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WHITEPAPER

New Developments in Thermal Dispersion Mass Flow Meters:

Real-Time Adjustments for Changes in Gas Composition at Low Flows

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INTRODUCTION

Accurately measuring the flow of gas mixtures is often complicated by changes in composition over time. Over the last five years, multi-path ultrasonic meters have been an ideal technology for applications with changing gas compositions. Ultrasonic meters infer density from the speed of sound; therefore, they are immune to changes in gas composition. However, recent updates to federal regulations require gas flow measurement at flow rates as low as 0.1 fps (0.03 mps). Ultrasonic flow meters can only measure flow greater than ~1 fps. Even though ultrasonic meters can handle changes in gas composition, they cannot measure down to the required low flows for EPA compliance. Gas users and producers need an alternative technology to comply with EPA regulations.

"QuadraTherm® thermal flow meters can provide real-time adjustments to gas composition changes by integrating with ... a gas chromatograph."

With advancements in thermal technology, Sierra's QuadraTherm® Thermal Mass Flow Meter offers a viable alternative to ultrasonic technology to comply with these new EPA regulations. Sierra's QuadraTherm has a wide flow range of 0.1 to 1000 sfps (0.03 to 305smps) and the ability to compute the properties of a specified gas mixture to manage changes in gas composition, gas temperature, gas pressure, and outside temperature. To take this technology a step further, QuadraTherm thermal flow meters can provide real-time adjustments to gas composition changes by integrating with a compositional sampling device, such as a gas chromatograph. The gas chromatograph determines the properties of the gas mixture as they occur real-time. This data is relayed to the meter and direct adjustments to the gas composition are then applied to the meter calibration settings. This immediate compensation maintains meter accuracy as both composition and flow rates vary. This breakthrough in thermal dispersion mass flow meters, along with the ability for accurate measurement at low flows, provides an immediate solution for gas applications, including distribution systems, flare gas produced in refineries, and flare gas produced in other applications, such as hydraulic fracturing.

BACKGROUND

In 2009, the EPA released the Mandatory Reporting of Greenhouse Gases Rule (40 CFR 98). All facilities emitting at or above 25,000 metric tons of CO_2 annually are required to report annual emissions. The most recent estimates indicate that there are over 5,500 facilities in the U.S. meeting this threshold. A typical accuracy of 5% is required by rule EPA 40 CFR 98, along with periodic flow calibration verification.

On February 1, 2016, amendments to 40 CFR 60.106a(a)(6)(i)(B) and (7)(i)(B) specified that refineries measuring flares must use a flow sensor meeting an accuracy requirement of ±20% of the flow rate at velocities ranging from 0.1 to 1 foot per second and an accuracy of ±5% of the flow rate for velocities greater than 1 foot per second.

"...EPA regulations present new hurdles for gas measurement because the requirement for low flow measurement is beyond the capability of many of the commonly used flow meters..."

THE CHALLENGE

These EPA regulations present new hurdles for gas measurement because the requirement for low flow measurement is beyond the capability of many of the commonly used flow meters, like ultrasonic and vortex flow meters. In addition, the flow of gas in applications such as distribution systems, flaring, and hydraulic fracturing often undergo changes in composition. Most flow meters that measure mass flow rate, except Coriolis meters, require knowledge of gas properties. Flow meters are then calibrated at the factory with a surrogate gas or gas mixture to match the gas properties of their application. In the field, these properties can change not only with the temperature and pressure in the pipeline, but also with any change in gas composition. These changes degrade the accuracy of mass flow rate measurement, left uncorrected, errors of 10% or more can occur. Traditionally, such changes in gas composition required returning the mass flow meter to the factory for flow recalibration wasting time, resources, and money.

EPA MANDATORY GHG REPORTING (40 CFR 98)

