Hex Chrome Free Coatings for Electronics

NASA-DoD-OEM Joint Project

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Hex Chrome Free Coatings for Electronics (NASA-DoD)

Objective

- Evaluate and test hexavalent-chrome free pretreatments for avionics and electronics applications

Benefits

- Project builds off of previously successful NASA and DoD testing
- Reduced risk for materials obsolescence of hex-chrome coatings with the discovery of coatings that perform to the requirements for current and future Programs within NASA, the DoD and ESA
- Continue to collaborate with DoD and industry to identify and test alternatives for various applications within the aerospace community

If a qualified technology or product is implemented, it will:

- Meet environmental and safety regulatory requirements
- Reduce need to monitor for chromium exposure due to new regulations
- Decrease risk of environmental, worker and public exposure
- Reduce maintenance cost and government liability

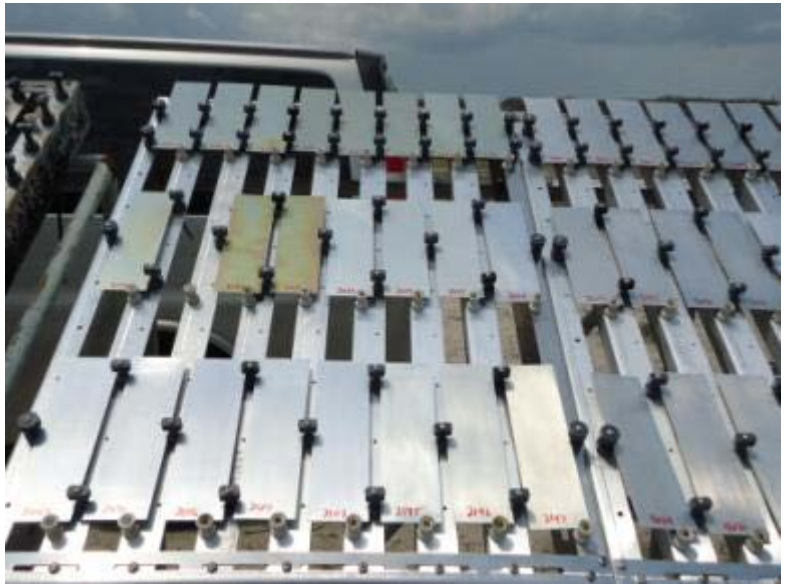
Hex Chrome Free Coatings for Electronics (NASA-DoD)

Pretreatments

- Alodine 1600 (Control)
- Metalast HF
- Metalast HFEPA
- SurTec 650
- SurTec 650 C
- Alodine T 5900 RTU
- Iridite NCP

Substrates

- 6061-T6
- 7075-T73
- 2024-T3
- 5052-H32



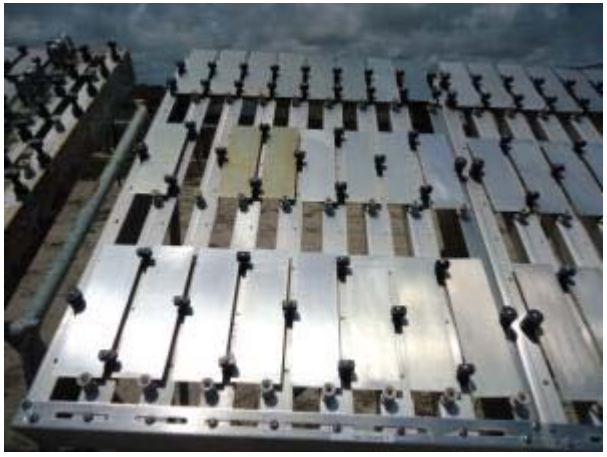
Limited Screening Tests

- Alodine EC2
- Corrlink 30A
- Deft RECC
- UMR CeCC
- EonCoat
- PPG X-Bond 4000
- Metalast TCPCC-600P
- NANOMYTE PT-10
- NANOMYTE TC-4001
- Alodine 160/161
- Alodine 5923 Plus
- Interlox 5705

Hex Chrome Free Coatings for Electronics (NASA-DoD)

Testing {NASA KSC Corrosion Technology Lab and Beachside Corrosion Lab}

- Salt Spray Resistance
  - ASTM B 117
    - 168 hours
    - To failure
  - Surface Resistance (ASTM D 257)
  - Contact Electrical Resistance (81706)
- Cyclic Corrosion
  - ASTM G 85, Annex 5
- 18-Month Marine Environment
  - KSC Beach Corrosion Test
- Patti-Jr. Pull-Off Adhesion Test
  - ASTM D 4541
- Cross-Cut Tape Test
  - ASTM D 3359, Procedure B
- Wet Tape Paint Adhesion
  - 24 Hour Immersion
  - 96 Hour Immersion at 120^{o}F



Hex Chrome Free Coatings for Electronics (NASA-DoD)

Panel Preparation {NASA KSC Corrosion Technology Lab}

- The panel preparation procedure was developed as part of the NASA TEERM Hexavalent Chrome Alternatives for Aerospace Project. Stakeholders participating in the Hexavalent Chrome Free Coatings for Electronics Applications Project agreed to the procedure.

