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Advocates for innovative water management.

Presented by:

Jeff Freitag, The Water Guy

Jon Tiegs, General Manager

BOILER SYSTEM KEY PERFORMANCE INDICATORS

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OBJECTIVES

- **Understand The Importance of Practicing Key Performance Indicators (KPI's) in Your Boiler Room**
- **Identify Key Components of the System**
- **Understand How Water Chemistry Relates to KPI's**
- **Review Mechanical Components to Monitor**
- **Discuss Automation Options for KPI Monitoring**

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WATER: The Universal Heating Medium

A. Relatively abundant (covers ¾ of earth's surface)
B. Easy to handle and transport
C. Non-Toxic and environmentally safe
D. Relatively inexpensive
E. Exists in three (3) forms
    1. Solid (ice)
    2. Liquid (water)
    3. Gas (steam)
F. Tremendous capacity to absorb and release heat
    1. high specific heat (1 B.T.U. of heat when added to 1 pound of water will increase the temperature of the water 1^{o} F)
    2. High heat of vaporization (amount of extra heat required to effect the change from a liquid to a gas – 970 B.T.U.'s/lb.)
    3. High heat of fusion (amount of extra heat required to effect the change from a solid to a liquid – 143 B.T.U.'s/lb)

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Basic Water Characteristics

- **Dissolved Gasses**
  - Carbon Dioxide
  - Oxygen
  - Hydrogen Sulfide
- **Dissolved Solids**
  - Calcium & Magnesium
  - Silica
  - Iron
  - Carbonate & Bicarbonate
- **Suspended Solids**
  - Dirt & Mud
  - Sand & Garbage
- **Organic Material**
  - Wood
  - Leaves & Seeds
  - Animal Remains
  - Oil

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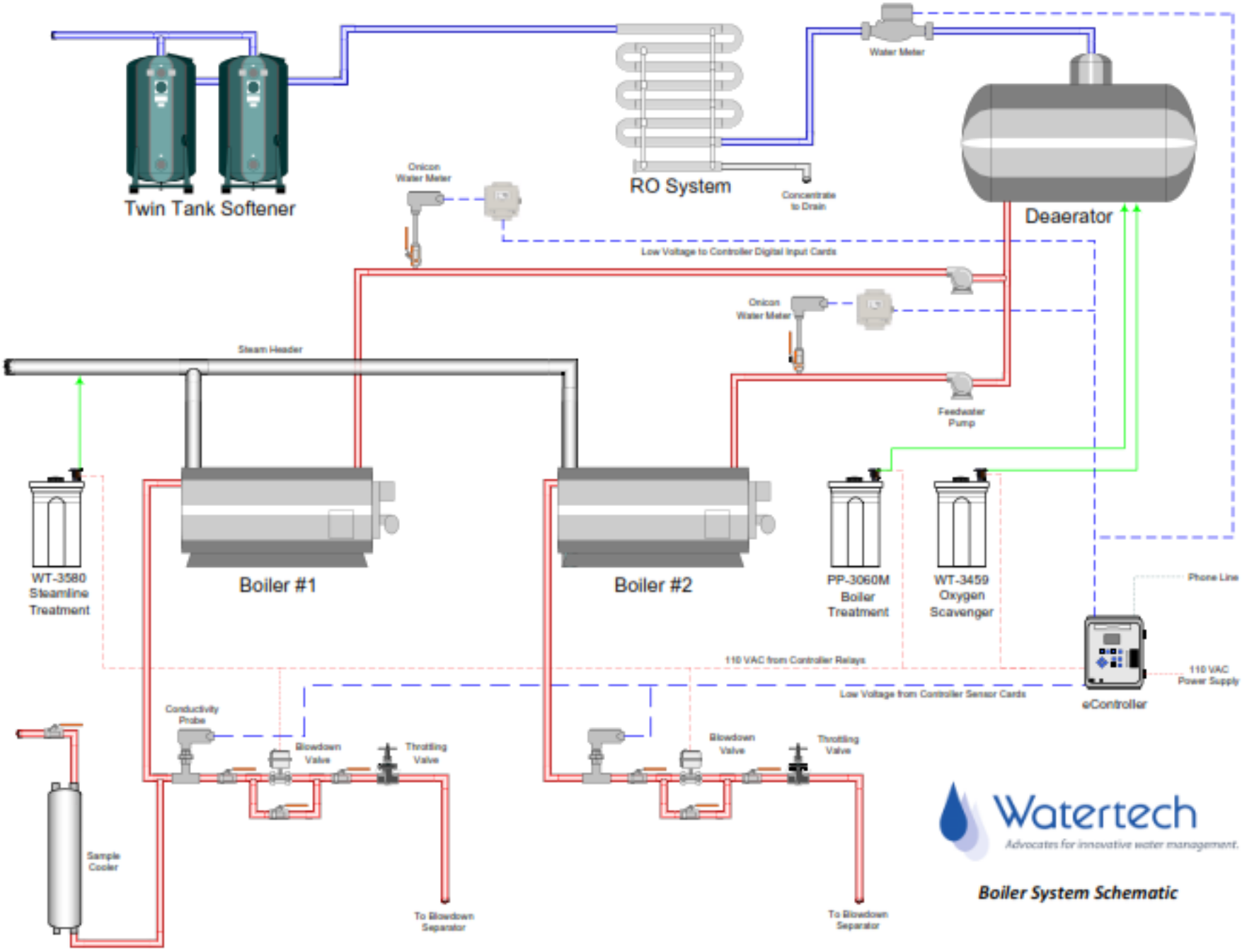
ASME Guidelines

Suggested Water Chemistry Limits Industrial Firetube, High Duty, Primary Fuel Fired

- Makeup Water Percentage: Up to 100% of Feedwater
- Conditions: No superheater, turbine drives, or process restriction on steam purity
- Steam Purity: 1.0 mg/L TDS maximum
- Drum Operating Pressure: 0-300 psig

Parameter	Range
Feedwater	
Dissolved Oxygen	<0.007 mg/L O_2
Total Iron	<0.1 mg/L Fe
Total Copper	<0.05 mg/L Cu
Total Hardness	<1.0 mg/L
pH @ 25 C	8.0 – 10.5
Nonvolatile TOC	<10 mg/L
Oily Matter	<1 mg/L
Boiler Water	
Silica	<150 mg/L SiO_2
Total Alkalinity	<700 mg/L $CaCO_3$
Free OH Alkalinity	NS
Specific Conductance	<7,000 µs/cm


Twin Tank Softener
RO System
Water Meter
Concentrate to Drain
Deaerator
Onicon Water Meter
Low Voltage to Controller Digital Input Cards
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Steam Header
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Sample Cooler
To Blowdown Separator
To Blowdown Separator
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Boiler System Schematic

