Water Treatment— The Key Process

WHY IS WATER TREATMENT NECESSARY?

The treatment of water is the key process of soft drinks manufacture. This is because water is the major component of a soft drink. A carbonated soft drink can contain about 87 to 92% water, whereas a bottled water product may be pure 100% natural spring water. As such, the quality of the water used in a beverage has a critical impact on the taste of the drink, its appearance, and its physical and microbiological stability on the shelves in the store. The water used by soft drink manufacturing facilities may come from two main types of sources. The most common source is the municipal water supply, but there are also water sources that are privately owned wells. The source water before it is treated in the factory is often referred to as "raw water," a term that is used in this handbook.

Though raw water is normally treated by the municipality or private well owner to render it potable and fit for human intake, it may still have characteristics and components that can adversely affect the quality of the beverages in which it is used. These need to be eliminated or at least reduced so that their effects are minimized. Raw water from a single source may also vary considerably in composition and physical and chemical characteristics due to seasonal or environmental changes in the source conditions. Again, though the raw water may still be completely potable, these changes could impact significantly on the quality of final beverages. A soft drink manufacturer should endeavor to maintain a consistent quality in its products, and such changes must be neutralized. Raw water from different source locations may differ considerably. Large soft drink companies, especially those with international markets, need to maintain a consistent quality image of their brands, regardless of the geographical location. Thus, water used in their products must be rigidly standardized in quality aspects.

Still another reason for the need to treat water for soft drink production is that on occasions, infrequent as they may be, municipal water treatment plants may encounter problems. Although these may be considered as mere inconveniences by the public so affected, to the soft drink manufacturer, it could present serious marketing and cost hazards should such water be used in its products.

In certain underdeveloped countries and communities, there are no source water treatment facilities. Soft drink manufacturing operations in such places must therefore treat the raw water themselves to render their products fit for human drinking. Still another factor to consider is that though the municipality may very well treat source water, it can become contaminated on its way to the end user due to faults in the often-complex distribution system.

The soft drink manufacturer cannot afford, for obvious reasons, to take a chance on using substandard water in any single batch of final beverage it produces. Raw water must, therefore, always be treated to meet the established quality specifications of the soft drink manufacturer.

RAW WATER ADVERSE QUALITY FACTORS

Raw water, as supplied to the public for human intake and general use, in most cases, meets stringent quality and health standards of local authorities or the World Health Organization (WHO). Even as such, it may still have characteristics that do not suit the delicate and sensitive interactive structure of a soft drink's composition on which its general good quality depends. This dependence on good quality water in the drink is especially true when source water treatment is inadequate or absent.

The following briefly describes the possible adverse factors of raw water that could affect the quality of final-product soft drinks.

SUSPENDED MATTER

Raw water often contains suspended colloidal matter and organic particles. These not only can cause unsightly appearance and turbidity, especially in clear beverages, but can also provide anchorage sites for microorganisms. Such “hiding places” can protect the microorganisms from the disinfection process in water treatment.

CHEMICAL COMPOSITION

The dissolved minerals determine the alkalinity and pH of the raw water. High alkalinity/pH neutralizes the acidity component of the beverage and, thus, could affect the overall taste profile of the beverage. Certain compounds, such as those of iron, chlorides, and sulfates, at even very low concentrations, can impart off-tastes to the beverage. This is also true of residual chlorine, which is sometimes deliberately retained in raw water by the source water treatment process. Raw water may sometimes contain dissolved organic compounds that impart an off-taste or off-odor to the beverage. Raw water may also inadvertently contain organic compounds hazardous to health, such as trihalom- ethane (THM) or residual pesticides. (THM will be discussed briefly later in this chapter.)

MICROORGANISMS

One of the prime aims of municipality treatment of source water is to eliminate pathogenic organisms from the source water. This is of prime concern from the public health aspect, and raw water is normally free of such hazards. However, soft drink manufacturers cannot take any chances in this matter, and all raw water must be disinfected adequately to remove such a potential health hazard from their products.

All local and WHO raw water specifications allow for a certain level of nonpathogenic bacteria. These microorganisms, as a rule, are not a major beverage spoilage factor, but it is always wise to be on the safe side. This, therefore, should also be checked by the soft drink manufacturer and addressed by disinfection in the treated water process.

