Webinar “marinAL”

Pretreatment and Painting

27.01.2023





Surface preparation of aluminum for long-term corrosion protection

List of content

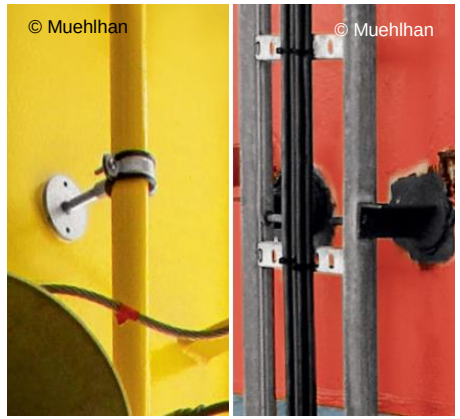
Business data Muehlhan

Muehlhan (2021)

- **General services**
  - Surface protection
  - Insulation
  - Specialty acces
  - Steel construction
  - Passive fire protection
- **General numbers**
  - 2,800+ Employees
  - 30+ Subsidiaries
  - 4 Business segments
- **Research & Development Department**

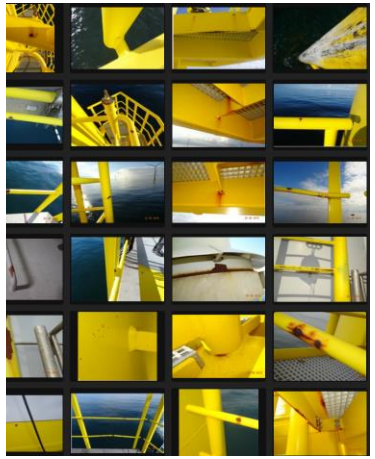
Business segment	Revenue	EBIT
Renewables	€81.4 million	€6.5 million
Ship	€61.0 million	€5.5 million
Construction/Infrastructure	€71.9 million	€0.7 million
Oil & Gas	€84.0 million	€3.9 million

Development of a foil solution for offshore use (on bare metal)



Mounting subsequent fixings with adhesive (instead of welding)

© Muehlhan



Online-condition monitoring system for marine structures

Regularly used standards: Surface pre-treatment

- **Surface preparation**
  - **Abrasive blast-cleaning**
    - ISO 11126 (steel): Specification for non-metallic blast cleaning abrasives
    - ISO 11127 (steel): Test methods for non-metallic blast-cleaning abrasives
    - DIN EN 1090-3 (Al): Blast cleaning: Al_2O_3, glass, free from Fe, Cu, Ni
  - **Spot repair**
    - ISO 8504-3 (steel): Rotary impact tool (Bristle Blaster, usable with stainless steel belts)
    - ISO 8504-3 (steel): Grinding (stainless steel brush, bronze brush, grinding disc)
    - DIN EN 1090-3 (Al): Stainless steel/copper-free brushes
    - DIN EN 1090-3 (Al): Repair coatings: brushed with fiber brush
- **Surface roughness of aluminum**
  - Norsok M-501: If coating is required, abrasive blast cleaning with a non-metallic abrasive to Rz=25 µm to 85 µm
  - GL: Guidelines for corrosion protection and coating systems: Blast-cleaning with white corundum to Rz=25 µm to 50 µm
  - German Ship Building BV 1900: Roughening the surface is allowed
  - Datasheet from manufacturers. For example „Jotamastic 90“: Rz=30 µm to 85 µm
- **Surface Roughness testing**
  - ISO 8503-2 (steel): Comparator
  - ISO 8503-4 (steel): Stylus instrument
- **Surface cleanliness after preparation**
  - ISO 8501-3 (steel): Preparation of weld seams: P3
  - ISO 8501-1 (steel): Surface preparation grade Sa 2½
  - ISO 8501-2 (steel): Repair: Power tooling grades
  - DIN EN 1090-3 (Al): Welds shall be brushed to a „metal bright“ finish
  - ISO 8502-6/9 (steel): Contamination with soluble salts (Brestle-Test)
  - ISO 8502-3 (steel): Contamination with dust

Regularly used standards: Surface preparation and coatings for offshore

Binding standards for the corrosion protection of aluminum in maritime environments are limited (Norok M-501).

2012

Coating system no. 6A: Un-insulated stainless steel when painting is required.	Sweep blasting with non-metallic and chloride free grit to obtain anchor profile of approximately 25 µm to 85 µm.	1 coat epoxy primer:	50
		1 coat two component epoxy:	100
Aluminium when painting is required.		1 coat topcoat:	75
Coating system no. 6B: Hot dipped galvanised steel when paining is required.	Cleaning with alkaline detergent followed by hosing with fresh water.	Minimum DFT (µm) of complete coating system:	225

2022

Coat number	Generic type	NDFT Note 3	MAX DFT
1: (Primer)	Epoxy	50 µm	The maximum DFT for each coat shall be within the limits given in the relevant CADS
	Epoxy	DFTs shall be as per the CADS	
3: (Topcoat)	UV-resistant topcoat Note 3		
Total DFT		225 µm	

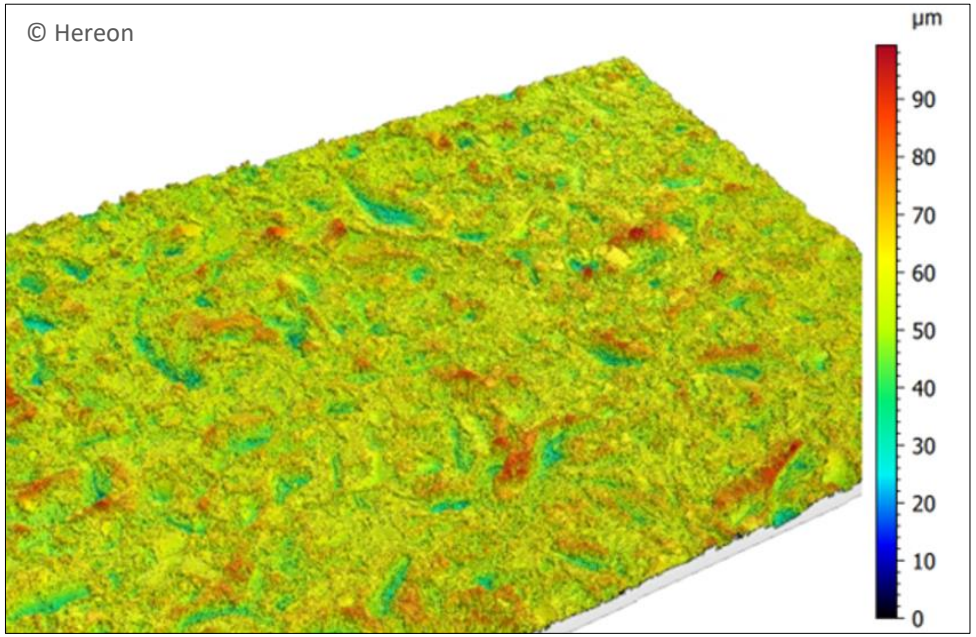
Surface roughness: Grit comparator, segment 1 ref. NS-EN ISO 8503-1, NS-EN ISO 8503-2 with grit comparator only, NS-EN ISO 8503-4 and/or NS-EN ISO 8503-5

Experimental & Techniques

- Morphology: Tescan Vega microscope, equipped with EDX detector (eumeX Instrumentebau GmbH)
- Roughness: Laser scanning confocal microscope (LMS 800, Zeiss) with ConfoMap®ST software (ISO 4287)
- Adhesion: Elcometer F510-20T (ISO 4624)
- VDA: DIN EN ISO 11997-1, Zyklus B (formerly VDA cyclic climate test 621-415) **with neutral artificial seawater** (up to 18 weeks)**:**
  - 24 h SST acc. to DIN EN ISO 9227 NSS (artificial seawater)
  - 96 h condensed water 40°C acc. to DIN EN ISO 6270-2 CH
  - 48 h standard climate 23°C acc. to DIN 50014
- Filiform corrosion (up to 6 weeks): ISO 4623-2 (modified)

Helmholtz-Zentrum hereon

Traditional methods: Regular garnet blast-cleaning

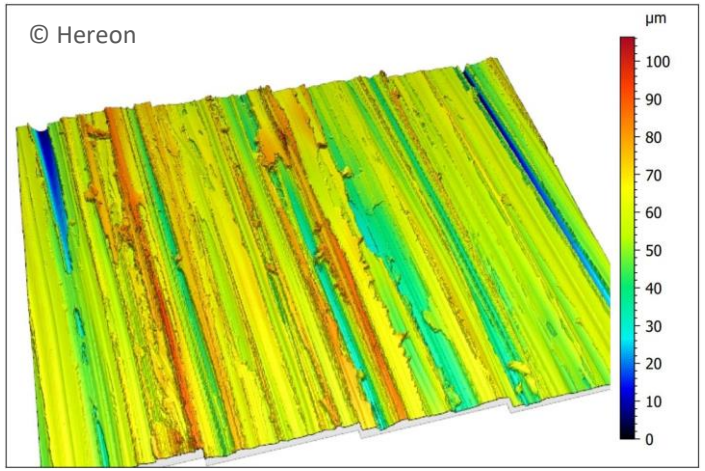


Garnet blast-cleaning

- Abrasive: GMA garnet; particle size: 0.25 to 0.60 mm
- Rz = 54 µm

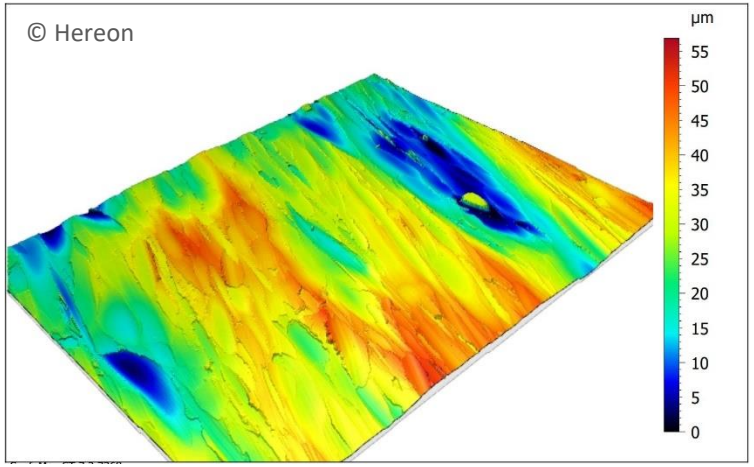
Garnet blast-cleaning of a part of an aluminum rail

