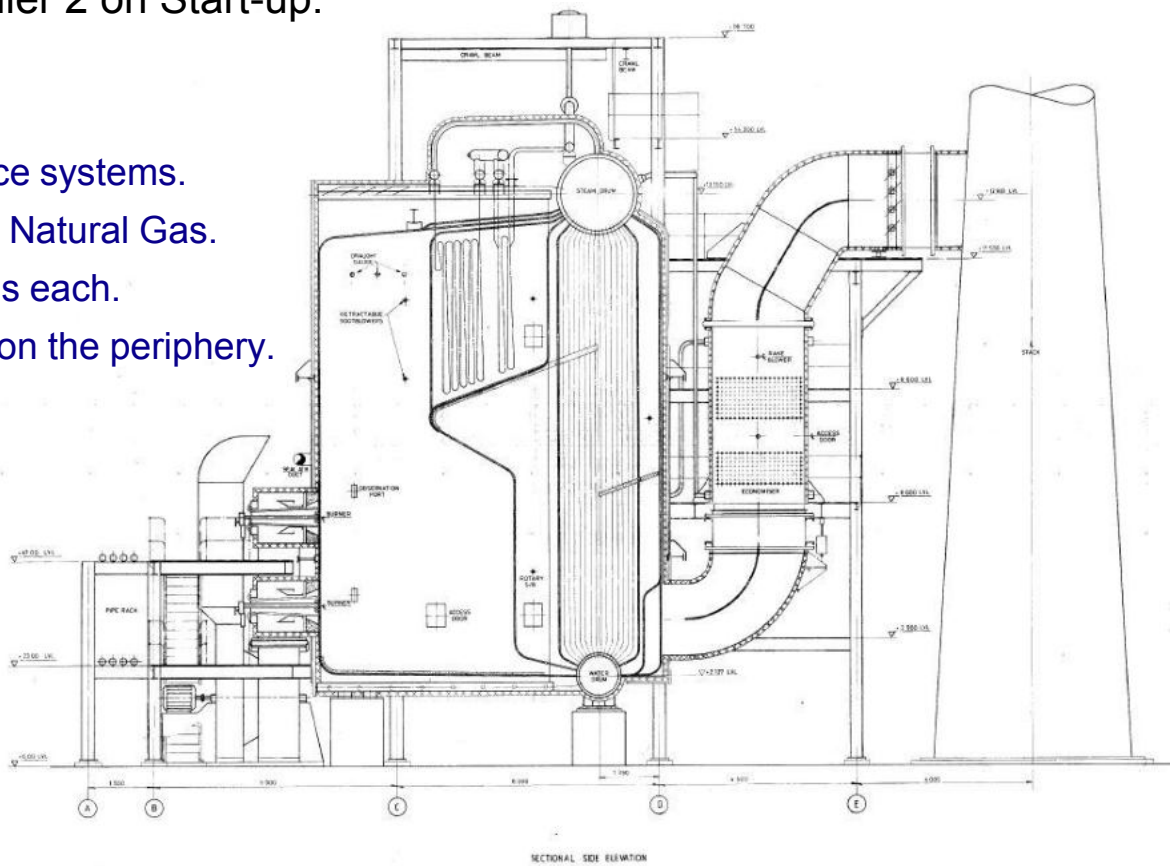
Incident Learning: Uncontrolled Combustion in Boiler

- A floor pool fire occurred inside Boiler 2 on Start-up.
  - Located at Steam Generation Unit.
  - Unit comprises of 3 Boilers.
  - Boiler 1 & 2 are Front Walled Furnace systems.
  - Uses LFO, HFO, Flash Gas or Lean Natural Gas.
  - 2 circular oil/gas burners - 2 Oil Guns each.
  - FG and LNG burner pokers located on the periphery.
  - Commissioned in 1991.
  - Supplies superheated steam.



- 3 Boilers – 2 Different Suppliers.
  - Boilers 1 and 2 by ICAL.
  - Boiler 3 by Steinműller.
  - Boiler 3 not designed for HFO.
  - Burners for all Boilers by XXX (UK).

