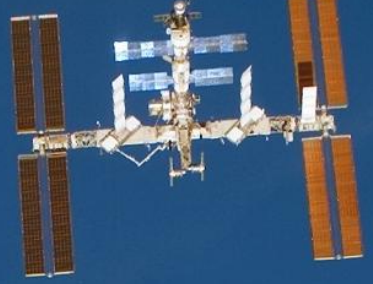


# NASA/ESA
# Hex-Chrome Project
# Phase 1 Results & Overview

**Technology Evaluation for Environmental Risk Mitigation**
**Principal Center**

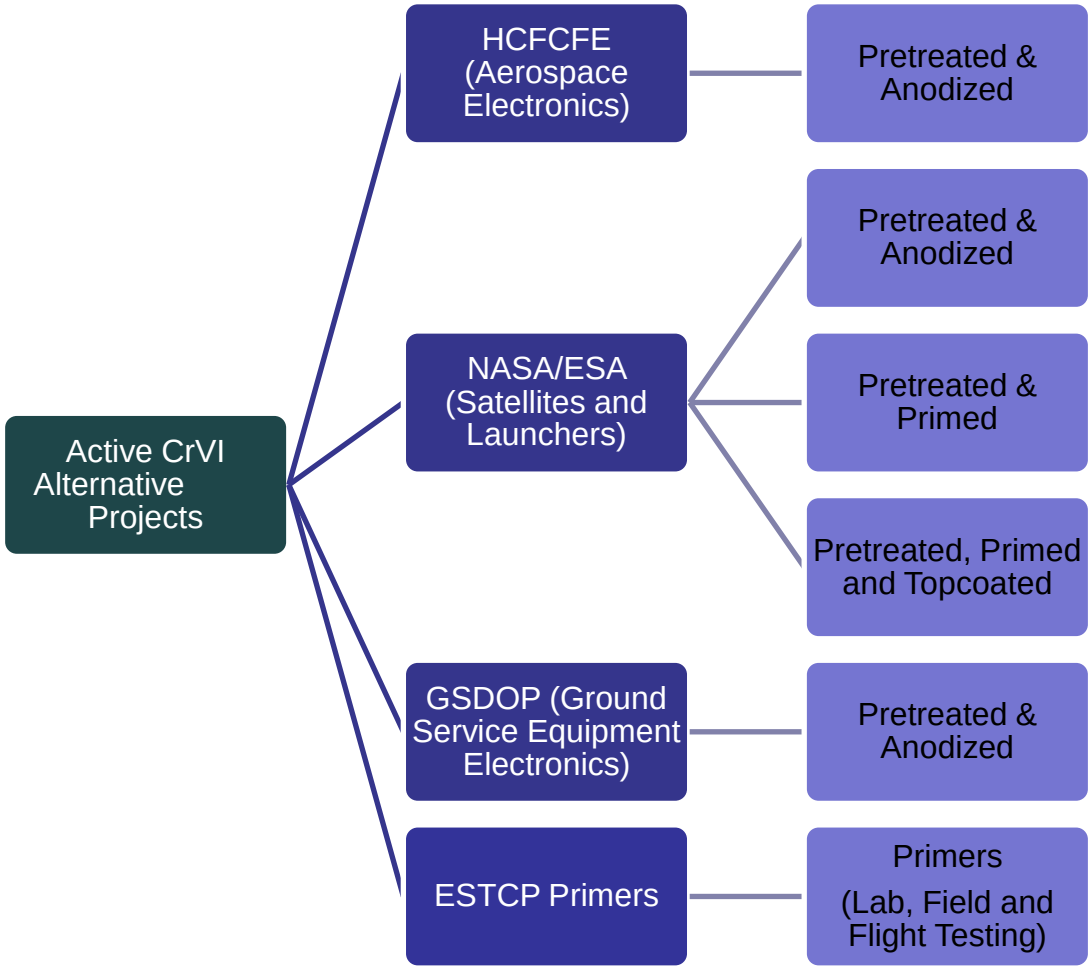
**Matt Rothgeb**

**International Workshop on Environment and Alternative Energy**

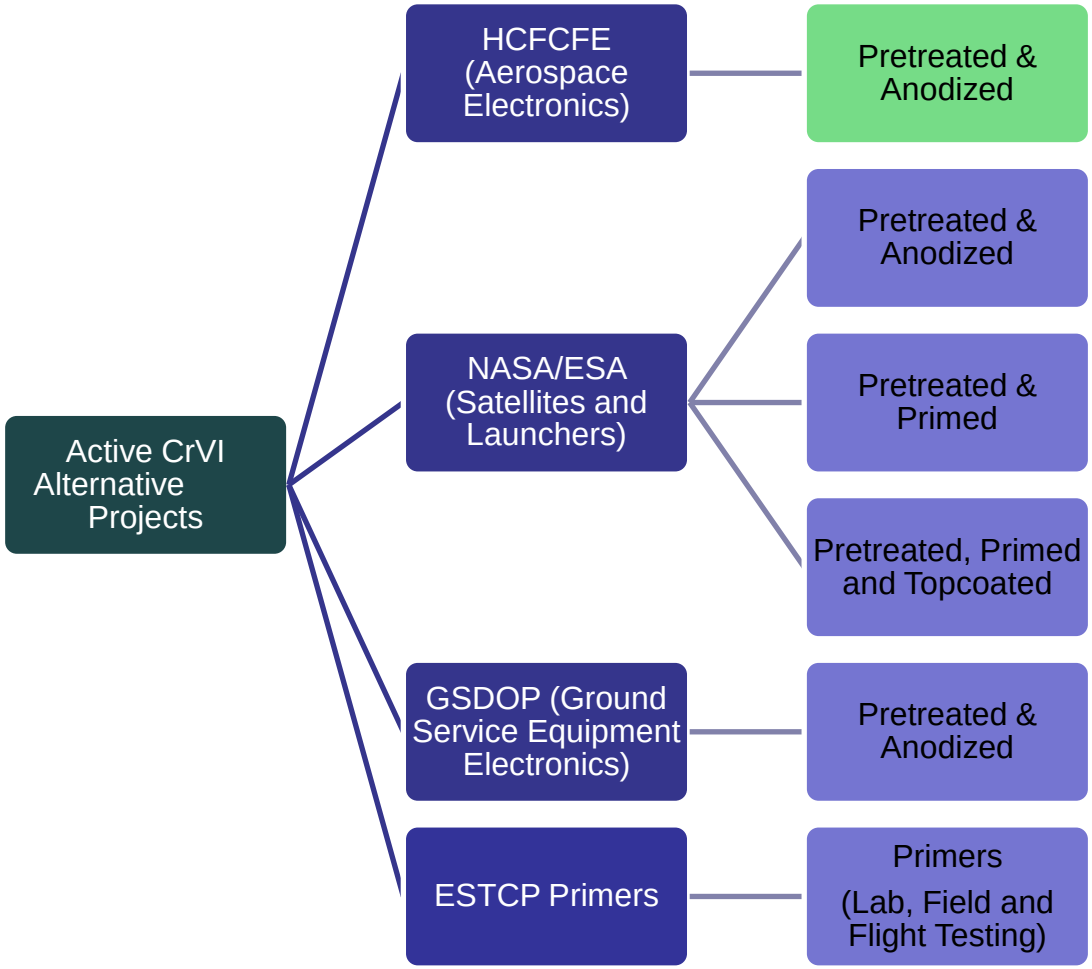
October 24, 2013

ESRIN – Frascati, Italy

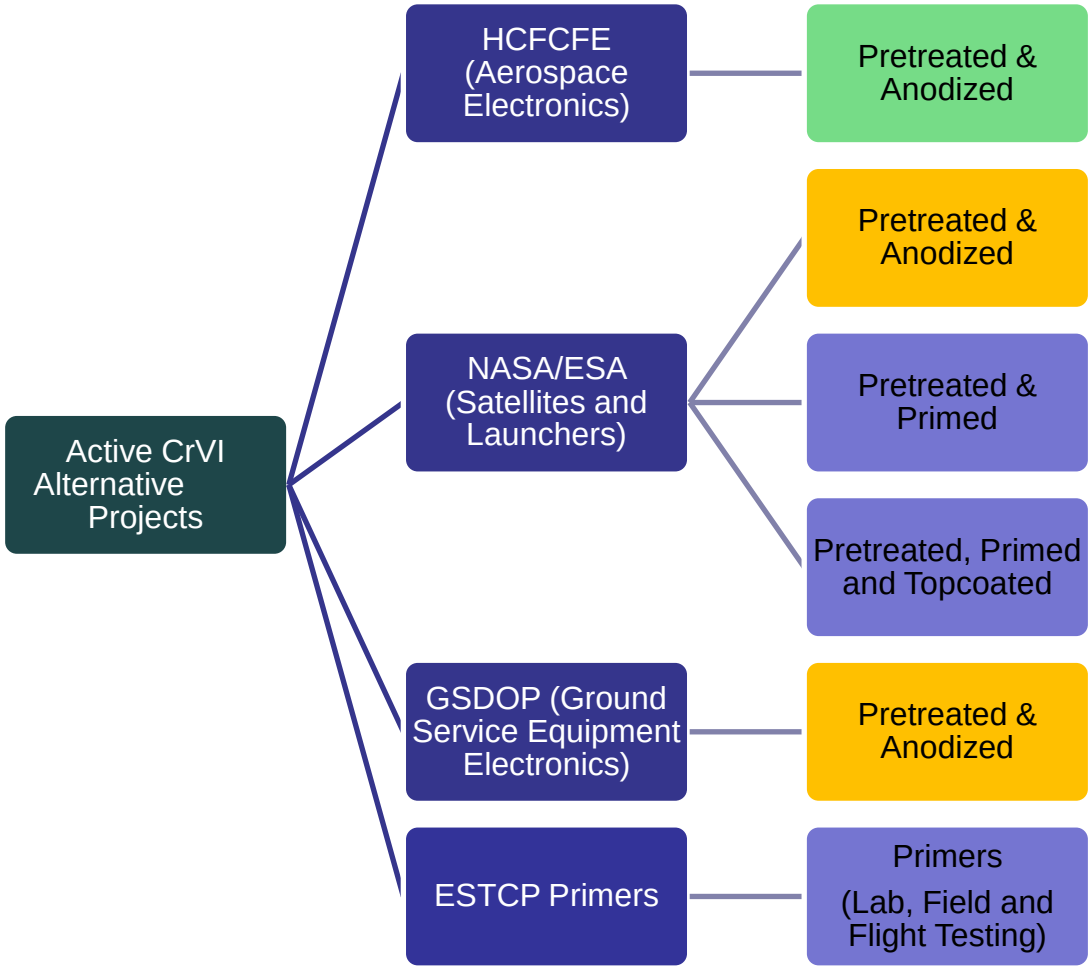
## Current NASA TEERM CrVI Projects:



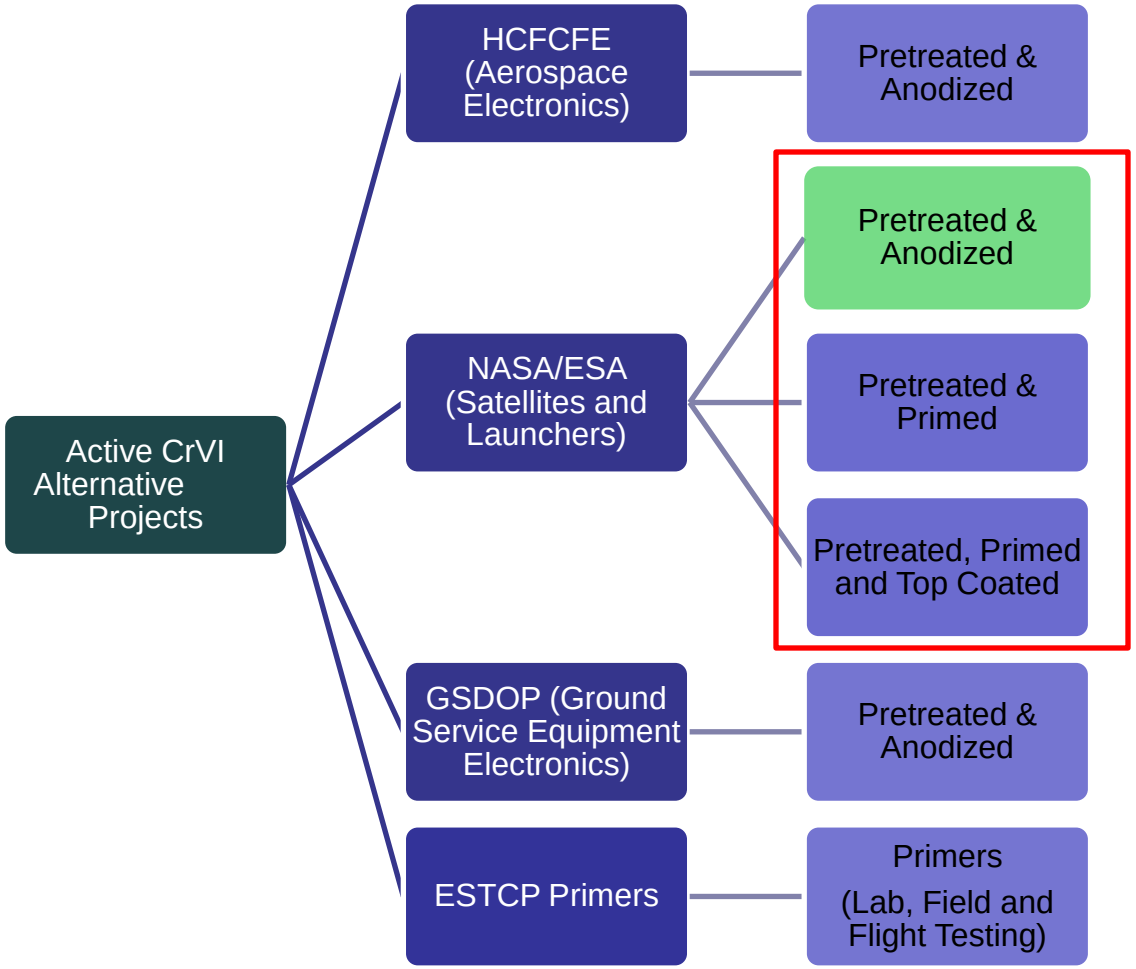
## Current NASA TEERM CrVI Projects:



## Current NASA TEERM CrVI Projects:



## Current NASA TEERM CrVI Projects:



# National Aeronautics and Space Administration (NASA)

Partial List

**HCFCFE**

Screening

| | |
|---|---|
| x | Alodine EC2 |
| x | Corrlink 30A |
| | Deft RECC |
| x | UMR CeCC |
| x | EON Coat |
| x | XBond 4000 |
| x | NANOMYTE TC-4001 |
| x | NANOMYTE PT-10 |

**HCFCFE**

Pretreatments

| | |
|---|---|
| x | Alodine 1600 |
| x | Alodine 5900 |
| x | Iridite NCP |
| x | Metalast HF |
| x | Metalast HF-EPA |
| x | Surtec 650 |
| x | Surtec 650C |

## Phase 1

**ESA/NASA**

Screening

| | | |
|---|---|---|
| | p | Alodine 1200s (added) Control |
| | x | Alodine 1600 Control |
| 1 | p | Alodine 160/161 |
| 2 | p | Alodine 5993Plus |
| 3 | p | Interlox 5705 |
| 4 | p | MAP Silico |
| 5 | x | Alodine EC2 |
| 6 | x | Corrlink 30A |
| 7 | p | Deft RECC |
| 8 | x | UMR CeCC |
| 9 | x | EON Coat |
| 10 | x | XBond 4000 |
| 11 | x | NANOMYTE TC-4001 |
| 12 | x | NANOMYTE PT-10 |
| 13 | r | Alodine 5900 |
| 14 | r | Iridite NCP |
| 15 | r | Metalast HF |
| 16 | x | Metalast HF-EPA |
| 17 | x | Surtec 650 |
| 18 | r | Surtec 650C |
| 19 | n | Surtec 650V |

# NASA/ESA & HCFCFE Test Programs

**Initial Screening Testing:**

- ASTM B117 – Salt Fog to Failure
- ASTM G85 - Cyclic Corrosion (A5)
- Beachfront Exposure Testing
- Wet Tape Adhesion

**Substrates:**

- 2024 - T3
- 7075 - T73
- 6061 - T6

**Results:**

- All Passed Adhesion
- Cyclic Corrosion was inconclusive
- Beachfront Analysis was inconclusive
- ASTM B117 Results showed mixed and unexpected results

# Hexavalent Chrome Free Coatings Process Optimization

# Test Panel Preparation Process Optimization

- Initial Screening testing results were mixed on known commodities (Controls and Approved Non-Chromes)
- Initial re-testing did not provide clear answers
- Decision made to spend effort on optimization of pretreatment application and panel preparation processes
- ≈ 5 Rounds of process optimization were conducted (Round considered major material or process change)

# Test Panel Preparation Process Optimization

## Round 1A

Substrates: 2024 / 2219 / 7075 / 6061
Cleaning: Scotch Bright + Ethanol

# Test Panel Preparation Process Optimization

## PROCESS 1

**Cleaner**

- Chemetall-Oakite NST – (5% by volume)

**Deoxidizer**

- 70% Nitric Acid/DI water = mixed 1:1 - agreed upon by stakeholder consensus

# Process Optimization - Process 1

Solvent Hand Cleaning
Ethanol {200 proof}
Scotch-Brite Pad

→

Chemetall-Oakite NST – (5% by volume)
- Bath temperature - 120ºF (49ºC)
- Immersion time - 4 minutes
- Stirred during test panel immersion

→

DI water rinse tank
- 77ºF (25ºC)
- Agitate test panels

↓

DI water rinse
- 77ºF (25ºC)
- Lightly spray

←

70% Nitric Acid/DI water = mixed 1:1
- Bath temperature – ambient
- Immersion time – 30 seconds

←

DI water rinse tank
- 77ºF (25ºC)
- Agitate test panels

↓

DI water rinse
- 77ºF (25ºC)
- Lightly spray

→

**Alodine 1200S**
**Metalast HF**
**SurTec 650C**
**Iridite NCP**

→

DI water rinse tank
- 77ºF (25ºC)
- Agitate test panels

↓

DI water rinse
- 77ºF (25ºC)
- Lightly spray

# Test Panel Preparation Process Optimization

## PROCESS 2

**Cleaner**

- Specialty 740 (9 oz/gal)

**Deoxidizer**

- Specialty 982 (15% by volume) – currently being used by local plating shop

# Process Optimization - Process 2

Solvent Hand Cleaning
Ethanol {200 proof}
Scotch-Brite Pad

→

Specialty 740 (9 oz/gal)
- Bath temperature - 140$^0$F (60$^o$C)
- Immersion time - 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

←

Specialty 982 (15% by volume)
- Bath temperature – 73$^o$F (23$^o$C)
- Immersion time - 2 minutes

←

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

**Alodine 1200S**
**Metalast HF**
**SurTec 650C**
**Iridite NCP**

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

# Process Optimization

**RESULTS:**

- **Alodine 1200S**
  - Failures on 2219 – Expected
  - Failures on 2024 – Not Expected (<168 Hours)
  - Passing on 6061 & 7075 – 336 Hours +

- **Metalast TCP**
  - Failures on 2219 – Expected
  - Passing on 2024 – Expected 168 Hours (barely)
  - Passing on 6061 & 7075 – 672 Hours +

- **Surtec 650 C**
  - Failures on 2219 – Expected
  - Failures on 2024 – Not Expected (<168 Hours)
  - Passing on 6061 & 7075 – 504 Hours +

# Process Optimization

| Pretreatment | Process | Alloy | 168 hrs | 336 hrs | 504 hrs | 672 hrs | 840 hrs | Process | Alloy | 168 hrs | 336 hrs | 504 hrs | 672 hrs | 840 hrs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alodine 1200S | 1 | 2024-T3 | Fail | | | | | 2 | 2024-T3 | Fail | | | | |
| | | | Pass | Fail | | | | | | Fail | | | | |
| | | | Pass | Fail | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| Alodine 1200S | 1 | 2024-T3* | Fail | | | | | | | | | | | |
| Alodine 1200S | 1 | 2219 | Fail | | | | | 2 | 2219 | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| Alodine 1200S | 1 | 6061-T6 | Pass | Pass | Pass | Pass | Pass | 2 | 6061-T6 | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| Alodine 1200S | 1 | 6061-T6* | Pass | Pass | Pass | Pass | Fail | | | | | | | |
| Alodine 1200S | 1 | 7075-T6 | Pass | Pass | Fail | Fail | | 2 | 7075-T6 | Pass | Pass | Pass | Pass | Fail |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Fail |
| | | | Pass | Pass | Fail | Fail | | | | Pass | Pass | Pass | Pass | Fail |
| | | | Pass | Pass | Fail | Fail | | | | Pass | Pass | Pass | Pass | Fail |
| | | | Pass | Pass | Pass | Pass | Fail | | | Pass | Pass | Pass | Pass | Fail |
| Alodine 1200S | 1 | 7075-T6* | Pass | Pass | Fail | Fail | | | | | | | | |

* Test panels purchased through AnaCon Laboratories; 3x10x.040", PVC cover both sides

# Process Optimization

| Pretreatment | Process | Alloy | 168 hrs | 336 hrs | 504 hrs | 672 hrs | 840 hrs | Process | Alloy | 168 hrs | 336 hrs | 504 hrs | 672 hrs | 840 hrs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Metalast TCP-HF | 1 | 2024-T3 | Pass | Fail | | | | 2 | 2024-T3 | Pass | Fail | | | |
| | | | Pass | Fail | | | | | | Pass | Pass | Fail | | |
| | | | Pass | Fail | | | | | | Pass | Fail | | | |
| | | | Pass | Fail | | | | | | Pass | Fail | | | |
| | | | Pass | Fail | | | | | | Pass | Fail | | | |
| Metalast TCP-HF | 1 | 2024-T3* | Pass | Pass | Fail | | | | | | | | | |
| Metalast TCP-HF | 1 | 2219 | Fail | | | | | 2 | 2219 | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| Metalast TCP-HF | 1 | 6061-T6 | Pass | Pass | Pass | Pass | Pass | 2 | 6061-T6 | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| Metalast TCP-HF | 1 | 6061-T6* | Pass | Pass | Pass | Pass | Pass | | | | | | | |
| Metalast TCP-HF | 1 | 7075-T6 | Pass | Pass | Pass | Pass | Pass | 2 | 7075-T6 | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Fail | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Fail | | | Pass | Pass | Pass | Pass | Pass |
| Metalast | 1 | 7075-T6* | Pass | Pass | Pass | Pass | Pass | | | | | | | |

* Test panels purchased through AnaCon Laboratories; 3x10x.040", PVC cover both sides

# Process Optimization

| Pretreatment | Process | Alloy | 168 hrs | 336 hrs | 504 hrs | 672 hrs | 840 hrs | Process | Alloy | 168 hrs | 336 hrs | 504 hrs | 672 hrs | 840 hrs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SurTec 650C | 1 | 2024-T3 | Fail | | | | | 2 | 2024-T3 | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| SurTec 650C | 1 | 2024-T3* | Pass & RTT | Fail | | | | | | | | | | |
| SurTec 650C | 1 | 2219 | Fail | | | | | 2 | 2219 | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| SurTec 650C | 1 | 6061-T6 | Pass | Pass | Pass | Pass | Pass | 2 | 6061-T6 | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| SurTec 650C | | 6061-T6* | Pass | Pass | Pass | Pass | Pass | | | | | | | |
| SurTec 650C | 1 | 7075-T6 | Pass | Pass | Pass | Pass | Pass | 2 | 7075-T6 | Pass | Pass | Pass | Fail | |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Pass |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Fail | |
| SurTec 650C | | 7075-T6* | Pass | Pass | Pass | Pass | Pass | | | | | | | |

* Test panels purchased through AnaCon Laboratories; 3x10x.040", PVC cover both sides

# Process Optimization

| Pretreatment | Process | Alloy | 168 hrs | 336 hrs | 504 hrs | 672 hrs | 840 hrs | Process | Alloy | 168 hrs | 336 hrs | 504 hrs | 672 hrs | 840 hrs |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Iridite NCP | 1 | 2024-T3 | Fail | | | | | 2 | 2024-T3 | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| Iridite NCP | 1 | 2024-T3* | Fail | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Iridite NCP | 1 | 2219 | Fail | | | | | 2 | 2219 | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | Fail | | | | | | | Fail | | | | |
| | | | | | | | | | | | | | | |
| Iridite NCP | 1 | 6061-T6 | Pass | Pass | Fail | | | 2 | 6061-16 | Pass | Pass | Pass | Fail | |
| | | | Fail | | | | | | | Pass | Pass | Pass | Pass | Fail |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Fail | | | |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Fail | | | |
| | | | Pass | Pass | Pass | Pass | Pass | | | Pass | Pass | Pass | Pass | Fail |
| Iridite NCP | 1 | 6061-T6* | Fail | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| Iridite NCP | 1 | 7075-T6 | Pass | Pass | Pass | Pass | Pass | 2 | 7075-T6 | Fail | | | | |
| | | | Pass | Fail | | | | | | Fail | | | | |
| | | | Pass | Pass | Pass | Pass | Pass | | | Fail | | | | |
| | | | Pass | Fail | | | | | | Fail | | | | |
| | | | Pass | Pass | Pass | Fail | | | | Fail | | | | |
| Iridite | 1 | 7075-T6* | Pass | Fail | | | | | | | | | | |

* Test panels purchased through AnaCon Laboratories; 3x10x.040", PVC cover both sides

# Test Panel Preparation Process Optimization

## Round 1B

Substrates: 2024 / 2219 / 7075
Cleaning: Scotch Bright + Ethanol

# Test Panel Preparation Process Optimization

- Focusing on hardest alloys to protect
  - 2024-T3
  - 2219-T8
  - 7075-T6

- Alodine 1200S – alter contact times for deoxidizer {Specialty 982 (20% by volume) only} and Alodine bath

- Hexavalent chrome-free alternatives – alter contact time for deoxidizer only
  - 70% Nitric Acid/DI water = mixed 1:1 - agreed upon by stakeholder consensus
  - Specialty 982 (20% by volume) – currently being used by local plating shop

# Process Optimization

**RESULTS:**

- **Alodine 1200S**
  - Failures on 2219 – Expected
  - Passing on 2024 – 3 Min Deox / 5 Min Alodine - 336 Hours
  - Passing on 7075 – 840 Hours + (quit at 840)

- **Metalast TCP**
  - Not tested on 2219 or 7075
  - Passing on 2024 - Specialty 982 Deox / 3 Min Optimal – 168 Hours
  - Failed on 2024 - Nitric Acid Deox

- **Surtec 650 C**
  - Not tested on 2219 or 7075
  - Failed on 2024 – Not Expected - Specialty 982 Deox
  - Failed on 2024 – Nitric Acid Deox

