Congresso Internacional de Corrosão, Integridade, Pintura e Revestimentos Anticorrosivos

CTQFF.ORG Centro de Treinamento e Qualificação Fernando Fragata

Experiences with coating FM for offshore assets –

How surface preparation technique and application conditions influence expected coating lifetime

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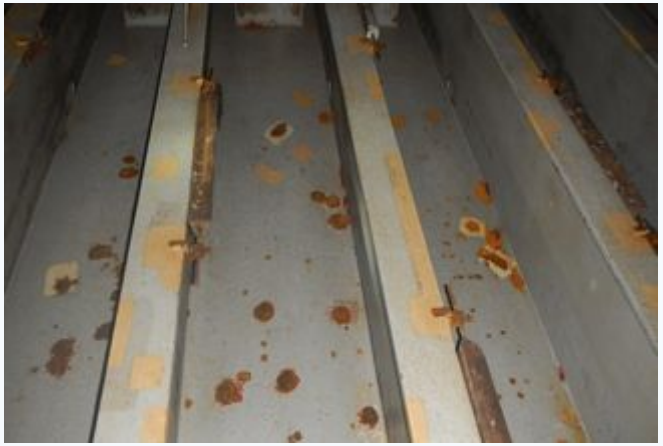
Content

- Introduction coating failure
- Coating lifetime offshore
- Coating surface preparation methods offshore
- Experiences with coating FM offshore
  - The case of corrosion prevention in FPSO storage tanks

Introduction to coating failure



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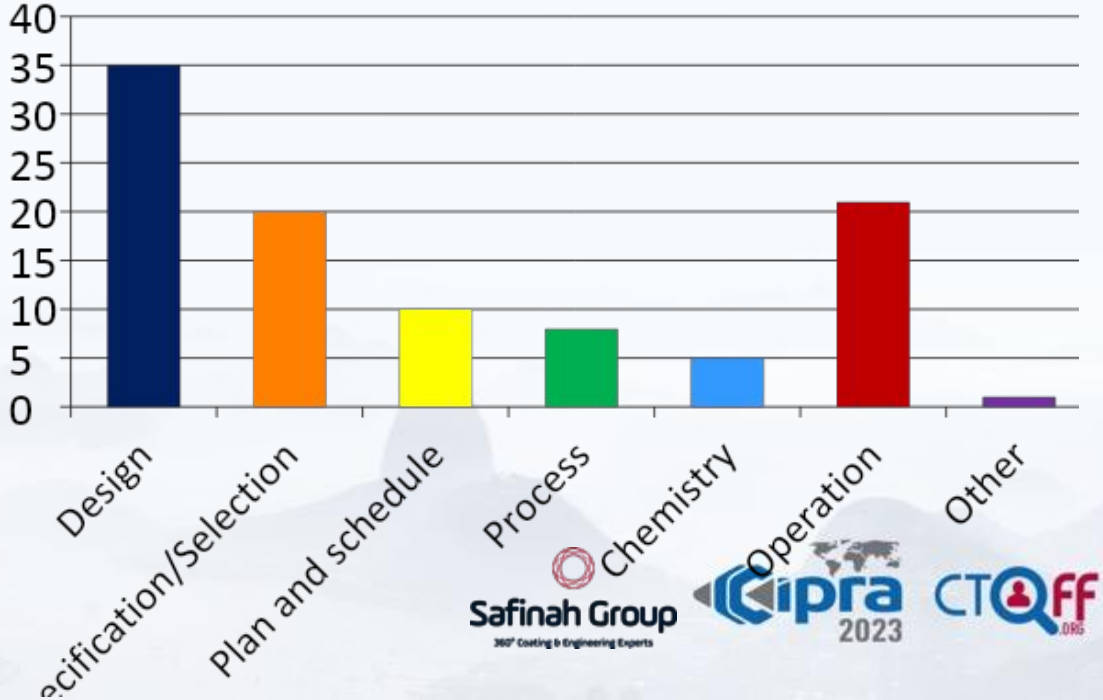
Why do coatings fail and corrosion occur ?

