Easy-Qote®
Unbreakable Self-Adhering Coating Solutions

Why Paint When You Can Patch?

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Stopaq B.V.

SEALFORLIFE Industries

Lifetime of assets by preventing corrosion

While planned obsolescence might have contributed to the economy in the past, long term we have witnessed effects of linear approach to Take, Make and Dump, have devastating effects on the environment we live in.

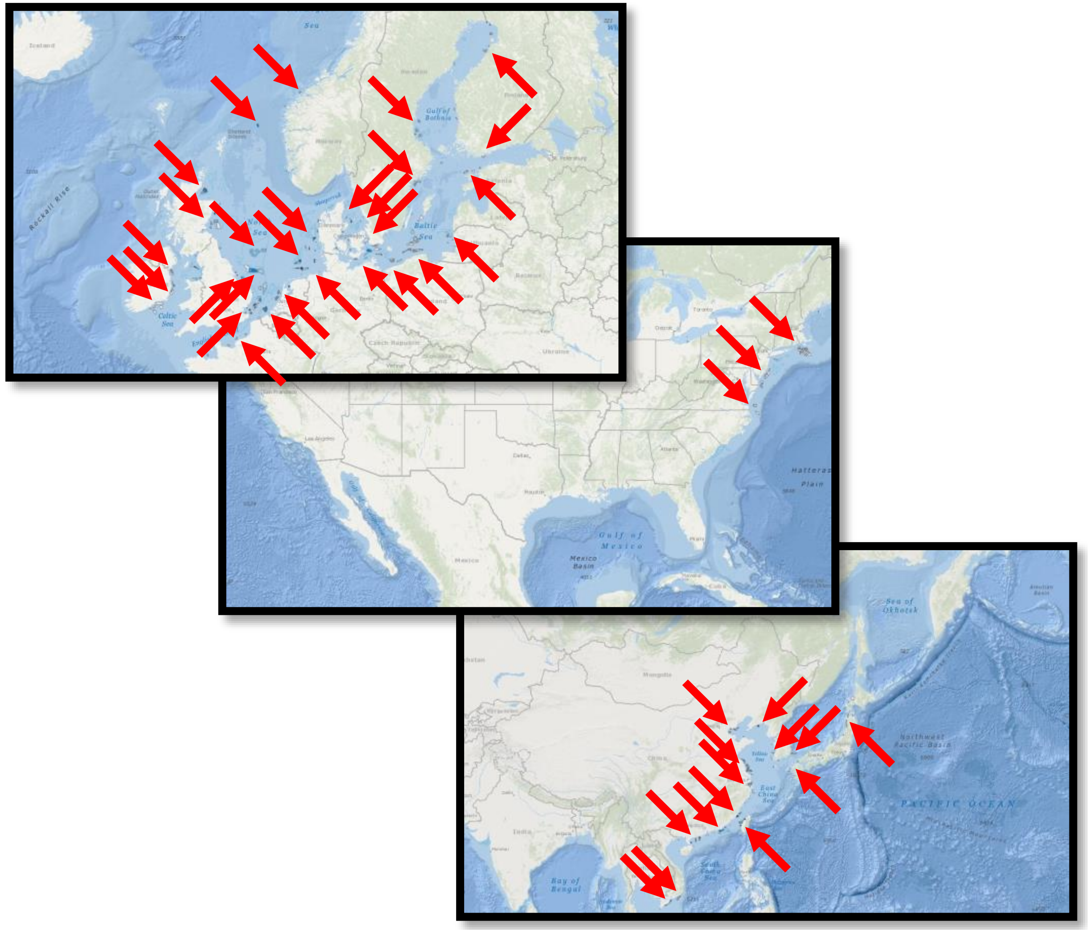
Consciousness on circularity, through renewable energy, offers the opportunity to question durability as well as re-usability of the products. Question stands, if we have durability, how long is it before we worry about recycling or reusability.

