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Defeating the rust – How steel substructures defy danger

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- Defeating the rust -

Table of Contents

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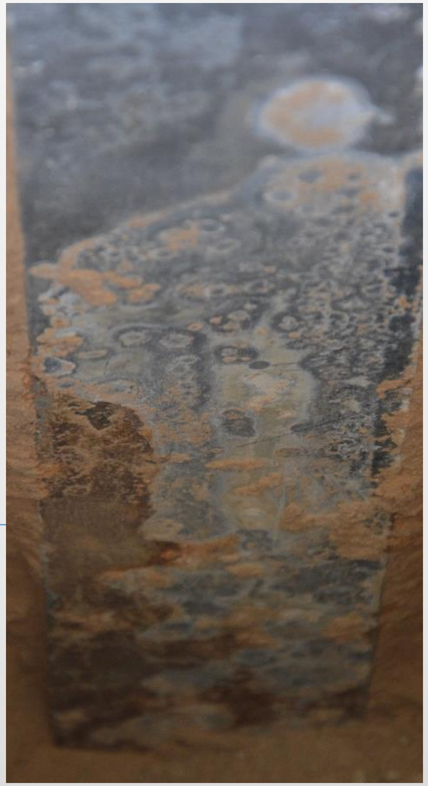
Experience and comparison / corrosion of PV-substructure

UK, 2016
after 2 years

Iran, 2017
after 1 year

UK, 2018
after 3 years

Japan, 2019
after 2 years



Mexico, 2019
after 6 months

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<u>Pictures where the complete zinc of the post is dissolved</u>






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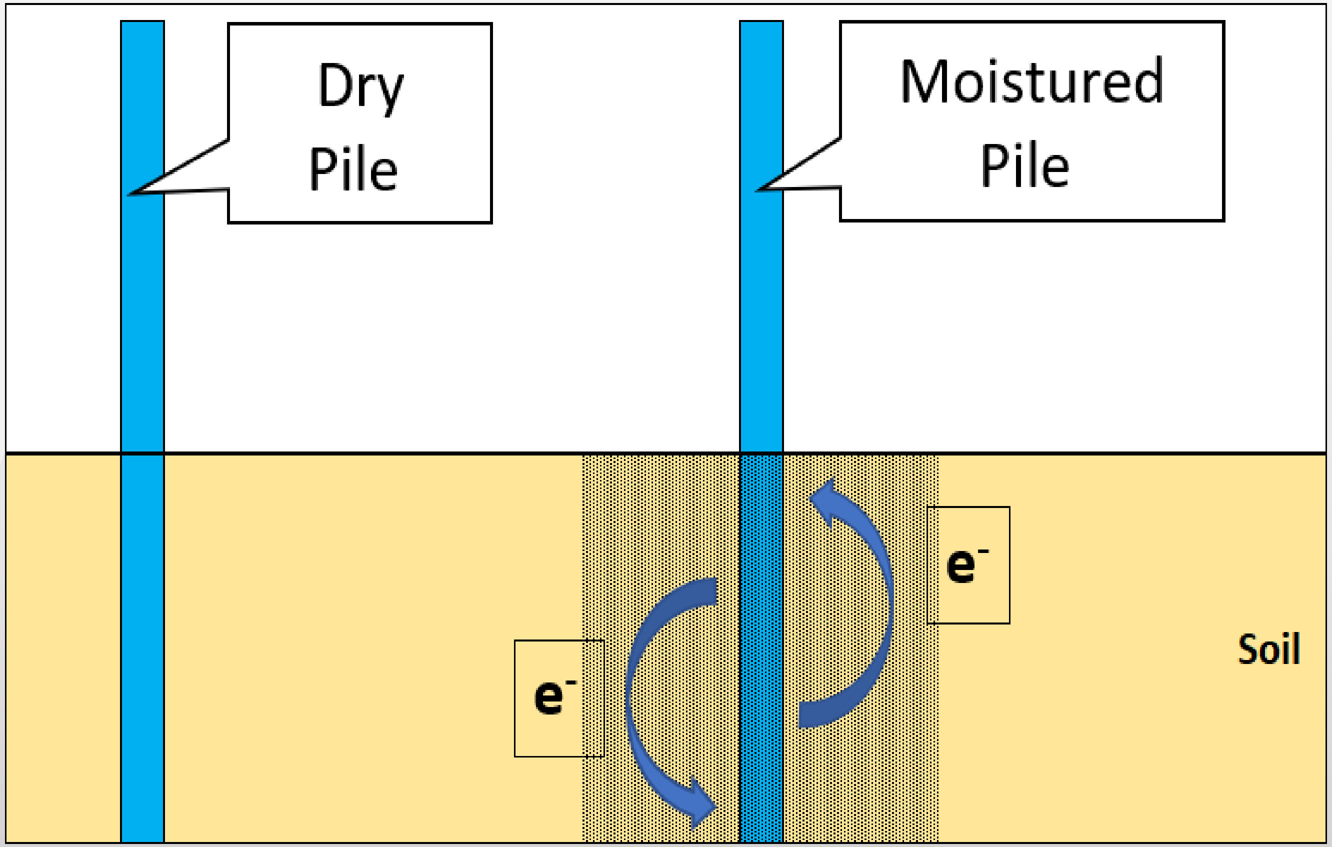
- CORROSION underground -
Required conditions and Influences

