The Benefits of a Venturi Meter

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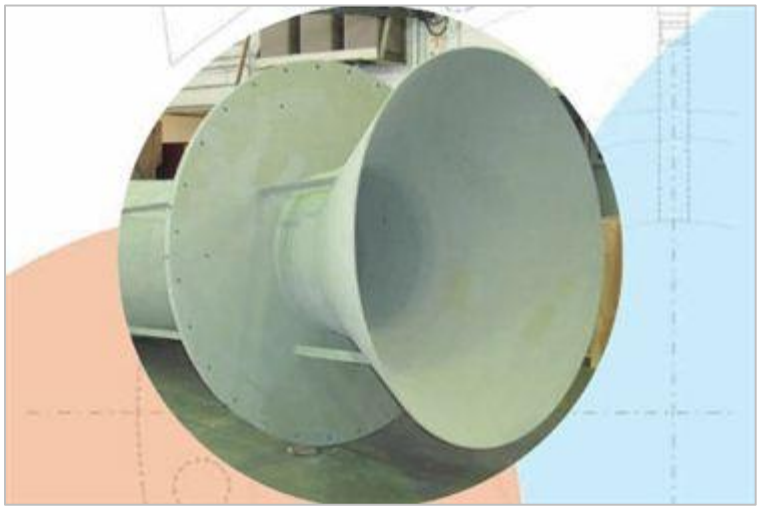

Primary Flow Signal is a global leader in municipal water and wastewater flow measurement.

With the introduction of new measurement technologies and the myriad of performance claims from sale literature, it's easy to lose sight of the important elements that an effective flow meter offers no matter what technology is used. Long known for their longevity, reliability, and long term performance, Venturi meters provide the widest variety of measurement options in piped systems for liquids, gas, steam, and mixed media of any metering technology – all while offering the highest degree of traceable accuracy.

Venturi meters are a versatile solution in that their laying length can be changed to fit a defined space; they can be modified to provide rate of flow control or measure sewage; they can be used reliably for billing or custody transfer; and they can be used for rectangular or circular metering. In addition, Venturi meters can be oriented in any plane and can measure accurately whether the line fluid is flowing upwards or downwards. To this end, Venturi meters are not subject to downstream piping effects and, with specially designed modified short form type Venturi meters, very short upstream straight pipe is required.

It is also important to note that most major independent laboratory flow calibration facilities around the world use Venturi meters as their primary standard. In addition, pump and blower manufacturers also use Venturi meters and other differential type devices as efficiency testing standards. Venturi meters have no moving parts, and can function reliably and accurately for decades, with some examples in service for more than 100 years. To this end, Venturis would render other devices ineffective.

However, it's important to note that as accurate and reliable as these meters are, there are still some limitations. Typically, the energy loss through a Venturi meter is between 0.10 to 0.25 psig. In addition, Venturi meters do consume energy but, unlike other devices, the recovery cone design of the modified short form type meters recovers a significant portion of the consumed energy. There are no intrinsic design limitations on either temperature or pressure of a proposed application or line size, which allows these meters to be effective in a variety of applications without the susceptibility of excess headloss when providing measurements. In addition, wide range flow measurement can be accurately accomplished by using multiple Differential Pressure (DP) transmitters, each calibrated for a certain flow rate range. Range of 50 or 100 to 1 on flow can be easily and accurately handled with the proper secondary instrument system. The Classical Venturi designs have also been characterized by relatively long laying lengths, and, therefore, they have generally been relatively expensive to manufacture compared to other known flow metering devices.

Designs

One of the significant benefits of the Venturi meter is that the design can be modified to fit almost any requirement, and it can be constructed with a broad range of materials depending upon application and the matter that will be measured. The actual Venturi meter design has not remained static over the last century, and there are two versions in particular that have made significant impacts on Venturi metering – the Modified Short Form Venturi meter and the Insert Venturi meter.

Modified Short Form Venturi Meters

Unlike the ASME and ISO codes for Classical Venturis, the Modified Short Form Venturi meter design was developed and patented by Dezsoe Halmi. His goal was to develop a venturi meter which was more accurate, had lower headloss, required no downstream and short upstream straight pipe and had a much smaller footprint thus was less expensive. In its patented form, the Modified Short Form Venturi eliminated a number of features that were disadvantageous, such as "annular pressure chambers" and excessively long component sections; thus improving the life expectancy of the meter and lowering its cost and headloss, while improving its basic accuracy. These improvements, and many more made since the mid-1960s, are the result of continual design refinements by top manufacturers who methodically applied knowledge and careful testing processes to even the most minute change.

The Modified Short Form Venturi is governed by an "interactive" code, which means that the designer/manufacturer is free to make modifications to the basic hydraulic shape of the meter as long as appropriate testing and documentation is provided to support all claims.

