INCINERATOR'S REFRACTORY AND SHELL DAMAGE DUE TO CONDENSATION IN TGTU ABSORBER OVERHEAD LINE

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Designations: Process Engineer

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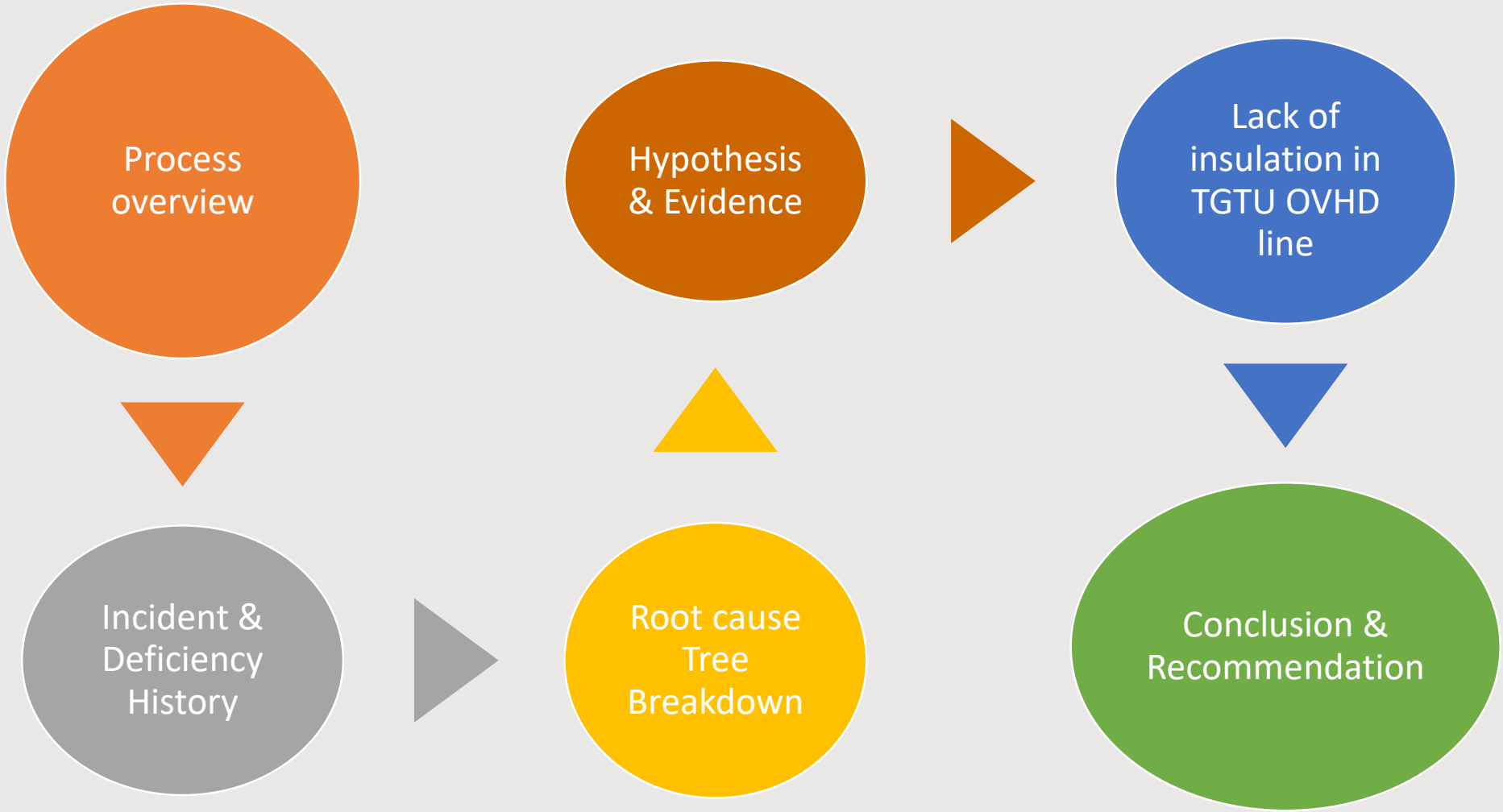
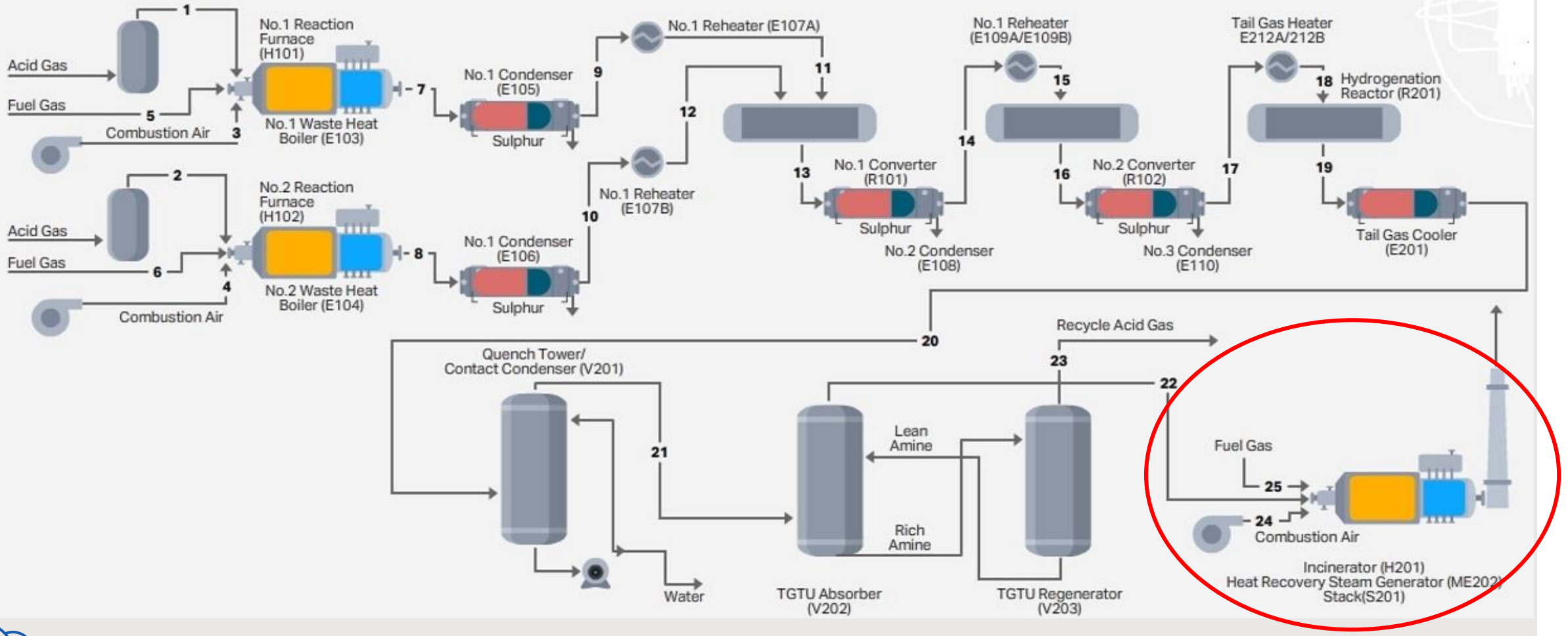
Outline


