Valves

What Does a Water Softener Valve Accomplish?

In practice, softeners can be:

- in service
- exhausted and waiting for regeneration
- in regeneration
- in standby, or
- bypassed and out of service

Service implies the resin bed is receiving and treating hard water and discharging hardness-free treated water. During this cycle, the resin is partially spent. After the resin is **exhausted** or the unit has "timed out" the softener may experience a **waiting period prior to regeneration**. To restore the capacity of the resin, the softener must be regenerated. **Regeneration** includes backwash, brining, slow rinse, and fast rinse. After the unit has been regenerated and the resin is fresh and ready for use, the unit is in **standby** mode until other units are exhausted. After standby, the unit is returned to service. Most systems have **bypass** valves. This is required when the unit is under repair.

The Five Cycles

The five cycles of water softening are:

- service
- backwash
- brining
- slow rinse, and
- fast rinse

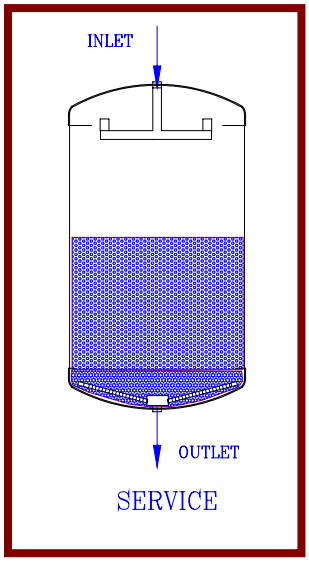
These five cycles are listed because all of the common automatic softener valves follow this sequence. Examples of five cycle softener valves are the Water King Task Master™ and Task Master II™ used in the RF, MF, and HF series. The Task Master™ has a single piston, which is the only moving part. The valve body is ported so that moving the piston can create different flow patterns and place the softener in each of the five different cycles. A timer and a drive motor control the valve position. Notice that the vessel requires only inlet, outlet, and drain connections. The valve system routes the water through the tank in the proper direction at the desired flow rate.

A nest of diaphragm or manual valves with automatic actuators and an electronic control system can also create the cycles. The Water King VN Series is an example of this type of system.

This discussion of the cycles will be limited to downflow service and downflow brining as used in the Water King Systems in this catalog. Counter current operation employs upflow brining, with the intent of reducing hardness leakage.

The Five Cycle Softening Process

1. **Service.** Raw water passes "down flow" through the resin bed.
2. **Backwash.** The resin bed is fluidized loosening the resin particles and removing suspended matter captured during the service cycle.
3. **Brine Draw.** A brine solution is applied "down flow" to the resin bed removing the hardness ions from the resin matrix.
4. **Slow Rinse.** The brine is rinsed from the resin bed at a low flow rate to reduce water use.
5. **Fast Rinse.** The resin is rinsed at a higher rate to remove all brine from the bed. After the fast rinse cycle, the softener is on **Standby** until returned to **Service**.

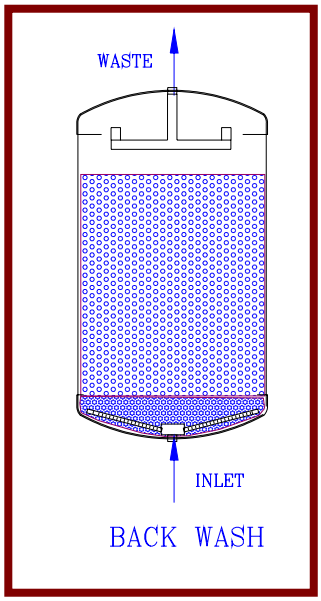


SERVICE

During the service cycle, the raw water enters the top of the tank, flows through the inlet flow distributor, passes through the resin bed and exits the tank through the gravel support bed and under drain system. In the service cycle, the softener removes the hardness from the water. A successful service cycle requires that all of the treated water be low in hardness and that the resin capacity be fully utilized. Completely expending the bed, allowing the softener to pass hard water, must be avoided.

