GREAT DESIGNS IN STEEL

GMAW CONSUMABLE INNOVATIONS TO IMPROVE WELDING QUALITY ON ZINC-COATED STEELS

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WELDING QUALITY CHALLENGES WITH ZINC-COATED STEEL

GDIS

Challenge #1: Paint Adhesion

Incompatible with acid descaling [1]

↓

Silicon-based slag obstructs post-weld coating adhesion

↓

Corrosion vulnerability of the weld surface

Challenge #2: Weld Quality

Zinc-based porosity

↓

Compromises fusion zone mechanical properties

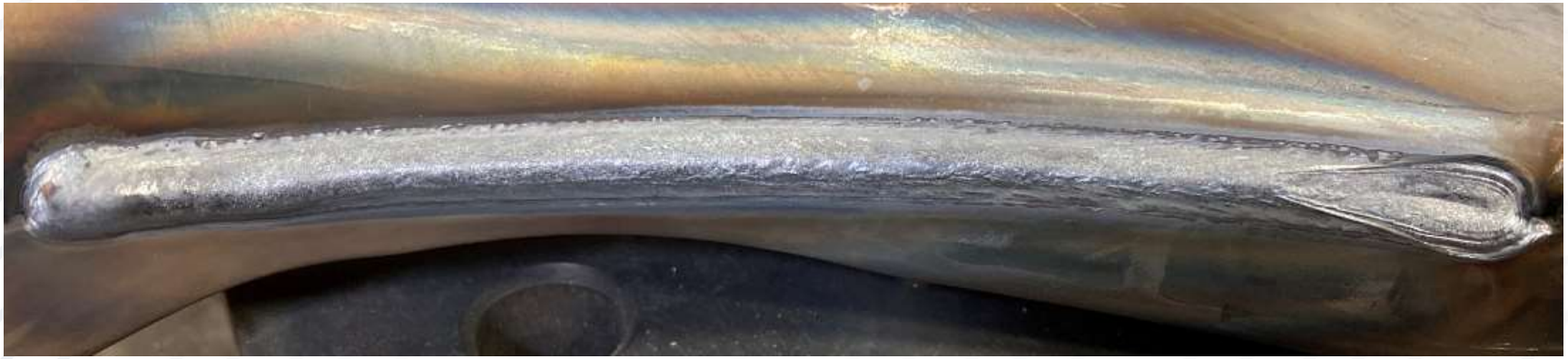
↓

Pre-mature failure of welded components [2]

GMAW OF ZINC-COATED STEEL

SuperArc® XLS

- Solid, copper coated GMAW wire
- Engineered to reduce silicon-based slag formation



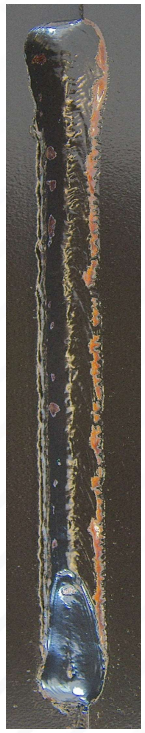
Alternative solution for zinc-coated steel [3]

- Improved post-weld coating adhesion and corrosion resistance

SURFACE SILICATE V. SURFACE OXIDE

ER70S-3

As-welded



Electro-coated

120 CCT

SuperArc® XLS

As-welded

Electro-coated

120 CCT

Non-conductive slag impairs the painting process

Uncoated materials: Acid descale for surface cleaning

Coated materials: Incompatible with acid descale

4.2 mm uncoated HSLA 550, no acid descale

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REALITIES OF WELDING ZINC-COATED STEEL

- Zinc contamination:
  - –Weld metal solidification traps zinc vapor
    - Porosity → weld integrity concerns

- Zinc-coated steel welding:
  - –Slower travel speeds
  - –Spatter → 5x greater than uncoated steel
  - –Fume generation and exposure → 3.5x higher particulate

