Oil refinery petrochemical plant

'It depends on the application'

Jesse Yoder of Flow Research focuses on three of the most important applications for gas flow measurement

Most flowmeter types, except for magnetic, can measure gas flow under certain conditions. However, gases have certain properties that make measuring them more difficult than measuring liquids.

The flowmeters that are most commonly used to measure gas flow are ultrasonic, thermal, differential pressure (DP) and turbine.

Coriolis meters are also used for certain applications. Vortex meters can also accurately measure gas flow, but what they really excel at is steam flow. Which flowmeter you select depends on the application.

Gases

Gases are distinguished according to their different atomic configurations. While there are some 'pure' gases, like hydrogen and oxygen, there are also many gas mixtures. Some are simply combinations of different atoms into molecules such as carbon dioxide (CO_2) and water (H_2O). Industrial gases are specific types of gases that are gaseous at ambient pressure and temperature and are specifically manufactured for use in industry. Any gas that is put in a canister is considered an industrial gas, with the exception of certain fuel gases.

The US Energy Information Administration (EIA) defines natural gas as "a gaseous mixture of hydrocarbon compounds, the primary one being methane". Some natural gas occurs deep below the ocean depths, and this has led to the development of some very advanced drilling involving subsea technology.

Custody transfer

Custody transfer occurs when the ownership of a product passes from one person or company to another. It is especially important in the oil and gas industry, due to the high value of both oil and gas.

At the wellhead, flowmeters are used to measure the volumes of crude oil, gas, and water that are arriving at the surface. The surface may be a platform on the sea, a point on the seabed, or up on dry land. Typically, custody transfer applications enter the picture after allocation metering occurs. Custody transfer occurs at the point in the process where the ownership of natural gas, crude oil, or refined petroleum products is exchanged. These important points of transfer typically occur at multiple points in the delivery systems. Accurate measurement at these points is critical, as it is at each of these points that a monetary value is established for the volume or mass of fluid being transferred from one owner to another.

In the US, criteria for custody transfer of natural gas are determined by the American Gas Association (AGA).

The AGA has a series of reports specifying how this measurement is to be done with different types of flowmeters. The earliest AGA report came in 1930 when it issued AGA-1, a report on the use of differential pressure flowmeters with orifice plates for custody transfer of gas.

This report was followed in 1935 with AGA-2, which incorporated the results of additional tests. In 1955, the AGA issued AGA-3, which built on the earlier reports and included the effects of installation piping.

In 1992, the AGA re-issued AGA-3, addressing upstream piping requirements and the use of flow straighteners.

The AGA also issued reports on custody transfer of gas using turbine meters. In 1981, the AGA issued AGA-7, a report that laid out the standards for using turbine flowmeters for custody transfer applications and called, *Measurement of Fuel Gas by Turbine Meters.*

An engineer checking an oil pipeline

In 2006, the AGA released a new version of AGA-7, called *Measurement of Natural Gas by Turbine Meters.*

The effect of these early approvals of DP and turbine meters for custody transfer purposes resulted in a large installed base of DP and turbine flowmeters used for custody transfer of natural gas. It was not until 1998 that the AGA issued AGA-9, a report on the use of ultrasonic flowmeters for custody transfer applications. Custody transfer measurement with ultrasonic flowmeters requires inline rather than clamp-on technology.

The ultrasonic flowmeters currently being used for custody transfer applications are multipath meters, meaning they have three or more paths. While there are different ways to count the number of paths, some ultrasonic flowmeters have been developed with as many as 18 paths.

Ultrasonic flowmeters have a number of advantages over turbine and DP meters. They cause less pressure drop, require less maintenance, and do not have moving parts to wear out. While orifice meters do not have moving parts, the orifice plates themselves are subject to wear, and also need to be checked periodically to make sure they are still positioned properly. There are diagnostic tools that can be used to check or verify whether an ultrasonic meter is reading correctly or needs recalibration.

Flare and stack gas flow measurement

Flare systems are used to burn off waste gases from refineries, process plants, and power plants. Flares can be a single pipe or a complex network of pipes and are subject to strict environmental regulations. Flues are typically large pipes, stacks, ducts, or chimneys that dispose of gases created by a combustion process. Ultrasonic, DP flowmeters with averaging Pitot tubes, and thermal meters are used to measure flare and flue gas.

