Aluminum Lithium Alloy 2195 Fusion Welding Improvements with New Filler Wire

AMPET 2000
Huntsville, AL

Carolyn Russell
NASA
Marshall Space Flight Center
Huntsville, AL.
256-544-2705
carolyn.russell@msfc.nasa.gov

Gerry Bjorkman
Lockheed Martin Space Systems Company
Michoud Operations
Huntsville, AL.
256-961-4438
gerry.bjorkman@msfc.nasa.gov
2195 Fusion Welding Improvements with New Filler Wire

Background

- Welding 2195 Aluminum Lithium for the Space Shuttle Super Lightweight External Tank

NASA Space Shuttle

Variable Polarity Plasma Arc Welding
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Background

1993
FILLER WIRE DEVELOPMENT
FOR
2195 ALUMINUM-LITHIUM
LMSS/MSFC/RMC
(14) AL-CU BASED FILLER WIRES

1995
PART II FILLER WIRE DEVELOPMENT FOR 2195 ALUMINUM-LITHIUM
LMSS/MSFC/RMC
(4) AL-CU BASED FILLER WIRES

1998
SDS 3750
ALUMINUM-LITHIUM WELD PROCESSES
AND
EQUIPMENT DEVELOPMENT
LMSS/MSFC
B218 FILLER WIRE QUICK LOOK

1999
SDS 3763
LMSS/MSFC
B218 REPAIR WELD EVALUATION

CTTP COOPERATIVE IRAD
LMA/MSFC/RMC
(5) AL-CU BASED FILLER WIRES

C458 AIR FORCE AL-LI ALLOY
WELD AND REPAIR EVALUATION
MSFC
CHEMISTRY #16 FILLER WIRE
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2195T8M4 VPPA Weld Ultimate Tensile Strength

![Bar Chart](chart.png)

- **ULTIMATE WELD TENSILE STRENGTH (ksi)**
- **0.200"t 4043**
- **0.200"t B218**
- **0.320"t 4043**
- **0.320"t B218**

Legend:
- **SHAVED**
- **AS-WELDED**
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2195T8M4 VPPA Weld Tensile Elongation

<table>
<thead>
<tr>
<th>Thickness (&quot;t&quot;)</th>
<th>Wire Type</th>
<th>Tensile Elongation (10&quot; Gage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.200&quot; 4043</td>
<td></td>
<td>4.0</td>
</tr>
<tr>
<td>0.200&quot; B218</td>
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<tr>
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<td>0.320&quot; B218</td>
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<td>12.0</td>
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</tbody>
</table>
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VPPA Weld Grain Structure Comparison

0.320t 2195 PLATE TO 2195 PLATE VPPAW

4043 WELD FILLER WIRE

B218 WELD FILLER WIRE

10X Original Magnification

10X Original Magnification
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B218 VPPA Weld Grain Structure

0.200t 2195 PLATE TO 2195 PLATE VPPAW

10X Original Magnification

10X Original Magnification
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B218 GTA Repair Weld Grain Structure

R1 GTA Repair 0.200t 2195 PLATE TO 2195 PLATE VPPAW

10X Original Magnification

10X Original Magnification
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2195 Repair Weld Residual Stresses

Diagram showing the relationship between VPPA Weld, Repair Weld, and Al-Li 2195 materials, indicating repair weld shrinkage.
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2195 Repair Weld Residual Stresses

Root Side Measurements
Panel Clamped Flat

Along a Line Parallel to the Weld

Transverse Residual Stress - Ksi

Distance From Repair Weld Midlength - Inches

- Unplanished
- Planished 70%
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2195 Repair Weld Residual Stresses

R5 GTA Repair 0.200t 2195 PLATE TO 2195 PLATE VPPAW

Photostress of Unplanished Repair Weld

Photostress of Planished Repair Weld
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Objective

• Assess B218 weld filler wire for Super Lightweight External Tank production, which could improve current production welding and repair productivity.

Approach

• Perform a repair weld quick look evaluation between 4043/B218 and B218/B218 weld filler wire combinations. Evaluate tensile properties for planished and unplanished conditions.

• Perform repair weld evaluation on structural simulation panel using 4043/B218 and B218/B218 weld filler wire combinations. Evaluate tensile and simulated service fracture properties for planished and unplanished conditions.
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VPPA/GTA Repair Weld Quick Look

- 14” X 24” Standard Repair Weld Panel

Manual GTA Repair Welding
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0.200”t 2195T8M4 Repair Weld Ultimate Tensile Strength -Coupon Level
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0.200"t 2195T8M4 Repair Weld Ultimate Tensile Elongation - Coupon Level

![Graph showing repair weld tensile elongation](image-url)
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0.200t 2195T8M4 VPPA/ GTA Repair Weld Metallography

- 4043/B218 0% Planished

**C008-RT02**
RT Tensile Test
36.2 ksi / 2.74% El. 1” gage

7X Original Magnification

**C009-CT01**
LH2 Tensile Test
62.5 ksi / 3.4% El. 1” gage

7X Original Magnification
2195 Fusion Welding Improvements with New Filler Wire

0.200t 2195T8M4 VPPA/ GTA Repair Weld Metallography

- B218/B218 0% Planished

C080-RT01
RT Tensile Test
45.2 ksi / 9.75% El. 1” gage

7X Original Magnification

C080-CT01
LH2 Tensile Test
68.1 ksi / 7.40% El. 1” gage

7X Original Magnification
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- VPPA/GTA Repair Weld Structural Simulation Panel Evaluation
  - 19" X 48" Repair Weld Wide Panel
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0.200t 2195T8M4 Structural Simulation Panel Weld Tensile Strength (-423°F)
2195 Fusion Welding Improvements with New Filler Wire

0.320t 2195T8M4 Structural Simulation Panel Weld Tensile Strength (-423°F)
2195 Fusion Welding Improvements with New Filler Wire

0.200t 2195T8M4 VPPA/GTA Repair Weld Simulated Service Fracture Toughness
2195 Fusion Welding Improvements with New Filler Wire

0.320t 2195T8M4 VPPA/GTA Repair Weld Simulated Service Fracture Toughness

![Graph](image)
Conclusions

- B218 weld filler wire displayed higher repair weld tensile strength and ductility compared to 4043.

- Unplanished and planished B218 repair welds exceeded the current SLWT 4043 repair weld tensile strength requirement.

- B218 repair weld simulated service results surpassed 4043 repair welds and were comparable to 2195 initial welds made with 4043.

- B218 displays a high potential for improving SLWT production through increased repair weldability and the reduction/elimination of planishing for the removal of repair weld residual stresses.