1. Solvent Hand Cleaning
   a. Ethanol {200 proof}.
2. Mild Alkaline Aqueous Degreaser (Non-Silicate)
   a. Chemetall-Oakite NST – (5% by volume @ 49º - 54ºC for 4 minutes.)
3. DI water rinse to water break-free. Preceding degreasing steps will be repeated until water break-free is achieved.
4. Deoxidize Bath (Oakite LNC)
   a. Oakite LNC (10% by volume @ ambient temperature for 3 - 4 minutes.)
5. Rinse thoroughly using clean (5 megaohm or better) DI ambient temperature water.
6. Take panels directly to pretreatment bath

Hex Chrome Free Coatings for Electronics (NASA-DoD)

Salt Spray Resistance (ASTM B 117, 168 hours)

Pretreatment	Alloy	B117 @ 168 Hours
Control	6061-T6	Fail
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Fail
Alternative 1	6061-T6	Pass
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Pass
Alternative 2	6061-T6	Pass
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Pass
Alternative 3	6061-T6	Pass
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Pass

Pretreatment	Alloy	B117 @ 168 Hours
Alternative 4	6061-T6	Pass
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Pass
Alternative 5	6061-T6	Pass
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Pass
Alternative 6	6061-T6	Pass
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Pass

Alternatives are not listed in the same order as they are listed on Slide 3

Hex Chrome Free Coatings for Electronics (NASA-DoD)

Salt Spray Resistance (ASTM B 117, to failure)

Pretreatment	Alloy	B117 to Fail
Control	6061-T6	4 of 5 Pass @ 168
	7075-T73	Failed @ 168
	2024-T3	Failed @ 168
	5052-H32	1 of 5 Pass @ 168
Alternative 1	6061-T6	3 of 5 Pass @ 168
	7075-T73	Failed @ 168
	2024-T3	Failed @ 168
	5052-H32	Pass @ 1008
Alternative 2	6061-T6	4 of 5 Pass @ 168
	7075-T73	Failed @ 168
	2024-T3	Failed @ 168
	5052-H32	4 of 5 Pass @ 1008
Alternative 3	6061-T6	1 of 5 Pass @ 168
	7075-T73	Failed @ 168
	2024-T3	Failed @ 168
	5052-H32	2 of 5 Pass @ 1008

Pretreatment	Alloy	B117 to Fail
Alternative 4	6061-T6	4 of 5 Pass @ 168
	7075-T73	Failed @ 168
	2024-T3	Failed @ 168
	5052-H32	Pass @ 1008
Alternative 5	6061-T6	4 of 5 Pass @ 168
	7075-T73	Failed @ 168
	2024-T3	Failed @ 168
	5052-H32	Pass @ 1008
Alternative 6	6061-T6	4 of 5 Pass @ 168
	7075-T73	Failed @ 168
	2024-T3	Failed @ 168
	5052-H32	4 of 5 Pass @ 1008

*Note - All five 6061-T6 test panels as well as 1 of 5 test panels for 7075-T73, 2024-T3, and 5052-H32 for all pretreatments were used for ASTM D 257 readings. Test panels were not tested at the same time as the others listed in the table. Testing with these test panels was stopped after 168 hours.

Alternatives are not listed in the same order as they are listed on Slide 3

Hex Chrome Free Coatings for Electronics (NASA-DoD)

Cyclic Corrosion (ASTM G 85, Annex 5, 168 hours)

Pretreatment	Alloy	G85 @ 168 Hours
Control	6061-T6	Pass
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Pass
Alternative 1	6061-T6	Pass
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Pass
Alternative 2	6061-T6	Pass
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Pass
Alternative 3	6061-T6	Fail
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Fail

Pretreatment	Alloy	G85 @ 168 Hours
Alternative 4	6061-T6	Pass
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Pass
Alternative 5	6061-T6	Pass
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Pass
Alternative 6	6061-T6	Pass
	7075-T73	Fail
	2024-T3	Fail
	5052-H32	Pass

Alternatives are not listed in the same order as they are listed on Slide 3

Hex Chrome Free Coatings for Electronics (NASA-DoD)

Combined Data

Pretreatment	Alloy	B117 @ 168 Hours	B117 to Fail*	G85 @ 168 Hours
Control	6061-T6	Fail	4 of 5 Pass @ 168	Pass
	7075-T73	Fail	Failed @ 168	Fail
	2024-T3	Fail	Failed @ 168	Fail
	5052-H32	Fail	1 of 5 Pass @ 168	Pass
Alternative 1	6061-T6	Pass	3 of 5 Pass @ 168	Pass
	7075-T73	Fail	Failed @ 168	Fail
	2024-T3	Fail	Failed @ 168	Fail
	5052-H32	Pass	Pass @ 1008	Pass
Alternative 2	6061-T6	Pass	4 of 5 Pass @ 168	Pass
	7075-T73	Fail	Failed @ 168	Fail
	2024-T3	Fail	Failed @ 168	Fail
	5052-H32	Pass	4 of 5 Pass @ 1008	Pass
Alternative 3	6061-T6	Pass	1 of 5 Pass @ 168	Fail
	7075-T73	Fail	Failed @ 168	Fail
	2024-T3	Fail	Failed @ 168	Fail
	5052-H32	Pass	2 of 5 Pass @ 1008	Fail
Alternative 4	6061-T6	Pass	4 of 5 Pass @ 168	Pass
	7075-T73	Fail	Failed @ 168	Fail
	2024-T3	Fail	Failed @ 168	Fail
	5052-H32	Pass	Pass @ 1008	Pass
Alternative 5	6061-T6	Pass	4 of 5 Pass @ 168	Pass
	7075-T73	Fail	Failed @ 168	Fail
	2024-T3	Fail	Failed @ 168	Fail
	5052-H32	Pass	Pass @ 1008	Pass
Alternative 6	6061-T6	Pass	4 of 5 Pass @ 168	Pass
	7075-T73	Fail	Failed @ 168	Fail
	2024-T3	Fail	Failed @ 168	Fail
	5052-H32	Pass	4 of 5 Pass @ 1008	Pass

