Get to know the corrosion mechanisms in power plants

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www.chemin.de

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Profile of CheMin: “Che” for Chemistry, “Min” for Mineralogy

CheMin Ltd
- Started in 1996
- located in Augsburg / Germany
- 100% private company
- 4 operation teams (4 to 6 persons each)
- 3 publicly appointed and sworn experts

Subject matter
- Materials
- Fuels
- Residues
- Thermochemical processes
- Thermic process engineering

For
- Power plants (waste / RDF / biomass / coal / peat / etc.)
- Other companies that deal with thermochemical processes

Clients
- Operators
- Manufacturers
- Suppliers
- Insurance companies
- Courts

- Damage analyses
- Expert Report
- Longterm consulting
- R&D
- Quality control

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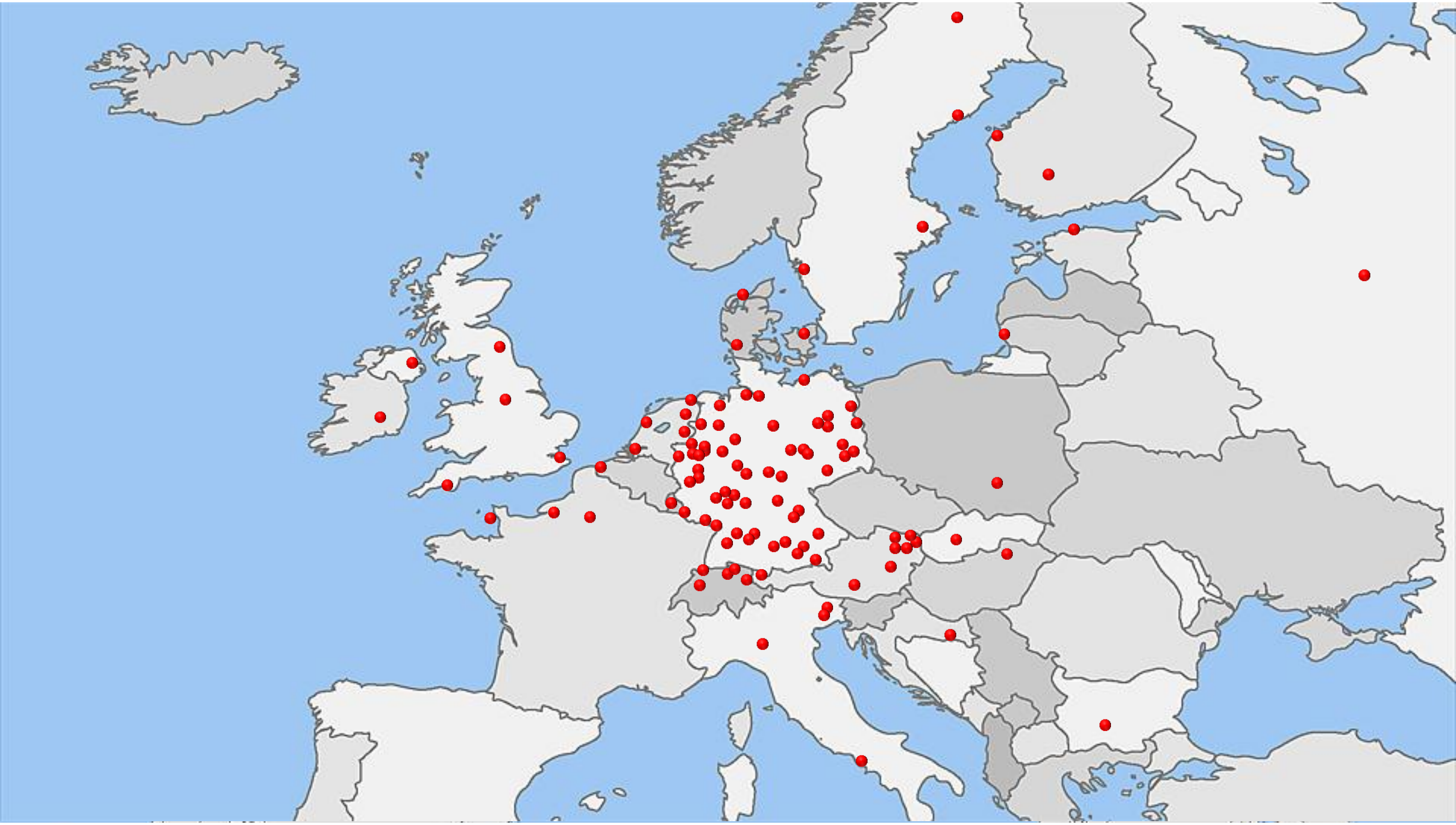
Profile of CheMin: Working sites in the last years



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Useful information for Manufacturer and Operator of Power Plants

