PETRONAS

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Self-Healing Coating for Bolts & Nuts

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Presentation Outline

1. Business Case
2. Self-Healing Technology
3. Sample Preparation
4. Result 1: Barrier Resistance Study
5. Result 2(a): Functionality Test at Different Healing Time
6. Result 2(b): Functionality Test at Different Temperature
7. Result 3: Multiple Healing Test at the Same Spot
8. Result 4: Adhesion Test
9. Result 5: Healing Test at Actual Nuts
10. Result 6: Salt Spray Testing
11. Result 7: Cyclic Salt Fog & UV Exposure
12. Conclusions
13. Standard Method References
14. Acknowledgements

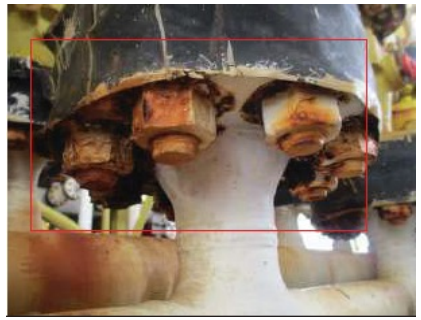
Business Case

1. DAMAGED COATED LAYER OF BOLTS & NUTS

Bolts and nuts are coated with an anti-corrosion type of paint. However, the coated layer is damaged during tightening and assembly activities.

2. CORRODED BOLTS & NUTS

Damage original coated layer leads to exposure of the substrate to moisture. Moreover, the environment is also a highly saltwater environment.

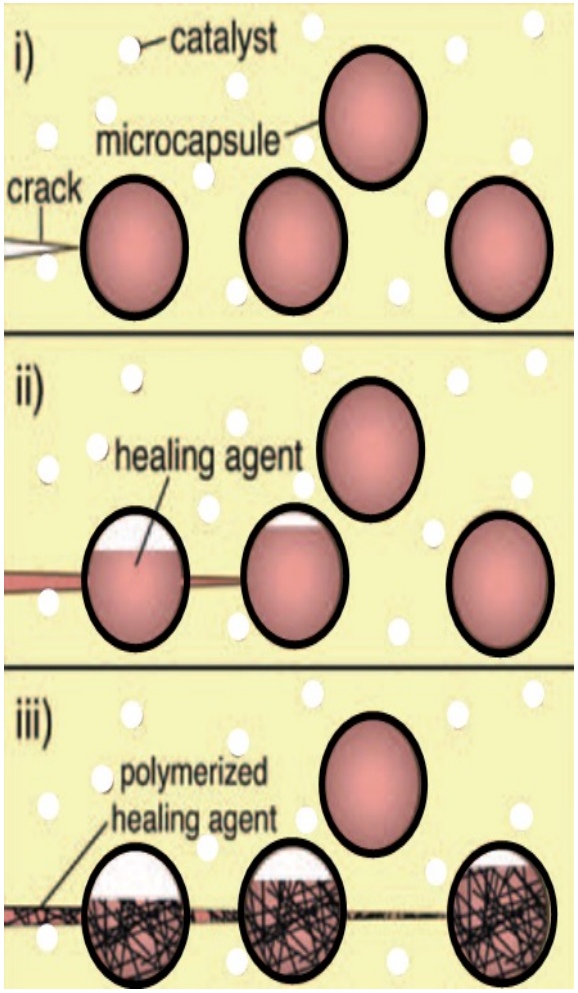


3. HIGHER MAINTENANCE COST

Higher cost is required to replace corroded bolts and nuts at the field.

