Permanent Pressure Loss Comparison Among Various Flowmeter Technologies

White Paper

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White Paper

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Permanent Pressure Loss Comparison Among Various Flowmeter Technologies

Abstract
This paper explores the issue of permanent pressure loss through various types of flow metering technologies. Of particular interest is the V-Cone. The V-Cone flowmeter is a differential pressure device produced by McCrometer, Hemet, California, USA. By design, the V-Cone measures differential pressure created by a cone positioned in the center of the pipe. The open area through which the fluid passes is stretched over the edge of the cone. This annular space appears to constrict flow dramatically compared to other metering technologies. This paper compares the permanent pressure loss among meters in a typical application.

Introduction
The V-Cone is a patented flowmeter made by McCrometer. With its unique geometry, the V-Cone creates a differential pressure signal that is proportional to the square of the flowrate. This differential pressure signal is then measured by a secondary device that converts the analog pressure signal to an electronic signal, usually a standard 4-20 mA current signal. The electronic signal can then be used to calculate flowrate, mass rate, etc. using tertiary devices.

One typical question regarding the V-Cone is the amount of permanent pressure loss to be expected through the meter in the application. On first look, the cone appears to occupy an inordinate amount of space in the pipeline, and thus constrict the flow greatly. In reality, the cone restricts the flow very little. Several factors contribute to allowing the V-Cone to measure flowrate very accurately without significant permanent pressure loss.

Permanent Pressure Loss Comparison
One method to compare differential pressure meters is by the beta ratio. The beta ratio is the ratio of the smallest open area to the largest open area in the meter. In traditional differential pressure meters, this is usually the ratio of the diameter of the constriction to the diameter of the pipe. This is identical to the ratio of the areas mentioned earlier. V-Cones also have beta ratios that share the same area definition. Since the V-Cone does not have a central opening, the beta ratio is calculated in a slightly different manner. See. figure 1.

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If a meter has a beta ratio of, for example, 0.65, this means that 42% of the pipe area is still open at the largest constriction (0.65 x 0.65 = 0.42). This applies to all differential pressure flowmeters, including the V-Cone.

A typical method to measure the permanent pressure loss in a differential pressure flowmeter is to state a percentage of the differential pressure created at a given flowrate. For example, a differential pressure meter may state a 50% permanent pressure loss of differential pressure created. If the maximum differential pressure created by the meter is 10 kPa, the permanent pressure loss at that flowrate is 5 kPa. If the flow decreased and the differential pressure becomes smaller, the permanent pressure loss will become smaller. The percentage of differential pressure permanently lost can be graphed as a relationship of beta ratio. See figure 2.

The V-Cone is positioned between the orifice and the nozzle curves. This, however, is not a true comparison between the permanent pressure loss expected through the meters because the V-Cone requires less differential pressure to remain accurate and repeatable. This is possible because of the stable and controlled differential pressure signal created by the cone.

A true comparison would be to compare the actual permanent pressure loss expected through various meters for a given application.

Application Comparison

An application was chosen to compare the permanent pressure loss through the following meters:

1. V-Cone

based on information from McCrometer

2. Orifice Plate
3. Flow Nozzle
4. Venturi with 15° exit angle
5. Venturi with 7° exit angle
6. Turbine
7. Vortex

based on information from Miller[1]

8. Coriolis
9. Vortex

based on information from Foxboro Co.

10. Coriolis

based on information from MicroMotion Co.

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The application parameters were as follows:

Application Information:		
Nominal Line Size:	3	inch
Fluid:	Water	
Temperature:	15	°C
Pressure:	5	barG
Density:	999.387	kg/m^3
Viscosity:	1.059	cP
Flowrate:	1145	LPM

Meter Sizing

Each differential pressure meter was sized according to standard specifications from McCrometer, Miller[1] and ISO 5167 [2]. The following chart shows specifics for each differential pressure meter:

	V-Cone	Orifice	Nozzle	Venturi
Beta ratio:	0.85	0.75	0.7	0.699
Max. DP (kPa):	12.3	45.8	24.6	24.6
Cf (Cd):	0.754	0.6	0.99	0.995

The V-Cone has a recommended differential pressure (12.3 kPa) that is half what is recommended for all other differential pressure meters (24.6 kPa).

