

OVERVIEW OF AGA REPORT NO. 7 REVISION

Angela Floyd – BP America

Presented by Robert Bennett – Elster

Introduction

Just when you thought you knew everything there was to know about Turbine meter measurement, wham, out comes a revised AGA 7 standard. Now those basic principles are all still valid but maybe those operating practices we have built into our operating procedures need a little review. Rather than proceed as generations have done before us, research has been completed on the meters, their installation and operating practices and the way we calibrate and field test them. So now we have some data to back up our methods and madness.

Contents and Feel of Document

The document is limited in definition to the measurement of Natural Gas. The content of the document provides more conclusive guidelines for specific installations and field practices. The document has recognized the transition made to the use of the turbine meter regarding single versus dual rotors, electronic readouts and correction devices and practices. It has also recognized the different field proving and testing capabilities of the meters AGA has designed the latest revision of AGA documents with a similar format and layout to make the documents much more user friendly; as they are typically serving the same range of users throughout the industry. Terms and definitions have also been compared and standardized when appropriate to do so.

Installation Guidelines

The research¹ shows that turbine meters may be operated according to the recommendations in the document with acceptable error. More severe piping arrangements, tees and elbows etc. may exceed this error. Dependent upon the meter design, the extent of the error, if any, will be a function of the flow disturbances, the quality of external and integral flow conditioning, and/or the meter's ability to adjust for such conditions.

Effects and uncertainty of temperature measurement also emphasized the need to establish thermowell location, 1 – 5 diameters downstream of the meter and be installed in such a way to prevent heat transfer from the pipe and radiation from the sunlight.

Flow Conditioning

Recent research has confirmed that turbine meters with adequate internal flow conditioning and nosecone flow passages operate satisfactorily in short and close-coupled installations. Adequate internal flow conditioning will have, in general, aspect ratios of $H/D < 0.15$ and $S/L < 0.35$. These parameters are described below.

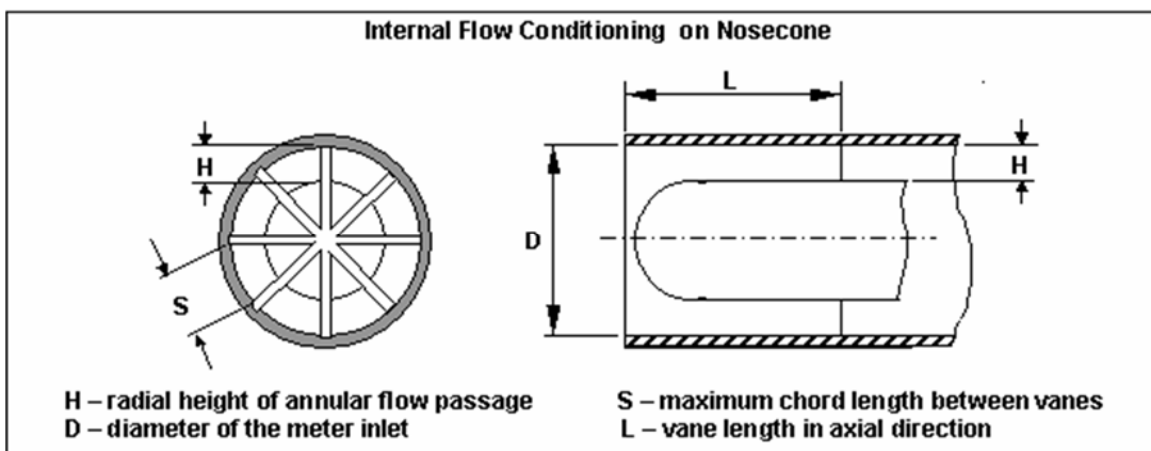


Figure 1. Internal Flow Conditioning

Operation guidelines

A great deal of turbine meter testing and research has been completed since the last document was released. This has focused on installation effects, the practice of calibrating meter modules versus the complete meter and also the capabilities of the labs to calibrate the meter under close to operating conditions.