Introduction of Self-Healing Coating to Resolve Current Business Pain Point

Self-Healing Technology



Extrinsic system
- ❑ **Microcapsule**

Source
- ❑ **Synthesized from metal node and organic ligand to generate an extended open network**

Mechanism
- ❑ **After the damage is introduced, the healing agent will be released, repaired & restored to the original state.**

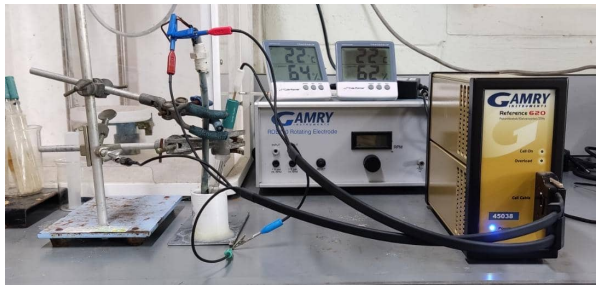
Operating Condition
- ❑ **Ambient temperature & pressure**
- ❑ **Epoxy based coating**

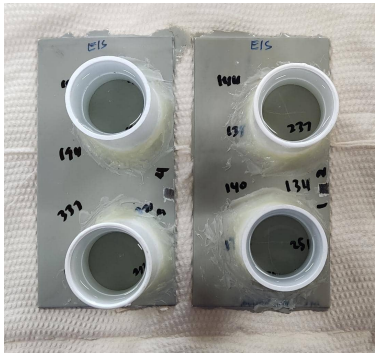
Product Upscaling
- ❑ **The process is not complex**