Information on mechanism and cause of **corrosion**

Information on cause and composition of **fouling**

Information on the impact of
- fuel
- way of operation

on **corrosion**

Longer operation period

Higher Availabilty

Higher Efficiency

Information on the impact of
- fuel
- way of operation

on **fouling**

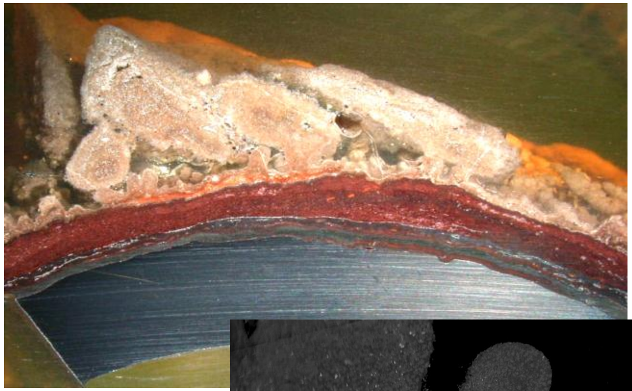
Information on Temperature threshold for **corrosion**

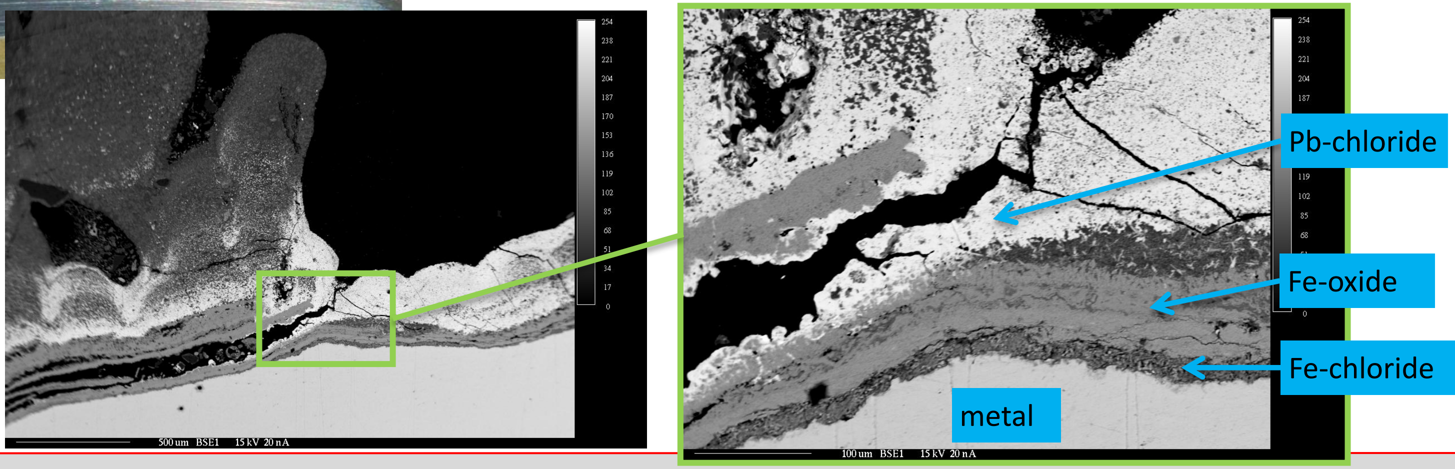
Information on most suitable **materials**

Corrosion mechanisms

Mechanisms of corrosion

High temperature chlorine corrosion





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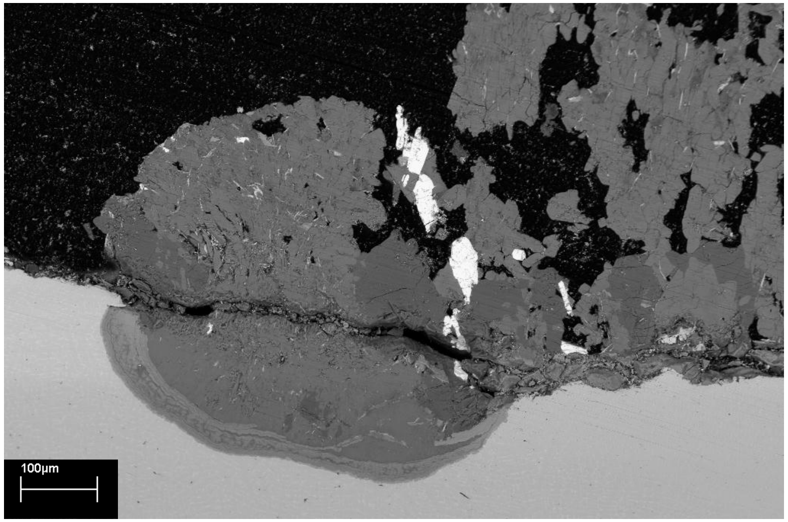
Corrosion mechanisms

Mechanisms of corrosion

High Temperature chlorine corrosion

Salt melt corrosion



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Corrosion mechanisms

Mechanisms of corrosion

High Temperature chlorine corrosion

Salt melt corrosion

Dew point corrosion

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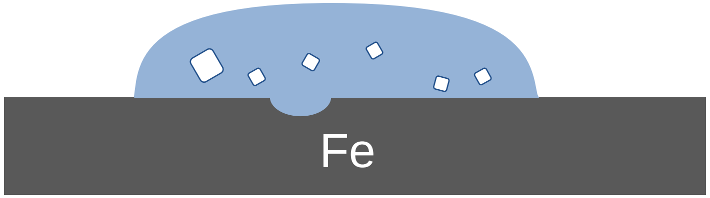
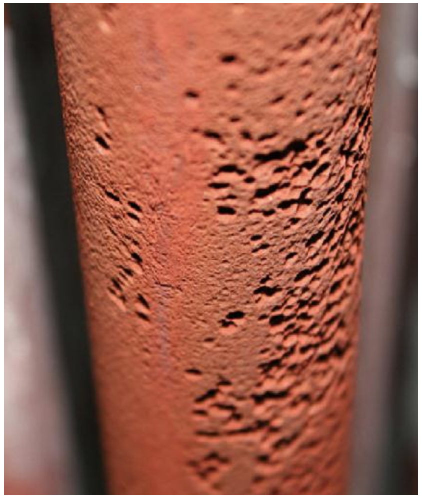
Deliquenscence corrosion





