Thermal Mass Flow for Greenhouse Gas Measurement

ISA Will-DuPage

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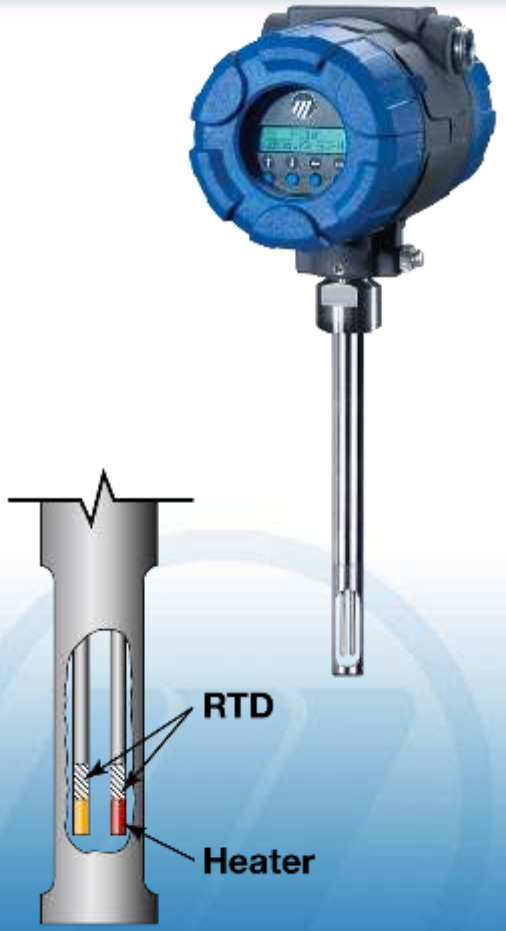
Theory

- Measuring heat transfer. Don’t overcomplicate!
- Convective heat transfer caused by gas flowing over a heated pin.
- Thermal mass flow meters measure flow rate independent of operating temperature or pressure (SCFH, Nm3/h).
- A set point or ΔT is established and maintained by a variable power.



Theory

- Convective heat transfer dependent on many thermal properties.
- Thermal properties effected by operating temperature.
- Manufacturers provide temperature compensation.

T (°F)	P (atm)	ρ (kg/m^3)	Cp (kJ/kg-°R)	k (W/mK)	μ (μPa-s)
70	1	1.200	0.559	0.026	18.301
120	1	1.096	0.560	0.028	19.628
170	1	1.009	0.561	0.030	20.907
220	1	0.934	0.562	0.031	22.143
270	1	0.870	0.564	0.033	23.339

REFPROP – NIST Reference Fluid Properties

Installation

- Probe or flow body.
- Proper install for optimal performance.
  - Straight run, flow arrow, depth into pipe.
- Compression fitting easiest. Adds versatility.
- Horizontal or vertical pipes and at different angles.

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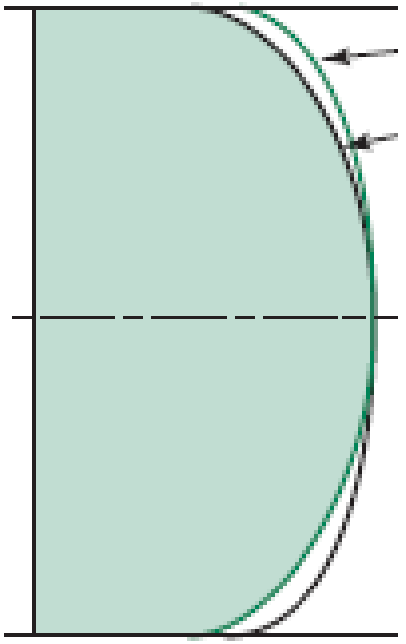
Installation



- Fully developed flow profile desired.
- Naturally occurs with enough straight run.
- Not uncommon for gas flow meters to require straight run and gas typically > than liquid.

