Impact of evolving foulings on HT chlorine corrosion

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Dynamic chlorine induced high temperature corrosion
of boiler and superheater tubes due to evolving foulings

- frequent finding in waste and biomass fired boilers
- impact on maintenance costs (inspection, material, time)
  - impact on availability (damage)

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Technology: Solid Municipal Waste Incineration, Biomass
Project: Failure Studies
Subject: Systematization of the Phenomena (SH in 'normal' WTE)

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'Dynamic' 
Chlorine-induced high-temperature corrosion

'Shallow pit' 
up to
'extensive surface pitting'

approx. 5 mm
Grate, Municipal Waste
~10 300 hours Operation
Superheater Tubes, Pass 3

Dynamic HT Chlorine Corrosion (SH in ‘normal’ WTE)

SH 2
T (fluegas) ~ 460-570°C
T (steam) ~ 390°C

SH 1.2
T (fluegas) ~ 420-510°C
T (steam) ~ 330-380°C

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## Technology
Solid Municipal Waste Incineration, Biomass

## Project
Failure Studies

## Subject
Dynamic HT Chlorine Corrosion (SH in ‘normal’ WTE)

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Grate, Municipal Waste  
1 Year Service  
Superheater Tubes

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![Image of corrosion]

- Extensive Material Loss
- "No" Material Loss
- Some Pits

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Example

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Impact on Availability (data from SH in ‘normal’ WTE)

- Increased maintenance costs
- Shorten the ‘normal’ lifetime
- Diminish the boilers availability

Trend of ‘Normal’ Corrosion

Wall thickness periodically measured

Failed by ‘extensive surface pitting’ Corrosion

Damage

Increased maintenance costs
Shorten the ‘normal’ lifetime
Diminish the boilers availability
These phenomena / damage occur at operating conditions of approximately:

- Fluegas Temperature [°C] > 450°C
- Material Temperature [°C] > 365°C

- Indifferent Expansion v = 10-15 m/s
- Corrosion, v = 5 m/s

Subject: Operating Conditions (data from SH in 'normal' WTE)
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Partial Pressures estimated from the identified Phases:
- Oxygen ~ very low
- Sulfur ~ medium to very high
- Chlorine ~ medium to very high

Identified Phases of corrosion products:
- Ironchloride
- Ironsulfide and Sulfate
- Ironoxide (Fe$_3$O$_4$ predominantly)
- Ironoxide (Fe$_2$O$_3$ predominantly)

Subject
‘extensive surface pitting’ corrosion under evolving foulings (SH in ‘normal’ WTE)

• High effectiveness
• Extensive involvement
• Long-term stability
Technology: Solid Municipal Waste Incineration, Biomass

Project: Failure Studies

Subject: ‘Normal Chlorine HT Corrosion’ vs. Stipulating Condition of Dynamic Corrosion (SH in WTE)

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Case Study Biomass (grate, Stoker; Plant A)

- Corroded tubes with flat surface (invisible corrosion)

- Section through Fouling:
  - Leadsalts: Barrier layer
  - about 1 mm per 1,000 h

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K-Na-SO₄ + Ash Spheres

Pb-K-Na-SO₄ + Ash Spheres

Fe-Oxide + Zn

K-Na-SO₄

Pb-K-Cl

Fe-Oxide
Chemical compositions of salts analysed by microprobe (wdx)

Plotted into the System K-Na-Pb-Cl-SO₄

Melting points of salts in the Pb-K-Cl-Layer approx. range from 400 to 450°C
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Evaporator, Pass 1
Examples with Cladding, Alloy 625
- e.g. 295°C Steam
- e.g. 325°C Steam

Superheater
Electroplated Nickel

Cladding, Alloy 625

Single Tubes, Pass 2,
approx. 410°C Steam
Local Attack approx. 1 mm deep,
Inspection after approx. 4 600 h

Banks, Vertical Pass,
approx. 400°C Steam,
Sampled after approx. 9 400 h

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Technology: Solid Municipal Waste Incineration, Biomass
Project: Failure Studies
Subject: Dynamic HT Chlorine Corrosion under Refractories (‘normal’ WTE)

System Pb-Zn-Cl-S-O
System Zn-K-Cl

1 mm
0.05 mm

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