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Ultrasonic flowmeter diagnostics provide sound advice

Continuous Flow Analysis (CFA) diagnostics generate actionable alerts to identify abnormal flow profiles, upstream blockage, deposit build-up within a meter, and the existence of liquid hydrocarbon in gas. **Jonas Berge**, director of PlantWeb Consulting with Emerson Process Management, discusses this latest development in ultrasonic metering technology.

CFA diagnostics provides real-time American Gas Association (AGA) 10 Speed of Sound (SOS) calculations to reduce measurement uncertainty by comparing AGA 10 SOS calculations with the meter-calculated SOS. Significant differences in SOS can indicate possible upstream process upsets and validate the integrity of the ultrasonic flow meter, gas analysis and measurements. Electronic Device Description Language (EDDL) enhancements make it easy to use these features.

Smart ultrasonic flowmeters can now be managed from the same management software as other smart devices in a plant. Continuous health monitoring from a central location is made possible using HART communication protocol and wireless adapter, reducing inspection in the field. Embedded expert knowledge helps less experienced technicians interpret diagnostics to resolve problems more rapidly.

Ultrasonic flowmeters (*see panel*) are suitable for gas or liquids, particularly for hydrocarbon custody transfer applications that require a high degree of accuracy, and are employed across the entire hydrocarbon value chain from production to consumption. In recent years the installed base of ultrasonic flowmeters has grown dramatically.

The benefits of ultrasonic flowmeters include:

- accuracy >0.1%
- large turndown (>50:1) *
- bi-directionality
- wet gas tolerance
- non-intrusiveness with no pressure drop
- low maintenance resulting from no moving parts
- fault tolerance: meters remain relatively accurate even after sensor failure.

** Turndown is the ratio of maximum to the minimum flowrate a flowmeter can measure with acceptable accuracy.*

A major attribute of ultrasonic flowmeters that brings substantial benefits to operators is meter diagnostics, which fall into two categories.

Functional diagnostics: Is the ultrasonic flowmeter operating correctly? Is it showing any signs of hardware or firmware degradation?

Process diagnostics: Are conditions in the metering stream stable, and suitable for custody transfer measurement?

Although diagnostics have been available from ultrasonic meters for some time, their use has mostly been limited to meter vendors and a few specialist operators. The monitoring of diagnostics has required periodic interrogation of the meter, resulting in essentially subjective interpretation. New CFA embedded within advanced ultrasonic meters automatically monitors each of these diagnostics in real time and compares them with configurable control limits to ensure meter functionality, process stability and system accuracy are within specification throughout the life of the device.

One of the simplest indicators of meter functional health is the presence of strong signals on all measurement paths. Today's multipath ultrasonic flowmeters have automatic gain control on all receiver channels. Any increase in gain on any channel indicates a weaker signal (lower signal to noise ratio), perhaps due to transducer deterioration, fouling of the transducer ports, or liquids in the line. Moreover, each transducer is capable of receiving noise from extraneous sources (rather than its mated transducer). Monitoring gain, signal to noise ratio and signal quality over time provides a clear indication of meter functional status and warns of impending problems. Maintenance is no longer prescriptive, but condition based.

Even with the meter functioning perfectly, there is still a possibility that the measurement accuracy is out of specification as a result of process upsets. As an example, if there is liquid in the gas or if the gas is dirty, then the flow profile will change. By constantly monitoring the flow profile, the meter can 'see' if the process becomes dirty or liquids are present. Although multipath ultrasonic meters do have a degree of immunity to these upsets, there is risk of mis-measurement, which is monitored, facilitating operator intervention.

Reduced maintenance

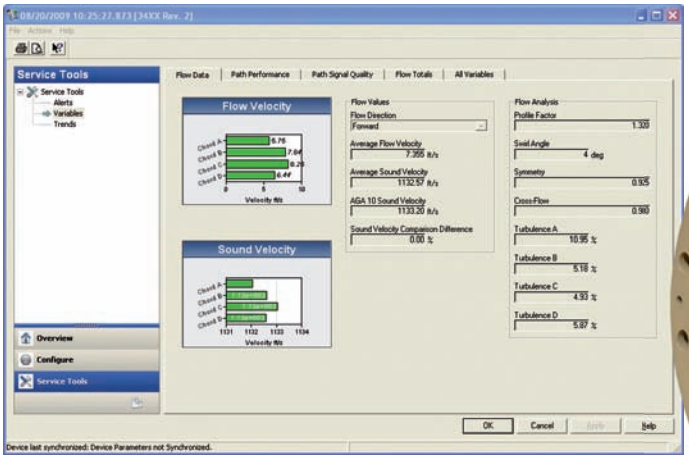
The flowmeter manufacturer uses standard EDDL (IEC 61804-3) to control how the flowmeter appears in the system software, making the flowmeter intuitive to use while providing full support for its functionality.