POROSITY AS A DEFECT

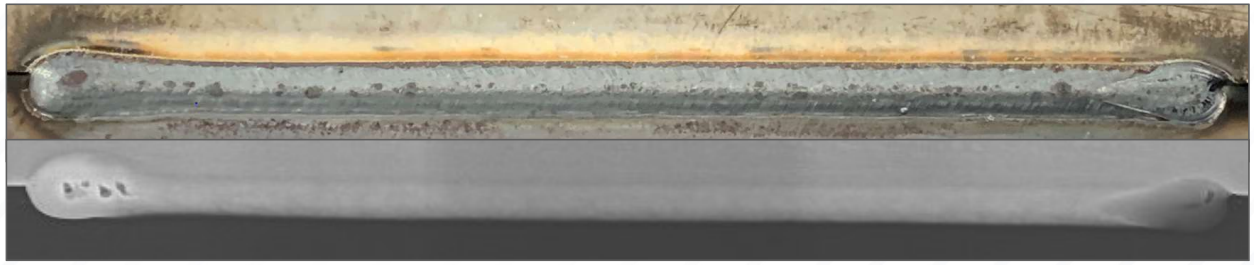
Example industry specification:

- 6mm of porosity allowed per 25mm of linear weld
- 10% by area for a 3mm fillet

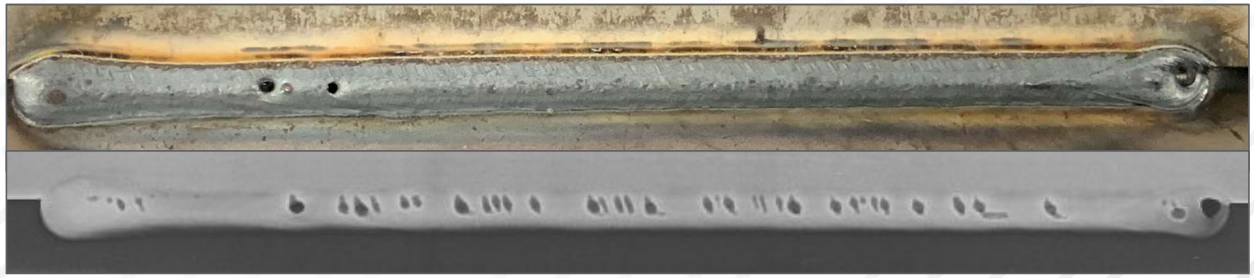
Visible/external: > 5% by area

Ideal condition: < 3% by area

1% or less



5% or more



GMAW OF ZINC-COATED STEEL

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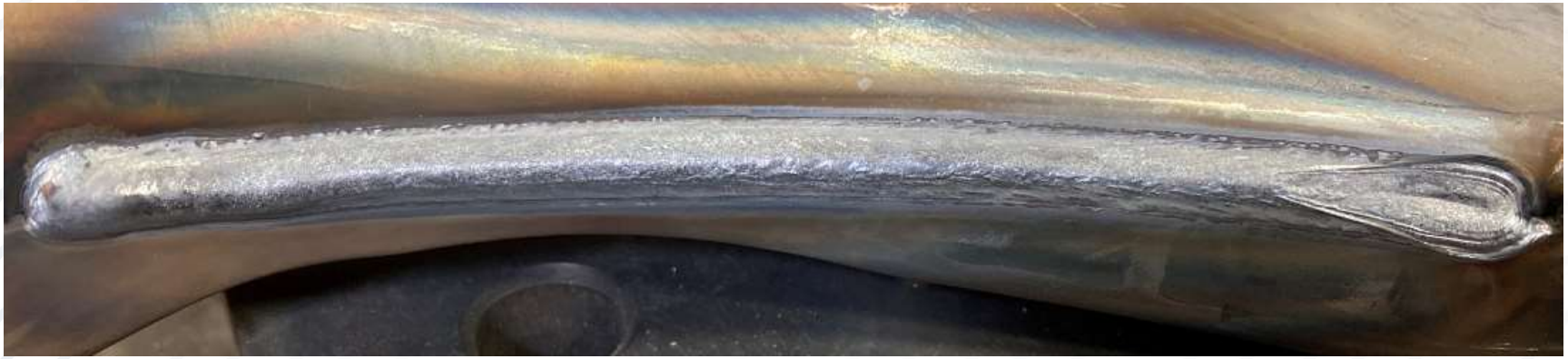
- Engineered to reduce silicon-based oxide formation