Corrosion of assets in atmospheric and splash zone conditions is mainly prevented using coatings. Coatings have an expected lifetime to meet the lifetime of the asset and a maintenance programme to extend it.

How long do coatings last and what are the innovative options available to offer extension of asset lifetime, is what we are striving to deliver.

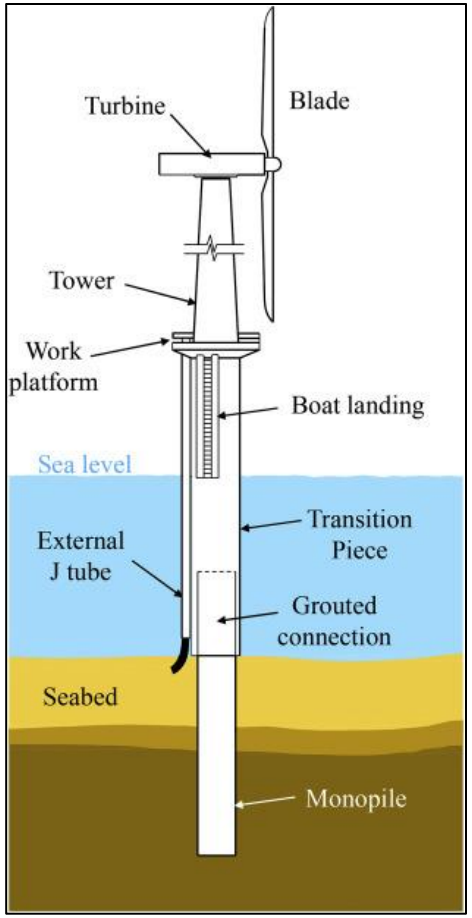
Offshore Windfarms – The worldwide quest for renewable energy