Process overview
Hypothesis & Evidence
Lack of insulation in TGTU OVHD line
Incident & Deficiency History
Root cause Tree Breakdown
Conclusion & Recommendation

Process Overview



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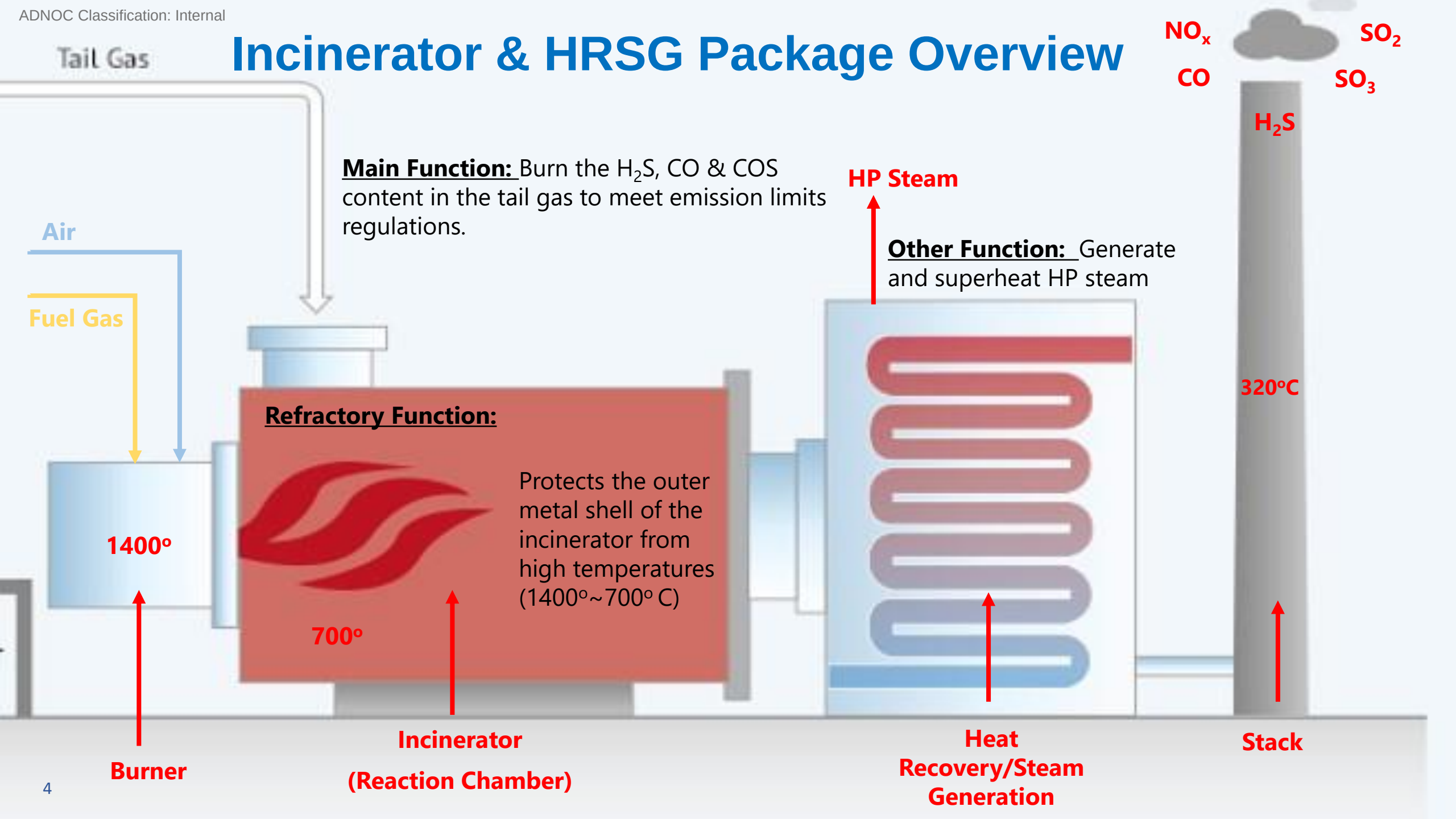
Incinerator & HRSG Package Overview



Incinerator deficiency History

2015

- February: The external rain shield material found damaged and the metal under extreme temperature become glowing red
- April: Refractory repaired, visual inspection conducted and refractory found acceptable

