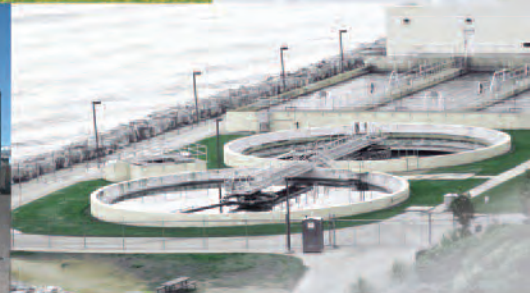




***Thermal Mass Flow Meters
for Greenhouse Gas
Emissions Monitoring***

- ❖ *Natural Gas Measurement
for Emissions Calculations*
- ❖ *Flare Gas Monitoring*
- ❖ *Vent Gas Monitoring*
- ❖ *Biogas and Digester Gas Monitoring*
- ❖ *Landfill Digester Gas Recovery*
- ❖ *Wastewater Digester Gas Monitoring*
- ❖ *Coal Mine Methane Recovery*



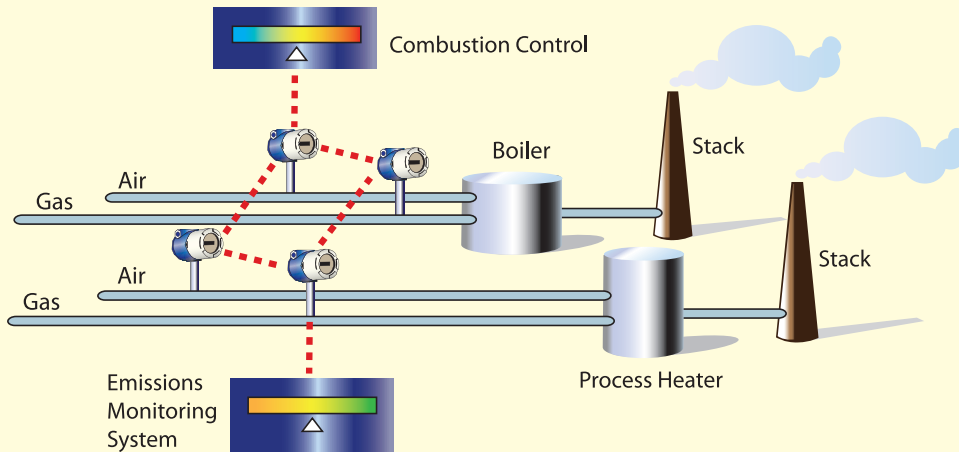
Natural Gas Monitoring



The U.S. EPA sets national ambient air quality and greenhouse gas emission standards to ensure public health. State agencies, as well as regional and metropolitan Air Quality Management Districts are responsible for ensuring attainment and maintenance of these standards. These agencies have published rules and regulations regarding NO_x and CO emissions from industrial, institutional and commercial boilers, steam generators and process heaters.

Owners or operators of units subject to these regulations may install a non-resetting totalizing fuel flow meter (TFF) to measure the fuel used by each individual unit. The regulations specify mass flow measurement of fuel usage and if a volumetric flow meter is installed it must compensate for pressure and temperature using integral gauges.

Thermal mass flow meters deliver a direct reading of mass flow rate of natural gas and other fuel gases – without temperature and pressure compensation – and provide a simple, reliable and cost-effective method for tracking and reporting fuel consumption.



Thermal Flow Meters Help Reduce Fuel

Costs and Improve Emissions Control

Tuning burners to reduce excess air is a cost-effective technique for reducing heat lost in exhaust. Monitoring and adjusting air-to-fuel ratios to maintain optimum combustion not only conserves fuel but also helps reduce emissions.

Sophisticated burner control systems optimize air/fuel ratio control to obtain peak thermal efficiency over the entire range of the burner, and to facilitate proactive emissions control.

Accurate, repeatable measurement of air and gas, at low and varying flow rates, is a critical variable in advanced combustion control. Fox thermal flow meters are designed for use in fuel gas and air feed lines found in process heating and utility operations. In addition to the primary benefits of direct measurement of mass flow rate, low-flow sensitivity, and fast response, the meter's no-moving parts design also helps reduce maintenance costs.

