SAGE METERING
8 Harris Court, Building D1, Monterey, CA 93940
Telephone: (831) 242-2030
www.SageMetering.com

Greenhouse Gas Emissions Monitoring Using Thermal Mass Flow Meters

By Bob Steinberg, President, CEO

Table of Contents

Introduction

With increasing pressure from society regarding environmental concerns, along with international and government mandates concerning greenhouse gas (GHG) emissions, there is a need to provide accurate measurement and monitoring of greenhouse gases. This paper explores greenhouse gas emission monitoring using thermal dispersion or thermal mass flow meters (TMFMs) in the applications of monitoring biogas, landfill gas, digester gas and flare gas.

New Regulations to Measure GHG

Rising levels of GHG and byproducts have been linked to the cause of global warming. Some GHG emissions are created from industrial processes as well as everyday living habits of the seven billion plus people on our planet.

Industrial nations from all over the world now recognize that climate change issues are associated with global warming. In 1997 the Kyoto Protocol was first adopted, in which many countries committed voluntarily to the reduction of four greenhouse gases: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), as well as two byproduct gas groups: hydrofluorocarbons and perfluorocarbons. While the United States rejected the Kyoto Protocol, the U.S. Environmental Protection Agency (EPA), has issued strict policies and regulations designed to reduce greenhouse gas emissions.

When the Kyoto Protocol was ratified a demand for CERs was created. CERs are more commonly known as carbon credits. A carbon credit is a license, for the holder of the credit, to produce one ton of carbon dioxide. Credits are only awarded to those parties or organizations that reduce GHG below a specific quota. Those parties which lower emissions can sell their credits to gas emission emitters which may be countries, large commercial entities or power generators.

The EPA, responding to the Consolidated Appropriations Act, 2008, released the Mandatory Reporting of Greenhouse Gases Rule (74 FR 56260) which requires owners and operators of United States facilities emitting 25,000 metric tons or more of GHGs each year, to monitor and measure GHGs and report other pertinent information to the EPA. The information is to be used to assist in future policy decisions. This regulation is commonly referred to as 40 CFR Part 98, while its implementation is known as the Greenhouse Gas Reporting Program (GHGRP).

According to the first released data through the program, in 2010 there were over 5,500 U.S. emitters which meet or exceed the minimum threshold of 25,000 metric tons of CO_2e (carbon dioxide equivalent).

Every gas has a different capacity to heat the atmosphere which is known as global warming potential (GWP). CO_2 has become the standard in which other gases are compared to and has a GWP of 1. When GHG data is reported, it is reported as though it is the equivalent of CO_2 (CO_2e or carbon dioxide equivalent).

Greenhouse Gases	GWP
Carbon Dioxide (CO2)	1
Methane (CH_4)	21
Nitrous Oxide (N_20)	310

EPA 40 CFR 98 accuracy requirements for measuring GHGs vary depending on the subpart, however 5% is typical. Additionally, 40 CFR 98 requires that flow meters calibration be periodically verified per manufacturer's recommendations.

Mass Flow Measurement

Flow Measurement Technologies

There are many flow technologies that can be used for GHG monitoring, the main ones noted below.

Coriolis flow meters provide a direct mass flow measurement based upon the deflection force of the fluid moving through a vibrating tube.

Advantages: very accurate with high turndown capabilities, independent of fluid properties
Disadvantages: very expensive to purchase and install and has large pressure drop. Also, not suitable for larger pipe sizes

Differential Pressure flow meters calculate the flow by measuring the pressure drop over an obstruction inserted in the flow. Common types of flow elements are: Orifice Plates, Flow Nozzles and Venturi Tubes.

Advantages: commonly accepted method of flow measurement
Disadvantages: limited turndown, poor low flow sensitivity, requires pressure and temperature measurement to get mass flow

Positive Displacement meters require fluid to mechanically displace components and measure volumetric flow.

Advantages: good accuracy
Disadvantages: because of the moving parts use limited to clean dry gases, requires pressure and temperature compensation

Thermal Mass Flow meter measures mass flow based on heat transfer from a heated element.

Advantages: not affected by changes in pressure or temperature. Has excellent repeatability, no moving parts, easy to install.
Disadvantages: none

Turbine Flow meters measure volumetric flow based on fluid flowing passed a free-spinning rotor; each revolution corresponding to a specific volume of fluid.

