MEETING THE CHALLENGES OF UPGRADING THE PLANT CONTROL SYSTEM YIELDS MAJOR OPERATIONS BENEFITS

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ABSTRACT

In conjunction with a capacity expansion of the CFPUA Sweeney WTP from 25 to 35 MGD, the old proprietary DCS control system was replaced with a “latest technology” non-proprietary and open architecture SCADA system. The old philosophy of “islands of automation” in the plant has been replaced with a total plant integrated architecture with all area local control systems integrated into the new central plant SCADA system resulting in major tangible operations benefits.

The success of this implementation philosophy has led CFPUA to make the decision of expanding the concept to all the facility assets of the entire water system and create a Total Water System Central at Sweeney which will integrate all geographically dispersed facilities including surface raw water pump stations, the nano-filtration water plant and its well field source, distribution system storage and ASR wells. This Total Water System Central concept can only be achieved with our new open architecture SCADA system which is readily compatible with all types of network and communications infrastructure.

Some of the advantages already attained at the Sweeney plant are greatly increased operations efficiency, repeatable water production quality, timely and accurate regulatory reporting compliance, personnel safety and improved working environment. These same advantages when attained throughout the entire water system will result in significantly more efficient delivery of water to the customers with significant cost control helping to control rate increases in the future.

This paper will describe the approach and methods taken during the design and construction phases that allowed the plant to operate at full capacity and win quality awards each of the four years of construction. This paper will also describe how the new system is designed to deliver the key benefits of operations and production optimization to Sweeney operators and describe the expected future advantages our Total Water System Central will accomplish once completed.

KEYWORDS
- SCADA
- Plant Upgrade
- Security
- Automated reports
- Water Treatment
- Operations trends
- Non-proprietary
- Open Architecture

INTRODUCTION

The Cape Fear Public Utility Authority (CFPUA) Sweeney water treatment plant provides water to a large portion of New Hanover County and the City of Wilmington and was originally built in 1943. The plant recently underwent 4 years of construction for a process capacity expansion completed in 2012 to a total
capacity of 35 MGD. The plant takes its raw water from the Cape Fear River at a pump station located 26 miles upstream northwest of the plant.

The plant treatment process is more complex than a typical surface water treatment plant in the Carolinas due to the nature of the Cape Fear water which has heavy organics, solids and bromides. The process treatment train employs critical raw water chemical dosing, rapid mix / flocculation, up-flow pulsating sludge blanket clarification / sedimentation with pre-ozone, gravity filtration, post filter ozone and ultraviolet disinfection (newly added with the last upgrade) and final chlorination for residual disinfection.

The previous plant upgrade and expansion was done in 1994 at which time the treatment train process was enhanced to utilize up-flow pulsating sludge blanket clarification / sedimentation and ozone. With the complexity of this new treatment process, the upgrade also included a plant process control automation system approach based on a Fischer & Porter (F&P) / Bailey distributed control system (DCS). The DCS was state of the art for its time and was capable of handling the automated control schemes, monitoring and alarming of all the parameters and process equipment required to produce quality finished water and maintain regulatory compliance. It also was able to give the operations personnel data reports and some trend analysis critical to daily operations. However, the applications software and hardware were proprietary to the manufacturer, F&P / Bailey, and any additional software application development such as new reports, trends or changes to the automated control loops required expensive custom programming by contract system integrator engineers. Operators had limited ability to create their own custom reports and trends as the software was not user friendly as currently available industry software for plant process automation systems.

During design of this latest expansion and upgrade, the decision was made to replace the now “long-in-the-tooth” DCS with a latest and best technology available and non-proprietary Supervisory Control and Data Acquisition (SCADA) system. As a result, the plant is now fully automated with control and monitoring by a SCADA system utilizing GE RX3i Programmable Application Controllers (PAC), Wonderware InTouch Human Machine Interface (HMI) software, Wonderware Historian running on Microsoft SQL server. Trends use ActiveFactory by Wonderware and Reports are built in Excel using the ActiveFactory Excel add-in for the data connection. ScadAlarm software monitors for critical alarms which it emails to a prioritized list of recipients and TopServer software monitors the Ethernet switches for abnormal functioning. --- See SCADA System Diagram – Appendix A ---

METHODOLOGY

Once the new final treatment process design changes and additions were determined, the consulting engineers, Black & Veatch, with input from the owner choose an open architecture, non-proprietary SCADA system design to replace the old DCS. The old automation system approach used the DCS as the central operations control system for the most critical processes. But many process areas of the plant were not incorporated into the DCS and were “islands of automation” with only local controls and monitoring requiring operators to visit those areas to make process assessments or process changes. The new SCADA system would have all processes controlled automatically and all process parameters and equipment monitored by the SCADA system for the entire plant.

