Technical Publication

Measuring Methane-Based Digester Gas Flow In Wastewater Treatment Plants

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Process and plant engineers at municipal wastewater treatment facilities need to measure, monitor and dispose of methane (CH_4) and other digester gases that occur naturally in their operations. These digester gases pose plant safety concerns, odor issues for surrounding communities and are greenhouse gas (GHG) sources contributing to the global warming phenomenon.

As a greenhouse gas, methane remains in the atmosphere for approximately 9 to 15 years according to the various U.S. and global government sources. Methane is over 20 times more effective in trapping heat in the atmosphere than carbon dioxide (CO_2) over a 100-year period and is emitted from a variety of natural and human-influenced sources. Beyond wastewater treatment facilities, other anthropomorphic sources of methane include landfills, natural gas and petroleum systems, agricultural activities, coal mining, stationary and mobile combustion and a variety of other industrial processes.

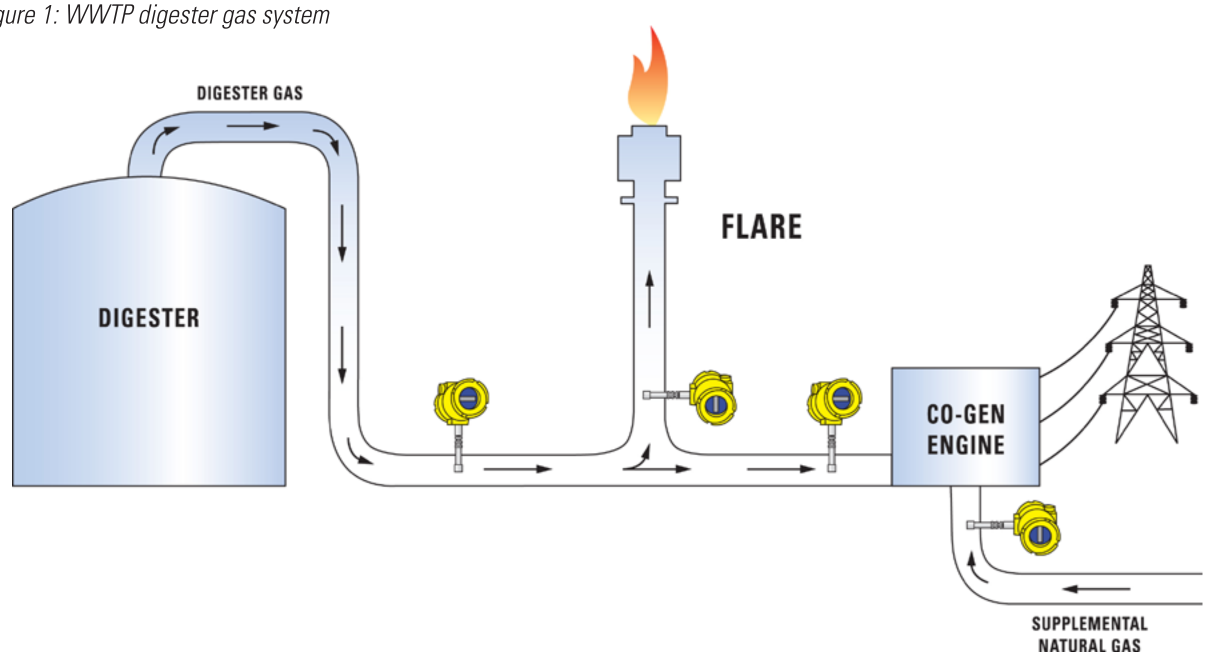
Methane digester gas is the primary component of natural gas, and is also an important energy source in the U.S and around the world. While traditionally flared by wastewater treatment plants (WWTPs), many facilities are now turning the methane produced by their digester processes (Figure 1) into a fuel source. The harvested digester gas is used to generate on-site heat, fuel boilers and, with co-generation technologies to generate electricity.

