ارامكو السعودية
Saudi Aramco

Mitigation to Abqaiq NGL Recovery Plant Corrosion Problem

Shadi Al-Adel, Saud Al-Mudaibegh & Vaughn Gdula
Process & Control Systems Department (P&CSD)

GPA - GCC Chapter
Corrosion Management in Gas Processing Facilities
The Diplomat Radisson SAS Hotel, Kingdom of Bahrain
November 28, 2007

Background

- Corrosion problems started with the introduction of the ethylene glycol (EG) hydrate inhibition system.
  - Stress Oriented Hydrogen Induced Cracking (SOHIC).
  - Localized pitting corrosion.
  - Piping and exchanger failures, which caused:
    - Gas leaks.

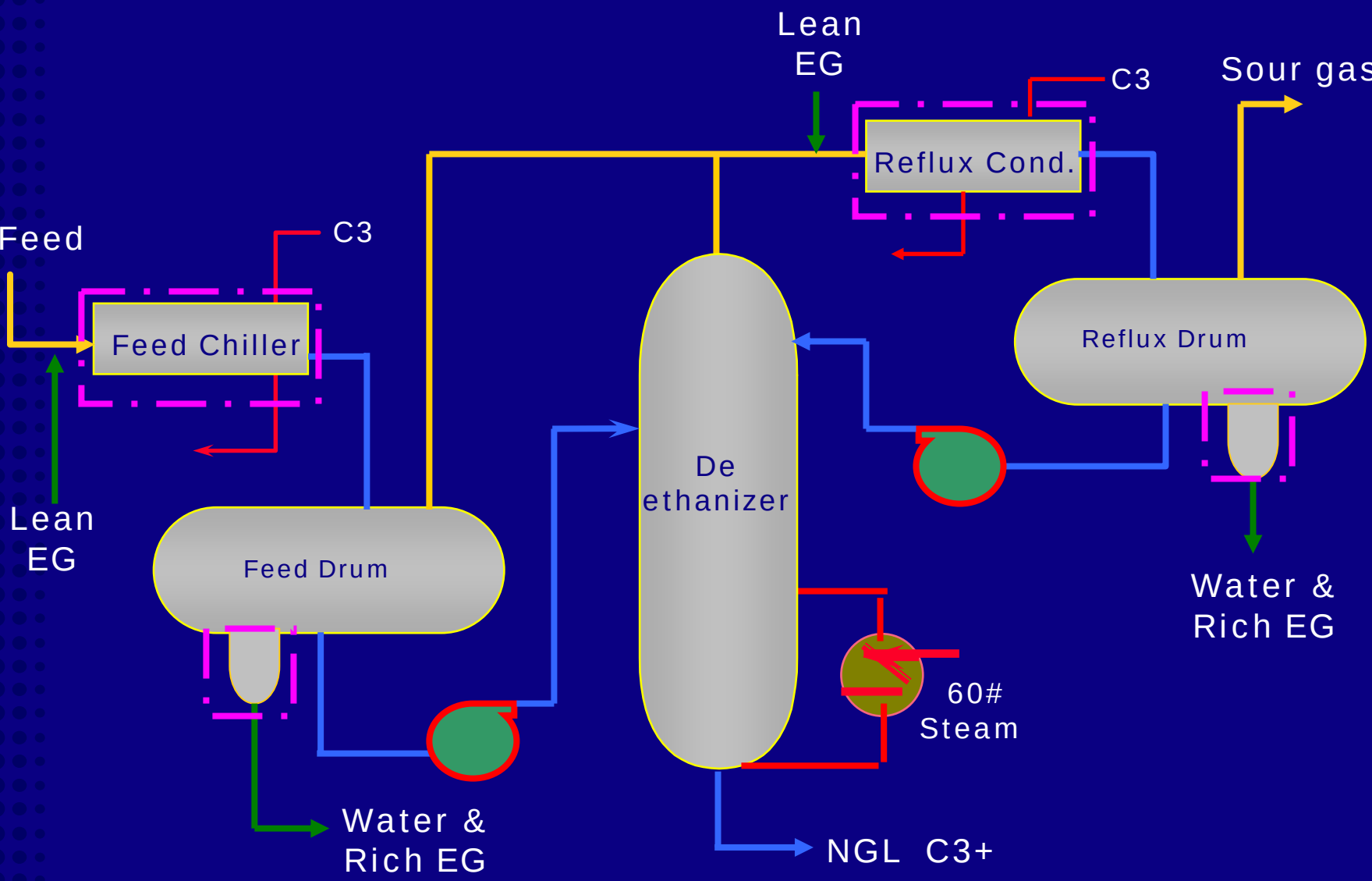
Background (contd.)

