The Oxyfuel Research Rig at E.ON New Build & Technology

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Coal Research Forum AGM and Combustion Division Meeting

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Contents

1. Introduction

- Process Engineer
- E.ON 2006-
- Combustion, flue gas cleaning, oxyfuel
- R&D and Engineering projects

1. Introduction - ENT

- Mission is to add value to the E.ON group via operational support, by supporting the new build program and in the future by research, development and innovation.
- ~1100 employees +
- 2 main office locations

Technology Centre,
Nottingham, UK

Humboldt-Forum
Gelsenkirchen, Germany

1. Introduction - ENT

- Outage & Maintenance
- Materials & Engineering
- Pressure Parts
- Power Plant Chemistry
- Turbines
- Power Engineering Services
- Electrical Engineering
- Networks
- Fuel Sciences
- Emission Monitoring
- Pollution Abatement
- Plant Performance
- Flexible Operation
- Life Extension
- Biomass Fuels
- Gas Turbine Optimisation
- Steam Turbine Performance
- Business Modelling
- Stimulator Training Systems
- New Build Optimisation
- Nuclear Development
- Risk Management
- Plant Status Review
- Maintenance Strategy
- Due Diligence
- Owner's Engineer
- Quality Assurance
- Sustainable Energy
- Technology Development
- Project Management
- New Technologies
- Emission Modelling
- CCS

