Water Treatment Fundamentals
Order of Operations

• Please Excuse My Dear Aunt Sally

• Parenthesis, Exponents, Multiply, Divide, Add, Subtract (PEMDAS)
Converting Units

1mg = 1,000µg

Example: The Action Level for lead is 0.015mg/L. What is this in µg/L?

\[
\frac{0.015 \text{ mg}}{1 \text{ L}} \times \frac{1,000 \mu \text{g}}{1 \text{ mg}} = 15 \mu \text{g/L}
\]

mg/L (or ppm) → µg/L (or ppb)  Move the decimal to the RIGHT 3 places

µg/L (or ppb) → mg/L (or ppm)  Move the decimal to the LEFT 3 places
Softener Sizing Calculations

MEP Fundamentals Module
B4-F-Water Treatment System Operations Badge
Learning Activity #5
My Learning Path > C2 > B4 > LA-F5

- 2 Knowledge Base articles
- 3 customer examples
Softener sizing calculations (MEP)

What information do I need?
1. Total hardness (including iron)
2. Number of people in the household or water usage
3. Exchange capacities
Calculate total hardness

- 17 gpg hardness
- 1ppm Iron

\[ 1 \text{ ppm Fe} \times \text{ ?} = \text{ ? mg Fe} \]

Total hardness =
Grains removed per day

Total Hardness x Daily Water Usage
Daily Water Usage = (3 people)(70 gallons/day)

\[
\frac{20 \text{ grains}}{\text{gallon}} \times \frac{? \text{ gallons}}{\text{day}} = ? \text{ grains/day}
\]
Exchange capacities

Choose the amount of resin that can handle the calculated grains of hardness for the desired level of salt.

<table>
<thead>
<tr>
<th>Resin Volume (ft³)</th>
<th>Saltion Capacities Per (ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>6 lbs.</td>
</tr>
<tr>
<td>1.0</td>
<td>20,000</td>
</tr>
<tr>
<td>1.5</td>
<td>30,000</td>
</tr>
<tr>
<td>2.0</td>
<td>40,000</td>
</tr>
<tr>
<td>2.5</td>
<td>50,000</td>
</tr>
<tr>
<td>3.0</td>
<td>60,000</td>
</tr>
</tbody>
</table>
Processed water volume

\[
\frac{\text{resin capacity (grains)}}{\text{total hardness (grains/gallon)}}
\]

\[
\frac{20,000 \text{ grains}}{20 \text{ (grains/gallon)}}
\]

1,000 gallons
Processed water volume w/ reserve

- 30% reserve capacity
  - \((20,000 \text{ grains capacity})(0.30) = 6,000 \text{ grains}\)

\[
\text{original resin capacity} - 30\% \text{ reserve capacity} = \frac{20,000 \text{ grains} - 6,000 \text{ grains}}{20 \text{ grains/gallon}}
\]

700 gallons
Service run length with reserve

\[
\frac{\text{processed water volume with reserve}}{\text{daily water usage}}
\]

\[
\frac{700 \text{ gallons}}{210 \text{ gallons/day}}
\]

3.33 days

Note: to prevent hardness breakthrough, round down to regenerate every 3 days.
Cycles per month:

$$\frac{30 \text{ days}}{\text{month}} \div \frac{3 \text{ days}}{\text{cycle}} = 10 \text{ cycles/month}$$

Salt per month:

$$\left( \frac{10 \text{ cycles}}{\text{month}} \right) \left( \frac{6 \text{ lbs NaCl}}{\text{cycle}} \right) = \frac{60 \text{ lbs NaCl}}{\text{month}}$$
% Rejection Calculations

MEP Fundamentals Module
B4-F-Water Treatment System Operations Badge
Learning Activity #8
% Rejection

What information do I need?
1. Influent concentration of specific contaminant
2. Influent TDS
3. RO % rejection rating of specified contaminant
Concentration in Permeate

**Example:**

- Feed-water Arsenic concentration: **10.0 ppm**
- RO rejection rating for As: **96%**
- How much As is in the permeate as a %? **4%**

\[
10 \text{ ppm} \times 0.04 = \text{ As in permeate}
\]
Pretreatment needs?