Multipath measurement compensates for changing flow profiles, thereby retaining high accuracy. Nevertheless, since changing flow profiles could be an indication of process problems such as liquid carryover in gas, maintenance should be alerted.

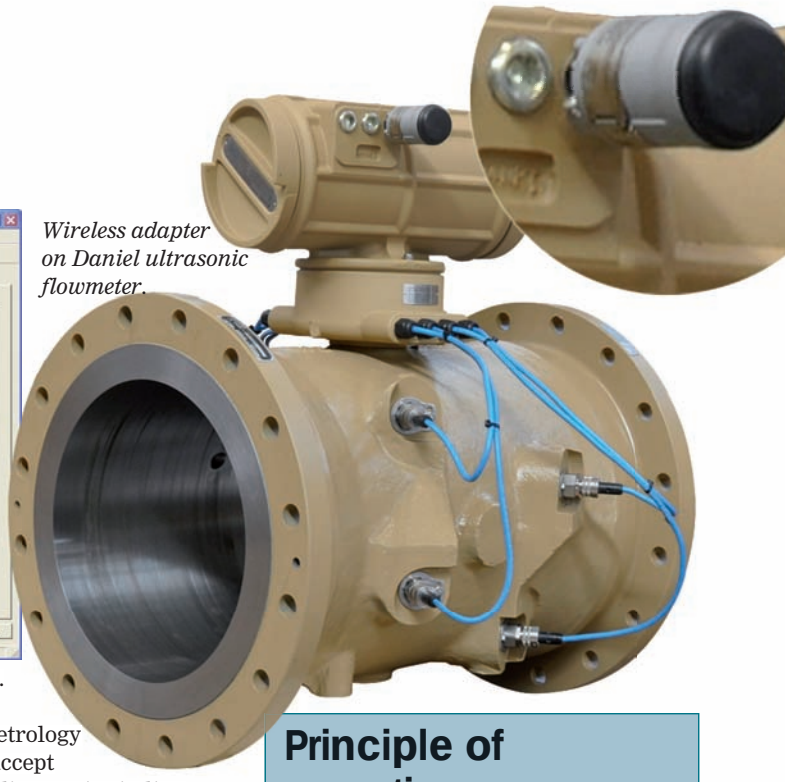
Since buildup is slow and debris is rare it is practical to set an alarm to trigger on problems between inspections. Inspection is required only if the change in profile factor, or other diagnostic indicators, from the baseline values 'learned' at calibration is significant. A setup wizard created by the flowmeter manufacturer using EDDL guides the technician step-by-step, capturing baseline values. It is also easy to re-baseline at installation if needed.

The alerts are plain text, easy to understand and act upon. No specialised training is required to interpret incomprehensible graphs or analyse trends. Alerts are reported to both operators and maintenance technicians directly at their workstations. The operator can take alternate steps to look after the process, while the technician initiates action to clean, calibrate, or repair the flowmeter.

CFA diagnostics detect build-up and provide an easy to understand alert.



Diagnostics depicted as EDDL bar graphs to visualise flow profile.



Wireless adapter on Daniel ultrasonic flowmeter.

Thanks to EDDL the flow profile is easily visualised as parallel bar graphs in case the technician needs more details. Measured SOS for the four flow and four sound velocity chords can easily be compared in bar graphs to identify buildup on transducers.

CFA diagnostics are done inside the ultrasonic flowmeter. EDDL is used for display and the provision of data to applications like desktop historians through OPC (OLE (object linking and embedding) for Process Control).

CFA diagnostics detect and alert on blockage by debris trapped in the flow conditioner. The technician can then explore the alert in greater detail, checking the flow profile bar graphs for turbulence.

Liquid carry-over into gas is detected and alerted by CFA diagnostics. The technician can drill down further to see signal level, transducer gain, SOS, and signal to noise ratio.

The ultrasonic flowmeter can detect faults in its internal clock by comparing the measured SOS against the value according to the AGA 10 standard based on external measurement of pressure, temperature, and gas composition. Standalone software, manual data entry, and expert validation are not required. The ultrasonic pulses are analysed for timing and rejected if criteria are not met. The percentage of accepted pulses is reported as performance, a measure of signal quality and transducer health.

