Power Plant Water Monitoring

1 links between power plant water systems
2New ELG and bromines
3 power plant Processes
4. EUCW 2015
5 Measurement technologies

Links Between Power Plant Water Systems

- More stringent effluent guidelines, the increasing requirement to use less than pristine waters for power plant makeup, and evolution of high-purity steam generation have greatly increased the complexity of water treatment system selection for new plants.

- No longer can water treatment systems be viewed individually. Rather a holistic approach is needed. Examples include:
  - Wastewater discharge guidelines may influence the choice of makeup water treatment technology.
  - Minimization of phosphorus in power plant discharge is influencing a change from phosphate/phosphonate-based cooling tower treatment programs to all-polymer schemes.
  - Makeup water treatment technology continues to evolve with greater use of bioreactors, high-rate clarifiers, and membrane filtration to protect downstream equipment.

Links Between Power Plant Water Systems

- With regard to steam generation chemistry, experience at coal-fired plants has shown that even seemingly minor chemistry upsets can cause severe problems that may lead to catastrophic failures and expensive outages.
- These lessons have often not been transferred to the many combined-cycle plants now on-line or being planned. Often, this is due to minimal staffing at these plants.
- KED personnel have been investigating all of these issues, and have been providing guidance and system design for both new and existing plants. Regarding the latter, a plant audit can often be very beneficial in identifying weaknesses in treatment programs. For new plants, early client meetings are quite informative with respect to proper equipment and chemical treatment selection.

ELG to be released by September 30

- On April 19, 2013, EPA proposed new effluent limitation guidelines (ELGs) under the Clean Water Act for fossil-fuel and nuclear power plants. The proposed ELGs set limits on the amount of pollutants that can be discharged into surface waters. EPA intends to coordinate the ELG rule with the CCR rule (below). A consent decree requires EPA to issue a final ELG rule by September 30, 2015. IMPACTS EPA estimates the proposal would cost $185 million to $954 million per year but would not cause any coal retirements.7 However, NERA's analysis for ACCCE indicates the proposed rule could cost approximately twice EPA's estimate and cause up to 10,000 MW of additional coal retirements.

5 options in new effluent limit guidelines -ELG

TABLE VIII–1—STEAM ELECTRIC MAIN REGULATORY OPTIONS

Wastestreams	Technology basis for the main BAT/NSPS/PSES/PSNS regulatory options							
	1	3a	2	3b	3	4a	4	5
FGD Wastewater	Chemical Precipitation.	BPJ Determination.	Chemical Precipitation + Biological Treatment.	Chemical Precipitation + Biological Treatment for units at a facility with a total wet-scrubbed capacity of 2,000 MW and more; BPJ determination for <2,000 MW.	Chemical Precipitation + Biological Treatment.	Chemical Precipitation + Biological Treatment.	Chemical Precipitation + Biological Treatment.	Chemical Precipitation + Evaporation
Fly Ash Transport Water.	Impoundment (Equal to BPT).	Dry handling ...	Impoundment (Equal to BPT).	Dry handling ...	Dry handling ...	Dry handling ...	Dry handling ...	Dry handling
Bottom Ash Transport Water.	Impoundment (Equal to BPT).	Impoundment (Equal to BPT).	Impoundment (Equal to BPT).	Impoundment (Equal to BPT).	Impoundment (Equal to BPT).	Dry handling/ Closed loop (for units >400 MW); Impoundment (Equal to BPT)(for units ≤400 MW).	Dry handling/ Closed loop.	Dry handling/ Closed loop
Combustion Residual Leachate.	Impoundment (Equal to BPT).	Impoundment (Equal to BPT).	Impoundment (Equal to BPT).	Impoundment (Equal to BPT).	Impoundment (Equal to BPT).	Impoundment (Equal to BPT).	Chemical Precipitation.	Chemical Precipitation
FGMC Wastewater	Impoundment (Equal to BPT).	Dry handling ...	Impoundment (Equal to BPT).	Dry handling ...	Dry handling ...	Dry handling ...	Dry handling ...	Dry handling
Gasification Wastewater.	Evaporation	Evaporation	Evaporation	Evaporation	Evaporation	Evaporation	Evaporation	Evaporation
Nonchemical Metal Cleaning Wastes[19].	Chemical Precipitation.	Chemical Precipitation.	Chemical Precipitation.	Chemical Precipitation.	Chemical Precipitation.	Chemical Precipitation.	Chemical Precipitation.	Chemical Precipitation

Option 5 would cost $ 12 billion

TABLE IX–3—COST OF IMPLEMENTATION (BAT AND PSES)

[In millions of pre-tax 2010 dollars]

Regulatory option	Number of plants	Capital cost	Annual O&M cost	One time costs	Recurring costs			
					3-year	5-year	6-year	10-year
1	116	$1,450	$194	$0	$0	$0	$10	($33)
3a	66	398	177	0	0	0	0	(21)
2	116	2,499	257	0	0	0	10	(33)
3b	80	998	244	0	0	0	1	(26)
3	155	2,897	434	0	0	0	10	(54)
4a [a]	200	5,478	689	0.3	1	38	10	(90)
4	277	8,011	988	0.6	28	65	16	(137)
5	277	11,755	1,753	0.6	28	65	19	(137)

Option 5 would control bromides

Finally, EPA notes that Option 5 is comparable to Option 4 with respect to much of the anticipated pollutant removals, particularly the expected removals of arsenic, mercury, selenium and nitrogen. At the same time, Option 5 would control other pollutants in FGD wastewater that Options 1 through 4 do not effectively control, namely boron, bromides, and TDS. EPA is aware that bromide in wastewater discharges from steam electric power plants located upstream from a drinking water intake has been associated with the formation of trihalomethanes, also known as THMs, when it is exposed to disinfectant processes in water treatment plants. EPA recommends that permitting authorities consider the potential for bromide discharges to adversely impact drinking water intakes when determining whether additional water quality-based effluent limits may be warranted. Although EPA did not select Option 5 as the preferred NSPS option, the technologies forming the basis for Option 5 are all technologically available and may be appropriate (individually or in totality) as the basis for water quality-based effluent limits in individual or general permits depending on site-specific conditions. EPA requests comment on its selection of Option 4 instead of Option 5 as the basis for NSPS.

Monitoring FGD wastewater

• FGD wastewater: Where an option proposes BAT/NSPS limitations for FGD wastewater that are not equal to existing BPT limitations,[92] EPA is also proposing to require monitoring for compliance with the proposed effluent limitations and standards prior to use of the FGD wastewater in any other non-FGD plant process or commingling of the FGD wastewater with any water or other process wastewater. This monitoring requirement would not, however, apply prior to commingling of FGD wastewater with combustion residual leachate (including legacy leachate) or

legacy FGD wastewater that is treated to achieve pollutant removals equivalent to or greater than achieved by the BAT/NSPS technology that serves as the basis for the effluent limitations and standards proposed today.

For example, many plants currently treat their FGD wastewater and leachate in onsite surface impoundments. EPA envisions that, under this proposed Option 3 requirements, some of these plants may choose to install tank-based FGD wastewater treatment systems for their newly generated FGD wastewater. Such a plant may chose to discharge the effluent from its new treatment system directly or may wish to discharge it to the existing surface impoundment containing legacy wastewaters. In this case, the plant would be required to demonstrate compliance with the proposed effluent limitations and standards for the newly generated FGD wastewater at the effluent from the tank-based FGD wastewater treatment system, and compliance with the BPT requirements for the commingled new/legacy FGD wastewater at the point of discharge from the FGD wastewater impoundment. The same plant may also

EPA promulgated Analytical methods

for the pretreatment program. The EPA has promulgated analytical methods for monitoring discharges to surface water at 40 CFR part 136 for the pollutants proposed for regulation in this notice. EPA is providing notice of standard operating procedures (SOPs) for the analysis of FGD wastewater using collision cell technology in conjunction with EPA Method 200.8. EPA Method 200.8 has been promulgated under 40 CFR part 136 and is an approved method for use in NPDES compliance monitoring. Also, the use of collision cell technology is an approved modification allowed under 40 CFR part 136.6. See DCN SE03835 and DCN SE03868 for the SOPs and information on EPA's development of the SOPs.

In addition, as explained in Section VIII, with the exception of the cases where BAT limitations are equivalent to BPT limitations, EPA is proposing that compliance with any final limitations or standards (except pH) based on any of the eight main regulatory options in this proposed rule reflects results obtained from sufficiently sensitive analytical methods. Where EPA has approved more than one analytical method for a pollutant, the Agency expects that permittees would select methods that are able to quantify the presence of pollutants in a given discharge at concentrations that are low enough to determine compliance with effluent limits. For purposes of the proposed anti-circumvention provisions, a method is "sufficiently sensitive" when the sample-specific quantitation level [93] for the wastewater matrix being analyzed is at or below the level of the effluent limit.