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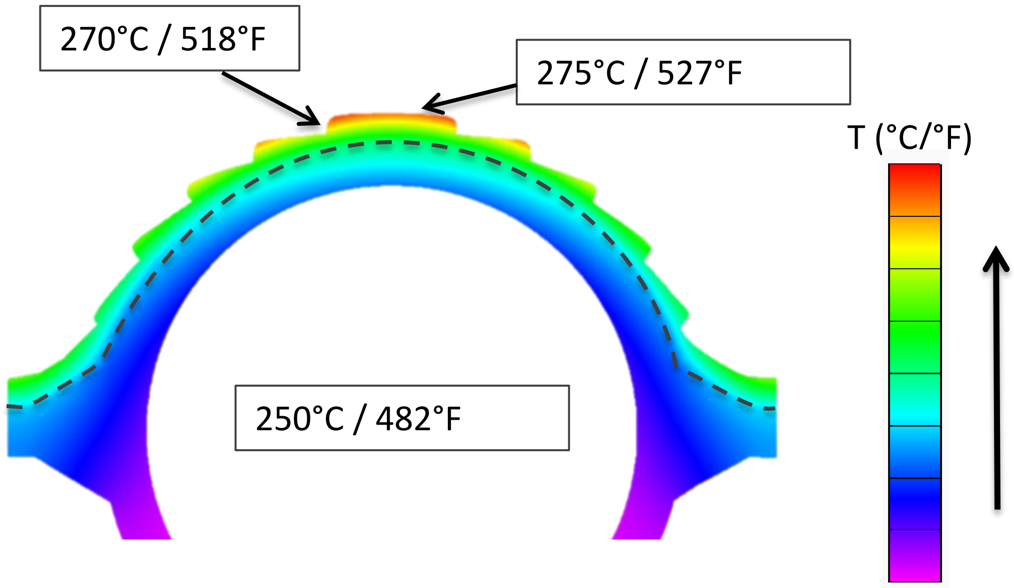
Corrosion mechanisms

Mechanisms of corrosion

- High Temperature chlorine corrosion
- Salt melt corrosion
- Dew point corrosion
- Deliquenscence corrosion
- Heat flux induced corrosion



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Corrosion mechanisms

Mechanisms of corrosion

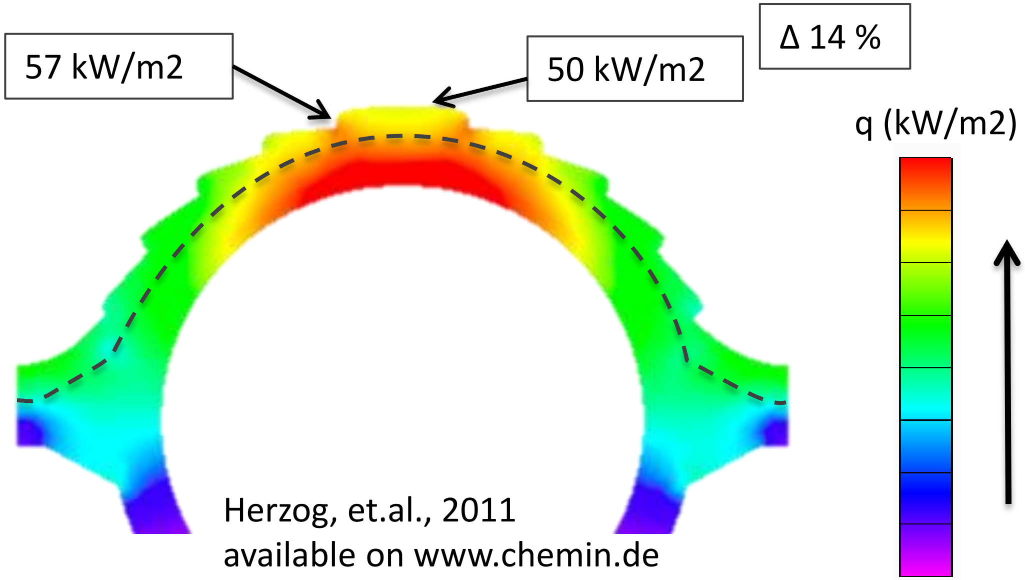
High Temperature chlorine corrosion

Salt melt corrosion

Dew point corrosion

Deliquenscence corrosion

Heat flux induced corrosion



Herzog, et.al., 2011
available on www.chemin.de

Probes and Sensors

Temperature Range Probes

→ For investigations in the power plant

'Corrosion Lab'