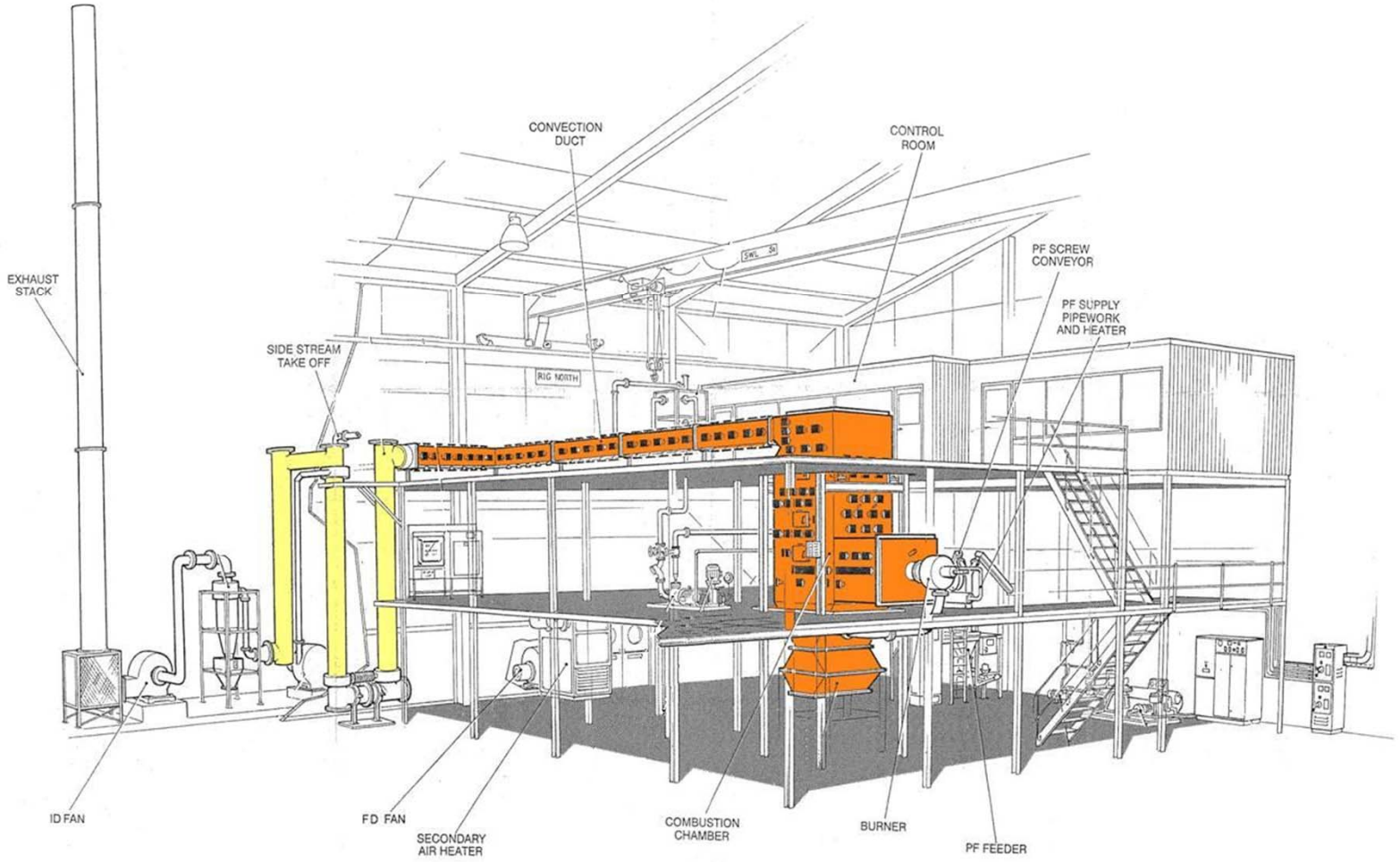
2. 1MWth Combustion Test Facility

- Design and Planning in 1980's with commissioning in early 1990's
- Located at Ratcliffe on soar, Nottingham, England
- Time-temperature scaled to simulate full scale plant
- Fuel flexible - Coal, biomass, oil, orimulsion, gas, additives, others
- Full combustion staging; overfire air, reburn
- Highly instrumented and controllable
- Other capabilities added such as TOMERED
- Graduated update to oxyfuel capability with FGR from 2006
- 100's data points auto logged (X, T, P, F…)

- Used to study fuel quality effects on combustion, emissions, slagging, fouling and corrosion. Research in LN combustion, atomisers, combustion additives, trace emissions, instrumentation, oxyfuel combustion, biomass co-firing and 100% firing, ash behaviour, heat flux….