- Corrosion Problem Source:
  - Elemental sulfur in the presence of free water.
  - Caused from:
    - Oxygen ingress.
    - Dissociation of hydrogen polysulfides at temperatures below 120 °F.

$$H_2S_2 \Leftrightarrow S\downarrow + H_2S$$

- Unique phenomena to Saudi Aramco.

NGL Recovery Plant Process Overview



Background (contd.)

- Current EG injection system was susceptible to the corrosion problem.
- Need for alternative process to the existing EG injection system.

Alternative Processes Evaluation

- Process to remove elemental sulfur, water or both.
- New technologies evaluated:
  - CrystaSulf for sulfur removal.
  - TWISTER for gas dehydration.
  - Both processes were found to be impractical.
- Conventional gas dehydration:
  - Molecular Sieves (MS).
  - Triethylene glycol (TEG).

Alternative Processes Evaluation (contd.)

- Challenges with presence of elemental sulfur within dehydration processes:
  - Presence of elemental sulfur not common.
  - Effect of elemental sulfur not certain.
  - Feed temperature had to remain relatively high (≈130 °F) in order to minimize sulfur deposition.
- Need for tests:
  - Field.
  - Lab.

Abqaiq MS & TEG Field Tests

- Test apparatus developed and operated with the team effort by P&CSD, Research & Development Center (R&DC) and Abqaiq Plants.

- Tests Objective:
  - Measure elemental sulfur in the feed gas and through the MS and TEG cells.
  - Determine if elemental sulfur gets filtered by MS and TEG.
  - Determine if hydrogen polysulfides carryover from the filtered gas.

Abqaiq MS & TEG Field Tests (Contd.)

Test Apparatus Field Location

Abqaiq MS & TEG Field Tests (Contd.)

Apparatus

Abqaiq MS & TEG Field Tests (Contd.)

Sulfur Measurement Device

Abqaiq MS & TEG Field Tests (Contd.)

- Test Results:
  - Significant amounts of elemental sulfur existed in the feed gas (more than 10 ppm).
  - Elemental sulfur was being filtered in MS.
  - TEG absorbed elemental sulfur.
  - Elemental sulfur was detected downstream of the cells.
    - Indicated hydrogen polysulfides carryover.

Lab Tests

- MS Lab Tests:
  - Fresh sour gas resistant desiccants from CECA (SILIPORITE RA) and UOP (SF-1087).
  - Accelerated Degradation & Crush Strength.
- TEG Lab Tests:
  - With presence of sulfur, water and chlorides:
    - Weight-loss corrosion test.
    - Online corrosion monitoring test.

Lab Tests (Contd.)

- Lab Test Results:
  - MS desiccant tests concluded the acceptance of both desiccant's performance.
  - TEG corrosion tests revealed normal corrosion rates and no major corrosion concerns.

Recommended Process

- TEG dehydration system with metallurgical upgrades and special filtering to essentially eliminate the sulfur pitting corrosion.

Recommended Process (Contd.)

Supporting Conclusions:

- Dehydration with TEG achieves the gas water dew point requirements.
- MS dehydration has higher operating and capital cost (≈ $ 17 MM) than the TEG system.
- Proper TEG filtering can remove solid contaminants including elemental sulfur.
- There are sour gas TEG dehydration systems operating with carbon steel equipment.

Recommended Process (Contd.)

- TEG Dehydration System Design:
  - Feed gas Flow 280 MMSCFD, 131 °F & 385 psig.
  - Dry gas water dew point was set at approx. 35 °F.
  - Special metallurgy was recommended where potential corrosive environment exists.
  - Special filtering was included to handle the presence of elemental sulfur.

Conclusion

- Elemental sulfur, along with free water, was the main source of pitting corrosion.
- TEG dehydration system was recommended to essentially eliminate corrosion and restore design operating conditions.
- The proposed TEG system included special metallurgy and filtering.
- Cost savings for selecting TEG over MS was approximately $ 17 MM.

