GREAT DESIGNS IN STEEL

ADVANCEMENTS IN GMAW TECHNOLOGY FOR IMPROVED SILICATE PERFORMANCE

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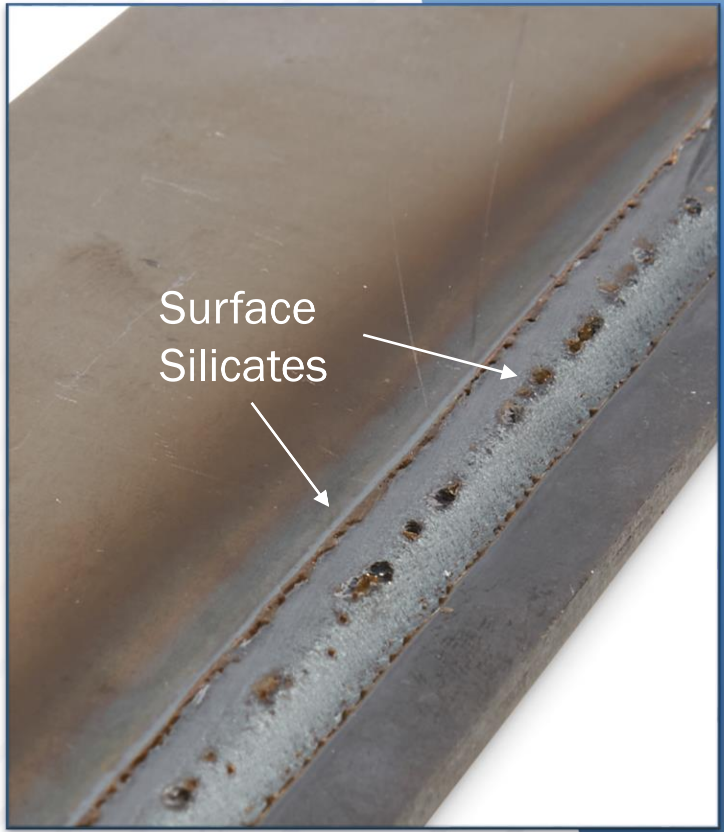
BACKGROUND

- Automotive OEM movement towards low silicon weld deposits for improved corrosion resistance
- Surface Silicates ("silicate islands")
  - Non-conductive oxides
  - Form as a reaction between deoxidizers in the weld/base metal and CO_2 in shielding gas
  - Difficult to E-coat -> Decreased corrosion resistance
- Problem Statement: Create a low silicon welding consumable that minimizes surface silicates to improve paint adhesion and increase corrosion resistance after E-coating.



PRODUCT DEVELOPMENT CONSIDERATIONS

C
SPH440

C
A36

Wire	Mn	Si	Additional Alloying Elements
Prototype A	High	High	
Prototype B	High	High	x
Prototype C	Low	Low	
Prototype D	High	Medium	x
Prototype E	Medium	Medium	x
Prototype F	Medium	Medium	x
Prototype G	Low	Low	
Prototype H	Medium	Low	x

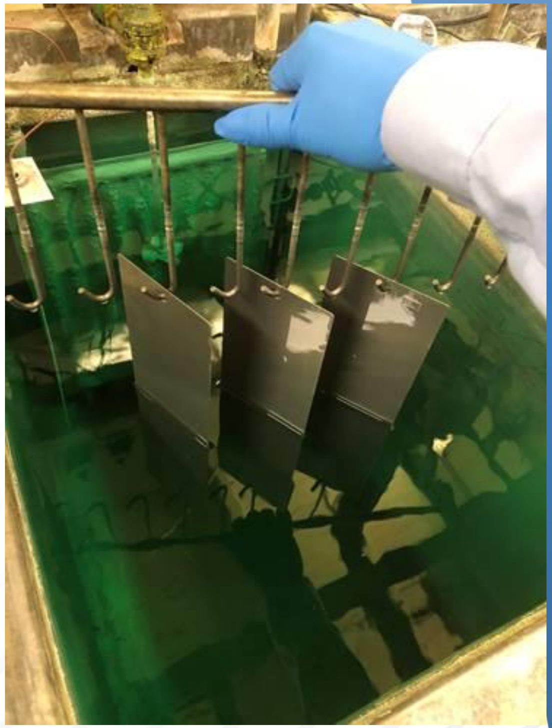
WELD SAMPLE METHODOLOGY

Fully automated robotic welding to mimic production application

Wires Baseplate	ER70S-6 and SuperArc® XLS SPH440	
Joint	Lap	
Gas	80% Ar / 20% CO2	
Gas	45	CFH
WFS	350	ipm
TS	39.4	ipm
CTWD	5/8	in
Work angle	45	degrees
Travel angle	0	degrees
Mode	Rapid X	
Trim	1.00	(roughly 26.5 V)