Bromine identified with trihalomethanes (THMs)

In addition, EPA has identified other potential impacts from combustion wastewater discharges. Steam electric plants also discharge bromide in large quantities. Bromide in wastewater discharges from steam electric plants located upstream from a drinking water intake has been associated with the formation of trihalomethanes (THMs) and haloacetic acids (HAAs) when it is exposed to chlorination disinfection processes in drinking water treatment plants. Bromate, a disinfection byproduct (DBP) associated with drinking water treatment plants that employ ozonation may also increase under the influence of increased bromide in the source water. Human exposure to THMs and DBPs in chlorinated drinking water is associated with bladder cancer.

- When Duke installed scrubbers at its Belews Creek power plant in Stokes County in 2008, court filings say, the Dan River town of Eden soon saw a leap in THMs. Duke later agreed to pay Eden $2.3 million and Madison, which also draws water from the Dan, $770,000 to modify their treatment systems.
- Duke has identified its Cliffside power plant, on the Broad River west of Charlotte, as another potential problem. Like Belews Creek, Cliffside is a large plant on a shallow river that can't readily dilute bromides.
- Duke installed scrubber equipment to reduce the plant's bromide discharge. Tests of the Broad in 2013 found no significant levels
- The state Public Water Supply Section recommended that discharge permits now under review require Duke to regularly test wastewater for bromides at both power plants.

Bromine control technology

Duke says no available control technology yet

- There is currently no commercially available solution for capturing, removing and disposing bromides from power plant wastewater. Duke Energy is working with the industry and third-party experts to proactively identify and test potential technologies and has evaluated more than a dozen different possible solutions.
- • For example, at our Belews Creek Steam Station on the Dan River in North Carolina, Duke Energy has piloted an advanced water filtration system and is partnering with the University of North Carolina at Charlotte to research ways to effectively capture and store bromides from wastewater.
- • Bromides in coal plant wastewater is an emerging topic for the entire utility industry
- . Duke Energy has joined with other utilities and invested in the Southern Research Institute’s Water Research Center in Cartersville, Ga. This facility investigates a number of water-related topics, including potential bromide reduction technologies

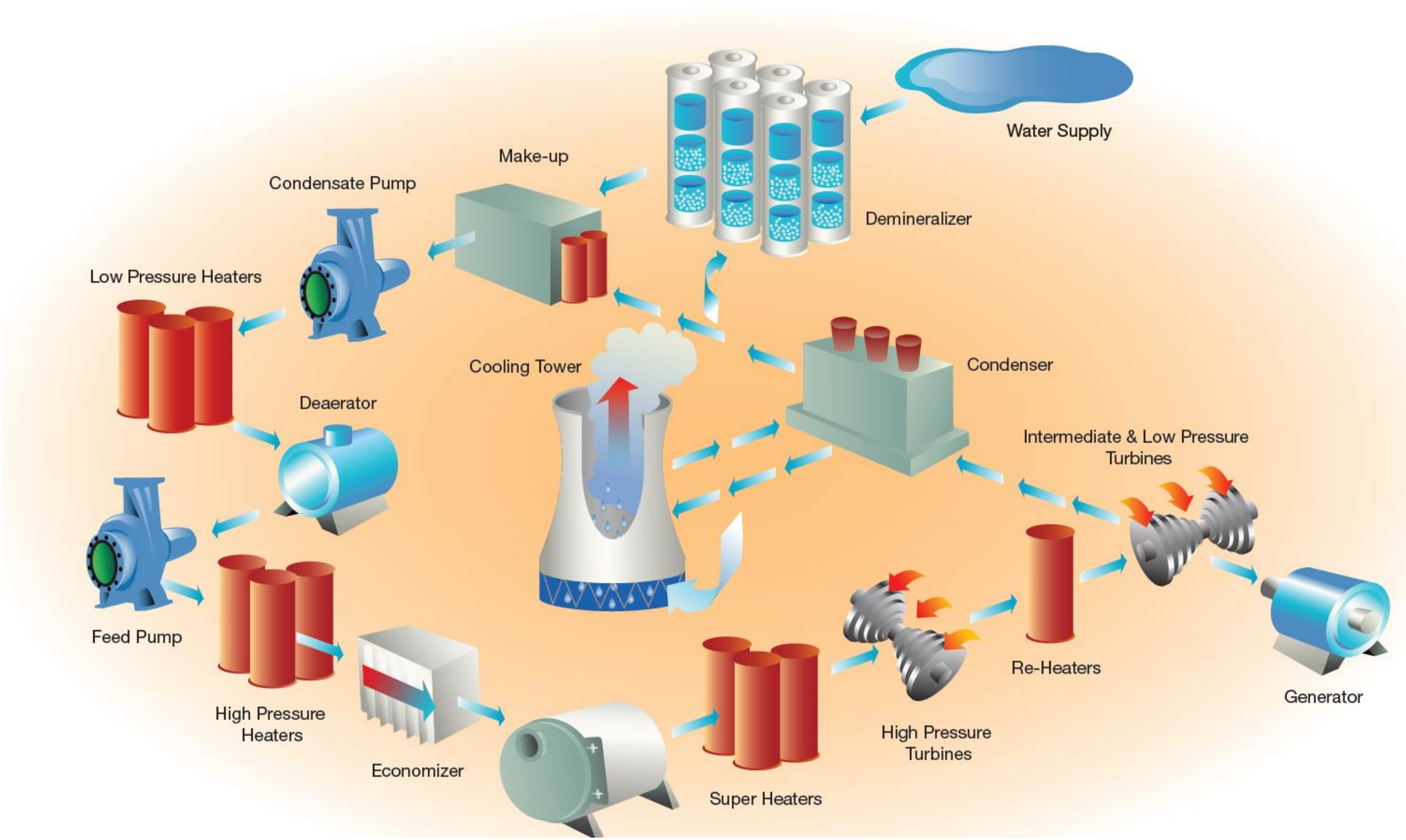
Carnegie Mellon has separation process

- Brines generated from oil and natural gas production, including flowback water and produced water from hydraulic fracturing of shale gas, may contain elevated concentrations of bromide (w1 g/L). Bromide is a broad concern due to the potential for forming brominated disinfection byproducts (DBPs) during drinking water treatment. Conventional treatment processes for bromide removal is costly and not specific. Selective bromide removal is technically challenging due to the presence of other ions in the brine, especially chloride as high as 30e200 g/L.
- This study evaluates the ability of solid graphite electrodes to selectively oxidize bromide to bromine in flowback water and produced water from a shale gas operation in Southwestern PA. The bromine can then be outgassed from the solution and recovered, as a process well understood in the bromine industry.
- This study revealed that bromide may be selectively and rapidly removed from oil and gas brines (w10 h⍰1 m⍰2 for produced water and w60 h⍰1 m⍰2 for flowback water). The electrolysis occurs with a current efficiency between 60 and 90%, and the estimated energy cost is w6 kJ/g Br. These data are similar to those for the chlor-alkali process that is commonly used for chlorine gas and sodium hydroxide production.
- The results demonstrate that bromide may be selectively removed from oil and gas brines to create an opportunity for environmental protection and resource recovery

Processes

- Process schematic on all monitoring locations
- Process variables for combined cycle plants
- GTCC water monitoring
- Condensate Polisher
- FGD
- ZLD
- Pre-treatment

Processes requiring water monitoring in power *plants* (*thermoFisher*)



Process variables for combined cycle power plants

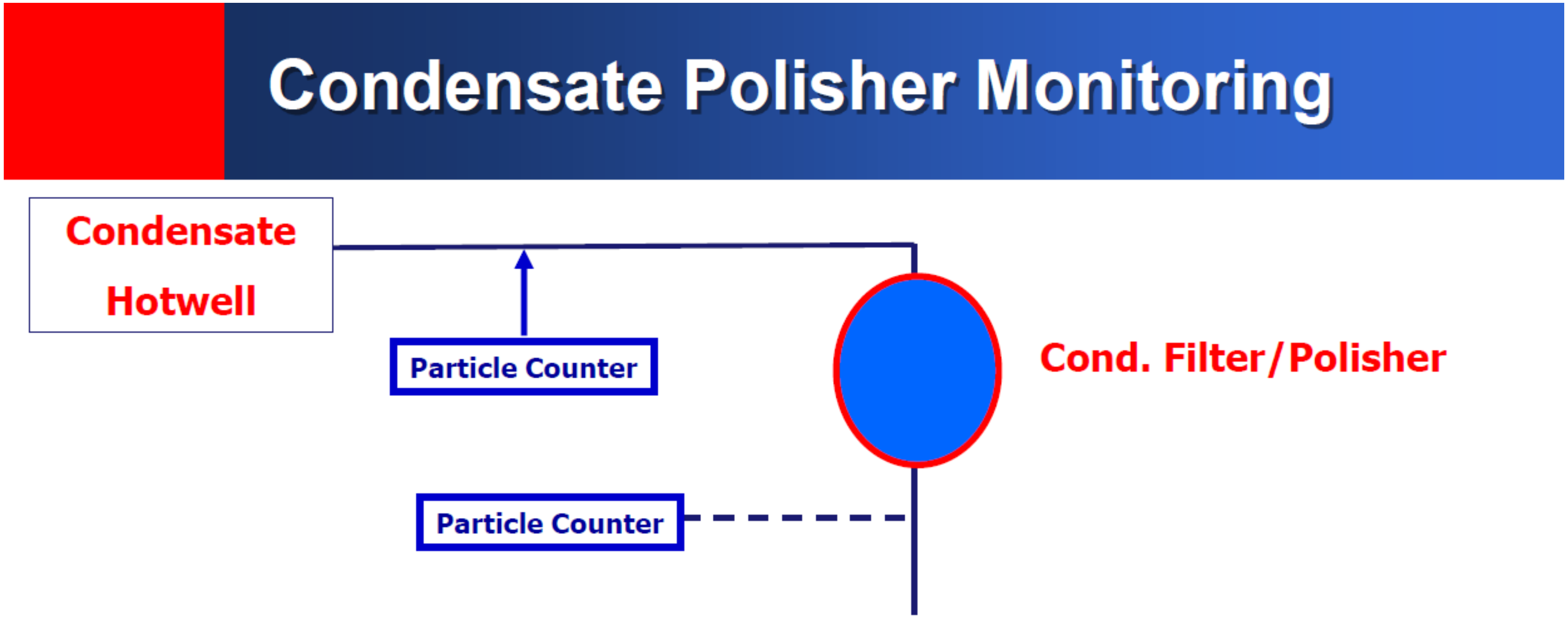
- Rapid cycling and load variations make it challenging to operate pumps at optimum efficiency
- Cooling can be with seawater, treated municipal wastewater as well as from a water source
- Changes from once-through to recirculation of cooling water
- Challenge to use existing pumping systems when installing gas turbine at existing coal plant site
- Zero liquid discharge has additional pumping requirements