Additionally, with new Homeland Security requirements for water production facilities, a very extensive CCTV system was installed with every process area and room visually monitored by camera and
displayed at the main SCADA control center. All cameras are recorded on DVR hard drives for time stamped historical reference for correlation with personnel maintenance and operations activities, intrusions, deliveries, etc., all from the SCADA central.

**COLLABORATION was key**

During construction of the plant upgrade, it was absolutely paramount that the transition and switch-over from the old DCS system to the new SCADA system not interfere with production and delivery of high quality water and continual regulatory compliance. To accomplish this, the project consulting engineer, Black Veatch, the contractor, Archer Western Construction, the owner’s operators and the SCADA system integrator, Revere Control Systems, formed a collaborative team which would meet daily to discuss required construction activities with operators to determine when and exactly how activities were implemented to NOT OBSTRUCT plant operations.

Very good project management and communications between all parties for this critical phase of switching over control systems resulted in the Sweeney plant effluent receiving AWOP awards each of the 4 years of construction.

**SYSTEM SWITCH-OVER approach**

After many years operating the plant on the old DCS control system, operators were used to the set procedures, control data and information presentation and limited complete plant automated controls of that system. The new SCADA system would force operators to adapt to an entirely new presentation “look and feel” and new interface to the system for monitoring and control. Since the entire interface to operate the plant was new and different, the systems integrator collaborated very closely with operations personnel to build the interface “look and feel” software applications to the exact formats and standards operators wanted with very extensive operator input. The operators knew how they wanted to view plant graphics, what groups of parameters the reports and trends should create, etc., so the integrator had operations review and sign off on every item of importance to them. Many plant SCADA systems software applications are designed with most interface decisions made by the consulting engineer with minimal input from an owner but here it was reversed – the owner dictated to the integrator with oversight by the consultant.
Further, during switch-over, a very good decision was made to operate the old DCS and the new SCADA system simultaneously for 2 years before pulling the plug on the DCS. This served to give operators a period to get comfortable operating the new SCADA system with a “security blanket” of having the DCS in backup if needed. This proved to be very well received by all the operations people and helped them to gain confidence in using the new system and adapting to the changes it required.

RESULTS & DISCUSSION

Implementing a non-proprietary and open architecture SCADA system will allow CFPUA to operate and maintain this system for an expected life of at least 10-15 years into the future. Hardware will be available off-the-shelf from multiple stocking distributors reducing the expense of stocking parts by the owner and is also “plug and play” for replacement when required, reducing the life cycle cost of maintenance of the system equipment.

The SCADA software all runs on the Microsoft operating system platform rather than old mainframe operating systems and is thus more recognizable and user friendly to operators who interact with the software that has the same look and feel as they are used to with their own personal PCs at work and home.

The PAC subsystem is distributed throughout the plant in the process areas with redundant control processors executing all control and monitoring functions locally in that area but networked via fiber optic backbone between all areas of the plant and the SCADA Wonderware HMI control room. The PAC control sub-network is separate and dedicated to control from the HMI supervisory sub-network, on which the Wonderware HMI monitors, alarms and collects data for historical functions. This minimizes network traffic on each sub-network and enables better security for control functions to not be impaired with administrative HMI functions. With a system having over 1460 physical input / output points and over 13,000 memory and system tags in the Wonderware HMI this is a very secure design approach.

The GE RX3i PAC system controls all plant process functions with heavy control of valves and flow paced chemicals and monitors all plant equipment. Since it is open architecture, the overall system also includes PLCs by other manufacturers networked together in the control sub-network and reporting back to the HMI. The ozone production equipment and the UV disinfection system both utilize Allen Bradley ControlLogix programmable logic controller (PLC) systems for automatic control of that equipment. The electrical switchgear employs Modicon Momentum PLCs which are also in the control sub-network. While each equipment system has local control by their PLCs they also provide access to the memory addresses for equipment status and alarm monitoring by the Wonderware HMI as seamlessly as the GE PACs.

The SCADA system continuously monitors and trends all parameters of the ozone and UV equipment systems via their PLCs and alerts operators when / if operations processes are trending toward out of limits values before a major process upset can occur. The sludge blanket clarifier does not have its own dedicated PLC control system for all its automatic control and alarm functions, so for that equipment there is a SCADA GE PAC area control panel provided as part of the SCADA system from the system integrator.

