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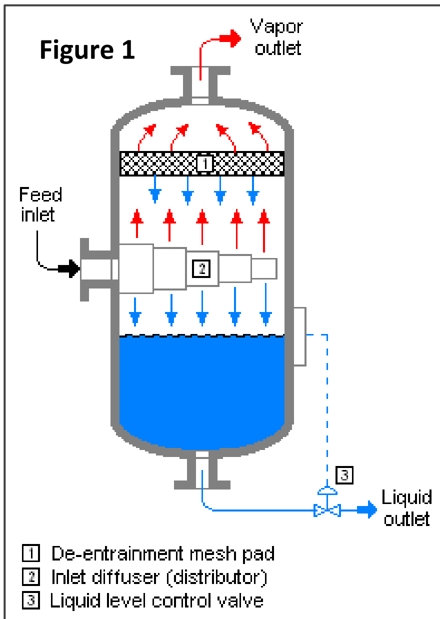
Inlet Feed Gas Separation Basics

Even in well operated plants, there are uncontrollable factors that generally cause a number of process upsets. Some of these factors are related to contaminants entering the plant via the gas feed. To better understand the ramifications, it is important to also understand what kind of contamination might be present in the gas stream. In addition to the gaseous hydrocarbon containing many contaminants such as H_2S and CO_2, the gas stream can carry many components generated in various upstream processes. These components include sand, slit, coke fines, catalyst residues, heat-stable salt precursors, corrosion products, cleaning products, produced water, additives (corrosion inhibitors and anti-foulants) and compressor lubrication oils among others. Most if not all of these components have some kind of surfactant activity or detrimental effect. The end result is that these contaminants can cause a multitude of process upsets and problems such as foaming, emulsification, erosion, corrosion, fouling, and many others leading to lower processing capacities, solvent losses, lower efficiencies, down time, and lower unit profitability. All of the inlet gas contaminants can exist in three possible states (solids, liquids and gaseous), making their effective separation rather challenging. In the solid state, it is generally found that iron clusters are predominant along with carbon fines. The majority of the contaminants in the liquid state are lubrication oils, cleaning products and water. Water can also contain a number of dissolved impurities such as chlorides and acetates. In the gas phase, the predominant contaminants are gases that act as precursors to heat stable salts (HCN, O_2, COS).

Figure 1



Inlet separation for gas streams is usually done using an initial knock-out drum or a demister with mesh pads (**Figure 1**). Some systems consider conventional horizontal filter-separators as well as cyclonic separator and vain-pack fitted devices. However, these systems are not entirely adequate for effective contaminant removal from the gas stream as they are typically designed for bulk liquids removal. In addition, none of these devices are really designed for solids separation (usually done by a wet scrubber or a particle filter) with the exception of cyclonic systems that could remove large solid particles and some liquids. Only a minority of plants have the necessary means to adequately condition gas streams prior to processing because of the diverse nature of the existing contaminants. *The most difficult and challenging contaminants in any gas stream are aerosols.* These are finely divided liquid particles with diameters ranging from a few hundred microns to less than 0.1 microns. Most of the approaches to separating liquid contamination from gas streams using demisters with mesh pads, vain packs or horizontal filter-separators have approximately 40-50% effectiveness at removing liquid aerosols.

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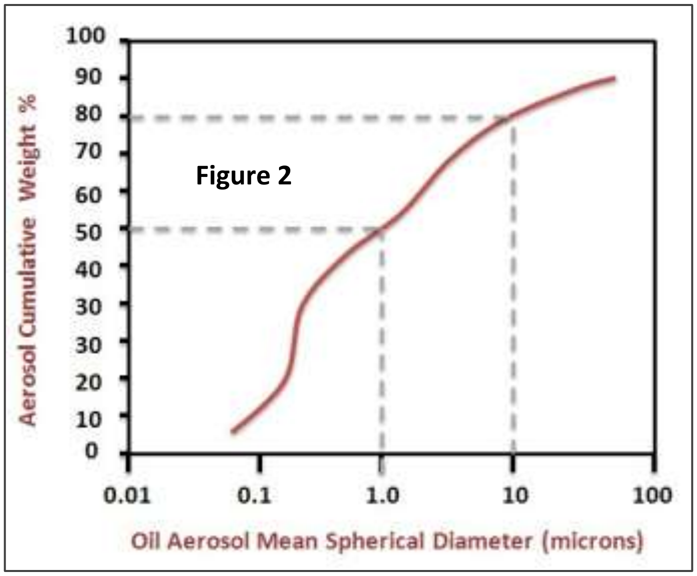
Aerosol removal inefficiencies are directly related to both aerosol droplet size distribution as well as flow configuration in the separation vessel. In other words, the separation media and the vessel design are not capable of intercepting and coalescing small liquid particles in order to promote separation. Most of the liquid aerosol droplets simply move through the vessel untouched. The internal flow configuration inside the vessel is also vital as, in many instances, the separation media is appropriate, but improper internal flow direction and routing in the vessel still causes considerable inefficiencies. Additionally, some vessel designs shatter liquid aerosols into smaller sizes and add even more difficulty to the separation.

