Technical Publication

City of St. Cloud Relies on Thermal Flow Meters For Digester Biofuel Co-Gen Power Process

Jacob Ethen, Industrial Electronics Tech, City of St Cloud
Steve Cox, Sr Applications Manager, Fluid Components International (FCI)

FLUID COMPONENTS INTERNATIONAL LLC

Visit FCI online at www.FluidComponents.com | FCI is ISO 9001 and AS 9100 Certifie

FCI World Headquarters
1755 La Costa Meadows Drive | San Marcos, California 92078 USA
Phone: 760-744-6950 **Toll Free (US):** 800-854-1993

FCI Europe
Persephonestraat 3-01 | 5047 TT Tilburg, The Netherlands | **Phone:** 31-13-5159989

FCI Measurement and Control Technology (Beijing) Co., LTD
Room 107, Xianfeng Building II, No.7 Kaituo Road, Shangdi IT Industry Base, Haidian District | Beijing 100085, P. R. China
Phone: 86-10-82782381

Figure 1: St Cloud wastewater treatment facility

The City of St. Cloud, Minnesota, straddles the Mississippi River near the center of the state a little more than 65 miles north of the twin cities of Minneapolis-St. Paul. This college town with a population of over 65,000 is home to the state's third largest public university, which sits between the downtown district and the Beaver Islands, a popular local recreation area.

The city's wastewater treatment facility *(Figure 1)* is located in south St. Cloud and also services other nearby communities including St. Augusta, St. Joseph, Sartell, Sauk Rapids, and Waite Park. This award winning operation has been recognized at both the state and national levels for its highly innovative and effcient sustainability initiatives, which include both biofuel and solar co-generation electric power.

The city's forward thinking staff began looking for sustainable green energy solutions in 2003. After planning and initiating a series of projects over several years, the site is today producing renewable energy with a 20 kW rooftop solar array, a 220 kW solar array and biofuels electricity generation.

Energy projections for the facility state that 80 percent of its energy demand will come from renewable sources by the year 2018. Biofuels will be responsible for meeting much of the facility's electric power demand.

Treatment To Biofuel Processes

The plant operates with a standard fve-step wastewater treatment process for the area's domestic and industrial wastewater, which includes three treatment phases, clarifcation and solids processing. After the frst three treatments and clarifcation, the liquids portion is treated with UV light for disinfection prior to discharge.

The remaining solids are dewatered and sent to the anaerobic digester for further treatment. This treatment process includes digester heating over a 15-day period, which produces liquids, gases and solids.

All biofuel produced is scrubbed of H_2S gas with a bio flter, and conditioned for moisture and siloxane removal. The conditioned biofuel gas is fed to a 630 kW CHP, combined heat and power engine/generator system. This generator system produces enough electricity to support on average 80% of plant operations. Heat produced and captured by the generator system heat exchanger, 2 MBtu/hr, is used directly for process and facility heating needs year round.

At 100 percent effciency, biofuels energy generation has the potential to generate 5.4 million kWhs of electricity annually. In 2016; the facility purchased 5.2 million kWhs of electricity to treat over 9.8 million gallons of infuent fow a day. Depending on daily conditions, such as solar energy potential, there will be days the facility will operate on 100 percent renewable energy.

Gas Flow Measurement

Accurate, reliable digester gas fow measurement over varying fow rates is essential to the success of wastewater biofuels co-gen energy production. Digester gas is a combination of methane (CH_4) and carbon dioxide (CO_2) with a small percentage of other trace gases.

The gas composition can vary with the process and temperature (e.g. seasonally with hot summers and cold or freezing winters), but a typical average is 65% (±5%) CH_4 and 35% (±5%) CO_2 is present. Digester gas is also a wet and dirty gas, typically containing entrained hydrogen sulfdes, which can be present in any condensation on pipe walls and instrumentation.

The CH_4 gas is potentially explosive and combustible, and can result in fow meter installation conditions that require hazardous Ex approval ratings. Any excess gas is fared for safe disposal as waste when it is more effcient to make use of digester gas to reduce energy costs.

Accurate, consistent fow measurement is essential to report digester gas production or for plant process control. Local, state and federal authorities require gas production data for regulatory reporting purposes to ensure environmental compliance for greenhouse gas reporting.

There are a number of key criteria to consider when specifying a fow meter for digester gas measurement:

- Accurate and repeatable measurement
- Low maintenance with no moving parts to clog or foul
- Simple threaded insertion for easy installation and periodic maintenance
- Wide turndown for accurate low and high fow rate measurement
- Approved for Class 1, Division 1 (Zone 1) hazardous environments
- Factory calibrated for digester gas compositions
- Direct mass fow measurement
- Temperature compensated fow measurement for accuracy in changing process gas temperatures

St. Cloud Digester Gas System

In 2010, the St. Cloud facility team chose four fow meters for their original digester gas units. The fow meters needed at that time were primarily for environmental monitoring purposes, with one meter installed on Digester 1, one meter on Digester 2, one meter on the fare gas header and one meter on the fare gas burner. The St. Cloud facility team contacted Jasper Engineering and Fluid Components International (FCI) to discuss the facility's requirements. After reviewing the application, the FCI ST98 thermal mass fow meter was recommended and installed at the site.