- electrical soil conditions
- chemical soil conditions
- thermal soil conditions

- bacteria
- external power sources

- **electrochemical configurations**



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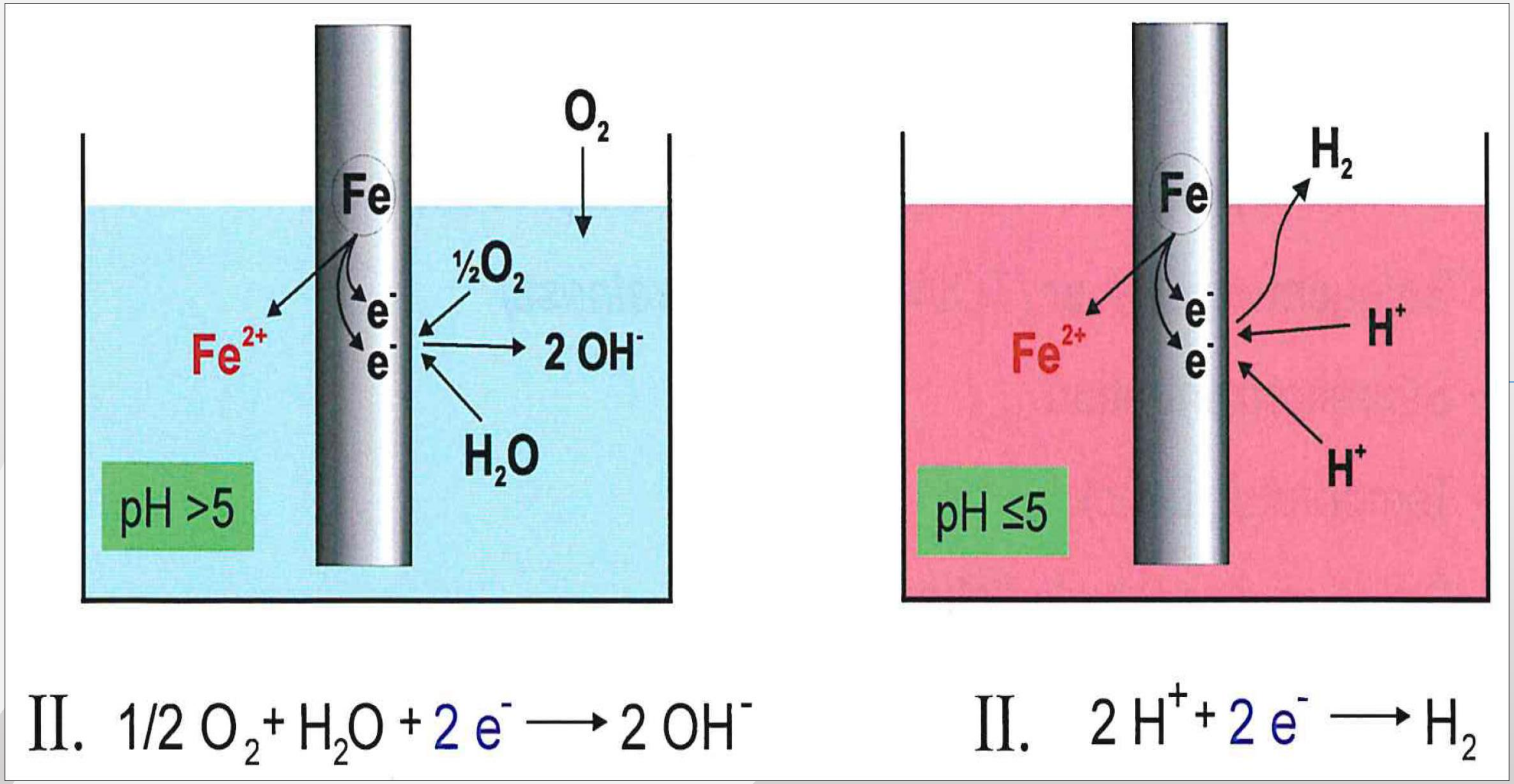
Fundamentals for natural corrosion



