TECHNICAL MEMORANDUM
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TOPIC: **How is the Softening Process Controlled?**
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HOW IS THE SOFTENING PROCESS CONTROLLED?

The key to practical and economic operation of a water softener is proper utilization of the resin. The resin must be regenerated before it is exhausted. If not, the product water will be hard. The resin capacity must be nearly exhausted otherwise, salt and rinse water will be wasted. This balance, between the continuous production of soft water and the necessity of fully utilizing the resin on every run, controls the frequency of regeneration. The interval between regenerations should be controlled to prevent hard water from passing the unit and still gain maximum capacity from the resin.

Correctly setting the softener conserves water and salt. Every regeneration cycle requires a preset amount of salt. If the bed is not near exhaustion salt will be applied to the bed and no exchange will take place. Every regeneration uses a preset amount of water for backwash, brining, and rinsing. As the frequency of regeneration is increased, the wastewater as a fraction of produced water increases.

Regeneration uses salt and water, which become waste products. Brine wastes produced by a water softener can increase the total dissolved solids of streams causing regulatory problems for industry. Water is a precious and expensive commodity, which should be conserved. Proper setting of the regeneration frequency reduces the discharge of salt into the environment and conserves water.

In commercial - industrial applications, softeners are used to protect equipment from scaling and calcining. They are frequently used to treat water for boilers, reverse osmosis units, ice machines, and other industrial process uses. Do not be so zealous in conserving water and salt that you produce hard water, which damages expensive equipment.

This chapter is concerned with the methods of setting and controlling the intervals between regenerations. There are four schemes used to control the time interval between regenerations. The regeneration cycle can be initiated manually; with a time clock; based on demand; or based on water quality. All of these schemes can result in efficient softener operation. Each has advantages in certain situations.

MANUAL CONTROL

Definition. "Manual" refers to systems that require an operator to throw a switch, push a button, or turn a valve to initiate the regeneration cycle. If the operator has the time to pay careful attention to the produced water hardness and volume, this can be the most efficient method.

Control Scheme. The operator should regularly monitor the produced water hardness and volume. Before the hardness starts to increase, the softener should be regenerated. By keeping consistent records, the operator can become an expert at predicting the optimal time between regenerations. Manual initiation of the cycle allows the operator to avoid regeneration during peak water use times in the plant. It also allows flexibility of operation. The disadvantage is the time and energy required of the operator. Manually initiated regeneration is best applied when continuous operator attention is available, raw water demand and hardness are variable, and water quality is critical. It should also be noted that all of the "automatic" regeneration systems allow for manual initiation of the regeneration cycle. Manual controls are often the least expensive and most cost effective option.

TIME CLOCK CONTROL

Definition. When regeneration is initiated with a timer it is called "timer controlled". If usage and hardness are consistent, a constant time interval between regenerations provides effective use of the resin.

Softeners can be equipped with a time clock that initiates the regeneration cycle at specific time intervals. This allows the operator to choose a recurring preset time of regeneration. The time interval between regenerations must be chosen so that the resin does not become completely exhausted and produces hard water. If water usage and hardness are constant, then time clock regeneration can be efficient. Variable demand can be troublesome to time clock initiation since high demand periods may exhaust the resin before it is due for regeneration. Low demand periods can cause premature regeneration resulting in partial use of the resin, which wastes salt and water. The main advantage of time clock regeneration is that the operator does not have to be present to initiate regeneration.

Control Scheme. When setting the softener controls based on time, the time interval between regenerations will be related to resin capacity, resin volume, water hardness, and flow. The following equation applies:

Time Interval Between Regenerations = 90% x (Resin Capacity x Resin Volume) / (Hardness x Average Flow per Day)

The time clock on the softener is set for a time equal to or less than the calculated time interval between regenerations. The resin capacity is based on the salt used for regeneration. The raw water hardness and flow must be assumed and will be different for each installation. Since the resin capacity and volume are constant, the time interval between regenerations is dependent on the hardness and flow. If either vary significantly, the preset interval between regenerations may be inefficient. In many situations, the hardness and flow are quite consistent and time clock regeneration is ideal. Usually regenerations are scheduled in the early morning hours when water usage is at a minimum.