Alternatives are not listed in the same order as they are listed on Slide 3

Hex Chrome Free Coatings for Electronics (NASA-DoD)

Cross-Cut Tape Test (ASTM D 3359, Procedure B)

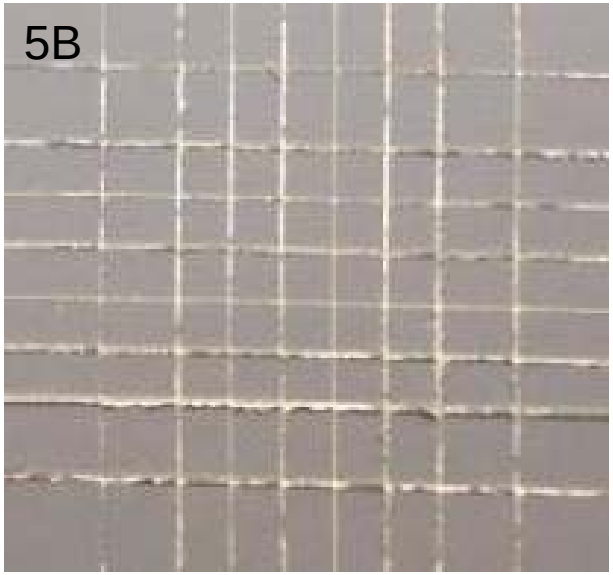
Primer (MIL-PRF-23377) - PPG CA7233

Pretreatment	Alloy	Result
Alternative 1	6061-T6	1B
		1B
	5052-H32	1B
		1B
Alternative 2	6061-T6	5B
		2B
	5052-H32	4B
		5B
Alternative 3	6061-T6	5B
		5B
	5052-H32	5B
		5B
Alternative 4	6061-T6	1B
		1B
	5052-H32	1B
		1B
Alternative 5	6061-T6	2B
		1B
	5052-H32	1B
		1B
Alternative 6	6061-T6	2B
		2B
	5052-H32	2B
		2B

Primer (MIL-PRF-85582) - Deft 44-GN-07A

Pretreatment	Alloy	Result
Alternative 1	6061-T6	5B
		5B
	5052-H32	5B
		5B
Alternative 2	6061-T6	5B
		5B
	5052-H32	5B
		5B
Alternative 3	6061-T6	5B
		5B
	5052-H32	5B
		5B
Alternative 4	6061-T6	5B
		5B
	5052-H32	5B
		5B
Alternative 5	6061-T6	5B
		5B
	5052-H32	4B
		5B
Alternative 6	6061-T6	5B
		5B
	5052-H32	5B
		5B

5B = 0% area removed
4B = less than 5% removed
3B = 5 – 15% removed
2B = 15 – 35% removed
1B = 35 – 65 % removed
0B = greater than 65%



Hex Chrome Free Coatings for Electronics (NASA-DoD)

Wet Tape Paint Adhesion (24 hour immersion, ambient temp)

Primer (MIL-PRF-23377) - PPG CA7233

Pretreatment	Alloy	Result
Alternative 1	6061-T6	3A
	5052-H32	5A
Alternative 2	6061-T6	5A
	5052-H32	5A
Alternative 3	6061-T6	5A
	5052-H32	5A
Alternative 4	6061-T6	3A
	5052-H32	3A
Alternative 5	6061-T6	5A
	5052-H32	4A
Alternative 6	6061-T6	4A
	5052-H32	4A

Primer (MIL-PRF-85582) - Deft 44-GN-07A

Pretreatment	Alloy	Result
Alternative 1	6061-T6	5A
	5052-H32	5A
Alternative 2	6061-T6	5A
	5052-H32	5A
Alternative 3	6061-T6	5A
	5052-H32	5A
Alternative 4	6061-T6	5A
	5052-H32	5A
Alternative 5	6061-T6	5A
	5052-H32	5A
Alternative 6	6061-T6	5A
	5052-H32	5A

- 5A = No peeling or removal
- 4A = Trace peeling or removal along incisions or at their intersection
- 3A = Jagged removal along incisions up to 1.6 mm (1⁄16 in.) on either side
- 2A = Jagged removal along most of incisions up to 3.2 mm (1⁄8 in.) on either side
- 1A = Removal from most of the area of the X under the tape
- 0A = Removal beyond the area of the X

Hex Chrome Free Coatings for Electronics (NASA-DoD)

Wet Tape Paint Adhesion (96 Hour Immersion at 120°F)

Primer (MIL-PRF-23377) - PPG CA7233

Pretreatment	Alloy	Result
Alternative 1	6061-T6	3A
	5052-H32	3A
Alternative 2	6061-T6	5A
	5052-H32	5A
Alternative 3	6061-T6	5A
	5052-H32	5A
Alternative 4	6061-T6	3A
	5052-H32	3A
Alternative 5	6061-T6	5A
	5052-H32	3A
Alternative 6	6061-T6	3A
	5052-H32	3A