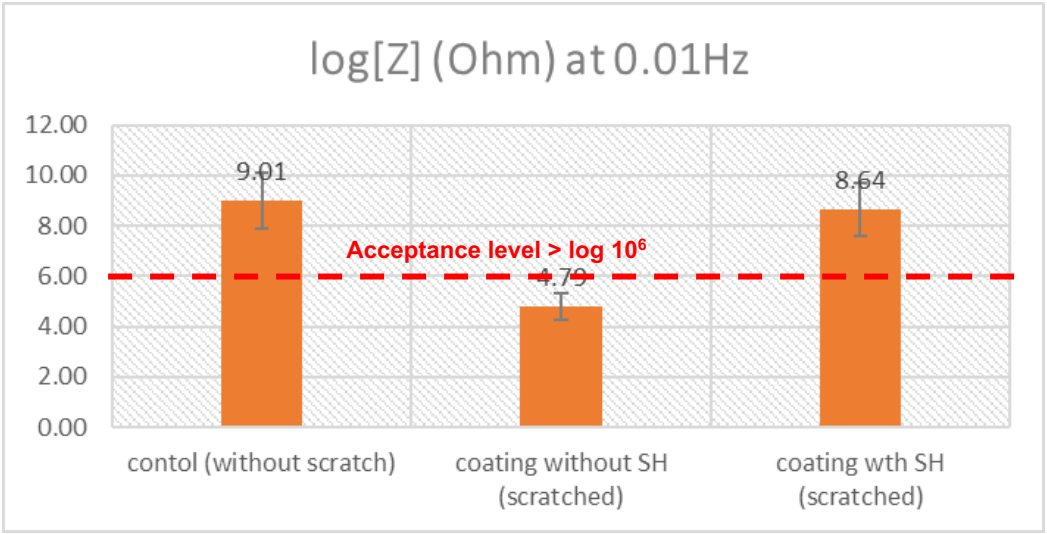
Sample Preparation

1. Method of Coating: **Brush**
2. Dry Film Thickness: **100 – 150 µm**

Result 1: Barrier Resistance Study



