SQUARE FOOTAGE AND DESIGN PHILOSOPHY AS APPLIED TO REGENERATIVE MEDIA FILTERS

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This topic has come up repeatedly over the years. It is probably time to revisit the issues involved based on recent popularity of Regenerative Media Filtration products.

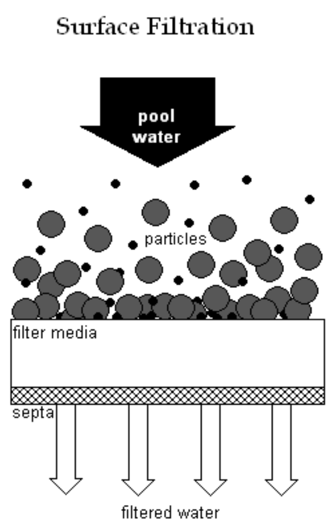
First of all, it would seem that there is a need to clarify the distinction between surface filtration and depth filtration (occasionally referred to as matrix filtration) processes. Based on our discussions with many design and industry professionals, there are a number of misconceptions existing regarding the two methodologies and their implementation with respect to recreational water filtration.

Precoat media filters are surface filtration based products. Somewhat simplified, filtration takes place only at the surface of the filter cake usually referred to as the precoat. The precoat media (usually diatomaceous earth or perlite) is a porous powdered material with channels or pores of varying size and shape. The grade of material is selected by air classification to produce powders with a given particle distribution roughly centered around the median particle size (greatly simplified). Through this classification process, a variety of filter aids can be produced for various filtration applications.

These air-classified materials are specified by various parameters: permeability, median particle size, and bulk density among others. Filter media manufacturers usually provide some guidance regarding the particle removal efficacy of their products. A rough estimation for a given particle removal size is related to the permeability of a particular filter aid. Minimum particle size removal for common filter aids can range from .3 microns up to 15 microns. In recreational water filtration, filter aids are generally chosen to provide filtration in the 1-3 micron range.

The above mentioned pores and channels determine the minimum particle size that will be trapped at the SURFACE of the filter cake and NOT proceed through the support layer of precoat. This is commonly called the “exclusionary model” or “size exclusionary model” of surface filtration. A rough analogy can be made; imagine a bucket perforated with holes slightly larger than a typical marble, introduce a mixture of marbles and golf balls. The marbles will easily pass through the aforementioned holes while the golf balls will be retained no matter how much force is applied until either the golf balls break or the bucket fails.

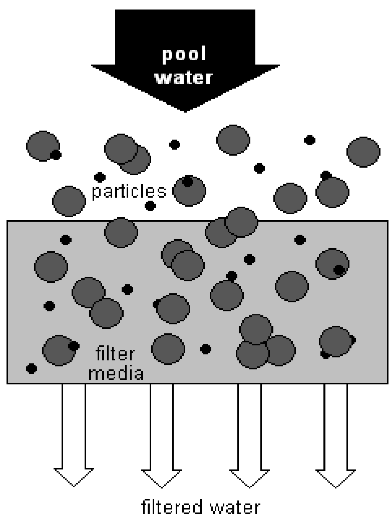
(See figure #1 below)



Depth or matrix filtration differs fundamentally from that of surface filtration in that particles will travel through the media until they reach an obstruction that prevents them from moving further. In recreational water filters, the most common type of depth filtration is the common high rate sand filter. A sand bed will load with particles until the holding capacity of the media is reached. At this point the hydraulic forces have increased to the point where these trapped particles are forced completely through the media and end up in the effluent stream or the liquid itself channels around obstructions and bypasses the media directly. This is commonly called breakthrough (although channeling is not technically breakthrough).

(See figure # 2 below)

Depth Filtration



The important point given the above is that in surface filtration, particle removal is independent of application rate. A WELL DESIGNED filter will deliver water quality that is an intrinsic function of the chosen filter aid over a wide range of application rates (typically between .8 GPM/sq. ft. and 2.5 GPM/sq. ft for recreational water filters depending on type and design). Whereas in depth filtration, particle retention will degrade with increasing application rates due to the higher velocities dislodging or forcing particles through the matrix.

Now to the heart of the matter, the square footage issue. We all want the most square footage we can get out of a given filter design, right? Yes, for the most part that is true. However there are caveats largely based on design constraints. What do we really want out of a filter design? A few primary concerns are: performance, longevity, operating economy, a small footprint and manufacturing cost. There are tradeoffs in satisfying these goals.

These matters were extensively explored in the late sixties and early seventies (with respect to flexible element or Flex-Tube type filters) by Vincent Pisani (my predecessor) and Cullen Cooper of the PER corporation along with some kindly assistance from Professor Frank Tiller of the University of Houston. Their (Pisani and Cooper's) collaboration continued well after the demise of the PER corporation when they moved on to form their own filtration companies.