The softening reaction removing calcium ions from the water can be represented as follows, where R is the resin:

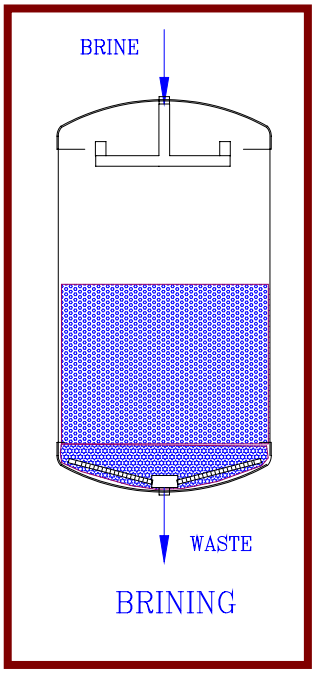
$2RNa + Ca^{+2} \rightarrow RCa + 2Na^{+}$



BACKWASH

In backwash, the raw water enters the bottom of the bed through the underdrain system and exits through the top of the tank to waste. Backwash is upflow and the resin bed is fluidized. During backwash, the resin bed is expanded to remove suspended solids trapped on the resin and to keep the bed from compacting. The rate of flow must be controlled during backwash to make certain the bed is expanded and still not wash any of the resin out of the softener. The upward velocity required to cause the bed to fluidize is dictated by the resin density and particle size. This is one reason resin particles should be relatively uniform in diameter and weight.

Flow Control. Flow controllers provide accurate backwash rates. These are installed in the waste line. Usually these devices consist of a plate with one or more orifices. The orifices are designed to give a constant flow rate over a broad range of pressure drops. Other methods of flow control include valves, orifice plates, weirs, and controlled pumps.



Purolite recommends a backwash rate of 3 to 5 gpm/ft^2 with a duration of 5 to 20 minutes. A brief backwash is sufficient to prevent compaction of the bed. If solids are present in the feed water, longer backwash periods may be required to eliminate solids accumulated in the bed.

BRINING

The resin has limited exchange capacity, which must be restored periodically through a process known as regeneration. The regeneration process reverses the calcium - sodium exchange by subjecting the resin to the high concentrations of sodium found in sodium chloride brine. The regeneration reaction can be represented as follows, where R is the resin:

$RCa + 2Na^{+} \rightarrow 2RNa + Ca^{+2}$

Water softeners often regenerate resin automatically. The frequency of regeneration is controlled by time or quantity of produced water. Separation of brining cycles and service flow is essential to avoid passing salt into the treated water.

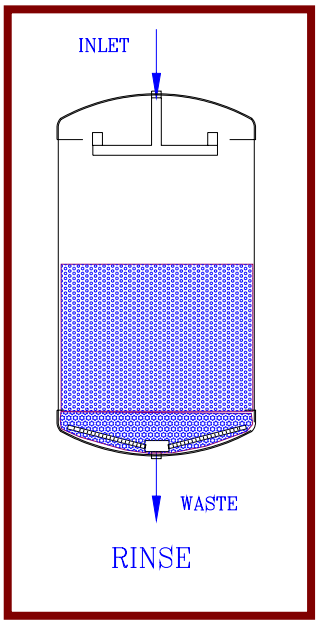
Brine Dilution. Although saturated brine would give the most complete regeneration, experience has shown that using a 10% brine solution minimizes salt usage. To create a 10% brine solution, the saturated salt solution from the brine tank is mixed with fresh water through an eductor. The eductor is a venturi type device or aspirator, which draws a vacuum as the flow, passes through an orifice or throat. The vacuum is used to draw brine into the eductor and mix it with fresh water creating brine that is less than 26% saturation. The injector on a water softener is designed to dilute saturated brine, initially at 26%, down to 10%. The water to brine ratio is 1.6 parts water to one part brine. The eductor must be matched to the softener size to create the right amount of diluted brine.

Brine Application. The regeneration reaction is much slower than normal softening and requires a significant contact time between the resin and the brine. Purolite suggests 0.25 to 0.9 gpm/ft^3 flow rate for the brine. This is about a tenth of the service flow rate. They suggest a duration for brining of 30 to 60 minutes applying 4 to 10 lb/ft^3 during that time.

Limiting the amount of saturated brine solution drawn from the brine tank controls the quantity of salt applied. The system works on a level float, which closes the brine valve after the specified amount of saturated brine has been drawn.

Slow Rinse

To gradually push the brine out of the resin bed, the system enters a slow rinse cycle. Purolite recommends 0.25 to 0.9 gpm/ft^3 for approximately 30 minutes. Water passes through the bed slowly to create a “piston” effect called the “slow rinse”. Slow rinse is actually a continuation of the brine cycle. After the brine valve has closed, fresh water continues to flow through the eductor even though it is not allowed to draw brine. Since the brine valve is closed, no brine is drawn and the flow rate is constrained by the eductor. The rate of slow rinse is thus about two thirds of the diluted brine flow. This continues until the softener sequences to the next cycle, fast rinse.



