CASE STUDY

Avoiding Re-Calibration of Flow Meters in Wastewater Applications:

Case Study on Changing Conditions in Biogas Flow Measurement

A Study of Re-Calibration Issues Associated with Flow Meters used in Wastewater Treatment

Written by:

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OIL & GAS | INDUSTRIAL | BIOGAS | WASTEWATER

SUMMARY

Used in conjunction with a gas sampler, the model FT1 thermal mass flow meter removed the need for flow meter re-calibration at the factory due to gas concentration changes in the biogas reclaimed in the anaerobic wastewater treatment system at an energy facility.

BIOGAS - THE CHALLENGE

Biogas flow measurement is challenging for many flow measurement technologies for several reasons.

Firstly, biogas has constituent gases of which the composition commonly changes and fluctuates over time. This results in accuracy errors for flow meters that have been calibrated for one gas or a fixed gas mixture. The flow meter must be returned to the factory for re-calibration to the new biogas composition to measure accurately again. As biogas is known to fluctuate as frequently as on a weekly basis, factory re-calibrations are not a feasible solution. Flow measurement devices must offer flexibility for changing gas compositions to maintain accuracy.

Secondly, biogas has variances in temperature and pressure that further complicate the flow measurement. For technologies that do not automatically compensate for temperature and pressure changes, the operator will need to purchase additional devices to measure the temperature and pressure of the flow. Furthermore, operators must do additional complicated calculations to account for the differences in temperature and pressure. A mass flow measurement device that compensates for changes in temperature and pressure is a more ideal measurement device.

Next, biogas flows in wastewater treatment applications

will often have low flow velocities. Many technologies lose accuracy at the low end. Differential pressure devices like orifice plates require higher pressures to operate accurately. The flow measurement device must be able to measure accurately at very low flow rates without losing accuracy as the flow increases.

Lastly, biogas is known for its dirty, high moisture content. This can cause measurement errors for some technologies like annubars, orifice plates, and turbine meters. The ports, tubes, or moving parts of these measurement devices get clogged with particulate matter, so they do not function efficiently for this gas type. In some cases, a back up device must be kept on-hand to replace the device that is removed periodically to be returned to the manufacturer for cleaning and repair. This adds significant lifetime operation costs to the process. Rather, the flow meter must be able to operate accurately in the flow stream without damage, offer an easy cleaning solution for regular maintenance, and a way to verify that the meter readings are still accurate.

Common Types of Biogas

The most common biogas applications are landfill gas, agricultural, and wastewater.

Landfill Gas

Landfills are the largest human-related source of methane in the U.S., accounting for 34% of all methane emissions. The CDC's Agency for Toxic Substances & Disease Registry (ATSDR) states that landfill gas can be composed of a mixture of many different gases. A typical analysis will have a range of 45% to 60% methane and 40% to 60% carbon dioxide as the primary constituents with trace amounts of other gases like nitrogen, oxygen, and hydrogen.

Agricultural Biogas

Biogas harnessed in the agricultural sector may be from agriculture residues or from livestock waste. Like landfill gas, these biogas compositions will have varying component gases, temperatures, and pressure.

Wastewater Digester Gas

Methane is the principle component of anaerobic digester gas (ADG) and a large wastewater treatment plant can produce roughly one million cubic feet of this gas each day. Wastewater treatment plants utilize recovered gas to fuel boilers or combustion engines to generate electricity.

Chemical Compositions of Biogas			
Gas Components	Agricultural	Landfill	Wastewater
Methane	50 - 80	50 - 80	50 - 70
Carbon Dioxide	30 - 50	20 - 50	30 - 50
Hydrogen	0 - 2	0 - 5	0 - 2
Nitrogen	0 - 1	0 - 3	0 - 1
Oxygen	0 - 1	0 - 1	0 - 1

CASE STUDY SITE DESCRIPTION

BioWorks Energy LLC provides expertise in operations of wastewater treatment systems for industrial, agricultural, and municipal wastewater treatment processes. Its focus is on anaerobic digestion processes that capture biogas for electricity generation. Their most recent project included the installation of a new digester that would require an instrument to read the flow of a changing biogas concentration from an anaerobic digester to an internal combustion engine as accurately as possible. The accuracy of the meter would help the operator to understand the gas usage and the efficiency of the engine. Drastic changes in the gas consumption can signify premature wear on the engine among several other issues. Keeping the measurement error as low as possible is paramount to monitoring consumption, but finding a flow meter designed to measure the flow of more than one gas or gas concentration wouldn't be easy.