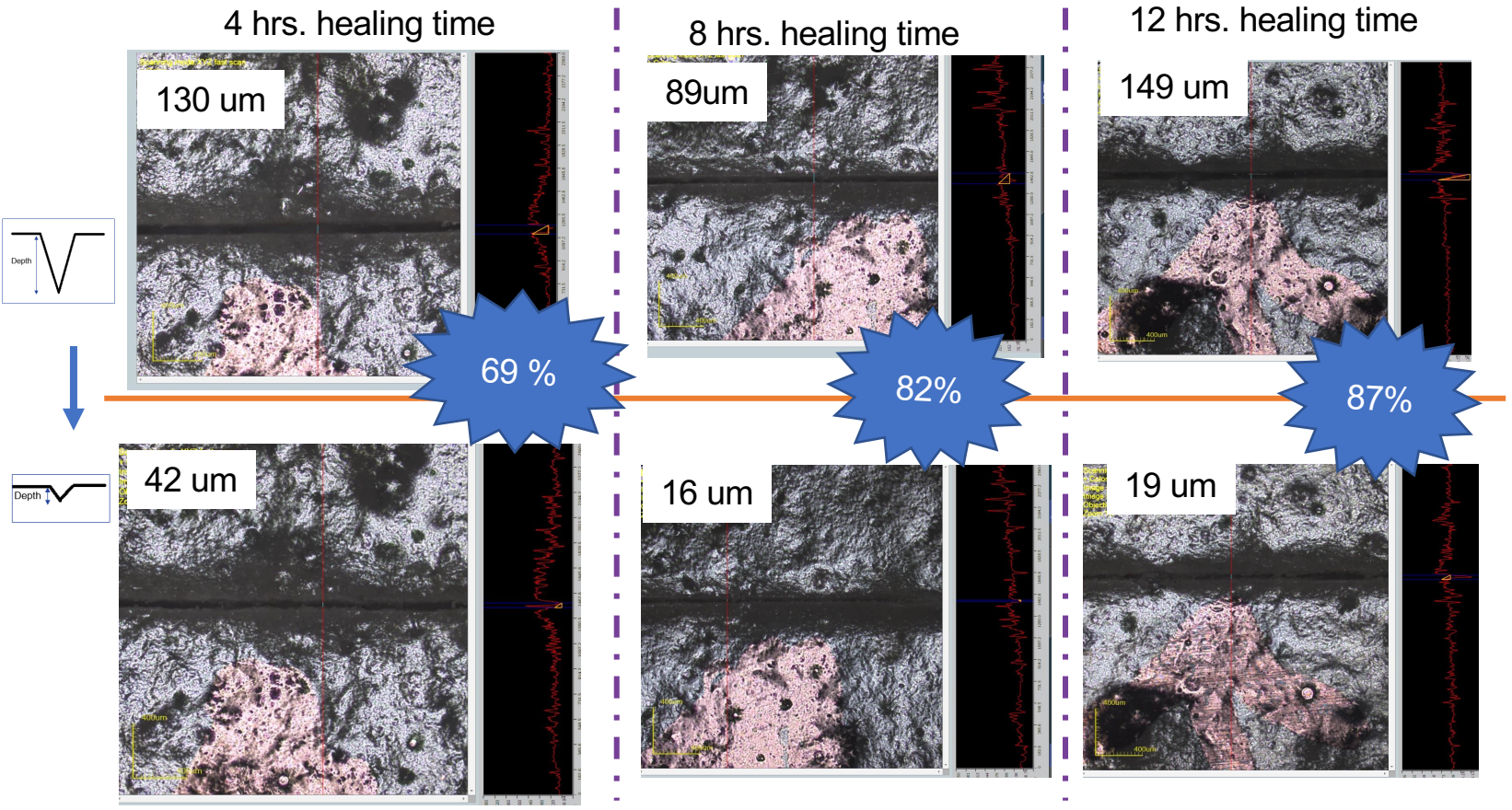




Sample	Log (|Z|/Ohm)
Control Epoxy	9.01
Scratched Epoxy system	4.79
Scratched MOFs self- healing system	8.64

