Filtration Media: Making the Right Choice: A Reference Guide for Dealers

By James A. Hunt

Summary: *With filtration products, determining effectiveness of a particular media can get fairly involved. Each may involve various processes and determining their capability for the intended application often is very scientific. Thus, selecting the proper media for your solution can be a true art as well.*

This discussion of filter media is intended to be a comparative summary of the products commonly used in residential and commercial pressure filtration. The topics covered here include descriptions, applications and operation guidelines. For basic principles of filter media, see Figure 1. For a comparison of filter media, see Table 1. There are any number of media available that could be included in this article, but we have limited this list to media that are in common use.

Activated alumina (AA)

Activated alumina is a mixture of amorphous and gamma aluminum oxide—amorphous meaning without structure; gamma meaning a specific type of structure—prepared by temperature dehydration (300-600°C) of $Al(OH)_3$.[1] The removal process is termed surface adsorption, which relies on the exchange of a surface hydroxide for the contaminant anion. AA is regenerated with sodium hydroxide and, in some applications, may also require an acid rinse. AA may be used to remove fluoride, arsenic, selenium, silica and humic acids—all of these involving adsorption. Adsorption, in which one substance adheres to the surface of another, is extremely pH dependent and works best here in the 5.5-6 pH range.

Density (lb / ft^3): 43*
Bed depth (inches): 36+
Service flow (gpm / ft^2): 1-2**
Backwash flow (gpm / ft^2): 8-10

* Pounds per cubic foot.
** Gallons per minute per square foot.

Anthracite

Anthracite coal when crushed and graded makes an ideal medium-weight filter media. Because of its irregular shape, sediment penetrates deeper into the bed resulting in longer service runs.[2] In recent times, anthracite has been primarily used in dual or multimedia filters. Coal can be used to cap greensand and is often used with sand. It's also available in several grades or sizes.

Density (lb / ft^3): 50
Bed depth (inches): 24-36
Service flow (gpm / ft^2): 5
Backwash flow (gpm / ft^2): 12-18

Birm ®

Birm is a trade name for a manganese dioxide-coated media. The result is a lightweight product that has catalytic oxidizing capabilities. The catalytic activity is between dissolved oxygen in water and iron, and manganese in the water supply. The chemical reaction causes the iron and / or manganese to precipitate (change from dissolved to a particulate) and the particulate then attaches to the surface of the media.[3]

Density (lb / ft^3): 40
Bed depth (inches): 30-36
Service flow (gpm / ft^2): 3.5-5
Backwash flow (gpm / ft^2): 10-12

Corosex ®

Corosex is trade name for a highly reactive magnesium oxide used to neutralize free carbon dioxide in water. It's used in high flow pH correction situations. Limitations include the propensity to overcorrect in low-flow or intermittent-use applications. In waters containing medium to high hardness, calcium may precipitate resulting in cementing of the media.[4]

Density (lb / ft^3): 75
Bed depth (inches): 24-30
Service flow (gpm / ft^2): 5-6
Backwash flow (gpm / ft^2): 10-12

Calcite

Calcite is a naturally occurring calcium carbonate media, made from crushed marble, or limestone.[5] This is a self-limiting neutralizer because it readily dissolves in the presence of acidic water but is practically insoluble in non-acidic water. When the acid is neutralized, the media no longer dissolves. The amount of calcite required is related directly to the amount of CO_2 in the water. CO_2 can be calculated if you know the pH and alkalinity. In the process of neutralizing the acid, it forms alkalinity. The more calcite you dissolve, the higher the resulting alkalinity of the water.

Density (lb / ft^3): 100
Bed depth (inches): 24-30
Service flow (gpm / ft^2): 2-6
Backwash flow (gpm / ft^2): 10-12

Filter-Ag ®

Filter-Ag is a trade name for a crystalline quartz material designed to be a lightweight "sand." It has an irregular surface, which increases surface area over many natural silica products. And it's intended for removal of suspended solids (turbidity).[6]

Density (lb / ft^3): 25
Bed depth (inches): 24-36
Service flow (gpm / ft^2): 5
Backwash flow (gpm / ft^2): 8-10

Garnet

Garnet is a high-density, small-mesh silicon dioxide, whose trace elements cause a very heavy form of sand. Due to its density, it usually classifies on the bottom and aids in very fine filtration.[7] Garnet is seldom used alone as filter runs would be very short. It's used in dual or multi-media filters where larger particles are filtered by lighter, larger mesh media on top.

