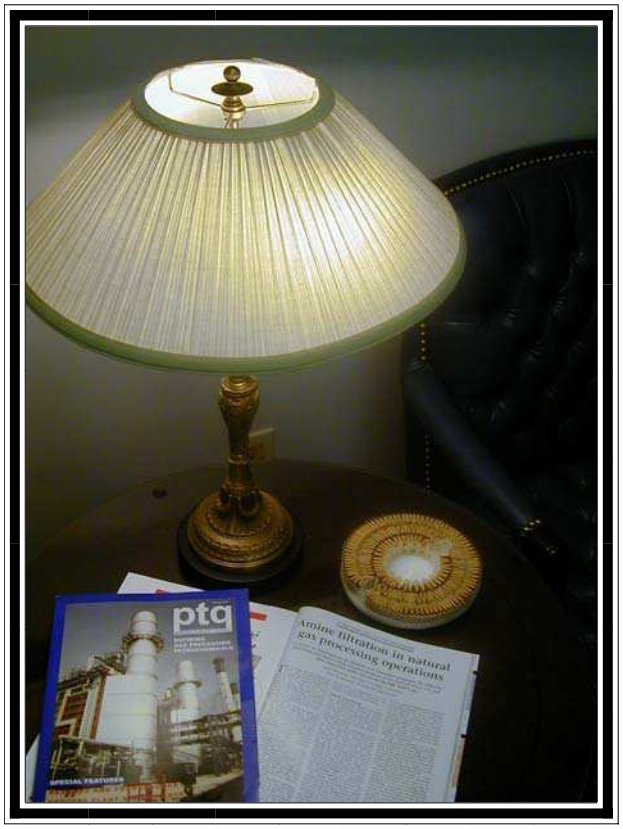
AMINE FILTRATION

By: John Hampton & Guy Weismantel



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FTC
FOREFRONT OF FILTRATION TECHNOLOGY

IMPORTANCE OF AMINE FILTRATION IN NATURAL GAS PROCESSING OPERATIONS

The looming need for natural gas in the United States means that non-producing fields of sulfur (S) laden gas (sour gas) are receiving renewed attention throughout North America. Owners or operators are anxious to turn these marginal fields into ones that produce pipeline quality gas. This effort includes looking at new technology and for ways to reduce both recovery and processing costs. There is, especially, a focus on the filtration and separations steps of natural gas processing.

Natural gas that contains inorganic or organic sulfur compounds is called sour gas. Sour gas can contain mercaptans and other sulfur constituents as contaminants, however, the most common sulfur compound is Hydrogen Sulfide (H_2S) which is highly toxic, flammable and is extremely corrosive to carbon steel when processing conditions are below the dew point of sulfuric acid – which is often the case for natural gas processing operations.

Consequently, natural gas processing plants constantly face rusting problems caused both by the acid and from other sources—particularly the common absorbent-recovery fluids. Most often (but not always) these absorbent liquids are amines. Amines are good scavengers for H_2S. Once the sour gas, and any other contaminant gases or particulates are removed, the end product is a high-Btu, pipeline-quality gas.

But, amines are expensive to purchase and difficult to handle. They are both toxic and hazardous. As well, they are subject to vaporization loss, fire hazards, foaming, and contamination by particulates and scale that develop during H_2S processing and amine regeneration.

However, amines offer the benefit of being a proven technology plus some amines remove the gaseous contaminant, carbon dioxide (CO_2), a major in-field, in-the-gas impurity that must be removed to attain a pipeline quality product. Generally producers turn to amine absorption technology because the amine first absorbs the H_2S, and then, the H_2S is easily stripped out and the amine is regenerated. Once the sulfur is removed, the “sweetened” gas is ready for pipeline transportation. Natural gas has no odor, so, at some point after processing, an odorant is added to assist in nasal detecting leakage.

Process Description

In the conventional amines processing unit, the H_2S passes through a contact tower counter-current to the liquid amine. There is an exothermic absorption of the acid gas by the amine solvent. That bond is easily broken, releasing the acid gas while the amine is sent to regeneration.

If one looks at the total process, there are several significant unit operations. To begin with, production gas from the field (sour gas) enters near the bottom of the contact chamber (tower). This sour gas first passes through a knockout drum. The sour gas passes upward (countercurrent) through the descending amine solution and the H_2S is absorbed by the amine solution. The then purified gas leaves through the top of the tower while the spent amine solution leaves the

bottom of the tower passing first through a flash tank and then through a heat exchanger. [This exchanger uses hot, regenerated lean amine to heat the H_2S-rich amine.] The amine solution carrying the absorbed acid gas is subjected to additional heat by using a reboiler. Steam rising through the stripper liberates the H_2S, which is sent to the field's S-recovery operations, for example a Claus unit.

During the various processing steps the amine becomes contaminated with both hard and with flexible particulates that can be a combination of dirt, scale, rust, long-chain polymers, reactant products (from foam-reduction compounds or other materials). Some of these chemicals have been added to the system deliberately. Other particulates may have entered as part of the sour gas itself – for example, one might even see compounds of heavy metals that can pass through the system as a powder.

