WATER TREATMENT FOR THE PRINTING INDUSTRY

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Abstract: While there have been changes within the printing industry over the years, the printing process and chemicals are basically the same - at least for the present. There is now concern and activity due to the impetus from governmental, environmental and occupational safety regulations that is changing the industry's focus. These changes range from utilizing water based fountain solutions to complying with regulations on discharge to the sewer system. Enforcement of such regulations will stimulate the industry to become cognizant of the different water treatment processes available. Based on this, the following is a description of the four major processes used within the industry. Note: From a suppliers perspective, the printing industry is fragmented. For example, sixteen SIC (Standard Industrial Classification) codes are used to characterize the industry from a census viewpoint. Therefore, it is not feasible to provide specific water treatment recommendations for a particular process as it may pertain to colors, inks, papers, press operation, etc.

There are four basic water treatment processes that the printing industry needs to consider: filtration, softening, deionization and reverse osmosis.

FILTRATION Most commercial/industrial filters use the multi-media principle called depth filtration, in which several layers of different types of media are contained in the same filter tank.

Typically, a depth filter will use four such layers, and starting from the top down, each layer is finer and heavier and has a higher specific gravity. A light top layer of coarse material traps large particles. The second layer traps smaller particles and the third and fourth successfully trap smaller particles. Therefore, the entire filter bed is being utilized.

Depth filters can trap particles as small as 10 microns. Using filter aids such as coagulants, they can trap particles as small as one micron.

When a depth filter is saturated it is regenerated, usually on a time basis or pressure differential basis. Backwashing flushes particulate matter from the tank and makes the filter ready for use again. Since the various media layers are of different weight and specific gravity, they automatically restratify themselves after the backwash cycle. The filter is then put back on line.

Due to different water conditions, three other types of filtration should be mentioned. The first is carbon filtration, which is primarily used for removal of tastes and odors from water. These associated problems are typically caused by organic material in the raw water. Carbon filters remove chlorine which for the graphic arts press operator, is a must to avoid gum arabic problems. The second is greensand filtration which is used when iron and manganese are present. The result to the end user is staining, even though the water may appear to be clear. The third type is a smaller version of the above. That is, when the water has dirt, sand, sediment or other types of particulate matter, a small compact in-line water filter (with replaceable cartridges) are installed. The cartridges range from fine filtration where the nominal particle removal rating is 5 micron to extra coarse filtration where the nominal particle removal rating is 300 micron.

SOFTENING In terms of defining when water is considered hard, the following classifies water hardness, compliments of the U.S. Department of Interior. Their breakdown in grains per gallon (GPG) are as follows:

Less than 1	-	Soft
1 - 3.5	-	Moderately hard
3.5 - 7.0	-	Hard
7.0 - 10.5	-	Very hard
10.5 & Above	-	Extremely hard

A discussion of the fundamentals is therefore in order. A softener's function is to remove the hardness from the water.

Hard water is defined as water that contains dissolved calcium and magnesium, minerals that are found in the earth and that dissolve into the water supply. Well water usually has a higher hardness than surface water from rivers and lakes, but most water supplies contain some hardness.

Hardness can be measured as grains per gallon, milligrams per liter or parts per million. One grain per gallon is roughly equivalent in weight to a grain of wheat, hence the term. One milligram per liter and one part per million are roughly equivalent to each other, and the terms are used interchangeably in the water treatment industry. One grain is also equal to 17.1 parts per million or 17.1 milligrams per liter.

Ion exchange softeners consist of a resin tank to hold the ion exchange resin, a brine tank that contains salt for softener regeneration and a control valve.

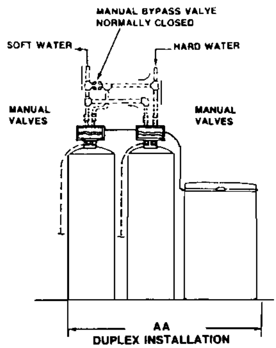
In operation, water flows down through the resin bed, an artificial plastic material made of millions of tiny beads. As the water passes across the beads, the calcium and magnesium, which have positive charges, are attracted and held by negatively charges exchange sites on the porous resin beads. In turn, the sodium ions on the beads are released and pass into the water supply, which is why softened water contains sodium. The amount of sodium released is equal to the amount of combined calcium and magnesium, since the ion exchange process takes place on a one-for-one basis.