CFA diagnostics detect problems early so that maintenance can be scheduled before measurement uncertainty is affected, helping reduce lost revenue and avoiding over billing. Conversely, if no problems are detected, inspection can be postponed, reducing production downtime.

Some national metrology institutes already accept or are considering diagnostics in lieu of calibration, potentially reducing calibration logistics costs significantly. Ruling out maintenance of flowmeters remotely confirmed to be OK eliminates unnecessary meter run inspections, saving a plant thousands of dollars in operating costs annually.

Incorporating diagnostics

Plants have hundreds or thousands of field devices. Flowmeters in fiscal, allocation and custody transfer applications are an important portion of these. In the past, flowmeters had self-diagnostics, but a technician still had to be sent to the field to hook up a laptop to know if the flowmeter had a problem. This maintenance approach was reactive rather than predictive and therefore not very effective. The intelligence in the ultrasonic flowmeter was not fully utilised.

Smart flowmeters support the HART protocol, already used in such devices as pressure and temperature transmitters and control valve positioners, which in turn is supported in all modern control systems. All instrumentation on the metering skid can be an integral part of the plant asset management solution. Ultrasonic flowmeter health is monitored continuously, with CFA diagnostics checked from the control room, obviating the need for a technician to go into the field.

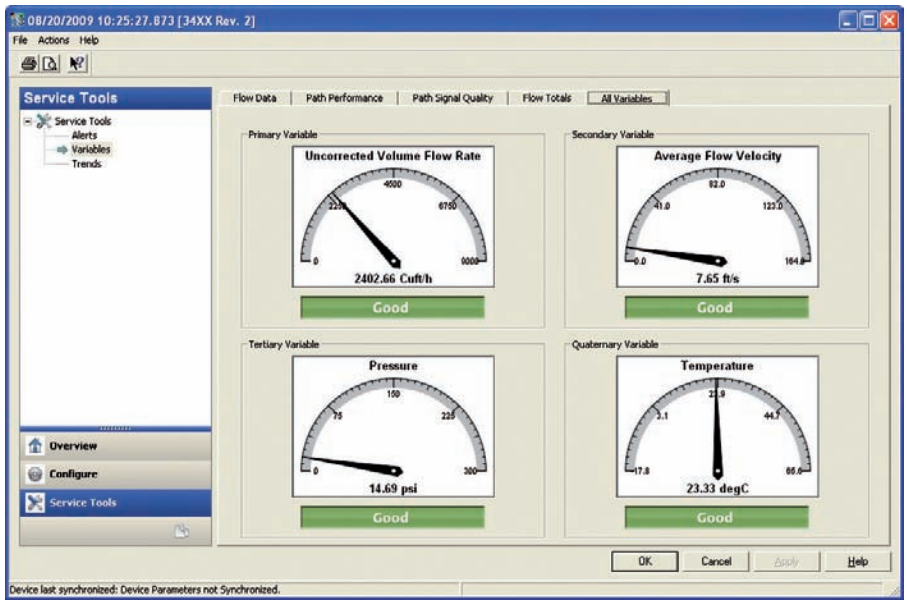
Even if a plant's existing system does not support HART, it is still possible to benefit from CFA diagnostics by fitting a WirelessHART adapter on the smart flowmeter. Wiring remains intrinsically safe, permitting use in hazardous areas. A wireless gateway and intelligent

Principle of operation

Ultrasonic flowmeters are based on the transit-time principle: the transmit time of ultrasound pulses between a pair of transducers determines fluid velocity. The transducers alternate as transmitter and receiver, taking turns sending pulses back and forth. The pulses traverse the pipe diagonally to the flow: in one direction with the flow and in the opposite direction against the flow. Pulse travel time with the flow is shorter than against, the time difference proportional to fluid velocity. The velocity, computed from the time difference, is multiplied by flowtube cross section area to obtain volumetric flow.

The fluid velocity is faster in the center of the pipe than along the pipe walls where flow encounters friction. This velocity pattern is known as the velocity profile or flow profile. In reality the flow profile is not symmetrical due to upstream piping and obstacles. Metering skids are engineered to include flow conditioner, and straight meter run piping to reduce the installation effect.

However, a single velocity measurement path does not accurately represent flow. Therefore, multiple paths are measured inside the flowtube when high accuracy is required. The number of measurement paths and their geometrical arrangement is a main differentiator among ultrasonic flowmeters.