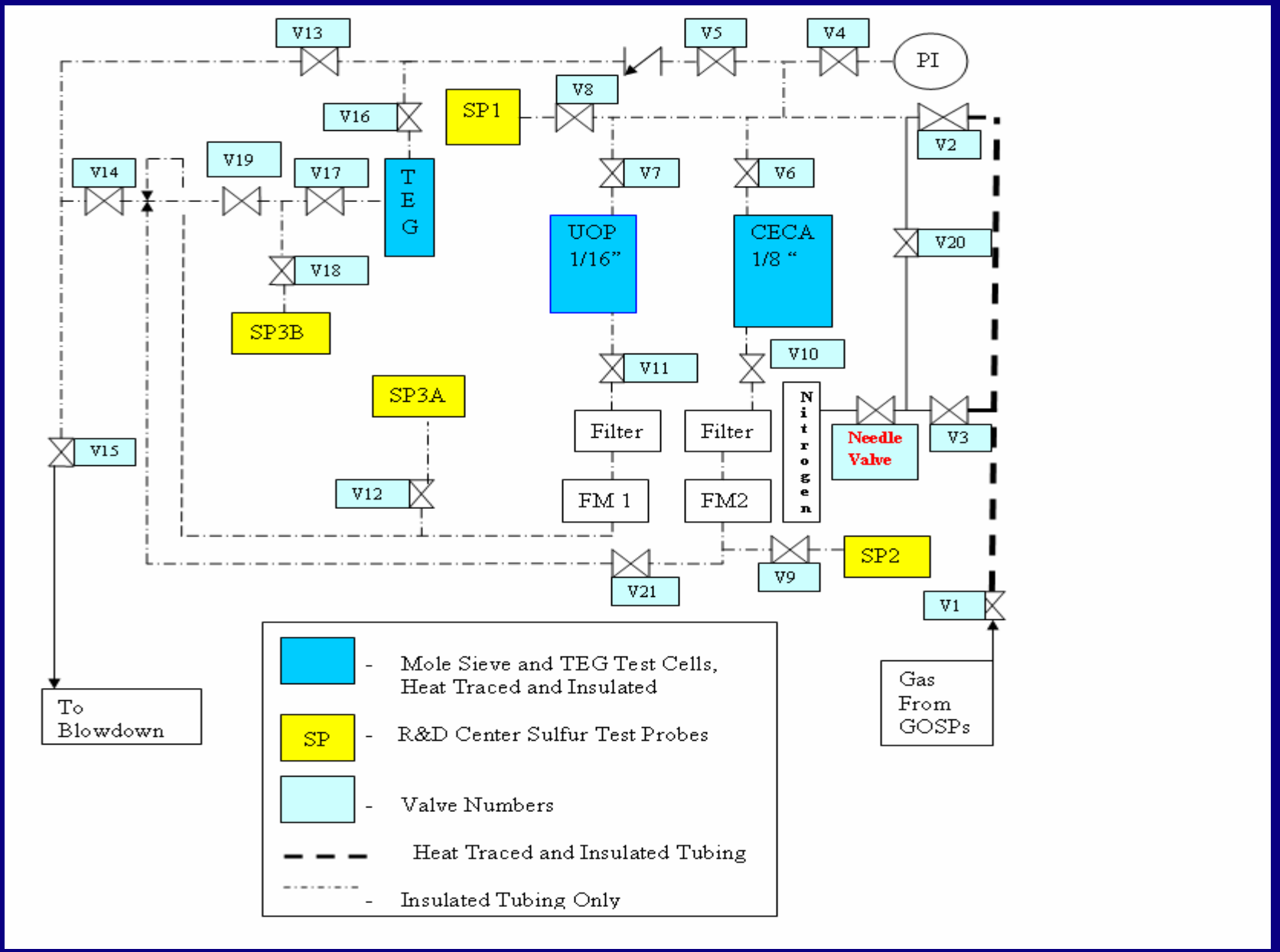
Acknowledgments

- Special thanks to team members from:
  - Abqaiq Plants Department.
  - Research and Development Center.
  - Facilities Planning Department.
  - Consulting Services Department.
  - Southern Area Producing.
- Also supporting departments such as:
  - Pipelines Department.
  - Oil Supply Planning & Scheduling (OSPAS).
  - Shedgum Gas Plant.
  - Tanajib Plants.

