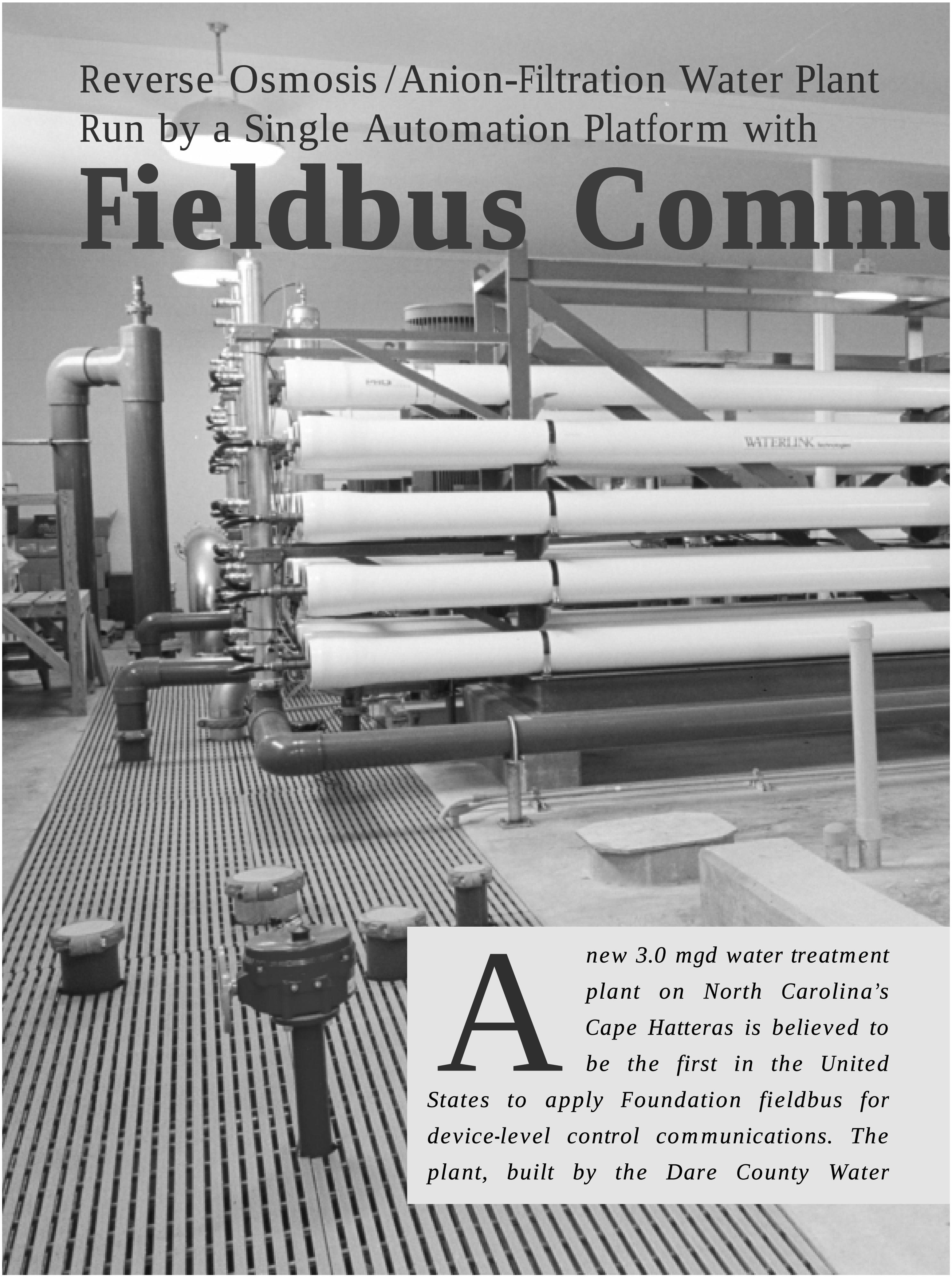
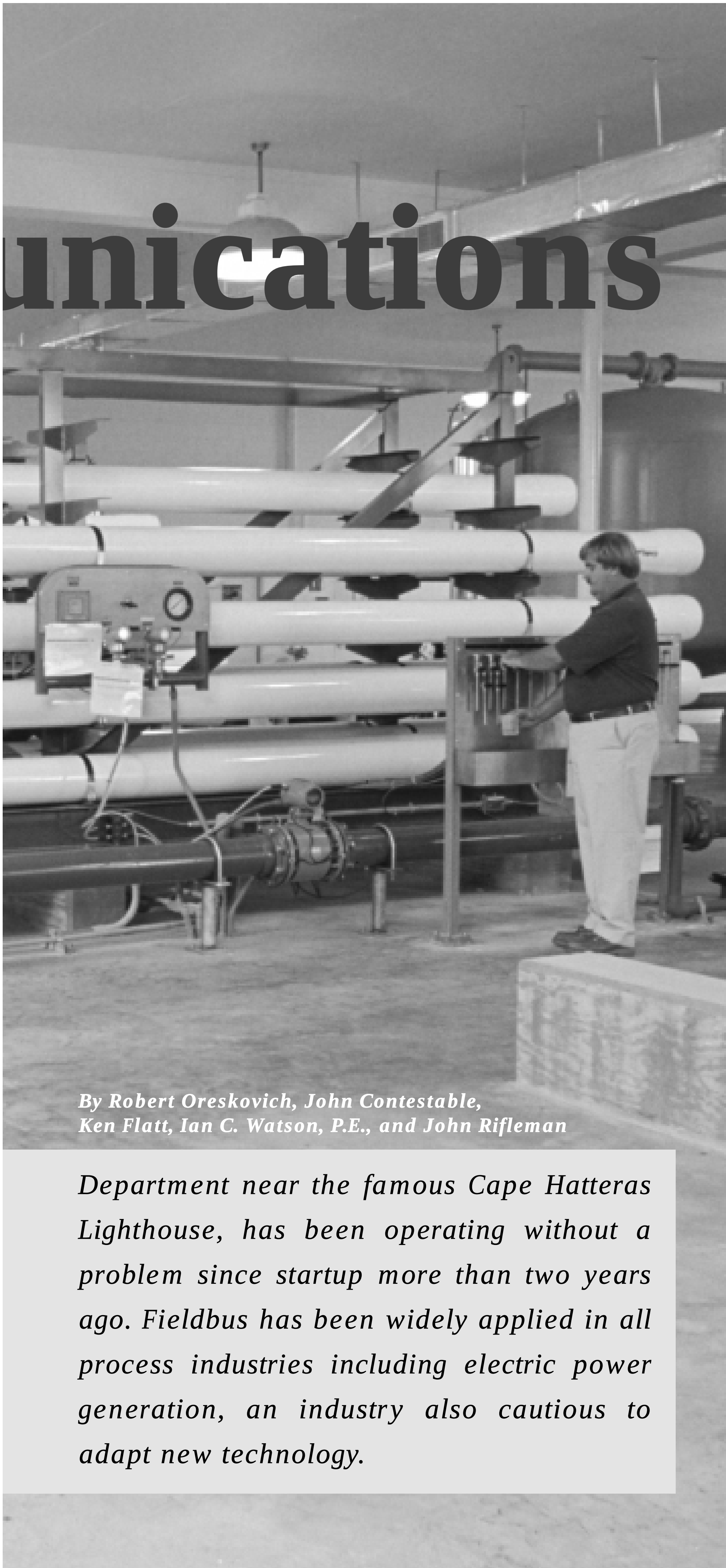
Reverse Osmosis/Anion-Filtration Water Plant Run by a Single Automation Platform with

