Orifice Meter Installation and Maintenance

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The term "orifice meter" is rather broad and applies to several types of devices. The history of the orifice meter might possible date back to the latter part of the 15th Century; it was about 1580 when a young Italian medical student, Galileo, decided that he did not approve the ancient theory that the heavier an object the faster it would fall through space. He proved his theory by dropping heavy and light objects from the top of the leaning Tower Pesa. It was Mr. Galileo's secretary who, in later years, gave us the theory concerning the movement of liquid through a drain orifice in a liquid filled tank, possible be the first known theory about orifice measurement. Time will not permit us to review history, but it should be noted that we are still working with some of the basic equations and theories developed by our predecessors centuries ago. Therefore this paper will not attempt to discuss theory or mathematical equations; rather it was written in terms of practical operation and for the benefit of those who have neither the time nor the opportunity to install or actually operate flow metering devices.

There are several types of orifice meters or devices that might actually be classified as such. Any device being used to measure differential pressure can essentially be called an orifice meter. Those most frequently used are the Mercury and Bellows type meters, and they might indicate, record, or integrate the difference in pressure in terms of flow. A metering station consists of two components, one being the primary device better known as the orifice fitting and the other being the secondary device better known as the orifice meter.

ORIFICE FITTINGS: PRIMARY DEVICE

Most commonly used are four primary devices: the orifice fitting, orifice flange union, Venturi tube, and flow nozzle.

The orifice fitting and orifice flange union are used for gas measurement, refinery processing, chemical processing, and other industries too numerous to mention. For creating a differential pressure, these two devices utilize the orifice plate which can be bored to various sizes and thereby, make the orifice fitting and orifice flange union the more versatile of all primary devices.

The Venturi tube and flow nozzle have affixed calibrated throat and cannot be changed. They are more generally used in the water works and many are found operating in the City of Lubbock.

Therefore, it is now known the primary device is the controlling factor in the consideration for a secondary device, or orifice meter. In fact, an Orifice Meter is actually a combination of the primary and secondary device.

MERCURY TYPE ORIFICE METERS

This type meter utilizes a Mercury U-tube differential pressure manometer and has been in use for many years. However, not until 18 yr ago was any other type of meter acceptable for gas sales. Certainly, it has been improved in quality throughout the years, but the basic principle remains the same. The Mercury meter has good calibration characteristics and does an excellent job in many operating conditions. It performs especially well where the gas is dry and the line pressure is not too erratic. The cross-section of a typical U-tube Mercury manometer is illustrated in Figure 1.

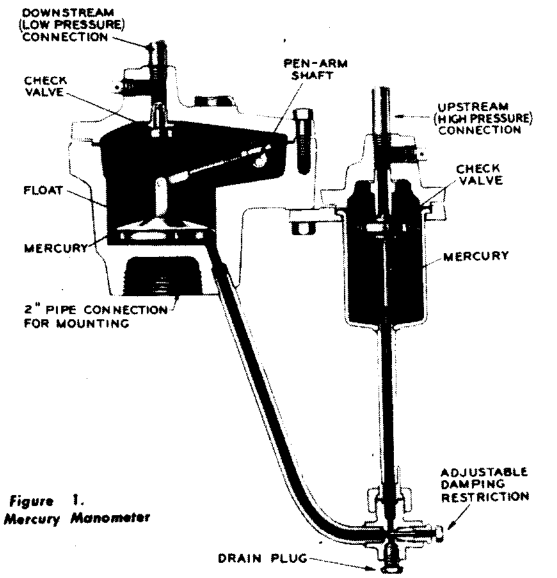
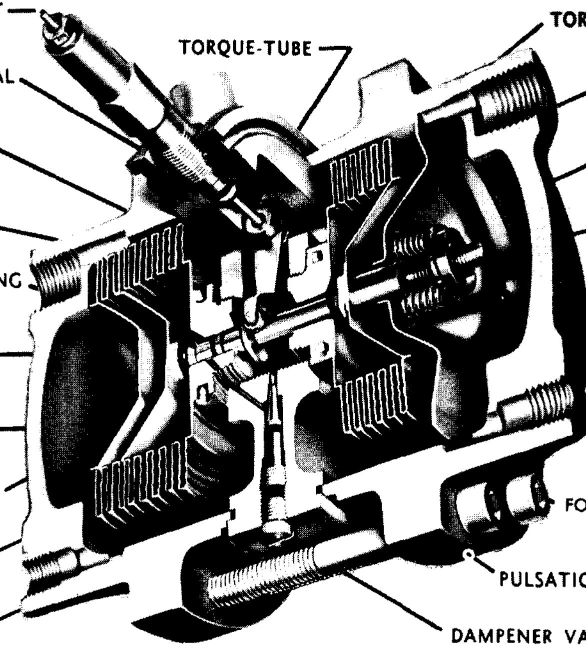