FOX Gives You the Green Light on CO₂e Monitoring

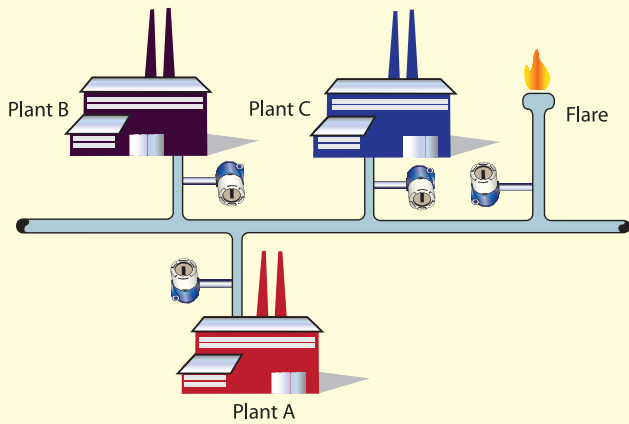
Aimed at U.S. companies that release more than 25,000 metric tons per year of CO₂-equivalent (CO₂e) emissions, the new U.S. EPA mandate 40 CFR part 98, requires owners or operators of facilities that emit Greenhouse Gases (GHGs) to monitor and report annual mass emissions.

FOX thermal mass flow meters' accuracy specification exceeds the requirements defined by the EPA rule, and helps provide a reliable, cost-effective solution to GHG emissions monitoring challenges. FOX flow meters directly measure mass flow rate, have no moving parts and can be installed via a single insertion point on a pipe or duct. Other features include:

- totalizer meets air quality management equipment requirements
- A variety of analog and digital output signals to easily interface with emissions management systems
- No pressure or temperature compensation
- Broad measurement range (100 to 1 typical) including very low velocity flow rates



Flare Gas Monitoring

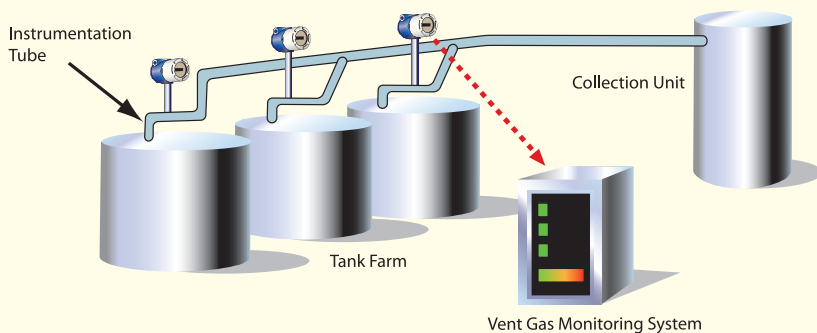


Flare stacks are used to burn waste gases from the plant, converting chemical and organic hydrocarbons into primarily water vapor and CO₂. Some processes also use relief valves to vent flammable gases to the flare stack during upset conditions. Applications include oil and gas well drilling operations, oil refineries, chemical process plants, gas distribution infrastructure, and landfills. Flares are subject to stringent regulations, requiring operators to measure, record and report the amount of flared gases.

Due to the potential for large changes in flow rates, density, pressure and gas composition, flare gas measurement is one of the most difficult and demanding flow applications. Fox thermal mass flow meters have demonstrated their ability to measure the low flow rates typical of normal flare conditions, and also the high velocities found in upset conditions.

Fluid composition and installation anomalies can also affect flow meter performance. Fox Thermal Instruments' Calibration Lab employs a wide range of gases, gas mixtures, temperatures, pressures and line sizes to simulate actual fluid and process conditions. This real-world approach improves installed accuracy and minimizes measurement uncertainty.

Vent Gas Monitoring



Rising levels of volatile organic compounds (VOCs) in the atmosphere are a subject of general concern and increasing environmental regulation. In order to monitor and quantify emissions, VOC concentrations as well as VOC flow rates must be measured to evaluate mass emission rate.

A recent study conducted for the Texas Environmental Research Commission (TERC) evaluated emission factors and regional emissions of speciated VOCs from oil and condensate storage tanks at wellhead and gathering sites in East Texas.