Primer (MIL-PRF-85582) - Deft 44-GN-07A

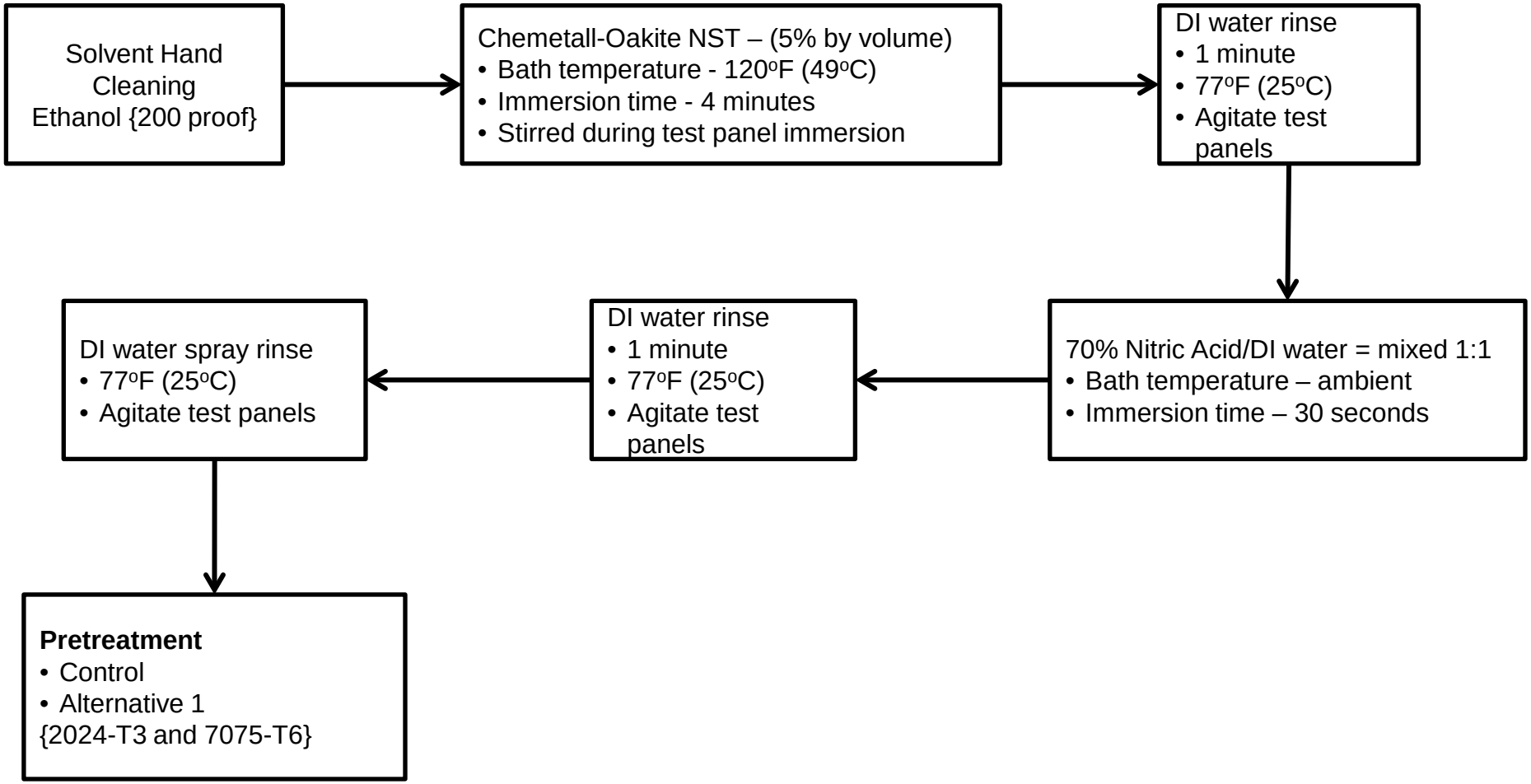
Pretreatment	Alloy	Result
Alternative 1	6061-T6	5A
	5052-H32	5A
Alternative 2	6061-T6	5A
	5052-H32	5A
Alternative 3	6061-T6	5A
	5052-H32	5A
Alternative 4	6061-T6	5A
	5052-H32	5A
Alternative 5	6061-T6	5A
	5052-H32	5A
Alternative 6	6061-T6	5A
	5052-H32	5A

- 5A = No peeling or removal
- 4A = Trace peeling or removal along incisions or at their intersection
- 3A = Jagged removal along incisions up to 1.6 mm (1⁄16 in.) on either side
- 2A = Jagged removal along most of incisions up to 3.2 mm (1⁄8 in.) on either side
- 1A = Removal from most of the area of the X under the tape
- 0A = Removal beyond the area of the X

Modified Panel Preparation Procedure

Hex Chrome Free Coatings for Electronics (NASA-DoD)