Aerosol distribution in a gas stream is primarily in the sub-micron range. Larger droplets tend to not be as persistent in the gas stream as they are more likely to gravitationally drop out; they are also more likely to shatter due to the shear of the gas around the droplet surface. When large droplets shatter they create smaller and smaller droplets until the droplet distribution is stabilized by the balance between surface energies, gravitational settling and shear. The distribution of a persistent aerosol is therefore primarily sub-micron (>50% by weight are smaller than 1-micron, and over 80% of particle sizes will be lower than 10-micron) (**Figure 2**).



Horizontal Filter Separators are commonly used for aerosol removal. Computational fluid dynamics (CFD) analysis indicates that due to the outside-to-inside flow, there high velocity as the gas exits the coalescing elements. This can in many cases cause re-entrainment any previously separated liquids. In addition, a review of the flow configuration reveals that the elements in the lower part of the housing can be affected by liquid draining from the top elements resulting in saturation, increased entrainment and reducing the overall separation efficiency.

Recommendations for Inlet Separation

A typical inlet separation configuration for inlet gas aerosol separation is comprised of a demister with a mesh pad for bulk liquids removal. The mesh pad will also act as a slug catcher if needed. This device is required and should be used only for bulk liquids removal. Downstream of this device, there should be another separator called a "**Sub-Micron Microfiber Gas Coalescer"** equipped with instruments, valves and specially formulated microfiber coalescing media with the ability to intercept-coalesce all the sub-micron aerosols and drain liquids from the separation element properly and effectively.

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As indicated in **Figure 2**, sub-micron liquid particles compose more than 50% of the total liquid contaminant species in a gas stream. Sub-micron microfiber gas coalescers are carefully designed depending on the flow, pressure and temperature and must be installed as close as feasibly possible to the equipment or process it needs to protect. **Figure 3** shows a typical design of a high efficiency coalescer capable of removing on average 99.97% of all aerosols from 0.1 to 1.0 microns. These systems can be protected with a particle separator (*with the proper separation media*) in order to extend the on-line life of the coalescer and to minimize operational costs, as the replacement separation elements for particle filtration are less expensive than coalescing elements.

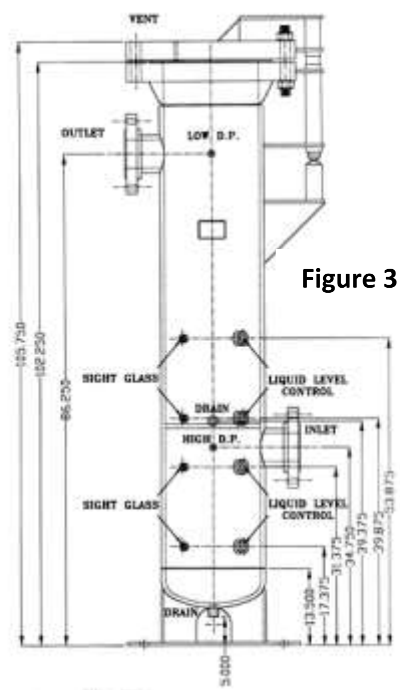

Figure 3

The system in **Figure 3** has the inlet on the bottom section of the vessel. The vessel has two stages; the bottom section is designed to remove larger liquid aerosols, and the upper high efficiency stage removes smaller aerosols. The bottom section can be fitted with a mesh pad, vain pack or designed in such way as to have cyclonic action. None of these methods have proven to enhance efficiency, however. The gas leaves the bottom chamber and flows into the second stage immediately above via the coalescing elements. This stage is where gas is passed through the formulated microfiber coalescing media. The fine aerosols are intercepted, coalesced and finally drained from the elements by gravity. Like the lower stage, the upper stage has a liquids removal system comprised of a level control and drain valves. The purified dry gas finally exits from the top of the vessel. Typical lifetimes for devices can vary anywhere from 6 months up to 2 years depending on the amount of solids entering the coalescing system. Many fabricators advertise that conventional systems are capable of removing sub-micron liquid aerosols; most do not correlate these expectations with actual performance. Only a small number of companies possess the technology to supply these high performance separators.

For more information, please contact **Amine Filtration** at Help@AmineFiltration.com