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Pre-Treatment Equipment

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Softeners

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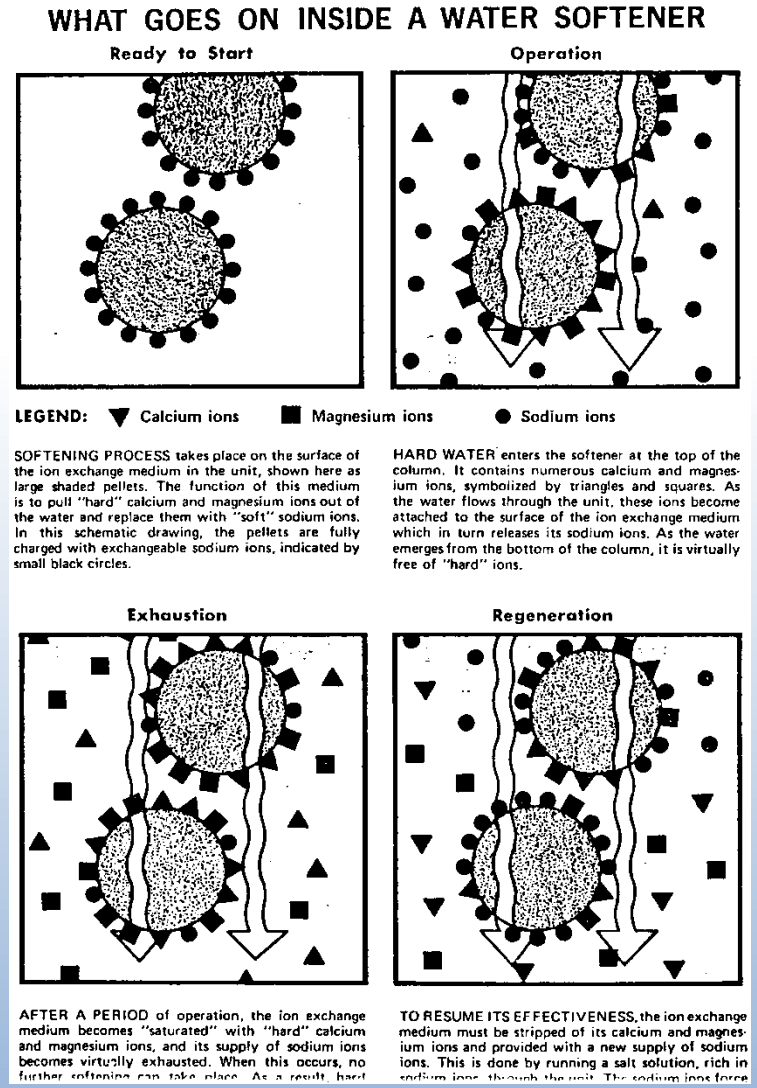
Water Softener

- What is it?
  - An ion exchanger that removes cations from the water and replaces them with either sodium or hydrogen.
  - Typical Cations Removed
    - Calcium
    - Magnesium
    - Strontium
    - Iron



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Water Softener

- Why is it important?
  - Hardness is the worst enemy in a boiler system.
  - Hardness will form scale deposition on the heat transfer surfaces causing severe damage and increased energy costs
- KPI's

  - Total Hardness Test on Water Samples (< 1ppm)

    All pre-treatment equipment: Softeners, Dealkalizers, Reverse Osmosis systems, Feedwater, Condensate Return

  -Check salt level in the brine tank

  -Gallons per Regeneration

  -Salt per regeneration

  -Pressure Drop – should not exceed 25 psig at peak flow

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Reverse Osmosis (RO)

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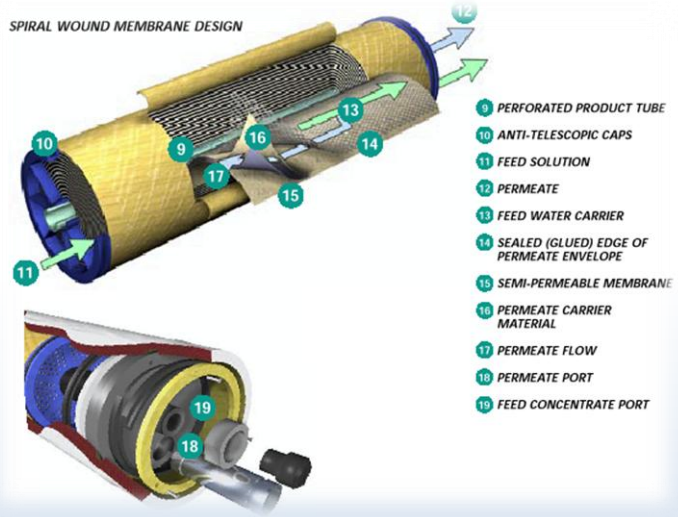
Reverse Osmosis

- What is it?
- Membrane-based separation process
- Involves the separation of dissolved solids from the feedwater by means of a semi-permeable membrane
  - Membranes allow water to pass through (permeate) readily, but are fairly impermeable to other constituents in the feed stream.
  - Removes ions from water before entering boiler
- Why is it important?
  - Improves water quality to help reduce water energy and chemical usage.
  - Improves overall system efficiency and provides excellent defense against scale buildup on the heat transfer surfaces.



- KPI's
  - RO Performance Data Monitoring Form

Parameter	RO Inlet	RO Interstage	RO Concentrate	RO Permeate	Other
Pressure	X	X	X	X	Across each prefilter
Flow rate	X	X	X	X	
Conductivity	X	X	X	X	
Temperature	X		X		
PH	X		X		
SDI	X				Inlet and outlet to each multimedia filter
Chlorine, free	X		X		
Turbidity	X				
LSI			X		
MB plates (one/week)	X		X	X	Before/after each piece of upstream equipment

- KPI's
  - Permeate conductivity levels should be at least 85 – 90% lower than the feedwater. Most designs call for 98% reduction.
  - Pressure drop on the pre-filter should be less than a 10 psi drop (or 5 psi over nominal)
  - If not feeding soft water to RO, proper chemical feed and control is critical to prevent membrane fouling
  - Monitor pressure drops across the vessels, especially the second stage.

RO Troubleshooting Guide

Problem	Product Flow	Salt Passage	Pressure Drop	Location
Scaling	Decreased	Increased	Increased	Last stage
MB Fouling	Decreased	Normal/increased	Normal/increased	Any stage
Colloidal Fouling	Decreased	Normal/increased	Normal/increased	First stage
Degeneration	Increased	Increased	Decreased	First stage
Abrasion	Increased	Increased	Decreased	First stage

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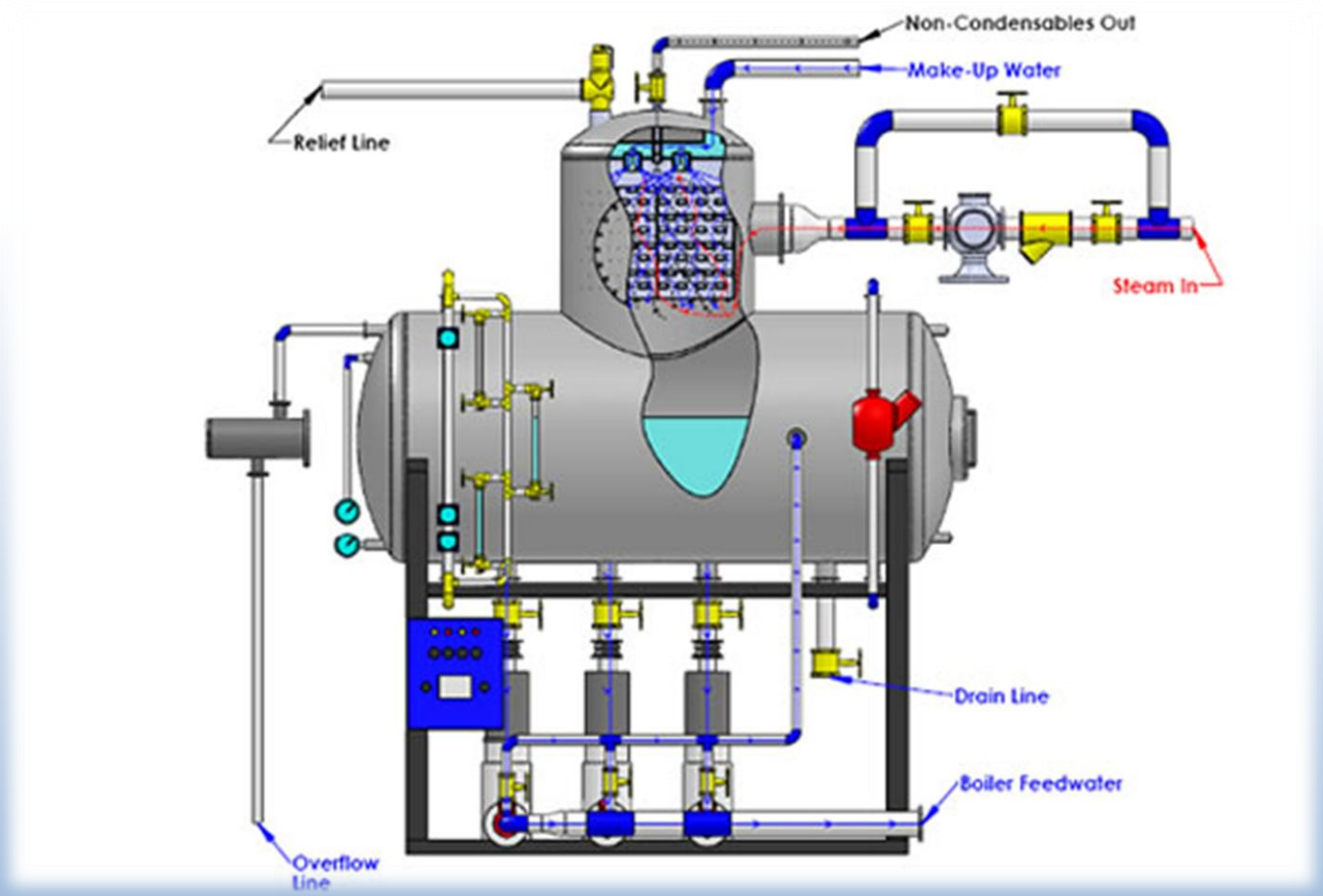
Deaerator

