WATER QUALITY SENSORS

Overview of Water Quality Sensors as Pertinent to Water Distribution Systems

There are a variety of reasons to employ water quality sensors in water distribution systems. Contamination by cross-connections with non-potable water, contaminated water entering the distribution system through leaking pipes in an area of low pressure, or microbial growth in the distribution system pipes are always management concerns (EPA 817-R-07-002). Nationally recognized water security experts have identified distribution systems as very vulnerable to attack because of the physical characteristics of the piping systems and the lack of monitoring and surveillance of the systems (WaterSentinal). Identifiable threats or indications of possible contamination are a management concern (EPA 817-R-07-002).

Water quality sensor data are used for decision-making on a variety of management issues. These include but are not limited to: 1) identifying compliance with regulatory water quality requirements; 2) identifying non-regulatory water quality for critical users (e.g., at industries requiring certain process water chemistry) and at other important locations throughout the system; 3) verifying water quality modeling; 4) planning hydrant flushing; and 5) implementing a contamination warning system (CWS).

A CWS is a proactive operation to generate distribution systems water quality data and combine that with a variety of other information to continuously monitor for the presence of unexpected contaminants in the system (Contamination Warning System CIPAC 2012). The intent of a CWS is to minimize the number of people who are negatively impacted by a contamination event in a distribution system. The location of the sensors for a CWS is critical to minimizing the people impacted. A number of computer programs exist that are used to optimize the location of water quality sensors for a CWS. WaterSentinel is a federal program to advance the knowledge and use of CWS in water utilities (see http://water.epa.gov/infrastructure/watersecurity/index.cfm). Threat Ensemble Vulnerability Assessment Sensor Placement Optimization Tool (TEVA SPOT) is software that optimizes the locations of water quality sensors to be used as components of a CWS in a distribution system (see https://software.sandia.gov/trac/spot).

The chemical, physical, and biological conditions of water form its quality. Even minute changes in these characteristics can impact the people and industries that depend on water. To preserve its quality, monitoring water parameters such as conductivity, pH, salinity, temperature, dissolved oxygen, chlorine residual and turbidity is crucial. For the same reason, water quality sensors have become common in most modern distribution systems.

www.veoliawaterst.com

Water quality sensors are employed using two main approaches. They are either used to directly measure constituents of interest (chemical concentrations, solids, etc.) in the water, or to measure surrogates. Surrogates are chemical concentrations or solids that may indicate the presence of unanticipated contaminants in the water.

Many types of water quality sensors are available. Below is a list of the most common ones in use.

Chlorine Residual Sensor - Measuring chlorine residual in drinking water treatment plants and distribution systems is a common process and has been necessary as long as chlorine has been used in water treatment. Chlorine is the most widely used disinfectant because of its efficiency and cost. Chlorine sensors measure free chlorine, monochloramine, and total chlorine. The primary application is drinking water disinfection, although total chlorine is also often measured in treated wastewater, including reclaimed wastewater.

TOC Sensor - Total organic carbon (TOC) is an important parameter for water quality analysis. It is used as a direct indicator and a surrogate for many water quality purposes. There are two different TOC measurement devices available on the market: TOC analyzers and TOC sensors. If the intended use is for regulatory reporting, managing an important process control variable, real-time release, or other critical-to-quality product attributes, instrument accuracy is essential. If the intended use is for general TOC monitoring—not for making critical quality decisions—then other characteristics may be more important than accuracy. Sensors are typically used to monitor a process and the data collected from them is used for information only.

www.geinstruments.com

Turbidity Sensor - Turbidity sensors measure suspended solids in water, typically by measuring the amount of light transmitted through the water. They are used in river and stream gaging, wastewater and effluent measurement, drinking water treatment process and control, control instrumentation for settling ponds, sediment transport research, and laboratory measurements.

Conductivity Sensor - Conductivity measurements are carried out in industrial processes primarily to obtain information on total ionic concentrations (e.g. dissolved compounds) in aqueous solutions. Widely used applications are water purification, clean in place (CIP) control, and the measurement of concentration levels in solutions. The measuring system consists of an appropriate inline sensor directly inserted or in a housing, a cable connected to a transmitter converting the received signals to a measurement result or forwarding it to a DCS


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pH Sensor - pH is an important parameter to be measured and controlled. The pH of a solution indicates how acidic or basic (alkaline) it is. pH sensor components are usually combined into one device called a combination pH electrode. The measuring electrode is frequently glass and quite fragile. Recent developments have replaced the glass with more durable solid-state sensors. The analyzer or transmitter has a man-machine interface for calibrating the sensor and configuring outputs and alarms, if pH control is being done.

