A MEMBRANE PRETREATMENT TECHNOLOGY

Dr. Marcus N. Allhands, PE, Amiad Filtration Systems, Oxnard, CA

Nearly all membrane systems, no matter what their raw water source, must utilize some form of pretreatment to remove unwanted organic and inorganic suspended solids. Bag and cartridge filters are efficient at removing suspended solids but must be replaced on a frequent and often costly basis. Some form of suspended solids removal system that cleans itself, maintains high flow rates and stays online at all times with a very low pressure drop would be ideal. That piece of equipment exists. A versatile fully automatic self-cleaning screen filter can remove up to 99% of all suspended solids from membrane influent allowing fine cartridge filters, if needed, to polish with very infrequent replacement. New screen filter technology makes possible the removal of all particles down to 10 microns without depending upon filter aids such as diatomaceous earth or self-forming filter cakes.

Terms and Definitions

Filtration degree: The smallest particle size requiring removal from the fluid stream in a specific application is called the *filtration degree*. Two conventions are used to define filtration degree. One is taken from the textile industry referring to the density of threads expressed as the number of threads per linear inch. This definition uses the term "mesh" to describe this density measurement. In the field of filtration the term has come to mean the number of pores or openings per linear inch in a woven media. Although still in common use, the term "mesh" is not a true parameter of measurement since the actual opening or pore size of such a described medium depends on the diameter of the threads or wires and the type of weave used in the manufacturing process. The second convention used to describe *nominal* filtration degree, preferred in the municipal and industrial arenas, is an actual linear dimension of the *shortest* straight-line distance (length or width) across an individual opening or pore of the filter medium. This is most often given in microns; i.e. 1/1000 of a millimeter or 0.00004 of an inch. The *absolute* filtration degree is the length of the *longest* straight-line distance across an individual opening of the filter medium.

Filtration open area: Another important definition needed when comparing filters and filtration methods is the *filtration open area*. This is the pore area or sum of all the areas of all the holes in the filter medium through which the fluid can pass. Filtration open area is expressed as a percentage of the effective filtration area. Basic physics says that the pressure drop across a porous medium is proportional to the *square* of the velocity. For a given flow rate, less open area means higher velocity thus, a higher pressure drop. Screen filters, when clean, have enough open area to cause insignificant pressure drops across the screen. However, as dirt and debris begins to plug up openings in the screen, the open area that is available for the fixed flow rate to pass through is decreased leading to an ever increasing velocity through the screen. Since the pressure drop is proportional to the square of this velocity, the differential pressure across the screen will increase over time as an exponential function. This phenomenon is clearly shown in Figure 1. Less open area also means less dirt required to increase pressure drop across the screen element. The type of weave used to construct a filter screen can affect the open area greatly as shown in Table 1. Notice the relative consistency in open areas of weave-wire screens regardless of the filtration degree while wedge-wire screens show a sharp decrease in open areas as the filtration degree diminishes.

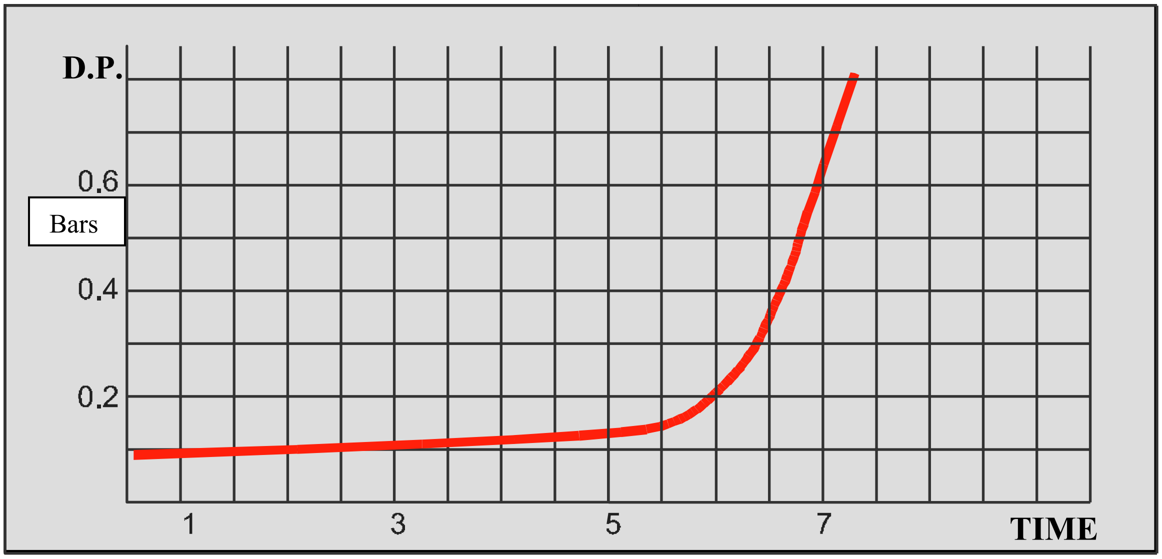

Figure 1. Time vs Differential Pressure (DP)