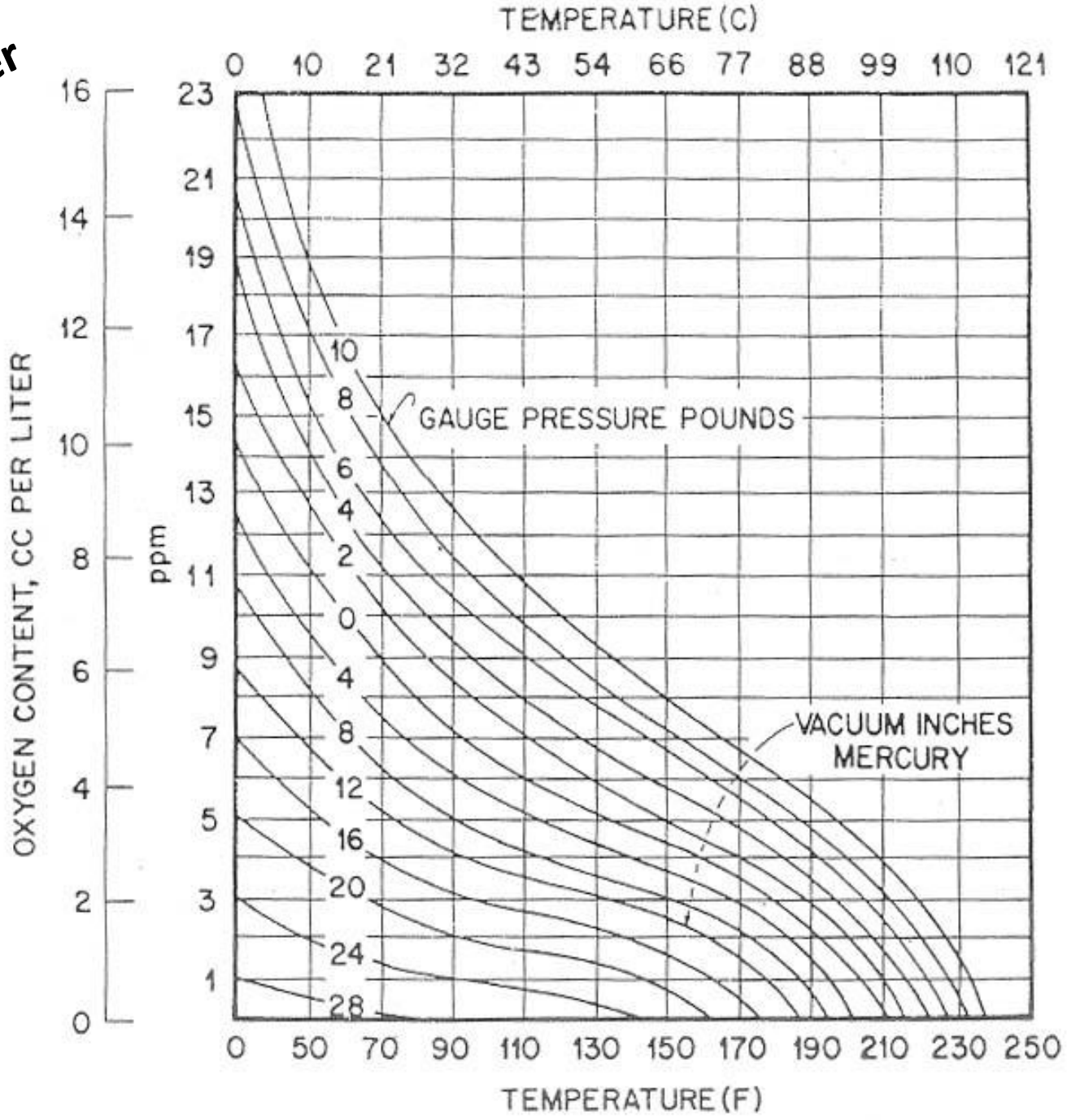


Deaerator

- What is it?
  - Primary purpose is to remove oxygen and other dissolved gasses from the feedwater.
  - Preheat the feedwater to prevent thermal shock on the boiler

- Why is it important?
  - At feedwater and boiler temperatures, even small amounts of oxygen greatly accelerate corrosion.
  - Corrosion will typically be observed in a few specific locations.
    - Economizer - dramatic increase in temperature
    - Steam drum at steam/drum interface
    - Condensate system

O2 Solubility in Water



- KPI's
  - Temperature
    - Temperature should be in the 212 – 240F range
    - For every pound of steam pressure maintained on the deaerator, the temperature increases 3F above the boiling point.
      - i.e. - 4 psig x 3 + 212F = 224
    - Temperature should be within three degrees of the saturation temperature for the operating pressure the system is running at.
  - Pressure
    - Most deaerators are designed to operate in the 3 – 10 psig range.

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Deaerator

- ✓Check Conductivity & Hardness
- ✓Check pressure
- ✓Check Temperature

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Boiler KPI's

KPI's for boilers

- Mechanical Items
  - Check water level in site glass
  - Monitor boiler pressure
  - Monitor boiler stack temperature
  - Perform column blow down, Low Water Cut Off (master & auxiliary)
    - Make sure burner cuts off
    - Reset auxiliary LWCO switch manually
  - Perform bottom blow down
  - Check for any alarms
  - Check the fire eye