Density (lb / ft^3): 140
Bed depth (inches): 10+
Service flow (gpm / ft^2): 10
Backwash flow (gpm / ft^2): 25-30

Granular activated carbon (GAC)

To manufacture activated carbon, charcoal is treated with high temperature steam or solvents. The activation process creates cavities in the charcoal resulting in a high surface to volume ratio. The high surface area gives GAC greater adsorptive capacity. GAC can be made from any charcoal, but coal, animal bones, wood and nut shells—particularly coconut—are commonly used. In powdered form, activated carbon can be used alone as a filtration media or reconstituted with a binder to a desired mesh size to form carbon block in a variety of shapes.

Bituminous coal accounts for most of the GAC in this country with coconut GAC commonly used in point-of-use drinking water applications and

Figure 1. The basic mechanisms

Filtration occurs in multiple mechanisms. One is simply a sieving action for removal of suspended matter, where anything larger than the spaces between grains of media is trapped. Filter media remove suspended particles to a smaller micron size than the spaces between granules. Grains of filter media are typically in the 300-1,700 micron size with spaces between them of 25-500 microns. The ability to filter to below the actual inter-particle space size is due to other attachment mechanisms—that's when particles adhere to the surface of the filter media.

This process is influenced by a number of variables including gravitational settling, diffusion, interception and hydrodynamics. These variables are in turn affected by physical properties such as filter size, filtrate rate, fluid temperature, density, size and shape of suspended matter as well as pH along with electrostatic forces (such as Van der Waal's forces) that involve electron attraction and repulsion.[1] Moreover, we use filter media that's formulated with additional characteristics including oxidation, reduction and neutralization qualities. All filter media requires backwashing, some utilize a regenerant and many have water constituent limitations or requirements.

As a consequence of the complexity of the filtration process with granular media, the service flow rates on product literature are estimates at best. Because of varying physical or chemical characteristics, some filter media may be better at removing particular contaminants than others. The measure of a given filter media's surface area can also affect its ability to remove certain constituents. If the flow rate exceeds the design rate, poor filtration or high pressure loss is likely. Backwash rates are designed to fluidize (lift and expand) the filter bed based on the density of the filter media. Low backwash rates result in incomplete cleaning of the bed and premature failure of the filter. Backwash rates that are too high can result in the loss of filter media.

Table 1. Filter media comparison

MEDIA	LB/C.F.	SERV GPM PER S.F.	DELTA P PSI	PK GPM PER S.F.	DELTA P PSI	Bed depth inches	BKWASH GPM*	USE	LIMITS
AA	43	1-2	<1	2	<1	36+	8-10	Arsenic, Fluoride	pH
Anthracite	50	5	<1	5	<1	24-36	12-18	Sediment	
Birm	40	3.5-5	<1	5	<1	30-36	10-12	Fe, Mn, H_2S	Dissolved oxygen
Corosex	75	5-6	1.5	6	2	24-30	10-12	Neutralization	Hardness & alkalinity
Calcite	100	2-6	1	6	2	24-30	10-12	Neutralization	Alkalinity
Filter AG	25	5	2	8	3	24-36	8-10	Sediment	Chlorine
Garnet	140	10	<1	10	1.2	10+	25-32	Sediment	Large particles
GAC Cl	25	3-5	<1	5	1	24-36	8-10	Chlorine	
GAC Organics	25	1-3	<1	3	<1	24-36	8-10	Organics VOCs	Flow rate
KDF 55	171	15		30		10+	30	Chlorine, H. metals	TDS >150, BW GPM
KDF 85	171	15		15		10+	30	Fe, Mn, H_2S	TDS >150, BW GPM
Greensand	85	2-5	2	5	4	30-36	12-15	Fe, Mn, H_2S	Regenerant
MTM	39	3-5	<1	5	<1	24-36	8-10	Fe, Mn, H_2S	Regenerant
Multi-media	92	10	6	16	11	36	15	Sediment	
Pyrolox	125	5	<1	6	<1	24+	25-30	Fe, Mn, H_2S	Dissolved oxygen BW GPM
Sand	100	3-5	<1	5	<1	18-30	15-20	Sediment	

* For 60 degrees F water. Warmer water requires smaller flow rate, colder requires a higher rate.
Note: All flow rates are per square foot of filter surface area. Multiply all values given by the filter tank square foot value.

MTBE reduction. Acid or water washing is sometimes used to reduce many contaminants naturally present in the carbon source or formed during its activation. This includes soda ash content that may elevate the pH of water passing through the GAC.

