Activated Carbon Prep Helps Ensure Full Bed Utilization

By Wayne G. Schuliger

Following proper operating procedures will help you eliminate high-pressure drop throughout the GAC bed, premature organics breakthrough, and increased carbon use.

Activated carbon systems range in size from one or two drums for treating small flows to dual pressure vessel systems containing as much as 9110 kg (20,000 lbs.) of granular activated carbon for treating high flows. The systems are popular for their:

- Ease of installation (GAC units can be pre-piped for series or parallel operation and can be shipped and on-line within 1 or 2 days);
- Ease of operation (after startup, except for periodic sampling and checks for pressure drips, the system only needs to be monitored during back-washing and carbon change out)
- Low capital cost (because units often are rented or leased instead of purchased, the only capital expenditures may be for onsite piping or foundations for the vessels); and
- Dependable results (units can remove most organics at the milligram-per-liter level completely from water).

As more facilities have begun to use granular activated carbon treatment, additional data about performance problems has surfaced. Unfortunately, many users assume that when they experience problems such as pressure drop, premature organic breakthrough, and decreased flow rate, something is wrong with the carbon in their systems. However, carbon quality rarely is the cause of performance problems; such problems typically are caused by users who fail to take the proper steps when putting a unit containing virgin carbon on-line. By familiarizing themselves with potential problems and how to prevent them, users can ensure that their GAC systems operate effectively and require minimal maintenance.

Problems associated with GAC systems vary depending on the stage of operation. Problems that arise shortly after startup and carbon change out include high-pressure drops, premature organics breakthroughs, and significant pH increases. Plant operators often assume that a high-pressure drop is due to excessive carbon fines in the bed, premature breakthrough is due to poor carbon quality or poor equipment design that results in channeling and a rise in pH is due to something leaching from the activated carbon. In most cases, none of these assumptions are valid.

Improper Activated Carbon Preparation

Improper pre-wetting of granular activated carbon is the root cause of many operating system problems and poor performance in many pilot tests, resulting in the rejection of activated carbon as a viable treatment option. If activated carbon is placed on-stream without being pre-wetted properly, air pockets develop in the carbon bed, causing high-pressure drop throughout the bed, premature organics breakthrough, increased carbon use, and reduced throughput.

In a typical coal-based granular activated carbon bed, 40% of the volume is void volume around the carbon particles, another 40% comprises the carbon’s pores, and 20% is skeleton carbon. As water enters the air-filled pores, air is displaced and enters the voids in the bed. As the water flows downward through the bed, the air forms pockets or bubbles that do not exit the bed but cause channeling, high-pressure drop, and premature organics breakthrough.

Unfortunately, wetting granular activated carbon properly can be time-consuming. In a typical system, carbon is only 90% wetted after 24 hours. Therefore, if an adsorber is put on-stream immediately after being filled with granular activated carbon and water, pressure will build and premature organics breakthrough will occur. The only practical solution is to schedule the arrival of the unit or carbon a day or two before it must be put on-line. The adsorber should be filled with water and allowed to stand at least 24 hours. For systems not designed to be back-washed, water should be drained and the vessel refilled with water.

For systems intended to be back-washed, back-washing granular activated carbon before putting it on-stream is essential. If this is not done, the activated carbon particles will not become segregated by size (small particles on top and large particles on the bottom). Consequently, when adsorption occurs and the bed is back-washed, the activated carbon particles will become reoriented and some of the larger particles, which contain adsorbed organics, will migrate to the bottom. Desorption then could occur and cause the contaminant concentration in the effluent to surpass the specified level before the carbon becomes saturated. The operator then would be forced to replace partially spent carbon with fresh granular activated carbon.

Once a bed is sufficiently back-washed, the particles become segregated and reorient themselves in essentially the same relative depth in the bed as they were in before back-washing. Therefore, the adsorption, or mass transfer, zone in the bed is not disturbed significantly. Thus, the solution to this potential problem is to backwash the bed at 25 to 37 m/h (10 to 15 gal/min * ft^2) for 45 to 60 minutes before placing the unit on-stream.

If a unit must be placed on-stream immediately, it should be allowed to stand for at least an hour, and then it should be drained and filled or back-washed. This procedure then should be repeated after 1 or 2 days.

pH Rise Phenomenon

When most carbons initially are put on-stream, effluent pH will rise to a value between 9 and 12, with the final value depending on the water source. This rise can hinder the carbon's ability to adsorb sufficient amounts of certain organics and also can cause iron or calcium to precipitate.

Researchers once believed that the rise in pH was caused by inorganics leaching out of the carbon. However, they now know it is due to the carbon's adsorption of chlorides, sulfates, nitrates, and other anions from the water. Water pH remains elevated until the carbon's pores become filled with these anions. Typically, 200 to 300 bed volumes of water must pass through carbon before pH drops to 8 or 8.5.

Four ways of dealing with the rise in pH exist. A facility with no upper limit specified in its discharge permit may choose to accept the rise. However, most facilities have an upper limit and must recycle the effluent from the carbon bed to a point upstream, add acid downstream of the carbon, or purchase pre-oxidized carbons.

High-pressure Drop

High-pressure drop, premature organics breakthrough, carbon losses, and carbon fines elution with intermittent operation are the most common problems that surface after a unit has been on-stream for several day, weeks, or months. Several typical causes of high-pressure drop exist:

- Suspended solids are present in the influent. Because carbon filters out suspended solids, if the carbon bed cannot be back-washed, a pre-filter must be installed upstream of the carbon. If the bed can be back-washed, back-washing should be performed on a regular basis.
- Iron or calcium deposits have formed on the carbon. When iron or calcium is the cause of pressure problems, the element should be removed from water before it reaches the carbon. One proprietary carbon can handle iron concentration up to 5 ml/L; higher concentrations would require excessively frequent back-washing.
- Air has entered the bed via the influent piping system, as a result of siphoning, or because of improper discharge-piping design. Air can enter the bed if the influent piping to the pump is not designed correctly. Care must be taken to ensure that the pump's suction piping is designed to prevent vortex formation in the supply tank and, therefore, introduction of air.