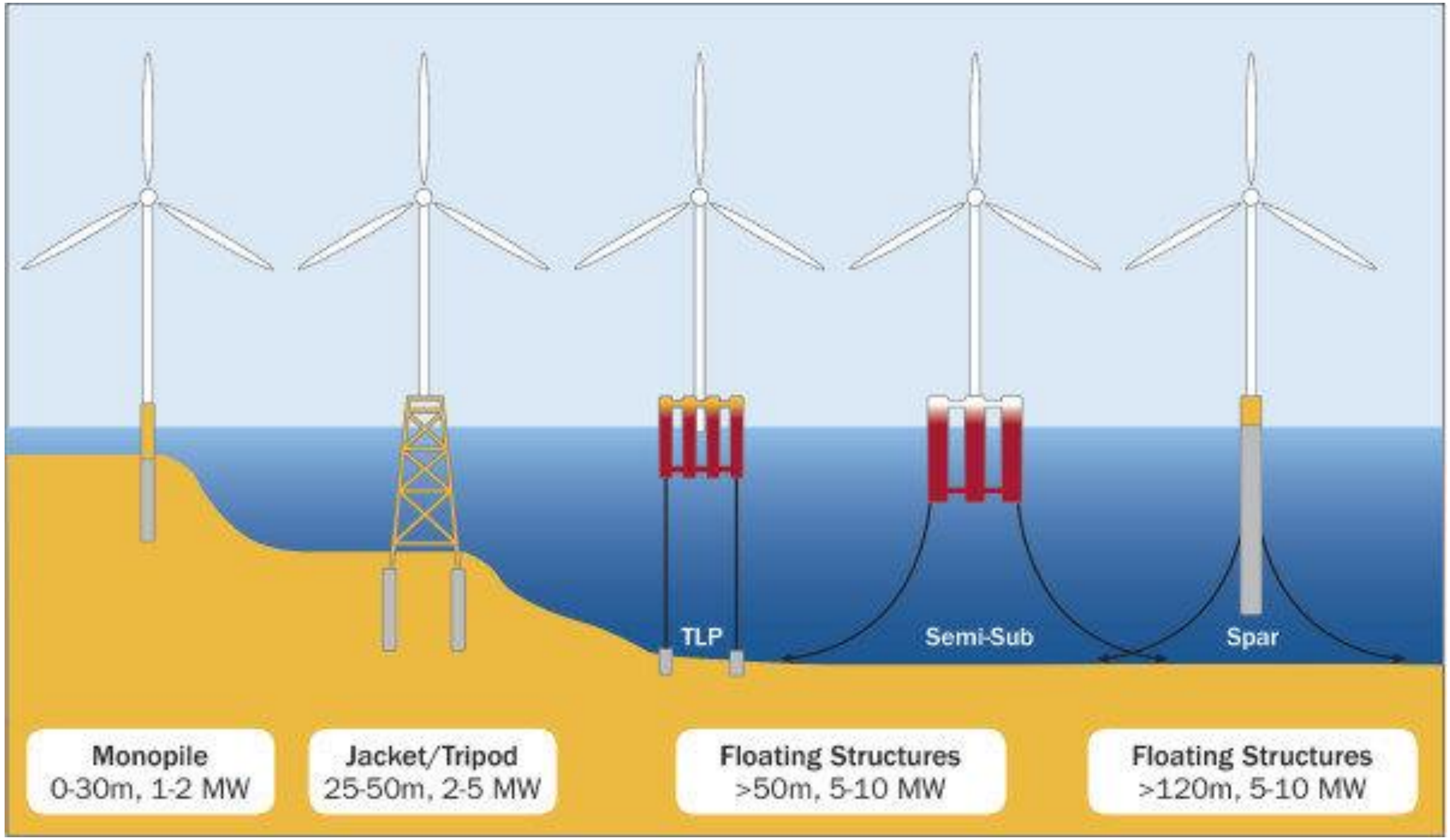
- 2854 projects across 53 countries



Source: https://www.4coffshore.com/windfarms/

Offshore Windfarms – Various constructions





Turbine

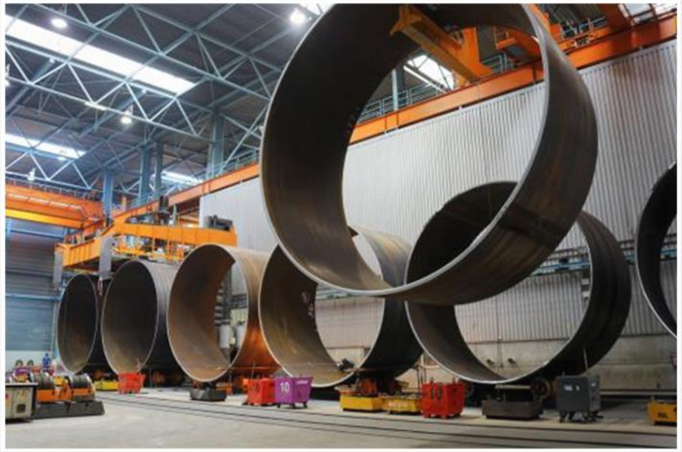
Tower

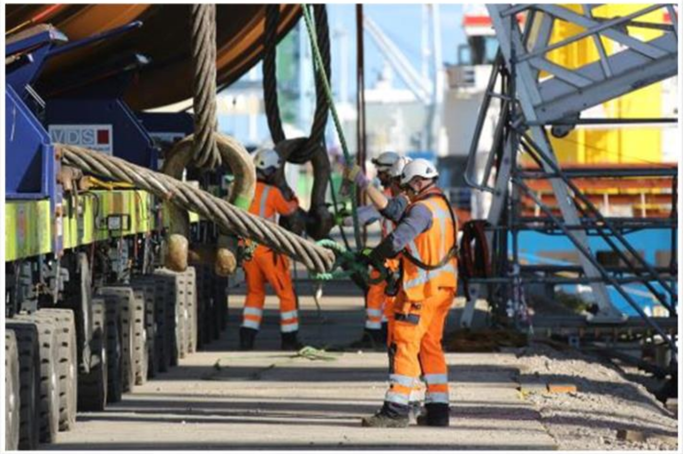
Foundation

Sources:

1) Tao Chen, Xian Wang, Guokai Yuan, Jinchao Liu, Fatigue bending test on grouted connections for monopile offshore wind turbines, Marine Structures, Volume 60, 2018, Pages 52-71, ISSN 0951-8339;
2) Bailey, Helen & Brookes, Kate & Thompson, Paul. (2014). Assessing Environmental Impacts of Offshore Wind Farms: Lessons Learned and Recommendations for the Future. Aquatic biosystems. 10. 8. 10.1186/2046-9063-10-8.

