Corrosion in Ballast Tanks of Merchant Ships
&
Maintenance Pays Off

By AMACORT

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

AMACORT

- 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

RW7

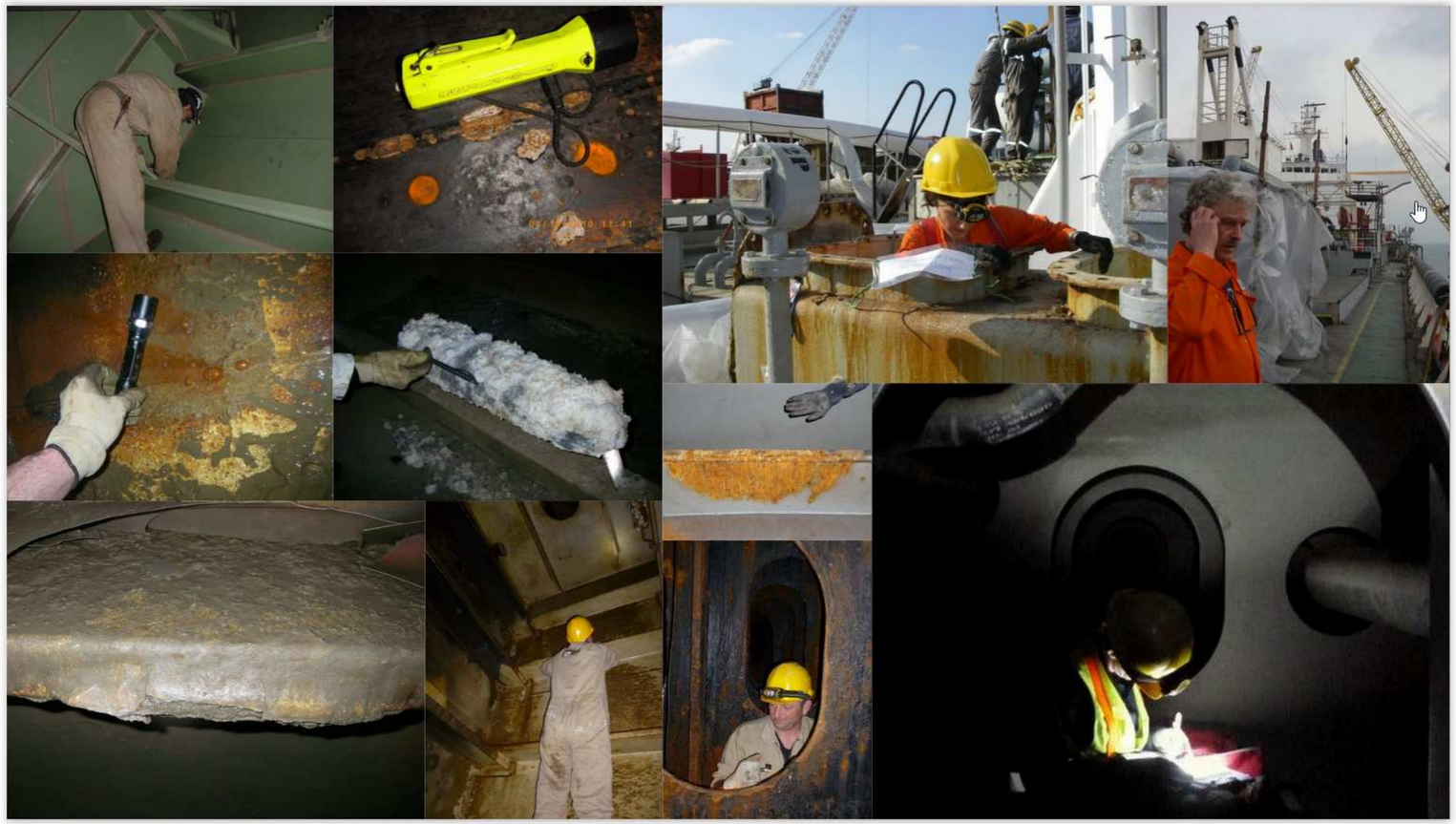
Present and future research

- 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”)