- **Safinah has gathered 25 years of coating failure data**

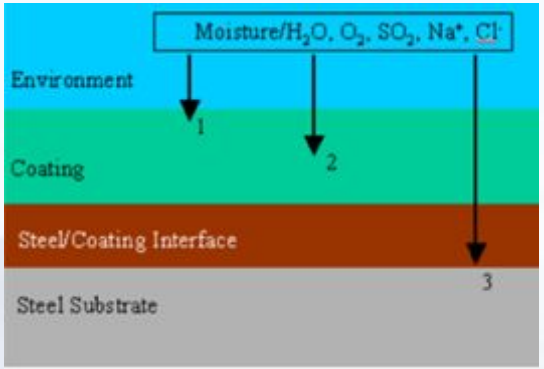
- shows process (surface pre-treatment and coating application) accounts for only 7-8% of coating failures,

- While **>75% of coating failure are due to poor design, wrong specification/selection and operational conditions**.



Factors infuencing coating lifetime

- Lifetime of a protective coating that is properly selected, applied on a correctly surface pre-treated steel surface, and correctly applied will depend on the **rate of coating degradation** and **corrosion rate** in the service environment.
- With an increasing number of offshore assets now reaching or exceeding the original design life and the economic pressures to maintain production, **corrosion management** will continue to be an integral component to maintain structural integrity and extend the life of an aging asset.
- The coating's ability to prevent ingress of water, humidity, oxygen and ions to reach the steel substrate ultimately determines the durability of the coating system.
- Ingress of corrosive reactants into the coating/steel interface:



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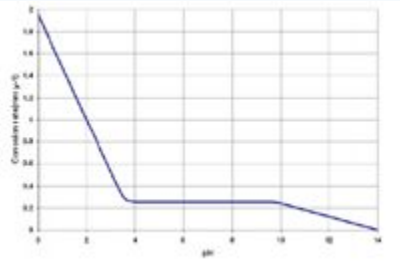
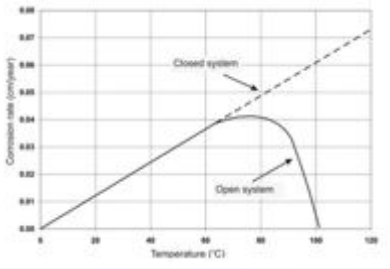
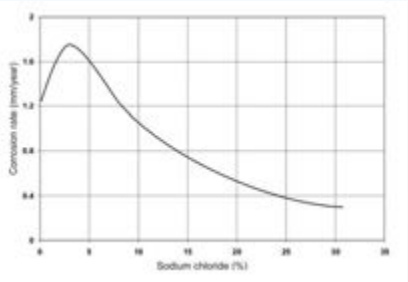
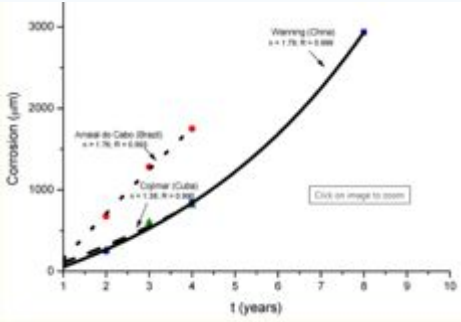
Corrosion rates marine/offshore Brazil

- Corrosion rates of mild carbon steel can vary a lot depending on environmental factors present at the site the structure is operating.
- Factors influencing corrosion rates are, oxygen level in water at the steel substrate, temperature, pH, conductivity of electrolyte (i.e., salinity of seawater) and ion type.
- Costal marine corrosion in Brazil can be an average 500 µm/year and offshore Brazil, GOM and in the North Sea corrosion rates can be expected to be as high as 800 µm/year.