Pressure Effects:

The research indicated that most turbine meters may not be capable of meeting the requirements of the AGA 7 document over their full range of operating pressure. Depending on meter manufacturer and design, some of the meters tested shifted in a positive direction by several percent. This would indicate that a meter that has been calibrated at atmospheric pressure can be expected to over-measure when placed in high-pressure service.

Meter performance should be within the following specifications after calibration. At atmospheric pressure:

Repeatability:	±0.2% from Qmin to Qmax
Maximum peak-to-peak error:	1.0% above Qt,
Maximum error:	±1.0% from Qt to Qmax, and, ±1.5% from Qmin to Qt,
Transition flowrate:	Qt not greater than 0.2 Qmax.

Calibration requirements

The AGA 7 has always recommended meter calibration. This may have been carried out either by the manufacturer on air at atmospheric pressure or by an independent calibration facility over a range of pressures and flow rates using air or natural gas.

Recent research has confirmed the possible shift in calibration curve of many meters by as much as 0.35%. This pressure shift can be directly related to Reynolds numbers effects on the meter, and is particularly significant at low and intermediate operating pressures and flow rates. Based upon this, the Reynolds number has been discussed in more detail in this document and translated to a conclusion that a calibration done at the same range of Reynolds number as the meter will be in operation, will have less uncertainty than when based upon flow rate and pressure alone.

$$Re = \frac{4(Q_f) / \pi(D) (\nu)}{\quad} \quad \text{(Equation 1)}$$

$$Re = \frac{4(Q_f) (\rho) / \pi(D)(\mu)}{\quad} \quad \text{(Equation 2)}$$

where,

Re	=	Reynolds number
Q_f	=	Volumetric flowrate
ν (nu)	=	Kinematic viscosity
D	=	Meter diameter
ρ (rho)	=	Density
μ (mu)	=	Absolute viscosity

Precautionary Measures

This section in the document discusses good practices when installing and operating the meter. They are commonly known practices, but often neglected, and can add to the uncertainty of the meter measurement while drastically reducing the life and performance of the meter. Please do not hydro test the meter run with the internals installed; go easy on the valve grease and if you plan to over-range the meter, do so in a controlled manner – 0-70ft/sec flow rates will burn out the bearings quicker than.....well you get the picture.

Filtration

Filtration is recommended upstream of turbine meters. With new installations, pigging and general pipe corrosion, it is recommended that a strainer with a basket of 3/32 inch maximum hole size and 40 mesh wire liners be installed upstream of the meter to catch the majority of this matter.

In some instances where fine particles can build up in the lubricating oil or on the meter internals and particularly the rotor, it may be preferable to install 10-micron maximum filters for the removal of this fine dust, thus increasing bearing life and minimizing deposits on the meters internal parts.

Field Maintenance

In-line Spin Tests

A major inclusion in this document is in-line spin tests. Although this practice has been available for many years thanks to pulse outputs from the meter rotor, it has not been adopted - possibly due to its lack of recognition.

You still have to blow down the meter run but can now do a spin test without removing the meter internals. By establishing an in-line spin time for the meters upon installation, you can now do frequent tests to establish if the bearings are degrading below allowable performance, then, determine if the meter internals should be removed or schedule cleaning and repair based upon the rate of degradation.

Dual Rotor meters

For dual-rotor meters, each rotor may have individual and unique rotor factors, in units of pulses/volume unit and may therefore be confused with the k-factor. Rotor factors are used specifically within the manufacturers electronics/flow computer software. Their applications are very different and they should not be used interchangeably

Examples of rotor factors for the primary and secondary rotors of a dual-rotor turbine meter are shown below:

Rotor factor (for primary rotor) = 95.2000 pulses / cubic foot

Rotor factor (for secondary rotor) = 143.4000 pulses / cubic foot

An example of the K-factor for primary rotor of the meter may be 103.3882 pulses / cubic foot.

