A+ FLOWTEK
Balanced Flow Meter
Patented 10 / 750,628

Balanced Flow Meter

by

A+ FlowTek

Fluid Flow Metering Specialists

www.APlusFlowTek.com

Agenda

A+ FlowTek Background with NASA & Balanced Flow Meter

Basic Equations of Fluid Flow

- Equation of Continuity
- Macroscopic Momentum Balance
- Macroscopic Mechanical Energy Balance
- The Bernoulli Equation for any Real Fluid

Physical Properties

- Extended Lee-Kesler Equation of State (EoS), Patent Pending
- QMC DYFLO Modeling
- Flow Meter Error Detection

A+ FlowTek Balanced Flow Meter, Patented

- Design Concepts
- Sizing Basis and Hole Layouts
- Restriction Orifice Plate with no Cavitation
- Test Results

Technical Background

- **QMC established in 1996 for advanced monitoring & control (health management, sensor validation, etc.)**
- **Founders developed ABB Instrumentation and DuPont’s flow meter sizing programs**
- **A+ FlowTek established in 2002**
  for commercialization of several co-patents with NASA and QMC
- **First commercial Balanced Flow Meter sale in 2004**

Technical Background – con’t

- **Paul Van Buskirk, MSChE - Developer of QMC software**
- **William Heenan, PhD - Flow metering and error detection**
- **C. B. Boyd Kilgore, BA - Specialist of compressors**
- **Carl Yaws, Ph.D. - Specialist of physical properties**
- **Roger G.E. Franks, MSME - Specialist of dynamic simulation**
- **Walter Bare, Ph.D. - Specialist of Refinery**
- **Anthony R. Kelley, MSEE, MSIT - NASA Avionics**

Supporting Technical Experience

- **A+ FlowTek Meter Sizing Program**
- **QMC Program**
  (Data Mining, Model, Audit, Monitor, Control, Optimization)
- **QMC Engineering Program**
  (Equipment Sizing & Specification)
- **QMC MIMT© Program**
  (Flow & Sensor Error Detection)
- **QMC DYFLO Program**
  (Dynamic & Steady State Flow Simulator)
- **QMC Extended Lee-Kesler Physical Property Program**
- **QMC Yaws Physical Property Program**
- **QMC SPC Program**
  (Statistical Analysis)
- **ABB Genie Program**
- **DuPont ETAP Suite**

Traditional Flow Meters

	Differential Pressure	**Positive Displacement**	**Turbine**	**Open Channel**	**Thermal**	**Variable Area**
Application	Clean liquids, steams, and gases	Clean, non-corrosive liquids and gases	Clean, steady, medium to high-speed flowing liquids or gases	Clean, free-flowing streams or partially filled pipes	Clean gases of known heat capacity	Clean liquids and gases where high accuracy is not required
Fluids	L, G, S	L, G	L, G	L	L, G	L, G
Disadvantage	Permanent pressure drop depends on primary element; orifice plates subject to wear	moving parts subject to wear, requires clean fluids	Moving parts subject to wear, requires clean fluids	Weirs and flumes require obstruction; pressure loss depends on technology	Limited use for liquids; low to medium accuracy	Low accuracy; many do not have output
Advantage	Low cost; well understood	Accurate; measures low flow rates and viscous flows	Reliable; well understood	Limited accuracy, depending on technology	Low cost; measures mass flow	Low cost; many do not require power
Principle of Operation	Flow rate proportional to amount of pressure drop created by constriction in pipe	Fluid trapped into compartments of known volume and emptied; flow rate determined by counting how often this happens	Flow rate proportional to speed of spinning rotor	Level or depth used to determine flow with weirs and flumes; area velocity measures flow rate and level or depth	Flow rate proportional to speed with which heat dissipates in the fluid	Flow rate indicated by how high the fluid lifts a float

Source: Flow Research, Inc.

New Technology Flow Meters

	Coriolis	Magnetic	Ultrasonic	Vortex	Multivariable Differential Pressure	Balanced Flow Meter
Application	Clean, medium to high speed liquids and gases in pipes of 2 inches or less	Clean, conductive liquids flowing through a full pipe	Clean, swirl-free liquids and gases of known profile	Clean, low-viscosity, swirl-free, medium to high speed fluids	Clean liquids (L), steams (S), and gases (G)	Liquids, gases, slurries, certain 2-phase fluids, high velocity flows, low to high viscosity fluids, etc.
Fluids	L, G, S	L	L, G, S	L, G, S	L, G, S	L,G,S
Disadvantage	Price; limited line sizes	Doesn't meter nonconductive fluids	Transit time requires relatively clean fluids	Affected by vibration; somewhat intrusive	Permanent pressure drop-depends on primary element	Minimally intrusive, dependent on beta ratio
Advantage	Accurate	Non-intrusive; minimal pressure drop	Nonintrusive; minimal pressure drop	Minimal pressure drop; accurate	Reduced cost; integrated solution	Significant improvement in accuracy and pressure recovery
Principle of Operation	Mass flow proportional to amount to twist in tube	Flow rate proportional to amount of voltage generate when liquid moves through a magnetic field	Flow rate determined by difference in time it takes an ultrasonic pulse to travel upstream vs. downstream	Flow rate proportional to number of vortices generated by buff body	Measures mass flow by inferential method, measuring pressure and temperature	Flow rate proportional to the SQRT of pressure drop created by area change in pipe
Source: Flow Research, Inc.						NASA

