Technical Publication

Advancing Thermal Mass Gas Flow Meters For 21st Century Process & Plant Needs

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Figure 1: FCI ST100 Series Thermal Mass Air/Gas Flow Meter

Process, instrument and plant engineers are challenged continuously by productivity and plant operating efficiency objectives as well as ensuring plant compliance with an ever expanding list of regulations. This situation burdens the plant's process engineering and operations team with requirements for more data and information about the processes to better manage, control and report on them all under the scrutiny of being cost effective. The bar keeps being raised for accuracy, repeatability, data, information, communications, diagnostics, record keeping, reducing maintenance and increasing service life.

This challenge was heard over and over again as Fluid Components International (FCI) listened to what users required in their process gas flow meters to support their current plant needs and what they expected to meet their plant of the future vision. With this voice of the customer feedback, FCI's engineering team began the process several years ago of developing its next generation thermal mass air/gas flow meter.

It is not surprising that thermal mass flow meters, applied in air/gas flow measurements, have been one of the top three fastest growing flow technologies the past six years[1] and projected to be the fastest growing, non-custody transfer driven technology the next five years[2]. Leading engineers in the process community are increasingly recognizing thermal dispersion flow meter technology, a direct mass flow measuring technology, as an extremely effective, no maintenance, highly reliable and low cost solution for their gas flow applications

What is surprising is that the vast majority of thermal flow meters in the market deploy sensor and electronics conceived and designed 20 or more years ago and are inherently limited by them. While effective in their basic measurement capabilities, their ability to provide process data and diagnostics information is extremely limited.

These older designs do not have the core processing capability, internal bus speeds or I/O linkage to support modern field bus communications. Older microprocessors, A/D and D/A converters have limited raw computing power and resolution that restrict application of sophisticated linearization techniques that improve output accuracy and resolution, store calibration and process data and perform diagnostics.

FCI has addressed these modern and dynamic engineering needs for industrial plant and process gas flow measurements by developing an all new thermal mass flow meter, the ST100 Series Thermal Mass Air/Gas Flow Meter.

The Great Communicator, Adaptable

Whether the need is for conventional 4-20 mA analog, frequency/pulse, alarm relays or advanced digital bus communications such as HART, FOUNDATION™ fieldbus, PROFIBUS or Modbus, the new ST100 Series Flow Meter is the solution (Figure 1). Should a plant's needs change over time or an upgrade be desirable, the ST100 Flow Meter adapts as necessary with a plug-in card replacement that can be changed out by plant technicians in the field. Revisions or upgrades to communications and new supporting firmware can be uploaded into the ST100's bus communications interface card to support it and keep current. This design approach takes "never obsolete" to a whole new level in flow measurement instrumentation.

HART is standard and included with the analog outputs interface. All of the outputs are interchangeable at any time. All measurements, including flow rate, total flow, temperature, and pressure with the STP models, are provided on outputs or over the bus communications. All ST100 Flow Meters also include a serial I/O port via a standard USB interface for direct connection to a PC and an Ethernet port with its own assigned IP address, which allows ease of access and interrogation by service personnel.

The ST100's HART I/O is fully compatible with the latest Version 7 standards. Today the ST100 is with the HART organization undergoing the final stages of its testing for independent certification by the organization. The ST100 already

has received its certification from the FOUNDATION™ fieldbus organization and was one of the first two instruments ever to be certified to meet its advanced diagnostics criteria.

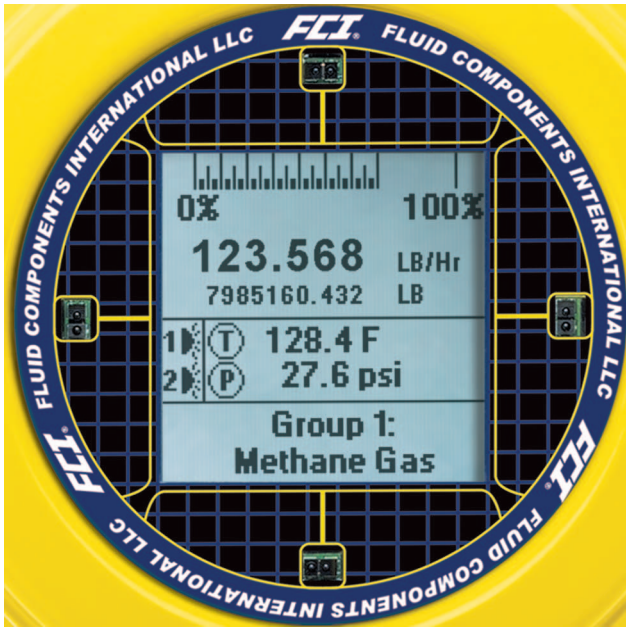

Figure 2: LCD Display/Readout

Data and Information

The ST100 Flow Meter features a sophisticated LCD display/readout (Figure 2) that brings new meaning to the term "process information." The ST100's unique graphical, multivariable, backlit LCD display provides the industry's most comprehensive process information with continuous display of all measurements and alarm status, and the ability to interrogate for service diagnostics. All process parameters are continuously available, including flow, total flow, temperature and alarm status.

