Aluminum Lithium Alloy 2195 Fusion Welding Improvements with New Filler Wire

AMPET 2000
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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
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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
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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 0.200" 2195 PLATE TO 2195 PLATE VPPAW

10X Original Magnification
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2195 Repair Weld Residual Stresses

Diagram:
- Al-Li 2195
- Repair Weld Shrinkage
- VPPA Weld
- Repair Weld

Al-Li 2195
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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

Photon 15KSI FILTER

Photostress of Planished Repair Weld

C065 20KSI FILTER
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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 unplanned 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 unplanned 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

VPPA INITIAL WELD
MANUAL GTA R5 FUSION LINE REPAIR

- LHe
- RT

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<th>REPAIR ULTIMATE TENSILE STRENGTH (ksi)</th>
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<tr>
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0.200"t 2195T8M4 Repair Weld Ultimate Tensile Elongation - Coupon Level

[Graph showing repair weld tensile elongation (% 1.0" gage) with data points for different conditions and temperatures.]
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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

C009-CT01
LH2 Tensile Test
62.5 ksi / 3.4% El. 1” gage
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)
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0.320t 2195T8M4 Structural Simulation Panel Weld Tensile Strength (-423°F)

ULTIMATE TENSILE STRENGTH (ksi)

- 49.4 ksi LH2 VPPA ALLOWABLEREQ.
- 38 ksi RT VPPA ALLOWABLEREQ.
- 38 ksi LH2 REPAIR ALLOWABLEREQ.
- 30 ksi RT REPAIR ALLOWABLEREQ.

VPPA INITIAL WELDS

VPPA INITIAL WELD
MANUAL GTA R5 FUSION LINE REPAIR

4043 VPPA
B218 VPPA
4043/B218 0% PLAN.
B218/B218 0% PLAN.
4043/B218 70% PLAN.
B218/B218 70% PLAN.
4043/4043 PLATE/EXT.
70% PLAN.
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0.200t 2195T8M4 VPPA/GTA Repair Weld Simulated Service Fracture Toughness
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0.320t 2195T8M4 VPPA/GTA Repair Weld Simulated Service Fracture Toughness

![Graph showing fracture toughness data with various symbols and labels for different crack lengths and gross fracture stress.]

- B218 repair
- t=0.320" at -423 F test temperature
- Various symbols represent different crack lengths and test conditions.
- Initial weld RT lower bound
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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.