Storage tank emissions were measured by determining vent gas flow rates and sampling the vent gas for chemical composition. Tank batteries having multiple tanks were sampled through common vent gas gathering pipes located at the tops of the tanks. Flow rates were measured using a FOX Model 10A thermal mass flow meter.

The TERC flow measurement team reported that...“Overall we were very pleased with the accuracy and reliability of the Fox flow meters.”

To learn more go to www.foxthermalinstruments.com/flashgas

Biogas and Digester Gas Monitoring



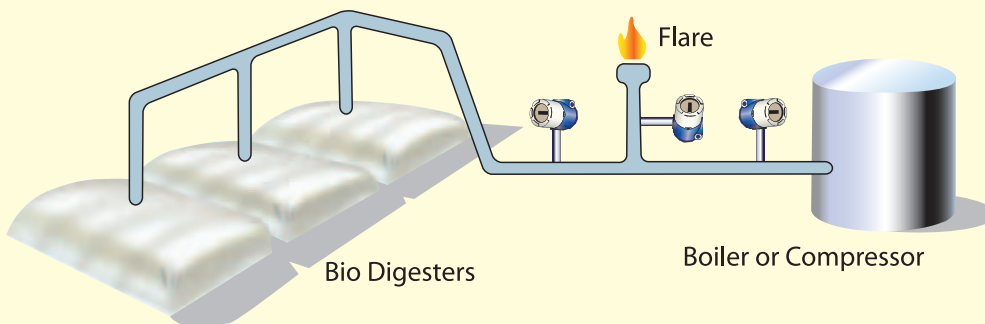
Biogas is produced when organic matter, such as sewage, manure or vegetable matter, decomposes in the absence of oxygen. This may take place in a landfill site or in an anaerobic digester. The biogas mixture is typically 70% methane and 30% carbon dioxide.

Methane is a powerful greenhouse gas that remains in the atmosphere for approximately 9 to 15 years. Methane is also a primary constituent of natural gas, and a valuable energy source. As a result, efforts to utilize methane emissions can provide significant energy, economic and environmental benefits.

Landfills are the largest human-related source of methane in the U.S., accounting for 34% of all methane emissions. Fox Thermal mass

flow meters are widely used in many landfill, wastewater and sewage treatment applications, including:

- *Digester gas flow monitoring*
- *Oxygen/ozone flow monitoring*
- *Chlorine gas flow monitoring*
- *Sample flow for gas chromatography*



RCM Digesters Specify Fox Flow Meters

RCM Digesters, leaders in livestock anaerobic digester systems, uses FOX thermal flow meters to measure the methane that is captured by the biodigester and then used to fuel boilers and generators associated with their applications. The FOX flow meter's stainless steel sensor and wide measurement range provide a simple solution here.

Variations in flow rate caused by seasonal climate changes and the gas spikes that occur after feeding the digester are not a challenge for FOX thermal flow meters. Their exceptional low flow sensitivity and ability to directly measure mass flow make them ideal for fuel flow measurement over a wide range of temperatures, pressures and flow rates.

RCM originally used traditional DP metering technology, but found that method unsuitable for the varying flow rates and corrosive gases they encounter.

FOX flow meters are also used to monitor flare gas from the digester. Measuring all combusted methane, including the excess gas that is flared, is an important element of the certification process needed to document, verify, register and monetize reductions in greenhouse gas emissions.

Methane is also produced during the anaerobic decomposition of organic material in livestock manure management systems. These systems can produce significant amounts of methane.

Many large swine and dairy operations are turning manure into a valuable resource by substituting biogas for natural gas or propane as fuel, and by monetizing the resulting carbon credits through greenhouse gas emissions allowance trading systems.



Landfill Gas Recovery



Landfill Gas (LFG) contains methane, a potent greenhouse gas. The EPA requires landfill operators to collect the methane produced on site, and where it is not being used for energy production, it must be flared to prevent its release.

