Fundamentals of Orifice Meter Measurement

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Fundamentals of Orifice Meter Measurement

Fluid meters are divided into two functional groups -

One measures **quantity** (Positive Displacement); the other measures **rate of flow** (Inferential.) All fluid meters, however, consist of two distinct parts, each of which has different functions to perform. The first is the **primary** element, which is in contact with the fluid, resulting in some form of interaction. This interaction may be that of imparting motion to the primary element; the fluid may be accelerated etc. The second or **secondary** element translates the interaction between fluid and primary element into a signal that can be converted into volume, weights or rates of flow and indicates or records the results.

For example, a weigher uses weighing tanks as its primary element and a counter for recording the number of fillings and dumpings as its secondary element. In an orifice meter, the orifice together with the adjacent part of the pipe and the pressure connections, constitute the primary element, while the secondary element consists of a differential pressure device together with some sort of mechanism for translating a pressure difference into a rate of flow and indicating the result, in some cases also recording it graphically and integrating with respect to the time. This same combination of primary and secondary elements will be observed in almost all other types of meters.

Positive Displacement (Quantity Meters) - Some of the more common positive displacement meters are: Weighers, Reciprocating Piston, Rotating Piston, Nutating Disk, Sliding and Rotating Vanes, Gear and Lobed Impeller, and the meter most commonly used to sell small quantities of gas at relatively low flow rates, the Bellows meter.

Inferential (Rate Meters) - **(a) Orifice Plates -** The most commonly used rate or inferential meter is the thin-plate, concentric orifice; a detailed discussion is covered in later paragraphs.

(b) Flow Nozzles & Venturi Tubes - Flow Nozzles and Venturi Tubes are primary rate devices which will handle about 60% more flow than an orifice plate for the same bore under the same conditions, and can therefore handle higher velocity flows. If a differential limit is chosen, then a smaller bore nozzle or Venturi may be used to measure the same flow. They are more expensive to install and do not lend themselves to as easy size change or inspection as orifice plates.

(c) Pitot Tubes - A Pitot or impact tube makes use of the difference between the static and kinetic pressures at a single point. A similar device which is in effect a multiple pitot tube, averages the flow profile.

(d) Turbine Meters - A Turbine meter is one in which the primary element is kept in rotation by the linear velocity of the stream in which it is immersed. The number of revolutions the device makes is proportional to the rate of flow.

(e) Swirlmeters, Vortex Shedding Meters, Rotometers, Mass Flow Meters, etc. - These are devices that have applications in flow measurement. The manufacturers should be contacted for detailed information.

What is an Orifice Meter?

An orifice meter is a conduit and a restriction to create a pressure drop. An hour glass is a form of orifice. A nozzle, venturi or thin sharp edged orifice can be used as the flow restriction. In order to use any of these devices for measurement it is necessary to empirically calibrate them. That is, pass a known volume through the meter and note the reading in order to provide a standard for measuring other quantities. Due to the ease of duplicating and the simple construction, the thin sharp edged orifice has been adopted as a standard and extensive calibration work has been done so that it is widely accepted as a standard means of measuring fluids. Provided the standard mechanics of construction are followed no further calibration is required. An orifice in a pipeline is shown in figure 1 with a manometer for measuring the drop in pressure (differential) as the fluid passes thru the orifice. The minimum cross sectional area of the jet is known as the “vena contracta.”

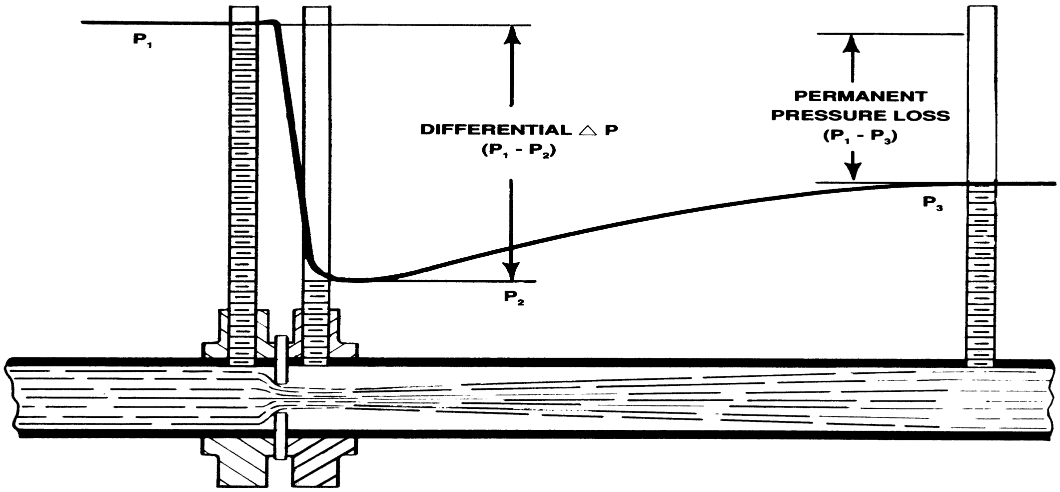
How does it work?