Offshore Windfarms – Manufacturing





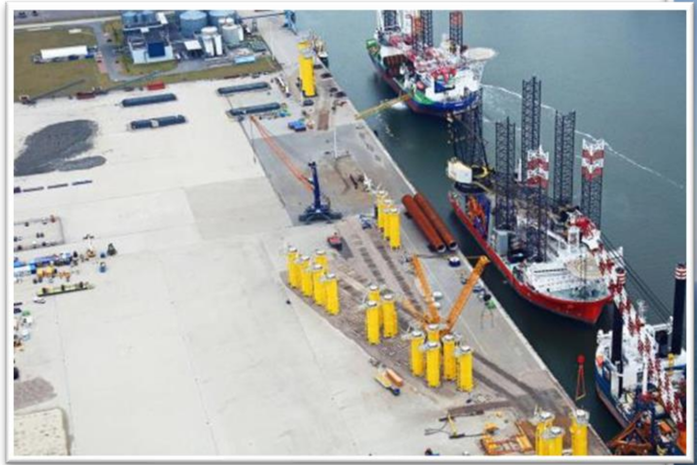
Source: https://www.geminiwindpark.nl/monopiles--transition-pieces.html

Offshore windfarms – Coating in workshop / at yard

- Traditional multi-layer 2-component paint systems:
  - ➢ Require high degree of steel surface cleanliness
  - ➢ Require minimum roughness profile of steel – peak density
  - ➢ Spray application of coatings
  - ➢ Require close control of ambient conditions during application and curing

- This process also creates
  - ➢ Release of hazardous substances
  - ➢ Generate hazardous waste like blast-media and buckets with paint and cleaner remnants
  - ➢ Energy and increase in CO2 emissions

Offshore Windfarms – Transport and installation



Source: https://www.geminiwindpark.nl/monopiles--transition-pieces.html

Offshore windfarms – Coating damages

- Factory-applied coating is prone to damages from hoisting, transport, installation, etc.
- Damage repair at site with same coating system is almost impossible:
  - Limited access, maintenance and repairs usually done by rope access
  - Surface preparation by blast cleaning:
    - Requires mobilization of equipment
    - Generates waste that must be collected
  - Control of application and curing conditions:
    - Exposure of steel surface to salt spray contamination is critical
    - Temperature and humidity control
  - Release of hazardous substances and paint spillage to environment must be avoided
  - Applicators have to return multiple times to same location (multi-coat systems require curing of each layer)

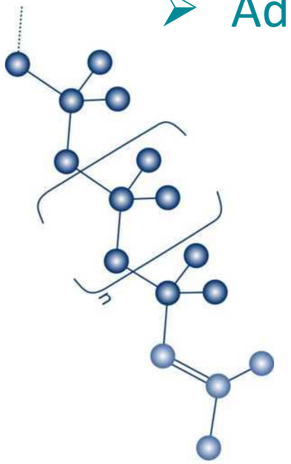
Development of repair coating – The idea

Coating based on pure homopolymer Polyisobutene (PIB)

- Succesfully used for more than 2 decades in oil & gas industry as field joint coating, and as repair and rehabilitation coating
- Meets requirements of ISO 21809-3 coating type 13

Properties of pure homopolyer Polyisobutene (PIB)

- No sensitive chemical groups; Does not cure or harden; Harmless
- Liquid polyolefin with glass transition temperature – 65 °C
    - Cold flow properties; Absence of internal stresses
- Low permeability for water vapour and oxygen
- Adhesion based on vanderWaals forces
    - Surface preparation not critical for proper adhesion
    - Excellent adhesion to various substrates like blast-cleaned and wire-brushed steel, PE, PP, FBE, Neoprene, Liquid Epoxies, etc.



