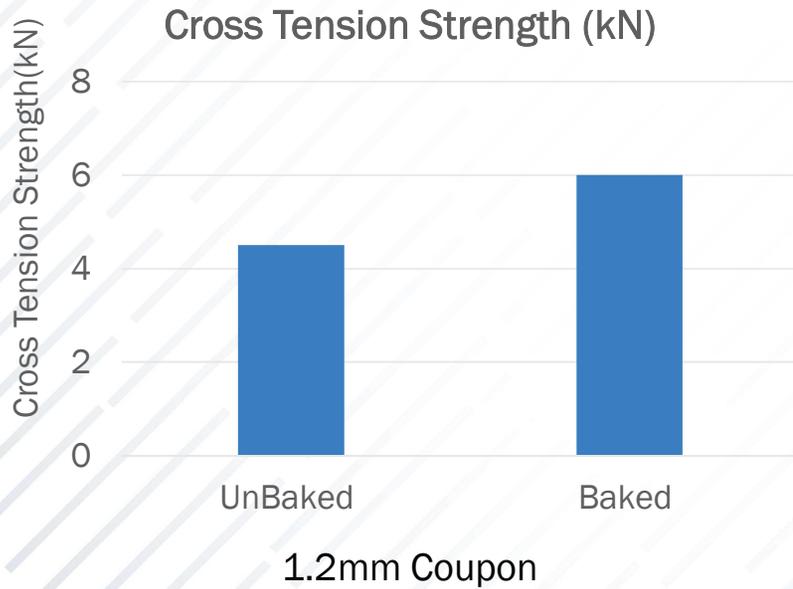
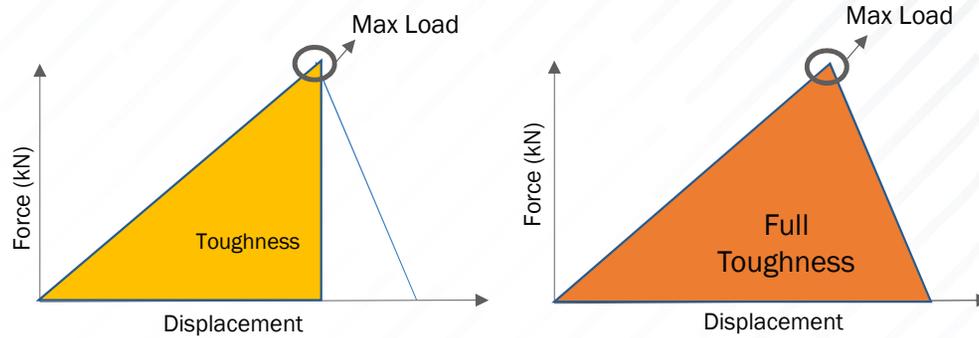
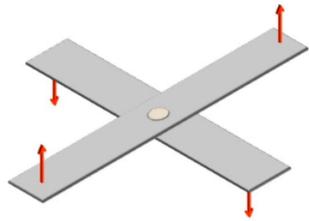


Sample 2



Repeatable crush pattern is observed. Effect of baking is not significant at 1.6mm thickness

