Impact of Alternative Beverage Production on Aluminum Cans in Tunnel Pasteurizers

ChemTreat®

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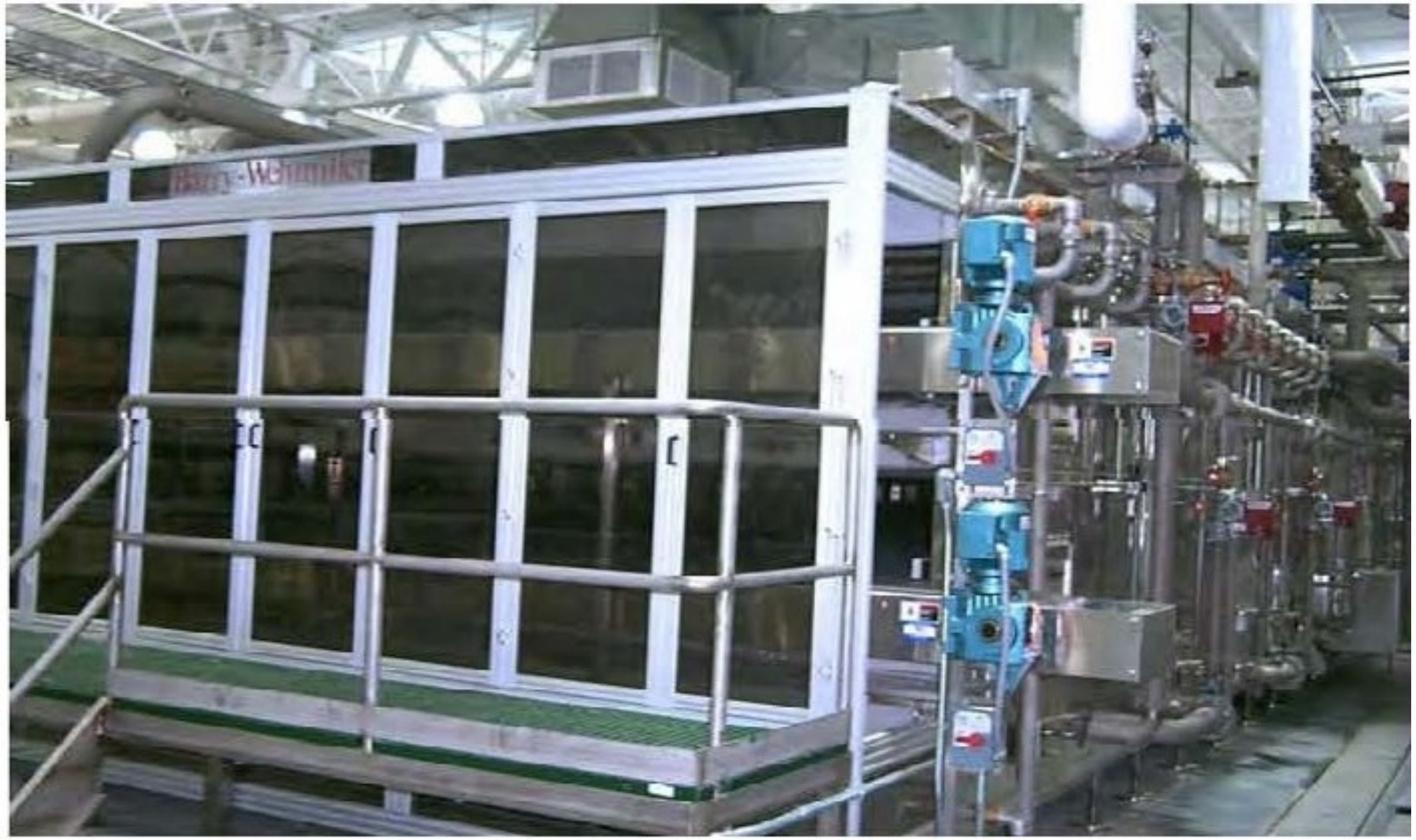
Tunnel Pasteurizer



Tunnel Pasteurizers

- Used in the brewing industry for more than 120 years
- Originally used by large brewers, now common in smaller craft breweries
- Pasteurization has several benefits: extended product shelf life is the primary consideration
- The presentation will discuss the challenges of producing flavored malt beverages in aluminum cans using tunnel pasteurizers originally designed to process conventional beer.

Growth of Flavored Malt Beverages and Seltzers

- Explosive growth in most categories continues during recent years and somewhat continuing during the pandemic
- The two-year ban on on-premises sales of flagship draft beers hurt both large and small breweries, especially craft breweries
- Natural business decisions were made to begin or increase contract brewing and packaging to utilize capacity
- Existing can fillers and pasteurizers could easily be used to produce 12 oz (355 mL) standard and sleek products

Contract Products

- Most required little change in filler and pasteurizer operation
- Max filler and pasteurizer throughput for can products targeted at 10–15 Pasteurization Units (PUs), same as most beer
- Newer pasteurizers are water and energy efficient
- Some seltzers and ciders required increased PUs
- Existing equipment: minimal adjustment in filler speed or pasteurizer temperature setpoints
- Water quality concerns were not initially an issue
- Pasteurizer mat top belt life not a significant concern

Achieving Target PUs in FMBs, Beer, and Low Alcohol (LA) Products

To achieve target PU levels, adjust the filler speed or pasteurization temperature. The table illustrates the PU effect of slowing the filler speed at 3 different hold zone temperatures, and the effect of raising the hold zone temperature at a given filler capacity (3 times).
Barry Wehmiller: Model B Pasteurizer

HOLD Zone Length (ft)	Packages/ft ^{2}	Filler Speed	Speed	Time in Hold Zone	Est. Heat Zone Temp	Hold Zone Temp	Lethal Rate	PU's in Hold Zone	Est. PU's in the Hold Zone	Est PU's Total	
11	23	1,850	2.51	4.38	152	144	2.069	9.05	72%	12.6	Normal
11	23	1,500	2.04	5.40	150	144	2.069	11.17	72%	15.5	FMB/ LA Beer
11	23	1,200	1.63	6.75	148	144	2.069	13.96	72%	19.4	FMB/ LA Beer
11	23	1,850	2.51	4.38	154	146	3.02	13.22	72%	18.4	FMB/ LA Beer
11	23	1,500	2.04	5.40	152	146	3.02	16.30	72%	22.6	FMB
11	23	1,200	1.63	6.75	150	146	3.02	20.37	72%	28.3	FMB
11	23	1,850	2.51	4.38	158	150	6.31	27.61	72%	38.4	**FMB**
11	23	1,500	2.04	5.40	154	150	6.31	34.06	72%	47.3	**FMB**
11	23	1,200	1.63	6.75	152	150	6.31	42.57	72%	59.1	**FMB**

Courtesy of Pro Engineering, Milwaukee

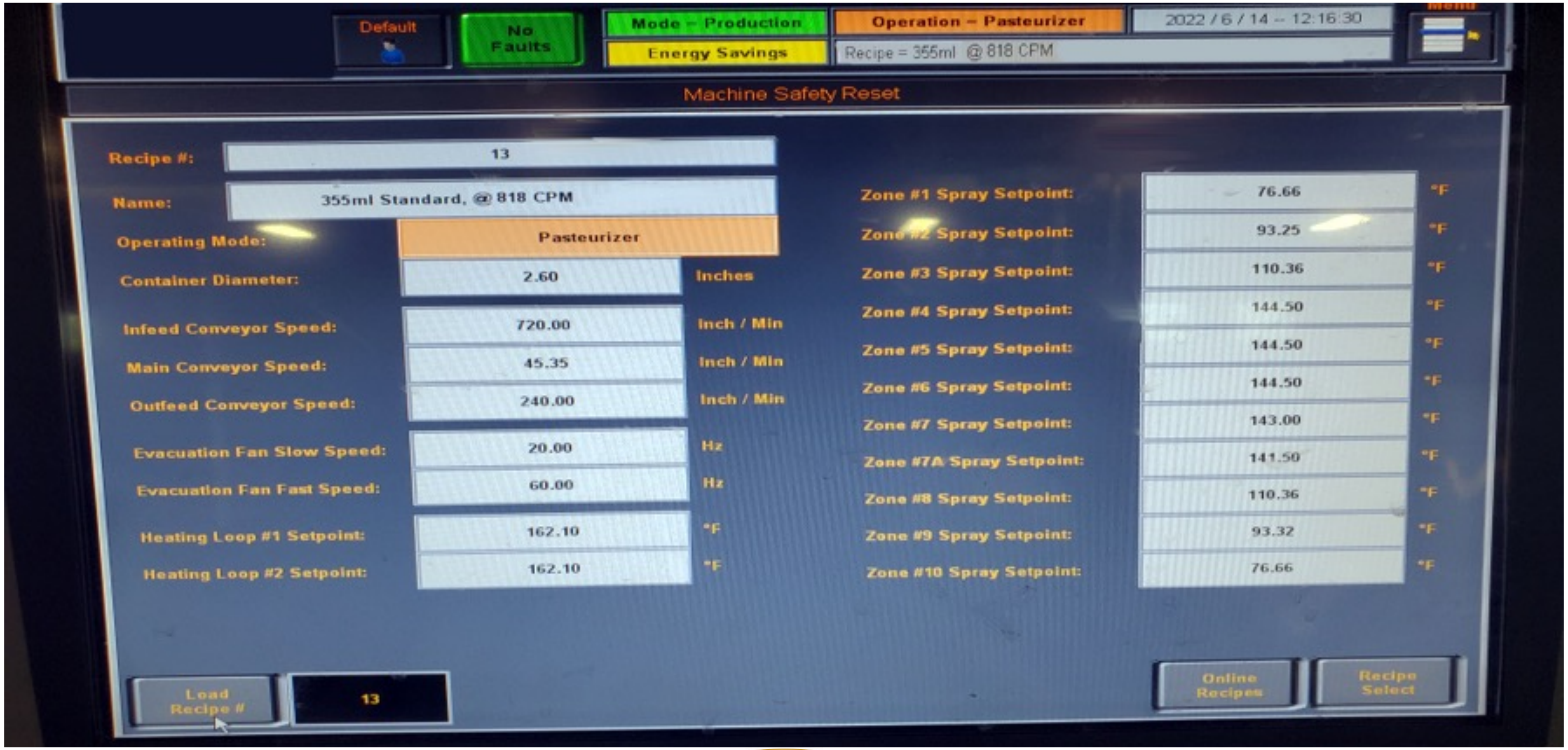
Slowing Filler Speed

- Water balancing: Less water loss for Beverage Out Temperatures (BOT's)
- Reduce staining potential during **skips** "pasteurizer extended stops"
- Increase polypropylene belt life because of lower pasteurization zone temperatures
- Some breweries have maximum product temperature in profile for specific products
- Chemical residual control is not as important at lower temperatures

Who Wants to Slow Process Time?

