Corrosion Prevention of Army Equipment in the 21st Century

Peter Morgan, Jenny Pick, Eric Kennett
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Corrosion Prevention of Army Equipment in the 21\textsuperscript{st} Century

Overview

1. BAE Systems
2. Finding new treatments and coatings
3. Process selection criteria
4. Assessing performance
5. Conclusion
A Global Company with Global Interests

Worldwide employees 100,000
(including 9,500 employees in our joint ventures)
Advanced Technology Centre - Structure and Facilities

- Turnover: ~ £43M
- Employees: ~ 500
- Employees: >100,000 worldwide
BAE Systems – Delivering Advantage
2. Finding new treatments & coatings
Current surface treatment process

1. **Shell body** → **Alkali clean**
   - Material: Pyrene 11-02
   - Temp: 35 - 42 °C
   - Time: 8 - 10 mins

2. **Cold water rinse**
   - Temp: 15 °C min
   - Time: 20 s min

3. **Hot water rinse**
   - Temp: 75 °C min
   - Time: 20 s minimum

4. **Shell body** → **Phosphate**
   - Material: Solution
   - Temp: 55 - 65 °C
   - Time: 15 - 20 mins

5. **Cold water rinse**
   - Temp: 12 °C min
   - Time: 10 s min

6. **Hot water rinse**
   - Temp: 75 °C min
   - Time: 20 s min

7. **Shell body** → **Chromic acid rinse**
   - Material: 0.02 – 0.05%
   - Temp: 82 °C min
   - Time: 10s min

8. **Air blow dry**
   - As required

9. **Coated shell body**
# Comparison of Technologies for Surface Treatment

<table>
<thead>
<tr>
<th>Technology</th>
<th>Process</th>
<th>Tanks</th>
<th>Temperature</th>
<th>Process Time</th>
<th>Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>current</td>
<td>Zn phosphate</td>
<td>7</td>
<td>5 heated</td>
<td>30mins</td>
<td>Zn (sludge) chromates</td>
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<tr>
<td>silane</td>
<td>Bespoke</td>
<td>5</td>
<td>Oven dry at 120°C</td>
<td></td>
<td>silane</td>
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<tr>
<td></td>
<td>Commercial</td>
<td>10</td>
<td>Oven dry</td>
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<td>Silane Zr</td>
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<tr>
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<td>6</td>
<td>RT</td>
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<td>Zr</td>
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<td>Zr</td>
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<tr>
<td>Vanadate</td>
<td>5</td>
<td></td>
<td>RT</td>
<td></td>
<td>Zr, V</td>
</tr>
<tr>
<td>Auto catalytic</td>
<td>polymer</td>
<td>7</td>
<td></td>
<td></td>
<td>organic</td>
</tr>
</tbody>
</table>
Current Painting Process

shell body → Phosphate
- temp: °C
- time: mins

coated shell body

Pre warm shell
- temp: 40 °C
- time: 30 mins

Prime
- material: w/b primer
- application: spray
- temp: °C

Dry
- temp: 100 - 110 °C
- time: 20 - 30 mins

Topcoat
- material: w/b
- application: spray
- temp: °C

Dry
- temp: 30 - 150 °C
- time: 30 mins

painted shell body

Pre warm shell
- temp: 40 °C
- time: 30 mins
New Coating/Painting Processes

- Current aqueous 2-coat
- New aqueous 2-coat (x3)
- Aqueous single coat (x2)
- Powder coat (x3)
- E-coat
# Test Matrix

