Rust Prevention beyond Zinc Plating, with a Vivid Appearance

Modified saturated polyester resin coating

Toff-coated Products

TOFF COATED PRODUCTS

TOKYO ROPE MFG. CO., LTD.
All tests have proven the superb performance of Toff-coated products.

1. **Excellent basic physical properties**
   Saturated polyester resins have excellent basic physical properties (mechanical properties, resistance to ultraviolet light, abrasion resistance, chemical stability, etc.).

2. **Weather resistance (ultraviolet light and salt damage)**
   In exposure tests on a beach of Miyake Island, Tokyo, the original heath remained almost intact after 16 years (according to Japan’s leading telecommunications company, NTT).

3. **Resistance to scratches and high adhesiveness**
   Salt spray tests, as done by scratching, have shown that Toff-coated products corrode more slowly than other coatings tested, confirming its high adhesiveness (according to Japan’s leading telecommunications company, NTT).

4. **Resistance to peeling and electrolytic corrosion**
   A construction field test of railroad rail fastening bolts/plates has revealed that Toff-coated products are more resistant to peeling and electrolytic corrosion than all other products tested (according to Japan Railways Group).

5. **Weather resistance (ultraviolet light and salt damage)**
   *Providing four times the resistant of zinc plating*
   Salt spray tests, accelerated weathering resistance tests, and soil-buried tests were conducted on steel sheets, steel bars, and bolts. Toff-coated products rank the best among the rust prevention methods tested (according to Japanese expressway company, NEXCO).

6. **Weather resistance (ultraviolet light and salt damage)**
   Exposure tests were conducted on a coast of Okinawa Prefecture to compare rust prevention methods offered by all suppliers of steel sheets and bolts. Toff-coated products were rated the best and fully adopted (according to the Ministry of Land, Infrastructure, Transport and Tourism and the Okinawa Development Agency).

7. **Weather resistance (ultraviolet light and salt damage)**
   Outdoor exposure tests and accelerated corrosion tests on steel sheets were conducted for rust preventive coatings. As a result, Toff-coated products were rated as the best coating, equivalent to aluminum in rust prevention (according to the Steel Barrier Association).
All tests have proven the superb performance of Toff-coated products. In addition, they can be colored to blend in with the surrounding landscape. Weather resistance (ultraviolet light and salt damage) can last as long as 35 years in salt-susceptible areas, and through rust prevention processing that combines plating with modified saturated polyester resin coating. They provide a new form of rust prevention beyond zinc plating.

Outdoor exposure tests and accelerated corrosion tests on steel sheets were conducted for rust preventive coatings. Salt spray tests, as done by scratching, have shown that Toff-coated products corrode more slowly than other materials. Excellent basic physical properties include four times the resistant of zinc plating, and as a result, Toff-coated products were rated as the best coating, equivalent to aluminum in rust prevention.

A construction field test of railroad rail fastening bolts/plates has revealed that Toff-coated products are more resistant than other materials. Weather resistance (ultraviolet light and salt damage) has been confirmed, and the materials compared are Epoxy and nylon. Materials were subjected to tensile test, impact resistance, pencil hardness, adhesive strength (N/mm²), and adhesion force remains satisfactory. Test outline is in accordance with Notification No. 45 by the Ministry of Health, Labour and Welfare (MHLW) based on the stipulations of JWWA Z 108: Leach test and JIS K 5600: Test method for evaluation of water resistance of construction materials. In Miyake Island, Tokyo, Place of installations: NTT exposure test station, Time of installation: June 1988 to February 1990. No abnormality during period from installation to July 2003 (elapse of 16 years).
Exposure Test of Toff-coated Rope on the Summit of Mt. Aso

Test outline
In February 2006, an exposure test was conducted, together with continual measurement of the concentration of sulfurous acid and hydrogen sulfide gases on the summit of Mt. Aso.

[Gas generation conditions]
These gases are generated just under every other day on average. The concentrations at the moment of gas generation were, on average, 10 ppm for sulfurous acid (ranging from 0.5 to 25 ppm; figures above 25 ppm were rounded to 25 ppm), and 5 ppm (ranging from 0.5 to 23 ppm) for hydrogen sulfide.

[Corrosion conditions of exposed materials]
1. Exposed material (3x7, ropes of 18 mm diameter):
   A. Three types of Toff-coated rope (coating on element wire in dark brown; coating on rope in dark brown/dark green)
   B. Zn plating (material for comparison)
   C. Zn-Al plating (material for comparison)
2. Results (see the photos below)
   (1) Toff-coated wires, after two years, were all satisfactory with no abnormality.
   (2) The Zn plating, after half a year, formed red rust, which completely covered it in two years.
   (3) The Zn-Al plating formed a thin layer of red rust in two years.