- No one! Most breweries opt for maintaining the max filler speed
- Max pasteurizer throughput/same process time as lower PU products (20-22 minutes in upcoming example)
- Increase number of heating-holding zones at higher temperatures to achieve target PUs in performance estimate
- Helps to have 3-4-R (regenerative zones) and max. number of heating-holding zones, to minimize sharp temperature changes to meet BOT targets

Pasteurization Zones, Max Filler Speed, and PU Target Increases

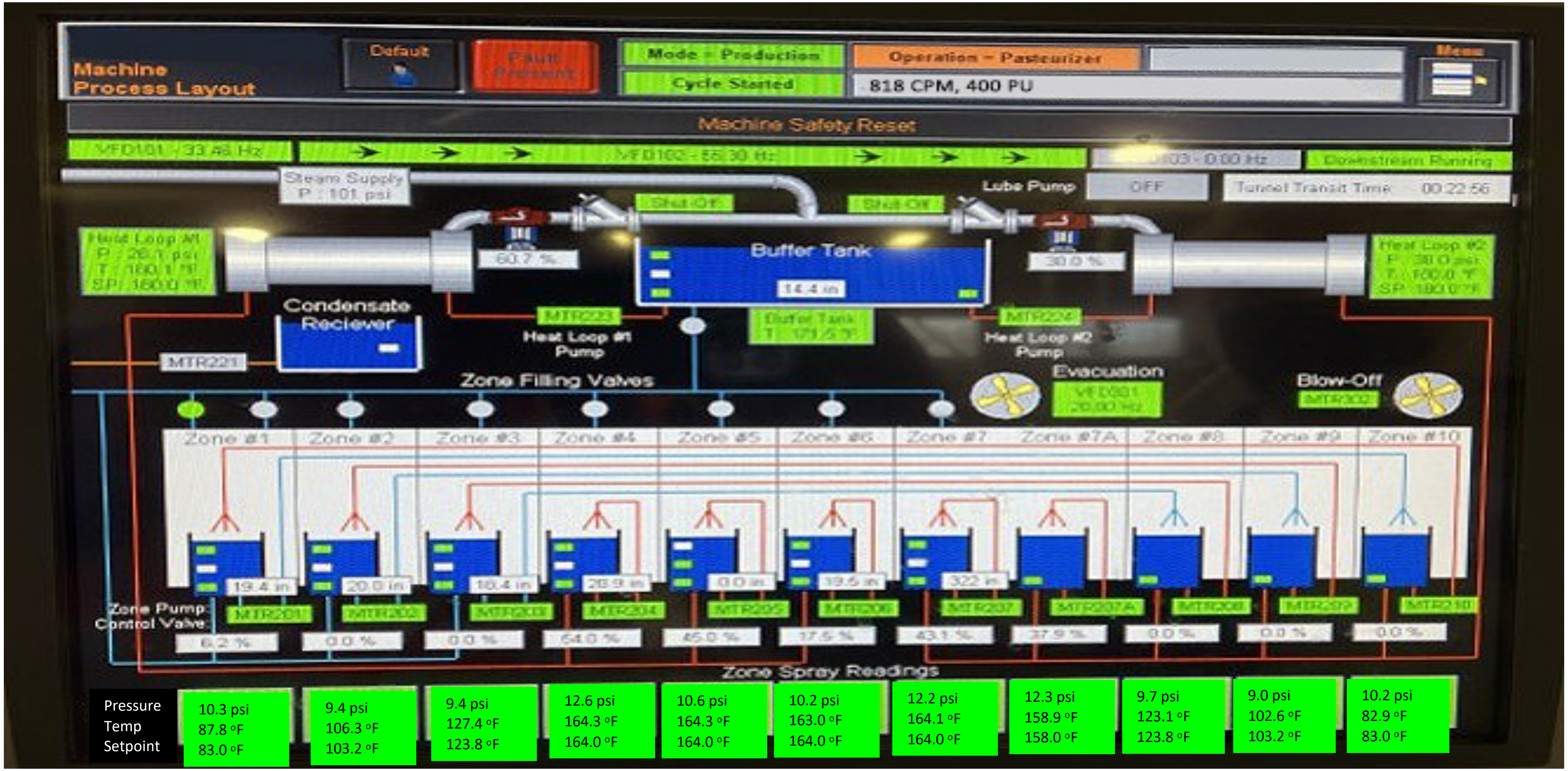


FMB Production with PU Targets >400 PU

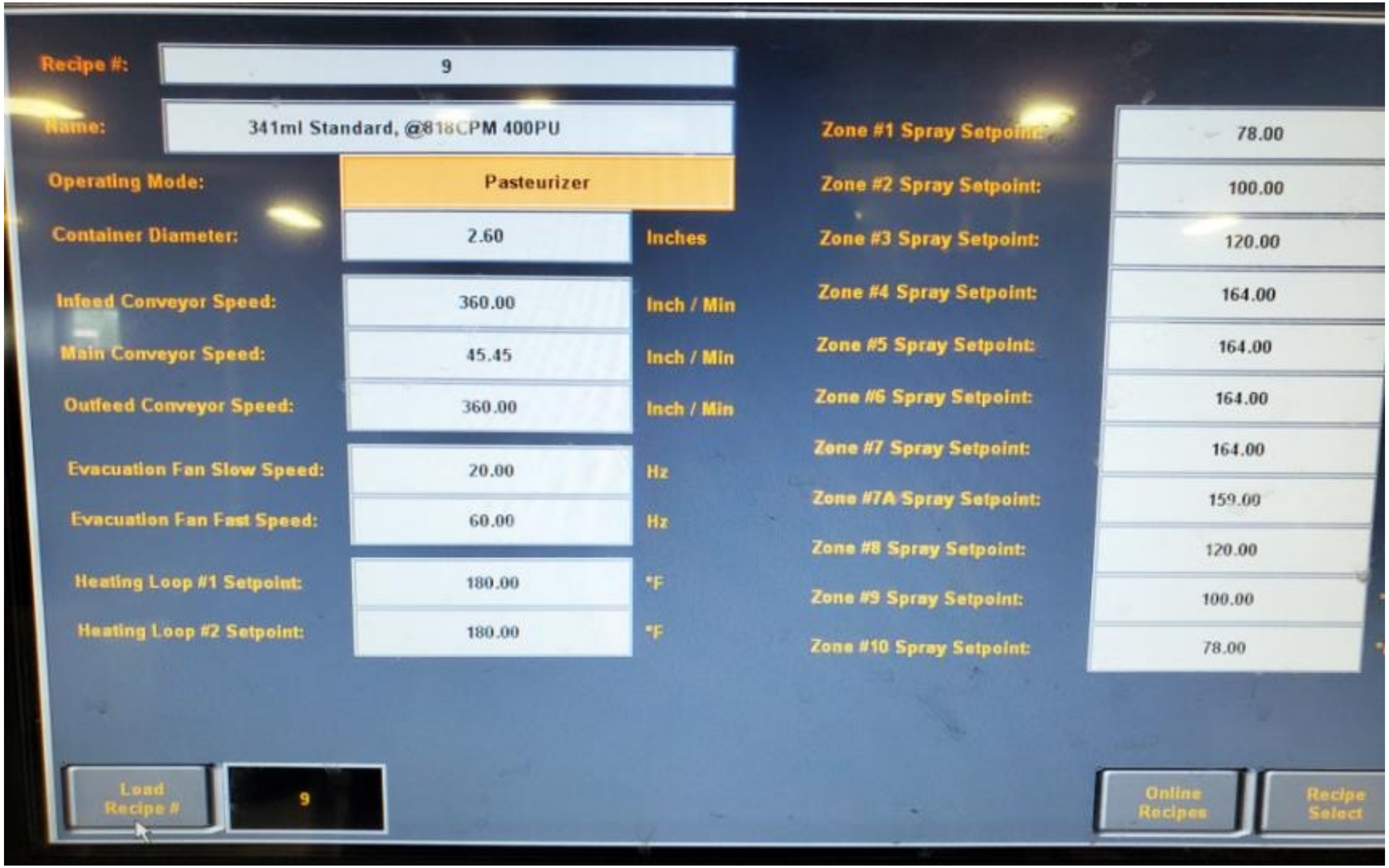
- Dramatic effect on pasteurizer operation compared to conventional PU targets for beer
- Significant increase in water usage to meet BOT targets
- Pasteurizer water quality required substantial adjustments
- Increased occurrence of product rejection because of can staining/spotting
- Degraded polypropylene mat top conveyor belt life