- **Chlorine.** Chlorine is a problem because it can degrade the polyamide thin film composite RO membrane, which is the most common membrane used in residential applications. A carbon pre-filter is typically used to remove chlorine.

- **Iron.** Iron can clog the membrane by precipitating on it. If dissolved iron exceeds 0.3 mg/L, reduction of the iron concentration is required.

- **Organic contaminants.** Organic contaminants such as VOCs may be too small to be removed by the RO membrane. Such contaminants can be removed by a carbon pre-filter, but their presence can require more frequent filter changes.

- **Hard water.** Hard water can cause scale on the membrane. Hardness ions must be removed or reduced in concentration prior to the RO.
Differential pressure

• Influent pressure
  • Most households are typically 60psi

• Osmotic pressure
  • Depends on the total dissolved solids in the feed water

• Back pressure
  • The back pressure from the pre-charge on the tank.
  • Typically, pressure is set between 5 and 10 psi.
Osmotic pressure

The reverse osmosis process has to overcome osmotic pressure to operate.

• Every 100ppm TDS is 1psi of osmotic pressure*

• Example: 150 ppm TDS

\[
(150 \text{ ppm TDS}) \frac{1 \text{ psi}}{100 \text{ ppm TDS}} = 1.5 \text{ psi}
\]

*This estimate is not an exact value for all possible combinations of water constituents, it is sufficient for calculations of performance.
Differential pressure

Feed-water pressure – (osmotic + back pressure)

Example:

60psi – (1.5psi + 8psi) = 50.5psi

Mfr. min. operating pressure is 40psi, do we need a booster pump? No.

When the differential pressure is below the minimum manufacturers operating pressure, then a booster pump is recommended.
Sizing A Filter

MEP Fundamentals Module
Learning Activity #11
Example: Customer #1

• Building demand (calculated by fixture count) = 10gpm

\[
\frac{5 \text{ gallons}}{40 \text{ seconds}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} = 7.5 \text{ gpm}
\]

• Backwash flow available = 7.5gpm
### Example 1:

<table>
<thead>
<tr>
<th>Model No</th>
<th>Service Flow GPM</th>
<th>Backwash Flow GPM</th>
<th>Media Cubic Feet</th>
<th>Drain Pipe Size</th>
<th>Inlet/Outlet Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC-10</td>
<td>5.0</td>
<td>3.2</td>
<td>1.5</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>AC-13</td>
<td>7.0</td>
<td>4.2</td>
<td>2.0</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>AC-1665</td>
<td>10.0</td>
<td>5.3</td>
<td>4.0</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>AN-10</td>
<td>5.0</td>
<td>5.3</td>
<td>1.5</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
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<td>10.0</td>
<td>10.0</td>
<td>4.0</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>FE-10</td>
<td>5.0</td>
<td>5.3</td>
<td>1.5</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>FE-13</td>
<td>7.0</td>
<td>6.5</td>
<td>2.0</td>
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<td>1&quot;</td>
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<td>FE-1665</td>
<td>10.0</td>
<td>10.0</td>
<td>4.0</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>MM-10</td>
<td>6.0</td>
<td>6.5</td>
<td>1.5</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>MM-13</td>
<td>8.0</td>
<td>10.0</td>
<td>2.0</td>
<td>3/4&quot;</td>
<td>1&quot;</td>
</tr>
<tr>
<td>MM-1665</td>
<td>10.0</td>
<td>15.0</td>
<td>4.0</td>
<td>1&quot;</td>
<td>1&quot;</td>
</tr>
</tbody>
</table>
POE System Sizing

MEP Fundamentals Module
Learning Activity #15
Service flow rate

1. Count the total* number of water supply fixture units (WSFU’s) using:
   a. Table A (in WQA Knowledge Base)
   b. WSFU worksheet

2. Convert the WSFU’s to gpm = service flow rate
Example – Step 1

*Note: **Total** WSFU’s is not found by adding the hot & cold WSFU’s, it’s the values from the Total column in Table A.