THE SEARCH FOR THE RIGHT TECHNOLOGY

When beginning the search for a flow measurement technology that would be able to meet the challenges of this project, Chad Antle, CEO of BioWorks Energy LLC, hit a few walls. He needed a meter that could handle two very important aspects of this project: the meter must measure the flow of biogas at different concentrations of carbon dioxide and methane, and it couldn't break the bank.

Researching flow technologies such as ultrasonic, positive displacement, turbine, and coriolis showed that the only technologies offering multiple calibration points were too expensive and also had issues with maintenance over time.

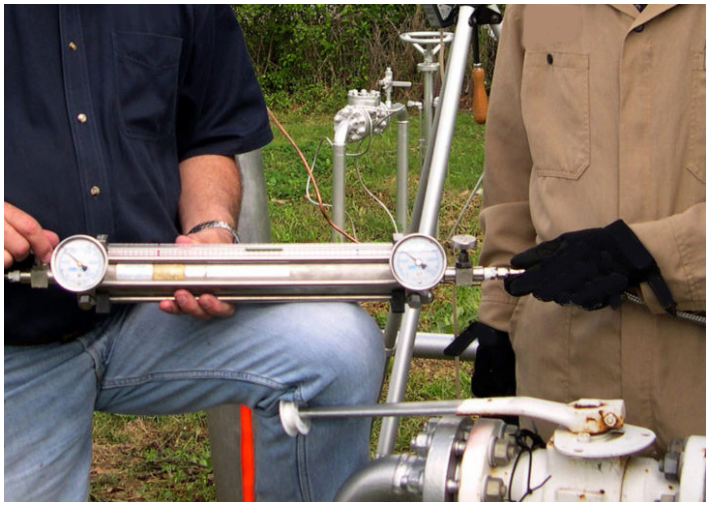
THERMAL MASS FLOW TECHNOLOGY FOR BIOGAS

After extensive research, Chad was able to narrow down the list of applicable technologies to thermal mass flow meters. When he came accross the cost-effective thermal mass flow technology, he was pleased to see it met so many of the requirements that had seemed so challenging with the other technologies. He reviewed the list of benefits thermal mass technology offers, such as:

- Direct mass flow measurement of biogas in standard volumetric units (eg SCFM or NM3/H)or mass units (eg LBS/M or KG/H)
- Measurement of flow rate and temperature
- No additional pressure temperature compensation required
- Repeatability and exceptionally broad measurement range, especially at low flow rates
- No moving parts design for easy maintenance

Chad really liked these attributes of the thermal mass flow meter technology, but was concerned about the changing gas composition. He needed to know if any of the thermal

Fox Thermal model FT1 thermal mass flow meter and temperature transmitter.



Sampling natural gas from the source is the best way to determine the gas composition.

mass flow meter manufacturers offered a solution - other than frequent factory re-calibrations - for the varying gas compositions inherent in biogas flow measurement.

NARROWING THE LIST OF MANUFACTURERS

There are many manufacturers of thermal mass flow meters, so how do you settle on one? Chad began like many do - he reached out to a flow meter rep in his area.

They discussed the challenges of the application and what he needed. The model FT1 by Fox Thermal was recommended. It offers the perfect solution to changing gas compositions with a feature that has revolutionized flow measurement technology: Gas-SelectX®.

THE PROBLEM

For this project, the methane concentration was expected to fluctuate between 68-71%; however, due to the occasional fluctuations from feedstock, this number could fall as low as 55% or jump up as high as 75%. A meter calibrated for 35% carbon dioxide and 65% methane, for example, would introduce a large measurement error. Chad needed to be able to get his flow meter to continue measuring accurately without sending it back to the factory for calibration. He wanted to adjust the meters settings - whenever necessary - to account for changes in biogas composition.

THE SOLUTION

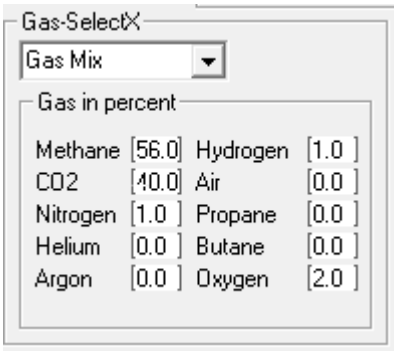
The Gas-SelectX® gas selection menu available on the model FT1 thermal mass flow meter and temperature transmitter allows the user to choose from Air, Argon, Carbon Dioxide, Helium, Methane, Nitrogen, Oxygen, Propane, or any mix of five of these gases equaling 100%.