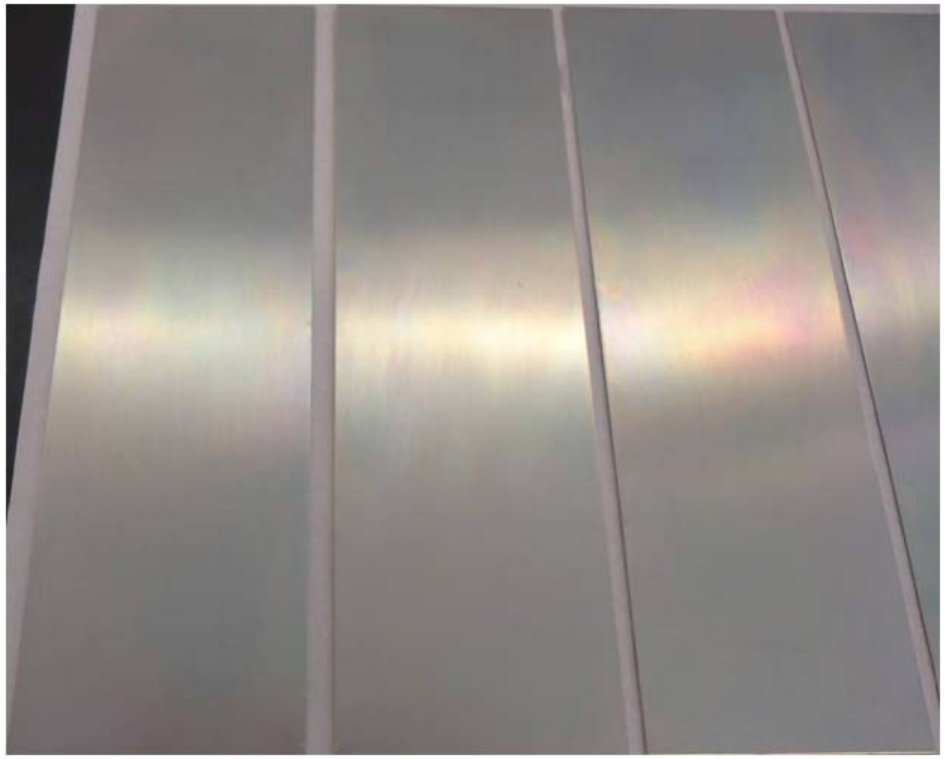
Modified Panel Preparation Procedure



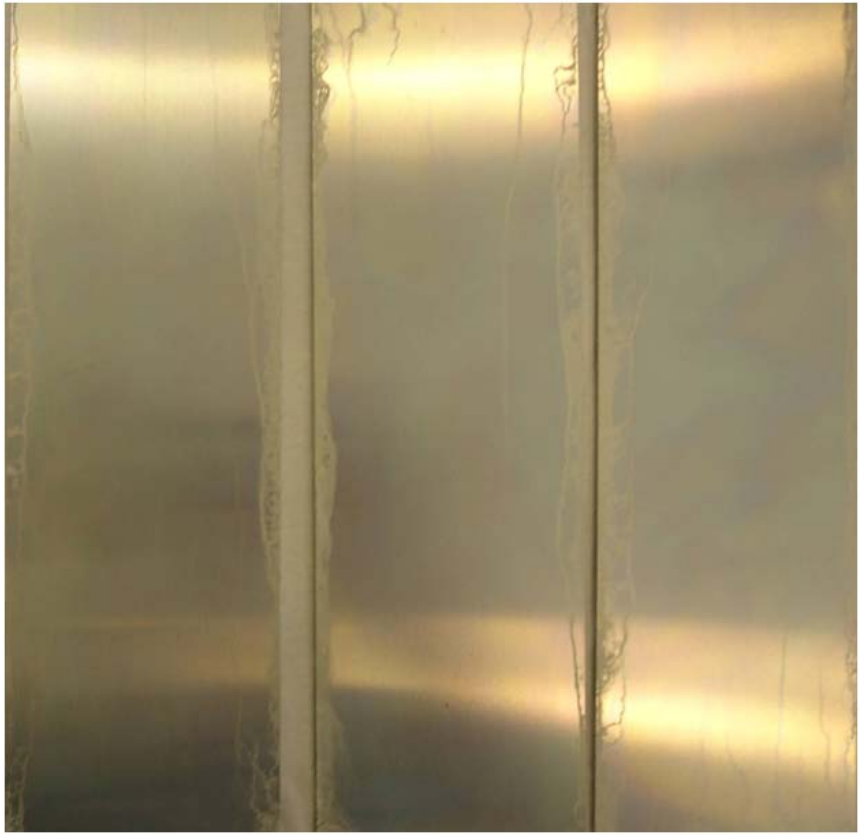
Hex Chrome Free Coatings for Electronics (NASA-DoD)

ASTM B 117 Testing

- Control performed very well on the 2024-T3 and 7075-T6 test panels through 336 hours of testing



