Using SCADA for real-time water disinfection calculations, modeling and alarming

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Of the many operational challenges associated with delivering clean, reliable drinking water, the management of the disinfection process in surface-water treatment plants is among the most difficult. Raw water, whether from lakes or rivers, contains small amounts of naturally occurring pathogens that must be removed and/or inactivated before the water is fit for human consumption.

The key process step used to accomplish this in a multiple-barrier treatment process is primary disinfection. To work effectively, primary disinfection requires that the dosage of the disinfecting agent, water flow rates and the amount of time the water spends in contact with the disinfecting agent be carefully controlled, monitored and alarmed. This is an application where computerized supervisory control and data acquisition (SCADA) systems have proven to be an important tool.

Better primary disinfection calculation tools

Using mathematical models for modeling primary disinfection is not a new concept. In fact, disinfection regulations have existed in Ontario and various other jurisdictions for many years, specifying standardized "contact times" and disinfectant "dosage residual concentrations."

This has resulted in the CT (Chlorine concentration x Time) concept, whereby a standardized calculation is performed to verify compliance with regulatory requirements.

From a day-to-day operations perspective, water plant operators have dealt with these regulations in several different ways. Some have created standard operating procedures (SOPs) that require operators to complete hand calculations manually at set times during the day. Others have created spreadsheets, or have utilized complex third-party software applications to help them perform the calculations.

In Ontario, drinking water systems must comply with the *Safe Drinking Water Act*, along with its accompanying regulations, technical bulletins and standardized procedures. In 2006, the Ontario Ministry of the Environment issued a set of updates to its *Procedure for Disinfection of Drinking Water in the Province of Ontario* in the form of updated log inactivation tables.

Rather than seeing this change as just another modification to its existing spreadsheet tools, Niagara Region carefully thought about how it could leverage the new procedures and use them to help optimize its water plants. With the help of the engineering firm Stantec, the Region embarked on a project to use the new regulations to develop a more sophisticated, feature-rich, spreadsheet-based model of the primary disinfection processes.

By utilizing key disinfection-related process parameters, that an operator could

enter into the spreadsheet, the Region now had the ability to see exactly how well its disinfection processes were performing and use these figures for process optimization. After a successful pilot project, the Region implemented the updated spreadsheet models at a number of its facilities.

While the spreadsheets were accurate, they did not offer a real-time view of the CT value. Each time operators wanted to use the spreadsheet, they had to collect the relevant process values from the plant and enter them into the calculator. What the Region really wanted was to be able to use the spreadsheet calculations in real time and free the operator from having to enter in numbers manually each time.

Fortunately, the Region already had the powerful tool of SCADA in each of its water treatment plants. In fact, when operators were entering numbers into the spreadsheet, they were getting information from the SCADA system's computer screens. So why not put the spreadsheet functionality right into the SCADA system?

Leveraging SCADA technology

With the help of Eramosa Engineering, R.V. Anderson Associates Ltd. (RVA) and Stantec, the Region converted the spreadsheet calculations into real-time programming in the SCADA system's programmable logic controllers (PLCs). By using one of its smaller plants as a pilot, and by consulting with the operators who would use the new online calculator, the team created a set of computer screens that displayed a schematic of the CT process, key disinfection process parameters and the all-important "chlorine concentration and time " calculations.

Eramosa and RVA jointly implemented the real-time online calculator and the results were positive. Operators especially appreciated that CT calculations could now be done in real time, utilizing live process values.

Based on the successes of its pilot project, the Region embarked on a program to add the new SCADA-based CT calculator to the rest of its surface-water treatment plants. By 2008, all of Niagara Region's plants were either using the new calculator, or in the process of having it installed.

Additional features possible with SCADA

The original CT calculation spreadsheet included the determination of a "safety factor" for the disinfection process. Measured as a percentage, it gave operators an indication of how much additional active disinfection capacity they had available at any time. Good operating practice is to always maintain some additional online capacity, but not too much. Having too much extra online capacity is costly, can result in higher chemical use than necessary, can potentially affect disinfection by-product formation, and the taste/smell of the treated water.

The inclusion of prioritized real-time alarming was another major advantage of the new system. Using the SCADA alarm system, the CT calculator can offer both "warning" and "critical" level alarms. If calculated CT values continue to decrease below the warning level, the SCADA system issues a critical alarm, set at a higher priority, which notifies operators that the disinfection system re-

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quires immediate attention.

As an added feature for the operators, a "virtual calculator" was incorporated into the PLC logic and SCADA. Operators like the tool, because they can quickly check to see what the effect of a proposed process change would be, such as operating at a lower reservoir level, or turning on an additional high lift pump, without having to type all of the values into an offline spreadsheet. When they want to test out a process adjustment, they can simply enable the virtual calculator by clicking a button on the SCADA screen, adjust the values in the virtual calculator in which they are interested and witness the outcome. This provides operators with a higher level of control over the disinfection process.

The CT calculators have also been seen as a benefit with local regulatory agencies, as they enable enhanced reporting and trending information.

Putting technology investments to work

When it implemented the online CT calculators, the Region was careful to leverage existing technology investments, instead of using a third-party application.

Additionally, the online CT information, calculations and alarms were easily integrated into the Region's existing historical SCADA databases. Best of all, by using the existing SCADA infrastructure, the Region now had a system that could be easily maintained, without requiring the ongoing services of an outside consultant.

Real-time calculations as a technology

Using the SCADA system for online calculations and implementing real-time process models, such as the Niagara Region's primary disinfection processes, enables this technology to be applied to a wide variety of processes and applications.

For the Region's disinfection CT calculators, real-time process values such as flows, temperatures, levels and pH, along with physical plant geometry, are used to calculate actual disinfection performance. Values calculated by the SCADA system include the actual CT, minimum required CT, log reduction achieved, log reduction required, and derived values such as a safety factor.

To use this same technology for other applications and processes, the inputs and outputs and the programming that links them together could be easily replaced by other mathematical models. Other municipal waterworks applications could include implementing process models for reverse osmosis membrane performance, monitoring degradation for residual secondary disinfection and modeling ongoing filter performance.

This technology could be used in wastewater treatment for mass balance calculations, thickening/dewatering processes, and tracking solids transport in activated sludge systems.

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