A key processing concern is that of amine salts that form during the recovery operations. These are corrosive and are heat stable and must be minimized both by system configuration, control of processing conditions, and by filtration (if they begin to show up as a solid). One can see that the typical amine filter is facing a severe challenge because it is being asked to take out a variety of materials having different characteristics and sizes and forms, and that conditions, and even the type and size of the particulate, may change quickly and dramatically because production operations are not always in equilibrium. At least some operators try to minimize the filtration problems within the unit by placing a separate filter or scrubbing system on the incoming sour gas prior to the initial knockout drum—this in order to remove particulates and gums before they get into the amine stream rather than face the more difficult problem of removing them afterwards.

In the field during actual operations, at least some of the suspended and/or dissolved organic contaminants are removed by using an activated carbon bed that is separate from the actual cartridge filtration system. Placement and relationship of the cartridge filter and the carbon bed will be addressed later in the article. The carbon bed itself acts as a filter, but this is not desirable because particulates and polymers will seal off the bed and reduce carbon activity. Particulate removal is the job of the cartridge filter system (mechanical filtration).

Indeed, one of the most critical steps in the process -- a step that is often ignored or taken for granted by some process engineers -- is the amine filtration operation that is integral to successful regeneration. Otherwise the particulate buildup will hinder efficient absorbent operation within the contact tower. Understanding the filtration technology (Appendix A) and the costs associated with amine filtration can be a key to achieving the desired Return-On-Investment (ROI) from any particular gas field.

Selecting the Amine

Monoethanolamine (MEA) is a common absorbent/solvent used in sour gas treatment because it is highly reactive thereby providing high quality (low-S) natural gas. Other amines (all which require filtration during regeneration) are: methyl diethanolamine (MDEA), diglycolamine (DGA), diisopropanol amine (DIPA) and diethanolamine (DEA) and solvent blends. Amine selection varies depending upon the type of contaminants and the quantitative analysis of the virgin sour gas. Regardless of the solvent, (some S-removal processes do not use amines), the mechanical filtration step is critical to economics.

In general, the filter system is not grossly affected by the type of amine solution

selected by the operator of the gas processing plant. One might conclude that MEA (which is one of the simplest amine molecules) might be less prone to plug a filter, which might be the case if the filter was seeing only the amine. However MEA is recommended where there are stringent outlet gas specifications suggesting that MEA might place a greater particulate removal load on the filter than another amine. This could create the need for a filter with higher dirt holding capacity (See Filter Selection section of this article) to assure Optimum Time Between Turnaround (OTBT). Ideally OTBT would be identical to Mean Time Between Turnaround (MTBT).

DGA systems are often chosen when there is a need to remove carbonyl sulfide and mercaptans in addition to the H_2S. This suggests the potential for the filter to handle more and more-difficult particulates than if the unit were handling H_2S alone.

In that light, amines are normally classified as primary, secondary and tertiary. Because the latter also are used as a crosslinking agent in coatings, one would therefore expect tertiary amines to produce more "foots" or globs that could decrease MTBT in a gas processing plant using amine absorption.

Similarly, additives that resist corrosion or lower freeze point can affect overall filter operations, however, while an amine unit operating near Red Deer, Alberta, Canada would require an additive to maintain flow rates during winter months, a similar unit in South Texas USA would not have to consider freezing as a problem nor an anti-freeze additive. The point is: Additives, DO –in fact – affect both the success and failure of process efficiencies and filtration operations. And – additives can exacerbate foaming problems as does the presence of fine particulates.

In that light, DOW's literature suggests that the additives that are used for amine salt management creates dramatic improvements in gas processing operations and MTBT when a facility adopts/utilizes salt neutralization technology. (Table #1).

TABLE # 1

Type of Maintenance	Six Months Before Neutralization	Six Months After Neutralization
Number of Heat Exchanger Water Washes	4	0
Number of Absorber Tray Water Washes	10	0
Number of Particulate Filter Changes	16	5

Source: Dow Chemical Company

The good news about the DOW data is that it is based on older cartridge technology. Selecting state-of-the-art highly efficient and high capacity (HE/HC) filter cartridges will dramatically improve MTBT.

Filter Selection

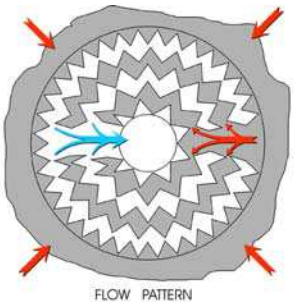
Many factors must be taken into consideration when choosing the filtration system for your amine stream. These include chemical and temperature compatibility, flow rate, acceptable pressure drop, degree of filtration, and overall filtration cost. In state-of-the-art amine filtration systems, the amine filter cartridges are almost always pleated. Depending upon the size of the amine unit, the filter system will use one of the following cartridges that are approximately 40 inches in length:

- 6.25" O.D. – High Capacity Filter (HCF)
- 12.75" O.D. – Ultra High Capacity Filter (UHCF)
- Full Housing O.D. (15", 18" & 20") – Ultimate Capacity Filter (UCF)

UCF systems are being Beta tested at this time and soon will become commercially available. In the UCF there is only one filter cartridge in the housing.