Not only is the price tag on the model FT1 economical, but it is has a short lead time, is easy to install, and offers the technology needed to measure different biogas concentrations. The model FT1 from Fox Thermal allows the user to manually enter the concentration of up to five gases available in the Gas-SelectX® menu in order to create the ideal mixture for the most accurate reading possible.

Chad was able to develop a routine to sample the gas at regular intervals for gas composition changes. When he finds that the composition has changed, he can

Gas-SelectX® Feature				
FT1 Gas-SelectX® Menus		FT4A & FT4X Gas-SelectX® Menus		
Pure Gas	Gas Mixture	Pure Gas	Gas Mixture	Oil & Gas
Air	Mixture of any 5 gases in first column. Mixture must total 100%	Air	Air	Methane (C1)
Argon		Argon	Argon	Ethane (C2)
Butane		Butane	Butane	Propane (C3)
Carbon Dioxide		Carbon Dioxide	Carbon Dioxide	Iso-Butane (C4)
Ethane		Helium	Ethane	Normal-Butane (C4)
Helium		Hydrogen	Helium	Pentanes (C5)
Hydrogen		Methane	Hydrogen	Hexanes (C6)
Methane		Natural Gas*	Methane	Heptanes (C7)
Natural Gas*		Nitrogen	Nitrogen	Octanes (C8)
Nitrogen		Oxygen	Oxygen	Nonanes+ (C9+)
Oxygen		Propane	Propane	Carbon Dioxide
Propane				Nitrogen

*Choosing Natural Gas sets the NAESB average in a pre-programmed mix of methane, ethane, propane, nitrogen, and carbon dioxide. This composition can be changed by the user in the field with no loss of accuracy.



Gas-SelectX® allows the user to choose gases in 0.1% increments to create a custom gas mix.

quickly access the flow meter's settings and change the percentages of the gas constituents. Any combination of gases (excluding natural gas) in the menu can be mixed in 0.1% increments to create a precise and custom gas mix. The Gas-SelectX® feature can be accessed through the front panel of the meter or by using the free FT View™ software tool.

CALIBRATION ADVANCEMENTS

GAS-SELECTX® AND GAS CORRELATIONS

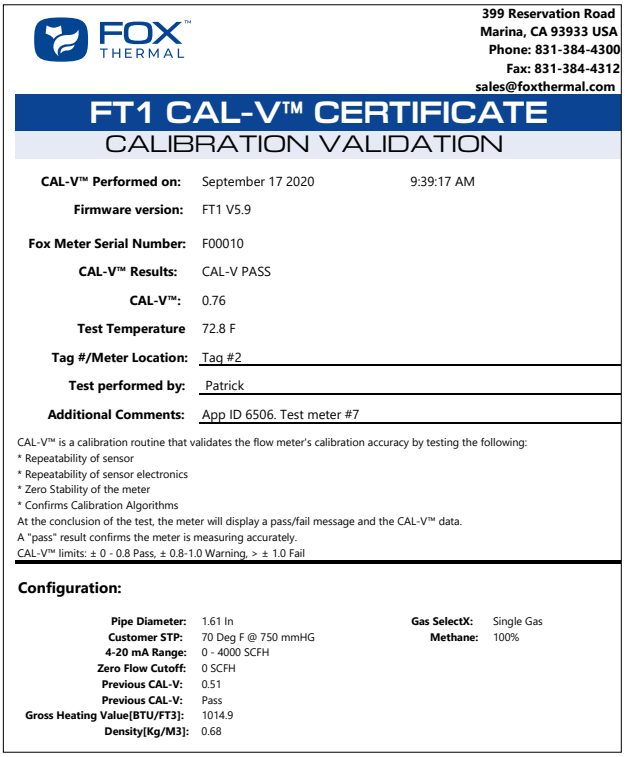
The Gas-SelectX® feature has a long list of common gases used in most wastewater, industrial, and oil & gas sectors. The flow meter's proprietary algorithms allow the user to switch gases or gas mixes in the field, as needed.

The Importance of NIST Calibrations

Meet NIST-traceable Flow Standards
Calibrations performed on flow meters must meet MIL-STD-45662A requirements.

Ensure Reliable Flow Meter Performance
Calibration equipment subject to a meticulous metrology program that includes the selection, usage, calibration, control, and maintenance of measurement standards.