→ For investigations in the laboratory

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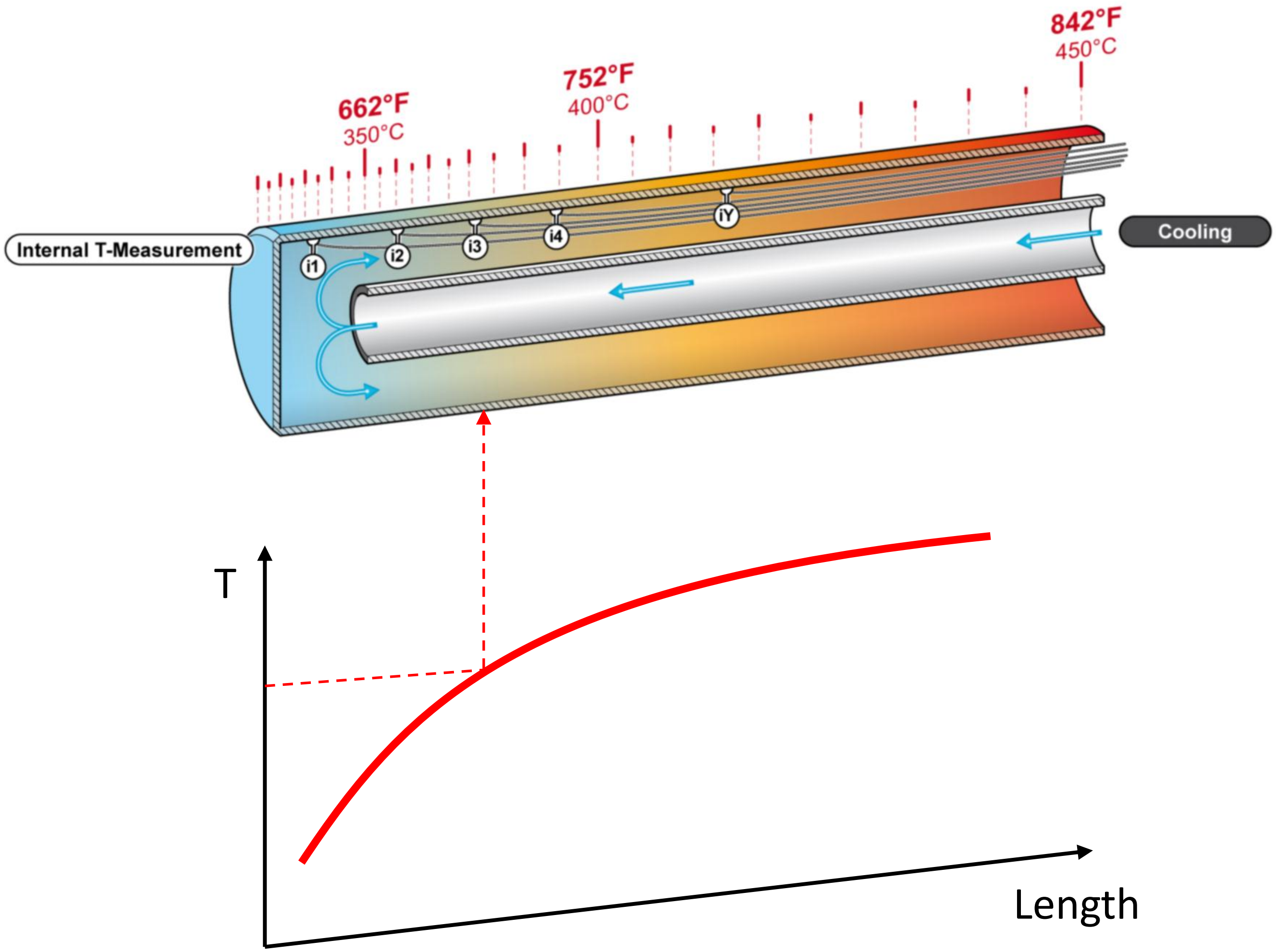
Temperature Range Probe - How does it work?



Temperature window is kept constant (controlled)

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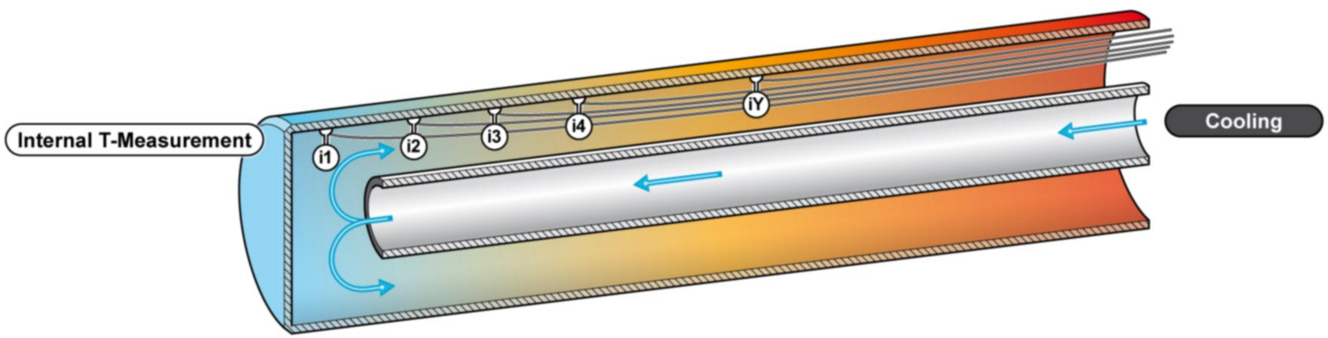
Temperature Range Probe



The design of the probe can be adjusted in terms of

- Length and diameter diameter: min. 30 mm = 1.4”,

  length max. 3000 mm = 120”
- Material (carbon steel, higher alloyed steel, Ni-based material, spray coating, refractory)
- Temperature window (1200°C to 100°C)
- Places of operation (different components of the HRSG;

  combustion chamber, superheater, evaporator, economizer, flue gas duct, etc.)

