Meters present interface challenges

Field experience is forming standards for microprocessor-based meters and flow computers.

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Microprocessor-based flow meters, such as ultrasonic or Coriolis meters, have well-documented advantages for end users. Discussions and developments have concentrated on the uncertainty and accuracy of the primary element. The use of these meter types has significantly increased in custody transfer applications. Field experience is forming the basis for emerging measurement standards from such organizations as the American Petroleum Institute (API) and the International Standards Organization (ISO). The unique interfacing issues associated with such meters can be compared to those of conventional flow meter types.

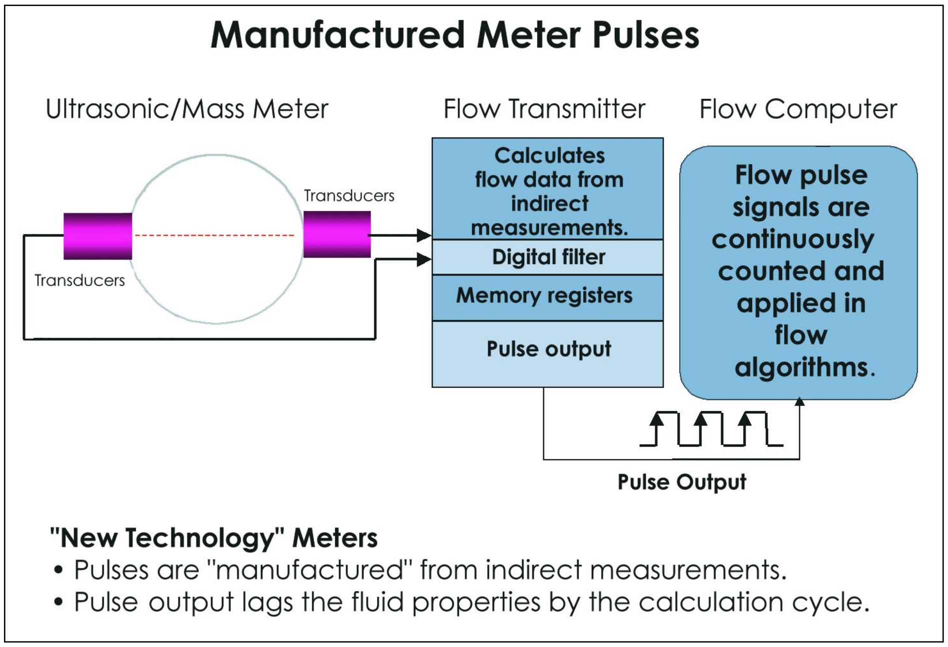

Figure 1. New technology meters are based on a calculation and measurement cycle time, during which a series of indirect measurements are taken, several calculations made and the results stored in memory.

Microprocessor-based meters

The microprocessor gives the instrument designer the ability to improve a device's performance by exploiting the fact that the measurement sensor is far more repeatable than it is accurate. For example, given the same set of operating conditions, the sensor is able to reproduce its results in an extremely predictable manner within the range of the sensors.

At a different set of operating conditions, the sensor results may be different, but still predictable. The microprocessor allows the manufacturer to characterize and correct the measurement sensor results by monitoring the measurement sensor's ambient and operating conditions; he does this by using secondary sensors or by calculating parameters such as temperature, pressure and density sensors. The net result is improved accuracy of the measurement output and the availability of other measured or calculated parameters used by tertiary devices (such as flow computers) as input parameters to "equations of state" and to determine the transmitter's diagnostic health.

The calculated flow to external flow computing devices are in the form of manufactured meter pulses, serially communicated data or both.

Manufactured meter pulses

In conventional flow meters (for example, turbine or PD), pulses are output from the meter by the inducement of an electromagnetic field in a circuit caused by a turbine rotor magnet that cuts a pick-coil in the meter body. The frequency of these meter pulses is proportional to the flow rate passing through the meter. By counting the pulses, one totalizes the fluid flow passing through the meter. The pulses are real-time, output at the same time the fluid impacts the turbine rotor.

