# Public Pool Filtration Trends – A Historical Perspective

Revised 2022

Swimming pool filter rooms are changing. The familiar banks of filters with associated face piping are giving way to compact fully automated systems requiring little operator intervention. Gone too, are the weekly rituals of backwashing thousands of gallons of heated and chemically treated water to waste. Today's filter rooms can be truly "lights out" operations.

The language of filtration is also changing. Words like, "regeneration"… bump cycle… precoat reuse… flexible septum…all contribute to a changing technology and the present state of the art. Automation, a concept that a few years ago was more dream than reality, is fast becoming the designer's prerequisite.

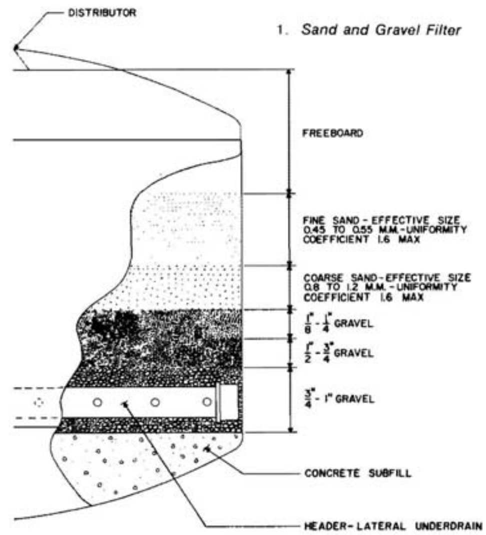
Today's filter room is a meld of hydraulic, electro-mechanical and solid-state technology. Through these mechanisms, the basic functions of moving water, removing particulate matter from it, sterilizing it, and finally, conditioning its chemistry and temperature are accomplished.

Let's briefly look at the filtration alternatives available to public pool designers including the latest technology.

**Sand & Gravel**

Sixty-five to 70 years ago, practically all filters in use on swimming pools were of the sand-and-gravel type. These were vertically or horizontally deployed pressure filters of which working media consisted of 18 to 24 inches of fine sand supported by several increasingly coarse layers of gravel (Ref. 1). Filter size was essentially determined to be the cross-sectional area of the tank. Service flows ranged from 1.5 to 3.0 gpm per square foot of cross-sectional tank area. Filtration occurred in down-flow fashion and was often aided by a flocking agent introduced to the filter during the first 4 to 6 hours of each new filter cycle. Cleaning was accomplished by backwashing at rates from 10 to 15 gpm per square foot.

From the standpoint of water clarification, these filters were extremely effective. They produced filter cycles of 1 to 2 weeks' duration, were durable and unusually trouble-free. Sand-and-gravel filters are seldom in use today, their huge physical size and high initial cost making them impractical, particularly where the equipment is located within a building.




Ref. 1 Sand and Gravel Filter

**High-Rate Sand Filters**

The high-rate sand filter is an outgrowth of attempts to modernize sand-and-gravel filter technology. Like its predecessor, the high-rate filter follows a vertical down-flow format. Filter size is, again, calculated as the cross-sectional area of the tank. The working media, however, is usually a single layer of fine sand supported by a mechanical under-drain. Filtration flows are approximately 20 gpm per square foot of filter area.

At these higher operating rates, the distribution of water through the media becomes critically important; for, if the flow is uneven, there will be a tendency for the sand to move around with resultant channeling of the filter bed. Channeling, as the term implies, is a cracking or displacement of the media which will permit unfiltered water to completely avoid the filtration process. In the design of high-rate sand filters, the distribution characteristics of both over-drain and under-drain are eminently important to the uniform movement of water through the filter bed, and truly determines the success or failure of the unit.

Since operating flow rates are high, dirt particles almost completely penetrate the sand bed during normal filtration. It is necessary, then, to discontinue the filter cycle before a breakthrough occurs; also, to use a relatively high backwash rate in order to dislodge and remove the collected matter from within the media.

Backwash rates for this type of filter normally equal the filter rate.

**Sand & Gravel Versus High-Rate Sand**

A comparison of sand-and-gravel and high-rate sand filters points out dramatic performance differences and similarities alike.

Based on operating rates of 3 and 20 gpm per square foot, respectively, high-rate filters occupy only 15 percent of the space required for sand and gravel filters. Their small size clearly affords cost- and housing-advantage over sand-and-gravel filters.

Sand-and-gravel filters, on the other hand, typically yielded filter cycles of 14 days' duration, while the high-rate units average 2 to 7 days. This brevity of filter cycle additionally penalizes the high-rate filter in terms of backwash water, since it consumes about 40 percent more wash water for each gallon of filtered water delivered than its sand-and-gravel cousin.

