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UNDER THE PATRONAGE OF H.H. SHEIKH KHALIFA BIN ZAYED AL NAHYAN, PRESIDENT OF THE UNITED ARAB EMIRATES

تحت رعاية صاحب السمو الشيخ خليفة بن زايد آل نهيان رئيس دولة الإمارات العربية المتحدة
SPE-188706-MS
Corrosion Control in Sulphur Recovery Units – Claus Process

A. Alkasem, A. Slavens, H. Dhinda, UniverSUL Consulting; A.S. Berrouk, The Petroleum Institute
Agenda

1. Introduction
2. Corrosion Mechanisms in SRUs and Their Control Methods
3. Guidelines for Corrosion Control through Construction and Fabrication
   A. Individual Equipment Items
   B. General Design Guidelines
4. Guidelines for Corrosion Control through Process Operation
   A. Normal Operation
   B. Startup
   C. Shutdown
5. Conclusions
Typical Three Stage Claus Sulphur Recovery Unit

- **1st Reactor**
  - Air
  - WHB
  - Steam

- **1st Condenser**
- **1st Reheater**
- **Fuel Gas**

- **2nd Reactor**
- **2nd Condenser**
- **2nd Reheater**

- **3rd Reactor**
- **3rd Condenser**
- **3rd Reheater**

- **Final Condenser**

- **Sulfur Pit**

- **Acid Gas**
  - K.O drum

- **Sour Water**

- **Incinerator**
  - Air
Corrosion & damage Mechanisms in SRUs (API 571)

- Sulfidation
- Wet H2S Damage
- Oxidation
- Refractory Degradation
- Steam Blanketing
- Sulfuric Acid
- Flue Gas Dew Point Corrosion
- Boiled Water / Condensate Corrosion

Diagram shows the flow of gases and liquids through various components such as reactors, condensers, and storage tanks, highlighting different mechanisms of corrosion and damage.
Effective Corrosion Control

- Process & equipment design, material selection, and operating & maintenance practices.

- Ignoring any part of the “triangle” can lead to:
  - Early failure of process equipment
  - Poor unit reliability.

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Proper materials selection is important to reduce corrosion problems.

Stainless steel, for very hot service (e.g. burner tips, catalyst screens, mesh elements in condensers)

Carbon steel can be used in all other areas up to a temperature of 600° F.

Refractory lined carbon steel should be used in services above 600° F
Note: Burner tips in the reaction furnace, burner tips of acid gas reheaters, catalyst screens, sulfur pit piping, refractory anchors and mesh elements in sulfur condensers / coalescers should all be Type 316 stainless steel, or 309 stainless steel.
General Design Guidelines

1. Plant design
   Plant should be designed so the operating conditions are always above water dew point

2. Metallurgy
   carbon steel metallurgy with a 1/8” corrosion allowance

3. Keep hot
   - steam jacketing, electric heat tracing, or steam tracing

4. Accumulation of liquids
   Gas piping design should avoid that

5. Refractory lining
   Probability of steel sulfidation due to high temperature exposure to H2S

6. Thermal shroud
   designed to maintain metal temperature between 150-315° C (300-600°F)
Thermal shroud

- maintain metal temperature between 150-315°C (300-600°F).
- provide an insulating air gap that allows free air flow between the shell and shroud
- protecting the carbon steel shell and internal refractory from thermal shock.

Ref. Duiker Combustion Engineering Book
General Design Guidelines

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5. **Refractory lining**
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6. **Thermal shroud**
   - Designed to maintain metal temperature between 150-315°C (300-600°F).

7. **Ferrules design**
   - Very important to protect WHB tubes.
   - Crack develops → hot gases will reach the tubesheet and tubes.
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7. **Ferrules design**
   Very important to protect WHB tubes. Crack develops → hot gases will reach the tubesheet and tubes.

8. **External Insulation**
   - To maintain a metal wall temperature above 120° C (250°F).
   - Tail gas piping should be kept as short as possible.