Time Clock versus Manual Control. Time clock initiated regeneration is usually more expensive than manual regeneration because the valves must be automated. This requires solenoid activated diaphragm valves or a five cycle softening valve. Time clock regeneration works well if the flow and hardness is relatively constant. If the flow increases over normal levels, it is possible to exhaust the resin thereby passing hard water. If the water usage is lower than normal, the time clocks will initiate regeneration well before the resin is exhausted. This premature regeneration will waste salt and rinse water. These objections can be overcome by attention to flow rates and appropriate adjustments. The time clock system is rugged and reliable.

Electronic Timers. Current practice is to use electronic timers that are capable of tracking both the time of day and the time of each of the softener cycles. These electronic devices provide contact closures at certain preprogrammed times of the day to initiate regeneration. Once initiated the timer controls the time of each of the five regeneration cycles. The Water King ERCt is an example of an electronic timer. (1)

DEMAND INITIATION

Definition. A totalizing flow meter can be added to a softener control system to regenerate based on the total volume of treated water. Demand regeneration initiates a regeneration cycle when the totalized flow applied to the bed reaches a preset quantity. The totalizing flow meter is reset after every regeneration. When the flow past the meter has accumulated to the set point, the flow meter initiates regeneration.

Control Scheme. A demand regeneration system consists of a flow meter, a totalizer, a preset volume, and an automated valve system. When the hardness is constant, the quantity of water required to exhaust the resin capacity will remain constant. Regenerating based on demand can be an exact method of control. It protects against totally expending the resin in times of high use and allows for longer runs if the flows are low.

When setting the softener controls based on totalized flow or demand, the volume setting on the flow monitor is based on the resin capacity, resin volume, and raw water hardness. The following equation applies:

Volume or Totalized Flow Set Point = 90 % x (Resin Capacity x Resin Volume) / (Hardness)

It has been mentioned that the capacity and resin volume are usually constant. If the hardness is also constant, which is often the case, the equation shows that the totalized flow must also be constant.

Demand versus Time Clock or Manual Control. The demand regeneration system is more expensive than timers or manual systems due to the extra cost of the meters and another layer of electronic controls. For most applications, the savings in salt and rinse water costs will justify the additional capital. If the flow rates are relatively constant the added efficiency of demand regeneration over time clock regeneration may be minimal. As compared to time clock control, demand initiation eliminates flow as a variable in the equation and decreases the chance for the release of untreated water.

Demand based regeneration can be a problem if the preset volume is reached in the middle of the day. Taking a softener out of service during a peak usage time is often unacceptable. Using twin alternating units can solve the problem of regeneration at inconvenient times of the day. One unit is in service while its twin is in regeneration or standby. Each unit is sized to treat the entire flow. In this way, a constant stream of softened water is always available.

Many demand controllers have a built in algorithm to predict the remaining volume that can be treated prior to regeneration and to anticipate the volume of water to be treated. A fixed time window (usually during off peak hours) is set for regeneration. If the algorithm predicts that the unit will be exhausted, it regenerates prior to reaching the set point. This avoids regeneration during peak demand periods. The Water King ERCd has such an algorithm called the variable reserve function.

Systems. All of the Water King Series (BF LT, MF, and VN) can operate in demand regeneration mode. These systems must have a meter to measure the flow of soft water from the unit. The meter is placed in the service line (outlet line) of the softener. The pulse must be counted and then converted into a flow measurement and then totalized. This is accomplished by the demand controller. The valve sequencing can be accomplished by the demand controller, or it can be done by a cycle timer at the valve. Finally, the valve or valves must be positioned to create the five cycles of softening.

(1) Electromechanical Timers. Prior to about 2000, water softener and filter valves are commonly equipped with electromechanical timers. The timers track the day, time of day, and also include a cycle timer. The latter is a separate dial, which sets the time of the cycles of regeneration. The timer has a clock with a time of day wheel and a day of the week wheel. It allows every day, every other day, every three days, every four days, every six days, or every twelve days. Seven-day timers are also available. They can be set to regenerate at a single time of the day on any day of the week. For example, a seven-day timer could be set to regenerate every Tuesday, Thursday, and Saturday at 2:00 am. If Sunday were a day off, the regeneration frequency would conveniently be every two working days.

A special type of timer is used in demand regeneration systems. These are simple cycle timers with no time of day or day clocks. They are designed to initiate and control the regeneration sequence when they receive a pulse of control voltage (usually one to three minutes). The control voltage pulse is sent from a demand controller such as the EDR II™ . The ARC timer is an example of a cycle timer used in demand regeneration systems on the now discontinued brass Task Master™ valves.