Water Treatment Fundamentals

Water Quality Association

Order of Operations

- **<u>P</u>**lease **<u>E</u>**xcuse **<u>M</u>**y **<u>D</u>**ear **<u>A</u>**unt **<u>S</u>**ally

- **<u>P</u>**arenthesis, **<u>E</u>**xponents, **<u>M</u>**ultiply, **<u>D</u>**ivide, **<u>A</u>**dd, **<u>S</u>**ubtract (PEMDAS)

Converting Units

1mg = 1,000µg

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

$$\frac{0.015\ \cancel{\text{mg}}}{1\ \text{L}} \text{ x } \frac{1{,}000\ \mu\text{g}}{1\ \cancel{\text{mg}}} = 15\ \mu\text{g/L}$$

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

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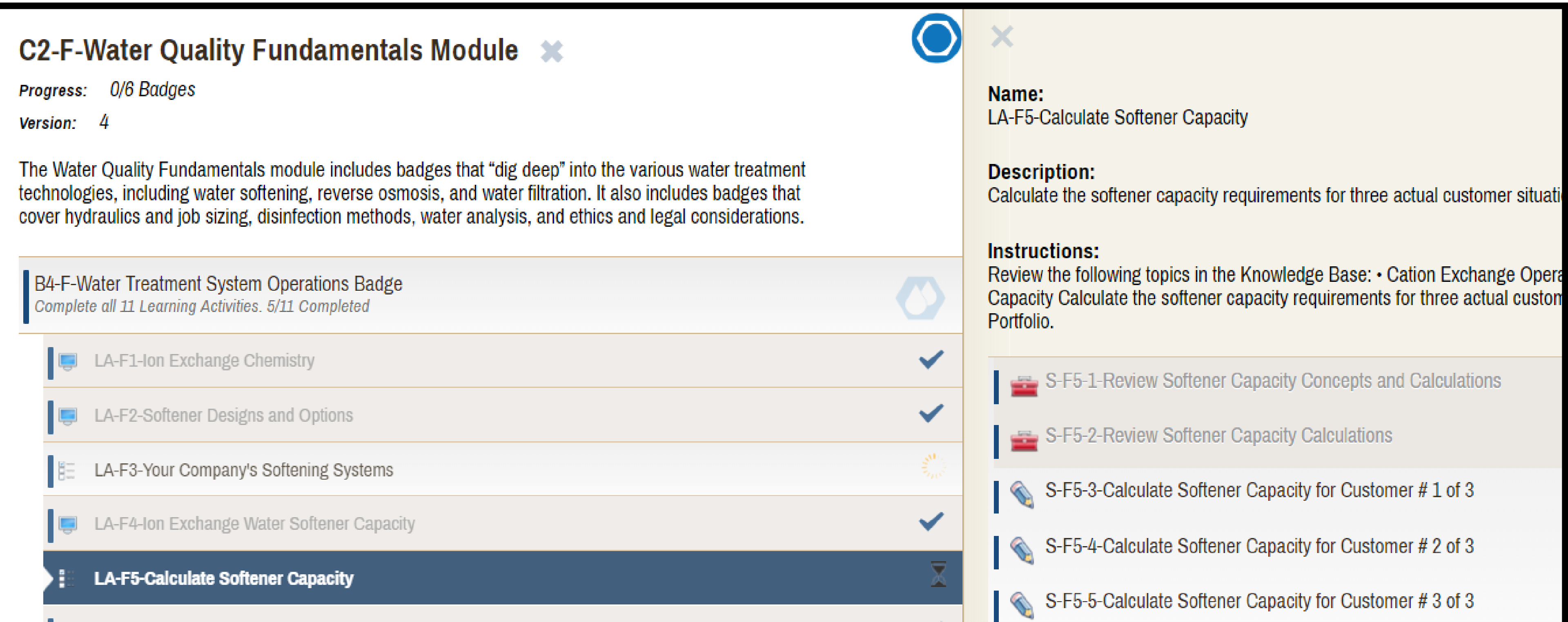
My Learning Path > C2 > B4 > LA-F5