Control – 2024-T3 – 336 hours ASTM B 117

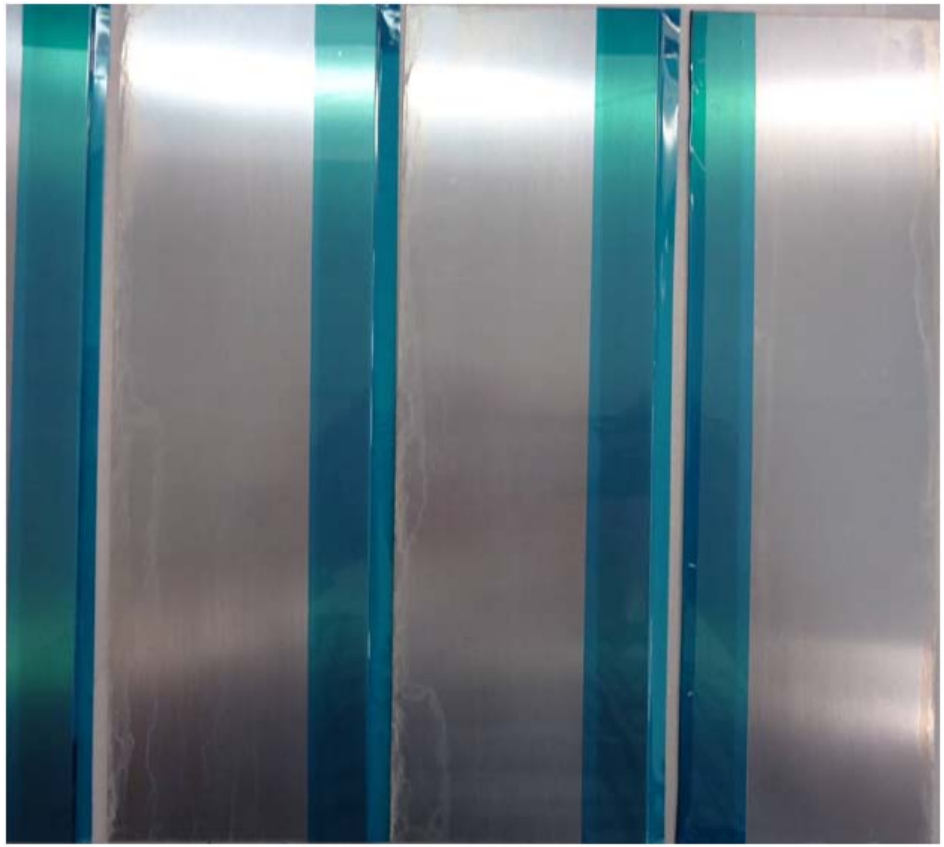


Control – 7075-T6 – 336 hours ASTM B 117

Hex Chrome Free Coatings for Electronics (NASA-DoD)

ASTM B 117 Testing

- Alternative 1 performed well on the 7075-T6 test panels through 336 hours of testing.
- Alternative 1 did not perform well on the 2024-T3 test panels following 168 hours of testing and were removed from test chamber.



Alternative 1 – 7075-T6 – 336 hours ASTM B 117

Alternative 1 – 2024-T3 – 168 hours ASTM B 117

Next Phase of Testing

Hex Chrome Free Coatings for Electronics (NASA-DoD)

Next Phase - Two panel prep procedures per pretreatment

Pretreatments

- Alodine 1600
- Metalast HF
- SurTec 650
- Iridite NCP

Substrates

- 2024-T3 (136)
- 7075-T6 (136)
- 6061-T6 (80)

