Anodized Aluminium
Sealing for Alkali Resistance
Anodised Aluminium is commonly used as a decorative exterior automotive finish
The Problem
The Problem

- Automotive exteriors are exposed to aggressive chemicals used in automatic car washes
- These chemicals cause deterioration of the decorative finishes
The Problem

Surface Deterioration
Volkswagen Test Procedure

■ 10 min. pre-dip in:
  – 2g/l Na$_3$PO$_4$
  – 200mg/l CL-
  – pH 12.5 (NaOH and H$_3$PO$_4$)
  – room temperature
■ Rinse & dry;
■ Kesternich Test: according to DIN 50018; 2.0 S; 5 cycles
Kesternich Test

Corrosion in damp heat alternating atmosphere containing sulphur dioxide (SO2)
Specification

- No visual change of the surface after cleaning with commercial polish
- No visual dip border
Sealing

Provides corrosion protection, color retention, stain & electrical resistance to anodised aluminum
What is Sealing?

The anodised part (color or clear) is immersed in a seal bath.

Over time and under the right conditions, a chemical change occurs within the pores which causes them to close.
Factors That Affect Any Seal

- Coating properties
  - Thickness
  - Porosity
- Process parameters
  - Chemical content
  - pH
  - Temperature
  - Time
- Contaminant level
  - Phosphates
  - Silicates
Objective & Method

- Produce clear & color anodised decorative coatings that pass the VW test
- Screen conventional 1 & 2-step seal methods via application test
Nickel Seals Tested

- Hot Nickel Acetate Seal
  - Typical conditions for use:
    - 95° to 100°
    - 2 to 3 min/μm

- Mid-Temperature Nickel Acetate Seal (US Formulation "C")
  - Typical conditions for use:
    - 75° to 90°
    - 1 to 2 min/μm

- Cold Nickel Fluoride Seal
  - Typical conditions for use:
    - 25° to 35°
    - ½ to 1 min/μm
Nickel-Free Seals Tested

- Hot Water Seal (with additive)
  - Typical conditions for use:
    - 95° to 100°
    - 3 min/µm

- Mid-Temperature Tenside Seals
  - Swiss formulation "A"
  - US Formulation "B"
  - Typical conditions for use:
    - 80° to 90°
    - 1 to 2 min/µm
2-Step Seal Combinations Tested

- Cold Seal followed by:
  - Hot water seal
  - Mid-temperature nickel free seal (Swiss formulation “A“)
  - Hot nickel acetate seal

- Hot nickel acetate followed by:
  - Hot water seal
  - Mid-temperature nickel free seal (Swiss formulation “A“)
  - Mid-temperature nickel free seal (US formulation “B“)
Test 1
First series of seal screening tests

- Aluminium sheet AlMg1
- Clear anodised 23-27µm
- Full Volkswagon test
- Pre-dip pH set at 12.5 (original value)
## Test 1
### 1-Step Seals

- Seal time: 60min (approx. 3 min/µm)

<table>
<thead>
<tr>
<th>Seal type</th>
<th>Product* concentration</th>
<th>Temperature °C</th>
<th>pH</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot water</td>
<td>2ml/l</td>
<td>98</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Mid-temperature A</td>
<td>2ml/l</td>
<td>88</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Mid-temperature B</td>
<td>20ml/l</td>
<td>88</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Hot nickel</td>
<td>20ml/l</td>
<td>98</td>
<td>5.7</td>
<td></td>
</tr>
</tbody>
</table>

* products listed in appendix
Test 1
2-Step Seals

■ Pre-seal:
  – 20ml/l Hot nickel;
  – 70°C; pH 5.7; 5min

■ Second seal: 40min;

<table>
<thead>
<tr>
<th>Second seal</th>
<th>Product* concentration</th>
<th>Temperature °C</th>
<th>pH</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot water</td>
<td>2ml/l</td>
<td>98</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Mid-temperature A</td>
<td>2ml/l</td>
<td>80</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Mid-temperature A</td>
<td>2ml/l</td>
<td>88</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Mid-temperature B</td>
<td>20ml/l</td>
<td>80</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

* products listed in appendix
### Test 1
#### 2-Step Seals (continued)

