It All Boils Down
To Service

Columbia Water Technology

Industrial Water Treatment
2903 NE 109th Ave. "G"
Vancouver, WA.98682

By: Mike Dunham

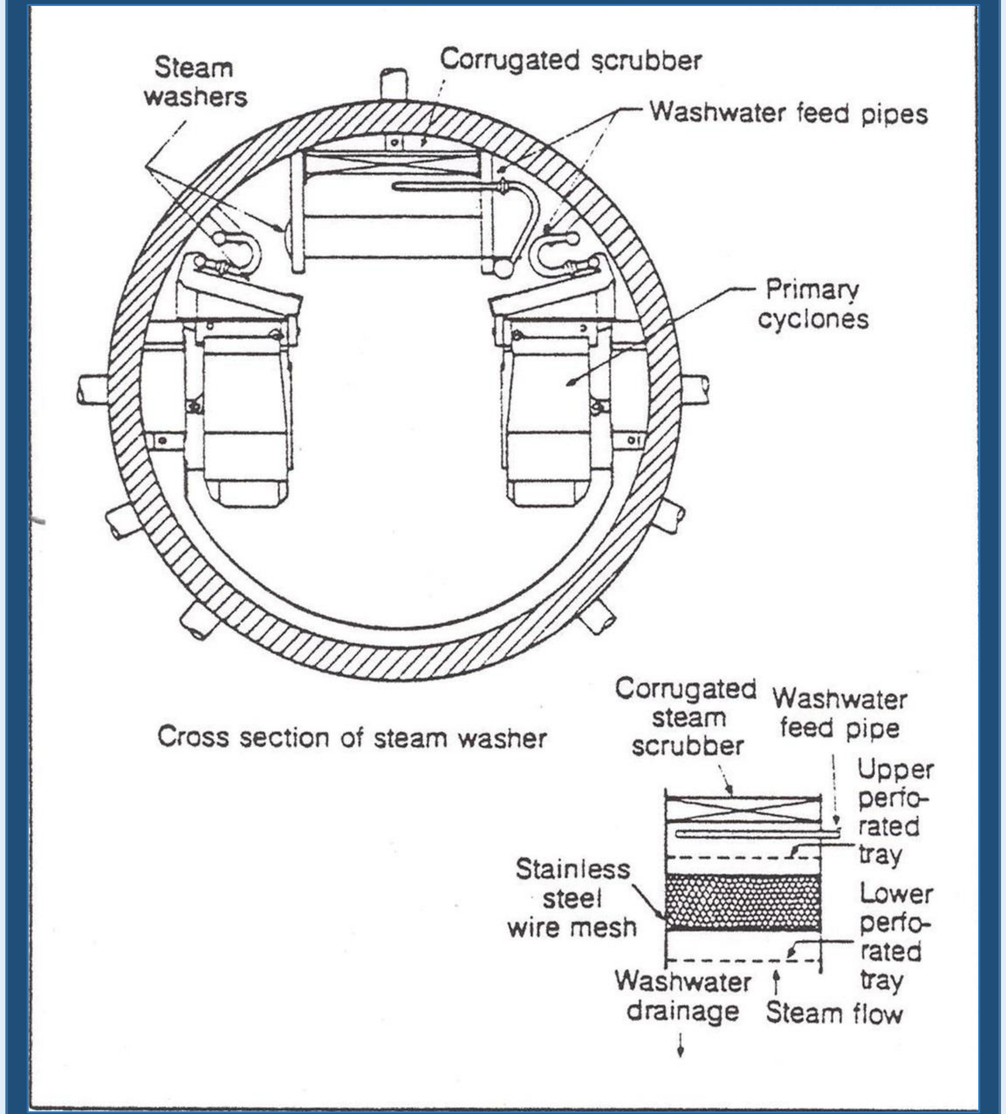
Steam Purity

- For Turbine Applications

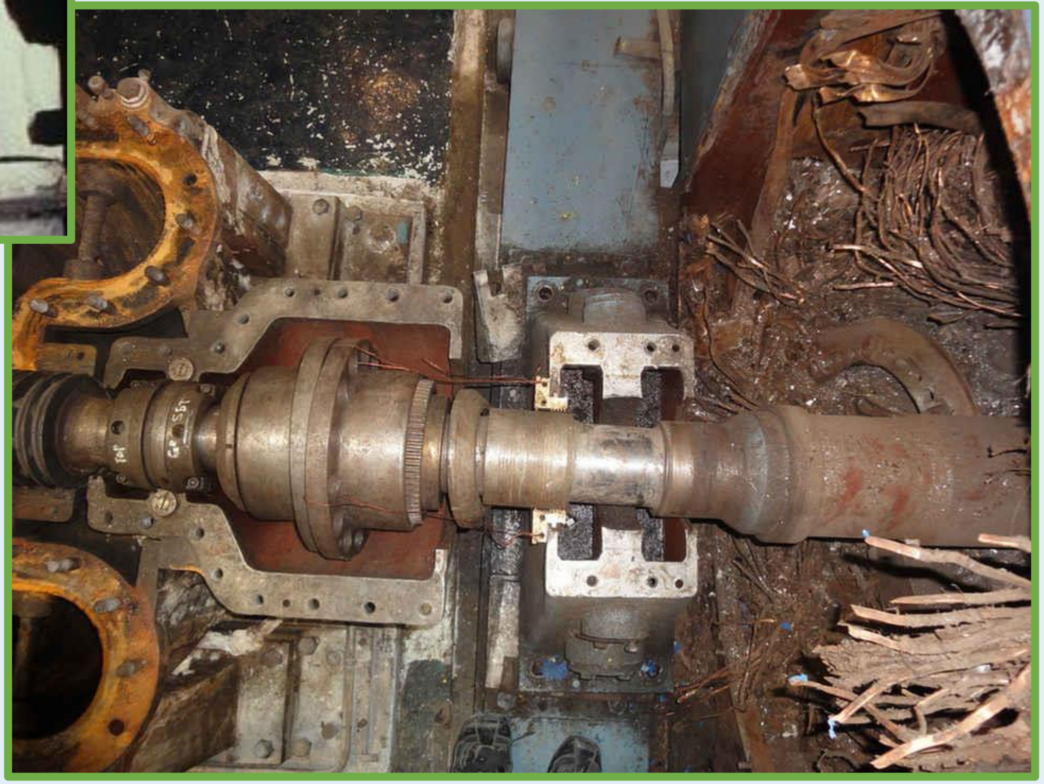
Steam Purity versus Steam Quality

- Steam purity is the condition of the steam in regards to the purity of the chemistry of the steam expressed as ppb (parts per billion) of TDS, sodium, cation conductivity or silica in the steam

- Steam Quality is the condition of the steam in regards to the % of moisture or boiler water carryover in the steam



Problems Caused by Poor Steam Quality or Poor Steam Purity



- Super heater deposits and failure
- Turbine Blade Deposits
- Deposits on stop valves
- Erosion-corrosion of Turbine Blades due to wet steam or particles
- Lost Production of Power Generation due to deposits
- Potential Danger to Personnel with Turbine Failure

Causes of Poor Steam Quality

- Operating variables such as high steam load above boiler design

- Steam space in the Drum level being minimal for good separation

- Boiler mechanical problems such as loose internal steam drum separation equipment

- Swinging of the boiler steam loading causing carryover

Causes of Poor Steam Purity

- Foaming in the boiler caused by organic contamination (oil, high total organics from the makeup water, high boiler water TDS).
- High chemical contamination caused by excessive TDS due to lack of boiler blowdown.
- Excessive alkalinity due to excess hydroxide feed in the boiler water.
- Excessive sodium in the steam due to excess phosphate chemical feed
- High cation conductivity values due to high amine feed(excessive CO_2),acid anion (Cl, SO_4, or others) leakage or excessive phosphate carryover to the saturated steam. These cause weak acids to corrode the turbine blading
- Selective vaporous carryover of silica from the boiler bulk water due to varying operating pressures.
- Poor pretreatment equipment or failure of that equipment

Turbine Steam Purity Specifications

EPRI limits for Boiler, Feedwater and Steam

Normal Chemistry Limits in High-Pressure Drum-Type Steam Generators with Phosphate Treatment and Conventional Feedwater Treatment