The orifice was sized with the largest suggested beta ratio to keep the differential pressure as low as possible. At the largest beta ratio, the differential pressure created exceeded the recommended by almost twice.

All other meters were selected according to line size alone. Standard meter specifications were used for the turbine and vortex. Other specific meters were selected based on manufacturer's recommendations and the following model numbers were used:

Foxboro Coriolis	I/A Series
Foxboro Vortex	E83
MicroMotion Coriolis	CMF300M

In all cases the line size remained 3" diameter nominal.

Results

By comparing permanent pressure loss for a given application, an accurate comparison can be drawn between metering technologies. See figure 3 for a graphical representation of permanent pressure loss through these meters over a 10:1 flow turndown. See figure 4 for a graph of maximum loss through each meter at maximum flowrate. MicroMotion data appears only in figure 4 due to lack of turndown information from the manufacturer.

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To summarize, the meters ranked in the following order according to permanent pressure loss:

1. Venturi with 7° exit angle
2. V-Cone
3. Venturi with 15° exit angle
4. Flow Nozzle
5. Vortex
6. Turbine
7. Foxboro Vortex
8. Orifice Plate
9. MicroMotion Coriolis
10. Foxboro Coriolis

Further Results

A similar comparison was completed on a 2″ line size to compare the effect of line size under generally similar conditions. The ranking changed slightly:

1. Venturi with 7° exit angle
2. V-Cone
3. Venturi with 15° exit angle
4. Flow Nozzle
5. Vortex
6. Turbine
7. Foxboro Vortex
8. Orifice Plate
9. Foxboro Coriolis
10. MicroMotion Coriolis

See figures 5 and 6 for graphical comparisons.

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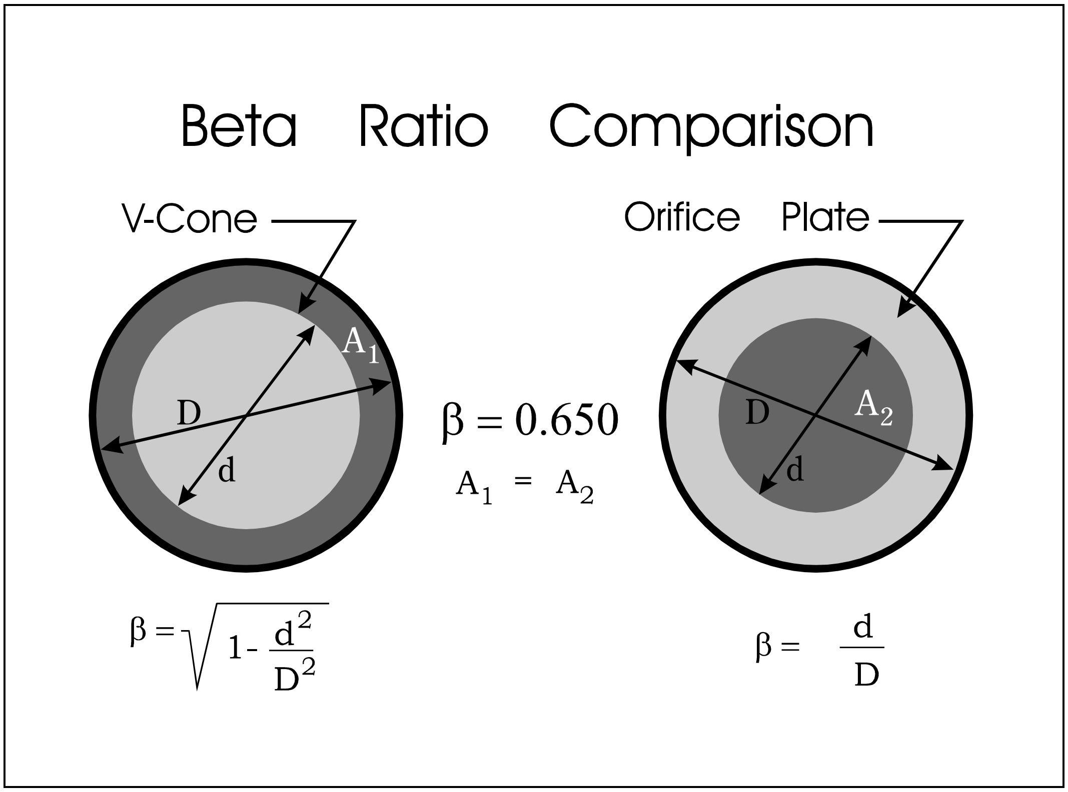

