FUNDAMENTALS OF ORIFICE METERING

Bill Buckley

Daniel Measurement and Control
P.O. Box 19097
Houston, Texas 77224

Introduction

The purpose to this paper is to discuss the fundamental components used in orifice measurement.

Background

The general concepts of head meters, which include the orifice, have been known for centuries. The orifice has been in commercial use since the early 1900's. The device is used to create a differential pressure that relates to the velocity of the gas from which a flow rate can be calculated. As the following gas passes through the restriction in the line caused by the orifice plate, the difference in the upstream and downstream pressure can be measured at set points, called taps, and a flow rate at the point can be determined.

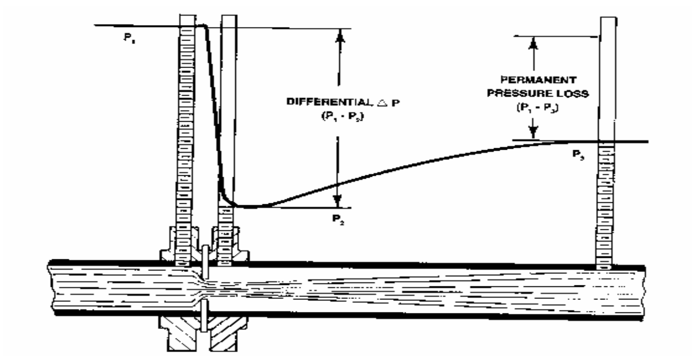

Figure 1. Head Meter

Standards and Importance

Orifice measurement is guided by the standards of several organizations. Primary among these is the American Gas Association and the American Petroleum Institute. The AGA #3 report is the standard that provides guidelines for the construction and installation of orifice meters. All orifice plates, holding devices, and meter tubes should be manufactured adhering to this standard in order to help ensure that the end product is an accurate measurement device.

Orifice Plates

The most fundamental component of orifice measurement is the orifice plate. This is typically a circular, flat device, which is held in the flowing stream by a holding device. Typically, it is made of a durable metal such as stainless steel. Orifice plates come in two types, the paddle plate and the universal plate. The paddle plate is held in place by flanges, while the universal plate fits into the various types of holding devices. AGA #3 standards spell out specific requirements for the orifice plates, including the concentricity of the orifice bore, the surface finish, flatness of the plate, and edge thickness. While the orifice plate is the least expensive of the components in orifice measurement, its importance should not be overlooked.

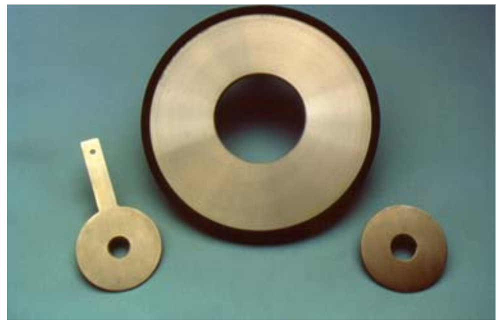

Figure 2. Orifice Plates

Orifice Devices

There are primarily three different types of devices used to help center an orifice plate in the flowing medium. The first and least expensive is the orifice flange union. This is a pair of flanges, which has been tapped to provide a differential reading. While it is the least expensive to purchase, it requires a higher maintenance level since the line must be bled down and the flanges spread apart in order to remove the plate.

The next device type is the single chamber orifice fitting. The single chamber device has an advantage over flanges in that it makes removal of the plate easier and safer due to the prevention of spillage that occurs when flanges are spread apart. Like flanges, however, the simplex device requires that the line pressure be bled off before the plate may be removed. The simplex device utilizes universal type orifice plates.

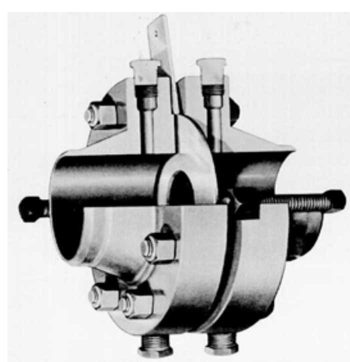

Figure 3. Orifice Flange Union

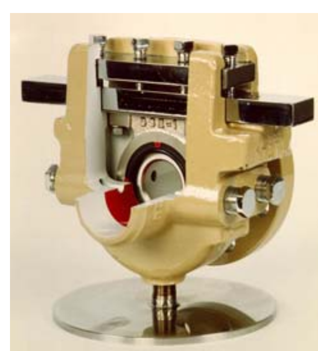

Figure 4. Single Chamber Fitting

The third device is the dual chamber orifice fitting. This fitting allows for the removal of the universal orifice plate without first bleeding down line pressure. This is accomplished through the use of internal valves, which isolate the upper (non-pressure) chamber from the bottom (pressured) chamber. The senior type is the most expensive of the plate holding devices to purchase, but could be the most economical when compared to the overall cost of the installation, since isolation valving is not required to allow plate removal.