Automated Calibration Procedures
Automated systems in calibration flow labs maximize calibration accuracy and repeatability as well as output and efficiency. Results are consistent and calculating measurement uncertainty simplified.



FOX THERMAL

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FT1 CAL-V™ CERTIFICATE
CALIBRATION VALIDATION

CAL-V™ Performed on:	September 17 2020	9:39:17 AM
Firmware version:	FT1 V5.9	
Fox Meter Serial Number:	F00010	
CAL-V™ Results:	CAL-V PASS	
CAL-V™:	0.76	
Test Temperature	72.8 F	
Tag #/Meter Location:	Tag #2	
Test performed by:	Patrick	
Additional Comments:	App ID 6506. Test meter #7	

CAL-V™ is a calibration routine that validates the flow meter's calibration accuracy by testing the following:
* Repeatability of sensor
* Repeatability of sensor electronics
* Zero Stability of the meter
* Confirms Calibration Algorithms
At the conclusion of the test, the meter will display a pass/fail message and the CAL-V™ data.
A "pass" result confirms the meter is measuring accurately.
CAL-V™ limits: ± 0 - 0.8 Pass, ± 0.8-1.0 Warning, > ± 1.0 Fail

Configuration:

Pipe Diameter:	1.61 In	**Gas SelectX:**	Single Gas
Customer STP:	70 Deg F @ 750 mmHG	**Methane:**	100%
4-20 mA Range:	0 - 4000 SCFH		
Zero Flow Cutoff:	0 SCFH		
Previous CAL-V:	0.51		
Previous CAL-V:	Pass		
Gross Heating Value[BTU/FT3]:	1014.9		
Density[Kg/M3]:	0.68		

Example of a CAL-V™ calibration validation certificate that can be generated from the free Fox Thermal FT View™ software.

AUTOMATED CALIBRATION FOR BETTER QUALITY

Fox Thermal has instituted automated systems in the calibration lab to maximize calibration accuracy and repeatability. This initiative has increased Fox Thermal's production output and created more efficient processes. Because procedures are executed the same way every time, flow calibration technicians can easily spot non-conforming outcomes and ensure consistent accuracy.

NIST TRACEABLE CALIBRATIONS

Fox Thermal's test tunnels are calibrated at appropriate intervals, monitored for stability, and under the custody of trained laboratory personnel. Measurement assurance procedures and monitoring results are maintained in the laboratory database to ensure that all calibrations are accurate, verifiable, and traceable to NIST primary standards.

CAL-V™ CALIBRATION VALIDATION

Sending flow meters for factory re-calibrations can be a costly inconvenience. The CAL-V™ Calibration Validation test was created by the Fox Thermal engineering team to avoid such inefficiencies and bring the power back to the user. CAL-V™ allows the user to confirm that their meter is running accurately in the field. The Calibration Validation

process is as easy pushing a button and receiving a pass/fail result within minutes. If the test is performed using the FT View™ software tool, a certificate can be generated at the end of the test for record-keeping.

FOX THERMAL VALUE PROPOSITIONS

Fox Thermal's DDC-Sensor™ (direct digitally controlled sensor) brings the Digital Difference. It is interfaced directly to the meter's microprocessor for more speed and programmability. This revolutionary advancement in the technology has laid the foundation for award-winning and truly innovative flow meter features like CAL-V™ and Gas-SelectX®.

Other benefits include:

- Standard linear 4-20mA output proportional to mass flow rate
- Low pressure drop
- Insertion, inline, and remote styles available
- Easy to install

Landfill gas presents many of the same challenges as the biogas found in wastewater biogas applications.

Calibration Technician performing an actual gas calibration in the flow laboratory.

CONCLUSION

Biogas does present many challenges to flow measurement technologies, but thermal mass flow meters with flexible solutions like Gas-SelectX® and CAL-V™ can put the power back into the hands of the operator.

The model FT1 used in this case study has out-performed competitor meters in this application. Used in conjunction with a gas sampler and regular calibration validation tests, the Gas-SelectX® feature on this meter has removed the need for frequent re-calibrations at the factory due to gas concentration changes. The Gas-SelectX® gas selection menu is convenient, easy to use, and has revolutionized how gas flow instrumentation can be used in the field.

AUTHOR BIOGRAPHY / CONTACT INFORMATION

Ria Edens, Marketing Communications Manager at Fox Thermal and Air Monitor, is a marketing professional with over ten years experience in technical writing along with application, market, and regulation research involving thermal mass flow meter technology and applications.

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