Fieldbus Commu



A new 3.0 mgd water treatment plant on North Carolina's Cape Hatteras is believed to be the first in the United States to apply Foundation fieldbus for device-level control communications. The plant, built by the Dare County Water



unications

By Robert Oreskovich, John Contestable, Ken Flatt, Ian C. Watson, P.E., and John Rifleman

Department near the famous Cape Hatteras Lighthouse, has been operating without a problem since startup more than two years ago. Fieldbus has been widely applied in all process industries including electric power generation, an industry also cautious to adapt new technology.

The new facility, located in the town of Frisco, is unique in another way. A single, non-PLC automation platform runs all of the plant's equipment (i.e., reverse osmosis trains and pumps, anion exchange units and pressure filters, blending and distribution storage tanks and pumps, and remote well and tank telemetry). In most water treatment plants, these functions are served by several control panels or platforms that either do not talk or poorly talk to one another.

Two Treatment Plants in One

To best understand the control system, a short discussion on the makeup of the Frisco plant helps. The facility treats and blends water from two sources:

- A long-used shallow well field (40- to 80-feet deep) of highly colored, variable iron content water whose output cannot be expanded (for environmental reasons) beyond the field's present 1.6 mgd capacity, and
- Four new deep wells (200 to 300 feet) that take brackish water from high yield limestone formations.

To prolong the life of the existing shallow well field, production is being limited to 0.9 mgd. Supplementing this water are the brackish deep wells, whose water is treated by two 0.7 mgd trains (of three eventual trains totaling 2.1 mgd) of standard-pressure, high-rejection, single-stage reverse osmosis (RO) equipment. The resulting 2.33:1 RO permeate-to-shallow well production ratio will provide a well-buffered blend even at maximum plant output.

The shallow well water is being treated for color/TOC reduction by anion exchange plus oxidation and filtration for iron removal. By significantly reducing THMFP and virtually eliminating iron, the natural calcium hardness and alkalinity of this water blends advantageously with the RO permeate that contains virtually no hardness or alkalinity. Most of the vessels used in the former shallow

Water Systems Analyses Superintendent Ken Flatt samples water from one of two RO units at the Dare County Water Treatment Facility. The foundations for a third unit are in the foreground.

Looks Like a PLC

with the Preengineered Features of DCS

DeltaV represents a new approach to process control automation. It is a fully scalable, open-architecture platform that retains the strengths and functions of a traditional distributed control system (DCS) and adds the many advantages of a modern programmable logic controller (PLC).

The platform resembles a PLC in that it features compact and modular controllers that mount on DIN rails in non-air-conditioned field cabinets close to equipment being controlled. Like PLCs, the controllers internally communicate and powerup over a backplane. They also rely on compact, plug-in cards for CPU, power supply, I/O and bus communications functions. Off-the-shelf AI, AO, DI, DO, combination, digital bus and specialty I/O cards can be mixed and matched to the application.

Also evoking PLC systems, the automation's workstations normally are office grade PCs loaded with Windows NT. The stations can be concentrated in a control room, scattered around a plant or both. Graphics are based on the familiar Intellution PLC SCADA design. However, unlike PLC systems, widely accepted and open IEEE 802.3 Ethernet TCP/IP serves as the control network tying controllers and workstations together. Foundation Fieldbus and other open digital buses (AS-i, DeviceNet, Profibus DP) can be selected to connect field devices and device communications bricks. Proprietary networks and proprietary remote I/O buses are not necessary.

Because the technology is fully scalable from as few as 25 tags to as many as 30,000, each installation can be right-sized to the application. Low first point cost is possible, a major advantage for small and mid-size projects. Also, an installed base need not be discarded for a plant or system expansion. Last, end-user design, installation and service is a realistic option because of the technology's ease of use.

The new automation improves on PLCs with a number of important DCS features.

- A global database that is tag- rather than point-based.
- Programming by graphical configuration (using IEC 61131.3 languages) from libraries of proven control modules rather than writing ladder logic from scratch.
- Preengineered options for handling complex analog, regulatory, alarming, redundancy, safety and data capture requirements.