Pasteurizer Makeup Quality: Brewery 1

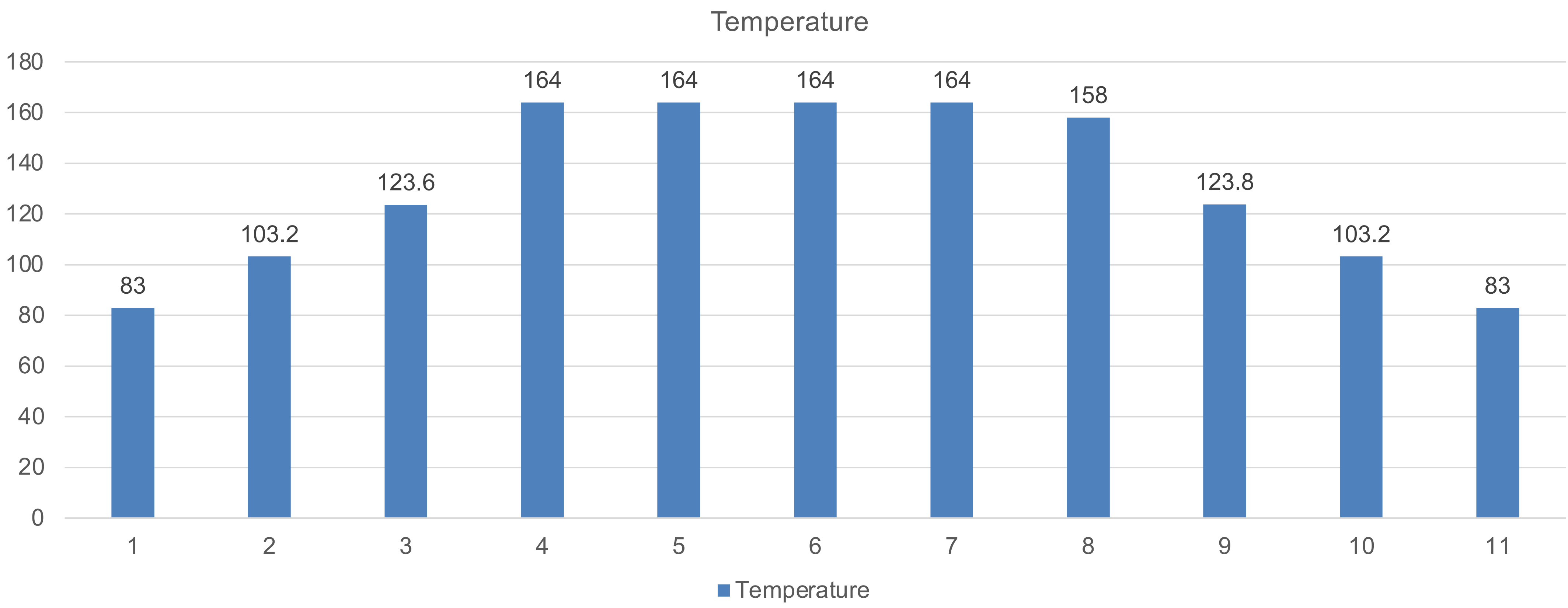
Analyte	Makeup	Zone 1	Zone 7	Zone 10
Lab pH	7.38	5.96	6.46	6.10
Conductivity	63	114	80	93
M-Alkalinity, ppm as CaCO3	26	10	12	10
Calcium Hardness, ppm as $CaCO_3$	1.9	2.5	2	2
Magnesium Hardness, ppm as $CaCO_3$	0.33	0.55	0.41	0.43
Iron, ppm as Fe	0.04	0.05	0.05	0.05
Zinc, ppm as Zn	<0.01	2.1	1.4	1.7
Chloride, ppm as Cl	1.9	9.3	5.9	7.3
Sulfate, ppm as SO_4	0.49	12	9.6	11
Ortho-Phosphate, ppm as PO_4	<0.1	8.2	6.3	7.5
Filtered Phosphate, ppm as PO_4	-	8	6.1	7.3
Silica, ppm as SiO_2	2.2	2.5	2.4	2.4
Benzotriazole	-	<0.1	0.76	0.78
Tolyltriazole	-	<0.1	<0.1	<0.1
Phosphonate, ppm as PO_4	-	2.3	2	2.7
Total Phosphate, ppm as PO_4	<0.5	11	8.3	10
Fluorescence, ppb as PTSA	-	96	73	83


Machine Process Layout
Default
Mode = Production
Cycle Started
Operation – Pasteurizer
818 CPM, 400 PU
Machine Safety Reset
Steam Supply
P : 101 psi
Lube Pump
OFF
Tunnel Transit Time 00:22:56
Buffer Tank
14.4 in
Condensate Reciever
MTR221
Heat Loop #1 Pump
Heat Loop #2 Pump
Zone Filling Valves
Evacuation
Blow-Off
Zone #1
Zone #2
Zone #3
Zone #4
Zone #5
Zone #6
Zone #7
Zone #7A
Zone #8
Zone #9
Zone #10
Zone Pump:
Control Valve:
Zone Spray Readings
Pressure
Temp
Setpoint
10.3 psi 87.8 °F 83.0 °F
9.4 psi 106.3 °F 103.2 °F
9.4 psi 127.4 °F 123.8 °F
12.6 psi 164.3 °F 164.0 °F
10.6 psi 164.3 °F 164.0 °F
10.2 psi 163.0 °F 164.0 °F
12.2 psi 164.1 °F 164.0 °F
12.3 psi 158.9 °F 158.0 °F
9.7 psi 123.1 °F 123.8 °F
9.0 psi 102.6 °F 103.2 °F
10.2 psi 82.9 °F 83.0 °F

Slight Staining Before Inhibitor Change


Recipe #: 9
Name: 341ml Standard, @818CPM 400PU
Operating Mode: Pasteurizer
Container Diameter: 2.60 Inches
Infeed Conveyor Speed: 360.00 Inch / Min
Main Conveyor Speed: 45.45 Inch / Min
Outfeed Conveyor Speed: 360.00 Inch / Min
Evacuation Fan Slow Speed: 20.00 Hz
Evacuation Fan Fast Speed: 60.00 Hz
Heating Loop #1 Setpoint: 180.00 °F
Heating Loop #2 Setpoint: 180.00 °F
Zone #1 Spray Setpoint: 78.00
Zone #2 Spray Setpoint: 100.00
Zone #3 Spray Setpoint: 120.00
Zone #4 Spray Setpoint: 164.00
Zone #5 Spray Setpoint: 164.00
Zone #6 Spray Setpoint: 164.00
Zone #7 Spray Setpoint: 164.00
Zone #7A Spray Setpoint: 159.00
Zone #8 Spray Setpoint: 120.00
Zone #9 Spray Setpoint: 100.00
Zone #10 Spray Setpoint: 78.00
Load Recipe #
9
Online Recipes
Recipe Select

Pasteurizer Temperature Profile 3R



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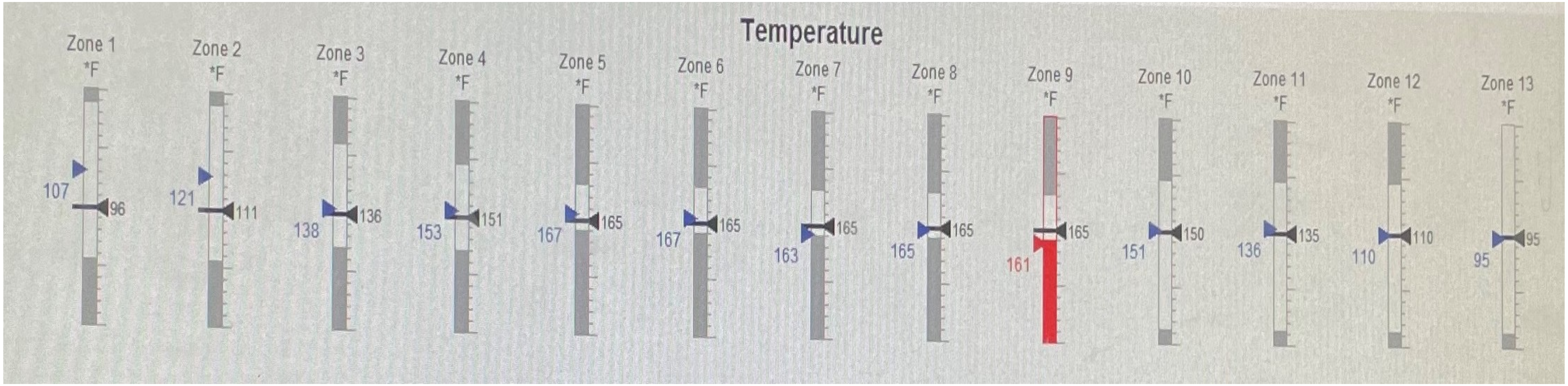
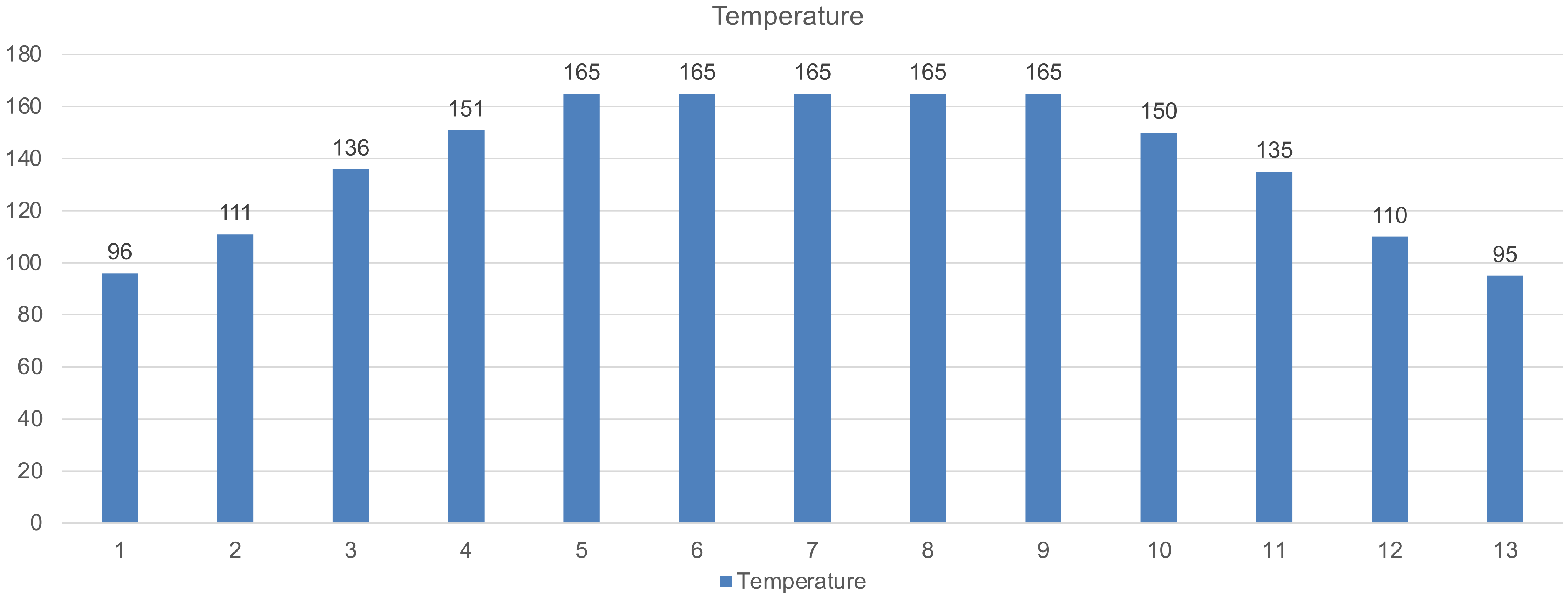
Pasteurizer Profile 4R:
Less Fresh Water Required With More Zones



