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Physics Instrumentation

INVESTIGATION OF BETH-FLO GENTILE FLOW TUBE

AUTHORS:

P. E. Tausche, Leader
C. C. Williams
R. N. Saleeby

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P. E. Tausche, Leader, C. C. Williams
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Engineering Practice School

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A B S T R A C T

Tests were made to determine the straight run limitations of the Beth-Flo Gentile Flow Tube. The effect of surface roughness on tube performance was also investigated. The permanent head loss of the tube was determined.

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I. SUMMARY

This report covers work done from February 28 to March 12, 1949.

In view of the fact that the Beth-Flo Gentile Flow Tube, a new flow-metering device (Fig. 1), is claimed to have no straight run limitations, negligible resistance to flow, and greater pressure differential than orifices and Venturi tubes of similar pipe to throat diameter ratio, it was considered of interest to investigate the performance of such a flow tube.

The straight run flow characteristics of the Gentile tube were determined. Using these data as a basis for comparison, the deviations in accuracy caused by the following flow disturbances were determined.

- (1) Valves and elbows placed at various distances upstream from the flow tube.
- (2) Simulated scale corrosion of the tube surfaces.
- (3) Simulated welding beads. (Internal beads resulting from welding the tube into a pipeline).

The permanent head loss of the tube was ascertained. In addition the pressure differential indicated by the Gentile tube was compared with that of an orifice. All investigations were conducted over a Reynolds number range of 10^4 to 10^5 . This fact places a limitation on the results.

From the experimental data, it was concluded that a Gentile tube of 2 in. o.d. and 29/32 in. throat diameter should be placed 5 diameters downstream from a 90° elbow and 10 diameters downstream from a globe valve, if recalibration is to be avoided by maintaining deviations from straight run accuracy within 3%. Furthermore, the flow tube cannot be used for metering gases which roughen its surfaces, nor is it advisable to weld it into the pipeline without recalibration. The permanent head loss is 60 to 75 % for pressure differentials up to 10 in. of water. The Gentile tube measures a differential head only 40% as great as that of an orifice of corresponding pipe to throat diameter ratio.

II. INTRODUCTION

A recent development in flow measurement which is of interest to the K-25 plant is the Beth-Flo Gentile (Gentilly) Flow Tube. Made by the Bethlehem Foundry and Machine Company (Bethlehem, Pa.), the flow tube consists of a constricted section at the throat of which are located six recessed ports (Fig. 1), three pointing upstream and three downstream. Each group of three is connected to a piezometer ring from which the pressure is transmitted to a differential manometer. This flow tube is claimed by the manufacturer to have the following advantages over orifices, flow nozzles, and Venturi tubes (1):

- (1) No straight run limitations.
- (2) A greater pressure differential for a given rate of flow and thus greater range and accuracy.
- (3) Less permanent head loss.
- (4) Ease of adaptability to compressible flow.
- (5) Measurement of flow in either direction due to symmetry of design.

The combination of these unusual characteristics in a single flow tube constitutes a considerable improvement in flow-metering technique. It therefore becomes advisable to study the properties of the Gentile tube.

The purpose of this investigation is to determine the straight-run performance characteristics of the Gentile tube and to compare with these the characteristics obtained under unusual conditions of flow. It is of special interest to evaluate quantitatively the effect of placing a valve and an elbow at various distances upstream from the tube, together with changes in the tube characteristics caused by surface roughness (simulated scale corrosion) within the tube itself.

III. PROCEDURE

The apparatus used in the investigation of the Gentile tube is shown in Fig. 2. A rotameter calibrated for air at 14.7 psia and 70 F was employed to measure the flow. By manually setting the throttle valve and the pressure controlled valve, both the static pressure and the flow of air through the system were controlled. A surge tank was provided in order to reduce pressure fluctuations of the 110 psig plant air (dry) used as a source.

In order to establish the performance of the flow tube under straight run flow conditions, an initial "base condition" run was made with a straight run of pipe extending 36 diameters upstream and 12 diameters downstream from the tube. Several related sets of runs were then made. Dimension A was successively reduced from 36 diameters to 1 diameter in order to ascertain the effect on performance of a valve upstream from the flow tube. Then a 90° elbow was inserted in the line between the upstream control valve and the Gentile tube, and the procedure was repeated. The position of the Gentile ports relative to the plane of the elbow was also varied. The effect of downstream disturbances was noted by making a run with dimension B 1 diameter keeping A 36 diameters. Scale corrosion was simulated by setting No. 20 Norbrite abrasive into wet shellac painted on the inside of the tube. Gaskets projecting 1/16 in. into the flow path were inserted on each side of the tube to approximate the effect of welding beads which could occur on the inside of the pipe if the Gentile tube were welded into the line.