Brazil costal environment, Arraial do Cabo
Mild steel, 4 years
Corrosion loss,almost 2000 µm
Average corrosion rate, costal 500 µm/year

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Coating maintenance onshore vs offshore

- **ONSHORE - New building – Service life (P)**
  - Surface preparation by abrasive blast cleaning to achieve an ideal surface
  - Paint application by airless spray under highly controlled conditions
- **OFFSHORE - Fabric maintenance – Service life P + 0.5P (FR)**
  - Surface preparation by abrasive blast but predominantly by ultra-high-pressure water jetting (UHPWJ)
  - Paint application by airless spray and usually not under controlled conditions
- **OFFSHORE - Spot / maintenance repainting – Service life P + 0.2P (MR)**
  - Surface preparation by water jetting, mechanical chipping etc and/or power tooling
  - Paint application predominately done by brush and usually not under controlled conditions

- I.e. if practical service life in CX environment is 15 years
- P = 15 Y
- MR = 15 Y + (0.2 x 15Y) = 18Y
- FR = 18 Y + (0.5 x 15Y) = 25.5Y
  - Note: more MR/FR sessions will extend service life

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Coating Lifetime Offshore

Coating Fabric Maintenance offshore

Factors that influence coating long term performance / service life

Surface cleaning prior to surface preparation

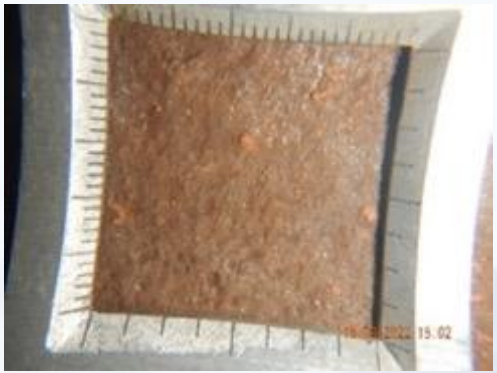
Reaching agreed surface cleanliness level

Proper surface preparation

Reaching agreed surface preparation level

Measuring soluble salt on surface

Staying below agreed x mg/m^2 salt level



Obtaining acceptable surface profile

Good planning and work execution

Proper scheduling of coating application

Micro Climate Control

Quality Control and Logging of data

Coating Fabric Maintenance offshore

- **Good housekeeping**
  - Remove garbage, avoid walking over contaminating a coated area, masking to prevent water ingress, avoid painting on dirty/contaminated surface, assuring proper mixing and curing of coating etc.
- **Habitat**
- **Delays/low productivity**
  - Weather, lacking spare parts, slow progress
- **Competance to use equipment**
  - Not knowing how to operate properly state of the art abrasive blasting equipment

Remove garbage

Competance to use equipment

Housekeeping

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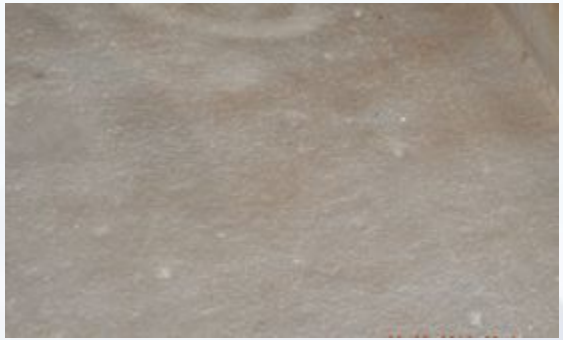
Surface Preparation

Abrasive grit blasting – pre-blast

UHP water blasting

UHP water blasting



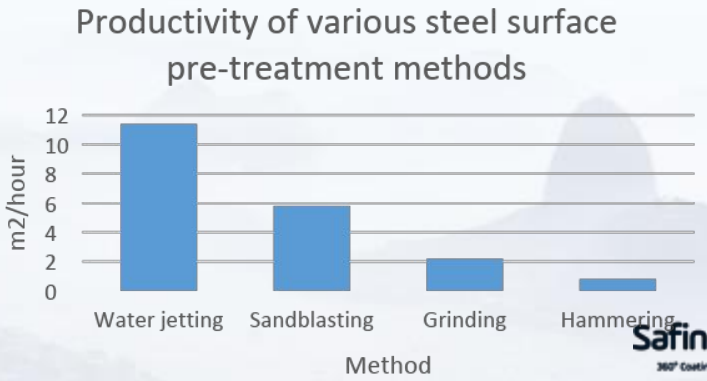
Full Abrasive grit blasting

Proper surface preparation is crucial

- Without good quality surface preparation with an ultra-clean surface with all contaminants removed and a proper surface profile a coating system will fail prematurely.