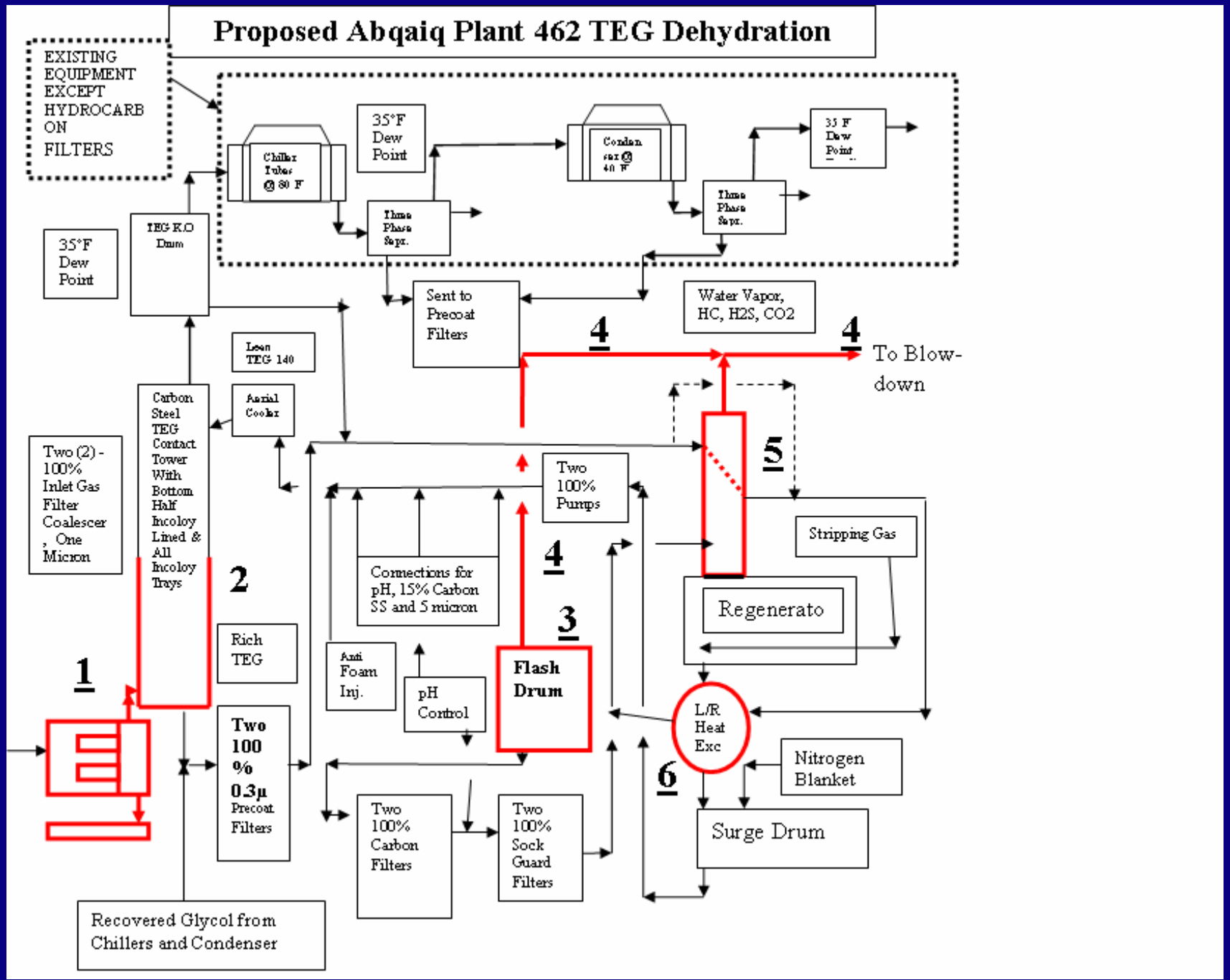
Thank you!

