https://doi.org/10.1002/opfl.1278

Richard R. Ross, Gerry Baker, and David Lucey are with WesTech Engineering (www.westech-inc.com), Salt Lake City.

Buoyant Media Can Improve Treatment Efficiency

Two utilities using clarifiers with heavy media sought to increase water production and reduce losses. By switching to adsorption clarifiers with buoyant media, the plants captured more solids and reduced chemical costs, waste production, and filter backwash frequency.

BY RICHARD R. ROSS, GERRY BAKER, AND DAVID LUCEY

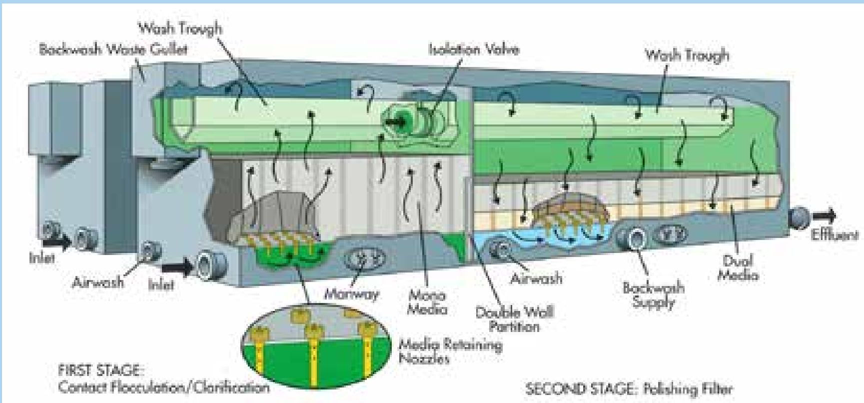
AS COMMUNITY drinking water demands rise, utilities are reconfiguring treatment systems to become more efficient. This allows them to increase water production, optimize costs, and reduce downtime for clarifier flushing and filter backwashing.

Operators at two surface water treatment plants reviewed their treatment processes and determined the clarification stage wasn't efficient. They found alternatives to increase net production and reduce chemical costs and waste production. Both plants replaced high-rate clarifiers, which can be found in many water treatment plants before filtration, with adsorption clarifiers that combine mixing, flocculation, and clarification in a single system. "High rate" means the hydraulic loading rate could be 5 gpm/ft^2 or greater.

The flow path with a high-rate clarifier is simple. Raw water flows into the plant and is typically dosed with a coagulant (and/or optional polymer); it then flows into the bottom of the clarifier. The clarifier media capture coagulated solids as the treated water flows upward until it reaches a terminal head loss, when the trapped solids must be flushed to waste. Flushing trapped solids uses raw water and air to scour the media, releasing more solids that have been adsorbed on the media surface. Changes in influent water quality (suspended and coagulated solids) and chemistry can cause the clarifier to clean more or less frequently. Adsorption clarifiers combine mixing, flocculation, and clarification in a single system.

Figure 1. Steel Packaged Treatment Unit

A typical heavy media clarifier and mixed-media filter package treatment unit has two process steps: upflow clarification followed by downflow filtration.



MEDIA TYPES

There are two types of media used in adsorption clarifiers: buoyant and heavy (nonbuoyant). Buoyant clarifier media have a specific gravity less than water. Before flow begins, the media rest against a top screen. As raw water flows upward through the adsorption clarifier, the screen holds the media in place, neutralizing the forces acting in the flow direction. As raw water flows through, the buoyant bed of the adsorption clarifier flocculates solids and removes them by adsorbing the floc onto the surfaces of the media grains. It traps and stores floc in the pores between the grains of the media bed.

To improve operations, the George R. Sweeney Water Treatment Plant converted seven clarifiers with heavy media to upflow adsorption clarifiers with buoyant media.

PHOTOGRAPH: WESTECH ENGINEERING

Nonbuoyant clarifier media in other systems have specific gravities greater than water. Before flow begins, the media sit on a bottom screen or other supporting device. As raw water flows upward through these systems, gravity holds the media in place. The media will remain in place if the downward gravitational force acting on them exceeds or equals the upward drag and buoyancy forces.

Heavy media clarifiers flocculate solids and remove them by one or more similar mechanisms, and they store floc in the media beds' pores. In both types of systems, these removed solids offer additional resistance to the flow of raw water, increasing the head loss across the bed as the filtration run progresses. This "developed head loss" must be added to the clean bed head loss to determine the total head loss across the media bed at any time during the process.

