FLUID COMPONENTS INTERNATIONAL LLC

Flow Meter Performance, Validation and Compliance to 40 CFR Part 98, Subpart HH

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Flow Meter Performance, Validation and Compliance to 40 CFR Part 98, Subpart HH

- Review of 40 CFR Part 98, Subparts A & HH as they apply to gas flow measurement.
- Brief description of Thermal flow meter technology.
- Common methods used for the validation or calibration of Thermal flow meters.

Image courtesy of LFG Specialties

40 CFR Part 98 – Subpart A

- Defines the requirements for any flow meter that is part of the Owner/Operator Greenhouse Gas (GHG) Monitoring Plan
  - The standard is non-restrictive when it comes to acceptable metering technology.
    - “Flow Meters” – Thermal, Ultrasonic, Turbine, etc.
    - Orifice, Nozzle & Venturi Flow Meters (ie Differential Pressure)
  - Fuel billing meters are exempt; focus is on emissions.

40 CFR Part 98 – Subpart A

- Defines flow meter calibration requirements:
  - Manufacturer's recommended procedure(s).
  - Appropriate industry standard concensus.
  - Method(s) specified in any relevant Subpart.

- Defines calibration accuracy requirements
  - Accuracy requirements vary by technology used:
    - Flow Meters – ±5% error
    - Orifice, Nozzle & Venturi Flow Meters – ±6% total error
      - Differential Pressure Transmitter
      - Pressure Transmitter
      - Temperature Transmitter
    - Note: There are allowances for using Pressure and/or Temperature readings from other parts of the collection system if you can demonstrate relevance

40 CFR Part 98 – Subpart HH

- If a Continuous Emissions Monitoring System (CEMS) is not being utilized to calculate the amount of CH_4 being destroyed, provisions to continuously monitor gas flow rates are required:
  - Cumulative values are to be collected on a weekly and annual basis for the volume of landfill gas being routed to a destruction device (eg flare, thermal oxidizer, boiler, etc.).
  - Gas flow measurements need to be corrected for pressure, temperature and, if necessary, moisture content.
  - Calculate CH_4 generation and actual CH_4 emissions (taking into account any recovery)

40 CFR Part 98 – Subpart HH

- Flow Meters used in Gas Collection Systems must conform to the following:
  - Measure the volumetric flow rate of the recovered landfill gas.
  - Recalibrate flow meters either biennially (every 2 years) or at the minimum frequency specified by the manufacturer.
  - Flow meter readings are to be corrected for pressure, temperature and, if necessary, moisture content.
  - The Owner/Operator shall document the procedures used to ensure the accuracies of disposal quantities and, if applicable, gas flow rate, gas composition, pressure, temperature and moisture content measurements.

40 CFR Part 98 – Subpart HH

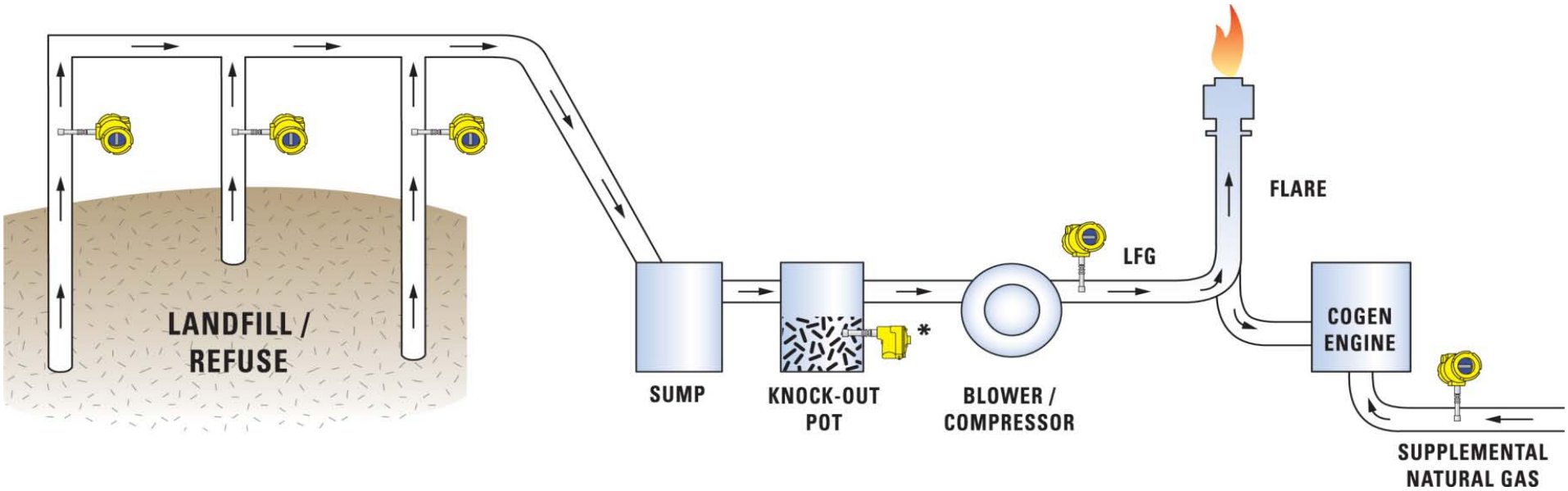
- The following data related to gas flow measurements shall be reported:
  - Total volumetric flow of landfill gas collected.
    - Cubic Feet @ 520ºR or 60ºF and 1 atmosphere
  - Monthly average pressure and temperature for gas collected for destruction.
    - Or
  - Statement that pressure and/or temperature is incorporated into internal calculations run by the monitoring equipment.

