MetalEase-ALF™ Water Processing Procedure

The processing of water for the removal of arsenic and fluorides water is accomplished similarly with Granular Activated Alumina (GAA). The following procedure is a condensation of Frederick Rubel Jr's Design Manual for U.S. Environmental Protection Agency – "Removal of Arsenic from Drinking Water by Adsorptive Media (EPA/600/R-03/019, March 2003).

SYSTEM DESIGN CONSIDERATION

Empty Bed Contact Time (EBCT) = 5 minutes per vessel

GAA density = 45 pounds per cubic foot

Minimum Bed Depth of Media = 3 feet for vessel greater than 2 feet diameter

Flowrate = 1 to 5 gpm per square foot of vessel cross-sectional area
= 1.5 gpm per cubic foot of media
= 6.0 gpm per square foot of media maximum

Vessel height = the media depth plus 0.5 times the media depth plus 7 inches

MEDIA SUPPLY

Granular Activated Alumina normally is provided in 2000 lb polyethylene supersacks for ease of loading into large vessels, or in 50 lb polyethylene bags, or greater than 300 lb fiber drums. The supersacks have a bottom tied off opening that is cut and then the bottom of the supersack is cut to permit the GAA to flow into the vessel for the initial charge. Please do not untie the top string or the inner liner may fall into the vessel.

Normally, 50 lb bags are used to fill small units or to replace media loss after regeneration. Vary rarely are drums used in this application because of their bulkiness and special handling equipment that is required.

Occasionally, a metal hopper with a bottom valve is used for loading the media when replacing the media after regeneration. The hopper with the activated alumina is raised over the vessel manway and the valve is open to recharge fresh alumina into the vessel.

LOADING MEDIA

The vessel should be filled 50% with water. The water helps separate any activated alumina fines on the surface of the granular activated alumina and helps prewet the media.

Open the top manway and install the hopper or chute for loading the GAA.

Once all the GAA is loaded into the vessel, the manway is closed and preparation for backwash can begin.

Backwashing of the GAA is now required to remove fines, remove entrained air to prevent channeling, wet the media, and stratify the bed before adsorption can begin.

An upflow backwash at a minimum of 7 gallons per minute per square foot of cross-section vessel area (gpm/sq.ft.) should provide a 50% bed expansion. The minimum time for this backwash is 30 minutes with a maximum of 2 hours to permit removal of all the GAA fines. All fines can be collected and disposed of at a sanitary landfill or sent to a recycler of activated alumina.

After backwashing, drain the vessel to vacuum off ¼ inch of the top of the bed to remove any settled fines. The level of bed from the top manway should be measured and recorded.

The vessel is closed and filled with water to begin operation. A standard water treatment system requires two beds operated in series (lead/lag) to permit continuous operation. The second vessel should now be filled in a similar manner.

SYSTEM OPERATION

The optimum arsenic and fluoride removal occurs at a pH in the range of 5.0 to 6.0. Therefore, the pH of the raw water (inlet) must be adjusted to permit optimum removal of the impurities. Sulfuric acid (H_2SO_4) is added to the raw water to lower the pH to 5.5. The operation cost can be reduced if the pH of the water is 6.5. The water is pumped downflow though the first bed where the water is returned to either a surge tank or back to the well until the pH is correct. The same procedure is then followed with the second vessel.

All adsorption of the impurities occurs in the first vessel. When the arsenic breakthrough occurs from the first vessel (lead) the second vessel (lag) will adsorb the arsenic. Arsenic levels in the discharge will be nondetectable. The lead vessel can be operated until total saturation of the GAA occurs with the arsenic (concentration of arsenic into the vessel equal to concentration out of the vessel). The lead vessel is now taken off line and the lag vessel performs all the treatment. At this point every water treatment plant has several option as how to proceed.

a. For nonregenerable systems, the lead vessel is taken off line and the spent treatment media is replace with new virgin GAA.
b. For regenerable systems, the lead vessel then placed in regeneration.

The pH of the discharged process water from the treatment system during operation with both vessels in operation or just a single vessel has a pH of 5.5 or 6.5. The water pH should be raised to the desired pipeline specification by either chemical addition (NaOH), aeration, and/or blending with raw water. It is important that pH adjustment and stabilization occur before delivering the treated water for distribution.

REGENERATION PROCEDURE

Backwash Mode

Backwashing the GAA bed with raw water upflow when it is exhausted is critical to the regeneration process. First, any suspended solids filtered from the raw water during treatment are removed to prevent bed blind. Second, the GAA bed is expanded to prevent channeling and wall effects that could occur with the downflow process, compaction of the bed, and the introduction of suspended solids.

First, the bed should be drained of all water. The upflow backwash with raw water can begin at a rate of 7 gpm/sq.ft. for 28x48 mesh GAA to expand the bed 50%. Normal backwashing takes about 10 minutes, but—with observation of the backwash water this time—may be reduced if the water become clear. Backwashing should be minimized to prevent excessive wear on the GAA and to reduce wastewater disposal.

