Alternative Systems for the Performance Standard for Protective Coatings

Presented by:

Peter D. McNulty
IMO Ballast Tank PSPC

- Extensive Documentation
- Tedious Preparation
- Difficult Application Conditions (e.g. humidity)
- Extensive Inspections (VLCC will have 50,000 inspection points)
- 2 Epoxy Coats w 320 um DFT
- Goal is 15 Years in “Good” Condition
- Expected to add 2 – 5% to Newbuild Cost
- Expected to Reduce Shipyard Productivity, AND…
“Invites Governments to encourage the development of novel technologies aimed at providing for Alternative Systems and to keep the Organization advised of any positive results.”
Hellespont’s Alternative System

- 4 x 440,000 DWT ULCCs built in 2002 (TI Pool)
- 300,000 m² coated ballast tank surface
- 2,620 25.7 kilo Zn Anodes in ballast tanks
- Total weight of ballast tank anodes = 67,334 kilos
- Anodes designed to be replaced every five years
Hellespont’s Alternative System
TI Africa 1st Special Survey - 2007
# TI Africa 1st Special Survey - 2007

## Detailed Tank Condition Survey Report

<table>
<thead>
<tr>
<th>Areas Surveyed</th>
<th>Structural Elements</th>
<th>Scale</th>
<th>Pitting</th>
<th>Coating Breakdown</th>
<th>Rust Grade of Steel</th>
<th>Substrate</th>
<th>Sacrificial Anodes % Remaining</th>
<th>Mud Sludge/Cargo Residue on Surface</th>
<th>UTM Taken</th>
<th>Estimated Average Steel Diminution (mm)</th>
<th>Fractures</th>
<th>Buckling/Deformation</th>
<th>Photographs Taken</th>
<th>See Sketch or Repair Ref. No.</th>
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**Symbols for Survey**
- X: Inspected & Satisfactory
- AD: Acceptable Defect
- CC: Condition of Class
- PR: Permanently Repaired
- TR: Temporarily Repaired
- NI: Not Inspected
- NA: Not Applicable

**Abbreviations for Scale & Corrosion & Pitting**
- G: General Corrosion
- P: Pitting/grooving
- HT: Hard Tight Scale
- CS: Calcareous Scale
- LS: Loose Scale
- BS: Buster Scale
- S: Scattered Coating Breakdown
- L: Localised Coating Breakdown
TI Africa 1st Special Survey - 2007

• CP Anodes Designed for 10% Remaining After 5 Years, but They Are 95% Intact

• Coating Breakdown Designed for 5% After 5 Years, but Only 0.5% Breakdown Observed

• No note of observed rust staining in ballast tanks.

• ABS Surveyor stated that he had never seen ballast tanks in such pristine condition after 5 years.

• How?
Ballast Tank Inerting

ABS Guide for Inert Gas Systems for Ballast Tanks, 2004
Hellespont’s Ballast Tank Inerting System

- Cargo IG = 4% O₂
- Double-Scrub Cargo IG to Remove Sulfur
- Inert Ballast Tanks
- Ballast Tanks Vented Through P/V Valves
- Slight Positive Pressure Maintained
- No Ballast Water Treatment
Why Is Such A System Needed?

- Sacrificial anodes only work when ballast tanks are full
- New design makes most cargo vessels double-hull with far more (up to 5x) ballast tank surface area
- In double-hull vessels much of early ballast tank coating breakdown results from impact damage from tugs, fenders, floating debris, and (in bulkers) clamshell buckets
- Atmospheric conditions inside empty ballast tanks are often above the dew point, resulting in a thin film of salt water and high corrosion rate (well above CSR est. 0.2 mm/yr)
- Corrosion doesn’t just follow coating failure, corrosion causes coating failure
- PSPC is expected to be expensive to implement
Sumitomo’s Ballast Tank Inerting System

- 18-month Experiment on Cape-size Bulker
- Pure Nitrogen Sparging in Full Ballast Tanks
- Ballast Tank $\text{O}_2$ Held to 0.5%, D.O. in Water to 0.2 mg/l
- Bare Steel Coupons in Tanks
- Control = 0.5 mm/yr, Treated = 0.06 mm/yr
- Almost 90% lower corrosion
- System Inefficient and Expensive
OceanSaver apparently has positive test results also.
NEI’s Ballast Water Treatment System
The Venturi Oxygen Stripping™ System

- Ballast Water Treatment D.O. to 0.7 mg/l
- Ballast Tank Inerting to <1% O₂
- Bare Steel Corrosion Rate as Low as 0.09 mm/yr
- Results Consistent w ULCCs and Sumitomo testing
- Capital and Running Cost is Significantly Less Than the Savings in Corrosion Maintenance
BMT Corrosion Rate Testing – 270 Days

Up to 84 % Lower Corrosion

Treated

Untreated
Naval Research Laboratory 1-Month Test

The graph shows the inverse of the resistance ($1/R_p$) in ohms$^{-1}$ for different conditions:

- **Raw SW Open to Air**
- **Stripped SW Open to Air**
- **Stripped SW Inert Gas HS**

The data is categorized by rows 1, 2, 3, and 4.
From 1 Month to 5 Years, Similar Results

- Shipboard Results are Better than Laboratory Testing
- Corrosion Reduction from 80 to 95 Percent
- The Longer the Trial the Better the Results
- “Aqueous corrosion of steels in natural waters depends entirely upon the availability of oxygen.” (ISSC 2005)
Why Is Such A System A Good Idea?