Figure 1. U-Tube Mercury Manometer

During the years between 1930 and 1940, a few American manufacturers attempted to develop such a device. These were mostly of the dry type of meter internally and could not take overrange conditions without serious damage. Most of the better materials required for making a good Bellows-type differential measuring device were being utilized in the war effort, and the development of such a meter was delayed possibly for that reason more than anything else. Then in 1944, the rupture-proof dual Bellows-type orifice flow meter was developed and introduced; however, most people did not give it much chance to succeed because the Mercury type meter was accepted by all types of industry as a standard. And as better materials became available after the war, many improvements were made and today we find the orifice meter of Bellows construction is being used successfully in all types of industries. There are now at least four of the major meter manufacturers marketing a Bellows-type meter, and it was first used by oil producing companies to measure wet gas such as encountered when taking gas-oil ratios. It proved to be a highly stable and accurate meter for this application and is now being used by gas transmission companies as well as for other applications where sales are involved. With a few exceptions, the Bellows meter is practically immune to inexperienced personnel. It will stand a full overrange equivalent to the pressure rating of the meter body; it has self-draining pressure connections which make it a desirable instrument for use in wet gas measurement. Furthermore, no seal factor is required for liquid



Cross Section of Bellows-type Manometer

Fig. 2

service or for use with liquid seals; it is excellent for the measurement of corrosive liquids and gases, and it has negligible zero shift due to ambient temperature changes. A cross section of a Bellows-type manometer is illustrated in Figure 2.

ORIFICE METER APPLICATION

Some years ago, this type instrument was considered primarily for use with high pressure and low pressure gas. However, times have changed, and the orifice meter is now regarded as a measuring device for several applications. But most important it should be known when and where to apply orifice type measurement.

(1) LOW PRESSURE GAS MEASUREMENT

The orifice meter is generally the only accepted device for low-pressure gas measurement. This would generally be an application in which gas is being measured from the production separator. This process is the most common usage of the orifice meter, but not too much should be said at this time about low-pressure gas measurement since this will be covered under installation and maintenance.

(2) HIGH-PRESSURE GAS MEASUREMENT

One application that should be discussed at this time is the measurement of gas for lifting oil, a particular application that is concerned with intermittent gas flow measurement. The time cycle installation gives the orifice meter a good workout and also presents problems so far as integrating charts are concerned. Five minutes on a seven day chart is nothing more than a straight line so it is almost impossible to determine how much gas is being used. Some producers are now using an integrating orifice type meter for this application, while others do not feel the expense for such an instrument can be justified.

Second best for this type measurement, would be the mechanical start-stop clock device or the gas driven clock. Thus a fast rotation clock can be used and will only run or turn the chart during the time cycle injection.

Another high pressure application would be in gas injection. Any high-pressure gas measurement can cause a considerable measurement problem unless adequate metering equipment is installed. Also, this is an application in which many inaccuracies occur, unless the gas has been dehydrated and practically all the entrained liquids removed. Too, hydrates cause many of the inaccuracies encountered in high pressure gas measurement. While it is often difficult to ascertain whether or not hydrates are present in piping, the possibilities of their presence may be anticipated with knowledge of gas quality, for hydrates will not form unless there is water entrained with gas. In the absence of both heat control and dehydration equipment, good measurement cannot be achieved without injecting some type of hydrate inhibitor.

(3) AUTOMATION

During the past ten years the oil industry has possibly improved its operations more than it has for any other period of time. The area consisting of west Texas and New Mexico has possibly seen more automation equipment installed than has any other part of the country. However, in a very short period of time, it was found that we did not have a gas measuring device compatible with this type of operation even though there have been gas-integrating devices on the market for many years. The conventional orifice meter could be used, but in so doing it was destroying a good portion of the automatic operation. The industry proposed the use of their single integrating device which was better to some extent than was a conventional orifice meter. It worked on the same principle, except that it utilized a square root extracting device with electrical components capable of sending a signal to a print-out or strip chart recorder at a central point. It was immediately found that this instrument did not have the range and was limited; hence, it still left much to be desired for some applications. As a result, we now have what is known as the wide-range integrating flow meter, a single integrating device. However, the variable comes about by using two meter runs rather than two differential pressure measuring elements. With such an instrument and with two meter tubes, a flow range of approximately 15:1 has been made available.