SOURCE WATER QUALITY VARIATION

Source waters, of both the surface and underground types, are often subject to seasonal changes as well as to unpredictable local events in the nearby environment that can cause significant changes to the raw water quality. These can still be within the specification of the source water treatment process and, as such, have no special significance to the public water user. However, the changes may impact heavily on the soft drink manufacturer as explained above. The manufacturer usually aims to keep product brand images as consistent as possible, and changes in appearance or taste are not desirable.

Raw water from different source locations may differ considerably. An individual soft drinks facility may have to use one or more raw water sources. This is unavoidably true for national or international multiplant organizations. In both of these cases of variations in source water quality and composition, there is a need for standard treated water specifications in order to achieve unwavering consistent quality in the facility’s products.

WATER TREATMENT TECHNOLOGY

The technology of water treatment in the soft drinks industry, if not too complex, is nevertheless too vast and diverse to be fully covered in this handbook. This chapter will be confined to a brief general outline of the technologies involved and issues related to water treatment in the soft drink manufacturing operation.

Water treatment technology is esoteric in nature, involving at least some basic knowledge of various chemistry disciplines, microbiology, engineering, and equipment design. The effective operation of a water treatment plant requires process-operating skills and more than a little experience. Staff members in the larger soft drink corporations charged with water treatment duties and responsibilities are usually specifically trained for this purpose. In smaller independent companies, if not properly trained in water treatment essentials, staff members are best advised to master the basics of the operation for the daily routine running of a water treatment plant and leave its design, installation, commissioning, and general maintenance to outsourced specialists in the field. With time, however, such company staff may well become experts in the field.

Water treatment plant design and level of technology involved should be based on a few pivotal considerations regarding the quality of raw water supplied to the soft drink manufacturer:

- Confidence in the source water treatment process
- Consistency in quality
- Standard levels of adverse raw water quality factors (e.g., alkalinity, microbiological, suspended matter, dissolved minerals, disinfectant residues, etc.)
- Protection from external contamination at the source as well as throughout the distribution system
- Seasonal variations in source water composition and characteristics

The more favorable these factors are, the less complicated and involved is the technology for the treated water plant design and operation. Also, the costs involved will be less.

Another major consideration is the type of soft drink end product. It would be pointless, for instance, to use ozone as a raw water disinfectant for a carbonated soft drink, where the residual ozone in the bottled product would be immediately used up by the various ingredients and also could oxidize some of the key flavor and color components. On the other hand, chemical treatment of raw water for bottled water products is not only sometimes prohibited by law, but also it will alter the natural or added mineral content of the product.

THE MULTIPLE BARRIER CONCEPTS

A series of complementary processes that incrementally eliminate or reduce adverse factors is a multiple barrier system.

The treatment of raw water intended for use in soft drink production consists of a number of processes aimed at controlling diverse and separate features that could adversely affect the quality of the final beverage. As such, the design and operation of an effective water treatment plant uses the multiple barrier principle to achieve a combined process system that will effectively and totally control these various features.

A multiple barrier system can generally be described as an orderly series of reliable processes that, in a complementary and incremental manner, completely removes or reduces targeted raw water adverse quality factors to acceptable levels. Each process on its own serves as a “barrier” to adverse factors, either eliminating one or more or reducing the level at that barrier stage. In soft drink water treatment, the multiple barrier principle is applied by combining separate individual processes, the end result of which is the highest-quality water at the lowest practical cost.

MULTIPLE BARRIER WATER TREATMENT

As mentioned before, the design and operation of a multiple barrier water treatment plant depend on the composition of the raw water, the consistency of its quality, the reliability of its supply, and, to a certain extent, the type of end product being manufactured. The major considerations for the design of the system that will result in high-quality treated water at the lowest possible cost for the final beverage are as follows:

- The quality of the raw water
- The treatment process for microorganisms
- The treatment process for removal of or reduction in suspended and dissolved materials
- The treatment process to eliminate off-tastes and off-odors
- The treatment to ensure high-quality product appearance
- The overall effective treatment for all water used in all the company's product types

Figure 5.1 is a schematic representation of the basic processes required of a multiple barrier water treatment plant. Each process will be briefly described separately. However, it must be remembered that in a multiple barrier system, the processes are complementary to each other. Only the full combined effects of each process result in the final end product of high-quality treated water for use in soft drink manufacture.