Perhaps the most compelling feature is the single, global database serving both controllers and workstations. Time-consuming and mistake-prone mapping between separate databases is unnecessary. The need to map PLC systems tends to discourage program alterations because of the reprogramming and checking efforts involved. Alterations also often require that a process be shut down.

The automation's global database also is tag based, which means that all data relating to one executable control module such as a PID feedback loop is located in the controller and has only one tag name. In other words, the tag carries its own PID parameter database of perhaps 25 or more values plus associated logic.

The DeltaV global database is object oriented. If a tag name is changed, the change is automatically reflected everywhere the tag is used. Because object-oriented programming of PLC systems is not possible, all linkages between points in controller logic must be traced and manually altered for every program change.

well treatment plant were reconditioned and installed in the new plant.

Each RO train is composed of 18 vessels of seven elements each, with each element providing 400 ft^2 of membrane. Because solute modeling predicts a steady increase in deep well total dissolved solids (TDS) over time to a limiting value of approximately 15,000 mg/L, the RO system has been designed to operate eventually at 50 percent recovery with an initial design recovery of 70 percent. The inclusion of energy recovery devices coupled with the planned reduction in recovery will maintain a relatively constant feed water pressure as recovery is reduced. This allowed the feedwater pumps to be selected for the full range of operating conditions. Space and foundations have been provided for a third RO train, to be installed when warranted by water demand.

Flatt checks the operation of the digital process automation controller running the entire water treatment facility. This controller is a key component of the field-based automation architecture.

High Efficiency Desired

To help minimize power costs as RO pump pressures eventually rise to 400 to 425 psi to overcome the rising TDS, each RO train utilizes high efficiency vertical turbine pumps driven by high efficiency 300 hp VFDs. The trains also incorporate energy recovery turbines that are expected to pay for themselves in 4½ years at the projected rate of TDS increase.

Other features of the new plant include permeate flushing of the RO systems plus, on the shallow well side, permeate backwashing of anion beds and permeate makeup for anion brining. Additionally, the RO system has an ultraviolet sterilizer to protect membranes should stored permeate become biologically active. The two water sources are blended prior to the addition of post-treatment chemicals (i.e., caustic soda, hydrofluorosilicic acid, sodium hypochlorite and a corrosion inhibitor). CO_2 stripping is not required.

Advanced Automation Simplifies Design, Installation

Operating the facility is the PlantWeb field-based process automation architecture from Emerson Process Management, Austin, Texas. The centerpiece of this architecture at the Frisco plant is a DeltaV digital process management system (ee "Looks Like a PLC" on page 12) consisting of the following.

- A single compact controller fitted with hot-standby redundant central processor unit (CPU) and power supply cards, two 2-segment Foundation fieldbus cards, numerous 4–20mA and discrete I/O cards, and one 2-segment serial communications card. (See photo above.)
- PC operator, application and engineering workstations. (See photo below.)
- An Ethernet network tying the controller and workstations together.
- Foundation fieldbus as well as conventional hard-wired field devices.
- Graphical configuration from a library of preengineered control modules using IEC Function Block Diagram and Sequential Function Chart languages.
- OSI (OSI Software, Inc., San Leandro, Calif.) PI historian for data capture, trend graphs and reports.

The automation was of particular interest to Dare County because a troublesome or failed component can be taken off line and the rest of the system will continue to run. Plant operations need not be interrupted to replace a component or recalibrate.

DeltaV is a powerful process control system that can be scaled from as few as 25 tags for running an OEM equipment skid to as many as 30,000 to operate a refinery. Because of this scalability, the cost of automating the Frisco plant was competitive with comparable PLC automation.

