Water Pretreatment

Pretreatment and internal water treatment for building systems protect against mechanical failure and ensure that any residual, scale-causing minerals will be neutralized. Treatment is necessary to counteract problems caused by hardness, dissolved gases, or sludge. Water softening is the most common pretreatment, but iron filters and aerators for hydrogen sulfide removal can be used, too.

Water pretreatment can be simple or complex. The decision to pretreat boiler water and the selection of equipment used to pretreat it are based on the following factors:

- volume of water used
- quality of the makeup water
- number of units using water
- temperature
- pressure
- end use of water and steam
- economics—compare the cost of bleedoff or blowdown with the cost of chemicals

Most municipalities use large settling basins and filters to remove suspended matter from the water. This filtration is often efficient enough that there is no need for additional filtration. However, when the water supply still contains finer suspended solids, it is necessary to filter the water before it can be used as boiler feedwater. (Keep in mind that internal treatment is almost always necessary, even when water has been pretreated.)

The four categories of pretreatment equipment used in industrial and commercial buildings are:

- filtration systems
- ion exchangers
- gas removal systems
- reverse osmosis

Filtration Systems

The main purpose of a filter is to remove suspended solids. The most commonly used filters are pressure and cartridge filters.

A **pressure filter** is a closed, cylindrical vessel. The water flows down through porous layers of sand, anthracite, or calcite that are supported by a gravel bed. Any matter suspended in the water is trapped, and the clarified water is collected at the bottom.

After a filter has been in service for a period of time, the filter bed will become plugged with suspended matter removed from the water. When this happens, the filter must be backwashed. Backwashing is reversing the direction of flow through the filter, freeing the trapped material from the bed, and washing the trapped material to waste.

Cartridge filters are widely used to remove suspended solids, especially fine solids. The filter element consists of one or more replaceable cartridges made of various types of finely woven filter material. When the solids filtered out start clogging the filter and the pressure drop between inlet and outlet reaches a specified maximum value, the cartridge must be replaced.

Ion Exchangers

Ion exchangers use the principle of ion exchange to remove harmful minerals from water. Water softeners convert scale-forming salts, such as calcium sulfate and magnesium bicarbonate, into soluble, non-scale-forming salts that contain sodium. Most sodium compounds are non-scale-forming because they are highly soluble and therefore do not drop out of solution to form scale. Deionizers and demineralizers remove even more minerals.

Water Softeners

A water softener is a piece of equipment that contains a granular, zeolite material, called ion exchange resin, that is impregnated with sodium cations (positively charged ions). When water passes through the resin, the zeolite material gives up the sodium cations in exchange for the calcium or magnesium ions.

When the ion exchange material has given up all its sodium cations in exchange for the calcium and magnesium cations, it has to be regenerated before it can resume the softening process.

To regenerate the resin, the softener is removed from service and backwashed so that raw water enters at the bottom and flows up through the bed. This water is sent out as waste. Backwashing expands the resin bed and removes particulate matter.

Next, a solution of brine (sodium chloride) is drawn into the resin bed. The resin absorbs sodium cations from the brine and discards the calcium and magnesium cations into the brine. The brine, now containing the calcium and magnesium cations, is flushed away, and the resin bed is rinsed out with water. The softener is returned to service until regeneration is again necessary.

The following are two examples of how cations are exchanged in a water softener:

- If water contains the scale-forming salt calcium sulfate, this salt is in the form of calcium cations and sulfate anions (negatively charged ions). If the calcium cations are exchanged for sodium cations, then the salt becomes sodium sulfate. This salt is extremely soluble, so it will not produce scale in a boiler.
- If water contains magnesium bicarbonate, this salt is in the form of magnesium cations and bicarbonate anions. If the magnesium cations are exchanged for sodium cations, the salt will become sodium bicarbonate. This salt is also extremely soluble, so it will not produce scale in a boiler.

The capacity of a water softener depends on the following five factors:

- the quantity, type, and condition of the exchange material
- the amount of dissolved minerals in the water

- the amount and strength of regenerant used
- proper regeneration
- the mechanical condition of the softener and regenerating equipment

The four steps of water softener operation are:

- service (softening)
- backwash
- regeneration
- rinsing

Service (Softening): The hard water enters the top of the softener and travels down through the bed of resin. The calcium and magnesium ions of the salts in the water are exchanged for the sodium ions held by the resin. The softened water leaves the softener at the bottom.

Backwash: When the resin becomes exhausted, the softener is taken out of service and backwashed by manipulating the valves so that raw water enters at the bottom and flows up through the bed to the wash water collector and then to waste. The backwashing expands the bed and removes particulates.

Regeneration: Untreated or raw water is admitted to an ejector or eductor. The water flowing through the eductor produces a vacuum that draws the brine up from the regenerant or brine tank, and the brine is then forced into the softener just above the surface of the beds. The sodium ions of the brine solution exchange places with the calcium and magnesium ions held by the resin.

Rinsing: Raw water entering the top of the softener flows through the resin bed and washes any remaining brine from the resin. When salimeter tests taken on the water leaving the softener show that all salts have been rinsed out, the softener is put back into service.

Deionizers and Demineralizers

Deionizers operate on the ion exchange principle much like water softeners. They are designed to produce water with almost all impurities removed, much like distilled water. Small deionizers are sometimes used in buildings to provide pure water for batteries, print shops, and mist-type humidifiers in computer rooms.

A demineralizer uses a hydrogen cation exchanger that removes the sodium, magnesium, and calcium cations. It also uses an anion exchanger to remove sulfate, chloride, and silica anions. The demineralizer that has the anion and cation exchangers mixed together in a container is called a mixed bed deionizer.

Gas Removal Equipment and Reverse Osmosis

Dissolved oxygen and carbon dioxide can be removed by applying heat and then agitating and venting gas into the atmosphere. Chemical treatment with oxygen scavengers can also help in closed recirculating systems and boilers. Three types of such equipment are aerators, deaerators, and reverse osmosis systems.

Aerators are commonly used in water purification plants to remove carbon dioxide and hydrogen sulfide. Deaerators are used in boiler feed systems to remove oxygen and dissolved gases. Reverse osmosis equipment can be found in water purification plants and electronic manufacturing plants, where it can remove up to 99 percent of all dissolved minerals.

This article is adapted from BOMI International's *Air Handling, Water Treatment, and Plumbing Systems* course. More information regarding this is available by calling 1-800-235-2664, or by visiting BOMI International's website.