The time will come when the beads have no more sodium ions and cannot absorb any more calcium or magnesium ions. At this point, the resin bed is exhausted and must be regenerated. Regeneration is done with a brine solution, prepared in the brine or salt tank. Since salt is sodium chloride, during regeneration the sodium ions replace the calcium and magnesium ions on the beads, and the resin bed is once again ready for service.

The regeneration process in most softeners is performed by automatic controls and valves, but can be overridden manually. Most controls operate on a time basis and also are available to regenerate on a volume basis. In addition, sensors are employed in more sophisticated softeners which compensate for variations in water usage or water hardness.

Softening is sometimes used to provide softened water to the deionizer. This increases the service cycle life of the deionizer, thereby fewer deionizer regenerations. This practice saves money; it is less expensive to regenerate a softener with salt than a deionizer with chemicals. Softening can also be used as pre-treatment for a reverse osmosis unit. Hardness minerals in unsoftened water can scale up reverse osmosis membranes causing premature membrane replacement which can increase RO system operating costs.

Another consideration is if the printing application operates 24 hours per day, a duplex softener should be installed. The reason for this is that when a softener is in its regeneration cycle - approximately 70 minutes - the raw water is sent to service. Therefore, the only way you can be insured of a constant supply of soft water is to have a duplex system. Duplex systems are interwired so that only one softener can be regenerated at one time.



DUPLEX INSTALLATION
(TYPICAL)

Ion exchange softeners remove more than hardness minerals from water. They also remove small quantities of iron, barium, manganese, naturally occurring radium 226 and 228, cadmium, lead and silver. In terms of performance, most ion exchange softeners reduce hardness to less than one grain per gallon, a level that is relatively harmless in most industrial equipment.

DEIONIZATION Deionizers also use the ion exchange process, but are more sophisticated than softeners. Whereas a softener uses one resin only, a cation resin, a deionizer uses both a cation and an anion resin.

A two-tank deionizer contains cation resin in the first tank and the anion resin in the second tank. As water passes through the cation resin, which is in hydrogen form rather than the sodium form used in softeners, the various cations such as calcium, magnesium, iron, etc., are removed and replaced by free mineral acidity, or FMA. The water then passes through the anion unit, where anions such as chloride and sulfate are removed and replaced by hydroxide. FMA and hydroxide combine to form water, now free of all ionic impurities.

There are other deionizer arrangements such as a two-bed strong base anion resin, a two-bed weak base and mixed bed. Strong base and weak base resins have different chemical formulations to do different jobs.

A weak base anion resin does not remove silica or carbon dioxide from the water. It produces water with a quality of about 50,000 ohms specific resistivity, and a pH slightly below 7.

A strong base resin removes both silica and carbon dioxide, produces a water with a quality of up to 200,000 ohms specific resistivity, and a pH of 7.5 to 9.5.

Obviously the choice of which resin to use, strong or weak base, depends on the chemistry of the incoming water and the desired quality of the product water. Weak base resins cost less, so there is no need to use strong base resins if silica or carbon dioxide are not present in the water supply.

In a mixed-bed deionizer, both the cation and anion resins are mixed in the same tank. Instead of one contact with the cation and anion resins, there are literally millions of contacts with both types of resin, with the ion exchange process taking place with each contact. In effect, it is like passing the water through a multitude of two-tank deionizers. Predictably, mixed-bed deionizers produce water of much higher quality than two-bed deionizers, from one million to 18 megohms specific resistivity.

Water quality can also be measured in parts per million of dissolved solids. Deionizers can be equipped with a TDS monitor that provides a continual readout of this measurement. It should be mentioned about the piping system materials. Pure water applications such as deionizers are very sensitive to piping materials. Without proper piping selection the end user could be adding back impurities into the treated water supply. Basically, the downstream service piping for the deionized water must be corrosion resistant material. This may consist of PVC, stainless steel or other corrosion resistant piping.

REVERSE OSMOSIS Reverse osmosis is an amazingly simple process of producing high quality water. Water is forced under high pressure through a semi-permeable membrane which traps particulate and dissolved matter and washes them away to drain while separating the purified water for use.

In the natural osmosis that occurs in nature, osmosis is the passage of a liquid through a membrane from a state of low concentration of solids to a state of high concentration. A tree leaf, cells in the human body, the liver, all use natural osmosis.