These HCF, UHCF and UCF cartridges generally utilize a staged pleated filter that is highly efficient and high capacity (HE/HC) that maximize dirt holding capacity in order to assure maximum time between change out (MTBC). Handling amine filters is hazardous, so producers try to keep the units on line as long as possible to improve MTBC.

The HE/HC cartridges feature segregated flow channels and flow chambers to optimize the Alpha Factor (Å) – a factor that is the key to determining total cost of filtration operations. Combining this design with the technique of pleating several different filter media together in a single pleat pack maximizes dirt-holding capacity. This design permits the use of many different types of filter media. This is essential for a wide range of fluid and temperature applications. The cross sectional view shown below details the basic design and flow paths of an HE/HC filter. This unique design works with either an "outside in" or an "inside out" flow path and is not limited to three rows of media.



FLOW PATTERN

Materials selection is very important in amine filtration. Since amine systems vary in chemical composition, it is difficult to designate a filter medium that is ideal. Other complications can arise from the glues and seals used in filter construction. Generally, polypropylene and cellulose medias are acceptable. However, operating temperature and presence of hydrocarbons in the system will affect filter choices.

The size of filter housings and pumps is usually dictated by the desired flow rate, pressure drop limitations, and required level of filtration. The recommended flow capacity of a filter element is used to determine the total number required for the desired flow rate. Housing size relates directly to the number of filter elements. Sufficient pump pressure must be provided to permit the desired flow rate through the filter element as it plugs so as to fully use the effective dirt holding capacity of the filter. It is imperative that daily testing of the process stream (using sample ports) be conducted (Appendix B). Testing is critical in identifying when upset conditions exist within the process.

Minimizing Filtration Costs

Filtration Cost Efficiency (E) is defined as the total costs, direct and indirect, that are associated with removing one pound of solids from a process stream. Direct cost is filter price and indirect costs include labor and disposal. A lower total cost results in a better efficiency rating. If we disregard equipment depreciation, we can express this relationship by the following formula:

$$E = \frac{P}{H} + \frac{L}{H} + \frac{D}{H}$$

D = Disposal Cost/Filter

H = Dirt Holding Capacity in Pounds

L = Labor Cost/Filter

P = Filter Price

Filter price and dirt holding capacity are the dominant components in operating cost. The relationship between these two items is defined by the following formula as the Alpha Factor (Å).

$$\text{ALHA FACTOR (Å) } = \frac{\text{FILTER PRICE (P)}}{\text{DIRT HOLDING CAPACITY (H)}}$$

Combining the Alpha Factor formula with the Filtration Cost Efficiency formula provides an interesting result.

$$E = Å + \frac{L}{H} + \frac{D}{H} \Rightarrow E = Å + \frac{L + D}{H}$$

The indirect costs shown in the equation are reduced as the dirt holding capacity of the filter increases. Therefore, the Alpha Factor becomes the dominant number in the equation. The lowest Alpha Factor results in the lowest filtration cost.

Typical Data For 20 Micron Absolute Pleated Polypropylene Cartridge

Cartridge Type	Dirt Holding Capacity	Typical Cost	Alpha Factor
Standard (2.5"OD)	1.7 Pounds	$33.25	19.6
HCF (6.25" OD)	17 Pounds	$267.75	15.8
UHCF (12.75" OD)	85 Pounds	$1,015.00	11.9
UCF (20.0" OD)	255 Pounds	$2,250.00	8.8

Maximizing Filter Life

Filter life is directly related to a filter's dirt holding capacity. It can be defined as the total volume of fluid that passes through a filter before reaching the maximum operating differential pressure.

