AMIAD SELF-CLEANING STRAINERS FOR WATER FILTRATION

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Abstract: The "art" of filtration utilizes many methods for separating solid particles from fluids. There is often no right or wrong method. Water quality and customer requirements usually determine the "best" method for each unique situation. The filtration spectrum divides solid particle sizes into five segments ranging from ions to macro particles. Three of these segments fall into the dissolved solids realm while the other two comprise suspended solids. Important terms to define include "filtration degree", "effective filtration area" and "filtration open area." A thorough study of this subject must look at water quality parameters important to proper filtration methods. The predominant physical parameters are total suspended solids (TSS) and particle size distribution (PSD). These two parameters are the key tools used in the "art" of screen filtration. Three common methods of fluid/solid separation are kinetic, surface and contact filtration. Surface filtration (straining) will be the focus of this paper. Filter or strainer cleaning methods can be categorized as manual cleaning, simple back flushing, mechanical cleaning, direct flushing and forced back flushing. Forced back flushing is also referred to as suction scanning. A complete description of the operating principles of a fully automatic self-cleaning suction scanning screen strainer are given in this manuscript.

Terms and Definitions

Filtration: The term *filtration* can be defined in its simplest form as the process of removing solid particles from a fluid (liquid or gas) by forcing the fluid through a porous medium through which the solid particles cannot pass. The filtration spectrum divides solid particle sizes into five segments ranging from sub-molecular ions to macro particles. See Table 1 for examples of each range.

RANGE	SIZE	EXAMPLES
Ionic	<0.001 micron	Ca^+, Cl^-, Fe^{++}, Na^+
Molecular	0.001 - 0.1 micron	Sugar, Virus, Gelatin
Macro-Molecular	0.1 – 1 micron	Tobacco Smoke, Bacteria
Micro-Particular	1 – 10 micron	Red Blood Cells, Flour
Macro-Particular	10 – 3500 micron	Pollen, Beach Sand

Table 1: Filtration Spectrum

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 the filtration degree. 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 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 industrial arena, is an actual linear dimension of the *shortest* 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.

Effective Filtration Area: The total area of the filter medium that is exposed to fluid flow and is usable for the filtration process is referred to as the *effective filtration area.* Any structural member or other solid barrier that prevents fluid flow and particle separation from occurring over any surface area of the filter medium, such as structural supports, is not included in the effective filtration area.

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 often expressed as a percentage of the effective filtration area. The type of filter medium can affect this greatly as shown in Table 2.

FILTRATION DEGREE	FILTRATION OPEN AREA	
	WEAVE WIRE	WEDGE WIRE
500 micron	43%	33%
200 micron	37%	13.3%
100 micron	32%	6.6%

Table 2: Filtration Open Area

Water Quality

Water quality consists of a multitude of parameters, some relevant to filtration and many of no consequence. These parameters can be divided into two basic aspects, chemical and physical. Of primary concern in the filtration process are certain physical parameters with a few chemical parameters as possible secondary concerns.

Total Suspended Solids (TSS): Particle load or *total suspended solids* (TSS) is of major concern in filtration and is best defined as the concentration of total solid particles above the molecular range given in milligrams per liter (mg/L) or parts per million (ppm). This alone offers limited help in the design of filtration systems.

Particle Size Distribution (PSD): If along with TSS the *particle size distribution* (PSD) is known, the concentration (or volume) of particles removed from the fluid by a filter is readily determined for a given filtration degree. PSD is given in particle counts (particle density) per size unit, usually in one-micron increments. PSD can also be given in percent volume of TSS (volume density) per size unit. The latter means of expressing PSD is much more useful in designing macro filtration systems.

Additional Water Quality Factors: Table 3 shows secondary water quality factors that may or may not affect the filtration process.