But to purify water, it is necessary to change the water from a state of high concentration to low. The osmotic process must be <u>reversed</u>.

That is what happens in an RO unit. Figure one shows the osmotic process. When pressure is applied to the concentrated solution, reverse osmosis takes place as indicated in figure two.

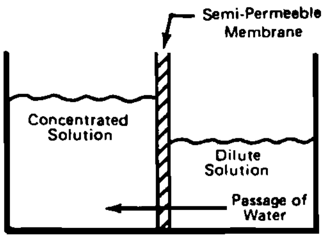


FIG. 1

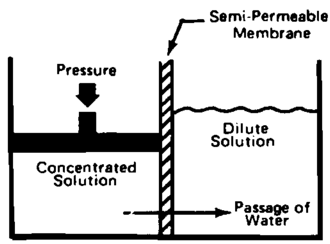


FIG. 2

Feed water is forced under high pressure through a membrane, usually a film wound on a perforated plastic tube. Product water for use, called permeate, enters the tube and is piped to service. Water that contains the rejected impurities, called concentrate, is piped to drain.

Reverse osmosis achieves about 97 to 98 percent rejection of solids from the incoming water supply. A reputable manufacturer of reverse osmosis systems will guarantee a rejection of over 95 percent, and in practice, rejection levels are shown above that. A reverse osmosis system is also very effective in removing virtually all suspended matter plus various bacteria and other micro-organisms. The amount of solids left in water after reverse osmosis treatment depends on the amount of solids in the incoming water, a fact revealed by the water analysis.

For example, much of Southern California receives their water from the Colorado River supply which has a TDS that typically runs about 500 parts per million (PPM). The product water supply from a reverse osmosis system will have a TDS of under 10 PPM or less than one half a grain per gallon.

Thus, either deionization or reverse osmosis can produce water when high purity water is required. If the ultimate in water quality is required, a water treatment system may incorporate depth filtration, softening, reverse osmosis, deionization and even sub-micron filtration. The systems approach can be costly and should be used only if engineering studies indicate a strong need for it.

It is obvious that because of the choices involved, users should deal with suppliers that provide all types of water treatment systems and use all known processes so that objective recommendations can be made. For example, a supplier that only offers deionizers will recommend deionization, not because that is what is needed, but because that is what the supplier provides.

It is just as important to select a supplier who can provide service locally. Irrespective of the manufacturer, water treatment systems do require maintenance from time to time and it is vital that their operation be continuous. Water treatment system downtime translates to production line downtime.

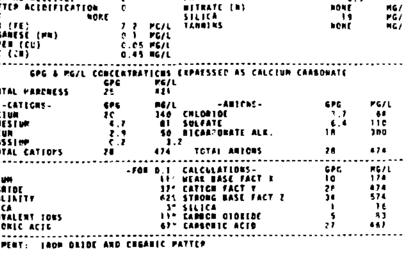
Just as obvious, some engineering evaluations are required in order to determine the answers to the question of which type and how much water treatment is required. Such evaluations must consider:

1. water chemistry
2. the water treatment process or combination of processes to be used
3. the economics of water treatment

To determine water chemistry, a water analysis is needed. This is absolutely a must because without it no feasible determination can be made as to if a water treatment system is needed, and if so, what type of system best suits the analysis. Most manufacturers of water treatment systems provide analytical laboratory services which provide determinations of inorganic contaminants of the raw water. If in doubt, the prospective buyer can always have the water analyzed by an independent laboratory. It is recommended that the laboratory chosen be certified by the state Environmental Protection Agency.

Water analysis should be studied for validity. Some checks to make include:

1. total hardness must equal total calcium and magnesium, usually expressed as MG/L or GPG
2. total cations and total anions must be within 10 percent of each other
3. the analysis should include deionizer calculations


WATER ANALYSIS REPORT Culligan.