Pumping costs favored the sand-and-gravel units because of their low operating-headloss and less frequent backwash cycles. On the other hand, pump selections usually prove more efficient for high-rate systems because of the single design point, since filter and backwash rates are usually equivalent.

Truly, the greatest difference between these filter types lies in their ability to remove dirt. Sand-and-gravel filters consistently remove particles in the 8 to 10-micron range; whereas, high-rate filters have only achieved a 20-micron-plus operating record.

**Diatomite Filters**

Diatomite filters have taken many shapes and forms in their evolutionary process during the last 3 decades. Unlike sand filters, whose media is permanent, diatomite – or, D.E. filters, as they are commonly called – employ porous internal elements which are used to support diatomite filter media. The diatomite is deposited on these elements at the start of the filter cycle, and then flushed from the filter at the conclusion of each cycle. It was the sanitary appeal of a non-permanent media along with its ability to remove dirt particles as small as 1 micron that gave early D.E. filters their great impetus into the swimming-pool field. Their extremely compact size also presented tremendous economic advantage in equipment costs and housing space, as well.

**Pressure or Vacuum**

For many years, the only engineering distinction between D.E. filters was their relationship to the recirculation pump. Units that were placed on the discharge side of the pump were termed pressure filters; those on the suction side were called vacuum filters. Pressure filters naturally required a closed tank and were hydraulically cleaned by reversing the flow of water through the filter elements. Often, compressed air was used to assist the hydraulic reversal in an attempt to make the backwash more effective.

Vacuum filters, on the other hand, typically set out a group of manifold filter elements in an open top tank. As with the pressure filters, filtration occurs through a layer of diatomaceous earth that is periodically replaced. In vacuum filters, the dirt-laden D.E. is removed from the elements by manually sluicing or hosing off the elements. Operator sluicing was found a more dependable procedure than backwashing; and so, vacuum filters gradually gained in popularity over pressure types. On the other hand, the manual nature of this procedure makes it virtually impossible to automate the vacuum filter.

In both D.E. filter types, filter size is determined to be the total surface area of filter elements that is served by drainage; or, in other words, only the area that will accept a precoat is considered. Precoat is the coating of D.E. applied to the filter elements at the start of each filter cycle. Since all precoat filters are essentially surface-type filters, their effectiveness declines as the surface becomes dirt-coated. In order to keep this filter surface porous for longer periods, small amounts of diatomite slurry are injected into the filter during the cycle. When applied at a rate of 0.1 lbs. per square foot of filter area per 24 hours' operation, the diatomite slurry – or continuous body feed, as it is called – randomly combines with the dirt and is able to extend the porosity of the filter cake and duration of the cycle. Public pools equipped with pressure-type D.E. filters and body feed typically average 3 to 4 days' run. Vacuum filters do considerably better and will run as long as 2 to 3 weeks between cleaning. It is significant to note that the longer vacuum cycles are more a function of lower application rates, usually 1.5 to 2 gpm per square foot, and not any great difference in dirt-holding efficiency on their part. Some observers, at times, argue the merits of a "looser, free-flowing cake" for vacuum units.

**Precoat Reuse**

Today's distinction between diatomite filters is measurably different than the filter's relationship to the recirculating pump: It is based on the number of times a diatomite precoat is used in any given filter cycle.

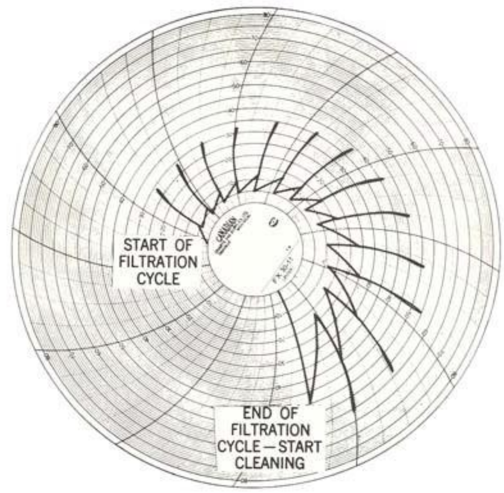
To illustrate – the conventional pressure or vacuum D.E. filter, whether augmented by continuous body feed or not, functions strictly as a surface filter. It is operated to a point of pressure differential, after which, the removal and replacement of the media takes place. This type of D.E. filter operation has now been classified *static cake* filtration. Once the filter cake is established, it remains undisturbed throughout the filter cycle, until it is expelled from the filter by backwashing or sluicing.