- There is a whole range of steel surface preparation standards available that describe various surface preparation grades of steel like from NACE/AMPP, SSPC, ISO

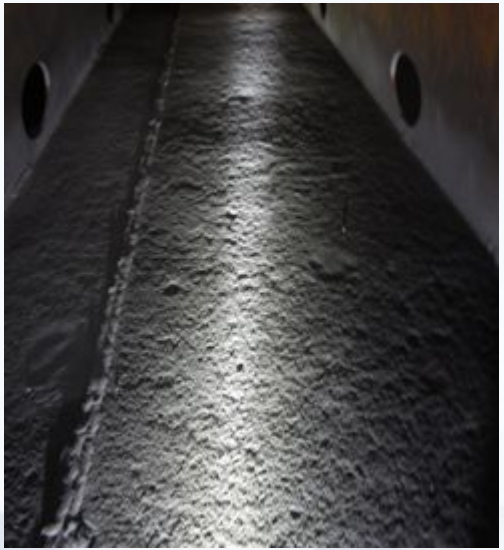
- Commonly applied surface preparation methods; abrasive blasting, ultra-high pressure water jetting, wet abrasive blasting, vacuum blasting, bristle blasting, power tool cleaning, hand tool cleaning



Surface preparation prior to coating application

- **Abrasive blasting +**:

  Provide good anchoring profile



Removes all paint, corrosion and rust from the surface

Surface preparation prior to coating application

- **Abrasive blasting -:**
  - hazardous dust is created and contaminates nearby areas
  - Solid waste to be removed and treated as hazardous waste
  - Cost of spent abrasive blasting media – when removing
  - Time and cost to put on protective gear and masking/cover nearby movable machine parts/pipes
  - Very high noise level, 110 dB at 1 meter distance
  - Blasting media that can get embedded in the steel substrate
  - Contamination of the substate by contaminants in the blasting media
  - Slightly worsen the original profile when de-coating as it flattens/hammers/deforms existing peaks
  - **Does not remove chloride salts from the surface**

hazardous dust

Solid waste to be removed and treated as hazardous waste

Surface preparation prior to coating application

- **Ultra high pressure water jetting+:**
  - No hazardous dust
  - No need for initial degreasing/cleaning (NAVSEA waives this)

  - Solid waste can easily be separated/disposed, and water can be filtered and reused
  - Removes efficiently thick and hard to remove coating systems, heavy rust & corrosion
  - Penetrates and removes surface contamination even deep in pores and pits

  - Removes ionic species such as chlorides (salts) to make the surface ultra-clean
  - Here is evidence that the surface microstructure is changed expanding surface area that offers better coating adhesion

  - High productivity and huge cost saving compared to abrasive blasting surface preparation
  - Other trades / operations can take place close to water jetting

  - No need and cost for covering close by sensitive equipment and movable machine parts
  - Can be done in all weather conditions so no unnecessary down time

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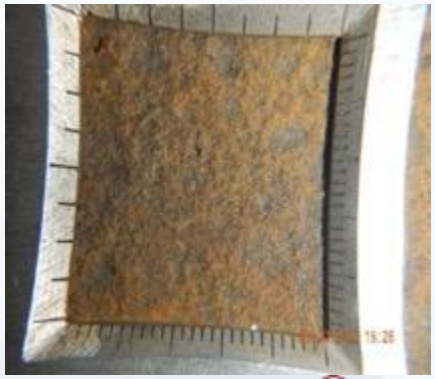
Surface preparation prior to coating application

Ultra high pressure water jetting -:

Flash rusting
(is chemically inert ferric oxide at low amounts) is not a serious contami- nation problem
Pressure above 2,800 bar/40,000 psi



UHPWJ does not affect the original blasting profile
Brings it back to the original NB profile.
Areas heavily corroded, pitted will require abrasive blasting to re-establish anchor profile

