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Several Factors Play Role in GAC Selection

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Granular Activated Carbon (GAC) is commonly employed as an adsorption media in many surface water treatment plants. Many plants, however, also rely on GAC to provide filtration. Mesh size, manufacturing techniques and starting materials play important roles in filtration performance.

Coal is the most common starting material for GAC, and the three primary types are bituminous, sub-bituminous or lignite. The selection of the starting material greatly impacts the quality of the finished product as it relates to adsorption and filtration parameters. Equally important is the manufacturing process, which can be either a re-agglomeration process or a direct activation process.

The re-agglomeration process consists of the following steps:

1) A high grade metallurgical coal is pulverized to a powder approximately 50 micron in size.

2) A coal tar or petroleum base binder is added.

3) The product is re-agglomerated into briquettes under several tons of pressure.

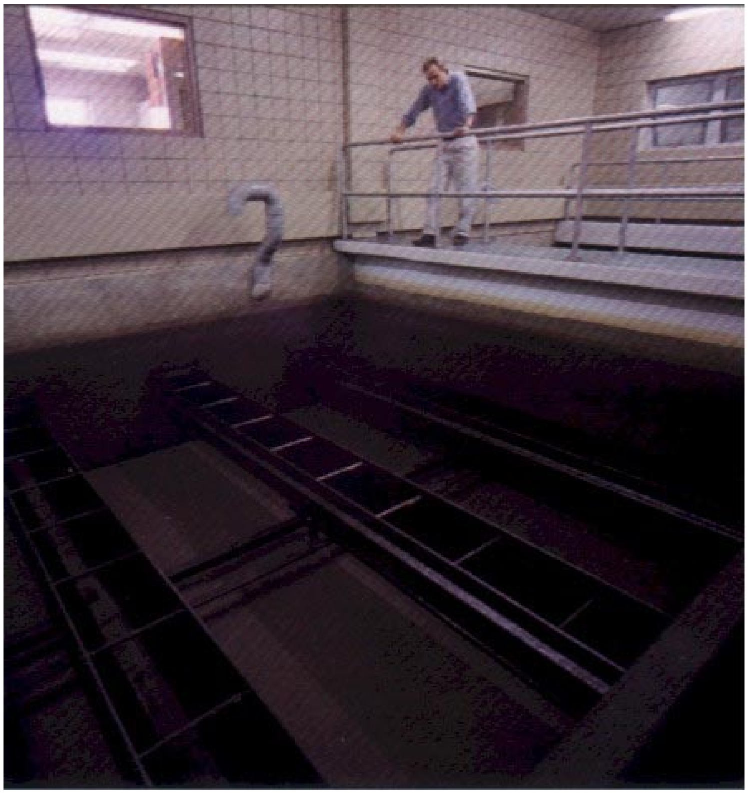
4) The briquettes are crushed to the desired size.

5) The carbon is baked to remove VOC’s at temperature up to 800 degrees F in a controlled atmosphere.

6) Finally, the carbon is thermally activated by exposing it to temperatures approaching 1900 degrees F in a controlled atmosphere.

The alternative to re-agglomeration is direct activation, which skips the initial steps and proceeds directly to crushing, sizing, baking and activation. Since the process must activate a relatively large granule completely from the outside, direct activation produces a granule with high surface activity on the outer shell and little surface area in the center of the granule.

These two different activation processes produce GAC with different performance characteristics. The re-agglomerated process produces an activated carbon that is much denser and more resistant to abrasion. Also, the addition of the man-made pores and the well distributed activity of the re-agglomerated granule allow increased adsorption performance in many applications.



Pictured is one of five GAC filters that comprise the shallow
bed system at the Robinson Township, PA, Water Treatment Plant.

Design Considerations

GAC particles are typically larger than the traditional sand media. A number of design and performance factors must be taken into consideration to properly employ the benefits of GAC in a surface water plant.

The different particle sizes available each have their specific niche dependent upon the application.

The particle size of GAC is described by its mesh size. Industry standards use the U.S. Sieve designation to denote particle size. This designation denotes two sieve sizes which describe the maximum and minimum size for the bulk of the material. For example, a 12 x 40 mesh GAC indicates that the bulk of the material would fall through a 12 mesh screen but be retained on a 40 mesh screen.

Initially, a 12x40 mesh GAC was the standard, as this size most closely approximated the effective size of sand. In an effort to retain the filtration properties but reduce head loss, the 8x30 product was introduced. This allowed for higher filtration rated and remains common in the municipal drinking water market. This move to the larger mesh size prompted the development of even larger GAC products such as the 8x16 and 8x20 products. These have been effective in direct filtration plants, as they allow deeper beds and higher filtration rates with acceptable head loss.

The GAC in a water filter is initially backwashed to segregated the granules. Following this backwash, the smallest granules will be at the top of the filter and the largest at the bottom.