Traditional methods: Rotary impact and grinding tools



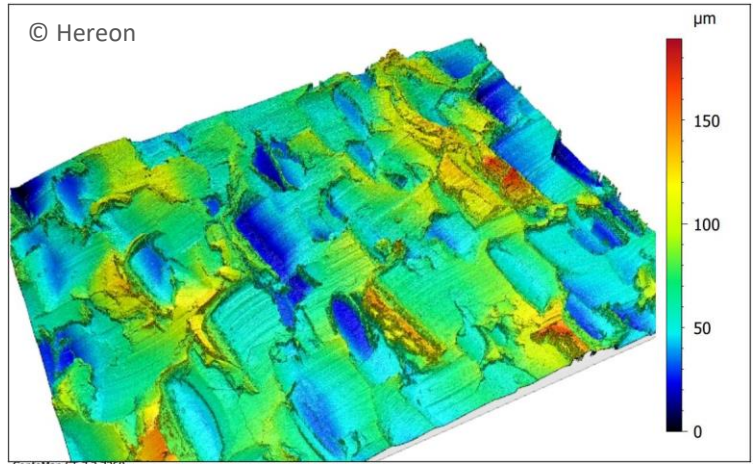
Corundum grinding disc

- Pretreated with angle grinder
- Attachement: Corundum (Al_2O_3) disc
- Rz = 58.8 µm



Stainless steel brush

- Pretreated with angle grinder
- Attachment: Stainless steel cup brush
- Rz = 22.9 µm



Bristle-Blaster

- Pretreated with Bristle-Blaster (stainless steel belt)
- Rz = 59.6 µm

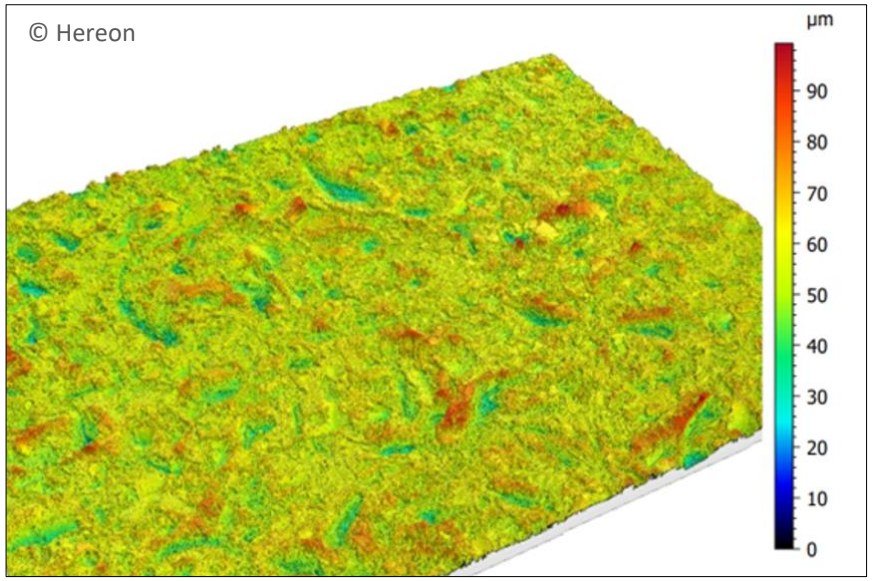
Innovative (sustainable) methods for surface pre-treatment

Hybrid blasting

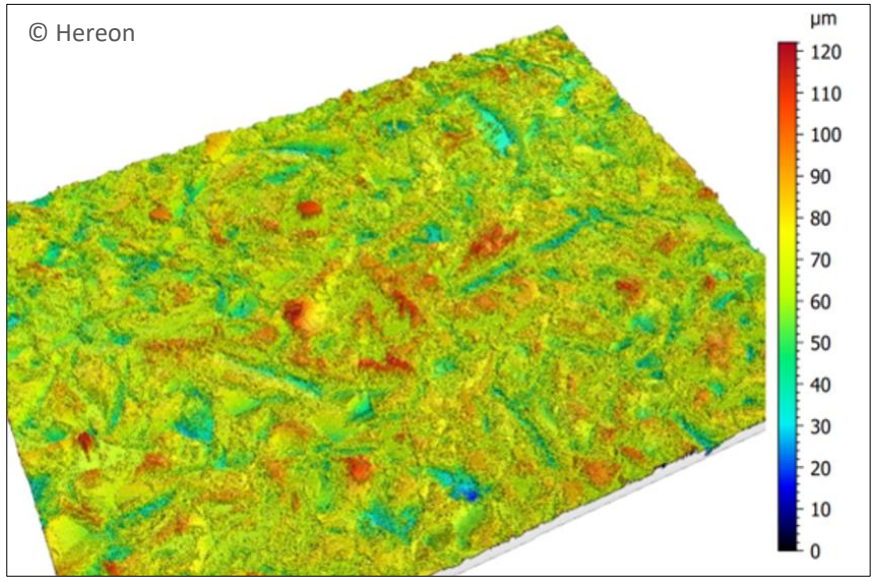
- Reducing the use of natural resources

Glass-grit blasting

- Avoiding the use of natural resources
- Use of recycled products



+



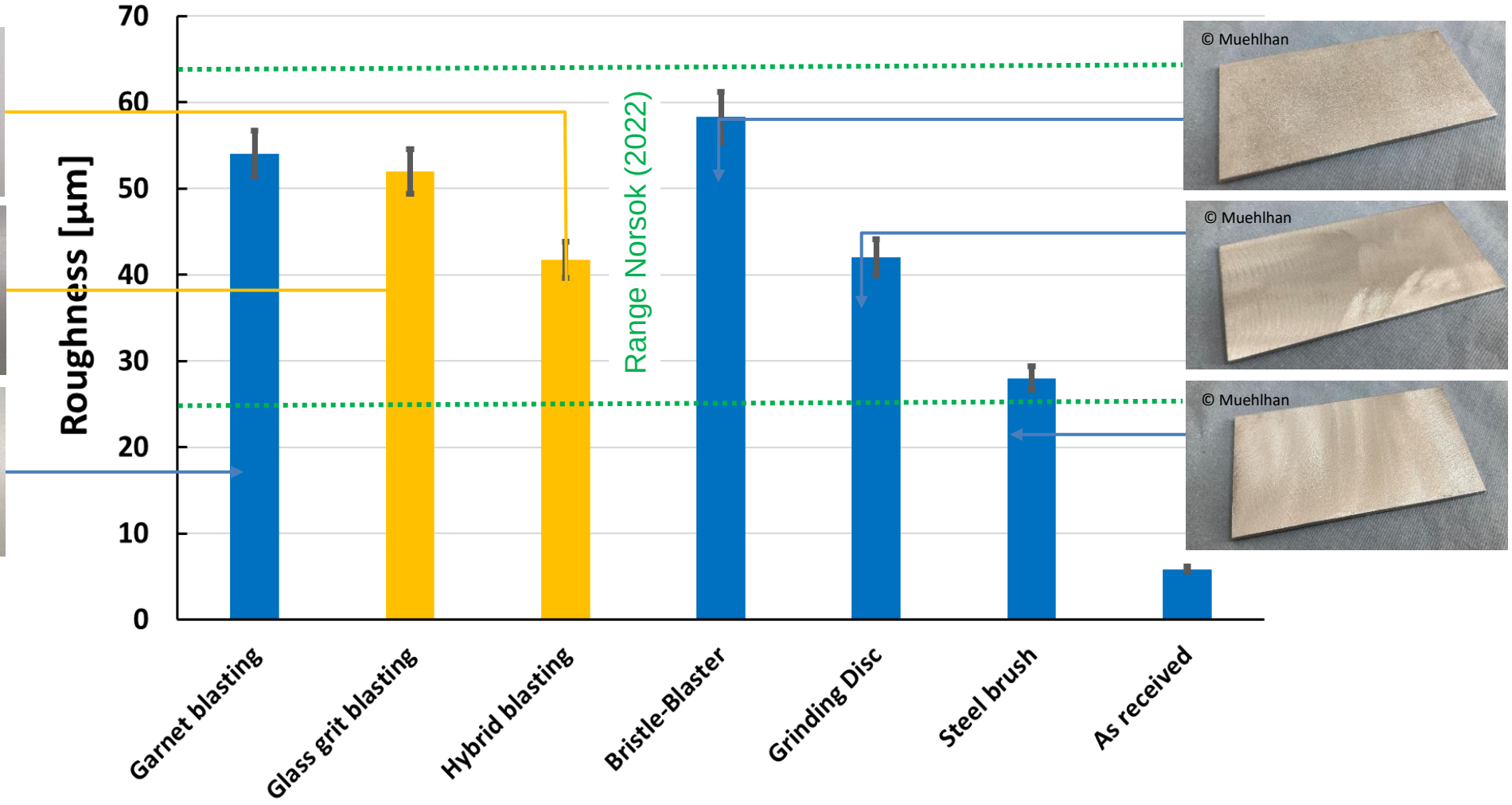
Hybrid blasting

- Abrasive: GMA; particle size: 0.25 to 0.60 mm
- Dry-ice pellets; particle size: 2.0 to 3.0 mm
- Rz = 44 µm