2. 1MWth Combustion Test Facility

Original Schematic Depicting Physical Layout



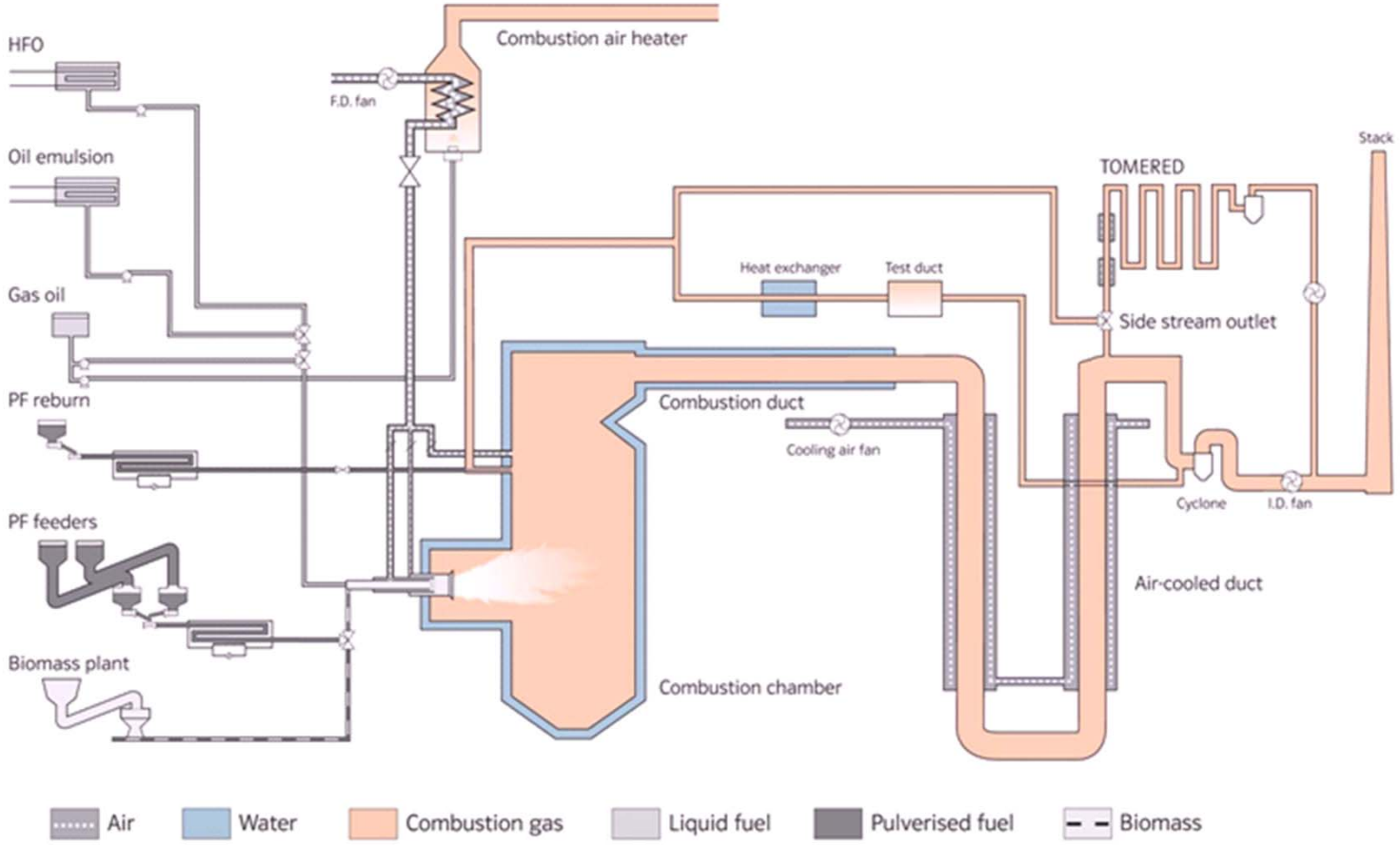
2. CTF Data

Thermal input	**1 MW_{th} (0.8 – 1.2MW_{th})**
Furnace	**Horizontally fired, refractory lined, water cooled, balanced draft**
Dimensions	**1m x 1m x 3m**
Burner	**Scaled MBEL Mk III Low-NO_X**
Windbox temp.	**300 to 330°C**
Primary air temp.	**80°C (70 to 90°C)**
Tertiary : secondary	**3.5:1 (1:1 to 7:1)**
Overfire air	**15% (0 to 25%)**
Flue gas cleanup	**High efficiency cyclone**