BOD	Biochemical Oxygen Demand
VSS	Volatile Suspended Solids
TDS	Total Dissolved Solids
pH	Acidity/Alkalinity
Hardness	Calcium/Magnesium
Turbidity	Measurement of light scattered through a water sample

Table 3: Secondary Water Quality Factors

Clogging Factors

Those elements that cause a filter or strainer to loose hydraulic capacity are referred to as clogging factors and can be divided into organic and inorganic segments. Organic clogging factors include all phyto-plankton such as algae and some bacteria, zooplankton like protozoa and small crustaceans, and animal and vegetal detritus. Typical inorganic factors include sand, silt, clay, metal shavings, pipe scale and rust flakes. The degree of difficulty for removing these clogging factors from a filter varies considerably, not only from factor to factor, but from filter medium to filter medium.

Filtration Methods

The terms "filtration" and "straining" are used synonymously in this paper. However, the term straining is usually reserved for removing larger solid particles from a fluid while filtration can mean the removal of any size particle. The methods of filtration addressed in this paper are those most commonly used to remove macro-particles from a liquid stream; therefore, the terms "straining" and "strainers" will be used often. Such methods are used in industrial, agricultural and municipal water systems. Each specific application should be evaluated independently to design the most appropriate filtration system. Macro-filtration can be classified into three distinct mechanisms. These are kinetic, surface and contact filtration.

<u>Kinetic Filtration:</u> The cyclonic type separator best exemplifies *kinetic filtration* (or separation). This mechanism utilizes the dynamic physical forces of angular acceleration, linear velocity, and specific gravity differentials to remove a percentage of the various macro-particles present in the raw fluid stream. This type of separation requires the solid particles to have a specific gravity appreciably greater than that of the fluid.

<u>Surface Filtration:</u> *Surface filtration* is a sieving process utilizing a medium such as a screen element to present a two dimensional physical barrier to particles too large to pass through its holes or openings. Amiad screen strainers adhere to this filtration mechanism.

<u>Contact Filtration:</u> Filters utilizing granular media represent *contact filtration*. Suspended solids in the fluid stream are held within the media by impingement and adhesion on the surface of media granules and entrapment between media granules. The long-standing sand filter is a classic example of a contact filter.

Strainer Cleaning Methods

Straine rs can be cleaned by many different methods. Some simply require a filtering element to be removed, discarded and replaced with a new element. This paper will look at only those strainers with elements that are reusable. There are several common element-cleaning methods in use.

Manual Cleaning: The *manual cleaning* method requires the screen element to be removed and cleaned by hand. This can be accomplished by running water, high-pressure spraying, brushing or other physical means.

Back Flushing: The *back flushing* method of cleaning requires the strainer to be taken off-line. Fluid is then passed through the filter backward to remove the solids from the media or element and expel them from the strainer body. Sand filters are cleaned by this method.

Mechanical Cleaning: Many types of strainers use a device to *mechanically clean* the screen element. These devices include brushes, wipers and scrapers. Generally this type of cleaning is used on screens with filtration degrees greater than 200 microns.

Direct Flushing: *Direct flushing* involves opening up the strainer body to the atmosphere during the filtration process. This directly flushes debris off the screen element without reversing the direction of flow.

Forced Back Flushing: *Forced back flushing* or "suction scanning" is the process of developing a suction force on a small portion of the screen element. The differential pressure between the positive working pressure of the system and atmospheric pressure creates this suction. The small portion of the screen area cleaned by this suction action and the subsequent reverse flow through the screen element in this small area is moved across the screen surface to progressively clean the entire screen.

Back Flushing Versus Forced Back Flushing (Suction Scanning)

Figure 1 shows a schematic of a simplistic screen strainer with body housing, inlet, outlet and screen media. As dirty water enters the strainer, particles larger than the filtration degree are trapped on the screen surface. These large particles start acting as a filter aid and begin trapping smaller and smaller particles. Eventually this layer of particles, or filter cake, will cause enough pressure loss across the filtration area that some cleaning method must be employed.