CLARIFIER EXAMPLES

Clarifiers can be contained in concrete basins or steel packaged treatment units. For example, Figure 1 shows a typical steel packaged treatment unit with two process steps: upflow clarification followed by downflow filtration. The first clarifier compartment contains a heavy media. The clarifier media sit on a plate-type support with media-retaining nozzles. The filter in this plant uses dual media; it could be a mixed-media configuration as well.

In a clarifier bed that has no top screen or similar device to hold the media in place, the media can be lifted when the total head loss across the relevant portion of the bed exceeds a differential head for that portion of the bed plus any frictional resistance. If that happens, the lifting will continue until the pressure imbalance that caused the lifting is relieved, at which point the part(s) of the bed that lifted will subside.

Several factors determine how the pressure imbalance is relieved. Unless a cleaning cycle relieves the pressure imbalance first, some part(s) of the bed will give way to relieve it. That part of the bed will release some solids that were trapped in it as a "burp" or "spike load" onto the polishing filter. It's impossible to predict what part(s) of the bed will give way or how much of the solids trapped there will be released.

The polishing filter will probably trap most of the burped solids. However, downflow filters work best when solids are applied to them at relatively stable rates. A burp or spike load onto the polishing filter may break through it, posing a risk of undesirable solids and/or pathogens such as *Giardia* cysts or *Cryptosporidium* cysts passing into the drinking water supply. Even if the polishing filter does trap all the burped solids, those solids will increase the polishing filter's head loss, which may mean a shorter filter run and possibly lower net production.

Figure 2 shows a packaged treatment unit with two process steps as well, but this unit uses buoyant media in the clarifier.

The clarifier media beds resist the raw water flow. For raw water temperatures of 0°–20°C, this resistance is called clean bed head loss. For a buoyant adsorption clarifier operating at the typical rate of 10 gpm/ft^2 of clarifier bed area, the head loss is typically less than 18 in. of water column (0.65 psi).

If head loss across the adsorption clarifier bed increases unexpectedly because of a rainstorm or other turbidity event, the top screen prevents burps and spike loads, thereby reducing the chances of undesirable particulates and pathogens such as *Giardia, Cryptosporidium*, viruses, and bacteria passing onto the filter.

In these cases, the inability for heavy media to effectively capture solids resulted in shedding more solids onto the filter, which shortened filter run time between backwashes. Also, cleaning a single clarifier consumed large amounts of water for rinsing. This increased costs because treated water is used and the unit wasn't treating and producing water while it was in cleaning mode. Excessive rinsing—often used to clean the clarifier as best as possible—allowed more media to be lost through the waste troughs. This reduced the bed depth and further decreased the solids holding capacity and clarifier run time between flushes.

The case studies found that replacing heavy media with buoyant media significantly improved clarifier and filter operation. The buoyant media clarifier captured more solids, reducing the frequency of filter backwashes and waste production. In one case, there was a 500 percent increase in solids holding.

With less time spent flushing the clarifier and less frequent filter backwashes, the plant had more up time to produce water. Filter run times between backwashes more than doubled, and costs were reduced by using less treated water for flushing. Because of the nature of the solids holding capacity in a buoyant media design, about 50 percent fewer chemicals were required, which reduced operating costs.

CASE STUDIES

The two water treatment plants that put these principles into practice are the George R. Sweeney Water Treatment Plant, operated by the Municipal Authority of Westmoreland County (Pa.), and the Huntsville Water Treatment Plant, Dallas, Pa., operated by Pennsylvania American Water. Both implemented WesTech Adsorption Clarifiers to improve operations. The Sweeney plant is located at the Beaver Run Reservoir in Bell Township, Pa. This pristine and protected reservoir, constructed in 1952 and enlarged in 1962, has a capacity of 11 bil gal and a safe yield of 45 mgd. The 24-mgd water treatment facility went online in July 1997 and used heavy media in its seven clarifiers. Plant operators sought to increase the plant's net water production more efficiently and operate more closely to the design flow than it had been. However, a tremendous amount of water was used to frequently flush the clarifiers and backwash the filters.

Plant superintendent Jack Ashton reported the plant's clarifiers took 45 minutes to flush; to flush all of the basins, it took upward of 10 mil gal as well as one filter being backwashed about every three hours. With the excessive amount of flushing required to clean the heavy media clarifiers, a lot of media was lost through the wash troughs. All the filters, raw water pumps, and high-service pumps were recently rebuilt and serviced, so the operators believed the biggest obstacle was the original clarifiers with heavy media.