GTCC water monitoring

(Mcilvaine webinar in September 2014)

- **Water Monitoring for Combined Cycle Power Plants Webinar - Hot Topic Hour September 18, 2014**
- The four speakers described instruments to make the critical measurements but also how the measurements can be used to maximize efficiency and reduce costs. The challenges of operating GTCC plants under rapid cycling and with air-cooled condensers were also probed.
- ***Revision Date:*** 9/18/2014
- ***Tags:*** 221112 - Fossil Fuel 化石燃料, Chemtrac, Hach, Ashland Water Technologies, Mettler-Toledo Thornton, Monitoring Equipment, Monitoring
- **Monitoring Iron transport in power generataion - Hach Application Note**
- Nephelometer has advantages over the particle counter. It is easily calibrated and can determine absolute iron oxide concentrations.
- ***Revision Date:*** 9/17/2014
- ***Tags:*** 221112 - Fossil Fuel 化石燃料, Hach, Monitoring Equipment, Particle Detection, Monitoring, Water Treatment
- **On-Line Particle Counters for Power Plants - Chemtrac presentation by Joe Zimmerman**
- Particle counters use light blockage measurement and can detect 2 micron particles and up to 8 size ranges. A new development allows volumetric measurement of volumetric concentration in ppb.
- ***Revision Date:*** 9/17/2014
- ***Tags:*** 221112 - Fossil Fuel 化石燃料, Chemtrac, Monitoring Equipment, Particle Detection, Water Treatment, Monitoring
- **Combined cycle On-Line Measurements - Mettler Toledo presentation by David Gray**
- Specific conductivity, cation conductivity, dissolved oxygen, redox, pH, sodium, silica and total organic carbon are all measured by MT instruments. Intelligent digital sensors have advantages. Optical DO offers faster measurement and less maintenance but polarographic offers measurement to lowest concentrations

Condensate Polisher (Chemtrac)



Particle Counters Upstream and Downstream

- See insoluble material reduction across the filter
- Better identify resin leakage

FGD

- **Overview**

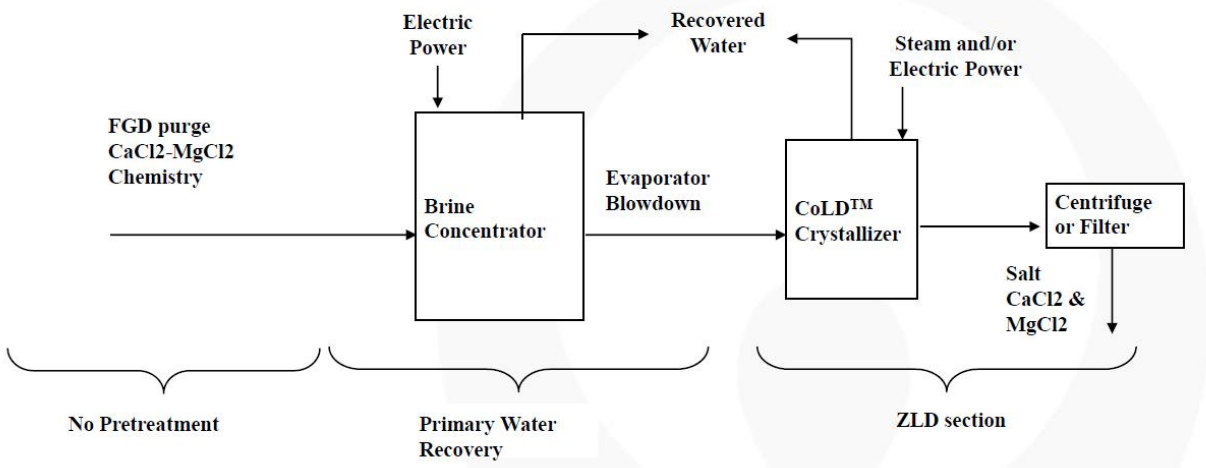
- **Recycle Slurry** : Limestone FGD systems are handling flows in excess of 20,000 gpm, at heads ranging from 13-20 meters often from several pumps. So the total could be more than 100,000 gpm demand
- **Feed streams .** – Concentrated limestone slurry feed from the ball mill is usually recirculated with a hydrocyclone being used to return the oversize material to the ball mill for further reduction
- **Fresh Water** - In a limestone FGD system, the most likely points at which fresh water would enter are the ball mills, pump seals, and the mist eliminator wash system

Veolia claims an improved ZLD process

What's new?