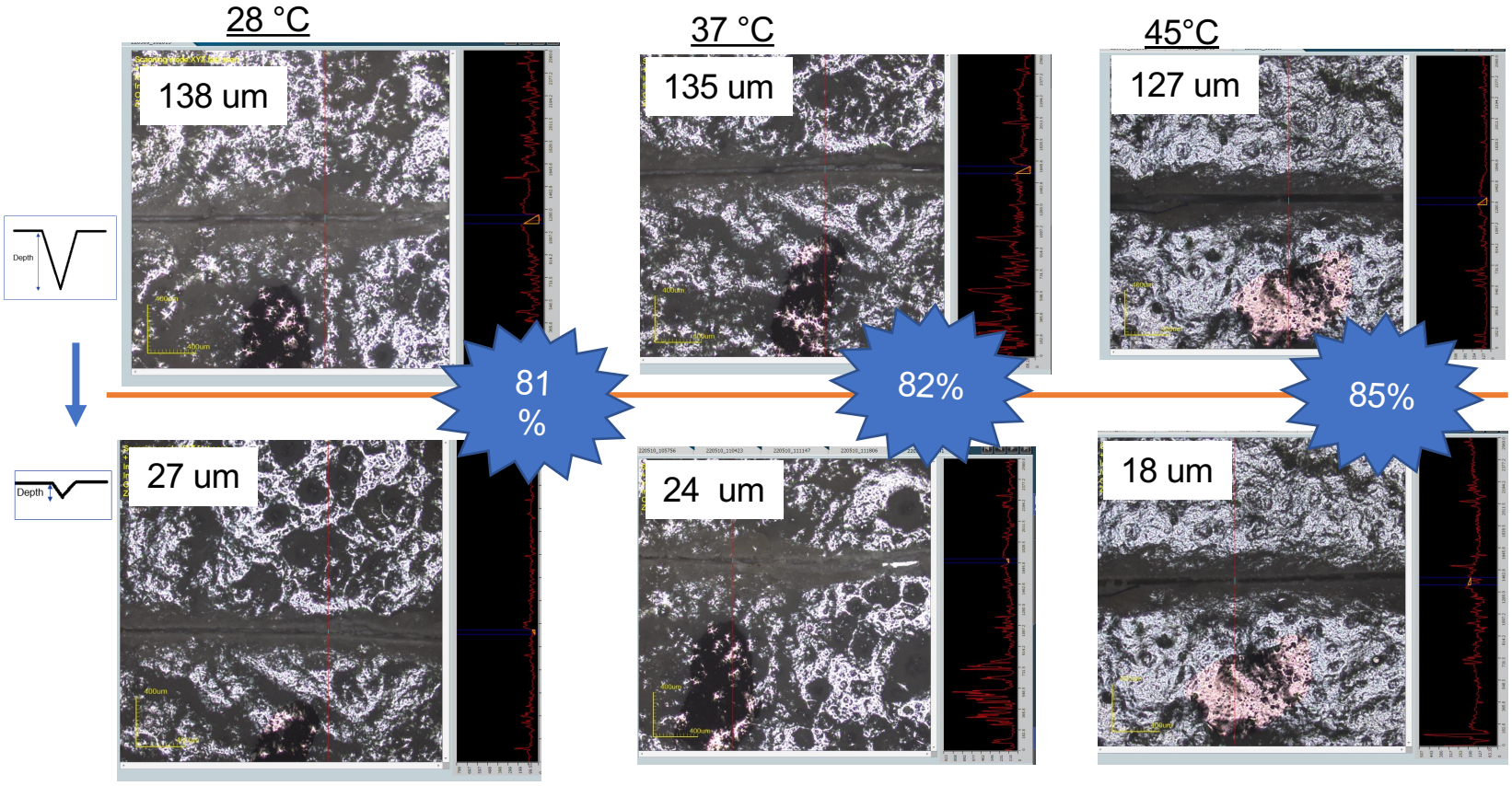
- **Coating with self-healing showed good coating accordance to ISO 16773.**

Result 2(a): Functionality Test at Different Healing Time



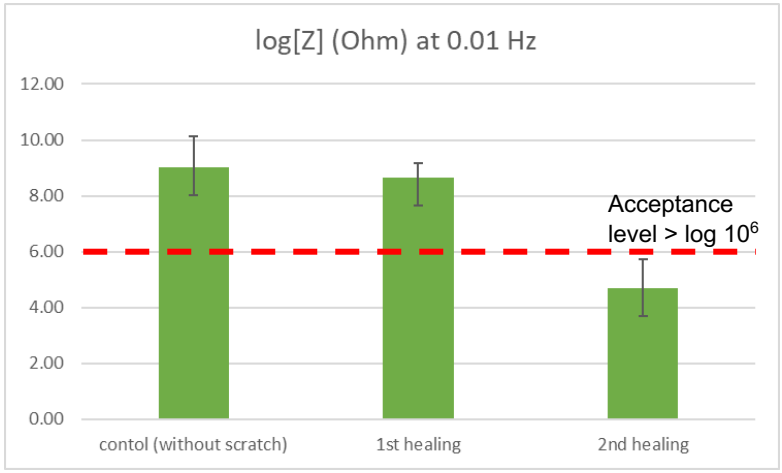
- **87% healing after 12 hours from original thickness**