BFM Technical Basis

- **Patented technology developed by NASA and A+ FlowTek, Patent serial number 10 / 750,628**
- **Design based on multi-hole orifice plate**
- **Flow proportional to SQRT of delta P**
- **100 percent increase in pressure recovery**
- **Ten-fold increase in accuracy**
- **15 to 1 reduction in acoustic power intensity**
- **Basic relation is the Bernoulli equation**
- **Key design factor is the hole distribution**
- **Permanent pressure loss, accuracy and discharge coefficient comparable with a venturi meter.**

Technical Basis – con't

- **Bernoulli Equation**

$$(P_a-P_b)/\rho + g(Z_a - Z_b)/g_c + (\alpha_a V_a^2 - \alpha_b V_b^2)/2g_c - h_{fb} = 0$$

- **Equation of Continuity**

$$(\rho AV)_a = m = (\rho AV)_b$$

- **Simplified Bernoulli Equation**

$$(P_a-P_b)/\rho + (V_a^2 - V_b^2)/2g_c = 0$$

Technical Basis – con’t

The Bernoulli effect is based on a flow area change:

A known change in flow area causes a proportional pressure head change, which can be measured directly by use of a differential pressure sensor. With the known pressure change and area ratio, the flow rate can then be determined.

$$(P_a - P_b)/\rho = (m/\rho A_b)^2(1 - (A_b/A_a)^2)/2g_c = (m/\rho A_b)^2(1 - \beta^4)/2g_c$$

Technical Basis – con’t

- **Generalized orifice equation**
  - Flow equation

$$\mathbf{m = C_O Y A_b (2 g_c \rho_a (P_a - P_b)/(1 - \beta^4))^{1/2}}$$

  - Super-compressibility factor

$$\mathbf{Y = 1 - (0.41 + 0.35\ \beta^4)(1 - P_b/P_a)/\gamma}$$

  - Area Ratio

$$\mathbf{A_b/A_a = (\beta)^2 = (1 + S)^{-1/2}}$$

where

$$\mathbf{S = (2 g_c \rho (P_a - P_b))(Y C_O A_a/m)^2}$$

Technical Basis – con’t

- **Balanced Flow Meter general equations**
  - Flow equation

$$m = C_O Y A_b \left(2 g_c \rho_a (P_a - P_b)/(1 - \beta^4)\right)^{1/2}$$

  - Super-compressibility factor (same as venturi meter)

$$\gamma = \left(\frac{P_b}{P_a}\right)^{1/\lambda} \left\{ \frac{\lambda\left(1-\beta^4\right)\left[1-\left(P_b/P_a\right)^{1-1/\lambda}\right]}{\left(\lambda-1\right)\left(1-P_b/P_a\right)\left[1-\beta^4\left(P_b/P_a\right)^{2/\lambda}\right]} \right\}^{\frac{1}{2}}$$

  - Area Ratio

$$A_b/A_a = (\beta)^2 = (1 + S)^{-1/2}$$

where

$$S = (2 g_c \rho (P_a - P_b))(Y C_O A_a/m)^2$$

Technical Basis – con’t

- **Basic equations of fluid flow**
  - Equation of Continuity

$$(\rho A v)_{a,b} = m_a = m_b = Const$$

  - Total energy equation

$$m\left[\frac{u_a^2 - u_b^2}{2 g_c J} + H_a - H_b\right] = 0$$

  - Kinetic energy correction factor

$$\alpha\, v^2 = u^2$$

Technical Basis – con’t

- **Basic equations of fluid flow**
  - Bernoulli equation for fluid flow, for any fluid

$$m = \rho_a \ A_a \sqrt{\frac{2g_c \ J\left(H_a - H_b\right)}{\alpha_a\left(\frac{\alpha_b}{\alpha_a}\left(\frac{\rho_a \ A_a}{\rho_b \ A_b}\right)^2 - 1\right)}}$$

Technical Basis – con't

- **The Bernoulli equation is derived from the first and second law and the Gibbs fundamental equation. Lost work is defined from momentum balances.**

$$\Delta\left(H + \frac{u^2}{2g_c} + \frac{gZ}{g_c}\right)_a m + Q - W_s = 0$$

$$-TdS + \delta LW + \delta Q = 0$$

$$dU_{fluid} = T_{fluid}\; dS_{fluid} - P_{fluid}\; dV_{fluid}$$

$$\int \delta LW = LW = kv_b^2 / 2g_c$$

Technical Basis – con’t

- **The Bernoulli equation can be developed from the Macroscopic Mass, Momentum, and Energy Balances**

Summary of the Macroscopic Balances for Nonisothermal Flow Systems Containing a Single Chemical Species		
Balance	Special Form	Steady State
Mass		$\Delta\, w = 0$
Momentum		$F = -\Delta\left(\frac{\langle v^2 \rangle}{\langle v \rangle} w + PS \right) + m_{tot}\, g$
Energy		$\Delta\left(U + P/\rho + \frac{1}{2}\frac{\langle v^3 \rangle}{\langle v \rangle} + \Phi - W \right)$
Mechanical Energy	Isothermal	$\Delta\left(\frac{1}{2}\frac{\langle v^3 \rangle}{\langle v \rangle} + \Phi + G \right) + W + E_v = 0$
	Isentropic	$\Delta\left(\frac{1}{2}\frac{\langle v^3 \rangle}{\langle v \rangle} + \Phi + H \right) + W + E_v = 0$