The ST98 fow meters *(Figure 2)* are a highly reliable no-moving parts design that provides direct mass fow measurement with a single process penetration. Their rugged construction also has no orifces to plug or clog in the dirty wet gas environment, and they have agency hazardous Ex global approvals for safety in explosive environments.

The wastewater treatment facility staff recognized the advantages of this fow meter's advanced thermal sensing technology design, which reduces cost and installation expenses. Other types of air/gas fow sensors generally require installing separate temperature and pressure sensors, as well as mass fow calculations to provide inferred mass fow measurement.

Thermal dispersion sensing technology provides direct mass fow measurement. It places two thermowell protected platinum RTD temperature sensors in the process stream *(Figure 3)*. One RTD is heated while the other senses the actual process temperature. The temperature difference between these sensors generates a voltage output, which is proportional to the media cooling affect and can be used to calculate the mass fow rate.

With this direct mass fow sensor technology, the meter also includes built-in temperature compensation to ensure repeatable

Figure 2 (left): FCI Model ST98 flow meter

Figure 3 (below): Thermal dispersion technology principle of operation

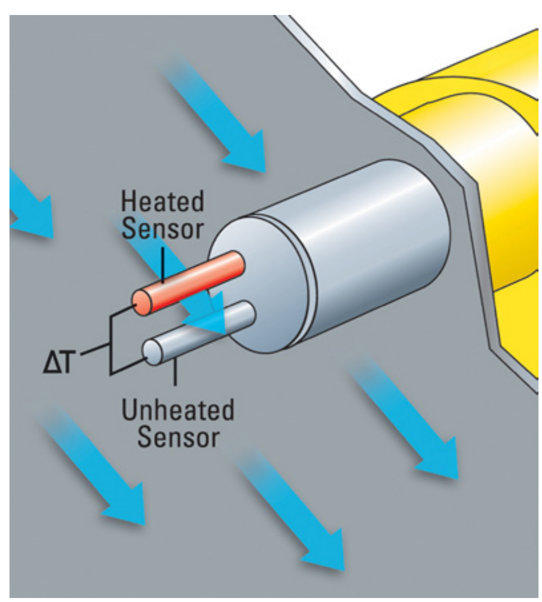

Figure 4: FCI Model ST98 installations

and reliable measurement for process temperature changes over ±30°F. This automatic temperature compensation technology compensates automatically to changes in seasonal temperatures, such as cold winters and hot summers.

With no moving parts to plug or foul, the ST98 meter delivered extensive future cost savings over higher maintenance alternative technologies for the digester gas application. This meter now provides the accurate gas fow measurement essential for dependable and safe plant operation at the lowest life cycle cost for the gas fed co-gen engines.

The St. Cloud facility engineering team was satisfed with ST98 meter's accuracy of ±1% of reading, 0.5% of full scale, with repeatability of ±0.5% of reading. The meters included a rugged, NEMA 4X/IP66-rated enclosure and is agency approved for installation in hazardous gas (Ex) locations involving combustible biogas and natural gas.

New Biofuel Co-Generation System

In 2017 when the facility added its full biofuel co-gen power capability, the ST98 Flow Meters had performed well for seven years and were considered a natural choice. The new system is designed to generate 160-180 cubic feet of digester gas per minute on average, which meets about two-thirds of the plant's energy needs at this time.

One fow meter was installed on the wet gas pre bio-flter line, and the other meter was installed on the engine side *(Figure 4)*. The actual gas composition was set differently for each of the two fow meters. On the wet side of the process, the meter was set to measure with a gas calibration of 62 percent CH_4, 37 percent CO_2, and 1 percent H_2O. On the dry side of the process, the meter was calibrated for 60 percent CH_4, 38 percent CO_2 and 2 percent O_2.

In processing the gas from the wet to the dry side, the gas is heated to 170°F and then chilled to 35°F for moisture removal. The process requires a 30 percent differential in going from the wet to dry side of the gas process. The facility's Rockwell Control Logix System monitors both gas production and co-gen gas usage. The two fow meters interface with the system via their 4-20 mA outputs. The meter readings from the wet and dry side of the process are cross-checked for measurement accuracy. If the two meters are outside of a 10% differential, then both meters are pulled for cleaning and calibration checks.

The new insertion style meters were installed at a 45-degree angle pointing up. Vortab Insertion Panel (VIP) fow conditioners were installed on both meters because of short pipe runs to ensure accuracy.

The new meters included a ball valve and packing glad assembly kit, which simplifes inspection and maintenance as necessary. The meters are easily removed from process line without shutting down the process.

Conclusions

The new fow meters have been installed, commissioned and running successfully for several months. They are supporting the St. Cloud facility's sustainability efforts and power generation goals with no issues to report. ■