Interactive codes foster performance evolution because they provide a basic structure and design from which creative engineering minds can contemplate then execute beneficial changes. Once the hydraulic shape of the Venturi meter has been defined, it must be thoroughly tested to determine its:

- Discharge coefficient value
- Shape of the coefficient as defined by its relationship to pipe Reynolds number
- Installation sensitivity based on testing “typical” disturbers for both upstream and downstream conditions
- Tap location sensitivity
- Headloss across the profile
- Accuracy and repeatability
- Applicability for liquids, gasses, slurries, sludge, mixed media and varying viscosities

  must be determine and proven

Modified Short Form Venturi meters are inherently more tolerant of upstream conditions, including asymmetric flow patterns, because they are shorter than the other Classical Venturi design, which features substantially straight and elongated structures. Due to the overall shorter laying length, these meters have intersecting angles that are much greater and the discharge end of the recovery cone does not end in the full downstream pipe line size, but rather, is truncated, while the flange is designed to mate directly to the downstream pipe flange. This means that there are no downstream straight pipe requirements for standard accuracy, the meters have lower headloss, are less susceptible to blockages and plugging, and are extremely accurate, which can be field verified.

The design of the Modified Short Form Venturi can be constructed with reduced manufacturing costs for the manufacturer. It also places a lower burden on the physical formation of the installation since piping configurations pose less problems for accuracy, energy loss, and potential for blockage.

Insert Venturi Meters

Another useful addition to the world of Venturi metering is the Insert Venturi meter. This design is similar to the shape of a true, Classical Venturi, but the profile is entirely inside the pipeline, aside for the thickness of the center flange. This type of meter is similar in its installation, to that of an orifice plate as it’s inserted rather than placed between to piping unions.

But the benefit of this design is that it utilizes a static low pressure throat tap. Unlike a “true Venturi meter” its high pressure sensation comes from a corner location on the inlet side of the center flange. In order to claim that a tap senses “true static pressure”, the tap must sense pressure perpendicular to the axis of the flowing line fluid. The Classic and Modified Short Form Venturi meters do that very successfully in the flanged design, but without an upstream section available to locate the high pressure tap, the Insert Venturi meters must handle the flow directly or “head on” at the high pressure tap location.

While this makes the Insert Venturi meter more sensitive to the effects of upstream non-straight piping, the basic accuracy of these meters is identical to the flanged design at +/-0.50% of the actual rate of flow. However, the Insert

Venturi meter design with a static high pressure tap off of the center flange and into the upstream spool piece has the same installation insensitivity as the traditional flanged, full body Venturi design at the proper static pressure sensing location.

Calibration

When it comes to obtaining accurate meter readings, Venturi meters are designed to a single flow metering shape equation that secures a flow metering mechanism. Although performing an internal inspection/measurement may be required to verify effectiveness, if a Venturi meter's internal dimensions and surface conditions have not changed, its reading will stay the same. The metering mechanism is a design that provides a discharge coefficient without impacting line size, Beta ratio, or Reynolds numbers above a manufacturers or code stated minimum.

Most other types of meters – particularly electronic meters – cannot be field calibrated properly. Venturi meters can be field inspected and, assuming no change to the critical cross sections, the DP transmitter can be accurately calibrated to the signal produced by the Venturi meter. With proper material selection, the risk of internal corrosion or scaling is low, and the ability to inexpensively field rehabilitate any Venturi meter is widely available thus making the use of Venturi meters a step towards sustainable technology since they last much longer than any of the electronic type meters on the market today, even in harsh environments.

Venturi meters are designed to provide an accurate and repeatable differential pressure signal based on a defined internal profile, surface finish, and tolerance program. A significant advantage of the Venturi meter technology is that each given design has its own discharge coefficient that is determined by building a number of line and throat size meters of that design, and submitting them to independent flow calibrations by third-party experts. Assuming the laboratory calibrations prove that the discharge coefficient is independent of line size and throat size, as it should if the basic design is appropriately engineered and manufactured, the laws of hydraulic similitude eliminate the need to calibrate every meter and also allow the use of a Venturi meter for lines that are too large to lab calibrate. In addition, unless there is a change to the internal geometry of the Venturi meter, the discharge coefficient will not change.

Conclusion

Despite their rich history and proven track record, Venturi meters have faced stiff competition from electronic measurement devices, which have neither the versatility nor the verifiable accuracy of a Venturi. With continual improvements over the years, Venturi meters – including the Modified Short Form Venturi and Insert Venturi – have proven to be adaptable to virtually any installation or application without the drawbacks of piping configurations or flow conditions.

The benefits of Venturi meters are indisputable, as is the fact that they serve as the standard measurement device in the world's preeminent flow measurement labs, calibration facilities, and research centers.

About the Author: Bruce Briggs is the president and principal of Primary Flow Signal Inc., a global manufacturing, engineering and technology resource focusing on highly accurate, repeatable and reliable differential flow meters. In his more than 30 years in the industry, Mr. Briggs has built, arguably, the largest team of expert flow metering, hydraulic and applications engineers, along with technicians and specialists of diverse critical expertise. The companies are comprised of a number of enterprise-owned, fully integrated manufacturing facilities offering a world-

class platform for solutions and support for the oil and gas, power, municipal water, wastewater and automotive markets.