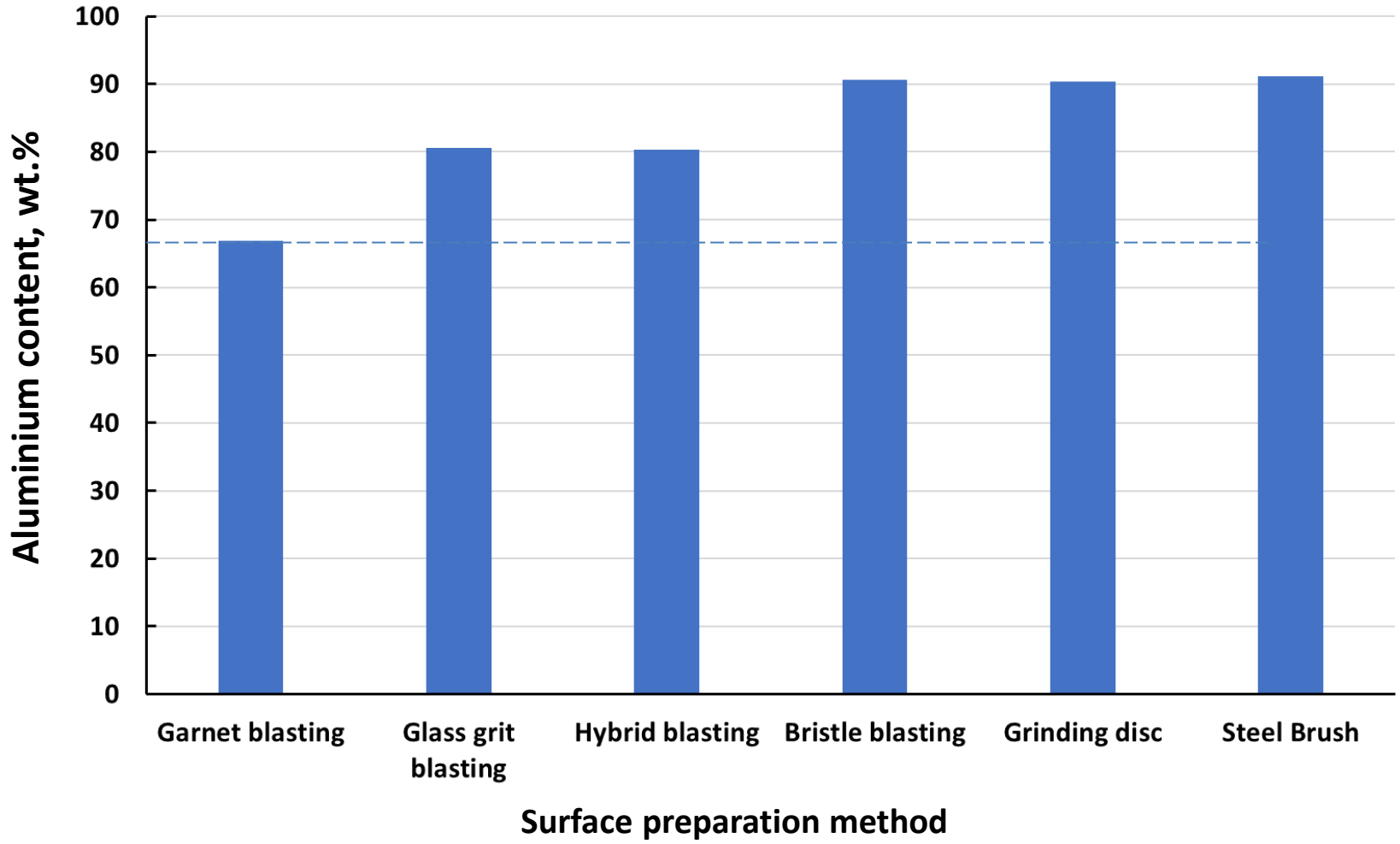
Glass-grit blasting

- Abrasive: VB4; particle size: 0.80 to 1.50 mm
- Rz = 52 µm

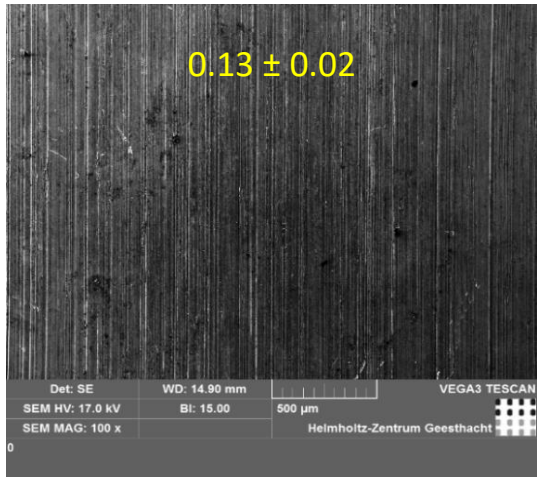
Comparison of different surface pre-treatment methods



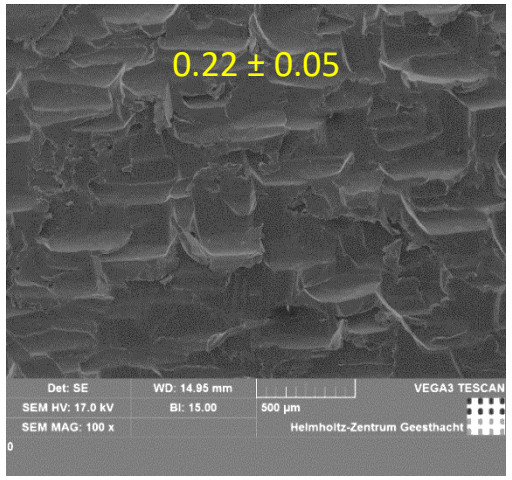
Surface pre-treatment methods: Surface analysis with EDX



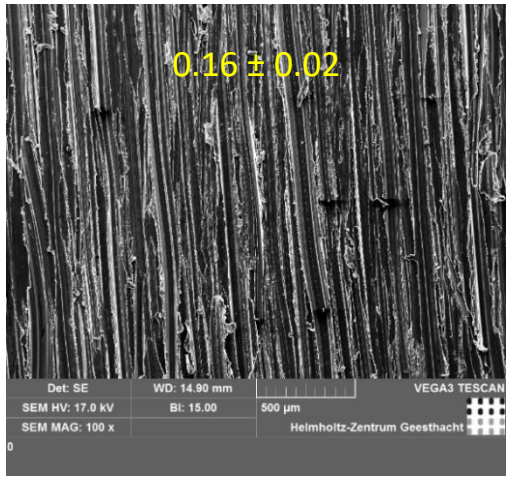
Surface pre-treatment methods: Morphology and iron content