40 CFR Part 98 – Subpart HH

- Records to be maintained for Flow Meters:
  - Calibration.
  - Method or Manufacturer’s specification used for calibration.

Flow Meter Selection

- Important to understand the advantages & disadvantages of the flow meter technology selected for your landfill gas measurement.

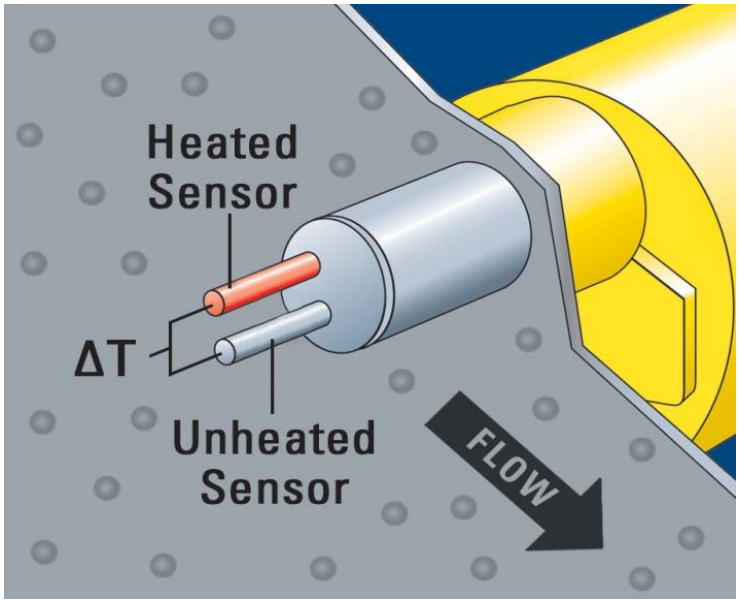


Flow Meter Selection

- Most technologies are volumetric measurements, requiring additional pressure & temperature compensation:
  - Differential Pressure – Orifice, Nozzle, Venturi, Pitot Tube, etc.
  - Ultrasonic
  - Turbine
  - Vortex
  - Variable Area
- Two technologies are industry recognized for mass flow measurements, requiring no additional compensation:
  - Thermal
  - Coriolis

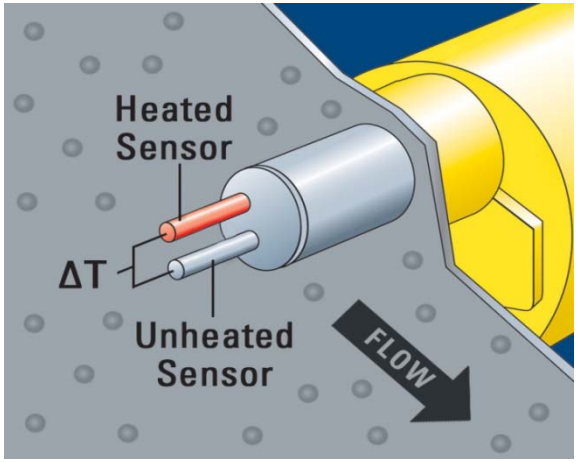
Thermal Flow Meter Overview

- Measuring the cooling effect of the gas flow:
  - Develop a Temperature Differential between an Active (Heated) and Reference (Non-Heated) RTD.
    - Constant Temperature or Constant DeltaT
      - Maintain the temperature differential by varying the current to the Active RTD.
    - Constant Power
      - Apply a fixed current to the Active RTD and measure the change in the differential.

