Level 2: Achieving softening efficiency
Learning objectives

• Understand softening efficiency and the factors that affect it

• Apply the relationship between softener efficiency factors to calculate efficiency and settings

• Be able to perform a simple optimization

• Use the Salt Savers app to perform and document an optimization
Softener efficiency

Grain capacity (grains) / Salt dosage (pounds) = Softener efficiency (grains per pound)

Grains of hardness removed per regeneration / Pounds of salt per regeneration = Softener efficiency

Similar to miles per gallon
Target efficiency

**Goal:** highest salt efficiency possible

**MMSD service area target:** 4000 grains per pound

**Example:** Softener rated for 32,000 grains @ 8 lbs. of salt

32,000 grains ÷ 8 pounds = 4000 grains per pound
**Settings that affect softener efficiency**

### Overview of settings
- Salt dosage
- Grain capacity
- Reserve capacity
- Hardness setting
- Settings exercises

### Control head examples

### Optimizing settings
- Truing up hardness setting
- Lowering salt dosage
- Truing up reserve capacity

### Practice scenarios

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- **Hardness setting**: The programmed concentration of hardness **assumed** to be coming through the softener
- **Salt dosage**: The amount of salt that recharges the softener with each regeneration
- **Grain capacity**: The total amount of hardness (grains) that can be removed by the softener with one salt dosage
- **Reserve capacity**: Buffer subtracted from total capacity to prevent hard water from coming through

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Dosage and grain capacity grouped together because they are related

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Efficiency varies between models

Outline

Softening efficiency
Overview of settings
Salt dosage
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Practice scenarios

1 pound of salt
<Softens less water
Softeners more water →

1 gallon of gas
< Goes fewer miles
Goes more miles →
Salt dosage

- **Definition:** Amount of salt needed to replenish the softener with sodium per regeneration

- Measured in pounds of salt per cubic feet of resin

- High, medium, low settings

Salt dosage of 8 lbs. per cubic foot regenerating 1 cubic foot of resin

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3.2 lbs. Na\(^+\) in softener
4.8 lbs. Cl\(^-\) to drain
8 lbs. NaCl in brine
Grain capacity

**What**: The number of grains of hardness that the softener can remove from water before needed to regenerate.

- **NOT** fixed – grain capacity depends on the salt dosage.
- In home softeners, you’ll typically see grain capacities expressed around 24,000 – 32,000 grains; some may be lower or higher.

**Examples in softener descriptions**

- Waterboss: **22,000-Grain Capacity Water Softener System**
- Whirlpool WHES30E 30,000 Grain Softener | Salt & Water Saving Technology | NSF Certified | Automatic Whole House Soft Water Regeneration, 0.75 inches, Off-White.

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**Poll Question 1**

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Grain capacity variation

- Less salt in the softener provides less sodium for ion exchange, so the grain capacity is lower at lower salt dosages.
- If you have access to softener user manual, rated grain capacities at different dosages can be found there.
### overview of settings

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### control head examples

### optimizing settings

- Truing up hardness setting
- Lowering salt dosage
- Truing up reserve capacity

### practice scenarios

#### same unit; different capacities

<table>
<thead>
<tr>
<th>Resin Cu. Ft.</th>
<th>Rated Capacity Low Salt Grains @ Lbs.</th>
<th>Rated Capacity Medium Salt Grains @ Lbs.</th>
<th>Rated Capacity High Salt Grains @ Lbs.</th>
<th>Flow Rate Cont.</th>
</tr>
</thead>
<tbody>
<tr>
<td>.50</td>
<td>9,800 @ 3.0</td>
<td>14,100 @ 5.0</td>
<td>16,600 @ 7.5</td>
<td>6.1</td>
</tr>
<tr>
<td>.75</td>
<td>14,700 @ 4.5</td>
<td>21,200 @ 7.5</td>
<td>24,900 @ 11.3</td>
<td>8.0</td>
</tr>
<tr>
<td>1.00</td>
<td>19,600 @ 6.0</td>
<td>28,200 @ 10.0</td>
<td>33,200 @ 15.0</td>
<td>10.0</td>
</tr>
<tr>
<td>1.50</td>
<td>29,400 @ 9.0</td>
<td>42,300 @ 15.0</td>
<td></td>
<td>10.0</td>
</tr>
<tr>
<td>2.00</td>
<td>39,200 @ 12.0</td>
<td>56,400 @ 20.0</td>
<td></td>
<td>10.7</td>
</tr>
<tr>
<td>3.00</td>
<td>58,800 @ 18.0</td>
<td>84,600 @ 30.0</td>
<td></td>
<td>11.5</td>
</tr>
</tbody>
</table>

**efficiency at low salt:**

\[
\text{Efficiency} = \frac{19,600 \text{ grains}}{6 \text{ lbs.}} = 3267 \text{ grains/lb.}
\]

**efficiency at high salt:**

\[
\text{Efficiency} = \frac{33,200 \text{ grains}}{15 \text{ lbs.}} = 2213 \text{ grains/lb.}
\]
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### Softening capacities at different salt dosages