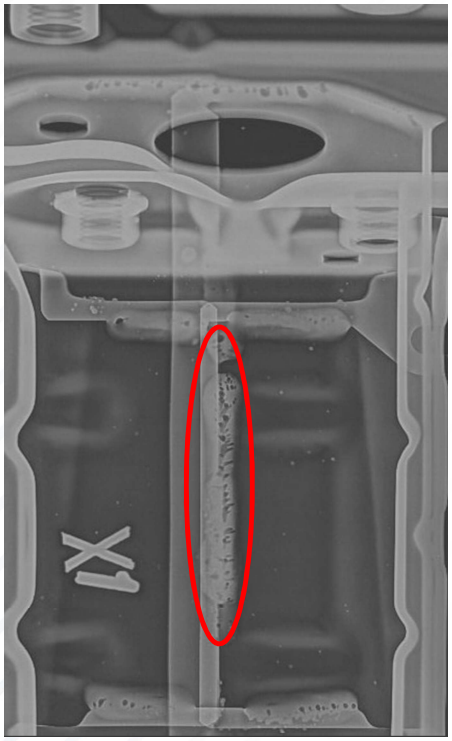


Alternative solution for zinc-coated steel [3]

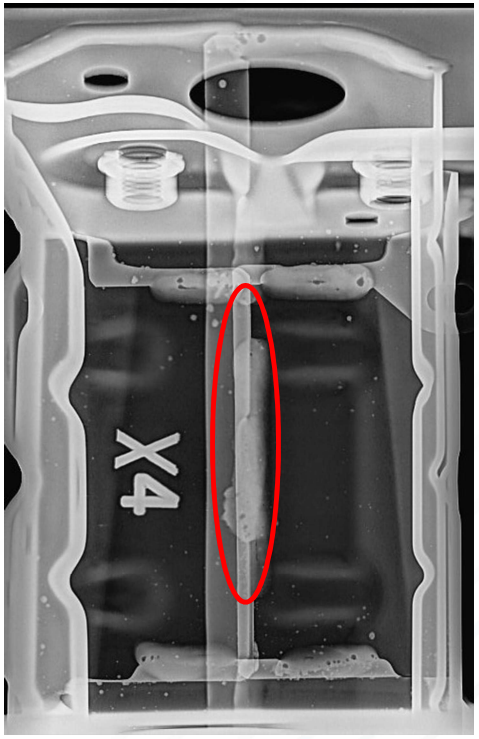
- Improved post-weld coating adhesion and corrosion resistance
- Reduced internal porosity

SUPERARC® XLS X-RAY EXAMPLES

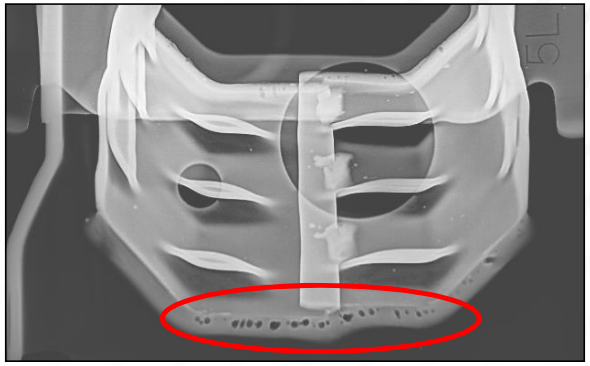
ER70S-3



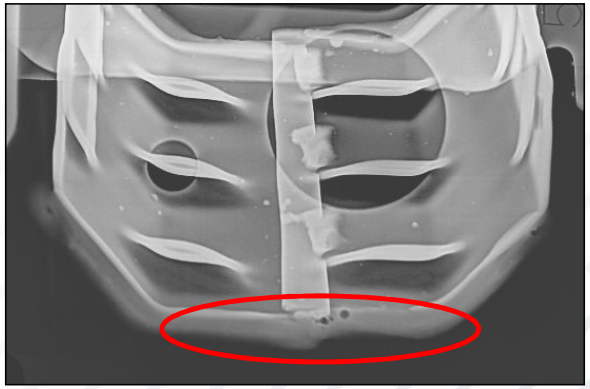
SuperArc® XLS



ER70S-3



SuperArc® XLS



Question: How does zinc interact with the weld pool differently between ER70S-3 and SuperArc® XLS?