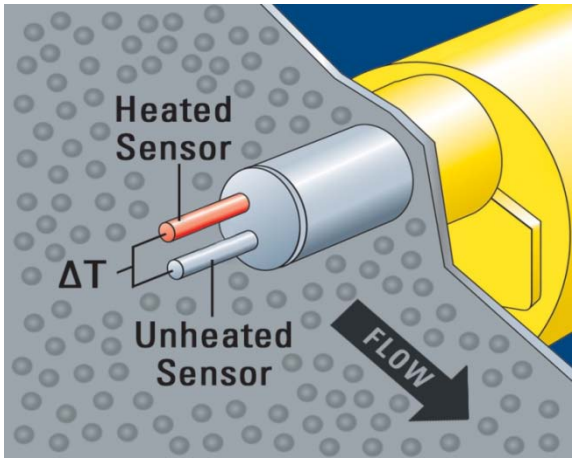


Thermal Flow Meter Overview

- $M = \rho \bullet V \bullet A$
  - M = Mass Flow Rate (lb/sec)
  - ρ = Density of Gas (lb/ft^3)
  - V = Velocity of Gas (feet/sec)
  - A = Area of Pipe I.D. (ft^2)
  - Mass flow readings are based on the assumption of a <u>constant</u> gas composition



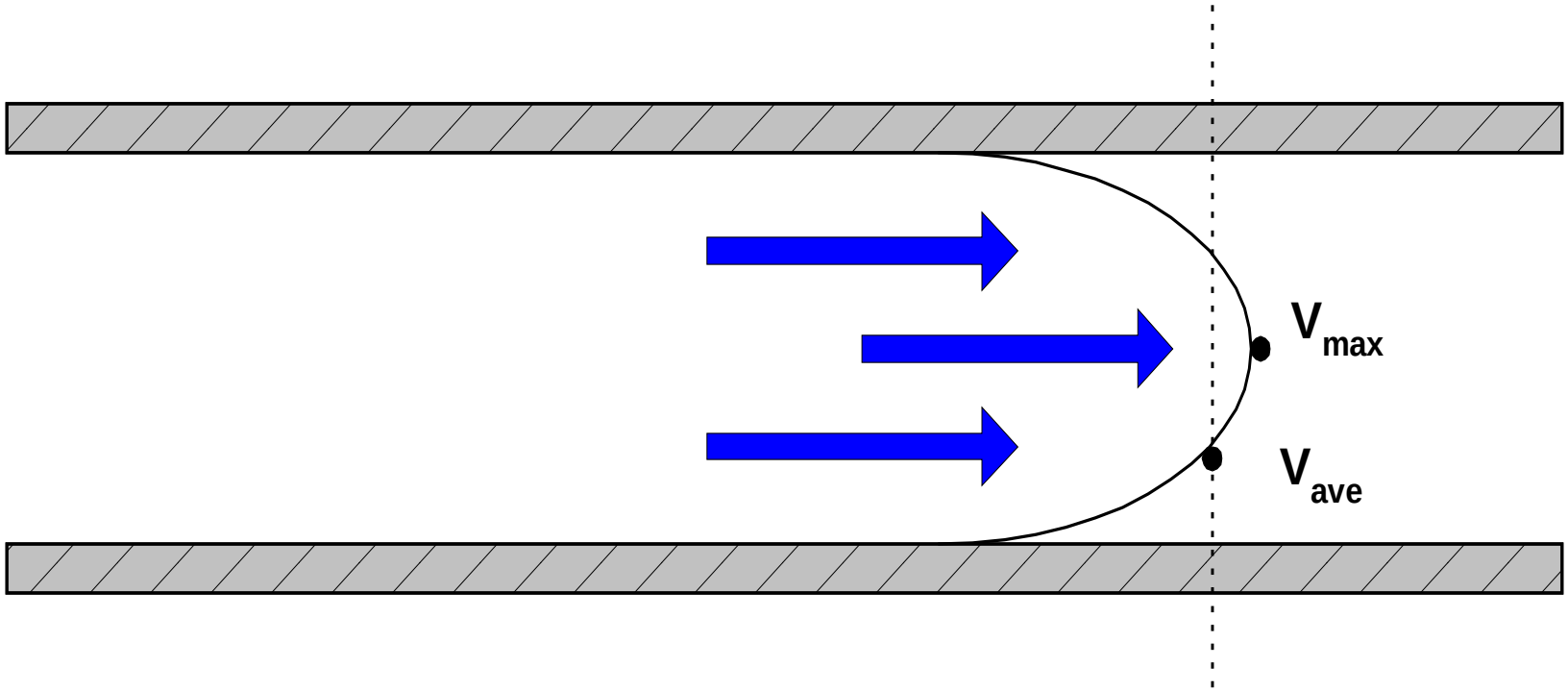
5 SFPS @ 0 PSI



5 SFPS @ 14.7 PSI

Thermal Flow Meter Overview

- Factory calibrations are performed with fully developed velocity profiles.