9. **Liquid sulfur lines**
   - Slope to promote draining.
Guidelines for Corrosion Control through Process Operation

Normal Operation

1. **Shutdowns**
   Do not purposely shut down unless it is for a scheduled turnaround

2. **Capacity**
   Operate the units as close to design capacity as possible

3. **Operating Temperatures**
   Do not permit any equipment surfaces to be colder than 120ºC (250ºF)

4. **Sub-stoichiometric combustion**
   Operate the burner in a sub-stoichiometric combustion condition to avoid sulphur fire in reactors

5. **Burner performance**
   Poor burner performance, resulting in unstable firing conditions and then refractory damage
Hot Spots
### Guidelines for Corrosion Control through Process Operation

#### Normal Operation

<table>
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<td>7. Blowdown</td>
<td>Intermittent blowdown connections on a routine basis to control solids accumulation in all boilers and condensers.</td>
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<td>8. BFW Quality</td>
<td>Continuous monitoring of the BFW in condensers and proper chemical injection.</td>
</tr>
<tr>
<td>9. Steam flow and pressure</td>
<td>Maintain adequate steam flow and pressure on steam jacket and steam tracing systems.</td>
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</table>
Flue gas dew point corrosion
Guidelines for Corrosion Control through Process Operation

Startup

1. Excess oxygen
   - Not allowed if there is any sulphur on the catalyst
   - Allowed during the initial startup and refractory dry out

2. Refractory curing
   Particular care after the main burner is lit to avoid sudden variations of Reaction Furnace temperature
Refractory Failure
Guidelines for Corrosion Control through Process Operation

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3. **heating-up curves**
   Ensure that any moisture is completely removed
heating-up curves

![Graph showing temperature vs. time for drying-out, heating-up, Comb. chamber, Incinerator, and Claus Reactors.](image-url)
Guidelines for Corrosion Control through Process Operation

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3. Heating-up curves
   Ensure that any moisture is completely removed

4. WHB overheating
   Fill WHB with BFW before establishing flame in RF
   Catalytic reactors and condensers should be bypassed

5. Plant metal temperatures
   Before acid gas can be burned in the RF, all metal temperatures in the plant must be above 120º C (250ºF)

6. RF pressure
   It may indicate internal corrosion problems

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Condenser Failure
Guidelines for Corrosion Control through Process Operation

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   - Fill WHB with BFW before establishing flame in RF
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5. **Plant metal temperatures**
   - Before acid gas can be burned in the RF, all metal temperatures in the plant must be above 120º C (250ºF)

6. **RF pressure**
   - It may indicate internal corrosion problems

7. **BFW level in condensers**
   - Before any heat is applied, all steam generators should be filled with BFW

8. **free water in rundown**
   - A sure sign of a leak in condenser or steam reheater
Shutdown

1. Air control
   - Following the acid gas cut off, closely control air flow
   - Check the oxygen content downstream of the furnace

2. Sulphur fire
   - Sulphur is retained in the catalyst bed

3. Do not operate below 120º C for extended period with steam as tempering
   This will cause high level of corrosion

4. Steam pressure in the WHB
   Lowering pressure may overstress and crack the tube-to-tube sheet

5. Checking the steam jacketing
   After any shutdown or trip, it is also important to ensure that the jacketing is functioning properly

6. Sulphur storage drum level
   It may indicate internal corrosion problems

7. BFW level in condensers
   Before any heat is applied, all steam generators should be filled with BFW
Conclusions

1. Damage from various corrosion mechanisms is prevalent in the industry
2. The majority are related to operating conditions and non-adherence to startup and shutdown procedures
3. Proper process control and understanding of operation modes of the SRU are essential for robust operation and prolonged service life
4. A comprehensive understanding of the most common damage mechanisms, and their possible locations, will help operators run their SRUs smoothly
5. Operator training and experience are critical
Thank You

Questions?