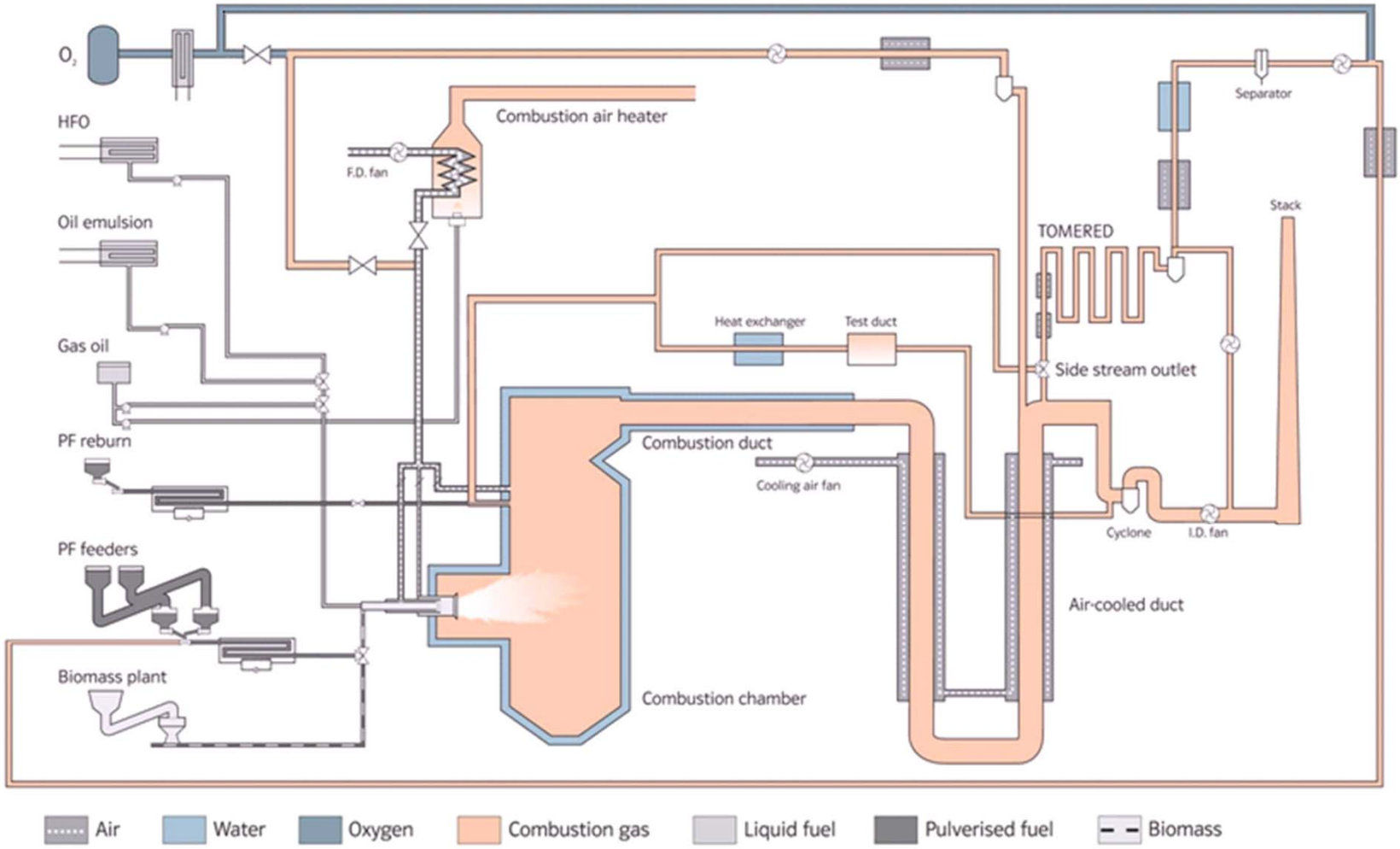
2. CTF History and Milestones

• Commissioned	1993
• At commissioning switch to include LNB	1993
• Coal reburning added	1996
• Lignite firing	1997
• Fuel logistics upgrade	1997
• Biomass co-firing	2002
• On-line PF blending	2002
• 100% biomass firing	2004
• TOMERED loop	2005
• Oxyfuel commissioning	2006
• Oxyfuel system upgrade	2009