PRETREATMENT METHODS

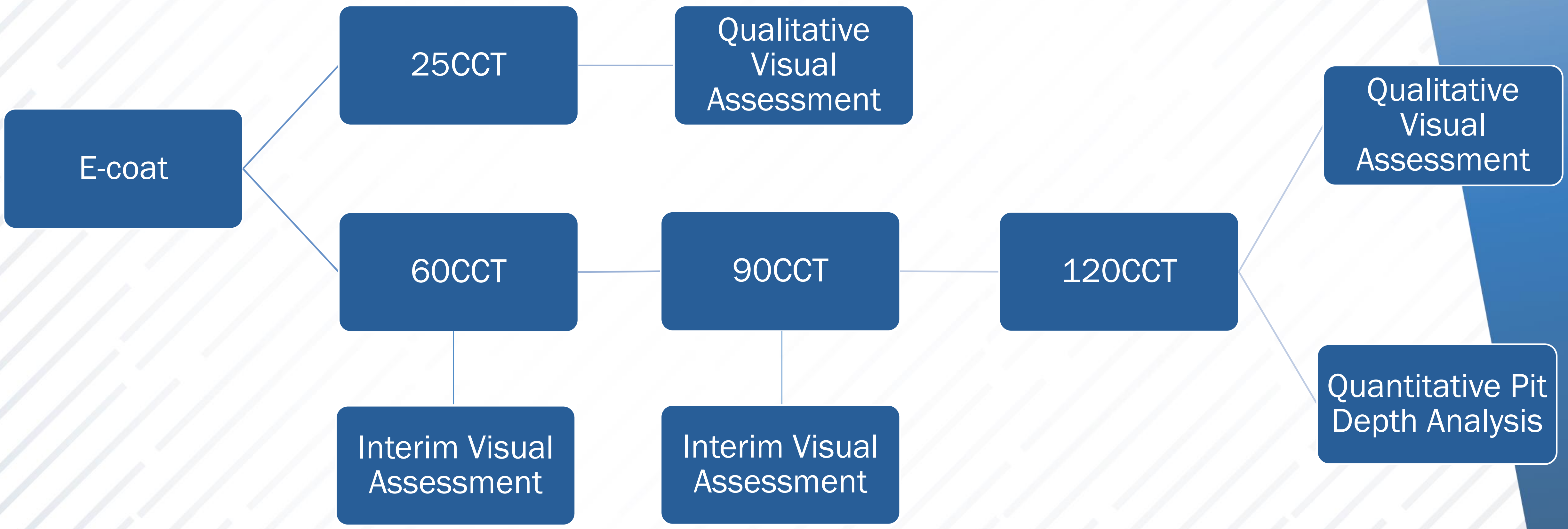
Trial Name	Alkaline Cleaning	Alkaline Conc. Temp, Time	Acid Cleaning	Acid Conc.	Acid Temp.	Acid Time	Conditioner
Control	Alkaline	5% 140ºF 3 min	None	None	None	None	Titanium-based OR Zinc-based
Near Neutral			Neutral Acid	20%	140ºF	3 min	
Acid Descale			Mineral Acid	10%	140ºF	3 min	