Technical Basis – con’t

- **From macroscopic balances, the Bernoulli equation is**

The enthalpy representation is,

$$m=\left(\frac{2g_c\,\Delta H}{\left(\frac{k+\alpha}{(\rho A)^2}\right)_b-\left(\frac{\alpha}{(\rho A)^2}\right)_a}\right)^{1/2}=\left(\frac{2g_c\,\Delta H}{\left(\frac{k+\alpha}{((\partial H/\partial P)_S\,A)^2}\right)_b-\left(\frac{\alpha}{((\partial H/\partial P)_S\,A)^2}\right)_a}\right)^{1/2}$$

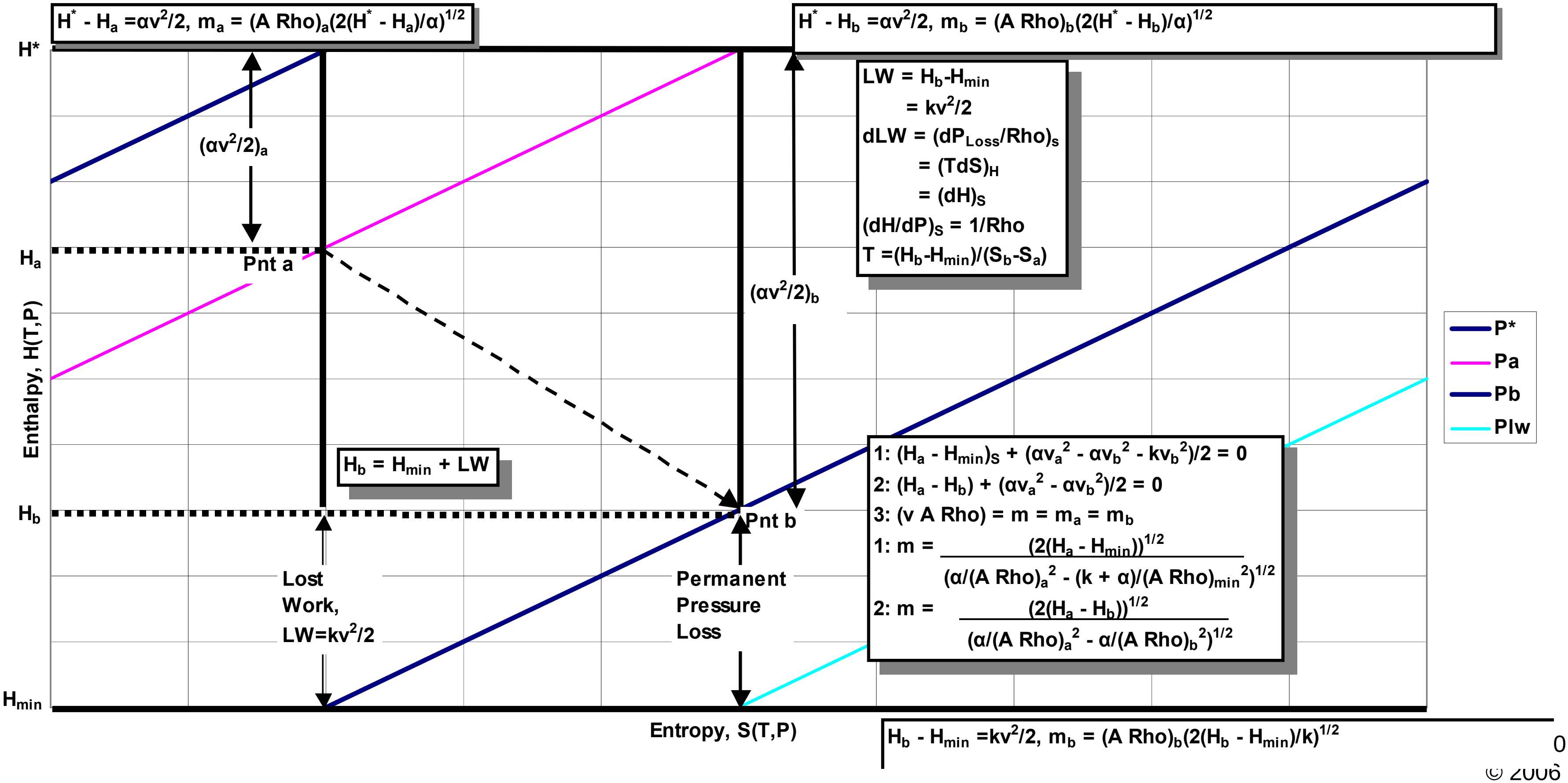
The Gibbs free enthalpy representation is,

$$m=\left(\frac{2g_c\,\Delta G}{\left(\frac{k+\alpha}{(\rho A)^2}\right)_b-\left(\frac{\alpha}{(\rho A)^2}\right)_a}\right)^{1/2}=\left(\frac{2g_c\,\Delta G}{\left(\frac{k+\alpha}{((\partial G/\partial P)_T\,A)^2}\right)_b-\left(\frac{\alpha}{((\partial G/\partial P)_T\,A)^2}\right)_a}\right)^{1/2}$$