Incident Description

- Friday: 21 July – A floor pool fire is identified inside the boiler.
  - Several failed attempts to commission the boiler.
  - Unburnt HFO and LFO accumulated on floor.
  - Uncontrolled combustion, high temperatures, boiler manually tripped @ 20H00.
- Saturday: 22 July @ 07H06 – Several failed attempts to commission.
  - Burner 2 lit @ 02H10, PSV lifted prematurely and removed for recalibration.
  - Commissioning started again @17H06.
- Sunday: 23 July @ 04H11 – A floor pool fire is again identified inside Boiler 2.
  - Burner successfully lit @ 02H10. Excessive vibration, smoke observed @ 04H09.
  - Boiler manually tripped @ 04H09. Shift Supervisor decided on internal inspection.
- Sunday: 23 July @ 07H13 – Decision to restart Boiler 2 to remove unburnt fuel.
  - Burner successfully lit. Excessive vibration, smoke observed @ 07H48.
  - Boiler manually tripped @ 07H48 for shutdown and internal inspection.

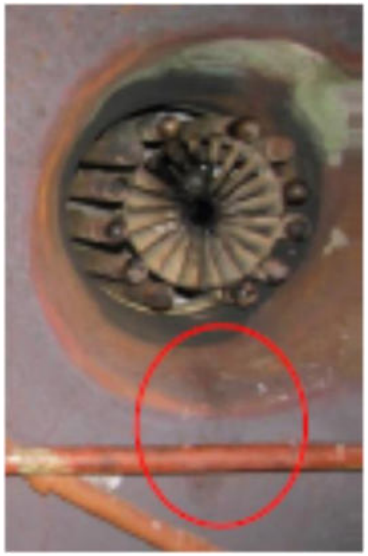
Boiler Internal Inspection

Photos 1 & 2 (Inspection Department photo 25/09/17) – Burner 1

- Burner in auxiliary port does not protrude far enough through port.
- Mechanical damage to swirler, top half bent forward.
- Unburnt fuel around auxiliary burner and primary burner port.

Boiler Internal Inspection

Photo 3 – Minor Refractor Repair



- Minor refractory repair between 01H00 and 02H00 around burner.
- Stains on refractory possibly indicating flow of unburnt fuel.

Boiler Internal Inspection

Photo 8 – Burner 2

- Unburnt fuel around auxiliary and primary burner port.
- Incorrect orientation of one gas poker nozzle. Correct orientation as per green arrow.
- Auxiliary burner port off-center to the left.
- Auxiliary burner guide tube misalignment with swirler port.

Investigation Findings: Direct Cause

1st and 2nd of Three Uncontrolled Combustion Incidents at the Boiler:

- The ignition of a combination of accumulated unburnt HFO and LFO on the boiler floor after numerous unsuccessful start-up attempts.

3rd and Last of Three Uncontrolled Combustion Incidents at the Boiler:

- Incomplete combustion of fuel due to incorrect combustion conditions.

- *Previous boiler incidents related to:*
  - *leaking HFO from the burner oil guns,*
  - *Incorrect operation of ignitor systems,*
  - *Smoking of boiler during start-up as a result of blockages.*
  - *No uncontrolled combustion incidents on record.*

Historic Mods: Not Fully Documented

Photo 9 – Burner Gun Length Comparison

- ***June 2000:*** Boilers 1 and 2 - Incorrect depth of refractory installed during shutdown.
- Burner quarl angle impacted and flame profile exceeding acceptable tolerances.
- Inner set of tubes moved backwards, *Burner guns lengthened* by 100mm.
- Burner 1's coupling block *(new design) now* not interchangeable with Burner 2's.
- Modifications not incorporated fully into all operating and maintenance procedures (MOCA).