Advantages: high turndown and accuracy
Disadvantages: because of the moving parts use limited to clean dry gases only, requires pressure and temperature compensation

Ultrasonic Flow meters measure the difference in transit time of pulses that travel from a downstream transducer to the upstream transducer, compared to the time from the upstream transducer back to the downstream transducer.

Advantages: extremely accurate
Disadvantages: expensive, requires pressure and temperature measurement

Vortex Flow meter, a bluff object or shedder bar is placed in the flow path. As gas flows around this shedder bar, vortices are cyclically generated from opposite sides of the bar. The frequency of vortex generation is a function of the gas velocity.

Advantages: frequency of vortex shedding is independent of fluid composition
Disadvantages: requires pressure and temperature compensation, requires minimum flow rate to generate vortices

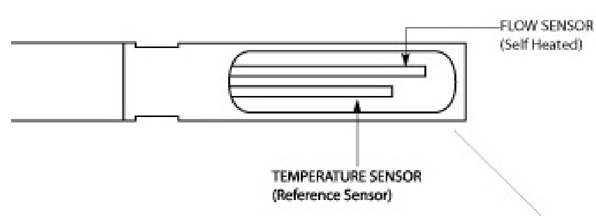
Thermal Mass Flow Meters Excel

Each flow meter technology has its own unique advantages and disadvantages. When evaluating technologies for GHG monitoring, thermal dispersion or thermal mass flow meters excel in key areas:

- The TMFM measures mass flow and is not impacted by changes in temperature and pressure, therefore there is no need for separate temperature or pressure transmitters
- TMFMs offer high accuracy and repeatability
- TMFMs offer excellent rangeability with over 100 to 1 and resolution as much as 1000 to 1
- TMFM have no moving parts
- TMFM are easy to install by insertion into a pipe
- The SAGE meter offers an easy onsite in-the-pipe calibration verification
- The TMFM offers negligible pressure drop, therefore it doesn't impede the flow or waste energy
- TMFMs are ideal for monitoring very low velocities which is common to some GHG monitoring applications
- Most TMFMs offer analog and digital communication options to interface with emission management systems to monitor GHG emissions.

Principals of TMFM operation

Thermal mass flow meters (TMFMs) measure gas flow based upon the principal of convective heat transfer. Either insertion style probes or in-line flow bodies support two sensors that are in contact with gas. The sensors are resistance temperature detectors (RTDs), and the SAGE METERING (SAGE) sensors consist of highly stable reference-grade precision matched platinum windings that are clad in a protective 316 SS sheath for industrial environments.



One of the sensors is heated by the circuitry and serves as the flow sensor, while a second RTD acts as a reference sensor, and measures the gas temperature. The SAGE proprietary sensor drive circuitry maintains a constant overheat between the flow sensor and the reference sensor. As gas flows by the heated sensor (flow sensor), molecules of the flowing gas transport heat away from this sensor, the sensor cools and energy is lost. The circuit equilibrium is disturbed, and the temperature difference (ΔT) between the heated sensor and the reference sensor has changed. Within one second the circuit will replace the lost energy by heating the flow sensor so the overheat temperature is restored.

The electrical power required to maintain this overheat represents the mass flow signal. There is no need for external temperature or pressure devices.

One of the advantages of TMFMs is that they have no moving parts which reduce maintenance and permit their use in difficult application areas including saturated gas. They also do not require temperature or pressure corrections and provide good overall accuracy and repeatability over a wide range of flow rates. This style of meter calculates mass flow rather than volume and is one of the few categories of meters that can measure flow in large pipes.

SAGE METERING Difference

SAGE has brought to market the first digitally-driven circuit design, which eliminates the traditional analog Wheatstone bridge. This feature provides SAGE products with the ability to:

- Eliminate analog drift which improves stability and long term reproducibility
- Show a reproducible zero flow point, permitting simple and reliable calibration verification
- Maintain higher resolution providing greater rangeability
- Eliminate self-heating because of digitally-driven temperature sensor
- Match overheat to application for greater signal resolution
- Offer a remote style up to 1000’ from the probe, and lead-length compensated (since the junction box has no circuitry it is suitable for harsh environments)
- Ensure accurate flow measurement over wide range of process temperatures due to improved temperature compensation

SAGE has brought to market the first graphic display in the thermal flow industry which provides:

- Flow rate, temperature, totalized flow, diagnostics, and signal at a single glance
- A high contrast graphic display that adjusts to ambient lighting, making it easy to read

Calibration Requirements

Flow meter performance is often impacted by installation variances and the gas composition. Most TMFM manufacturers require periodic recalibration to assure accuracy; in that case the meter must be taken off line and returned to the factory (or a third party). This is expensive and inconvenient.