- 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

$$1\ \cancel{ppm}\ Fe\ x\ \ ?\ = \ ?\ \ gpg\ Fe$$

Total hardness =

Grains removed per day

Total Hardness x Daily Water Usage

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

$$\frac{20\ grains}{\cancel{gallon}}\ x\ \frac{?\quad \cancel{gallons}}{day} = \ ?\quad grains/_{day}$$

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Exchange capacities

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

Exchange Capacities (grains)

Resin Volume (ft^3)	Salting Capacities Per (ft^3)			
	6 lbs.	8 lbs.	10 lbs.	15 lbs.
1.0	20,000	24,000	27,000	30,000
1.5	30,000	36,000	40,500	45,000
2.0	40,000	48,000	54,000	60,000
2.5	50,000	60,000	67,500	75,000
3.0	60,000	72,000	81,000	90,000

Processed water volume

$$\frac{resin\ capacity\ (grains)}{total\ hardness\ (\frac{grains}{gallon})}$$

$$\frac{20{,}000\cancel{grains}}{20(\frac{\cancel{grains}}{gallon})}$$

$$1{,}000\ \text{gallons}$$

Processed water volume w/ reserve

- 30% reserve capacity
  - (20,000 grains capacity)(0.30) = 6,000 grains

$$\frac{original\ resin\ capacity\ - 30\%\ reserve\ capacity}{total\ hardness}$$

$$\frac{20{,}000\cancel{grains} - 6{,}000\cancel{grains}}{20\,\frac{\cancel{grains}}{gallon}}$$

700 gallons

Service run length with reserve

$$\frac{processed\ water\ volume\ with\ reserve}{daily\ water\ usage}$$

$$\frac{700\ \cancel{gallons}}{210\,\frac{\cancel{gallons}}{day}}$$

3.33 days

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

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Cycles per month:

$$\frac{30\,\frac{\cancel{days}}{month}}{3\,\frac{\cancel{days}}{cycle}} = 10\ cycles/month$$

Salt per month:

$$\left(\frac{10\ \cancel{cycles}}{month}\right)\left(\frac{6\ lbs\ NaCl}{\cancel{cycle}}\right) = \frac{60\ lbs\ NaCl}{month}$$

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% Rejection Calculations

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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%

10ppm x 0.04 = 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*
- <u>Example: 150 ppm TDS</u>

$$(150\ \cancel{ppm\ TDS})\ \frac{1\ psi}{100\ \cancel{ppm\ TDS}} = 1.5\ \text{psi}$$

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

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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

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Learning Activity #11

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Example: Customer #1

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

$$\frac{5 \text{ gallons}}{40 \text{ seconds}} \text{x} \frac{60 \text{ seconds}}{1 \text{ minute}} = 7.5 \text{ gpm}$$

- Backwash flow available = 7.5gpm

Example 1:

	Model No	Service Flow GPM	Backwash Flow GPM	Media Cubic Feet	Drain Pipe Size	Inlet/ Outlet Size
AC (Carbon) Series	AC-10	5.0	3.2	1.5	3/4"	1"
	AC-13	7.0	4.2	2.0	3/4"	1"
	AC-1665	10.0	5.3	4.0	3/4"	1"
AN (Calcite) Series	AN-10	5.0	5.3	1.5	3/4"	1"
	AN-13	7.0	7.5	2.0	3/4"	1"
	AN-1665	10.0	10.0	4.0	3/4"	1"
FE (Birm™) Series	FE-10	5.0	5.3	1.5	3/4"	1"
	FE-13	7.0	6.5	2.0	3/4"	1"
	FE-1665	10.0	10.0	4.0	3/4"	1"
MM (Multimedia) Series	MM-10	6.0	6.5	1.5	3/4"	1"
	MM-13	8.0	10.0	2.0	3/4"	1"
	MM-1665	10.0	15.0	4.0	1"	1"

POE System Sizing

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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.