Development of repair coating – The product

Compound based on pure homopolymer Polyisobutene (PIB)

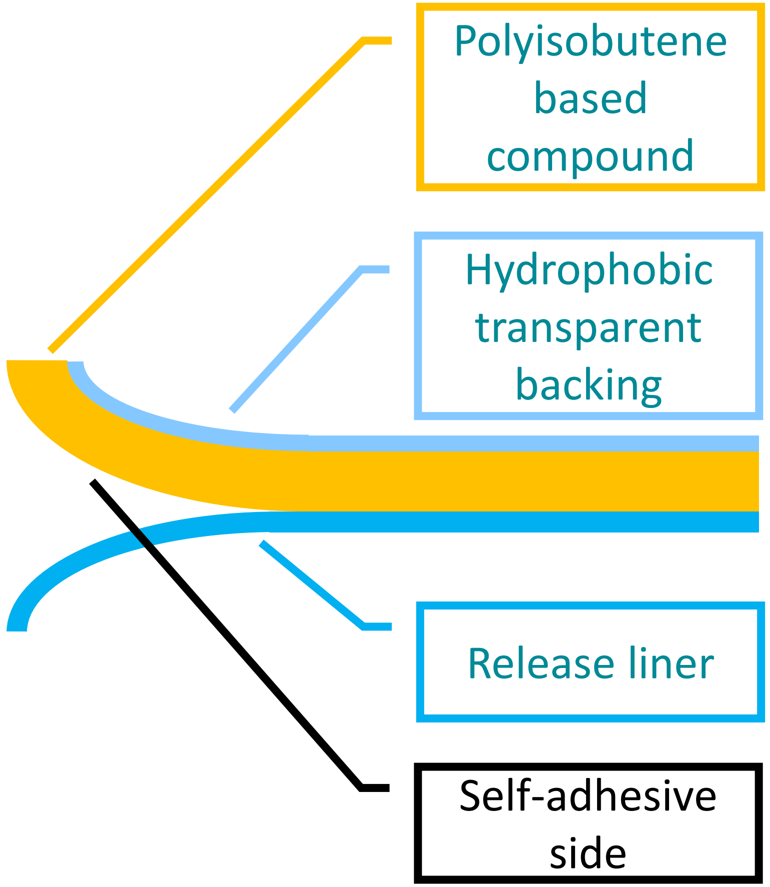
- Available in colours commonly used at wind farms (Yellow, Grey)
- Self-adhesive to many types of substrate

Hydrophobic transparent backing

- Repels water, dirt, marine growth
- High resistance to UV degradation

All layers in one in predefined thickness

- Primer and mid-coat: Compound
- Top-coat: Hydrophobic backing



Repair coating – Laboratory tests

Protective paint systems are commonly tested acc. ISO 12944-9 cat. CX for offshore applications

- PIB based coatings currently not included as “type of paint” in ISO 12944-5
- Chemistry and physics of PIB-based coatings are totally different from protective paint systems

Experimental

- Carbon steel panels (EN 10025-2 type S355JR)
  - Initial rust grade C (ISO 8501-1)
  - Wire brush cleaning to cleanliness grade St 3 (ISO 8501-1)
  - Surface roughness 62 µm (ISO 8503-5 replica tape)
  - Salt contamination approx 30 mg/m² (ISO 8502-9)
- Coated with single coat of PIB-based coating