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GENTILE FLOW TUBE
2" DIAM. TYPE "VD"

DATE 3-12-49	DRAWN BY P.E.T.	FILE NO. EPS-K32	FIG. 1
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500-17

The pressure differential across the tube was multiplied by a Taylor DBM. The maximum pressure differential which could be measured by this DBM was 10 in. of water. This was magnified to 25 psi and read on a manometer. A similar arrangement was used to measure the static pressure in the Gentile tube.

During each run, the flow was increased in small increments while the static pressure was maintained constant at 5 psig. At each point the static pressure and pressure differential were read on the manometers, and the rate of flow observed on the rotameter. The temperature of the air leaving the rotameter was also recorded, as was the barometric pressure. As a check on any hysteresis in the pressure transmitters, readings were taken as the flow was decreased from its maximum value.

During the "base condition" run, static pressure taps were inserted in the line 2.5 diameters upstream and 8 diameters downstream from the flow tube in order to measure the permanent head loss of the metering device.

Only one Gentile tube, 2 in. i. d., 29/32 in. throat diameter, was thoroughly tested. In addition, a Gentile tube of similar design, 2 in. i. d., 1.125 in. throat diameter, was submitted to a "base condition" run.

IV. RESULTS

The principal quantitative results of this investigation are shown in Fig. 3 through Fig. 7. The Gentile tube coefficient, C , is defined by the equation

$$q_H = C A (2 g_c H)^{0.450}$$

and is analogous to the orifice coefficient, C_o (See Discussion of Results). In addition to the above results, the following were also obtained from this investigation:

1. Varying the position of the Gentile tube relative to the plane of the elbow does not affect the value of C .
2. The Gentile tube gives approximately 40% of the pressure differential given by an orifice of corresponding throat to pipe diameter ratio.

V. DISCUSSION OF RESULTS

The experimental data from which the Gentile tube coefficient, C , and the Reynolds number, Re , were calculated have a precision of 3% and an accuracy of 10% at low flow rates. The accuracy improves to 0.5% at high flow rates. The flow rate of air through the system as read on the rotameter was used in the calculation of both these values. The rotameter could not be read any closer than 0.4 cfm, thus introducing a maximum error in C and Re of 3% for low flow and 0.6% for maximum flow. Since the rotameter accuracy was

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GENTILE TEST APPARATUS

DATE 3 12-49	DRAWN BY C.C.W.	FILE NO. EPS-K 32	FIG. 2
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EFFECT OF AN ELBOW ON A
2 IN. TO 29/32 IN. GENTILE TUBE

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500-10

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EFFECT OF A REDUCING VALVE ON A
2 IN. TO 29/32 IN. GENTILE TUBE

DATE 3-12-49	DRAWN BY PET	FILE NO. EPS-K32	FIG. 4
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MISCELLANEOUS EFFECTS ON A
2 IN. TO 29/32 IN. GENTILE TUBE

DATE 3-12-49	DRAWN BY PET	FILE NO. EPS-K32	FIG. 5
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PERCENT DEVIATION IN TUBE COEFFICIENT "C"

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PERCENT DEVIATIONS IN "C"
FOR A
2 IN. TO 29/32 IN. GENTILE TUBE

DATE 3-12-49	DRAWN BY PET	FILE NO. EPS-K32	FIG. 6
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PERMANENT HEAD LOSS IN A 2 IN.
TO 29/32 IN. GENTILE FLOW TUBE

DATE 3-12-49	DRAWN BY C.C.W.	FILE NO. EPS-K32	FIG. 7
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BASE CONDITION CHARACTERISTICS			
OF TWO GENTILE FLOW TUBES			
DATE	DRAWN BY	FILE NO.	FIG.
3-12-49	R.N.S.	EPS-K32	8