As the fluid approaches the orifice the pressure increases slightly and then drops suddenly as the orifice is passed. It continues to drop until the “vena contracta” is reached and then gradually increases until at approximately 5 to 8 diameters downstream a maximum pressure point is reached that will be lower than the pressure upstream of the orifice. The decrease in pressure as the fluid passes thru the orifice is a result of the increased velocity of the gas passing thru the reduced area of the orifice. When the velocity decreases as the fluid leaves the orifice the pressure increases and tends to return to its original level. All of the pressure loss is not recovered because of friction and turbulence losses in the stream. The pressure drop across the orifice (Δ **P** in Fig. 1) increases when the rate of flow increases. When there is no flow there is no differential. The differential pressure is proportional to the square of the velocity, it therefore follows that if all other factors remain constant, then the differential is proportional to the square of the rate of flow.

Orifice Flow Measurement - History

The first record of the use of orifices for the measurement of fluids was by Giovanni B. Venturi, an Italian Physicist, who in 1797 did some work that led to the development of the modern Venturi Meter by Clemons Herschel in 1886. It has been reported that an orifice meter, designed by Professor Robinson of Ohio State University was used to measure gas near Columbus, Ohio, about 1890. About 1903 Mr. T.B. Weymouth began a series of tests in Pennsylvania leading to the publication of coefficients for orifice meters with flange taps. At the same time Mr. E.O. Hickstein made a similar series of tests at Joplin, Missouri, from which he developed data for orifice meters with pipe taps.

A great deal of research and experimental work was conducted by the American Gas Association and the American Society of Mechanical Engineers between 1924 and 1935 in developing orifice meter coefficients and standards of construction for orifice meters. In 1935 a joint A.G.A. - A.S.M.E. report was issued title “History of Orifice Meters and The Calibration, Construction, and Operation of Orifices For Metering.” This report is the basis for most present day orifice meter measurement installation. An updated version of this standard based on new data was issued in early 1991 by A.P.I. titled: Manual of Petroleum Measurement Standards, Chapter 14, Section 3, Parts 1-4. Several additional publications are available to simplify measurement by orifice meters. These are: ASME Fluid Meters 6th Edition, ASME Power Test Code, Chapter 4 on Flow Measurement and Flow Measurement Engineering Handbook by R.W. Miller.



Typical Orifice Flow Pattern
Flange Taps Shown
Note: See pressure recovery curves on page 7

Fundamental Gas Laws

All matter is composed of exceedingly tiny particles called molecules   A molecule is defined as the smallest particle which can exist in the free and undecomposed state, i.e., natural gas is composed of molecules of methane, ethane, etc. These molecules are in constant motion and it is the impact of these molecules on the sides of a container which is measured as pressure. Temperature regulates the speed of the molecules and therefore, an increase in temperature increases the motion of the molecules which in turn increases the pressure.

As decreased temperature and pressure causes decreased motion of the molecules, it follows there must be some point where there is no molecular activity. The points where there is no molecular activity are absolute zero temperature (approximately -460°F) and absolute zero pressure (approximately 14.7 pounds per square inch below atmospheric pressure). Absolute pressure is equal to gauge pressure plus atmospheric pressure (14.7 p.s.i.). Absolute temperature is equal to degrees Fahrenheit (°F) plus 459.67° and is called degrees Rankin.

Boyles Law states that in an ideal gas the volume is inversely proportional to the absolute pressure. If a cylinder has a volume of gas at an absolute pressure of 14.7 and a piston was to displace the volume in the cylinder until the pressure reached 29.4 p.s.i., then the cylinder would contain one-half of its original volume.

Charles Law states that the volume of an ideal gas is directly proportional to the absolute temperature. If a cylinder has a volume of gas at 60°F or 514.67° Rankin (absolute) and a piston was used to displace the volume so as to maintain a constant pressure while the temperature was doubled to the 580°F or 1039.67° Rankin (absolute) the cylinder would contain twice its original volume.