Regeneration Mode

Regeneration removes the arsenic ions from GAA before it is returned to process raw water. The pH must be raised to a minimum of 10.5 to break the adsorptive bonds of the arsenic ions from the GAA. The control of the regeneration mode is critical to low operation cost by reducing the amount of sodium hydroxide used and the breakdown of GAA by too high of a pH.

After backwashing has been completed, the bed should be drained of all water. This reduces the amount of caustic needed by preventing dilution due to an excess of water in the bed. The volume of 5% caustic solution required per regeneration step is 15 gallons per cubic foot of GAA (1 gallon of 50% caustic per cubic foot of GAA per regeneration).

Once the bed has been drained, a 5% caustic solution is pumped upflow at a minimum rate of 1 gpm/sq.ft. until the bed is flooded. The caustic pump is shut off and the raw water rinse is pumped upflow at a minimum rate of 2.5 gpm/sq.ft. for 60 minutes. At no time should this step exceed 90 minutes. The bed is then drained until the water level is at the top of the bed.

A 5% caustic solution is then pumped downflow at a minimum rate of 1 gpm/sq.ft. for 60 minutes. At no time should this step exceed 90 minutes. The bed is then drained until the water level is at the top of the bed prior to the start of the neutralization step (see below). The total regeneration time—exclusive of draining and flushing—should be 2 hours.

Neutralization Mode

The objective of this step is to return the bed to the treatment mode as rapidly as possible without dissolving the GAA. The pH of the GAA must go from 13+ to 5.5 to permit arsenic ion adsorption again. The pH of raw water is adjusted to 2.5 and is pumped downflow until the discharge water from the GAA reaches 8.0. When the raw water from the bed reaches 8.0, the inlet pH of the raw water is adjusted to 4.0 and pumped downflow to complete the neutralization. When the discharge water from the GAA reaches a pH equal to 6.5, the raw water in pH is adjust to the operating condition of 5.5. The GAA is now ready to be placed into the lag position.

Prior to placing the regenerated GAA into the lag position, the vessel should be drained to the top of the bed. The operator should open the manway and measure the level of the GAA. Approximately 5% of the GAA will have dissolved during regeneration. The operator should add new GAA to bring the bed height back to the original level. The vessel should be backwashed as described above and the water adjusted to a pH of 5.5 for 30 minutes. The vessel is now full regenerated and is placed in the lag position until it is time to be put in the lead position again.

SUMMARY OF TYPICAL PROCESS CONDITIONS FOR THE REGENERATION OF A GRANULAR ACTIVATED ALUMINA TREATMENT SYSTEM

<table>
<tr><th>STEP NO.</th><th>STEP</th><th>LIQUID</th><th>FLOW DIRECTION</th><th>RATE GPM/ SQ.FT.</th><th>TIME MINUTES</th><th>WATER GAL.</th></tr>
<tr><td>1</td><td>Backwash</td><td>Raw Water</td><td>Upflow</td><td>7</td><td>10</td><td>30</td></tr>
<tr><td>2</td><td>Regeneration</td><td>5% NaOH</td><td>Upflow</td><td>1.2</td><td>60–90</td><td>15</td></tr>
<tr><td>3</td><td>Rinse</td><td>Raw Water</td><td>Upflow</td><td>2.5</td><td>60</td><td>30</td></tr>
<tr><td>4</td><td>Regeneration</td><td>5% NaOH</td><td>Downflow</td><td>1.2</td><td>60–90</td><td>15</td></tr>
<tr><td>5</td><td>Neutralization</td><td>Raw Water adjusted to pH 2.5</td><td>Downflow</td><td>Varies</td><td>Time to acheive pH of 8.0</td><td rowspan="3">240</td></tr>
<tr><td>6</td><td>Neutralization</td><td>Raw Water adjusted to pH 4.0</td><td>Downflow</td><td>Varies</td><td>Time to acheive pH of 6.5</td></tr>
<tr><td>7</td><td>Neutralization</td><td>Raw Water adjusted to pH 5.5</td><td>Downflow</td><td>Varies</td><td>Time to acheive pH of 5.5</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>Total</td><td>330</td></tr>
</table>

The operating cost for various treatment options (including chemicals, labor, utilities, GAA, and parts) range from \$0.27/1000 gallons of treated water for a GAA system with regeneration and pH adjustment to \$2.52/1000 gallons of treated water for a GAA system with spent media replacement and no pH adjustment (see EPA design manual – EPA/600/R-03/019 page 62).

The capital costs will vary depending upon the type of plant required, the amount of automation, and volume (see EPA design manual – EPA/600/R-03/019 Appendix D). The range for a 50 to 700 gpm treatment system is between \$74,000 and \$689,000 based on August 2001 prices.

DISPOSAL OF LIQUIDS AND SOLIDS

The bed is regenerated with caustic to removal the arsenic. The arsenic and the alumina is collect in a holding tank or basin. The pH is reduced from >12.0 to 5.5. At this time the dissolved alumina in the liquid re-precipitates and extracts the arsenic from the water on the GAA. The precipitate is collect and in the past has been classified as nonhazardous and sent to a sanitary landfill. The liquid may have a small percentage of arsenic in it and can be reprocessed. The same procedure will also occur with the treatment of fluorides.