2. CTF Diagram Pre Oxy



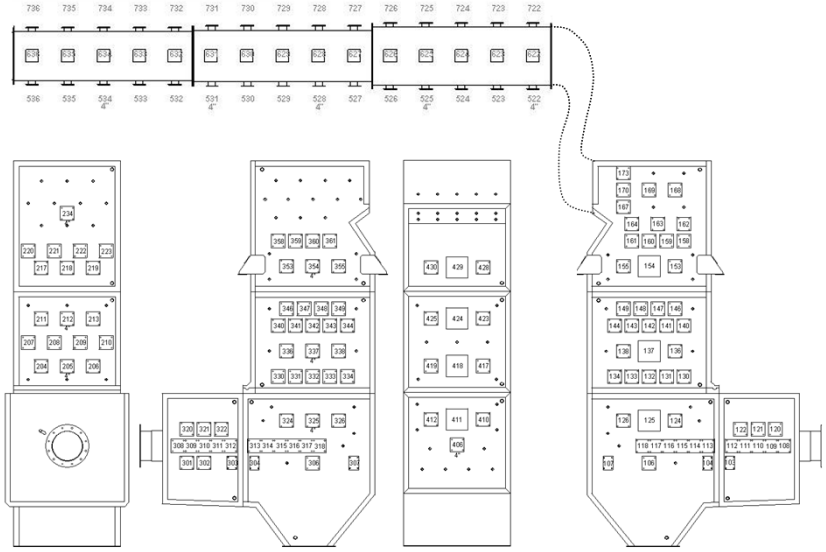
2. CTF Diagram Post Oxy



2. CTF Pictures

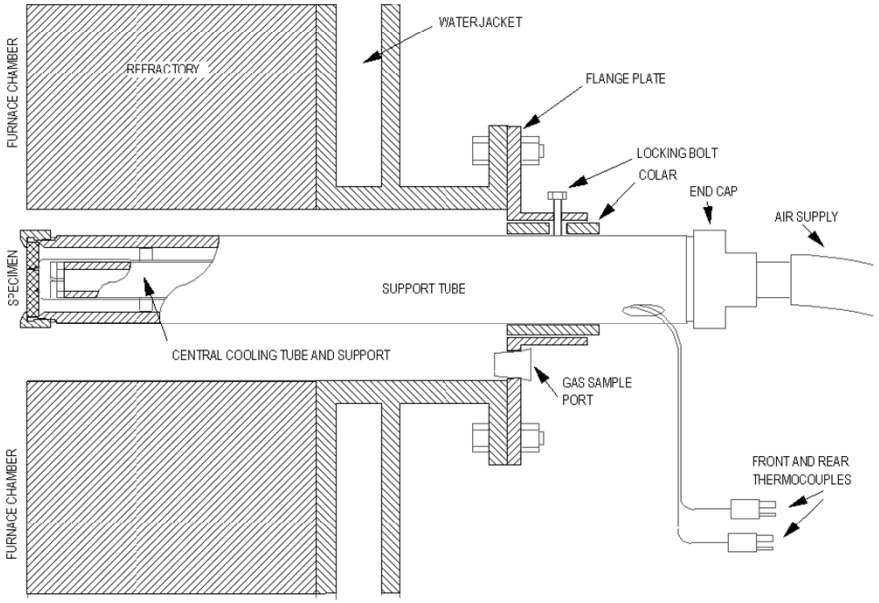
3. Precision Metrology Corrosion Probes

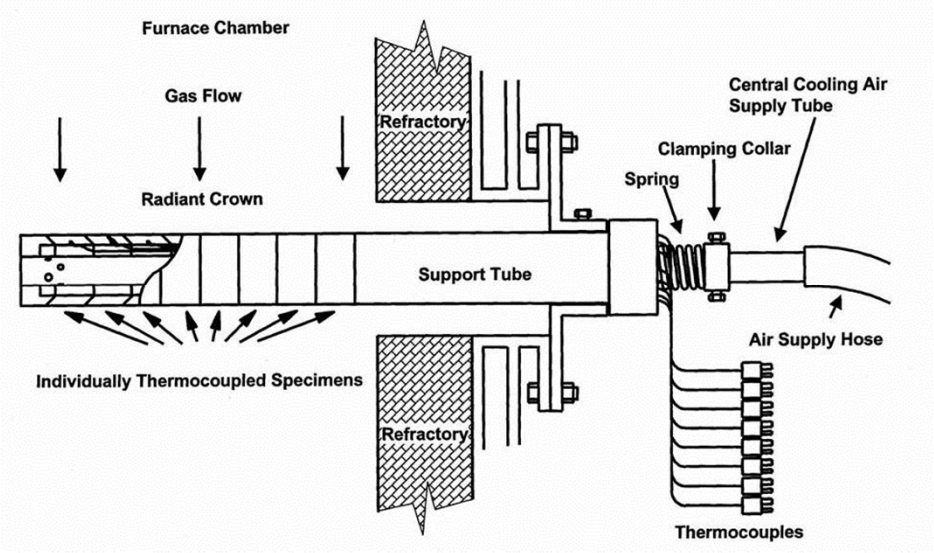
- Metal Losses Determined Using Digital Image Analysis On Polished Cross Sections
- Optical & Electron Microscopy Used to Characterise Damage & Mechanisms
- Multiple port allow simultaneous testing of all important corrosion variables; tube material, metal temperature, gas environment (reducing, oxidising) and heat flux