Pasteurizer Temperature Profile: Easier to Maintain Water Balance



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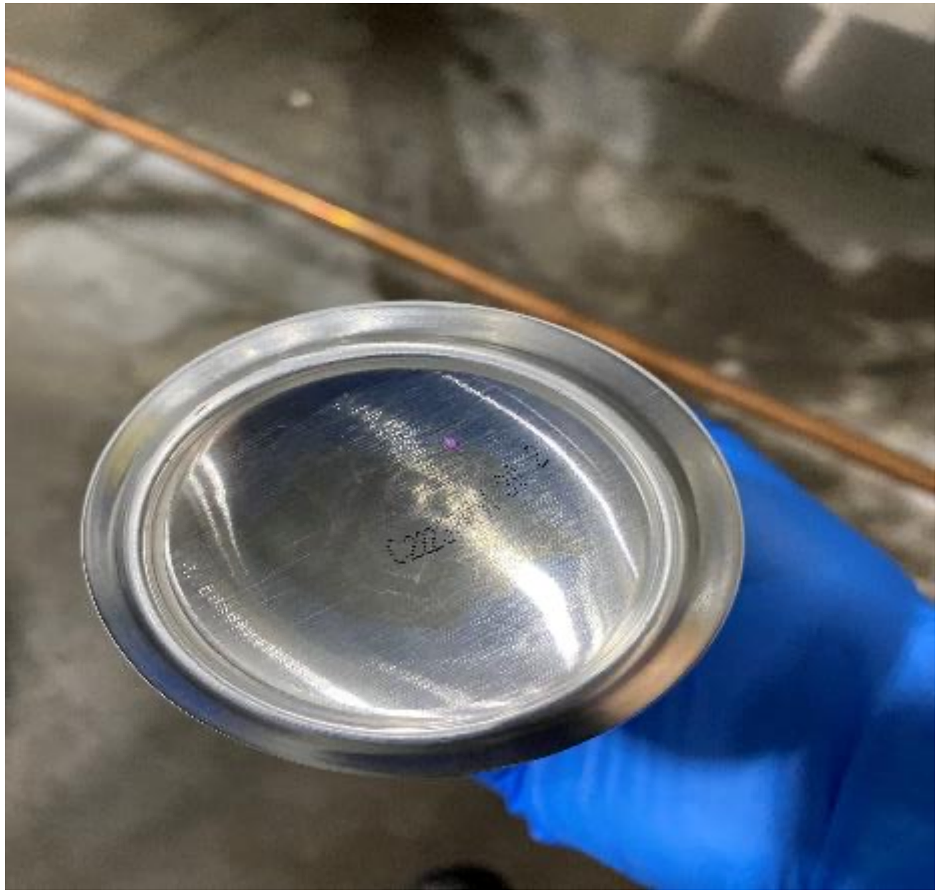
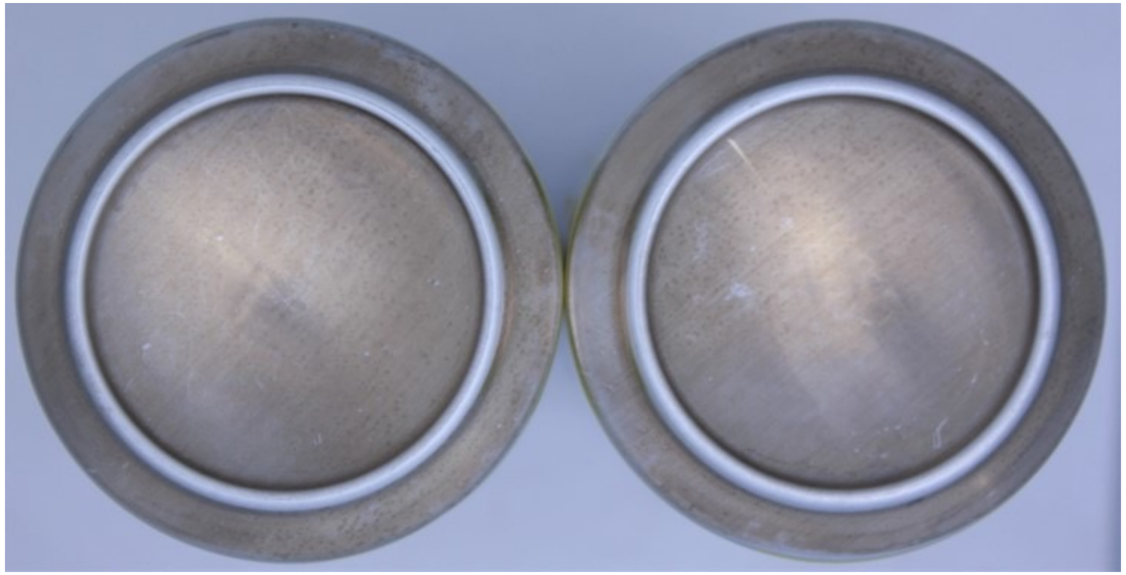
Slight Dome Staining Before Inhibitor Change

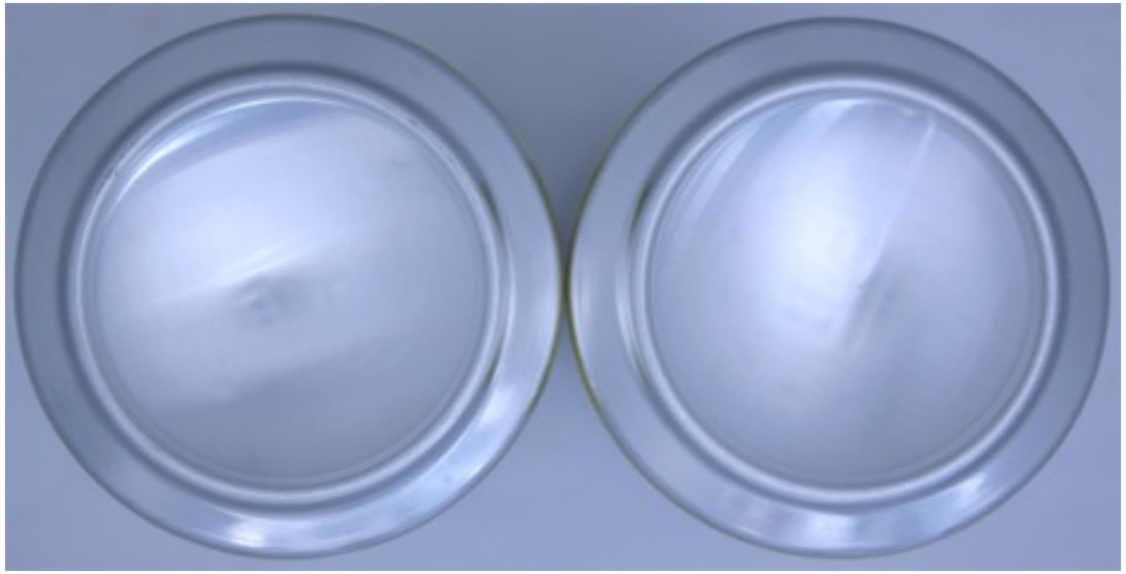


Dome Staining/Ring Tab Discoloration

- Examples
- Chemical description
- Aluminum corrosion or deposition issue
- Pasteurizer water quality issues
- High PU product temperature issue
- pH and alkalinity influence
- Need for customized inhibitor approach