Result 2(b): Functionality Test at Different Temperature

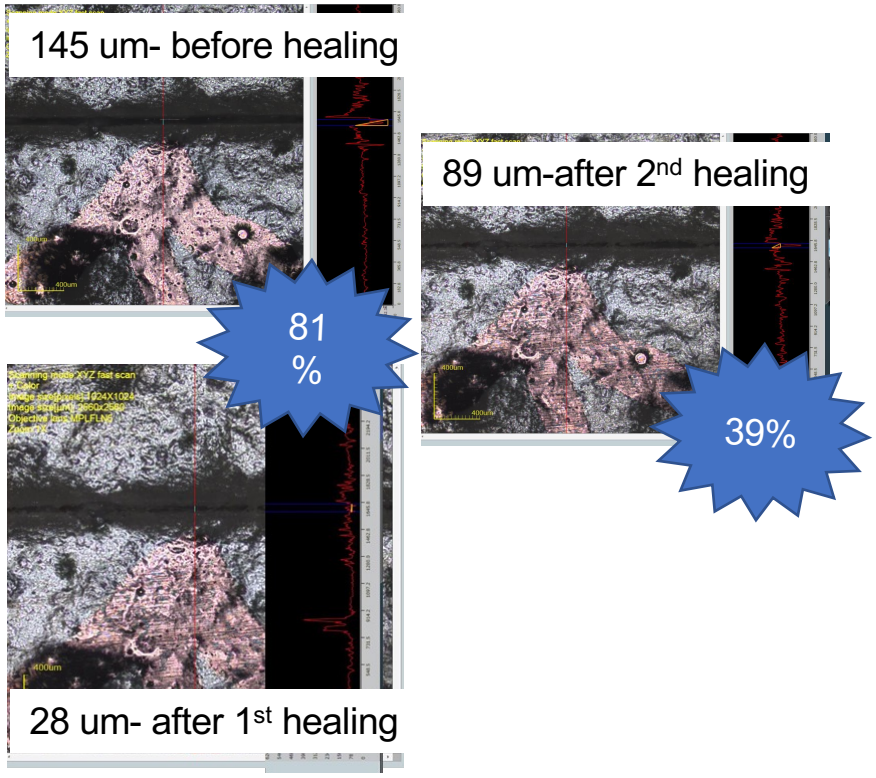


- **85% healing at 45ºC from original thickness**

Result 3: Multiple Healing Test at the Same Spot

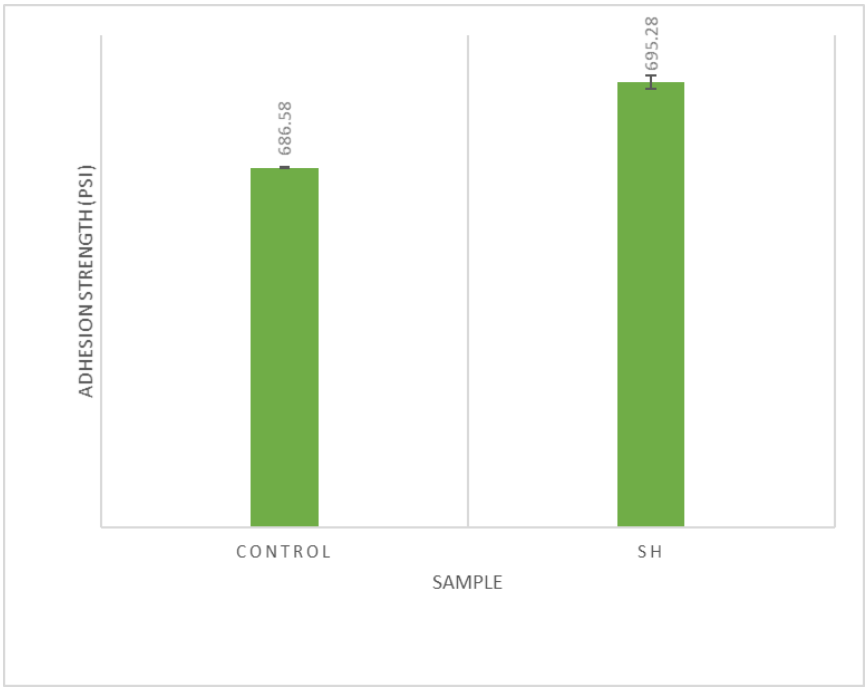


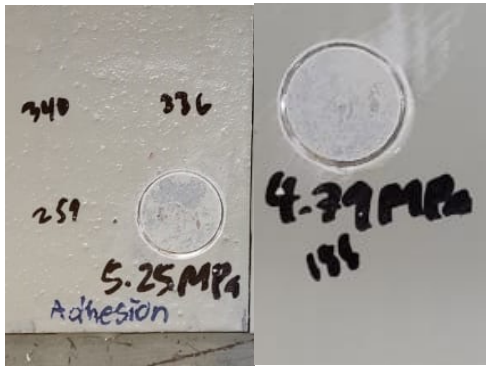
ISO 16773: Barrier resistance for good coating ≥ log 10^6 Ohm at 0.01 Hz