ENHANCED FILTRATION

The most critical process of a multiple barrier system is that of enhanced filtration. This refers to a filtration process that is capable of removing minute matter at the molecular level, as opposed to simple filtration in which only relatively larger particulate matter is filtered out of the water. Enhanced filtration removes a variety of adverse suspended matter and dissolved chemicals:

- That could not be filtered out by operations further along the line in the water treatment process
- That could protect microorganisms from the disinfection process
- That could react with the disinfectant and reduce the latter's effectiveness
- That could serve as precursors for THM formation
- That the activated carbon filter would otherwise remove, which reduces the working load on the carbon filter and enhances its performance in removing the specifically adverse materials at which it is targeted; also, the carbon filter's operating life is lengthened, with subsequent cost savings in regeneration or replacement of activated carbon granules

There are two main types of enhanced filtration systems: coagulation/flocculation and mem- brane filtration.

COAGULATION/FLOCCULATION

BATCH SYSTEM

As the name implies, this consists of two processes. The following is an outline of these processes as they occur in a batch system of coagulation/flocculation. A cationic coagulant such as ferric chloride is added to the tank with the water to be treated (Figure 5.2).

It is converted to its gelatinous hydroxide form (1), and its cationic positive charges neutralize the negative charges of suspended colloidal particles in the water (2). These particles now do not repel each other, and together with the hydroxide flocculent, start coagulating into larger gelatinous masses that are commonly called floc (3).

The floc masses grow in size until they are large and heavy enough to start slowly sinking to the bottom of the tank (Figure 5.3). As this now dense cloud of floc slowly sinks, it physically entraps and carries organic and inorganic particulate matter with it. This layer of cloudy floc can be likened to a very fine filtering device slowly moving downward through the water, trapping matter in its path (instead of the more common filtering situation of moving water passing through a stationary filter).

The floc with all the entrapped material eventually settles at the bottom of the tank in the form of sludge, which is periodically removed and disposed. The supernatant water in the tank is drawn off and passed through a conventional type of pressure sand filter that entraps any floc that remains in the water. It also retains any small amounts of suspended matter that for some reason may not have been previously filtered out.

IN- LINE SYSTEM

In an in-line coagulation and flocculation system, the same principles apply, but the equipment design is different. Small amounts of cationic flocculent are continuously dosed at a predetermined rate into the incoming raw water flow leading to a relatively small static mixer. From the mixer, the raw water is fed into a deep-bed granular filter (e.g., sand filter). The rapid coagulation and flocculation process starts immediately in the pipes after the mixer and continues in the deep-bed sand filter in the spaces between the sand granules. As flocculation proceeds, much the same as in the batch system, the floc penetrates deeper into the filter bed and is retained on its way by the filter media. For this reason, the filter vessel needs to be much taller with a deeper media bed than a regular sand filter to ensure that all the floc is retained and only clear filtered raw water exits from the bottom outlet.

The advantages of the in-line system, as opposed to the batch system, are that it is less expensive in equipment, coagulant, and wastewater costs; it occupies less space; and it is relatively easy to operate. However, it is only suitable for raw water of very good quality with low levels of suspended or dissolved materials. Also, the in-line system does not combine alkalinity reduction with the filtration processes, as does the batch system.

MEMBRANE FILTRATION

The second type of enhanced filtration technology used in raw water treatment for soft drinks is that of membrane filtration. The basic principle involved in membrane filtration technology is the use of a pressure differential to force materials through a membrane on a selective basis. The membranes are called semipermeable, because, depending on the pore sizes, small particles and molecules may permeate (pass through) the membrane, while others of larger sizes are not allowed to do so and are retained in the water being filtered.

There are different classes of membrane filtration based on the sizes (or molecular weights) of the materials that can permeate through the membrane. Of interest to us are three types of membrane filtration systems:

- Reverse osmosis
- Nanofiltration
- Ultrafiltration

REVERSE OSMOSIS

dissolved solids diffuses through a semipermeable membrane into another solution of higher solute content. A special case of osmosis is when instead of the low solute solution, we have pure water. The pure water as "the low solute solution" diffuses through the membrane into the high solute solution.

This process of osmosis and that of reverse osmosis are explained in Figure 5.4. The first diagram (1) shows that when a solution of salt is brought into contact with water, the molecules of water, according to the principle of diffusion, migrate toward the salt; those of the salt migrate into the water. This process, if allowed, will continue until a state of equilibrium is reached in which a homogenous diluted salt solution is formed. The molecules of water and of salt are dispersed evenly throughout the liquid.

In diagram (2), a semipermeable membrane is first placed between the water and salt solution. This membrane is permeable to water molecules but not to those of the salt. Simple diffusion will start, but there will only be migration of water molecules through the membrane into the salt solution. The membrane barrier will block the salt molecules' diffusion into the water. The water passing through the membrane is called the permeate.