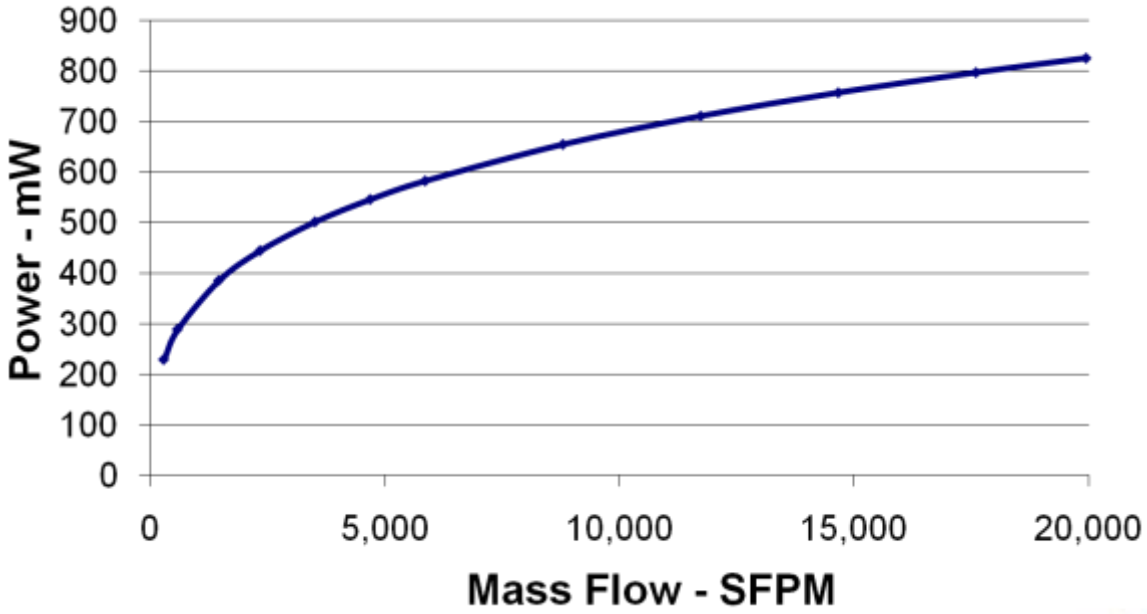
Installation

- Retractable probe assembly (hot tap).
- Various allowable pressure ratings and blowout prevention.
- Reduces process downtime considerably for maintenance (cleaning, preventative maintenance, diagnostics).

Calibration

- All thermal mass flow meters get calibrated.
  - Necessary to provide flow information up front.
  - Makes for less effort upon installation.
- Essential in establishing relationship between heat transfer and mass flow.
- Flow known amount of gas past sensor and measure signal at multiple points.
  - Optimal to have at least ten data points in the flow range.
- Calibrate on traceable flow bench.
  - Most common is NIST. ISO 17025 compliance desirable.
- Receive calibration certificate(s).

Calibration



- Really measuring the power it takes to maintain ΔT and inferring mass flow rate.
- Curve unique for each device and application.
- High sensitivity (change in signal) at low flows.
- Relatively no heat added to process.