COATINGS

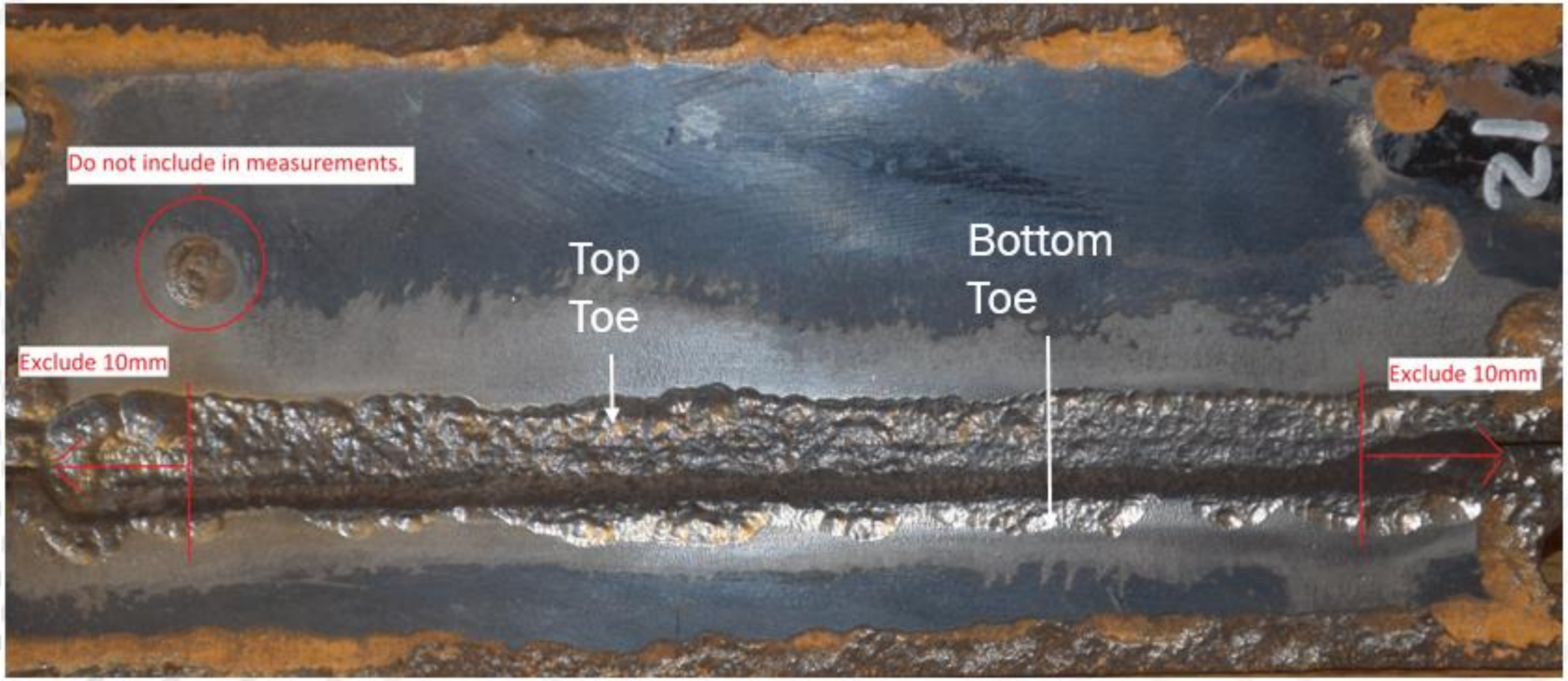
All panels were electro-coated as follows:	
E-coat	Cathodic Epoxy
Temperature	90 ° F
Voltage	260 Volts
Amperage	3.5 max
Ramp Time	30 seconds
Total Time	90 seconds
Rinse	Virgin DI water, ambient, 30 seconds
Cure	20 minutes at 350 ° F metal temperature
Film Thickness	0.7-0.8 mils

CYCLICAL CORROSION TESTING



PITTING DEPTH TESTING: METHODOLOGY

- Remove corrosion from weld surface
- Level area of interest in bench vise: top toe versus bottom toe
- Zero the gauge on non-corroded material
- Take 5 measurements along corroded material



				
CR3	CR4	CR5	CR6	CR6
CCT 25 Cycles	CCT 60 Cycles	CCT 90 Cycles	CCT 120 Cycles	CCT 120 Cycles Rust Removed

ER70S-6 CONTROL TITANIUM-BASED

Average Loss: 0.021”