CULLIGAN WATER CONDITIONING
123 FOURTH STREET
SOMEWHERE, USA

ANALYSIS NUMBER N 547189
CONSUMER A. CUSTOMER

US ZIP OF SAMPLE LOCATION 0000
SOURCE PRIVATE WEL
SAMPLING POINT WEL
SAMPLING REPRESENTS UNTREATE

FILE NUMBER 54-321 MM
SAMPLE 00/00/00
RECEIVED 00/00/00

TURBIDITY AS RECEIVED	25	NTU	CONDUCTIVITY (MMHOS/CM)	800	
AFTER FILTER (<10 U)	3	NTU	EST TDS BY CONDUCTIVITY	510	MG/
COLOR AS RECEIVED	2		PH	6.9	
AFTER ACIDIFICATION	0		NITRATE (N)	NONE	MG/
ODOR	NONE		SILICA	19	MG/
IRON (FE)	7.2	MG/L	TANNINS	NONE	MG/
MANGANESE (MN)	0.1	MG/L			
COPPER (CU)	0.05	MG/L			
ZINC (ZN)	0.45	MG/L			

GPG & MG/L CONCENTRATIONS EXPRESSED AS CALCIUM CARBONATE

	GPG	MG/L			
TOTAL HARDNESS	25	421			
-CATIONS-	GPG	MG/L	-ANIONS-	GPG	MG/L
CALCIUM	20	340	CHLORIDE	3.7	64
MAGNESIUM	4.7	81	SULFATE	6.4	110
SODIUM	2.9	50	BICARBONATE ALK.	18	300
POTASSIUM	0.2	3.2			
TOTAL CATIONS	28	474	TOTAL ANIONS	28	474

	-FOR D.I	CALCULATIONS-	GPG	MG/L
SODIUM	11%	WEAK BASE FACT X	10	174
CHLORIDE	17%	CATION FACT Y	28	474
ALKALINITY	62%	STRONG BASE FACT Z	34	574
SILICA	3%	SILICA	1	16
MONOVALENT IONS	11%	CARBON DIOXIDE	5	83
CARBONIC ACID	67%	CARBONIC ACID	27	467

SEDIMENT: IRON OXIDE AND ORGANIC MATTER

Another factor to look for in a water analysis includes the amount of turbidity, which is an indication of the suspended particulate matter.

The analysis should show the pH of the water. The pH scale runs from 0 to 14, with 7.0 being the numerical neutral point. Low pH waters are acidic and corrosive; high pH waters are alkaline and tend to build up scale faster. Hopefully, any variation from neutral should be slightly toward the alkaline side because the scale is easier to tolerate and correct than corrosion. Chemical feeders or neutralizer filters that maintain pH at acceptable levels may be required in certain situations.

It is recommended that free chlorine be tested on site since chlorine escapes from water samples sent to laboratories. High amounts of chlorine typically require the use of an activated carbon filter.

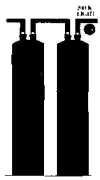
The water analysis provides instant clues as to whether some water treatment processes should be employed in the system - depth filters, activated carbon units or pH control equipment.

In any case, the major decision is whether or not to use deionization or reverse osmosis as the principal treatment process. Both produce high quality water with TDS approaching zero and both provide water that is free of contaminants. If the decision is made to use deionization another decision must be made, either an automatic on-site deionizer or exchange service deionizer tanks.

The principal costs of an on-site deionizer are the initial purchase price, cost of regenerant chemicals, cost of water used in the backwash/regeneration cycle, neutralization and labor. Deionized water can also be provided by exchange service deionizer tanks known as portable exchange or PE tanks. These are usually 9, 12 or 14-inch cylinders that measure about 44 inches high and are supplied by a local water treatment dealer in quantities sufficient to meet the volume demands of the user. The dealer periodically picks up tanks from the user, leaves freshly regenerated tanks in their place and takes the exhausted tanks back to his plant for regeneration.

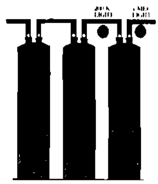
High purity water systems using exchange tanks are available in different system configurations. Some of these are shown below.

TWO-BED
A cation exchanger and anion exchanger connected in series. The cation exchange unit removes positively charged ions from water, including calcium, sodium, magnesium, iron, manganese and potassium. The anion exchange unit removes negatively charged ions, including sulfates, chlorides, carbonates, bicarbonates, nitrates, and silica. May use weak base or strong base resin, depending on application

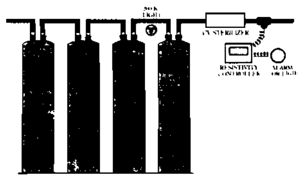


MIXED-BED
Cation and anion resins are combined and mixed in a single tank, permitting thousands of cation and anion exchange processes to take place as water passes through the resin beds.