Slide 4

RW7 added text ter ondersteuning afkortingen
Remke Willemen, 25-02-2015

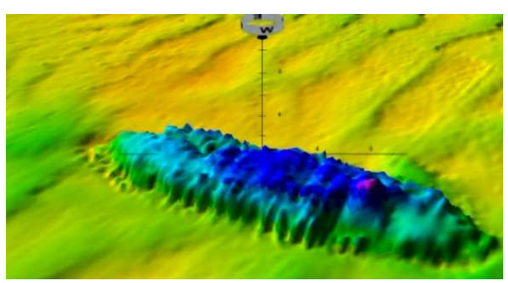
Present research



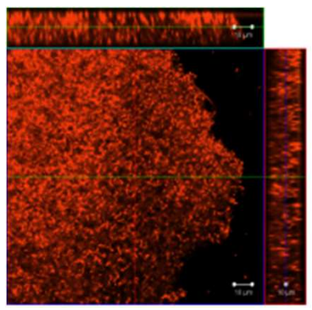
RW6

Present research

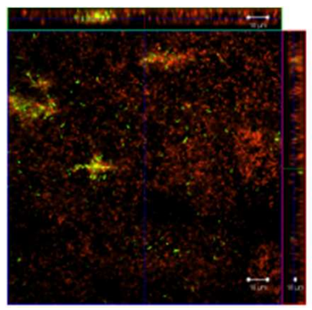
Pilot Boat 1 – FOD Mobiliteit
Anti-Fouling comparison



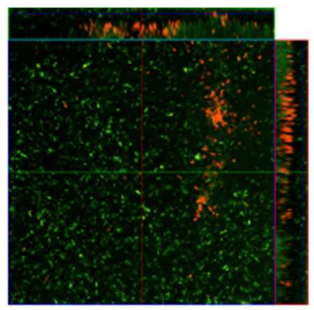
West-Hinder Lichtvessel, 2014 (Flanders Heritage Agency, photo Dieter Decroos)



0,5% PHMG-HCl



0,01% PHMG-HCl



Untreated biofilm

HMS Wakeful

Slide 6

RW6 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

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 **<u>one figure only</u>** (based on IACS Rec. 87)