3. Precision Metrology Corrosion Probes

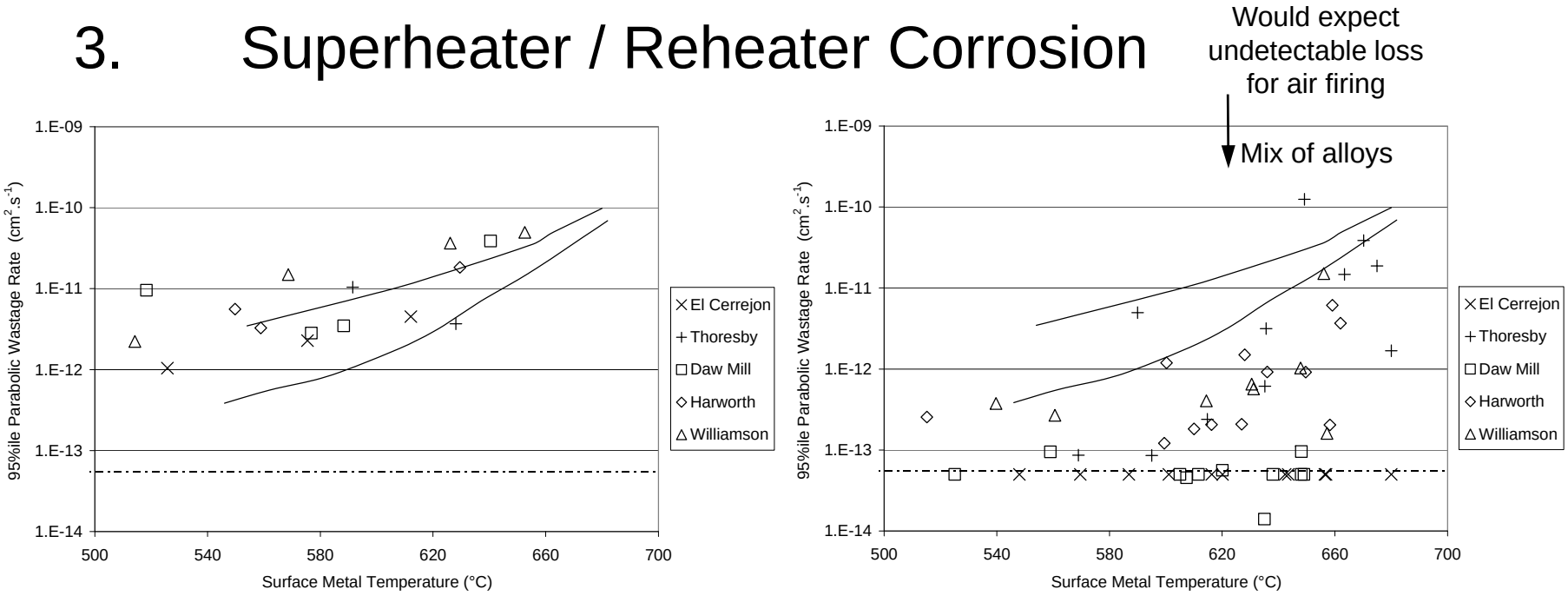
Furnace Wall:
Single Specimen
Air Cooled
(15Mo3, T23, T91, HR3C, IN671)





Superheater / Reheater:
Multiple Specimens
Air Cooled
(T22, T91, E1250, Super304H, TP347HFG, HR3C, Sanicro25, IN740)

3. Superheater / Reheater Corrosion



- Comparison With T22 Pilot Scale Data Air Coal Firing
- Left – Oxy-Fuel Firing T22 Data Broadly Similar Or Slightly Elevated Rates
- Right – Oxy-Fuel Firing Austenitic Data Wide Range Responses

