Technical Publication

Accurate Gas Flow Measurement Improves Water Disinfection Process Efficiency

By Tristan J. Williams, Sr. Member Technical Staff
Fluid Components International

FLUID COMPONENTS INTERNATIONAL LLC

Visit FCI on the Worldwide Web ■ www.fluidcomponents.com
Headquarters ■ 1755 La Costa Meadows Drive
San Marcos, California 92078 USA
Phone 760-744-6950 ■ **Toll Free** 800-854-1993 ■ **Fax** 760-736-6250

European Office ■ Persephonestraat 3-01 5047 TT Tilburg, The Netherlands
Phone 31-13-5159989 ■ **Fax** 31-13-5799036

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Figure 1. Thermal Mass Flow Meter

Many of today's large urban water treatment plants rely upon sophisticated chlorination processes in order to provide clean, sanitary water to millions of consumers in the US and around the globe. The efficiency and cost-effective operation of chlorination processes in water treatment facilities can be significantly improved with the installation of flow meters that accurately measure the flow of chlorine gas in the treatment process.

Turning raw water obtained from various ground or surface water supplies into clean potable water fit for human consumption or industrial purposes requires the removal of contamination sources. Such sources can include algae, bacteria, fungi, minerals, parasites and viruses. Many of these contaminants are potentially dangerous or even lethal to humans. Some contaminants merely affect the taste of water and are removed to make the water more palatable.

There are three major stages of water treatment: primary treatment occurs that involves screening of water during the collection phase from ground or other sources. Secondary treatment removes fine solids and contaminants with filters and other techniques. Tertiary treatment includes disinfectant and other processes that improve taste and overall quality. Flow measurement is involved at all three stages in the process, but gas flow measurement is critical during disinfection processes that rely on chlorine gas.

The proper dosing of chlorine into the water filtration system requires precise and repeatable flow measurement of chlorine gas. Chlorine gas is a toxic gas that can be a deadly hazard to plant employees if improperly handled or if there are leaks in tanks, lines or valves. This gas is also corrosive and reacts with instrument-wetted materials over time, potentially causing oxidation and failure.

When too little chlorine is added to the water, disease problems can result that affect people's health. When too much chlorine is added, the quality of taste can resemble a "swimming pool" flavor. To ensure the right amount of chlorine is added to water, water plant technicians continuously monitor the process and rely on flow meters for precision chlorine gas flow measurement.

Flow Measurement Problems

In a typical large urban municipal water plant, a distributed control system (DCS) controls the flow of liquid chlorine through a pipe line to a chlorination building. The liquid chlorine is circulated through an evaporator that boils it and the gaseous vapor is drawn off. The chlorine gas is then added to the water in precise and accurate concentration levels as measured by a gas flow meter to ensure high quality and safe potable water.

The water plant staff continuously monitors the quality level of incoming water from its distribution network to determine the correct amount of chlorine necessary to achieve water purity. Gas flow meters are typically inserted in the chlorine gas process piping, which are then connected via input/output (I/O) modules to the control system. The control system then continuously controls the amount of chlorine required for water purity.

There are some challenging problems associated with metering chlorine gas. It is corrosive, wet, and the flow rates can be extremely low for this type of application. Some flow meter sensing technologies are better suited to measuring low flow chlorine gas levels than others for this type of application. Moving-part designed flow meters are generally more subject to corrosion damage in chlorine gas, while differential pressure type flow meters tend to suffer from inlet plugging. The result can be degraded performance, more frequent maintenance needs and added maintenance costs.