The original Flex-Tube type filters as pioneered by PER used 7/8" diameter filter elements on 1.625" triangular pitch utilizing a stainless steel braided septum. With advances taking place in the late sixties and availability of synthetic materials, it was felt that the overall design of regenerative filters could be optimized. Dr. Tiller was of particular help in the selection of septa material and precoat media. Many filter element designs were explored. Various diameters, lengths, spacings, core pitch and materials were tested. Eventually the .5" diameter element on 1" triangular pitch utilizing a polyester braid was settled on as giving best performance, lowest maintenance cost, best longevity and square footage for a given filter diameter. Testing of the various design configurations took place over a number of years in the lab and in the field for both industrial and recreational water applications.

Now, back to square footage. Given the establishment of a .5" element on 1" triangular pitch, how does one develop square footage? Well, there are two ways. Increase element length or increase the number of elements. There are drawbacks to both. Increasing the number of elements adds significant costs i.e.; number of elements required, machining tube sheet/holdown plates, larger/more complex gaskets/seals and a greater tank diameter among others.

Lengthening the filter element would seem to be the logical choice. Here is where we differ from the design philosophy of our competitors. We employ filter elements of a 36" maximum length, while our competitor's typical filter length is 48". Over many years (40+) of real world applications we have found:

1. A longer element is more difficult to control movement during operation of the filter. With a length of 48", no matter how carefully the inlet distributor is designed, the lower portions of the element will move about and contact each other causing filter aid leakage and loss of precoat. This action will begin to take place at rise rates of less than 10 feet per minute. This effectively limit's the specified application rate of the filter in most cases to approx. 1 GPM/sq. ft. or less.

2. During normal filter operation and during the bumping process (with a 48" long element), there is inevitable contact between adjacent elements at the lower extremes that causes abrasion and premature filter element failure. It may take some years to develop, however it is inherent in lengthy filter elements.

3. Sedimentation problems in the internal portion of the element, especially when operated at low application rates can also be problematic leading to an actual reduction of square footage over time. It takes a longer period to develop a velocity profile (from bottom to top) in a longer element; this causes heavier particles to settle in the lower portion of the filter element that cannot be flushed during the precoat recycle period.

Our self imposed filter element length of 36" (for recreational water filters) effectively negates the above cited problems giving greater filter element longevity (typically 15 to 20 years) and consistent performance through typical application rates of .8 GPM/sq. ft. through 1.6 GPM/sq. ft.

In the marketplace in some cases we do not match the square footage of our competitor's product. This is true. In a given class of filter the competitor's filter is rated at 1.09 to 1.29 times our square footage. However let's look at the perceived benefits. Will the performance be better with greater square footage? *No, this is surface filtration not depth filtration.* Will greater square footage result in longer filter runs? In theory, yes. However, in practicality, we have not found this to be the case. Two of the largely unrecognized factors in filter run length are frequency and quality of regeneration.

Filter run length is a direct function of filter cake porosity. We typically regenerate our systems every 4 to 9 hours with a 6-hour regeneration being typical. Regeneration frequency varies with the application (a heavily used water park filter will need to be regenerated more frequently than one installed in a typical college or university venue). Our bump mechanism is far more "energetic" than the competitor's giving superior filter cake release. In addition, our filter design incorporates a high velocity mixing chamber below the inlet distributor. This allows us to break up the filter cake far more effectively and keep it in a more porous condition (free flowing) during the filter run, extending the life of a given filter aid to it's maximum.

Given the above, are there applications where an "extended" length filter element is desirable? In short, yes. Where minimal filter footprint is a requisite overriding other concerns, longer filter elements can be employed effectively. Indeed, we manufacture several small diameter filter models with filter element lengths ranging from 42" to 55". However they are predominantly employed in industrial applications with high solids influent concentrations (300 ppm to 1000 ppm by volume) and operated at application rates no higher than .8 GPM/ sq. ft. They generally utilize a triangular pitch of 1.5" (to minimize filter element abrasion) and given the high solids application rates, produce relatively short filter runs. Filter aid is changed frequently and the elements are removed for cleaning or replacement at 1-8 year intervals. This is obviously impractical for recreational water filters. It should be noted that at teardown (internal component maintenance/replacement) this class of filter exhibits many of the previously cited problems associated with the use of longer elements. However, given the nature of the application, this is an acceptable trade off.

Element Comparison

Filtrex vs. Competitor

MODEL NO.	TANK DIAMETER (in)	EFFECTIVE FILTRATION AREA+ (ft^2)	NUMBER OF FILTER ELEMENTS	ELEMENT LENGTH (in)
Filtrex EC 350 S	30	351.2	572	36
Competitor SP-27-48-487	27	381	487	48
Filtrex EC 2100	60	1538.8	2506	36
Competitor SP-55-48-2076	55	1625	2076	48

+ Effective Filtration Area based on current NSF Listings.

In the above chart two equivalent class filters from our line are compared with those of our competitor. Note that in the case of our model EC 350 S filter, our tank diameter is 3 inches larger and we provide 85 more filter elements. Similarly, in the case of our EC 2100, our tank diameter is 5 inches larger and we provide 430 additional filter elements.

From an owner's or end user's point of view, it is our opinion that there is far more value (both long and short term) in a conservatively designed filtration product than one that has a basic design precept of minimal production cost.

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