Figure 1

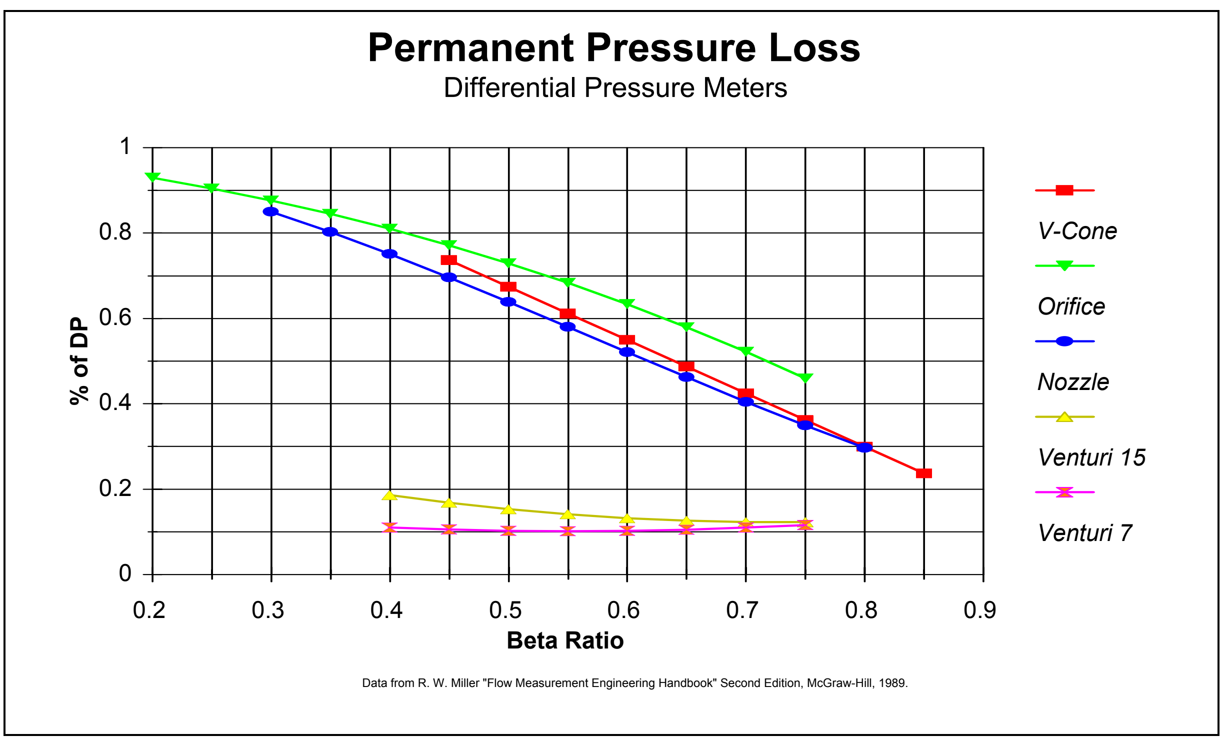

Figure 2