Dome Staining





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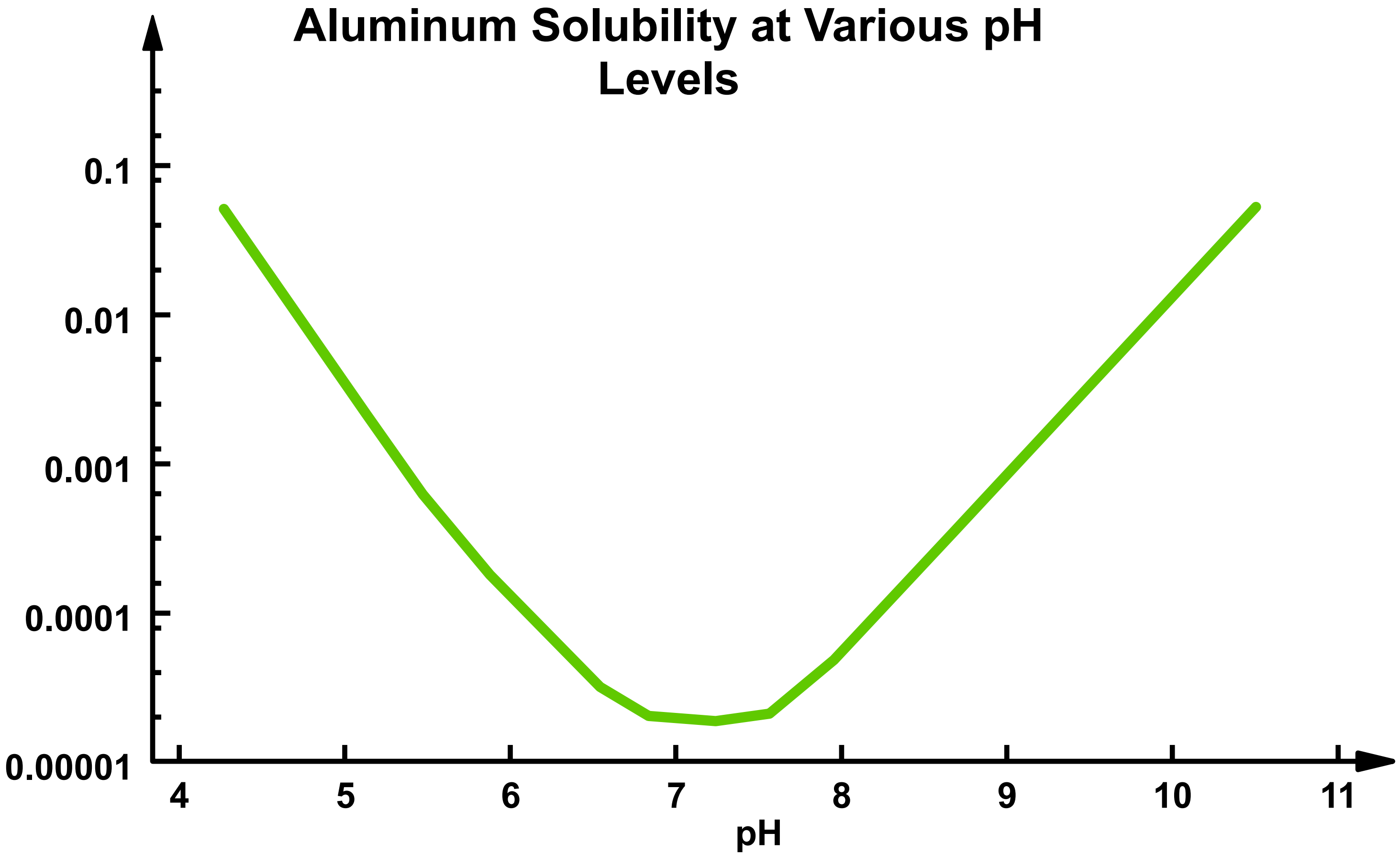
Metallurgy and Water Quality Influences

- Aluminum is amphoteric
  - pH
- Iron and manganese in alloy
- High hardness and alkalinity
- Magnesium and silica in the water
- Iron and copper in the water

Can Metallurgy

Element	Body	Tabs
Iron	0.7	0.35
Manganese	1.0–1.5	0.2–0.5
Silicon	0.3	0.2
Copper	0.25	0.15
Magnesium	0.8–1.3	3.0–4.0
Chromium		0.1

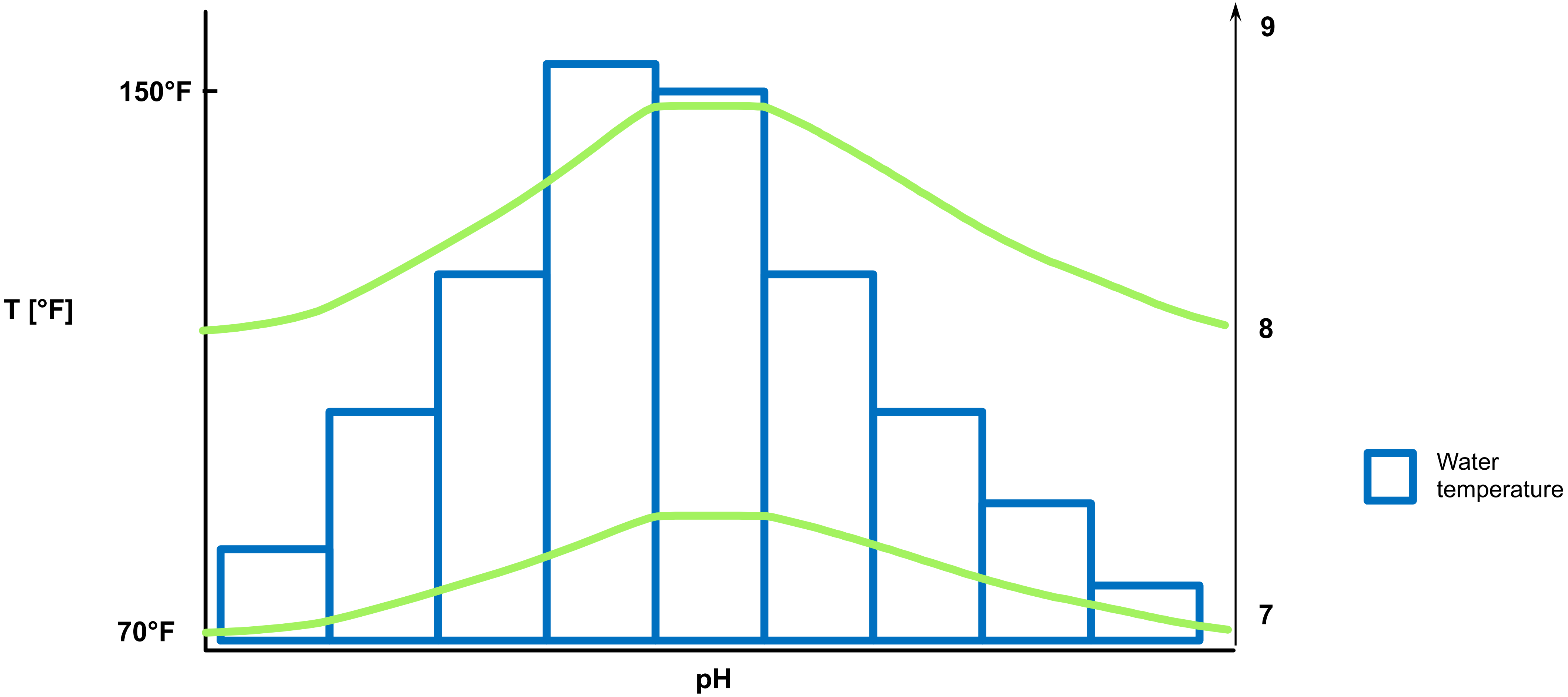
Aluminum Solubility



Water Quality Influences

- pH
  - Aluminum corrosion at low and high pH
- Mineral hardness (calcium and magnesium)
  - Deposition because of high pH and temperature
- Silica
  - Deposition because of high pH and temperature
- Iron
  - Deposition
- Copper
  - Galvanic corrosion and deposition

Pasteurizer pH Profile: pH Increase with Water Temperature



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Pasteurizer Makeup Water Quality Variations: Influence on Staining/Deposit Potential

Analyte	Location 1	Location 2	Location 3	Location 4
pH	7.5	8.0	6.5	7.5
Conductivity	600	690	103	98
‘M’ Alkalinity	98	208	50	26
Calcium	99	204	23	33
Magnesium	56	116	14	7.5
Iron	<0.05	0.07	<0.05	0.04
Chloride	82	71	5.5	6.4
Sulfate	63	27	4.3	11
Zinc	<0.05	0.04	<0.05	0.01
Phosphate	<0.05	<0.05	<0.05	<0.05