500-15

claimed by the manufacturer to be 2% of full scale reading, calibration of the instrument was unjustified in the light of the magnitude of such scale reading errors. In addition, there were two sources of error in the manometer readings. The mercury column fluctuated as much as 0.1 units (readings ranged from 3.5 to 25), creating an uncertainty of approximately 5% in the lower pressure differentials. Although the Taylor DBM pressure transmitters showed no marked hysteresis between ascending and descending readings, the zero reading on the manometer was not exactly reproducible. In one particular run, the initial value was 3.01 and the final value was 3.09. Although the initial zero reading was used in all calculations, a difference of 0.08 would reflect an error of 11% in the values of C for low Reynolds numbers, but only 0.5% for high values of Re . Thus the accuracies of C and Re increase with increasing flow. The precision of the investigation is best demonstrated by noticing the scatter of points on the C vs. Re curves. Precision in all cases is better than 3%.

The following development is given by the manufacturer concerning the operation of the Gentile tube. Calling the static head S and the velocity head $v^2 / 2 g_c$:

$$\text{Total head on upstream ports} = S + k_1 (v^2 / 2 g_c)$$

$$\text{Total head on downstream ports} = S - k_2 (v^2 / 2 g_c)$$

$$\begin{aligned} \text{Differential head on meter} = H &= S + k_1 (v^2 / 2 g_c) - S + k_2 (v^2 / 2 g_c) \\ &= K (v^2 / 2 g_c) \end{aligned}$$

or

$$v \propto H^{0.50}$$

On the basis of the data obtained in this investigation, the exponent of H is not 0.50 as predicted but approximately 0.45. The H vs. rotameter reading data for the "base condition" run (no flow disturbances upstream or downstream from the flow tube) formed a straight line on log-log paper having a slope of 0.450 (Fig. 8). The data of all runs were plotted in this manner, and the slopes ranged from 0.444 to 0.487 for the 2 in. to 29/32 in. Gentile tube (Appendix). In order to correlate the data of all the runs with that of the "base condition" run, however, the exponent 0.450 was used in all calculations. The equation used to calculate C was

$$C = \frac{q_H}{A (2 g_c H)^{0.450}}$$

where q_H = volumetric flow rate through the tube throat, in cfs.

A = throat area, in sq. ft.

g_c = dimensional constant, 32.2.

H = pressure differential across the flow tube, in feet of fluid flowing.

The fact that a straight line plot was obtained for the "base condition" run on log-log paper should indicate that C for this run is not a function of the Reynolds number over the Re range investigated (10^4 to 10^5). The choice of an expanded scale, however, combined with any possible inaccuracy in the exponent of H gave a slight curvature to the "base condition" curves shown in Fig. 3 through Fig. 5. Due to the choice of 0.450 as the exponent in all calculations, the other C vs. Re curves are displaced upward or downward from the "base condition" curve. In cases where the deviation in the exponent from 0.450 is marked, a definite curvature is noticeable which is either concave upward or downward depending upon whether the exponent is larger or smaller than 0.450.

It should be noted that the values of C for the corrosion and welding bead runs are greater than those for the "base condition" run. It might be that such surface disturbances reduce the velocity of the air impinging upon the ports, thus requiring a greater factor to be incorporated into C to correct the instantaneous velocity at the ports to average velocity of the stream. The fact that the C vs. Re curve for the welding bead run exhibits a maximum is anomalous. No explanation for this fact is evident.

In addition to the runs with the 2 in. to 29/32 in. tube, one "base condition" run was made with a 2 in. to 1 1/8 in. Gentile tube. No explanation is apparent for the fact that a slight curvature was obtained in the log-log plot of H vs. rotameter reading. In this connection, it is recommended that further investigation be made into the variation of the exponent with throat to pipe diameter ratio for different tubes.

The curves of percent deviation in C vs. Re show the limitations on the use of the Gentile tube as a flow metering device. Over the Re range investigated, the Gentile tube can be used with a 90° elbow 5 diameters upstream without introducing a deviation from straight-run accuracy of over 3%. A 4% deviation is incurred if the flow tube is placed immediately (1 diameter) downstream from the elbow. On the other hand, the influence of a control or reducing valve of the globe type on the accuracy of the Gentile tube is great. A reducing valve placed 10 diameters upstream from the tube introduces an average 3% deviation from straight-run accuracy in the flow rate. By way of comparison, an orifice of similar throat to pipe diameter ratio must be placed at least 6 diameters downstream from an elbow and 24 diameters downstream from a globe valve. Although downstream flow disturbances caused by a throttling valve have negligible effect on the performance of the flow tube, the effect of simulated scale corrosion is so great that it cannot safely be used to meter gases which roughen the internal surfaces of the tube. Since welding beads would probably have a considerable effect (predicted by the simulated welding bead run), it is inadvisable to weld the Gentile tube into a pipeline if an internal bead is to result.