The EPA GHG Reporting Rule requires that the meters be checked frequently for calibration. The SAGE meter offers the convenience of easily verifying that the meter is accurate through the SAGE In-Situ Calibration. The SAGE product does not have to be removed. Calibration verification can be performed in the pipe, easily and inexpensively, which saves time and money from having to remove the meter and returning it for periodic re-calibration.

All SAGE meters are able to perform the in-situ calibration check as long as a “no flow” (0 SCFM) condition can be created. “No flow” is easily created using an isolation valve assembly with the insertion meter style. Unlike other TMFMs, the SAGE In-Situ Calibration not only verifies that the unit is accurate; it also detects that the sensor is clean. If the meter does not pass the calibration check the first time, in most cases simply cleaning the sensor, and re-testing will verify that the meter is accurate and hasn't drifted or shifted.

When the SAGE meter is calibrated, the SAGE Zeroing Chamber is used to record the "no flow" or 0 SCFM data point while subjecting the unit to the customer's specified conditions (i.e. the gas or gas mix and pressure). This data point at "no flow" is one of many data points used for the flow meter's NIST traceable calibration and is used as a convenient standard for the calibration check. This data point is conveniently recorded on the meter's tag and also on the meter's Certificate of Conformance.

Traditionally, TMFMs have relied upon the Wheatstone bridge, which is an electrical circuit used to measure resistance, but is prone to drifting. One of the unique elements of SAGE's approach is the ability to use a hybrid digital method of driving the sensors. The proprietary technology provides additional benefits which include: improved signal stability, enhanced temperature compensation, better sensitivity to detect flow changes, improved resolution, and the capability of adjusting the meter's operating range to match the customer's specific operating conditions.

The EPA regulations (CFR 40 Part 98) requires that the calibration of the flow meter be verified per manufacturer's recommendations on a regular basis. Other TMFM manufacturers have recognized the benefit of an in-situ calibration verification and a few manufacturers have developed their methods to verify calibration for their meters:

- One manufacturer's verification process requires the purchase of expensive add-on hardware.
- Other manufacturers require the TMFM be returned to the factory or a third party for recalibration. This is inconvenient and expensive, especially if the meter is being used out of the manufacturer's country, which is common for companies measuring carbon credits.
- Another manufacturer's process only verifies the electronics are operational, and not that the meter is calibrated.

SAGE's In-Situ Calibration verification process is very simple, can be performed in the pipe easily and is inexpensive. The process verifies that the sensor and electronics are operational, eliminates the need for a factory recalibration and meets all EPA regulations.

GHG Emissions Monitoring Applications

Facilities emitting 25,000 metric tons of CO_2e annually are required by the EPA to report annual emissions per EPA mandate 40 CFR Part 98.

TMFMs offer a reliable solution to measure, monitor and control gas mass flow for various environmental applications. Because of their low-end sensitivity, the SAGE TMFM can accurately measure extremely low velocity, down to 5 SFPM, making it extremely effective for biogas, digester gas, landfill gas and flare gas operations. When measuring gas mass flow with TMFMs, temperature or pressure compensation is not required like it is in many other flow measurement technologies. With no moving parts, TMFM have less maintenance and repair issues than other technologies.

TMFMs not only offer solutions for the measurement and monitoring of GHG emissions, there are opportunities to use these flow meters for projects which turn waste gas to energy.

General Stationary Fuel Combustion Subpart C

Subpart C of 40 CFR 98 covers all aspects of general stationary fuel sources, which are mechanisms that combust fuel, usually to produce electricity, generate steam, or provide energy for industrial, commercial, or institutional use. Alternatively they can decrease waste by removing combustible matter.

These combustion sources include: boilers, furnaces, engines, simple and combined-cycle combustion turbines, process heaters and incinerators, which are found in commercial buildings and various industries including refineries, chemical plants, paper mills, natural gas production fields and pipelines.

Subpart C requires the reporting of GHG (CO_2, CH_4, and N_2O), which are waste products in fossil fuel combustion. One method facilities can use to report emissions from combustion sources is continuous emission monitoring (CEM). Here the facility measures the total flow rate of exhaust gas along with the individual concentrations of CO_2, CH_4, and N_2O in the total gas flow. This method is very expensive and requires ongoing maintenance.