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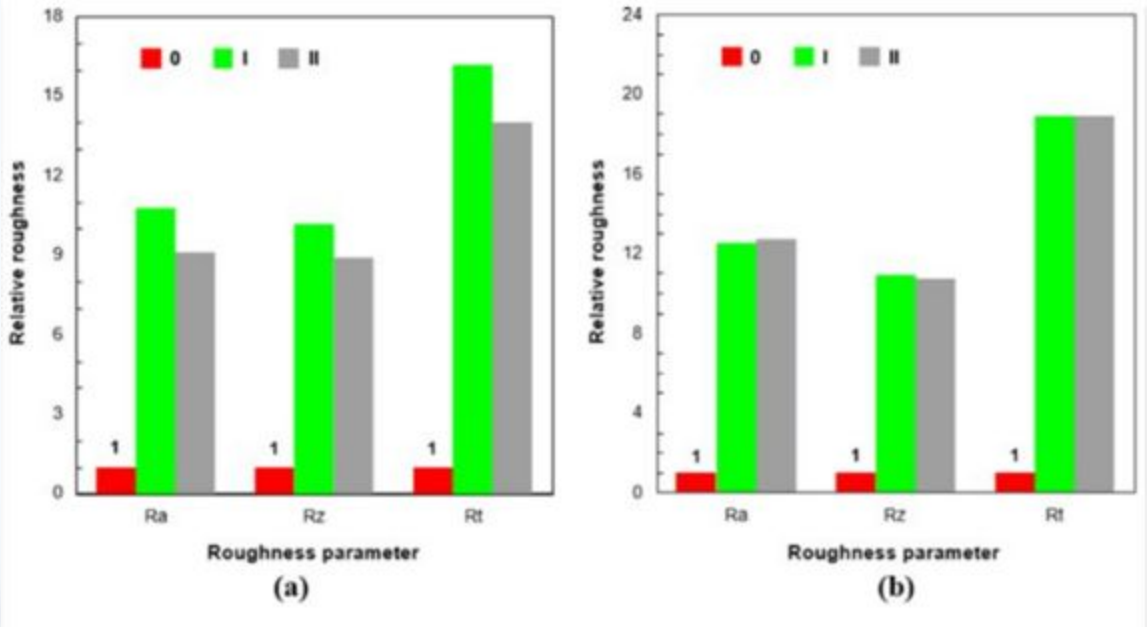
Surface preparation prior to coating application



a. Abrasive blasting of steel the 2nd time will reduce surface profile compared to primary blast, due to bending & buckling of peaks.
b. UHPWJ will fully bring back original blast profile

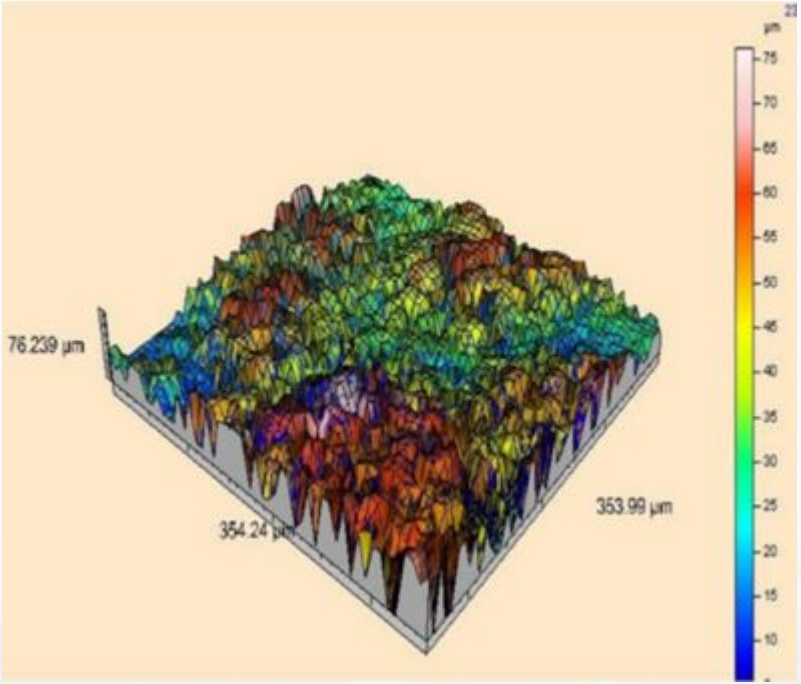
Surface roughness profile measures are given as **Ra** – arithmetical mean roughness, **Rz** – average maximum peak hights or ten points mean roughness and **Ry** (Rt) – Total maximum profile peak/valley hights

a-untreated (0), primary abrasive blast(I), de-coating with abrasive blast (II)