In large WWTPs, cleaned gas and electrical energy produced by the co-generation technologies is frequently connected into the public power grid, creating an income stream resulting in an even better ROI and payback for the WWTP operator. In addition to the obvious cost savings and economic benefits, the WWTP plant gets ahead of the greenhouse gas regulations curve as well as reaps the strategic benefits of being environmentally and tax rate attentive with their local community. Properly measuring, treating and utilizing a historical by-product gas as an energy resource provides a win-win solution for the WWTP and the entire community of stakeholders.

The Problem

Wastewater treatment digester gas systems, as well as other biogas applications such as landfills, are challenged by wide flow variations, dirty and wet gas, and a potentially explosive gas. These dynamic process variables make accurate and repeatable gas flow measurement a challenge for WWTP process and plant engineers. Flow rates can vary from low production in start-up phases to much higher flows as the process matures and with seasonal and population changes. To overcome this challenge flow meters capable of measuring both low flow rate sensitivity

Figure 1: WWTP digester gas system



and be wide ranging (i.e. a high turndown ratio) are installed.

Typical wastewater treatment plant digesters (Figure 2) produce a mixed gas composed of methane and carbon dioxide along with a small percentage of other trace gases. The gas composition can vary with the process state and temperature (e.g., seasonally), but a typical average is in the 65% (±5%) CH_4 35% (±5%) CO_2 range. Adding to the engineering challenge is that digester gas is also a wet and dirty gas, typically containing entrained hydrogen sulfides, which condense and deposit on pipe walls and anything else in the pipe. Flow meters must be accurate and calibrated for mixed gases and not be susceptible to performance degradation or intensive maintenance from moisture and deposits.

Figure 2: Typical WWTP digester tank and flare gas process loop

Modern wastewater treatment plant processes incorporate digester gas flow measurement for:

- Data on digester process performance and control
- Environmental compliance to report, control and reduce emissions
- Process control of co-generation systems using digester gas as fuel source

Figure 3: ST100 Series flow meters

The Solution

Process, plant and instrument-and-control engineers at many wastewater treatment plants with digester systems, as well as their outside consulting engineering service partners, have turned to Fluid Components International (FCI) for gas flow measurement advice because of FCI's five decades of experience and expertise in the field. The company manufactures four different series of flow meters (Figure 3) that all provide highly accurate and reliable flow measurement of methane and other digester gases and are installed around the world.

Thermal dispersion type mass flow meters feature a wide-turndown ratio—typically up to 100:1, but some up to 1000:1-- and are highly sensitive to low flow gas measurement. They have no moving parts and their insertion probe design is easy and low cost to install. In addition, they are preferred by plant engineers for digester applications because their no moving parts designs makes them highly resistant to clogging or fouling by the dirty residue and condensates present in this environment.

Thermal flow meters provide direct mass flow measurement, resulting in higher performance at a lower cost than differential pressure (dP)/orifice plate meters, vortex shedding, ultrasonic and other technologies. High quality thermal flow meters include built-in temperature compensation circuitry to ensure accurate measurement in fluctuating fluid and outdoor temperatures. Furthermore, thermal flow meters are inherently dual function and will provide measurement of both gas flow and temperature.

FCI's flow meters deploy constant power technique thermal dispersion technology (Figure 4). This constant power technique has proven superior and is preferred in moist digester gas applications because its heated sensor provides a drying effect resulting in a stable and repeatable reading. Other thermal flow meters using the constant ΔT technique are more susceptible to the moisture and water droplets condensing on the sensors, which results in erratic and unstable readings.

FCI's flow meters feature an advanced thermal mass sensing element that is comprised of two all-welded 316L stainless steel thermowells, which protect two matched precision platinum resistance temperature detectors (RTDs). With a highly reliable no-moving parts solid-state design, one RTD is slightly heated relative to the reference RTD, and the temperature difference between the two is proportional to changes in the gas flow rate.