To simplify reporting, the EPA permits the facility to measure fuel consumption over the course of a year, and then apply EPA formulas which calculate the emissions of various GHGs. The formulas are found in 40 CFR 98 Subpart C. A facility fueled by natural gas or biogas can easily measure (totalize) the fuel used with a flow meter and apply the EPA formulas. Since the EPA has different factors for each type of fuel, a facility using different fuels will need to totalize consumption of each fuel type.

The SAGE meter is easy to install, and provides a direct mass flow measurement. With a built-in totalizer, total flow in SCF (or NCM) is also provided. The SAGE meter has an extremely low-end sensitivity which is needed in this application. It can be verified onsite through the easy in-situ calibration check without removing the meter from the pipe, fully complying with the EPA flow measurement standards.

Industrial Wastewater Treatment (Subpart II)

Subpart II covers methane emissions from industrial wastewater treatment facilities including ethanol production and food processing.

Biogas

Methane (CH_4) in the form of biogas naturally occurs from the decomposition of organic material in the absence of oxygen. This typically occurs in an anaerobic reactor or anaerobic lagoon. Biogas typically contains approximately 65% CH_4 and 35% CO_2 along with traces of other gases.

In the wastewater process digesters breakdown the waste material creating digester gas; a mixture of methane and carbon dioxide. Digester gas can be converted to renewable energy to fuel onsite boilers and flare the excess. Other systems can use the gas to generate electricity, sell the energy to local industries or even create fuel for natural gas fueled vehicles.

Anaerobic digester gas is dirty, wet (saturated), and contains contaminants which can collect within the piping. A TMFM has no moving parts making it an optimum choice for this application. Most wastewater digester gas applications function at low pressure and TMFMs have no pressure drop. The SAGE Meter has an extremely low-end sensitivity which is needed to handle the very low flow typical of digester gas. Throughout this process, TMFMs are used to optimize the process and comply with the EPA regulations.

Manure Management (Subpart JJ)

Subpart JJ covers all aspects of manure management system, which stabilizes or stores livestock manure in at least one of the following: uncovered anaerobic lagoons; liquid/slurry systems with and without crust covers (including but not limited to ponds and tanks); storage pits; digesters, including covered anaerobic lagoons; solid manure storage, drylots, including feedlots; high-rise houses for poultry production (poultry without litter); poultry production with litter; deep bedding systems for cattle and swine; manure composting.

Biogas

Biogas is produced from organic matter. It can be derived from a fermentation or anaerobic digestion process from organic feedstock, such as manure, sewage, agricultural waste, municipal waste, biomass, and some industrial waste from food and beverage manufacturers. Biogas is a blend of approximately 65% CH_4 and 35% CO_2. Methane traps heat in the atmosphere over 20 times more than carbon dioxide and remains in the atmosphere nine to fifteen years.

The biogas can be used to create energy while simultaneously reducing GHG emissions to improve the environment.

Among the industries producing methane include farming operations and landfills.

Farming Operations

Digester gas from farming and other agricultural operations is generated from the breakdown of livestock waste when the gas is captured within a large plastic cover, known as a digester. The manure decomposes in the absence of oxygen (anaerobic digestion). Normally the decomposition of livestock waste results in vast amounts of methane which vents naturally to atmosphere.

The digester creates biogas which is a mixture of approximately 65% CH_4 and 35% CO_2. This gas can then be captured and destroyed in a process called methane destruction, which is accomplished by burning the gas in a flare or in an engine. While the process creates carbon dioxide (a GHG), methane destruction is a very responsible method to reduce GHG emissions since methane is 21 times more potent than carbon dioxide.

In addition, methane destruction can also provide a source of fuel for heating or generating electricity.

There are hundreds of farming operations which reduce GHG emissions, accrue emissions credits to meet EPA's reporting standards, and create renewable energy.

TMFMs can quantify the emissions saved by measuring mass flow rate. Since the environment is challenging and there are varying flow rates, many other flow technologies are not suitable . The SAGE meter has rangeability of at least 100:1 and as high as 1000:1 making it extremely accurate over a wide flow ranges which is needed because of gas spikes and seasonal climate changes. The SAGE sensors are clad in protective 316 SS sheath and protects against corrosion.

The SAGE meter excels in these applications:

- They have low-end sensitivity making them accurate at very low flows.
- The easy in-situ calibration verification procedure complies with the EPA's requirement for periodic calibration checks.

Municipal Solid Waste Landfills (Subpart HH) and

Industrial Waste Landfills (Subpart TT)

Subpart HH covers all aspects of municipal solid waste landfills while Subpart TT covers industrial waste landfills. In both subparts, flow meters can be used to measure landfill gas, and determine methane emissions.

