# DESIGN OF A HIGH PURITY WATER SYSTEM

ASME RESEARCH COMMITTEE ON POWER PLANT AND ENVIRONMENTAL CHEMISTRY
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# PROJECT OUTLINE

- This high purity water system was designed and built for a power plant in Mid-west, near Lake Michigan. Makeup water comes from shallow wells near site.
- The system is capable of delivering 400 gpm of high purity water, in two (2) 200 gpm independent trains.
- The system design incorporates multimedia filters, 1-micron cartridge filters, first pass RO high pressure pumps, first pass RO trains, second pass RO trains, RO permeate storage tank, primary mixed bed and polishing mixed bed demineralizers.
- One of the most critical component is owner furnished, automation system which controls the entire high purity water system from the plant DCS.
- This system was totally custom-engineered, with 100% input from the Project Manager, plant engineers, plant operators, plant maintenance department.
- AWTS' role as consultant became one of the facilitator and mentor , all the way from helping customer with budget estimates, engineering specifications, design and fabrication oversight, review of installation, startup and acceptance tests.
- The system was started up in January 2012. All of the water quality objectives have been met and exceeded.

# BASIS OF DESIGN

- Complete water analysis, collected over several years of operation. All of the “worst-case” raw water (Inlet of the HPW system) parameters were identified including turbidity, iron, TDS, SDI, min/max water temperatures, minimum and maximum supply water pressure
- Expected treated water analysis, at the end of EACH process block was identified
- Allowance of 50 psi extra pressure, due to membrane fouling conditions.
- Installed standby spare critical components
- Complete access to all critical components for maintenance
- Lots of custom-engineering features from the point of view of the operators and maintenance personnel
- Final water quality: <0.07 mmho conductivity, <5.0 ppb silica, <5.0 ppb Sodium

# ENGINEERING SPECIFICATIONS

- AWTS provided initial specifications documents. This document was reviewed and approved by all concerned departments including Project Manager, Plant engineering, mechanical, electrical, Instrumentation and Controls, operations and Maintenance.
- The Engineering Specifications reflected standard practices by the Power Plant, not the “Standard Package” by the equipment suppliers, although the OEMs were allowed to bid their standard systems as an alternate.
- Evaluation criteria was extensive, based on over 300 points of evaluation, five bids on a side-by-side comparison. Evaluation was tough but fair. Evaluation team consisted of Plant Engineers, Operations and Consultant.
- Most “unusual” component of the project was the elimination of PLC from OEM’s scope, however the OEM was expected to provide controls logic and support to the supplier and engineers responsible for DCS automation and interface
- Final award was made on the basis of several factors including price, close compliance to Engineering Specifications and Quality.

# EXAMPLES OF CUSTOM ENGINEERING FEATURES

- Plant DCS system to control the entire high purity water system.
- All 316SS process piping including interconnecting piping headers. PVC piping was allowed for CIP and some chemical feed systems
- Installed spare media filter, cartridge filter, piping design and space for adding future high pressure pumps, spare mixed bed units, lead/lag capability of mixed bed
- Filtered water storage tank and dedicated pumps for backwashing media filters
- Separate skids for all major process blocks.
- Plant-standard pumps, instruments, valves and controls. Only “non-standard” pumps were RO high pressure pumps (Grundfos)
- Powder coated carbon steel skids, stainless steel hardware throughout the plant
- Ample sample points in each process block.
- Chemical totes to supply chemicals. Double containment for all chemical feed systems

# ENGINEERING/DESIGN REVIEW

- Upon award of the contract, the interactive process of engineering/design review was initiated.
  - Extensive review of Process Flow Diagram including mass balance, pressures, chemicals selection and consumption
  - Extensive review of mechanical and electrical design of all skid mounted components
  - Several versions of overall plant layout, because of limited space
  - Review of demolition plan of the existing equipment, reworking of floor trenches and piping layout
  - Review of all process pumps selection, First pass and Second pass RO projections

