INSTALLATION OF GAS ULTRASONIC FLOW METERS

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**Introduction**

Ultrasonic meters measure with exceptional precision when they are installed according to the manufacturer’s and the AGA recommendations. Keeping this in mind, the success or failure of an ultrasonic meter installation for custody transfer applications heavily depends on how it is installed. The challenges to successful installations arise when shortcuts are taken to lower costs or to meet specific site related issues. It is normally when these shortcuts are employed that one finds the meter’s installed performance varies from the meter’s calibrated performance. In custody transfer using liquid ultrasonic metering installations a field standard called a prover is used to compare it’s known volume to the volume measured by the meter. A correction factor, referred to as the meter factor, is applied to the volumetric calculations as an adjustment to the meter’s measurements. Gas ultrasonic metering installations typically do not have this standard known volume in the form of a prover and as a result, the gas industry depends upon transferring the meter’s laboratory calibrations directly to the field. This makes it imperative that the installation replicate as closely as possible the calibration conditions. This paper outlines the methods of installation that are known to deliver optimum performance. There are also references to AGA Report #9 2017 dealing with installation guidelines.

**Basics of Installations**

**Envirionmental Considerations**

First the environment where the meter is installed should be evaluated. Ultrasonic Flow Meters are designed to operate over a wide temperature range, but the designer must insure the installation is within the rated operating limits of the equipment. If needed, shelters should be provided to insure the equipment will be protected from extremes of temperature or radiation from the sun. If the meter will operate at low flow rates, then the designer must pay attention to outside air temperature differences between the meter and associated piping compared to the fluid temperature. At low flows the meter body metal along with the upstream and downstream piping can cause thermal stratification of the gas temperatures. A basic operating assumption of ultrasonic meters is that the temperature is consistent across the flow stream. At high flow rates the flow is turbulent which causes mixing of the fluid and evening of the overall gas temperature. In this scenario there is little need to be concerned with temperature differences between the pipe and fluid. However, at lower flow rates there is less mixing of the gas and this can result in temperature differences between the pipe wall and the gas. Imagine the sun beating down on a metering section in the summer. The pipe in the sun is hot to the touch while the pipe on the bottom is cool to the touch. The gas being at different temperatures will have different speeds of sound. Unfortunately, the ultrasonic meter assumes that the speed of sound is constant across all paths. If there are differences in the speed of sound, then the velocity calculations will be incorrect. To correct the potential issue of thermal stratification one of two things must occur: shade must be provided to shield from the sun or the upstream and downstream piping including the meter can be insulated. As a step taken at some facilities, the assembly can be built indoors. Please note that the issue is a temperature difference between the flowing gas and the meter body and meter run piping. Thermal stratification can occur in very cold settings as well as very hot settings, the issue with the effect comes from temperature differences, not just hot sun.

Vibration is another consideration for meter station design. It does not interfere with the meter’s operation, however it can create issues with the electronics integrity by shaking the boards loose from their mountings. Today the electronics of major manufacturers is subjected to vibration testing as part of the design and approvals process, The manufacturer can provide information on the vibration testing in case this is a concern.

Process pulsation can result from compressors, control valves, and check valves. Fast operating electronics may be the simple solution but a pulsation study may be required if the meter is to be installed at a location where it would seem to be exposed to pulsation. Separation of the meter from the source of pulsation is a good strategy.

**Meter Hydraulic Considerations**

We will divide the discussion of hydraulic installation into two parts, the first is the meter run and the second part is the piping leading up to the meter run. Strict adherence to the manufacturer’s recommendations should be followed. There are, however, common rules to be followed in the installation of all ultrasonic meters regardless of the manufacturer, so the user does not need to despair over one manufacturer’s recommendations compared to another. First, the piping configuration must be preserved as closely as possible between calibration and installation in the field to minimize field installation effects. The meter, when installed, is no longer in the lab, swirl and asymmetry are different, and these can affect the meter’s calculations very slightly, but in the game of custody transfer, slight differences matter. Most importantly, there must not be introduction of elements that will affect the meter linearity.

First, the pipe schedule of the meter must be identical to that of the upstream and downstream piping. The maximum deviation between the piping and meter should be less than +/- 0.5% of the nominal pipe bore. AGA Report #9 calls for a 1% difference but minimizing differences between the ID of the piping and the meter is important, particularly in smaller ID meters. All welds must be ground smooth to avoid causing eddies in the flowstream. Temperature measurements should be carried out downstream of the meter. This is because the thermowell protrudes into the flowing stream and generates flow irregularities that the meter will measure as timing differences. This will contribute to meter error if the thermowell is located upstream. AGA Report #9 indicates the manufacturer should recommend thermowell orientation in the piping. Most of the manufacturers are not as concerned with the orientation of the thermowell in downstream mounting applications, however, and the vertical orientation is suitable. In unidirectional flow, the thermowell must be located within at least 6 inches or 2ND from the flange weld and no farther than 5D downstream from the USM flange face. If the meter is to be operated bi-directionally, then the thermowell should be installed downstream of the predominant direction of the flow. AGA Report #9 addresses the insertion depth of thermowells as ½ to 1/3 the Nominal Diameter of piping between 2 and 10 inches in diameter. For 12 inch ND and larger, the thermowell must be installed between 1/5 and 1/3 ND. The ASME TC 19TW-2010 provides calculations for the maximum probe length as it pertains to gas velocities. This must be observed as gas ultrasonic flow meters are typically sized for flow rates in the range of 100 ft/sec and lower. Sample probe installation recommendations are found in API MPMS standard 14.1. In general, the recommendation is for the center 1/3 of the piping.

