Technical Bulletin No. PB-899: ***Glass Fiber Media vs. Synthetic Media in Gas Turbine Applications***

Many owners and operators of Gas Turbines are asking the question *"should I be using air filters made of synthetic filter media or glass fiber filter media in my inlet air housings?"* Over the past decade, many types of filters have been introduced to the marketplace, some produced with synthetic filter media and others with glass fiber media. Considering the technological advances made in both media types, the choice of whether to use glass or synthetic filters has become an issue in many gas turbine systems around the world.

Koch Filter Corporation produces several types of filters, constructed with both media styles, for applications ranging from gas turbines to hospitals. In certain applications, such as hospitals and commercial office buildings, synthetic fibers have proven to be quite reliable and affordable. Tests performed in real-world applications as well as laboratory conditions have shown synthetic to work well in these relatively low moisture, low velocity applications. But in turbulent, corrosive, hydrocarbon-laden environments such as gas turbine air intakes, our tests have repeatedly proven that glass fiber media remains the medium of choice. Over the years, our studies have resulted in conclusive findings regarding the performance capabilities of glass fiber versus synthetic filter medias in those extreme environments.

The presence of hydrocarbons reduces the effectiveness of electrostatically-charged synthetic filter medias.

Unlike glass fiber medias, which rely solely upon mechanical filtration to achieve their desired efficiency, high efficiency synthetic air filter medias rely on an electrostatic charge to enhance efficiency. This electrostatic charge provides good initial efficiency ratings, low initial pressure drop, and is relatively effective in commercial grade filtration systems. But in gas turbines and other heavy industrial systems, hydrocarbons and other airborne aerosols are commonly present in the atmosphere. During operation, these contaminants will form a thin aerosol coating which will "mask" over the fiber, negating the electrostatic charge after a short period of time.[1] At the point where this "masking" occurs, the user will experience a "dip" or reduction in the filter's efficiency as the synthetic filter media loses its electrostatic charge and makes the switch from electrostatic filtration to mechanical filtration as its primary means of removing contaminant from the atmosphere.[2]

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[1] *Characterization of Synthetic Filtration Media and Filter Performance*, published by Farr Company, circa 1995.

[2] *The Role of Electret Materials in air Filtration*, published by Freudenberg Nonwovens North America, 1993

The diameter of the fibers in high efficiency synthetic filter media are generally substantially larger in diameter than the fibers found in high efficiency glass fiber filter media.[3] This allows the synthetic media to offer low resistance to airflow at the beginning of its lifecycle, but there is also a downside to these larger fibers. Because of the relatively large diameter of synthetic fibers, once the transition from electrostatic filters to mechanical filter occurs, synthetic filter media cannot possibly perform as well as glass fiber filter media in terms of efficiency and dust holding capacity.

The much smaller fibers in the glass media provide much greater mechanical filtration capabilities, and it becomes impossible for the synthetic media to be as efficient as glass media when both medias are acting as mechanical filters. Also, as the transition from electrostatically-charged filter to mechanical filter occurs, the synthetic filter may actually begin to release or unload contaminant downstream into the turbine, allowing potentially damaging fouling of the blades and compressor to occur.

Special Considerations for Coastal, Marine, and Offshore Installations [4]
In addition to the potential problems of using synthetic medias in areas where high concentrations of hydrocarbons and other contaminants are present, gas turbines in coastal, marine, and offshore installations present still more unique problems for inlet air filtration systems. Due to the large amounts of air required to operate a gas turbine, the cleanliness of the air is of primary importance for turbine performance and life expectancy. Contaminated intake air will cause erosion, fouling, corrosion, and cooling air passage plugging. In particular, due to their environs, coastal, marine, and off shore gas turbine applications are susceptible to hot gas path section corrosion by ingestion of airborne sea salt. Because of the dual nature of airborne sea salt, special considerations must be taken to insure gas turbine inlet air to be free of this contaminant.

Airborne sea salt varies in quantity due to wind and wave action. Sea salt density for a given time and place is a function of wave height, wind velocity and direction, temperature, humidity, and elevation. Salt content of air above or near the sea is from two sources; very fine droplets ejected from bursting bubbles (oxygenation) and course spray from whitecaps and breaking waves. Salt in a marine environment can exist in three forms: aerosol, spray, and crystal.