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.

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

Table C: Conversion of Water Supply Fixture Units to Gallons Per Minute

Water Supply Fixture Units	Home with Predominately Flushometer Type Water Closets	Home with Predominately Flush Tank Type Water Closets
1	-	1
2	-	2
3	-	3
4	-	4
5	15	4.5
6	18	5
7	21	6
8	24	6.5
9	26	7
10	27	8
20	35	14
30	40	20
40	46	24
50	51	28
60	54	32
70	58	35
80	62	38
90	65	41
100	68	42

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

$$(\text{actual WSFU} - \text{WSFU below})\frac{(\text{flow above} - \text{flow below})}{(\text{WSFU above} - \text{WSFU below})} = \quad \text{gpm}$$

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

$$8\ \text{gpm} + 3\ \text{gpm} = \boxed{11\ \text{gpm}}$$

Example – Step 1

System Sizing Scenario

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Type of fixture or group	Number of fixtures or groups	Hot water (WSFU)	Cold water (WSFU)	Total (WSFU)
Grp: Shower, lav, water closet - flush tank	2	4	7	8
Lavatory	1	0.5	0.5	1
Water closet, flush tank	1	0	2	2
Kitchen sink	1	1	1	1.5
Dishwasher	1	1	0	1
Clothes washer	1	1	1	1.5
Total WSFUs		7.5	11.5	15
Converted to flow rate (might require interpolation)		6.25gpm	8.90gpm	$\boxed{11.00gpm}$

Sample Control Valve Specifications – 1"

XY 1.0 VALVE SPECIFICATIONS

MODEL	XY1.0-24	XY1.0-32	XY1.0-32-10	XY1.0-48	XY1.0-64	XY1.0-96	XY1.0-128	XY1.0-160	XY1.0-192	XY1.0-032RC
Backwash; Min	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**	**8**
Brine; Min.	**60**	**60**	**60**	**60**	**68**	**68**	**68**	**68**	**68**	**60**
Fast Rinse; Min	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**
Refill-Minutes										
-Low Salting*	3.0	4.0	4.0	6.0	8.0	12.0	16.0	20.0	24.0	4.0
-Medium Salting	5.0	6.7	6.7	10.0	13.5	20.0	27.0	33.5	40.0	6.7
-High Salting	7.5	10.0	10.0	15.0	20.0	30.0	40.0	50.0	60.0	10.0
Refill-Lbs of Salt										
-Low Salting*	4.5	6.0	6.0	9.0	12.0	18.0	24.0	30.0	36.0	6.0
-Medium Salting	7.5	10.0	10.0	15.0	20.0	30.0	40.0	50.0	60.0	10.0
-High Salting	11.5	15.0	15.0	22.5	30.0	45.0	60.0	75.0	90.0	15.0
Capacity Grains										
-Low Salting*	17,200	22,930	22,930	34,400	45,870	68,810	91,750	114,690	137,620	20,192
-Medium Salting	21,040	28,060	28,060	42,090	56,120	84,180	112,240	140,300	168,360	29,978
-High Salting	24,230	32,310	32,310	48,460	64,620	96,930	129,240	161,550	193,860	34,871
Water Usage (U.S. Gallons) At Factory Settings and 40 psi inlet pressure Includes water for brine make-up	32.1	39.2	45.2	49.8	95.2	101.3	139.6	185.0	217.6	45.2
Service Flow Rate; Flow Rate @ 10 psi	9.8	10.1	11.3	10.5	14.2	14.4	15.1	17.3	17.8	10.4
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	10x44	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
Injector; color	C-Violet	D-Red	D-Red	E-White	G-Yellow	H-Green	I-Orange	J-L. Blue	K-L. Green	D-Red

Questions?

Thank you!

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