IACS Rec.87

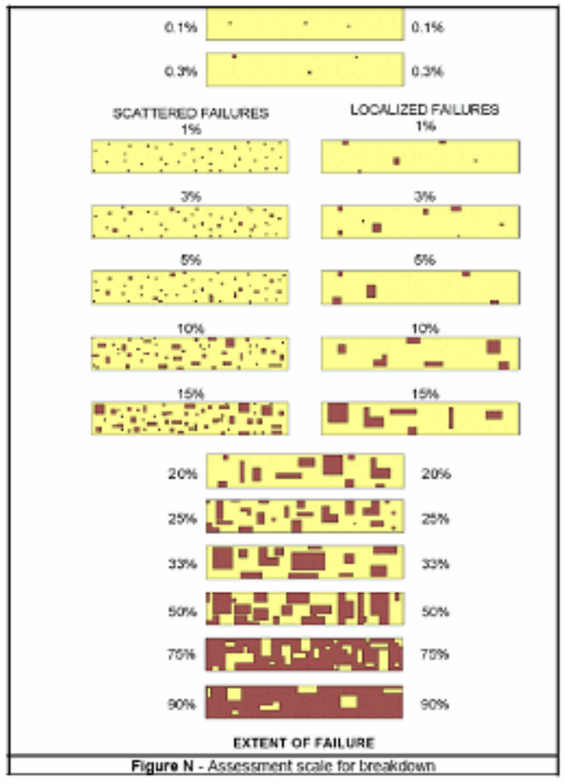
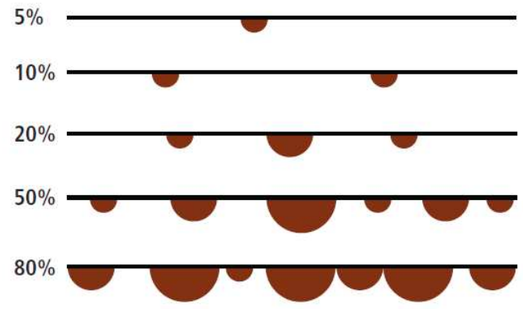
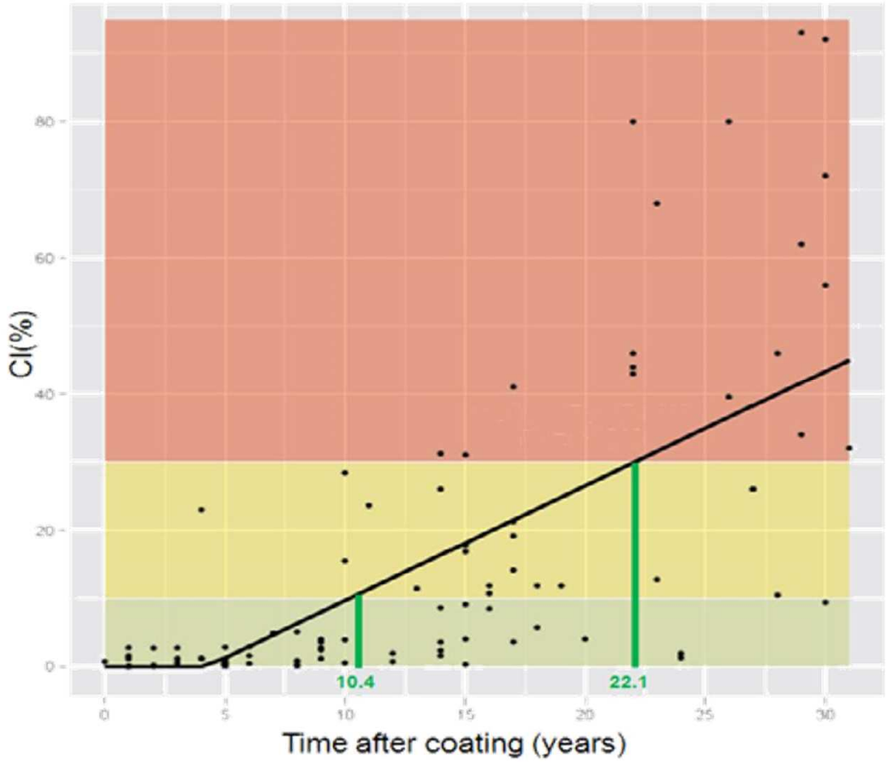