- At start of exposure test
  - Zn plating
  - Toff-coated (Element wire coated in brown)
  - Toff-coated (Rope coated in dark brown)
  - Toff-coated (Rope coated in dark green)

- After six months
  - Zn plating (Red rust formed partially)
  - Toff-coated (Rope coated in dark brown)
  - Zn-Al plating

- After one year
  - Zn plating (Spreading of red rust)
  - Toff-coated (Rope coated in dark brown)
  - Zn-Al plating

- After two years
  - Zn plating (Complete covering of red rust)
  - Toff-coated (Rope coated in dark brown) (No abnormality)
  - Zn-Al plating (Thin layer of red rust)
Exposure Test in Severe Salt-susceptible Area for 16 Years

Time of installation: June 1988
Place of installations: NTT exposure test station in Miyake Island, Tokyo.
Date of photographing: July 2003

6 years after installation
Toff-coated
Fluorine coating
Special urethane coating

16 years after installation
The Toff-coated products, as many as 16 years later, show almost no deterioration and adhesive force remains satisfactory.

Outline of Japan Railways Group (JR) Corrosion Resistance Test

Test outline

<table>
<thead>
<tr>
<th>Product name</th>
<th>Railroad rail fastening device; tie plate mounting bolts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation location</td>
<td>Line section prone to electrolytic corrosion</td>
</tr>
<tr>
<td>Test period</td>
<td>June 1989 to February 1990</td>
</tr>
<tr>
<td>Test materials</td>
<td>From left in photo: conventional product, epoxy, nylon, and saturated polyester</td>
</tr>
<tr>
<td>Test result</td>
<td>Saturated polyester was the best.</td>
</tr>
</tbody>
</table>

Scene of Miyake Island test station

Rail fastening device in installation

Basic Performance

Raw material test certificate

<table>
<thead>
<tr>
<th>Item</th>
<th>Test name/description</th>
<th>Measuring method</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Limiting viscosity</td>
<td>Alternative value to the molecular weight measured by Uberoze viscometer</td>
<td>Toyobo method</td>
<td>0.83 to 0.87</td>
</tr>
<tr>
<td>Melting point</td>
<td>Measurement of melting temperature of polymer</td>
<td>DSC method</td>
<td>235±3°C</td>
</tr>
<tr>
<td>Specific gravity</td>
<td>Measurement by sink-float method</td>
<td>JIS K 5600</td>
<td>1.35±0.05</td>
</tr>
</tbody>
</table>

Results of coating test (Conditions: coating after zinc plating)

<table>
<thead>
<tr>
<th>Item</th>
<th>Test name/description</th>
<th>Measuring method</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impact resistance</td>
<td>80-cm drop (300 g, 1-inch tip diameter)</td>
<td>JIS K 5600</td>
<td>No abnormality allowed</td>
</tr>
<tr>
<td>Adhesive strength</td>
<td>Tensile test</td>
<td>JIS K 5600</td>
<td>≥ 15</td>
</tr>
<tr>
<td>Tensile strength</td>
<td>Tensile strength and elongation</td>
<td>JIS K 5600</td>
<td>≥ 50</td>
</tr>
<tr>
<td>Wear resistance</td>
<td>CS-10, 4.90 N, 1000 cycles</td>
<td>JIS K 5600</td>
<td>≤ 100</td>
</tr>
<tr>
<td>Pencil hardness</td>
<td>Pencil scratch value</td>
<td>JIS K 5600</td>
<td>≥ 2H</td>
</tr>
</tbody>
</table>

Other properties

<table>
<thead>
<tr>
<th>Item</th>
<th>Test name/description</th>
<th>Measuring method</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosion resistance</td>
<td>Salt spray test method</td>
<td>JIS Z 2371</td>
<td>No rust or swelling for 6 months</td>
</tr>
<tr>
<td>Weather resistance</td>
<td>NTT outdoor exposure test in Miyake Island, Tokyo</td>
<td>JIS K 2381</td>
<td>No abnormality during period from installation to July 2003 (elapse of 16 years)</td>
</tr>
<tr>
<td>Immersion test in sea water</td>
<td>3 years, off the coast of Yokohama</td>
<td>—</td>
<td>No abnormality</td>
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<tr>
<td>Combustion gas ingredient</td>
<td>Generation of harmful gas</td>
<td>JIS K 7217</td>
<td>None</td>
</tr>
<tr>
<td>Detection of harmful components</td>
<td>JWWA Z 108</td>
<td>All below criteria</td>
<td></td>
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