As a result of the permeation of the water into the salt solution, the level of the latter will rise and form an osmotic head (A) in the tube. The level of this head will rise as more water permeates through the membrane. When the weight of the now somewhat diluted salt solution in the head becomes equal to the osmotic pressure generated by this particular system, the osmosis process will stop.

Diagram (3) shows that if a high enough pressure (B) is applied to the osmotic head, e.g., by means of a pump, it will overcome the osmotic pressure of the system and start pushing the water molecules back through the semipermeable membrane. With sufficient applied pressure, a large portion of the water molecules of the salt solution will also be pumped through the membrane, and the level of the water will rise in the tube (C). We can see that the process in diagram (3) is the reverse of what happened in the osmosis process of diagram (2). Hence, this process is called reverse osmosis.

If the semipermeable membrane is such that it allows some molecules other than water to pass through it, this can be used to selectively allow these to also be included in the water permeate and block other undesirable ones.

NANOFILTRATION

Nanofiltration is similar to reverse osmosis but only treats particles of slightly larger sizes.

ULTRAFILTRATION

Ultrafiltration can be considered a straightforward filtering of small particles through membranes of larger pore sizes than those of nanofiltration and reverse osmosis.

ALKALINITY REDUCTION

The next step of alkalinity control is only necessary with raw waters of high alkalinity. If this is the case, it must be reduced, as high alkalinity neutralizes some of the acidity of soft drinks and could adversely affect the overall taste profile of the beverage.

Many raw waters have satisfactory low alkalinity levels, and if consistent in this respect, the alkalinity step may be omitted. As a rough guideline, raw waters of alkalinity below 85 ppm expressed as calcium carbonate do not require alkalinity reduction treatment.

Raw waters usually contain bicarbonates and carbonate of calcium and magnesium and, to a lesser degree, those of sodium. These are all soluble components in the water, and their presence in dissolved form contributes to the alkalinity of the water.

HYDRATED LIME TREATMENT

The most commonly used process for alkalinity reduction is that of hydrated lime treatment. Hydrated lime is actually calcium hydroxide and is commonly called “slaked lime.” It would seem strange that the addition of one calcium compound can result in the removal of another calcium compound from the water. However, this is based on a simple chemical reaction in which the hydroxide converts the soluble calcium bicarbonate to an insoluble carbonate, which, in turn, precipitates out and is thus removed from the water:

With the magnesium bicarbonate, the reaction takes place in two steps: first, some of it is converted to insoluble calcium carbonate and the remainder into magnesium hydroxide, which is also insoluble and precipitates out. Thus, more hydrated lime is required for magnesium alkalinity reduction than for that of calcium.

The reader will notice that we talk of alkalinity reduction and not complete elimination. This is because a low level of alkalinity improves the enhanced filtration of the coagulation and flocculation treatment process, which is usually performed in conjunction with the hydrated lime treatment in the same reaction tank. This low alkalinity provides the pH conditions for the solubility of the cationic coagulant as well as the hydroxyl ions to convert it into the gelatinous flocculent hydroxide form. Furthermore, the settling out of the precipitated calcium carbonate and magnesium hydroxide enhances the flocculation effect. In raw waters not requiring alkalinity reduction, the low alkalinity already present is sufficient for the above-mentioned purposes.

Sodium bicarbonate alkalinity cannot be reduced by hydrated lime treatment alone. It must first be reacted with calcium chloride or calcium sulfate to convert it into calcium bicarbonate, which then reacts with hydrated lime as described above. These reactions also produce sodium chloride or sodium sulfate, which in excessive amounts can cause salinity taste problems in the treated water and in the final beverage. Care must be taken to control this salinity factor.

ION EXCHANGE

Ion exchange systems in various cation and anion combinations can also be used for alkalinity reduction, but they can be associated with some major disadvantages. An ion exchange system may completely eliminate the alkalinity of the water. Usually, the ion exchange water needs to be blended with some untreated water to achieve the required low alkalinity in the finally treated water. Second, ion exchange water can result in high levels of acids and their salts, the presence of which may need to be somehow negated. In some systems, the resin beds require periodic regeneration using concentrated acids or alkalis, which could present safety hazards to operators.

Ion exchange systems do not really suit straightforward and simple alkalinity reduction pur- poses, but they are very effective in dealing with specific inorganic salts that are excessively abundant and problematical in some raw waters destined to be used in soft drink manufacture. Ion exchange systems are very well suited to soft drinks that for some reason require demineralized water in the final products, such as in bottled waters, some types of health and diet beverages, etc.