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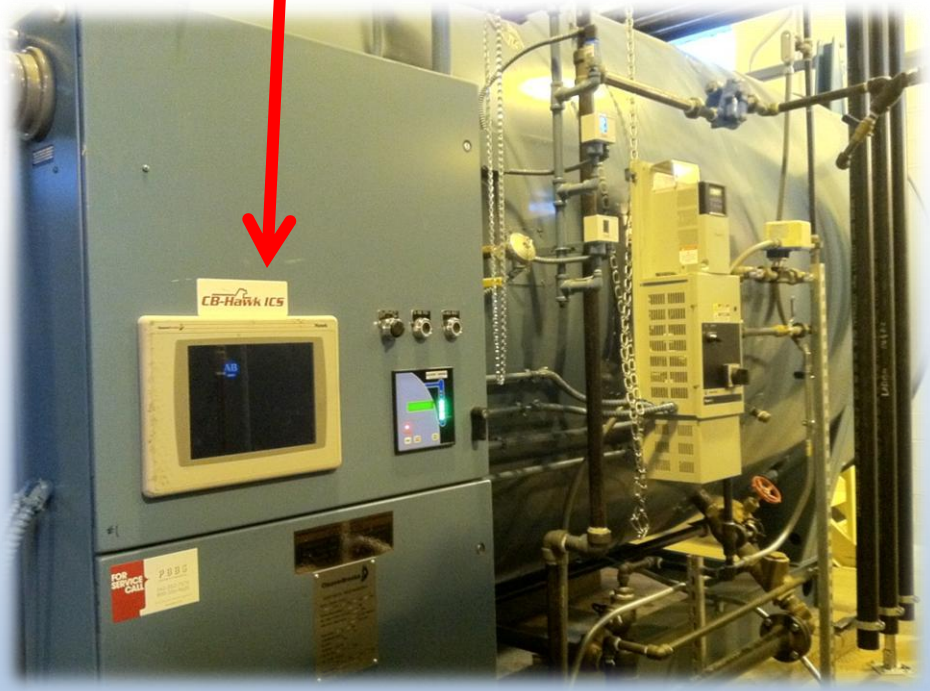
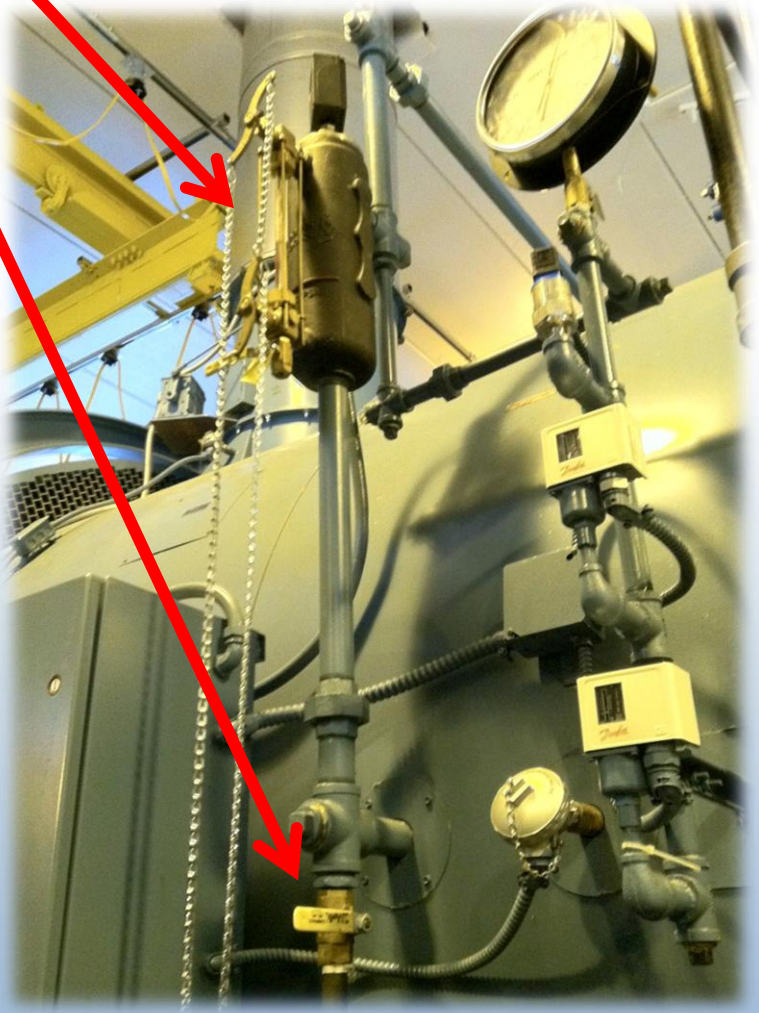
Water Level Site Glass

Displays Boiler PSI & Stack Temps

Column Blow Down





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Water Testing

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KPI's for boilers

- Water Testing – *Relates to ASME guidelines*
  - Conductivity
  - Oxygen Scavenger
  - Internal Treatment (phosphate, polymer, chelant)
  - Alkalinity
  - Water clarity

BOILER WATER TEST CONTROL CHART

Test	Range	Corrective Actions
Total Polymer (*PP-3060M*-Absorbance)	**.6-.8**	• If out of range, check conductivity of the boilers. High or low conductivity will cause high or low readings. • If conductivity is okay, increase addition of ***PP-3060M*** if absorbance is low, decrease if absorbance is high.
Sulfite (WT-3462)	**20-40 ppm**	• Check deaerator temperature. • Check conductivity in the boilers. • If both are in range, increase feed of ***WT-3462*** if the reading is low and decrease the feed of the ***WT-3462*** if the reading is high.
Alkalinity (WT-3732)	**P= 300-450 M= 350-650 OH=200-400**	• Check conductivity levels. High or low conductivity will cause high or low alkalinity. • Check for proper feed of the ***WT-3732*** sodium hydroxide. • If both are correct, increase the feed of the ***WT-3732*** to increase alkalinity levels and decrease the pump to decrease alkalinity levels.
Total Hardness ***(Softeners, Feedwater & Condensate)***	**<.5 ppm**	• If hardness if present, check the softeners and condensate for possible contamination. • Regenerate softener on line if necessary.
Boiler Conductivity (Un-Neutralized)	**mmho 1,800-2,300**	• If conductivity is out of range, check operation of blowdown controllers. • Calibrate as necessary
pH (*WT-3516*)	**8.3 – 8.8**	• Increase feed of the ***WT-3516*** if pH is low. Decrease feed if pH is high. • Wait for two days of below 8.0 readings to increase feed of the ***WT-3516.***

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Sample Cooler

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Water Testing

- Always use the same sample port
- Flush sample port well
- Rinse sample container 3 times
- Testing frequency will vary depending on the type of facility, operating conditions, staffing
- Check chemical inventory levels at least once per week
- Check testing reagent expiration dates
- Log data on log sheet and into eService

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KPI's

- **DAILY SERVICE**
  - Check that all chemical pumps are primed and pumping chemical
  - Check liquid levels in all drums and tanks
  - Check the motorized bleed valve for proper operation
  - Conduct column and bottom blowdown
  - Check the controller readings and any potential alarms
  - Conduct full range of water tests
    - Make corrective actions if needed
  - Check salt level in brine tank
  - Record makeup meter reading
  - Record pressure and temperature on DA

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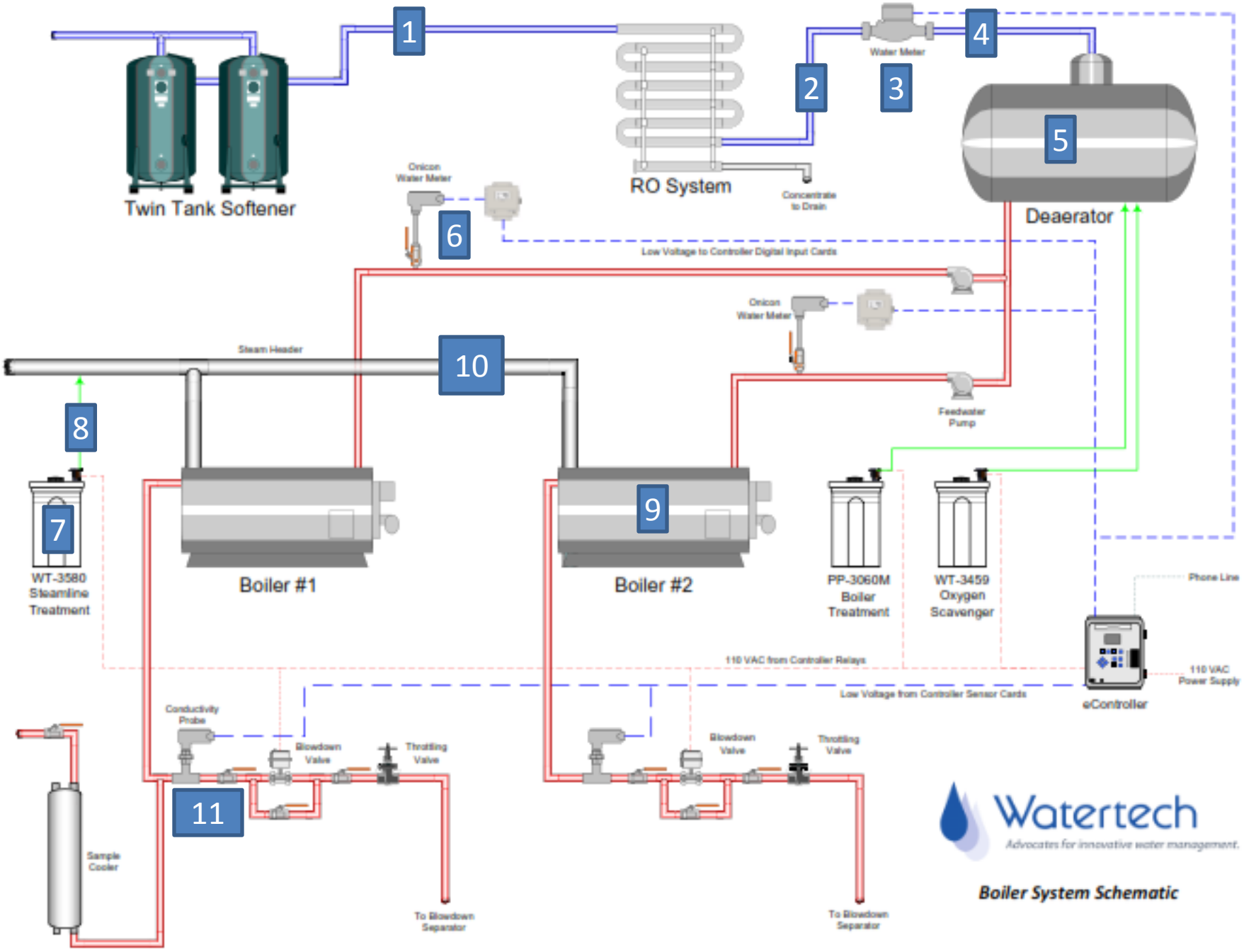
Automation

