Thermal Mass Flow Meters. What Does Half Percent Accuracy Really Mean?
Sierra Instrument's new QuadraTherm™ 640i and 780i thermal mass flow meters promise to lift Thermal MFMs out of the commodity market.

Although immersible thermal mass flow measurement technology has evolved over the last 40 years, sensor technology, a key driver for accurate mass flow measurements, has been fairly stagnant over the last decade. The innovation in Sierra's new QuadraTherm™ 640i insertion and 780i in-line thermal mass flow meters have changed this story. With groundbreaking advancements in sensor design along with leveraging today's hyper-fast microprocessors, QuadraTherm's thermal dispersion technology yields accuracy and features not found in other thermal meters, creating a new standard for immersible thermal technology.

Let's talk groundbreaking accuracy. The 640i insertion meter comes in at 0.75% of reading, while the 780i in-line version has an accuracy of 0.5% of reading. How does the new QuadraTherm technology achieve half a percent accuracy? As Founder and inventor, Dr. John G. Olin, understands, "I have spent my life with the vision of supplying industrial customers with the worlds' most accurate thermal mass flow meter. And, I know, it's a sensor game." Traditionally, thermal sensors have two sensors-one temperature and one velocity sensor, each in a separate probe. QuadraTherm (the term "Quad" meaning four) introduced four sensors-three precision platinum temperature sensors and one patented DrySense mass velocity sensor (To read more details about the technology, see G& I's "Executive Views" Q&A with John Olin, Founder and Chairman of the Board of Sierra Instruments in our January/February 2013 print issue.)

The move from two temperature sensors to four temperature sensors allows QuadraTherm to achieve the 0.5% of reading accuracy specification, the highest accuracy spec in the immersible thermal measurement market. This creates a new paradigm, pushing thermal technology accuracy potential far past what has been generally understood by engineers and creates a new thermal standard that can compete with the accuracies of coriolis technology at much lower costs.

Another advantage of QuadraTherm is its iTherm "brain", a complex math algorithm set, powered by today's hyper-fast microprocessors and QuadraTherm sensor inputs. iTherm essentially solves the first law of thermodynamics in a split second to calculate the various heat transfer properties of the gas. "It's basically about conservation of energy", says Rouse. "We are putting heat into that sensor, and it has to go somewhere. Most of the heat goes with flow and that's called forced convection which is what we want to measure. But it goes other places too. There is heat that is radiated away; there is heat conducted up the stem and heat lost due to natural convection. So, all of those factors, all of those other pathways where heat can be lost are false flow readings, unless you account for them. iTherm plus Quadratherm allow us to do just that, resulting in extremely accurate measurements."

iTherm manages changes in gas selection, temperature, and pressure and outside temperature via a comprehensive heat transfer model using only pertinent variables which instantly calculate precise, stable, and vary accurate flow measurement. Without iTherm, flow readings are affected by temperature and pressure. The only way a non-

iTherm enabled meter can be absolutely accurate is if the installation in the field exactly matches the calibration conditions in the lab. iTherm allows much more flexibility.

One aspect of this flexibility is Dial-A-Gas. QuadraTherm allows end users to change process gases to be measured in the field. With QuadraTherm, you can program up to four different gases. New gases or gas mixtures can also be introduced from Sierra's proprietary iTherm gas Library. Another aspect is Dial-a-Pipe. Standard thermal insertion meters have to calibrate for the pipe size they are in. But what if, prior to installation, the pipe size changes? Before QuadraTherm, you would have to send the flow meter back to the factory to be recalibrated. Rouse says, "With QuadraTherm basically you can pick the pipe once you get to the field. You just go into the menu and say, 'I have a 4-inch schedule 40 pipe', and the meter knows the inside diameter of that pipe and the pipe roughness."

While Dial-A-Pipe is not applicable to the in-line 780i, it does have some unique properties of its own. The 780i is more accurate (0.5 % of reading). Scott Rouse, Sierra's Product Line Director, says, "since it is calibrated with its flow body, the 780i is inherently more accurate because we can control all the aspects of the pipe. If you put a 640i in a pipe in the field, we don't really know what's inside that pipe, what the pipe walls look like, or what kind of corrosion that have built up on them. Such variables affect the pipe inside diameter and flow profile."

The 780i also comes with built-in flow conditioning and it is calibrated with this in place. Measuring flow is tricky in field applications. The meter is measuring the velocity at the point where the sensor is and it is affected by the flow profile. The assumption is that one is working with a fully developed flow profile; that means that the velocity is zero at the walls of the pipe and maximum velocity occurs at the center. Rouse adds that, "we have a good video on our website that demonstrates the flow conditioning we use, but things like elbows, other valves, bends in the pipe, really affect that velocity profile". To accurately measure, you have to condition the flow.

This is accomplished by having the gas pass through a flow conditioner. Sierra uses a double screen setup. "By the time it gets past those two screens, it's a really flat velocity profile. It takes away the effects of any upstream disturbances", says Rouse.
There are also cost savings. Ordinarily, Rouse explains, "it will take up to 20 pipe diameters after a bend to establish a fully developed flow profile. With conditioning, you can drop that down to 5 diameters. Less piping means less money."

Now that we understand how the accuracy is achieved, how does a half a percent in increased accuracy pay off? In the industrial market, where energy efficiency and cost saving are key drivers, a half of a percent accuracy increase does pay off in thousands of dollars of cost savings.

But since many mass flow meters tout 1% reading accuracy (usually with a percent full scale adder, which further degrades overall performance), I asked Rouse why this improved 0.5% reading accuracy is important. "Here's a good example," he explains. "A semiconductor fab uses a lot of hydrogen in the production line. Ultrapure H_2 is about $100/kg which is about $.25 per standard cubic foot. Typically, those gas cylinders that you've probably seen hold about 600 scf. But in a semiconductor plant, they typically use a lot more… 225 scf every minute. That's $56.00 a minute. So if you look at a flow meter with 0.5% accuracy, you are at plus or minus $.28 a minute. With a 1% device you are obviously twice that – you are at $.56

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With the high accuracy and advanced multiple gas and pipe change capabilities, the Sierra QuadraTherm immersible thermal meter breaks the mold and lifts the MFM market out of the commodity market to an extremely accurate, flexible meter which offers notable cost savings to industrial customers.

Learn more at www.sierrainstruments.com