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Possible speed of corrosion

- **passive corrosion**
  - -> 30–60 µm/year zinc
  - -> 80–200 µm/year steel
  - -> ISO 12944-2 - C5-M
  - -> depending on soil conditions

- **aktive corrosion**
  - -> 0 - >1.000 µm/year zinc/steel
  - -> electrochemical situations
  - -> external power sources
  - -> couplings of high-voltage lines

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Possible anti corrosion solutions

• Protection on a technically base		-> high costs
replacement of piles using stainless steel piles		Lifetime- up to 25 years
• Passive protection		-> high danger
previously	surface sealing of the posts	Lifetime- 1 to (15)* years
subsequent	surface sealing of the posts	Lifetime- 1 to (15)* years
subsequent	concreting	Lifetime- 1 to (25)* years
• Active protection		**-> reasonable and quick**
realization of a cathodic corrosion protection		**Lifetime- design base up to 100 years**

(*) Lifetime is not determinable

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- Attention ! -
In the event of subsequent sealing

- High costs are to be expected
- A sealing close to 100% is only achievable with a high effort

- Risk:
  - Damage to the existing system is possible
  - The lifetime of the rehabilitation measure cannot be determined
  - Possibility of stronger local corrosion (corrosion hotspots)

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- Attention ! -
In the event of subsequent concreting

- Concrete recipe needs to be suitable for ground and location specialties
- Lifetime is questionable and to ensure with high effort
- Ecologically unfriendly

- Risk:
  - Contact of the pile with the rebar can be dangerous
  (Possibility of stronger local corrosion)
  - Transition of conrete to air is crucial
  (Possibility of corrosion at point with most mechanical stress)

- Attention ! -

In the event of subsequent concreting

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PV-Plants with Electrical Corrosion Protection

