

Corrosion Control Experiences associated with Flare Gas Recovery Units in a Gas Plant

Mohammad Al-Ghufaili

Wasit Gas Plant Department
Saudi Aramco Oil Company
P.O. Box 8350, Ras Tanura
Saudi Arabia

Mohamed M. Farah

Wasit Gas Plant Department
Saudi Aramco Oil Company
P.O. Box 8350, Ras Tanura,
Saudi Arabia

Abdullah Al-Oraer

Wasit Gas Plant Department
Saudi Aramco Oil Company
P.O. Box 8350, Ras Tanura
Saudi Arabia

Abdulmalik Mirdad

Wasit Gas Plant Department
Saudi Aramco Oil Company,
P.O. Box 8350, Ras Tanura
Saudi Arabia

ABSTRACT

Recent environmental awareness, drive to lower emission and economic benefits associated with flare gas recovery has seen a shift in flaring practice. Flare Gas Recovery Unit (FGRU) often use well-established amine sweetening technologies to scavenge the deleterious hydrogen sulfide gas, and therefore achieve sweet gas specifications suitable for fuel gas in the plant. However, unlike conventional acid gas treating units, the FGRU feed stream contains wide array of composition from the plant, and therefore pose unique process and corrosion challenges. Consequently, corrosion control measures in the FGRU systems tend to be more challenging. This paper will chronicle the corrosion control experience garnered in the operation of FGRU in a gas plant, following a number of operational challenges that has led to high risk of corrosion. The presence of oxygen in the sour gas stream further exacerbated the corrosion risk as a result of amine degradation, leading to high content of heat stable salts and other contaminants. A proactive inspection program revealed thinning across the lean amine carbon steel (CS) piping loop. A set of robust design modifications, process and corrosion control mitigations such as jump-over lines to the compressors, ion-exchange reclamation, inspection and monitoring of process parameters (temperature, pH, amine strengths) were implemented. A long-term solution involving material upgrade was subsequently implemented. The dissemination of these experiences will prove beneficial to the integrity robustness of FGRU systems, which utilizes amine technology.

Key words: Amine, corrosion control, damage mechanisms, flare, FGRU, gas, hydrogen sulfide, inspection, material selection, monitoring, sweetening

INTRODUCTION

Gas flaring is often a frequent occurrence in the oil and gas industry, where significant unrecovered gas is flared to the atmosphere with wide ranging negative environmental implications such as increased greenhouse emission, and other pollutants that have negative health implications on local populations¹. However, recent environmental awareness, drive to lower emission and economic benefits associated with flare gas recovery has seen a shift in flaring practice. The recovery of flared gas reduces noise and thermal radiation, operating and maintenance costs, air pollution and gas emission and reduces fuel gas and steam consumption.² Saudi Aramco has been at the forefront of these endeavors by establishing a robust flaring minimization program and committing to the World Bank “Zero Routine Flaring by 2030” initiative.³

One of the prominent flaring minimization technologies leveraged is the integration of Flare Gas Recovery Units (FGRU) in new gas plants. There are plethora of FGR technologies such as; caustic treatment, solid scavenging, liquid scavenging and membrane technologies⁴ The final selection is determined by techno-economic factors, however, the most ubiquitous FGR technology consists of a compression system that is used to increase the pressure and a sweetening system that is used to remove the hydrogen sulfide in the gas stream, and therefore achieve sweet gas specifications suitable for fuel gas in the plant.⁵ A number of different amines, including Monoethanolamine (MEA), Diglycolamine (DGA), Methyldiethanolamine (MDEA) and Diethanolamine (DEA) are widely utilized across the industry. Unlike conventional acid gas treating units, the FGRU feed stream contains wide array of composition from the plant, and therefore pose unique process and corrosion challenges. Specifically, the presence of Oxygen in the stream can be extremely detrimental to the performance of the regenerative amine system due to the rapid degradation of the amines⁶. Throughout the operation of the FGRU units in the gas plant, a number of challenges were encountered. These includes; design limitations, incapability of performing hot circulation of the amine prior to shutdown alongside corrosion issues from the degradation of the amine. This paper will detail the experiences garnered from tackling these issues and the proactive approaches such as effective inspection, process modifications, process and laboratory monitoring that were implemented to determine the best mitigation.