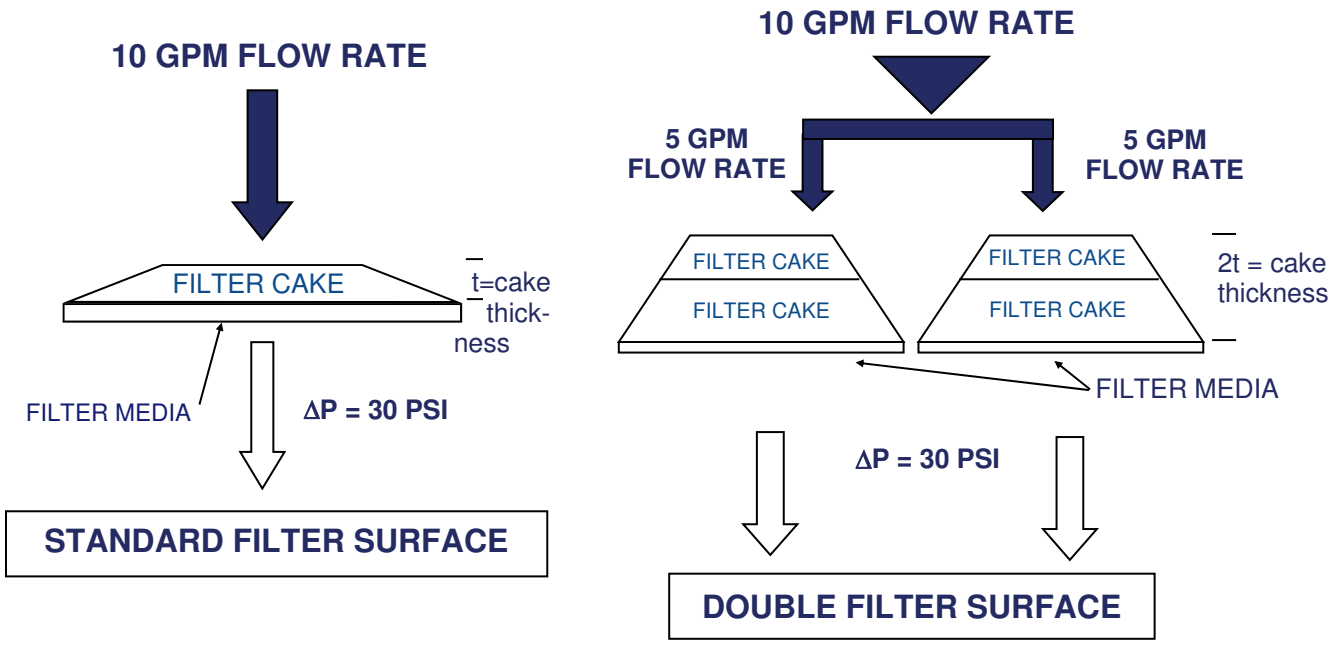
Under a constant flow rate, the life of most absolute rated filters is significantly increased when their effective surface areas are increased. This property of filter life is a direct result of the relationship between flow density (gallons per minute per square foot) and the resulting differential pressure across the filter area.

Under ideal conditions the maximum increase in filter life is equal to the square of the increase in effective surface area. Doubling the effective filter surface area can increase filter life up to four times!

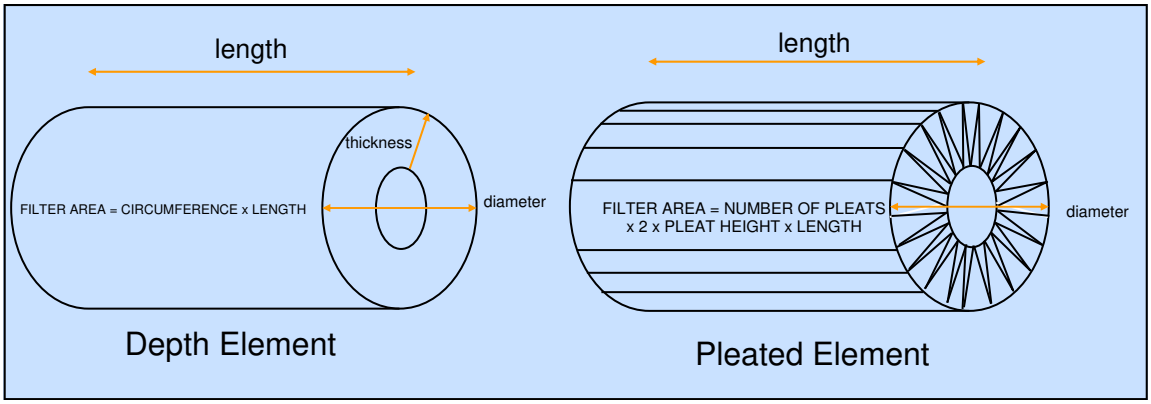
$$\text{FILTER LIFE INCREASE} = \frac{Le}{Lo} = \left(\frac{Ae}{Ao}\right)^{N}$$

Le = Extended Filter Life
Lo = Original Filter Life
Ae = Expanded Filter Area
Ao = Original Filter Area
$1 \leq N \leq 2$

An example of the doubling the surface area:



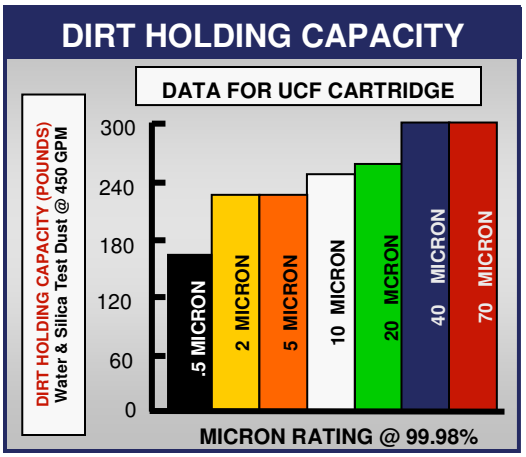
An easy way to increase filter life using an existing housing is to replace depth filters with pleated filters. In the following diagrams, the surface area of the cylindrical depth element is much less than that of the pleated element.