Technical Basis – con’t

- **Graphically, the enthalpy representation is,**

Head-Meter Enthalpy-Entropy Plot



$H^* - H_a = \alpha v^2/2$, $m_a = (A\,Rho)_a(2(H^* - H_a)/\alpha)^{1/2}$

$H^* - H_b = \alpha v^2/2$, $m_b = (A\,Rho)_b(2(H^* - H_b)/\alpha)^{1/2}$

$LW = H_b - H_{min}$
$\quad = kv^2/2$
$dLW = (dP_{Loss}/Rho)_S$
$\quad = (TdS)_H$
$\quad = (dH)_S$
$(dH/dP)_S = 1/Rho$
$T = (H_b - H_{min})/(S_b - S_a)$

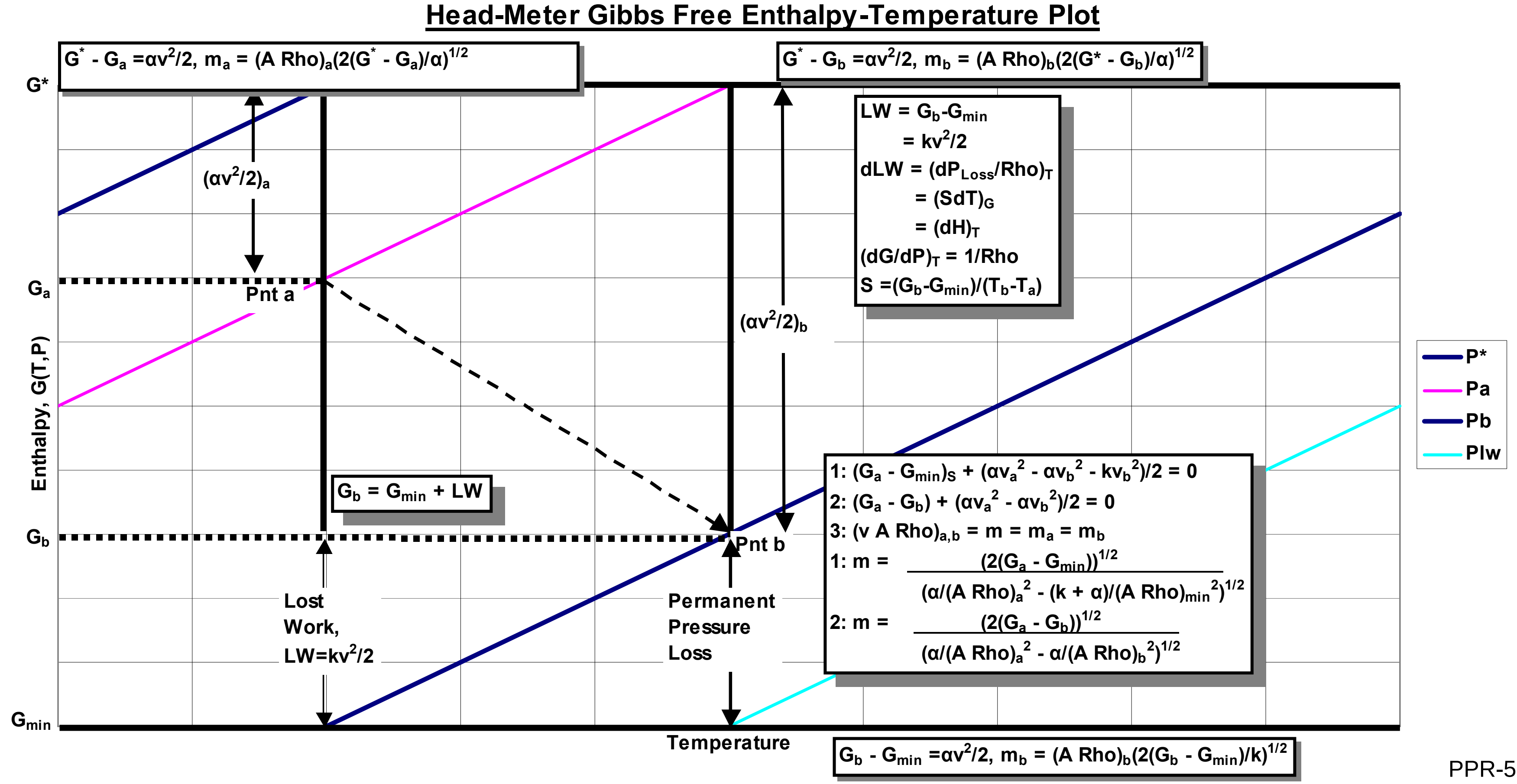
$H_b = H_{min} + LW$

1: $(H_a - H_{min})_S + (\alpha v_a^2 - \alpha v_b^2 - kv_b^2)/2 = 0$
2: $(H_a - H_b) + (\alpha v_a^2 - \alpha v_b^2)/2 = 0$
3: $(v\,A\,Rho) = m = m_a = m_b$
1: $m = \dfrac{(2(H_a - H_{min}))^{1/2}}{(\alpha/(A\,Rho)_a^2 - (k + \alpha)/(A\,Rho)_{min}^2)^{1/2}}$
2: $m = \dfrac{(2(H_a - H_b))^{1/2}}{(\alpha/(A\,Rho)_a^2 - \alpha/(A\,Rho)_b^2)^{1/2}}$