Example 1: High temperature chlorine corrosion

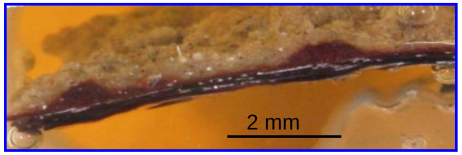
Situation: Superheater of a WtE plant is strongly corroded

Method used: Temperature range probes were applied at different flue gas temperatures

After 15 h of exposure:

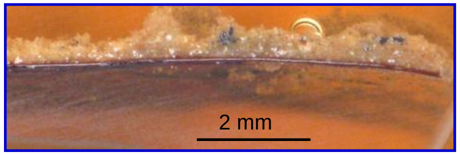
At medium temperature of 400°C

T_{FG} ~640°C



Corrosion rate: 0.5 mm / 1000 h

T_{FG} ~600°C



Corrosion rate: 0.05 mm / 1000 h

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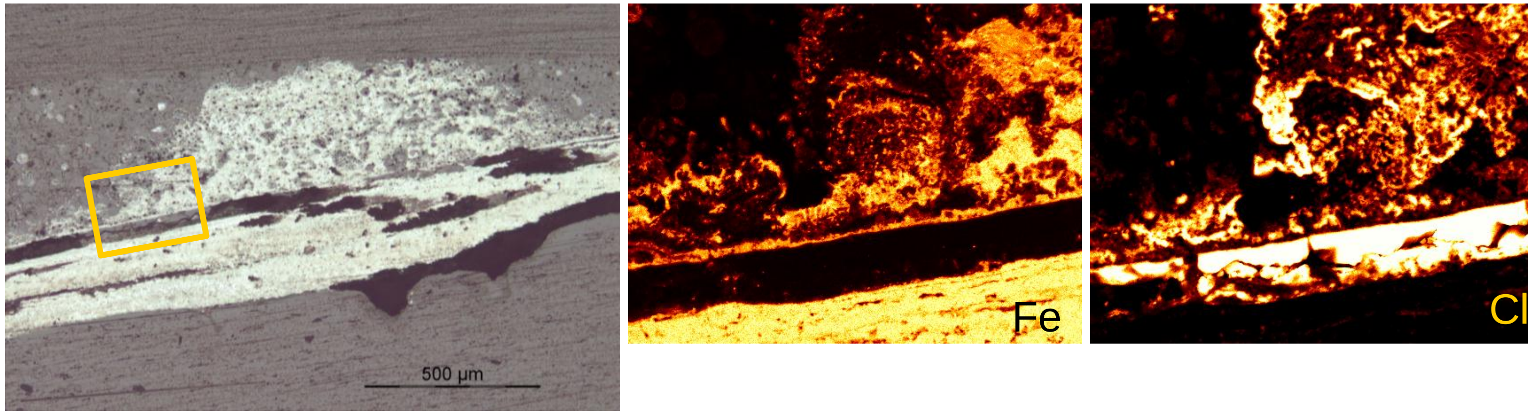
Example 1: High temperature chlorine corrosion

T_{FG} ~640°C



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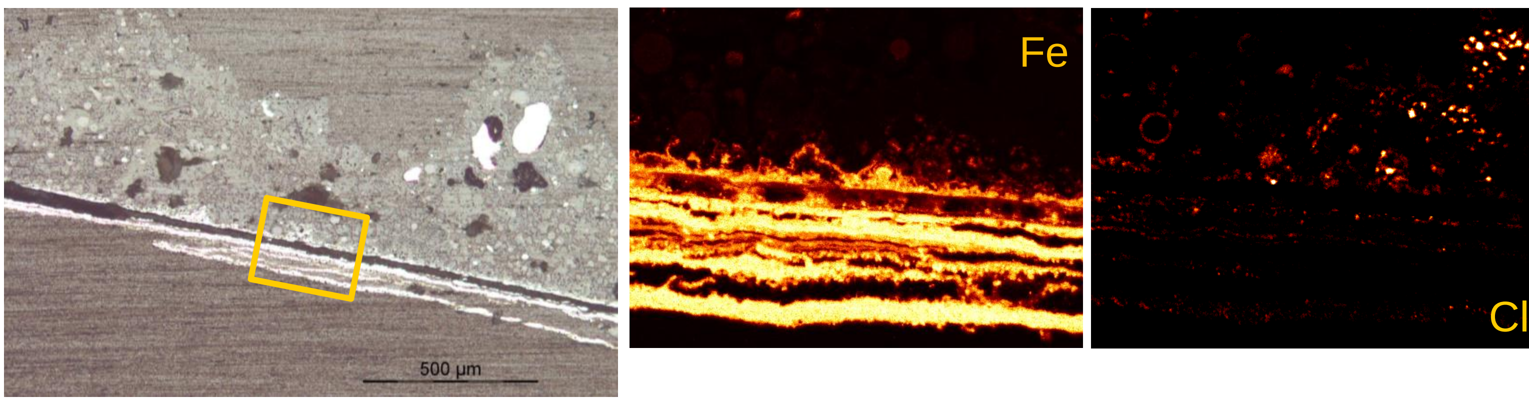