The combined ideal Boyles and Charles Law is commonly written in the form of the equation:

$$\frac{P_1 \quad V_1}{T_1} = \frac{P_2 \quad V_2}{T_2}$$

Where:

P = Pressure at Condition 1 or 2	1 = Flowing Conditions
V = Volume at Condition 1 or 2	2 = Base Conditions
T = Temperature at Condition 1 or 2	

When discussing a quantity of gas it is necessary to define it. We could use weight such as pounds or ounces but it is difficult for most people to think of gas as having weight. So, the common definition is a cubic foot at some base pressure and base temperature. The base conditions used by most areas of the United States are 14.73 p.s.i.a. and 60°F. See USEFUL FORMULAS on page 15.

ORIFICE GAS FLOW EQUATION

$Qv = 218.527*Cd*Ev*Y1*(d^2)*[Tb/Pb]*[(Pf1*Zb*hw)/(Gr*Zf1*Tf)]^{0.5}$ (3-6)

Where

Cd	=	Orifice plate coefficient of discharge
d	=	Orifice plate bore diameter calculated at flowing temperature (Tf) - in.
Gr	=	Real gas relative density (specify gravity)
hw	=	Orifice differential pressure in inches of water at 60 degF
Ev	=	Velocity of approach factor
Pb	=	Base pressure - psia
Pf1	=	Flowing pressure (upstream tap - psia
Qv	=	Standard volume flow rate - SCF/hr.
Tb	=	Base temperature - degR
Tf	=	Flowing temperature - degR
Y2	=	Expansion factor (downstream tap)
Zb	=	Compressibility at base conditions (Pb,Tb)
Zf1	=	Compressibility (upstream flowing conditions - Pf1, Tf)

Orifice Plate Coefficient of Discharge - Cd

This has been empirically determined for flange-tapped orifice meters. To accurately use these coefficients, the orifice meter must be manufactured to the specifications of Chapter 14 - Natural Gas Fluids Measurement of the manual of Petroleum Measurement Standards Section 3 Concentric, Square-edge Orifice Meters Part 2 Specifications and Installation Requirements (Also referenced as AGA Report No. 3, Part 2 and GPA 8185-9, Part 2). Basically, the coefficient of discharge depends on the Reynolds number, sensing tap location, meter tube diameter and orifice diameter with some other smaller influences.

Each coefficient of discharge applies to the Reynolds number at which it is calculated.

Orifice Plate Bore Diameter - d

This bore must represent the bore at flowing conditions so corrections to account for the effects of temperature must be made if the temperature at which the plate was miked is different from the flowing temperature.

Real Gas Relative Density (Specific Gravity) - Gr

This is the normal specific gravity obtained from a specific gravity test or recording instrument and represents the ratio of the relative densities of the gas, divided by air at the same conditions. With a given applied force to a gas, a larger quantity of .25 specific gravity gas can be passed through an orifice than a 1.00 specific gravity gas. Since flow varies as the square root of one over the specific gravity twice as much gas will flow with the lighter gas,

(I.e. $\sqrt{1/.25} = 2, \sqrt{1/1} = 1.0)$

Orifice Differential Pressure in Inches of Water at 60 degF - hw

This is a measure of the pressure drop across the orifice and is measured in inches of water. (Note: Approximately 27.7 inches of water is equal to one pound drop.)

Velocity of Approach Factor - Ev

This factor corrects for the change in velocity between the upstream meter tube and the velocity in the orifice bore. This factor varies with the beta ratio.

Base Pressure (psia) - Pb

To define the quantity of a gas measured, the base pressure must be defined. This is set by contract, governmental law or agreement by the two parties to the measurement. The AGA-3 used 14.73 psia as its base pressure.

Flowing Pressure (psia) Pf1 or 2

The pressure is measured at either the upstream (1) or downstream (2) tap. It has been common in the natural gas business to use the downstream tap. Pressure has two effects on volume. The higher pressure makes the gas denser so less volume flows through the meter. However, when the volume is expanded to base pressure, the volume is increased.

Base Volume Flow Rate - Qr

The standard equation calculates an hourly volume rate which must be multiplied by time to get total volume. The volume is expressed at the base conditions of temperature and pressure.

Base Temperature in Degrees Rankin - Tb

The base temperature is defined by the contract, governmental law or agreement by the two parties to the measurement. To correct degrees Fahrenheit to degrees Rankin, 459.67 degrees is added. Most natural gas uses 519.67°R (i.e. 60°F + 459.67°) as the base temperature.