MULTIPLE-TANK SYSTEMS
Three tanks or more, connected in series or parallel or a combination of the two, to produce highest purity water in any desired quantity. Systems may be a cation-anion-mixed bed, cation-cation-weak base anion, cation-strong base-strong-base, or any of several combinations, depending on the specific water problem.



COMPLETE MULTIPLE-PROCESS TREATMENT SYSTEMS
Exchange service tanks using other water treatment processes may be added to create a more complete high purity water system. Typically, a system may include one or more of the following processes: softening, depth filtration, carbon adsorption, UV sterilization, submicron filtration, or other processes.



The user pays for such services according to the number of tanks used, the number of regenerations required, the volume of water used on a cost-per-gallon basis or a combination of these factors. Probably the biggest advantage of using exchange service tanks is that the user does not have to handle regenerant chemicals and thereby, there is no possible disposal problem. Also, there is no cost for chemicals or labor. These costs are all built into the water treatment dealer's charges but the use of exchange tanks greatly simplifies both the mechanics and accounting of obtaining high quality water. The cost of using exchange service tanks include:

1. monthly rental per tank
2. regeneration charges

   or

3. cost per gallon of water used

If water is paid for by the gallon, that cost can range from 3 cents to 40 cents per gallon depending again on local factors and water chemistry.

The costs of using reverse osmosis includes:

1. acquisition cost of the RO unit
2. electrical operating cost
3. water cost
4. eventual module replacement cost

In an RO system, from one third to two thirds of the water passing through the system is sent to drain depending on the recovery rate of the RO system. That water cost must be figured as part of the operating cost. Some users are able to recycle that water for other uses and in such cases it should also be part of the calculation.

Reverse osmosis modules must eventually be replaced and this cost must be factored into the equation. As a general rule of thumb, the higher the TDS of the incoming water, the more economical it is to use reverse osmosis to produce high quality water. The reason is that the cost of regenerant tank exchanges or the cost of operating an on-site deionizer becomes high enough at a certain point to warrant buying a reverse osmosis system. One recent trade publication documented that based on per 1,000 gallons, RO costs less per gallon than DI whenever the TDS is 200 PPM or above.

Since both the deionization and reverse osmosis system provide high quality water, the following are the major benefits of the two systems.

<u>DEIONIZATION</u>

- 100% removal of total dissolved solids
- produces gallon of quality water for every gallon used
- mineral bed life longer than membrane life
- requires less space than reverse osmosis
- no maintenance for the end user

REVERSE OSMOSIS

- lower operating cost
- effective in organic and micro-organism removal
- less aggressive than deionized water
- more stable pH and consistent quality
- does not require handling hazardous chemicals (vs. automatic DI)

Premised upon feedback from a survey with the major water treatment company's as well as end users, the following are some of the benefits of conditioned water within the printing industry.

- consistent water quality to control print quality
- quality control due to less scuffing and faster drying
- overall maintenance savings
- with spray bar technology - prevention of nozzle clogging
- reduce problem of ink not staying on roller
- eliminate varying water quality that municipal plants supply
- controlling pH of fountain solutions especially critical in offset printing
- pure water reduces the quantity of printing chemical needed
- multiple benefits for boilers and cooling towers
- provides consistent press performance
- pure water to control the variables in fountain solutions
- reduce solvents used in drying process
- less acid used for pH adjustment
- ink lays down better on sheet
- more consistent reproduction quality
- overall eliminates one more problem to deal with - inconsistent water quality from the city supply.
- consistent water quality to facilitate balancing of solutions

The above represents a cross section of the major processes used in commercial printing, these being offset lithography, gravure, flexography, letterpress and screen. The dominant printing process of the future will be those that use imaging materials that are non-toxic, non-flammable and non-polluting and at a reasonable cost. Water treatment will certainly be a factor in the industry's continued growth.

The printing industry is in need of water quality standards. As more is learned about the effects of water within the industry, that knowledge needs to be gathered by an industry committee for the purpose of creating and promulgating a water quality standard. Representatives from the water treatment industry should be members of such a committee. It is hoped that this paper will serve as a base of knowledge from which a Printing Water Quality Standard can be created for all to use, and from which all can benefit.