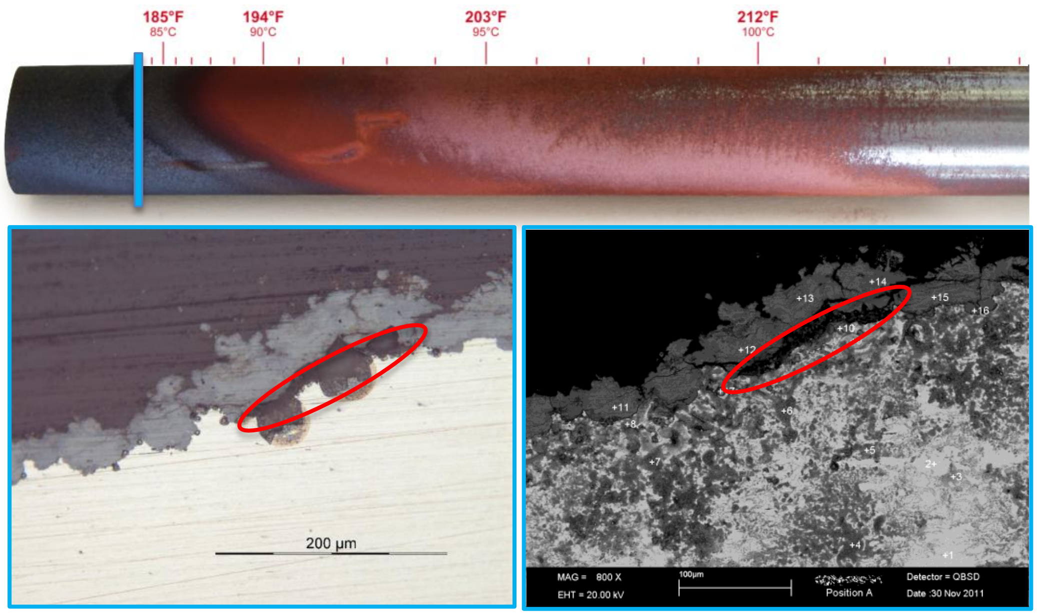
Result:
- Degree of corrosion depend on flue gas temperature
- different amount of chloride salts at different flue gas temperatures

Solution: Flue gas temperature has to be kept below 600°C before entering the superheater

Example 2: Deliquenscence corrosion

Situation: Cold end of a gasfired boiler suffers strong corrosion

Method used: Temperature range probes were applied at different flue gas compositions



ammomium chloride and
ammonium bromide

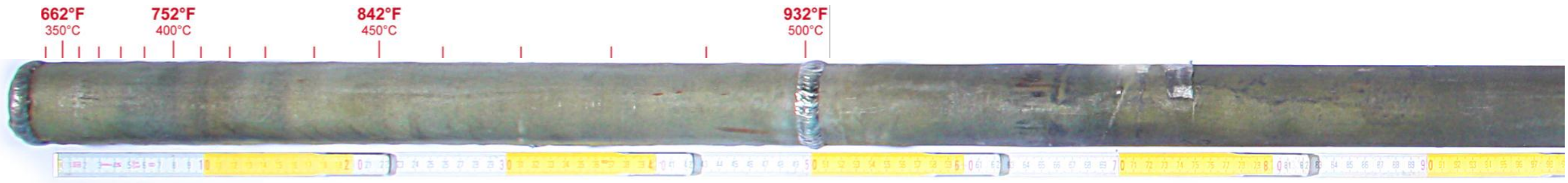
Result:
- Ammonium salts cause corrosion at cold end
- Temperature threshold for corrosive attack 103°C / 217°F, strong corrosion below 83°C/ 181°F

Solution:
- all metal surfaces have to be kept above 103°C / 217°F

Example 3: Material Tests

Situation: WtE plant wants to choose a more suitable material for superheater

Method used: Temperature range probes with different coating materials were applied