2016

- October: Reliability shutdown (RSD) of unit 0752, refractory from 9~11 o'clock was found detached from equipment shell plate, and subsequently repaired

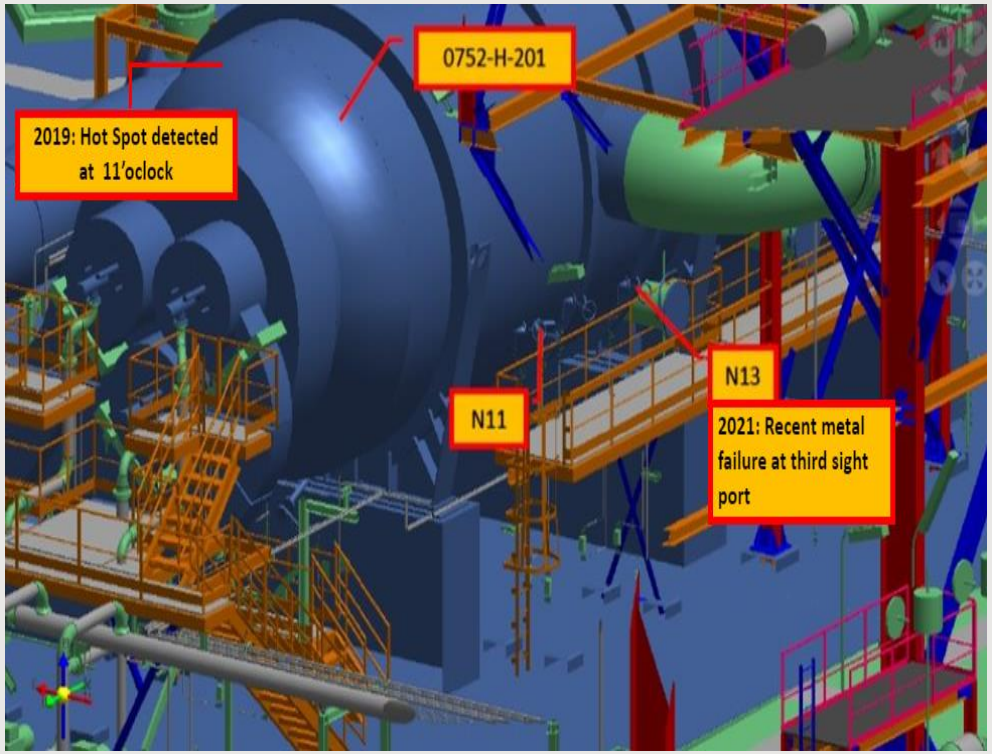
2019

- February: Thermography carried out, condition was good.
- September: During a routine thermography survey ,Hot spot was detected with Max. temperature of 335°C at 11 o' clock
- **Mitigation Action:** external cooling fan was installed to cool down the affected area and frequent thermography monitoring to check growth of the damage.