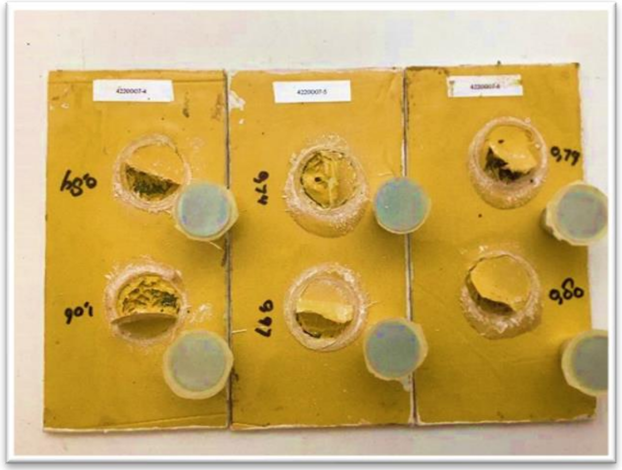

Repair coating – Laboratory tests

Unexposed coated panels were tested for adhesion (ISO 4624) and color (ISO 11664-4)

Three coated panels were scribed and exposed for 25 weeks to cyclic ageing test as specified in ISO 12944-9 Annex A:

- ➢ 72 hours of exposure to UV and condensation (ISO 16474-3 method A; cycle 1)
- ➢ 72 hours of exposure to neutral salt spray (ISO 9227)
- ➢ 24 hours of exposure to low temperature at -20 ± 2 °C

After termination of cyclic ageing, the panels were inspected for adhesion, color, blistering, rusting, cracking, flaking, and corrosion at scribe



Repair coating – Laboratory tests

Results unexposed panels

Property	Requirement	Results	
Adhesion (ISO 4624) • Pull off value; Failure mode	≥ 5 MPa; 0% adhesive metal/coat	0.5 Mpa; 0% adhesive metal/coat	✓

Intrinsic properties of PIB

Results after cyclic ageing

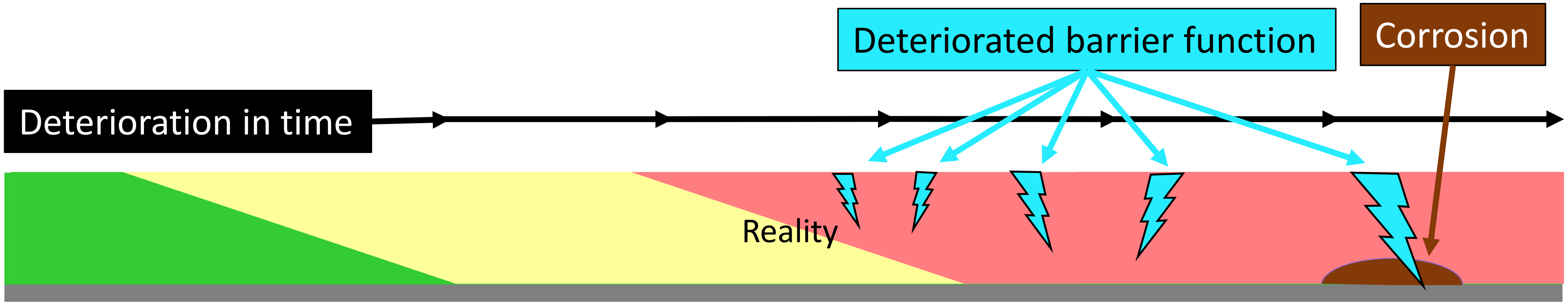
Property	Requirement	Results	
Adhesion (ISO 4624) • Pull off value; Failure mode; • Ratio to unexposed coat	≥ 5 Mpa; 0% adhesive metal/coat ≥ 50% of original value	0.4 Mpa; 0% adhesive metal/coat 80 %	✓
Color difference (ISO 11664-4)	ΔE* = 3.5	ΔE* = 2.7 (no visual difference)	✓
Blistering (ISO 4628-2)	0 (S0)	0 (S0)	✓
Rusting (ISO 4628-3)	Ri 0	Ri 0	✓
Cracking (ISO 4628-4)	0 (S0)	0 (S0)	✓
Flaking (ISO 4628-5)	0 (S0)	0 (S0)	✓
Corrosion at scribe (ISO 12944-9)	M ≤ 8.0 mm	19.4 – 24.3 mm	?