The manufacturer claims that for the same pipe to throat diameter ratios, the Gentile tube provides a differential pressure reading greater than the orifice or Venturi meter. This was not found to be true. The pressure differential which would have been measured by a sharp-edged orifice had it been installed in the line was calculated by means of the orifice compressible flow equation (Appendix). For a flow rate of 59.5 cfm, the orifice meter would have read 20.9 in. of water, while the Gentile tube actually measured only 8.74 in. of water.

The manufacturer also claims that the Gentile tube offers negligible resistance to flow. The experimental data of this investigation, however, show that the permanent head loss for the Gentile tube is 60 to 75% as compared to 75% for an orifice of equivalent diameter ratio (Fig. 7). Venturi tubes normally have a permanent head loss of 10 to 20%.

On the other hand, a great advantage of the Gentile tube is its ease of adaptability to compressible flow. Since both the upstream and downstream ports are built into the same cross section, all pressure readings are taken at the same section of the flow path, and hence the usual corrections for internal energy change drop out of the flow formula. Therefore the compressible flow formula for the Gentile tube is identical with the incompressible flow formula.

The Brooklyn Polytechnic Institute reports the value of C as 1.19, constant with Re over the range 10^4 to 10^5 , for the 2 in. 29/32 in. Gentile tube. From the data of this investigation, the value of C is 1.64, but this was calculated on the basis of a 0.450 exponent for H . Recalculated using a 0.50 exponent, the values of C vary with increasing Re from 1.15 to 0.99 for the "base condition" run. These data do not correlate with the constant value of 1.19 obtained by B. P. I.

It should be noted that the Reynolds number range of 10^4 to 10^5 studied in this investigation was very narrow. Furthermore, this marks the extreme upper part of the transition region between laminar and fully developed turbulent flow, where peculiar flow patterns are likely to be encountered (4). The equipment available did not permit investigation of a wider range of Reynolds numbers.

VI. CONCLUSIONS AND RECOMMENDATIONS

The following may be concluded concerning the performance of a 2 in. to 29/32 in. Gentile tube:

- (1) The flow tube must be placed at least 5 diameters downstream from a 90° elbow and 10 diameters downstream from a globe valve in order to maintain deviations from normal accuracy within 3%. The relative position of the upstream ports and the plane of the elbow is unimportant.
- (2) The fraction of head permanently lost is 60 to 75% depending upon flow rate.
- (3) The Gentile tube cannot be used to meter gases which roughen its surfaces.
- (4) The pressure differential registered on a Gentile tube is only 40% of that obtained with an orifice of similar throat to pipe diameter ratio.

In order to expand the data obtained in this investigation, it is recommended that the effect of throat to pipe diameter ratio on the flow-metering characteristics of the Gentile tube be evaluated. A wider range of Reynolds numbers should also be investigated.

VII. APPENDIX

A. Table of Exponents for a 2 in. to 29/32 in.

Gentile Flow Tube

	Run Number	Conditions	Exponent
Elbow Effects	1	Base Conditions A - 36 diam B - 12 diam	0.450
	9	A - 10 diam B - 12 diam	0.444
	8	A - 5 diam B - 12 diam	0.447
	7	A - 2.75 diam B - 12 diam	0.447
	5	A - 1 diam B - 12 diam Outside of elbow feeding directly into one of the Gentile inlet ports.	0.449
	6	A - 1 diam B - 12 diam Outside of elbow feeding directly between two of the Gentile inlet ports.	0.450

	Run Number	Conditions	Exponent
Control or Reducing Valve Effects	1	Base Conditions A - 36 diam B - 12 diam	0.450
	2	A - 10 diam B - 12 diam	0.462
	3	A - 5 diam B - 12 diam	0.453
	4	A - 1 diam B - 12 diam	0.457

	Run Number	Conditions	Exponent
Miscellaneous Effects	1	Base Conditions A - 36 diam B - 12 diam	0.450
	12	A - 36 diam B - 1 diam	0.454
	14	Simulated corrosion A - 36 diam B - 12 diam	0.487
	15	Simulated welded connection A - 36 diam B - 12 diam	0.447