Wastewater treatment digester gas, biogas and landfill gas compositions present a potentially hazardous combustible gas installation environment. Sound engineering practice and often regulations mandate that instrumentation meet guidelines and have agency approvals for installation zone safety. Depending on actual installation location, at a minimum the environment will require Class I, Division II [Zone 2] and often a more rigorous Class I, Division I [Zone 1] approvals.

The thermal flow meters produced by FCI meet all of these industry requirements and carry the global agency approvals that ensure their installation is always safe. Unlike some manufacturers who merely provide their transmitter electronics in an approved OEM enclosure, FCI submits its entire instrument to agency testing.

The company's product safety approvals are therefore different and have the highest integrity because their agency approvals that also take into account the sensors, electronics and enclosures for a full instrument approval. With these flow meters, plant users are assured of the highest total instrument approval pedigree which meet or exceed safe engineering practices for their applications.

Thermal flow meters support BACT (Best Available Control Technology) facility practices. Such practices require technologies that achieve the maximum degree of emissions control that can be achieved by a particular facility. BACT facility practices are determined on a case-by-case basis, which takes into account technical feasibility, cost and other energy, environmental and economic impacts.

FCI's range of thermal flow meters include solutions that provide flow accuracy to ±0.75% of reading, flow ranges from 0.25 SFPS to 1000 SFPS (0.07 MPS to 305 MPS), turndowns up to 1000:1 and repeatability of ±0.5 percent of reading. Insertion-type flow elements are available for use in pipe diameters greater than 2 inches (51 mm) and an in-line type (spool-piece) is used for smaller diameter applications. Models are offered with multiple 4-20 mA analog outputs, frequency/pulse outputs, HART, Profibus, Foundation™ fieldbus and Modbus digital bus communications, digital readouts and integral or remote up to 1000 feet (300 m) electronics. Built-in temperature compensation is standard in all FCI thermal flow meters.

The flow meters' robust thermal mass flow sensing element have no moving parts and no orifices to clog or foul to attain virtually maintenance-free service in wet, dirty biogas applications. A wide range of process connections are available, including compression fittings, flanged, packing glands, ball valves and more to match the installation of users.

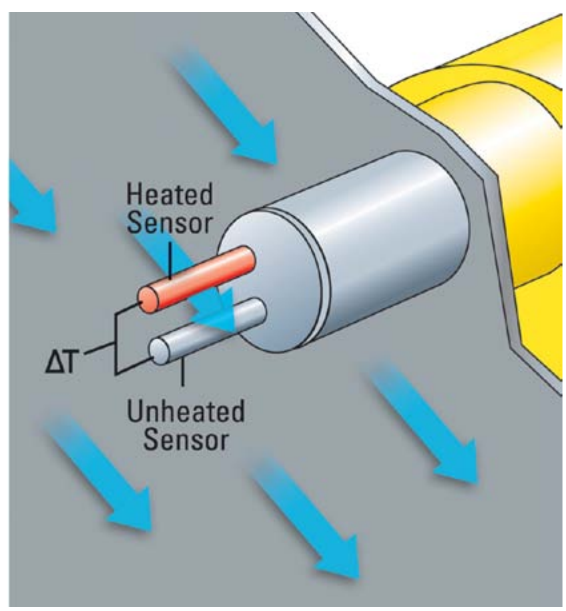


Figure 4: Thermal dispersion mass flow sensing theory of operation

Conclusion

Methane digester gas is a natural by-product of WWTP processes and will continue to require the attention of process and plant engineers at wastewater treatment plants. Whether flared or harvested as fuel gas, methane and other digester gases will be measured, monitored and controlled one way or another. Accurate measurement of methane and other digester gases is critical to all of these processes, and thermal mass flow meters with constant power technology from FCI provide high accuracy, low maintenance, long-life instrument solution designed for this purpose. (Figure 5). ■

Figure 5: Flow meter installed on digester gas pipeline