HYDRAULIC SENSORS

General Overview of Hydraulic Sensors as Pertinent to Water Distribution Systems

Hydraulic sensors are common place in most modern water distribution systems. By far, the two most common hydraulic sensors found in a water distribution system are:

- Pressure Sensors – A manual read-out pressure sensor is commonly referred to as a pressure gage. Pressure gages have been around for several centuries and are proven accurate and reliable. Pressure gages were one of the first sensors integrated to meet our digital needs. In modern SCADA systems, pressure sensors are simply pressure gages that are connected to a 4-20 mAmp analog signal and calibrated over a specific pressure range. For example, if you wanted to measure system pressure on a scale from 0 to 100 psi. One would simply calibrate the 4 to 20 mAmp signal over the 0 to 100 psi range on the pressure sensor. This would translate a 4 mAmp signal to a corresponding pressure of 0 psi, and a 20 mAmp signal to 100 psi. Pressure can be a function of static water pressure or dynamic pressure. An example of static water pressure is measuring the water level in a storage tank, and an example of dynamic water pressure is measuring the water pressure in a water line in the distribution system, in order to monitor transient pressures or pipe bursts.

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- Flow Sensors – Methods to measure flow rates have also been around for many centuries. Some of the earliest methods are still in use today, such as pitot tubes, venturi systems that measure differential pressure, microturbins, or pressure sensitive probes that measure the bending force on the sensors tip to measure water velocity, and thus a corresponding flow rate. More modern flow meters utilize electromagnetics, vortex swirl measurement, or Coriolis mass measurement methods. Similar to the pressure sensors, the output is analog in nature and is calibrated over the 4-20 mAmp signal to provide a flow output.


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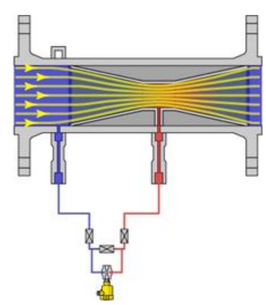
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Uses of Hydraulic Sensor Data

For many system applications flow and pressure sensors give an adequate sense of the current operating conditions of water distribution systems. A properly designed hydraulic monitoring system can provide valuable information to water system managers that can be used to analyze current and historical demand, detect pipe bursts, identify illegal connections, optimize system efficiency, and a variety of other uses. In addition to operations, hydraulic sensors have the capacity to detect unauthorized intrusions and can be a valuable security tool when combined with the proper software. When used in tandem with a modern SCADA system these sensors become the eyes and ears of system managers, providing real time actionable information that can be used to maintain and optimize a water distribution system.

The typical suite of hydraulic sensors includes flow and pressure. These sensors are used in conjunction with a SCADA system, hydraulic computer model, or both which provides a means to analyze the real time or forecasted hydraulic parameters within a water distribution system. The hydraulic sensors connect to an RTU/PLC via hardwire or wireless connection and stream hydraulic data through the communication network on demand or at set time intervals. This data ultimately ends up at the HMI and/or SCADA Master where it is presented to the end user for analysis, or compiled in a historian (database system) where it can be accessed for forecasting demand patterns, evaluating system efficiency, and analyzing system hydraulic head deficiencies.

Hydraulic sensor data play an important role in distribution system management. Uses of the data include but are not limited to: 1) assure adequate flow of water for supply and fire-fighting to industries, schools, and other critical users or locations in the system; 2) identify water turnover in ground and elevated water storage tanks; 3) detect major water loss incidents; 4) plan hydrant flushing; 5) verify distribution system hydraulic modeling; 6) verify distribution system water quality modeling; 7) identify distribution system valve problems; 8) provide data that is used as a component of a contaminant warning system (CWS), 9) provide an understanding of flows and pressures in the distribution system to analyze water quality issues, assure adequate fire flows and system pressures, etc.

In a number of situations, it may be of value to have both hydraulic and water quality sensor data from the same location in the distribution system for decision making. It should be expected that combining both types of sensors in the same location will be less costly than having two monitoring stations. Making this decision must be on a case-by-case basis.

Sensor Equipment Sources

Several sources for hydraulic sensors are:

- ABB, abb.com
- Ashcroft, ashcroft.com
- Holykell, holykell.com
- Honeywell, honeywell.com
- Keyence, keyence.com
- Truck, truck-usa.com

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

Hydraulic Sensors Costs and Specifications

The cost of the sensors is frequently a very small portion of the cost of the sensor installation. (Berry et al, 2005) Site specific installation cost projections need to be developed. A variety of cost components are involved in the installed cost of sensors in a distribution system. These 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 (Berry 2005). Other costs include design and bidding the construction and installation work, access to the site, and security fencing and lighting. Obviously, the more remote and/or less accessible the location of the sensors, the higher the installed costs will be.

Combining hydraulic and water quality sensors in the same locations should yield lower installed costs for all the sensors in the system. However, the efficacy of combined installations with respect to the management, operations, and/or future design decisions needs to be considered. The authors' collective experience has shown that some distribution systems have long-standing water quality problems associated with excess water residence time in some areas in distribution systems that are a considerable distance from the water treatment. This is especially true of water supplies that purchase their treated water from other utilities. Because the sensors themselves are such a small portion of the total installed costs, it appears to be prudent to optimize the number of locations by carefully deciding the combinations of sensors at each RTU.

Pricing surveys conducted at the time of this report showed as much as two orders of magnitude cost differences on sensors that appear to be equivalent in nature. Determination of value (relative to price) is a process that you should rely on your design consultant to help you with. However, some considerations to try to stay aware of include:

- Product customer service and technical support: Customer service is a series of activities designed to enhance the level of customer satisfaction – that is, the feeling that a product or service has met the customer expectation. Customer service includes providing technical support in an easy to understand and effective manner.
- Warranty: No piece of hardware can be warrantied forever. However, the longer the warranty the better the indication that the sensor is made from quality materials and quality components.
- Sensor replacement availability: This is an important question that needs to be considered. If the sensor you plan to install in your system is not readily available, then perhaps a different sensor or manufacturer should be considered.
- Ease of maintenance and testing: A water system operator understands that all equipment that needs to be regularly maintained and/or tested needs to be easily accessible. However, not all equipment manufacturers understand that the equipment being maintained and/or tested equally needs to be operator-friendly. Be sure to take into account how easily regular maintenance and testing can be performed on the sensor.
- Compatibility with the rest of the SCADA system: If you have an existing system, new sensor compatibility is an absolute requirement, or else you are essentially buying a new stand-alone piece of equipment.

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 specifications 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 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 specification 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 Hydraulic Sensors

When considering a SCADA system, 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		