Landfill Gas Monitoring

Landfill gas (LFG) is a type of biogas which has been derived from municipal solid waste. Its composition can vary, yet it generally contains more carbon dioxide and less methane than digester gas. Composition is closer to half and half. In some landfills, gases are extracted from multiple wellheads and collected through a network of pipes leading to a common header pipe. Some landfill facilities use LFG to generate renewable energy (LFGTE). These facilities create energy to heat onsite buildings, boilers and kilns, run generators to create electricity, and even produce liquid or liquefied natural gas (LNG) for vehicles.

Aside from generating energy from waste, landfills frequently participate in carbon offset projects through methane destruction. Landfill gas is collected and destroyed at over 1000 landfills worldwide, which reduces GHG emissions and accrues carbon credits.

In facilities where LFG is not being used to create renewable energy, the EPA requires that the gas be collected and flared to the atmosphere to prevent its release.

Accurate flow measurement is required to quantify emissions being saved for landfill gas monitoring and reporting. Whether the gas is being extracted from wellheads, recovered in LFGTE applications, collected for carbon offset projects, or flared to prevent its release, TMFM offer accurate and repeatable measurement.

TMFMs meet the challenges of the environment which include varying gas compositions, wet (saturated) and dirty gas, a potentially explosive environment, fluctuations in gas flow, including extremely low flow. The calibration of the SAGE meter can be verified onsite through the easy in-situ calibration check without removing the meter from the pipe, complying with the EPA flow measurement standards.

Petroleum and Natural Gas Systems (Subpart W)

Subpart W covers all aspects of natural gas industry, including offshore production, onshore production, onshore gas processing, transmission, underground storage, liquefied natural gas (LNG) storage, LNG import and export and natural gas distribution.

There are a number of different applications ranging from high flows for the blown-down vent stack to the very low flow rates found in compressor seal leakage. Many of the emission sources are from venting and fugitive emissions. The EPA estimates that fugitive and vented GHG emissions in petroleum and natural gas facilities is the second largest source of human made methane emissions in the United States.

While some GHG sources can be estimated or modeled, the large number of different sources makes calculating GHG emissions very complex. Over the long term, direct measurement of the GHG emissions will be simpler requiring much less time and manpower than performing all the necessary calculations. In addition, obtaining exact measurement of the natural gas leakage loss will provide the operator with valuable information to help improve the performance of their operations.

SAGE TMFMs are ideally suited for direct measurement of GHG emissions. The very low flow rates in small pipe sizes can easily be measured using SAGE's flow body designs which range from ¼ inch to four inches. The higher flows in the larger pipe sizes can easily be handled with the insertion probe. The high turndown capabilities and the excellent resolution provide the most accurate flow measurements over a broad range of flow rates. Particularly of importance is the in-situ calibration verification which permits the user to verify that the operating performance of the SAGE insertion TMFM meets the performance when the unit was originally calibrated. The ability to simply perform this test without removing the flow meter from the pipe is of utmost importance to the user.

Flare Gas Monitoring

There are many operations or applications where waste gas is flared to atmosphere. Flare stacks are typically seen at oil and gas wells, refineries, well drilling rigs, natural gas plants, wastewater treatment plants, chemical plants and landfills. Strict regulations, like the Mandatory Reporting of Greenhouse Gases Rule (40 CFR 98) require operations to measure and record the consumption of flare gas.

EPA 40 CFR part 98 requires reporting by 41 industrial categories. The categories are divided into subparts. Since flaring gas is common in many industries the following subparts apply:

Subpart Q – Iron and Steel Production
- Flaring blast furnace gas and coke oven gas

Subpart Y – Petroleum Refineries
- Flaring waste gas

Subpart W – Petroleum and Natural Gas Systems
- Flaring natural gas
- Flaring various gases created during the processing of natural gas

Subpart X – Petrochemical Production
- Flaring various gases during petrochemical production

Subpart II – Industrial Wastewater Treatment
- Flaring biogas (rather than using it for fuel at a combustion source)

Subpart JJ – Manure Management
- Flaring biogas (rather than using it for fuel at a combustion source)

Subpart HH – Municipal Solid Waste Landfills
- Flaring LFG at municipal landfill

Subpart TT – Industrial Waste Landfills
- Flaring LFG at industrial waste landfill

Measuring flare gas becomes a challenge for most flow meters. Ultrasonic flow meters are an effective tool to measure flare gas. They tolerate some condensed liquid, are not affected by gas composition and endure fluctuations in pressure and temperature. With this type of performance however, come high costs ranging from $50,000-$100,000 per installation.