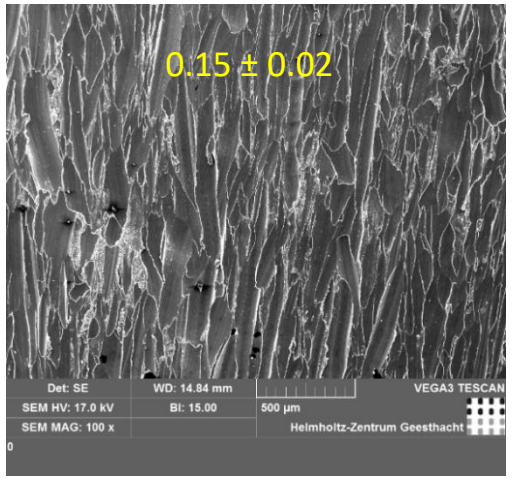
As received



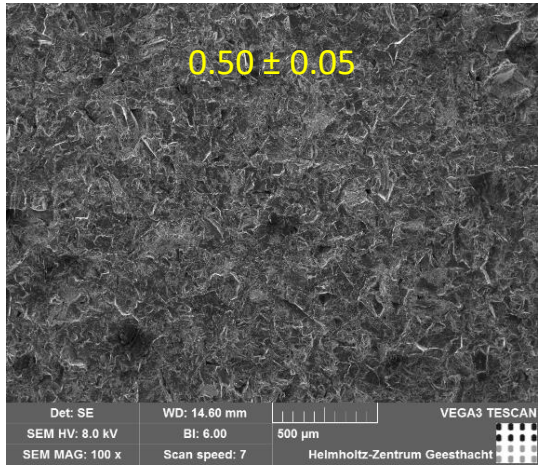
Bristle-Blaster



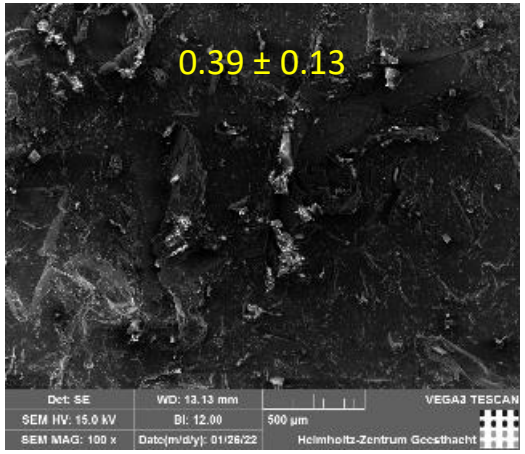
Grinding disc



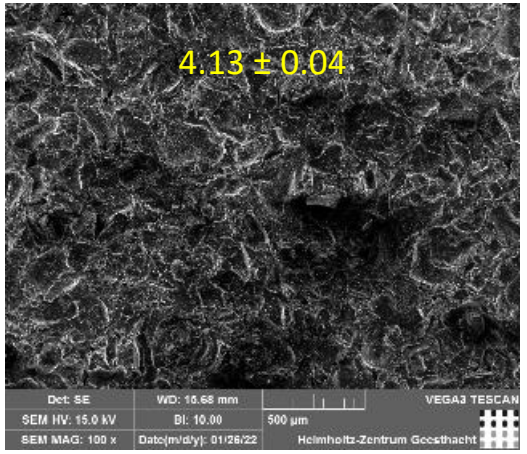
Steel brush



Hybrid blasting



Glass grit blast-cleaning



Garnet blast-cleaning

Iron content in wt.%,
5 points average,
ca. 1.5 x 2 mm area

Standard marine coating systems

- In regular projects the customer determines the coating system which has to be used for the upcoming project with the paint manufacturer for the system responsibility
  - As a service provider for the application of corrosion protection systems, Muehlhan focuses on surface preperation technologies

- GL: Guidelines for corrosion protection and coating systems suggets two examples for alternative coating systems on aluminium

System No. 1
- Adhesive primer (6-10 µm)
- Epoxy coating (40 µm)
- Filler (if needed)
- Epoxy coating (160 µm)
- Top coat (100 µm)

System No. 2
- Epoxy-adhesive primer (40 µm)
- Filler (if needed)
- Epoxy coating (200 µm)
- Top coat (100 µm)

- As **reference coating systems**, two commercial, certified and proven offshore coating systems were choosen:
  - Immersed Zone: „Jotamastic 90“ (DNV Category II):
    - 250 µm – 1-layer epoxy coating
  - Tidal- and Splash Zone: 3-layer system Norsok M-501, coating system No. 6A (2012), 6D (2022)
    - Primer: 50µm – epoxy coating
    - Barrier (intermediate): 100 µm – epoxy coating
    - Top coat: 75 µm – polyurethane coating

Coating systems

Sample manufacturing/ preparation

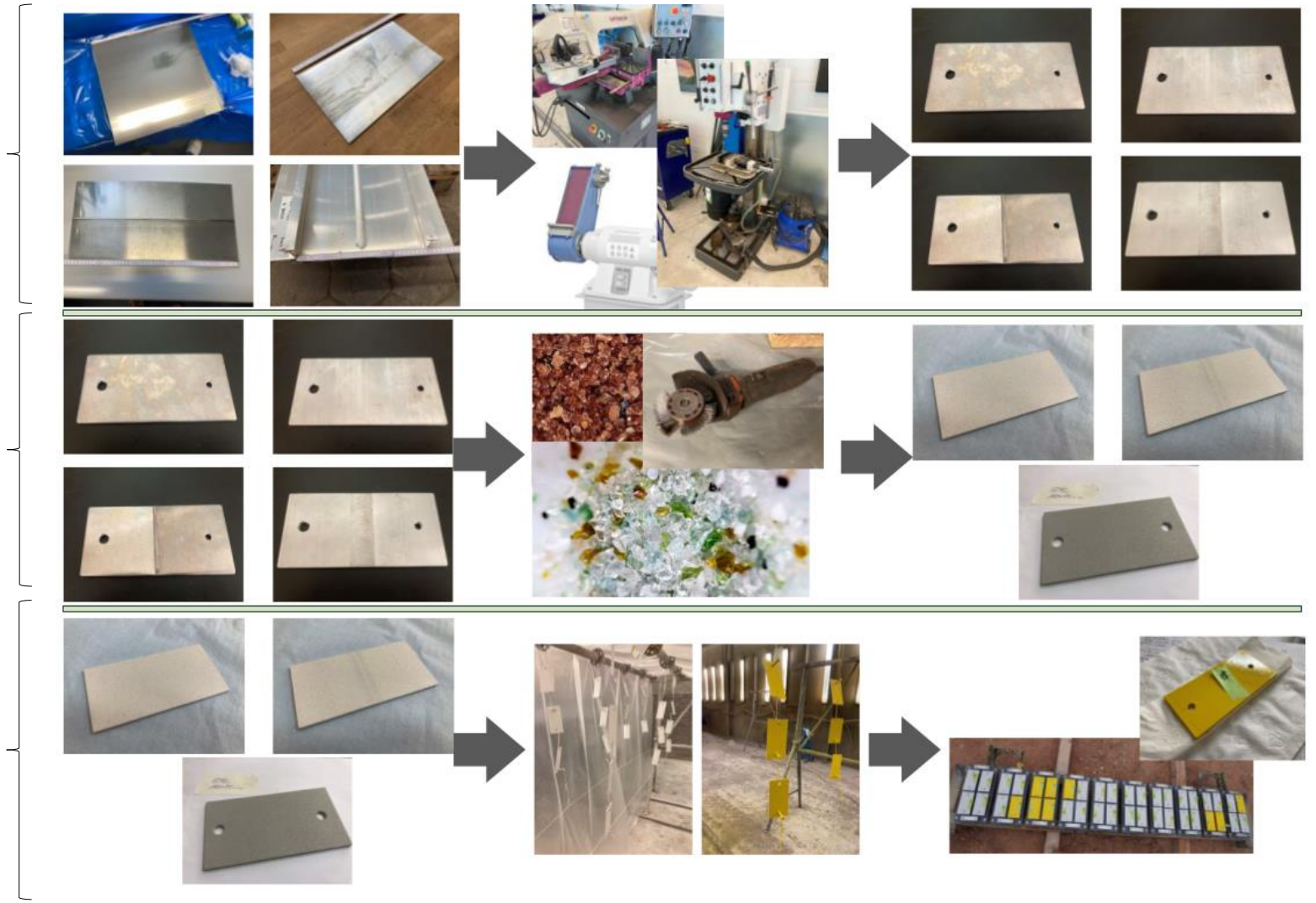
- Deliver, clean, cut, mark, drill and thread all samples.
- Regarding the pre-experiments: approximately 400 samples

Surface pre-treatment

- Degrease, grind, brush and blast-clean all samples.

Sample coating/handling

- Clean prepared samples with compressed air
- Mark, sort, separate and fix samples for coating application
- Coating application
- Pack samples and delivery to the project partners in Europe



Hereon profile

Helmholtz Zentrum Hereon

Science and technologies for:

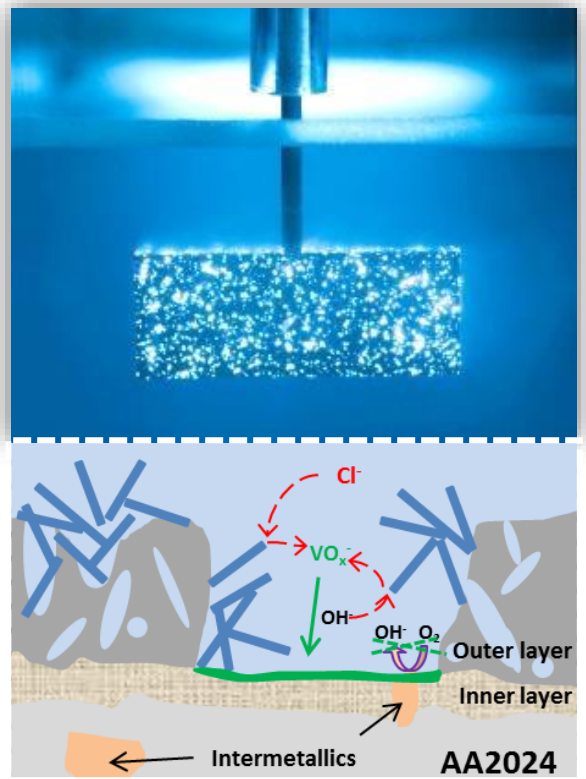
- Environmentally friendly mobility
- Medicine and people
- Sustainable energy systems and environmental protection

Research and consulting for:

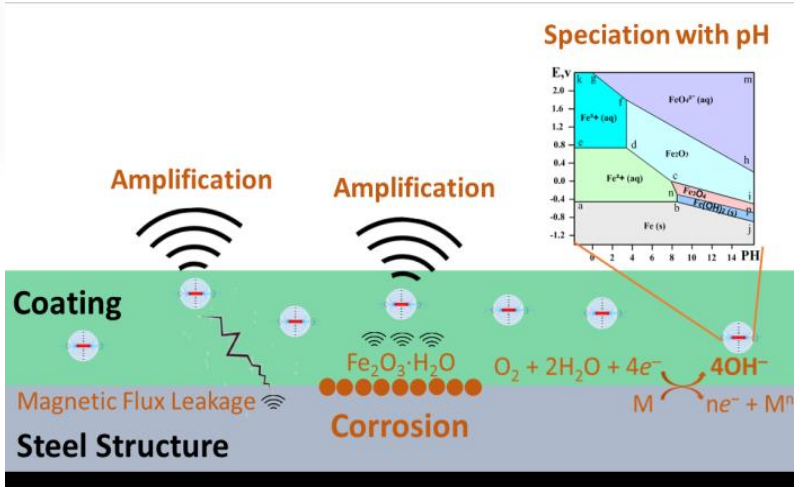
- Adaption to climate change
- Mitigation of greenhouse gases
- Sustainable use of coastal regions

Institute of Surface Science

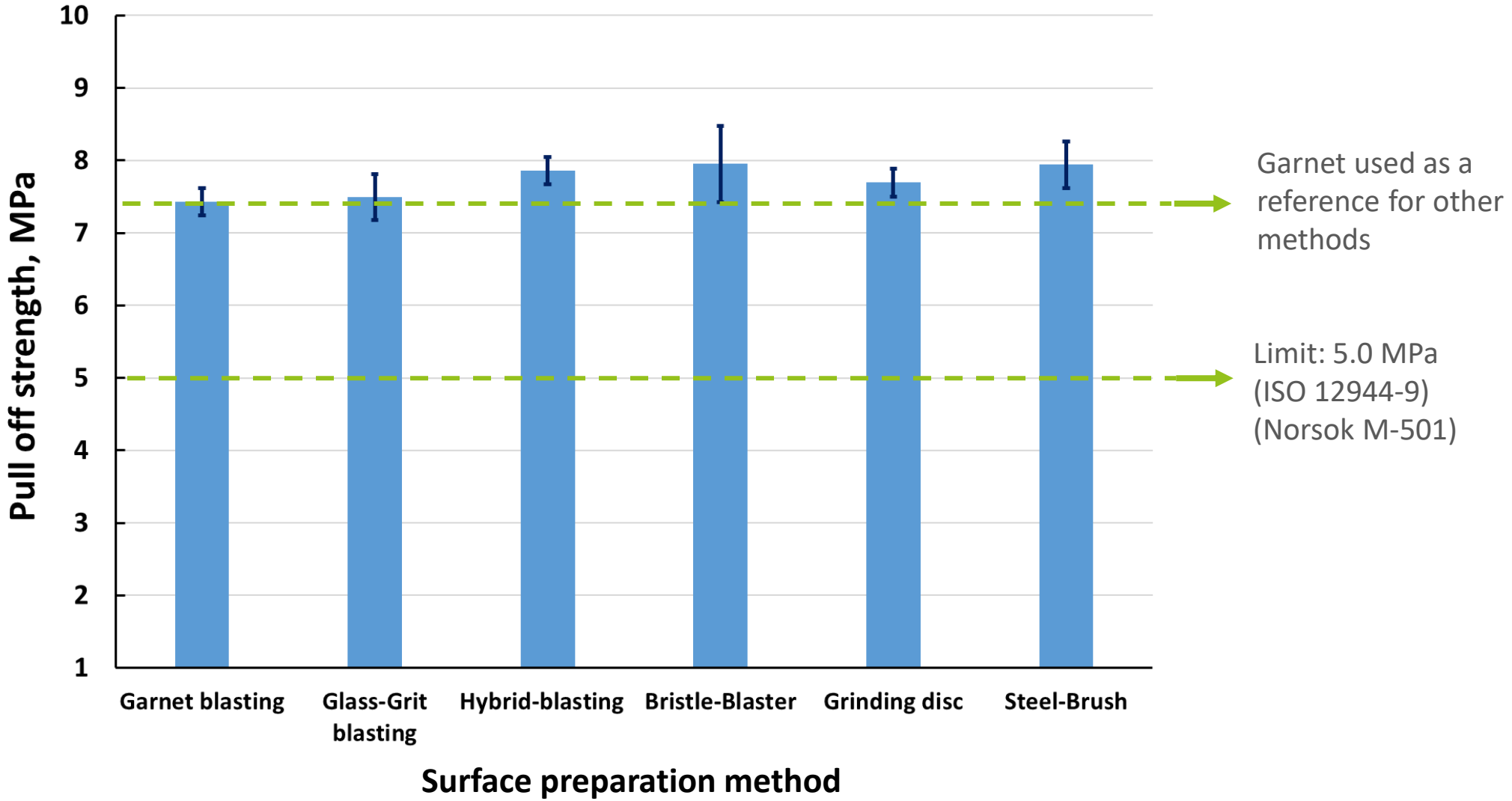
The main focus of Institute of Surface Science is on increasing **the sustainability of material systems** used in complex environments via optimization of alloy systems, design of functional surfaces and extending their service life through **control of the corrosion processes**. Simulation & modelling creates synergistic effects that lead to the sustainable development of future-oriented protection, functionalization and maintenance concepts.



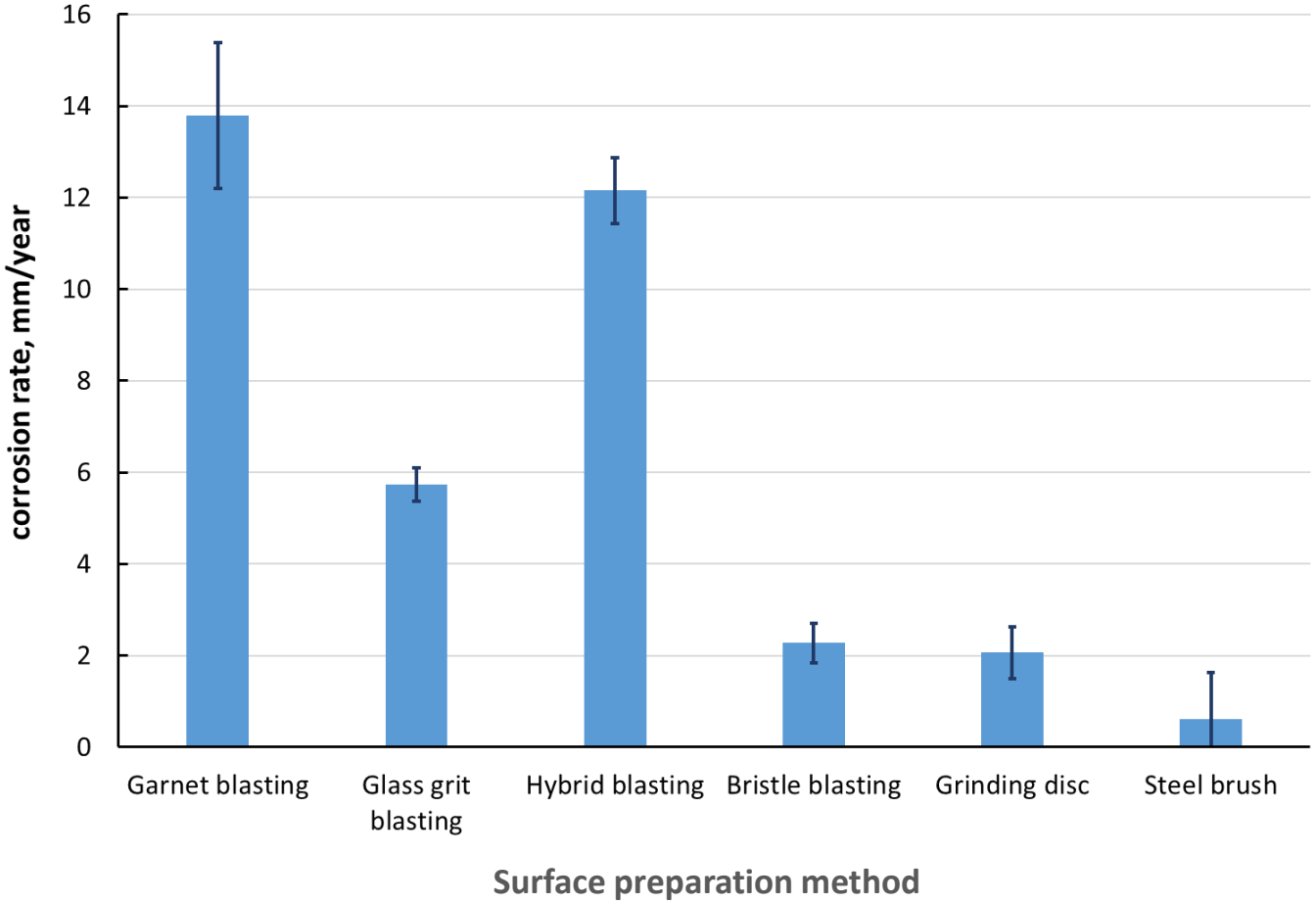
Institute of Surface Science is represented by two departments within Marinal project: **Department of Functional Surfaces** and **Department of Interface modelling.**