New-technology meters cannot work in this real-time manner. They are based on a calculation and measurement cycle time, during which a series of indirect measurements (the movement of oscillating tubes or the time of flight of an ultrasound beam) are taken, several calculations made and the results stored in memory (Figure 1). Usually, this cycle time is not constant, particularly when process conditions are changing. The meter's microprocessor will take these indirect measurements and calculate either the gross volume or mass flow rate, or the flow increment during the calculation and sample time. The meter then outputs the results by varying a pulse output in proportion to the calculated flow over the calculation cycle time. Therefore, these pulses have been "manufactured" by the microprocessor and are not generated as a result of any direct flow-rate measurements. They also lag the fluid flow in the meter by the processor and meter cycle time.

As previously mentioned, this cycle time may not be constant and is directly affected by the number of indirect measurements needed by the microprocessor to complete its calculation routine. Applied electronics is a variable within the same metering technology and differs from manufacturer to manufacturer. Variations in the number of these indirect measurements are common. Successive indirect measurements then have to be made until sufficient data exists to complete a measurement and calculation cycle. These repeated measurements increase the calculation time needed by the meter and further delay the transmission of the pulse data to the computing devices. This presents some challenges when proving these meter types or undertaking flow control.

Data transmission

As these flow meters are microprocessor-based, the addition of serial data communications means for flow data transmission to the flow-computing device is a minor challenge. These typically are in the form of RS232/485 transmission protocols using Modbus messaging formats. These serial ports also can be used for the connection of some form of meter or device configuration tool. However, the wealth of diagnostic data that can be obtained from these meters is not uniformly presented to the user. Such data varies according to the individual meter vendor selected and the specifics of his metering technology. For example, using totalizer data can be difficult unless the data is provided in a numeric format that increments and rolls over predictably.

Floating point variables, for example, normally keep increasing in value and do not roll over to zero. This causes a problem; as the totalizer increases in size, a point is reached when the bit resolution of the number's mantissa portion is exceeded, and the totalizer begins to increment using larger and larger steps.

As such, the communications protocol implementation can be an impediment to easy interface to a computational device – whether flow computer, PLC or DCS. Any notion that Hart, Fieldbus or some other communications hardware and software combination will make the problems go away in a fiscal environment is without merit for the foreseeable future.

Flow data

The type of flow data being transferred is the key issue. Should the flow increment data (the flow since the last calculation) be transferred, or should the nonresettable totals in the meter be transferred to the computer? Initially, the flow increment data appears to be the most favorable. However, this presents an issue regarding the elapsed time from the last calculation cycle. Any computational device in fiscal transfer should be working on a fixed-time calculation cycle of once per second or better. The API *Manual of Petroleum Measurement Standards* requires a calculation cycle of no less than once per second for gas systems, 5 seconds for liquids. Typically these meters do not operate on a fixed calculation cycle. In practice, it is possible that new data is available from between 0.5 to 8 seconds after the real-time event – a significant time skew due to an inability to synchronize the data between the meter and host the computing device.

A flow computer expects new data during its fixed-time cycle (say 0.5 seconds), but the flow calculations would have to cease because there is no data available to process. Updating a flow computer's totalizers on this same period would result in somewhat erratic totalizers and sampler pulse outputs, which could upset other equipment connected to the flow computer. An Omni flow computer, for example, provides a smooth totalizer update by monitoring the time interval between the meter totalizer updates and distributing the volume increment over a matching time period.

A flow computer, for example, should subtract the latest total from the previous total to obtain the flow increment and update its hourly and daily batch totals accordingly. The flow rate then is determined from the calculated flow increment and the time between updates from the meter. This means totalizer data within the meter's database must be date- and time-stamped. Should the communication from the flow meter fail, the new total would be subtracted from the last known value when communication is restored. Effectively, no data is lost by this method.