The versatile ST100 Series' STP models also include pressure measurement, which makes this FCI instrument the first and only triple-variable (flow, temperature and pressure measurement) thermal dispersion flow meter in the world. Adding temperature and pressure capability reduces the need for separate instruments and wiring runs to greatly reduce installation costs.

The display also includes diagnostics data, which is made available via bus communications. The ST100 was the first thermal mass flow meter certified by the Fieldbus Foundation with advanced diagnostics. The advanced diagnostic features available with the ST100 Series include remote interrogation and troubleshooting by FCI staff over the instrument's built-in Ethernet connection.

Standard on all ST100 models is an on-board data logger, capable of storing 21 million readings on removable 2GB micro-SD card. It stores and recalls up to five unique calibrations and with extended calibration routines achieves up to 1000:1 turndowns. Flow ranges to as low as 0.25 SFPS (0.07 NMPS) up to 1000 SFPS (305 NMPS) are available and accurate to ±0.75 percent of reading, ±0.5 percent of full scale

Advancements and Choices in Sensor Designs[3]

With the ST100, FCI becomes the industry's first thermal mass sensor technology manufacturer to offer three different types of flow sensors to best match user applications (Figure 3). The FPC-style is a fast response type that features an integral, patent pending flow conditioner and protective shroud optimized for compressed air and clean gas applications. The FP-style is a fast response, general purpose design with a protective shroud and is also the sensor used with FCI's VeriCal™ in-situ calibration option. For applications with wet or dirty gases, or erratic flows, the unshrouded S-style facilitates easy cleaning and provides a smoothed response.

The ST100 Series is comprised of two core model families: the ST and STP. The ST family measures both mass flow and temperature, and the exclusive STP family adds a third parameter—pressure. The STP configuration makes the ST100 the world's first triple-variable thermal flow meter, measuring flow, temperature and pressure. Both families include single-point and dual-element models as configurations outfitted with FCI's exclusive in-situ calibration option, VeriCal.

Figure 3: Multiple Sensor Heads

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The ST100 can be calibrated to measure virtually any process gas, including wet gas, mixed gases and dirty gases. The basic insertion style air/gas meter features a thermal flow sensing element that measures flow from 0.25 SFPS to 1000 SFPS (0.07 NMPS to 305 NMPS) with accuracy of ±0.75 percent of reading, ±0.5 percent of full scale.

For ease of installation, the ST100 Series features an etched depth gauge in both English and Metric units on the sensor probe. The depth gauge takes the guesswork out of installing the insertion style flow meter sensor probe, allowing for precision sensor head placement in the center of the pipe for optimum contact with the flow stream. By placing the sensor into the center of the flow stream, accurate and repeatable flow measurement is ensured.

Dual Sensors Option, Dual Purpose

Models ST102, ST112, STP102 and STP112 are dual-element systems that can be applied in an averaging mode or as two discrete and independent sensors operating through a single transmitter (Figure 4). A single dual-element instrument can result in significant cost and space savings compared to installing and integrating two single-element instruments.

Two-in-One Configuration: Two sensors sharing single transmitter – a totally new and unique concept offered by FCI. Plants or applications with two or more flow meters can realize cost savings of 25 percent or more by multiplexing two separate flow elements into a single transmitter.

The flow elements' process connection and calibration(s) can be the same or completely different and independent. Each of the flow elements is interfaced and controlled by its own "front-end" electronic circuit board within the transmitter. Any of the available 4-20 mA analog outputs or relays can be assigned to either sensor. The digital readout is settable to display measurements from either sensor, selected by the user or automatically alternating between the two.

In units with bus communications, all data from both sensors is continuously available and transmittable over the bus. This can provide even more savings because the cost of the bus communications is reduced by 50 percent, bus wiring is reduced by 50 percent and only half of the nodes are required.

Two Sensor Averaging System: Applications involving line sizes 16 inches [406 mm] or greater can realize improved installation accuracy and repeatability by averaging the flow rates of two elements. Distorted, swirling and non-repeatable flow profiles can result in decreased accuracy of single point

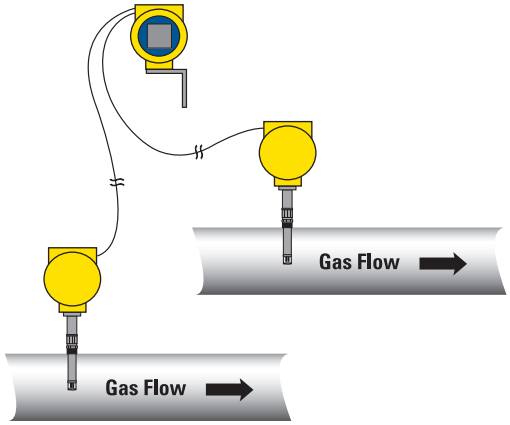

Figure 4 :Dual Sensor Configuration

meters. In many cases, it is impractical or impossible to provide the required straight-run for a fully developed flow profile in large lines.

Models ST102, ST112, STP102 and STP112 overcome these flow profile concerns with a simple, economical "dual-element averaging system." The transmitter electronics will average the input from two independent flow elements into a single output.