- **Pre-seal:**
  - 5g/l Cold seal;
  - 20min; 29°C; 5.7pH

- **Second seal:** 40min

<table>
<thead>
<tr>
<th>Second seal</th>
<th>Product* concentration</th>
<th>Temperature °C</th>
<th>pH</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot water</td>
<td>2ml/l</td>
<td>98</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Mid-temperature A</td>
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<td>80</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Hot nickel</td>
<td>20ml/l</td>
<td>80</td>
<td>5.7</td>
<td></td>
</tr>
</tbody>
</table>

* products listed in appendix
Summary of Test 1

- Hot nickel alone or in combination with mid-temperature nickel-free seals can pass the original VW test using thick clear coatings.
- Cold seal in combination with hot water or mid-temperature nickel-free seals can also be used under these conditions.
- Many results are good however:
  - VW test was modified: pre-dip at pH 13.5 instead of 12.5
  - Thinner coatings were of interest to the automotive OEM
Test 2
Second series of seal screening tests

- Aluminium sheet AlMg1
- Clear anodised 5-7µm (thinner)
- Abbreviated test:
  - Pre-dip only in pH 12.5 & 13.5
Test 2
1-Step Seals

- Seal time: 15min (approx. 3 min/µm)

<table>
<thead>
<tr>
<th>Seal type</th>
<th>Product concentration</th>
<th>Temperature °C</th>
<th>pH</th>
<th>Result 12.5</th>
<th>Result 13.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-temperature C</td>
<td>20ml/l</td>
<td>90</td>
<td>6.0</td>
<td>🔴</td>
<td>🔴</td>
</tr>
<tr>
<td>Hot nickel</td>
<td>20ml/l</td>
<td>98</td>
<td>5.5</td>
<td>🟢</td>
<td>🔴</td>
</tr>
</tbody>
</table>

* products listed in appendix
**Test 2**

**2-Step Seals**

- **Pre-seal:**
  - 5g/l **Cold seal**
  - 4min; 29°C; 5.7pH

- **Second seal:** 15min

<table>
<thead>
<tr>
<th>Seal type</th>
<th>Product* concentration</th>
<th>Temperature °C</th>
<th>pH</th>
<th>Result 12.5</th>
<th>Result 13.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hot water</td>
<td>2ml/l</td>
<td>98</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid-temperature A</td>
<td>2ml/l</td>
<td>80</td>
<td>6.0</td>
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<tr>
<td>Mid-temperature C</td>
<td>20ml/l</td>
<td>90</td>
<td>6.0</td>
<td></td>
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</tr>
<tr>
<td>Hot nickel</td>
<td>20ml/l</td>
<td>98</td>
<td>5.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mid-temperature B</td>
<td>20ml/l</td>
<td>90</td>
<td>6.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* products listed in appendix
Summary of Test 2

- Pre-dip in a pH 13.5 solution is very severe
- The best results use a cold pre-seal followed by hot nickel
**Test 3**  
*Focus on the 2-Step seal (cold/hot nickel)*

- Aluminium sheet AlMg1
- Clear anodised 5-7µm

**Pre-seal:**
- 5g/l **Cold seal**;
  - 28°C; 5.7pH

**Second seal:**
- 20 ml/l **Hot Nickel**,
  - 98°C; 5.5 pH

**Abbreviated test:**
- Pre-dip only in pH 13.5
### Test 3
2-Step Seal (cold/hot nickel)

<table>
<thead>
<tr>
<th>Cold Seal min.</th>
<th>Hot Seal min.</th>
<th>Result 13.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>15</td>
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</tr>
<tr>
<td>4</td>
<td>30</td>
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</tr>
<tr>
<td>4</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>15</td>
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<tr>
<td>6</td>
<td>30</td>
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</tr>
<tr>
<td>6</td>
<td>40</td>
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</tr>
<tr>
<td>8</td>
<td>15</td>
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<tr>
<td>8</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td></td>
</tr>
</tbody>
</table>

- For thin clear coatings
  - Many combinations pass (not process sensitive)
  - As little a 6-8 min plus 15 min produce a quality seal
**Test 4**