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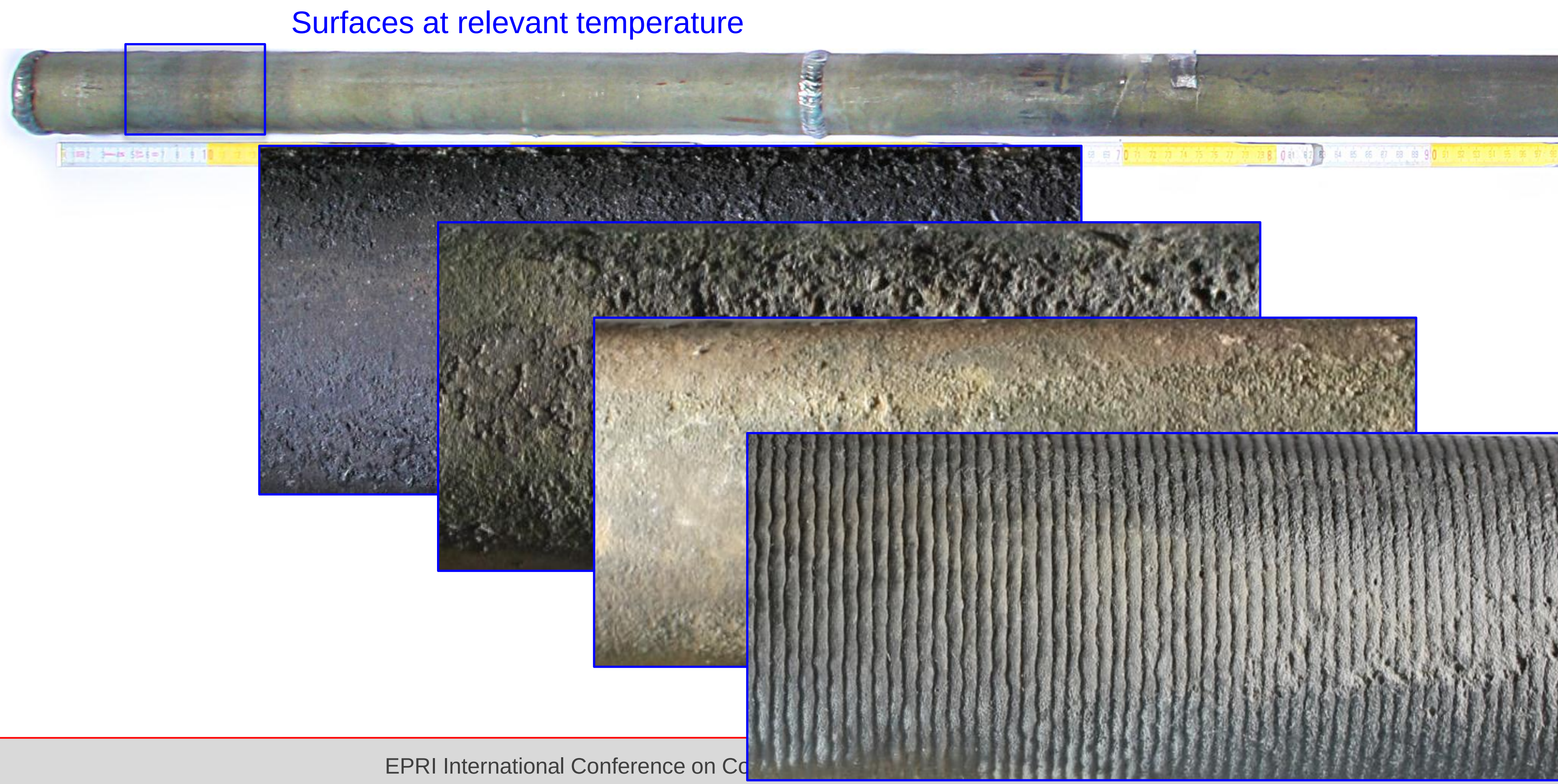
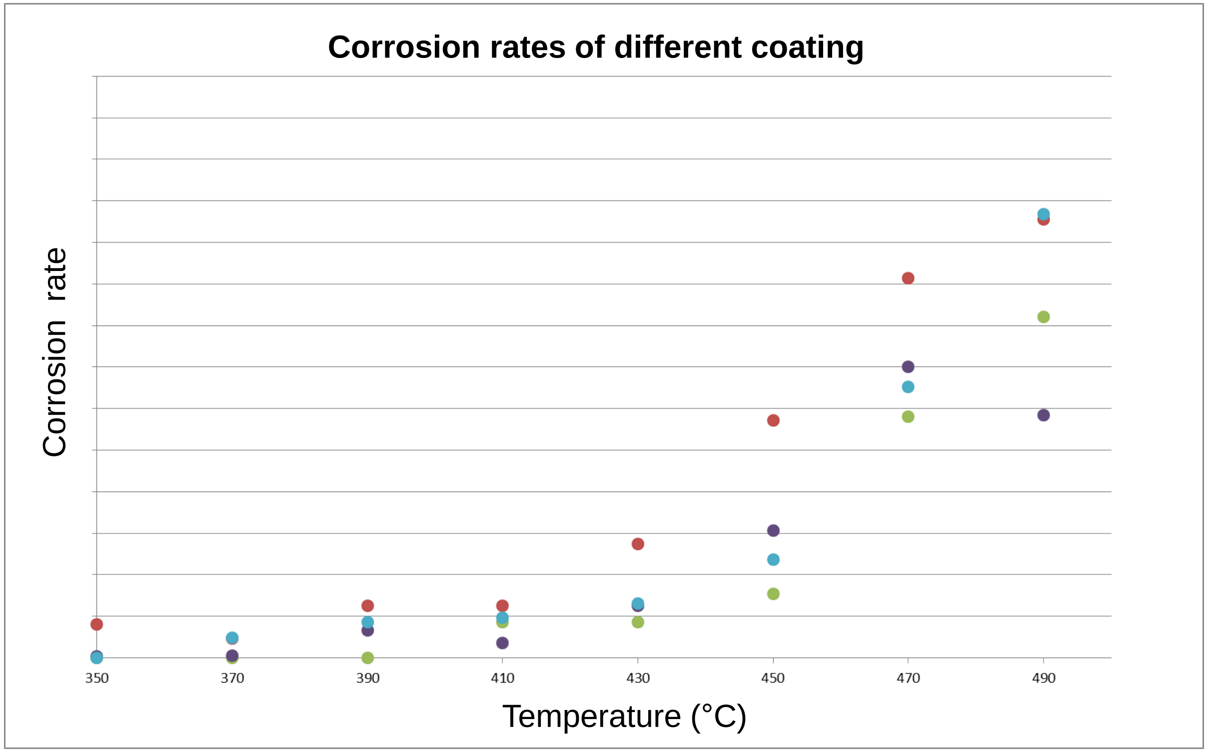