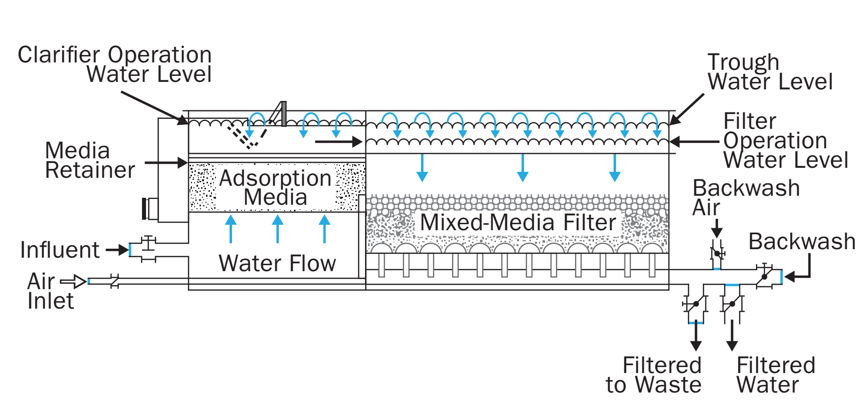
The Huntsville plant had faced similar performance issues. The facility was constructed with four heavy media clarifiers feeding four filters, which provided only minor reductions in turbidity through the clarifier. To improve the plant's operation, the clarifier was converted to an upflow adsorption clarifier with buoyant media.

Although clarifier flush cycles didn't substantially change, dramatic reductions in clarified effluent turbidity were observed across the retrofitted clarifiers. Because adsorption clarifiers efficiently capture coagulated particles, filter runs were increased from a typical 40 hours to more than 100 hours. The result for the facility was a 40 percent increase in capacity and a 50 percent reduction of filter wash water.

At the Sweeney plant, the goal was to upgrade two basins to receive raw water in the spring, summer, and late summer/early fall (August–September 2015) to see how they perform under various conditions. (In the fall, operators tend to see significant changes in

Figure 2. Filtration Mode

This packaged treatment unit has a buoyant media clarifier and a mixed-media filter.



Each plant was able to reduce waste, meet its service area's water demands, and optimize filter runs thanks to simple clarifier changes.

The Huntsville plant improved operations by converting its clarifiers to upflow adsorption clarifiers with buoyant media.

PHOTOGRAPH: WESTECH ENGINEERING

pH, which they believe influences the performance of the units.) Then, assuming all went well, they planned to have all seven basins installed by the end of 2015 because the plant had a contract to provide water to the neighboring town of Monroeville in March/April 2016.

Gibson-Thomas Engineering worked with Sweeney plant personnel and WesTech Engineering to develop plans, specifications, construction sequence, and performance monitoring to convert the seven clarifiers from heavy media to an upflow adsorption clarifier with buoyant media in time to meet the additional water demand.

Several basins were measured, and detailed drawings were made before bidding to determine what was needed to replace the clarifiers. New raw water piping, air distribution headers and laterals, and a support system for the adsorption clarifier media retaining screens were required. Typically, the adsorption clarifier basins don't exceed 11 ft wide; however, these basins were much larger at 29 ft wide.

Measurable successes would be the performance of the adsorption clarifier in removing solids effectively, the amount of water needed to flush them, and the wastewater produced. Additional benefits were expected from increased filter run time between backwashes.

POSITIVE RESULTS

According to Chris Light, Sweeney's plant manager, as of August 2019 the new adsorption clarifiers are operating well.

- Wastewater samples taken off the heavy media clarifiers during a flush showed solids content of about 50 NTU in the waste stream. Conversely, samples taken from the new buoyant media adsorption clarifiers ran about 250 NTU. This indicated there was a 500 percent increase in solids capture with the new adsorption clarifier.
- The clarifier run time was about 16 hours between flushes (versus 45 minutes for the heavy clarifier media mentioned previously).
- The new clarifiers require only about 30 percent of the amount of raw water to flush compared with the older units with heavy media.
- Filter run times with the previous units were about 40–60 hours before backwashing. Often the clarifiers would burp solids onto the filters, shortening the run time and rapidly increasing head loss across the filter, putting the filter in backwash mode frequently.
- The filter run time using the new buoyant media clarifiers increased twofold, backwashing at 95 hours and not even reaching terminal head loss at that time. The Pennsylvania Department of Environmental Protection required that it not exceed 100 hours.

In both cases, operators sought to expand their water treatment plant production capabilities by taking advantage of relatively new technologies. They evaluated what was needed to meet current and future regulatory requirements. As a result, each plant was able to reduce waste, meet its service area's water demands, and optimize filter runs thanks to simple clarifier changes.