$H_b - H_{min} = kv^2/2$, $m_b = (A\,Rho)_b(2(H_b - H_{min})/k)^{1/2}$

Technical Basis – con’t

- **Graphically, the Gibbs free enthalpy representation is,**



Head-Meter Gibbs Free Enthalpy-Temperature Plot

$G^* - G_a = \alpha v^2/2$, $m_a = (A\ Rho)_a(2(G^* - G_a)/\alpha)^{1/2}$

$G^* - G_b = \alpha v^2/2$, $m_b = (A\ Rho)_b(2(G^* - G_b)/\alpha)^{1/2}$

$LW = G_b - G_{min}$
$= kv^2/2$
$dLW = (dP_{Loss}/Rho)_T$
$= (SdT)_G$
$= (dH)_T$
$(dG/dP)_T = 1/Rho$
$S = (G_b - G_{min})/(T_b - T_a)$

$G_b = G_{min} + LW$

1: $(G_a - G_{min})_S + (\alpha v_a^2 - \alpha v_b^2 - kv_b^2)/2 = 0$
2: $(G_a - G_b) + (\alpha v_a^2 - \alpha v_b^2)/2 = 0$
3: $(v\ A\ Rho)_{a,b} = m = m_a = m_b$
1: $m = \dfrac{(2(G_a - G_{min}))^{1/2}}{(\alpha/(A\ Rho)_a^2 - (k + \alpha)/(A\ Rho)_{min}^2)^{1/2}}$
2: $m = \dfrac{(2(G_a - G_b))^{1/2}}{(\alpha/(A\ Rho)_a^2 - \alpha/(A\ Rho)_b^2)^{1/2}}$

$G_b - G_{min} = \alpha v^2/2$, $m_b = (A\ Rho)_b(2(G_b - G_{min})/k)^{1/2}$

Technical Basis – con’t

- **The discharge coefficient C$_D$ and thermodynamic efficiencies**

$$\eta_{eff} = \frac{v_{b,f}^2}{v_{b,ideal}^2} = \frac{(m/\rho)_{b,f}^2}{(m/\rho)_{b,ideal}^2} = \frac{H_b^* - H_{b,f}}{H_a^* - H_{\min,S}} = \frac{\alpha v_{b,f}^2}{\alpha v_{b,f}^2 + k v_{b,f}^2} = \left(\frac{\alpha}{\alpha + k}\right)_b$$

$$C_D \equiv \frac{m_{actual}}{m_{ideal}} = \frac{(\rho A v)_{friction}}{(\rho A v)_{ideal}}$$

$$C_D = \frac{\rho_{b,f}}{\rho_{\min,S}} \left(\frac{\alpha}{\alpha + k}\right)^{1/2} = \frac{\rho_{b,f}}{\rho_{\min,S}} \left(\eta_{eff}\right)^{1/2}$$

Technical Basis – con't

- **Plate hole layout basic equation**

$$\kappa\rho A V^n = \text{Constant for each hole}$$

- **Velocity distribution, as one example,**

$$V_R/V_{max} = (1 - R/R_w)^{1/7}$$

- **Radial areas**

$$A_0 + A_1 + A_2 + \ldots\ldots. + A_n = \beta^2 A_{pipe}$$

- **Radial area ratios @ $\kappa_1\rho$ = Constant and n = 1**

$$A_1/A_i = V_i/V_1$$

- **Radial velocity ratios**

$$V_i/V_1 = ((1 - R_i/R_p)/(1 - R_1/R_p))^{1/7}$$

Technical Basis – con't

- **Base area (A_1) at R_1**

$$A_1 = (\beta^2 A_{pipe} - A_0)/(1 + ((1 - R_1/R_p)/(1 - R_2/R_p))^{1/7} + \ldots$$
$$\ldots + ((1 - R_1/R_p)/(1 - R_n/R_p))^{1/7})$$

- **Subsequent radial areas**

$$A_i = A_1((1 - R_1/R_p)/(1 - R_i/R_p))^{1/7}$$

- **Hole diameters**

$$D_i = (4A_i/\pi N)^{1/2}$$

Technical Basis – con’t

- **Typical hole layout ($\beta \approx 0.6$)**

18” NDP

Physical Properties

Extended Lee-Kesler Equation of State (ELK-EoS), Patent Pending

- **Based on a modified Taylor Series using argon, octane and water as reference fluids**
- **Accuracies over 100,000 data points for 1,700 organic and inorganic compounds show errors within the experimental error of 3 to 5 percent**
- **Errors can be further reduced by accurate volumetric data and adjustment of the ELK-EoS Q Factor. Errors are less than the original experimental data.**
- **ELK-EoS applies to volumetric, thermodynamic and transport properties of pure components, their mixtures and across multiple fluid-fluid phases.**

Physical Properties

Extended Lee-Kesler Equation of State (ELK-EoS), Patent Pending

$$z_{fluid} = z^{(0)} + z^{(1)} + z^{(4)} - \left(\Theta / \Theta^{(0)}\right)\left(z^{(1)} - z^{(2)} - z^{(3)} + z^{(4)}\right)$$

where

$$z^{(1)} = ((\omega - \omega^{(0)})/(\omega^{(R)} - \omega^{(0)}))\,(z^{(R)} - z^{(0)})$$

$$z^{(2)} = ((\sigma - \sigma^{(0)})/(\sigma^{(R)} - \sigma^{(0)}))\,(z^{(R)} - z^{(0)})$$

$$z^{(3)} = ((\omega - \omega^{(0)})/(\omega^{(W)} - \omega^{(0)}))\,(z^{(W)} - z^{(0)})$$

$$z^{(4)} = ((\sigma - \sigma^{(0)})/(\sigma^{(W)} - \sigma^{(0)}))\,(z^{(W)} - z^{(0)})$$

and with the Modified Benedict-Webb-Ruben EoS,

$$\begin{aligned} z = (P_r V_r / T_r) &= 1 + B/V_r + C/V_r^2 + D/V_r^5 \\ &+ c4/(T_r^3 V_r^2)(\beta + \gamma / V_r^2)\exp(-\gamma / V_r^2) \end{aligned}$$