	Sodium (μg/L)	Chloride (μg/L)	Sulfate (μg/L)	Silica (μg/L)	Specific Conductance (μs/cm)	TOC (μg/L)	Oxygen (μg/L)	Hydrazine (μg/L)	Ammonia (μg/L)	Cation Conductivity (μs/cm)	pH	Iron (μg/L)	Copper (μg/L)	Phosphate (mg/L)
Makeup to condenser	≤5	≤3	≤3	≤10	≤0.1	≤300								
Condenser leak detection	a													
Condensate pump discharge						≤200	≤20							
Plants with polisher	≤10									≤0.3				
Plants without polisher	≤5									≤0.2				
Condensate polisher effluent (if applicable)	≤5			≤10						≤0.2				
Deaerator inlet							≤20	≥20 or ≥3 × O_2						
Deaerator outlet							≤7							
Economizer inlet					b		≤5		b	≤0.2		≤10	≤2	
All ferrous metallurgy											9.0–9.6			
Mixed Fe-Cu metallurgy											8.8–9.3			
Boiler water	c	c	c	c	d						e			e
Superheat/reheat steam	f	<3	<3	<10		≤100				≤0.3 (degassed)				

Specific conductance, cation, conductivity, and pH all referenced to 25° C.

[a]Monitored to detect deviations from normal values.
[b]Consistent with pH.
[c]Consistent with curves of maximum allowable concentration versus pressure.
[d]Monitored as general indication of boiler water dissolved solids content.
[e]See phosphate/pH curves.
[f]Generally <5 μg/L, but may be lower depending on steam generator manufacturer's guidelines.

Turbine Steam Purity Specifications

- ASME limits for Boiler, Feedwater for good steam purity

Guidelines for Water Quality in Modern Industrial Water-Tube Boilers for Reliable Continuous Operation

	Boiler Feedwater			Boiler Water		
Drum Pressure (psig)	*Iron (ppm Fe)*	*Copper (ppm Cu)*	*Total Hardness (ppm $CaCO_3$)*	*Silica (ppm SiO_2)*	*Total Alkalinity** (ppm $CaCO_3$)*	*Specific Conductance (microohms/cm)*
0- 300	0.100	0.050	0.300	150	700*	7000
101- 450	0.050	0.025	0.300	90	600*	6000
451- 600	0.030	0.020	0.200	40	500*	5000
601- 750	0.025	0.020	0.200	30	400*	4000
751- 900	0.020	0.015	0.100	20	300*	3000
901-1000	0.020	0.015	0.050	8	200*	2000
1001-1500	0.010	0.010	0.0	2	0***	150
1501-2000	0.010	0.010	0.0	1	0***	100

*Alkalinity not to exceed 10% of specific conductance.

**Minimum level of OH alkalinity in boilers below 1000 psi must be individually specified with regard to silica solubility and other components of internal treatment.

***Zero in these cases refers to free sodium or potassium hydroxide alkalinity. Some small variable amount of total alkalinity will be present and measurable with the assumed congruent control or volatile treatment employed at these high pressure ranges.

Ways to Maintain Steam Purity

- Silica Testing
- Sodium monitoring
- Cation Conductivity
- Boiler Water Chemistry Limits should be strictly adhered to so steam purity is good.
- Feedwater quality should be strictly adhered to if it is used to attemperate the superheat

Ways to monitor for Steam Purity

- Good record keeping of the chemical steam purity results.

- Good testing equipment for monitoring ULR silica. ULR can be monitored with saturated steam grab samples using a flow thru cell like a lab model Hach unit (DR 2800, DR3800, DR4000, etc.)

- Good online equipment for monitoring sodium, silica and cation conductivity. Most often used is the online sodium analyzer with a sodium ion electrode due to its simplicity and ease to keep operational.
- Sodium Analyzers give good repeatable results down to 0.1 ppb

Trouble shooting poor steam purity

- Monitor closely the boiler water chemistry to make sure it is within recommended limits.

- Monitor the saturated steam for proper chemistry limits.

- If NO online monitoring equipment then monitor the saturated silica conductivity values of the saturated steam and super heated steam (if sampling is available).

- Determine if there are enough proper sample points in the system to get a saturated steam sample and a superheat sample. If not, we recommend installing at least a saturated steam sample for any turbine operation.