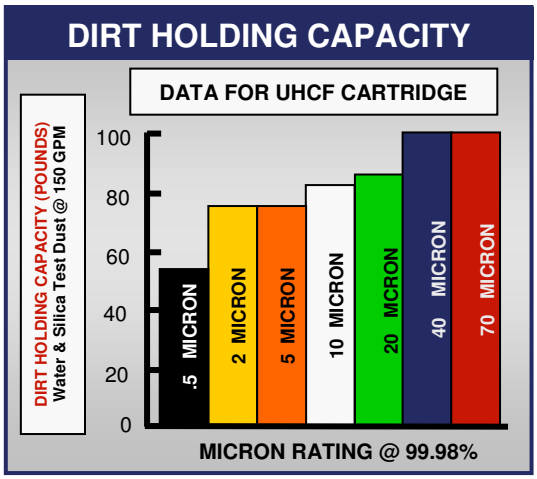


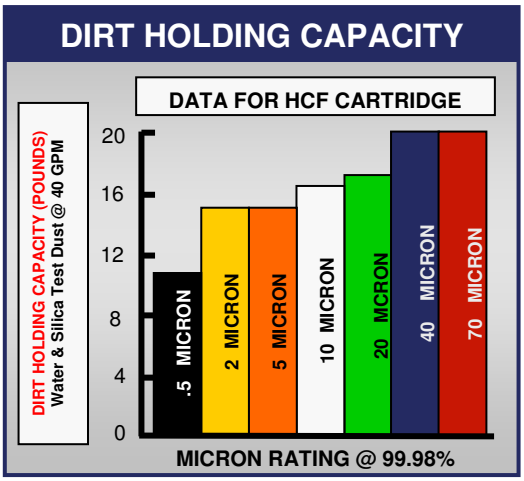
Another alternative is to increase the actual number of filters by increasing the size or number of housings.

The same results can be achieved by reducing the flow rate through the filter. By cutting the flow rate in half, it is possible to quadruple the filter life.

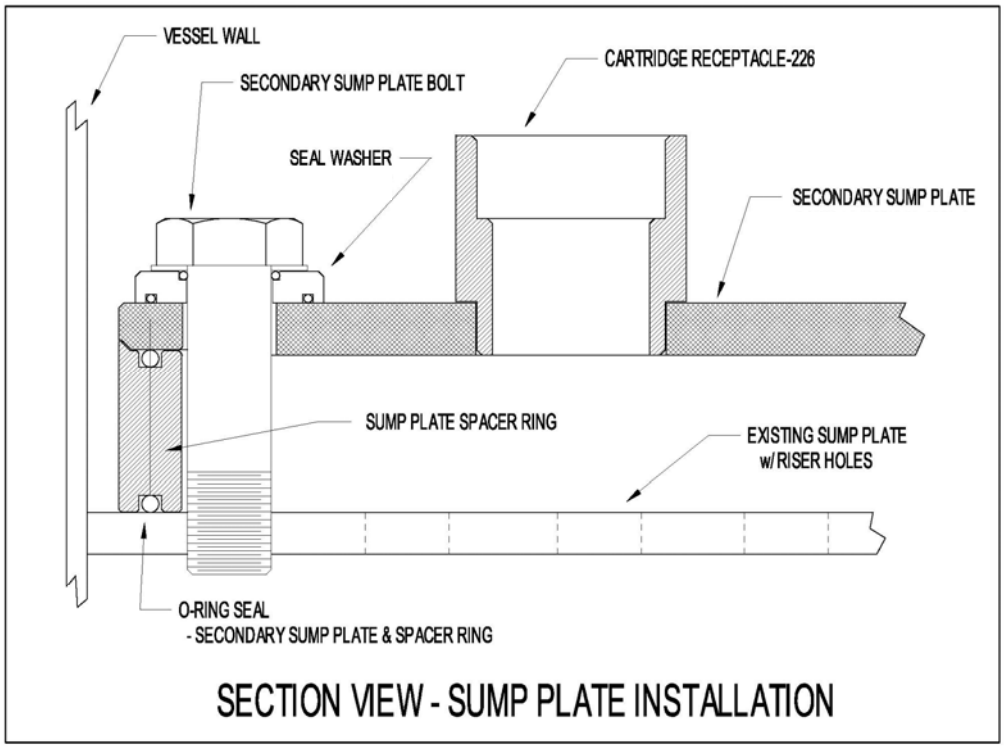
In respect to cartridges, with an HCF filter, the product is designed to replace up to forty string wound or ten pleated 2.5"OD cartridges. The UHCF replaces two hundred string wounds or fifty pleated elements. The UCF for a 24" OD housing is 20.0 inches in diameter and replaces six hundred string wounds or 150 pleated elements.







Constructed to fit most standard cartridge housings with minor, if any, hardware modifications, HE/HC filters provide a very cost effective method of maximizing effective surface area in existing housings.



When one considers capital spending costs for new installations, the savings associated with filter housing costs is equally important. Many plant engineers design their filtration systems based on a maximum flow rate. If a 2.5" OD cartridge is used in the base flow rate calculations, a larger vessel will be required to meet the maximum flow requirements. Using an HE/HC design will minimize the filter vessel size (and costs) required for specific flow rates and can result in significant cost reductions when high-pressure filter vessels are required.