# PROGRESS REVIEWS

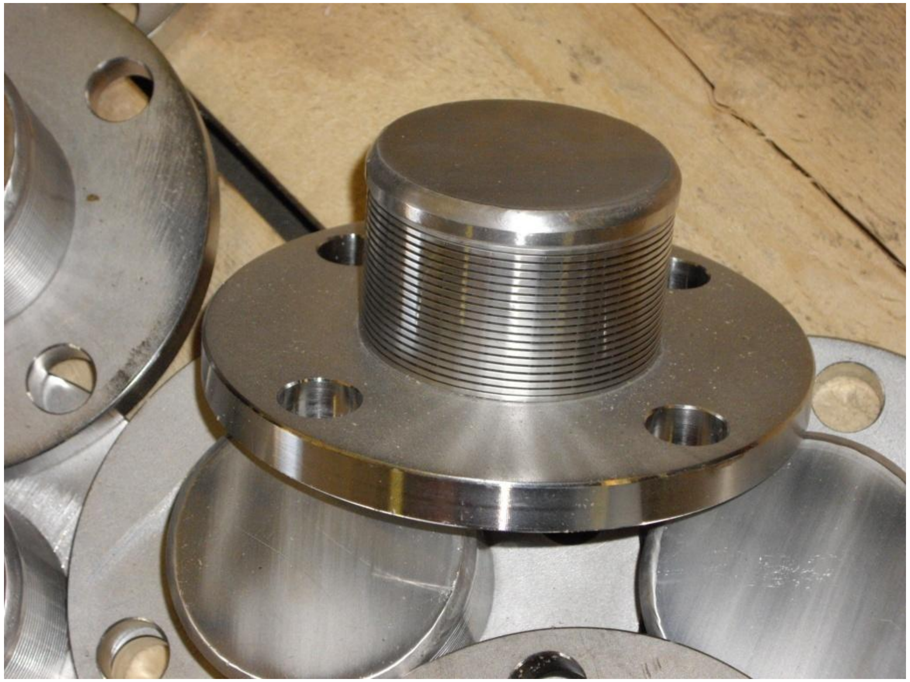
- Progress reviews were carried out to make sure that the system was designed and built in exact accordance with the Engineering Specifications
  - RO Design reviews based on latest water analysis
  - Review of Skid fabrication at the OEM's assembly plant. Minor changes, corrections were carried out. This minimized any surprises, and prepared the engineers responsible for installation of the system.
  - Review of automation scheme with the OEM, Plant E&C and Consultant.
  - Simulation of automation at the DCS contractor's facility.
  - Periodic reviews of installation

# CHALLENGES

- Tight budgets (What's new!), which put lot of pressure on the Plant Engineer to "cut corners", such as providing PVC piping headers. The good engineering judgment prevailed in the end, and final quality was NOT compromised.
- Budget over-runs mostly during installation, due to factors unknown or not envisaged at the time of designing the system. OEM's price was on target.
- Bigger OEMs were not happy about losing the job. They put lot of pressure on the management to consider their "standard" packages. Again, our team was able to justify the decision to go with the selected OEM based on evaluation spreadsheet with 320 points, five bids
- New system had to go in the same place as the old system. That required an extensive demolition plan, rental of the temporary system for several months (expensive) and lots of PATIENCE.
- Since OEM did not supply the standard PLC, the customer had the responsibility of organizing a Controls team, with DCS supplier (Emerson), Plant E&C Engineer, and controls /automation designers. There was quite a bit of "learning curve" , but in the end, worth the effort.