**Filter Aid Efficiency through Regeneration**

The latest technique in diatomite filter operation completely reverses the concept of static cake filtration. By periodically removing the surface-contaminated filter cake from the elements, mixing it within the filter, and then reapplying the mixture to the elements, it becomes possible to continue the filter cycle on the original precoat. Studies have shown that static cake operation of a D.E. filter utilizes only 10 percent of the media's dirt holding capability since filtration essentially occurs at the surface of the media only. Studies also indicate that when a surface-contaminated filter cake is removed and reapplied, unused filter surfaces are randomly presented to the filtration stream. Thus, the collective filter cake is again made porous and free-flowing.

Each time the process is repeated, the dirt-to-filter-aid ratio increases. The end result is an in-depth usage of the diatomite precoat. Since there is an apparent revitalization each time the precoat is removed and reapplied to the elements, the term "regenerative filtration" has been given to this operating technique. Filtration engineers define regeneration as a restoration of a used filter cake to nearly its original characteristics.

The accompanying chart (Ref. 2) typically pictures the regenerative cycling of a single precoat in a modern regenerative pressure filter. Notice the saw-tooth pattern formed by successive regenerations. The low points of the curve are the starting points in each filter run. The peaks are the points of maximum differential caused by the dirt buildup on the surface of the filter cake.




Ref. 2 Chart showing pressure throughout filter cycle

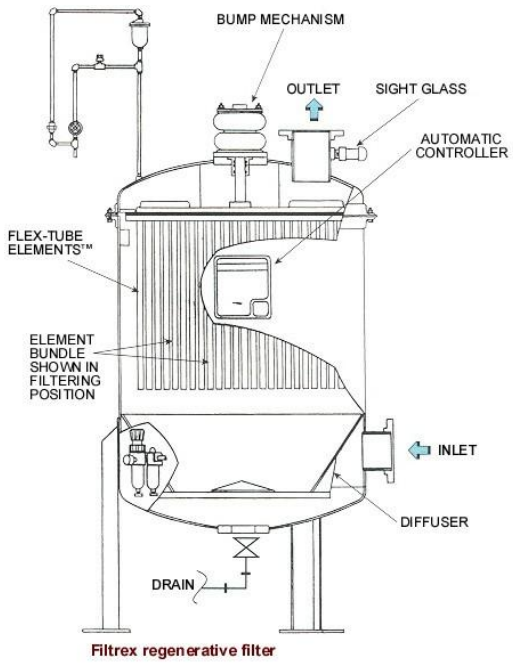
The fall-off immediately following the peak occurs as a direct result of regeneration or "bump" cycle. It should be apparent from this display that each time the diatomite is regenerated, filtration continues at the design rate of flow with only a minimal increase in starting pressure.

Also apparent is the area of accelerated pressure rise just before the "bump." During this period, the filter output declines sharply, and continued filtration becomes increasingly impractical. It is at this very point that regeneration is initiated in regenerative filters, and at the same point where static-cake filters would have their filter cycle terminated.

**The Regenerative Filter**

Let's look inside a modern regenerative filter and observe some physical differences.

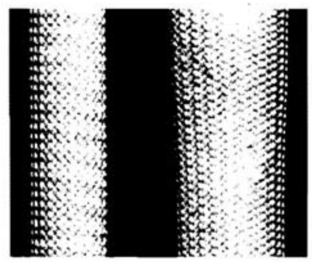
In the cross section (Ref. 3) note that the filter elements are surrounded by a closed tank equipped with inlet, outlet and drain connections. Also observe that the tank is diametrically divided across its upper section by a tube sheet which also serves to support the filter elements. Thus far, the description fits any number of pressure-type, static-cake filters in use today; also, many that can be historically recalled. Further study of the picture reveals a diffuser at the bottom of the tank and a lift shaft and pneumatic cylinder at the top. The lift shaft attaches to the tube sheet with its elements to the cylinder, and so, the entire assembly is made movable in reciprocating fashion.




Ref. 3 Regenerative D.E. Filter

The Flex-Tube™ elements used in regenerative filters are flexible and expandable, open-top cylinders. They have a non-confining interior framework and a porous outer membrane. The membrane, or outer covering of the element, consists of a series of relatively small diameter strands that are grouped together in a braided fashion.

Unlike the rigid filter elements common in static-cake filters, the Flex-Tube™ has an inherent ability to change (Ref. 4) as a direct function of its pressure environment.