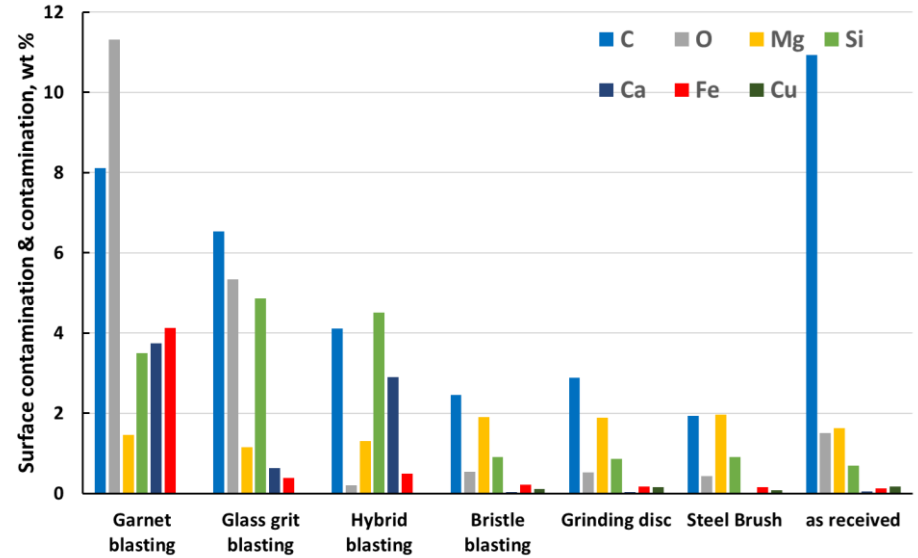


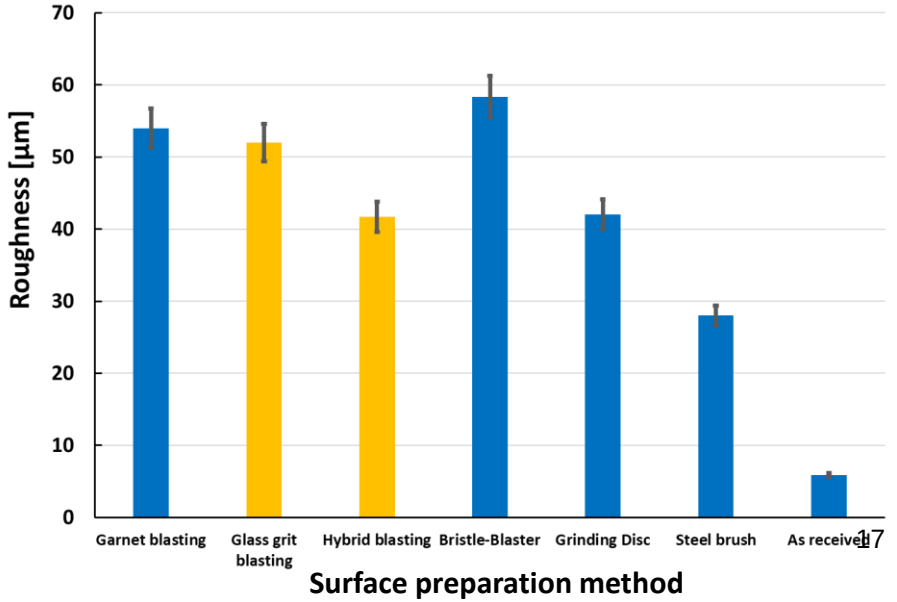
Adhesion of not corroded coated specimens



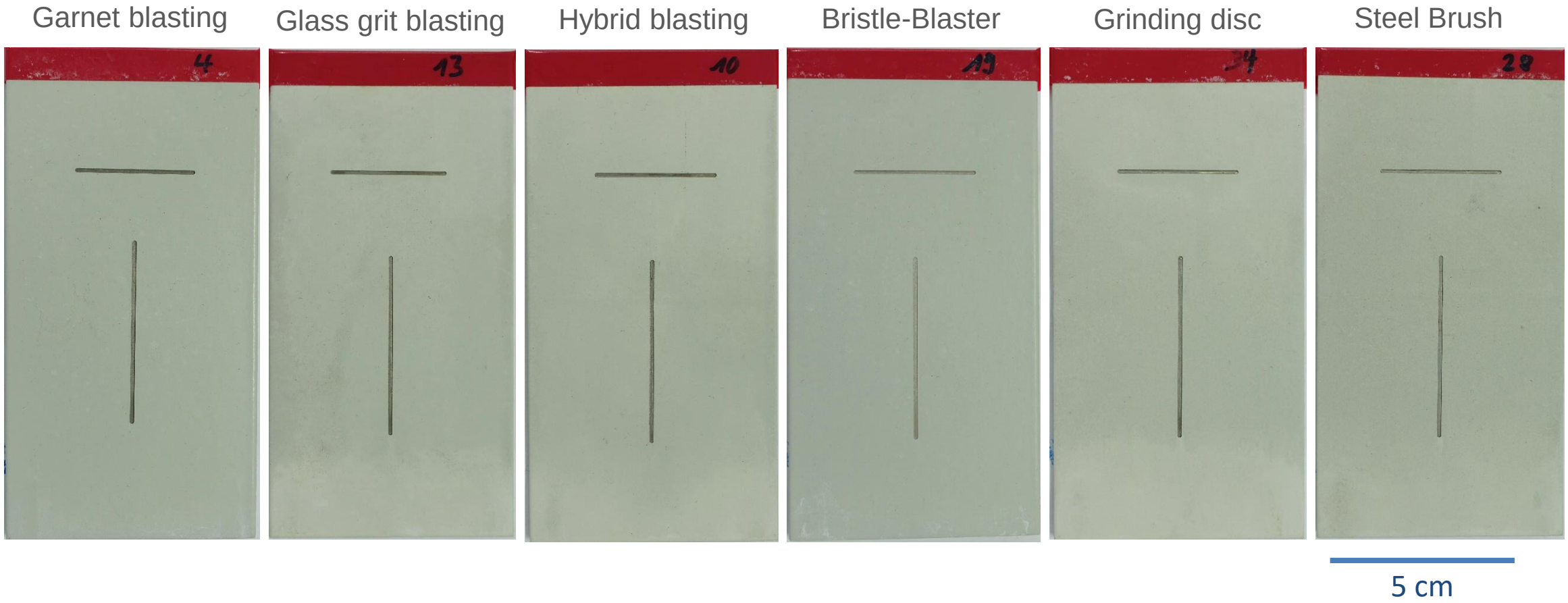
SST (VDA): Results for prepared surfaces



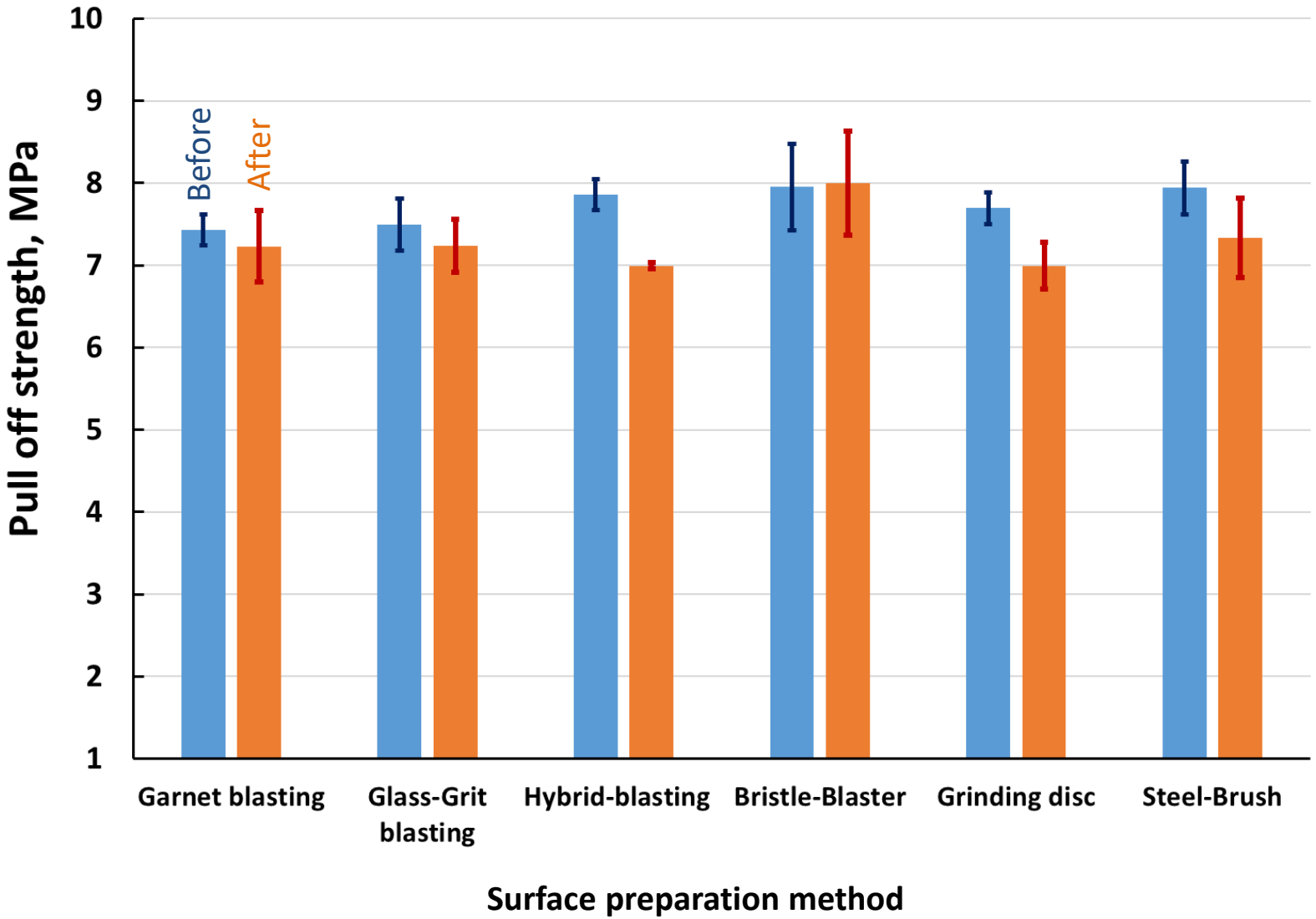




Coated surfaces after VDA testing (3000 hours)