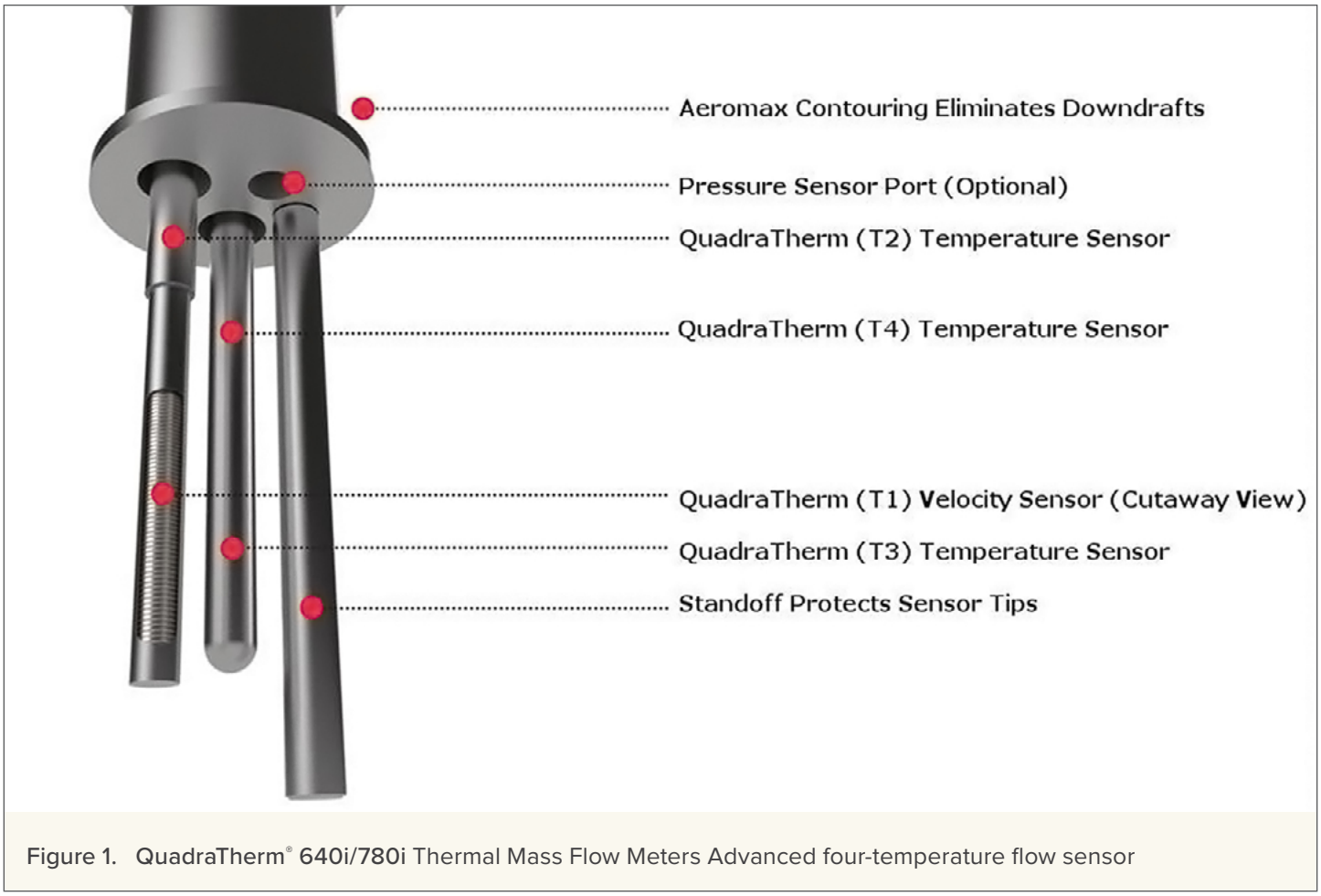

Figure 1. QuadraTherm® 640i/780i Thermal Mass Flow Meters Advanced four-temperature flow sensor

THE SOLUTION

With new advancements in thermal technology, QuadraTherm 640i/780i thermal mass flow meters can read low flows and manage changes in gas composition without factory recalibration. The Sierra QuadraTherm is a microprocessor-based thermal dispersion mass flow meter that uses four-temperature sensing elements (See Figure 1) in its flow sensor instead of the traditional two elements in conjunction with an advanced mathematical model. This new sensor technology is capable of yielding a high accuracy heretofore unachievable in thermal dispersion mass flow meters (inline +/- 0.5% of reading, insertion +/- 0.75% of reading).

The QuadraTherm also has a greatly extended flow range compared to prior generations of thermal flow meters from 0.1 up to 1000 sfps (0.03 to 305 smps).

THE qMIX™ APP

QuadraTherm thermal flow meters use a custom Sierra gas mixing app called qMix™, which is the underlying engine enabling the QuadraTherm to compensate for changes in gas composition. The qMix app has a library of over 120 pure fluid components and facilitates building any natural gas or other mixture from these components to allow for determination of the gas properties. With qMix, oil and gas engineers can create new gas mixtures.

qMix computes updated calibration settings which account for the change in composition. These updated calibration settings are then loaded to the meter and result in a direct adjustment to flow output—all while retaining accuracy without factory recalibration (See Figure 2).