# Process Optimization – Alodine 1200S 2024-T3 & 7075-T6

Solvent Hand Cleaning
Ethanol {200 proof}
Scotch-Brite Pad

→

Specialty 740 (9 oz/gal)
- Bath temperature - 140$^0$F (60$^o$C)
- Immersion time - 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

←

Specialty 982 (20% by volume)
- Bath temperature – 73$^o$F (23$^o$C)
- Immersion time:

1. 3 minutes
2. 3 minutes
3. 5 minutes

←

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

Alodine 1200S
Bath temperature - 73$^0$F (23$^o$C)
pH – 1.8
- Immersion time:

1. 2 minutes
2. 3 minutes
3. 3 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

# Process Optimization – Alodine 1200S

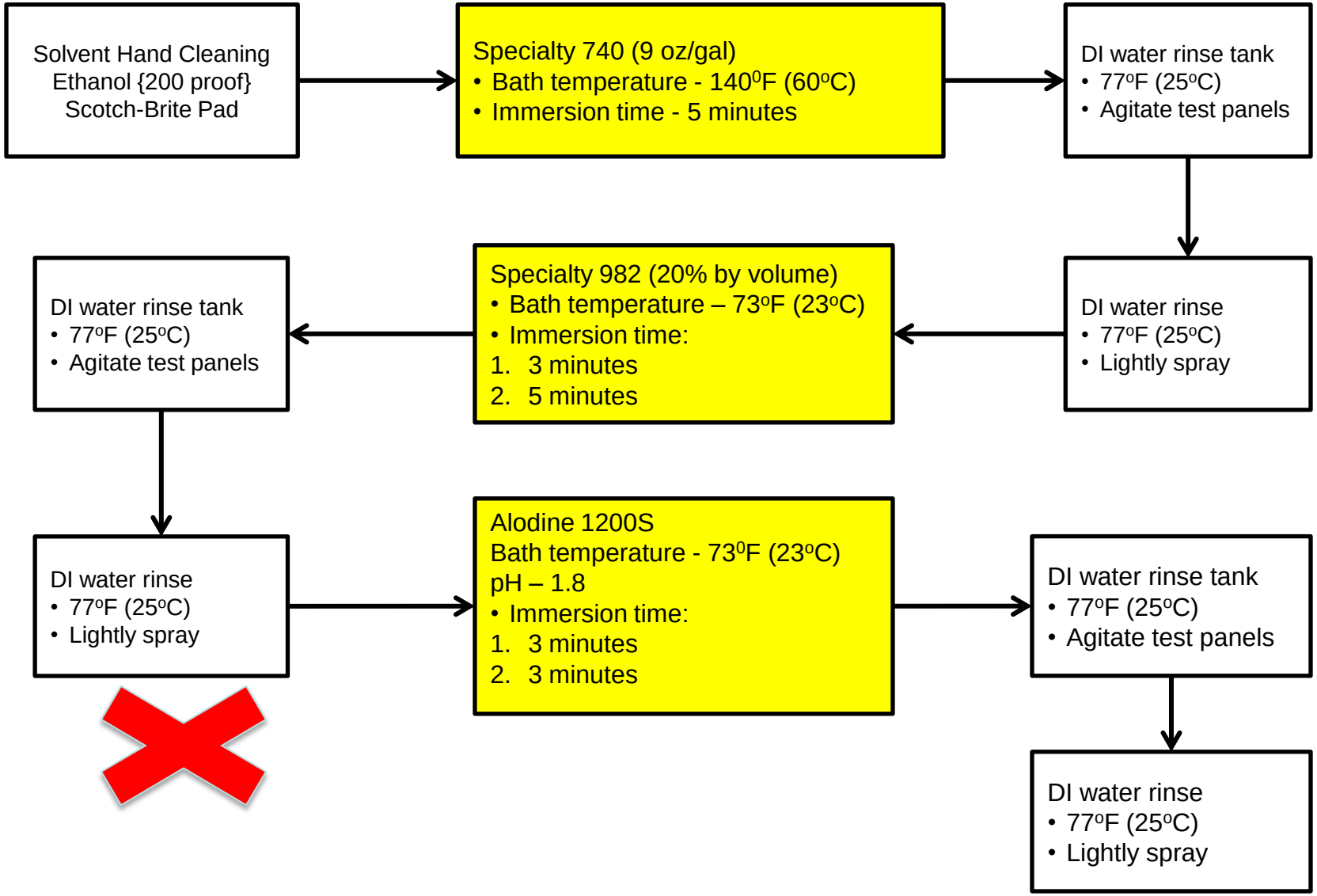
## 2024-T3

| Specialty 982 Deoxidizer | | | |
|---|---|---|---|
| 3 min de-ox / 2 min Alodine 1200S | ASTM B117 | | |
| | Pit Count 168 Hours | Pit Count 336 Hours | Pit Count 504 Hours |
| A20 100 | 5+ | N/A | N/A |
| A20 101 | 0 | 5+ | N/A |
| A20 102 | 5+ | N/A | N/A |
| 3 min de-ox / 3 min Alodine 1200S | ASTM B117 | | |
| | Pit Count 168 Hours | Pit Count 336 Hours | Pit Count 504 Hours |
| A20 012 | 1 | 5+ | N/A |
| A20 013 | 0 | 5+ | N/A |
| A20 014 | 0 | 5+ | N/A |
| 5 min de-ox / 3 min Alodine 1200S | ASTM B117 | | |
| | Pit Count 168 Hours | Pit Count 336 Hours | Pit Count 504 Hours |
| A20 002 | 0 | 1 | 5+ |
| A2[illegible] | 0 | 1 | 5+ |
| A20[illegible] | 0 | 1 | 5+ |

## 7075-T6

| Specialty 982 Deoxidizer | | | | | |
|---|---|---|---|---|---|
| 3 min de-ox / 2 min Alodine 1200S | ASTM B117 | | | | |
| | Pit Count 168 Hours | Pit Count 336 Hours | Pit Count 504 Hours | Pit Count 672 Hours | Pit Count 840 Hours |
| A7 004 | 0 | 0 | 0 | 2 | 0 |
| A7 005 | 0 | 0 | 0 | 0 | 0 |
| A7 006 | 0 | 0 | 0 | 0 | 0 |
| Pits observed are attributed to test panel damage, scratches and dings | | | | | |
| Testing stopped after 840 hours | | | | | |
| 3 min de-ox / 3 min Alodine 1200S | ASTM B117 | | | | |
| | Pit Count 168 Hours | Pit Count 336 Hours | Pit Count 504 Hours | Pit Count 672 Hours | Pit Count 840 Hours |
| A7 001 | 0 | 0 | 0 | 0 | 0 |
| A7 002 | 0 | 0 | 0 | 2 | 1 |
| A7 003 | 0 | 0 | 0 | 0 | 0 |
| Pits observed are attributed to test panel damage, scratches and dings | | | | | |
| Testing stopped after 840 hours | | | | | |
| 5 min de-ox / 3 min Alodine 1200S | ASTM B117 | | | | |
| | Pit Count 168 Hours | Pit Count 336 Hours | Pit Count 504 Hours | Pit Count 672 Hours | Pit Count 840 Hours |
| A7 013 | 0 | 0 | 0 | 2 | 0 |
| A7 014 | 0 | 0 | 0 | 0 | 0 |
| A7 015 | 0 | 0 | 0 | 2 | 0 |
| Testing stopped after 840 hours | | | | | |

# Process Optimization – Alodine 1200S 2219



# Process Optimization – Alodine 1200S

2219

| Specialty 982 Deoxidizer | | | |
|---|---|---|---|
| 3 min de-ox / 3 min Alodine 1200S | ASTM B117 | | |
| | Pit Count 168 Hours | Pit Count 336 Hours | Pit Count 504 Hours |
| 22 01 | 5 + | N/A | N/A |
| 22 02 | 5 + | N/A | N/A |
| 22 03 | 5 + | N/A | N/A |
| 5 min de-ox / 3 min Alodine 1200S | ASTM B117 | | |
| | Pit Count 168 Hours | Pit Count 336 Hours | Pit Count 504 Hours |
| 22 04 | 5 + | N/A | N/A |
| 22 05 | 5 + | N/A | N/A |
| 22 06 | 5 + | N/A | N/A |

# Process Optimization – hexavalent chrome-free alternatives – 2024-T3

Solvent Hand Cleaning
Ethanol {200 proof}
Scotch-Brite Pad

→

Chemetall-Oakite NST – (5% by volume)
- Bath temperature - 120ºF (49ºC)
- Immersion time - 4 minutes
- Stirred during test panel immersion

→

DI water rinse tank
- 77ºF (25ºC)
- Agitate test panels

↓

DI water rinse
- 77ºF (25ºC)
- Lightly spray

←

70% Nitric Acid/DI water = mixed 1:1
- Bath temperature – ambient
- Immersion time:

1. 1 minute
2. 2 minutes
3. 3 minutes

←

DI water rinse tank
- 77ºF (25ºC)
- Agitate test panels

↓

DI water rinse
- 77ºF (25ºC)
- Lightly spray

→

**Metalast HF**
**SurTec 650C**

→

DI water rinse tank
- 77ºF (25ºC)
- Agitate test panels

↓

DI water rinse
- 77ºF (25ºC)
- Lightly spray

# Process Optimization – hexavalent chrome-free alternatives – 2024-T3

| Metalast TCP-HF | ASTM B117 |
|---|---|
| 1 minute in deoxidizer | 168 Hours |
| M20 001 | 5+ |
| M20 002 | 5+ |
| M20 003 | 5+ |
| 2 minutes in deoxidizer | 168 Hours |
| M20 004 | 5+ |
| M20 005 | 5+ |
| M20 006 | 5+ |
| 3 minutes in deoxidizer | 168 Hours |
| M20 007 | 5+ |
| M20 008 | 5+ |
| M20 009 | 5+ |

| SurTec 650C | ASTM B117 |
|---|---|
| 1 minute in deoxidizer | 168 Hours |
| S20 001 | 5+ |
| S20 002 | 5+ |
| S20 003 | 5+ |
| 2 minutes in deoxidizer | 168 Hours |
| S20 004 | 5+ |
| S20 005 | 5+ |
| S20 006 | 5+ |
| 3 minutes in deoxidizer | 168 Hours |
| S20 007 | 5+ |
| S20 008 | 5+ |
| S20 009 | 5+ |

# Process Optimization – hexavalent chrome-free alternatives – 2024-T3

Solvent Hand Cleaning
Ethanol {200 proof}
Scotch-Brite Pad

→

Specialty 740 (9 oz/gal)
- Bath temperature - 140$^0$F (60$^o$C)
- Immersion time - 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

←

Specialty 982 (20% by volume)
- Bath temperature – 73$^o$F (23$^o$C)
- Immersion time:

1. 1 minute
2. 2 minutes
3. 3 minutes

←

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

**Metalast HF**
**SurTec 650C**

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

# Process Optimization – hexavalent chrome-free alternatives – 2024-T3

| Metalast TCP-HF | ASTM B117 | |
|---|---|---|
| 1 minute in deoxidizer | 168 Hours | 336 Hours |
| M20 010 | 1 | 5+ |
| M20 011 | 0 | 5+ |
| M20 012 | 5+ | N/A |
| 2 minutes in deoxidizer | 168 Hours | 336 Hours |
| M20 013 | 0 | 5+ |
| M20 014 | 5+ | N/A |
| M20 015 | 5+ | N/A |
| 3 minutes in deoxidizer | 168 Hours | 336 Hours |
| M20 016 | 3 | 5+ |
| [illegible] | 0 | 5+ |
| [illegible] | 1 | 5+ |

| SurTec 650C | ASTM B117 |
|---|---|
| 1 minute in deoxidizer | 168 Hours |
| S20 010 | 5+ |
| S20 011 | 5+ |
| S20 012 | 5+ |
| 2 minutes in deoxidizer | 168 Hours |
| S20 013 | 5+ |
| S20 014 | 5+ |
| S20 015 | 5+ |
| 3 minutes in deoxidizer | 168 Hours |
| S20 016 | 5+ |
| S20 017 | 5+ |
| S20 018 | 5+ |

# Test Panel Preparation Process Optimization

## Round 2

Substrates: 2024 / 5052 / 6061
Cleaning: MEK

# Test Panel Preparation Process Optimization

- Changing initial solvent cleaning process
  - Replace ethanol (200 proof) to methyl ethyl ketone (MEK)
- Eliminating the use of Scotch-Brite pads
- Eliminated Nitric Acid Deoxidizer
- Alloys:
  - 2024-T3
  - 5052-H32 (ADDED AS PART OF GSDOP)
  - 6061-T6 (ADDED AS PART OF GSDOP)

# Process Optimization

**RESULTS:**

- **Alodine 1200S**
  - Failed on 2024 - Not Expected – (<168 Hours)
  - Passed on 5052 – Expected - 336 Hours
  - Failed on 6061 – Not Expected – (<168 Hours)

- **Metalast TCP**
  - Some Passed on 2024 – Dried Before TCP Added – 168 Hours
  - Passed on 5052 – Expected 504 Hours + (quit test)
  - Passed on 6061 – Expected 504 Hours + (quit test)

- **Surtec 650 C**
  - Skipped Testing for this Round – Tested in Round 4

# Process Optimization – Alodine 1200S

Methyl Ethyl Ketone
Brushed applied

→

Specialty 740 (9 oz/gal)
- Bath temperature - 140$^0$F (60$^o$C)
- Immersion time - 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

Specialty 982 (20% by volume)
- Bath temperature – 73$^o$F (23$^o$C)
- Immersion time:
- 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

Alodine 1200S
Bath temperature - 73$^0$F (23$^o$C)
pH – 1.8
- Immersion time:
- 3 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