Flowing Temperature in Degrees Rankin - Tf

The flowing temperature is normally measured downstream from the orifice and must represent the average temperature of the flowing stream in degrees Rankin. Temperature has two effects on volume. A higher temperature means a less dense gas and higher flows, but when this higher flow is corrected to base temperature, the base flow is less.

Expansion Factor - Y1 or 2

The expansion factor corrects for the density change between the measured tap density and the density at the plane of the orifice face. Since the common static pressure tap used in natural gas measurement is the downstream factor Y2; this factor is smaller than the Y1 correction.

Compressibility at Base Conditions (P_b T_b)

This correction is very close to one so in the past it has been ignored. However, since 1985 it has been required to correct for the gas compressibility from the base pressure to absolute zero pressure at 60° F.

Compressibility Flowing conditions (Pf and Tf) Zf 1 or 2

The real gases compress more than the ideal gas law predicts and this must be corrected for when gas is measured at high pressure and temperatures other than 60°F mathematically reduced to base conditions. This correction, when applied outside of the square root radical is called supercompressibility. In round numbers at ambient temperature the compressibility affects volume by 0.5 percent per 100 psi of pressure.

Critical Flow

The above square root flow formula applies to subsonic flow only. Sonic or critical flow occurs when the velocity of the gas or vapor reaches the speed of sound (approx. 700 miles per hour in air). A gas cannot be made to travel any faster and remain in the same state.

A rule of thumb to use in gas flow is that critical flow is reached when the downstream pipe tap registers an absolute pressure of approximately 50% or less than the upstream pipe tap.

Major Advantage of Orifice Meter Measurement

Flow can be accurately determined without the need for actual fluid flow calibration. Well established procedures convert the differential pressure into flow rate, using empirically derived coefficients. These coefficients are based on accurately measurable dimensions of the orifice plate and pipe diameters as defined in standards, combined with easily measurable characteristics of the fluid, rather than on fluid flow calibrations.

With the exception of the orifice meter, almost all flow meters require a fluid flow calibration at flow and temperature conditions closely approximating service operation in order to establish accuracy.

In addition to not requiring direct fluid flow calibration, orifice meters are simple, rugged, widely accepted, reliable and relatively inexpensive.

No moving parts!

BETA RATIO is the ratio of orifice plate bore divided by pipe I.D. is referred to as the Beta Ratio or d/D where d is the plate bore and D is the pipe I.D.

THE THREE "R's"

Reliability (uncertainty/accuracy)

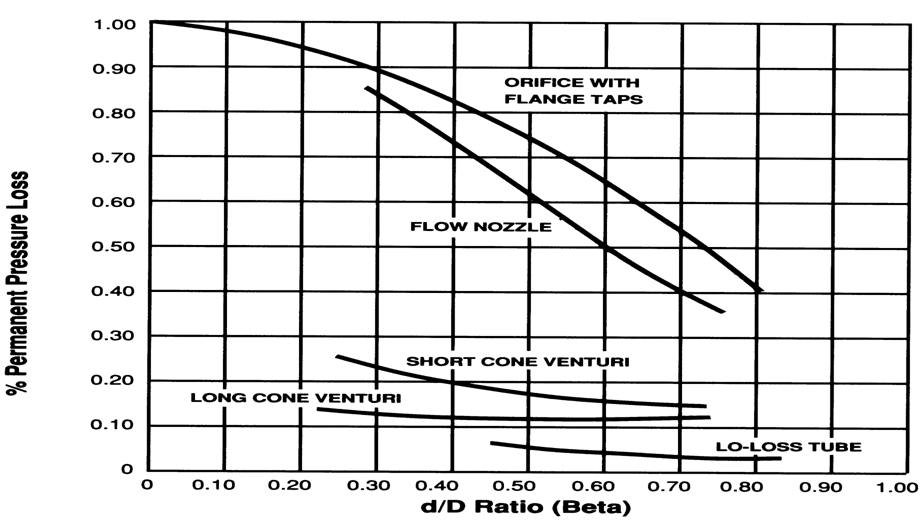
The coefficients calculated for flange taps by the equations in AGA Report No. 3 (API 14.3) are subject to an uncertainty of approximately $\pm$ .5 percent when the beta ratio is between 0.20 and 0.70. When the beta ratio is between 0.10 & 0.20 and .70 & .75, the uncertainty may be greater. Minimum uncertainty occurs between 0.2 and 0.6 beta ratios. Below 1,000,000 Reynolds number there will be some small increase in uncertainty with the minimum Reynolds number of 4,000 being the limit of the standard.