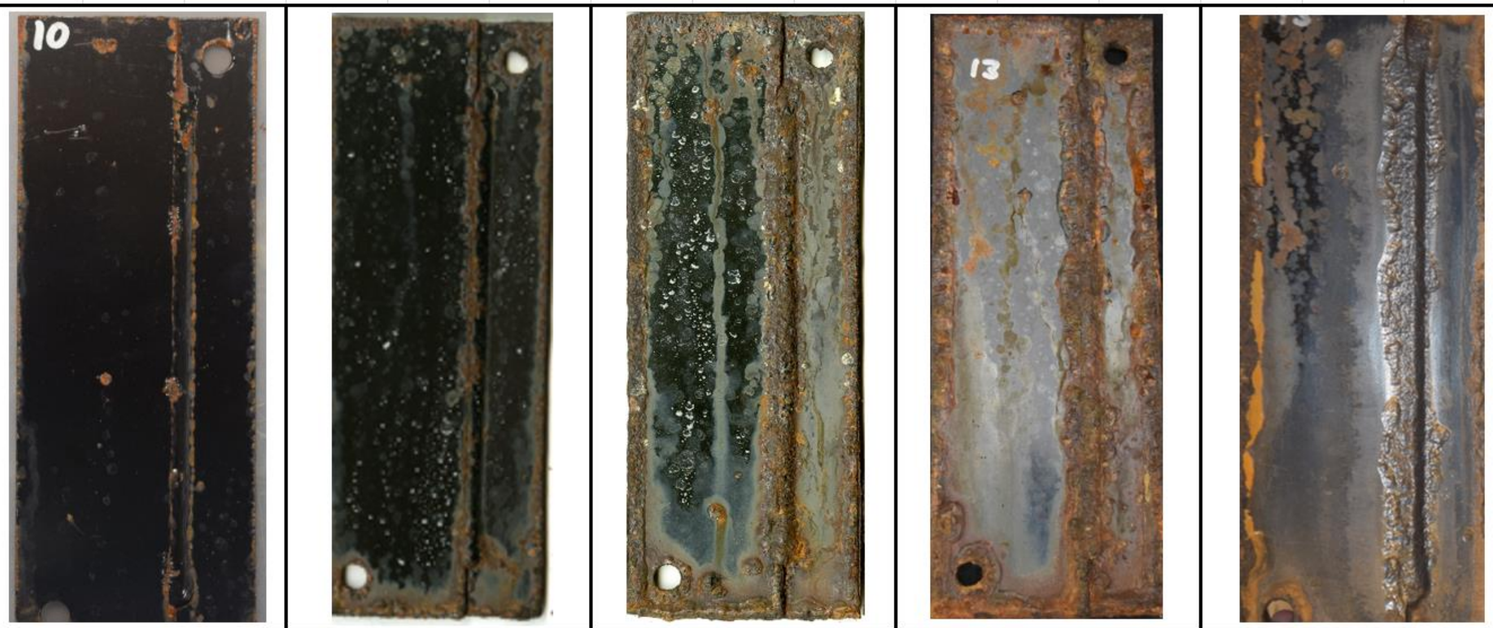
Max Loss: 0.040”

				
CR24	CR25	CR26	CR27	CR27
CCT 25 Cycles	CCT 60 Cycles	CCT 90 Cycles	CCT 120 Cycles	CCT 120 Cycles Rust Removed