DISINFECTION

Disinfection is aimed at the total elimination of any pathogenic microorganisms present in the raw water and the reduction, if not elimination, of nonpathogenic microorganisms to acceptable levels. This may be done with chemicals or by physical means or through a combination of both.

CHLORINATION

Chlorine treatment is the most preferred chemical method for disinfection of raw water for soft drinks manufacture. The advantages of chlorine are the following:

- Effective against a wide range of microorganisms
- Effective at very low dosages
- Rapid microorganism inactivation rate (short contact time)
- Able to provide residual disinfection
- Able to oxidize some types of soluble organic matter into insoluble forms
- Can destroy off-tastes and off-odors
- Can easily be removed by activated carbon
- Can easily be detected in order to determine and control its level in the water

Sources for chlorine may be one of the following:

- Chlorine gas
- Liquid sodium hypochlorite
- Solid calcium hypochlorite

CHEMISTRY OF CHLORINATION

The basic principle is that the chlorine source is converted to hypochlorous acid when added to water. Thus, with calcium hypochlorite, for example, the reaction is as follow;

The hypochlorous acid is a strong oxidizing agent and is the component that destroys the microorganisms and oxidizes other organic matter. It can ionize in a reversible reaction to the hypochlorite

ion OCL^{-} and hydrogen ion H+, but at around pH 8 more hypochlorous acid is available, and disinfection is more effective.

ACTIVATED CARBON PURIFICATION

Raw waters may contain compounds causing off-tastes and undesirable odors. Enhanced filtration processes in the multiple barrier system do not always remove these compounds. This is also true for other organic compounds, such as THMs and some pesticides.

Even if such compounds are absent in the raw water or were removed by an enhanced filtration process, there is still a need to remove the chlorine residue introduced in the disinfection process. Removal of chlorine is the prime function of the activated carbon purification process. The removal of chlorine and the other adverse quality compounds in the raw water being treated is accomplished by means of activated carbon.

WHAT IS ACTIVATED CARBON?

Activated carbon is an amorphous form of carbon that has been specially treated with steam at very high temperatures. This results in a material with a very porous internal structure. The pore sizes are microscopic, and the extensive porosity of the activated carbon gives it a very high total surface area with which to carry out the water purification action. This is achieved by a physical chemical process called adsorption.

Adsorption is not to be confused with the process of absorption, which is basically a simple physical penetration of one substance into the internal structure of another. Adsorption on the other hand, is based on the van der Waal forces, which simply put, is a weak attraction force that exists between all molecules. It can be likened to gravitational force but of much lower magnitude and at much shorter ranges. This force is the principle on which the activated carbon attracts molecules (or atoms and ions) of impurities as they flow through the microscopic pores and holds them on its highly porous and enormous surface area.

THE CARBON FILTER

The carbon purifier, often referred to as the carbon filter, is the equipment used in the water treatment multiple barrier system. In design, it is very much the same as a pressure sand filter, where a bed of granular activated carbon replaces the bed of sand (Figure 5.6).

The operation life of an activated carbon charge in the filter depends on the “load” placed on the filter. An activated carbon charge may last a few years, but the sure sign that it needs replacing or regenerating is a “chlorine breakthrough,” namely, the presence of chlorine, at any level, in the filter effluent of the carbon filter. This indicates that the ability of the activated carbon to remove chlorine has been exhausted. Regeneration or replacement of the carbon bed then becomes necessary and should be performed according to the supplier’s recommendations.

As the total free available surface area of the activated carbon in the filter is related to its operational efficiency, effective enhanced filtration is important in keeping the surface of the carbon granules free of foreign matter for the elimination of which it is not designed.

The carbon filter, like the sand filter, can become a site for microorganism growth. Normally, the flow of chlorinated backwash water will take care of this problem. However, it is still necessary to periodically open the carbon filter and sanitize it thoroughly. This sanitizing is to be performed according to methods recommended by the supplier. The design, operation, and maintenance of the carbon filter is preferably accomplished in consultation with the supplier.