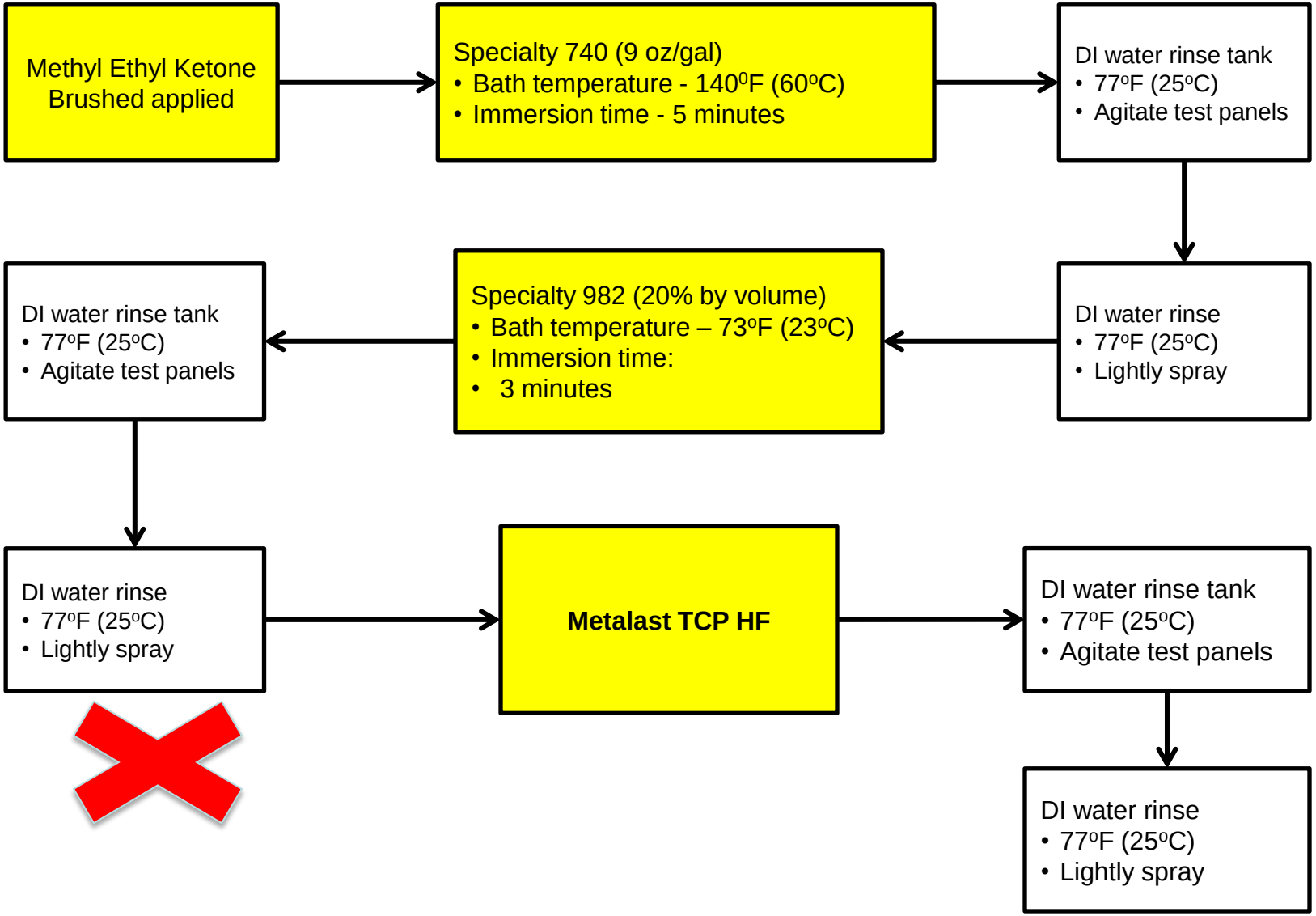
# Alodine 1200S

| 2024-T3 | |
|---|---|
| Specialty 982 Deoxidizer | |
| 5 min de-ox / 3 min Alodine 1200S | ASTM B117 Pit Count 168 Hours |
| Al2024 01 | 5+ |
| Al2024 02 | 5+ |
| Al2024 03 | 5+ |
| Al2024 04 | 5+ |
| Al2024 05 | 5+ |
| Average Coating Weight 72 | |

| 5052-H32 | | | |
|---|---|---|---|
| Specialty 982 Deoxidizer | | | |
| 5 min de-ox / 3 min Alodine 1200S | ASTM B117 | | |
| | Pit Count 168 Hours | Pit Count 336 Hours | Pit Count 504 Hours |
| Al5052 01 | 0 | 0 | 5 |
| Al5052 02 | 0 | 0 | 3 |
| Al5052 03 | 0 | 0 | 1 |
| Al5052 04 | 0 | 0 | 2 |
| Al5052 05 | 0 | 0 | 2 |

| 6061-T6 | |
|---|---|
| Specialty 982 Deoxidizer | |
| 5 min de-ox / 3 min Alodine 1200S | ASTM B117 Pit Count 168 Hours |
| Al6061 01 | 5+ |
| Al6061 02 | 5+ |
| Al6061 03 | 5+ |
| Al6061 04 | 5+ |
| Al6061 05 | 5+ |

# Process Optimization – Metalast TCP HF



# Metalast TCP HF

| 2024-T3 | |
|---|---|
| Specialty 982 Deoxidizer | |
| 3 min de-ox / 4 min Metalast | ASTM B117 |
| | Pit Count 168 Hours |
| M20 01 | 5 |
| M20 02 | 5+ |
| M20 03 | 5+ |
| M20 04 | 5+ |
| M20 05 | 5+ |
| Test panels allowed to dry prior to pretreatment | |

| 2024-T3 | | |
|---|---|---|
| Specialty 982 Deoxidizer | | |
| 3 min de-ox / 4 min Metalast | ASTM B117 | |
| | Pit Count 168 Hours | Pit Count 336 Hours |
| M2024 06 | 0 | 5+ |
| M2024 07 | 1 | 5+ |
| M2024 08 | 5+ | 5+ |
| M2024 09 | 5 | 5+ |
| M2024 10 | 1 | 5+ |

| 5052-H32 | | | |
|---|---|---|---|
| Specialty 982 Deoxidizer | | | |
| 3 min de-ox / 4 min Metalast | ASTM B117 | | |
| | Pit Count 168 Hours | Pit Count 336 Hours | Pit Count 504 Hours |
| M50 01 | 0 | 0 | 0 |
| M50 02 | 0 | 0 | 0 |
| M50 03 | 0 | 0 | 0 |
| M50 04 | 0 | 0 | 0 |
| M50 05 | 0 | 0 | 0 |

| 6061-T6 | | | |
|---|---|---|---|
| Specialty 982 Deoxidizer | | | |
| 3 min de-ox / 4 min Metalast | ASTM B117 | | |
| | Pit Count 168 Hours | Pit Count 336 Hours | Pit Count 504 Hours |
| M60 01 | 0 | 0 | 0 |
| M60 02 | 0 | 0 | 0 |
| M60 03 | 0 | 0 | 0 |
| M60 04 | 0 | 0 | 0 |
| M60 05 | 0 | 0 | 0 |

# Test Panel Preparation Process Optimization

## Round 3

Substrates: 2024 / 5052/ 6061 / 7075
Cleaning: Acetone

# Test Panel Preparation Process Optimization

- Used on two sets of test panels processed at different times (Part of 3 Projects)
- Changing initial solvent cleaning process
  - Replace methyl ethyl ketone (MEK) with Acetone
- Adjust concentration and pH of Alodine 1200S
- Modify SurTec 650C process

# Process Optimization

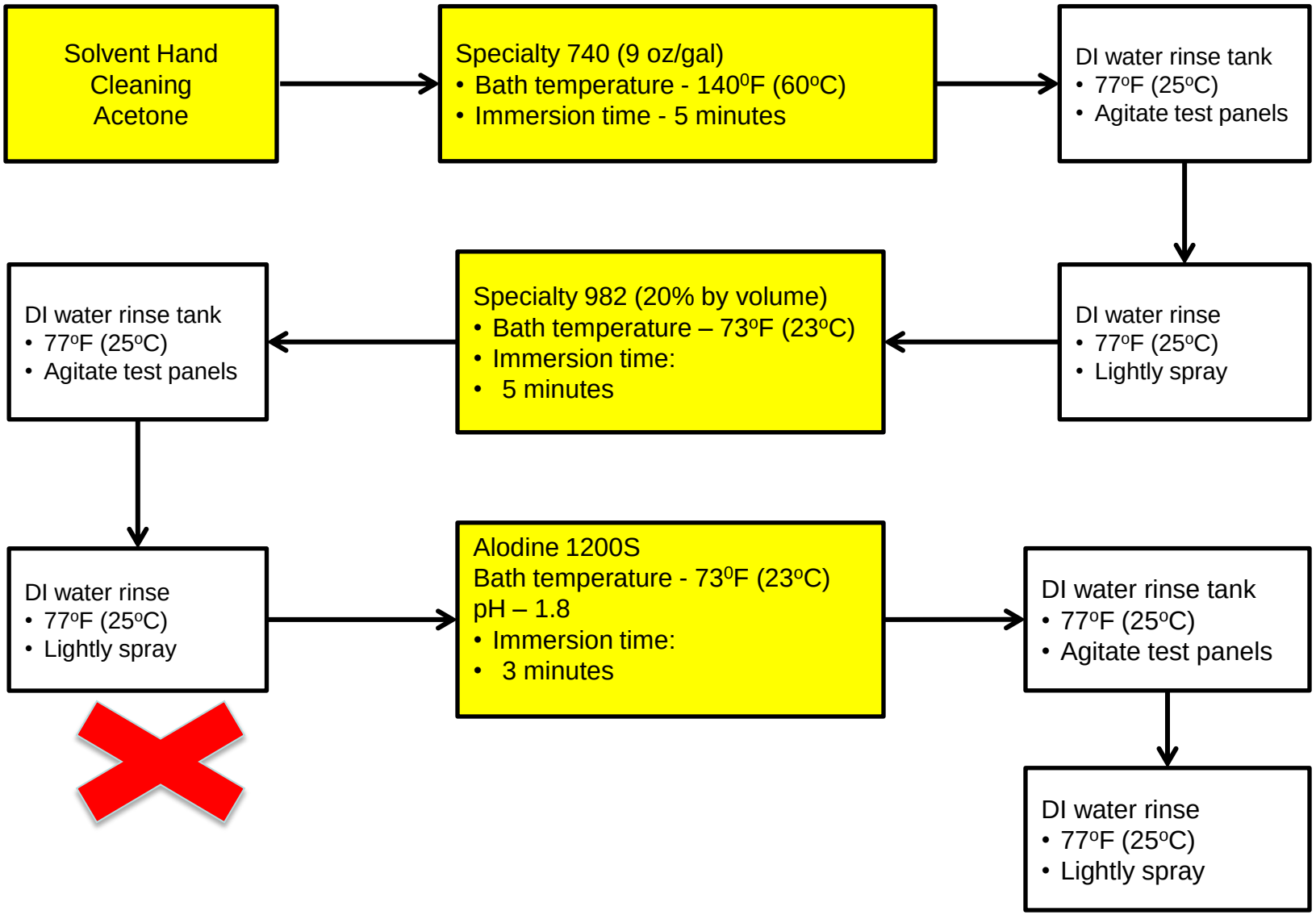
**RESULTS:**

- **Alodine 1200S**
  - Some Passed on 2024 – 168 Hours
  - Some Passed on 6061 – 672 Hours + (quit test)
  - Passed on 7075 – 672 Hours + (quit test)
  - Passed on 5052/6061 – 672 Hours + (quit test) - GSDOP

- **Metalast TCP**
  - Failed on 2024 – (<168 Hours)
  - Passed on 6061 – 672 Hours + (quit test)
  - Passed on 7075 – 672 Hours + (quit test)
  - Passed on 5052/6061 – 672 Hours + (quit test) - GSDOP

- **Surtec 650 C (2 Deox Times)**
  - Failed on 2024 – (<168 Hours)
  - Passed on 6061 – 672 Hours + (quit test)
  - Passed on 7075 – 672 Hours + (quit test)
  - Passed on 5052 – 168 Hours – GSDOP
  - Passed on 6061 – 672 Hours - GSDOP