- **Efficiency drops off as salt dosage increases.**
- Efficiency: 3267 grains/lb.
- Efficiency: 2820 grains/lb.
- Efficiency: 2213 grains/lb.
Grain capacity and gallon capacity

**Gallon capacity** is another way of expressing softening capacity.

**Definition:** Gallon capacity is the number of gallons of water softened between regenerations.

\[
\text{Gallon capacity} = \frac{\text{Grain capacity}}{\text{Hardness setting}}
\]
Grain capacity and gallon capacity

Gallon capacity often seen on control heads with a dial

This softener will go 975 gallons between regenerations
Example: What is the gallon capacity of a softener with a 24,000 grain capacity and a hardness setting of 21?

\[
\frac{24,000 \text{ grains}}{21 \text{ grains per gallon}} = 1143 \text{ gallons}
\]
Reserve capacity

**Definition:** Buffer programmed into softeners that prevents soft water from running out before regeneration

- Causes a softener to regenerate before it is due to run out of total softening capacity
- Subtracted from total possible softening capacity
Reserve capacity example

**Rated grain capacity:**

22,000 grains at 6 pounds

**Hardness setting:** 20 grains per gal.

**Assumed soft water use per day:** 300 gal.

1) Total gallon capacity = $\frac{22,000}{20} = 1100$ gallons per regeneration

2) Gallon capacity **adjusted for reserve** = $1100 - 300 = 800$ gallons per regeneration
Reserve capacity effect on regenerations

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Example: Total softening capacity = 1000 gallons

Actual softening capacity = 850 gallons
Reserve capacity = 150 gallons

Actual softening capacity = 700 gallons
Reserve capacity = 300 gallons

Regenerates earlier
Regenerates later
Optimized reserve capacity

Reserve capacity, if set manually, should reflect the actual soft water use of the home per day (not an overestimate)

Practice scenarios

Actual softening capacity = 850 gallons
Reserve capacity = 150 gallons

Actual softening capacity = 700 gallons
Reserve capacity = 300 gallons

Regenerates at the right time
Regenerates too early

Actual soft water use = 150 gallons/day
Tank configurations

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**Single tank**
- Requires reserve capacity

**Multiple tank**
- Does not require reserve capacity
Many newer softeners calculate reserve capacity automatically based on actual soft water use of home.

• More efficient than fixed
Hardness setting affects salt use

4WD a good idea for tough conditions...

...but wastes gas if in use when unnecessary
Hardness setting affects salt use

Using a high hardness setting is a good idea when the source water is very hard...

...but wastes salt if the hardness setting is higher than the source water hardness.
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**Practice scenarios**

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**Same unit, different hardness settings**

Example: 20,000 grains @ 6 pounds (Same efficiency of 3333 grains/lb.)

- Hardness setting = 32 grains/gallon
  
  \[ 20,000 \div 32 = 625 \]
  
  625 gallons between regenerations

- Hardness setting = 18 grains/gallon
  
  \[ 20,000 \div 18 = 1111 \]
  
  1111 gallons between regenerations
### Same unit, different hardness settings

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<tr>
<td>625 gallons between regenerations</td>
<td>625 ÷ 150 ~ 4 days</td>
<td>6 pounds of salt used every 4 days</td>
<td>45 pounds of salt used every 30 days</td>
<td>1111 gallons between regenerations</td>
</tr>
</tbody>
</table>

**Example:** Home uses 150 gallons of soft water per day.
Other settings to look for

- Time-clock override – may cause softener to regenerate too soon
- Salt efficiency mode – found on some softeners
Recap of settings

- Lower salt dosage → lower salt use
- Lower hardness setting → lower salt use
- Lower reserve capacity → lower salt use
- Time-clock override off → lower salt use
- Salt efficiency mode on → lower salt use
Exercise 1

- Calculating softener settings
- P. 8 in guidebook
Exercise 1

a. A softener has a grain capacity of 32,000 grains and a gallon capacity of 1280 gallons. What is the hardness setting of this softener?

\[ \text{32,000 grains} \div \text{1280 gallons} = \text{25 grains per gallon} \]

b. A softener has a gallon capacity of 1500 gallons and a hardness setting of 20. How many grains of hardness will be removed by the softener between regenerations?

\[ \text{1500 gallons} \times \text{20 grains per gallon} = \text{30,000 grains} \]
Exercise 1

c. A softener has a grain capacity of 24,000 grains, a hardness setting of 18 grains per gallon, and a fixed gallon capacity of 1000 gallons per regeneration. What is the reserve capacity?

1. Determine total possible gallon capacity: $24,000 \div 18 = 1333$ gallons
2. Subtract actual gallon capacity to determine reserve:
   $1333 - 1000 = 333$ gallons

What should the gallon capacity be for a 24,000-grain, single-tank softener with a source water hardness of 18 grains/gallon and an average home water use of 200 gallons per day?

1. Determine total possible gallon capacity: $24,000 \div 18 = 1333$ gallons
2. Use average water use/day as reserve capacity.
3. Subtract reserve from total: $1333 - 200 = 1133$ gallons
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