Dial gauges provide a view of flow, pressure, and temperature.

device management software enable CFA diagnostics to be monitored from a centrally located device management computer.

Once the wireless infrastructure is established, it can be used for many functions. Wireless transmitters for pressure, temperature, and valve position feedback, for example, can be added at will to enable process improvement in 'mini projects' previously impractical. Devices from different manufactures interoperate since WirelessHART is a standard. Wireless adapters also access valuable diagnostics in other devices such as control valve positioners. As a result, undetected failures and unnecessary trips to the field can be reduced.

Standardising software

Instrument technicians face the challenging task of managing a mix of device types from different manufacturers. In the past, flowmeters and level transmitters all required specialised software from each manufacturer. A better solution is universal device management software that is part of asset management solutions. EDDL has made it possible to configure, calibrate, and diagnose smart ultrasonic flowmeters from the same application used for other devices on a skid or in a plant. Smart ultrasonic flowmeters are consistently displayed with transmitter data that include DP (differential pressure), pressure and temperature.

Technicians, applying what they have learned from working with other devices to the ultrasonic flowmeter are in consequence already familiar with the keyboard and display screen controls at their finger tips and therefore less likely to make errors.

It is possible to use the smart flowmeter without having to stop and think and pay attention to peculiarities of stand-alone software, since EDDL can diagnose from any control system supporting the language (www.eddl.org), which all leading systems do.

For easy correlation the universal device management software maintains a single audit trail for changes to all devices, and a single alarm summary and log for all device events.

A trend chart screen displays the record of dynamic variables over time to spot intermittent behaviour and tendencies.

CFA diagnostics are available on operator or maintenance consoles in only two clicks. The flowmeter manufacturer has used EDDL to share know how in the form of text and illustrations guiding the technician with advice towards a fast resolution of the problem.

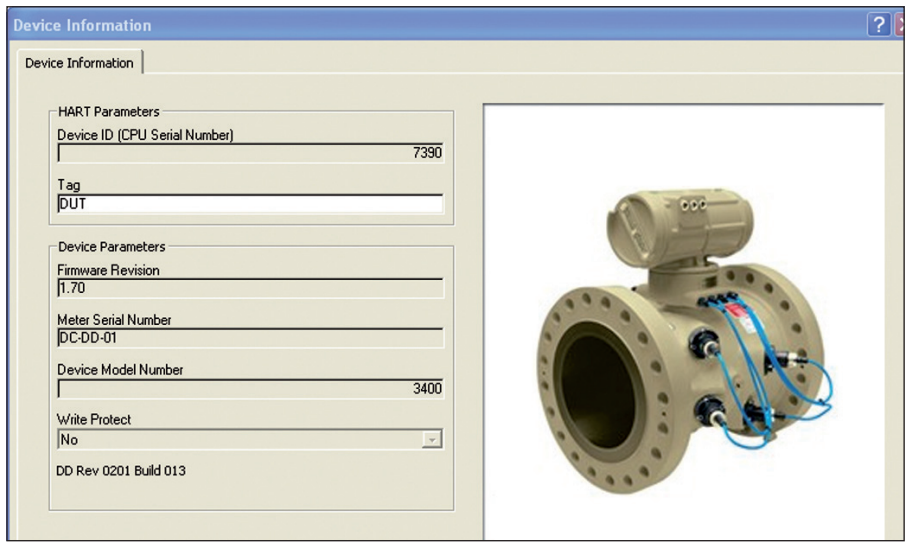
Technicians can remotely login to check the health of not just the ultrasonic flowmeter, but all devices, whether in a compressor station or offshore installation.

Measurement trust

Because meter run, the length of straight, unobstructed fluid-flow conduit preceding an orifice or venturi tube, should be kept clean to ensure low uncertainty, CFA diagnostics is a sensible investment, reducing operating and maintenance costs by providing operators with the information needed to inspect and calibrate meters only when truly necessary.

These advanced new functions are user-friendly because EDDL hides any underlying complexity embedded deep inside the device. It is not necessary to switch device management technology to benefit from new innovative devices. All that's required is an upgrade from traditional DD to enhanced EDDL.

A digital plant architecture that uses the power of field intelligence to improve plant performance utilises an unbroken chain of smart flowmeters and other devices, digital networking, and universal device management software to deliver accurate, actionable information to the right person in time to make a difference. ■



Device depiction and information for easy remote identification.