Rangeability

Sometimes called "turn-down" is the ratio of maximum flow to minimum flow throughout which a stated accuracy is maintained. For example, if an orifice meter installation is said to be accurate to $\pm$ 1% from 600,000 SCFH to 200,000 SCFH, the rangeability would be 3 to 1.

Repeatability

The meter to same time the conditions readings not be will repeat. is important meter is control.



ability of a flow indicate the readings each same flow exist. These may or may accurate, but This capability when a flow used for flow

PRESSUR CHARACT PRIMARY

E LOSS ERISTICS OF DEVICES

It should be noted that total system pressure loss should be based on amount of differential created at a given beta ratio for a given flow. Devices having a lower coefficient of discharge may not have a lower permanent loss for the same flow.

THE ORIFICE PLATE

The orifice plate bore can be made in many configurations to handle various flow measurement jobs. The flowing conditions should be checked to see which of the configurations is suitable for each measurement job.

a. The Thin Plate, Concentric Orifice

In the design and use of orifice plates, several basic factors must be followed to assure accurate and reliable measurement.

The upstream edge of the orifice must be sharp and square. Minimum plate thickness based on pipe I.D., orifice bore, etc. is standardized. The plate should not depart from flatness along any diameter by more than 0.01 inch per inch of the dam height (D-d)/2. To conform with recommended practices, the orifice-to-pipe diameter ration d/D (called Beta ratio), must not exceed recommended limits.

b. Eccentric Orifice Plates

The eccentric plate has a round opening (bore) tangent to the inside wall of the pipe. This type of plate is most commonly used to measure fluids which carry a small amount of non-abrasive solids, or gases with small amounts of liquid, since with the opening at the bottom of the pipe, the solids and liquids will carry through, rather than collect at the orifice plate.

c. Segmental Orifice Plates

The opening in a segmental orifice plate is comparable to a partially opened gate valve. This plate is generally used for measuring liquids or gases which carry non-abrasive impurities such as light slurries or exceptionally dirty gases. Predictable accuracy of both the eccentric and segmental plate is not as good as the concentric plate.

d. Quadrant Edge Plate

The quarter-circle or quadrant orifice is used for fluids of high viscosity. The orifice incorporates a rounded edge of definite radius which is a particular function of the orifice diameter.

e. Conic Edge Plate

The conic edge plate has a 45° bevel facing upstream into the flowing stream. It is useful for even lower Reynolds numbers than the quadrant edge.

METER TAP LOCATION

a. Flange Taps

These taps are located one inch from the upstream face of the orifice plate and one inch from the downstream face with a $\pm$ 1/64 to $\pm$1/32 tolerance.

b. Pipe Taps

These taps are located 2½ pipe diameters upstream and 8 pipe diameters downstream (point of maximum pressure recovery). Flange taps are almost universally used in the United States with some older meter stations still using pipe taps.

c. Vena - Contracta Taps

These taps are located one pipe diameter upstream and at the point of minimum pressure downstream (this point is called the vena-contracta). This point, however, varies with the Beta ratio and they are seldom used in other than plant measurement where flows are relatively constant and plates are not changed. Exact dimensions are given in appropriate tables.

d. Corner Taps

These taps are located immediately adjacent to the plate faces, upstream and downstream. Corner taps are most widely used in Europe, in line sizes less than 2 inches they are used with special honed flow meter tubes for low flow rates.

THE PRIMARY ELEMENT

Orifice Flanges

The most elementary device used to hold an orifice plate in place is the orifice flange union. Orifice flanges have been used for a great many years but gained in importance during the 1920's, when the petroleum industry began making extensive use of orifice measurement. It did not take many years to discover that the orifice flange, in spite of simplicity, had many shortcomings in certain applications. It was apparent that it could not be conveniently used for wide variations of flow, dirty fluids requiring frequent plate cleanings, or in services where flow interruptions are expensive. Therefore, it was often necessary to bypass the flow so that the orifice plate could be inspected or changed as conditions warranted.

The Senior® Orifice Fitting

Changing plates in orifice flanges is time consuming and expensive. It is evident that operating personnel are in need of some device which would make the operation of plate changing or inspection less tedious. Therefore, the first significant type of orifice fitting is known as the Senior type, having a design permitting the change or the removal of a plate under flowing conditions.