Questions

Field Testing Apparatus Schematic Diagram



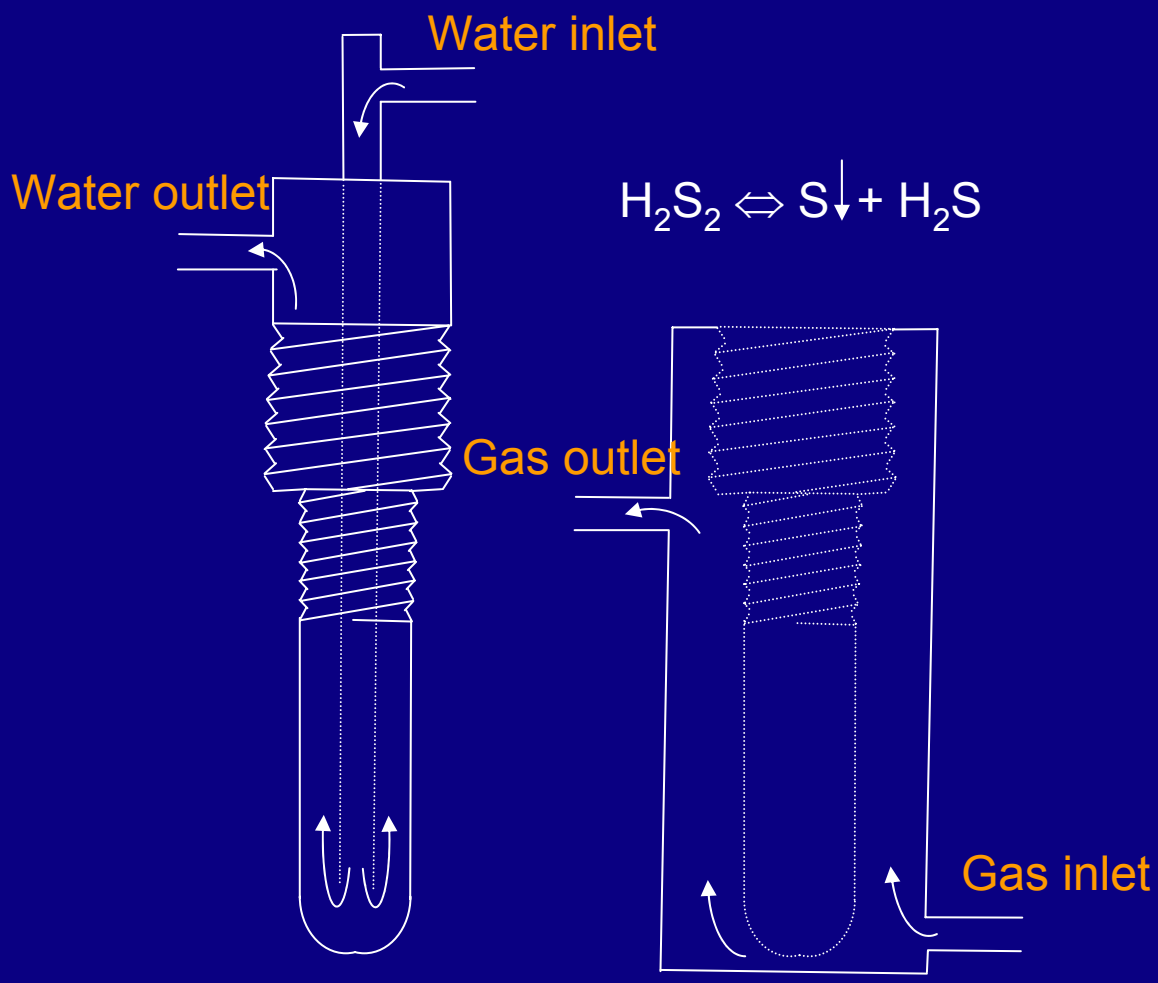
Proposed Abqaiq Plant 462 TEG Dehydration



Abqaiq Plants Off-Gas Stream

Case Name	Design Basis
Temperature (F)	131.0
Pressure (psig)	385.0
Mole Flow (MMSCFD)	280.000
	Mole %
H2O	0.31
H2S	8.78
CO2	7.04
Methane	15.22
Ethane	33.44
Propane	25.57
i-Butane	2.29
n-Butane	5.28
i-Pentane	0.72
n-Pentane	0.84
n-Hexane	0.25
n-Heptane	0.25
Total	100.00

Sulfur Measurement Methodology



Sulfur probe used with pressure and Temperature reduction in gas sampling lines.