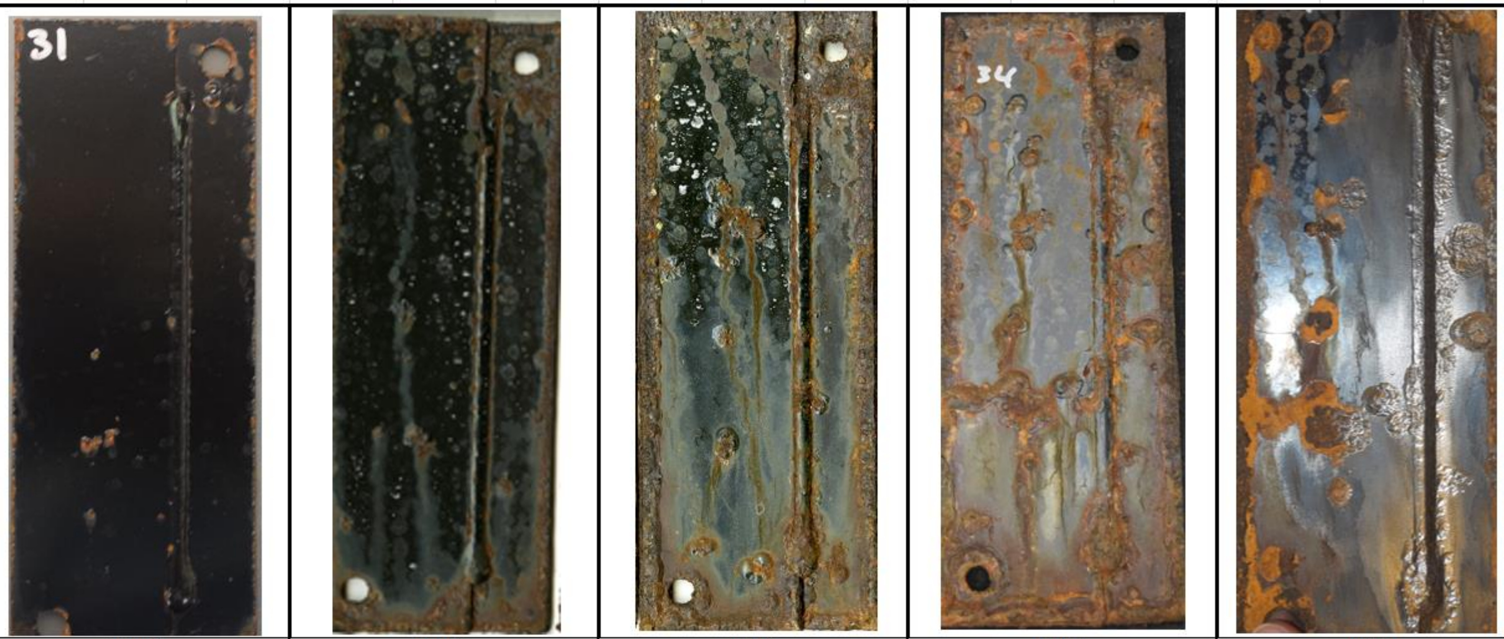
SUPERARC® XLS CONTROL TITANIUM-BASED

Average Loss: 0.015”

Max Loss: 0.038”



NR10	NR11	NR12	NR13	NR13
CCT 25 Cycles	CCT 60 Cycles	CCT 90 Cycles	CCT 120 Cycles	CCT 120 Cycles Rust Removed



NR31	NR32	NR33	NR34	NR34
CCT 25 Cycles	CCT 60 Cycles	CCT 90 Cycles	CCT 120 Cycles	CCT 120 Cycles Rust Removed

ER70S-6
NEUTRAL ACID
TITANIUM-BASED

Average Loss: 0.020”

Max Loss: 0.185”

SUPERARC® XLS
NEUTRAL ACID
TITANIUM-BASED

Average Loss: 0.009”

Max Loss: 0.024”

AR17	AR18	AR19	AR20	AR20
CCT 25 Cycles	CCT 60 Cycles	CCT 90 Cycles	CCT 120 Cycles	CCT 120 Cycles Rust Removed

AR38	AR39	AR40	AR41	AR41
CCT 25 Cycles	CCT 60 Cycles	CCT 90 Cycles	CCT 120 Cycles	CCT 120 Cycles Rust Removed

GDIS

ER70S-6 MINERAL ACID TITANIUM-BASED

Average Loss: 0.002”

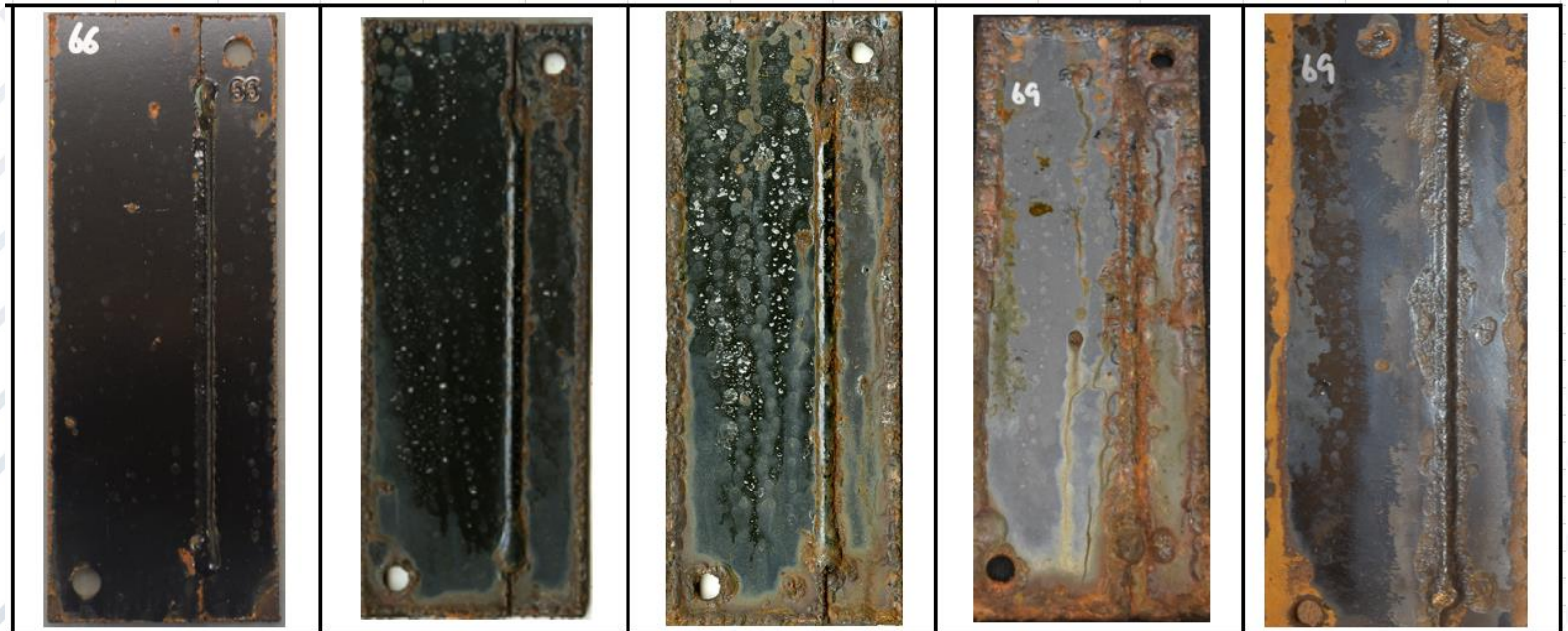
Max Loss: 0.008”

