CAMERON GREAT LAKES, INC.
MOLECULAR FILTRATION SPECIALISTS

Molecular Filtration: Principles and Design Parameters

The two principal methods of molecular filtration used in the commercial and industrial sectors are adsorption and chemisorption. While there are other methods available to remove contaminants from air streams they are generally more specialized and are not incorporated into an HVAC system; therefore they will not be addressed in this paper.

Adsorption is the process by which one substance is attracted and held onto the surface of another. It is a surface phenomenon. **Capacity is independent of particle size and the adsorption rate is inversely proportional to particle size.** Adsorption is generally associated with activated carbon, however there are other media, for example zeolites, used as well. There are numerous types of activated carbon, generally designated by its source, i.e. coal, coconut, wood, and several others. These various carbons come with different properties, including pore structure, pore distribution, and hardness to mention a few. The choice of a carbon in a given application is dependent upon a number of factors, which will be reviewed later.

Chemisorption is a chemical reaction on and in the surface of the adsorbent; it is fairly specific and depends upon the nature of the media and the contaminant. It is irreversible and essentially instantaneous. Chemisorption is associated with chemically treated activated carbons and potassium permanganate impregnated media. Chemically treated activated carbons are fairly specific for a compound or a chemical family. They also offer the added benefit of maintaining the adsorptive properties of an untreated activated carbon, thus making it a very versatile product, in an air stream where only one contaminant family requires the use of a chemically treated carbon. Potassium permanganate media is a much broader based oxidant. For example you would be capable of cleaning and air stream containing both formaldehyde and acid gases with a potassium permanganate media, whereas it would require two different chemically treated carbons.

In order to understand some of the design criteria it is important to review some of the terminology used in association with molecular filtration.

CONTACT EFICIENCY (E):
- The percentage of total contaminant molecules which have come into contact with the media.
- For (E) to approach 100 % the residence time must be around 0.07 seconds.

RESIDENCE TIME:
- The time it takes air to cross a distance equal to the thickness of the filter (or media bed depth) without accounting for the resistance of the media through which it travels.

REMOVAL EFFICIENCY:
- The fraction of the contaminant that, once in contact with the media, is removed by either physical or chemical means.

REMOVAL CAPACITY:
- The amount of the contaminant removed over the useful life of the media.

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DESIGN CONSIDERATIONS

Contaminant(s) & Concentration: This is necessary for the proper selection of media. The more specific the information the easier the selection. In many industrial applications this information is often readily available, however in commercial air quality situations it is much more arbitrary. In these instances one generally knows the source and from that can determine the contaminants that are most likely present.

Temperature & Humidity: Activated carbons and potassium permanganate media are not recommended for use in air streams with temperatures greater than 120°F. At relative humidities greater than 60% activated carbon will begin to adsorb water, somewhat decreasing its capacity for contaminants. This generally doesn't pose major problems, unless the humidity is very high and you have 100 % outside air.

Air Volume: When designing a system it is noted from above that we need a minimum amount of time (residence time) to effectively remove a contaminant. The volume of air being treated is critical to the design of the system.

Pressure Drop: The pressure at the given velocity must be within the capacity of the blower. This is often a problem when retrofitting an existing air handling unit that was not designed to accommodate the additional filter bank. The pressure drop of a carbon/permanganate filter bed does not increase with time. The exception to this are the disposable impregnated media filters using a non woven polyester or similar material that will remove particulate in addition to gases. In this instance in addition to the initial resistance one would need to know the filters rated final resistance. Note that carbon and permanganate filter beds should be protected with a particulate filter to protect the media from particulate contamination.

Removal Efficiency: We know that the removal efficiency required is different depending upon the application. In some critical application such as semiconductor or computer control rooms, high efficiency is required. Designing high efficient filters requires more detailed information on the exact contaminants and concentrations, whereas when designing for a commercial light odor complaint, one need only to drop the contaminant below it's odor threshold which may not require the same level of efficiency on a one pass. It is also important to remember that the efficiency of the filters will decrease with time.

Removal Capacity: Capacity will determine life of the filters and thus also affects filter selection. The type and concentration of contaminants in the air stream determine the capacity of the filter. One would not want to design a system with too short a life thus increasing maintenance/service costs.

Having the above information allows one to design a system that meets the requirements in a given application. There are a few other items to consider when designing and selecting a filter system and that involves maintenance and service. Access and location of the system may cause one to select a filter of a different size or weight to accommodate service personnel.

As with most filtration applications the more information you have, the more knowledgeable you are as to your customer's goals, the better you can design a system to meet all his needs. In many applications, some of the above information will be limited, thus it becomes critical to rely on similar installations and market knowledge of applications.