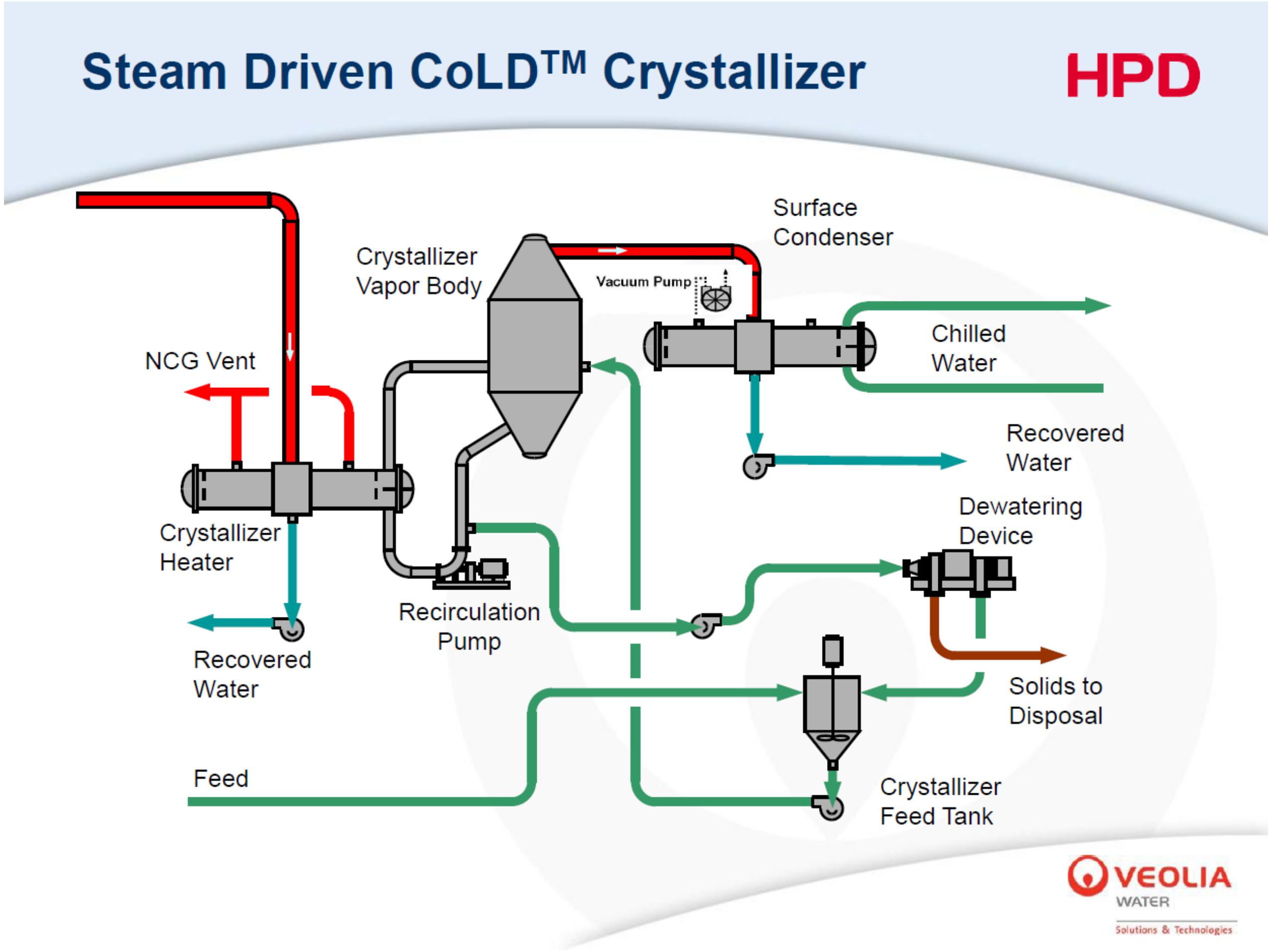
HPD

No pretreatment –
Crystallizer based on industrial $CaCl_2$ production



VEOLIA WATER
Solutions & Technologies

Veolia COLD™ Process for ZLD

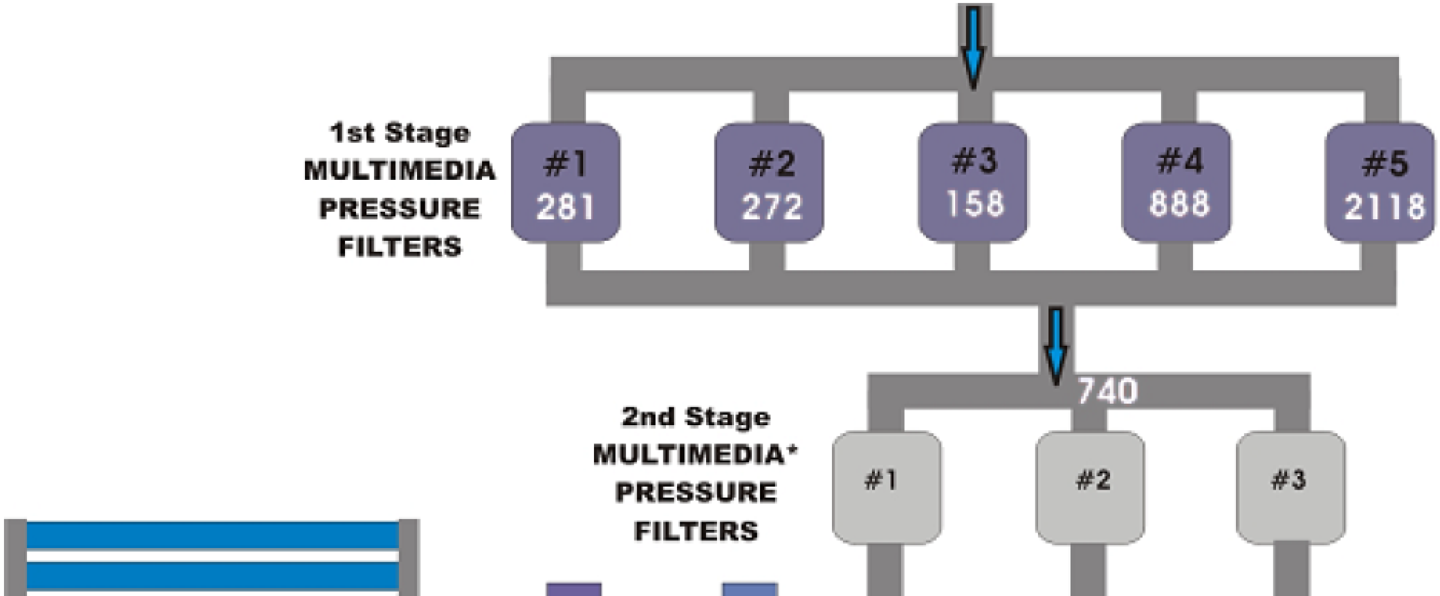


Pre-treatment (chemtrac)

Applications

Pre-Treatment

- Monitor filter performance



EUCW

- Exhibitors 2015
- Oxamine Presentations 2015
- pH and glycol
- Phosphate, membranes
- FAC and Sodium
- Organics and boron
- EUCW 2011

EUCW exhibitors 2015

- tlantium Technologies
  Baker Hughes
  Buckman
  ChemStaff
  Chemtrac, Inc.
  ChemTreat
  Conco Services Corporation
  Day & Zimmermann
  Emerson Process Management
  Evoqua Water Technologies
  GE Power & Water
  Graver Technologies
  Hach
  Illinois Water Technologies
  LANXESS Sybron Chemicals Inc.
  Loprest Water Treatment Company
  Martek Instruments, Inc.

-
  Mettler-Toledo Thornton
  Missouri Filter & Process Equipment Co.
  Nalco, an Ecolab Company
  Plastocor, Inc.
  Plymouth Tube Co.
  Purolite Corporation
  Rocky Mountain Industrial Services
  Sentry Equipment Corp
  Solenis
  Swan Analytical USA
  Thermo Fisher Scientific
  Veolia Water Technologies
  Waltron Bull & Roberts
  Waters Equipment
  Wolcott Water Systems, Inc

EUCW Oxamine Presentations 2015

- **First Use: Experience and Results of Oxamine Treatment of Service Water and Cooling Tower Make up at Nipsco's Michigan City Generating Station**
  David Stamp, Northern Indiana Public Service Company (NIPSCO)
  Nipsco's Michigan City Gen Station installed a monochloramine generator for biological control in July of 2014. The purpose of the system is provide a low dosage biocidal treatment to the service water, which then provides makeup to the cooling tower. This paper will present the data and results determining effectiveness on microbiological control in the service water, internal heat exchangers, the effect on zebra

- **First Use: Experience and Results of Oxamine Treatment of Service Water Polyamine Technology in Gas Turbine Heat Recover Steam Generators: Overview and Case Study**
  Gregg Robinson, Craig Cannon, Trevor Dale, and Dan Harding, GE Water and Process Technologies
  Through the diligent work of the Power companies, organizations such as EPRI/VGB/IAPWS and the research of select water treatment companies, great strides have been made in understanding and preventing the corrosion mechanisms that have historically plagued the reliability of the Power Industry. However, the ever changing landscape under which the Power industry operates, as

pH and Glycol at EUCW 2015

- **Calculated pH of Alkaline Mixtures**
  Randy Turner, Swan Analytical USA, Inc.
  Proper measurement of pH is a key factor of corrosion risk surveillance in water-steam cycles. Since it still seems to be difficult to measure the sample pH directly with glass electrodes, pH calculation, using the difference of sample conductivity before and after a strong acid ion-exchanger, is a frequently used alternative. The precision and reliability of this measuring method is well known and proofed in water-steam cycles containing one alkalization agent only. For applications using mixtures of alkalization agents, the pH calculation model was never verified. We present here calculation models to predict the precision and limitation of the pH calculation by differential conductivity measurement in morpholine-ammonia and ethanolamine-

- **Glycol Systems: Background, Problems, Control, & Monitoring**
  K. Anthony Selby, Water Technology Consultants, Inc.
  Glycol systems are used in power plants for the purpose of freeze protection. Glycol systems have many benefits but also many limitations. This presentation will discuss glycol system applications, types of glycol solutions, potential problems, operating characteristics, and monitoring.

Phosphate, membranes –EUCW 2015

- **Maintaining Drum Chemistry in "Phosphate Continuum Box"—Practical Aspects**
  Nisso Fazliddinova, Florida Power and Light
  The paper discusses importance of drum PC (Phosphate Continuum) Box trending as a tool for monitoring drum chemistry performance in plant cycle. Drum PC Box trends help understand chemistry behavior specific to the unit and recognize if there are chemistry control issues that need to be addressed. The PC Box trending procedure is discussed in detail. Multiple PC box patterns are analyzed and trend interpretations with corrective steps are offered. The paper also reviews practical aspects and challenges in maintaining drum chemistry in PC Box during unit startup, unit shutdown and cycle contamination events. A brief overview of "phosphate hide out/hideout return" phenomenon and hideout driving factors is included.

- **Monitoring Membrane Systems**
  Miller Truby and Gregory Madden, Professional Water Technologies, LLC
  Reverse osmosis (RO) membrane systems are a trusted treatment process that has become common in the power industry as a step in the production of high purity water. As feedwater streams vary, the pretreatment requirements and operational issues of RO systems change. Chemistry of systems that operate on make-up from city water, surface water, groundwater, or groundwater under direct influence (GWUDI) of a surface source differs greatly. There are three primary mechanisms that cause membranes to become dirty – organic fouling, colloidal fouling, and inorganic scaling. Careful monitoring of your membrane system will indicate slight changes in operational conditions that point to one or more of those phenomena. By catching the signs of fouling or scaling early, an effective maintenance and cleaning protocol can be established to minimize the impact on production, and maximize membrane life. This presentation will include a brief exploration of the three mechanisms of membrane contamination; monitoring; and cleaning.