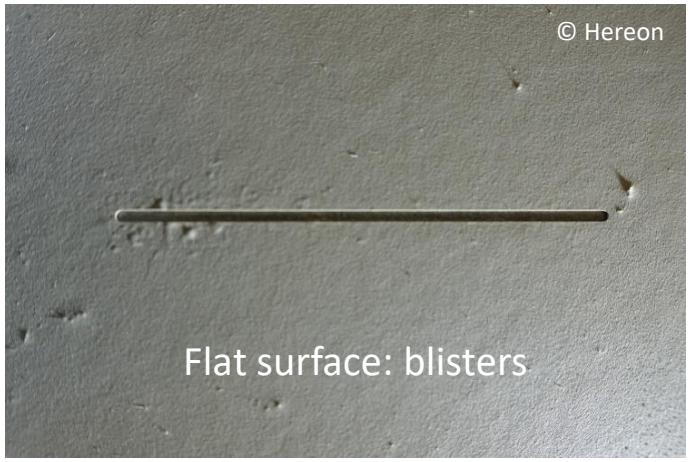


Coated surfaces after VDA testing (3000 hours)

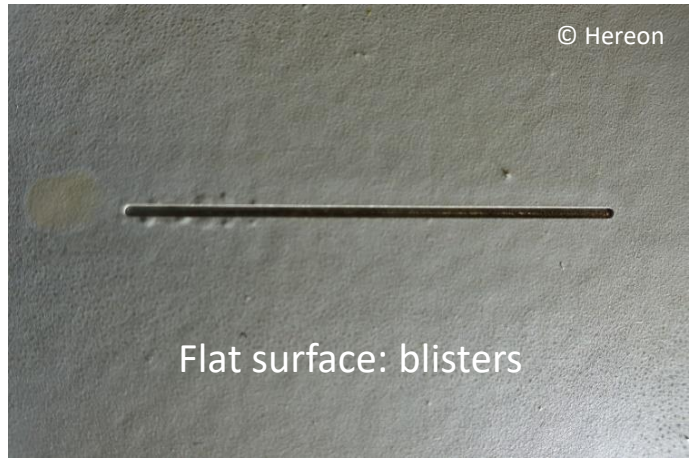


Filiform tests on prepared coated AA6082 substrates (delaminated area in %)

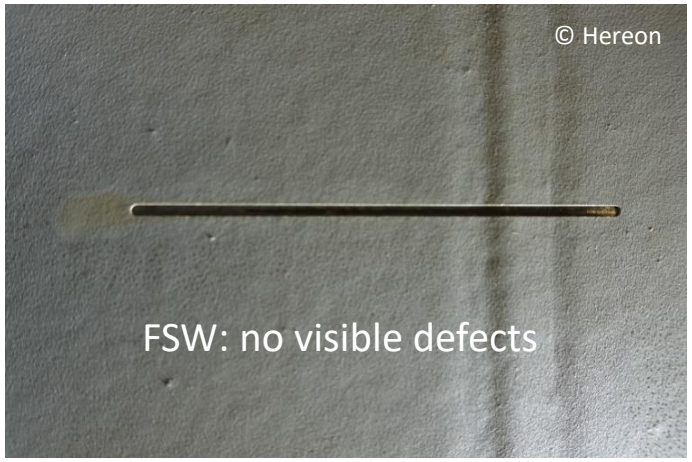
Glass blast-cleaning

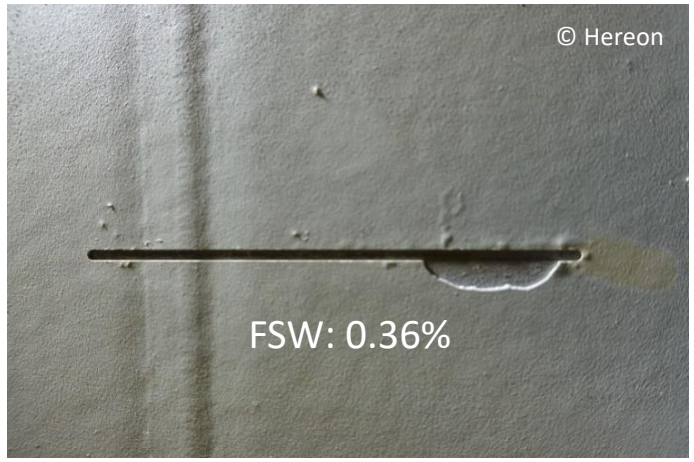


Garnet blast-cleaning

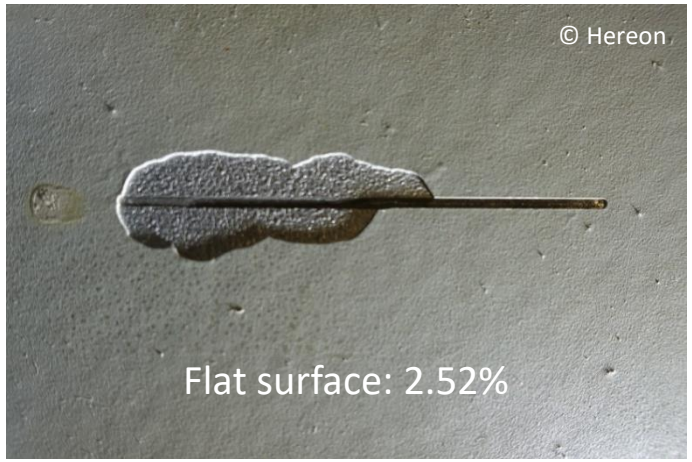


Hybrid blasting

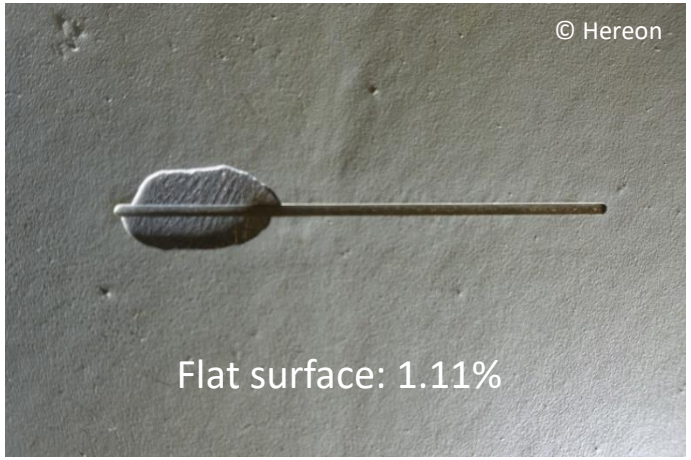




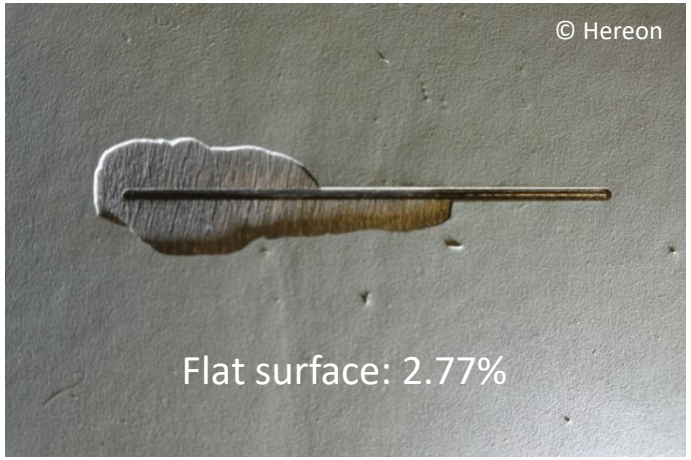
Filiform tests for prepared coated AA6082 substrates (delaminated areas)



