A review of best practices for Selection, Installation, Operation and Maintenance of Gas meters for Flare Applications used for Managing facility mass balance and compliance
1. What, When and Why?
2. Flare Measurement Challenges
3. Flare meter process selection
4. Installation best practices
5. Operation & Maintenance best practices
6. Questions
What, When and Why?

Flare gas can come from a variety of sources and for different reasons.

- Chemical/Petrochemical Plants
- Refineries
- Gas Processing Plants
- Oil & Gas Production
- Storage
- LNG
What, When and Why?

Flaring Situations

➢ Process unit upsets.
➢ Loss of compression.
➢ Over pressurization of relief valves.
➢ Start-up and shut-down.
➢ Blow Down.
➢ Loading & Unloading.
➢ Storage.
Flaring is typically a safety measure to safely dispose of gas during upset and/or emergency conditions resulting from a loss of power or pressure control. It is performed to burn gas that cannot be stored or sold, and/or to burn waste gas that contains contaminants such as H2S.
FLARE GAS MEASUREMENT CHALLENGES

- Wide Gas Flow Velocity Range
- Large Pipe Diameters
- Changing gas composition
- Noise – SNR
- Exposure to Erosion/Corrosion
Review considerations

➢ Selection process

  Pipe size, velocity calculations, Gas composition

➢ Installation

  Straight run, Orientation, Intrusive or not, Spool or hot tap, Noise sources

➢ Operation & Maintenance

  Inputs & Outputs, Process conditions, Erosion/Corrosion, Calibration
Large Pipe Diameters can present their own set of issues.
LARGE PIPE DIAMETERS

- Large Pipe Diameters create similar and different issues:
  - Larger pipes, especially with lower velocities, can result in non-ideal Re.
  - Attenuating gases challenge the ability to maintain sufficient energy for signal acquisition.
  - Large diameters also challenge the ability to provide sufficient straight runs.
WIDE RANGE OF FLUCTUATING VELOCITIES

- Standard operation of plant - small quantities of waste gas are burned, and some gases are used as a pilot gas to keep the BTU content at or above a federally regulated level. (Velocities are typically 0.1 to < 1.0 ft/sec).

- Low velocities can result in a non-axial, asymmetric flow regime where temperature-induced cross flows can contribute to a significant difference in travel times.
SELECTION PROCESS - PART 2

WIDE RANGE OF FLUCTUATING VELOCITIES

➢ In Emergency/Upset conditions - very large volumes of gas accumulate in a short period of time, and have to be disposed of immediately.

   (Velocities can be > 300 ft/sec).

➢ High velocities create noise in the form of turbulence, and in some cases can cause the signal to blow by the receiving transducer (signal loss).
The received signal power depends mainly on:
- Emitted sound pressure from the sender
- Signal Attenuation (signal damping in the gas and reflection losses)
- Filter characteristics of the receiver sensor

Noise sources in the piping are:
- The flowing gas itself (turbulence creates noise)
- Valves, pressure regulators or any obstructions in the gas stream
- Powered equipment producing frequencies close to that of the ultrasonic sensors

The most practical ways to increase the Signal to Noise ratio are:
- Maximize the emitted sound power from the sending transducer
- Optimize signal processing with the target to have a minimum limit value for the SNR, where the meter stops giving reliable results.
- Selecting a frequency range which is relatively insensitive to other noise (background) generated in the piping.
Transit times measured with cross-correlation and phase detection.

The excitation signal is optimized for high and low velocities:

- Combination of Continuous Wave (CW) and Chirp is used for low velocities.
- Chirp signal (varying frequency, defined shape and duration) is used for high velocities.

Using a continuous sine wave signal in combination with variable frequency (“Chirp”), improves low flow resolution and enables measurement through process noise generated from high velocity gas.

Robust velocity measurements up to 120 m/s
SELECTION PROCESS - PART 3

CHANGING GAS COMPOSITIONS

- Multiple process units to a common flare header
- Densities/MWs can vary greatly
- How to accurately determine Density, MW, Mass?

![Image of flare tower with process units diagram]
H2 can be problematic for USFM.
- SoS = 1000+ m/s: Large volumes can reduce the low flow sensitivity, and can create multiple reflections in small pipes.

CO2 is very attenuating to USFM.
- SoS ~ 267 m/s: Can reduce the upper flow limit by as much as 25%.

N2 can affect the Mass flow result.
- SoS ~ 350 m/s: Has no BTU value, but will increase the apparent mass flow.
SELECTION PROCESS SUMMARY

➢ Pipe size
  ➢ Plan for worst case scenario but do NOT over do it!