PROCESS DESCRIPTION

The FGRU consists of two 100% (each) trains designed to treat 5.96 MMSCFD (min.) to 10.25 MMSCFD (max.) of flared gas using 35 wt.% concentration Methyl-Di-Ethanol Amine (MDEA) solvent. Each individual train of FGRU is designed to operate independently with no common equipment between the two trains. Furthermore, dedicated flare gas recovery compressor is provided for each FGRU train. The objective of the FGRU is to remove H₂S and CO₂ from the flare gas that is routed from across the plant (Separators, Strippers, Flash Drums and leakage from NGL etc.).

The Flare gas from the gas treating plant is compressed, cooled and fed to the FGR unit battery limit which and into the amine contactor to remove H₂S to the target concentration of H₂S <16 ppmv. CO₂ concentration in the treated gas is <5.45 mol%. The sweet treated gas from this unit is used as Fuel gas for the sulfur recovery unit and in the Utilities. The compressed sour gases are filtered and routed to the Amine Contactor, where it counter-currently contacts the lean MDEA amine solution. The resulting rich MDEA solution is routed to the Hydrocarbon Flash Drum, where hydrocarbon flash gasses are removed and routed to the thermal oxidizer in the Sulfur Recovery Unit (SRU). The rich MDEA is routed to the lean/rich heat exchangers where the temperature increases before entering the Amine Stripper, where pressure reduction, heat and steam help to strip the acid gases. Reboiler is used to maintain the stripper temperature at 264 °F. The acid gases go to the overhead condensers and the reflux DRUM, where the gas is either routed to the LP Flare Header or SRU Reaction Furnace. The lean amine from the bottom

of the Amine Stripper is pumped to the exchanger, cooled via lean amine cooler and transferred to the Lean Amine Surge Drum. The lean amine is then routed to the contactor. Figure 1 gives the process flow diagram for each FGRU train

This results in a high number of shutdowns/idle time as only one FGRU train + compressor is in service at a time. Figure 1 gives the process flow diagram for each FGRU train.