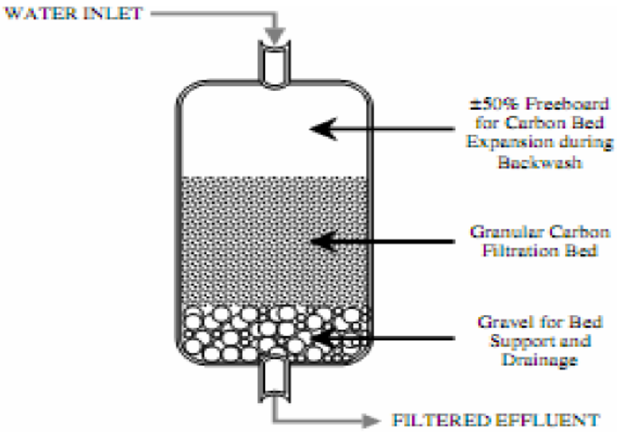

FIGURE 5.6 Carbon filter.

BACKWASHING

Backwashing is the flow of water through the carbon filter in the reverse direction to its normal operation and at higher flow rates and pressures. This vigorously stirs up the activated carbon bed into the upper freeboard space of the filter chamber.

Backwashing of the carbon filter is required because of the channeling effect that occurs in the filter due to the relatively low weight of the granules. When the raw water being treated passes through the carbon bed, it seeks the “path of least resistance” and forms small channels through which most of the water would rapidly flow, thus decreasing the overall adsorption efficiency of the bed. The backwash stirs up the carbon granules and destroys these channels.

Note: Channeling in the carbon bed can result in chlorine presence in the carbon filter effluent.

This type of “chlorine breakthrough” should not be interpreted as indicative of the complete exhaustion of the chlorine adsorption capability of the activated carbon, as mentioned in a previous section of this chapter.

Theoretically, the carbon filter should not entrap foreign matter, as this should have been removed in the earlier stages of enhanced filtration; however, this can still occur. Therefore, backwashing of the carbon filter is also required for this purpose, as the powerful stirring up of the carbon bed dislodges these entrapped particles that are then removed to waste by the backwash flow. Only chlorinated water should be used for backwashing purposes in order to avoid possible introduction of microbiological contamination into the filter beds.

POLISHING FILTRATION

Polishing filtration is considered as mandatory in any multiple barrier water treatment design. Its purpose is to remove any granular activated carbon granules that occasionally may have been carried out of the carbon filter bed during the forward flow of the treated water. Sand particles may also be carried through the system, as well as flakes of scale or rust that occasionally break loose into the water and pipes.

The aim of polishing filtration could be summed up simply as to provide crystal-clear treated water for use in soft drink manufacture. As such, the polishing filters are positioned downstream of the carbon filter and immediately before the final product filling line.

THE POLISHING FILTER

There are a few types of polishing filters that use different filtration media, such as paper sheets, membranes, or cartridges. The media most commonly used in soft drink operations is the wound fiber cartridge type.

As the name implies, these cartridges are constructed of wound fibers, usually made out of polypropylene and available in a variety of size lengths. The cartridges are fitted into supplier-designed housings. The number and configuration of cartridges in the housing unit will depend mainly on the required treated water flow rate. The pore size for these filters in the soft drinks industry is typically between 5 and 20 µm.

Figure 5.7 shows a typical structure of a single cartridge and how it works. The water flows from the exterior, through the wound fiber media, to the center core from which the effluent is discharged. As the water proceeds to the core, the wound fiber becomes denser, and the pore size decreases. The operational lifetime of a cartridge depends on the filtering load to which it is subjected. In an effective water treatment system, they could last for months at a time.

Polishing filters can be considered as ideal sites for microorganism growth, as any organic matter not effectively removed during previous treatment stages can be trapped and lodged in the cartridge pores, serving as substrate for microbial growth. Chlorinated treated water left in the lines and filling equipment overnight can take care of this problem. However, if this is not the case, the cartridges must be periodically removed and adequately cleaned and sanitized.

Cartridges need to be periodically checked visually for fouling, which is evident as discolored areas in the woven fiber penetrating along the radius of the cartridge. Rapid fouling of the cartridge would indicate improper design or operation of the water treatment system. Fouling of the cartridge with black carbon specks serves as an indication that there is an unusually high frequency of carbon breakthrough from the carbon filters.

It is a good idea to position a pressure gauge on the effluent side of the polishing filter. When the pressure drops below a designated value that can be determined by experience (or by supplier recommendation), this would serve to indicate that the cartridge is becoming blocked and needs to be replaced.

The main problematical item with polishing filters is the fouling issue — how to minimize this and to determine when the cartridges need to be replaced. Otherwise, polishing filtration is a simple operation with proven results in the aim of supplying the filling lines with crystal-clear clean treated water.