2021

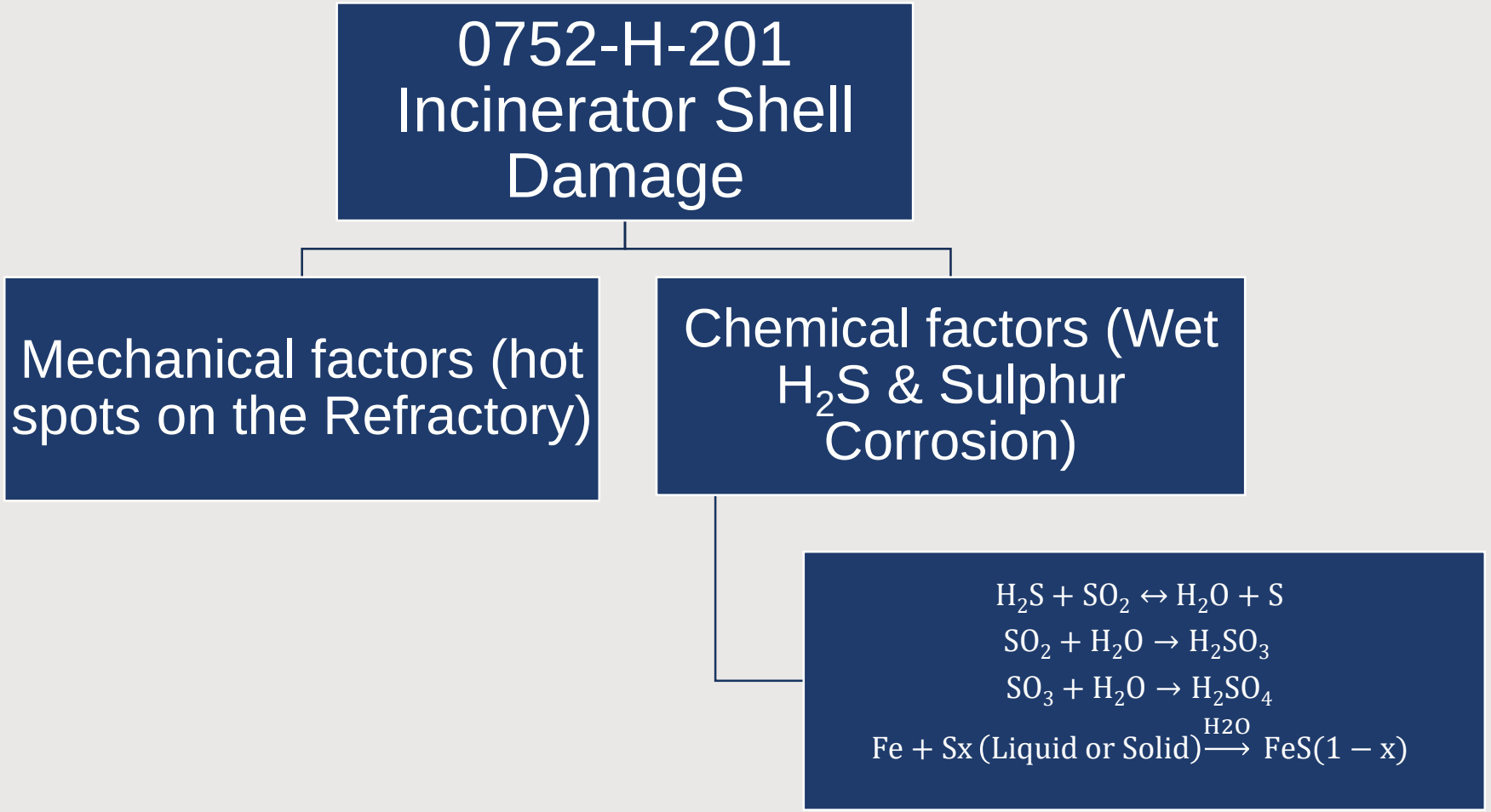
- January: Metal failure reported on third sight port (at 3 o'clock position), far from detected hot spot

Incident Overview



- Metal failure was reported on the third sight port at the 3 o'clock position (N13)