EXPERIMENT

Objective: to compare the interaction of zinc vapor with the weld pool for two electrodes:

- ER70S-3 and SuperArc® XLS

Test: observe zinc vapor behavior via two in situ imaging methods:

1. High-speed X-ray video to show inside the weld pool
2. High-speed video of weld pool surface

Power Wave® R450

STT® Module

Joint Type	lap, zero gap
Shielding Gas	90% Argon / 10% CO_2
Welding Process	(1) Rapid X®, (2) Rapid X® LS
Travel Speed	40 in/min (1 m/min)
Contact Tip to Work Distance	3/4” (19 mm)
Electrode Size	0.045”
Electrode Type	(1) ER70S-3, (2) SuperArc® XLS

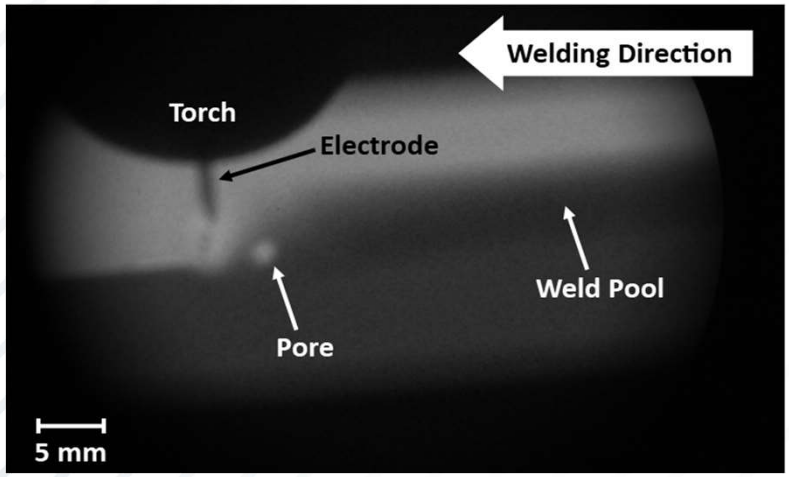
TEST 1: HIGH-SPEED X-RAY VIDEO

Test Plan

- Weld 5 joints with each electrode
- Capture X-ray video at 1000 fps

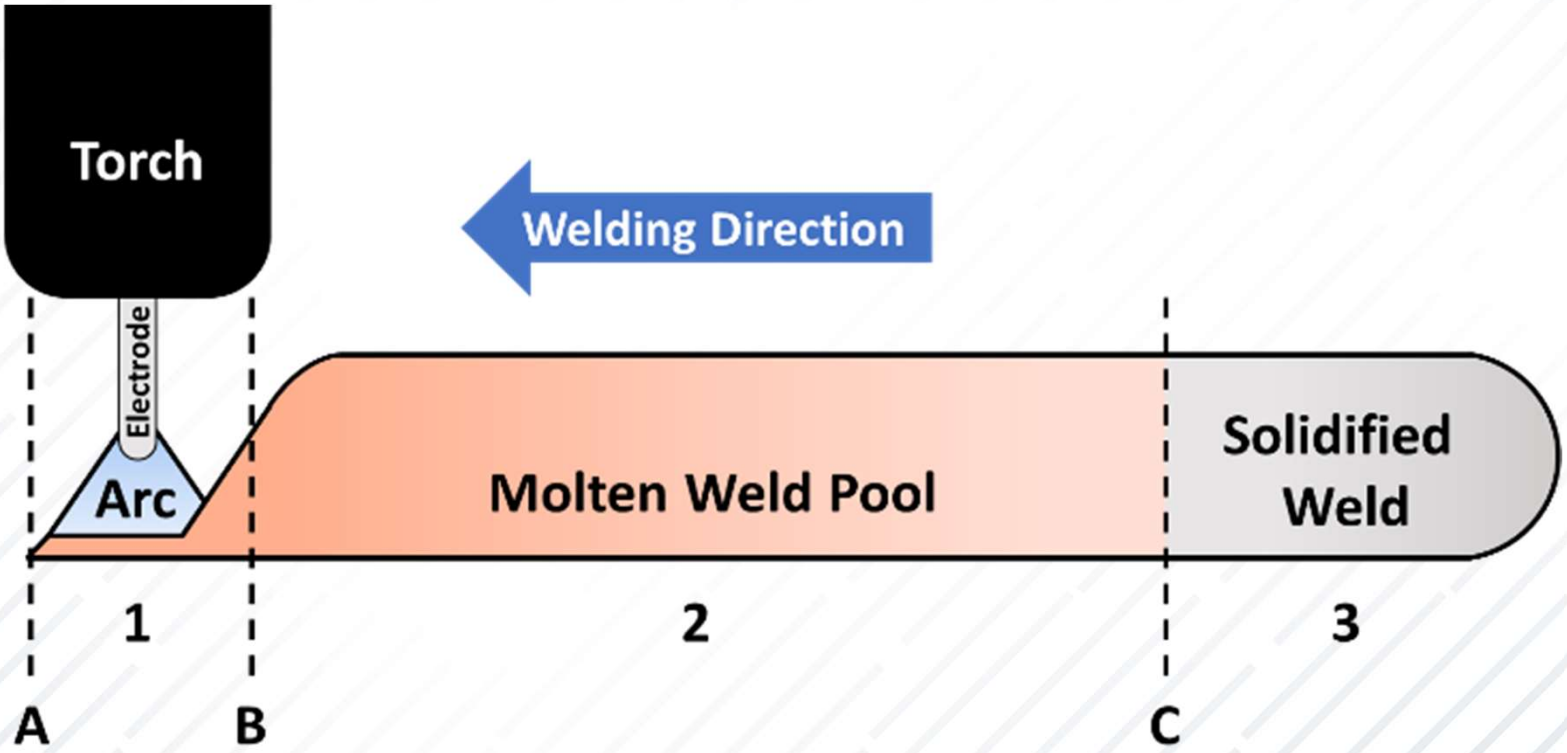
Response

- X-ray video analysis
  - Characterize behavior of zinc vapor inside the weld pool



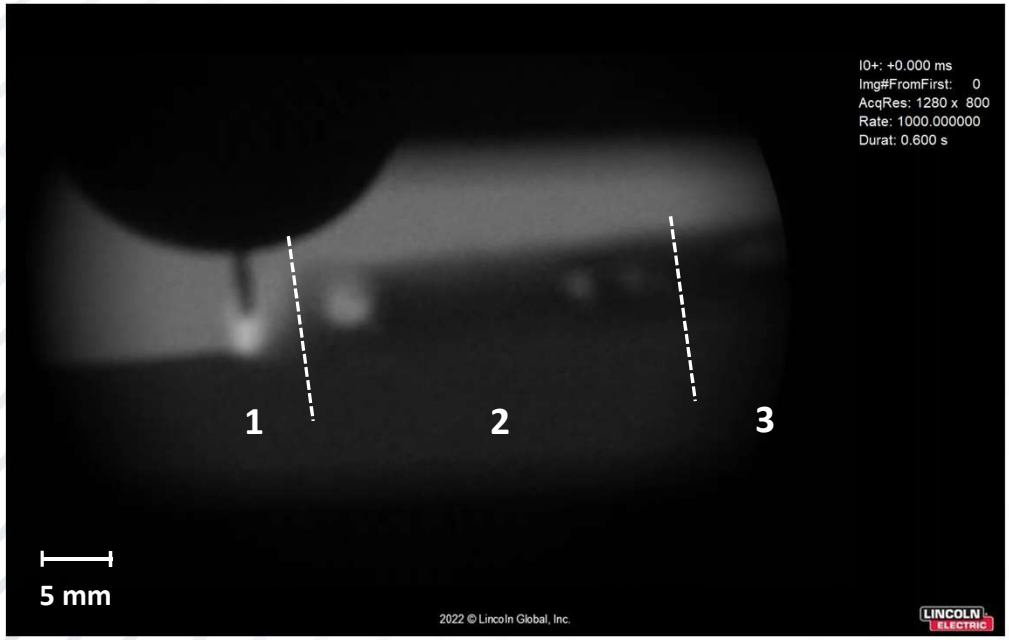
Base Material Thickness	2.0 mm
Base Material Type	HSLA 550
Coating Type	Hot Dipped Galvanized (GI)
Coating Weight	50G/50G
Welding Position	horizontal