➢ Velocity range
  ➢ Evaluate low, normal and high flow conditions and consider to manufacturers limitation
  ➢ Evaluate the signal processing method that better fits the application and installation requirements

➢ Gas composition
  ➢ Evaluate all potential scenarios for Gas composition
  ➢ Study impact of fluids that have adverse effect in measurements

![Customer Process Data Table]

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Review considerations

➢ **Selection process**
   
   Pipe size, velocity calculations, Gas composition

➢ **Installation**
   
   Straight run, Orientation, Intrusive or not, Spool or hot tap, Noise sources

➢ **Operation & Maintenance**
   
   Inputs & Outputs, Process conditions, Erosion/Corrosion, Calibration
INSTALLATION - PART 1

Straight run

Other ultrasonic's require 20/10 - In a 16” pipe that’s 20 Feet of additional straight pipe!

Preferred orientation: Horizontal installation on a horizontal line

10 x D

5 x D
INSTALLATION - PART 2

Orientation: horizontal, vertical, incline

Avoid/Manage liquid accumulation, if any
INSTALLATION - PART 3
INTRUSIVE DESIGN

Diagonal 45° for low range

Bias 90° for high range

Multiple sets of sensors to cover the full flow range/turndown
Exposure to erosion/corrosion
Potential high velocity interference

probes are intrusive
INSTALLATION - PART 3

FULL PROFILE DESIGN

Single set of non-intrusive sensors, using broadband (multi-frequency), un-dampened transducers to measure the whole range of probes are wetted but non-intrusive.
✓ Spool piece is ideal for new facilities or planned
✓ Hot tap should be done between welding crew and flare meter vendor
✓ Tools for angle, measurements and pipe markings
✓ Follow all HSE applicable procedures and company policies
INSTALLATION SUMMARY

➢ Straight runs: significant installation deviations from standard recommended practice will impact accuracy

➢ Orientation: manage or avoid liquid buildup exposure as per manufacturer’s recommendation

➢ Avoid intrusive or manage risk of high velocities that may cause erosion or corrosion issues

➢ Spool piece installation is recommended but hot tapping is a viable alternative when shutting in the line is not possible

➢ Isolate or keep distance from sources of noise
Review considerations

➢ Selection process

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➢ Installation

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➢ Operation & Maintenance

  Inputs & Outputs, Process conditions, Erosion/Corrosion, Calibration
Operation & Maintenance - PART 1
Inputs & Outputs

➢ Inputs
  • Transducer tip distance (path) should be measured properly and given as an input
  • P&T transmitters not only help standard volume calculations but also play a role in flow regime compensation (Reynolds number)

➢ Pressure & Temperature
  • Transmitters should be ranged properly for the proper resolution

➢ Density from calculations or from analyzer?
  • Weigh in accuracy of density versus measurement resolution

➢ Output variables
  • Define critical variables to monitor

➢ Remote connection and protocols
  • Analog signals (4-20mA) are very well established in the industry
  • Digital interface offers the best results in terms of resolution and data available.
  • Modbus, 4-20mA, HART, etc.
Operation & Maintenance - PART 2
PROCESS CONDITIONS

➢ Sensors are exposed to a variety of corrosive gases and liquids.
  ❖ Acid Gas, Liquid carry over
  ❖ Solids / particulates
  ❖ Sensors can become coated, even damaged
  ❖ Combined with high velocities creates an erosive atmosphere
➢ Periodical cleaning and inspection
➢ Material selection
How to verify your meter is still reliable/accurate?

Calibration

- The nature of flare service precludes the ability to calibrate in-situ.

- You could send the meter out to a calibration facility
  - Costly
  - NO UNPLANNED SHUTDOWNS!!
  - No measurement while meter is being calibrated
  - Lab conditions very seldom can replicate the field conditions (piping, velocity)

- Required accuracy is +/- 5% or better (non-custody transfer), so is the cost of a calibration justified?
- Calibration can reduce the turndown
How to verify your meter is still reliable/accurate?

Verification/Validation

➢ An on site “calibration” performed by most USFM manufacturers is really more of a verification.
  ❖ Zero Box - controls temperature and pressure, to verify a zero.
  ❖ Transducers are removed from the line and placed in the zero box.
  ❖ Insertion depths are set so that path lengths remain constant.

➢ Verification can be performed on-site by analyzing a variety of diagnostics such as signal quality, amplitude, gain, signal to noise ratio and speed of sound.
OPERATION & MAINTENANCE SUMMARY

➢ Identify critical measurement inputs and outputs and define the right communication protocol for your facility

➢ Provide initial input about process fluids under normal and upset conditions to improve material and sensor type selection (anticipate fluids that may affect measurements)

➢ Periodical verification (usually once a yr.) to check integrity of measurement system, communication and necessary adjustments based on process conditions changes

➢ All these aspects will ensure compliance with regulations and better measurement data management
ADVANCED ULTRASONIC TECHNOLOGY

FOOD FOR THOUGHT

➢ API has been conducting Ultrasonic Flare Flow Meter testing
   ➢ Accuracy/Performance
   ➢ Velocity Limitations

➢ Current acceptable accuracy +/- 5%

➢ Royalty/Lease Payments
   ➢ Higher accuracy requirements?
   ➢ Additional paths?

➢ What will the next generation of a Flare Flow Meter look like?
Thank you!

Any Question?