  Cleaner Coals & Lower Heat Flux: Little Or No Attack

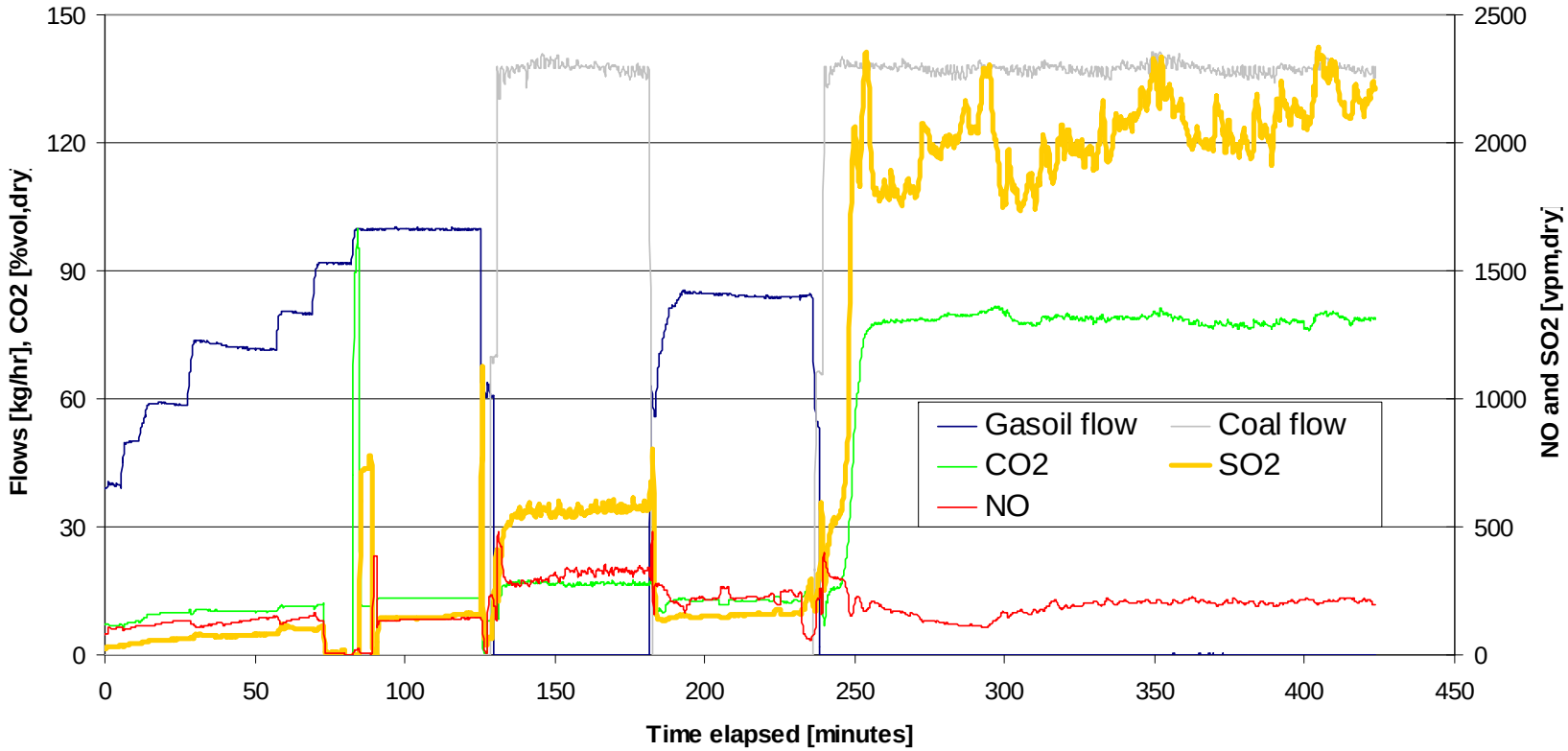
  Dirty Coals (Higher Cl In Particular & High Heat Flux: Increased Wastage Rates – Occasionally Greater Than T22 Wastage Rates

4. Oxyfuel Coals and Projects

- Coals fired in oxyfuel
  - Kleinkopje (SA), El Cerrejon (Col.), Tselentis (SA), Thoresby, Daw Mill, Harworth, Williamson (USA), Cutacre.
  - Corrosion coals – S (0.6% - 3%+), Cl (0.02% - 0.45%)

- Projects
  - ASSOCOGS (RFCS)
  - Supplier burner testing
  - Oxycoal I (DTI)
  - "OxySOx" (TSB)
  - Oxycoal II – HFCCAT programme (TSB)
  - Project H0639C (TSB)
  - ASPECT (TSB)

5. Plant Start Up and Emissions



6. Other Findings

- Safe start up, change over and operation demonstrated
- Early, low O2 enrichment tests demonstrated poorer combustion (CO, LOI, flame detachment) compared to air firing
- More recent higher enrichment tests have shown similar to better combustion compared to than air (CO, LOI)
- High levels of CO2 in the fluegas (80%+ dry) possible
- Similar/slight increase in conc. of NOx
- Increased conc. of SO2 by factor of 3-4
- Reduced mass rates of SO2 and NO (mg/MJ fuel)
- Similar ash composition but with increased S and trace elements
- Evidence of increased superheater / reheater corrosion rates for austenitic stainless steels and nickel based alloys.
- More complex operation and control – expanded system with feedback loops.

7. Close and Questions

- Any follow on question feel free to contact me

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