TEST 1: 3 REGIONS OF ZINC VAPOR BEHAVIOR

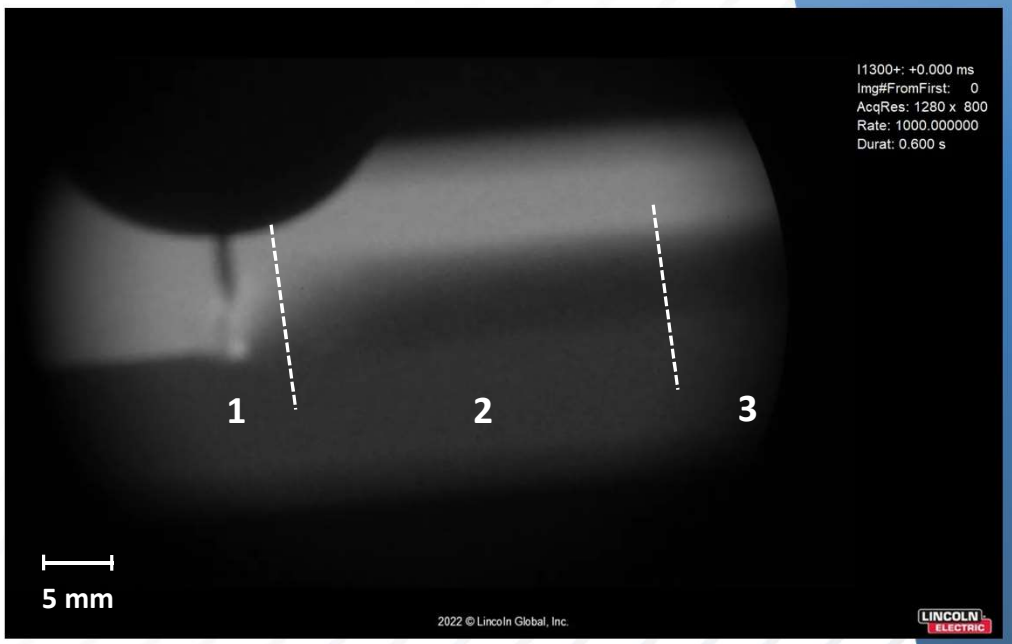


TEST 1: HIGH-SPEED X-RAY VIDEO CLIPS

ER70S-3



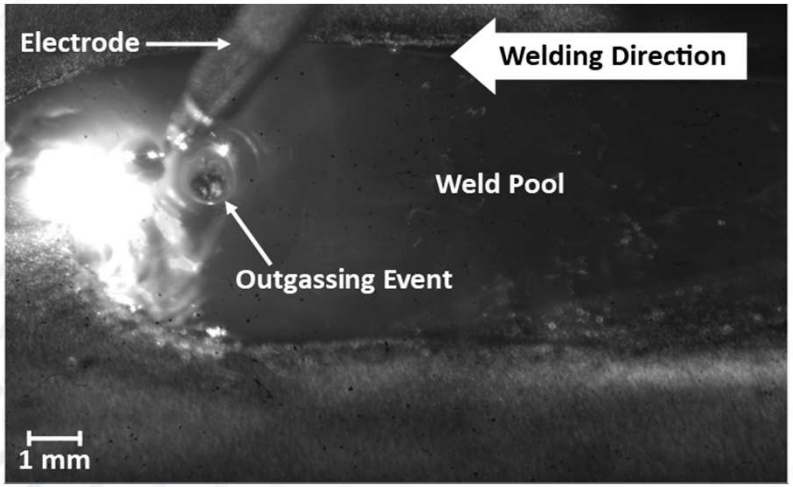
SuperArc® XLS



TEST 2: HIGH-SPEED VIDEO OF OUTGASSING

Test Plan

- Weld 5 joints with each electrode