Steam Chemistry Target Values

- Silica – normal saturated steam should be < 20 ppb in most boilers. High pH in the boiler water will reduce silica carryover from the boiler water.

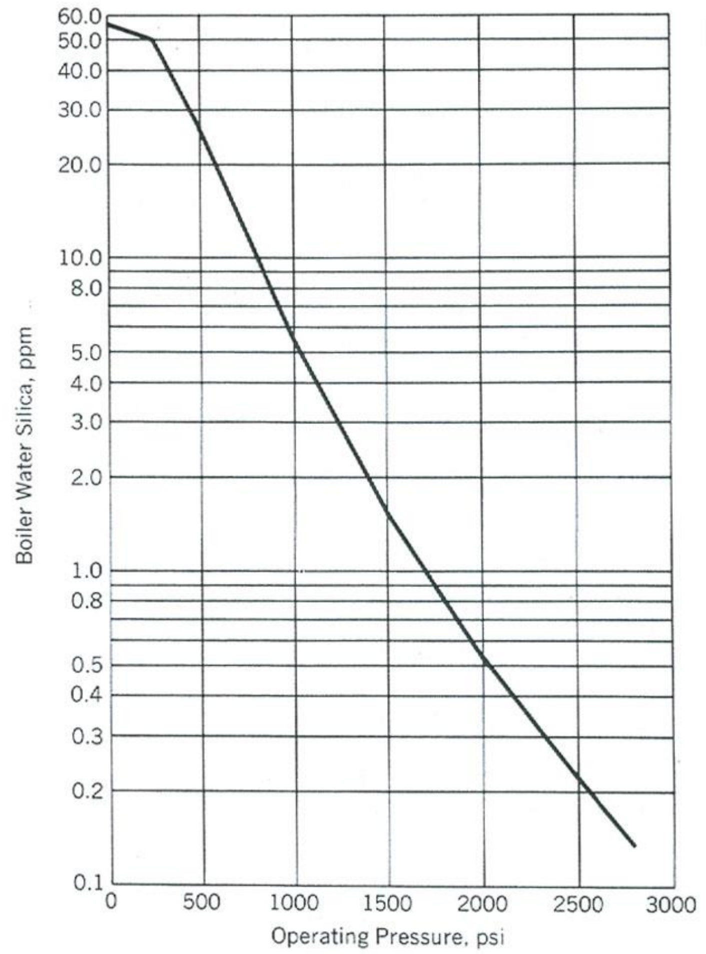
Monitor the steam because:

- Precipitation of silica forms silicate deposits on the cold end of the turbine that are not water soluble and are very difficult to remove. The deposits may cause superheater failures or turbine failures.

- Silicate deposits cause losses in turbine capacity and efficiency

3 ways to monitor steam purity

- SILICA -- coming thru the makeup water to the feedwater that may be used for attemperation can cause problems in the turbine area. Especially if colloidal silica is present in the makeup water.
- Recommend maintaining close limits of allowable silica in the boiler water to keep sat steam silica < 20 ppb. Record all values daily
- Online silica analyzers are expensive and difficult to keep operational



Recommended maximum silica concentrations in Boiler water at pH 9.5 (drum-type boilers).

Sodium

- SODIUM – The sodium in steam can come from the boiler water chemicals as sodium phosphate (phosphate chemistry program) or from the pH/alkalinity contributed by sodium hydroxide in the chemistry program or both.

- A good value for the sodium in the steam is < 5 ppb for phosphate chemistry programs.

Steam Sodium Problems

- High steam sodium values can cause deposits in the steam turbine blading that are normally water washable.