Fieldbus Saves Money and Time

The fieldbus cards serve 33 Rosemount pressure, temperature and dp pressure transmitters connected to venturi flow tubes and magnetic flow transmitters. The 4–20mA cards connect 12 turbidity, chlorine, pH and conductivity instruments plus 10 servomotor-operated butterfly valves (MOVs) for non-regulatory flow rate setting of lines serving two anion and three pressure-filter blending vessels. Fieldbus MOVs were not yet available. The serial card takes care of communications for the radio telemetry, the RO VFD pumps, three VFD distribution and backwash pumps and two VFD booster pumps feeding shallow well water to the anion system.

Although the cost of fieldbus devices was somewhat higher than conventional 4–20mA versions, the difference was more than overcome by the need for fewer conventional I/O cards, reduced engineering time when preparing drawings, faster configuration, reduced wiring material and labor costs and quicker installation and commissioning. Instead of 33 separate loop diagrams, two fieldbus one-lines were sufficient. When connected, the fieldbus devices were instantly auto-recognized, appearing on the engineering workstation with license plate data and settings available without looking in registers. No wire tracing and labeling, or

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instrument field calibration, was required. Startup proceeded quickly and smoothly.

All process logic is run within the controller, even though fieldbus devices can perform logic. There was no need to distribute control to enhance process reliability or heighten response. Plant operators are finding that troubleshooting fieldbus devices is simpler. Although the systems integrator, who is located in Florida, has the ability to access the automation and fieldbus devices remotely using pcAnywhere software, a need to assist operators in this manner has arisen only two times.

Graphical Programming

The systems integrator largely configured the Frisco plant process control system on site while supervising installation of both the RO equipment and the plant-wide control equipment. By bringing all plant areas into the single automation platform (RO system, anion and filter system, distribution and telemetry) configuration was much easier, faster, cheaper and better coordinated than trying to program and cobble together separate standalone control platforms. Further, operator monitoring/control of all plant functions is concentrated in the display screens of one interface.

The controllers, graphics, fieldbus instruments and communications and serial communications were developed using one configuration package. The system's global database also eliminated the need to map between separate controller and HMI databases. If a tag name was changed, the change automatically was reflected everywhere the tag was used.

The systems integrator divided the configuration into numerous small sections to ease troubleshooting by operators and maintenance technicians and to make it simple for an unfamiliar engineer to follow at some later date. All function blocks were drawn from a provided library with the exception of a derived totalizer block and faceplate prepared for the daily water output.

Two Configuration Languages Used

Sequential function charts (SFCs) served as the step-by-step and interlock backbones of the control system with function block diagrams added to create PID loops and other control details. For instance, function blocks were simply popped into the filtration system's SFC to tell the five valves on each vessel to perform their routines without having to write separate lines of ladder logic. Also, to shorten configuration time and minimize checking, the logic for one vessel was simply copied and pasted to create the other vessels. To make changes easier in the future, the logic for all vessels is located in one place in the configuration.

Plant Superintendent John Contestable (standing) and Plant Operator Chuck Ethridge monitor operations at the PC workstation. Through the window they can view the anion exchange vessels (left) and reverse osmosis units.

Graphic configuration simplified cascading the caustic and chlorine injection PID loops for pH control. Cascading is necessary because caustic and chlorine both affect pH, and water properties vary greatly depending on whether one or two RO units are in use or whether water is being blended. The cascaded loops react quickly to sudden changes in water quality and flow and slowly when near their setpoints, all the while precisely coordinating the ratio of caustic and chlorine injected.

The automation's historian generates three performance and efficiency reports per RO unit, a plant-wide alarm report and numerous plant-wide trend graphs for operators and management to assess operations and backtrack for finding causes should problems arise.

Future

The scalability of the control system means that the addition of the third RO unit at the Frisco plant as well as other possible expansions can be handled at minimal incremental expense.

It also means that the advanced automation is useful for any new or retrofitted water or wastewater treatment plants of any size or complexity. In fact, the larger and more complex the project, the more the strengths and resources of the process automation can be utilized. A 50-mgd or larger integrated membrane system for brackish surface water treatment plus conventional treatment for non-brackish water is well within the power of the automation.

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