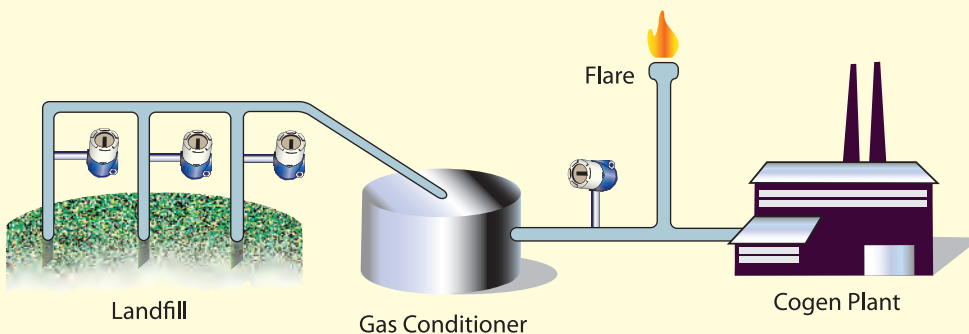
Landfill Gas to Energy (LFGTE) facilities typically extract gases from multiple wellheads, which are connected to a common header pipe, and then recovered for a variety of uses, including:

- *Fueling on-site engines or turbines*
- *Generating electricity for surrounding homes and businesses*
- *Conversion to Liquid Natural Gas, a clean vehicle fuel*

Accurate flow monitoring is essential for gathering system-wide information on the amount of gas being extracted, flared or recovered. Some of the measurement challenges in the LFG environment are changing gas compositions, varying flow rates caused by seasonal temperature changes, and wet, dirty and potentially explosive gases.

Fox thermal mass flow meters

can help LFGTE operators comply with clean air regulations, as well as improve the operation of co-gen engines or methane oxidizers. With turndowns from 100:1, specified accuracy of $\pm 1\%$ of reading plus .2% of full scale, and repeatability of $\pm .2\%$ of full scale, Fox flow meters exceed the requirements of EPA's 40 CFR part 98.



Actual Gas Calibrations Reduce Measurement Uncertainty

Fox Thermal Instruments' Calibration Lab utilizes a wide range of pure gases and specialty mixed gases to optimize measurement accuracy and fulfill customers' delivery requirements.

Whether your meter requires a straightforward air calibration or a complex mixed gas calibration, our goal is to achieve the highest accuracy and the fastest turnaround time. On-site gas reserves, gas mixing equipment and configurable test fixtures help ensure that calibration lab accuracy is transmitted to the actual installation.

Typical calibration gases include:

- Carbon Dioxide
- Carbon Monoxide
- Digester Gas
- Ethane
- Flare Gas
- Biogas
- Hydrogen
- Methane
- Natural Gas
- Nitrogen
- Propane



Wastewater Digester Gas Monitoring



Wastewater Treatment Plants (WWTPs) use large heated digester tanks to remove and dispose of solid waste material. Here, bacteria break down the material, producing digester gas in the process. Methane is a primary component of anaerobic digester gas (ADG) and a large wastewater treatment plant can produce roughly one million cubic feet of this gas each day.

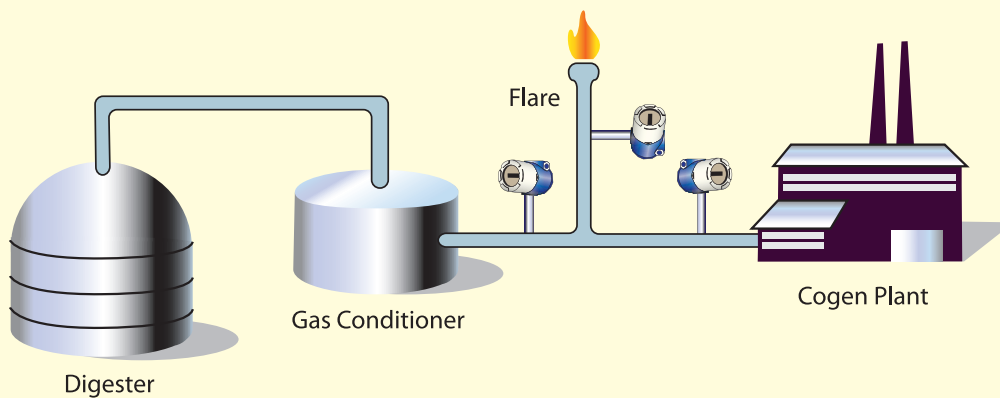
Most WWTPs utilize recovered gas to fuel boilers and flare off the excess. Other biogas uses include fuel for combustion engines to generate electricity, fuel for natural gas vehicles, and sale and distribution to neighboring industries and communities.