# FORTIFORM® 980 GI WELD TOUGHNESS IMPROVEMENT – BAKING EFFECT

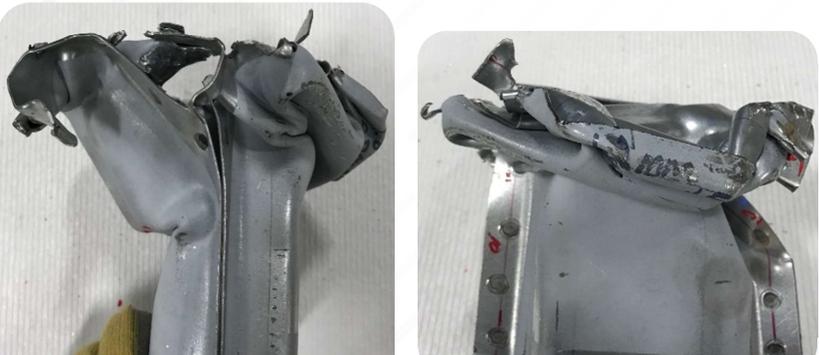


# FORTIFORM® 980 GI 1.2MM SAMPLES

Un-Baked Sample  
25mm Weld Pitch, 5.3mm Nugget Size



Sample 1



Sample 2

Baked Sample  
25mm Weld Pitch, 5.3mm Nugget Size



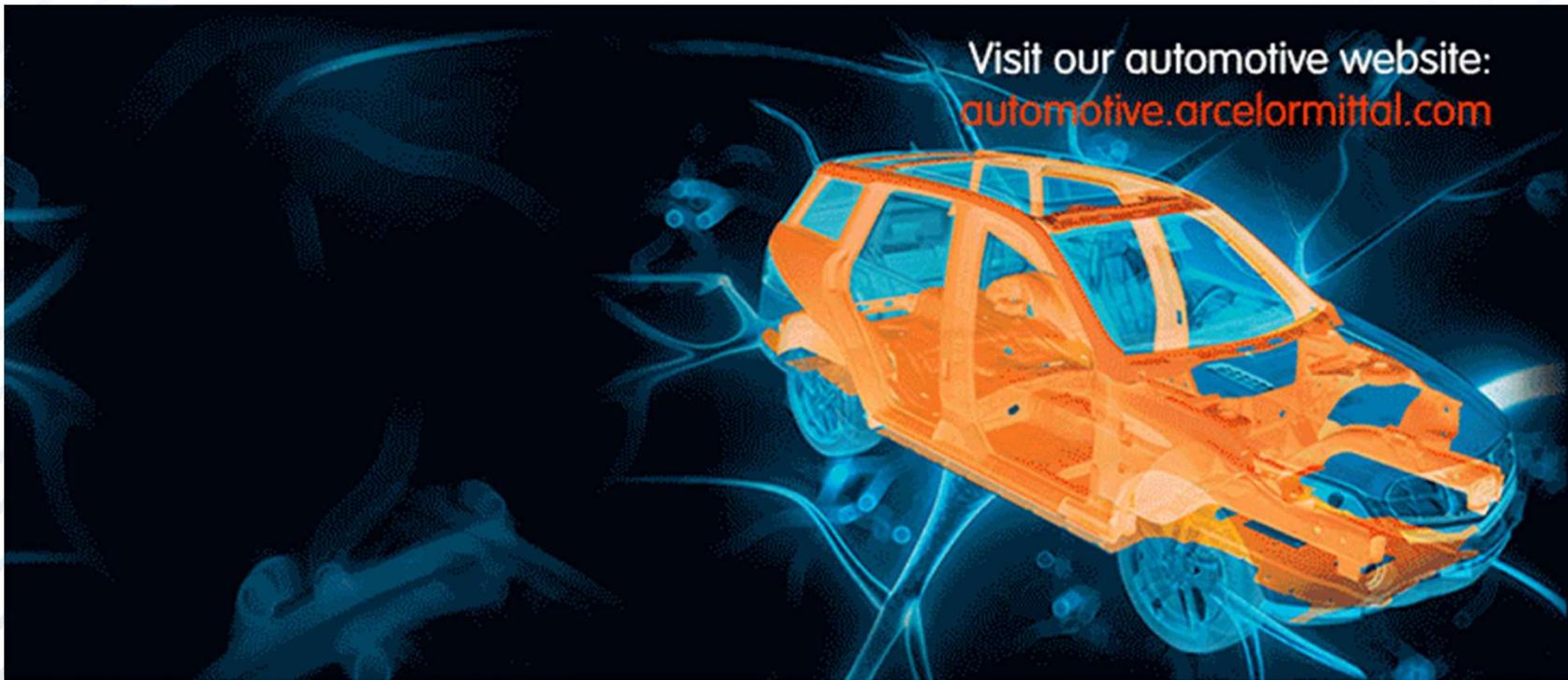
Repeatable crush pattern is observed. Effect of baking is significant at 1.2mm thickness

## SUMMARY

- Fortiform® 980 GI 3<sup>rd</sup> GEN product,
  - Combines excellent strength & formability and offers light weighting opportunities
  - Product can absorb energy during crash events and deform in a controlled manner similar to currently used steel grades
  - Exhibits superior weldability
  - Effect of baking on weld performance during crash is more pronounced at lower thickness
    - 3<sup>rd</sup> GEN samples should always be baked when testing samples
- Four different welding types of Resistance Spot-Welding (RSW), Laser Welding, MIG Brazing and Gas Metal Arc Welding (GMAW) have been examined with no signs of surface cracks in critical zones
- Important to note that Fortiform® 980 GI 3<sup>rd</sup> GEN is compatible with the current welding technology used in the industry

For More Information about ArcelorMittal Fortiform® grades:

<https://automotive.arcelormittal.com/fortiform>



Visit our automotive website:  
[automotive.arcelormittal.com](https://automotive.arcelormittal.com)

**Steel:** the strongest choice

# GREAT DESIGNS IN STEEL

Presentations will be available for download on SMDI's website on Wednesday, May 22