- Capture video at 2500 fps

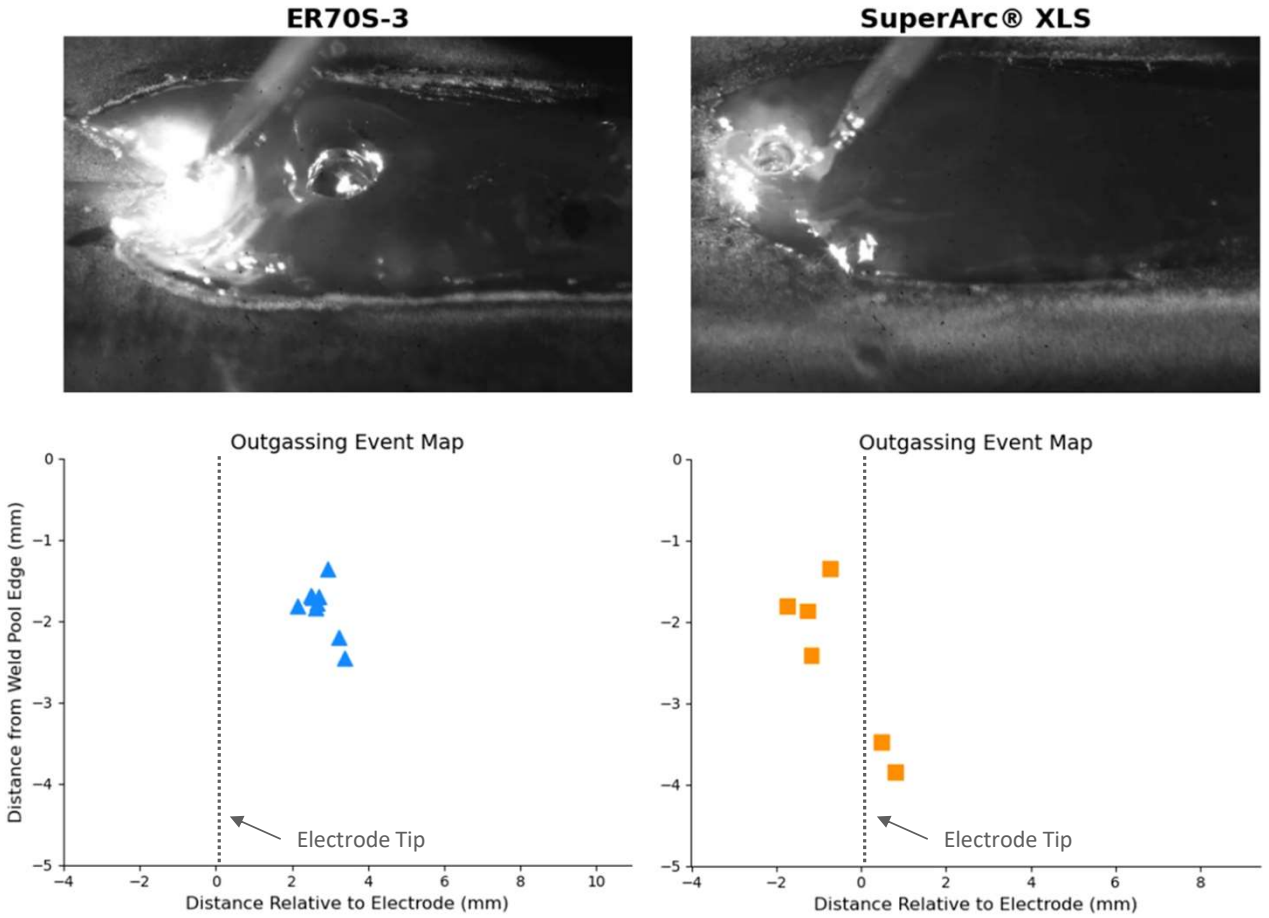


Responses

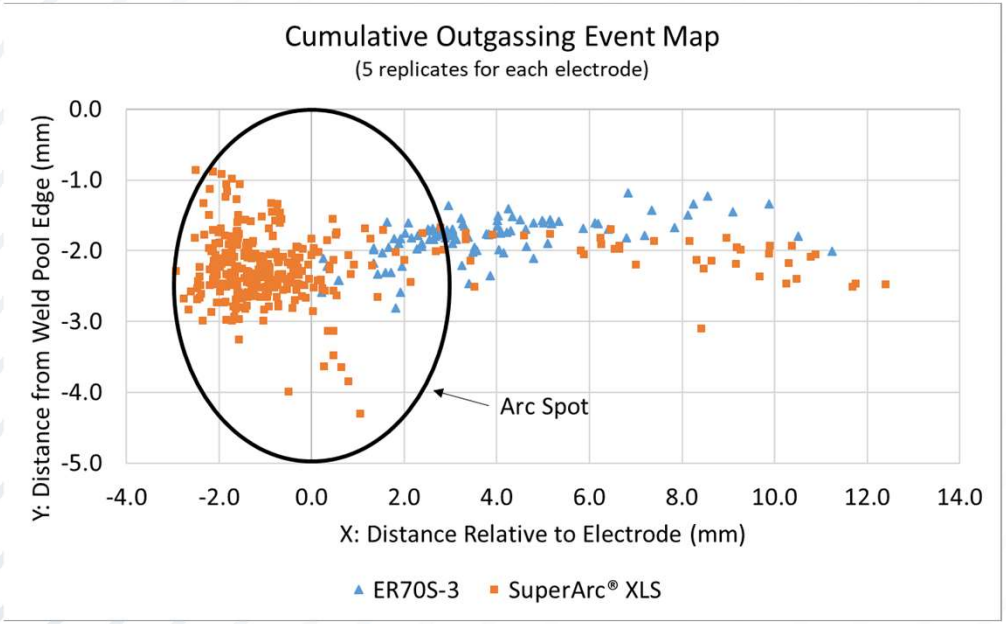
- High-speed video analysis
  - Characterize zinc vapor outgassing in the near-arc region
- Post-weld X-ray, porosity by % area