The Chlorine Gas Flow Solution

For this reason, water treatment plants have often turned to thermal mass flow meters such as the GF90 Flow Meter manufactured by Fluid Components International (FCI) (Figure 1). Thermal mass flow meters are available from several manufacturers, and they are widely recognized for their superior accuracy in air/gas flow

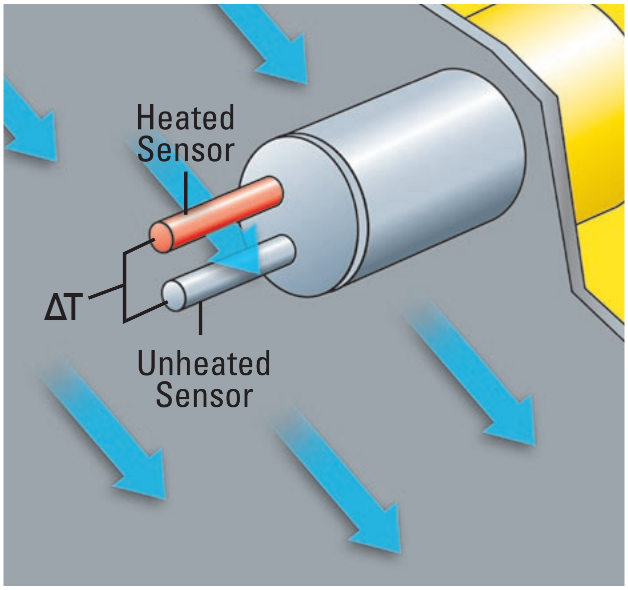

Figure 2. Thermal Mass Flow Sensing Theory of Operation

applications in challenging environments, such as chlorine gas in water treatment plants.

A thermal type flow meter employs a no-moving parts flow sensor that is inserted directly into the chlorine gas pipe line with no orifices to foul. A typical thermal flow meter measures gas flow over a wide range from 0.25 to 1600 fps (0.08 to 488 NMPS). Some designs use a constant current thermal technology that provides a stable and repeatable reading in the wet gas because the flow meter returns to natural equilibrium even if the sensor surface is fouled.

The flow accuracy of an industry standard thermal flow meter is +1 percent of reading, +0.5 percent of full scale, which is suitable for chlorine gas measurement in water treatment plants. The repeatability of such a flow meter is +0.5 percent of reading—again supporting the need for reliability in a critical process with potentially hazardous operations. The turndown ratio is generally factory preset and field adjustable from 2:1 to 100:1 within the calibrated flow range, but can be set as high as 1000:1 depending upon the application's characteristics. Some more advanced microprocessor-based thermal flow meters also have the ability to support multiple calibration groups that can further enhance the flow meter range.

Thermal mass flow rate is determined by measuring the temperature rise ("heat gain") or the temperature drop ("heat lost") of a constant powered heated sensor (Figure 2). Thermal sensing is one of only a few technologies that measure mass flow rate; it is also one of the few technologies that can be used for measuring gas mass flow in large pipes, ducts, or stacks. Measurement of the fluid temperature is also provided by thermal technology.

A thermal mass flow sensing element contains two thermowell-protected platinum resistance temperature detectors. When placed in the process gas stream, one resistance temperature detector (RTD) is heated and the other RTD senses the process gas temperature. The differential temperature between the two RTDs is directly related to the process gas flow rate and the specific properties of the process gas. Higher flow rates due to higher velocities or more dense media cause greater cooling of the heated RTD and a reduction in the RTD temperature differential, making possible the precise measurement of the gas flow rate over a wide flow range.

The flow element is manufactured out of a material compatible with the gas. In most cases, Hastelloy C is adequate, however, other exotic metals are also available. In addition, the typical insertion flow element results in a negligible pressure drop in most applications. This benefit can translate into significant reductions in energy usage and thereby result in a more cost effective process.

Many flow meters feature a local LCD display. A typical display includes four lines of 20 characters that generally indicate flow rate, total flow, temperature, relay status, current calibration mode and sample rate. Meters with microprocessor-based transmitter can provide a 4-20mA output with an RS-232C serial port for communications. A variety of communication buses are available for flow meters of all types, including PROFIBUS, HART, Modbus and Ethernet. Dual relays are included for low and high flow alarms.

Conclusions

Measuring chlorine gas for water disinfection applications is challenging due to the wet and corrosive nature of the gas, as well as the relatively low flow levels of gas that must be measured with accuracy. When choosing a flow meter for this application, be sure to consider how reliably the meter will perform at the low end of the flow range and select an instrument that also performs well in wet gas. Don't forget that chlorine gas is corrosive and remember to specify your flow meter with corrosion-resistant materials. ■