Flow Meter Selection

- Thermal flow meters have many advantages when utilized in gas flow measurements:
  - Mass flow measurement
  - High turndown (100:1 is common)
  - Low pressure drop (<1 in w.c., 8-inch line)
  - All welded sensor (common)
  - Single process penetration
  - No moving parts
  - Low maintenance

Flow Meter Selection

- Key things to keep in mind about the application of Thermal flow meters:
  - Factory calibrations are based on:
    - A specified gas composition of the process being measured.
    - Inside diameter of the pipe being measured.
    - Fully developed velocity profiles (laminar or turbulent).
    - Minimal moisture in the calibration gas.

Flow Meter Selection

- Addressing actual field conditions in order to maintain accuracy without factory recalibration of the meter:
  - Utilize K-factor corrections or multiple gas calibrations when changes in gas composition occur.
  - Change the pipe I.D. parameter if installed in a smaller or larger line than originally calibrated.
  - Utilize flow conditioners or in-situ calibrations when straight-run limitations cause distortion of the velocity profiles.

Flow Meter Selection

- Addressing actual field conditions in order to maintain accuracy without factory recalibration of the meter
  - Orient the thermal meter to minimize the effects of moisture that may condensate within the process piping.
    - Ideally, the meter would be located downstream of any moisture removal systems or knock-out drums.

Angled at 45° from Horizontal

Side Mounted

Bottom Mounted

Flow Meter Validation & Calibration

- There are several approaches available when it comes to either validating or calibrating a thermal flow meter.
  - Validation – Performing sensor and electronics tests that indicate the unit is performing as originally calibrated at the factory.
  - Calibration – Performing an actual test under known flow conditions that verify the accuracy of the thermal flow meter.

Flow Meter Validation

- Common validation procedures:
  - "Delta R" test of the sensor
    - This can be either a Dry or Wet test.
      - If a Wet test is performed, need to ensure that the field gas composition, pressures and temperatures are the same as those used by the factory.
    - Verifies that the sensor output has not changed under a "no-flow" condition.
  - Review of instrument calibration parameters
    - Verifies that internal calibration parameters have not been changed in a manner that would affect the original factory calibration.
  - Simulated test of the sensor & electronics
    - Verifies internal functionality of the instrument by driving the sensor to a known value and confirming that the values received by the electronics are within acceptable parameters.

Flow Meter Validation

- Common validation procedures:
  - Simulation of flow conditions to verify the entire meter is functioning as originally calibrated.
    - By creating several repeatable flow conditions across the sensor, data can be compared to the same tests ran at the Factory during calibration or on-site during start-up in order to verify that the readings are the same as originally calibrated after being in service.
    - This method actually exercises the entire instrument, sensor and electronics.

Flow Meter Calibration

- Common calibration procedures:
  - In-Situ calibration
    - An on-site calibration based on actual field conditions.
      - Either simple K-factor corrections or adjustments to flow meter coefficients (dependent upon the ability to run multiple flow rates).
      - Performed using acceptable calibration methods (eg 40 CFR Part 60, Method 2)
  - Factory calibration
    - The unit is either verified to original calibration conditions or recalibrated to new process conditions on an NIST traceable calibration stand.

Flow Meter Calibration

- Common concerns regarding In-Situ or Factory calibrations:
  - In-Situ calibrations need to be performed by Factory field technicians or Factory certified technicians.
    - There are no specifics in either Subpart A or Subpart HH defining this requirement. Ultimately, the Owner/Operator needs to demonstrate that sound practices were applied.
  - A temporary meter needs to be installed while the primary meter is being recalibrated.
    - Both Subpart A and Subpart HH have “missing data” provisions.

Flow Meter Calibration

- Conclusions:
  - 40 CFR Part 98, Subparts A and HH are non-restrictive when it comes to the type of flow meter technology selected by the Owner/Operator.
  - Thermal flow meter technology is suitable for landfill gas measurements and does provide some advantages over other technologies when properly understood and applied.
  - There are several methods offered for thermal flow meter validation and calibration. It is up to the Owner/Operator to determine which is suitable and provide sufficient documentation to support the selected method when submitting annual GHG reports.