FAC and Sodium at EUCW 2015

- **New Findings on Monitoring Flow Accelerated Corrosion**
  Ken Kuruc, Denton Slovacek, and Luke Johnson, Hach Company
  Much work has now been completed documenting laser nephelometry as a viable surrogate for monitoring suspended iron in the steam cycle as an indicator of flow accelerated corrosion (FAC). The next step in this research is to demonstrate that it can be used to accurately pinpoint and interpret various events that can impact FAC in the process, either positively or negatively, such as load change, cycling of a unit and metal passivation. In this paper, data will be discussed based on changing scenarios

- **Effect of Base Reagents on Trace Level Sodium Ion Measurement with Glass Electrode**
  CD Feng, Hoang Nguyen, and Dave Anderson, Rosemount Analytical Inc.
  Sodium glass electrode method (ASTM-D2791) has been well adapted for continuous sodium ion monitoring in various industrial processes. Based on the sensing mechanism of a sodium glass electrode (ion-selective-electrode), the interference from, or the selectivity coefficients of other cations in the solution (including H+ in the solution), is determined by their mobility inside the hydrolyzed glass membrane,

Organics and boron -EUCW 2015

- **Reliable Organics Detection Helps Protect Power Plant Components**
  Peggy Banarhall, Kirk Buecher, Steven Carelli, and David Gray, Mettler Toledo Thornton
  Increasing use of reclaimed waters and other changes in sourcing raw water can cause significant increases and variability in the amount of organics entering the power plant makeup water treatment system. At the same time, there is an increasing recognition of the harmful effects organics can have in both the water treatment system and in the water-steam cycle. Membranes and ion exchange resins can be fouled and steam cycle components can experience corrosion as a result of organic contamination.

- **Start Up of a Full Scale Boron Removal System for FGD Waste Water**
  Matt Roth, Bill Carlin, and Lauren Versagli, Dow Chemical, and Shelley Wojciechowski and David Reed, NRG
  An increase in environmental regulations has many coal fired power plants evaluating solutions for treatment of flue gas desulfurization (FGD) waste water, which contains particulate and other dissolved contaminants such as Boron, Selenium, and Mercury. NRG's Conemaugh Generating Station has installed the first full scale boron removal system for treating FGD waste water. This paper discusses the system design, start up challenges, and current operational data of the boron removal ion exchange system.

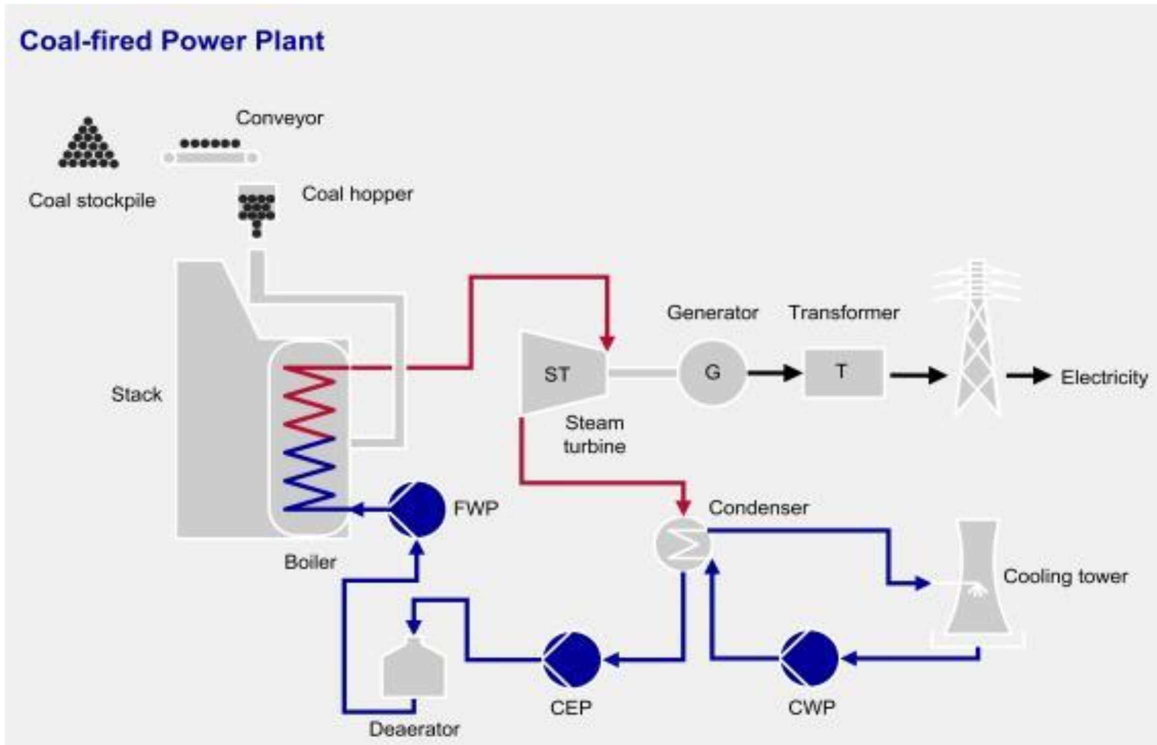
Monitoring at EUCW 2011

- **Overview of Microbiological Control & Monitoring in Utility Cooling Systems, presented by K. Anthony Selby, Water Technology Consultants, Inc., at Electric Utility Chemistry Workshop, June 7-9, 2011, Champaign, Illinois**Overview of Microbiological Control & Monitoring In Utility Cooling Systems K. Anthony Selby, Water Technology Consultants, Inc. Cooling water systems in electric utility plants face challenges related to corrosion, mineral scale deposition, microbiological fouling, and suspended solids accumulation.----.***Revision Date:*** 4/14/2011***Tags:*** 221112 - Fossil Fuel 化石燃料, Water Technology Consultants, Monitoring, Cooling, USA
- **On-Line Water chemistry Measurements for Power Plants, Presented by Ravi Jethra, Fred Kohlmann, Bhupen Patel, Endress + Hauser Inc., at Electric Utility Chemistry Workshop, June 7-9, 2011, Champaign, Illinois** On-Line Water Chemistry Measurements for Power Plants Ravi Jethra, Fred Kohlmann, Bhupen Patel, Endress + Hauser Inc. At the center of every efficient power plant, there is a well run water treatment ----.***Revision Date:*** 4/14/2011***Tags:*** 221113 - Nuclear Electric Power Generation * , 221112 - Fossil Fuel 化石燃料, Endress + Hauser, Monitoring, Water Treatment, Steam Cycle, USA
- **Using in-situ Feedwater ORP Control to Improve Boiler System Operation,presented by Daniel Cicero, Nalco, at Electric Utility Chemistry Workshop, June 7-9, 2011, Champaign, Illinois**
- Using in-situ Feedwater ORP Control to Improve Boiler System Operation Daniel Cicero, Nalco Company This paper discusses the value controlling reductant feed based on in-situ feedwater ORP measurements. Two case studies will be presented:

Pump monitoring

- Sulzer, feedwater and condensate pump
- Primary pumps in GTCC
- Secondary pumps in GTCC