<table>
<thead>
<tr>
<th>Type of fixture or group</th>
<th>Number of fixtures or groups</th>
<th>Hot water (WSFU)</th>
<th>Cold water (WSFU)</th>
<th>Total (WSFU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grp: Shower, lav, water closet - flush tank</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>Lavatory</td>
<td>1</td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>Water closet, flush tank</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Kitchen sink</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Clothes washer</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Total WSFUs</td>
<td></td>
<td>7.5</td>
<td>11.5</td>
<td>15</td>
</tr>
<tr>
<td>Converted to flow rate (might require interpolation)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

System Sizing Scenario

As a sales person you need to select a point of entry (POE) water ion exchange softening system for a customer’s home. The home has two full baths with showers, one half bath, a kitchen sink, a dishwasher, and a clothes washer. All water closets are flush tank type.
The relationship between WSFU’s and gpm is not linear and, therefore, requires interpolation.
**WSFU to gpm interpolation**

**Table C: Conversion of WSFU’s to gpm**

Total WSFU’s = 15

Look below & above the actual WSFU of 15; which is 10 @ 8gpm & 20 @ 14gpm

\[
\text{(actual WSFU} - \text{WSFU below}) \times \frac{(\text{flow above} - \text{flow below})}{(\text{WSFU above} - \text{WSFU below})} = \text{ gpm}
\]

\[
(15 - 10 \text{ WSFU}) \times \frac{(14 - 8 \text{ gpm})}{(20 - 10 \text{ WSFU})} = 3 \text{ gpm}
\]

8 gpm + 3 gpm = 11 gpm
## Example – Step 1

**System Sizing Scenario**

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<td>7</td>
<td>8</td>
</tr>
<tr>
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<td>1</td>
<td>0.5</td>
<td>0.5</td>
<td>1</td>
</tr>
<tr>
<td>Water closet, flush tank</td>
<td>1</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Kitchen sink</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td>Dishwasher</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Clothes washer</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1.5</td>
</tr>
<tr>
<td><strong>Total WSFUs</strong></td>
<td></td>
<td><strong>7.5</strong></td>
<td><strong>11.5</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

** Converted to flow rate (might require interpolation)**

| | 6.25gpm | 8.90gpm | **11.00gpm** |
## Sample Control Valve Specifications – 1”

**XY 1.0 VALVE SPECIFICATIONS**

<table>
<thead>
<tr>
<th>MODEL</th>
<th>XY1.0-24</th>
<th>XY1.0-32</th>
<th>XY1.0-32-10</th>
<th>XY1.0-48</th>
<th>XY1.0-64</th>
<th>XY1.0-96</th>
<th>XY1.0-128</th>
<th>XY1.0-160</th>
<th>XY1.0-192</th>
<th>XY1.0-032RC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Backwash; Min</td>
<td>8</td>
<td>8</td>
<td><strong>8</strong></td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Brine: Min.</td>
<td>60</td>
<td>60</td>
<td>60</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>68</td>
<td>60</td>
</tr>
<tr>
<td>Fast Rinse; Min</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td><strong>4</strong></td>
</tr>
</tbody>
</table>

### Refill-Minutes

**- Low Salting**

<table>
<thead>
<tr>
<th></th>
<th>3.0</th>
<th>4.0</th>
<th>4.0</th>
<th>6.0</th>
<th>8.0</th>
<th>12.0</th>
<th>16.0</th>
<th>20.0</th>
<th>24.0</th>
<th>4.0</th>
</tr>
</thead>
</table>

**- Medium Salting**

<table>
<thead>
<tr>
<th></th>
<th>5.0</th>
<th>6.7</th>
<th>6.7</th>
<th>10.0</th>
<th>13.5</th>
<th>20.0</th>
<th>27.0</th>
<th>33.5</th>
<th>40.0</th>
<th>6.7</th>
</tr>
</thead>
</table>