Physical Properties

QMC DYFLO Modeling

- **DYFLO, developed by DuPont for dynamic simulation of all processes for design, control and optimization.**
- **The Balanced Flow Meter is implemented into a rigorous steady state and dynamic modeling system for handling multi-component and multi-phase systems.**
- **For systems that deviate from ideal gas or incompressible liquids, the DYFLO modeling tool is preferred.**
- **All macroscopic mass, momentum, energy, and power equations are rigorously calculated within DYFLO on a steady state and dynamic basis.**
- **DYFLO will also perform cavitation analysis and phase calculations within the 2-phase dome based on the spinodal curve.**

Physical Properties

Flow Meter Error Detection

- The Balanced Flow Meter system with multi-variable (T,P) and multi-location pressure and temperature taps can be equipped for self-calibration and total error minimization.
- The error minimization routine is the Modified Iterative Measurement Test© (MIMT), as copyrighted by the AIChE.
- MIMT© is also used for total plant mass balancing and metering error minimization.
- With the MIMT© algorithm, coupled with the performance of the Balanced Flow Meter and the ELK-EoS, errors for flow measurement are negligible and self-calibrating.

Experimental Results

The Balanced Flow Meter Measurement device has been tested and verified. This new and unique device utilizes a patented (10/750,628) multi-hole layout design, and provides:

- **Over one-hundred percent (100%) increase in pressure recovery**
- **A ten-fold increase in accuracy**
- **A fifteen-to-one (15 to 1) reduction in power intensity (i.e. noise reduction) when compared to a standard knife-edged orifice meter.**
- **Results show that the Balanced Flow Meter plate approaches the performance of a venturi meter.**

Experimental Results

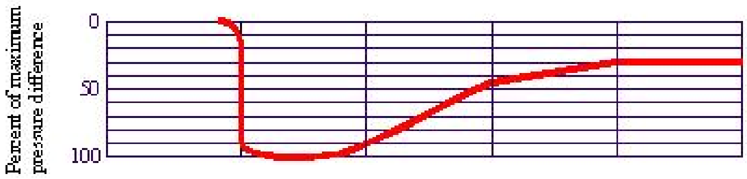
Kinetic energy and momentum correction factors for the Balanced Flow Meter (BFM) versus the standard knife-edged orifice plate

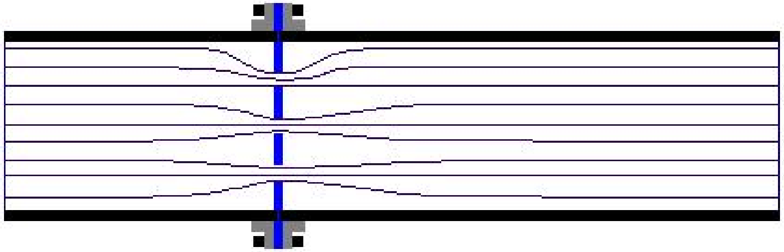
$$kE_{cf} = \alpha = \frac{\int u^3 dA}{v^3 A}$$

$$mom_{cf} = \beta = \frac{\int u^2 dA}{u^2 dA}$$

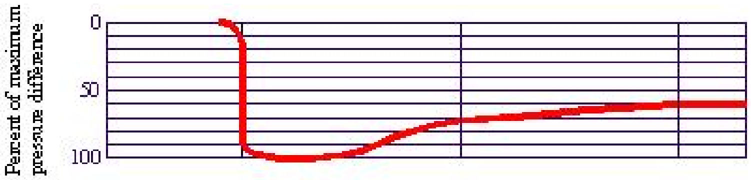
Balanced Flow Meter

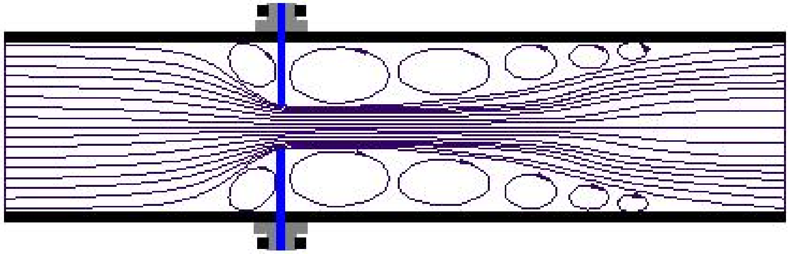
Orifice Plate





α,β can be calculated for the BFM





α,β cannot be calculated for the orifice plate since velocity profiles are random/chaotic and α(mass flow).