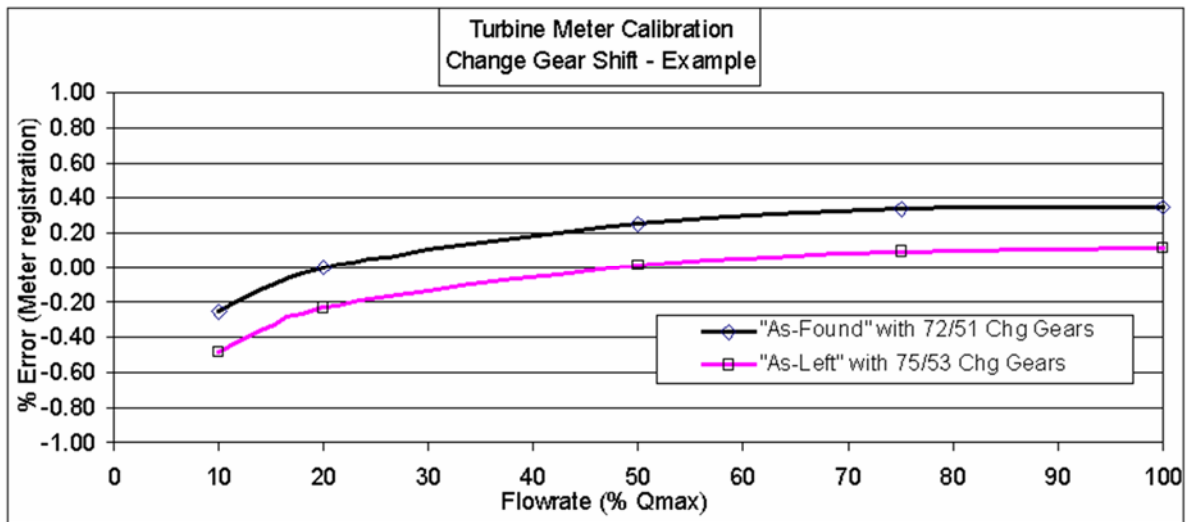


Figure 2. Results of New Change Gear Installation

Mechanical and Electrical Adjustments – Linearization, Meter Factors versus K-Factor, Rotor factors

Turbine meters have outputs that can be adjusted prior to calibration. Whether it is the mechanical change gear design or electronically by meter factor adjustments, these adjustments establish an uncertainty of the meter over its specified flow range.

Calibration adjustment of the mechanical output of a turbine meter is typically accomplished by choosing an appropriate set of change gears. The overall gear reduction allows for one complete output shaft revolution of the meter to represent a finite volume, for example (100 cubic feet, 1000 cubic feet, 1 cubic meter or 10 cubic meters). However, due to manufacturing tolerances within the meter and possible needs for increased accuracy, alternative change gears can be

installed to vary the gear ratio so as to adjust the mechanical volumeregistration output accuracy. Note that the adjustment shift will be the same amount for all flow rates.

The figure above shows an example of a turbine meter mechanical output accuracy performance before and after installation of New change gears, (i.e. resulting in a registration shift of -0.24 %).

Similarly, the electronic device applies a k-factor to provide a specific number of pulses per unit of volume. A single factor of mean, median or flow weighted design may be applied to the electronic calculation.