Repair coating – Laboratory tests

<u>Conclusions and discussion:</u>

Corrosion at scribe did not meet requirements:

- Application conditions and properties of PIB based coatings are far different from protective paint systems
  - Single coat on de-rusted steel with St 3 clanliness
  - Coating does not cure nor harden
- Scribe made through coating is believed to represent:
  - Mechanical damage to bare steel; unlikely to happen in atmospheric part of wind tower
  - Deterioration of coating barrier properties in time



Repair coating – Field inspection after 5 years in service at Dutch North Sea

Repair coating – Laboratory tests versus field experience

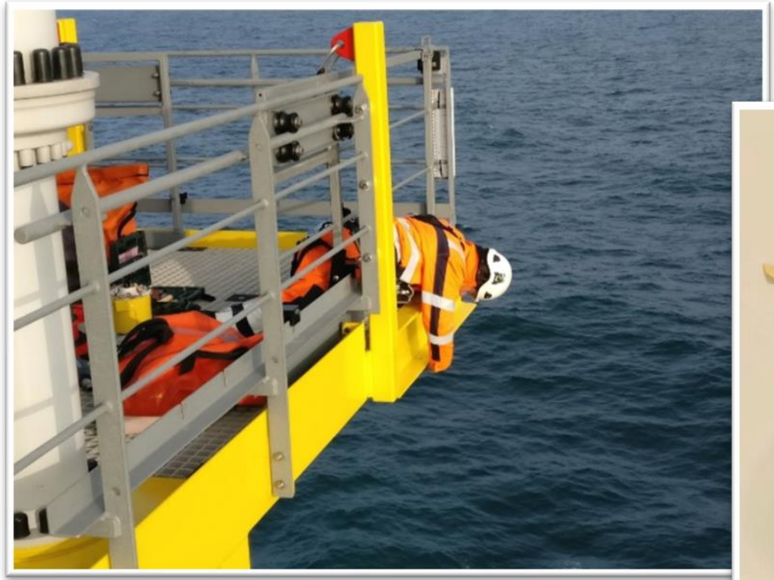
Laboratory tests contradicts with field experience:

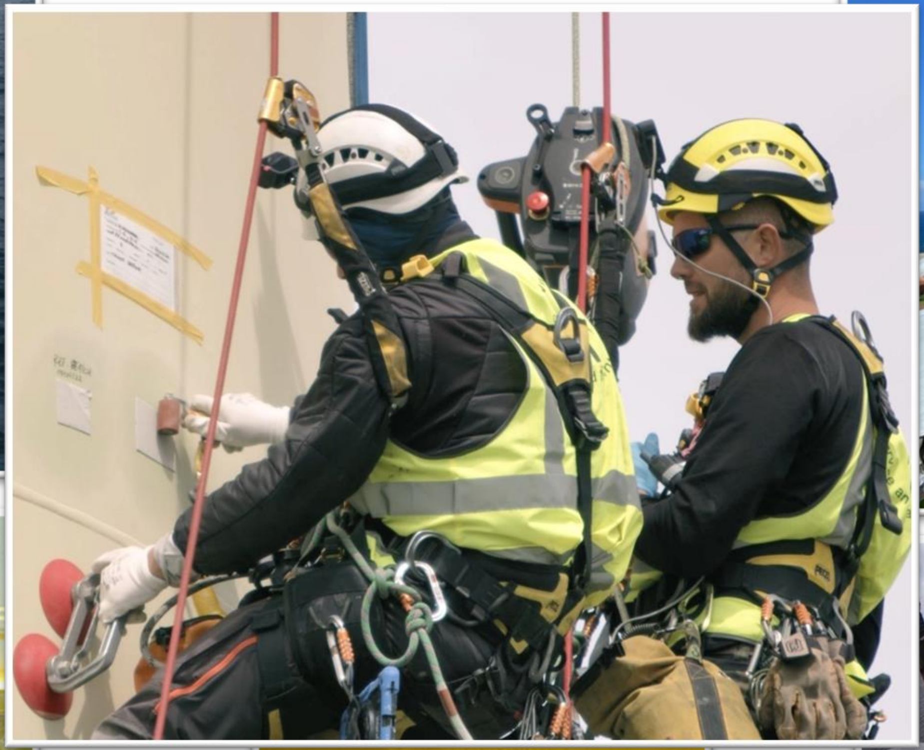
- Test acc. ISO 12944-9 CX did not meet requirements for corrosion at scribe
- Field inspection after 5 years in service at Dutch North Sea revealed that coating is still in good condition