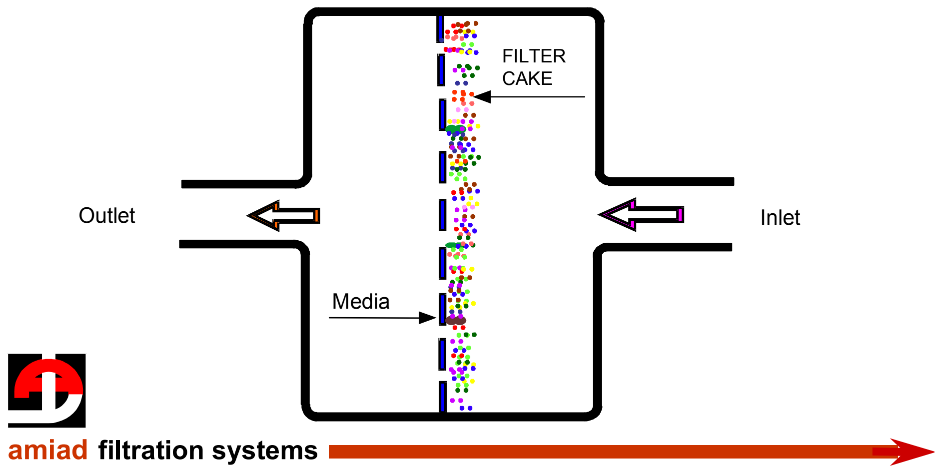

Figure 1: Simply Screen Strainer

As an example an 8" Amiad Model EBS strainer with a filtration degree of 100 microns has an inlet cross sectional area of 50 square inches and an outlet cross sectional area of 50 square inches. However, the open area of the screen (sum of the areas of holes) in this strainer is 500 square inches. If we simple back flush the strainer by reversing the flow we get the situation shown in Figure 2.

Once 50 square inches of the filter open area is cleaned, the fluid velocity through the inlet, outlet and cleaned screen area will be equal. Therefore, there is no energy available to clean the remaining 450 square inches of filter open area. The screen remains 90% blocked yet the differential pressure across the screen is zero. No amount of back flushing will clean more than 10% (50 square inches) of the screen in this example. This results in the fallacy of cleaning screen strainers by simple back flushing methods.

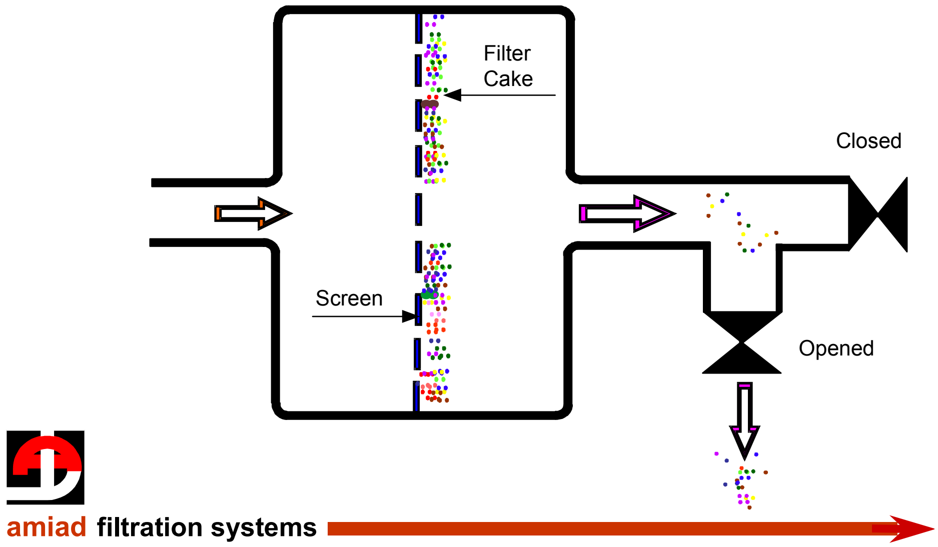

Figure 2: Strainer Back Flushing

Again, taking the simple strainer of Figure 1, let us apply *forced back flushing* to the screen as shown in Figure 3.