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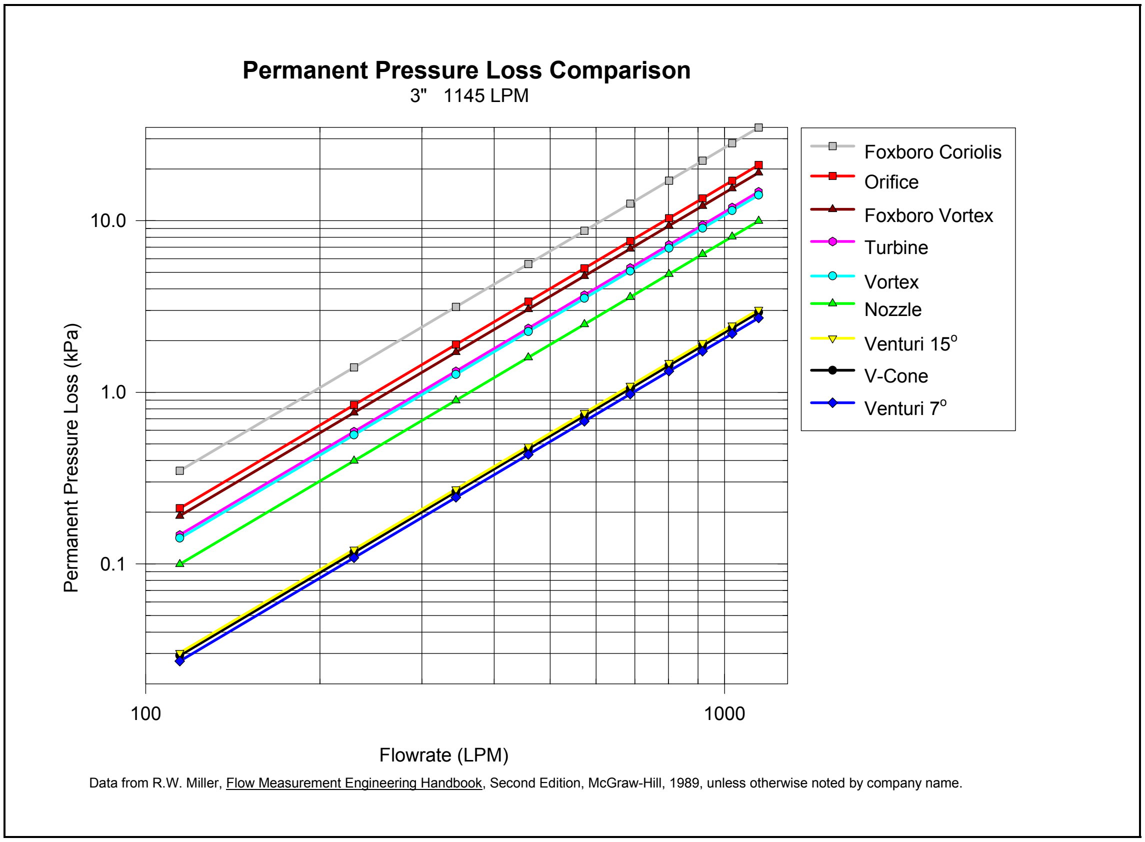