Client Designs

Experimental Results

Balanced Flow Meter plate performance, from minimum flows to sonic

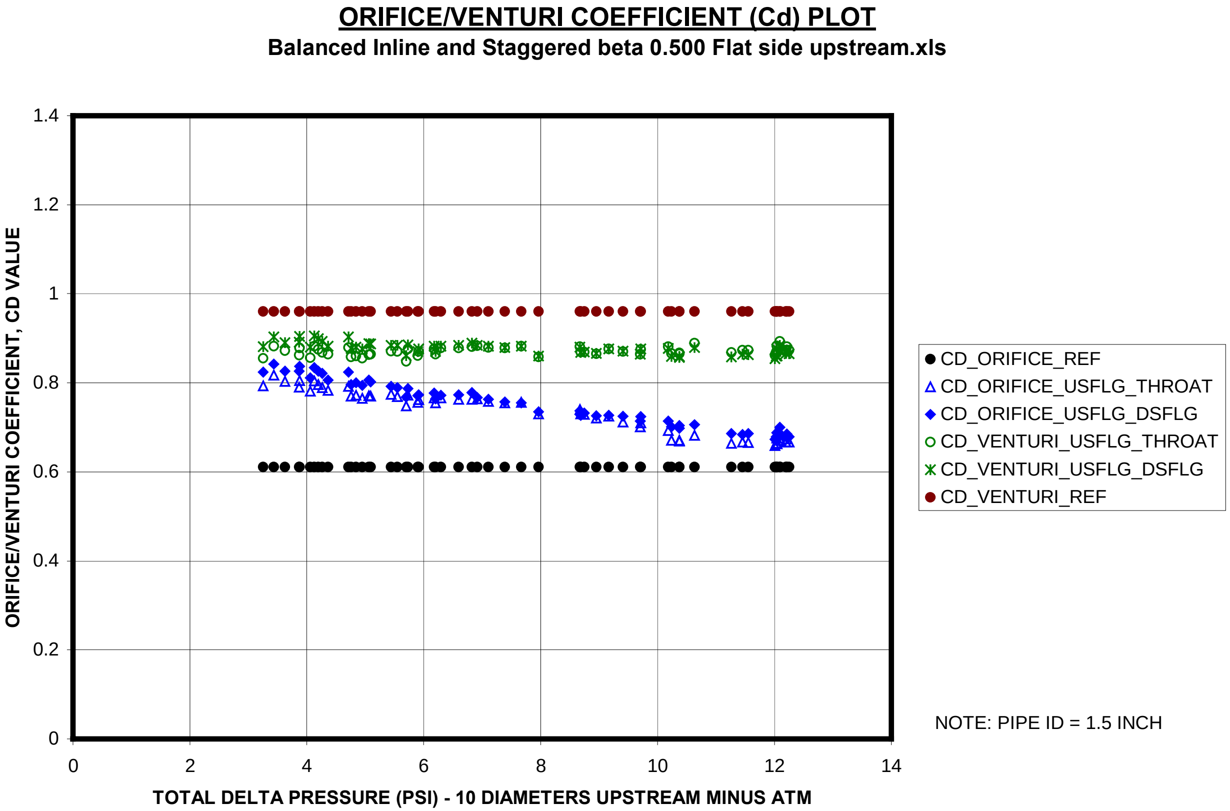
BETA	0.25	0.500	0.521	0.650	0.500,fouled	0.500,elbow
Avg Cd	0.892	0.882	0.881	0.911	0.824	0.848
Cd Dev	0.032	0.001	0.009	0.010	0.038	0.008
Avg K Val	287.1	16.3	13.2	4.0	15.65	18.63
K Dev	20.8	0.60	0.53	0.16	1.23	0.38

BETA	0.25	0.500	0.521	0.650
Venturi K, Cd=0.96	134.2	5.8	4.7	1.3
Venturi K, Cd=0.80	255.9	12.9	10.7	3.5
BFM K	287.1	16.3	13.2	4.0
Orifice K	669.4	31.5	25.7	7.4

Note: Venturi values do not include downstream losses.