*Focus on the 2-Step seal (cold/hot nickel)*

- Aluminium sheet AlMg1 & MgSi profile
- Clear & color anodised 5-7 µm & 12-14 µm
- Pre-seal:
  - 5g/l Cold seal;
  - 28°C; 5.7 pH
- Second seal:
  - 20 ml/l Hot Nickel,
  - 98°C; 5.5 pH
- **Full VW test:**
  - Pre-dip in pH 13.5
### Test 4
2-Step Seal (cold/hot)
Clear anodised coatings on AlMg1

<table>
<thead>
<tr>
<th>Cold Seal min.</th>
<th>Hot Seal min.</th>
<th>Coating μm</th>
<th>Result</th>
<th>13.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>30</td>
<td>5-7</td>
<td></td>
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<td>8</td>
<td>40</td>
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<td></td>
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<tr>
<td>10</td>
<td>30</td>
<td>12-14</td>
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<td></td>
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<tr>
<td>10</td>
<td>40</td>
<td>12-14</td>
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<tr>
<td>15</td>
<td>30</td>
<td>12-14</td>
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<tr>
<td>15</td>
<td>40</td>
<td>12-14</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- This seal combination can pass the severe VW test for both thin & thick clear anodised coatings on aluminum sheet.
## Test 4

### 2-Step Seal (cold/hot)

**Overdyed coatings on AlMg1**

<table>
<thead>
<tr>
<th>Cold Seal min.</th>
<th>Hot Seal min.</th>
<th>Coating µm</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>30</td>
<td>5-7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>40</td>
<td>5-7</td>
<td></td>
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<tr>
<td>10</td>
<td>30</td>
<td>12-14</td>
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<td>10</td>
<td>40</td>
<td>12-14</td>
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<tr>
<td>15</td>
<td>30</td>
<td>12-14</td>
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<tr>
<td>15</td>
<td>40</td>
<td>12-14</td>
<td></td>
</tr>
</tbody>
</table>

- This seal combination can pass the severe VW test for both thin & thick color anodised coatings on aluminum sheet
### Test 4

#### 2-step Seal (cold/hot)

**Profiles**

<table>
<thead>
<tr>
<th>Cold Seal min.</th>
<th>Hot Seal min.</th>
<th>Color</th>
<th>Coating µm</th>
<th>Result 13.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>30</td>
<td>Clear</td>
<td>5-7</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>40</td>
<td>Clear</td>
<td>5-7</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>30</td>
<td>Clear</td>
<td>5-7</td>
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<tr>
<td>8</td>
<td>40</td>
<td>Clear</td>
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<tr>
<td>10</td>
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<td>Overdye</td>
<td>12-14</td>
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<tr>
<td>10</td>
<td>40</td>
<td>Overdye</td>
<td>12-14</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>60</td>
<td>Overdye</td>
<td>12-14</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>30</td>
<td>Overdye</td>
<td>12-14</td>
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<td>15</td>
<td>40</td>
<td>Overdye</td>
<td>12-14</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>60</td>
<td>Overdye</td>
<td>12-14</td>
<td></td>
</tr>
</tbody>
</table>

- This seal combination can pass the severe VW test for both thin & thick:
  - color anodise coatings on aluminum profile
  - color anodise coatings on aluminum sheet
**Recommendations**

- The preferred method of sealing anodised aluminum for maximum alkali resistance is to use a 2-step process consisting of a cold nickel fluoride followed by a hot nickel acetate.

- For thinner coatings a pre-seal of 8-10 minutes followed by a minimum 30 minutes of hot seal should be used.

- For thicker coatings a pre-seal of 10-15 minutes followed by a minimum 30-40 minutes of hot seal should be used.

- Longer seal times are better however time limitations and cracking are a concern.
Appendix

- Hot nickel: Anodal Sealing Salt ASL liq
- Cold nickel fluoride: Anodal CS-2 pdr
- Hot water additive: Anodal SH-1 liq
- Mid-temperature nickel “C” (US formulation): Anodal MS-1 liq
- Mid-temperature nickel free “A” (Swiss formulation): Anodal SH-2 liq
- Mid-temperature nickel free “B” (US formulation): Anodal ES-1 liq