Corrosion in Ballast Tanks of Merchant Ships

&

Maintenance Pays Off

By AMACORT

Prof. capt. dr. Kris De Baere
Prof. dr. Helen Verstraelen
Prof. dr. Geert Potters
Prof. Raf Meskens
Prof. ir. Remke Willemen

Presenting: Capt. dr. K. De Baere and ir. dra. Remke Willemen

Antwerp Maritime Academy

02 March 2015
A group of “corrosion fanatics” within the Antwerp Maritime Academy

It started with a captain foreign going (myself), a biologist specialized in plant physiology (Geert) and a specialist in maritime safety (Helen)

In 2012 the group was reinforced with a naval architect (Remke) and a master in nautical sciences (Raf)
Present and future research

• Research on corrosion in ballast tanks of merchant ships started in 2007 and is still going on
• In 2009 we presented our preliminary results at an MID meeting, here in Breda
• In 2009 we visited 70 ships, today more than 170
• We would like to present the evolution since then
Present and future research

• At this moment 4 additional research lines
  – Making coatings more sustainable (2012) (H2020 project)
  – Objective comparison of anti-fouling paints (2014) (MIP – IWT project)
  – Study towards innovative anti-fouling techniques based on ionic liquids (NATO-project) (2014)
  – Preservation of historic steel wrecks in the North Sea (2014) (IWT project together with the “Vlaams Instituut voor onroerend erfgoed”)
RW7 added text ter ondersteuning afkortingen
Remke Willemen, 25-02-2015
Present research
Present research

Pilot Boat 1 – FOD Mobiliteit
Anti-Fouling comparison

0,5% PHMG-HCl
0,01% PHMG-HCl
Untreated biofilm

West-Hinder Lichtvessel, 2014 (Flanders Heritage Agency, photo Dieter Decroos)

HMS Wakeful
titel naar present daar dit nu allemaal lopende is
Remke Willemen, 25-02-2015
Some Recapitulation

• 2009 is already a long time ago
Driving Force: Do ships rust?
Definitely they do! – Rust Never Sleeps (Neil Young)
Ballast tanks are of particular interest

- Constant wet/dry situation
- Complex structure
- Increased surfaces
- Use of high tensile steel
- Thermos effect
- Difficult and expensive maintenance
- Non optimal surface preparation and coating application at construction
Driving force

Towards greener ships

Extension of ships life span through extension of ballast tanks coating life

• The rate of corrosion in ballast tanks is a decisive factor for ending the economic life of a ship and sending her to the scrap yard (LR, 2006)

• 90% of ships failures can be attributed to corrosion (Melchers, 1999)
Why focusing on ballast tank coatings?

1. Greener ships: Wasting ships is wasting energy
   - Reduction steel production = saving energy
     - Worldwide 1 ton of steel turns into rust every 90 sec.
     - The energy required to produce 1 ton of steel ≈ the energy an average family consumes over 3 months (Javaherdashti, 2008).
     - 50% of world steel production is for the replacement of corroded steel
   - If ballast tank coatings become more sustainable
     - Less need for ship building
     - Less repair operations
     - Less emission
Also on board dredgers
Why focusing on ballast tank coatings?

1. Greener ships
2. Reduction of dry dock periods
   - A ship in dry-dock does not make any money 😞
     - TCE (Time Charter Equivalent) tanker market 10,000 - 20,000 USD/Day
   - Shorter dry-dock periods are less costly

Happy Ship Owner
Why focusing on ballast tank coatings?

1. Greener ships
2. Reduction of dry dock periods
3. Reduction of maintenance costs in double hull structures
   - Horrible corrosion rates
   - Enclosed and poorly accessible spaces
   - Compromised and expensive maintenance

Ballast tanks in bad condition
Recoating ballast tanks

NIGHTMARE and horribly expensive
Methodology

• In 2007 we started spelunking ballast tanks
• Today, > 170 ships have been inspected and collected in a database
• To ease statistics we developed the corrosion index [CI] representing the condition of a tank with one figure only (based on IACS Rec. 87)
IACS Rec.87

- Plate corrosion
- Edge corrosion
- Scaling
2009 Results

- Scatter diagram & linear regression
- Coating intact about 4.5 years
- Corrosion about 1.7% per year.
- GOOD condition about 10.4 years
- POOR after about 22.1 years

CI = 1.6817t – 7.1449
1.7% per year
initiation after 4.5 years
$R^2 = 0.4916$
The coating systems remain intact for approximately 5.4 years. Afterwards, a rather steady degrading process at a rate of 1.53% surface per year starts. The coating becomes “FAIR” after 12 years, and after 25 years, the coating becomes “POOR.”
Ships with little attention for coating application and little and/or no “in life” maintenance

The “average” ship

High standard ships

Logistic Model
Ship owner “X”

- In 2012 we obtained the permission of “X” to visit all of his ships when calling at Antwerp
- “X” has an outstanding reputation when it comes to application and maintenance of ballast tank coatings
- “X” sails with his ships from “cradle to grave”
- At this moment 21 “X”-ships have been added to the database (yellow and red dots)
Time dependent weighted corrosion

\[ y = 1.5313x - 8.2799 \]
\[ R^2 = 0.4215 \]

Average corrosion rate is 1.53% per year
Owner “X” statistically significant difference – linear presentation

Corrosion rate on “X” ships is 0.15% per year compared to 1.5% for the other ships.