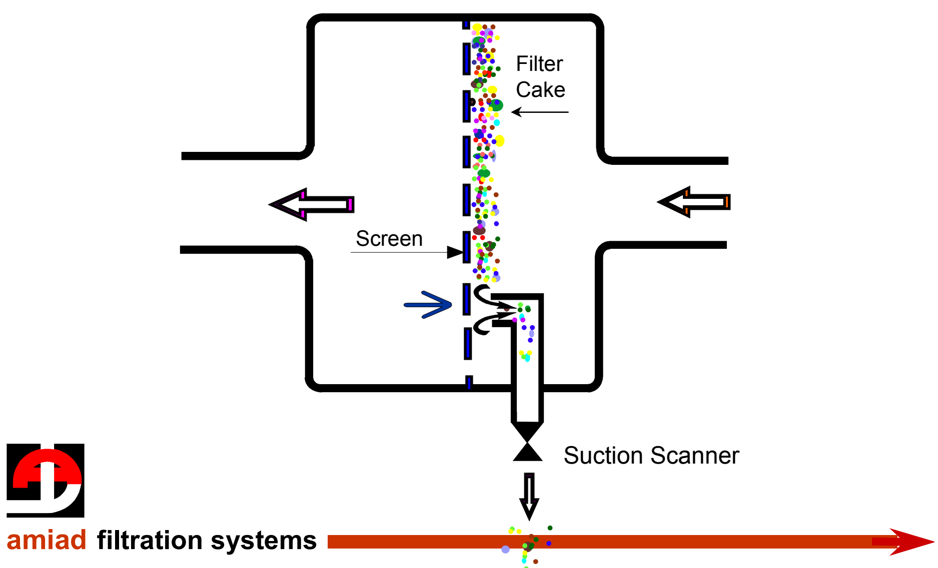

Figure 3: Forced Back Flushing

A device called a *suction scanner* is used to limit the cleaning of the screen to a small confined area. The suction scanner is nothing more than a hollow tube with one end very close to the screen surface and the other end exposed to the atmosphere. The differential pressure between the inside of the strainer body (the fluid working pressure) and atmospheric pressure (zero gauge pressure) creates a tremendous suction in a small area near the screen surface. The filter cake (trapped debris) is quickly sucked off the screen and expelled to the atmosphere. The suction scanner is then moved across the entire surface of the screen in less than one minute to remove all debris from the screen. In the meantime, the filtration process continues without interruption.

Operation of the Amiad Self-Cleaning Strainer

Figure 4 shows a cutaway of an Amiad Model EBS strainer utilizing the suction scanning method of screen cleaning.

1. Drive unit
2. Exhaust valve
3. Suction scanner
4. Weavewire screen
5. Wiring box
6. Pressure differential switch

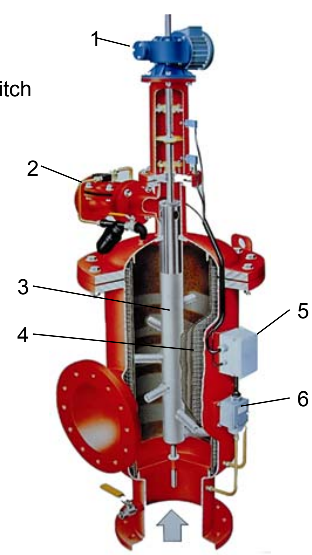

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Figure 4: Amiad Model EBS Automatic Strainer

Dirty water enters the inlet flange at the bottom of the strainer housing. The water passes into the cylindrical screen element made of 316L stainless steel, through the screen and out the side outlet flange. Macro particles (debris) are captured on the inside surface of the screen and build a filter cake. As this cake builds, the fluid pressure drops across the screen. A pressure differential switch constantly compares the pressure inside and outside of the screen element. When a preset differential pressure is reached (usually 7 psi), the differential pressure switch signals the programmable logic controller (PLC) that it is time to begin a cleaning cycle. The PLC first opens the hydraulic diaphragm exhaust valve to atmospheric pressure. This valve is connected to the hollow 316 stainless steel suction scanner that has nozzles with openings in the ends very close to the screen surface. The differential pressure at each nozzle hole, caused by the difference between the working gauge pressure (35-150 psi) and atmospheric gauge pressure (0 psi), results in a low-pressure area in the vacinity of each nozzle. This low pressure causes water to flow backward through the screen in this small area 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 a speed that will 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 between two limit switches. This gives each suction scanner nozzle a spiral motion such that the entire screen surface is sucked clean by the scanner in 12-40 seconds depending upon the filter model. When the upper limit switch is reached, signaling that every square inch of the screen has been covered by nozzles, the PLC checks with the pressure differential switch to see that the pressure drop across the screen is less than 1 psi. If so, 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. At this point, the drive unit stops and the system waits for the next 7-psi pressure drop across the screen to occur. If the pressure differential across the screen is greater than 1 psi, the cleaning cycle will repeat itself. This will continue as needed or until the PLC program signals a fault and carries out a preprogrammed function, i.e. turns on a warning light, stops a pump, opens a by-pass, etc..