Ultrasonic flowmeters have a number of advantages over turbine and DP meters

One of the biggest challenges of measuring flare gas is large turndown. Flare gas flow can range from low fuel gas purge during normal operation, to large flow during emergency relief and/or total plant blowdown. Ultrasonic flowmeters can cope with a wide range of flows, and they also offer low pressure drop, tolerate some condensed liquid, operate at high temperatures, and introduce no internal, insertion, or moving parts to block flare lines.

In the early 1990s, new environmental regulations began requiring companies to detect and reduce the emissions of sulphur dioxide (SO2) and nitrous oxide (NOx) into the air.

SO_2 and NOx were identified as two of the principal causes of acid rain. The Environmental Protection Agency (EPA) initiated federal programmes in the US to reduce pollution in the atmosphere. EPA regulations have resulted in the development of an entire industry around continuous emissions monitoring (CEM).

In response to CEM requirements, thermal flowmeter companies developed multipoint thermal flowmeters. In many cases, continuous emissions monitoring occurs in large stacks that emit pollution from industrial sources. Single point thermal flowmeters measure flow at a point, making it difficult to accurately compute flow in a large pipe or smokestack.

Multipoint thermal flowmeters measure gas flow at multiple points and use these values to compute flow for the entire pipe,

An Ultrasonic inline device by Flow Research

Gas being flared at a process plant

duct, or stack. Some multipoint flowmeters have as many as 16 measuring points.

In response to the same CEM requirements, DP manufacturers developed multipoint averaging Pitot tube meters that accurately measure flow in large pipes and smokestacks.

These were an improvement over single point averaging Pitot tubes that measured only at one point. These insertion meters can handle flow of widely varying temperatures and flow ranges.

Ultrasonic flowmeters are also widely used to measure flare gas and flow in large pipes and smokestacks. Both inline and insertion ultrasonic meters are used for this purpose; ultrasonic meters are non-intrusive, highly accurate, can handle a wide range of pipe diameters, and can readily deal with the rugged environment of stack flow measurement.

While CEM is still important, the Paris Agreement of 2015 created a new urgency for measuring greenhouse gas (GHG) emissions.

As the successor to the Kyoto Accord of 2005, the Paris Agreement issued in a new age of environmental awareness, this has resulted in a rewriting of the rules on measuring greenhouse gas emissions, and a need to measure GHGs in applications that formerly may have gone unnoticed.

Liquefied natural gas (LNG)

LNG is a vital method of transporting and storing natural gas. The primary advantage of LNG is that it reduces the volume of natural gas by a large amount, to 1/600th of its gaseous form. This is accomplished by cooling the natural gas to -260°F (-162°C).

Coriolis, DP, turbine, and ultrasonic flowmeters are the technologies most often used for LNG measurement. Ultrasonic and Coriolis flowmeters have a competitive advantage here because of their accuracy and reliability, and because of their non-intrusive design. Because their design does not impede the flowstream, higher throughput is possible for a given line size.

LNG is especially important as a convenient form of storing gas on ships. Before the natural gas is put on the ship, it is liquefied. Onboard the ship it is sometimes used as an energy source for the ship itself. Once it reaches its destination, it is re-gasified and often put into pipelines for distribution. LNG has become a vital source of natural gas for many Asian countries, many of which have low amounts of oil and natural gas; these include Japan, India, and China, among others. The source of the LNG being shipped is mostly from European and Middle Eastern countries, along with the US and Canada. Qatar is the leading exporter of LNG in the world.

Many other applications

While the applications described above are three of the most important applications for gas flow measurement, there are many other applications involving gas flow.

Some include submetering, compressed natural gas (CNG), shale gas, landfill gas and biogas, industrial gas processes, and process gas measurement. The dominant technologies for gas flow measurement are ultrasonic, DP, turbine, and thermal.

Coriolis flowmeters are also important for some applications, but they typically perform better with liquids, because liquids are denser than gas.

The drive for renewable energy and the shift away from coal and oil creates a great opportunity for natural gas. While natural gas is a fossil fuel, it burns much cleaner than either coal or oil. Though substantial strides have been made in renewable technology, especially in reducing their cost, more research and development is required before solar, wind, biogas, and other renewable energy forms can be widely implemented.

A big part of this effort is building the infrastructure to support wide adoption of renewable energy forms.

In the meantime, natural gas remains a logical alternative, and is correctly called "a bridge to renewables". This is good news for manufacturers of those flowmeters that measure gas flow.

While the 2020s in terms of energy may be marked by a drive to renewables, in terms of the sources of energy, it may well be considered "the decade of natural gas."

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An LNG carrier