Change in Supplier's Agent: Critical Matter

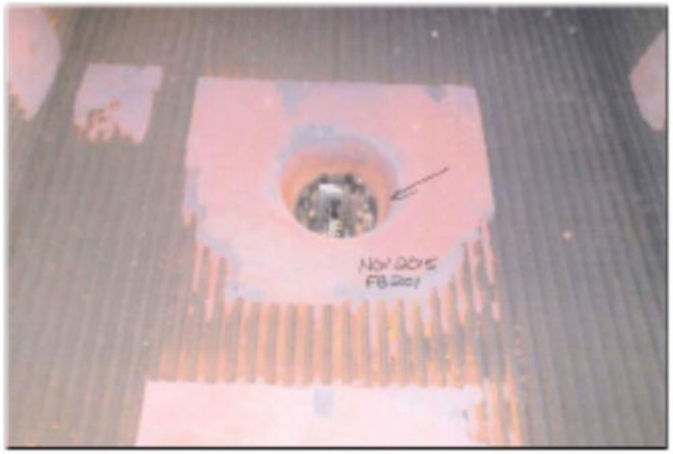


Photo 12: - 49-FB201 Burner 2 with "Missing" Air Swirler

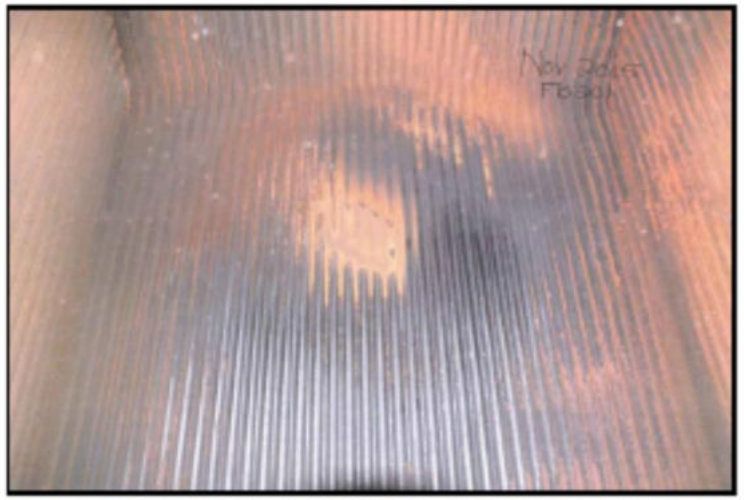


Photo 14: – Burner Flame Impingement opposite Burner 2 with "Missing" Air Swirler

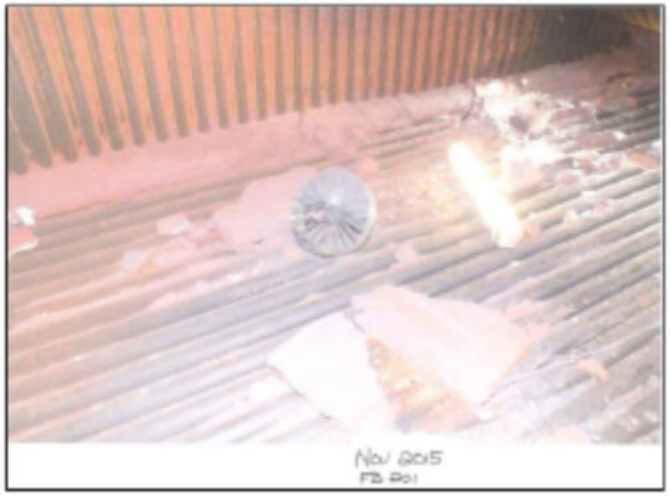


Photo 13: - "Missing" Air Swirler lying on Boiler Floor

Non-standard OEM air swirlers installed.

- XXX (UK) appointed new agents in SA.
- Swirlers obtained from previous SA agent.
- Change in agent not communicated by Supplier (No MOCA).
- Change in (SA) supplier's agent must submit to MOCA.