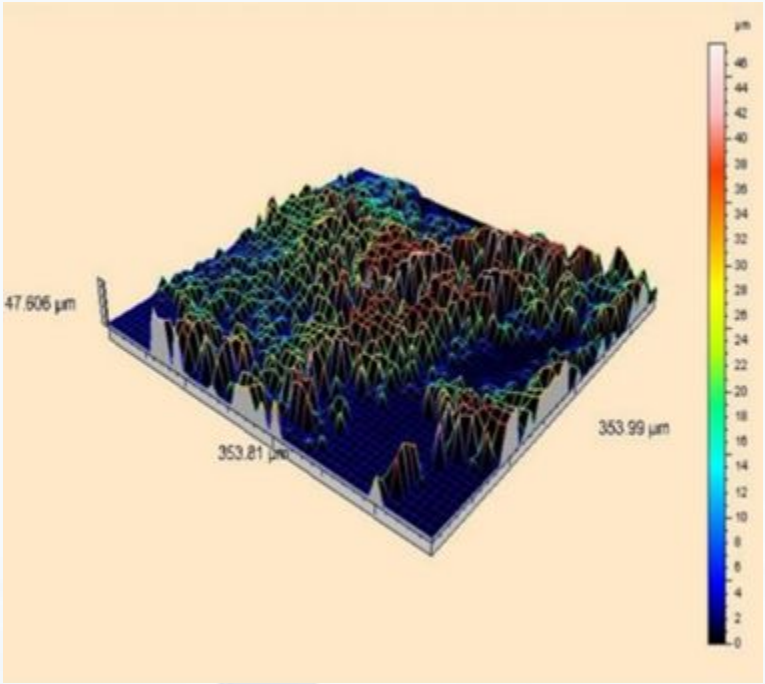
b-untreated (0), primary abrasive blast(I), de-coating with water jetting (II)

Water jetting vs. Abrasive blasting, by VertiDrive, April 12, 2021
https://www.vertidrive.com/market/waterjetting-vs-abrasive-blasting/

Surface topography after 1st and 2nd AB



Primary abrasive blasting(AB)
Gives high surface roughness



Secondary de-coating by AB
Deforms some existing peaks, leading to reduced surface roughness

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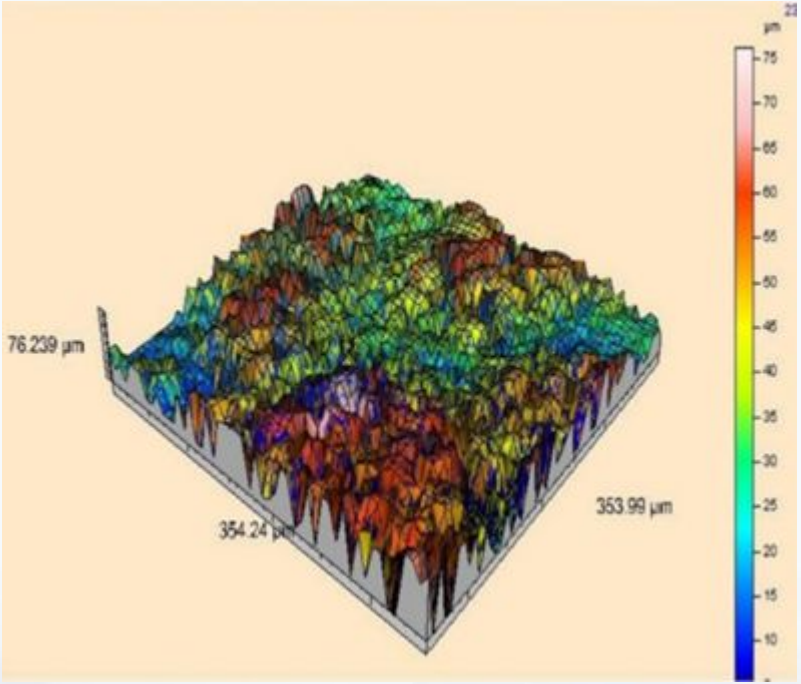
Surface topography after 1st AB and 2nd WJ