This cleaning method results in thorough cleaning of the screen element during each cleaning cycle, minimum pressure drop through the system and uninterrupted filtration. Macro particles are removed from the fluid and sent, along with a small volume of carrier water, to a wastewater drain, fluid recovery system or surface water source (lake, pond, river, ocean, etc.). This simple cleaning system uses one slow moving part (suction scanner) and one hydraulically operated diaphragm valve. Wear and maintenance are minimal. The heavy-duty four ply 316L stainless steel screens are typically replaced only when the filtration degree requires changing. The polyester coating on the housing provides a high degree of protection. All 316 stainless steel housings are available in critical situations and a rubber coating can be applied during the manufacturing process allowing the filter to be used in seawater applications. Total water volume wasted is dependent upon the TSS concentration and the filtration degree of the screen. This volume is typically much less than 1% of the total flow through the strainer.

Applications

Amiad weavewire 316L stainless steel screens are strong and long lasting, capable of withstanding a 250-psi pressure differential across the screen with no distortion. Filtration degrees are available from 500 microns down to 10 microns. Macro particles typically removed by Amiad self-cleaning suction scanning strainers include sand, silt, pollen, insects, fibers, pipe scale, rust flakes, algae, metal fines, metal hydroxides, vegetable matter, weld balls, sealer, plastic chips and all life forms of zebra mussels including their eggs, to mention a few. They are found in industries such as automotive, foundry, mining, irrigation, food, pulp & paper, plastics, municipal water supply, wastewater treatment and penguin ponds at the zoo.

Municipalities are finding the Amiad self-cleaning strainer to be the economical choice for pre-treatment of surface water sources. The Amiad strainer removes early season sand and silts resulting from snow melt and spring rains. The Amiad strainer easily removes algae and other organics caused by late summer blooms. The result is consistent water quality delivered to the municipal water treatment plant all year round at a fraction of the cost of flocculation and sedimentation pre-treatment systems.

Municipal, industrial and commercial wastewater treatment facilities that cannot discharge effluent year-round are finding Amiad self-cleaning strainers allow them to stay within regulatory limits. Effluent stored in holding ponds accumulate algae, bird feathers, turtles, fish, wind-blown debris and other suspended solids. Though once of discharge quality, the effluent discharged from these ponds often cannot meet the daily solids load limit imposed by regulatory agencies. A small pump and Amiad strainer can solve this problem very economically.

The Amiad self-cleaning strainer coupled with a 10-micron stainless steel weavewire screen can pre-filter potable water down to a level ready for most membrane systems. Some companies using this approach state they are getting an average 5-micron nominal filtration and go directly to RO membranes. Others feel more comfortable installing a cartridge filter between the Amiad strainer and the membrane to polish the influent. Either way, Amiad strainers provide a fully automatic self-cleaning system to remove all or nearly all of the suspended solids that would cause havoc with typical membrane systems.

Due to its low maintenance and attention requirements, the Amiad self-cleaning strainer lends itself to industrial and commercial cooling tower systems. Installed either as a sidestream closed-loop system or as a full flow system, this strainer will maintain clean cooling fluid to prevent the clogging of spray nozzles or the coating of heat exchange surfaces.

Summary

Amiad fully automatic self-cleaning strainers provide an economical means of removing suspended solids down to 10 microns from water streams. The efficient suction scanning principle allows the filter cake to be removed completely from the screen surface within seconds without physically touching the cake or screen. During the suction scanning cleaning cycle the filtration process is uninterrupted; thereby, providing filtered water downstream of the strainer at all times, eliminating the need for duplex systems. Due to their proven record of long-life, wide range of filtration degrees and low maintenance, Amiad strainers lend themselves to many uses in industrial, commercial and municipal markets.