Figure N - Assessment scale for breakdown

- Plate corrosion
- Edge corrosion
- Scaling



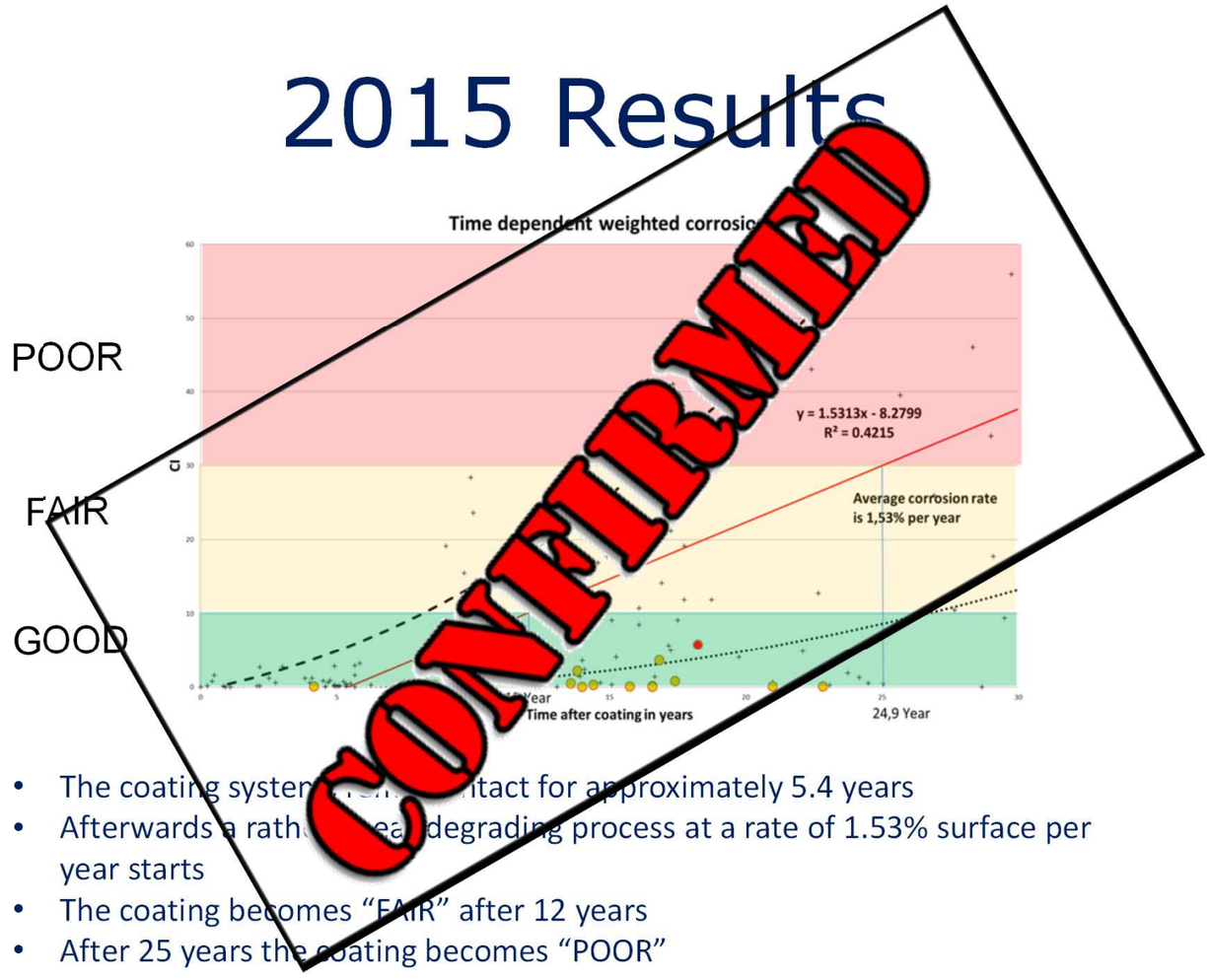
2009 Results



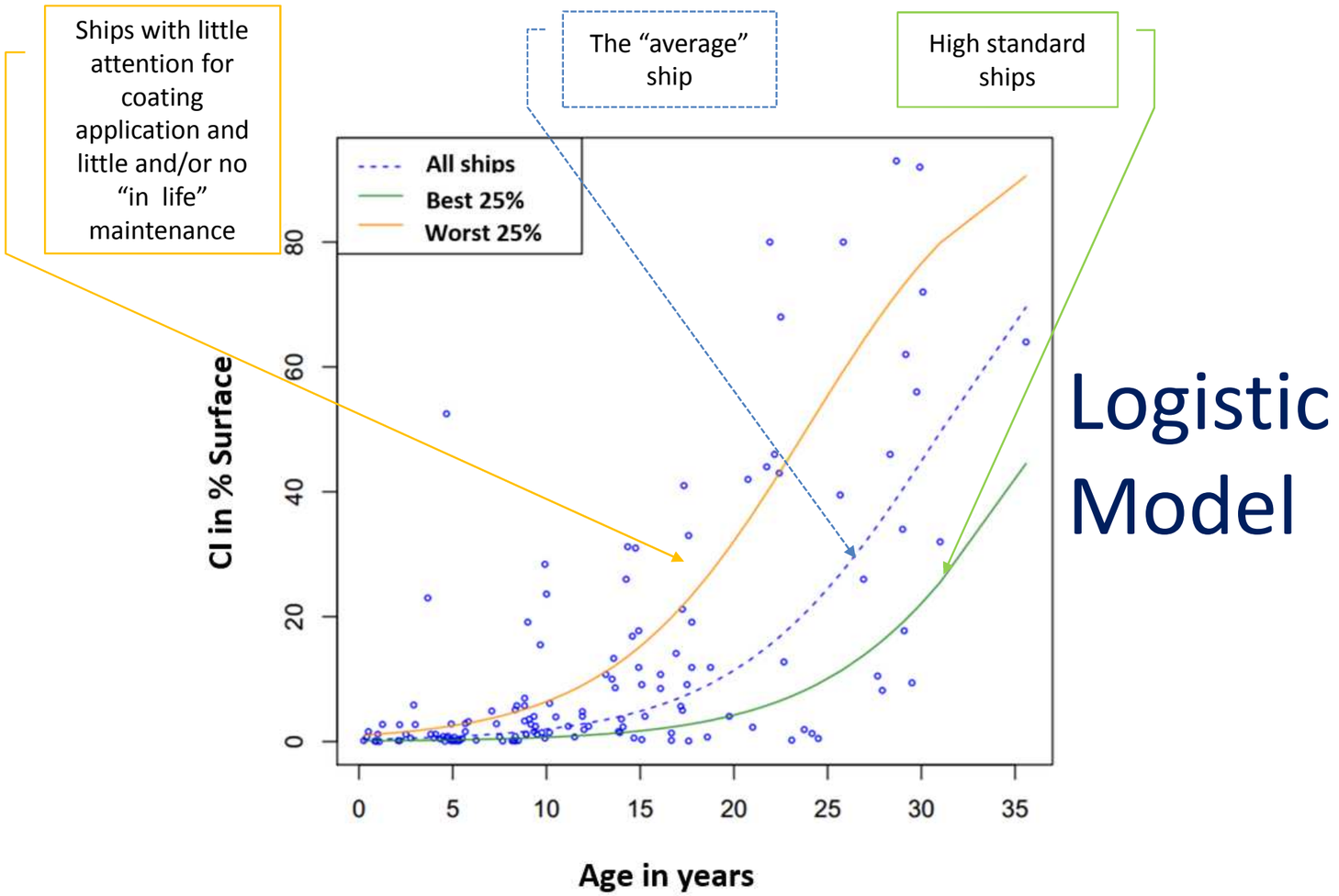
- Scatter diagram & linear regression
- Coating intact about 4.5 years
- Corrosion about 1.7% per year.
- **GOOD** condition about 10.4 years
- **POOR** after about 22.1 years