Primary abrasive blasting(AB)
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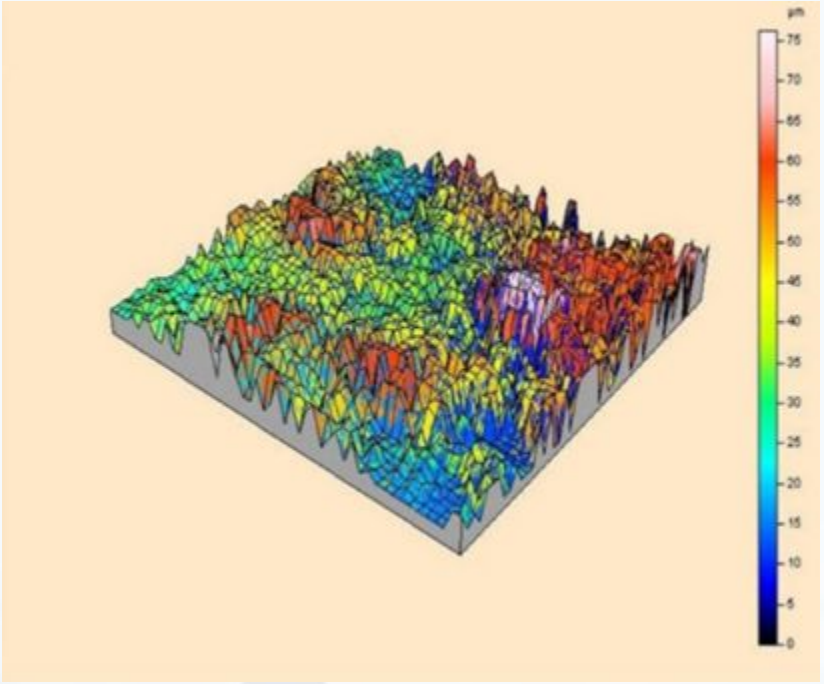
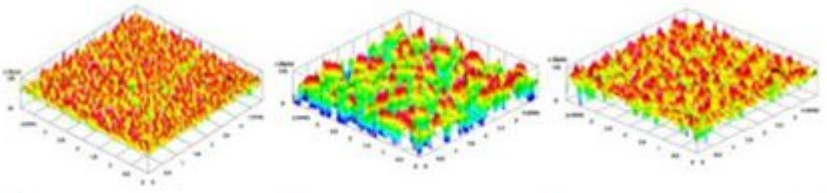


Secondary de-coating by water jetting (WJ)
Gives the surface a more fractal surface roughness with expanded surface area

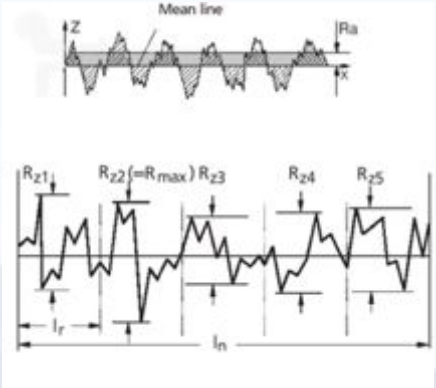
Surface preparation and surface profile

- Roughening the steel surfaces by grit blasting prior to coating them is very important to obtain a strong anchor pattern to obtain consistently high tensile bond strength between the coating and the substrate
- There is a strong correlation between roughness (Rz) and corrosive delamination of coated surfaces
- To have good adhesion you need **peak to valley hight, Rz**, but you also need **peak density** that creates the higher surface area for good adhesion



GMA Garnet™	Typical Slag	Other Garnets
• Uniform profile with increased surface area.	• Non-uniform surface profile.	• Less-uniform surface profile.
• Less coating required and greater adhesion.	• Potentially poor paint wetting resulting low adhesion between the coating and substrate.	• Lower peak density will reduce coating adhesion.

Source: Comparative Study of Prevalent Blasting Abrasives in the US Market, April 2019.