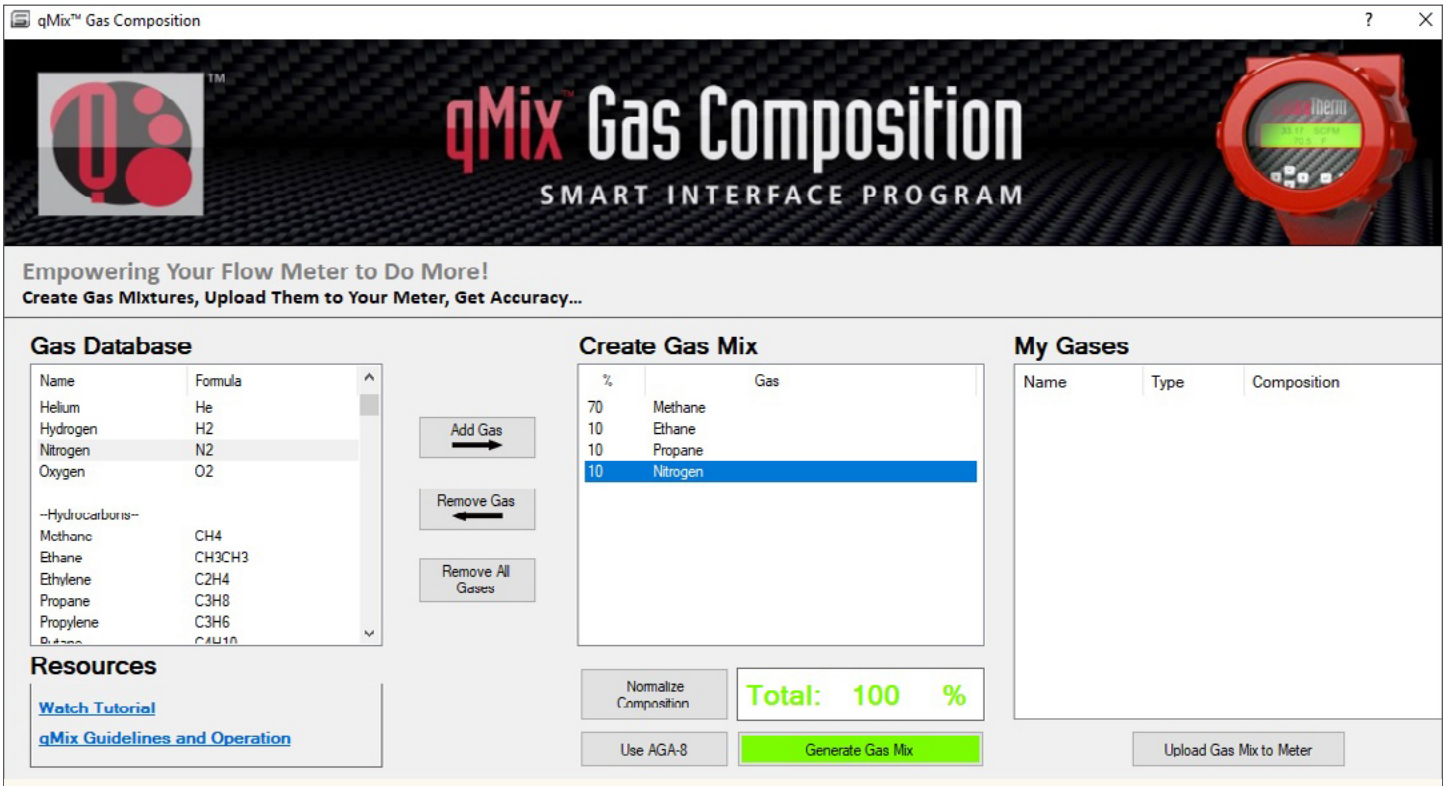

Figure 2. qMix™ App gas mixing user interface - create gas and upload to meter

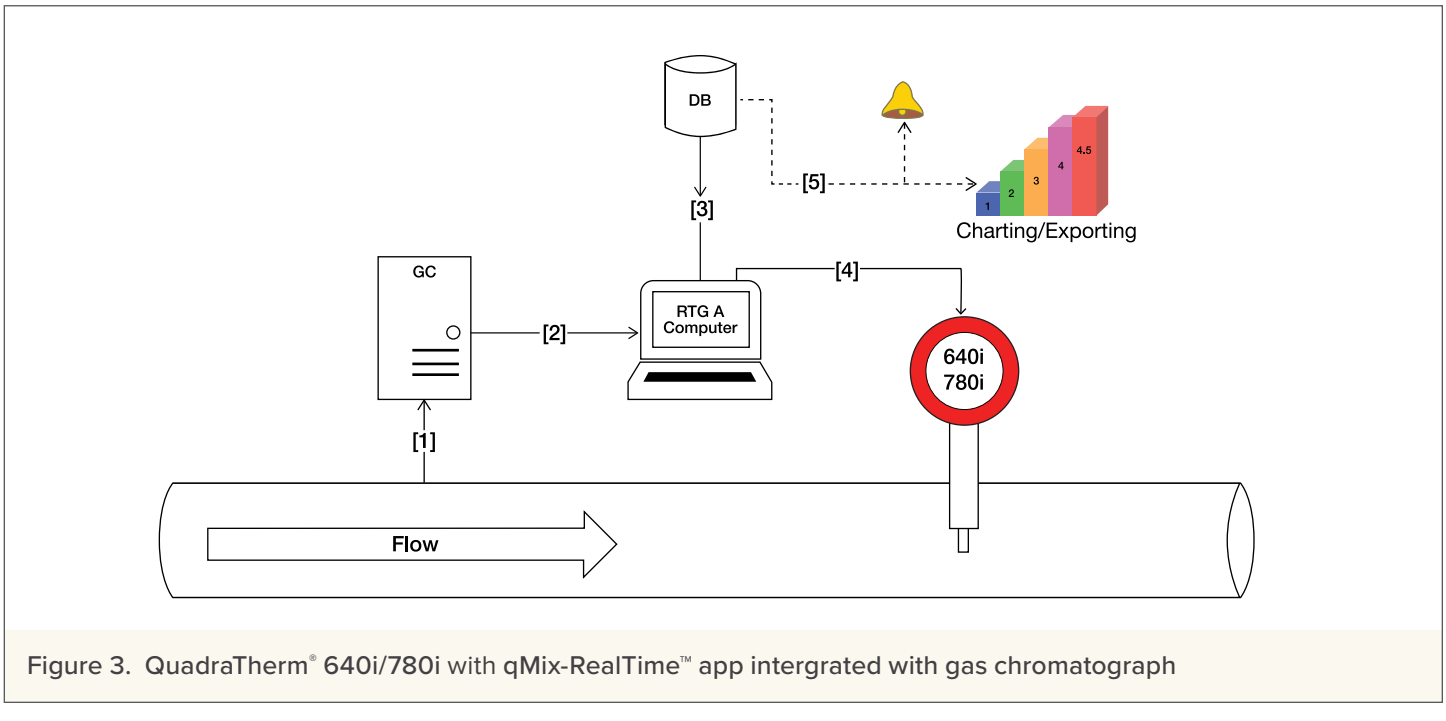

Figure 3. QuadraTherm® 640i/780i with qMix-RealTime™ app intergrated with gas chromatograph

THE BREAKTHROUGH

qMix alone, however, does not have the capability to adjust for gas compositions changes real-time. Sierra has taken adjustments for gas compositional changes one step further with the qMix RealTime™ app. By integrating the QuadraTherm thermal flow meter with a compositional sampling device, like a gas chromatograph, real-time compensation for gas compositional changes for thermal flow meters has become a reality.

As shown in Figure 3, when the gas chromatograph detects a change in gas composition, the outputs of the inline analyzer are fed directly to the qMix RealTime app where compositional changes are processed instantaneously. The qMix RealTime app automatically creates a unique gas composition to match the real- time reading from the gas chromatograph. Once the new gas composition is created, the new gas mixture is automatically uploaded to the meter, compensating for any compositional variation real-time and retaining accuracy (See Figure 4). The meter will start reading the flow using the latest gas mixture data. Along with updating the meter, the qMix RealTime app also saves the compositional data allowing for data mining and event processing like alarms and triggers.