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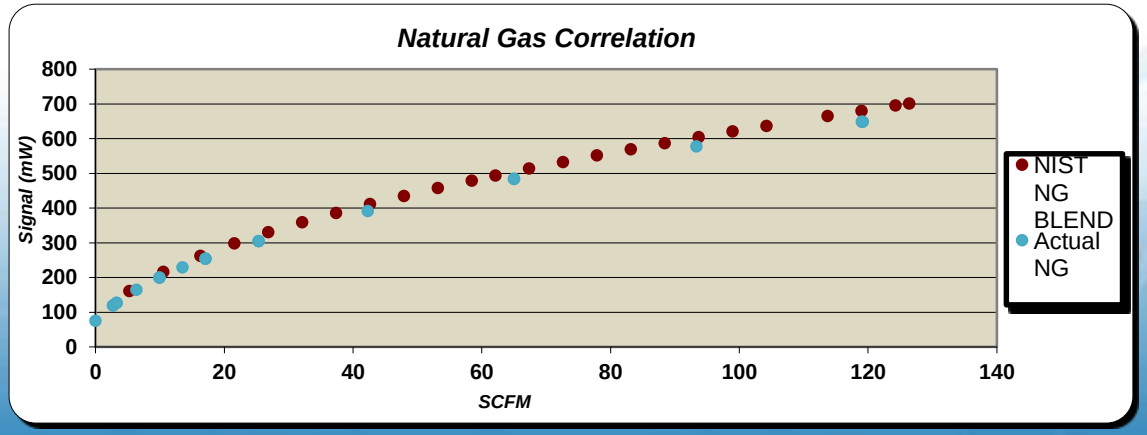
Calibration

- Calibration can take place on the actual gas or an equivalency / correlation type calibration.
- Actual gas reduces uncertainties but not always possible depending on the application.
- Equivalency is based on historical data and a correlation is theoretical.



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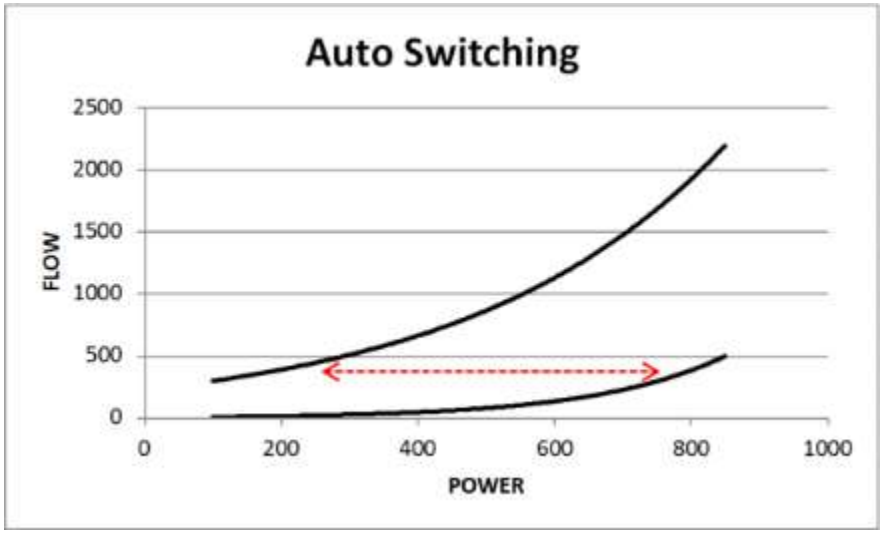
Calibration



- Multiple calibration curves possible with newer thermal mass meters.
  - EX: Propane and Natural Gas possible fuel usages.
- Possible to adjust curve for new gas mix in the field if wide variation.
- Advanced calibrations allow turndown ratios that surpass the typical 100:1 specification.

Diagnostics

- Configuration check.
  - Manual check.
  - Live power to verify calculation.
- Measurable heater current or power.
  - Actual measurement to verify power.
- Calibration verification procedures.
  - Field tests instead of returning devices back to manufacturer.
  - Most common is a no flow test.
  - Many different manufacturer methods.

Outputs

- Multiple 4-20.
  - Temperature is being measured allowing multiple outputs from transmitter (Q & T).
  - Extended turndown possibilities (>100:1).
- Pulse.
  - Similar to other flow technologies transmitting a pulse output to be totalized.
- Alarm.
  - Low or high flow indication.
- Important to know difference between actively and passively powered.

Applications

- Common themes:
  - Low initial cost.
  - Minimal maintenance with no moving parts.
  - Small footprint.
  - Measure at lowest pressures in any pipe size.
  - High turndown capabilities.
  - Direct mass flow and temperature from a single device.
  - Advanced diagnostics to avoid returns.
- Not an AGA approved technology.