Sulzer feedwater, condensate extraction and cooling water pumps



FWP: Feed Water Pump. CEP: Condensate Extraction Pump CWP: Cooling Water Pump

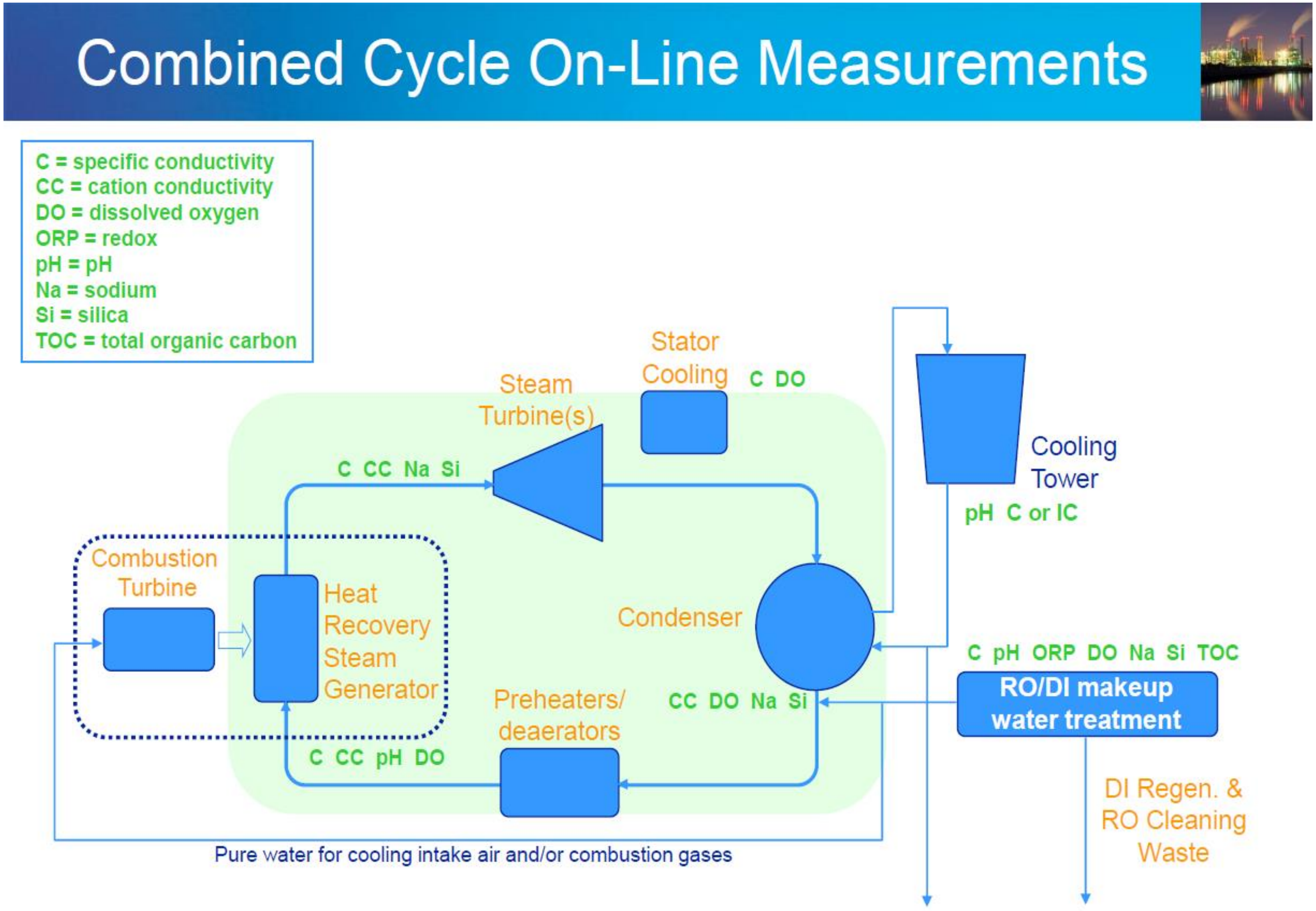
Primary pumps in a GTCC plant

- Primary Pump Systems include:
  - Boiler Feed Pumps (primary and startup)
  - Condensate Pump
  - Cooling Water Circulation Pump
  - Cooling Water Make-up Pump
  - Heater Drain Pumps
- Boiler Feed Pumps
  - High pressure, high flow barrel type multi-stage centrifugal pumps rated ~5000 gpm and 2400 psi for utility power plant systems (pressures will vary for subcritical vs. supercritical).
- Condensate Pumps
  - High flow centrifugal pumps rated ~5000 gpm to move condensate from the condenser hot well to a deaerator and back to the feed water stream ahead of the boiler.
- Once-through Systems
  - Pump surface water through cooling unit and directly back to source (lake, river or ocean).
- Loop Systems
  - Circulating Pumps
    - Large centrifugals rated 100,000 gpm or more. Total coolant flow more than 200,000 gpm for a 400 MW plant.
  - Makeup Water Pumps
    - Large centrifugals rated 5,000 gpm. Makeup is typically two percent to three percent of total flow and is require replace water lost to windage, evaporation, and blowdown.

Secondary Pumps in GTCC plant

- Secondary Pumps include:
  - Chemical Feed Pumps
  - Chemical Transfer Pumps
  - Fuel Transfer Pumps
  - Fuel Injection Pumps
  - Slurry Pumps and De-watering Pumps (used in zero liquid discharge systems)
  - Lubrication Pumps
  - Service Water Pumps, Fire Service Pumps, others.
  - Fogging nozzles
  - Ammonia injection for NO_x control

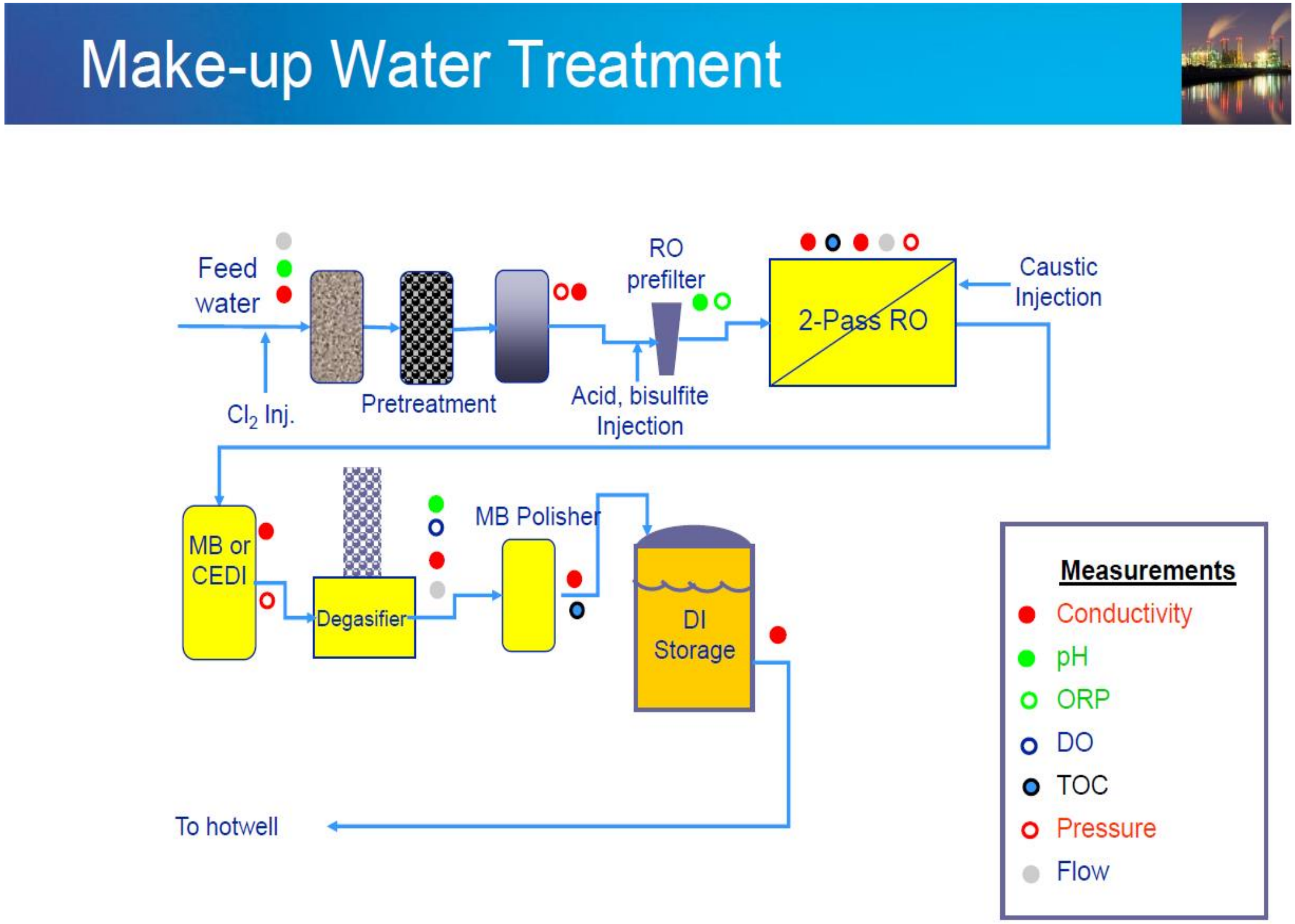
Measurement in GTCC (MT)



Pump Monitoring (ITT)

- **Overview**
- Leveraging our 160+ years in process machinery design, manufacture, and operation, ITT PRO Services® has one goal - improving the profitability of your plant. Our products and services target your biggest issues of **process uptime**, **maintenance**, and **energy costs**.
- Our monitoring portfolio helps you to make the crucial decisions about your equipment before there is a problem.
- ***i-ALERT®*** was the first continuous monitoring device offered as a standard by a pump OEM. *i-ALERT* acts like a check engine light for your equipment.
- ***i-ALERT®2*** combines the latest in Bluetooth low energy and sensor technology into a rugged, safe, industrial certified package. *i-ALERT2* puts monitoring and diagnostics in the hands of everyday users, empowering anyone to safely monitor equipment from a distance.
- **ProSmart** provides continuous monitoring of your rotating equipment, that will proactively send you warning or alarm conditions 24/7.
- **PumpSmart** pump control systems provide real-time control and protection of your pumps while also providing valuable process insight. By protecting against unplanned pump failure due to process upsets, we can keep your process running longer and eliminate unplanned repair activities. By Right-Sizing your pumps to your system, we can reduce not only your energy consumption, but the wear and tear on your process system.