# Process Optimization – Alodine 1200S



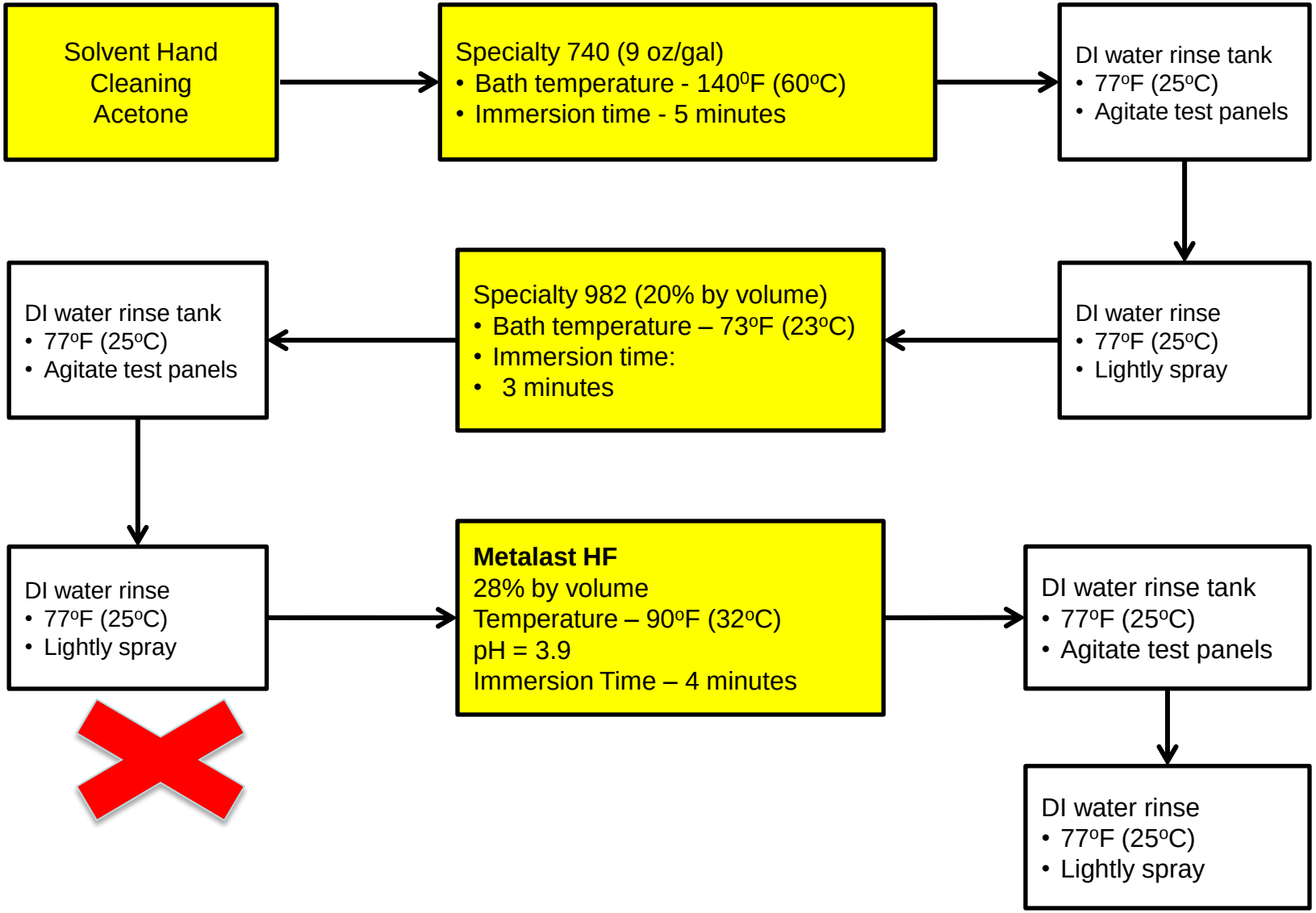
# Alodine 1200S

| 2024-T3 | @ 168 Hr | @ 336 Hr |
|---|---|---|
| 1200S 20 01 | 5+ | N/A |
| 1200S 20 02 | 3 | 5+ |
| 1200S 20 03 | 4 | 5+ |

| 6061-T6 | @ 168 Hr | @ 336 Hr | @ 504 | @ 672 | Total |
|---|---|---|---|---|---|
| 1200S 60 01 | 2 | 0 | 0 | 0 | 2 |
| 1200S 60 02 | 5+ | N/A | N/A | N/A | 5+ |
| 1200S 60 03 | 2 | 2 | 2 | 2 | 8 |

| 7075-T6 | @ 168 Hr | @ 336 Hr | @ 504 | @ 672 | Total |
|---|---|---|---|---|---|
| 1200S 70 01 | 0 | 1 | 1 | 2 | 4 |
| 1200S 70 02 | 0 | 0 | 0 | 0 | 0 |
| 1200S 70 03 | 1 | 1 | 2 | 2 | 6 |

# Process Optimization – Metalast TCP HF



# Metalast TCP HF

| 2024-T3 | @ 168 Hr | @ 336 Hr |
|---|---|---|
| MTL 20 01 | 5+ | N/A |
| MTL 20 02 | 5+ | N/A |
| MTL 20 03 | 5+ | N/A |

| 6061-T6 | @ 168 Hr | @ 336 Hr | @ 504 | @ 672 | Total |
|---|---|---|---|---|---|
| MTL 60 01 | 0 | 0 | 0 | 0 | 0 |
| MTL 60 02 | 0 | 0 | 0 | 0 | 0 |
| MTL 60 03 | 0 | 0 | 0 | 0 | 0 |

| 7075-T6 | @ 168 Hr | @ 336 Hr | @ 504 | @ 672 | Total |
|---|---|---|---|---|---|
| MTL 70 01 | 0 | 0 | 0 | 0 | 0 |
| MTL 70 02 | 0 | 0 | 0 | 0 | 0 |
| MTL 70 03 | 0 | 1 | 1 | 0 | 2 |

# Process Optimization – SurTec 650C

Solvent Hand Cleaning Acetone

→

Specialty 740 (9 oz/gal)
- Bath temperature - 140$^0$F (60$^o$C)
- Immersion time - 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

Specialty 982 (20% by volume)
- Bath temperature – 73$^o$F (23$^o$C)
- Immersion time:
- 15 seconds – 2024-T3 only
- 3 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

**SurTec 650C**
25% by volume
Temperature – 90$^o$F (32$^o$C)
pH = 3.95
Immersion Time – 4 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

# SurTec 650C

| 2024-T3 | @ 168 Hr | @ 336 Hr |
|---|---|---|
| ST 20 01-15 | 5+ | N/A |
| ST 20 02-15 | 5+ | N/A |
| ST 20 03-15 | 5+ | N/A |

| 2024-T3 | @ 168 Hr | @ 336 Hr |
|---|---|---|
| ST 20 01 | 5+ | N/A |
| ST 20 02 | 5+ | N/A |
| ST 20 03 | 5+ | N/A |

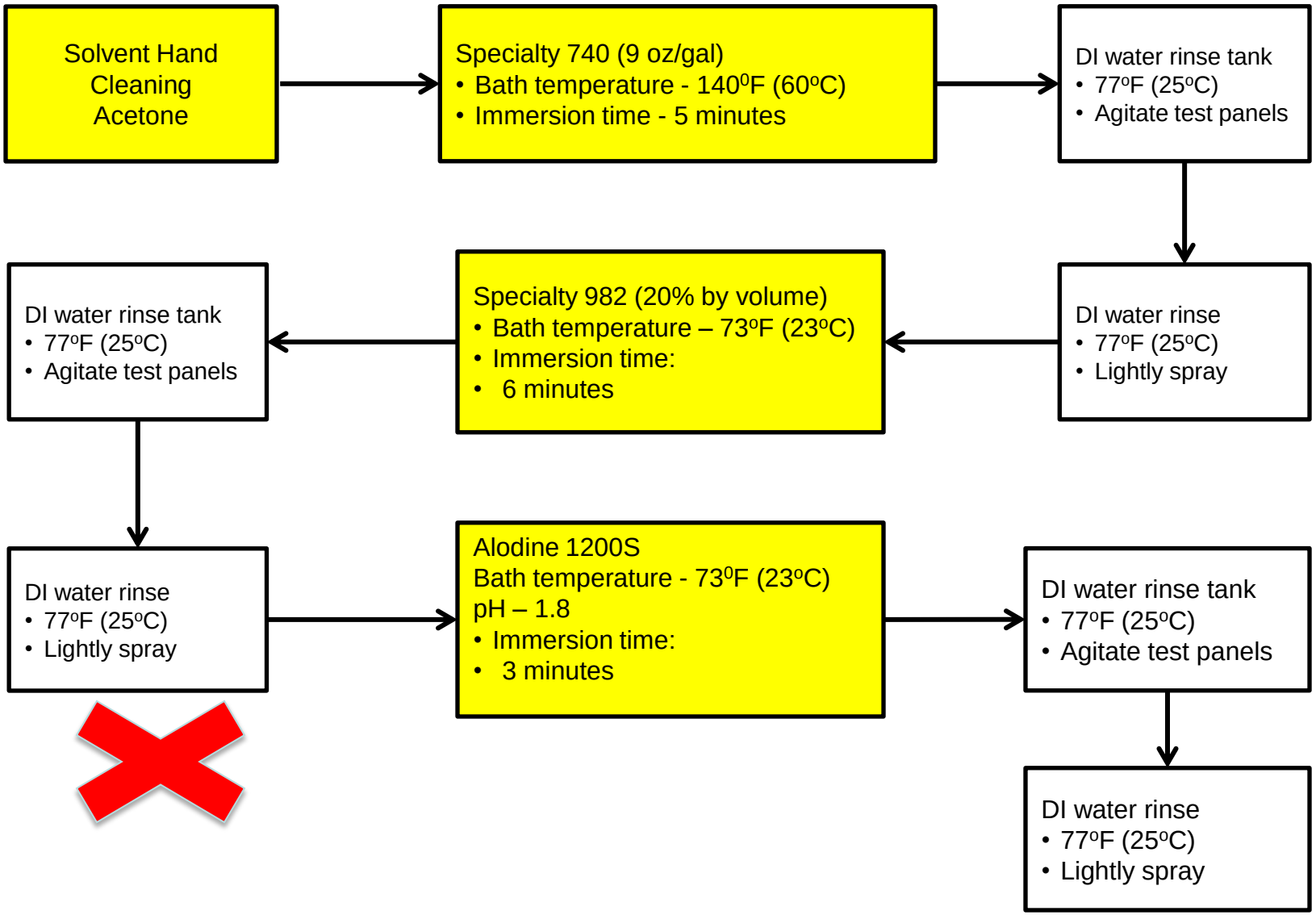
| 6061-T6 | @ 168 Hr | @ 336 Hr | @ 504 | @ 672 | Total |
|---|---|---|---|---|---|
| ST 60 01 | 0 | 0 | 0 | 0 | 0 |
| ST 60 02 | 0 | 0 | 0 | 0 | 0 |
| ST 60 03 | 0 | 0 | 0 | 0 | 0 |

| 7075-T6 | @ 168 Hr | @ 336 Hr | @ 504 | @ 672 | Total |
|---|---|---|---|---|---|
| ST 70 01 | 0 | 1 | 0 | 0 | 1 |
| ST 70 02 | 0 | 0 | 0 | 0 | 0 |
| ST 70 03 | 0 | 1 | 0 | 0 | 1 |

# Test Panel Preparation Process Optimization

- Used on two sets of test panels processed at different times

# Process Optimization – Alodine 1200S

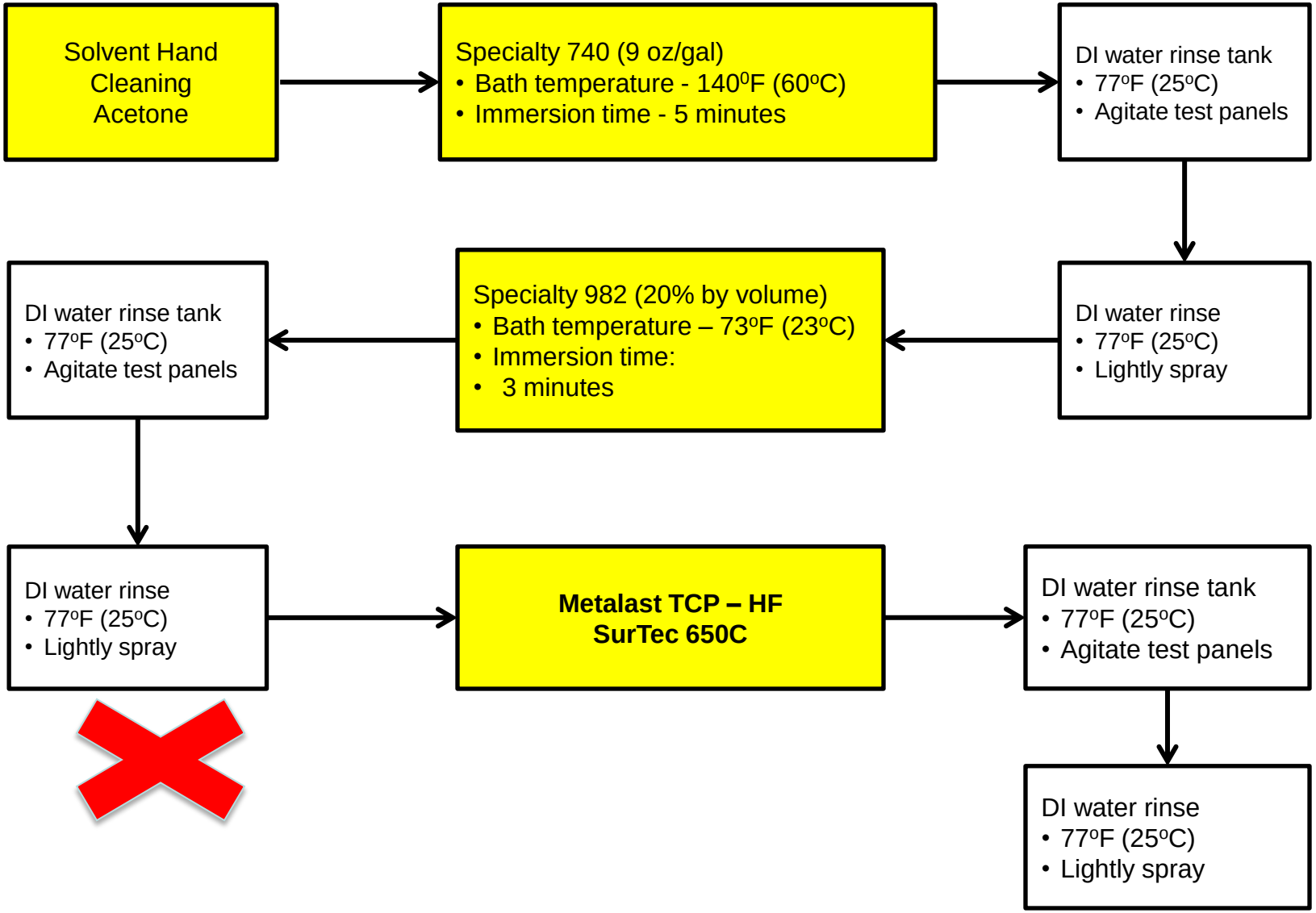


# Alodine 1200S

| Pretreatment | Panel # | Substrate | @168 | @336 | @504 | @672 | Total |
|---|---|---|---|---|---|---|---|
| Alodine 1200S | Al 50 - 004 | 5052-H32 | 0 | 0 | 0 | 1 | 1 |
| Alodine 1200S | Al 50 - 005 | 5052-H32 | 0 | 0 | 0 | 0 | 0 |
| Alodine 1200S | Al 50 - 006 | 5052-H32 | 0 | 0 | 0 | 1 | 1 |

| Pretreatment | Panel # | Substrate | @168 | @336 | @504 | @672 | Total |
|---|---|---|---|---|---|---|---|
| Alodine 1200S | Al 60 - 004 | 6061-T6 | 1 | 3 | 0 | 0 | 4 |
| Alodine 1200S | Al 60 - 005 | 6061-T6 | 2 | 3 | 0 | 0 | 5 |
| Alodine 1200S | Al 60 - 006 | 6061-T6 | 1 | 0 | 0 | 0 | 1 |