CI = 1.6817t – 7.1449
1.7% per year
initiation after 4.5 years
R^2= 0.4916

2015 Results



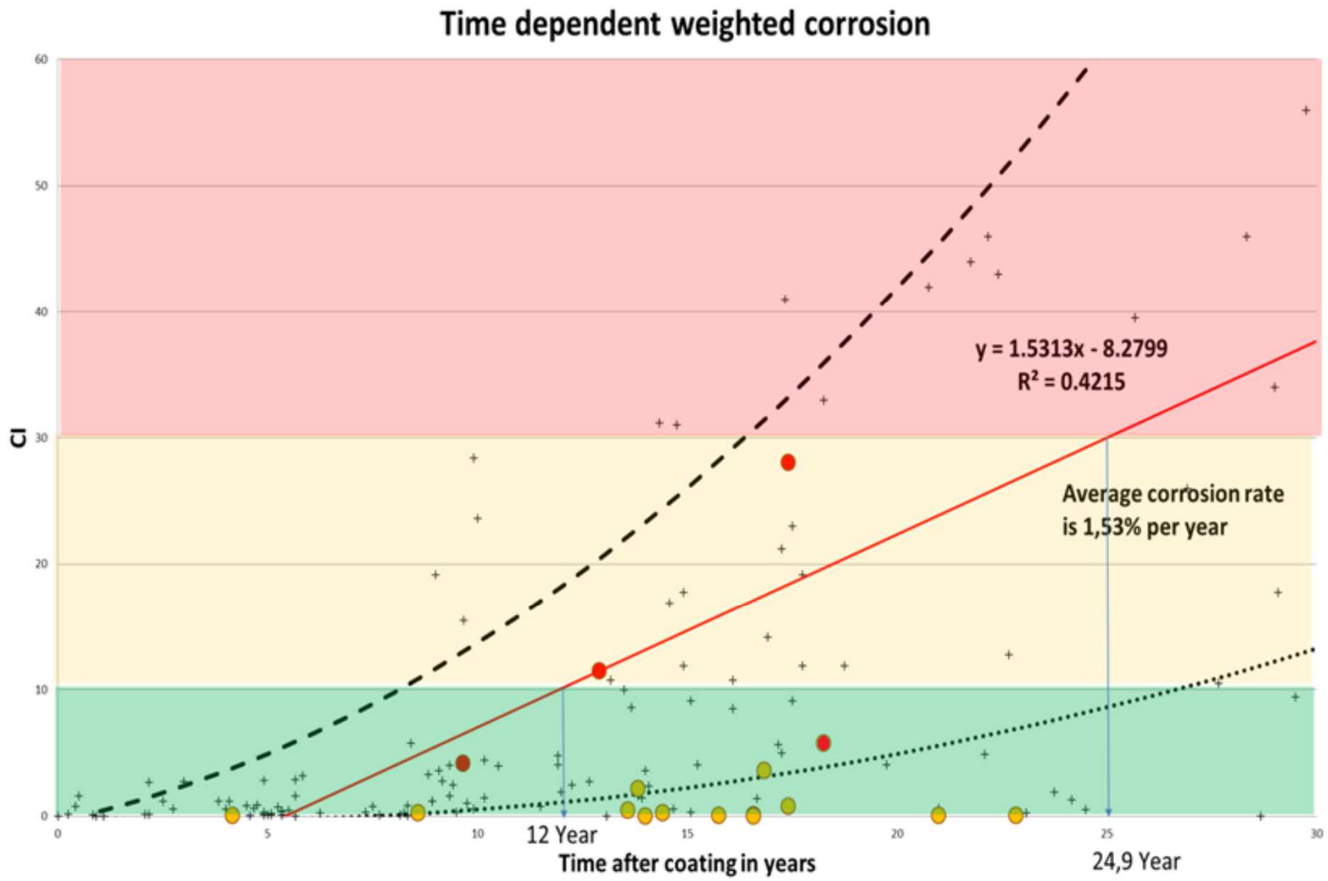
- The coating system remains intact for approximately 5.4 years
- Afterwards a rather linear degrading process at a rate of 1.53% surface per year starts
- The coating becomes “FAIR” after 12 years
- After 25 years the coating becomes “POOR”



Logistic Model

Ship owner “X”

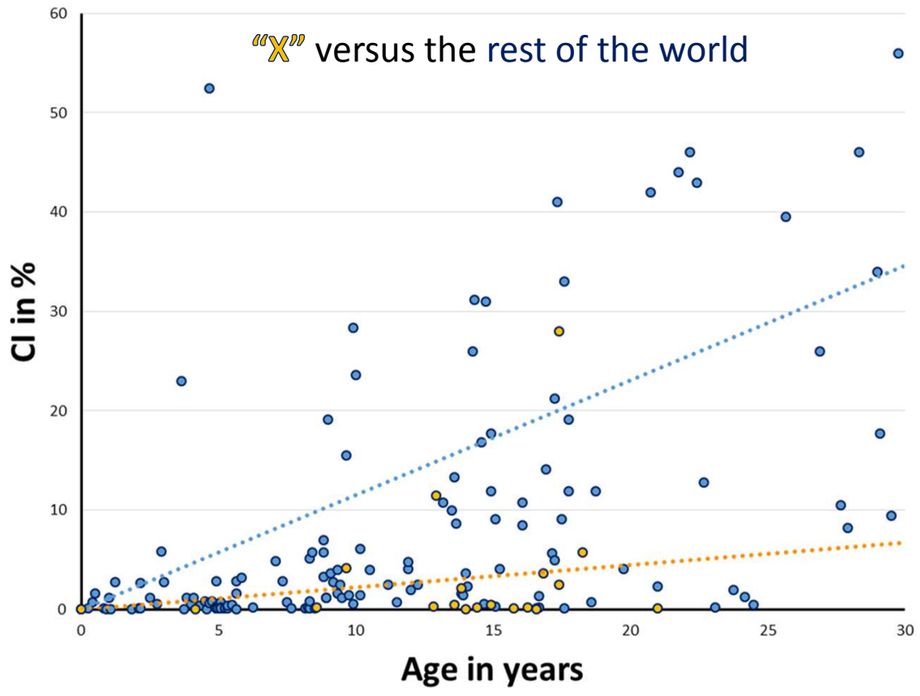
- In 2012 we obtained the permission of “X” to visit all of his ships when calling at Antwerp
- “X” has an outstanding reputation when it comes to application and maintenance of ballast tank coatings
- “X” sails with his ships from “cradle “ to “grave”
- At this moment 21 “X”-ships have been added to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