Sea Salt Aerosol
The generation of sea salt aerosol is a complex process of bubble film shattering on the sea surface. Most of the aerosol droplets are in the 2 to 20 micron diameter. The larger droplets have a high settling rate and drop back to the sea surface. Smaller droplets collide and

[3] *Air Filtration Efficiency Comparison Test, American air Filter versus Viledon*, published by American Air Filter, February 1989.

[4] *Special Considerations for Gas Turbine Coastal, Marine, and Offshore Installations*, published by Mueller Environmental Designs, 1997.

agglomerate into larger droplets and again fall back to the surface. The vast majority of aerosol droplets that escape into the atmosphere are less than 10 microns in diameter.

Sea Salt Spray

The creation of sea salt spray by wave interaction, moving ships at sea, or stationary platform structures in high seas, are responsible for generating large droplet sizes up to 200 microns in diameter. Because of their mass, the gravitational effect causes sea salt spray droplets to rapidly fall back to the surface. Additionally, wave spray acts as a wet collection system, washing the larger droplets back to the surface. Sea salt spray is locally generated in the immediate vicinity of wave action.

Salt Crystal

Salt crystal is always cubiform and hydroscopic in nature. Critical humidity of pure salt is 80% relative humidity. At this humidity, the salt crystal will continue to absorb moisture until it reaches super-saturation, at which time it deliquesces. The saline droplet is five times larger than the original crystal cubiform.

Therefore, at relative humidity below 70%, the salt is always dry and cubiform. At relative humidity between 70% and 78%, the salt crystal has not changed its shape, but is supersaturated. At 80%, the critical relative humidity, the salt crystal becomes a saline droplet 5 times its original size. The relative humidity between 75% and 80% is referred to as the dynamic range for salt.

The relative humidity at sea surface if 98.2%, the vertical distribution of the relative humidity 25 feet above sea surface track a logarithmic curve depending on wind velocity. The average relative humidity 25 feet above sea surface is around 80%. At 125 feet above sea surface, offshore operators with meteorological capabilities, have recorded frequently and regularly varying relative humidity, below the 70% to 75% relative humidity level where salt begins to change from dry crystalline to the dynamic super-saturated state.

Subsequently, the gas turbine inlet air filter design for coastal, marine and off shore installations must handle salt in its wet, dry and dynamic phases.

The wet and dry phases of airborne sea salt can be easily handled utilizing weather louvers, coalescers, pre-filter pads, and 90% ASHRAE efficient barrier filters. The dynamic phase of airborne sea salt represents the most difficult aspect of inlet air filtration due to the possibility in a change of state as the relative humidity rises and falls above or below the critical relative humidity.

To illustrate this problem consider the following scenario:

> *A typical inlet air filter system consisting of 2 ½ pass weather louver, coalescer pad, pre-filter, and high efficiency barrier final filter have been operating for several weeks in a warm, pleasant, dry period when the relative humidity of the ambient air has been below 70%. However, air*

entering the system does contain large quantities of dry salt crystals of 1 to 2 microns. The high efficiency barrier filter is doing a great job retaining millions of salt crystals within interstices of the filter media. Then the weather changes at the platform site. The relative humidity gradually increases above critical relative humidity of salt. There is no free moisture entering the filtration system. However, potential catastrophic conditions exist. The collected dry salt crystals, being deliquescent, have absorbed moisture in the vapor phase from the incoming airstream. The salt crystals are now in their dynamic phase and can hold no more moisture. The relative humidity exceeds the critical phase causing the salt crystals to deliquesce, forming saline droplets. If the high efficient barrier filter media is not waterproof, the saline droplets will leach through the media and into the turbine inlet. When saline droplets reach the second stage of axial compressor, the heat of compression is sufficient to evaporate the moisture. At this point, dry salt crystals enter into the hot gas section of the turbine. The filtration system has failed to accomplish its intended purpose.

To prevent system failure, high efficiency final filters composed of specialized glass fiber media, will collect and retain both liquid and solid particulate more efficiently than synthetic medias, protecting the substantial capital investment of a gas turbine.

For these important performance-based reasons, Koch Filter Corporation recommends filters constructed with dual-density, wet-laid glass fiber media (with aluminum separators or separatorless minipleat configurations) for all rotating machinery air intake applications.