SUPERARC® XLS MINERAL ACID TITANIUM-BASED

Average Loss: 0.013”

Max Loss: 0.039”

CV45	CV46	CV47	CV48	CV48
CCT 25 Cycles	CCT 60 Cycles	CCT 90 Cycles	CCT 120 Cycles	CCT 120 Cycles Rust Removed



CV66	CV67	CV68	CV69	CV69
CCT 25 Cycles	CCT 60 Cycles	CCT 90 Cycles	CCT 120 Cycles	CCT 120 Cycles Rust Removed

GDIS

ER70S-6 CONTROL ZINC-BASED

Average Loss: 0.021”

Max Loss: 0.060”

SUPERARC® XLS CONTROL ZINC-BASED

Average Loss: 0.013”

Max Loss: 0.025”

NV52	NV53	NV54	NV55	NV55
CCT 25 Cycles	CCT 60 Cycles	CCT 90 Cycles	CCT 120 Cycles	CCT 120 Cycles Rust Removed

NV73	NV74	NV75	NV76	NV76
CCT 25 Cycles	CCT 60 Cycles	CCT 90 Cycles	CCT 120 Cycles	CCT 120 Cycles Rust Removed

ER70S-6 NEUTRAL ACID ZINC-BASED

Average Loss: 0.026”

Max Loss: 0.065”

SUPERARC® XLS NEUTRAL ACID ZINC-BASED

Average Loss: 0.015”

Max Loss: 0.045”

GDIS

ER70S-6 MINERAL ACID ZINC-BASED

Average Loss: 0.003”

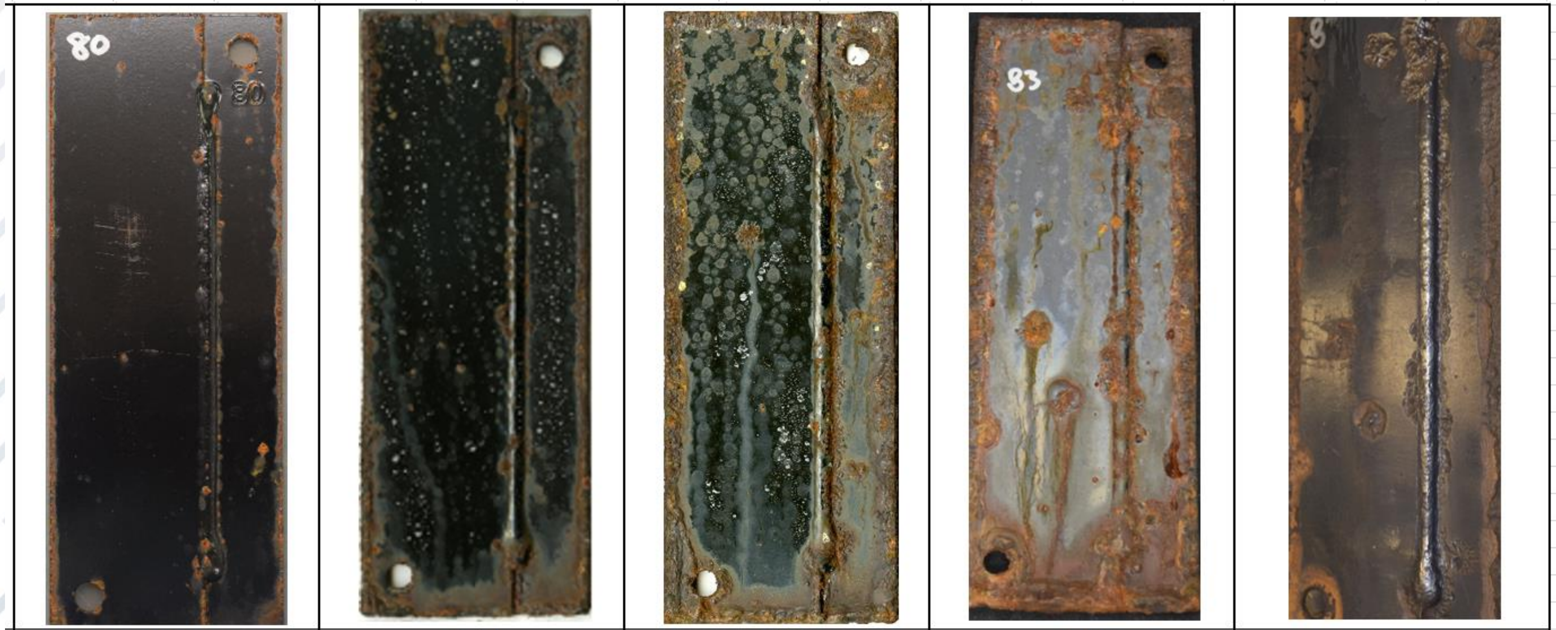
Max Loss: 0.019”