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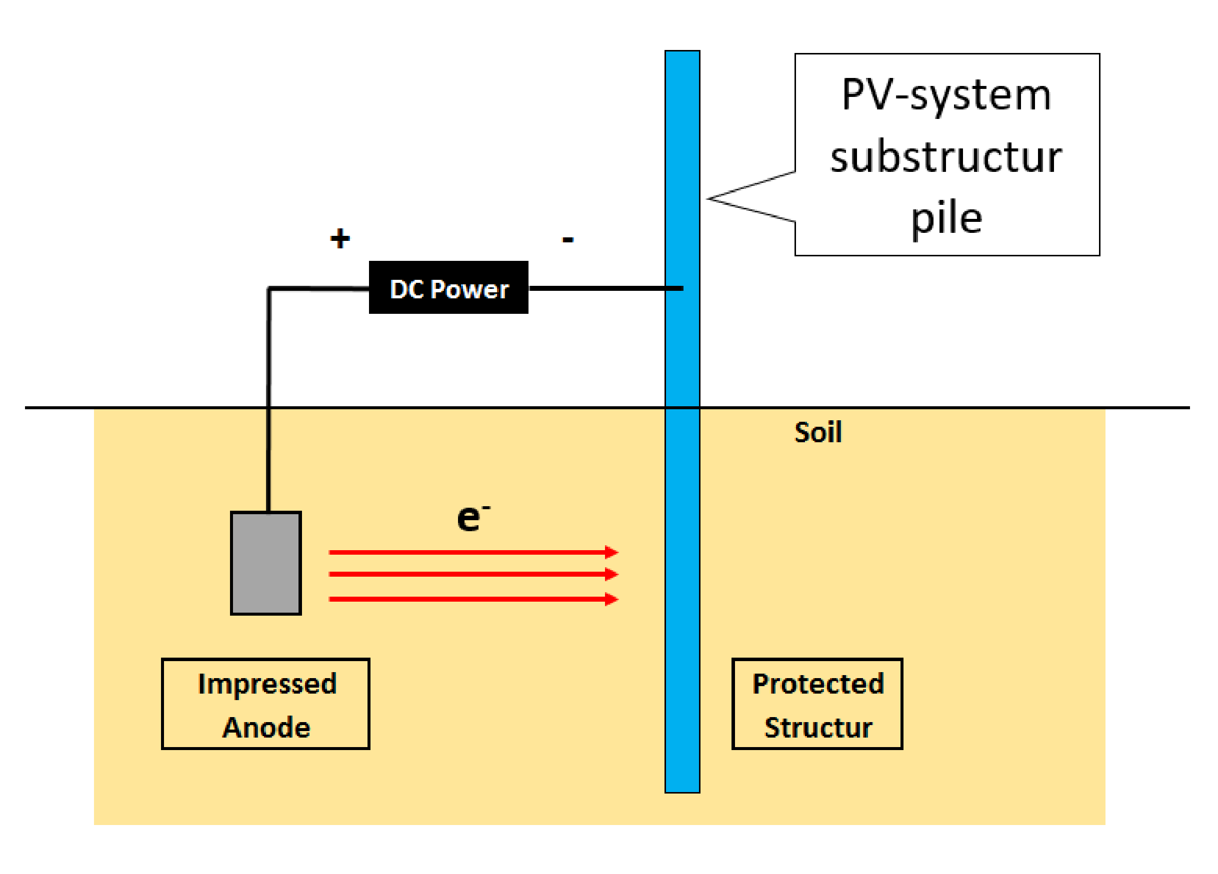
Principle and advantages of electrical corrosion protection

- medium cost range
- fast implementation
- normatively regulated process
- No increase risk of damage
- Easy O&M possible for entire system
- Highest quality assurance through online Monitoring
- System Lifetime can be designed



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Standards

- EN 12944 – Classification of environmental conditions
  - Atmospheric categories clearly divisible (C1 – CX), soil categories significantly more influencing factors and not clearly divisible
- EN 50929 – Corrosion likelihood of metallic materials when subject to corrosion from the outside
  - Classification of environmental conditions
- EN 12501-1 & 2 – Corrosion likelyhood in soil
  - Not only soil & bedding material, inclusion of other factors such as external plants & surroundings
- EN 12954 – General principles of corrosion protection of buried metallic structures
  - General principles for planning, implementation and management of standard applications
- EN 14505 – Corrosion protection of complex structures
  - General principles for planning, implementation and management of complex structures

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Example, 12 MW, UK
designed by Ache Engineering GmbH in 2018