Otherwise the flow computer could be forced to make excessively large assumptions on what is occurring at the meter. Should communications between the meter and the flow computer be lost, the flow measured during calculation cycles would be lost. Knowledge of how the meter calculates its flow increment and its measurement units is imperative, and the selection of the flow rate or totalizer output from the meter is all-important. Selection of the tertiary flow-computing device should not be assumed to be that supplied on a proprietary basis by some meter vendors. A failure to maintain an open-architecture system may limit a user's scope to maintain and improve specific aspects of system technologies.

Incorrectly implemented measurements can impair flow control. Valves will fail "open" for safety reasons. Bad installation is more often the norm than the exception in some markets. Consider also the effects of lost or reduced electrical power, where a meter will effectively reboot itself, much like a PC. This occurred recently with a mass meter, resulting in the loss of 7,063 cu ft of fluid.

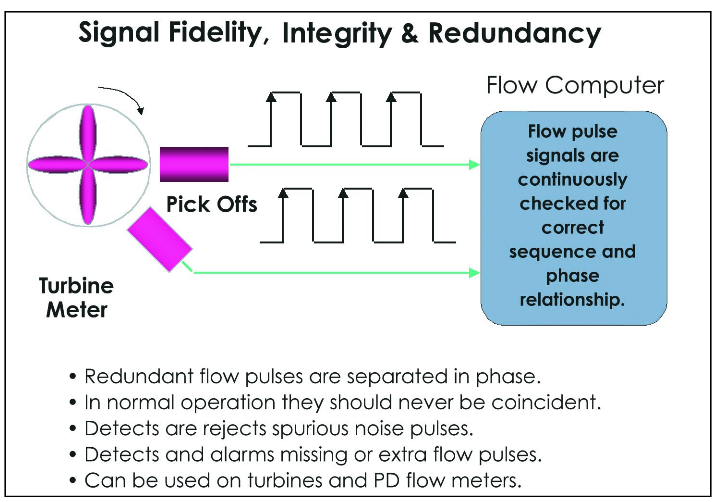

Figure 2. Pulse signals are checked for discrepancies; alarms are reported where discrepancies exceed a specific threshold.

The only practical flow data exchange in the authors' experience, then, is the nonresettable totals for some of these meters. But this requires meter manufacturers to assist experienced system vendors and manufacturers of tertiary computing devices in an open, nonproprietary framework. Issues of totalizer rollover between the meter and computer should be addressed using established techniques. Because the process measurement market is so much larger than the fiscal markets, some meter manufacturers do not comprehend some of the issues behind OIML R117 or EN12405 or ISO 6551.

Dual-pulse fidelity

With conventional flow meter types, the principles of ISO 6551 cabled transmission of electric and electronic pulsed data frequently are applied. The flow meter has two pulse output trains with a phase separation usually of 90°. The computer monitors each pulse for correct phase and sequence. Each A channel pulse must be followed by a B channel pulse before the next A channel pulse arrives and vice versa.

Electrical transients induced into the pulse-input wiring will be registered as in-phase common mode noise and rejected. The out-of-phase pulse outputs are compared against each for discrepancies between them in the form of missing or additional pulses. Alarms are raised and reported where discrepancies exceed a specified threshold (Figure 2). This is referred to as Level B fidelity. The highest level, Level A fidelity, requires rejection of simultaneous noise pulses and correction of the pulses when additional or missing pulses are detected. Level A fidelity, in reality, cannot be achieved. The idea that totalizers can be modified within the flow computer runs counter to electrical, mechanical and metrological theories, practice and fiscal data security.

For a microprocessor-based flow meter, obtaining two pulse outputs is simple; even putting a phase difference between the two pulse outputs is not difficult. These two pulse outputs would, however, be meaningless; they are derived from the same set of indirect measurements, by the same microprocessor, using the same software routine and output from the same set of data, by the same microprocessor. They are not two independent sources such as the two individual pulse transmitters on a turbine meter envisaged by ISO 6551. Unless there is a software fault in the flow transmitter (and all others installed with the same application software), these two pulse outputs would always be in agreement. They would only detect such faults as disconnected cables or induced EMFs in the field cabling.