Typical Boiler System - I/O Point Description

POINT #	DESCRIPTION	ANALOG/DIGITAL
1	Hardness Analyzer	Analog or Digital
2	Make Up Flow Meter	Analog or Digital
3	Make Up Inlet Temp – Blowdown Heat Exchanger	Analog
4	Make Up Outlet Temp – Blowdown Heat Exchanger	Analog
5	Deaerator Temperature	Analog
6	Deaerator Pressure	Analog
7	Economizer Inlet Temp	Analog
8	Economizer Outlet Temp	Analog
9	Boiler Steam Flow	Analog
11	Boiler Conductivity	Analog
13	Blowdown Flow	Analog or Digital
14	Blowdown Inlet Temp	Analog
15	Blowdown Outlet Temp	Analog
16	Condensate Conductivity	Analog
17	Oxygen Scavenger Tank Level	Analog
18	Oxygen Scavenger Feed Pump Verification	Digital
19	Internal Treatment Tank Level	Analog
20	Internal Treatment Feed Pump Verification	Digital
21	Steam Line Treatment Tank Level	Analog
22	Steam Line Treatment Feed Pump Verification	Digital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To Blowdown Separator
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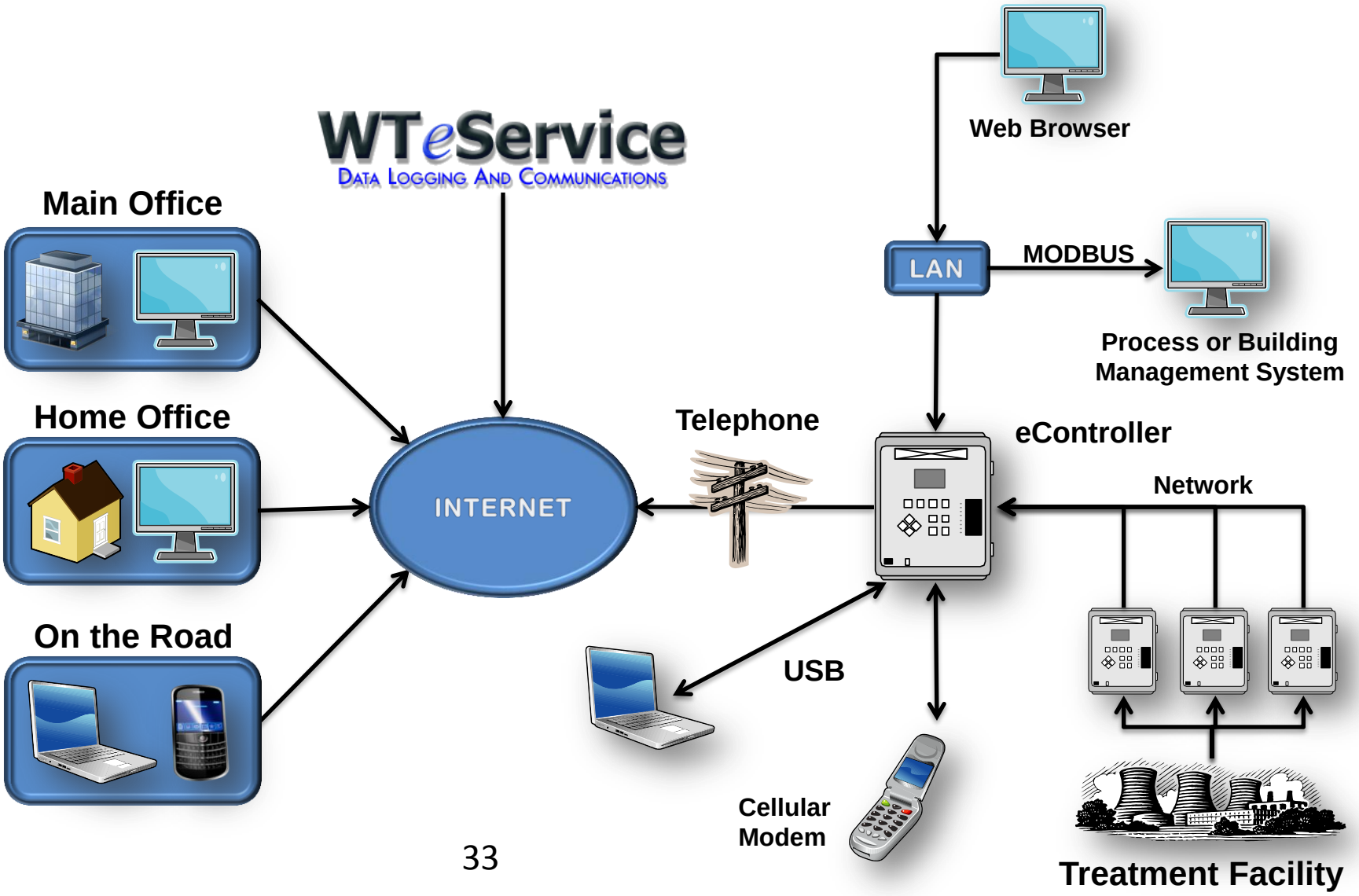
Boiler System Schematic

Industrial Water Treatment 2011



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eController Communicating to the outside world

Alarms & Status Reports

Remote Access & Datalogs

Datalogs are automatically sent to WTeService for trending and graphing. Data can also be compared to manually entered data.

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WTeService

DATA LOGGING AND COMMUNICATIONS

"Taking the Log Sheet to the Next Level"