The Senior® Orifice Fitting is a dual chambered fitting allowing the removal of an orifice plate under flow conditions. The lower chamber, which holds the orifice plate in the fluid flow, is bolted to an upper chamber. Separating the two chambers is a slide valve that opens/closes with a gear shaft. Opening the slide valve allows elevation of the plate carrier and orifice plate into the top chamber. Once the slide valve is closed again and pressure bled from the top chamber, the plate carrier/plate can be removed to the atmosphere.

The Junior Orifice Fitting

Some time after the development of the Senior Orifice Fitting, attention was given to the problem of changing orifice plates when a bypass was in existence, or where two or more meter tubes were joined by common headers. Since orifice flanges are not convenient and require a considerable amount of time when used, thought was turned to developing a simple fitting for speedy operating. The result was the Junior type fitting. The Junior Fitting is much like the Senior, except the Junior does not have a slide valve and a top chamber. The Junior fitting requires only the following steps to remove an orifice plate from the line:

1. Shut in meter tube.
2. Depressure tube.
3. Loosen set screws, remove top clamping bar, sealing bar, and gasket.
4. Turn shaft, elevating orifice plate out of the fitting.

The procedure is reversed to install an orifice plate.

The Junior Fitting is currently available in line sizes 10" through 34" and for special applications, has been manufactured in larger sizes up to 48".

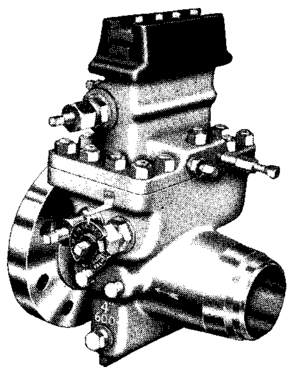
The Simplex® Orifice Plate Holder

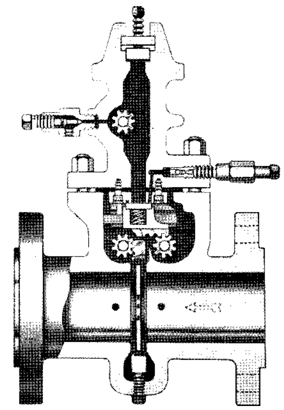
The Simplex Orifice Plate Holder is the third basic type of orifice fitting, and was developed specifically to provide an economical, accurate replacement for conventional orifice flanges where plate changings are infrequent and orifice flange unions are too cumbersome. The Simplex is basically the same as the Junior except you do not elevate the orifice plate with a shaft and pinion gear. Since the Simplex is made in sizes
1½ " thru 8" only, the plate and plate carrier can easily be removed by hand.

DANIEL SENIOR® ORIFICE FITTINGS

Daniel Senior® Orifice Fittings are made to provide the best possible conditions for orifice metering accuracy and convenience. They also meet AGA/API recommendations for sizes and tolerances, pressure ratings and tap locations Senior Orifice Fittings have the dual chamber design that permits the orifice plate to be removed from pressurized lines safely and quickly. For operators, this means considerable savings. Regular inspection and replacement of orifice plates results in higher accuracy and more economy.

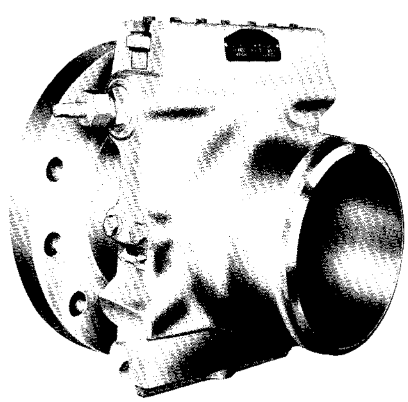
Senior Orifice fittings are available in line sizes from 2" through 48" and pressure ratings up to 10,000 PSI WOG.





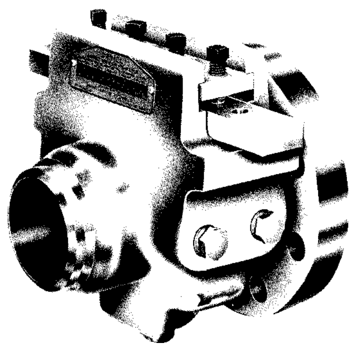
DANIEL JUNIOR ORIFICE FITTINGS

On line sizes of 10" to 48", where line by-pass or pressure shut-down is permitted, Junior Orifice Fittings are advantageous to use. The Junior is a single chamber fitting with all of the qualities of Senior Fittings except plate removal under pressure. To raise the plate carrier a operating shaft is provided. Designed for large volume meter stations, the Junior fittings saves the time and trouble of breaking apart large orifice flanges. All Juniors are made to AGA/API recommendations.