- **Only one time healing at the same spot**

Result 4: Adhesion Test

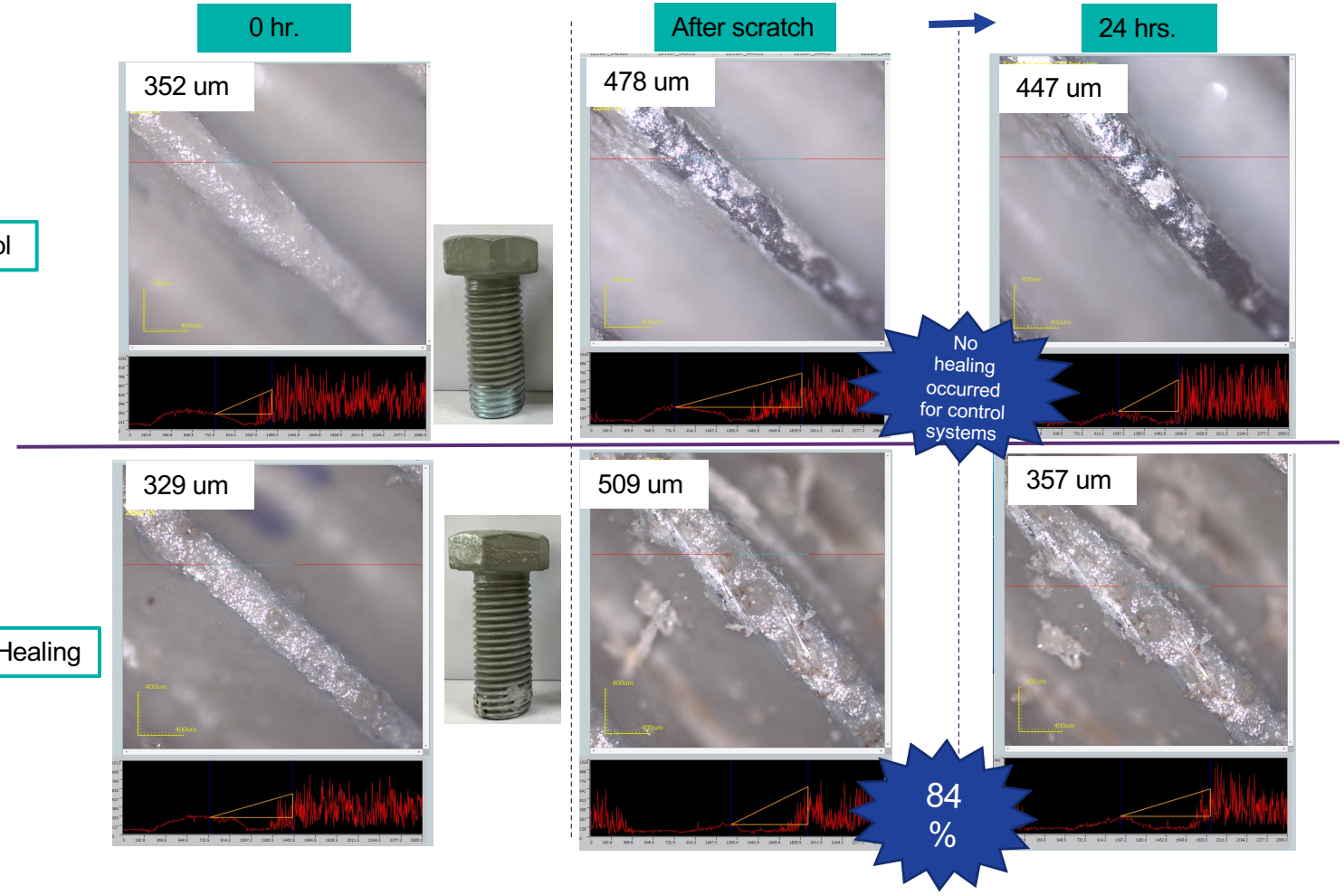




Example of samples after pull-off adhesion testing

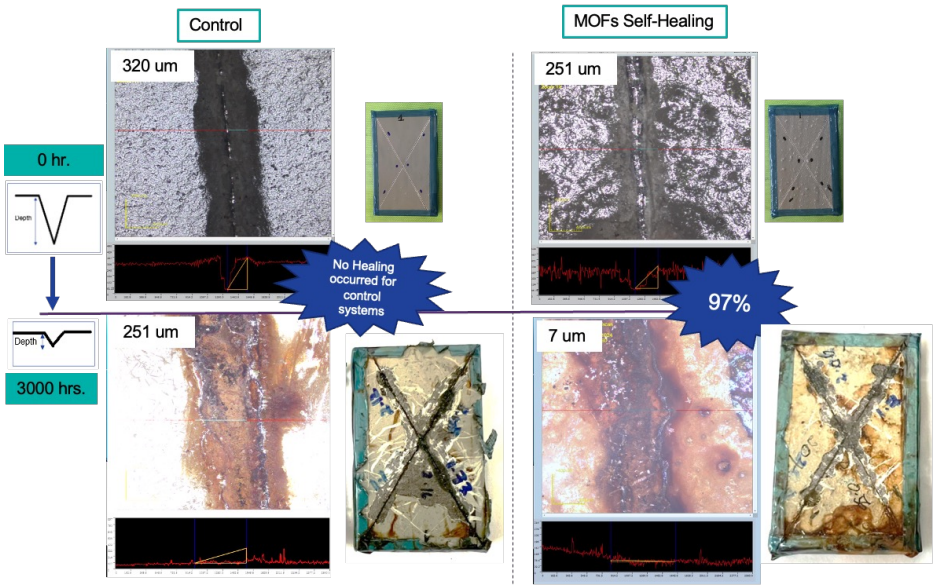
- **Adding a self-healing additive maintains adhesion strength compared to the control.**

Result 5: Healing Test at Actual Nuts



- **No healing occurred at the control**
- **84% healing after 24 hours from original thickness**