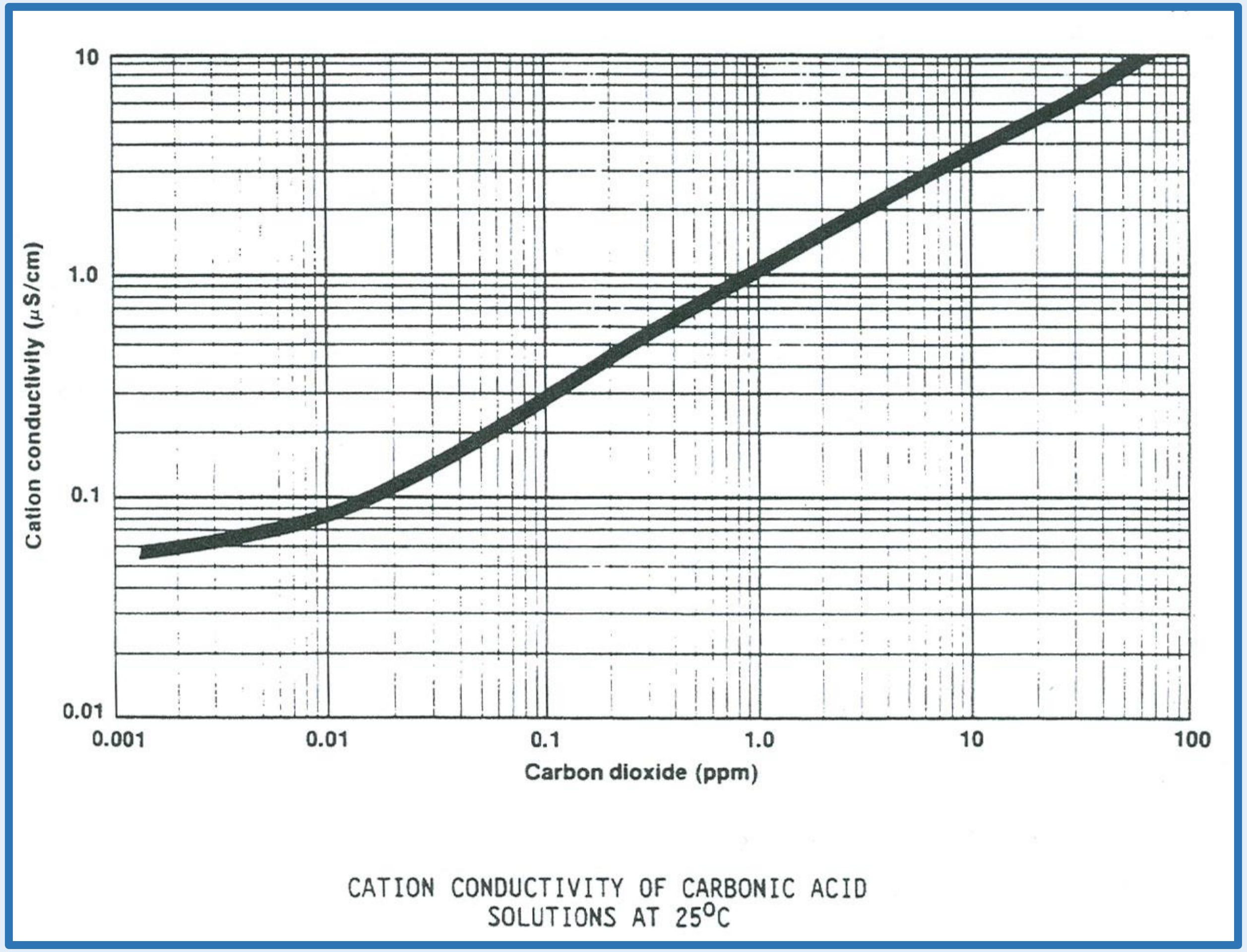
- Monitoring of sodium is critical for high pressure steam because both sodium hydroxide and sodium chloride are major corrodents of the turbine blading.

Cation Conductivity (Degassed)