# Process Optimization – hexavalent chrome-free alternatives



# Metalast TCP HF

| Pretreatment | Panel # | Substrate | @168 | @336 | @504 | @672 | Total |
|---|---|---|---|---|---|---|---|
| Metalast TCP HF | M 50 - 004 | 5052-H32 | 0 | 0 | 1 | 1 | 2 |
| Metalast TCP HF | M 50 - 005 | 5052-H32 | 0 | 0 | 0 | 0 | 0 |
| Metalast TCP HF | M 50 - 006 | 5052-H32 | 0 | 0 | 0 | 0 | 0 |

| Pretreatment | Panel # | Substrate | @168 | @336 | @504 | @672 | Total |
|---|---|---|---|---|---|---|---|
| Metalast TCP HF | M 60 - 004 | 6061-T6 | 1 | 1 | 0 | 1 | 3 |
| Metalast TCP HF | M 60 - 005 | 6061-T6 | 2 | 0 | 0 | 1 | 3 |
| Metalast TCP HF | M 60 - 006 | 6061-T6 | 2 | 0 | 3 | 0 | 5 |

# SurTec 650C

| Pretreatment | Panel # | Substrate | @168 | @336 | Total |
|---|---|---|---|---|---|
| SurTec 650C | S 50 - 004 | 5052-H32 | 0 | 9 | 9 |
| SurTec 650C | S 50 - 005 | 5052-H32 | 0 | 15 | 15 |
| SurTec 650C | S 50 - 006 | 5052-H32 | 0 | 10 | 10 |

| Pretreatment | Panel # | Substrate | @168 | @336 | @504 | @672 | Total |
|---|---|---|---|---|---|---|---|
| SurTec 650C | S 60 - 004 | 6061-T6 | 0 | 0 | 0 | 2 | 2 |
| SurTec 650C | S 60 - 005 | 6061-T6 | 0 | 0 | 0 | 0 | 0 |
| SurTec 650C | S 60 - 006 | 6061-T6 | 0 | 0 | 0 | 1 | 1 |

# Test Panel Preparation Process Optimization

## Round 4

Substrates: 2024 / 2219 / 6061 / 7075
Cleaning: Acetone

# Test Panel Preparation Process Optimization

- Changing deoxidizer to an iron free based deoxidizer
  - {Metalast Deox 3300(A)}
- Using new batch of Alodine 1200S
- Using new batch of Metalast HF with HPA-100 additive
- Using Alodine 5923 plus, from Henkel Europe

# Process Optimization – Alodine 1200S

Solvent Hand Cleaning Acetone

→

Specialty 740 (9 oz/gal)
- Bath temperature - 140$^0$F (60$^o$C)
- Immersion time - 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

←

Deox 3300(A) @ 45 grams/liter with 25% by volume nitric acid
- Ambient
- Set 1 – 30 seconds
- Set 2 – 3 minutes

←

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

Alodine 1200S
Bath temperature - 73$^0$F (23$^o$C)
pH – 1.8
- Immersion time:
- 3 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

# Process Optimization – Metalast TCP HF HPA-100

Solvent Hand Cleaning Acetone

→

Specialty 740 (9 oz/gal)
- Bath temperature - 140$^0$F (60$^o$C)
- Immersion time - 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

←

Deox 3300(A) @ 45 grams/liter with 25% by volume nitric acid
- Ambient
- Set 1 – 30 seconds
- Set 2 – 3 minutes

←

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

**Metalast TCP – HF : HPA-100**
30% v/v + 30% v/v
- 80$^o$F (27$^o$C)
- pH – 3.6
- 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

# Process Optimization – SurTec 650C

Solvent Hand Cleaning Acetone

→

Specialty 740 (9 oz/gal)
- Bath temperature - 140$^0$F (60$^o$C)
- Immersion time - 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

←

Deox 3300(A) @ 45 grams/liter with 25% by volume nitric acid
- Ambient
- Set 1 – 30 seconds
- Set 2 – 3 minutes

←

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

**SurTec 650C**
- 25% by volume
- 90$^o$F (32$^o$C)
- pH – 3.8
- 4 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

# Process Optimization – Alodine 5923 plus

Solvent Hand Cleaning Acetone

→

Specialty 740 (9 oz/gal)
- Bath temperature - 140$^0$F (60$^o$C)
- Immersion time - 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

←

Deox 3300(A) @ 45 grams/liter with 25% by volume nitric acid
- Ambient
- Set 1 – 30 seconds
- Set 2 – 3 minutes

←

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

**Alodine 5923 plus**
- Ready To Use
- Ambient
- 8 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

# Process Optimization

**RESULTS:**

- **Alodine 1200S**
  - Passed on 2024 / 6061 / 7075 – 336 Hours
  - Failed on 2219 – (<168 Hours)
- **Metalast TCP + Additive**
  - Some Pass on 2024 – 168 Hours
  - Passed on 6061 / 7075 – 504 Hours
  - Failed on 2219 – (<168 Hours)
- **Surtec 650 C**
  - Failed on 2024 – (<168 Hours)
  - Passed on 6061 – 336 Hours
  - Passed on 7075 – 504 Hours
  - Failed on 2219 – (<168 Hours)
- **Alodine 5923 Plus**
  - Some Passed on 2024 – 168 Hours
  - Passed on 6061 / 7075 – 504 Hours
  - Failed on 2219 – (<168 Hours)

# Overall Summary

| Process 3 | | | | | | |
|---|---|---|---|---|---|---|
| | | | Hours | | | |
| Pretreatment | Alloy | De-ox | 168 | 336 | 504 | 672 |
| Alodine 1200S | 2024-T3 | 30 | | | | |
| | | 180 | | | | |
| | 2219 | 30 | | | | |
| | | 180 | | | | |
| | 6061-T6 | 30 | | | | |
| | | 180 | | | | |
| | 7075-T6 | 30 | | | | |
| | | 180 | | | | |
| Alodine 5923 plus | 2024-T3 | 30 | | | | |
| | | 180 | | | | |
| | 2219 | 30 | | | | |
| | | 180 | | | | |
| | 6061-T6 | 30 | | | | |
| | | 180 | | | | |
| | 7075-T6 | 30 | | | | |
| | | 180 | | | | |
| Metalast HF HPA-100 | 2024-T3 | 30 | | | | |
| | | 180 | | | | |
| | 2219 | 30 | | | | |
| | | 180 | | | | |
| | 6061-T6 | 30 | | | | |
| | | 180 | | | | |
| | 7075-T6 | 30 | | | | |
| | | 180 | | | | |
| SurTec 650C | 2024-T3 | 30 | | | | |
| | | 180 | | | | |
| | 2219 | 30 | | | | |
| | | 180 | | | | |
| | 6061-T6 | 30 | | | | |
| | | 180 | | | | |
| | 7075-T6 | 30 | | | | |
| | | 180 | | | | |

Green - all panels had fewer than 5 pits
Yellow/Orange - some panels failed
Red - all panels failed