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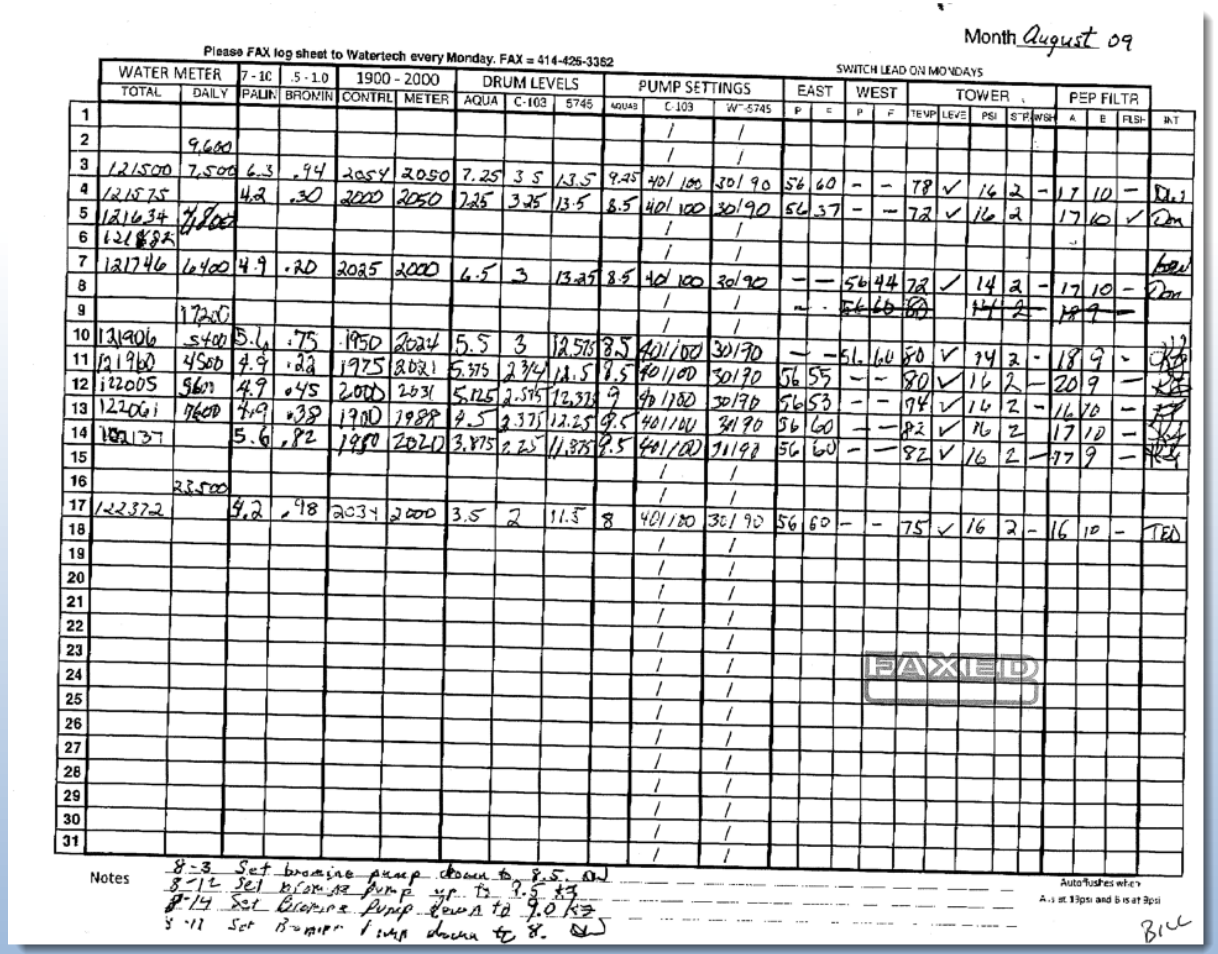
Are you still using something that looks like this?



Please FAX log sheet to Watertech every Monday. FAX = 414-425-3382

Month August 09

SWITCH LEAD ON MONDAYS

	WATER METER TOTAL	WATER METER DAILY	7-10 PALIN	.5-1.0 BROMIN	1900-2000 CONTRL	1900-2000 METER	DRUM LEVELS AQUA	DRUM LEVELS C-103	DRUM LEVELS 5745	PUMP SETTINGS AQUA9	PUMP SETTINGS C-103	PUMP SETTINGS W-5745	EAST P	EAST F	WEST P	WEST F	TOWER TEMP	TOWER LEVEL	TOWER PSI	TOWER STP	TOWER WSH	PEP FILTR A	PEP FILTR B	PEP FILTR FLSH	INT
1											/	/													
2		9,600									/	/													
3	121500	7,500	6.3	.94	2054	2050	7.25	3.5	13.5	9.25	401/100	301/90	56	60	–	–	78	✓	16	2	–	17	10	–	D.J
4	121575		4.2	.30	2000	2050	7.25	3.25	13.5	8.5	401/100	301/90	56	37	–	–	72	✓	16	2		17	10	✓	Don
5	121634	7,800									/	/													
6	121835										/	/													
7	121746	6400	4.9	.20	2025	2000	6.5	3	13.25	8.5	401/100	301/90	–	–	56	44	78	✓	14	2	–	17	10	–	Don
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9		17,500									/	/	–	–	56	60	80		14	2	–	18	9	–	
10	131906	5400	5.6	.75	1950	2024	5.5	3	12.5	8.5	401/100	301/90	–	–	56	60	80	✓	14	2	–	18	9	–	KB
11	121960	4500	4.9	.22	1975	2021	5.375	2.75	12.5	8.5	401/100	301/90	56	55	–	–	80	✓	16	2	–	20	9	–	KB
12	122005	9600	4.9	.45	2000	2031	5.125	2.5	12.375	9	401/100	301/90	56	53	–	–	94	✓	14	2	–	16	10	–	KB
13	122061	7600	4.9	.38	1900	1988	4.5	2.375	12.25	9.5	401/100	301/90	56	60	–	–	82	✓	16	2		17	10	–	KB
14	122137		5.6	.82	1950	2020	3.875	2.25	11.875	9.5	401/100	301/90	56	60	–	–	82	✓	16	2	–	17	9	–	KB
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16		23,500									/	/													
17	122372		4.2	.98	2034	2000	3.5	2	11.5	8	401/100	301/90	56	60	–	–	75	✓	16	2	–	16	10	–	TED
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FAXED

Notes

8-3 Set bromine pump down to 8.5. DJ

8-12 Set bromine pump up to 9.5 KB

8-14 Set Bromine pump down to 9.0 KB

8-17 Set Bromine pump down to 8. DJ

Autoflushes when A is at 13psi and B is at 3psi

Bill

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Disadvantages of the Paper Log Sheet

- Hard to find trends.
- Hard to related data points.
- Hard to find trends over time.
- Require manual entry into spreadsheet.
- Only finds problems if you look for them.
- Hard to summarize and draw conclusions

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If we are doing this testing then let's make use of the data.

- Alert when system is out of control.
- Help identify little problems before they get bigger.
- Identify trends.
- Provide reports demonstrating performance.

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Today's Log Sheets Should…

- Be easy to email
- Email alerts when out of range
- Identify results out of range
- Identify trends
- Perform calculations
- Summarize data

Communicate

Watertech of America, Inc.

Operator Log

Back eMail PDF Edit

Thursday, November 3, 2011 2:38 AM CDT

Company Name
Company Address
City, State Zip

Report Number: **104932**
Recorded By: **Operator Name**
Date & Time

Boiler Room → Cooling Water

Test		Well Water	Cooling Tower Water	Tower Bleed	
Conductivity, mmho		630.1	2872		
	Limits	980 max	2625 - 2725		
Organo Phosphonate, ppm			5		
	Limits		3.5 - 6		
Total Hardness, ppm		380	1780		
	Limits	400 - 600	1400 - 1650		
Free Chlorine, ppm			.36		
	Limits		0.3 - 0.7		
Total Chlorine, ppm			.66	0	
	Limits		0.5 - 4	0 max	
pH			8.02		
	Limits		8.3 - 8.45		
Total Dissolved Solids, ppm			2642.24		
	Limits		2560 max		
Conductivity Cycles (Calculated)			4.6		
	Limits		2.5 - 3.5		
Conductivity, Controller, mmohs			2785		
	Limits		2650 - 2725		
pH, Controller			8.25		
	Limits		8.3 - 8.45		
ORP,mV,Controller			623		
	Limits		600 - 750		
Tower Bleed, gpm				231	
	Limits			450 max	

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Identify Problems

Watertech of America, Inc.