Time dependent weighted corrosion
CI
60
50
40
30
20
10
0
0
5
10
15
20
25
30
y = 1.5313x - 8.2799
R² = 0.4215
Average corrosion rate
is 1,53% per year
12 Year
24,9 Year
Time after coating in years

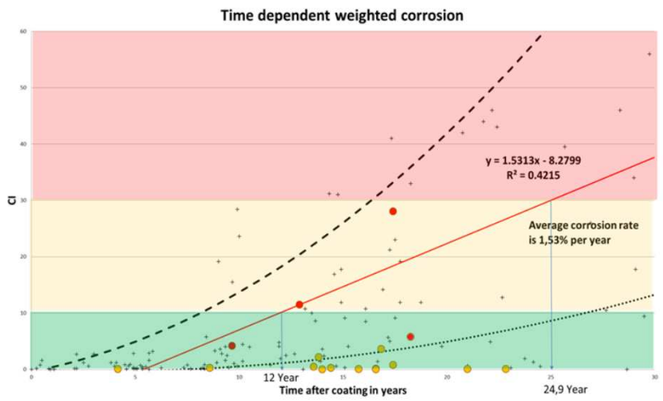
Owner “X” statistically significant difference – linear presentation

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

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.

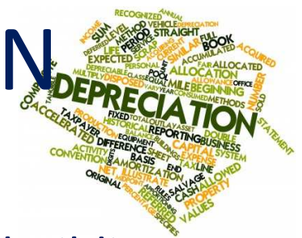
Economic appreciation - Introduction

- 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.