B. Literature Citations

1. Advertising circular distributed by the Bethlehem Foundry and Machine Company, Bethlehem, Pa., on the Beth-Flow Gentile Flow Tube (1948).
2. Perry, J. H., "Chemical Engineers' Handbook", 2nd ed., section 6, New York, McGraw-Hill Book Co., Inc., 1941.
3. Peters, W. H., "Scale Corrosion in a Venturi Tube", Power, 79, 263 (1935).
4. Dodge, R. A., and Thompson, M. J., "Fluid Mechanics", 1st Edition, pp. 320-330, New York, McGraw-Hill Book Co., Inc. (1937).

C. Location of Original Data

The original data for this investigation are located in Notebook 1079, pages 9 - 14, Notebook 1077, pages 7 - 14, and Notebook 1075, pages 14 - 17.

D. Sample Calculations

Calculate P_H

P_H , the static pressure in the throat of the flow tube, is determined by the equation

$$P_H = \frac{(\text{manometer reading} - \text{zero reading})}{1.5} + P_L$$

P_L is the normal barometric pressure, and 1.5 is the calibration factor for the Taylor DBM used to amplify the static pressure. The units of P_H are psia.

Calculate F

F is a factor which corrects the rotameter reading to cfm of air at flow conditions in the rotameter. Using subscript "st" for standard (calibrated) conditions, and "L" for actual flow conditions in the rotameter, the rotameter correction equation is

$$q_L = \sqrt{\frac{(P_F - P_L)}{(P_F - P_{st})} \left(\frac{P_{st}}{P_L} \right)} q_{st}$$

Where P_F is the density of the rotameter float and q_{st} is the rotameter reading in cfm.

$$P_L = \frac{P_L}{RT} = \frac{14.7}{53.39 T} = \frac{2.705 P_L}{T}$$

The rotameter was calibrated for air at 14.7 psia and 70° F. P_{st} and P_L are negligible in comparison to P_F , and hence

$$\begin{aligned} q_L &= \sqrt{\left(\frac{14.7}{P_L} \right) \left(\frac{T}{530} \right)} q_{st} \\ &= \sqrt{0.0277 \frac{T}{P_L}} q_{st} \\ &= F q_{st} \end{aligned}$$

$$\text{where } F = \sqrt{0.0277 \frac{T}{P_L}}$$

T is in °R and P_L in psia. T is the air temperature in the rotameter.

Calculate C

$$\begin{aligned} q_H &= \left(\frac{P_L}{P_H} \right) \left(\frac{T_H}{T_L} \right) q_L \\ &\approx \left(\frac{P_L}{P_H} \right) q_L \end{aligned}$$

Where q_H is the flow rate in cfm at flow tube conditions and q_L is the flow rate at rotameter conditions. Substantially perfect Joule - Thompson expansion from 5 psig to atmospheric pressure is assumed, and therefore the temperature correction drops out.

$$C = \frac{q_H}{A (2gH)^{0.45}} \quad (\text{empirical exponent})$$

Where A is the cross-sectional area of the throat in square feet, and H is the head of fluid flowing in feet.

$$H = \frac{\Delta P}{\rho_H}$$

Where ΔP is the differential across the flow tube and ρ_H the density of air at flow tube conditions.

$$\begin{aligned} \Delta P &= \frac{(\text{manometer reading} - \text{zero reading})}{(2.5)(12)} \quad 62.4 \\ &= \frac{\Delta P_m (62.4)}{30} \quad \text{lb/ft}^2 \end{aligned}$$

2.5 is the calibration constant for the Taylor DBM used to amplify the pressure differential across the tube, and 62.4 converts ΔP from ft of water to lb/ft².

$$C = \frac{\left(\frac{\rho_L}{\rho_H}\right) \frac{F q_{st}}{60}}{\frac{\left[\frac{29}{32(12)}\right]^2}{4} \left[64.4 \left(\frac{\Delta P_m}{(2.5)(12)}\right) \left(\frac{62.4}{2.705 \rho_H}\right) \right]^{0.45}}$$

$$C = \frac{0.644 \rho_L F q_{st}}{(\rho_H)^{0.55} (\Delta P_m T)^{0.45}}$$

Where ΔP_m is the actual differential pressure reading minus the zero reading.

