Effect of Edge Preparation Methods on Edge Retention Rate of Epoxy Coatings

Hyundai Heavy Industries Co., Ltd.
IMO’s PSPC

Water Ballast TK

Water Ballast TK

Epoxy HB (160 μm)

Epoxy HB (160 μm)

I.O.Z. (15 μm)

Steel

Performance Standard For Protective Coating
Corrosion Control of Water Ballast TK:

- **Steel Thickness**
- **Protective Coating**
- **Sacrificial Anode**
- **Maintenance**
<table>
<thead>
<tr>
<th>ITEM</th>
<th>PSPC</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.F.T.</td>
<td>2-Coats, 320 μm NDFT(90/10)</td>
</tr>
<tr>
<td>D.F.T. Measurement</td>
<td>Annex 3, Avg. 3~4 points/10 m²</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt;, 2&lt;sup&gt;nd&lt;/sup&gt; Surface Treatment</td>
<td>Sa 2.5 Blasting, Profile: 30~75 μm</td>
</tr>
<tr>
<td>Erection Joint</td>
<td>Welds, Damaged Area &lt;2%: St 3(Grinding)</td>
</tr>
<tr>
<td>Edge Preparation</td>
<td>2R, or 3-Pass or at least equiv.</td>
</tr>
<tr>
<td>Edge Stripe Coating (S/C)</td>
<td>□ Min. 2 S/C; proven weld seams 1 S/C</td>
</tr>
<tr>
<td></td>
<td>□ Brush, Roller (Specified area only)</td>
</tr>
<tr>
<td>Dust</td>
<td>□ Size [5],[4],[3]: remove to Rating [1]</td>
</tr>
<tr>
<td></td>
<td>□ Size [2],[1],[0]: remove if visible on steel</td>
</tr>
<tr>
<td>Soluble Salt</td>
<td>&lt;50 mg/m² NaCl, Bresle, Min. 1 Point/Block</td>
</tr>
</tbody>
</table>
4.4 Basic coating requirements

Table 1 - 3.1 Secondary surface preparation

The steel surface shall be prepared so that the coating selected can achieve an even distribution at the required NDFT and have an adequate adhesion by removing sharp edges, grinding weld beads and removing weld spatter and any other surface contaminant.

Edges to be treated to a rounded radius of min. 2 mm, or subjected to 3 pass grinding or at least equivalent process before painting.
Background

- IMO’s PSPC: “3-Pass or 2-R” edge grinding treatment
- Negative, side-effect:
  - DFT tend to be thicker than flat areas
  - More vulnerable to coating cracks
- Practical edge preparation methods?
  - Several Practices
  - Cross sectional measurement of DFT at Flat/Round area (Edge Retention Rate, %)
Experimental Methods
Preparation of Specimen/Spray Coating

Edge roundness condition:
Flame cutting, R=1mm, R=2mm, R=3mm, RC

Measurement of Roundness at Edge
(HHI Yard Practice)
- RC : One Pass Grinding + Burr Removal (Sand Paper)
- Automatic Edge Roundness M/C
- RC Cutter

Cross-sectional observation of D.F.T.

Evaluation: Edge Retention Ratio, Edge Roundness
Edge Retention Ratio (ERR)

**Steel Plate**

Primer coat

Top coat

ERR(Primer) = E1/F1

ERR(Top coat) = E2/F2

ERR(%) = \( \frac{\text{DFT(Edge)}}{\text{DFT(Flat)}} \)
<table>
<thead>
<tr>
<th>RC</th>
<th>Automatic Edge Roundness M/C</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1 Pass grinding + Sand Papering)</td>
<td></td>
</tr>
</tbody>
</table>

- **Cutted Surface**: Abt. 1mm
- **Burr Removal**: 45° ± 10°
- **After Burr Removal**: Abt. 1mm

