WHITE PAPER

New Breakthrough in Differential Pressure Flow Measurement

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Overview:

The difficulties arising in flow measurement are numerous: non-homogeneous processes, abrasive materials, wide pressure variations, etc. The TORUS Wedge Primary Flow Element sets the stage for revolutionizing modern flow measurement of liquids, gases, slurries, steam, etc., by combining the best attributes of various proven technologies into a single device to address these issues.

PRINCIPAL OF OPERATION:

The relationship of differential pressure to flow rate is expressed by the following equation:

$q_m = \frac{KCdY_d^2}{\sqrt{1-\beta^4}}\sqrt{\rho \Delta P}$ Where:

q_m = Mass flow rate constant
K = Unit Conversion C
C_d = Discharge Coefficient
Y = Expansion Factor
d = Diameter of min. flow area
β = Diameter/area Ratio
ρ = Density of Flowing Fluid Pressure
ΔP = Differential

An obstruction or constriction in the flow stream will create a differential pressure that will conform to the above equation. A differential pressure transmitter relays pressure from the meter to a flow computer, which calculates a volumetric flow rate. A few well-known differential pressure flow devices include: orifice plates, venturis, wedge meters, and pitot tubes.

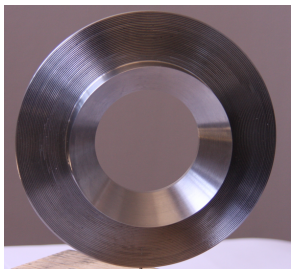
EFFICIENCY:

As the Colorado Engineering Experimental Station, Inc. (CEESI) Report concluded, the TORUS Wedge allows fluids to pass through more efficiently than an orifice plate, which means the end user needs less horsepower (money) to pump the process downstream.

AVAILABLE CONFIGURATIONS:

The TORUS Wedge can be mounted directly between two flanges, or within a body (wafer-style). Remote seals can be added to insulate the process from the transmitter.

COMPARISON TO CONCENTRIC SHARP EDGE FLANGE TAPPED ORIFICE PLATES



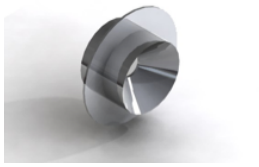
TORUSWEDGE

Nominal Line Size	Nominal Beta Ratio	Pipe Reynolds Number Range	Average C_d	Linearity %	Average Efficiency
2-Inch	0.3	53,920-564,700	0.8842	1.6258	0.7818
2-Inch	0.5	95,920-1,010,000	0.9035	1.5174	0.8165
3-Inch	0.3	84,130-838,400	0.8238	3.2558	0.6789
3-Inch	0.5	420,200-2,303,000	0.8151	4.2533	0.6651
4-Inch	0.3	106,600-1,178,000	0.8005	7.9086	0.6418

Orifice Plate

Nominal Line Size	Nominal Beta Ratio	Pipe Reynolds Number Range	Average C_d	Linearity %	Average Efficiency
2-Inch	0.3	53,920-564,700	0.5981	0.1415	0.3577
2-Inch	0.5	95,920-1,010,000	0.6036	0.2597	0.3643
3-Inch	0.3	84,130-838,400	0.5982	0.1044	0.3579
3-Inch	0.5	420,200-2,303,000	0.603	0.1015	0.3637
4-Inch	0.3	106,600-1,178,000	0.5983	0.0912	0.358

COMPARISON TO OTHER PRIMARY DEVICES:



	Torus Wedge	Orifice Plate	Turbine Meter	Coriolis Meter	Venturi	Wedge Meter
Bidirectional	Yes	No	No	Yes	No	Yes
Moving Parts	No	No	Yes	No	No	No
Self-Cleaning	Yes	No	No	No	No	Yes
Highly Durable	Yes	No	No	No	No	Yes
Non-Homogeneous Process	Yes	No	No	No	No	Yes

Field Testing – Durability:

Everyone knows of products that looked great on paper but fell apart quickly in the field. The TORUS Wedge has proven itself to be an extremely durable primary flow element for measuring drilling mud, sand, acid, gas, and various petroleum products. The reason for the unit's durability lies in the circumferential ramp. As the process encounters the ramp, it is merged gradually into the orifice, and discharged along the downstream ramp. This ensures that the process never impacts a sharp, hard edge; thus, there is a minimum of wear. Another benefit of the circumferential ramp is its self-cleaning nature. Both turbine meters and orifice plates can build a coating of grease or oil, leading to loss of measurement accuracy. Figure 1 to the left shows a TORUS Wedge after thirty-one days of use in ten-pound drilling mud. Close examination shows original machining grooves remain on the unit.

LONG TERM. OPERATIONAL COST SAVINGS:

With labor and materials costs escalating yearly, operators are looking for new tools to increase profitability. Field personnel can easily check or replace any TORUS Wedge unit since its simple design allows it to fit between standard pipe flanges and the unit will not bow or distort. The TORUS Wedge is bi-directional so field personnel cannot install the unit backwards.

FEATURES:

- Four model designs for any application and retrofit requirement
- Ideal for ***gas, liquids, multi-phase, slurries, high viscous, saturated or superheated steam, drilling fluids, corrosive, toxic, and sanitary flow streams***
- Process flow parameters include laminar, turbulent and high viscous fluids with Reynolds Number (Re) of 500 and greater
- Bi-directional flow is standard and can be installed in any orientation
- Complies with API 22.2 testing by recognized third party flow laboratory
- Available to meet any competitive dimensional standard or customized dimension for easy field replacements

- Available with chemical seals for corrosive, toxic or other fluids requiring a positive barrier to the ∂P measurement device
- Wide range of sizes, end connections and pressure taps
- Available in a wide variety of materials
- Turndown ratio is greater than 15.1, with TORUS wedge elements available in a (ß) beta ratio from 0.100 to 0.900 as standard
- Less than 1% of reading error without calibration; less than 1/2% error with gas or water calibration
- Repeatability of ±0.20%
- 5-year standard warranty

BENEFITS:

- No filters, strainers or upstream cleaning devices required
- No moving parts, no critical surfaces to maintain or inspect
- Meter alignment issues are non-existent
- Not affected by erosion due to entrained particles in the flow stream. It can be coated with an erosion resistant surfacing without effecting accuracy
- Not subject to bending or axial distortion due to high flow velocities
- No upstream flow conditioners required (but suggested) for general flow accuracy and the highest degree of measurement accuracy. (Upstream lengths can be manufactured completely integral to meter upon request.)

THIRD PARTY EVALUATION:

Testing conducted by CEESI comparing two-, three-, and four-inch TORUS Wedge to same-size orifice plates concluded that, "…the TORUS Wedge element shows much higher discharge coefficients and efficiencies. Higher discharge coefficients and efficiencies are expected as the design of the element allows the fluid to pass through while expending less energy."

IMPOSSIBLE MEASUREMENT MADE POSSIBLE

If you can't measure it, you can't manage it

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