

Theory Of High Flow Vacuum Sand Filtration

The High Flow Sand filter was the first entrant into the field of depth filtration. Studies done in England and Europe, beginning some 50 years ago, indicated that the filtration process itself dramatically changed in a media bed of sand when flow rates were increased to 7.5 gallons per minute per square foot of filter surface area and above. Present practice in this type of filtration utilizes flow rate from 12 to 20 gallons per minute per square foot of filter surface area. At these higher flow rates; through a media bed of sand, the filtration process becomes a depth filtration phenomenon with electrostatic attraction between the sand grains and the contaminant particles being the method of removal. It is quite a different process from the mechanical straining at the surface, which is employed in DE, Rapid Sand, and Cartridge filtration. Properly designed sand filters utilizing the higher filtration rates can remove particles to a diameter of 1.0 micron. A particle 1.0 micron in diameter passing through a sand bed approximates a horsefly flying down a twisting railroad tunnel. Its chances of a successful passage are excellent unless the walls of the tunnel are lined with flypaper. Therefore, a more complete explanation of the electrostatic attraction between the sand grains and the contaminant particles is in order.

Most people today accept the fact that under certain conditions, electrostatic charges form on dust, fabrics, etc. Many people have experienced the slight shock of either walking on synthetic fiber carpets or wearing clothes of synthetic fabrics. What is being experienced is the effect of charged particles on the surface of the various fabrics. By a charged particle, we mean the accumulation of positive or negative forces on the surface of the particle.

The same things happen in water. O'Melia and Crapps¹ state "All solid particles have a charge on their surface when placed in contact with water for one or more of the following reasons:

- (1) Ionization of molecules at the particles surface
- (2) Unsatisfied charges because of imperfections in the crystal lattice
- (3) Direct chemical reaction with specific ions in the solution, which results in the formation of chemical bonds
- (4) Weaker physical absorption of ions from solution

However, by whatever means they do so, both the sand grains and the dirt particles will have a charge on their surface. Fortuitously, the sand grains have a positive charge and the dirt particles have a negative charge. This is generally due to the fact that the dirt particles are very much smaller than the sand grains and much more strongly affected by the highly polarized water molecules. Being of opposite charges, the dirt particles and the sand grains will have an affinity or attraction for each other if they can be brought close together. The attraction is like what is felt when materials are brought out of a hot air clothes dryer, and the phenomena taking place is identical.

To bring the dirt particle into close proximity with the sand grain, a filter must be designed and constructed to certain hydraulic principles that are very important. The velocity of the water through the filter, in terms of gallons per square foot per minute, is

¹ Charles R. O'Melia and David K. Crapps, "Some chemical Aspects of Rapid Sand Filtration." Paper presented June 4, 1964 in Toronto, Ontario Canada.

deliberately maintained at a high rate to (A) insure sufficient inertia on the particles to carry them to the sand grains, and (B) propel the particles deeper into the sand bed once the sand grains at the surface have been neutralized by the incoming soil particles.

The minimum size of particles capable of being removed by a High Flow Sand Filter is somewhat difficult to assess, but it can be assumed that the size will be about 1.0 micron in diameter. Particles below this size are generally colloidal and difficult to remove, and the type found in water is called hydrophobic. The term hydrophobic means that the particle has no affinity for water and the major portion of inorganic and organic material found in turbid water comes under this heading. We knew good hydraulic design would produce a water with the quality of the DE Filter, but that no system would take out particles in the range of 1.0 micron down to half a micron in size. How to improve the efficiency of the High Flow Sand process was the problem confronting Paddock's engineers.

Hydrophobic particles are extremely stable in solution and their stability depends on a number of factors. It is interesting to note that a gold colloidal suspension made in England just over 100 years ago is still as stable as it was when produced. The extreme stability of colloidal particles depends on a number of factors. The particles are held apart by repulsion forces due to electrostatic charges developed on their surfaces. The origin of these electrostatic forces is complex, but it can be considered that it is mainly due to adsorption of ions onto the particle's surface.

In this condition, unless acted on by other and stronger forces, the particles will remain separated indefinitely.

A property of water that has been well established is its ability to change its state under vacuum conditions. This is because the molecules of water are less restricted in their movement as the pressure decreases. This enhanced molecular movement will increase further the movement of the colloidal particles to an extent that random collisions will occur sufficiently to begin the cohesion of hydrophobic particles. Paddock was aware of the foregoing and knew that in a vacuum, the activity of the small stable hydrophobic particles changed and that they grouped together into a particle with sufficient inertia and electrostatic charge to be thrown near and attracted to the sand particle. The answer to greater efficiency then was to place the entire High Flow Sand filtration process under a vacuum.

The Vacuum Sand Filter operates under this condition. The water in the tank is open to atmospheric pressure; however, the hydraulic design of the filter is such that the pressure will steadily decrease as the water penetrates deeper into the sand bed. This lowering of pressure will continue until, at the bottom of the sand bed, there will be a vacuum of up to 18 inches of mercury. Large particles, i.e., particles having a size about 1.0 microns, will be removed by the method pertaining under normal high rate sand conditions. Particles below 1.0 microns, i.e., the hydrophobic particles of colloidal size, will be affected by the vacuum; will be formed into larger particles by collision and will be removed in the same manner as a larger particle.

As the pressure of the swimming pool water in the filter is reduced below atmospheric, dissolved gases will be released. The order of release will follow their vapor pressures, the more volatile being released first. Among the first will be Nitrogen Trichloride and this has a beneficial effect on the water in that it is irritating to swimmers. An automatic

electrical control panel is provided with the Paddock Vacuum Sand Filter to ensure the release of these entrapped gases. Studies have shown the gases, if not allowed to bubble out of the media bed, will impede the flow of water through the sand, having much the same effect as contaminant particles reducing the filtration efficiency and increasing the frequency of backwashing.

The Paddock Vacuum Sand Filter is efficient in removing particles to .5 microns in diameter and an effluent turbidity of less than .5 FTU's. After a one-time adjustment of the main drain valve to establish the Minimum Operating Level, the VSC Filter is placed in filtration at the proper rate and operational mode by simply opening the ports into the filter compartment. Equally simple is the pumpless backwash. When the filter is open and set for backwashing, pool water will upflow through the filter media at the filtration rate without the recirculating pump being used. In two to four minutes, the media bed will be cleaned and the VSC may be returned to the filter mode. No filter aids to add after backwashing, no chemical tanks to fill; upon reaching a preset vacuum, the backwash cycle is automatically initiated.