Fast Rinse

The fast rinse cycle is a service to waste cycle. The inlet water flows through the service piping and into the bed but rather than being routed to the softener outlet, it is routed to drain or waste. The flow rate is dictated by the inlet pressure, piping, valves, and waste line constrictions (such as the backwash rate of flow controller). If the waste line is relatively unconstrained, the fast rinse flow may exceed normal service flows. Purolite recommends a fast rinse of 1.0 to 5.0 gpm/ft^3, with a duration of approximately 30 minutes. The purpose of the fast rinse is to completely rinse the brine from the softener so it can be returned to service. Thorough rinsing is critical to finished water quality since relatively small amounts of salt cause an objectionable taste.

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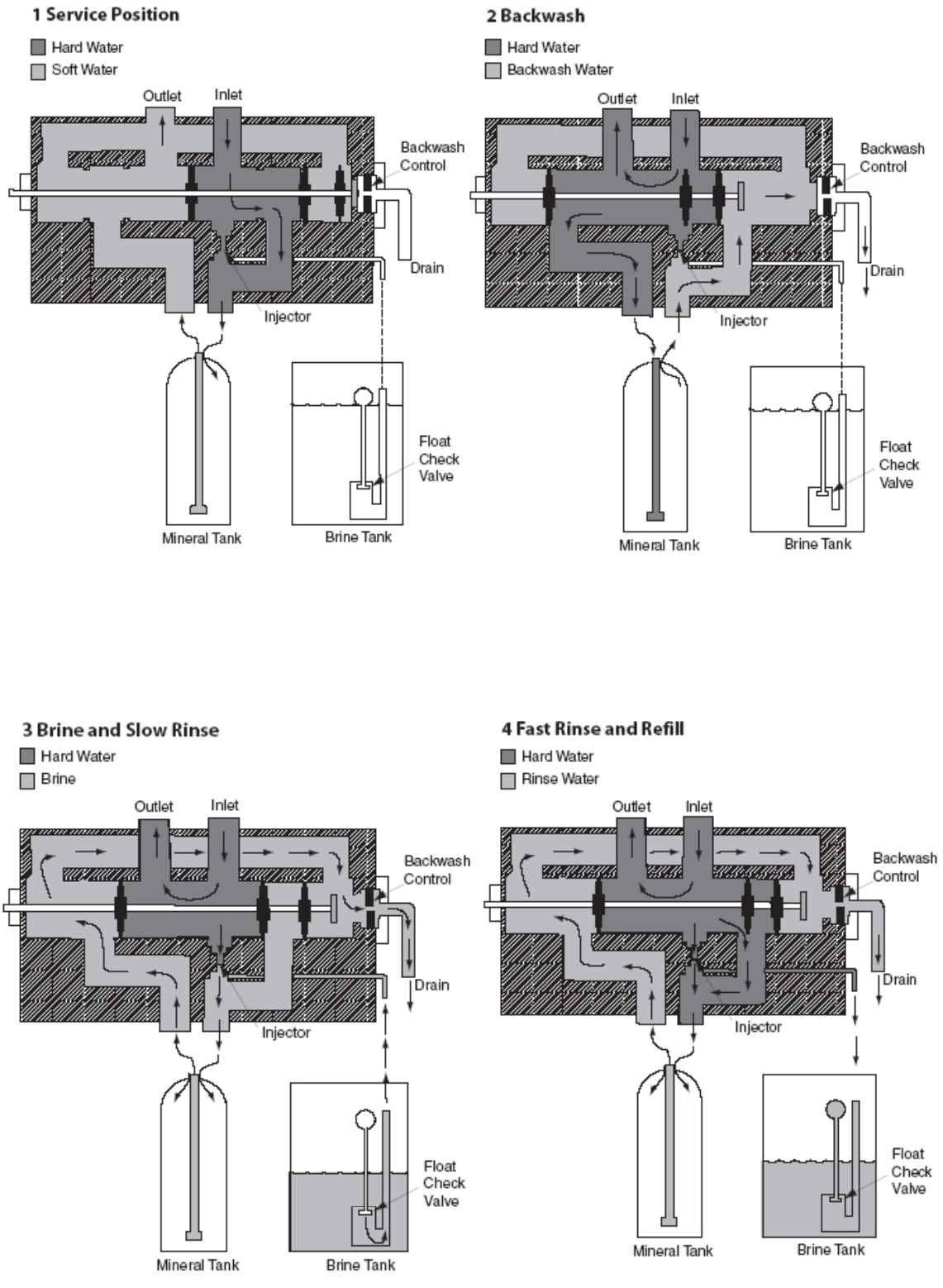
TASK MASTER™ OPERATION SEQUENCE SHOWING PISTON POSITION



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