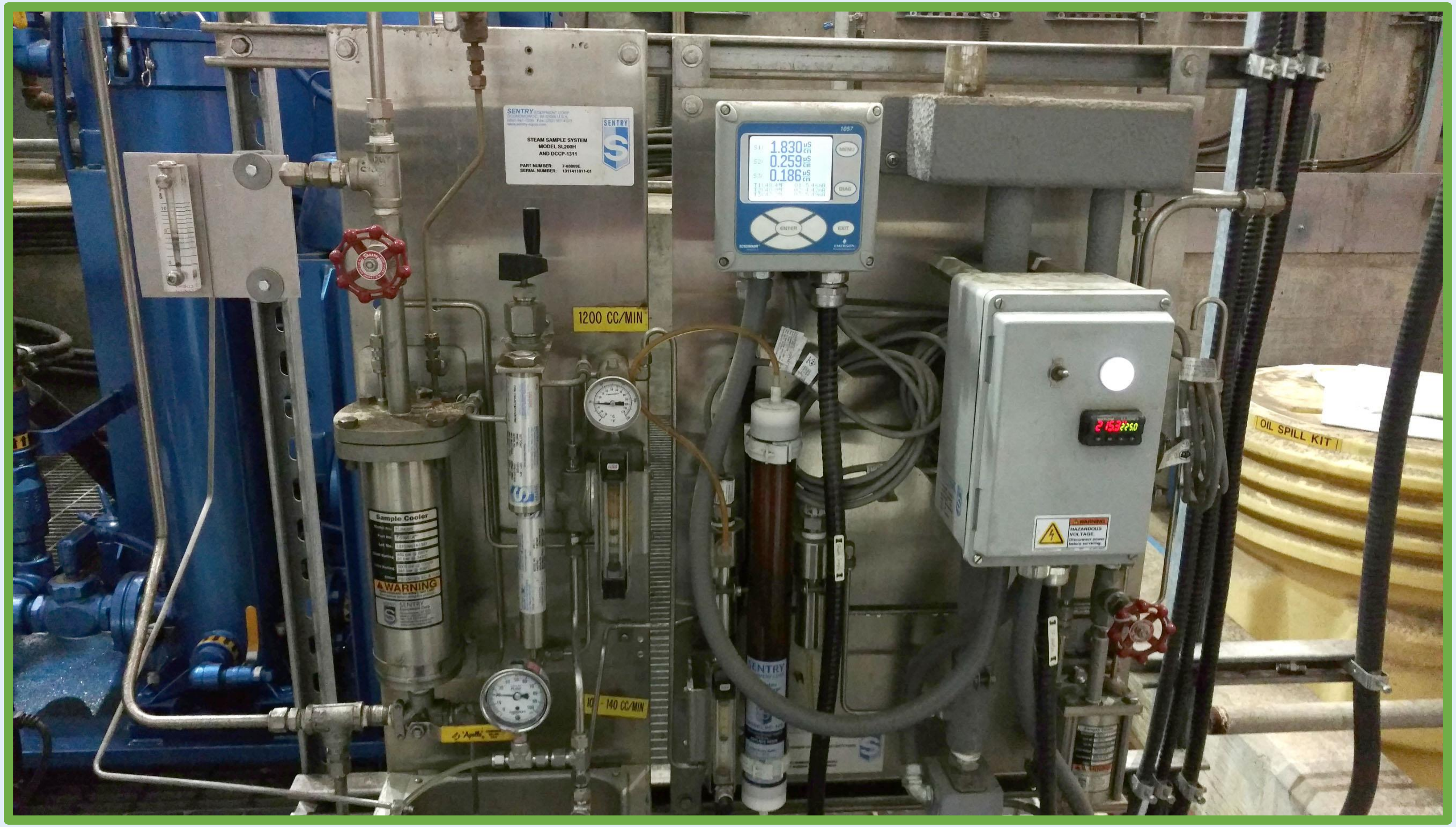
- Cation Conductivity – This analysis is also a good way to monitor steam purity. It is actually called "acid conductivity" since it measures the acid contaminants (weak chlorides, sulfates or phosphates) in the steam that would corrode the turbine blading. However, carbon dioxide in the steam from any carbon molecules will distort the reading, so a degassed cation conductivity analyzer is often used to take out the CO_2 from the reading. Degassed cation conductivity readings should be < 0.3 uS/cm or for a supercritical < 0.15 uS/cm. Overfeed of amine to the system will distort the true cation conductivity reading since it is the major source of CO_2 in the steam.

Steam Chemistry Target Values -II

- A continuous cation conductivity readings on the steam will monitor any damaging acids that are going to the turbine and causing corrosion in the blading.



Degassed Cation Conductivity Analyzer



Excellent steam purity is essential for a turbine operation

- It is essential to monitor the steam purity of the steam going to a high pressure turbine.

This includes:

1) Monitoring the steam purity of the silica, sodium and cation conductivity where possible
2) Maintaining very good control of the boiler chemistry limits for the given operating pressure.
3) If feedwater is used to attemperate maintain very strict water chemistry limits for the feedwater.