Each flow element can be independently configured for insertion length and process connection to allow installation flexibility. One flow element can be integral with the flow transmitter, or both can be configured as remote to accommodate easy access to terminal blocks and the optional digital display/optical four button interface. The flow transmitter also provides independent information for each flow element, saving time when performing service checks.

Unsurpassed Calibration Capability[4]

While a single calibration is sufficient for many operations, the ST100 Series can provide up to five unique calibration groups. Depending on your application need, this feature can provide significant cost and time savings. Some examples include:

- **Broaden measuring range** – Extend the turndown ratio up to 1000:1 or have different ranges for the same gas to maximize accuracy and resolution under changing conditions. This is particularly beneficial with flares, which can require both a low flow range for normal operation and leak detection, and also a very high flow range for upset

conditions. Multiple calibration group settings save on the cost of using multiple flow meters.

- **Different mixtures of same gases** – Embed calibrations to optimize flow measurement accuracy in dynamic or seasonally affected processes (e.g. Digester Gas Group 1 is 65% CH_4, 35% CO_2; Group 2 is 62% CH_4, 38% $CO_{2)}$.
- **Different gases** – Portable or temporary installations for multiple applications, or to reduce spare parts inventory in plants with multiple installations and applications. Multiple gases, such as dual fuel sources (e.g. natural gas and propane).

The ST100 is calibrated in FCI's own Calibration Laboratory to the user's plant gas, as compared to air-equivalency method that is typical throughout the industry. FCI's flow meters are calibrated under the user's plant conditions with the actual gas and temperature to ensure the best installed accuracy performance.

With over 40 years of flow instrumentation experience, FCI operates one of the industry's leading flow analysis and calibration laboratories. All laboratory equipment is National Institute of Standards (NIST) traceable, as well as certified to ISO 9001:2000 and AS9000 compliant. The laboratory also meets MIL-STD-45662A and ANSI/NCSL-Z-540 requirements.

FCI's Flow Calibration Laboratory provides gas flow calibration capabilities ranging as low as 0.001 SCFM (0.00017 NCMH) to ranges that exceed 5000 SCFM (8500 NCMH) and higher for line sizes in excess of 10 inches (250 mm). Flow calibrations for applications with temperature ranges from -100 °F to +1000 °F (-73 °C to 538 °C) and pressure ranges from 0 psig to 1000 psig (0 atmospheres to 68 atmospheres) are commonly performed for many fluid services.

This advanced Flow Calibration Laboratory is utilized across the aerospace, aviation, process control and discrete manufacturing industries for precision thermal flow/level sensor design, manufacture, calibration, and research. The company's laboratory has supported a large number of leading-edge development programs, including preflight testing sensors for the F22 Raptor Fighter, the V-22 Osprey Helicopter, the Global Express Program and others.

Rugged Design, Agency Approved for Demanding Processes

ST100 Flow Meters are designed for rugged industrial process and plant applications, including service up to 850 °F (454 °C). Both integral and remote (up to 1000 feet [300 meters]) electronics versions are available.

The complete ST100 instrument is agency approved for installation in hazardous environments. Often other suppliers evade or mask that their approvals are on the enclosure only. FCI and the ST100 approvals are for the entire instrument, sensor element, electronics/transmitter and the enclosure. Instrument approvals (submitted and pending) include: FM and FMc: Class 1, Division 1, hazardous locations, Groups B, C, D, E, F, G; ATEX and IECEx: Zone 1, II 2 GD Ex d IIC T4; The rugged enclosure is NEMA 4X/IP67 rated and is the only thermal flow meter with 4-conduit ports to provide best-practice wiring isolation and signal integrity.

Another feature only obtainable with state-of-art electronics and which can be a big cost avoidance in process installation is the use of optically activated programming and interrogation buttons that come with the digital display. The buttons are activated through the front panel glass, no need to open the instrument. In hazardous gas installations, this means the instrument does not need to be removed from service or the area decommissioned to change settings or obtain information about the unit.

Conclusion

With the thermal mass flow meter industry's widest selection of outputs and compatible digital communication protocols plus the flexibility to change communication protocols easily, the ST100 Flow Meter sets a new benchmark in flexibility. Its triple variable measurement capability — flow, temperature and pressure — along with built-in datalogger provides process and plant engineers with all the data they need by installing a single instrument requiring a single wiring interface.

The long list of additional ST100 Flow Meter capabilities, such as its graphics-based LCD digital display with through the glass touch control, multiple calibration groups built-in, SpectraCal gas equivalency calibration and more, provide exceptional functionality and ease-of-use. Process and plant engineers will find this instrument offers exceptional value to help them increase plant efficiency and reduce total operational costs. ■

References

1 *The World Market for Thermal Flowmeters*, October 2009; Flow Research

2 *The World Market for Flowmeters* - 2011 Edition; September 2011; IMS Research

3 *Advances in Thermal Dispersion Flow Meter Accuracy*, 2007, D. McQueen, Fluid Components International

4 See FCI Calibration Laboratory video: http://www.youtube.com/watch?v=b3Blg6sQQvc