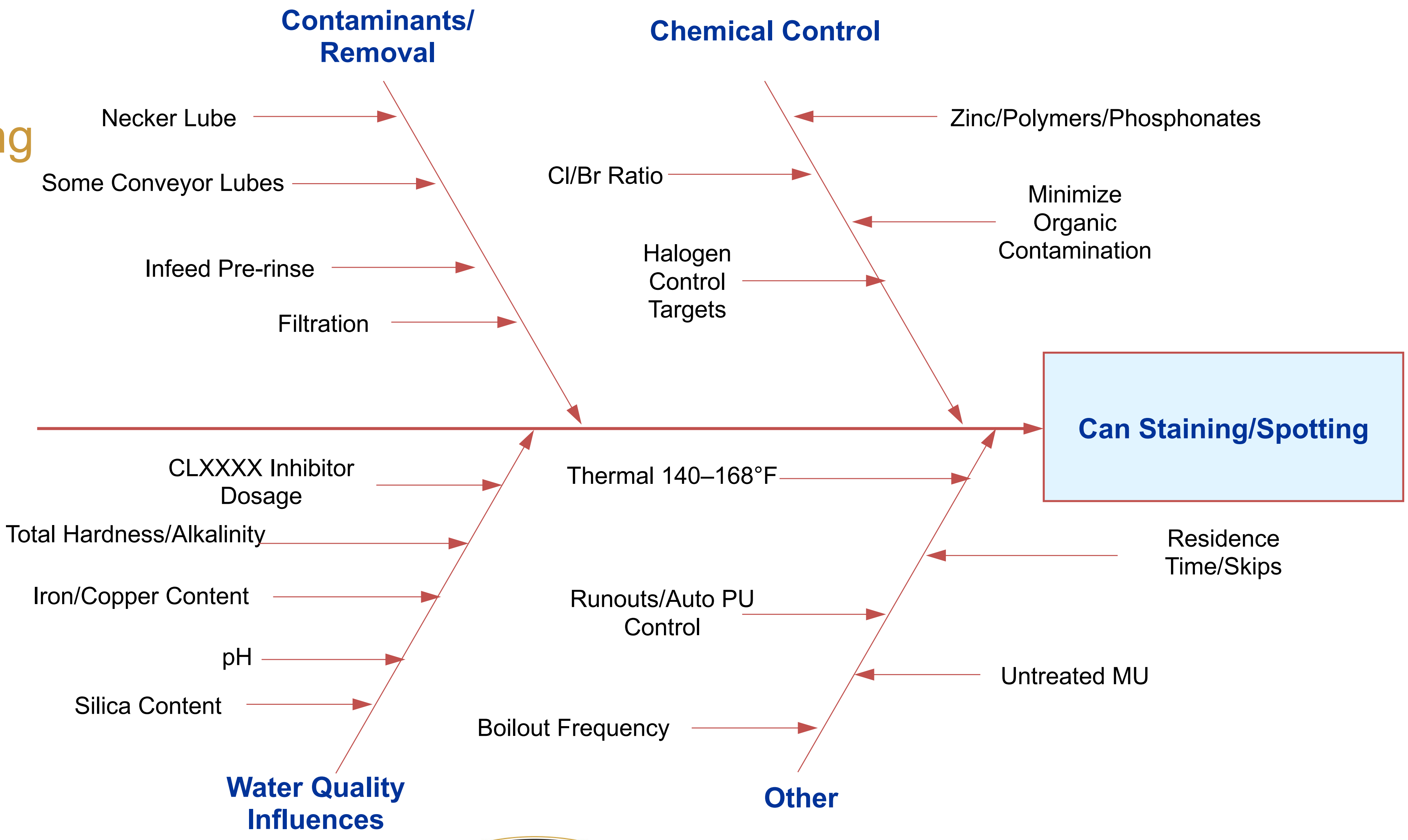
Discolored Ring Tabs on FMB Product

With previously used inhibitor for lager beer and low-alcohol products, there was no need to adjust pH using city water makeup

Dome Staining Prevention for FMB Pasteurization

- pH control first
  - At lower temperatures, higher pH is feasible (8.0–8.5) <140°F
  - At higher temperatures, pH must be 6.5–7.5 at 160°F (FMB's)
    - The increased temperatures and current water chemistry the reason why it is necessary to adjust the pH now versus before; when lower temperatures and pH were not a concern.
    - Lower the total 'M' alkalinity to <60 ppm in makeup to pasteurizer
- Anodic/cathodic inhibitors
- Minimize skips (pasteurizer stoppage for extended periods)
- Zeolite softening and/or Reverse Osmosis blended with makeup water may be required to meet water quality recommendations

RCFA: Can Staining/Spotting in Brewery Pasteurizers



Spinner Bath Study to Evaluate Can Dome Staining at 160°F and pH 7.6 and 8.5

- Need for pH/Alkalinity control with high PU FMBs

Test Protocol

- Fill the spinner bath pots with 10 liters of makeup water and heat to 160°F
- Aerate the spinner baths with standard flow rates, add inhibitors, and adjust the pH
- Take samples from each bath to test for inhibitors and submit to the water lab
- Place two of the provided empty cans in each bath by submersing while ensuring the can dome does not capture an air bubble and is fully-wetted
- Expose for 20 minutes
- Take water samples for analysis

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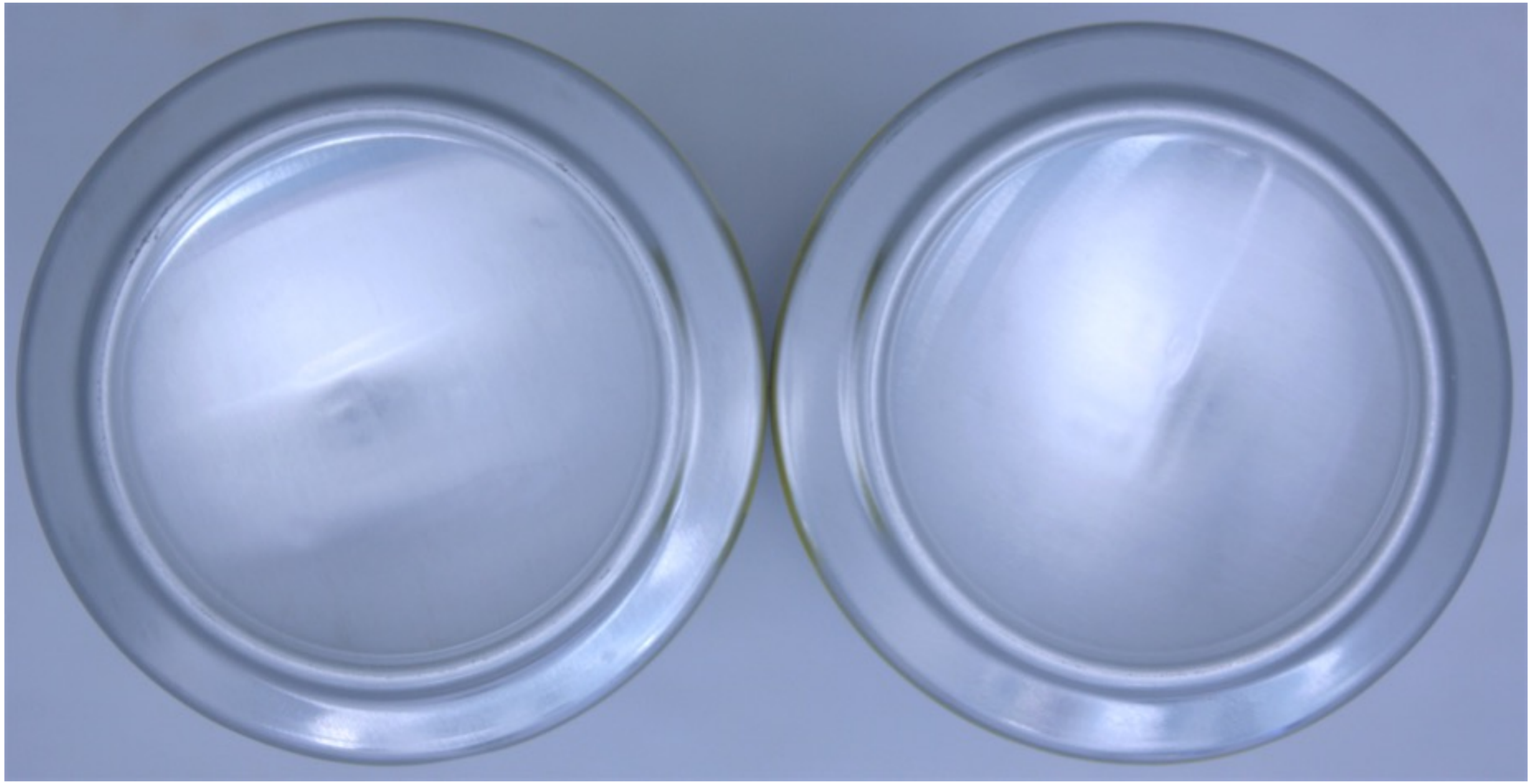
City Water versus Dealkalized Makeup: Brewery 2

Analyte	City Water	City Water	Dealkalized Water	Dealkalized Water
Lab pH	7.67	7.71	6.96	7.06
Conductivity, µmhos	425	432	488	488
'M' Alkalinity, ppm as $CaCO_3$	153	153	52	53
Calcium Hardness, ppm as $CaCO_3$	110	109	114	114
Magnesium Hardness, ppm as $CaCO_3$	45	45	48	48
Iron, ppm as Fe	0.03	0.02	0.03	0.03
Zinc, ppm as Zn	<0.01	<0.01	<0.01	<0.01
Chloride, ppm as Cl	28	28	31	31
Sulfate, ppm as SO_4	31	31	142	141
Ortho-Phosphate, ppm as PO_4	<0.1	<0.1	0.13	0.11
Filtered Phosphate, ppm as OPO_4			<0.1	<0.1
Silica, ppm as SiO_2	13	13	14	14
Phosphonate ppm as PO_4			< 0.5	< 0.5
Total Phosphate ppm as PO_4	< 0.5	< 0.5	< 0.5	< 0.5
Molybdenum, ppm as Mo			0.22	0.05
Total Suspended Solids, mg/L	< 1	< 1		

Inhibitor Chemistry and Water Quality from Previous Treatment Program

- Bath 1. Blank with pH maintained at 7.6
- Bath 2. Blank adjusted to pH 8.5
- Bath 3.
  - pH adjusted to 7.6 with 150 ppm of CLXXXX
  - 20 ppm of CTXXX added
- Bath 4.
  - pH adjusted to 8.5 with 150 ppm of CLXXXX
  - 20 ppm of CTXXX added
- Bath 5. pH adjusted to 7.6 plus 100 ppm of acidic inhibitor
- Bath 6. pH adjusted to 8.5 plus 100 ppm of same inhibitor