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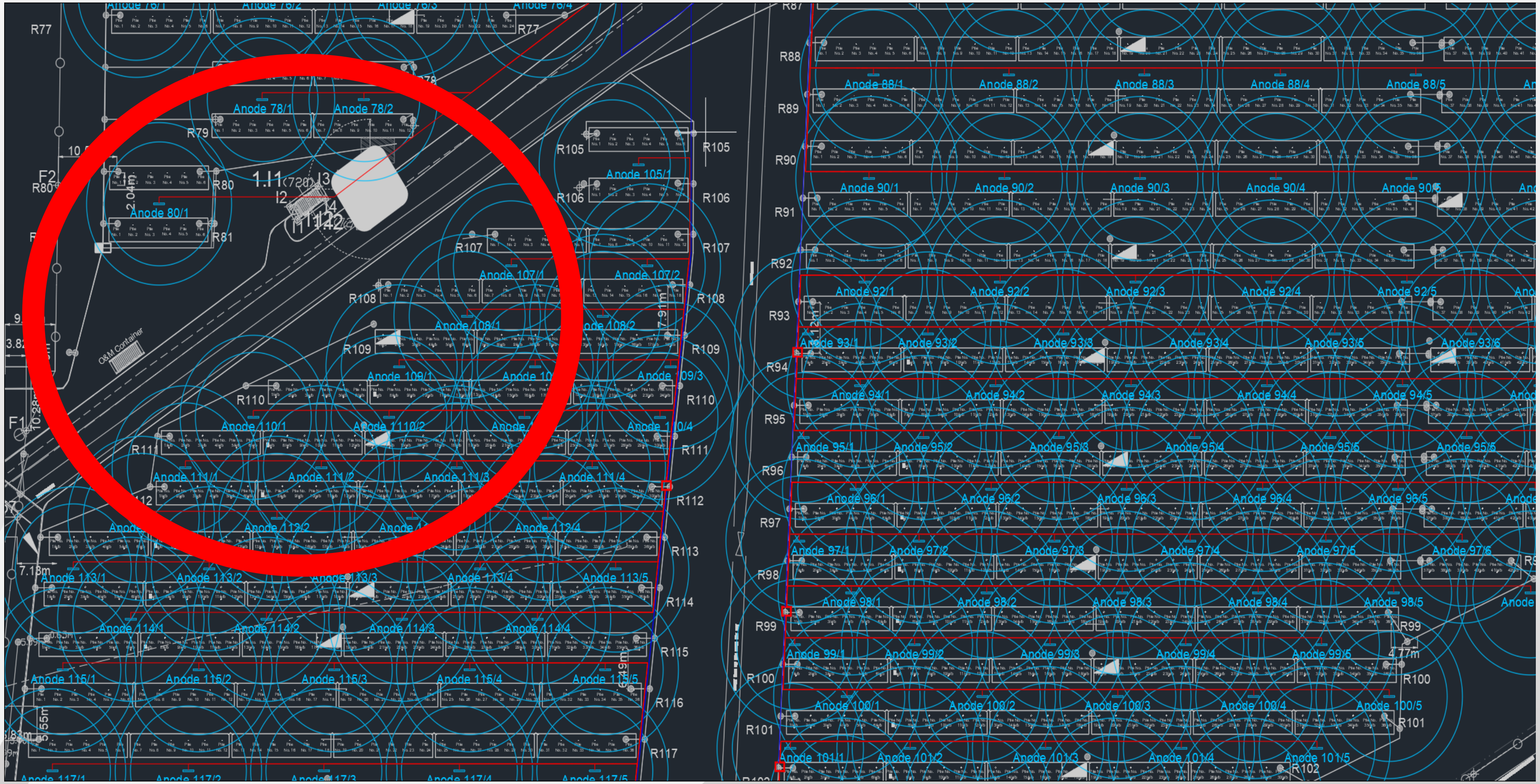
Anode Range