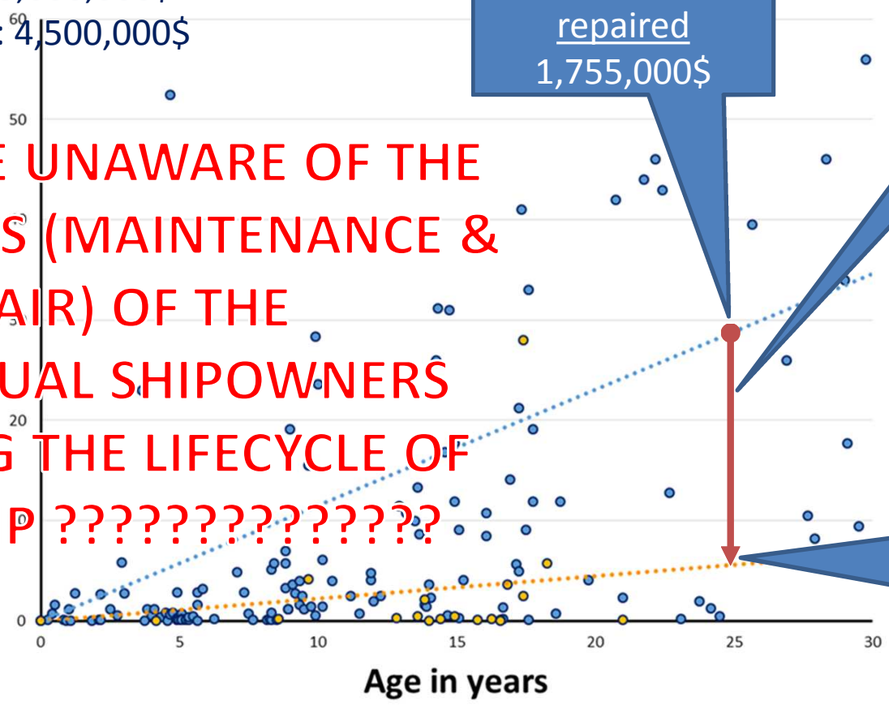
RW9 geherformuleerd

Remke Willemen, 25-02-2015

Validating the DEPRECIATION

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

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



Many question marks

Validating the DEPRECIATION

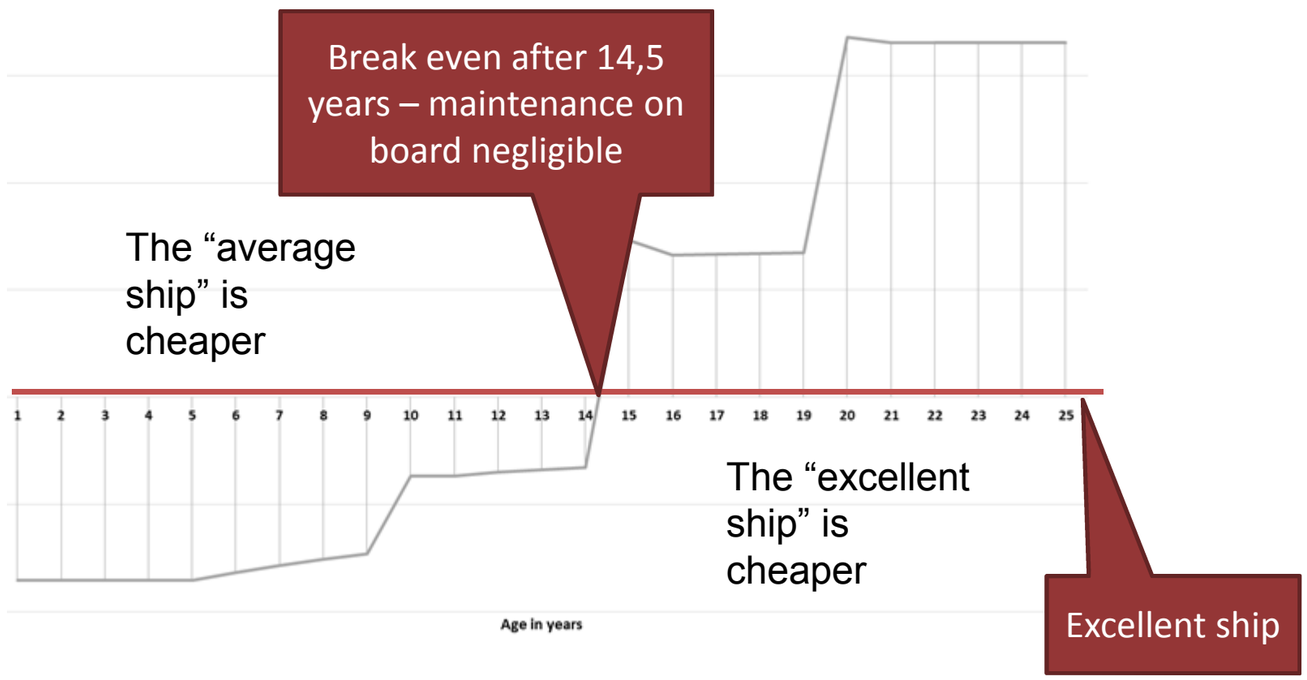
- Maintenance and repair cost made during the life cycle of the ship are crucial, especially dry-dock costs
- **Next, we make just one of the many possible assumptions**, we suppose that the “average ship” replaces 100% of the coating in dry-dock during it’s 25 year lifecycle. 10% after 10 years, 40% 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



RW24

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

RW24 titel aangepast

Remke Willemen, 26-02-2015

RW18

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

Slide 38

RW18 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)
Remke Willemen, 25-02-2015

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

This work had been impossible without ……

- Helen, Raf & Geert - Amacort
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- 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