## Water Professionals at Your Service!

# Using Media Inspection & Maintenance for Filtration Optimization

Filtration remains one of the most important steps in water treatment today. With increasing regulations, the filtration process has become even more crucial to the overall water quality leaving the facility. In down economic times, new technologies such as granular activated carbon and membrane filters are often not feasible for small water systems due to cost constraints. Improved performance, longevity and reduced costs can be attained for existing filters with proper operations and maintenance of these systems, thus chemical cleaning solutions should be considered as a cost-effective alternative to expensive plant upgrades and treatment changes.

**Filtration Systems Impacted by Regulatory Changes**

The emerging EPA Long Term 2 Surface Water Rule requires additional filtration performance and the Stage 2 Disinfection Byproduct Rule makes it impractical to feed high dosages of chlorine to improve filterability. Both of these regulations entail improved performance requirements, while placing additional loading demands on the filter media. As a result, many systems have moved away from pre-chlorination and have begun utilizing pre-oxidants, such as potassium or sodium permanganate. The use of these pre-oxidants has in turn lead to a significant increase in organic and inorganic contaminant buildup on filter surfaces and filtration media. Moreover, overfeeding coagulants to improve total organic carbon (TOC) reduction affects the inorganic constituent levels and has a tendency to scale and encapsulate filter media, actually decreasing the media's ability to perform. Further, this buildup can change densities of the media, affecting backwash flow rates, expansion, turbidity break through, as well as reducing capacities to operate at designed filtration rates – all factors that increase operational costs due to lost water and excess energy consumption.

**The Importance of Operation & Maintenance of Filtration Systems**

Filtration systems are extremely complex pieces of equipment that provide results based on the physical and functional design of the process, as well as the influent water to be filtered. While state regulatory agencies require periodic inspections of all portions of the water treatment process, filtration systems by design and location are very difficult to inspect due to confined space limitations and operational complacency. For this reason, not only are they often overlooked, but the filtration media is rarely inspected until an issue arises with its performance. It should be noted that if severe conditions occur such as flooding, extremely high turbidity or unusual flow patterns during backwashing, the filter process should be investigated as soon as practical.

To remain most efficient and effective, filtration media, regardless of its type, should be inspected at least once a year. An annual inspection should include laboratory analysis of a core sample of the media to determine the viability of the media particles, as well as the depth and proper stratification of the layers. Media density, particle size and uniformity should also be thoroughly evaluated. Once this annual assessment has been performed, it is critical to keep this recorded to construct quality control benchmarks to compare past and present filter performance. This data will be foundational for water plant personnel to determine inconsistencies and accurately diagnose problem sources within the filter before major issues arise and cause large-scale and cost prohibitive failures in the filtration system.

Additionally, each filter is a distinct piece of equipment and all filters will not operate the same due to hydraulics and mechanical configurations. Therefore, each filter should be individually assessed for best operational control.

**Filter Media Sampling and Testing**

The operating capacity of the media is the most critical component of the filter's overall performance. Overtime, media becomes fouled with organic and inorganic matter, reducing absorptive sites, altering media densities and causing media channeling. As this process of encapsulation continues, several problems can occur ranging from shorter filter run times, higher head loss, increased turbidity, lower filtration rates, increased risk of contaminant breakthrough and inadequate bed expansion during backwash. All of these negatively impact costs and can usually be avoided with diligent media management.

Encapsulation is often confused with rounding of the media, which leads many operators to incorrectly assume the media is worn-out and requires replacement. Figure 1 demonstrates that the apparent rounded media could be completely restored after being cleaned with a chemical solution. Therefore, proper testing of filtration media is an integral part of operating and maintaining filtration systems.

