How much do you flare?

How to measure flowrates of flare gas accurately and reliably

Measuring the flow of flare gas is important in chemical, petrochemical, refining, and other plants that vent hydrocarbons and other waste gases. Ultrasonic flowmeters help customers comply with environmental emission requirements, reduce leaks and understand their process losses.

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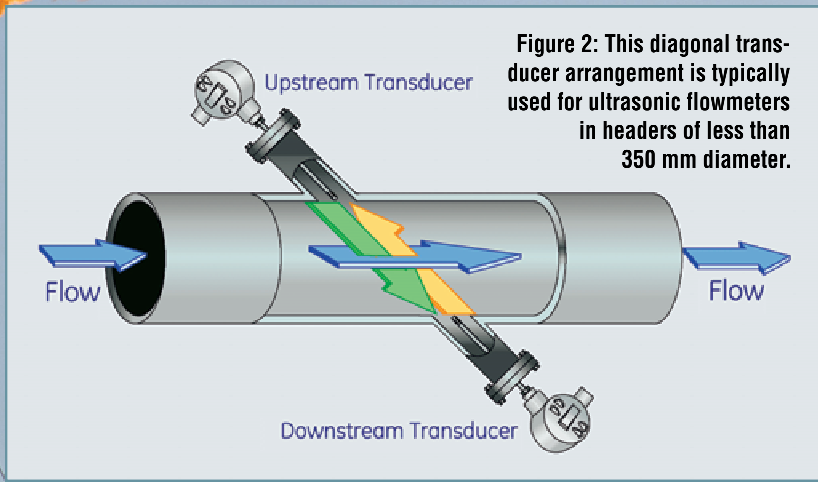

Figure 2: This diagonal transducer arrangement is typically used for ultrasonic flowmeters in headers of less than 350 mm diameter.

Photos: GE Sensing

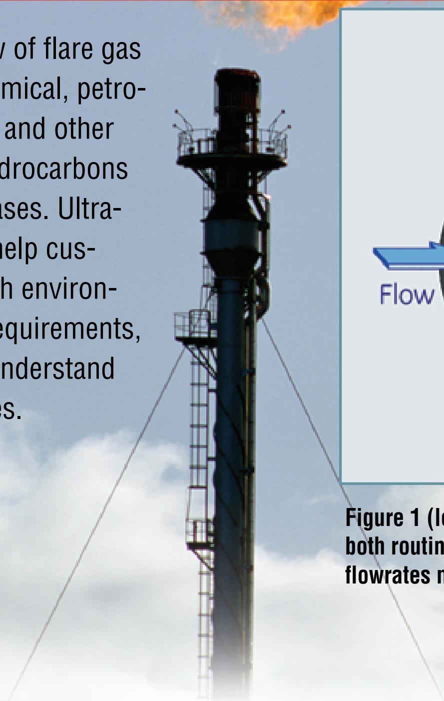

Figure 1 (left): Flares are used to burn off unwanted gases under both routine and emergency conditions. The wide range of flowrates makes this a challenging application for flowmeters.

Reasons to measure flare gas flow include compliance with environmental regulations; identifying leaks, for instance from pressure relief valves that have failed to re-seat properly; reconciling plant mass balances; and flare burner control, which is especially important when the flare gas contains a lot of inerts.

A typical flare gas system is a kind of "sewer" used to burn off waste gases (Figure 1). Headers from individual process units range in diameter from 50 to 200 mm, while main flare lines leading to the actual flare are anywhere from 300 mm to 1.8 m in diameter. A typical installation includes at least one flowmeter on the main flare line upstream of the knock-out drum. Smaller headers from individual process units may have their own flowmeters.

Figure 4: Isolating valves allow the transducers to be changed while the flare header is in service.

A challenging application

Flare gas flow measurement is a challenging application. It requires the ability to measure over a wide range of velocities: from 0.03 m/s under lowest flow conditions, through 0.15–0.5 m/s for most normal operation, up to 80 m/s or more in the main header during emergency flaring. Temperatures range from –20 °C to 80 °C for typical flare systems and from –200 °C to 100 °C for liquefied natural gas (LNG) flares. Pressures range from 5–15 kPa in normal operation up to 7 bar under emergency conditions.

Flare header flowmeters must withstand condensation and corrosion from water, liquid hydrocarbons and acid gases. They must be mechanically strong, to resist the high drag forces that occur under emergency conditions. And they must operate with high levels of hydrogen and carbon dioxide, which are challenging for ultrasonic flowmeters because of their high attenuation factors.

Flowmeters based on differential pressure, vortex shedding and insertion thermal-mass types have all been tried on flare gas duty, but none has performed particularly well. Their failings include limited turndown, inability to follow unsteady flows, corrosion, intolerance of liquid carry-over, and sensitivity to changes in gas composition.

Ultrasonic flowmeters are better suited to this duty. The measurement of flare gas flow with ultrasound began in the early 1980s with development work by Panametrics and Exxon in Baytown, Texas, USA. Today ultrasonic flowmeters are the accepted technology for flare gas measurement, with more than 3,000 installations worldwide.

Ultrasonic flowmeters

An ultrasonic "transit time" (or "time of flight") flowmeter for low-pressure gas applications uses a pair of ultrasonic transducers in direct contact with the gas. Ultrasound pulses are transmitted alternately from one transducer to the other; the mounting arrangement of the transducers means that the pulses in one direction travel with the gas flow, while in

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the other direction they travel against the flow (Figure 2). Measuring the difference between the downstream and upstream transit times allows the gas velocity, and hence the volumetric flowrate, to be calculated.