When flare applications of known gas composition exist, and water vapor isn't condensing, TMFM make an attractive alternative for flare gas metering. The SAGE meter has wide turndown, of up to 1000:1 rangeability which means it accommodates extreme flow conditions and large flow swings. Under normal venting situations, low velocities are associated with flare gas, yet high velocities are typical in upset conditions. Additionally, their fast response to flow changes, low pressure loss, accuracy (1% of reading plus 0.5% of full scale over a 100 to1 turndown) and reproducibility make the meter a contender in flare applications.

Companies are taking advantage of the cost savings associated with TMFM which are $5000 or less, versus the $50K to $100K for an ultrasonic application. Operations are realizing that by identifying the gas at the flare application, SAGE can adjust the meter to measure the known flare gas. This works for applications where compositional changes are known or are seasonal. While a bit more inconvenient than an ultrasonic meter, in many cases the savings warrant the minor difficulty.

It is clear that while TMFMs are not the perfect choice to measure flare gas, in many flare applications the meter makes good sense; specifically where the composition is known and where there is no condensation. Such applications include flare of natural gas at on shore or off short facilities. In applications with known variations in gas composition, SAGE can estimate variations in accuracy based on analysis of the gas composition.

SAGE Insertion Style TMFMs provide the wide turndown required to cover both the extremely low flows (low velocities) associated with normal venting, as well as the extremely high flow (high velocities) associated with an upset condition. Their fast response to flow changes, low pressure drop, and reproducibility, are important characteristics for a flare application. In addition, SAGE products provide the customer with a unique in-situ calibration check at a "no flow" (0 SCFM) condition. This important procedure, assures that the meter has retained the original NIST Traceable calibration, verifies the meter's accuracy, confirms that the sensors are clean, and that the flow meter hasn't drifted or shifted. This is a tremendous benefit, since it eliminates the cost and inconvenience of annual calibrations on the flow meter, and also provides the data needed to comply with a number of environmental protocols.

Other Noteworthy Subparts

There are other subparts to EPA 40 CFR 98 that worthy of noting:

Underground Coal Mines (Subpart FF)

Both active and under development underground coal mines are required to sample mine ventilation systems and degasification systems. The flow rate and methane concentration from each ventilation well or shaft need to be measured. A continuous flow meter can be used or the flow rate can be periodically sampled on a quarterly basis. This will be high volume with low methane concentration. The SAGE Prism portable data logging flow meter is perfect for taking periodic samples of the flow rate.

Sage Thermal Mass Flow Meter Prism

Petrochemical Production (Subpart X)

Facilities producing various petrochemicals are required to report GHG emissions, specifically CO_2, CH_4 and N_2O from petrochemical units not associated with combustion sources which would be reported under Subpart C.

Petroleum Refineries (Subpart Y)

Petroleum refineries produce gasoline, gasoline blending stocks, naphtha, kerosene, distillate fuel oils, residual fuel oils, lubricants, or asphalt (bitumen) by the distillation of petroleum or the re-distillation, cracking, or reforming of unfinished petroleum derivatives. These facilities need to calculate and report CO_2, CH_4 and N_2O from various refinery processes

These facilities are also required to report under Subpart MM – Suppliers of Petroleum Products.

Geologic Sequestration of CO_2 (Subpart RR)

Facilities that inject CO_2 underground for geologic sequestration, must report the amount of CO_2 sequestered. Geologic sequestration is a process of injecting CO_2 into deep subsurface rock formations for long-term storage. This is more commonly known as carbon capture and storage (CCS).

Injection of Carbon Dioxide (Subpart UU)

Facilities that inject CO_2 underground for improved oil and gas recovery must report CO_2 received for injection.

Summary

With EPA now requiring emitters to report annual GHG emissions, flow meters are being scrutinized to find the best ways to measure and report data. TMFM are becoming the preferred choice to monitor and measure GHG emissions in applications such as: biogas, digester gas, landfill gas and flare gas. One of the primary advantages TMFM have over volumetric meters is that the meter measures mass flow. The SAGE products are state-of-the-art as the manufacturer is the first to bring to market a digitally driven sensor, a graphic display and onsite calibration verification. The SAGE meter is the only TMFM which provides a convenient, in-situ and in-line calibration check that assures the flow meter retains the original NIST traceable calibration and is accurate.