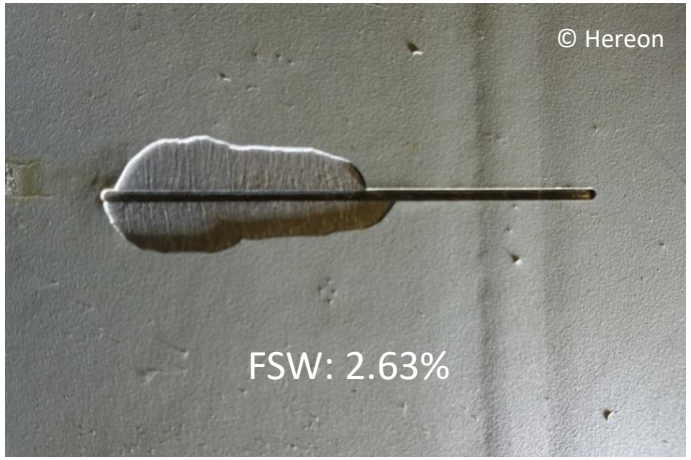
Bristle Blaster



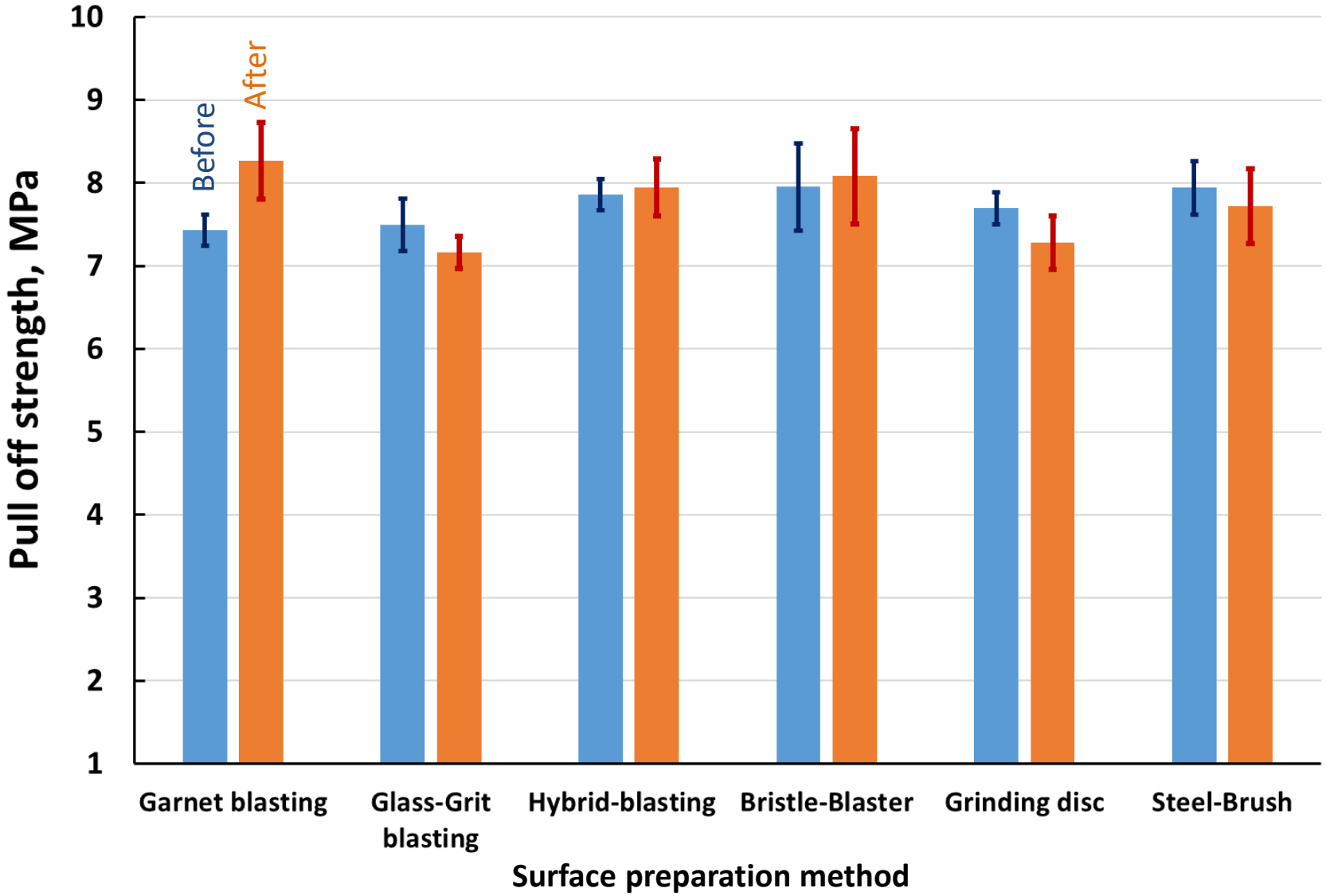
Steel Brush



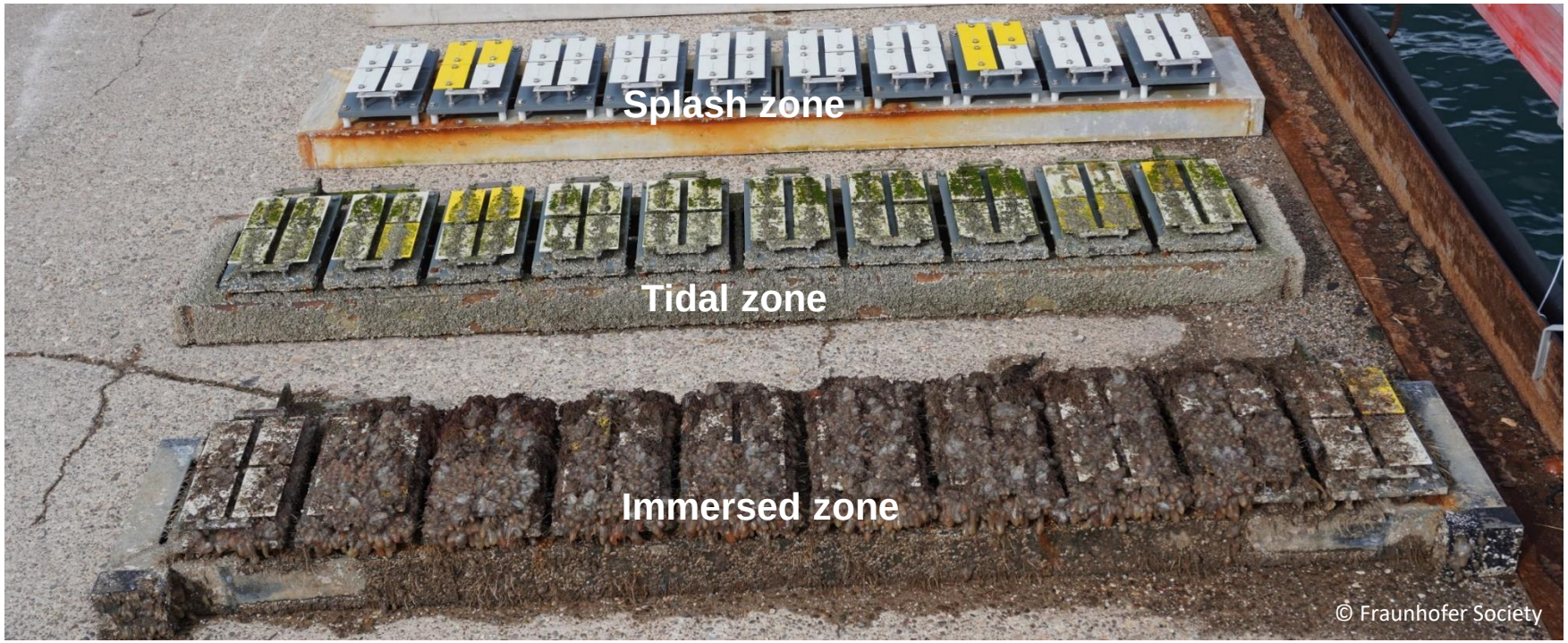
Rotating disc

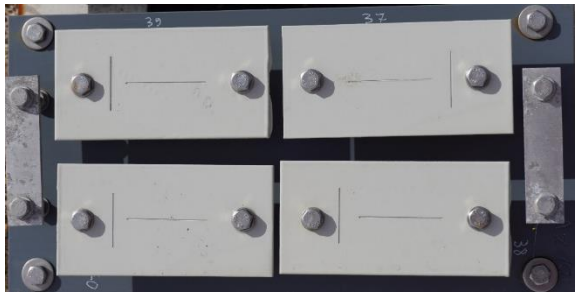


Filiform corrosion results on coated samples



Samples at Fraunhofer Test Side at Helgoland after 6 months of exposure





Splash zone

Tidal zone

Immersed zone

Conclusions and outlook

1. Repair pre-treatment methods are not as good as classical pretreatment methods, they are much more susceptable to filiform corrosion damage.
2. Alternative blasting methods generate surface quality features and adhesion strength equal to, or better than, traditional garnet blast-cleaning.
3. The most contaminated specimen (garnet blast-cleaning) shows the highest corrosion rate during VDA testing.
4. Adhesion testing of the coatings cannot be used for the prediction of the performance in seawater.
5. VDA corrosion testing is not aggressive enough to cause corrosion signs after 3000 hours exposure.

Outlook

1. Ecological footprint of aluminum surface treatment: Calculating useful numbers for project planing and method comparison (Muehlhan).
2. Investigation and modelling of galvanic protection of aluminium substrates, suitable for marine application (SINTEF + Hereon).
3. Comparison with actual results of specimens exposed at Helgoland (Hereon).
4. Corrosion mechanism for aluminium substrates in sea water (Hereon).

Acknowledgements

The project „MarTERA-MARINAL“ is funded through the European Community and the German Federal Ministry for Economic Affairs and Climate Action (BMWK) under grant 03SX552(b).

Many thanks for your attention!

- Are there any questions?

Muehlhan Hamburg:
Jan Bertram
Dr. Andreas Momber

Schlinckstraße 3,
21107 Hamburg

Hereon, Surface characterisation:
Dr. Maria Serdechnova
Dr. Carsten Blawert

Max-Planck Str., 1,
21502, Geesthacht

Hereon, Modelling:
Dr. Natalia Konchakova
Dr. Daniel Höche

Max-Planck Str., 1,
21502, Geesthacht