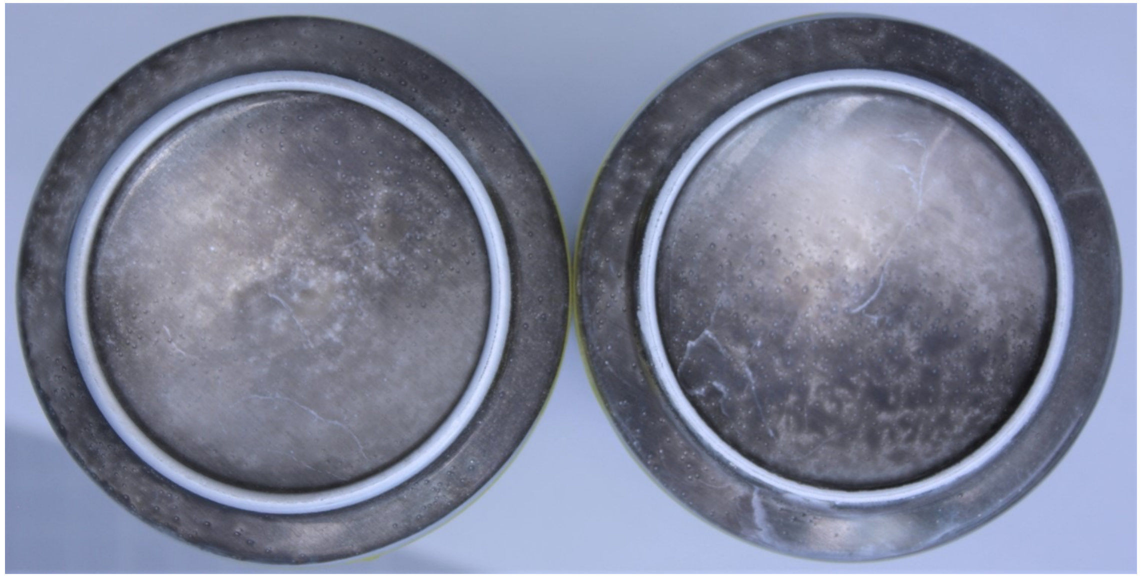
New Can Dome Surface



Can Dome Surface Results

Can Dome Surface After Test:
Blank at pH 7.6

Can Dome Surface After Test:
Blank at pH 8.5



Can Dome Surface Results

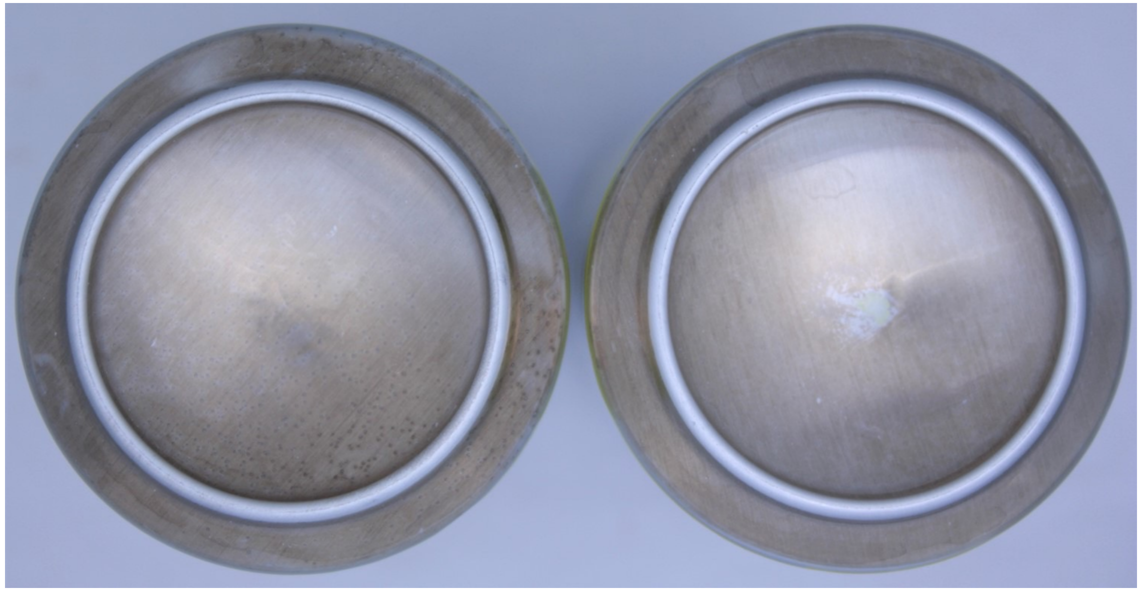
150 ppm of CLXXXX and 20 ppm of CTXXX at pH 7.6

150 ppm of CLXXXX and 20 ppm of CTXXX at pH 8.5

Can Dome Surface Results

100 ppm of Acidic Inhibitor at pH 7.6

100 ppm of Acidic Inhibitor when pH Raised to 8.5



Can Dome Surface Results

- 100 ppm CLXXXX, 20 ppm CTXXX at pH 7.2 and 50 ppm alkalinity
- No observed can dome staining

R&D Test Summary

- Can dome surfaces were stained in absence of any treatment at both high and low pH
- For treated cans, can staining was observed at higher pH for all tested treatment programs using existing makeup water
- For treated cans, less can staining was observed at lower pH for all treatment programs
- Conclusions:
  - Temperature, pH, total alkalinity, and mineral hardness have a primary impact on can staining
  - Water chemistry and inhibitor levels must be adjusted when running FMB's in tunnel pasteurizers requiring high PUs

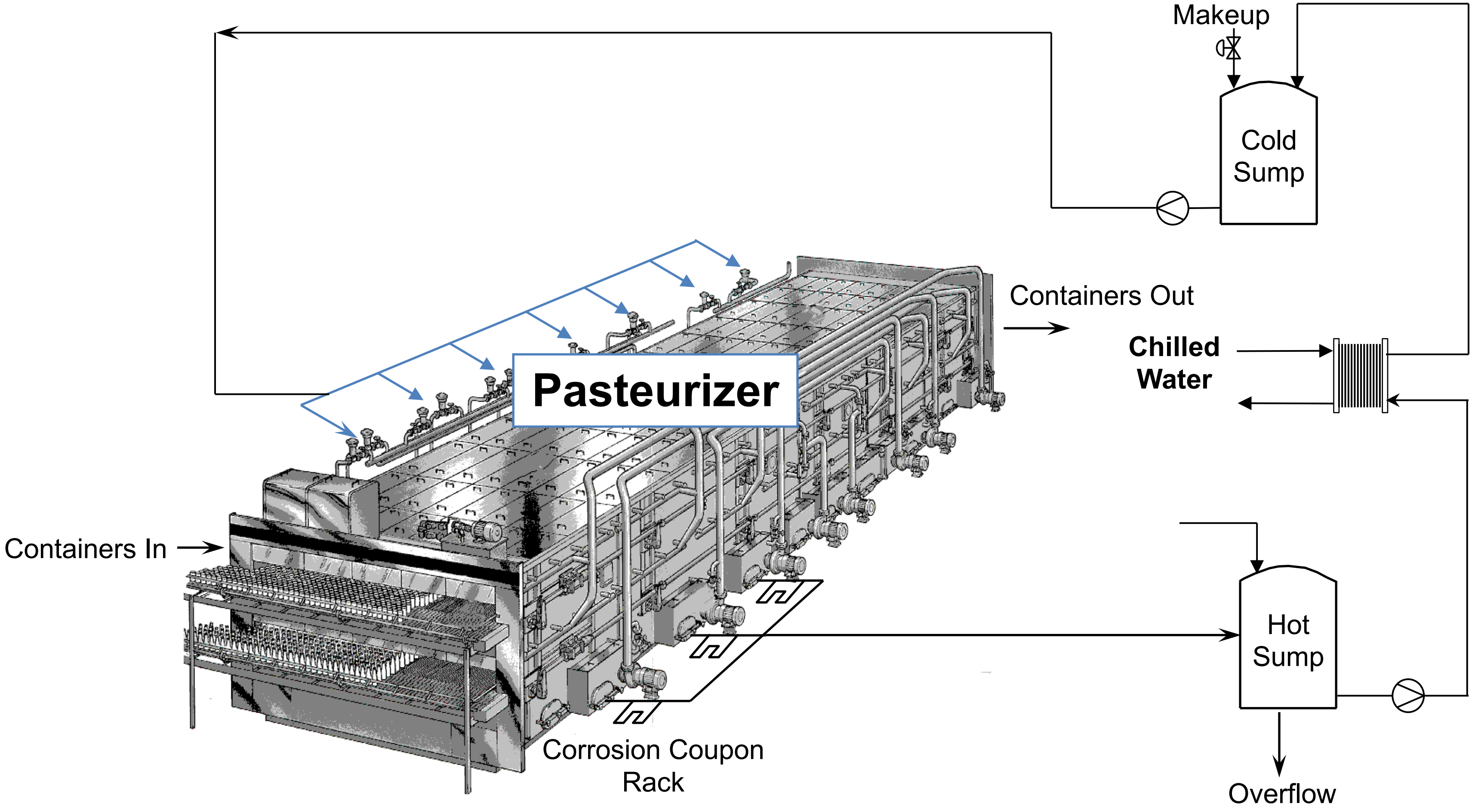
Best Practices: Pasteurizer Water Quality