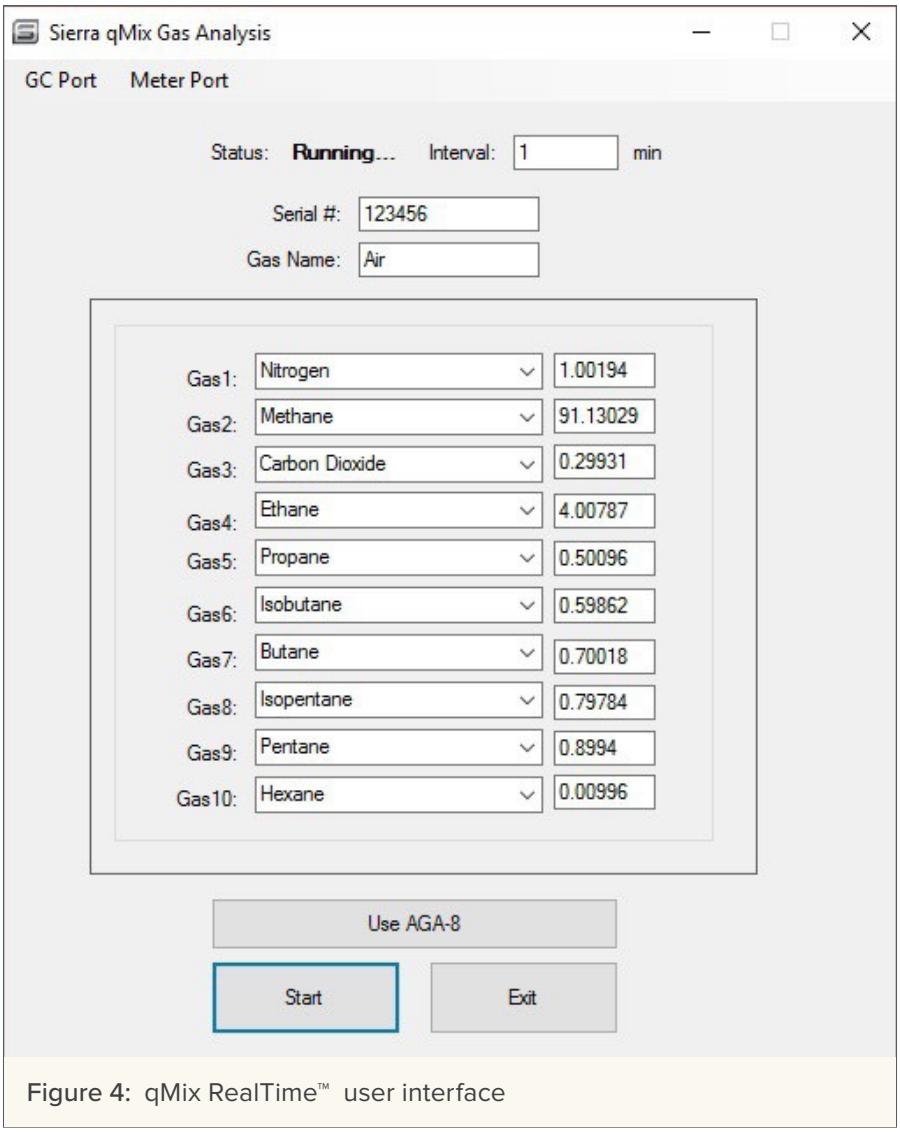

Figure 4: qMix RealTime™ user interface

Depending upon the intended application, periodic sampling is performed on an interval basis (e.g., by the minute, hourly, daily, weekly, monthly). Real-time sampling can be performed with a tandem inline gas composition sampling and analyzing system, typically based on gas chromatography. The qMix RealTime solution not only offers a breakthrough in real-time gas compositional change detection and calibration adjustment but a viable alternative to ultrasonic flow meters for meeting EPA's regulations for low flows.

"qMix-RealTime™ app offers... a viable alternative to ultrasonic flow meters for meeting EPA regulations for low flows."

CASE STUDY

qMix RealTime™

Sierra has currently developed a system which uses qMix RealTime to manage a QuadraTherm mass flow meter and a Siemens Maxum II Gas Chromatograph (GC). qMix RealTime monitors the GC and when a change in composition is detected, the QuadraTherm calibration is adjusted. The interval of this operation is determined by the user. The system also included functionality which allows for setting a minimum amount of predicted change in flow output. This prevents constant updates and limits changes to the meter to only when the compositional variance is calculated to be greater than a certain percentage of error. This system is fully functional and ready for application in refineries and other natural gas applications across the country.

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