Maximum Number of Cartridges Per Vessel ID			
Vessel I.D.	2.5" OD Standard Cartridge	6.25" OD HCF Cartridge	12.75" OD UHCF Cartridge
15"	19	3	1
28"	70	12	3
36"	120	19	5

With an increasing demand for more cost effective filtration, this new HCF and UHCF filter technology provides an excellent opportunity for reducing filtration costs in existing and future operations.

The Economics of Amine Filtration

The following exercise shows how cost savings can be realized by applying the basics of amine filtration to current operations.

MONTHLY OPERATING PARAMETERS (36" ID Vessel, Contaminate Load 72 Pounds per Month)				
Parameters	**2-1/2" OD String Wound**	**2-1/2"OD Pleated Filter**	**HCF (6.25" OD)**	**UHCF (12.75" OD)**
Housing Depreciation	$400.00	$400.00	$400.00	$400.00
Filter Quantity	120	120	19	5
Filter Price	$9.00	$33.25	$267.75	$1015.00
Pounds of Dirt per Filter	0.4	1.7	17.0	85
Change Outs per Month	1.5	0.35	0.22	0.17
Change Out Time (Hrs)	4 Hours	4 Hours	2 Hours	1 Hour
Labor Cost per Hour	$25.00/hr	$25.00/hr	$25.00/hr	$25.00/hr
Disposal Cost per Filter	$4.00/ea	$4.00/ea	$25.00/ea	$105.00/ea

MONTHLY OPERATING PARAMETERS (36" ID Vessel, Contaminate Load 72 Pounds per Month)				
Parameters	**2-1/2" OD String Wound**	**2-1/2"OD Pleated Filter**	**HCF (6.25" OD)**	**UHCF (12.75" OD)**
Depreciation	$400.00	$400.00	$400.00	$400.00
Filter Cost	$1,620.00	$1,396.50	$1,119.20	$862.75
Labor Cost	$150.00	$35.00	$11.50	$4.25
Disposal Cost	$720.00	$168.00	$104.50	$89.25
Total Cost	**$2,890.00**	**$1,999.50**	**$1,635.20**	**$1,356.25**
Alpha Factor (Å)	22.5	19.6	15.8	11.9

Conclusion

In summary there are several important factors when selecting a filter for amine absorption systems:

- Filter elements used in amine systems should be constructed with a filter media that contains fixed controlled pore sizes.
- Beta ratios provide a profile of a filter's efficiency at different micron levels.
- A portable test stand unit should be used to provide on-site solutions for specific filtration problems.
- Total filtration operating cost must include: equipment depreciation, filter element cost, labor cost for element change out, and element disposal cost.
- A filter element's Alpha Factor (Å) is easy to calculate. The lowest Alpha Factor results in the lowest filtration cost.
- An increase in effective surface area or a reduction in flow rate will result in a significant increase in filter life.
- Fluid quality is an important aspect of operating an amine system. Operators should be able to test for fluid quality online or by using a representative sample.
- HE/HC filtration technology reduces filtration costs – both capital costs and maintenance costs – and is applicable to both retrofit and in new construction.

Cartridge filtration, integrated with activated carbon filter/polishing, will continue to be the basic separation operation in amine absorption systems. Most large-scale gas processing operations will utilize continuous slip-stream (side-stream) filtration to constantly upgrade the plant's regenerated amine — regardless of the type of amine used. The slip-stream will typically handle 20 to 30% of the circulating solution. [Small plants may actually be designed to handle 100% of the circulating/recirculating amine solution.] HE/HC filters are equally applicable to absorptive liquids that are not based on amines.

It is important that gas plant operators also recognize the importance of mechanical filtration in non-amine systems like those using glycol ethers or other solvents. These are usually organic solvents with equipment arranged in a variety of flow schemes and using solvents that act similar to amines in their absorptive characteristics. Such solvents may offer focused removal of carbonyl sulfide, mercaptans, hydrogen cyanide, carbon dioxide, metal carbonyls or other compounds. Some of these absorbents are chemically inert and not subject to degradation, but they still must be properly mechanically filtered to maintain absorbency. They can still experience foaming problems exacerbated by the presence if fine particulates.

Finally, operators should recognize that an activated carbon filter is critical to some operations to remove minute quantities of chemicals that cause foaming or for other reasons. But -- the activated carbon filter bed introduces finely divided carbon fines into the train. So, under normal conditions, the cartridge filter is placed downstream of the carbon unit in order to facilitate the removal of those carbon fines.

Foam control is a constant battle in amine processing facilities. Adding a foam control agent is expensive, and in some cases possibly would be unnecessary if the plant

filter was doing its job properly. It has been proven that fine particulates, when not removed from the amine solution, actually exacerbate foam production. The presence of solids stabilize foam. It is important that these solids be removed. Symptoms of problems include: overloading of gas knockout vessels, decreased flow rates and cause pump cavitations. While some foam can be expected in normal operations, in a really bad foaming incident, the tower will actually be filled with foam and foam will carry over into downstream equipment. While foaming can be tied to improper gas velocity in the unit, foam is almost always initiated by some type of a contaminant that can often be removed by proper filtration. Foam affects absorbency, and some suggest that it can add to amine degradation. Amine degradation means that the amine molecule breaks down into components that no longer absorb H_2S (or other gases such as carbon dioxide). Degradation should be determined by using chromatography in lieu of wet titration. The chemistry of degradation and its causes deserves close attention by a plant's industrial chemist, to include a maintenance look at how oxygen sources and acid sources are entering into the amine system. Oxygen and acid lead to degradation. For example, an amine coupled to an acid form an amine salt.