DANIEL SIMPLEX® ORIFICE PLATE HOLDERS

On line sizes of 1½" through 8", where line by-pass or pressure shut-down is permitted, Simplex Orifice Plate Holders offer more convenience and operating economy than orifice flanges. First, Universal Size plates are used instead of more expensive paddle-type plates. Secondly, plate removal is faster, safer and simpler. Finally, the line does not have to be jacked apart nor liquid product spilled. Four types of end connections (body styles) are available. All Simplex Plate Holders are made to AGA/API recommendations. Pressure ratings are available to 10,000 PSI.



DANIEL ORIFICE METER TUBES

All Daniel Meter tubes are manufactured to meet or exceed the recommendations of AGA, API and other societies. Tubing is made to Daniel specifications at the mill to guarantee uniform roundness, wall thickness and strength. Automatic welding, and special internal alignment methods are employed. Extra pipe connections are available. All critical location welds are ground internally and all others where possible. X-ray and hydrostatic testing are available.

Orifice fittings and orifice flanges are available in a wide variety of end connections and care is taken to ensure against steps or offsets in the line bore between tube and fitting.

For bore inspection, the "Flangnek" body style of fitting is recommended because the down stream tube section can be unbolted at the flange, inspection made and the important upstream alignment left undisturbed.

Daniel bolts together all meter tubes before shipment when length permits.

Meter Tubes

In recent years many companies have joined with industry to study the effects of the upstream and the downstream pipe immediately adjacent to the orifice plate. These lengths of pipe are known as meter tubes, meter runs, flow sections, meter sections, etc.; however, the most generally accepted terminology is meter tubes. It has been clearly demonstrated by tests that the length and the condition of the pipe used in meter tubes has a very important bearing on the overall accuracy of the measurement. The proper manufacture of orifice meters and orifice fittings is a highly developed technology.

Visual Manometers

A manometer in its simplest form is a glass tube bent in the form of the letter "U" and partially filled with some liquid. If both ends of the "U" are open to atmosphere, the pressure on each side would be alike, and the column of liquid on the one side of the "U" tube will exactly balance the column of liquid on the other side, and the surface of the two heights will be on the same level. If one leg of the "U" is connected to a supply pipe in which the pressure is a little greater than the other leg, then the column of liquid will be down on the high pressure side and up on the low pressure side, and the difference in height is a true measure of the difference in pressure (pressure drop) in the two legs of the manometer. Because the visual manometer is basic in calibration, friction-free, and simple, it is used in field and laboratory calibrations of primary devices.

Bellows or Dry Type Differential Meter

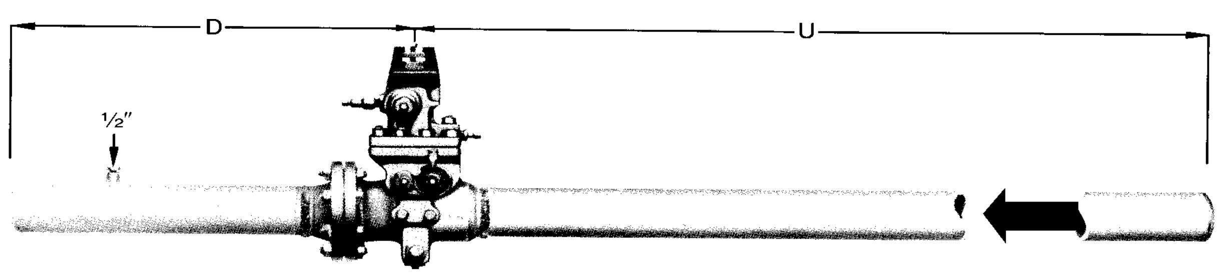
This type meter uses concentrically corrugated diaphragms or bellows. Modern designs use two bellows with the space between filled with liquid. This liquid prevents deformation at high over-range conditions and makes it possible to install an adjustable damping device between the two bellows.