AV59	AV60	AV61	AV62	AV62
CCT 25 Cycles	CCT 60 Cycles	CCT 90 Cycles	CCT 120 Cycles	CCT 120 Cycles Rust Removed

SUPERARC® XLS MINERAL ACID ZINC-BASED

Average Loss: 0.011”

Max Loss: 0.055”



AV80	AV81	AV82	AV83	AV83
CCT 25 Cycles	CCT 60 Cycles	CCT 90 Cycles	CCT 120 Cycles	CCT 120 Cycles Rust Removed

CONCLUSIONS: 25CCT VISUAL COMPARISON

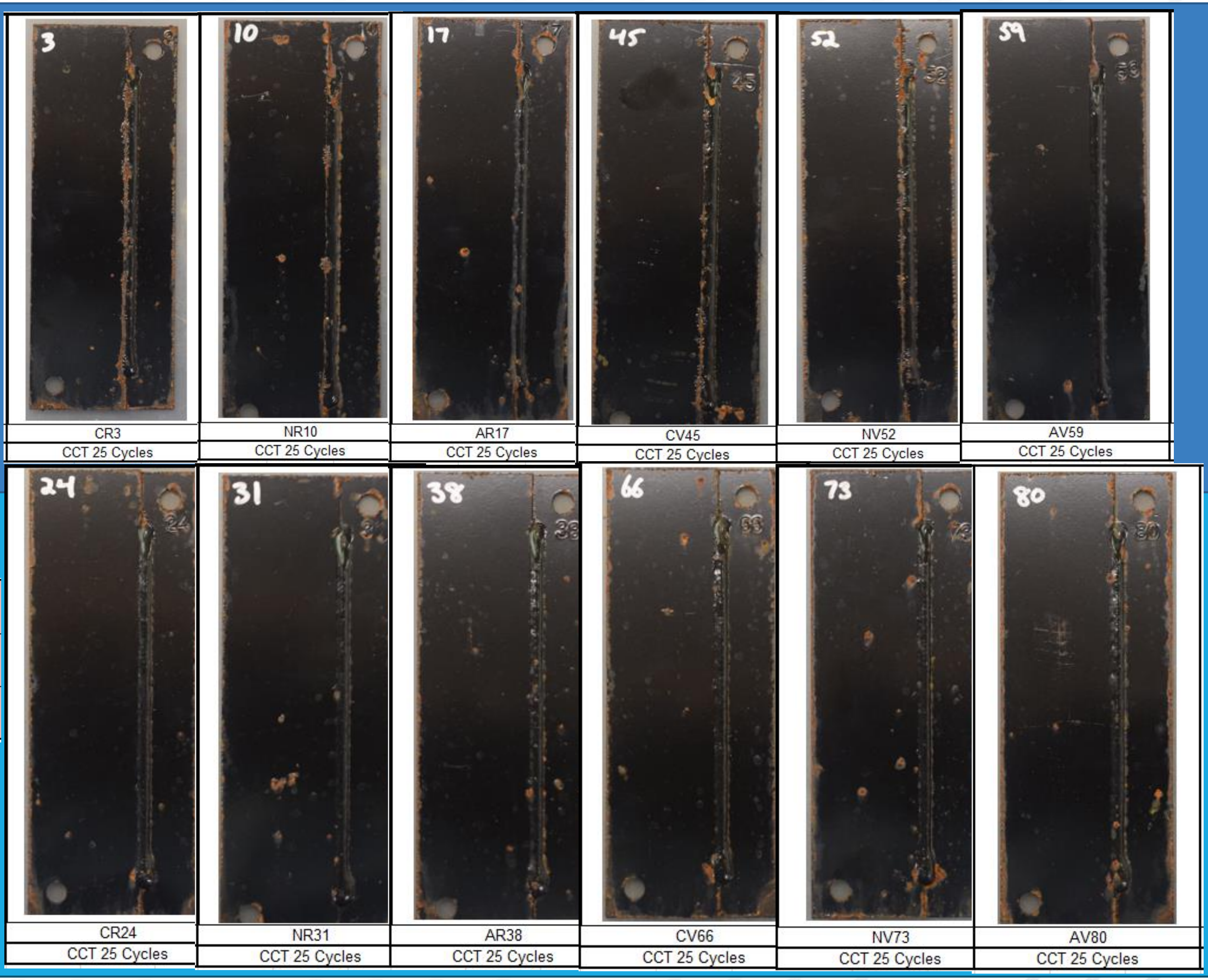
GDIS

ER70S-6

Pack ID	Panel ID	Conditioner code	Weld Wire	Trial Name
C	CR7 CR1, CR2 CR3, CR4, CR5, CR6	R	ER70S-6	Control
N	NR14 NR8, NR9 NR10, NR11, NR12, NR13	R	ER70S-6	Near Neutral
A	AR21 AR15, AR16 AR17, AR18, AR19, AR20	R	ER70S-6	Acid Descale
C	CV49 CV43, CV44 CV45, CV46, CV47, CV48	V	ER70S-6	Control
N	NV56 NV50, NV51 NV52, NV53, NV54, NV55	V	ER70S-6	Near Neutral
A	AV63 AV57, AV58 AV59, AV60, AV61, AV62	V	ER70S-6	Acid Descale

SuperArc® XLS

C	CR28 CR22, CR23 CR24, CR25, CR26, CR27	R	SuperArc® XLS	Control
N	NR35 NR29, NR30 NR31, NR32, NR33, NR34	R	SuperArc® XLS	Near Neutral
A	AR42 AR36, AR37 AR38, AR39, AR40, AR41	R	SuperArc® XLS	Acid Descale
C	CV70 CV64, CV65 CV66, CV67, CV68, CV69	V	SuperArc® XLS	Control
N	NV77 NV71, NV72 NV73, NV74, NV75, NV76	V	SuperArc® XLS	Near Neutral
A	AV84 AV78, AV79 AV80, AV81, AV82, AV83	V	SuperArc® XLS	Acid Descale



CONCLUSIONS: 120CCT OVERALL COMPARISON RANKED BY MAX PIT DEPTH

Rank	Wire	Acid Cleaning	Conditioner	Avg (in)	Max (in)