RCA: Tree Breakdown of Hypothesis and Evidence

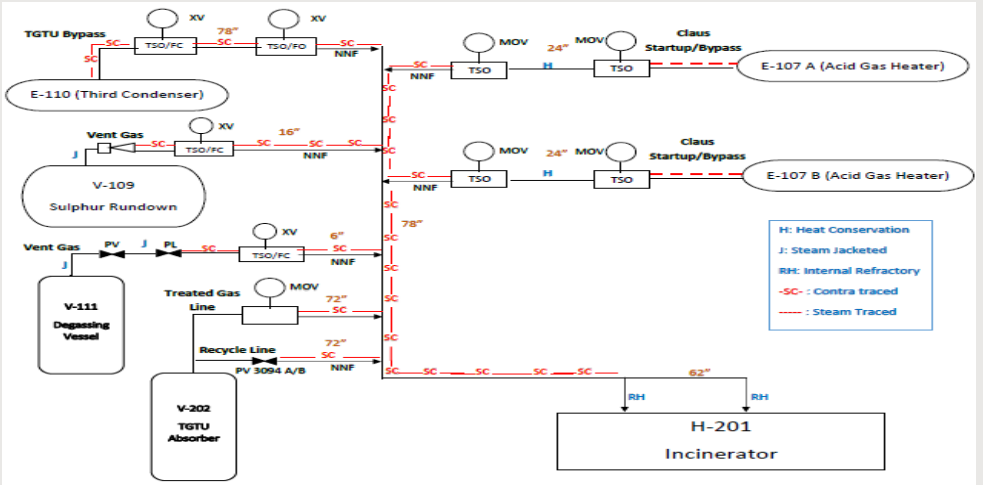


RCA: Hypothesis and Evidence

Mechanical factors (hot spots on the Refractory):	
1. Flame Impingement	✓
2. Incompatible refractory material for operating temperature	✓
3. Operating life of the refractory	✗
4. Refractory dry-out	✗
5. Zone A (burner section of the incinerator) temperature too high	✓

RCA: Hypothesis and Evidence

Chemical factors (Wet H_2S & Sulphur Corrosion):	
1. Liquid formation in the waste gas inlet line	✓
2. Shell skin temperature low in some locations	✓
3. Passing Valves on inlet lines to incinerator	✗
4. Damage in the steam jackets of MOVs & XVs	✗



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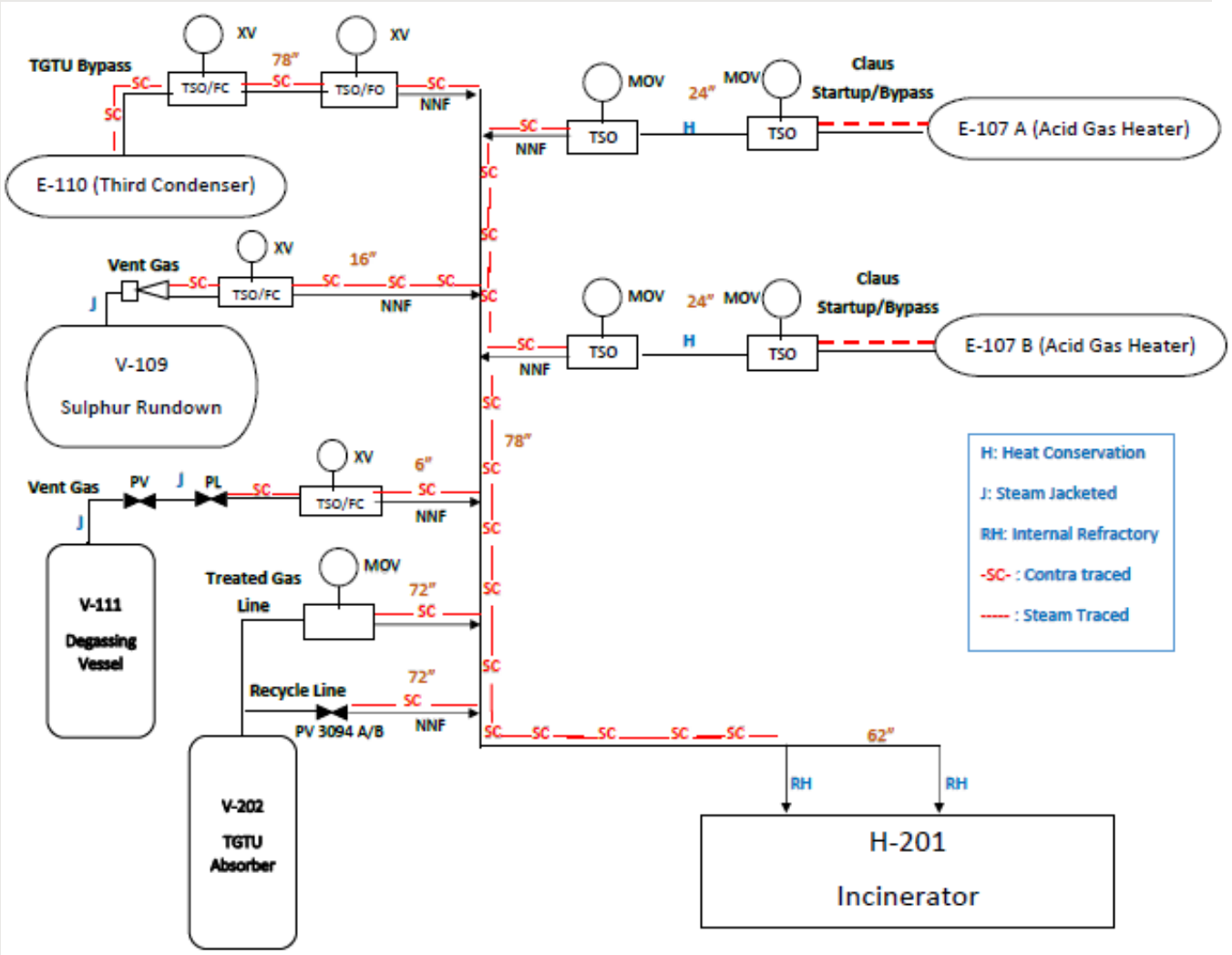
RCA: Hypothesis and Evidence