# Test Panel Preparation Process Optimization

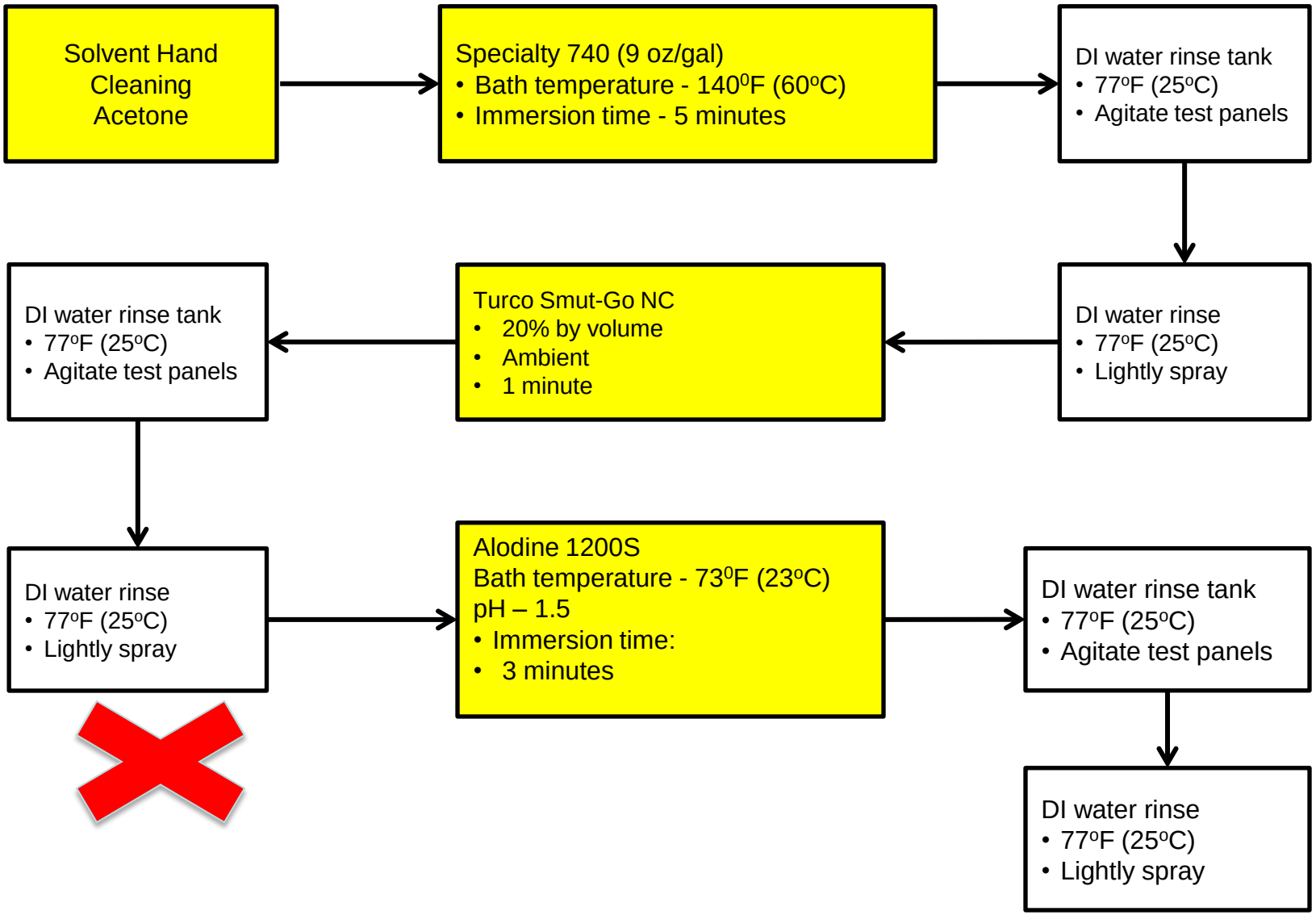
# Round 5A

Substrates: 2024 / 5052 / 6061 / 7075
Cleaning: Acetone

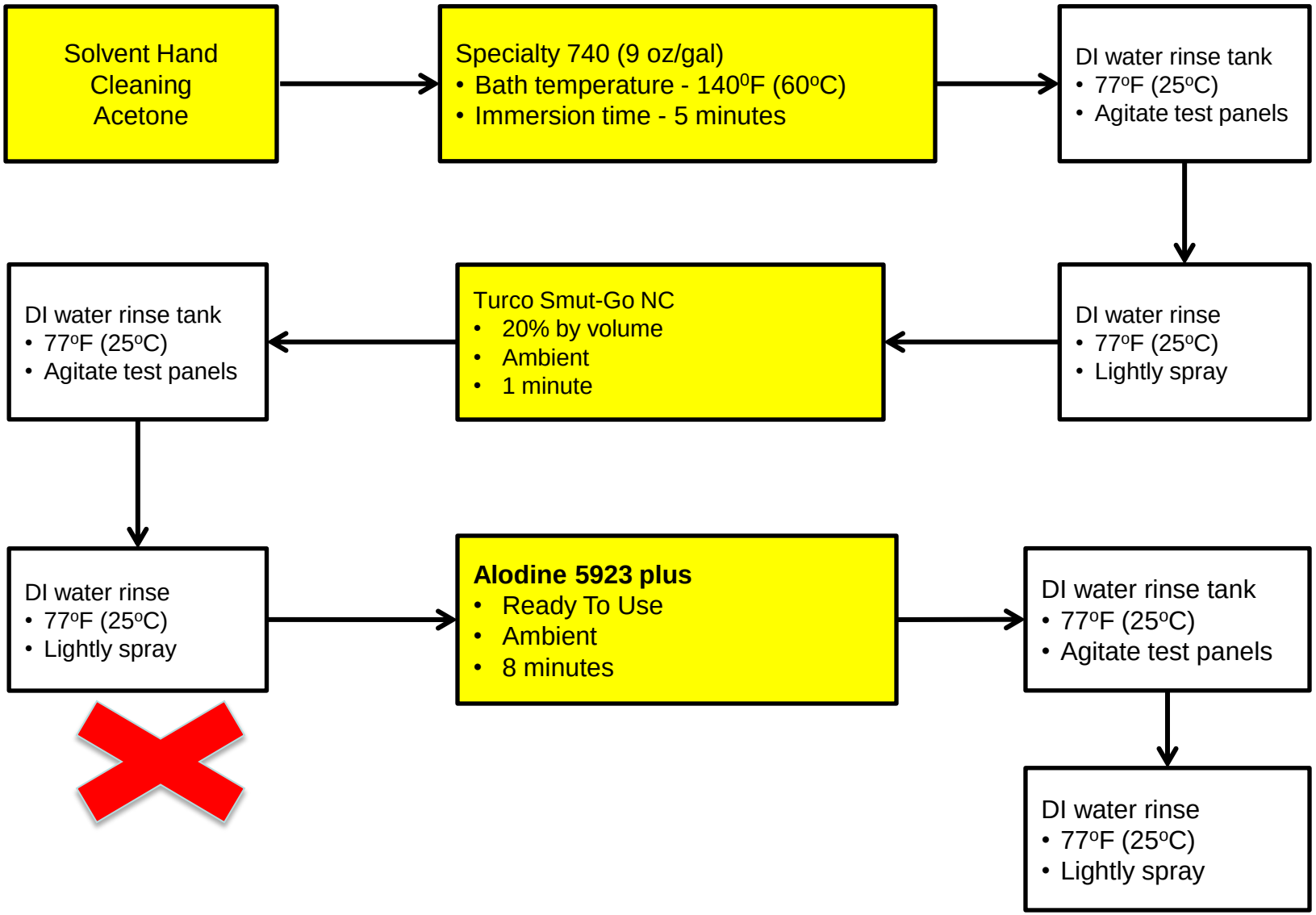
# Test Panel Preparation Process Optimization

- Changing deoxidizer to Turco Smut-Go NC
  - Unable to acquire material at KSC prior to this
- Using SurTec 650V and 650C
  - Based on Navy Testing
- Dropped 2219
- Added 5052 (GSDOP)

# Process Optimization – Alodine 1200S



# Process Optimization – Alodine 5923 plus



# Process Optimization – Metalast TCP HF HPA-100

Solvent Hand Cleaning Acetone

→

Specialty 740 (9 oz/gal)
- Bath temperature - 140$^0$F (60$^o$C)
- Immersion time - 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

←

Turco Smut-Go NC
- 20% by volume
- Ambient
- 1 minute

←

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

**Metalast TCP – HF : HPA-100**
30% v/v + 30% v/v
- 80$^o$F (27$^o$C)
- pH – 3.6
- 5 minutes

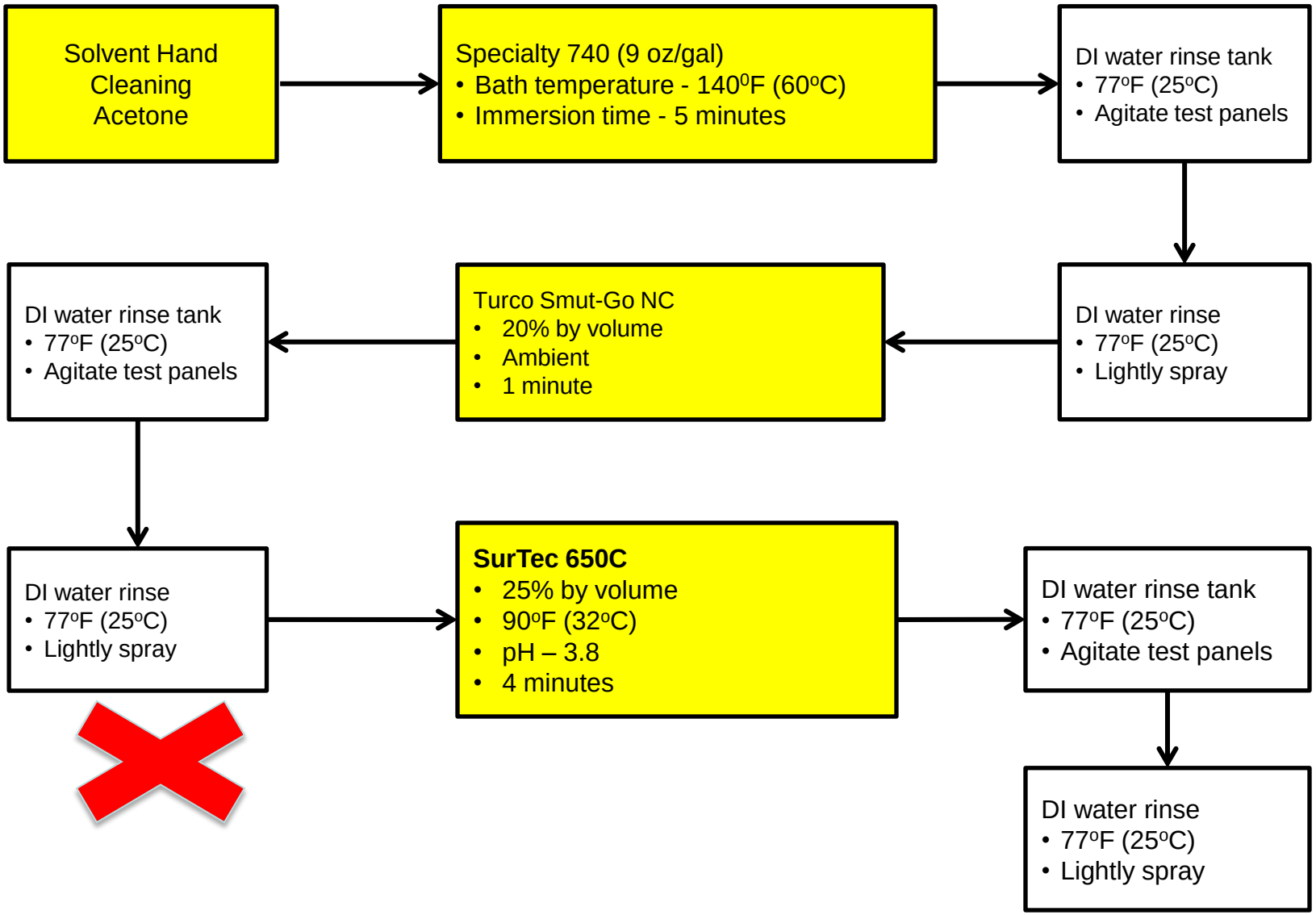
→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

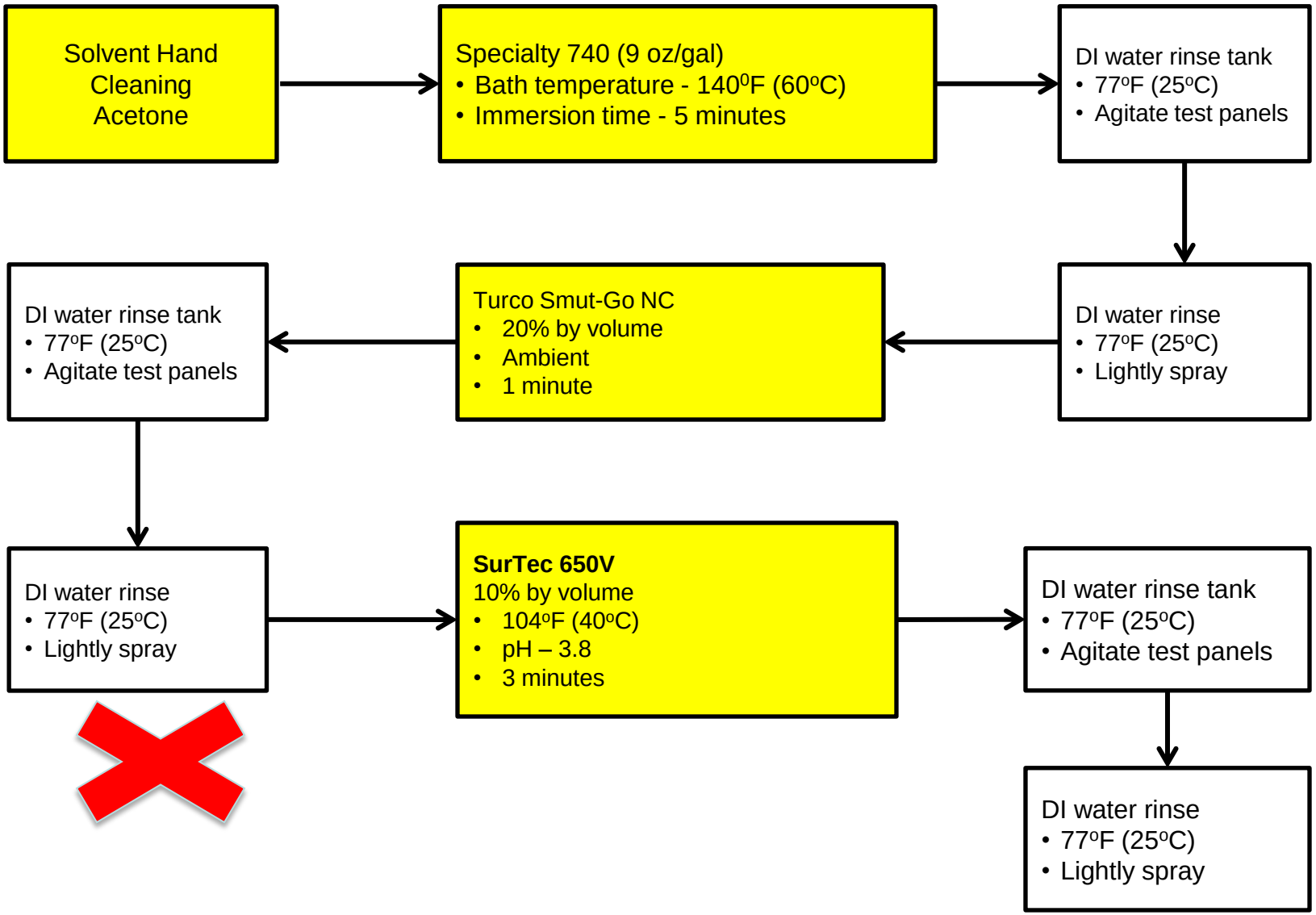
↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

# Process Optimization – SurTec 650C



# Process Optimization – SurTec 650V



# Process Optimization

**RESULTS:**

- **Alodine 1200S**
  - Failed on 2024 – (<168 Hours)
  - Passed on 5052 – 504+ Hours
  - Passed on 6061 – 336+ Hours
  - Passed on 7075 – 336 Hours
- **Metalast TCP + Additive**
  - Failed on 2024 – (<168 Hours)
  - Passed on 5052 – 672 Hours (quit)
  - Passed on 6061 – 672 Hours (quit)
  - Passed on 7075 – 504 Hours
- **Surtec 650 C**
  - Some Passed on 2024 – 168 Hours
  - Passed on 5052 – 672 Hours (quit)
  - Passed on 6061 – 672 Hours (quit)
  - Passed on 7075 – 504 Hours
- **Surtec 650 V**
  - Passed on 2024 – 336+ Hours
  - Passed on 5052 - 672 Hours (quit)
  - Passed on 6061 - 672 Hours (quit)
  - Passed on 7075 - 672 Hours (quit)
- **Alodine 5923 Plus**
  - Failed on 2024 – (<168 Hours)
  - Passed on 5052 – 672 Hours (quit)
  - Passed on 6061 – 672 Hours (quit)
  - Passed on 7075 – 672 Hours (quit)

# Overall Summary

| Process 4 | | | | | |
|---|---|---|---|---|---|
| | | Hours | | | |
| Pretreatment | Alloy | 168 | 336 | 504 | 672 |
| Alodine 1200S | 2024-T3 | Red | Red | Red | Red |
| | 5052-H32 | Green | Green | Green | Yellow |
| | 6061-T6 | Green | Green | Yellow | Red |
| | 7075-T6 | Green | Green | Red | Red |
| Alodine 5923 plus | 2024-T3 | Red | Red | Red | Red |
| | 5052-H32 | Green | Green | Green | Red |
| | 6061-T6 | Green | Green | Green | Red |
| | 7075-T6 | Green | Green | Green | Red |
| Metalast HF HPA-100 | 2024-T3 | Red | Red | Red | Red |
| | 5052-H32 | Green | Green | Green | Green |
| | 6061-T6 | Green | Green | Green | Green |
| | 7075-T6 | Green | Green | Green | Red |
| SurTec 650C | 2024-T3 | Yellow | Red | Red | Red |
| | 5052-H32 | Green | Green | Green | Green |
| | 6061-T6 | Green | Green | Green | Green |
| | 7075-T6 | Green | Green | Green | Red |
| SurTec 650V | 2024-T3 | Green | Green | Yellow | Red |
| | 5052-H32 | Green | Green | Green | Green |
| | 6061-T6 | Green | Green | Green | Green |
| | 7075-T6 | Green | Green | Green | Green |