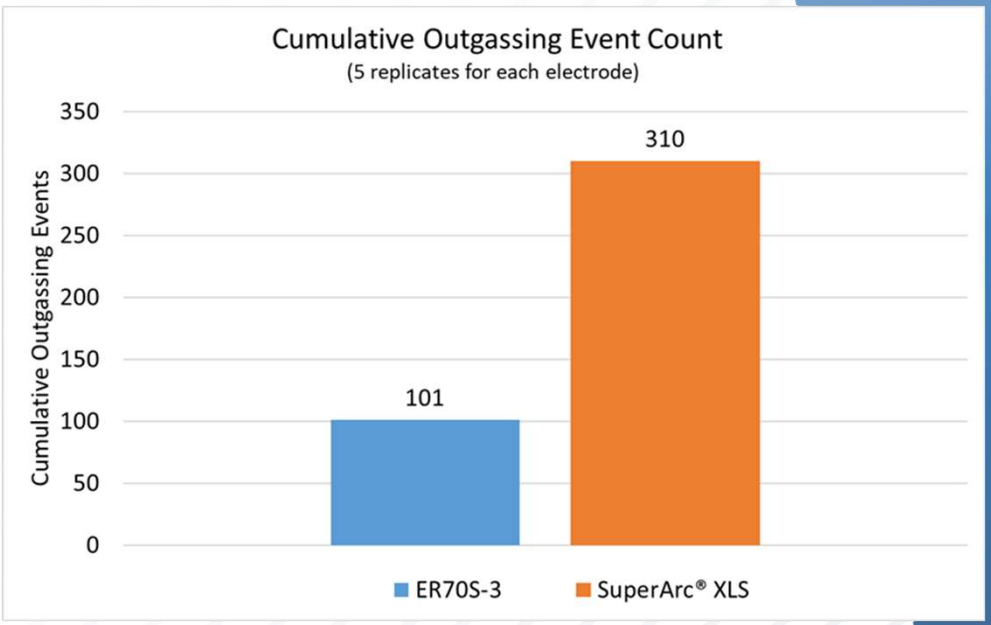
Base Material Thickness	2.0 mm
Base Material Type	HSLA 550
Coating Type	Hot Dipped Galvanized (GI)
Coating Weight	70G/70G
Welding Position	flat

TEST 2: OUTGASSING VIDEO CLIPS



TEST 2: OUTGASSING EVENT SUMMARY





SuperArc® XLS showed 38% less porosity in post-weld X-rays.

CONCLUSIONS

Improved welding on zinc-coated steels with SuperArc® XLS

- Slag improvements impact paint adhesion
  - Increase corrosion life of welded regions

SuperArc® XLS exhibited a fundamentally distinct interaction with zinc vapor in the weld pool

- 3x more outgassing events
- Unique location of outgassing events
  - Close to the arc
  - Region of greatest benefit
- Lower porosity improves productivity and quality
  - Increases travel speeds
  - Improves internal weld quality

QUESTIONS

References

[1] Anderson, B. “Descaling: Challenges of Processing Zinc and Aluminum Substrates.” *The Electrocoat Conference, Apr. 2018*.

[2] Mei, L., Chen, G., Jin, X., Zhang, Y., Wu, Q. “Research on laser welding of high-strength galvanized automobile steel sheets.” *Optics and Lasers in Engineering, Nov. 2009, Vol. 47, Issue 11, p1117-1124*.

[3] Dittrich, T., Fleming, K., Hurley, T. “Advancements in GMAW Technology for Zinc-Coated Steels.” *Sheet Metal Welding Conference XIX, Nov. 2021.*