The particle size distribution is further described by two parameters: effective size and the uniformity coefficient. The effective size is typically measured in millimeters (mm) and equals the diameter of the smallest 10 percent of the GAC granules. From a mechanical standpoint, the size of the GAC granules in the top part of the filter relates to the pressure drop and the filtration efficiency. The smaller the particle, the higher the pressure drop and the higher the filtration efficiency.

The uniformity coefficient is a dimensionless value that indicates the degree of uniformity of the GAC. A value of one (1) would indicate all particles are identical in size; greater values relate to a higher degree of variation. AWWA

Standard B604-96 specifically defines uniformity coefficient as "A ratio of the size opening that will just pass 60 percent of a representative sample of the filter material divided by that opening that will just pass 10 percent of the same sample.

Density, measured in grams per cubic centimeter (g/cc), determines the amount of carbon that is needed to occupy a specific filter volume. Higher density GAC is preferred for several reasons. First, high density GAC products have more carbon structure. In addition, a denser product indicates that for each cubic foot of volume, more GAC can be installed . The denser material also provides a stronger material which is better able to withstand frequent backwashing. With the limited space available in filters originally designed for sand filtration only, this becomes critical. Bituminous coal based GAC provides a much denser material as compared to lignite, and sub-bituminous alternatives.

The abrasion number defines the GAC's resistance to abrasion with a higher number indicating greater resistance. This parameter is important in municipal drinking water applications due to the rigors of routine backwashing that may rapidly degrade a softer GAC. When GAC is used for filtration, adsorption, and as a biological support media, this benefit is even more pronounced, as backwashing is required on a more frequent basis. Bituminous coal-based GAC offers the greatest resistance against abrasion as indicated by this measurement.

The amount of GAC to be installed for surface water treatment must provide sufficient contact time with the water to facilitate adsorption and provide enough be depth to allow for proper filtration. Both adsorption and filtration performance of the GAC are closely linked to the particle size.

As previously stated, a smaller particle size provides a higher degree of filtration. In addition, the deeper the GAC bed, the greater the filtration ability of the filter. One would think that the optimum solution for filtration would be a very deep bed of very fine particles. This does not, however, take into account the increased pressure loss associated with this approach. Certainly, the preferred solution would be the selection of bed depth and media size that provides sufficient filtration at a minimal head loss across the bed. This relationship between bed depth, particle size and filtration efficiency can be best expressed by the ratio: (depth of media)/(effective size of filter media), or L/de.

Typical surface water treatment systems require a gravity flow rate through the GAC bed. Maximum flow rates in shallow bed filters are typically in the 2-3 gpm/ft^2 range but can exceed 9 gpm/ft^2, especially with deep bed monomedia filters. The operational flow rate needs to provide the predetermined contact time for both adsorption and filtration and at the same time be rapid enough to maintain the economics of the plant.

Due to the build-up of filtered materials on the filtration media, periodic backwashes need to be performed. The common triggers for a backwash are: a) effluent water quality as measured by turbidity, particle count or both, b) timed basis, or c) head loss basis, Operator experience also contributes heavily to the start of the backwash cycle.

The backwash consists of the filter taken off-line and an aggressive countercurrent wash of the filter media bed. Although the rate and duration of the backwash vary depending upon the specifics of the installation, there are common practices. In plants which utilize a surface wash, it is common to backwash at a low rate to allow the surface wash to scrub the top of the filter. The backwash rate is then increased to 15-17 gpm/ft^2 for 10-15 minutes to wash the filtered particles from the filter.

In deep bed filters and those in difficult filtration situations, an air scour is used. Typically, the filter is drained to the surface of the filter media. Air is then injected at 4-8 scfm/ft^2 at pressures of 4-10 psi. The air is allowed to sour the entire filter from the bottom to the top. When this is complete, the air is turned off and the filter is backwashed at 15-17 gpm/ft^2 for 10-15 minutes to wash all removed particles from the filter.

It should be pointed out that as the temperature affects the viscosity of the water, the backwash rate must be adjusted to compensate for this temperature difference. For example, if the water temperature is 35 degrees F, a backwash rate of 10 gpm/ft^2 would expand an 8x30 bed 22 percent. If the water temperature increased to 75 degrees F, this backwash rate would expand the bed to only 10 percent. In the summer months with the increased temperature of the water, the backwash rate typically needs to be increased to compensate for this viscosity effect.

Compatibility with other media must be taken into account during the backwash step. Although some filters use

GAC only, many filters use a combination of sand and GAC for filtration. During the backwash process, the media bed will become fluidized and if proper attention is not paid to the compatibility of the sand with the GAC, intermixing and ineffective backwashing will occur.

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This paper was presented at the AFS Filtration Conference held in Boston, Massachusetts, April 6-9, 1999 and sponsored by the American Filtration and Separations Society.

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Reprinted from the May 1999 edition of **WATERWORLD**