<table>
<thead>
<tr>
<th>Surface treatments</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
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<tbody>
<tr>
<td>Zn phosphate</td>
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<td>Zr</td>
<td>Zr</td>
<td>Zr</td>
<td>C</td>
<td>V</td>
<td>Si</td>
</tr>
<tr>
<td>1 Water-based 2- coat</td>
<td>A1</td>
<td>B1</td>
<td>C1</td>
<td>D1</td>
<td>E1</td>
<td>F1</td>
<td>G1</td>
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<tr>
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<td>A2</td>
<td>B2</td>
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<td>3 Ecoat</td>
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<tr>
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<td>F5</td>
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<td>H5</td>
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<td>B6</td>
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<td>D6</td>
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<td>F6</td>
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</tr>
<tr>
<td>7 Water based 2-coat system 2</td>
<td>A7</td>
<td>B7</td>
<td>C7</td>
<td>D7</td>
<td>E7</td>
<td>F7</td>
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<tr>
<td>8 Water based single-coat 2</td>
<td>A8</td>
<td>B8</td>
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<td>D8</td>
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<td>F8</td>
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<td>9 Water based stoving enamel</td>
<td>A9</td>
<td>B9</td>
<td>C9</td>
<td>D9</td>
<td>E9</td>
<td>F9</td>
<td>G9</td>
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</tbody>
</table>
3. Process selection criteria
Process Selection Criteria

*Corrosion resistance*

Corrosion creep
Process Selection Criteria

- Corrosion resistance
- Paint adhesion
Process Selection Criteria

- Corrosion resistance
- Paint adhesion
- Paint thickness
Process Selection Criteria

- Corrosion resistance
- Paint adhesion
- Paint thickness
- Economics

$$$
Process Selection Criteria

- Corrosion resistance
- Paint adhesion
- Paint thickness
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- Environment
Process Selection Criteria

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Process Selection Criteria

- Corrosion resistance
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- Environment
- Support
Process Selection Criteria

- Corrosion resistance
- Paint adhesion
- Paint thickness
- Economic
- Environmental
- Support

Corrosion creep

0.2mm
4. Assessing Performance
Corrosion

- Sample coatings were damaged (scribed X)
- Accelerated corrosion tested to ASTM B117
- After corrosion they were dried and cleaned with abrasive (scotchbrite) and examined using optical microscopy
- Measurements of the corrosion damage were made
Assessing corrosion

- Paint blistering
- Corrosion creep
- No & size of pits
# Assessment of Accelerated Corrosion Test Results

<table>
<thead>
<tr>
<th>Surface treatments</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tr>
<td><strong>Paints</strong></td>
<td>Zn phosphate</td>
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</table>
Assessing Paint Adhesion
## Assessment of Paint Adhesion

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<td>Zr</td>
<td>Zr</td>
<td>C</td>
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<td>Si</td>
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<tr>
<td>1 Water-based 2-coat</td>
<td>adhesive</td>
<td>Top coat</td>
<td>Top coat</td>
<td>X</td>
<td>mix</td>
<td>pr/aq</td>
<td>Top Coat</td>
<td>mix</td>
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<tr>
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<td>topcoat</td>
<td>Top coat</td>
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</tr>
<tr>
<td>3 Ecoat</td>
<td>pr / phos</td>
<td>glue</td>
<td>glue</td>
<td>X</td>
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<td>glue</td>
<td>X</td>
<td>glue</td>
<td>110</td>
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</tr>
<tr>
<td>9 Water based stoving enamel</td>
<td>pr / phos</td>
<td>mix</td>
<td>mix</td>
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</table>
Measuring paint film thickness

B6

B4
# Optical Microscope Assessment of Paint Thickness

<table>
<thead>
<tr>
<th>Surface treatments</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
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<tbody>
<tr>
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</tbody>
</table>
5. Conclusions
## Overall Assessment of the Performance of New Technologies

### Paints

<table>
<thead>
<tr>
<th>Surface treatments</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
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<td>7 Water based 2-coat system 2</td>
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<td>x</td>
<td>x</td>
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<td>x</td>
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</tr>
</tbody>
</table>
Recommendations

- The technical assessment suggests the 4 following combinations should be considered for further investigation:
  - Surface treatment B & ecoat
  - Surface treatment B & powdercoat 2
  - Surface treatment E & ecoat
  - Surface treatment H & ecoat
Thanks for listening!