Knowing the distance between the transducers also makes it possible to calculate the speed of sound in the gas, and hence the average molecular weight. This not only yields the mass flowrate, which is important for reporting purposes, but can also help to identify the nature and source of the gas being flared.

Most ultrasonic flowmeters in flare headers of less than 350 mm diameter use the diagonal mounting arrangement of Figure 2. Larger pipes typically use the “mid-radius bias-90” configuration of Figure 3, which is easier to maintain and is less sensitive to velocity profile effects. Other arrangements are used where space is tight. Isolating valves and insertion glands allow the transducers to be changed without shutting off the gas flow (Figure 4).

Location and installation

Finding the right location for a flowmeter can be tricky. Ultrasonic flowmeters, like many other flow measurement technologies, do not measure velocity across the full cross-section of the pipe. This means that for accurate results they depend on a fully-developed flow profile of known shape. For low-pressure gas applications such as flare headers, the standard advice is to allow a straight length equivalent to 20 pipe diameters upstream of the flowmeter, and 10 diameters downstream. This may be difficult to achieve in a flare header with many joins and bends, but it is important for accurate results.

Avoid locating an ultrasonic meter downstream of any source of gas-borne ultrasonic noise, such as flow-control and pressure-regulating valves. Despite advanced digital signal processing technology, these ultrasonic noise will degrade the signal to noise ratio, and in extreme cases could affect flowmeter performance.

The transducer nozzles need to be positioned to a tolerance of ±1.5 mm and ±1°. This is a difficult task that is best carried out in a workshop rather than in the field. For new flare systems, or plants that can be shut down for maintenance, the preferred approach is to use a “flow cell”—a pipe spool that carries all the mounting hardware needed for the transducers.

This approach allows machining and welding to be carried out under controlled conditions, and final dimensions to be measured accurately. The path length and the axial distance between the transducers, for instance, are typically measured to ±0.1 mm. The complete flow cell is calibrated using air at known conditions of temperature and humidity.

On-site installation

The flow cell approach is a luxury that many plants cannot afford. Instead, three-quarters of all GE flare gas ultrasonic flowmeter installations worldwide are installed directly into the pipe in the field. This is known as a “hot tap” or a “cold tap”, depending on whether flare remains in service during installation. Properly done, this procedure results in a flowmeter installation that is accurate enough for most purposes and causes little or no loss of production.

Jigs and clamps are used to locate the two nozzles accurately on the flare header and hold them securely while they are welded in place. After welding, inspection and pressure testing, isolating valves are fitted to the nozzles. The final step is to penetrate the pipe, using first a pilot drill and then a hole saw manipulated through the bores of the isolating valves. Further taps are made to accommodate pressure and temperature transmitters downstream of the ultrasonic transducers.

Modern ultrasonic flowmeters offer a range of features to aid calibration and maintenance. For instance, diagnostic data can be sent to service engineers by e-mail or even in real time, via a web server.

Operation and maintenance

Once installed, flare header flowmeters have several useful functions. For environmental reporting and mass balancing, the average molecular weight and mass flowrate derived from the flowmeter signals are typically recorded by the plant’s control system.

If a flowmeter indicates gas flow in the flare header, but this is not expected from the plant’s operating conditions, the installation point of the flowmeter and the molecular weight can both help in tracking down the unit responsible. The actual source of the flow is often a pressure relief valve that has failed to re-seat properly.

Operators also use flare gas flowmeters to control steam injection to the flare, as a way to prevent smoke formation. ■

Further reading

[1] Industrial Flares, Section 13.5. Sept. 1991. http://www.epa.gov/ttn/chief/ap42/ch13/final/c13s05.pdf.

[2] Flare Gas Ultrasonic Flow Meter. Proceedings from the Thirty-Ninth Annual Symposium on Instrumentation for the Process Industries. 1984. By Smalling, Lynnworth, Wallace.

[3] Flare Gas Ultrasonic Flowmeters – Optimising Performance & Verification of New and Existing Installations. Steve Milford. GE Panametrics. June 2002. NEL Flare Gas Seminar.

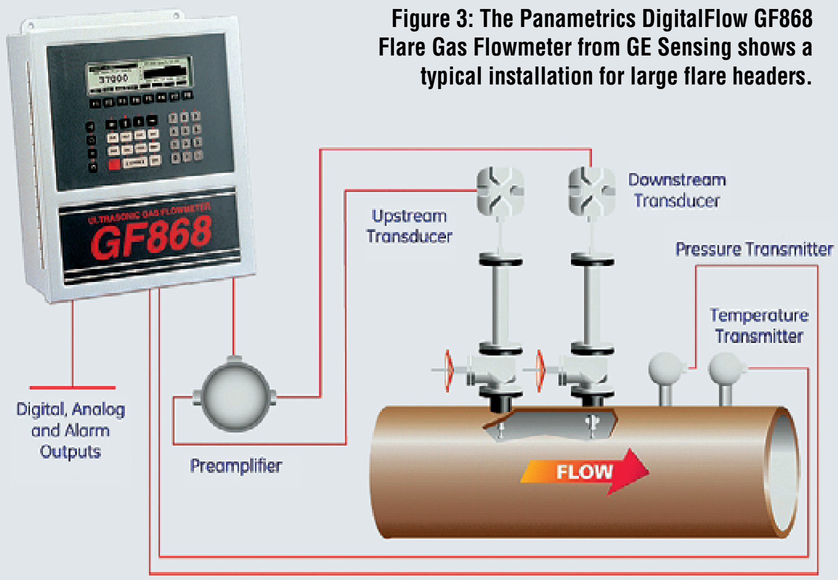

Figure 3: The Panametrics DigitalFlow GF868 Flare Gas Flowmeter from GE Sensing shows a typical installation for large flare headers.