Primary Test Panel Count {2024 / 7075}

- 17 panels per alloy
- 2 alloys
- 4 pretreatments
- 2 processes

272 panels

Limited Test Panel Count {6061}

- 10 panels per alloy
- 1 alloys
- 4 pretreatments
- 2 processes

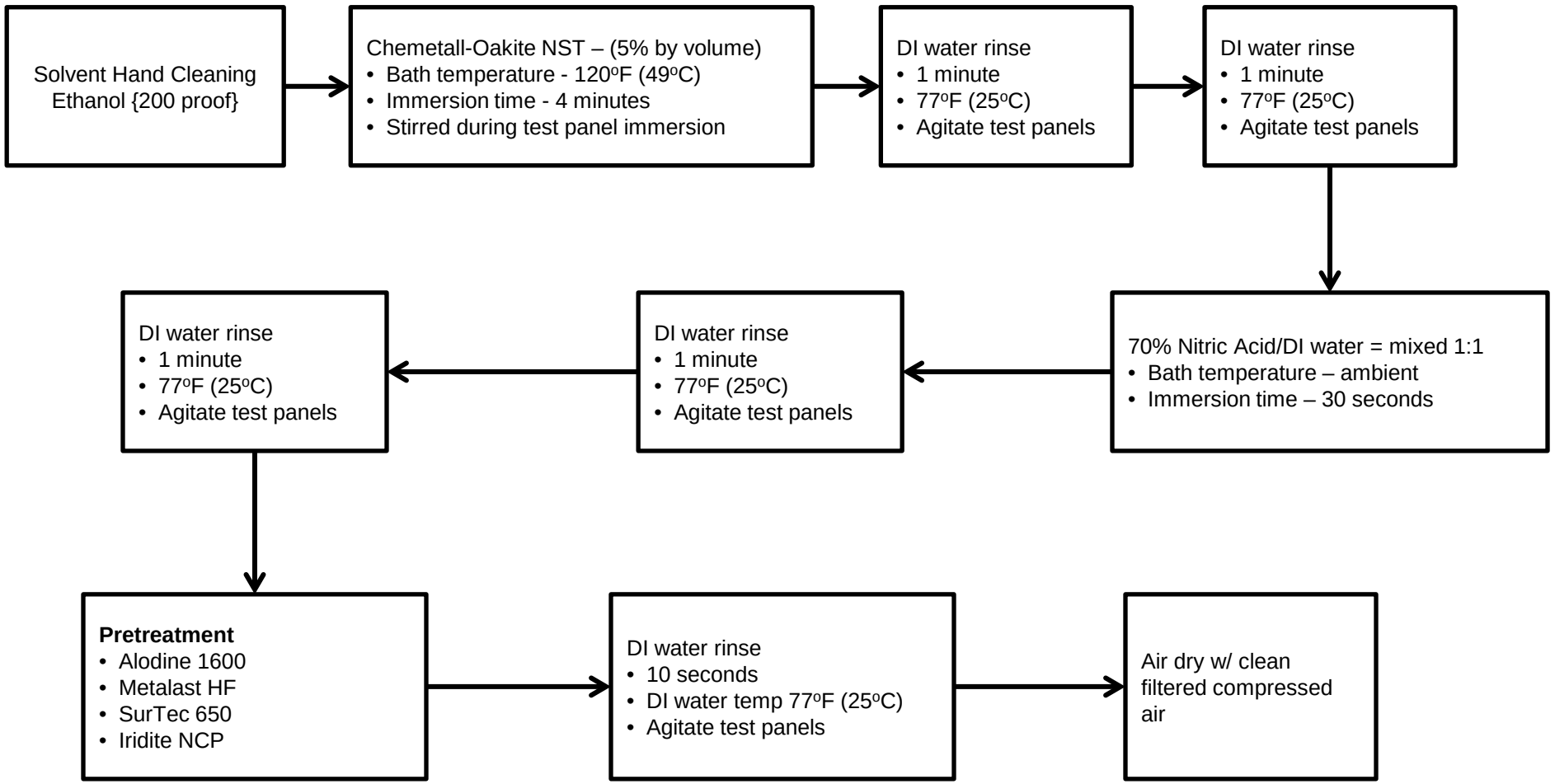
80 panels

Vendor Applied Pretreatments {2024 / 7075}

- METALAST TCP-HF / HPA 100
- Deft RECC
- NANOMYTE

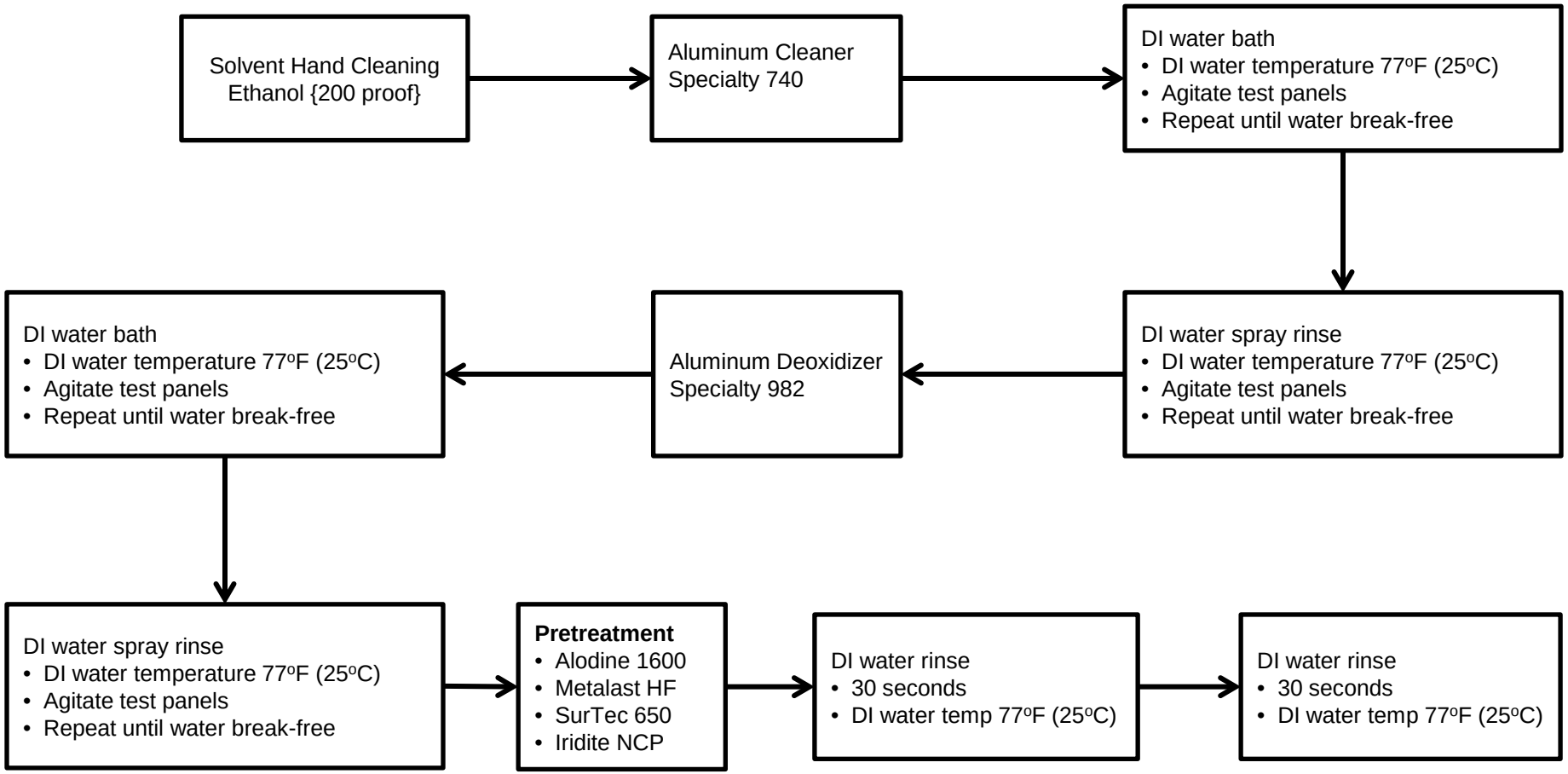
Hex Chrome Free Coatings for Electronics (NASA-DoD)