There are several measures of GAC quality including Iodine Number, which is a measure of the amount of iodine adsorbed by weight. Iodine is used as an indicator of the adsorptive capacity but there's no direct correlation between iodine and other constituents, so applications must be done with care.

GAC is used to reduce organics, volatile organic compounds (VOCs), and taste and odor causing constituents. The best uses of GAC *does not* include sediment removal. Most suspended solids will fill the cavities in GAC, thus reducing its surface area and adsorptive capacity.

Density (lb / ft^3): 25
Bed depth (inches): 24-36
Chlorine removal service flow (gpm ft^2): 3-5
Organic removal service flow (gpm / ft^2): 1-3
Backwash flow (gpm / ft^2): 8-10

KDF55 ®

KDF process media are a trade name for a high purity copper-zinc granules (50 percent Cu; 50 percent Zn) that use the redox (the exchange of electrons) to remove chlorine and heavy metals. It's also bacteriastatic. It has a high service flow rate compared to other filter media.[8] KDF works best in a pH range of 6.5-8.5 so when outside that range some pH adjustment is required.

Density (lb / ft^3): 171
Bed depth (inches): 10+
Service flow (gpm / ft^2): 15
Backwash flow (gpm / ft^2): 30

KDF85 ®

KDF process media are a trade name for a high purity copper-zinc (85 percent Cu; 15 percent Zn) granules that offer a large oxidation potential to remove iron, and hydrogen sulfide. It's also bacteriastatic. It has an unusually high service flow rate compared to other filter media.[8] KDF works best in a pH range of 6.5-8.5 so when outside that range some pH adjustment is required

Density (lb / ft^3): 171
Bed depth (inches): 10+
Service flow (gpm / ft^2): 15
Backwash flow (gpm / ft^2): 30

Manganese greensand

Manganese greensand is naturally occurring glauconitic greensand coated with manganese resulting in a purple-black media. It's also an alumino-silicate like a zeolite, which has natural softening properties. The intended use is as a contact oxidizer for precipitation of iron, manganese and hydrogen sulfide. Greensand is continuously regenerated (CR) with $KMnO_4$ (potassium permanganate) and / or chlorine. Greensand may also be intermittently regenerated (IR) with $KMnO_4$. CR capacity is 10,000 parts per million (ppm) per ft^3 when regenerated with potassium permanganate and is calculated by $KMnO_4$ demand; where iron = 1:1, manganese = 1:2, and hydrogen sulfide = 1:4 ppm. That translates as removal of 10,000 ppm iron alone, 5,000 ppm manganese alone, or 2,500 ppm hydrogen sulfide alone. IR has half the capacity of CR or 5,000 ppm. It's common practice to place a layer of anthracite on top of the greensand in CR applications.[9]

Density (lb / ft^3): 85
Bed depth (inches): 30-36
Service flow (gpm / ft^2): 2-5
Backwash flow (gpm / ft^2): 12-15

MTM ®

MTM is a trade name for a granular manganese dioxide filtering media used for reducing iron, manganese and hydrogen sulfide from water.[10] MTM works in the same fashion as greensand including regeneration with $KMnO_4$ and / or chlorine. The primary difference between MTM and greensand is that MTM is manufactured with a lightweight core. This lightweight property reduces backwash rates and its larger partical size reduces pressure drop of service flow.

Density (lb / ft^3): 39
Bed depth (inches): 24-36
Service flow (gpm / ft^2): 3-5
Backwash flow (gpm / ft^2): 8-10

Multimedia (multi-layer)

The practice of layering several different media (usually 3 or 5) results in higher service flow rates and finer filtration down to 10 micron. The media are loaded by density and reverse grading. The most dense media with the smallest mesh size is loaded first and the least dense with the largest mesh size is loaded last with intervening media layered in the same manner. Mesh size isn't as important as density, as the heavier particles generally find their way to the bottom. Still, using this reverse grading, larger particles are largely filtered in the first or top layer and successively smaller particles are adsorbed in succeeding layers. The most common media mix from top to bottom is: anthracite, filter sand, garnet 30×40, garnet 8×12, gravel 1 / 8× 1 / 16, and gravel 1 / 4×1 / 8. Gravel is considered support media, not filter media. While any combination of media can be labeled multimedia, the above section has come to be called "multimedia."