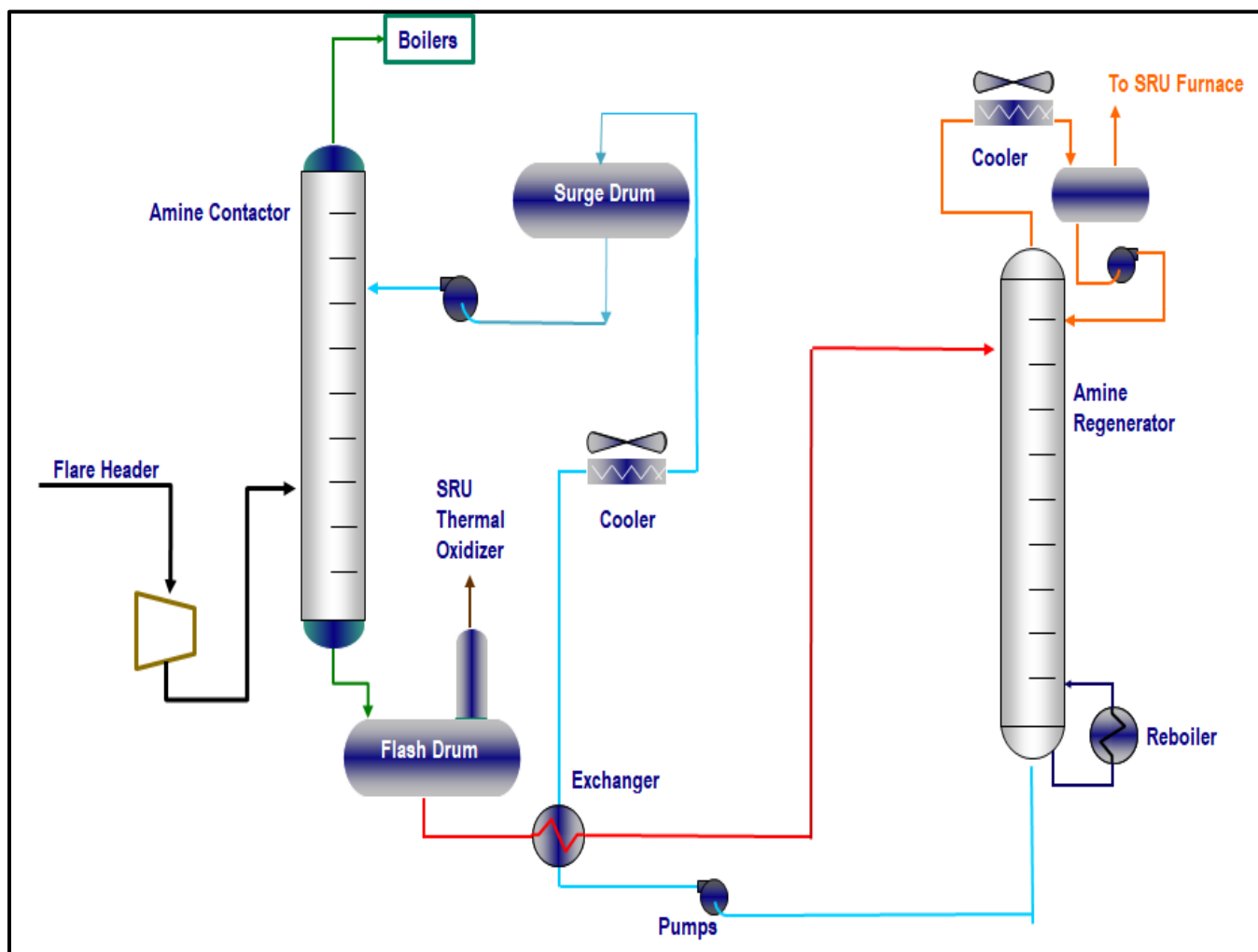


Figure 1: FGRU Process Flow Diagram

FGRU MATERIAL SELECTION PHILOSOPHY

The sour gas feed stream contains substantial amount of wet corrosive species that can lead to a number of plausible damage mechanisms, dependent on the material of construction (MOC) and operating conditions. The FGRU material selection philosophy relied on limiting a number of damage mechanisms such as CO₂ & H₂S corrosion, cracking such as Sulfide Stress Cracking (SSC), Amine Stress Corrosion Cracking (ASCC), Chloride Stress Corrosion Cracking (CISCC). As a result, the rich amine loop, from the contactor to the stripper were constructed of Austenitic 316L stainless. The Lean Amine loop, starting

from the piping downstream of the Stripper to the inlet piping of the Contactor was constructed of Carbon Steel (CS) with corrosion allowance of 3.2 mm. All the piping and equipment weldments in amine service were also post-weld heat treated to mitigate against ASCC. The inlet piping containing the wet sour gas, Carbon steel pipe HIC/SSC resistant with 6.4mm corrosion allowance is selected per NACE MR 0175/ISO 15156 and Saudi Aramco Engineering Standard SAES-L-132 para.4.4 requirements.