**- High Salting**

<table>
<thead>
<tr>
<th></th>
<th>7.5</th>
<th>10.0</th>
<th>10.0</th>
<th>15.0</th>
<th>20.0</th>
<th>30.0</th>
<th>40.0</th>
<th>50.0</th>
<th>60.0</th>
<th>10.0</th>
</tr>
</thead>
</table>

### Refill-Lbs of Salt

**- Low Salting**

<table>
<thead>
<tr>
<th></th>
<th>4.5</th>
<th>6.0</th>
<th>6.0</th>
<th>9.0</th>
<th>12.0</th>
<th>18.0</th>
<th>24.0</th>
<th>30.0</th>
<th>36.0</th>
<th>6.0</th>
</tr>
</thead>
</table>

**- Medium Salting**

<table>
<thead>
<tr>
<th></th>
<th>7.5</th>
<th>10.0</th>
<th>10.0</th>
<th>15.0</th>
<th>20.0</th>
<th>30.0</th>
<th>40.0</th>
<th>50.0</th>
<th>60.0</th>
<th>10.0</th>
</tr>
</thead>
</table>

**- High Salting**

<table>
<thead>
<tr>
<th></th>
<th>11.5</th>
<th>15.0</th>
<th>15.0</th>
<th>22.5</th>
<th>30.0</th>
<th>45.0</th>
<th>60.0</th>
<th>75.0</th>
<th>90.0</th>
<th>15.0</th>
</tr>
</thead>
</table>

### Capacity Grains

**- Low Salting**

<table>
<thead>
<tr>
<th></th>
<th>17,200</th>
<th>22,930</th>
<th>22,930</th>
<th>34,400</th>
<th>45,870</th>
<th>68,810</th>
<th>91,750</th>
<th>114,690</th>
<th>137,620</th>
<th>20,192</th>
</tr>
</thead>
</table>

**- Medium Salting**

<table>
<thead>
<tr>
<th></th>
<th>21,040</th>
<th>28,080</th>
<th>28,080</th>
<th>42,090</th>
<th>56,120</th>
<th>84,180</th>
<th>112,240</th>
<th>140,300</th>
<th>168,360</th>
<th>29,978</th>
</tr>
</thead>
</table>

**- High Salting**

<table>
<thead>
<tr>
<th></th>
<th>24,230</th>
<th>32,310</th>
<th>32,310</th>
<th>48,460</th>
<th>64,620</th>
<th>96,930</th>
<th>129,240</th>
<th>161,550</th>
<th>193,860</th>
<th>34,871</th>
</tr>
</thead>
</table>

### Water Usage (U.S. Gallons)

At Factory Settings and 40 psi inlet pressure, includes water for brine make-up.

- **32.1**
- **30.2**
- **45.2**
- **49.8**
- **95.2**
- **101.3**
- **139.6**
- **185.0**
- **217.6**
- **45.2**

### Service Flow Rate;

<table>
<thead>
<tr>
<th>Flow Rate @ 10 psi</th>
<th>9.8</th>
<th>10.1</th>
<th><strong>11.3</strong></th>
<th>10.5</th>
<th>14.2</th>
<th>14.4</th>
<th>15.1</th>
<th>17.3</th>
<th>17.8</th>
<th>10.4</th>
</tr>
</thead>
</table>

| Peak Flow Rate @ 15 psi | 13.1 | 13.0 | 14.5 | 14.1 | 18.2 | 19.2 | 20.1 | 22.7 | 23.1 | 12.8 |
| Resin; Cu Ft. | 0.75 | 1 | 1 | 1.5 | 2 | 3 | 4 | 5 | 6 | 1.0 |
| Mineral Tank | 8x44 | 9x48 | 10x48 | 10x54 | 13x54 | 14x65 | 16x65 | 18x65 | 20x62 | 10x54 |
| Brine Tank | 18x40 | 18x40 | 18x40 | 18x40 | 18x40 | 24x41 | 24x41 | 24x50 | 24x50 | 18x40 |
| Drain Line Flow Control | 1.3 | 1.7 | 2.2 | 2.2 | 4.2 | 4.2 | 5.3 | 7.5 | 7.5 | 2.2 |
| Brine Line Flow Control | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
Questions?

Thank you!