**Roller**: R = 2 - 3 mm

**FACE PLATE**
<table>
<thead>
<tr>
<th>RC Cutter</th>
<th>Rolled Plate</th>
</tr>
</thead>
</table>

**RC Cutter**
- SHARP EDGE
- R = 2 mm

**Rolled Plate**
<table>
<thead>
<tr>
<th></th>
<th>Product “A”</th>
<th>Product “B”</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
<td>Pure epoxy (Tar Free)</td>
<td>Modified epoxy (Tar Free)</td>
</tr>
<tr>
<td><strong>Thinning</strong></td>
<td>5 %</td>
<td>5 %</td>
</tr>
<tr>
<td><strong>Color</strong></td>
<td>Grey/Light Grey</td>
<td>Bronze/Aluminum</td>
</tr>
<tr>
<td><strong>Specific Gravity</strong></td>
<td>1.5 kg/ℓ</td>
<td>1.25 kg/ℓ</td>
</tr>
<tr>
<td><strong>Viscosity (cP/KU)</strong></td>
<td>1,237/91.8</td>
<td>1,103/88.6</td>
</tr>
<tr>
<td><strong>Solid Vol. Ratio (SVR)</strong></td>
<td>80 %</td>
<td>60 %</td>
</tr>
</tbody>
</table>
Coating Sample Preparation

RC

- Abt. 1mm
- R = 1

- Flame cutting
- abt : 1mm
  - R = 1

- abt : 2mm
  - R = 2

- abt : 3mm
  - R = 3

Spray coating

Stripe coating
Results & Findings
Coating Thickness Effect

- Sharp Edge

- One “C” Grinding

D.F.T. Increase $\rightarrow$ Outer Surface Radius Increase
- Edge Cracking after 4 Point Bending Test
- Crack width varies directly as coating D.F.T.
- Initial crack site varies inversely as coating D.F.T.
- Number of crack: Thin coating > Thick coating
- Crack Width: Thin coating < Thick coating
**Edge Roundness Effect**

**Coating Material A**

- **Before Blasting**
- **After Blasting**
- **Increasing Rate**

**Edge Retention Ratio (%)**

![Graph showing edge retention ratios for different edge roundness effects](image)

**Edge Roundness Effect**

- Sharp Edge
- C
- RC
- R=1
- R=2
- R=3
Edge Roundness Effect

Coating Material B

- Before Blasting
- After Blasting
- Increasing Rate

<table>
<thead>
<tr>
<th>Edge Roundness Effect</th>
<th>Before Blasting</th>
<th>After Blasting</th>
<th>Increasing Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sharp</td>
<td>80</td>
<td>100</td>
<td>20</td>
</tr>
<tr>
<td>C</td>
<td>90</td>
<td>105</td>
<td>5</td>
</tr>
<tr>
<td>RC</td>
<td>100</td>
<td>110</td>
<td>10</td>
</tr>
<tr>
<td>R=1</td>
<td>110</td>
<td>120</td>
<td>10</td>
</tr>
<tr>
<td>R=2</td>
<td>120</td>
<td>130</td>
<td>10</td>
</tr>
<tr>
<td>R=3</td>
<td>130</td>
<td>140</td>
<td>10</td>
</tr>
</tbody>
</table>
Edge Blasting Effect

- **Before Blasting**

- **After Blasting**
 Stripe Coating Effect

![Chart](chart.png)

- **Spray**
- **Spray & One Stripe**
- **Increasing Rate**

- **Edge Retention Ratio (%)**

- **Sharp**
- **C**
- **RC**
- **R=1**
- **R=2**
- **R=3**

- **Spray & One Stripe Coating Effect**

- **Increasing Rate**
3-pass Grinding

3 Pass Grinding

Cutted Surface

Abt. 1mm

45° ± 10°

R = 2.0 mm
<table>
<thead>
<tr>
<th>RC or Edge Rounder</th>
</tr>
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<tbody>
<tr>
<td><strong>RC</strong> (1 Pass G/R + Sand Papering)</td>
</tr>
</tbody>
</table>

| R = 2.0 mm | R = 3.5 mm |

**RC** or **Edge Rounder**
<table>
<thead>
<tr>
<th>RC Cutter</th>
<th>Rolled Plate</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Image" /></td>
<td><img src="image2" alt="Image" /></td>
</tr>
<tr>
<td>R = 2.0 mm</td>
<td>R = 2.75 mm</td>
</tr>
</tbody>
</table>
Roundness Summary

Edge Roundness (mm)

<table>
<thead>
<tr>
<th></th>
<th>R = 2mm</th>
<th>RC</th>
<th>RC Cutter</th>
<th>Rolled Plate</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Pass Grinding</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Edge Roundness M/C</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R = 2mm

Global Leader
1. Variation of coating D.F.T. at the edges with different roundness were measured.

2. Equivalency for $R = 2\text{mm}$ or $3$ Pass grinding
   - RC(One Pass grinding + Sand Papering)
   - Automatic Edge Roundness M/C
   - RC Cutter
   - Rolled Plate

**Total thickness $\geq 300\mu\text{m}$**
Thank you !