Heat stable amine salts add to a plant's operational problems including corrosion and high solvent (amine) loses. While these stability problems might be more common in amine units tied to refineries, it is important to understand that these salts (as many as ten types) have a significant negative impact on overall alkanolamine gas processing economics.

Ironically, simple operational changes in filter operations can alleviate bigger problems. One might suggest that the age and experience of plant personnel plays a role in a plant's ability to function properly. However, when it comes to filtration, neither the old timer nor the novice have been properly schooled in how filtration technology dramatically affects overall plant performance and overall plant economics.

APPENDIX A
THE BASICS OF AMINE FILTRATION

The process of removing hydrogen sulfide (H_2S) from natural gas effectively means that the equipment must deal with sulfuric acid (H_2SO_4) or other sulfur-acids within the system. This is because there is always some moisture present that allows H_2S or other sulfur compounds to form acid. This is also why H_2S itself is referred to as "acid gas".

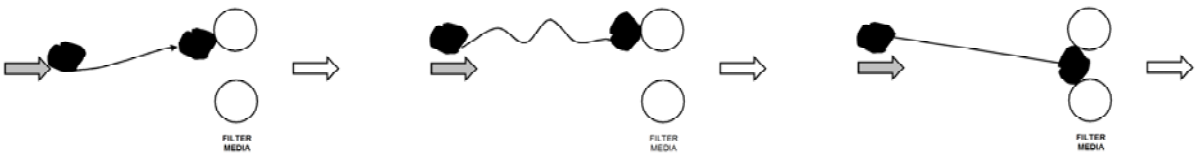
As a consequence, amine absorption and regeneration equipment is exposed to corrosive and oxidizing conditions. Coupled with dirt or foreign particulates in the natural gas, the conventional amines unit experiences the buildup of black sulfides and oxides and other particulates that must be removed in order to assure proper operation of the absorber and other equipment. The fine black particulates that form in the system loop must be removed by filtration.

The fine-particulate filter is normally placed in a slipstream loop around the cooler pump that carries regenerated/reclaimed amine back to the absorber-contact tower. This placement means that the filter is not exposed to (1) the heat of absorption from the absorber-contact tower, nor to (2) hot acid gas. The principles of filtration, therefore, become similar to standard liquid filtration.

Liquid Filtration is the process of separating suspended particles from a liquid by passing the stream through a permeable medium. Dissolved solids generally cannot be removed by filtration without some form of pretreatment. Filter bags and filter cartridges are typically used to remove particles that range in size between 0.5 and 70 microns. A micron represents a dimension of 0.001 millimeters or 0.000039 inches. As an example of size, the smallest particle that can be seen by the unaided eye is 40 microns in diameter.

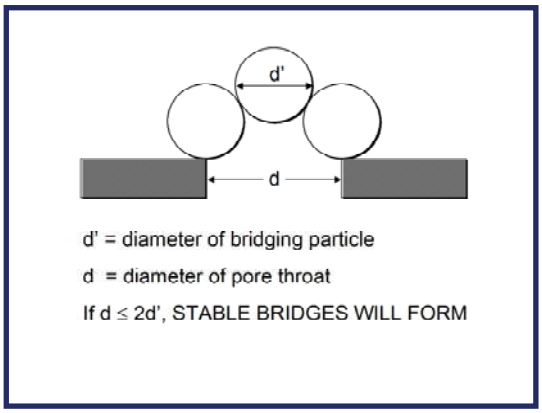
Basic Filtration Process

The basic mechanisms of filtration are inertial impaction, diffusional interception and direct interception. Since the density of a particle is typically closer to that of a liquid rather than that of a gas, direct interception is the desired mechanism for separating articles from liquids.



INERTIAL IMPACTION | DIFFUSIONAL INTERCEPTION | DIRECT INTERCEPTION

By combining the direct interception mechanism with particle bridging theory, we are able to explain why filter medium with specific size pores or openings are able to capture particles with smaller diameters than those of the pores. According to classic bridging theory, a stable bridge will form over a pore if two or more particles with diameters at least one half that of the pore diameter contact the opening at the same time. This newly formed bridge contains even smaller pores that in turn capture smaller particles.



Under certain conditions, collected particles can be released from the filter medium and pass downstream. Variations in flow rates and pressure surges are common causes of particle release. Even under ideal flow conditions, filters can release particles if their medium structure is subject to pore enlargement. This is a typical occurrence in string wound filters and low density felt bags whose pore sizes change in response to increased pressure. The best filters are designed with filter medium that have fixed pore structures that are not affected by variations in pressure and flow rate.

Filter Types

The most commonly used filters in amine filtration can be classified as having either a non-fixed random pore size medium or a fixed controlled pore size medium. Understanding the differences between these two types of medium is important in predicting how each of these filters will perform during the filtration process.