ADG is a wet, dirty gas, often containing entrained hydrogen

sulfides, which may condense and accumulate on pipe walls or equipment inside of the pipe. Selecting a flow meter with no moving parts can dramatically reduce costs associated with maintenance and repair.

Most digester gas applications operate at relatively low pressure. Fox flow meters create virtually no pressure drop and can be used to accurately measure these flow rates. They are

widely used in WWTPs to optimize digester processes, comply with environmental regulations, and control fuel and air flow ratios in combustion processes.



Fox Flow Meter Benefits

Direct Mass Flow Measurement

Fox flow meters do not require pressure or temperature compensation.

Outstanding Rangeability

Fox flow meters' low-flow sensitivity improves measurement accuracy over a wide range of conditions.

Rugged, Low-Maintenance Design

Fox flow meters' no-moving-parts design makes them relatively immune to oils and particulates and reduces service requirements.

Low Installed Cost

Fox flow meters are available in both insertion and in-line versions to suit any application.

Safety Approvals

Fox flow meters are FM, FMc and CSA approved for operation in hazardous areas and housed in NEMA 4X enclosures.



Coal Mine Methane Recovery



Coal mine methane (CMM) is a potent greenhouse gas that, if vented to the atmosphere contributes to climate change. If not vented, however, CMM can create an explosive hazard inside the mine. However, if CMM is recovered safely and used for energy, it is a valuable, clean-burning fuel source.

There are three major sources of CMM:

- Degasification systems (drainage) both pre-mine and gob
- Ventilation air (VAM)
- Abandoned or closed mines

As technology advances are made, as greenhouse gas reduction incentives increase, and as environmental pressure intensifies, the benefits of capturing and using CMM as a fuel gas become more significant.

Thermal mass flow meters can help mining operations comply with regulations, improve the operation of co-gen engines or methane oxidizers, and facilitate the data management processes needed to

monetize greenhouse gas emission reduction.

The percentage of methane in the extracted gas can be as little as 1% (in VAM processes) to more than 20% in drainage systems. Other components in the gas may include air, carbon dioxide (CO₂) and/or nitrogen (N₂) in various combinations.

Because fluid composition anomalies can dramatically affect the performance of the flow meter, it is important that the measuring device be calibrated with an actual gas mixture.



FOX Calibration Ensures Reliability

Fox Thermal Instruments Calibration Lab offers our valued customers the services they need to ensure that their flow meters meet specified performance parameters and provide accurate, repeatable measurements in the field, day after day, year after year.

Automated data acquisition optimizes calibration accuracy and efficiency and reduces the opportunity for human error. It also facilitates access to calibration data, parameters, flow conditions and instrument variables.

The Fox Cal Lab employs a wide range of gases, gas mixtures, pressures, temperatures, and line sizes to simulate actual fluid and process conditions. This real-world approach improves installed accuracy and minimizes measurement uncertainty.

Calibration capabilities range from as low as 0.02 SCFM (.03 NM³/HR) and up to many thousands of SCFM (NM³/HR) using velocity equivalency methods. The Calibration Lab is also equipped to calibrate for applications with temperatures ranges from -40 to 650F (-40 to 343C) and pressure ranges from 0 to 500 psig (0 to 35 barg).





FOX Model FT2 Flow Meter

- Measures gas mass flow rate and temperature
- 2-Line, 16-character LCD character display
- FM and FMc approved for Class I, II, III, Division 2, Groups A, B, C, D, E, F, G, T4A hazardous locations CE approved
- Housing: NEMA 4X, Indoor/Outdoor
- Standard Outputs: 2 x 4-20mA for Flow and Temperature, Pulse Output, RS-232
- Communication Options: RS422/RS485-Modbus, Profibus-DP, DeviceNet or Ethernet Modbus TCP



FOX Model 10A Flow Meter

- Measures gas mass flow rate
- 4-character LED display
- FM and CSA Approved for Class I, Division 1, Groups B, C & D, T3C hazardous locations. CE approved
- Housing: NEMA 4X, Indoor/Outdoor, explosion-proof
- Standard Output: 4-20mA



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