*4. On left, Flex-Tube™ element under filtration pressure. On right, element shown during "bump" cycle. Note expanded diameter*

Ref. 4

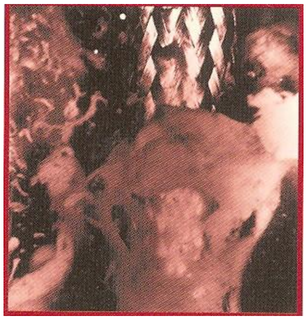
To illustrate – during filtration, the pressure surrounding the element is greatest. This tends to reduce the tube diameter. Conversely, during the "bump" or regeneration cycle, a high pressure is created within the interior structure of the Flex-Tube™, causing the tube diameter to expand as its overall length shortens.

It is the combination of these characteristics that makes the Flex-Tube™ a successful filter element for regenerative cycling.

The operation of present regenerative filters is up-flow with the filtered water leaving the tank at the head outlet. Both precoat and dirt form a coating on the outer surface of the Flex-Tube™. Filtered water passes through minute openings in the wall of the element to a hollow area within. As the accumulation of dirt increases, the element will tend to elongate and, also, become smaller in diameter.

**The "Bump" Cycle**

When it is time to regenerate, the filtration flow is stopped. The pneumatic cylinder is alternately pressurized so that the tube sheet and elements move as a unit, down and up through the static tank of water. It is the upstroke that causes the high pressure inside the element, the immediate expansion of the tube diameter, and the relative flow-reversal through the membrane. The practical effect is instantaneous propulsion of the filter cake from the surface of the element (Ref. 5).



Ref. 5

Unaltered photo of Flex-Tube™ being bumped

**Operating Economies of Regenerative Filters**

The final step of regeneration occurs when the filtration flow is again resumed and the mixture of dirt and precoat is reapplied to the elements.

Regenerative filters are precoated at a rate of 0.33 pounds per square foot of filter area, or approximately 3 times the normal precoat quantity for static-cake filters. However, their in-depth utilization of this precoat through successive regenerations yields substantial operating economies.

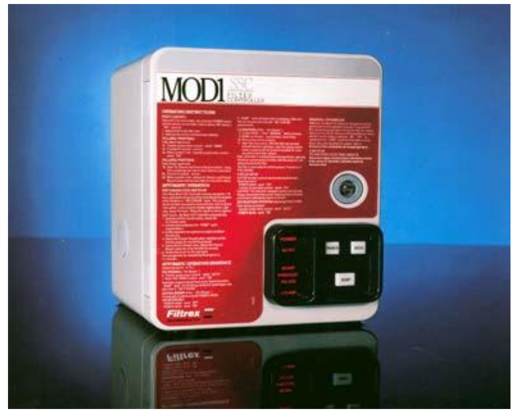
In equivalent settings, regenerative filters can be expected to reduce diatomite consumption by almost 90 percent. This becomes a two-fold advantage in that waste-disposal quantities are similarly reduced.

Regenerative filters also conserve chemically conditioned swimming pool water, since they do not operate on a backwash principle. Instead, the regenerative filters are "bumped" and drained when it is time to remove the precoat and dirt.

**Automation Now and Practical Reality**

Cyclical regenerations of the precoat typically yield filter cycles of 3 to 4 months' duration for heavily used indoor pools and approximately a month shorter for outdoor installations. This operating predictability has led to practical automation of large public pool systems. By using time for the basic filter program, extremely reliable moderate-cost packaged filter controllers have been introduced to the field in recent years. These standard products now provide the pool designer with a tested, factory-built package that is still flexible enough to fine-tune to his particular requirements. An internal microprocessor is used to control various filter functions. Pressure-sensing devices may also be added to override the basic timing program, thus making it possible for the system to automatically cope with unexpected dirt loads.

Automated regenerative-filter controllers are wall-mounted in many instances, being housed in a compact enclosure (Ref. 6). An entire automated filter room can now occupy a floor space of only 12 ft. by 18 ft. for a 1,000-gpm regenerative filter with pump and other accessories.




Ref. 6 Automatic Filter Controller

As construction costs escalate, the physical size of swimming pool filter room equipment becomes increasingly important. Both filters and accessories must now justify their existence as part of the often-referred-to "bottom line." Components that waste energy, material resources, installation and maintenance labor, and precious building space – of necessity – rapidly pass from the designer's view. This has increasingly led to the selection of regenerative systems with their inherent space, water, filter-aid and manpower economies.

In summary, it has become evident that regenerative filters have changed not only the face of filter room technology, but the economics of public swimming pool filtration, as well. Where the next breakthrough will occur is difficult to assess; however, regenerative filtration, today, is a performance-proven technique which deserves careful consideration.

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