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Non-HFO Atomiser installed in HFO Service

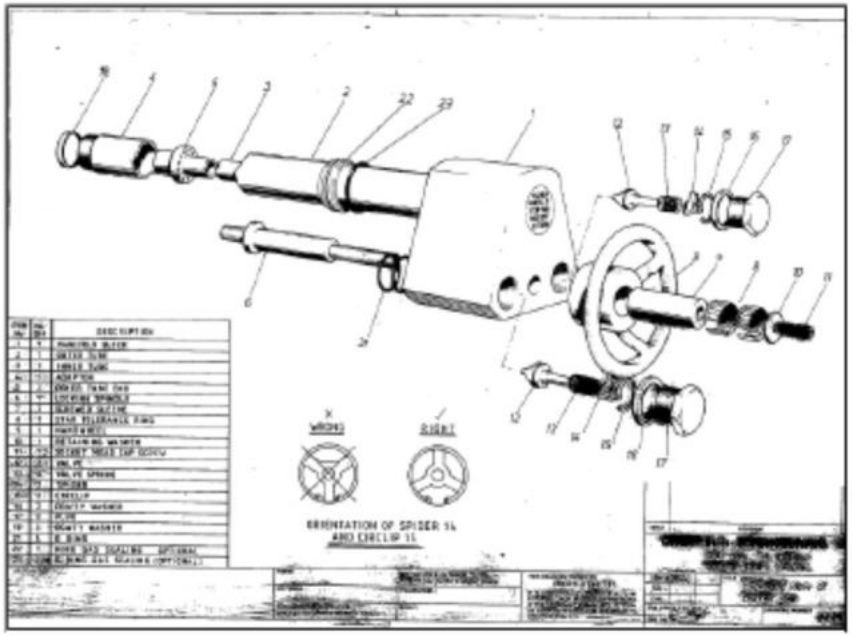

Figure 6: Burner Oil Gun General Assembly

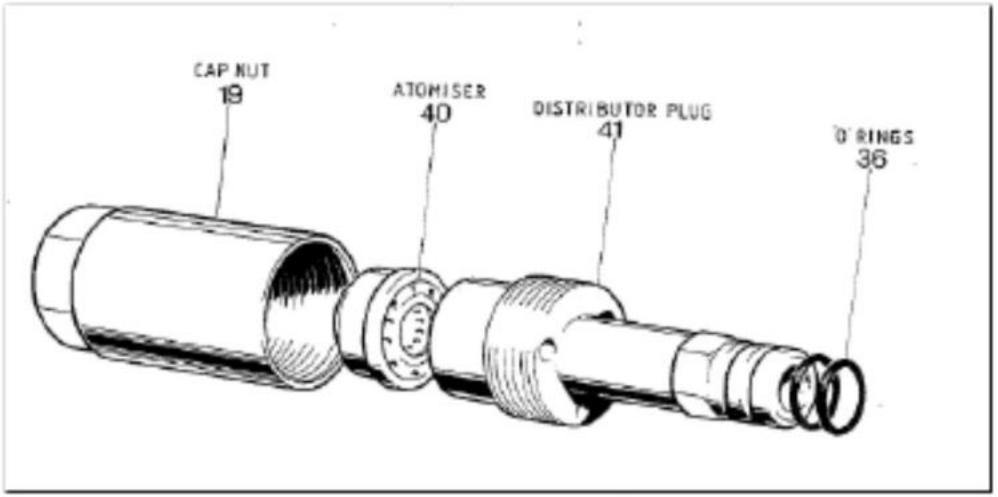

Figure 7: Exploded View of Atomiser Tip

- All 3 boilers have burner equipment designed by XXXX Ltd (UK).
- Atomiser of Boiler 3 (lower duty – smaller holes) was installed in Boiler 2.
- Boiler 3 not designed for HFO.
- HFO firing on Boiler 2 – *thus impossible for start-up & stable operation with HFO.*

Investigation Findings: Recommendations

Compile Boiler 1/2/3 Operating Procedures & Training Manuals:

- Unofficial guidelines are in use.
- Revise process controller Portfolio Of Evidence (POE) competency profiles.

Integrity of Fuel Management System & Burner Assemblies:

- Compile and Align maintenance procedures and work practices.
- Review and Update all Boiler maintenance manuals and drawings.

Update Material Master's and BOM on SAP:

- Consult XXXX (UK).
- Confirm valid supplier in Procurement Database. *Perform MOCA.*