Operator Log

Back eMail PDF Edit

Thursday, November 3, 2011 2:38 AM CDT

Company Name
Company Address
City, State Zip

Report Number: **104932**
Recorded By: **Operator Name**
Date & Time

Boiler Room → Cooling Water

Test		Well Water	Cooling Tower Water	Tower Bleed	
Conductivity, mmho		630.1	2872		
	Limits	980 max	2625 - 2725		
Organo Phosphonate, ppm			5		
	Limits		3.5 - 6		
Total Hardness, ppm		380	1780		
	Limits	400 - 600	1400 - 1650		
Free Chlorine, ppm			.36		
	Limits		0.3 - 0.7		
Total Chlorine, ppm			.66	0	
	Limits		0.5 - 4	0 max	
pH			8.02		
	Limits		8.3 - 8.45		
Total Dissolved Solids, ppm			2642.24		
	Limits		2560 max		
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Conductivity, Controller, mmohs			2785		
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pH, Controller			8.25		
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	Limits		600 - 750		
Tower Bleed, gpm				231	
	Limits			450 max	

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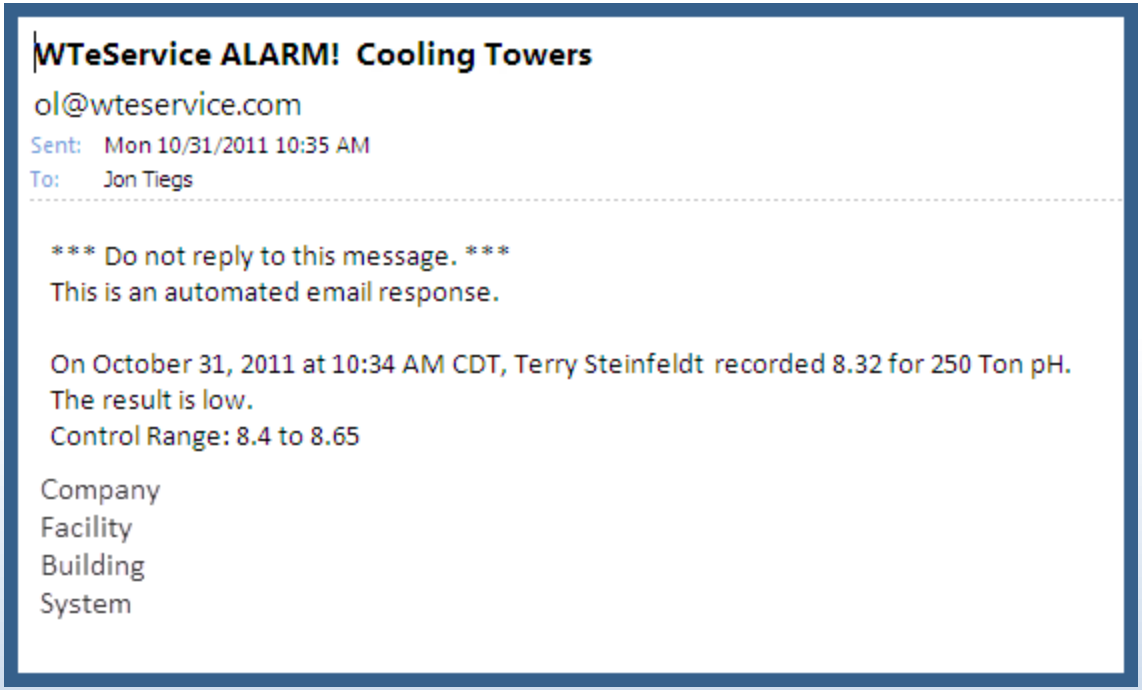
Proactively Alert



WTeService ALARM! Cooling Towers

ol@wteservice.com

Sent: Mon 10/31/2011 10:35 AM

To: Jon Tiegs

*** Do not reply to this message. ***
This is an automated email response.

On October 31, 2011 at 10:34 AM CDT, Terry Steinfeldt recorded 8.32 for 250 Ton pH.
The result is low.
Control Range: 8.4 to 8.65

Company
Facility
Building
System

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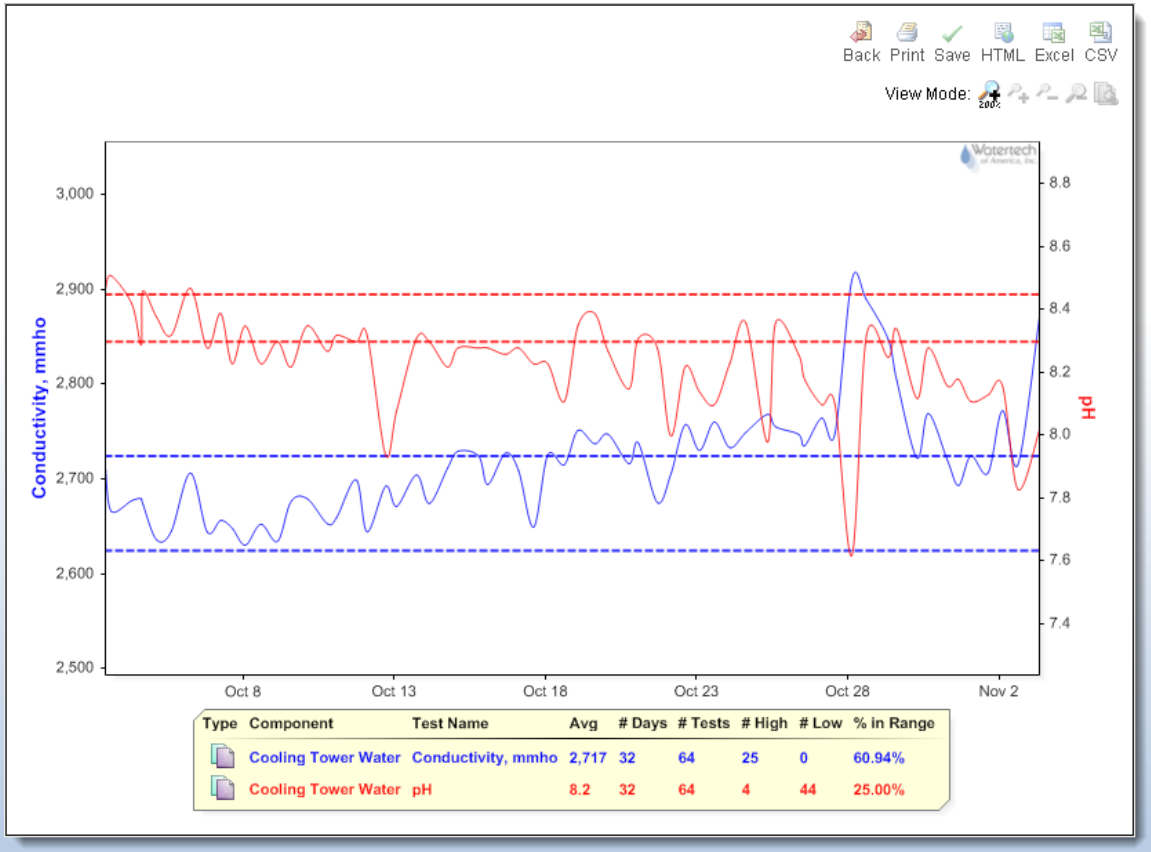
Show Trends