# MULTIMEDIA FILTERS

# FILTER INTERNAL SCREENS



# CARTRIDGE FILTERS


# CHEMICAL FEED SYSTEM

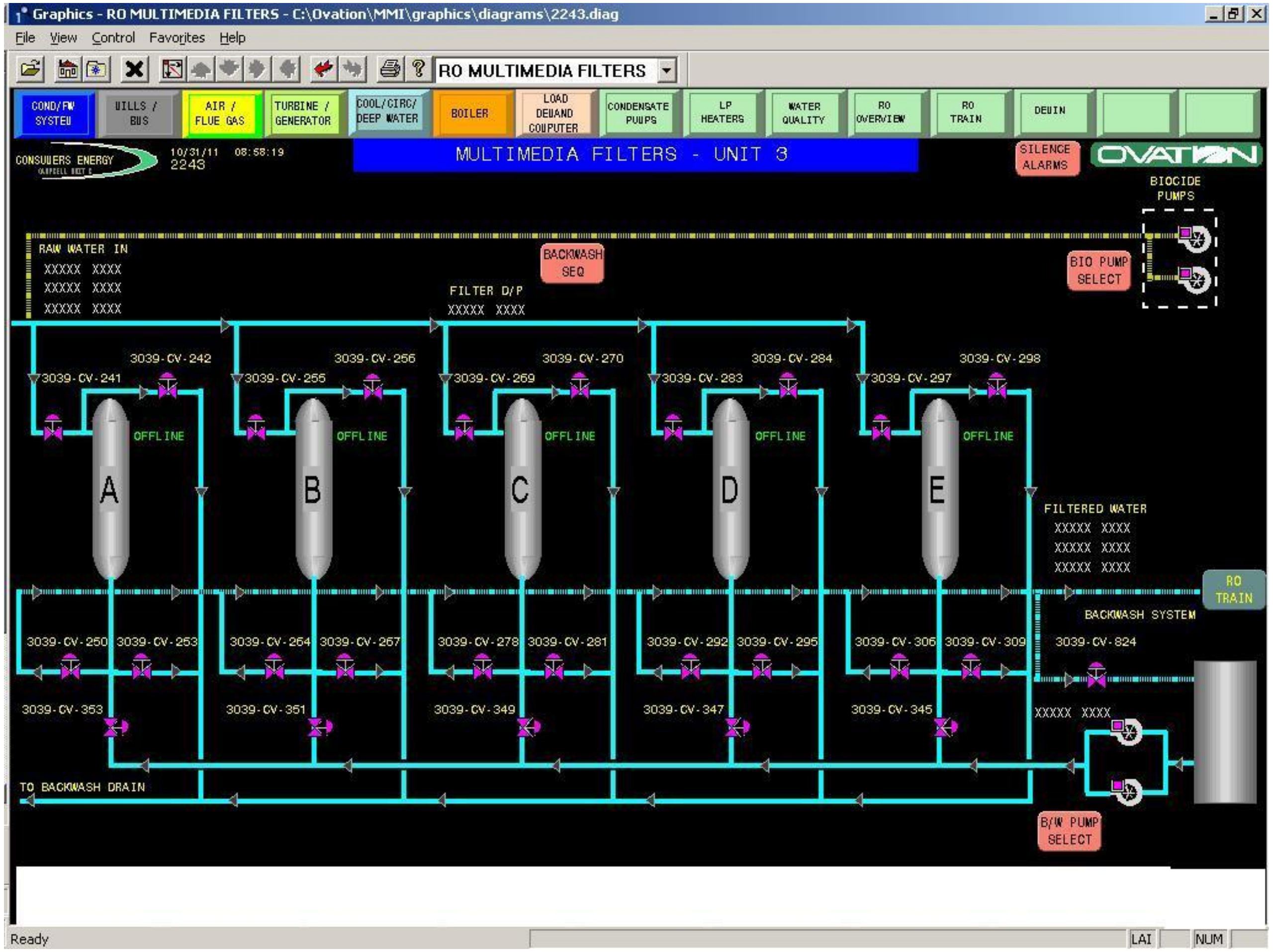
# RO HIGH PRESSURE PUMPS

# RO HIGH PRESSURE PUMPS

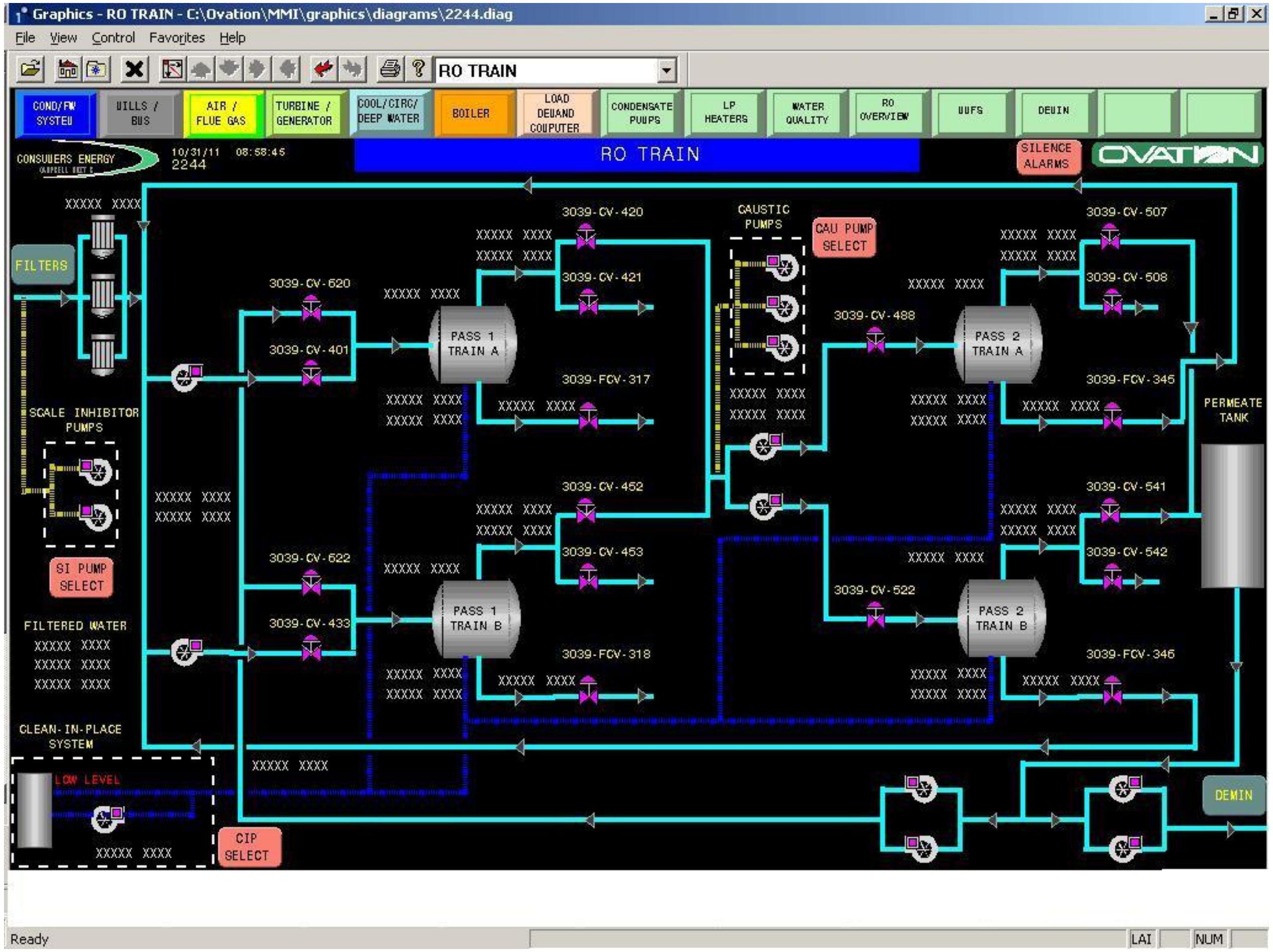
# RO SKIDS

# MIXED BED VESSELS

# DCS GRAPHICS



# DCS GRAPHICS



# WATER QUALITY
# 2 MONTHS AFTER STARTUP

- Media filter effluent turbidity:  <0.02 NTU
- Media filter outlet SDI (15 minutes) 0.9
- First pass RO outlet conductivity:  1.3  uS
- Second pass RO outlet conductivity: 0.4 uS
- Mixed bed water quality: Less than 0.06 uS conductivity, 2.08 ppb silica, 0.01 ppb Sodium
- All of these values are well below the specified limits.

# LESSONS LEARNED

- Project Manager and Consultant's roles are critical. Communication with all responsible parties and making sure that all parties "buy in" the critical decision, was an important element for project success.
- Specify the system based on site-specific requirements and plant-standard components,  not based on "OEM standard" systems. When we look at options on a side-by-side comparison, we made the right decision.
- If you build the system that is O&M friendly, then the system will be operated and maintained properly.
- Cutting out the PLC from OEM's scope was a huge risk. There was quite a bit of learning curve. However, to operate the system from the plant DCS is invaluable. The plant controls engineers are well qualified to make the changes if required.
- Customer is very happy with the quality of the product, installation and ease of operation.