- Contradictory findings call for alternative test methods or development of new testing methodology, e.g.
    - EIS - Electrochemical Impedance Spectroscopy
        - Coating capacitance is influenced by water penetrated into / through coating
    - Polymer degradation
    - Alternative accelerated weathering / ageing tests

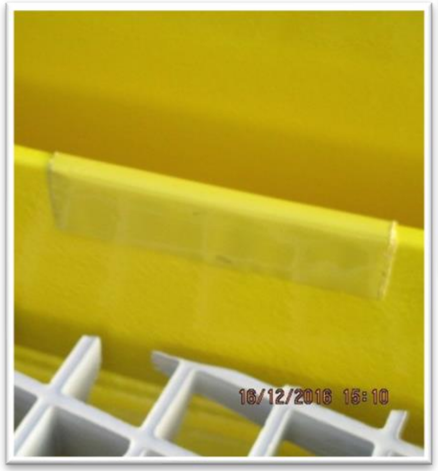
Case histories - Surface conditions and preparation

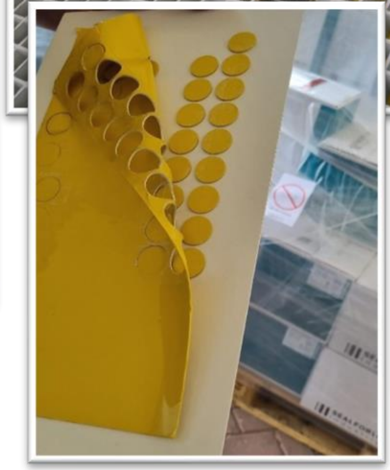
Case histories – Coating application





Repair coating – Installed coating





Client evaluation of HSE impact of 100 m² Paint versus PIB-based coating

Criteria	Blast & Paint	PIB-based coating	Performance
Waste	• 300 kg other waste • 2.000 kg General Waste • Total 2.300 kg Waste	• 11 kg General Waste	**>99%** Waste reduction
CO_2 emissions	• Materials 2,3 kg CO_2 / m² • Logistics 2,8 kg CO_2 / m² • Use 0,05 kg CO_2 / m² • End-of-life 25 kg CO_2 / m² • Subtotal 30 kg CO_2 / m² • Service life 10 years • After 30 years 89 kg CO_2 / m²	• Materials 2,5 kg CO_2 / m² • Logistics 0,3 kg CO_2 / m² • Use n.a. kg CO_2 / m² • End-of-life 5 kg CO_2 / m² • Subtotal 8 kg CO_2 / m² • Service life 30 years • After 30 years 8 kg CO_2 / m²	**11 x** less CO_2 emissions than traditional systems Or **91%** CO_2 emission reduction
Safety	• Hazard labelled • Flammable • Allergic reaction to skin due to chemical exposure • Respirator mask required due to dust content and exposure	• VOC . CMR free • Non-flammable • No chemical exposure • No dust content nor exposure	Non-hazardous material and exposure
Performance	• 10+ years maintenance interval • 24 months shelf life • 24-36 hours intervals between layers – system several days	• 30+ years maintenance interval • Unlimited shelf life • Hot or cold applied • Complete system installation in same day	3x Extended maintenance interval

Thank You

Questions?