ORP Sensor - ORP sensors measure the Oxygen-Reduction Potential of a solution. Used in tandem with a pH sensor, the ORP measurement provides insight into the level of oxidation/reduction reactions occurring in the solution. The ORP Sensor requires a compatible interface and software to collect data.


www2.emmersonprocess.com

For many system applications these sensors provide an indication of water quality conditions. A properly designed water quality monitoring system can provide valuable information to operators and engineers that can be used to calibrate their hydraulic models, predict formation of regulated substances, provide compliance data and track the change in quality over time which in turn helps system operators make important decisions about water treatment unit processes and operational conditions. When used in tandem with a modern SCADA system these sensors become the eyes and ears of system operators, providing real time actionable information that can be used to maintain and optimize the water quality in distribution systems.

Sensor Equipment Sources

Several sources of water quality sensors are

- ABB, abb.com
- GE, ge.com
- Hach, hach.com
- Siemens, siemens.com
- Emerson, emersonprocess.com
- Yokogawa, yokogawa.com/us

This is a brief list of manufacturers. A more complete list is provided below.

Water Quality Sensors Costs and Specifications

Site specific installation cost projections need to be developed. Typical cost components in the total cost of a sensor installation at each potential location include:

- Land purchase
- Construction of the vault in which the sensors and connections to the distribution piping will be located
- Installation of the sensors and RTU
- Supplying power to the site
- Installing the communications equipment and upgrading/installing equipment at the central control room
- Design and bidding the construction and installation work
- Access to site
- Security fencing and lighting

There are two generic types of SCADA and sensor specifications. These are the Use Requirements Specification and the Detailed Technical Specification type. Either type of specification should include a complete explanation of the intended uses of the sensor data, and details of existing SCADA components (system architecture) with which the sensor system will must be integrated, and require operator training associated with the sensors and sensor data management.

The Use Requirement Specification identifies the data to be sensed and the uses of the data. It leaves the technical details up to the suppliers and contractors. In general, this type of specifications takes less time and cost to develop than the Detailed Technical Specification. It may also allow greater competition from bidders. However, it does reduce the ability of the Utility to control who bids on the project, if that is of interest for any reason.

The Detailed Technical Specification includes detailed specifications for each item in the system to be constructed/installed. The specifications are usually provided by the supplier who assists the designer in the design of the sensor system. Detailed specifications are often used to reduce the number of bidders, or to try to exclude certain products, types of products, or bidders. However, when federal funds are used to pay a portion of the cost of the construction/installation, these specifications are required to include multiple supplier names and/or an “or equal” statement. A potential pitfall to using a Detailed Technical Specification is not including the specification for one or more of the components of the system.

Technical specifications and costs are impacted by 1. measurement sensitivity, 2. monitoring range, 3. measurement accuracy, 4. measurement response time, 5. measurement interferences, 6. installation location restrictions (e.g., turbulence interference), 7. routine maintenance required, 8. sensor life expectancy, 9. calibration methods and frequency, 10. materials of construction, 11. installation methods, and 12. other technical requirements that are based on the experience of the distribution system SCADA technical experts. This information should be included in either the Use Requirement Specification or the Detailed Technical Specification.

Most Efficient Strategy for Obtaining Water Quality Sensors

When considering a SCADA system and the associated components, there are traditionally two methods that are utilized for implementation. These methods are:

- **Design-Bid-Build Method**
- **EFI (Engineer, Furnish and Install) Method**

Listing of Water Related Sensor Manufacturers 2012

ABB	Eureka Environmental Engineering	Mena Water
ADS Environmental Service	Eutech*	Meter Master
Advanced Measurements & Controls	GE	METTLER TOLEDO
Anacon	Georg Fischer	multitrode
Analytical Sensors & Instruments Ltd	Global Water Instrumentation, Inc.	Oakton Instruments
Analytical Technology	Hach	OI Analytical
AquaMetrix	Hanna Instruments	Omega Engineering, Inc.
Arjay Engineering	HF Scientific	Process Instruments (Pi)
ASA Analytics	Honeywell	ProViro Instrumentation
Banner Engineering	Horiba	Real Tech
BeLink	Icx Technologies (FLIR)	RMS Water Treatment
Cambell Scientific	In USA Inc.	Rosemount*
Chemical Injection Technologies, Inc. (Superior)	Inficon	Scan Measurement Systems
Cole-Parmer	Innovative Components	Severn Trent Services
Control Micro Systems	Innovative Waters	Siemens
Datalink Instruments	In-Situ Inc	Stedham Electronics
DEVAR Inc.	Invensys	Stevens Water Monitoring Systems, Inc
EMEC Liquid Control Systems	Itron	Thermo Scientific
Emerson	ITT Water and Wastewater	Vega Controls
Endress + Hauser	JMAR	Wedgewood Analytical
Entech Design	Keco Engineered Controls	YSI
Environment SA		