As we see from above, a huge advantage of this open architecture system is the ability to seamlessly incorporate control hardware of multiple manufacturers into the SCADA system. The SCADA system also
has ability to allow a number of different communications protocols and transmission methods (fiber, metallic, radio, etc.) to be readily incorporated into the SCADA system. The old DCS was not open and would require proprietary custom written software which would be expensive in capital and life cycle maintenance costs. The future Master Plan for the water utility is to have all water facilities and process assets continuously monitored and networked into the Sweeney SCADA central control center. The open architecture will greatly facilitate networking different facilities hardware and software into the Sweeney SCADA system. Further, some facilities will connect via fiber optic cable or radio link both of which can be readily implemented into this architecture.

The combination of the extensive SCADA monitoring and alarming of all process areas, equipment and parameters with the installation of CCTV throughout the plant has had substantial benefits to operations. The Sweeney WTP operates 24 / 7 and only requires 2 operators on duty at a time. The CCTV allows control room operators to visually see all important process basins and equipment and even check the actual performance of a piece of equipment or read local gauges at the equipment via the pan-tilt-zoom cameras.

From an operations safety point of view, when one operator or maintenance person has to go to a process area to work on a piece of equipment, he is continually visually monitored in the control room by an operator there. Should an unforeseen accident occur, the control room operator can alert emergency personnel to come to the rescue. Or should the work on the equipment adversely affect the plant production process of making water, the SCADA system will alert the control room operator who can visually check what the maintenance person did and communicate instructions to correct the procedures to correct the process problem. Chemical delivery trucks off-load chemicals to the plant on a daily basis. Via the camera system in the chemical storage area, the operators can watch the delivery to make sure a wrong connection isn’t made to an incorrect tank or the driver doesn’t forget to shut off a fill that the SCADA will alert is approaching too high a level in the tank which could cause an overflow.

Since the SCADA system operates with software industry standards of human interface, CFPUA has taken advantage of having operator mobility with iPads connected to the SCADA HMI via Wi-Fi. To see if having HMI, trends and reports available to operators as they roam the plant is of value, the filter gallery was designed with Wi-Fi routers on a trial basis so the operators can use an iPad while in the gallery to access graphic displays and data from the SCADA system. The iPad essentially becomes another workstation on the supervisory network. Wonderware graphics run on a terminal services server that the iPad connects to. The screens look and behave on the iPad identically to any other workstation except an operator can zoom in and out using normal Apple finger pinching movements. The performance has worked extremely well and it is the intent to expand additional areas of the plant with this capability. Additionally, the operators intend to extend use of iPads to more areas and add electronic versions of Standard Operating Procedures (SOPs) to the system to allow personnel to call up drawings, O&M and SOP information as needed on the fly with the iPad.

An important new benefit of the SCADA system is the ease of operators creating personalized trends and reports. The initial scope of the contract required the system integrator to deliver a certain number of pre-configured trends and reports of real-time process and historical data. By using Microsoft based standard software, the operators quickly developed a comfort level creating personalized trends and reports. Presently, the system has hundreds (100s) of operator created trends and reports that each operator uses as a personal preference to operate the plant.

The system was delivered with automation of all required regulatory reports pre-configured by the integrator. The monthly DENR reports are created by the system from real-time parameters and
calculations from historical data in the system combined with any manually collected laboratory data. Approximately 75% of the data is SCADA fed via macros in Excel connected to the Wonderware historian and 25% manually measured and entered data.  --- See sample report screen shots – Appendix B ---

CONCLUSIONS

It is important to remember the concept that a process automation SCADA system must be a TOOL that enables operators to run the plant more efficiently and continuously deliver high quality water for the customers while always staying in regulatory compliance. A TOOL must become intuitive and easy to use by people. To that end, installing a SCADA system based on open architecture hardware and software with a modern and universally accepted interface to people quickly becomes intuitive and easy for operators to use. They can think of how to operate the process and NOT how to operate the SCADA system.

The authority is developing an “Integrated Water Resources Master Plan” which will integrate all water facilities with the Sweeney WTP. Complete integration and central supervision of all facilities will provide better system and cost efficiency as well as pave the way for future growth and customer demand. The open architecture SCADA system at Sweeney will readily allow complete integration networking of all facilities for this central supervision and control strategy from Sweeney.

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ACKNOWLEDGEMENTS

Tiffanie Hawley – CFPUA Sweeney Water Plant Chief Operator
Michael Cunningham – Revere Control Systems - Software Technology Leader
## Appendix

### Combined Filter Effluent Turbidity Monitoring Report

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**State Report**

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