Measurements in make up water treatment (MT)



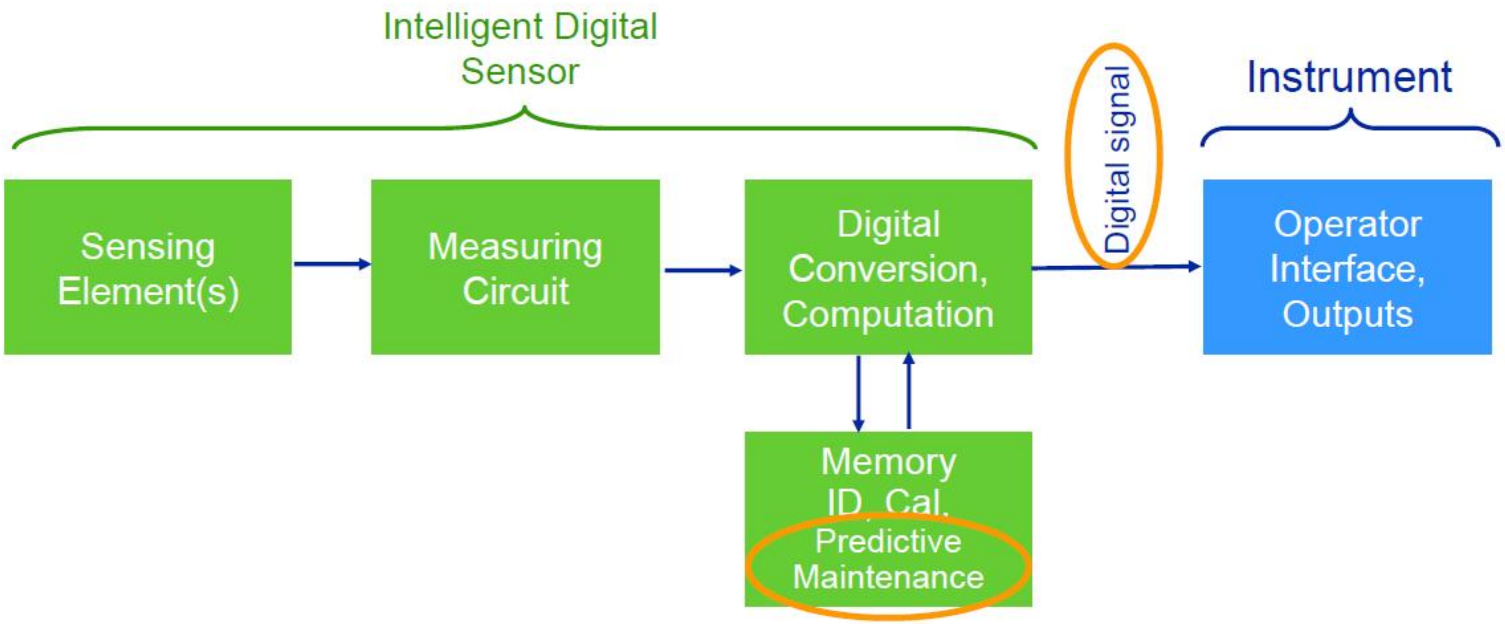
Measurement technologies

- Digital
- Optical –DO
- Silica
- Particles
- Corrosion Product
- pH
- Steam

Advantages of digital sensors (MT)

Measurement Functions—Digital Sensor

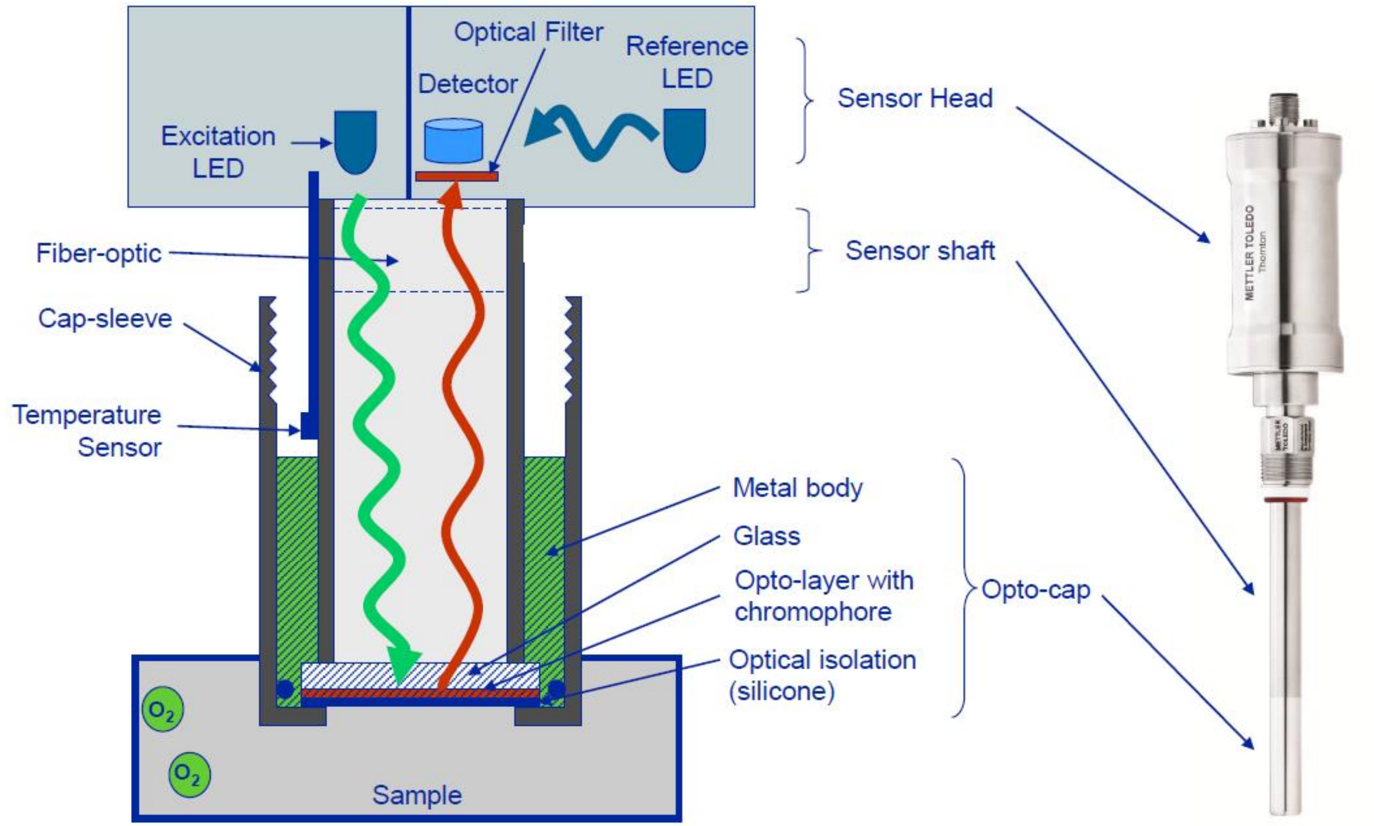
Intelligent Sensor Management **ISM®**



Leading performance and diagnostics are achieved by locating more signal handling and intelligence within the sensor

DO Measurement (Mt)

Optical DO Measurement



The presence of oxygen “quenches” the fluorescence → smaller light intensity and shorter duration