Compressor Leakage

- Monitor amount of gas being leaked from packing system of compressors.
- Commonly small line sizes (2”-4” or DN50-DN100).
- Low flow rates and pressures.
- As seals wear flow rates increase.
- Insertion thermal mass capable of being relocated and reconfigured for multiple lines at the unique compressor stations.

Separator

- Separator gas may be on its way to being compressed, used as an internal fuel source or going to flare.
  - Thermal most common for internal fuel sources or gases going to flare.
- Variation in flow rate may be significant.
- Extended turndown characteristics beneficial.
- Moisture OK but condensation increases heat transfer.
  - Knock out pots to reduce condensation.
  - Angling probes during install.

VRU

- Recovered hydrocarbon vapors that are compressed and used as onsite fuel.
- Reduces emissions by utilizing gas that would have been vented or flared.
- Probes available in pipes down to 2” (DN50) and flow bodies for smaller.

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Storage Tanks

- Measurement off of condensate storage tanks reduces emissions by not venting hydrocarbon gases into atmosphere.
  - Example: Compressor Stations.
- Measurement at or near atmospheric pressure.
- Hot taps beneficial for removal of flow meter under process to allow diagnostics or preventative maintenance.

Pilot Gas

- Keeping flare lit.
- Continuous measurement in typically small line sizes.
- Flow bodies or inline sensors are common.

Boiler Inlet

- Natural gas flow measurement to individual combustion source (boilers, kilns, etc.).
  - Not the billing meter.
  - Industrial and commercial facilities. Anywhere there is a boiler!
- Very popular due to advantages over traditional technologies.
  - Direct mass flow.
  - Low flow sensitivity.
  - High turndown.
  - Little to no pressure loss.
  - Fast response.

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Coal Mine Methane

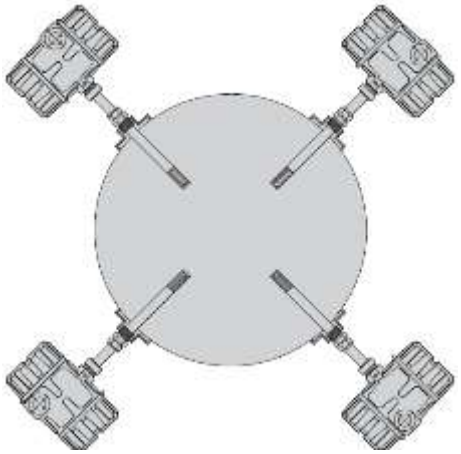
- Product of mining, methane can no longer be vented to atmosphere.
- May be flaring this methane or finding alternative ways to create usable energy.
- Atmospheric pressures and large line sizes.
- Used as an economical choice as a “portable” type flow measurement in multiple line sizes with calibration adjustment if gas composition varies significantly.
- Use of calibration verification to satisfy regulatory committees.

DG/Biogas/LFG

- Moist gases consisting primarily of methane and carbon dioxide.
  - Digester Gas/Biogas/Landfill Gas
- Very low flow rates and pressures.
- Common to have a knock-out pot or other ways of eliminating condensation.
- May measure before flare for reporting purposes or capturing the gas to meet onsite demands.

Limitations

- Condensation.
  - Moisture or vapor phase OK.
  - Liquids have higher heat transfer than gases (high measurement).
  - Knock out pot helpful.
- Buildup.
  - Effects all insertion and inline technologies.
  - If possible schedule regular maintenance.
  - Hot taps help.
- Gas composition.
  - Properties dependent.
  - More concern over wide variation from calibration.
  - May have ways of compensating.



Conclusion

- Thermal mass is a quickly growing market with new development.
- O&G is primary driver, but widely accepted in many industrial, municipal, or commercial facilities.

Thomas Kemme

tkemme@magnetrol.com

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