Gaskets are another area that can cause issues with the flow profile uniformity. These must always be sized and installed to not protrude into the flow stream. The issues of incorrectly sized or installed gaskets will cause jetting of the flow, which can lead to measurement errors. Proper sizing and alignment are the key to success.

Orientation of the meter in the piping is often assumed to make the measurement paths horizontal, but it is worth mentioning because occasionally the question arises. In general, an ultrasonic flow meter may be installed in any direction. However, the practical reality is that installation recommendations for manufacturers typically recommend that the measuring paths be horizontal. This will avoid the transducer openings in the piping from becoming filled with debris that will prevent proper operation of the meter in the event paths are vertically oriented.

**Flow Conditioning**

AGA Report # 9 2017 states flow conditioners are not required if the manufacturer has test data from OIML Tests R137 1 & 2 showing the meter operates just as well without a flow conditioner. These tests include testing various upstream piping configurations ahead of the meter designed to introduce swirl and asymmetry into the flow stream. The meter is first calibrated in a straight upstream piping section with approximately 80D of upstream piping. The meter is calibrated on straight piping. Next the upstream piping is altered and the meter is tested at two orientations, paths horizontal and paths vertical on each piping configuration. The meter must not register more than 0.3% error from the 80 D upstream ahead of the meter calibration. Some USM manufacturers have designed meters that pass these tests without the use of a flow conditioner using as little as 5D of straight upstream piping. This decreases the installation footprint significantly and provides users with greater flexibility when considering applications with limited space.

Figure 2 in AGA 2007 document, Recommended Default Unidirectional and Bi-Directional Installations, has been replaced with three Options, 1, 2, and 3 and there is NO reference to the drawings as being recommended in any order. The drawings include three piping arrangements. Option 1 is similar to the original drawing in AGA 9 2007 and illustrates 10D upstream piping ahead of a flow conditioner, the Flow conditioner, 10D downstream, and the meter. The downstream length is variable. Option 2 is a manufacturer recommended configuration utilizing a flow conditioner as in Option 1, but the length of piping between the meter and the flow conditioner is variable depending upon the meter manufacturer’s recommendation supported by test data. Option 3 is a manufacturer recommended configuration without a flow conditioner and a single spool upstream of the meter. There is no flow conditioner in this option and the manufacturer shall specify the length of upstream piping ahead of the meter.

 Option 1 Traditional Flow Conditioner

Option 2 Flow Conditioner with less the 10D between meter and flow conditioner



Option 3 No Flow Conditioner



It is worth noting that the installation diagram no longer includes the elbows designed for sound reduction.

AGA Report #9 also says that manufacturer’s recommendations are to be considered.

**Wiring and Communications**

Most of the meters operating today can operate at numerous voltages, however, 24 Volts DC is typically the voltage applied to meters and other instrumentation, so most instrumentation designs incorporate a 24VDC power supply. The outputs from an ultrasonic meter are usually all encompassing, they include analog inputs, analog outputs, discrete I/O, and pulse outputs. Flow volumes are usually output to the flow computer by pulses, which are in units of pulses per unit volume. The meter pulses can be configured to register flow in the forward direction or both forward and reverse. On occasion, meters will utilize two sets of pulse outputs for both forward and reverse outputs. The second set of pulse outputs is sometimes connected to another customer’s flow computer so that each party to the transaction can make separate measurements. Today’s meters contain serial ports and ethernet ports for communication to SCADA, Flow Computers, laptops for maintenance, and engineering computers. Depending upon the ability of the ethernet interface capabilities of the specific site, the database capabilities of the meter can be utilized. However, not every installation includes an actual ethernet connection to the meter even if ethernet communications is present within the meter. It is strongly suggested that that the ethernet connection be installed to the network for remote monitoring. At a minimum, the serial port should be wired to the RTU and a few basic alarm points within the meter can easily be monitored by the SCADA system. These alerts are useful to insuring the operation of the meter at all times and that should the meter require attention it is quickly discovered and maintenance can be performed. At a minimum, the use of the digital outputs should be wired to the RTU to indicate these same alarms.

**Conclusion**

Ultrasonic meters are a very reliable and maintenance free technique of measuring high volumes of natural gas. By paying attention to the installation details of the manufacturer and AGA Report #9 2017, the ultrasonic meter will deliver excellent performance for many years.