• Structural Strength is determined by Thickness

CSR Predicted Corrosion Rate of 0.2 mm/yr
Why Is Such A System A Good Idea?

- Reduction of Thickness results from flow of electrons:

\[ \text{Fe} \rightarrow \text{Fe}^{n+} + \text{ne}^- \quad \text{(corrosion)} \]
Why Is Such A System A Good Idea?

• Coating is basically Insulation

• Thicker Coating = Better Insulation
Why Is Such A System A Good Idea?

• Cathodic Protection is an attempt to redirect e- flow
Why Not Reduce The Current, Too?

• Deoxygenation Lowers Current Density for Bare Steel

110 mA/m² is reduced to less than 15 mA/m²
**How These Elements Relate (DNV-RP-B401)**

\[ I_c = A_c \, i_c \, f_c \]

- \( I_c \) is polarizing current from CP (A)
- \( A_c \) is areal coverage per anode (m\(^2\))
- \( i_c \) is current density (A/m\(^2\)), and
- \( f_c \) is coating breakdown factor

\[ f = a + bt \]

<table>
<thead>
<tr>
<th>Depth (m)</th>
<th>I (a = 0.10)</th>
<th>II (a = 0.05)</th>
<th>III (a = 0.02)</th>
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<tr>
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<td>b = 0.10</td>
<td>b = 0.025</td>
<td>b = 0.012</td>
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<td>b = 0.05</td>
<td>b = 0.015</td>
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</table>

**Category I:** One layer of epoxy paint coating, min. 20 um nominal DFT

**Category II:** One or more layers of marine paint coating (epoxy, polyurethane or vinyl based), total nominal DFT min. 250 um.

**Category III:** Two or more layers of marine paint coating (epoxy, polyurethane or vinyl based), total nominal DFT min. 350 um.
**At 15 Years, What is the CP Current Demand?**

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<tr>
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<th>Cat. III w CP</th>
<th>Cat. II w VOS and CP</th>
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<tr>
<td>$A_c$</td>
<td>130 m²</td>
<td>130 m²</td>
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<tr>
<td>$i_c$</td>
<td>110 mA/m²</td>
<td>15 mA/m²</td>
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<td>$I_c$</td>
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15 Years in Service?
Should Be “Good” Throughout Design Life
Ballast Tank Deoxygenation Can Reduce Life Cycle Cost

www.nei-marine.com
Ballast Tank Coatings

Ballast Tank Surface Area of Double Hull Ships

- Single Hull VLCC had 40,000 m$^2$
- Double Hull VLCC has 200,000 m$^2$

Cost to Coat and Repair – Imabari: Panamax Bulk Carrier ballast tank coating to PSPC will be $2,500,000 (\$50/m^2)$

New Performance Standard for Protective Coatings

Target Useful Coating Life of 15 Years… But Section 4.1 – “The actual useful life will vary, depending on numerous variables including actual conditions encountered in service.”

Accelerated oxidation of retained solvents may reduce coating elongation, leading to premature embrittlement, flaking, cracking, etc.
Cathodic Protection

Zinc is uncoated and degradation rate is directly proportional to concentration of dissolved oxygen in ballast water.

High residual dissolved oxygen in ballast water will increase degradation of CP.

\[5 \text{ mA/m}^2 = 1 \text{ kilo zinc per } 7 \text{ m}^2 \text{ of ballast tank surface area} = 325 \times 22 \text{ kilo zinc anodes for Panamax Bulker (approx. $500,000 at newbuild yard)}\]

Oxidizing BWT may increase the required amount of zinc.
What is the change to the cost of a ship if the ballast tank steel corrosion additions need to be changed? What if they need to be doubled?
## Example Illustration of Total Cost

<table>
<thead>
<tr>
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<th>Tank-Damaging BWT Technology</th>
<th>Tank-Neutral BWT Technology</th>
<th>Tank-Protective BWT Technology</th>
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Owner and Yard Questions for Ballast Water Treatment System Suppliers

1. What does your treatment do to ballast water? (Chemistry)

2. What is the change to Oxidation Reduction Potential of this treatment? (Strength)

3. What is the required total and residual dose? (Dose)

4. How is the required initial dose affected by influent water chemistry? Does this have any affect on residual dose? (Application)

5. How long does the treatment chemical survive after dosing?

6. What are the breakdown products? Dissolved oxygen level?

7. Do you have proof that this treatment will have no negative affect on coatings, cathodic protection, or steel?
Suggestions for Shipyards and Ship Design Companies

1. Include structural and coating specialists in technical presentations by Ballast Water Treatment Equipment suppliers, not just piping team.

2. Demand information regarding treatment technologies’ affect on coatings, CP, and steel. MEPC 56: TRO, TRC info should be provided with application for evaluation [IMO Type Approval]

3. Consult with ballast tank coating suppliers about compatibility with ballast water treatment technology.


5. Design the ballast tank corrosion protection system (i.e., the ship’s structural protection system) to account for the affect of the ballast water treatment system.