Table 1. Filtration Open Area

Filtration Degree	**Filtration Open Area**	
	Weave-Wire	**Wedge-Wire**
500 micron	37%	33%
300 micron	31%	23%
100 micron	32%	7%

Technology

Algae have traditionally been one of the biggest contaminants in raw surface waters going to membrane systems. Because surface water sources such as lakes, rivers, reservoirs and canals are dynamic, water quality can change dramatically. Future changes to the watershed such as land developments or changing farming practices can significantly alter the water quality in both still and moving water bodies. These watershed changes, more often than not, increase sediment runoff due to accelerated erosion. Not only does the inorganic TSS increase in the water body but nutrient runoff also accelerates adding to the organic TSS load and eventually leading to the overgrowth of organic matter causing the condition of eutrophication. Since the pretreatment system must handle present water quality conditions and anticipate possible future degraded conditions, the controls along with the inlet and outlet manifolds are designed for the future addition of more filtration capacity. The filtration system is provided with a programmable logic controller (PLC) for system operation and monitoring functions

Each filter is made up of the components shown in Figure 2. Dirty water enters the inlet flange at the bottom of the filter housing. The water passes into the cylindrical screen element made of multiple 316L stainless steel layers, through the screen and out the side outlet flange. Suspended solid particles such as algae or sand are captured on the inside surface of the screen and build a filter cake. The open area of the screen decreases as this cake thickens causing the water velocity through the screen to increase thus, increasing the differential pressure across the screen element. A differential pressure switch (DPS) constantly compares the pressure inside and outside of the screen element. When a preset differential pressure threshold is reached (0.5 bars or 7 psi), the DPS signals the PLC to first open the exhaust valve to atmospheric pressure. This valve is connected to the hollow 316 stainless steel suction scanner that has nozzles that end with a small opening (12 – 14 mm in diameter) within a few millimeters of the screen surface. The differential pressure at each nozzle opening caused by the difference between the working gauge pressure (2.4 – 10 bars or 35 – 150 psi) and atmospheric gauge pressure (0 bars or psi) results in a low-pressure area in the vicinity of each nozzle opening. This pressure differential causes water to flow backward through the screen in this small area at a velocity of 9 – 15 m/sec (30-50 ft/sec) violently pulling the filter cake off the screen and sucking it into the suction scanner and out the exhaust valve to waste. While this is taking place, the PLC starts the electric drive unit that slowly rotates the suction scanner at 24 rpm. This slow rotation does not disturb the filter cake except where it is being sucked into the scanner at the nozzles. At the same time, the suction scanner is moved linearly by a threaded shaft passing through a fixed threaded bearing. This gives each suction scanner nozzle a spiral motion. When the upper limit switch is reached by an actuator on the drive shaft, signaling that every square inch of the screen has been covered by nozzles and that all debris has been cleaned from the screen surface, the PLC closes the exhaust valve and the drive unit reverses to move the scanner down to its starting position at the lower limit switch. The second filter will then go through the same cleaning cycle if the system has multiple filters, then the third, fourth and so on until all the filters in the system have been cleaned. Each filter takes from 15 to 40 seconds, depending upon filter model, to complete its cleaning cycle. At this point the system waits for the next threshold pressure differential across the filtration system to occur. The filtration process is never interrupted therefore; clean water is always being delivered downstream even if the filtration system is made up of only one filter. A time backup system is standard in the PLC control to initiate a cleaning cycle periodically even if a threshold pressure differential does not occur. If one or more filters should be off-line in a multiple system for repairs or any other reason, the PLC will skip those filters during the cleaning cycle and go to the next operating filter. A typical multiple filter installation is shown in Figure 3.