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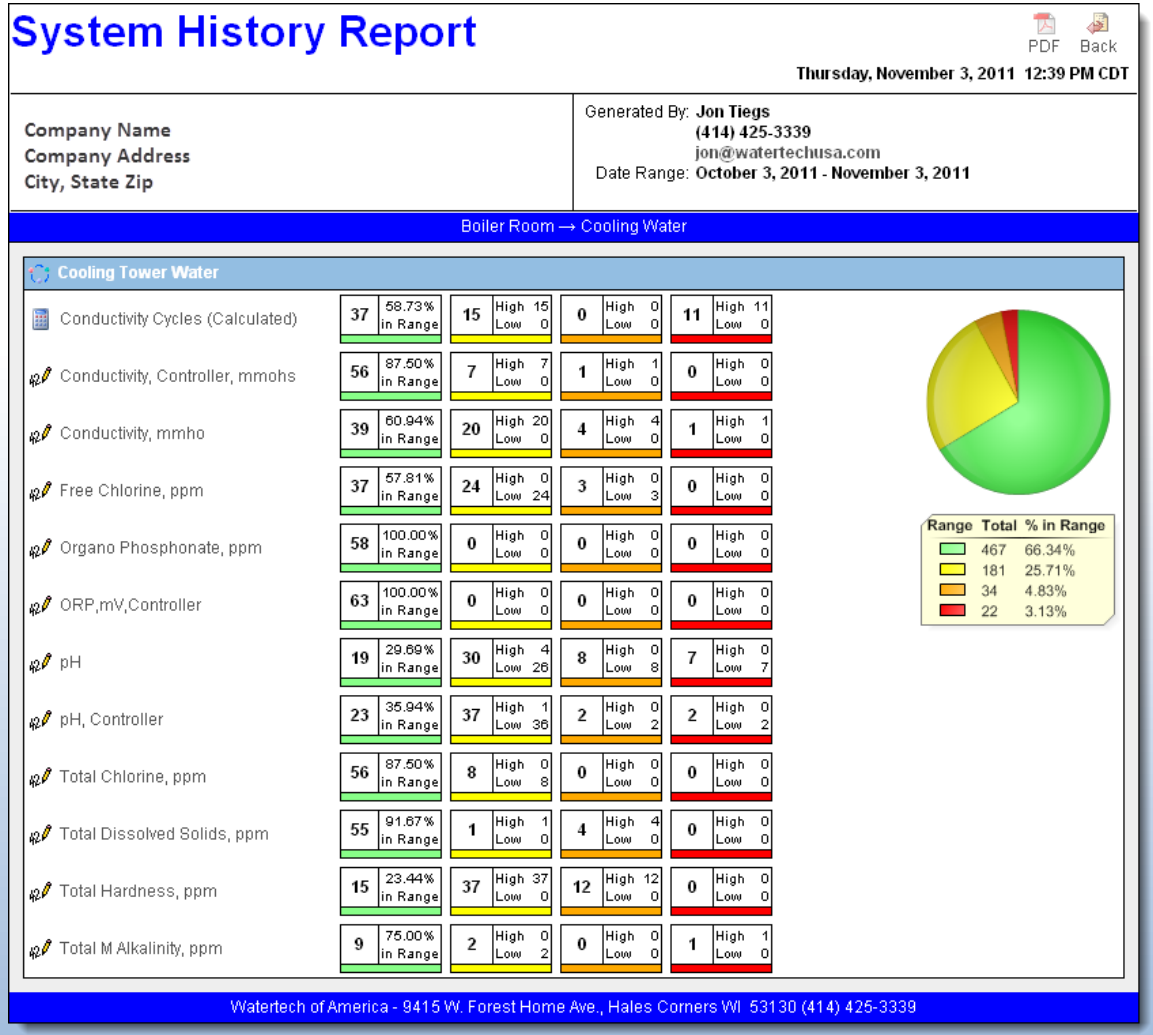
- Summarize data

Summarize Data



System History Report

PDF Back

Thursday, November 3, 2011 12:39 PM CDT

Company Name
Company Address
City, State Zip

Generated By: Jon Tiegs
(414) 425-3339
jon@watertechusa.com
Date Range: October 3, 2011 - November 3, 2011

Boiler Room → Cooling Water

Cooling Tower Water

Conductivity Cycles (Calculated)	37 58.73% in Range	15 High 15 Low 0	0 High 0 Low 0	11 High 11 Low 0
Conductivity, Controller, mmohs	56 87.50% in Range	7 High 7 Low 0	1 High 1 Low 0	0 High 0 Low 0
Conductivity, mmho	39 60.94% in Range	20 High 20 Low 0	4 High 4 Low 0	1 High 1 Low 0
Free Chlorine, ppm	37 57.81% in Range	24 High 0 Low 24	3 High 0 Low 3	0 High 0 Low 0
Organo Phosphonate, ppm	58 100.00% in Range	0 High 0 Low 0	0 High 0 Low 0	0 High 0 Low 0
ORP,mV,Controller	63 100.00% in Range	0 High 0 Low 0	0 High 0 Low 0	0 High 0 Low 0
pH	19 29.69% in Range	30 High 4 Low 26	8 High 0 Low 8	7 High 0 Low 7
pH, Controller	23 35.94% in Range	37 High 1 Low 36	2 High 0 Low 2	2 High 0 Low 2
Total Chlorine, ppm	56 87.50% in Range	8 High 0 Low 8	0 High 0 Low 0	0 High 0 Low 0
Total Dissolved Solids, ppm	55 91.67% in Range	1 High 1 Low 0	4 High 4 Low 0	0 High 0 Low 0
Total Hardness, ppm	15 23.44% in Range	37 High 37 Low 0	12 High 12 Low 0	0 High 0 Low 0
Total M Alkalinity, ppm	9 75.00% in Range	2 High 0 Low 2	0 High 0 Low 0	1 High 1 Low 0

Watertech of America - 9415 W. Forest Home Ave., Hales Corners WI 53130 (414) 425-3339

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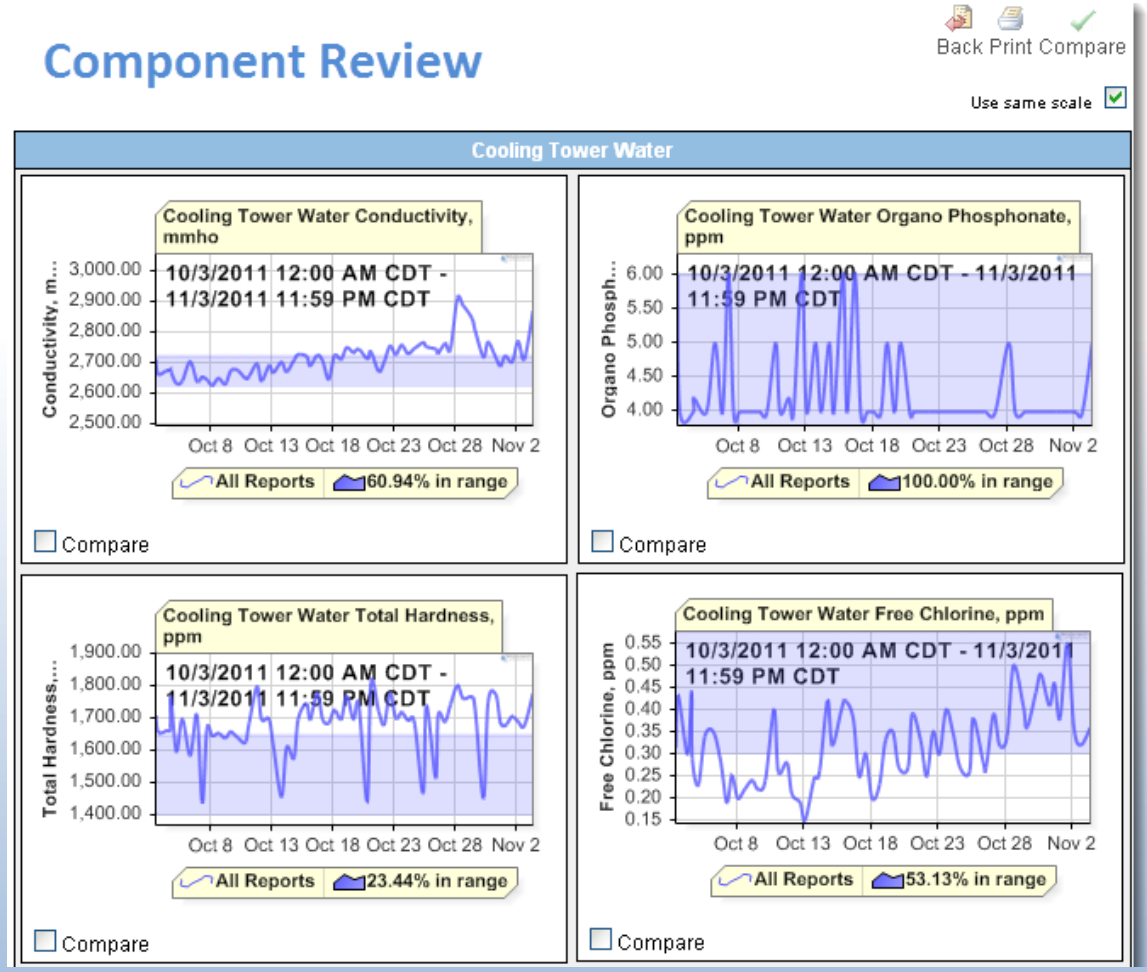
Advocates for innovative water management.

Today's Log Sheets Should…

- Be easy to email
- Email alerts when out of range
- Identify results out of range
- Identify trends
- Perform calculations
- Summarize data

Summarize Data



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Questions?

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http://www.watertechusa.com/html/literature.php