The “average” ships corrode 10 times faster than the “X” ships.
“X” broken down

- Within the “X” group 4 ships “escaped” high standards
- These ships are shown in “red” and perform just as any other “standard” ship
- Statistical significant difference between “X” ships and the “average” ship
- Statistical significant difference between “red” and “yellow” X-ships
Why owner “X” makes a difference

• A lot of attention paid to the technical selection of the coating, especially to type, water absorption and solvent category and concentration
• Severe selection of applicator and yard (sometimes hampered by commercial considerations)
• Specifications: standard comparable to TSCF$_{25}$ or better
• Meticulous inspection during coating application and a proper on-board maintenance post-delivery
Conclusion

• Even when using a well selected off the shelf epoxy coating, and applying it without compromises regarding surface preparation and application circumstances a protection of more than 30 years in an excellent condition is unequivocally possible.

• Life time lasting coatings (> 30 years) for ballast tanks with only “on-board” maintenance is achievable.

Antwerp Maritime Academy
Our research does not end here !!!!

• In depth investigation towards application parameters

• Cost-effective validation
Economic appreciation - Introduction

• The ship’s model selected for this economic appreciation study is a “standard” chemical tanker with a Summer Deadweight (SDWT) of 37,000MT, a Length Over All (LOA) of 170m, a breadth of 32m and 90,000m² of coated ballast tank surface.
Economic appreciation - Introduction

• Starting point is the “in situ” observations on board of 2 groups of ships, the “X-ships” or “excellent ships” and “all the others” or so called “average ships”.

• We are only aware of the conditional difference between “average” and “excellent” at any moment in time but not of the efforts during the life cycle of the ship to obtain and or maintain this situation.”
An example: both ships same age
Difference is huge – WHY!!!!!!!!!!

We are ignorant about the “foreplay” – for each of the 170 ships different
Economic DEPRECIATION

- By using a less stringent coating standard at new building and maintaining less adequate, a ship loses value over time. = depreciation

- This depreciation equals the investment necessary to bring the “average ship” in the same condition as the “excellent ship” by means of maintenance and or repair at any moment in time.
geheerformuleerd
Validating the DEPRECIATION

Initial application cost
“Average ship”: 3,600,000$
“Excellent ship”: 4,500,000$
Diff: 900,000$

After 25 years
27,000m² to be repaired
1,755,000$

Difference
1,579,500$

Difference in value between the 2 ships is the “cost” to bring the “average ship” in the same condition as the “excellent ship”

WE ARE UNAWARE OF THE EFFORTS (MAINTENANCE & OR REPAIR) OF THE INDIVIDUAL SHIPOWNERS DURING THE LIFECYCLE OF THE SHIP ???????????????

After 25 years
2,700m² to be repaired
175,500$
Many question marks

Making a generic economic model is difficult
Validating the DEPRECIATION

- Maintenance and repair cost made during the life cycle of the ship are crucial, especially dry-dock costs.
- **Next, we make just one of the many possible assumptions**, we suppose that the “average ship” replaces 100% of the coating in dry-dock during its 25 year lifecycle. 10% after 10 years, 40% after 15 years and 50% after 20 years.
- Maintenance on board is not taking into account (according our info (p.c. some Belgian shipowners) this is negligible any way)(confirmed Raouf Kattan – Safinah)
- Seeing that the average “X” vessels are still being characterized as good after ca 25 years, no dry dock coating replacements have to be considered.
Validating the DEPRECIATION

• Maintenance & repair regime on board ships is not only function of the “enthusiasm” of the ship owner but is also governed by the trade/region/flag/class society.

• Tankers have to satisfy the highest standards
  – Charter contracts, and customer requests a CAP 1 or at least CAP 2 rating. CAP 1 is new ship standard, and CAP 2 is excellent - above and beyond class requirements

• Bulk carriers, general cargo ships, dredgers follow less stringent requirements
A first scanning of the problem indicates the following pattern:

1. The "average ship" is cheaper.
2. The "excellent ship" is cheaper after 14.5 years. Maintenance on board is negligible.

---

Antwerp Maritime Academy
First scanning conclusion

• A good coating well applied and well maintained pays off
• One condition – one has to sail long enough with the ship – break even: 14 -15 years
• Additional advantages
  – Extra safety for crew and cargo
  – Reduced risk on pollution
  – Less VOC due to less paint used
  – Easier to charter
  – Access to more expensive cargoes => better freight
  – Improved image of the ship owner
Caution

• The presented economic model is valid for ship owner “X”
• Outcome is dependent on built in assumptions such as % coating repair during dry-dock
de laatste bullet mag weg daar we geen prijzen geven (Financial parameters, prices and costs were determined to the best of our abilities, however, variations are possible)
Contact

- “Easy” questions will be answered right away
- “Annoying” questions will take a little bit more time 😊
- kris.de.baere@hzs.be
- remke.Willemen@hzs.be

AMACORT 2015
Thank you!

This work had been impossible without ............

• Helen, Raf & Geert - Amacort
• Ed Jansen – ABS
• Johnny Eliasson – Chevron
• David McKellar
• Antwerp Dry Docks
• Marc De Boom – DEME
• Jan De Nul
• Maarten Dreser – MSC
• All Belgian ship owners
• Antwerp Maritime Academy Colleagues
• Many more