1	ER70S-6	Mineral Acid	Titanium-based	0.002	0.008
2	ER70S-6	Mineral Acid	Zinc-based	0.003	0.019
3	SuperArc® XLS	Neutral Acid	Titanium-based	0.009	0.024
4	SuperArc® XLS	None	Zinc-based	0.013	0.025
5	SuperArc® XLS	None	Titanium-based	0.015	0.038
6	SuperArc® XLS	Mineral Acid	Titanium-based	0.013	0.039
7	ER70S-6	None	Titanium-based	0.021	0.040
8	SuperArc® XLS	Neutral Acid	Zinc-based	0.015	0.045
9	SuperArc® XLS	Mineral Acid	Zinc-based	0.011	0.055
10	ER70S-6	None	Zinc-based	0.021	0.060
11	ER70S-6	Neutral Acid	Zinc-based	0.026	0.065
12	ER70S-6	Neutral Acid	Titanium-based	0.020	0.185

CONCLUSIONS: 120CCT PIT DEPTH

- With mineral acid cleaning, ER70S-6 wire performed the best with the least amount of corrosion
- In most other cleaning/conditioner combinations, SuperArc® XLS performed the best with the least amount of corrosion
- Neutral acid and control samples for ER70S-6 consistently performed the worst in terms of corrosion resistance

PHASE 2 TESTING

- Plan to perform testing on a variety of base materials with a wider array of welding consumables
- Will include zinc-coated materials and x-ray to determine porosity

Involved parties:

Lincoln – Perform all welding and sample labeling

PPG – Perform all pre-treatment /coating on samples

OEM – Supply base material and perform corrosion testing

FOR MORE INFORMATION

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