Density (lb / ft^3): 92
Bed depth (inches): 36
Service flow (gpm / ft^2): 10
Backwash flow (gpm / ft^2): 15

Pyrolox ®

Pyrolox is a trade name for a mined ore (manganese dioxide) used for iron, manganese and hydrogen sulfide reduction. Pyrolox—like Birm—acts as a catalyst to oxidation. Waters low in dissolved oxygen cannot use the catalytic properties of Pyrolox. It doesn't require a regenerant but must be backwashed aggressively. Backwashing causes the media to abrade itself

Figure 2. Sizing calculations

In addition to selecting appropriate media for a filter application, sizing cannot be ignored. Obviously, one must size for normal service flow, but peak flow and backwashing requirements must also be considered.

Most filter media have negligible pressure drop at the recommended service flow rate and can easily handle peak loads without pressure loss concerns. There are exceptions, however, where double the service flow rate of 11 gpm would result in a pressure loss of 18 pounds per square inch (psi).

In some water, filter quality suffers with any flow disruption. Peak flows should be limited to the gallons of the empty bed volume (EBV) of the filter. In other words, if you have a 10×54-inch filter tank, the peak volume shouldn't exceed 17 gallons (see *Table 2*).

Backwash rates are often double or triple the service flow rate causing problems if the filter was sized to handle the total available flow from a well pump. If the well pump delivers only 10 gpm, it will be difficult to reach a backwash flow rate of 15-20 gpm.

resulting in a new exposed surface. Inadequate backwash rates and low dissolved oxygen are the two primary causes of filter failure when using Pyrolox.

Density (lb / ft^3): 125
Bed depth (inches): 24+
Service flow (gpm / ft^2): 5
Backwash flow (gpm / ft^2): 25-30

Sand

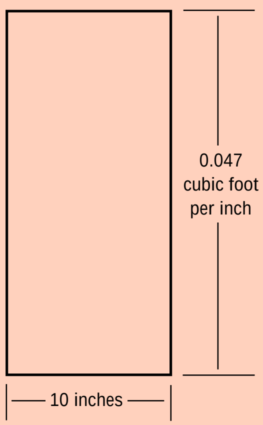
Filter sand is naturally occurring, graded and washed silicon dioxide.[11] It's used for sediment filtration (as well as iron removal) and is often part of a multimedia mix. An inert media, it has a long service life and is resistant to breakdown due to excessive pressure or turbulence. Sand filters mimic nature's filtration and may be the oldest manmade filters. Moreover, they're the most commonly used in municipal and small community water systems.

Density (lb / ft^3): 100
Bed depth (inches): 18-30
Service flow (gpm / ft^2): 3-5
Backwash flow (gpm / ft^2): 15-20

Conclusion

Using the formulas or values in the Tank Formula Chart referred to in Table 2, one can size applications appropriate for each. In the strictest sense, all filter applications and proper sizing are pure science. In practice, you often don't have the space, flow rates, pressure or budget required. The art of filter applications is balancing what you want with what you have. Thus, the proper application of filter media is both an art and a science.

Table 2. Tank Formula Chart



Square foot = ((D/2)^2 x 3.14)/144
Example (10 x 54 tank):
10/2 x 10/2 = 25
25/144 = 0.545 Ft^2

Cubic foot of a vessel = D^2 x H (inches)/1,728
Example (10 x 54 tank)
10 x 10 = 100 x 54 = 5400/1728 = 3.125 Ft^3

Gallon volume of a tank = D^2 x H (inches) x .0034
Example (10 x 54 tank)
10 x 10 = 100 x 54 = 5400 x .0034 = 18.36 gal

Dia.(inch)	Ft^2	Ft^3/inch	Gal/inch
8	0.349	0.037	0.218
9	0.442	0.047	0.275
10	0.545	0.058	0.340
12	0.785	0.083	0.490
14	1.068	0.113	0.666
16	1.396	0.148	0.870
20	2.181	0.231	1.360
22	2.638	0.280	1.646
24	3.140	0.333	1.958
30	4.906	0.521	3.060
36	7.065	0.750	4.406
42	9.616	1.021	5.998
48	12.560	1.333	7.834
54	15.896	1.688	9.914
60	19.625	2.083	12.240

References

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4. *Corosex and Corosex II*, Form No.2387, Clack Corporation, Windsor, Wis., February 1999.

5. *Calcite*, Form No. 2386, Clack Corp., Windsor, Wis., February 1999.

6. *Filter-Ag*, Product Specification sheet, Clack Corp., Windsor, Wis.

7. *Garnet*, Form No. 2355, Clack Corp., Windsor, Wis., February 1999.

8. *KDF 55 Process Medium in Point-of-Entry Water Treatment Systems—Chlorine Reduction*, Form No. 1003-596 AMS, KDF Fluid Treatment, Three Rivers, Mich.

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