FGRU OPERATIONAL CHALLENGES

Compressors Shutdown:

During the early operation of the FGRU trains, frequent blockage of the compressor suction strainers necessitated the compressor shutdown in-order to clean the strainers. Furthermore, as a result of the arrangement where one compressor is specific to one FGRU train, there were frequent unit shutdowns, driven by the need for the frequent cleaning of the compressor suction strainers due to the presence of iron sulfide corrosion products and elemental sulfur. The presence of sulfur deposits potentially indicates the presence of oxygen in the flare sour gas stream, which then oxidizes the hydrogen sulfide and other species such as mercaptans to form the sulfur deposits. The sudden shutdown of FGRU, also impacted the Stripper efficiency, as it was not possible to regenerate the amine solution. This in-turn, resulted in high rich amine loading stagnating in the lean amine CS piping loop system during the shutdown periods.

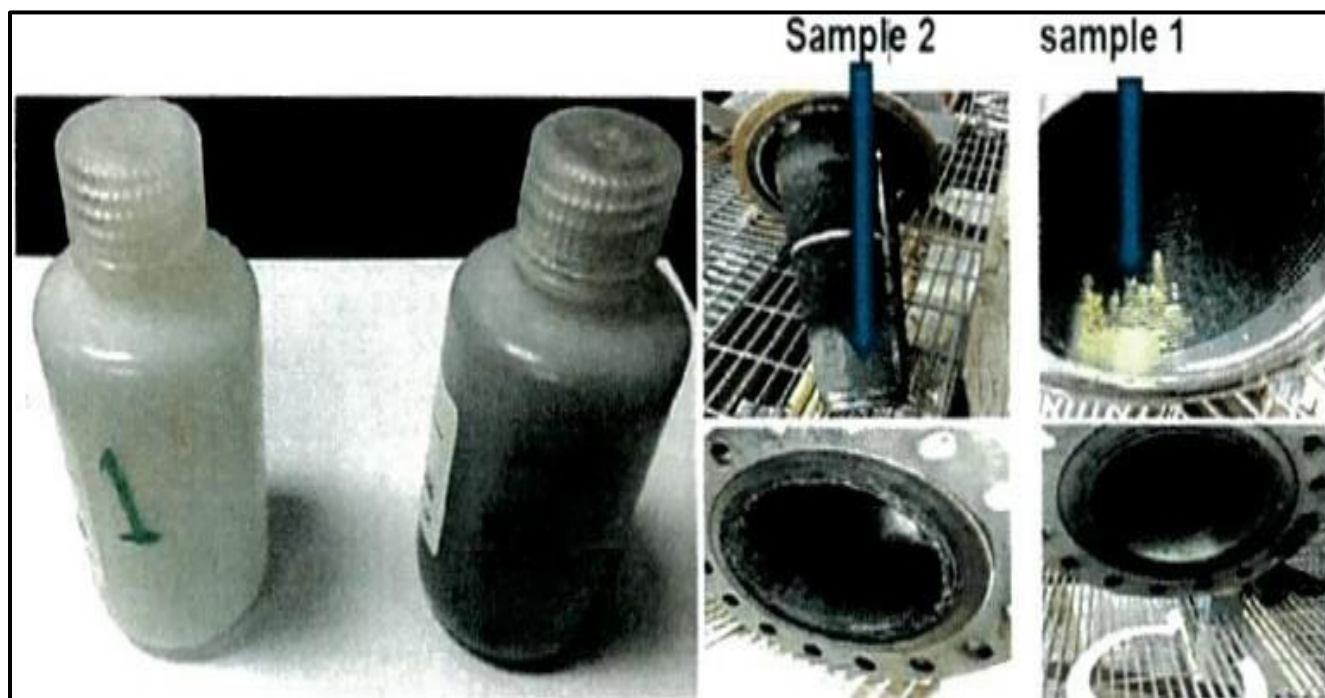


Figure 2: Presence of Elemental Sulfur Deposits on the Compressors

Hot Circulation:

Standard operating procedures of the FGRU demands that hot circulation of the amine is performed during the unit's shutdown to ensure the sufficient stripping of the amine solvent to achieve acceptable lean amine loading targets. The maintenance of positive pressure to mitigate against oxygen ingress is