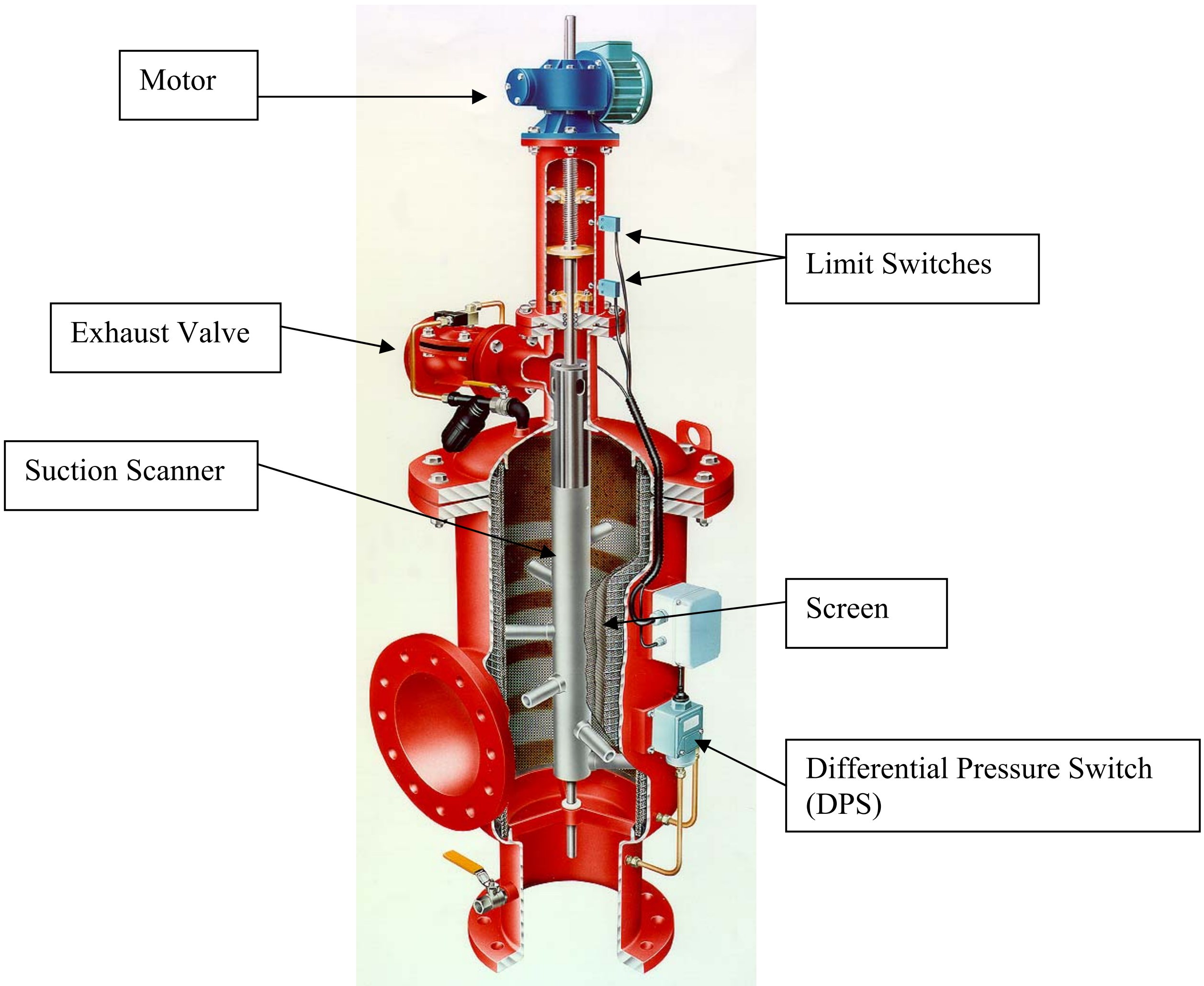

Figure 2. Filter Components

Figure 3. Typical Installation

Summary

Membrane technology has come a long way in the past few years. System dependability as well as durability is increasing just as operating pressures are decreasing. New applications are appearing around the world and the technology will be heavily depended upon in the foreseeable future. With each application comes the need for pretreatment to remove organic and inorganic particles that can damage or at least compromise the membrane structure. Membranes can only perform to the degree that the pretreatment system performs. Therefore, the pretreatment system must function adequately and be reliable and robust. Automatic self-cleaning screen filters have proven their reliability and functionality as companions to membrane systems. With the ability to remove all or nearly all particles greater than 10 microns in size, these filters can stand alone as pretreatment for all but the finest R.O. membrane systems. And even R.O. systems need only add a fine polishing cartridge between the automatic self-cleaning screen filter and the membranes to form a complete functional and reliable water treatment system.

Author

Dr. Marcus N. Allhands, PE
Senior Application Engineer
Amiad Filtration Systems
P.O. Box 261
Lewisville, IN 47352
(805) 377-8580 cellular
(765) 987-7843 office phone/fax
marcus@amiadusa.com

Biography

Author Marcus N. Allhands, Ph.D., P.E. is Senior Application Engineer with Amiad Filtration Systems. His job includes working closely with engineering design firms on applications and specifications. Dr. Allhands' background consists of industrial experience, work as a water quality manager, and seven years with Amiad in a number of positions He received his engineering doctorate from the University of Florida.