Optical DO vs Polargraphic

Optical vs. Polarographic Technology

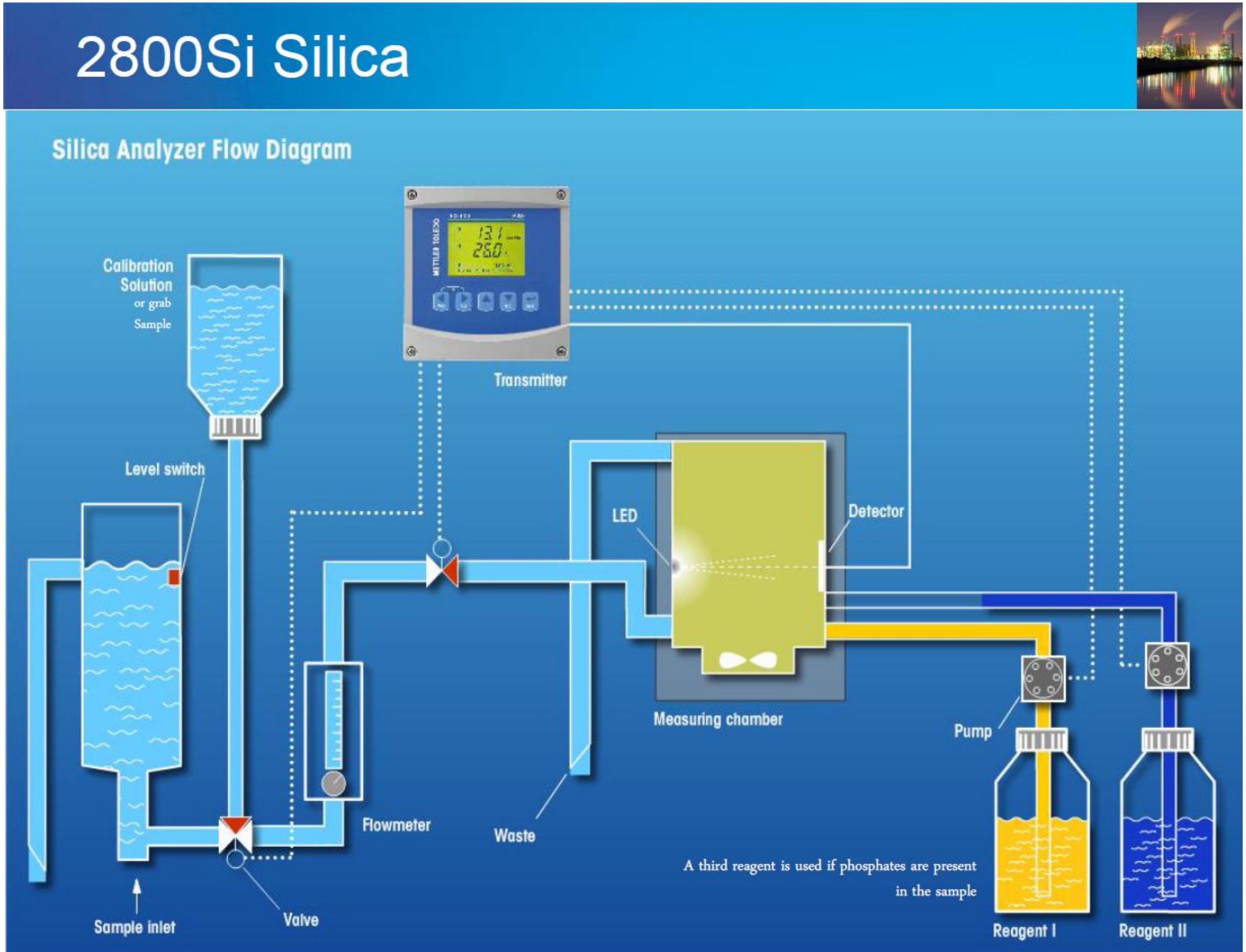
Optical technology

- Fast response time
- Innovative technology
- Electrolyte-free
- Easy to maintain
- Extended maintenance intervals
- No polarization time
- No flow required
- No hydrogen interference – suitable for stator cooling

Amperometric technology

- Proven, reliable technology
- Rugged system
- Measurement to lowest concentrations
- Broad application coverage
- Susceptible to hydrogen interference

Silica measurement (MT)



Silica- Hach

- , Hach Company has recently launched a new silica analyzer designed for the Power industry: the Hach 5500sc. This analyzer builds on the technology of Hach’s Series 5000 Silica Analyzer, offering new features to reduce maintenance and downtime, thus supporting customers in driving efficiency.
- The Hach 5500sc features a unique pressurized reagent delivery system that has no pumps and begins the measurement when silica in the sample reacts with molybdate ions under acidic conditions to form silicomolybdic acid complexes. The addition of citric acid destroys the phosphate complexes. Amino Acid Reagent is then added to reduce the yellow silcomolybdic acid to an intense blue color, which is proportional to the silica concentration. The lower limit of detection on the unit is 0.5 µg/l.

Particle Monitoring Advantages(Chemtrac)

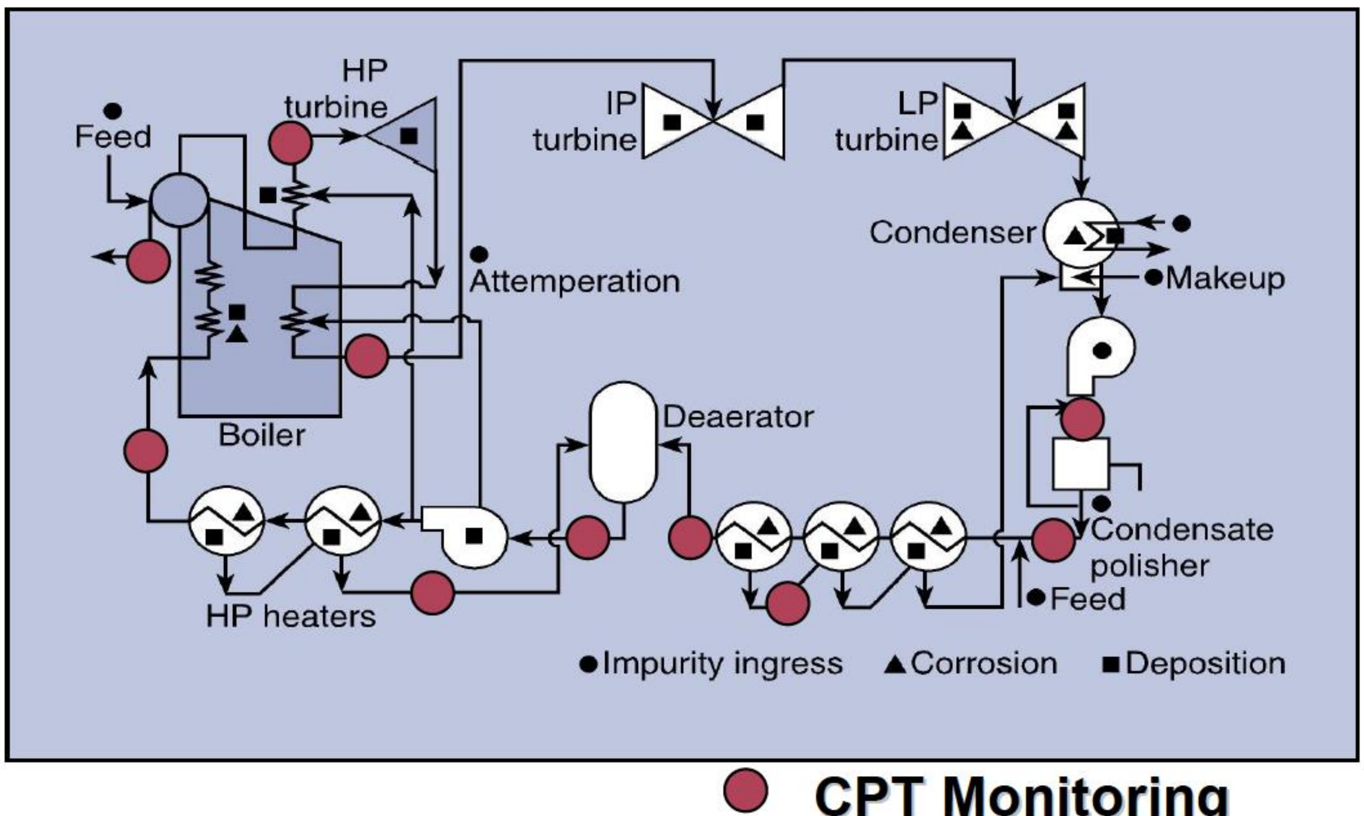
Conclusions

On-line Particle Monitoring:

- provides ***real-time*** indication of insoluble CPT particulate loading
- allows for ***continuous*** data collection & trending
- Events or upsets can be detected very quickly
- Pretreatment filter performance can be significantly improved using the proper tools and techniques
- Savings can be realized in energy costs, membrane cleaning costs, and in cartridge filter replacement costs.
- Upstream and downstream monitoring across the condensate polishers would offer additional comparative data

Corrosion Product Monitoring (Chemtrac)

Applications



pH - Thermofisher

At a large power generation plant in the southwestern region of the United States, on-line pH readings of the steam cycle drifted and did not reliably match lab/grab sample measurements. Frequent recalibration increased labor costs.

The Solution: The power plant upgraded to Thermo Scientific™ Orion™ 2001SC High Purity ROSS™ pH electrodes and Orion analyzers.

The Benefit: Stable pH readings and excellent agreement with lab/grab sample measurements have dramatically reduced calibration frequency, thus saving 92% in labor costs associated with calibrations. In addition, Orion 2001SC electrodes outlast other pH electrodes, dramatically reducing replacement frequency and costs.

pH -Yokogoawa

- Measurement of pH in high purity water is a difficult measurement at best. In order to achieve a successful measurement, care must be taken to address the unique problems of the application.
- Selecting the proper electrodes and holder will eliminate problems with reference junction potentials, slow glass electrode response and surface static charges. Selecting the proper transmitter or analyzer will eliminate ground loop problems and allow for accurate temperature compensation for both the Nernst potentials and the dissociation constant of pure water. In addition, sensor diagnostics gives the operator the ability to assure the measurement loop is functioning properly.
- Yokogawa has the electrodes (Bellomatic reference and special G-glass measure electrode, or combination style); the sensor holder (model FF20/FS20 stainless steel flow through style); and the transmitter or analyzer (Models PH450G/FLXA21 with sensor diagnostics and "process temperature compensation") to provide an accurate pH measurement in high purity water.

Steam flow- Yokogawa

- **Accurate Steam Measurement: from Start up to Full Operation**
- Measuring energy consumption is an important factor in the quest to improve energy efficiency. Efficient and accurate metering is paramount to determining excess use, along with an accurate picture of where the steam is being used. The more accurate and reliable measurements that are made, the more informed decisions can be taken that affect costs and product quality. Traditionally the most common method of steam metering is the orifice plate and differential pressure transmitter technique. General areas of concern with this type of measurement are the orifice plate's susceptibility to wear introducing immediate inaccuracies, the relatively high permanent pressure losses introduced into the system by the orifice place and the small measuring range, typically 3:1.
- Yokogawa's digitalYEWFLO Reduced Bore Type Vortex Flow meter features a cast stainless steel body and a concentric reducer and expander that enable stable flow rate measurements in low-flow conditions. This expands the range of measurements that can be performed, from the higher flow rates down to the lower end of the flow span, which is normally difficult for Vortex Flow meters, and ensures stable and accurate flow rate output.