Next Phase – Process 1



Hex Chrome Free Coatings for Electronics (NASA-DoD)

Next Phase – Process 2



Hex Chrome Free Coatings for Electronics (NASA-DoD)

Next Phase

Testing – Primary {2024 / 7075}

- Salt Spray Resistance (5 test panels)
  - ASTM B 117 - To failure with 168 hour inspections
- Cyclic Corrosion (5 test panels)
  - ASTM G 85, Annex 5 – To failure with 168 hour inspections
- Marine Environment (5 test panels)
  - KSC Beach Corrosion Test - To failure with 168 hour inspections
- Wet Tape Paint Adhesion (2 test panels {3x5} per test procedure; 1 for each primer)
  - 24 Hour Immersion
  - 96 Hour Immersion at 120^{o}F

Testing – Limited {6061}

- Salt Spray Resistance (5 test panels)
  - ASTM B 117 - To failure with 168 hour inspections
  - Electrical contact resistance after salt spray exposure
- Electrical Contact Resistance Without Salt Spray Exposure (5 test panels)

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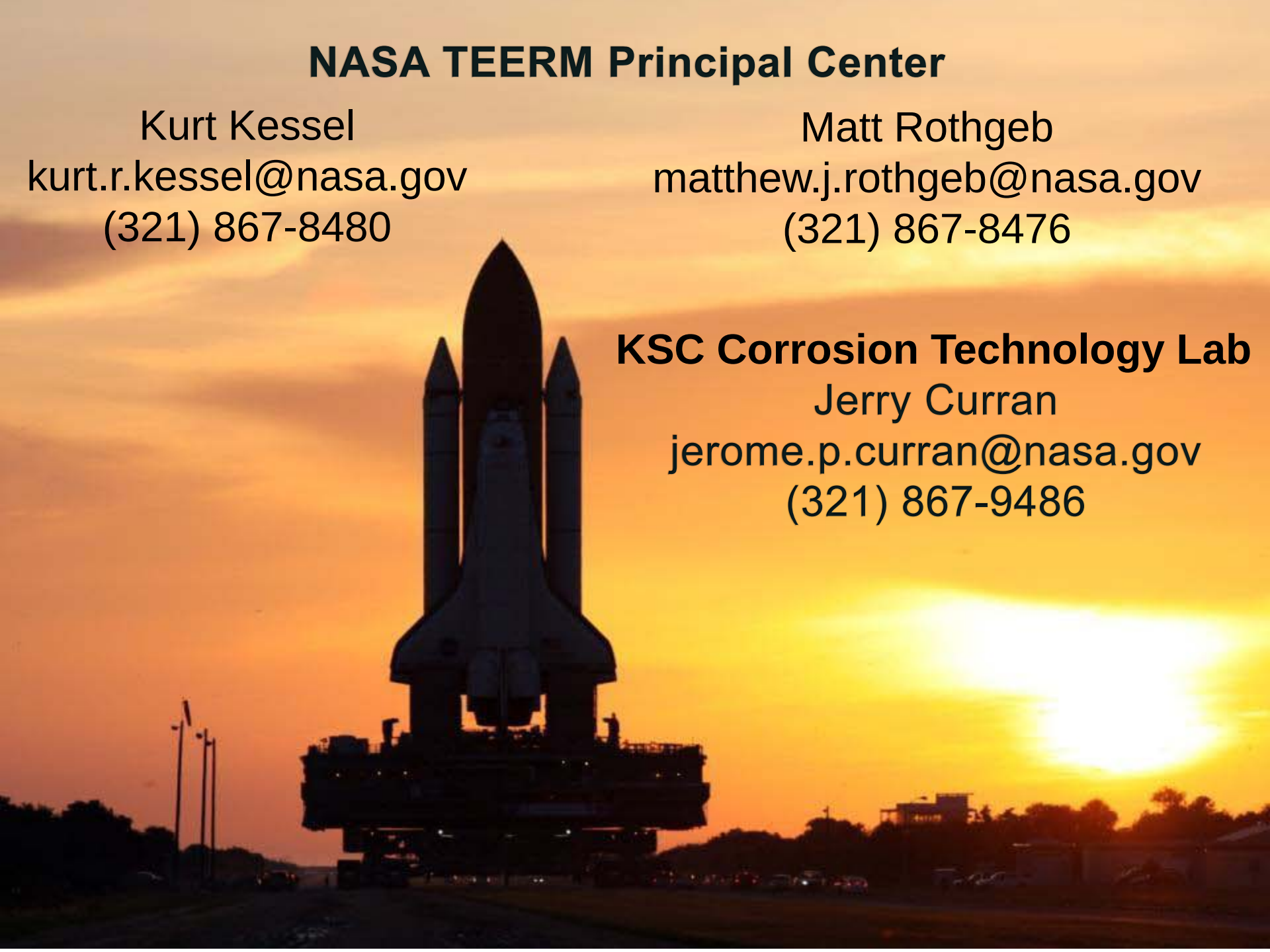

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Questions?