Non-fixed random pore size medium filters such as felts, woven yarns, packed fiberglass are constructed of media that contain pores of various dimensions that can enlarge as flow rate and differential pressure changes. These types of filters are subject to particle unloading, channeling, and media migration.

Fixed controlled pore size medium filters are constructed in a manner that prevents the pores from enlarging under pressure and flow changes. Although these filters contain pores of varying sizes, their overall pore structure is controlled during the manufacturing process to assure quantitative removal of particles larger than a given size. With this type of filter, any particles released during impulse conditions should be smaller than those designated by its removal rating.

Removal Ratings

Various systems for rating filter removal efficiency exist today. Two of the most common are the Nominal Rating and the Absolute Rating systems. Unfortunately, each manufacturer is free to utilize variations of the different testing procedures to assign the Nominal or Absolute Ratings of their specific filters.

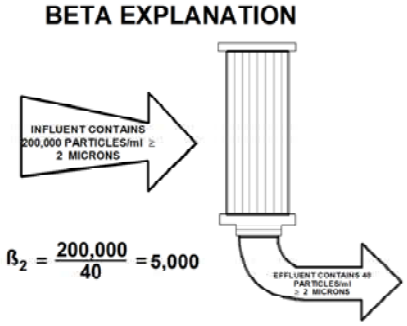
A Nominal Filter Rating is generally defined as an arbitrary micron value based upon the particle removal by weight of some percentage of all particles of a given size or larger. Common percentages used by various manufacturers include 98%, 95%, and 90%. This rating system bases results on gravimetric testing rather than actual particle counting. Problems associated with the Nominal Rating system include a poorly

defined test procedure, removal percentages may vary with manufacturer, test data is not usually reproducible, and it is not uncommon to find downstream particles larger than the micron rating of the filter.

An Absolute Filter Rating is generally defined as the diameter of the largest hard spherical particle that will pass through the filter under specific test conditions. Several recognized tests exist for establishing the Absolute Rating of a filter and their choice may vary with manufacturers. However, in all tests, the filters are subjected to a particle challenge by pumping a known contaminant through the filter and measuring upstream and downstream particle counts. Only fixed controlled pore size medium filters can have an Absolute Rating.

Beta Ratios

Beta ratios were originally developed for evaluating the performance of hydraulic and lubricating oil filters. Today, these ratios can be very useful in measuring and predicting the performance of Absolute Rated filters under specific test conditions in a variety of liquids.



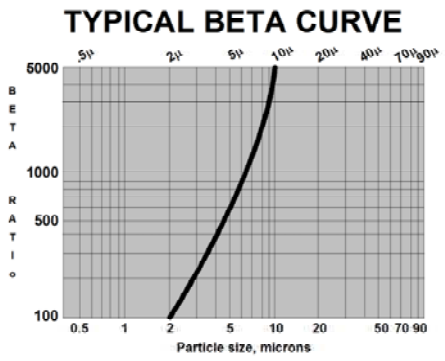
Beta Value x =

Number of Particles of Given Size $_x$ and Larger in Inlet

Number of Particles of Given Size $_x$ and Larger in Outlet

FILTER EFFICIENCY (%) = $\left[\frac{b - 1}{b} \right]$ **x 100**

The Beta ratio concept involves measuring total particle counts at several different micron levels in both the influent and effluent streams. These counts provide a profile of the filter efficiency at the different micron levels and can be plotted as a Beta curve for the given filter.



TYPICAL BETA VALUES

Beta Value	% Removal
100	99.0
1000	99.9
5000	99.98

APPENDIX B
THE IMPORTANCE OF DAILY TESTING OF PROCESS STREAM PARTICULATE BUILD UP

Without testing different filter elements under actual operating conditions, it is difficult to make a proper filter choice. But, this type of testing can be expensive.

However, a less expensive alternative involves using a portable test stand that is designed to provide on-site custom engineered solutions for specific fluid filtration problems. This unit assures the proper selection of filter medium for the desired level of filtration. It can then be used to determine the proper pre-filtration medium, if any, that will optimize filter life while minimizing filtration costs.

Portable

Test Stand

Overall filtration cost must include the capital cost of the equipment as well as the daily cost of operating and maintaining the system. Although most people usually understand the capital cost of the equation, many do not fully comprehend the costs associated with daily operation and maintenance. Operating and maintenance costs include: cost of the filter element; cost of labor installing and changing out the element; and cost of disposing of the element. This latter cost is very high if the material is toxic or hazardous. An example of calculating monthly operating cost follows on the next page.

Example:

Housing contains 120 filters costing $9.00 each.
Housing depreciation is $400.00 per month.
Filters are changed twice a month. Change out takes 4 hours.
Labor cost is $25.00 per hour.
Disposal cost is $4.00 per filter

Calculating monthly operating cost:

Depreciation	$ 400.00
Filter cost (120 x 9 x 2)	2,160.00
Labor cost (4 x 25 x 2)	200.00
Disposal cost (120 x 4 x 2)	960.00
Total Monthly Operating Cost =	$3,720.00