Proper Filtration in Amine Sweetening Systems Improves Natural Gas Processing Plant and Oil Refinery Operations

Introduction

Amine treating systems are a critical part of natural gas processing plants and oil refineries. They significantly impact the overall operating costs of the plant and the plant's ability to meet sales gas specifications. Natural gas processing facilities and refineries use treatment solvents to reduce acid gas components from gas streams. Amines such as MDEA, DEA, MEA, and specially designed formulations absorb hydrogen sulfide (H_2S) and carbon dioxide (CO_2) to "sweeten" the gas stream. In this Customer Application Brief (CAB), the use of high efficiency filtration systems in Amine Sweetening Processes is discussed and the benefits provided through efficient filtration of both the recirculating amine stream and the inlet gas to the plant are identified. The benefits include a significant reduction in contactor plugging and heat exchanger, reboiler and carbon bed fouling, resulting in lower operating and maintenance costs.

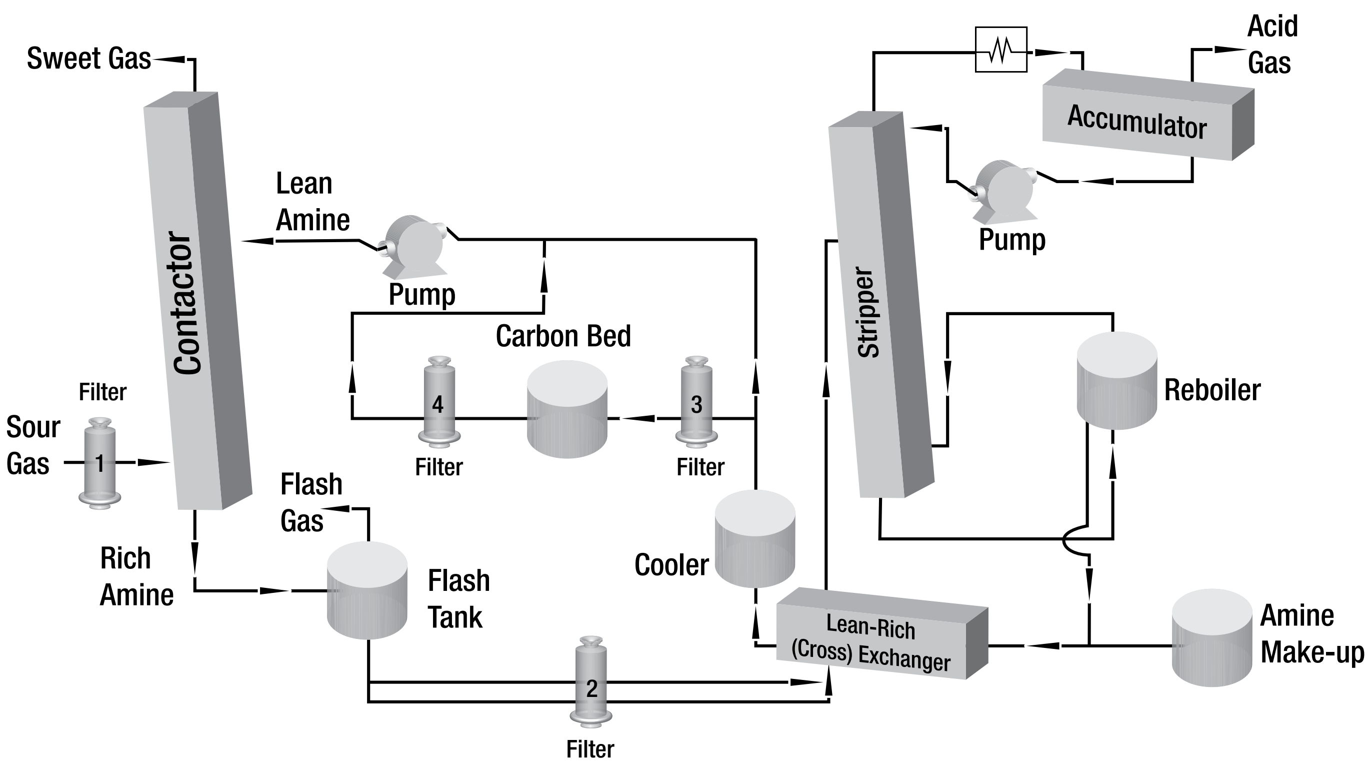

Figure 1 . – Amine Sweetening System

The Process

In the operation of a typical gas-sweetening unit, the inlet gas first passes into the bottom of the contactor and flows upward through a series of trays, counter current to the aqueous amine solution, which absorbs the acid gas components. The "rich" amine solution, which has the CO_2 and/or H_2S molecule attached to it, flows from the bottom of the contactor through the lean/rich heat exchanger where its temperature is elevated to minimize the additional heat required for regeneration. The rich amine is then sent to the upper section of the stripper and flows downward contacting the hot vapors from the reboiler causing the acid gas molecules to be stripped from the amine solution. The acid gas liberated from the amine solution flows out the top of the stripper to a condenser where vaporized amine is recovered and recycled back to the system. The hot "lean" amine solution, which no longer contains acid gas, flows from the reboiler back through the lean/rich heat exchanger and is cooled prior to being pumped back to the contactor for reuse.

The Problem

Solid and semi-solid contaminants in the amine system cause many problems including:

Contactor Plugging – Solids deposited on the trays of the contactor can plug the bubble caps on the trays resulting in higher gas velocities through the trays. Higher velocities will increase the tendency of the amine to foam and not allow the gas to come in full contact with the amine at the subsequent trays. If contact is missed at enough trays, ineffective absorption will take place and off-specification gas (with a concentration of CO_2 and/or H_2S that exceeds specification) will exit the contactor. Solids deposition on the trays will also increase differential pressure resulting in amine carry-over and eventually a maintenance shutdown to clean the trays.

Heat Exchanger / Reboiler Fouling – Solids deposited on the heat exchanger and reboiler tube surfaces cause poor heat transfer resulting in ineffective regeneration of the amine solution. As the reboiler tubes become fouled and ineffective regeneration occurs, operators typically increase heat to the reboiler to improve the regeneration process, which in turn results in higher energy usage. The tubes of the reboiler are not coated uniformly by the deposited solids and the additional heat to the reboiler causes "hot spots" to form. These hot spots, or points on the tubes where high temperatures exist, are sites where rapid degradation of the amine solution can occur. As amine degradation occurs, corrosion rates increase and the tendency of the amine to foam increases. As a result, amine carryover rates increase, maintenance costs are incurred to clean out the exchangers and lost revenues occur as the system is shut down to complete the necessary repairs.

Carbon Bed Fouling – contaminants introduced into the carbon bed increase differential pressure across the bed, block access to the active sites of the carbon, and increase the tendency for amine to "channel" through the bed. The result is reduced absorptive capacity resulting in frequent carbon bed regeneration or, in the worst case, premature replacement of the expensive carbon bed.

Foaming – solids in the amine stabilize foaming that occurs by increasing the surface viscosity of the amine and making it more difficult for the individual foam "bubbles" to break. As previously described, if the foam is stable enough to prevent full contact at the next tray, ineffective absorption can occur resulting in off-specification gas to exit the contactor. In addition, foaming results in high amine carryover rates and, therefore, high amine replacement costs.

The Solution

3M Purification's absolute-rated Betapure™ PK series depth filter cartridges have demonstrated excellent performance in protecting recirculating amine sweetening systems. 3M Purification recommends four stages of filtration to ensure optimal operation of amine sweetening systems at natural gas processing facilities and in refineries.

