Feed Contamination to Amine and Sour Water Stripper Units Affecting the Sulfur Recovery Process - A Domino Effect

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Sulfur Recovery Units

\[ 3 \text{H}_2\text{S} + \frac{3}{2} \text{O}_2 \Rightarrow \frac{3}{x} \text{S}_x + 3 \text{H}_2\text{O} \]
Sulfur Recovery Process

Acid Gas Feed Into SRU Originates at Amine and Sour Water Stripper Units

Amine Units

Sour Water Stripper Units

Sulphur Recovery Units
Sulfur Recovery Process

Amine and Sour Water Stripper Units Feed originates from many Refinery units

- FCC, Hydrotreater, Hydrocracker, Coker
- FCC, Hydrotreater, Hydrocracker, Coker, Amine Unit, Crude Unit and others

Amine Units

Sour Water Stripper Units
Amine and SWS Unit Feed Contaminants

**Amine Units**
- Hydrocarbons
- Surfactants
- BTEX
- Methanol
- Glycols
- Process Additives
- Solids

**SWS Units**
- Hydrocarbons
- Surfactants
- BTEX
- Phenols
- Process Additives
- Amines
- Solids
Main Chemical Reactions

Amine Treating

\[ \text{H}_2\text{S} + \text{NR}_3 \rightleftharpoons \text{HNR}_3\text{SH} \rightleftharpoons \text{NR}_3 + \text{H}_2\text{S} \]

\[(\text{HNR}_3^+ + \text{HS}^-)\]

Sour Water Stripping

\[ \text{NH}_4^+ + \text{HS}^- \rightleftharpoons \text{NH}_4\text{SH} \rightleftharpoons \text{H}_2\text{S} + \text{NH}_3 \]
Contaminants in SRUs

Effects on the Claus process
- Hydrocarbons consume large amounts of oxygen in the reaction furnace, affecting $\text{H}_2\text{S}:\text{SO}_2$
- Cause unstable operation

Potential catalyst soothing and deactivation
- Plant can’t always supply the necessary $\text{O}_2$ for HC combustion
- Catalyst Fragmentation

Discolouration of Sulfur
- Leading to poor quality product

Decrease plant capacity

Emissions
Carbon Contamination (from HC) of Activated Alumina Catalysts

External Powder (Soot)

Hydrocarbon Cracking (BTEX)

Glassy HC Coating (Amine)
Water Feed Quality to SWS Units
Feed Gas to Amine Units
Amine Regenerator Reflux Water
Rich Amine Hydrocarbon Contamination
Hydrocarbons Water

Free Hydrocarbons
- Separate easily from water
- Removed in flash and holding tanks

Soluble Hydrocarbons
- pH, pressure and temperature dependent
- Not readily visible
- Dependent on amine type/water temperature

Emulsified Hydrocarbons
- Held in water by surfactants (similar to soaps or detergents)
- Range from 2 – 500 microns size droplets
- Take weeks to separate naturally
Hydrocarbons Water

- Free HC
- Dissolved HC
- Emulsified HC
Optimize SW Holding Tank Operation

- Maximum residence time
  - 50-60% full, based on tank volume
  - Only actual “sour” water to be fed
- 600 mm hydrocarbon layer floating on top of water
- Level control not simple
- Bypass for annual cleaning
- Inlet and outlet nozzles located opposite to each other
Minimizing Hydrocarbons in Sour Water Stripper Acid Gas

1. Minimize hydrocarbon content of SWS feed
2. Optimize SW Flash Tank Operation
3. Optimize SW Holding Tank Operation
4. Utilize filtration and/or coalescing technology
5. Optimize operation of the sour water stripper
Minimizing HC in Amine Acid Gas

1. Minimize hydrocarbon content of gas feeds
2. Optimise operation of the amine absorber
3. Optimise flash tank operation
4. Utilizing skimming connections
5. Utilize filtration & coalescing technology
Amine Plant Operation
Circulation Rate

Hydrocarbon solubility: MEA > DGA > DEA > MDEA > DIPA

Higher amine circulation rates will increase the amount of hydrocarbon in amine acid gas.

- Downcomer clearance
- Weir height
- Downcomer width
Amine Plant Operation: Rich Amine Loading

TREATED GAS

LEAN AMINE

m³/h GPM

Higher rich loadings reduce hydrocarbon solubility in amine

RICH AMINE LOADING

TYPICAL REFINERY = 0.45-0.55 mol/mol

SOUR GAS INLET

e³ m³/h MMSCF/D

mol% H₂S

mol% CO₂
Amine Plant Operation: Lean Amine Temperature

Lean Amine should be as cool as possible, but minimum 5°C (10°F) warmer than the inlet feed gas.
Amine Flash Tank & SWS 3-Phase Separator

- Proper HC removal design
- Maximize residence time

Rich Amine Inlet → Lean amine → Fuel Gas

Pressure as low as possible

Baffle Plate 2-3 inches below weir

Water or Amine

Rich Amine Outlet → Hydrocarbon drain

Hydrocarbons

Level control
Rich Amine / Sour Water Feed Filtration & Coalescing

Traditional “filtration” is for solids removal
- Emulsified HC penetrate filtration media

Coalescers remove (and recover) HC from amine
- Emulsified droplets smaller than 15-20 microns will not separate in the flash tank

Main HC Separation Technologies:
- Inclined plates (don’t have the efficiency)
- Metal mesh (metal fibers, easily fouled)
- Centrifuges (emerging technology, low flow/pressure)
- Micro-fiber coalescers. RECOMMENDED
- Carbon beds should NOT be used (only for solubles)
Rich Amine Filtration/Coalescing

Rich Amine Filtration/Coalescing

Rich Amine

Off Gas to Flare or Fuel Gas

FLASH TANK

Hydrocarbons

Lean Amine

Acid Gas to SRU

REGENERATOR

Solids Separation Stage

Liquids Separation Stage
Sour Water Filtration/Coalescing

Sour Water Feed

Solids Separation Stage

Liquid Separation Stage

Stripped Sour Water

3-PHASE SEPARATOR

Hydrocarbons

Off Gas to Flare or Fuel Gas

Feed Sour Water Stabilization Tank

Sour Gas to SRU

Sour Water

STRIPPER
Amine Unit Inlet Separation

- Feed Gas
- Treated Gas
- KO Drum
- Recovered Amine
- Gas Coalescer
- Lean Amine
- Rich Amine
- AMINE ABSORBER
- Recovered Gas
Basic Inlet Separators (Demisters)

- **Bulk separation** of liquids slugs
- Demister pad provides removal of liquid droplets down to 10-20 micron at best
- Cant handle well high solids content

Important Aspects
- Level controller
- Differential pressure
- Demister pad
- Bulk liquid volume
Submicron Coalescers

Free Liquids and Aerosols

Vertical design has two chambers

Good efficiency for large liquid droplets down to 0.1 microns

Vessel design is critical

Instrumentation-intensive

Last line of defense system
Real Cases

Amine Units

SWS Units