Figure 3

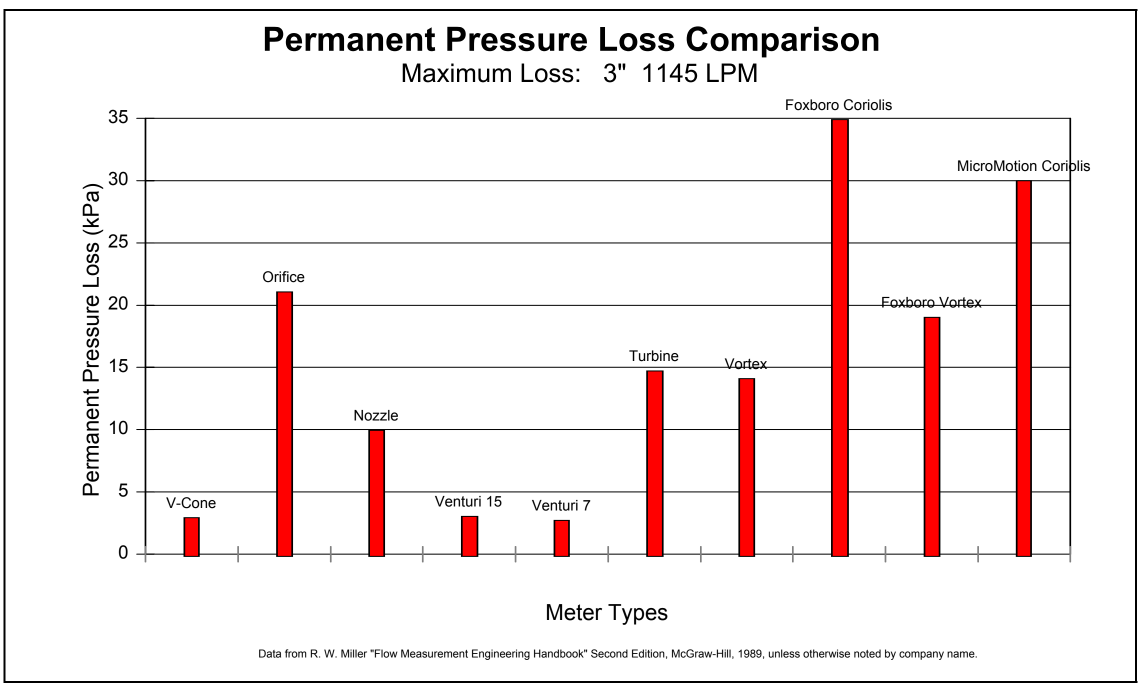

Figure 4

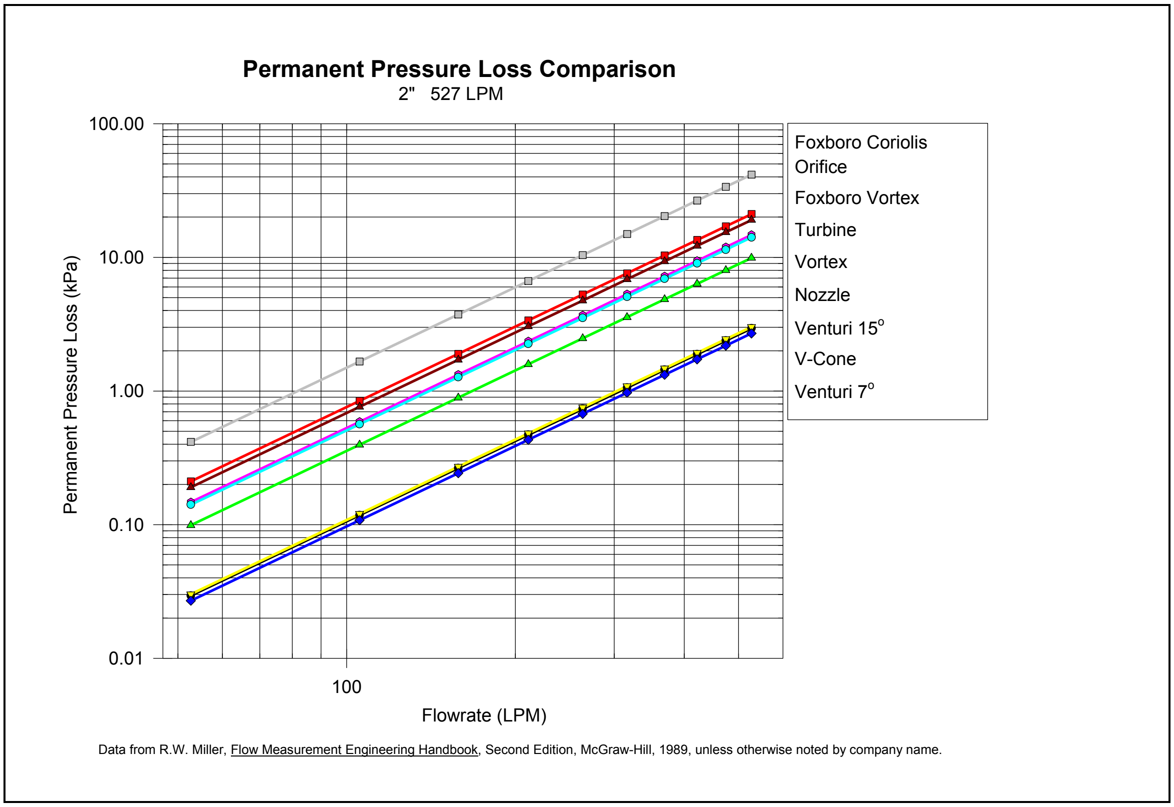

Figure 5

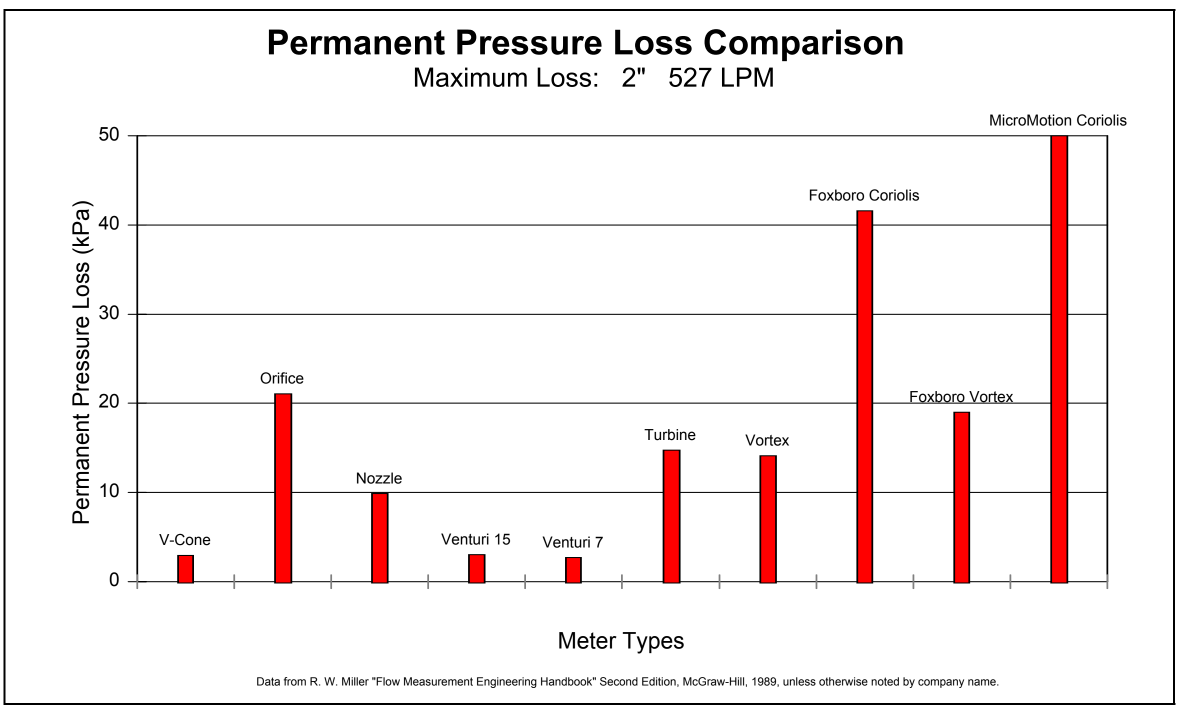

Figure 6

References

1. Miller, R. W., Flow Measurement Engineering Handbook, Second Edition, McGraw-Hill, 1989.

2. International Standard ISO 5167, "Measurement of fluid flow by means of orifice plates, nozzles and venturi tubes inserted in circular cross-section conduits running full.", Ref. No. ISO-5167-1980 (E).

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