(4) WATER AND LIQUID MEASUREMENT

Orifice meters are constantly being used for water measurement in water injection projects. Extremely high pressures and large liquid volumes, make the orifice meter more applicable to this type of measurement than most other types of devices available. Entrained air and gases present a problem and should be vented, but this problem applies to other measuring devices as well. Oil can be measured if the orifice meter is satisfactorily installed in accordance with recommended procedure for measuring liquids.

INSTALLATION OF ORIFICE METERS

A little experience and good judgment are all that are required to install a meter properly. Orifice meters can be installed on the meter tube. A pipe leveling saddle and a 2 in. pipe nipple of sufficient length are used to give the meter proper height for drainage and are set up on a pipe stand near the meter tube, or in a panel board. To eliminate unneccessary piping the instrument should be installed as closely as possible to the orifice fitting. The manifolding for connecting the instrument to the orifice fitting should be made of good material and all connections assembled sufficiently tight to avoid leaks. Piping from the meter to the orifice fitting should have at least 1 in. per ft drop, and an effort should be made to avoid 90° ells or bends, especially where wet gas is being measured. The manifold assembly for the meter should be of 5 valve construction so it may be checked or repaired without unnecessary trouble and delay. Valves at the orifice fitting taps should be full opening or at least have a straight through port. If the meter is located within 8 ft of the orifice fitting, the 2 valves on the orifice fitting taps may be used as a portion of the 5 valve manifold. If the instrument is located in excess of this distance, it will be necessary to use 2 valves on the orifice fitting taps and a 5 valve manifold at the instrument. Mercury-type meters must be installed perfectly level, regardless of the mounting accessories. If not the instrument will not measure flow accurately. The Bellows-type meter should be mounted as nearly level as the eye can see so it will offer good appearance, but it does not have to be level to operate accurately.

ORIFICE METER MAINTENANCE

This is the area in which most manufacturers and users alike are concerned. If one knows what an instrument or meter is supposed to do, he can more easily understand its performance. This fact is just as true with an orifice meter as it is with any other type of equipment, but meter men do not have to be mathematicians to understand the fundamental principles or rules for orifice meters.

"How frequently should meters be checked?" Quite often this question arises. Some companies check their meters once each week; some once each month; some quarterly; some semi-annually; and others never check them until their measurement becomes so erroneous that it cannot be tolerated. However, it would be well to consider what is expected of a meter and let it fall into its area of importance accordingly. One should consider the importance of the measurement, or how relative is the information required, or how does the end result actually represent dollars Certainly, it represents dollars regardless of the application or else there is no reason for having the meter.

There are certain elementary maintenance points to check to be sure that an instrument is working properly. Each time that a chart is changed -- especially if operating on seven or eight day rotation -- the chart should first be inspected: inking system, clock, differential pen zero at both atmospheric and line pressure, static pressure pen zero, and the entire meter station are all checked. At least three or four times a year, all meters should be checked with a water manometer to determine if the differential-pressure element is in calibration. At least three times a year, the static-pressure element should be checked with a dead weight tester or some other suitable accurate device.

Problems most frequently encountered with mercury-type meters are dirty mercury as a result of measuring gas containing sulphur, trapping condensate or oil on top of mercury, loss of mercury because to overrange conditions where check valves fail to hold, bad pressure bearing, and deposits or corrosion inside the manometer.

Generally speaking, Bellows-type meters require less maintenance than do the mercury-type. If by the "quick-check" method, one finds that the bellows meter needs maintenance, there are two component parts to examine: the differential range spring assembly and the differential Bellows unit. The housing surrounding the Bellows unit should be removed and the range spring assembly inspected to determine if it is in proper condition. Generally, the problem will be in this assembly. If it is not, the differential unit should be inspected to determine if the convolutions are distorted. Damage to the differential unit in a Bellows meter can be caused by faulty construction, by letting a deposit build up inside the meter housing to such an extent that the Bellows cannot travel horizontally, or by operating the unit on a liquid harmful to 316 stainless steel.

In conclusion, it is well to note that problems accompanying gas measurement are compounded usually at the maintenance level. Most of these can be solved by using proper equipment and having good trained personnel. Furthermore, accurate measurement depends upon good instruments and equipment, and a well designed meter station all in the hands of capable personnel.