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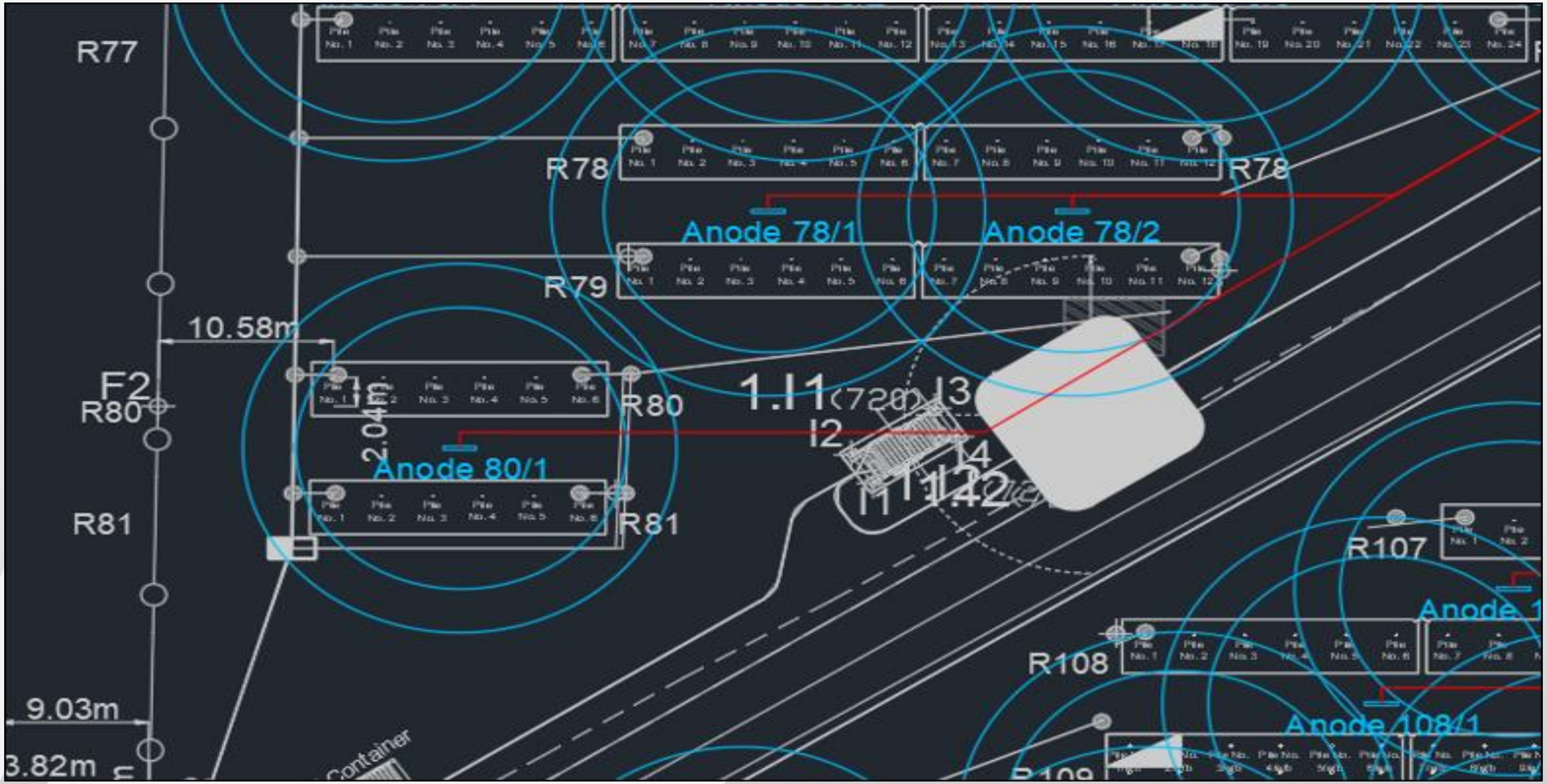
Anode Range



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Implementation of electrical corrosion protection

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O&M

- Remote monitoring of functionality with alarm function
- Self-regulation within certain parameters to comply with the protection criteria (initial increased effort due to polarization)
- Semi-annual reports with analysis
- Annual on-site appointments for optical checking, measuring and determining deviations from the planning state