Example 3: Material Tests



Result: Different coating show different corrosion rates

Solution: The most suitable coating for this plant could be selected

Probes and Sensors

Temperature Range Probes

→ For investigations in the power plant

'Corrosion Lab'

→ For investigations in the laboratory

Corrosion Lab

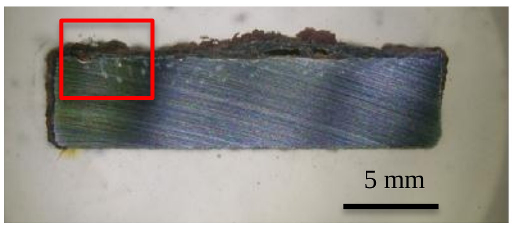
Parameter	possible
Absolute moisture	0 to 70 [Vol.-%]
Surface Temperature	up to 150° C / 300° F
Gas Temperature	up to 180° C / 356° F
Oxygen content	< 6 to 21 [Vol.-%]

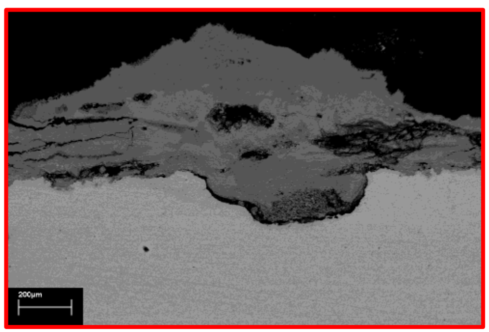
- A steel plate is exposed with a chosen aggressor under defined conditions
- Corrosive character of different salts under various conditions
- Corrosive character of real deposits (fly ash, deposits on tubes, filter ash, etc.) under various conditions
- Material testing under defined conditions with salts or real deposits

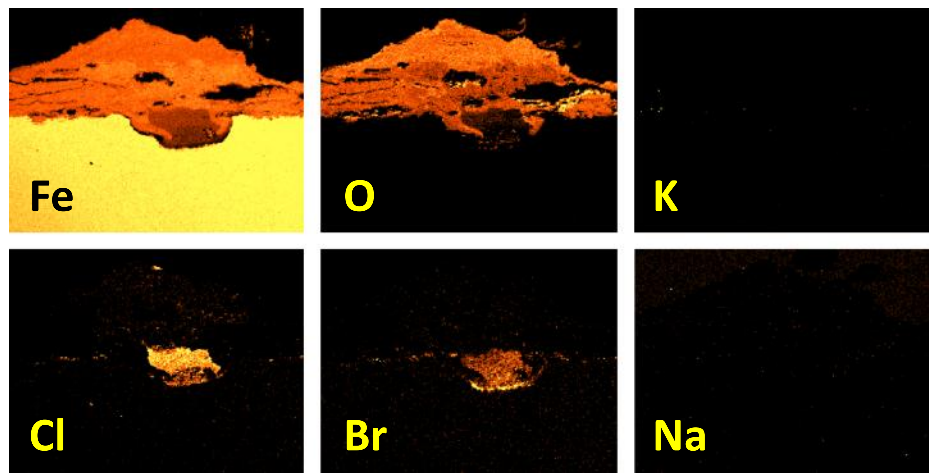
Example 4: 'Corrosion Lab'

Situation: Corrosion on clean gas side of a biomass plant

Method used: Boiler ash taken from the surfaces during outage was investigated for its corrosive character on the original metal in the Corrosion Lab under realistic conditions.







Result: Ammoniumbromide and Ammoniumchloride are the most aggressive species in the boiler ash.
In combination with a temperature range probe the temperature threshold for corrosive activity could be identified

Conclusions

Corrosion is the result of a complex interaction between fuel, firing, flue gas streaming and temperature conditions in the boiler.

Cause, dynamics and mechanism of corrosion can be studied with temperature range probes.

With temperature range probes different investigations can be made (corrosion, fouling, temperature threshold for corrosion, material tests, etc.)

Temperature range probes can be implemented at conditions between 1200°C and 100°C.

With the help of temperature range probes a simulation of planned optimization measures

At low temperature conditions (< 180°C), additional studies about the corrosion mechanisms and the aggressor can be done with the help of the ‘Corrosion Lab’.

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