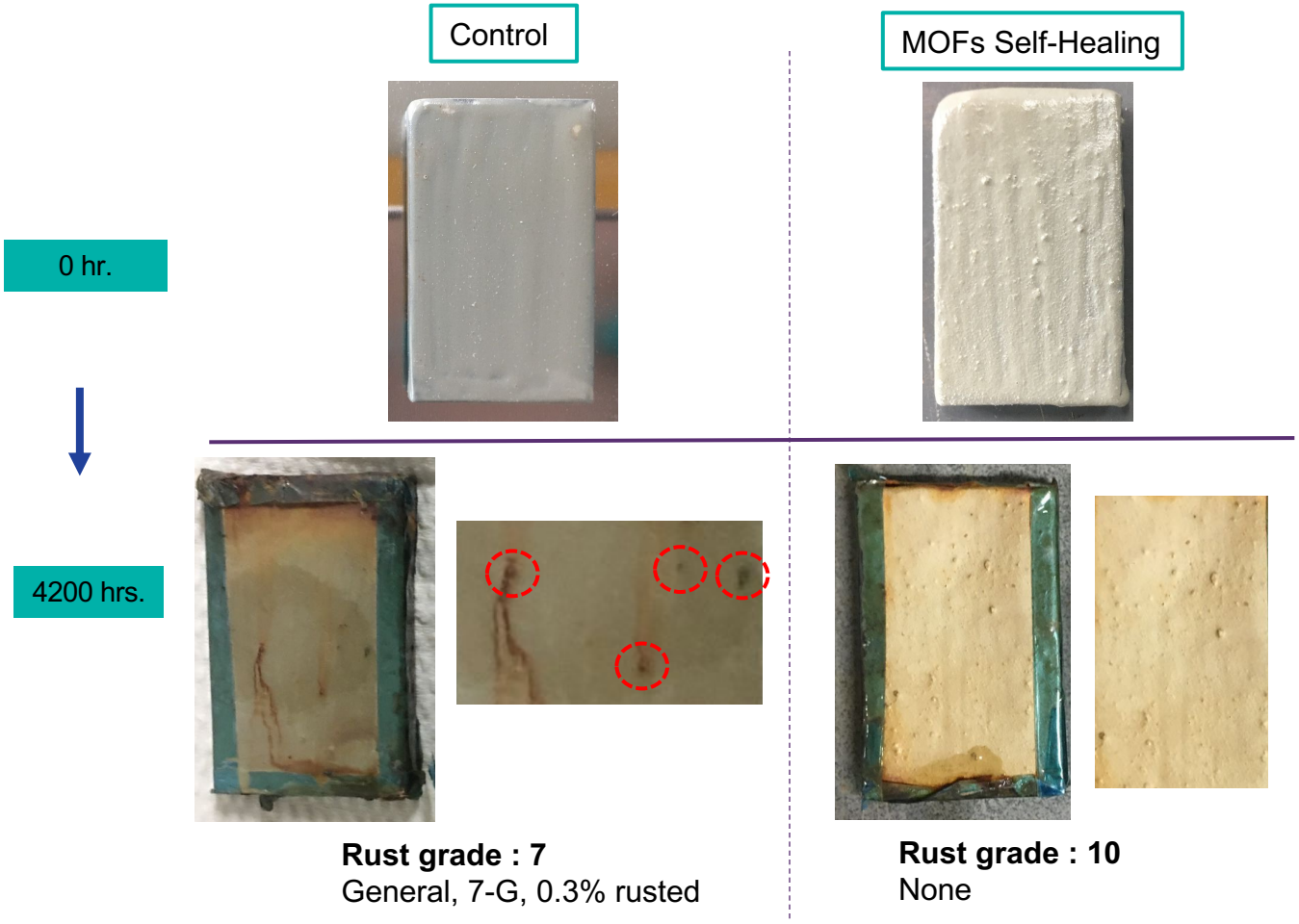
Result 6: Salt Spray Testing



Samples	Mean creepage (mm)	Rating number
Control	2.1	6
MOFs	1.34	7

- **97% healing after 3000 hours of exposure with a creepage rating of 7. Acceptance criteria is rating 4-5.**

Result 7: Cyclic Salt Fog & UV Exposure



- **A rust grade of 10 which meets the acceptance criteria of rust grade is 9.**

Conclusions

1. Healing efficiency: 87% after 12 hours of exposure, 85% at 45ºC and 84% at the actual nut.
2. One time healing at the same spot.
3. Coating properties:
    - ❑ Good coating barrier resistance
    - ❑ Better adhesion
    - ❑ Creepage rating of 7
    - ❑ Rust grade of 9

Based on the findings, a self-healing coating solution can solve business pain point.

Standard Method References

1. ISO 16773
2. ASTM B117
3. ASTM D1654
4. ASTM D5894
5. ASTM D4541

Acknowledgements

1. Dr NorFarah Diana Aba
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Thank you for your passion!