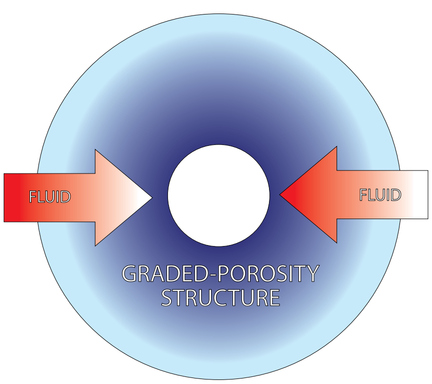

Figure 2. – Graded Pore Structure

Stage 1 – Ten-micron absolute Betapure PK series filters, rated at 0.5 micron in gas, are recommended to filter the inlet natural gas stream, Filter Position # 1, ahead of introducing the gas into the amine sweetening contactor. Betapure PK series gas filters will effectively reduce both solid and semi-solid contaminants while coalescing entrained liquids from the gas stream.

Stage 2 – Ten micron absolute-rated Betapure PK series depth filter cartridges are very effective in full-flow filtration of the recirculating amine stream, filter Position # 2, downstream of the flash tank. Some amine systems employ "partial flow" filtration, typically ten to twenty percent, which does not effectively protect downstream equipment. Locating the filter in the rich line upstream of the heat exchanger will reduce solid contamination including iron sulfide and corrosion products. This protects both the heat exchanger and stripper. The combination of high efficiency and rigid media construction ensures effective particle reduction and high dirt holding capacity without the danger of particle unloading during operation.

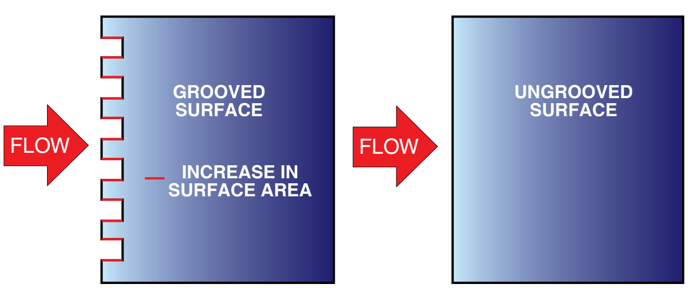

Figure 3. – Betapure™ PK Series Grooved Structure

Stages 3 & 4 – Betapure PK series ten-micron absolute filters are recommended upstream and downstream of the carbon bed, filter Positions # 3 and #4. The carbon bed reduces entrained hydrocarbons and surface-active compounds, reducing the tendency of the amine solution in the contactor to foam. Locating the Betapure PK series elements upstream of the carbon filter reduces carbon bed fouling. Downstream filters will protect the contactor by reducing carbon fines that would otherwise be deposited onto the column's trays.

Betapure™ PK series filter cartridges are manufactured using a process that achieves a true graded pore structure with a clean and smooth inside diameter reducing the need for a center core. Figure 2 illustrates that the openings between the fibers become progressively smaller as the fluid flows from the outer surface to the inner core of a graded porosity structure. Each fiber is locked in this arrangement by a thermosetting binder to create a rigid structure. The overall effect is to sort, classify and stop particles by size as they progress through the cartridge. Larger particles are trapped in the upstream region of the filter and finer particles towards the inner core of the filter. Contaminants at or near the filter's absolute rating are reduced in the inner section of the filter cartridge.

Betapure PK series cartridges also feature an optimized groove pattern that increases the surface area by over 65% when compared to smooth cylindrical cartridges (see Figure 3). The grooved surface prevents premature blinding of the outer surface by large particles and allows full utilization of the depth structure. Maximum surface area with a true graded pore structure means that Betapure PK series can provide significantly greater service life than competitive filter cartridges of comparable efficiency.

Figure 4. – Betapure™ PK Series Cartridge Configurations

Recommendations

Filter Position	Process Stream	Recommendation
Filter Position # 1	Inlet Natural Gas, at Natural Gas Processing Facilities	Betapure™ PK Series PG-M100, 0.5 micron absolute in gas service
Filter Position # 2	Rich Amine, Full Flow Filtration	Betapure™ PK Series M100, 10 micron absolute
Filter Position # 3	Lean Amine, upstream of Carbon Bed	
Filter Position # 4	Lean Amine, downstream of Carbon Bed	

Filtration with Betapure PK series filter elements improves process efficiency, provides process protection and ensures consistently high quality natural gas.

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