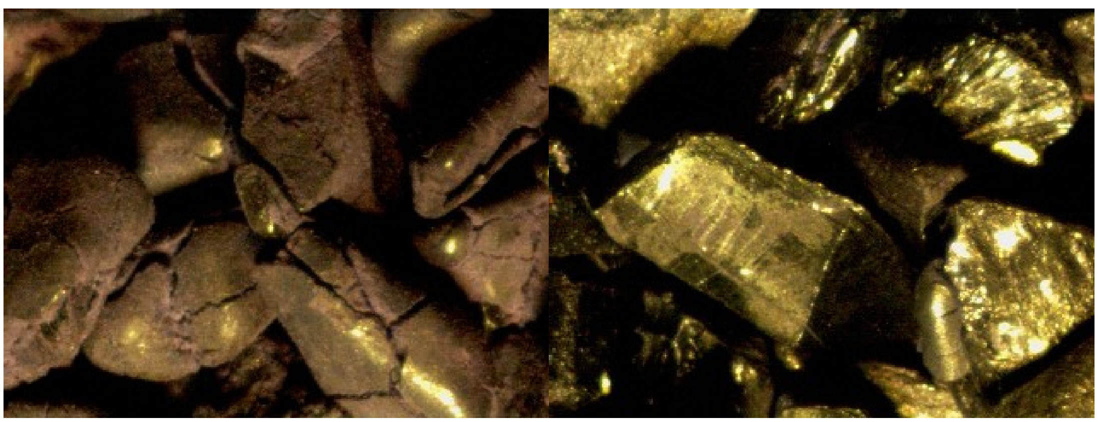

**Figure 1: The sharp angles of apparently rounded media (l.) are restored after cleaning (r.)**

To determine whether or not filter media can be chemically cleaned or if it has degraded to a point that replacement is more cost effective, controlled laboratory tests must be performed. For proper testing, samples taken from the filter bed should be representative of the particular media types and the physical size of the filter. In the lab, media will be tested for its current density in a dry state. Microscopic examinations reveal the angular surface areas of the media particles, and detailed sieve tests determine the effective size and uniformity coefficient ranges for the media. These tests allow for a comparison of the sampled media to accepted specifications of density, size and uniformity coefficients of standard media materials.

If preliminary lab testing concludes that the media can be effectively cleaned with a chemical solution, then additional tests can be performed to determine the composition of the contaminant buildup. Providing a complete analytical testing of the constituents attached to the media is the best way to decide which chemical solutions should be applied, the quantities of chemicals needed and how effective they will be at removing the deposits from the filter media.

Laboratory cleaning procedures will determine what constituents have been removed and the volumes of constituents removed. This is measured by the dry weight of the media before and after cleaning. The weight loss difference will be a direct correlation of the total constituents removed from the media. Laboratory cleaning results will be applied to the overall specifications of the filter media and provide an estimate of how many pounds of contaminants can be expected to be removed from the entire filter bed.

This is accomplished by examining the chemical solution and rinse water mixture to determine what constituents were removed from the media during the cleaning process. Often times, this process will reveal coagulant residuals, iron, manganese, calcium or other constituents that are found in the raw water supply that have been encapsulated around the media particles.

These analytical results are very important because they provide a baseline which will assist in determining the optimal intervals between media cleaning and inspection. Furthermore, they can provide a window into treatment that may suggest changes in coagulant feed rates to improve filter performance or treatment efficiencies of the sedimentation process and loading on the filtration system. The results can be analyzed from year to year to see the overall operation control of the filtration system (See Table 1).

**Table 1**: Amount and composition of the constituents removed during standard laboratory cleaning.

| Filter ID<br>Standard Cleaning | | 4 |
|---|---|---|
| | | |
| Anthracite | | |
| | Dry Weight Loss | 4.0% |
| | Total lbs removed | 984 |
| | Mg removed (ppm) | 448 |
| | Ca removed (ppm) | 2,467 |
| Sand | | |
| | Dry Weight Loss | 0.8% |
| | Total lbs removed | 399 |
| | Mg removed (ppm) | 112 |
| | Ca removed (ppm) | 519 |
| | | |
| Combined | | |
| | Total lbs removed | 1,383 |

**Two-step Media Cleaning Application**

Varying chemistries have been utilized to clean filtration media with less than stellar effects due to the lack of proper testing, application and experientially developed methodologies. New advancements in cleaning technologies and a more thorough understanding of chemistries has allowed for more specialized chemical formulations to be generated. These formulations are NSF 60 certified and safe to use in-place – the filter media does not need to be removed from the filter. These chemical formulations are designed to clean several varying types of filtration media and can be utilized in all current filtration system configurations. They can also be used to remove surface stains from filter walls and troughs.

The most applicable approach is a two-step cleaning process which utilizes powdered chemistries that have slow dissolution rates and are applied with an activation catalyst. This approach is proven to be much more effective than traditional liquid cleaners.

In step one of the cleaning process, the powder formulation is mixed with water and pumped as slurry on top of the filter media bed. This step allows for coverage of the cleaner over the entire surface area of the filter and allows for penetration throughout the media depth. In step two, an activation catalyst is added to the mixture and allowed to mix utilizing air scourer or surface sweeps. The catalyst starts the reaction of the cleaning process and allows for organic breakdown to speed up the removal process. The amount of residence time that the cleaning chemistry stays in contact with the media is very important. The slurry must sit long enough to penetrate the depth of the media through to the underdrains. This can be accomplished in a 24 hour period on most projects, but is dependent on the severity of the fouling. As previously mentioned, the use of a catalyst increases the efficiency of the cleaning process and aids in the removal of organic and inorganic contaminants from the encapsulated media. Adding the catalyst at varying times can improve the cleaning process and is proven to be more effective with air agitation or mixing.