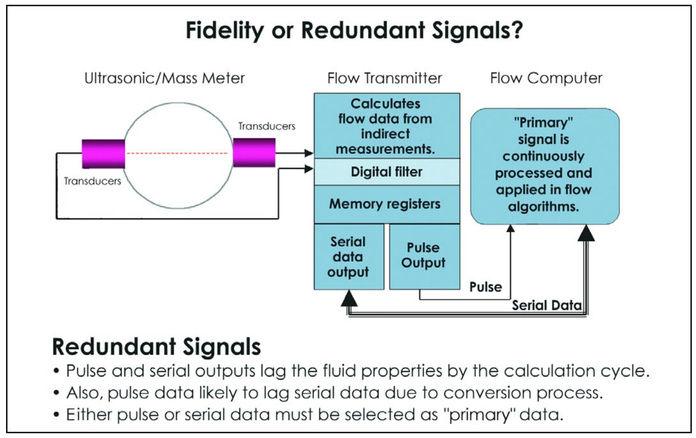

Figure 3. The combining of the two signal types – pulse and serial – cannot achieve meaningful fidelity checks, only signal redundancy.

With these "smart" flow meters, knowledgeable users require pulsed and serial data to be transmitted to the flow computer for fidelity purposes in an attempt to meet national weights and measures regulations (usually based on ISO 6551 or OIML R117 regulations) and for signal redundancy purposes. But in these so-called mixed systems, the combining of the two signal types – pulse and serial – cannot achieve meaningful fidelity checks, only signal redundancy (Figure 3). Unfortunately, existing standards are not being modified to reflect changing technologies and guide users. For example, in interruptible measurement systems, as legislated in Dutch metrological law, the minimum specified volume deviation should equal 1% of the minimum measured quantity.

When attempting to perform meaningful fidelity checks on single pulsed data transmission and data presented by serial communications, the following should be considered.

- Is the data transmitted in serial format from the same data set transmitted by pulses? Is the same data set being compared? The data transmitted by serial means is not real time. It is subject to the meter and computer's polling times, transmission times and calculation cycle times.
- The data transmitted by pulse means is likely to be older than the serial data, as it has had to undergo conversion from the digital format in the flow transmitter to flow-time-related pulses.
- Under fluctuating flow conditions, does the potential for differing values of flowing quantity make Level A or B fidelity checks all but impossible or useless? Of course, the user could increase the amount of data sampled or increase the time before and after fidelity checks to remove this time dependence from the equation. However, the data set would be so large that these checks would be nearly meaningless.
- Finally, the Netherlands Metrological Institute (NMI) states the minimum volumetric deviation between two signals should be less than 1% of the minimum measured quantity. The time required to meet this criterion, under normal operating conditions, typically would be 0.06 seconds for the total measurement through the fidelity check cycle. So can this criteria for the interaction between microprocessor-based meters and computational devices that already is being achieved

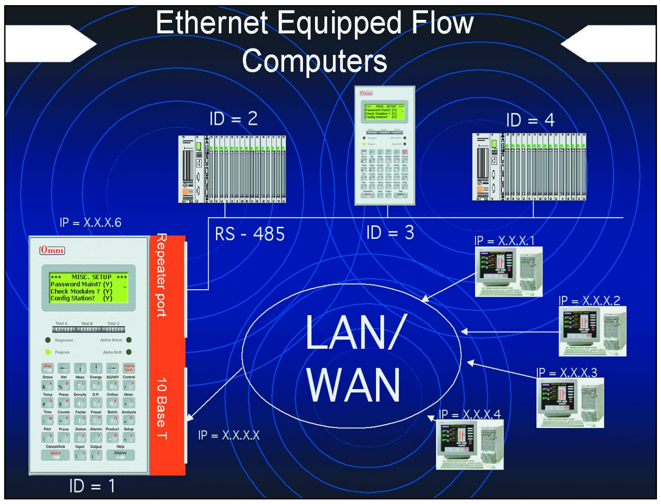

Figure 4. Each flow computer is connected serially to the same redundant ultrasonic meters, redundant gas chromatographs, local PCs and redundant H_2O and H_2S analyzers.