Calculate Re

$$\begin{aligned} Re &= \frac{D_v \rho}{\mu} \\ &= \left[\frac{29}{(32)(12)} \right] \left[\frac{\left(\frac{\rho_L}{\rho_H}\right) F q_{st}}{A 60} \right] \left[\frac{2.705 \rho_H}{0.000672 T \mu} \right] \\ &= \frac{1131 \rho_L F q_{st}}{\mu T} \end{aligned}$$

Where μ is in centipoises.

In order to make use of these equations, the following data are taken from the "base condition" run:

$$P_L = 14.42 \text{ psia}$$

$$P_H = 19.45 \text{ psia}$$

$$\Delta P_m = 9.80$$

$$q_{st} = 42.3 \text{ cfm}$$

$$T = 62.0 \text{ }^\circ\text{F}$$

$$\mu = 0.0182 \text{ centipoises}$$

$$F = \sqrt{0.0277 \left(\frac{522}{14.42} \right)} = 1.00$$

$$C = \frac{(0.644) (14.42) (1.00) (42.3)}{(19.45)^{0.55} [(9.80) (522)]^{0.45}}$$

$$= 1.65$$

$$Re = \frac{(1131) (14.42) (1.00) (42.3)}{(522) (0.0182)}$$

$$= 7.3 \times 10^4$$

Comparison of Pressure Differential

Taking the following data from the "base condition" run:

$$P_L = 14.35 \text{ psia } P_H = 19.35 \text{ psia.}$$

$$\Delta P_m = 21.83$$

$$q_{st} = 59.5 \text{ cfm}$$

$$T = 74.5 \text{ }^\circ\text{F}$$

$$K = \frac{C_P}{C_V} = 1.41 \text{ for air}$$

$$D/D_o \text{ for Gentile tube} = \frac{29}{(32) (2.067)} = 0.438$$

$$\text{For an orifice of similar } D/D_o, C_o = 0.63$$

$$\text{Area of throat} = A_2 = 0.00448 \text{ ft}^2$$

$$\text{Area of pipe} = A_1 = 0.0233 \text{ ft}^2$$

$$q_H = \left(\frac{P_L}{P_H} \right) F_{qst} = \left(\frac{14.35}{19.35} \right) = (1.016) (59.5)$$

$$= 44.8 \text{ cfm.}$$

$$V_2 \text{ (at throat)} = \frac{44.8}{(0.00448) (60)} = 167 \text{ ft/sec.}$$

For an orifice, for compressible flow,

$$V_2 = C_o \sqrt{\frac{2g_c \left(\frac{K}{K-1} \right) \left(\frac{RT}{M} \right) \left[1 - \left(\frac{P_2}{P_1} \right)^{\frac{K-1}{K}} \right]}{1 - \left(\frac{A_2}{A_1} \right)^2 \left(\frac{P_2}{P_1} \right)^{2/K}}}$$

$$167 = 0.63 \sqrt{\frac{64.4 \left(\frac{1.41}{0.41} \right) \frac{(1546)(535)}{28.8} \left[1 - \left(\frac{P_2}{P_1} \right)^{\frac{0.41}{1.41}} \right]}{1 - \left(\frac{0.00448}{0.0233} \right)^2 \left(\frac{P_2}{P_1} \right)^{2/1.41}}}$$

Squaring both sides and rearranging,

$$27,900 - 1.03 \left(\frac{P_2}{P_1} \right)^{1.42} = 2,520,000 - 2,520,000 \left(\frac{P_2}{P_1} \right)^{0.291}$$

The $\left(\frac{P_2}{P_1} \right)^{1.42}$ term is clearly negligible.

Solving,

$$\left(\frac{P_2}{P_1} \right)^{0.291} = 0.9889$$

$$\frac{P_2}{P_1} = 0.9624$$

$$P_1 = \frac{P_2}{0.9624} = \frac{19.35}{0.9624} = 20.11 \text{ psia}$$

$$\Delta P = 20.11 - 19.35 = 0.76 \text{ psi}$$

$$\left(\frac{0.76}{14.70} \right)^{405.4} = 20.9 \text{ in. water}$$

For the Gentile tube,

$$\Delta P = \frac{21.83}{2.5} = 8.74 \text{ in. water}$$

At a given flow rate of 59.5 cfm for equivalent diameter ratios, the pressure differential on the orifice is 2.4 times that on the Gentile tube.

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