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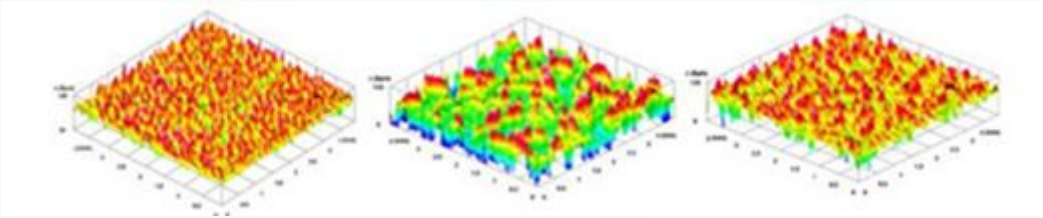
Measuring surface profile on rough/pitted surface

- When removing coating on heavily pitted steel, the original blast profile might be completely eroded away and peak density is significantly reduced and then it is important to do correct measurements as you often get false readings.
- measure profile hight R_z by Testex tape or needle profile as well as assessing peak density by a magnifying glass and comparator is important to assure a good picture of surface roughness

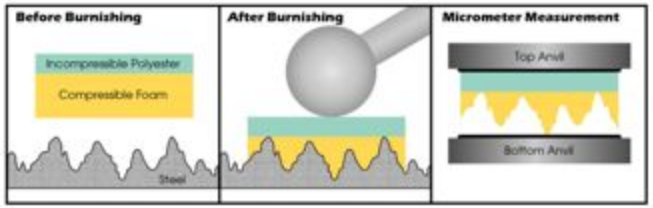


Very high peak density Low peak density Medium peak density

Measuring surface profile & roughness

- A: Profile hight: Testex replica tape, ISO 8503-5:2017
- B: Surface roughness : Surface profile comparator, ISO 8503-1:2012
- C: Surface profile gauge: Elcometer 224
- D: Surface topography imaging: laser scanning digital microscopy

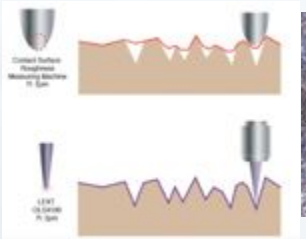
A:

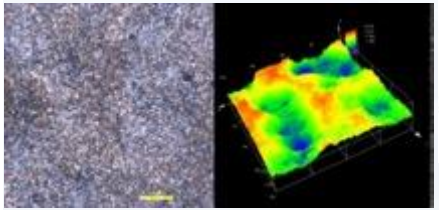


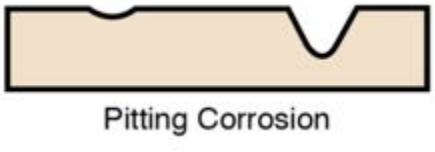
B:

C:

D:







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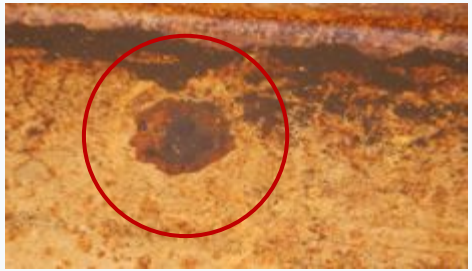
EXPERIENCE WITH COATING FM OFFSHORE

The case of corrosion prevention in FPSO storage tanks

Corrosion Prevention in Storage Tanks

- While the effects of corrosion in offshore platforms and FPSOs storage tanks can be devastating, they can be avoided by implementing appropriate corrosion prevention methods.



- Corrosion damage can:
  - Significantly compromise the tank's structural integrity
  - Result in leaks and spills that pollute the environment.
  - Lead to fire and explosions (in the case of petrochemicals and other hazardous liquids)

Strategies to Control Corrosion

- Storage tank corrosion can be prevented or controlled using several methods ranging from state-of-the-art technology to simple, historically proven methods.
- Common tank corrosion prevention strategies include the following.

    - Structured plan for coating condition inspections
    - Maintenance Strategy
    - Project Planning incl Functional Coating Specification
    - Coatings and linings

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