Alternatively, a k-factor can be applied to each flow rate calibrated and therefore perform a linearization of the flow curve, thus reducing the uncertainty at any given flow rate.

$$Q = \text{frequency} / k\text{-factor} \quad \text{(Equation 3)}$$

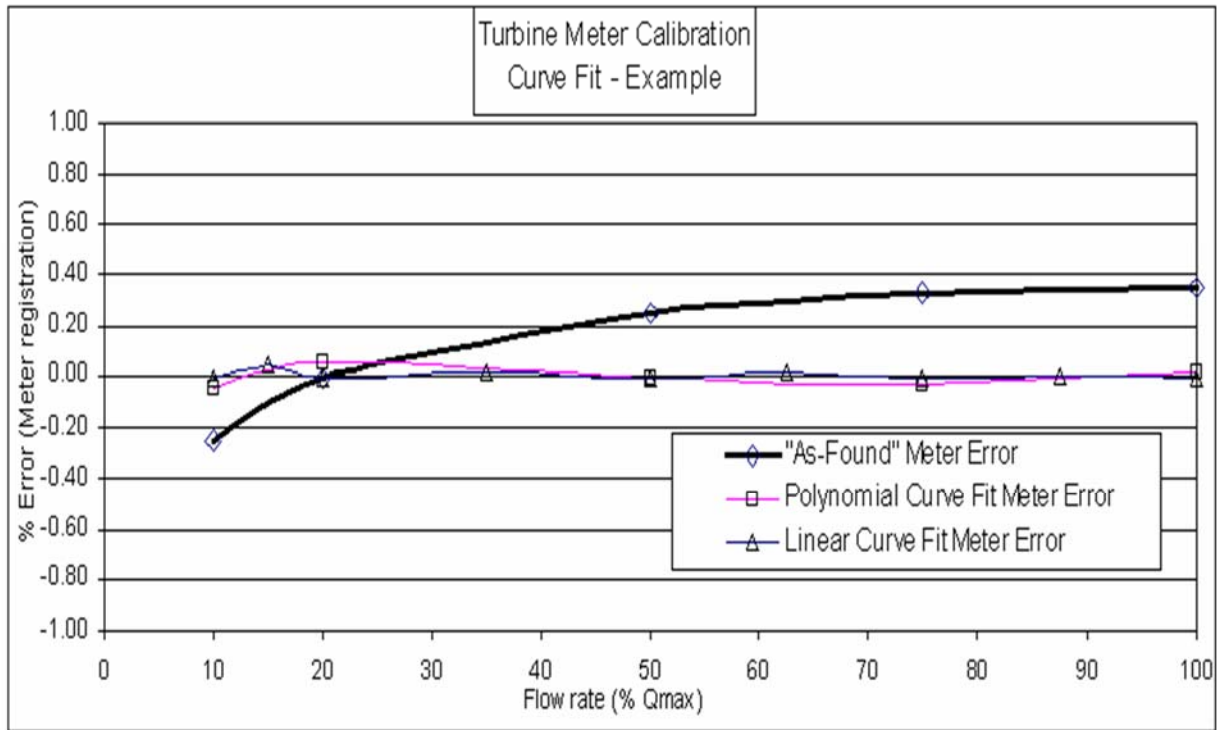


Figure 3. Polynomial vs. Linear Curve Fit Calibration Results

Conclusion

This brief overview has touched on some of the major changes in the AGA 7 document. Getting your hands on one will provide a more detailed explanation of many of the changes that have been recommended. While the previous documents covered the workings of the meter and its limitations I believe this document extends an understanding of the performance capabilities of the turbine meter.

The contents of the document provide a concise set of recommendations for the application and installation of the meter while the addition of appendices allows for details and examples of many of the processes described.

References

George, D. L., GRI Topical Report GRI-01-0226, "Metering Research Facility Program: Turbine Meter Research in Support of the Planned AGA Report No. 7 Revision" Gas Research Institute, Des Plaines, Illinois, January 2003.

George, D. L., GRI Topical Report GRI-03-0172, "Metering Research Facility Program: Effects of Line Pressure and Gas Density on Turbine Meter Measurement Accuracy at Conditions from Atmospheric Air to 700 psig in Natural Gas". Gas Research Institute, Des Plaines, Illinois, July 2003.

Reference 3: AGA, Measurement of Gas by Turbine Meters, Transmission Measurement Report No. 7.1996