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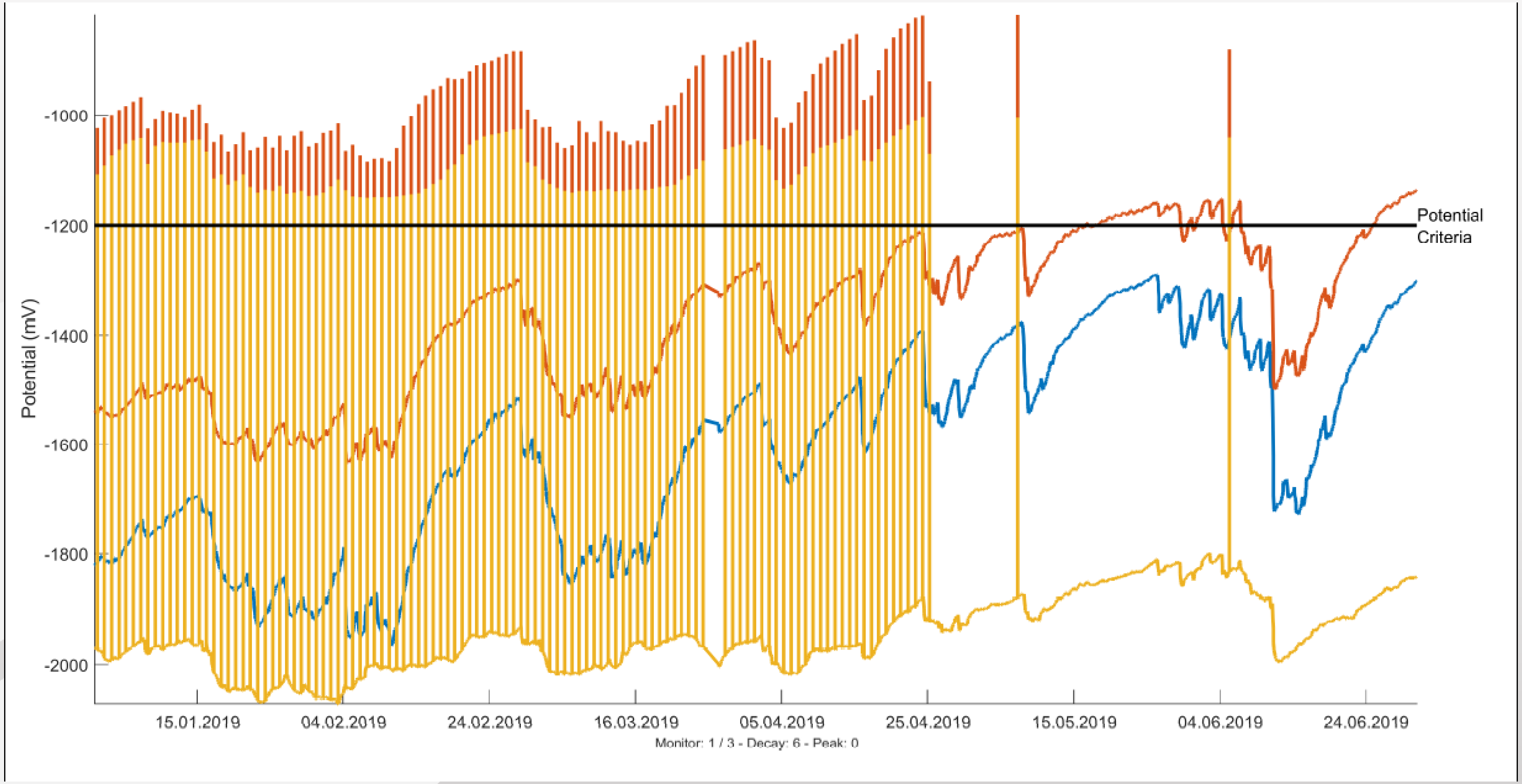
O&M - online monitoring



Summary

• Underground corrosion	-> critical for PV-Plants	unpredictable speed
• Protection on a technically base	-> high costs	estimated lifetime
• Passive protection	-> high danger	Lifetime not determinable
• **Active protection**	**-> reasonable and quick**	**designable lifetime**
• **Active protection**	**-> positive Experience in PV**	**design according to standards**

Thank you very much for your attention

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