Differential Pressure (DP) Cells

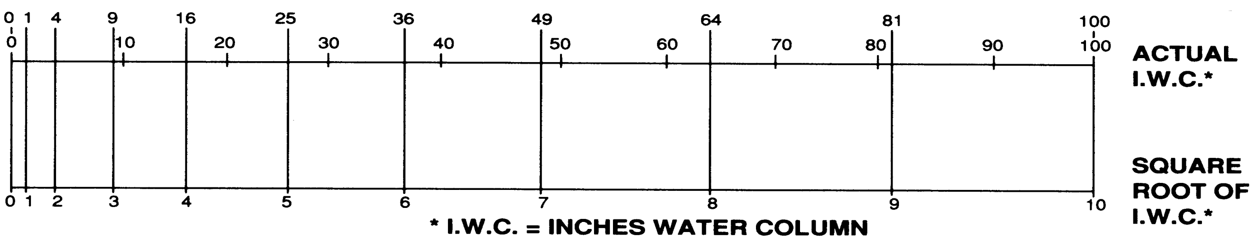
The DP transducer measures the differential pressure and converts the reading to an electrical signal for input into a flow computer. The latest DP's are "smart transducers" that correct for the effects of temperature and pressure and are more stable than the standard DP's.

Recording Charts

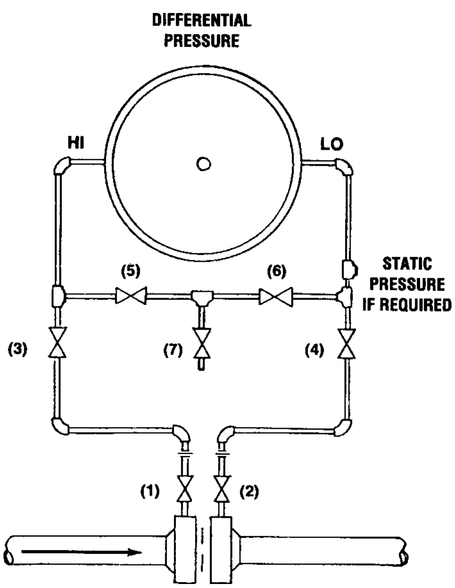
Most orifice meter recording charts are circular and will revolve one revolution every 1 hour, 24 hours,



7 days, 8 days, or any other pre-determined length of time. The chart should be replaced when the time period is completed. This is done either manually or by automatic chart changers.



Recording orifice meters come equipped with one, two or three pens. For liquid measurement a single pen for differential pressure is all that is required. For gas, two pens are required in order to account for changes in static pressure. If significant temperature changes are anticipated, a third pen or a separate recorder is used. In order to know which pen line is which, Red ink is normally used for differential pressure and Blue or Black for static pressure. There is no set color for temperature.



To facilitate the estimation of flow at any point in time, orifice charts may be graphed on a square root scale rather than a liner scale. The following comparison graph shows the relationship of these two scales.

General Installation Recommendations

1) Meter manifold piping should always be installed to enable calibration as well as to protect the differential element against overange.

2) The meter should be installed as close as possible to the orifice fitting.

3) Always slope the manifold lines gently from the orifice fitting to the meter to eliminate any high or low points in the manifold lines.

4) Use condensate chambers or air traps to remove either liquid from a gas system or gas from a liquid system if lows or highs in the manifold piping cannot be avoided.

It is important when pressurizing or depressurizing differential measuring devices to apply or release pressure to or from the high and low meter chambers uniformly, so as not to impose excessive overange.

PRESSURIZE

A) Be sure (1) & (2) are closed (if not, follow depressure procedure).

B) Open (3), (4), (5), & (6) and close (7).

C) Slowly open (1) & (2).

D) Close (5) & (6) and open (7).

USEFUL FORMULAS

DEPRESSURIZE

A) Close (7).

B) Open (5) & (6).

C) Close (3)& (4) (or (1) & (2) if checking piping for leakage).

D) Slowly open (7) (this will evenly vent hi & low sides).

Pressure correction

Absolute pressure = gage pressure + 14.73 = psia

$$Q \text{ new} = \sqrt{\frac{P_2}{P_1}} \times Q \text{ old}$$

Where P_1 = Old psia
P_2 = New psia

Example: if Q old = 100,000 SCFH @ 100 psig (old)
What would flow be at 200 psig (new)
100 psig = 114.73 psia
200 psig = 214.73 psia

$$Q \text{ new} = \sqrt{\frac{214.73}{114.73}} \times 100{,}000 = 136{,}800 \text{ SCFH}$$

Temperature correction

Absolute temperature = °F + 460 = °R (Rankin)

$$Q\ \text{new} = \sqrt{\frac{T_1}{T_2}} \times Q\ \text{old}$$

Where T_1 = Old absolute temp.
T_2 = New absolute temp.

Example: if Q old = 100,000 SCFH @ 60°F
What would flow be at 70°F
60°F = 520°R
70°F = 530°R

$$Q\ \text{new} = \sqrt{\frac{520}{530}} \times 100{,}000 = 99{,}052\ \text{SCFH}$$