Parameter/Metric	Beer Pasteurizer Target	FMB Pasteurizer Target
pH	7.5–8.6 (± 0.2)	6.5–7.5
Chloride (ppm as Cl)	<150 or Corp Max	
Total Hardness (ppm as $CaCO_3$)	<400	<200
Total Alkalinity (ppm as $CaCO_3$)	<300	<60
Total Organic Carbon (ppm as C)	<40	
Turbidity (NTU)	<40	
Conductivity (µmhos or mS)	<3.0 X Makeup	
Free Residual Halogen (non H-H) (ppm as Cl_2)	0.5–1.5	
Free Residual Halogen (H-H) (ppm as Cl_2)	<0.2	
Cl_2 Splits (Free/Total) (ppm as Cl_2)	<0.75	
Biocounts (Aerobic) (cfu/mL)	$<10^3$	
Biocounts (Anaerobic) (cfu/mL)	N/D	
Active Polymer (ppm as polymer)	7–10	10 min
Zinc (ppm as Zn)	>0.5	1.0–2.0

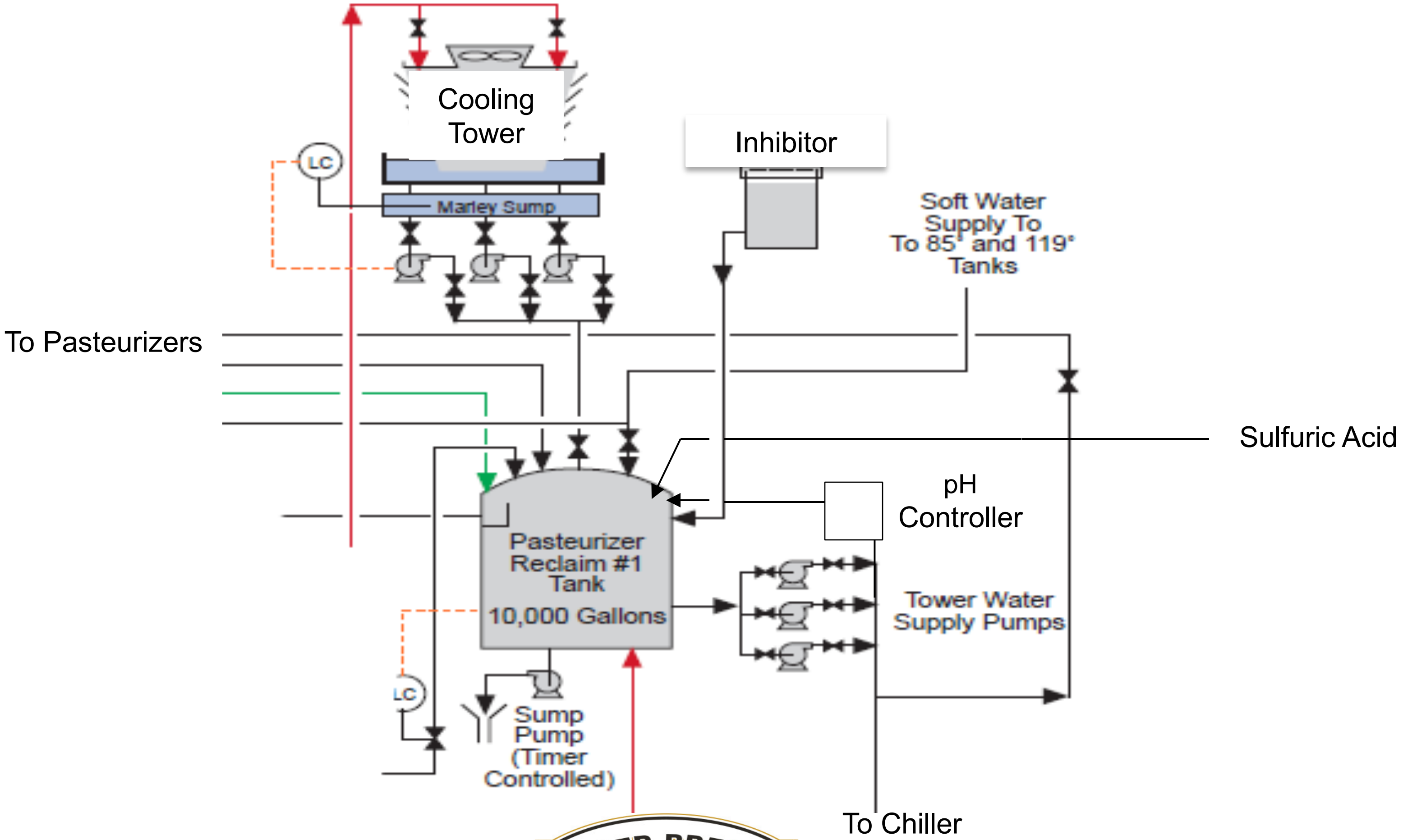
Minimizing Pasteurizer Problems with High PU FMBs: Recommendations

- Water chemistry adjustment is essential for pH and total alkalinity
- It may be necessary to use an inhibitor specific to each product
- May require a chilled water source (reclaim water system) to minimize high water usage to meet BOT targets
- Consider the max. water temperature to extend polypropylene mat top belt life
- Must automate chemical inhibitor and halogen feed to extend forgiveness window during skips
- Do not add mineral acid directly to pasteurizer for pH control

Pasteurizer Systems with Chilled Water Makeup

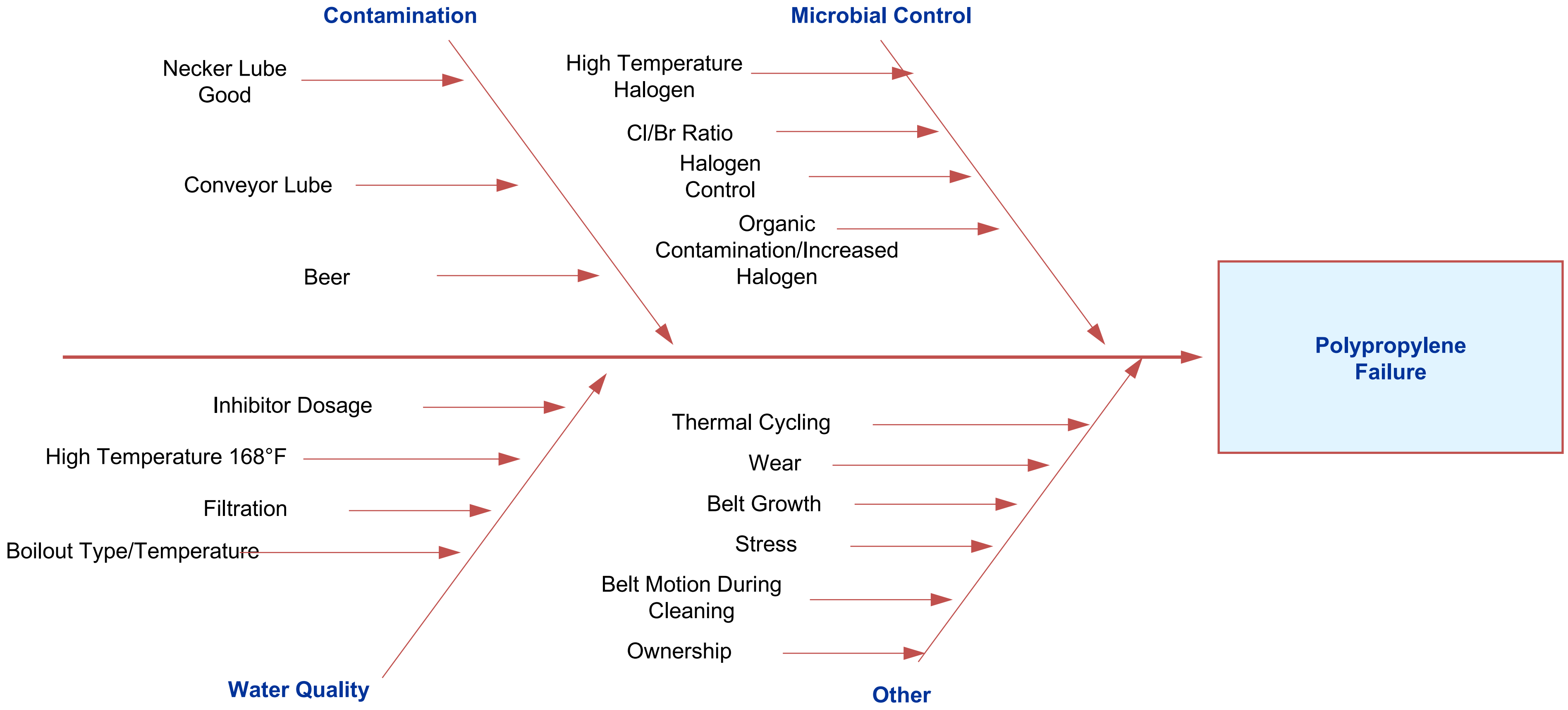


Reclaim System: pH Control, Zeolite Softening, Acid Feed to Central Reclaim Tank



Result of Acid Overfeed Directly to Pasteurizer

Polypropylene Failure Influencers with FMB Production



Custom Flash Pasteurizer Options for High-PU Beverages

Suggestions for Future Work

- Run cost/benefit analyses to measure the frequency of can rejections versus can production numbers
- Compare excess water usage versus FMB production to achieve BOT specifications where water and sewer charges vary considerably by location
- Tunnel pasteurization versus customized flash pasteurization for FMB production

Presenter Bio and Questions

Jack Bland

- ChemTreat, Inc., 1980–2011
  - Held various technical and management positions
- United Water Consultants, 2012–present
- Cooling Technology Institute, 1980–present
  - President in 1996 and 2012
- Master Brewers Association, 1980–present
  - Instructor at MBAA Packaging Course (1990–2008)
  - Instructor at MBAA Utilities Maintenance Course (2013–present)
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