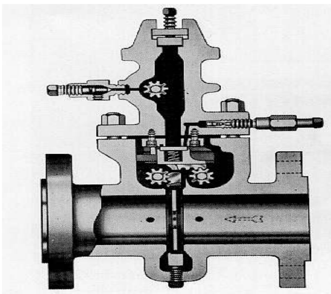

Figure 5. Dual Chamber Fitting

Meter Tubes

A meter tube basically consists of upstream tubing, the orifice fitting or flanges and downstream tubing. The purpose of tubing is to insure as smooth a flow profile, going into the orifice plate, as possible. The AGA #3 standard has very specific requirements for meter tube pipe, including the smoothness of the inside surface of the tubing and minimum lengths required under particular installations. If these standards are not met in the manufacture of the meter tube, then degradation in measurement could result.

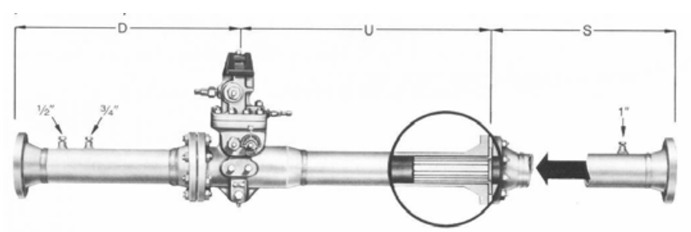

Figure 6. Three-Section Meter Tube

Straightening Vanes and Flow Conditioners

Straightening vanes are bundles of small diameter tubing, which are placed inside the upstream section of a meter tube. They are commonly of two types, flanged and in-line. The flanged types are held in the line between a pair of flanges in the upstream. The in-line vane is held in place inside the tubing by setscrews. Their purpose is to facilitate the smoothing of flow going into the orifice plate while allowing for shorter upstream tubing lengths.

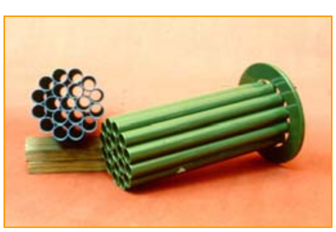

Figure 7. Straightening Vanes

The flow conditioners eliminate swirl like a straightening vane and, also, generate a near fully-developed flow profile. The conditioner also reduces the amount of required upstream tubing needed to meet AGA #3 requirements.

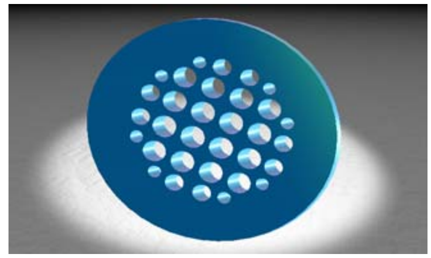

Figure 8. Flow Conditioner

Secondary Devices

The orifice fitting with its orifice plate is known as the primary devices in the orifice measurement package. There are other devices known as secondary devices, which translate the raw information from primary devices into more useable information. The most common of these are pneumatic chart recorders and flow computers.

The pneumatic chart recorder presents the information from the differential pressure, static pressure, and temperature transmitters in a graphical form, usually circular charts. The chart usually represents a 24-hour or 8-day period, which can be integrated later to provide volume figures.

Figure 9. Secondary Devices

Flow computers have increased in use in recent years due to the requirements for measurement information on a more "real time" basis. Flow computers, like the pneumatic chart, take the flow information from the differential pressure, static pressure, and the temperature transmitter and calculates flow volumes. Unlike the chart, flow computers do not have to go through an integration step to come up with these figures. There are several levels of sophistication available in flow computers. The battery-powered, solar charged devices have the best utility as field devices, which can store the flow information on site, do the volume calculations and then send that information on to a higher device such as a mainframe computer. The higher-level flow computers are usually AC or DC powered and provide not only the same calculations capability as the solar–powered units, but also have advanced flow control and alarm capabilities.

Conclusion

The latest AGA #3/API MPMS Chapter 14.3 measurement standard has greatly tightened the tolerances for the manufacture of orifice devices and meter tubes. It is very much in the best interest of the users of these devices to have sound maintenance programs in place to insure that the like-new quality of the tubes be maintained for as long as possible. The primary device, whether a fitting or flange, cannot be expected to provide accurate, reliable flow information if the orifice plate is bowed or otherwise degraded in some way. The vast body of data supporting orifice measurement over the years becomes meaningless if the guidelines for the design, manufacture, installation and maintenance of these devices are not followed.

Bill Buckley