Liquid formation in the waste gas inlet line :

- Only 21m of the 125 m line was insulated
- Thermal survey of the line confirmed a temperature drop in the range 1 to 3 °C
- A benchmarking activity was done to compare ASG design with other licensor units (Worley, Shell etc.) and found that the line was specified with heat conservation insulation.



Conclusion & Recommendation

Root causes (Bad Actors) can be summarized, as follows :

- Most Prominent Cause: Lack of Heat Conservation Insulation (elimination of condensation) on the TGTU Tail Gas line

- Other contributing causes:
  - Passing of valves / jacketing leaks in Degassing and Rundown Vessel Vent lines (NNF).
  - Passing of valves on TGTU bypass line (NNF)

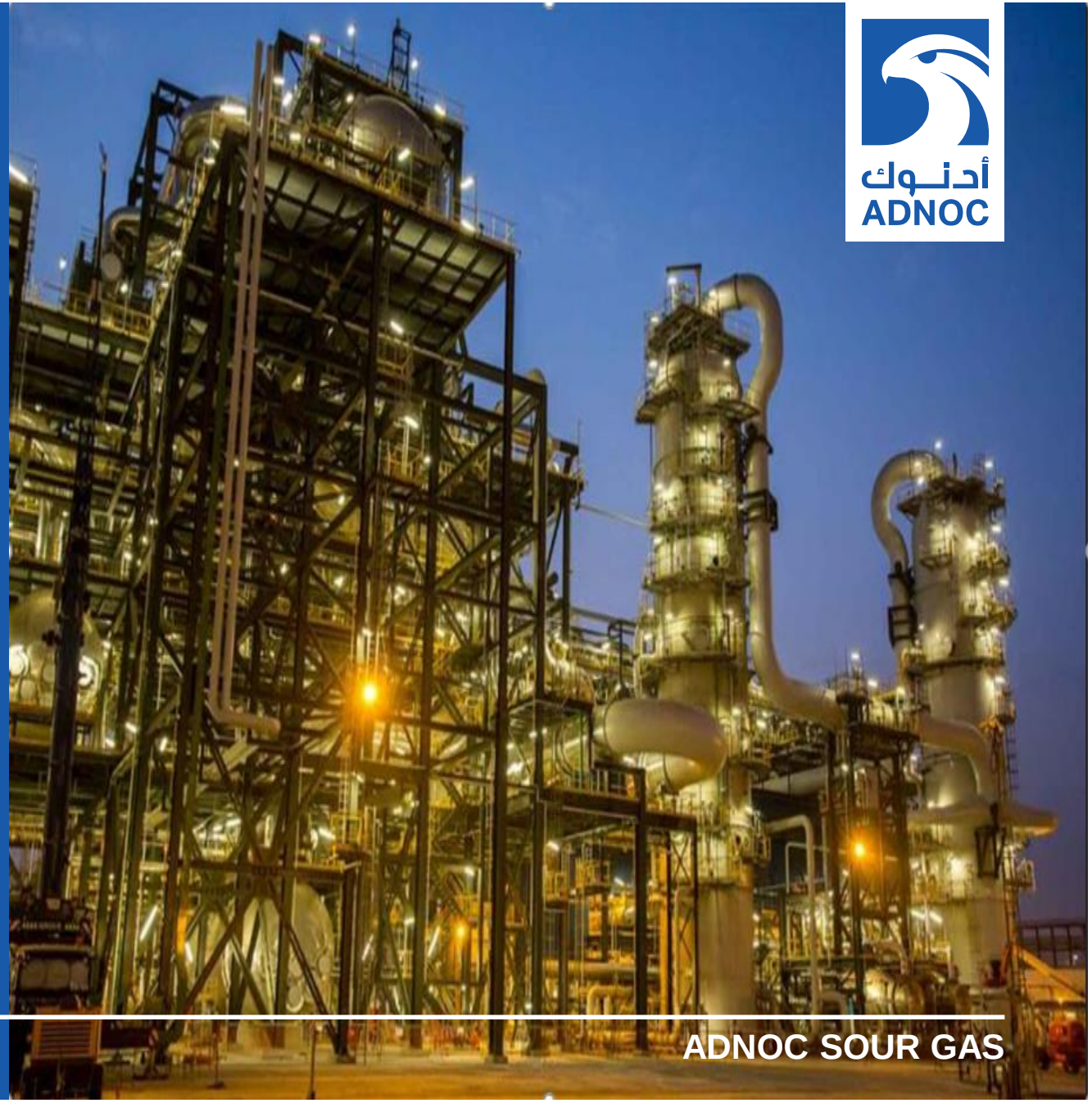
- Contributing Causes due to design:
  - Localized cooling due to dead-zone and air purging at the west side 3rd sight glass port (N13)
  - Piping layout is slightly different between the two inlet nozzles. Liquid might be coming more on one side compare to the other inlet line

Conclusion & Recommendation

Most important corrective actions can be summarized, as follows :

- Installed insulation layer on the TGTU Absorber Overhead lines. As an additional protection, heat tracing can be considered later.
- Upgraded the refractory in the Incinerator inlet nozzle lines, for better acidic corrosion resistance
- Re-located the 3rd sight glass port (N13) to another location

THANK YOU



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BACK-UP SLIDES

Lab analysis of Refractory Samples

Summary of findings :

- 5 samples sent to laboratory testing, only 2 were eligible for conducting the mechanical testing. 3 samples were deteriorated during probe cutting, showing completely lack of mechanical properties of the refractory material.
- Mechanical properties of the Dense material sample (S1) presented only 15% of the values required by the datasheet on upper location exposed to high temperatures. Excessive branched cracking observed, limiting testing.
- Mechanical properties of the Backup material sample (S2) presented nominal properties showing good density and Cold crushing resistance.

Lab analysis of Damaged Shell plate

Summary of findings :

- Microstructural examination of metallic samples showed signs of oxidation products on the inner surface indicating exposure for high temperature conditions. Electrochemical reactions on the metallic surface (acidic low temperature corrosion) were found not predominant and evidenced by satisfactory UT readings on the feed gas line and laboratory results on the metallic samples.
- Refractory degradation (chemical attack) associated with carried liquid level. The sight of whitish deposit (Calcium Carbonates) is a visual sign that calcium is being leached from the structure and the refractory matrix degraded allowing spalling of the material and exposure of metallic surface to combustion chamber operating conditions.