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Witnessing Orifice Meter Verification/Calibration
Class # 4160

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Introduction

All custody transfer gas meters require periodic calibration in order to assure that they are measuring accurately. The meter numbers are used to pay the seller for the gas going through the meter, and if at a production site it is also used for royalty payments, and to optimize production and reservoir management. Consequently the need for accurate measurement is very important. The primary element needs to be checked and the instrumentation must also be verified. If the instrumentation is correct there is no need to calibrate the devices. If however the verification shows that the instruments are not reading correctly, calibration will be required.

Orifice Meter

The orifice meter consists of two major parts; the primary and secondary elements. The primary element is defined as the upstream and downstream lengths of the meter tube, the orifice fitting including the taps and the orifice plate. The secondary element consists of the gauge lines from the orifice taps to the instrumentation, the valves necessary to allow the calibration of the instrumentation and the instrumentation itself. The instrumentation consists of devices to determine the static pressure, the differential pressure and the flowing temperature over time and record the data. Chart recorders are mechanical devices which record the data on a chart. Flow computers record the data electronically and then the data is either collected manually or remotely.

If the primary element is not correctly designed and installed, it is impossible to get accurate results from the instrumentation. API Manual of Petroleum Measurement Standards Chapter 14 Section 2 details the requirements for the primary element.

Primary Element

The upstream length of the meter tube is specified by API MPMS Chapter 14 Section 2 and is dependent on the piping configuration ahead of the upstream length. The type of fittings, elbows, tees or 45 degree elements, and other things which impact the required upstream length is detailed in Table 2-7 if there is no flow conditioner and table 2-8 if there is a flow conditioner. The separation distance between the fittings is also important in the length determination. The worst case scenario exists if the configuration in the field is not found explicitely in one of the above tables. In this case the upstream length required is 145 pipe diameters. Thus if the pipe is 10 inches in diameter, the upstream length required is 1450 inches of upstream length. The downstream length of the primary element is considered to be 5 pipe diameters in all cases. The primary element should be within surface roughness tolerances specified in the API document as well.

The orifice fitting is also part of the primary element and should not allow any leaking around the orifice plate. The simplest fitting is an OFU (orifice flange union) which is simply two flanges holding the plate in place. A proper OFU should be a quality fitting that keeps the plate centered in the fitting. Many of the OFU's in the field are not of sufficient quality to center the plate. If an OFU is utilized it is necessary to blow down the meter tube, break the bolts on the OFU and pull the plate out for inspection. If an OFU is utilized, one should check for that the plate was properly centered when it is pulled for inspection. The tap holes should be sharp and square to the inside of the meter tube as well.

Other types of fittings commonly found are the single chamber fittings, either the simplex type or the type with a crank to remove the plate more easily. A dual chamber orifice fitting is utilized if the time and expense to blow down the meter tube needs to be minimized and there is sufficient capitol money available to purchase a better fitting. These fittings allow the fitting to be equalized so that a gate can be opened and the plate can be raised into the upper chamber. The gate is then closed again, so that the two chambers are isolated. At this time, it is possible to bleed off a very small amount of gas to the atmosphere. Once this is done, the clamping bars can be removed and the plate removed for inspection.

The orifice plate is a major part of the primary element. It should be inspected each time the secondary instrumentation is verified or calibrated. Things that may go wrong with an orifice plate are the following: not centered, in backwards (the sharp square edge should be upstream), insufficient bevel, too much bevel, fins in the orifice bore, nicks in the orifice bore, surface roughness too large exceeding the 34 micro inch limit. The plate should be flat and have no fins, should not be dirty or show evidence of liquids in the line. Any of these deficiencies can cause significant error. In the available literature a plate in backwards can cause a 25% error.

Today's orifice plates are stamped with the material from which it was made and the temperature at which the reference diameter was determined.

Other things to be checked for are the presence of vibration and pulsation. A compressor nearby or a snap acting valve can be a source of significant measurement error. There may be both square root error and gauge line error. A pulsation tester should be utilized if pulsation is suspected. If indeed pulsation exists, it should be eliminated between the source and the measuring equipment if at all possible. Another class will cover pulsation in detail.

Industry typically tries to inspect the meter tube every five years, because if there is anything wrong with the primary element, it is impossible to obtain accurate measurement. If a film is seen on the orifice plate, a film probably coats the meter tube and the tap holes as well.

It should also be noted that if the primary element does not meet the API installation requirements, it is possible to continue using the meter station without modification unless the meter tube is either moved or refurbished. It should also be noted that if it is used, a measurement bias may occur.

Secondary Element

The secondary elements sense the static pressure, the differential pressure and the flowing temperature. These are either recorded on a chart recorder or in a flow computer. Today, the majority of custody transfer measurements are made with transducers and a flow computer. In the past, charts were the primary recording device. Transducers are capable of more frequent measurements, but even with a transducer, square root errors can occur, because the transducer can simply not sample frequently enough to eliminate the pulsation effects.

When verifying the instrumentation, it is extremely important not to make any adjustments until all of the verification data has been documented. Once the "as found" conditions have been documented, it is not acceptable to make adjustments. It should be noted, that it should be extremely rare to need to adjust a new transducer as it should be factory tested in controlled conditions. Also the test equipment the manufacturer utilizes is more accurate than those typically used in the field. It should also be noted, that the test equipment utilized in the field should be at least two times more accurate than the device they are calibrating.

If calibrating the instrumentation on a chart recorder, it is general practice to test both upscale and then back downscale. Some chart recorders are known for having an S curve, where the readings are on at 100, 50 and 0 but off in between.

If calibrating transducers, it is always good to follow the recommendations of the manufacturer of the transducer and the flow computer.

The test equipment utilized in the calibration should be certified at least yearly.

Once the primary element and the secondary elements have been verified, both parties can have a high degree of confidence that the measurements are accurate, fair and equitable.