by conventional meters and computer arrangements be met with any degree of certainty in the life of the system? In the authors' opinion, the answer is no.

Gas metering redundancy

In a newly designed high-volume gas system, the design criteria include redundant local area networks (LANs) for communication to a central gas measurement control center. Each redundant flow computer has up to eight communication ports and is connected to the redundant LAN by dual Ethernet links and communicating Modbus over TCP. Each flow computer is to be connected serially to the same redundant ultrasonic meters, redundant gas chromatographs, local PCs and redundant H_2O and H_2S analyzers (Figure 4).

On the metering side, the main point is that the transporter and shippers desire to see serial and pulsed data communicated to both redundant flow computers. No single point failure is to be tolerated. The two redundant flow computers are required to communicate with each other. The flow computers also compare each ultrasonic meter against the other as a means of checking respective performance, in addition to looking at the diagnostic data from each meter.

Conclusions

The principal issues of data timing, updates and fidelity checking as they relate to measurement and proving standards must be addressed. Can conventional thinking and established industry practice be applied when interfacing these meters to proving and flow computer systems? Can deployment of these meter types be properly evaluated? Can system requirements be modified given the apparent cost benefits these technologies offer over the life of the meter?

The use of serial data for communication from the flow meter to flow computing devices needs to be assessed in terms of its suitability as a stand-alone signal means relative to custody transfer flow measurement.

The issue is not whether the protocol should be Modbus, Ethernet, Hart, Profibus or Fieldbus. These are simply means for getting the data from one point to another. Instead, the issue should be whether a serial, two-wire or four-wire digital means alone is a suitable medium given the latency in data transfer.

The answer will depend on improvements to speed of the measurement update and the latency of data transfer in the meter device, coupled with close integration with the computational device. Manufactured meter pulses also need to be addressed for stand-alone suitability reasons. Fidelity checking may not be achievable when compared to conventional meter types. Ultimately, many concerned users look to the standards organizations for guidance. This can take time. However, instrument and measurement engineers worldwide will make the compromise between cost of ownership and conventional thinking.

Users must assure themselves they have the necessary expertise in an increasingly technological environment. A sound understanding of the electronic and software basis for new technologies always will be preferred. It should be essential that proper testing and metrological and electrical certification is evidenced before systems are permitted into fiscal use beyond user trials.

Training of staff will be at a premium. A high level of instrumentation and technical expertise will be needed to maintain and debug an installation. The average metering technician is unlikely to be familiar with serial communication protocols, or able to operate a serial data protocol analyzer needed to interpret the data messages received from the flow meter.

Measurement data can only be deduced, defined and proven at a metering system level that incorporates proposed system combinations of primary, secondary and tertiary devices. System vendors are less equipped than ever to undertake the technological challenges.

Complex simulation equipment probably will be made available to emulate real-life electrical disturbances when accepting electronic-based systems compatible with IEC and CE standards. Testing methodologies employed to validate the metrological results may not always make practical sense to some users but still provide a guide to nominal environmental and measurement performance. Measurement and electronic standards are being revised constantly in continuing efforts to reduce uncertainty and improve system performance. Calculation standards are becoming more exacting and require additional processing power. Electronic and signal integrity also is more of an issue due to flow computers becoming multitasking operational devices with many control, calibration, security and data logging functions embedded.

This only elevates their importance. These changing standards and expectations from new technologies are the continuing challenge for designers and users of metering instrumentation.