Green - all panels had fewer than 5 pits

Yellow/Orange - some panels failed

Red - all panels failed

# Test Panel Preparation Process Optimization

# Round 5B

Substrates: 2024
Cleaning: Acetone

# Test Panel Preparation Process Optimization

- Changing deoxidizer times for Turco Smut-Go NC
  - Brackets around previous Round (60 seconds)
  - 0s, 10s, 30s, 120s
- Only evaluating 2024-T3
- Removed Alodine 1200S
- Removed Surtec 650 C

# Process Optimization – Alodine 5923 plus

Solvent Hand Cleaning Acetone

→

Specialty 740 (9 oz/gal)
- Bath temperature - 140$^0$F (60$^o$C)
- Immersion time - 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

←

Turco Smut-Go NC
- 20% by volume
- Ambient
- Immersion Time:
- 0
- 10 seconds
- 30 seconds
- 2 minutes

←

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

**Alodine 5923 plus**
- Ready To Use
- Ambient
- 8 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

# Process Optimization – Metalast TCP HF HPA-100

Solvent Hand Cleaning Acetone

→

Specialty 740 (9 oz/gal)
- Bath temperature - 140$^0$F (60$^o$C)
- Immersion time - 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

←

Turco Smut-Go NC
- 20% by volume
- Ambient
- Immersion Time:
- 0
- 10 seconds
- 30 seconds
- 2 minutes

←

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

**Metalast TCP – HF : HPA-100**
30% v/v + 30% v/v
- 80$^o$F (27$^o$C)
- pH – 3.6
- 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

# Process Optimization – SurTec 650V

Solvent Hand Cleaning Acetone

→

Specialty 740 (9 oz/gal)
- Bath temperature - 140$^0$F (60$^o$C)
- Immersion time - 5 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

←

Turco Smut-Go NC
- 20% by volume
- Ambient
- Immersion Time:
- 0
- 10 seconds
- 30 seconds
- 2 minutes

←

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

→

**SurTec 650V**
10% by volume
- 104$^o$F (40$^o$C)
- pH – 3.8
- 3 minutes

→

DI water rinse tank
- 77$^o$F (25$^o$C)
- Agitate test panels

↓

DI water rinse
- 77$^o$F (25$^o$C)
- Lightly spray

# Process Optimization

**RESULTS:**

- **Alodine 5923 Plus**
  - Failed on 2024 – all deox times

- **Metalast TCP + Additive**
  - Failed on 2024 – all deox times

- **Surtec 650 V**
  - Some Passed on 2024 – 168 Hours (0s)
  - Passed on 2024 – 336 Hours (10s)
  - Some Passed on 2024 – 336 Hours (30s, 120s)

# Overall Summary

| Process 5 on 2024-T3 only | | | | | |
|---|---|---|---|---|---|
| Pretreatment | De-ox | Hours | | | |
| | | 168 | 336 | 504 | 672 |
| Alodine 5923 plus | 0 | | | | |
| | 10 | | | | |
| | 30 | | | | |
| | 120 | | | | |
| Metalast HF HPA-100 | 0 | | | | |
| | 10 | | | | |
| | 30 | | | | |
| | 120 | | | | |
| SurTec 650V | 0 | | | | |
| | 10 | | | | |
| | 30 | | | | |
| | 120 | | | | |

Green - all panels had fewer than 5 pits

Yellow/Orange - some panels failed

Red - all panels failed

Black - data not collected

# Test Panel Preparation Process Optimization

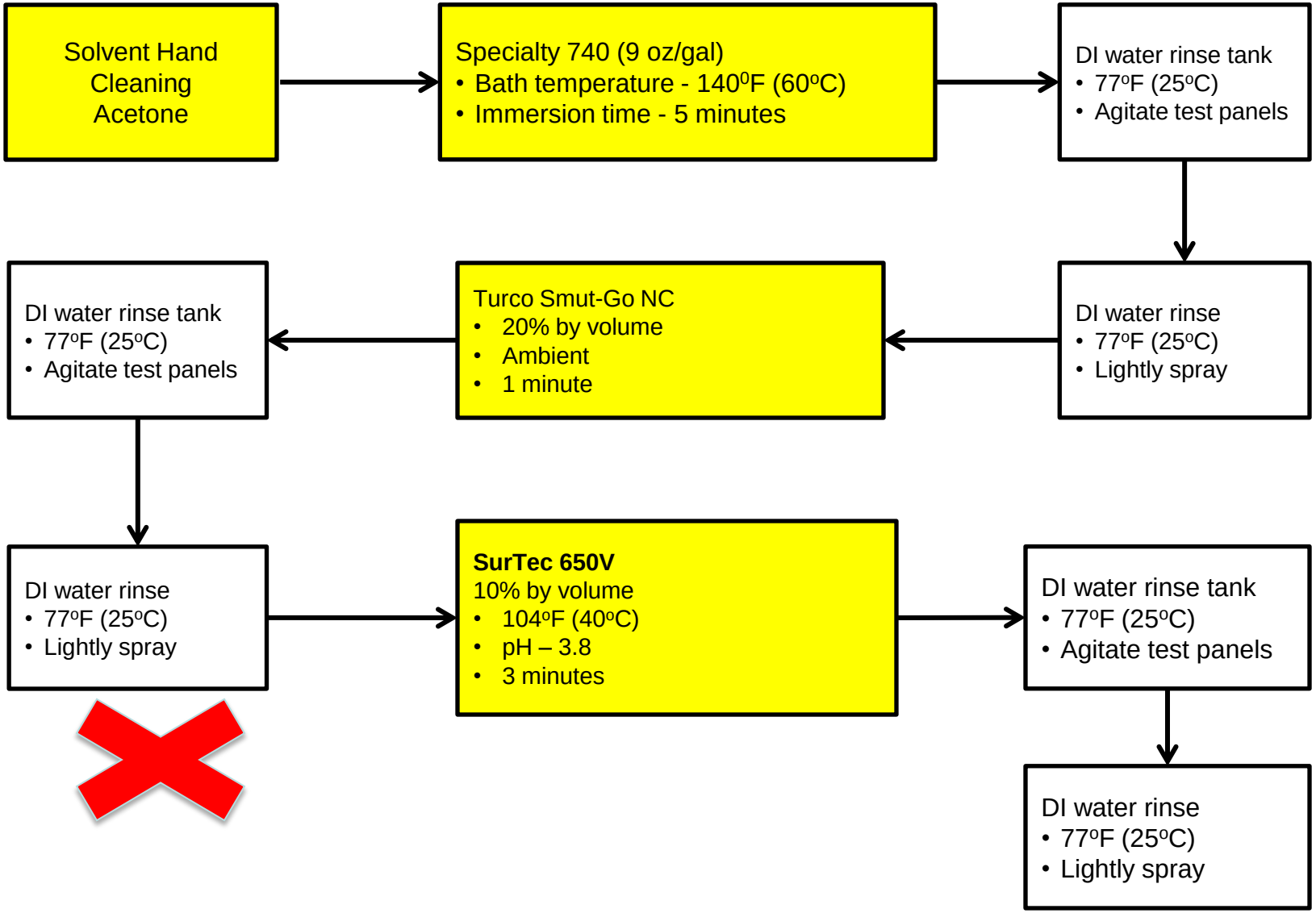
## Round 5C

Substrates: 2219
Cleaning: Scotch Bright (for Clad) + Acetone

# Test Panel Preparation Process Optimization

- Tested only Alloy 2219 (limited quantity available)
  - Clad test Panels scrubbed with Scotch-Brite pads to a dull surface
  - Bare test panels; no Scotch-Brite scrubbing
- Tested only Surtec 650V

# Process Optimization – SurTec 650V



# Process Optimization

**RESULTS:**

- **Surtec 650 V**
  - Passed on 2219 Clad – 336 Hours
  - Some Passed on 2219 – 168 Hours

| Alloy | Pretreatment | Test Panel ID | ASTM B 117 Results | | |
|---|---|---|---|---|---|
| 2219 | | | 168 hrs. | 336 hrs. | 504 hrs. |
| Clad test Panels scrubbed with Scotch-Brite pads to a dull surface | SurTec 650V | 1 | 0 | 0 | 5+ |
| | | 2 | 0 | 0 | 5+ |
| | | 3 | 0 | 0 | 5+ |
| | | 4 | 0 | 0 | 5+ |
| | | 5 | 0 | 0 | 5+ |
| Bare panels, no clad, Scotch-Brite scrub | | 6 | 0 | 5+ | |
| | | 7 | 0 | 5+ | |
| | | 8 | 4* | 5+ | |

*Pits on test panel #8 were very small and difficult to detect

# NASA/ESA Phase I Project Results & Overview of Next Phases

**HCFCFE**

Screening

| | |
|---|---|
| x | Alodine EC2 |
| x | Corrlink 30A |
| | Deft RECC |
| x | UMR CeCC |
| x | EON Coat |
| x | XBond 4000 |
| x | NANOMYTE TC-4001 |
| x | NANOMYTE PT-10 |

**HCFCFE**

Pretreatments

| | |
|---|---|
| x | Alodine 1600 |
| x | Alodine 5900 |
| x | Iridite NCP |
| x | Metalast HF |
| x | Metalast HF-EPA |
| x | Surtec 650 |
| x | Surtec 650C |

## Phase 1

**ESA/NASA**

Screening

| | | |
|---|---|---|
| | p | Alodine 1200s (added) Control |
| | x | Alodine 1600 Control |
| 1 | p | Alodine 160/161 |
| 2 | p | Alodine 5993Plus |
| 3 | p | Interlox 5705 |
| 4 | p | MAP Silico |
| 5 | x | Alodine EC2 |
| 6 | x | Corrlink 30A |
| 7 | p | Deft RECC |
| 8 | x | UMR CeCC |
| 9 | x | EON Coat |
| 10 | x | XBond 4000 |
| 11 | x | NANOMYTE TC-4001 |
| 12 | x | NANOMYTE PT-10 |
| 13 | r | Alodine 5900 |
| 14 | r | Iridite NCP |
| 15 | r | Metalast HF |
| 16 | x | Metalast HF-EPA |
| 17 | x | Surtec 650 |
| 18 | r | Surtec 650C |
| 19 | n | Surtec 650V |

# Screening (phase 2)

**ESA/NASA**

Screening PT+PR

| | | |
|---|---|---|
| Alodine 1200S | + | Koropon |
| MAP Silico | + | MAP Silico |
| MAP Silico | + | Deft 084 |
| MAP Silico | + | Hentzen 16708 |
| MAP Silico | + | PM820 |
| Alodine 5923Plus | + | MAP Silico |
| Alodine 5923Plus | + | Deft 084 |
| Alodine 5923Plus | + | Hentzen 16708 |
| Alodine 5923Plus | + | PM820 |
| Metalast TCP | + | MAP Silico |
| Metalast TCP | + | Deft 084 |
| Metalast TCP | + | Hentzen 16708 |
| Metalast TCP | + | PM820 |
| SurTec 650V | + | MAP Silico |
| SurTec 650V | + | Deft 084 |
| SurTec 650V | + | Hentzen 16708 |
| SurTec 650V | + | PM820 |
| MAP Silico | + | NAVALCOAT |
| Alodine 5923 Plus | + | NAVALCOAT |
| Metalast TCP | + | NAVALCOAT |
| Surtec 650V | + | NAVALCOAT |

**Substrate:**

- 2024-T3

**Testing:**

- ASTM B117 – Salt Fog
- Adhesion – PATTI Jr.

## Phase 2

**ESA/NASA**

Pretreatments

Alodine 1200S

Iridite 14-2

Metalast TCP

MAP Silico

Alodine 5923Plus

SurTec 650V

**Substrates:**

- 2024-T3
- 2024-T8
- 6061-T6
- 7075-T6
- 7075-T73

**Testing:**

- B117 – Salt Fog
- Humidity Exposure
- Thermal Cycling
- Adhesion – X-Cut Tape
- Resistivity

## Phase B

**ESA/NASA**

| Pretreat+Primer | | | |
|---|---|---|---|
| Alodine 1200S | + | PR | (NASA Control) |
| Iridite 14-2 | + | PR | (ESA Control) |
| Metalast TCP | + | PR1 | (NASA Alternative 1) |
| MAP Silico | + | PR2 | (NASA Alternative 2) |
| Alodine 5923Plus | + | PR3 | (ESA Alternative 1) |
| SurTec 650V | + | PR4 | (ESA Alternative 2) |

**Substrates:**

- 2024-T3
- 2024-T8
- 6061-T6
- 7075-T6
- 7075-T73

**Testing:**

- B117 – Salt Fog
- Atmospheric Exposure
- Adhesion - X-Cut Tape
- Adhesion – PATTI Jr.

## Phase B

### ESA/NASA

| Pretreat+Primer+Topcoat | | | | | |
|---|---|---|---|---|---|
| Alodine 1200S | + | PR | + | TC | (NASA Control) |
| Iridite 14-2 | + | PR | + | TC | (ESA Control) |
| Metalast TCP | + | PR1 | + | TC | (NASA Alternative 1) |
| MAP Silico | + | PR2 | + | TC | (NASA Alternative 2) |
| Alodine 5923Plus | + | PR3 | + | TC | (ESA Alternative 1) |
| SurTec 650V | + | PR4 | + | TC | (ESA Alternative 2) |

**Substrates:**

- 2024-T3
- 2024-T8
- 6061-T6
- 7075-T6
- 7075-T73

**Testing:**

- B117 – Salt Fog
- Atmospheric Exposure
- Adhesion - X-Cut Tape
- Adhesion – PATTI Jr.

# THANK YOU!

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# Any Questions?