Typically, the chemical cleaning solution is left to sit overnight to ensure full removal of deposits. Once the solution has penetrated the media and soaked through to the underdrains, backwashing is performed until the backwash water runs clear. Often times, several short backwashes are better than one extended wash. This allows for bed expansion and improved water contact with media particles. Depending on rinsate disposal methods, the backwash water may need to be neutralized before being discharged to a sludge lagoon or sanitary sewer system. Figure 2 shows what the backwash water normally looks like after a filter cleaning.

The entire cleaning process is much less labor intensive and time consuming compared to complete replacement. A typical filter cleaning requires a three man crew and can be completed within 24 hours. Cleaning process and instructions are provided in a step by step checklist to ensure proper cleaning and safety procedures and protocols are executed.

**Figure 2: Typical backwash water after cleaning the filter media**

To demonstrate the effectiveness and longevity of chemical cleaning, a water treatment plant in the New Jersey area that was scheduled for media replacement in 2004 opted to clean their three filter pressure vessels. The original media was installed in 1992 and lab testing showed black crust and brown grainy deposits on the greensand and anthracite media. Nickel-sized mudballs and other solid aggregates were also present in the samples. After performing the two-step chemical treatment on all three filters, approximately 10,000 pounds of contaminants were removed and the 13-year-old greensand filters were restored to near new operating conditions for one-third of the price of media replacement saving the utility over $100,000. This cleaning was performed in 2005 and is still operating within specifications in 2010.

**Benefits and Costs of Chemical Cleaning**

Expected benefits of in-place media cleaning include reduced head loss, reduced effluent turbidity, improved media stratification, longer filter run times, improved backwash flow, reduced chlorine demand, removal of mudballs and other particulates, prevention and reversal of cementing and extended media life.  In addition, while the media is being cleaned the entire vessel can be cleaned to remove contaminates that have accumulated on the side walls, troughs and wetted surfaces. This will allow for a much better inspection of all wetted surfaces and will enhance the appearance. It will also improve performance due to reducing disinfectant demand or prevent sloughing off of material into the filter bed.   Figure 3 depicts a filter basin before and after applying the chemically cleaning solution to the walls and troughs.

**Figure 3: The spray-on/rinse-off chemical cleaning solution makes it easy to remove unsightly surface stains from filter basins.**

Furthermore, the application of the cleaning chemistries has proven to restore nearly any media back to original specifications at a significantly lower cost compared to replacement.

Table 2, based on actual cleaning projects, shows a cost comparison of media cleaning and full media change-out. For all media types, cleaning is less than half the cost of replacement.

**Table 2:** Replacement versus Media Master/ Catalyst Cleaning Costs for Various Media Types

| Media Type | Replacement Cost* | Cleaning Cost** |
|---|---|---|
| **Filter Sand** | $40/ft^3$ | $23/ft^3$ |
| **Anthracite** | $55/ft^3$ | $23/ft^3$ |
| **Greensand** | $65/ft^3$ | $30/ft^3$ |
| **GAC** | $80/ft^3$ | $30/ft^3$ |
| **Zeolite Resin** | $110/ft^3$ | $30/ft^3$ |

* Includes average labor and average shipping

** Includes catalyst, neutralization process and average shipping

For example, a 320 square foot dual media filtration system utilizing Wheeler underdrains was recently cleaned at an average cost of $16,850 per filter. The cost to replace the media was bid at $43,320 per filter unit. Chemical cleaning of their filtration system provided a savings of $26,470 per filter unit. This savings was sufficient enough to allow the system to clean all four filter units in one year while remaining within their yearly maintenance budget. After cleaning, the system realized a 30% reduction in backwash flushing over the prior year's operation. Moreover, the cleaning allowed for more flow to be processed per filter unit, improved turbidity removal and increased filter run times.

**Conclusion**

Filtration is a critical step in potable water treatment and its effectiveness is directly proportionate to the condition of the filtration media. With more importance being placed on log reduction in the filtration process, the optimization of filter performance is critical to meeting the ever-increasing regulatory requirements. Annual filter assessments, including media sampling and analysis is more important than ever and should be a part of an optimization program to maintain superior performance. This can be accomplished at a much lower cost than complete media change out. With utilities facing strong economic pressures, filter media cleaning is an effective solution with near and long-term benefits that can and should be part of the maintenance budget instead of being treated as a capital expenditure. Through annual monitoring and inspections, optimization of filtration systems can be much less stressful and inexpensive compared to media replacement.

**About the Author**

Bob Cashion is the Business Development Manager for S4 Water Sales & Service located in Bowling Green, KY. S4 Water Sales and Service provides water treatment chemistries, scale and corrosion inhibitors,   cleaning solutions infrastructure for industrial, commercial, municipal water treatment infrastructure. Bob is a Certified Water Technologist with over 38 years of experience and specializes in chemical treatment programs and applications. Cashion can be contacted at rkcashion@s4water.net or (270) 790-2726.