Experimental Results – con't

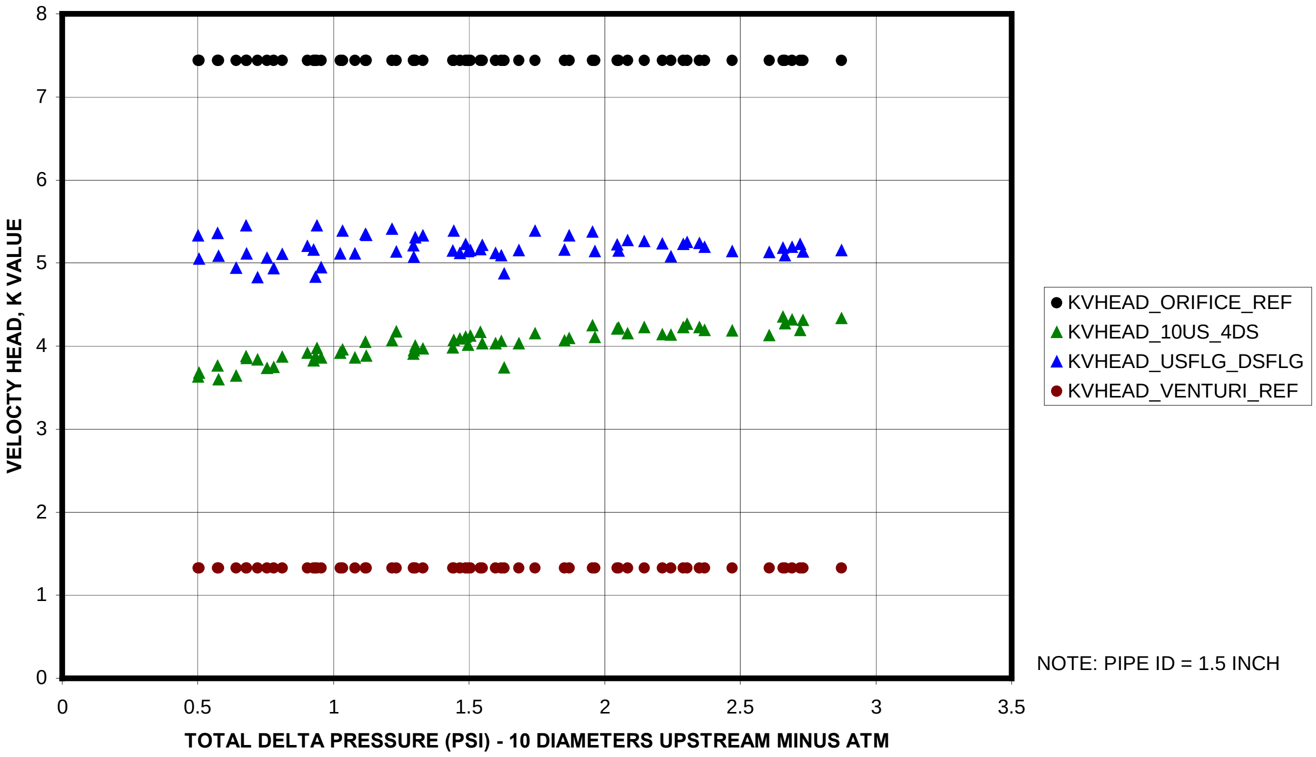
Balanced Flow Meter calibrations



NOTE: PIPE ID = 1.5 INCH

Experimental Results – con't

Balanced Flow Meter k Factors

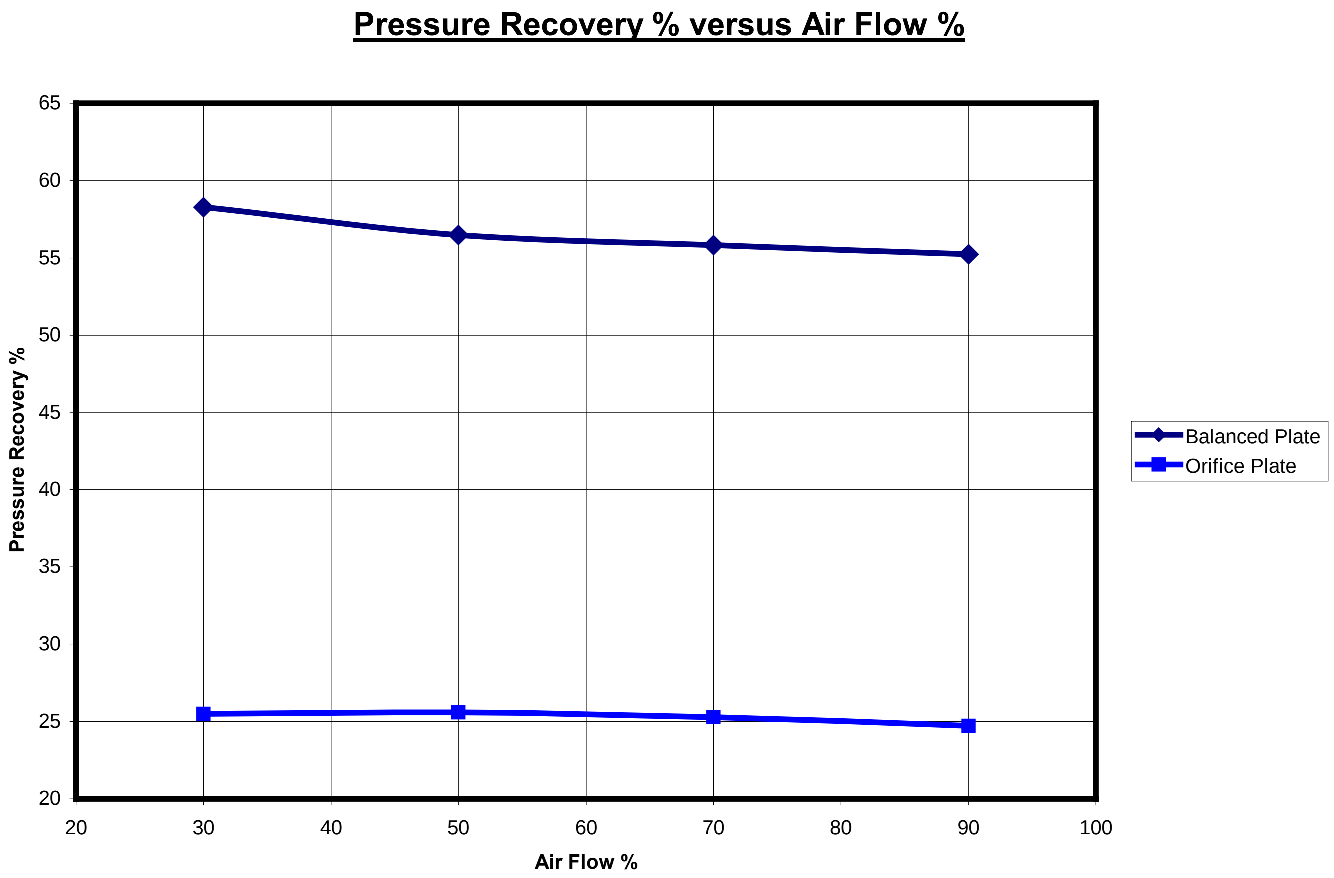


VELOCITY HEAD LOSS CONSTANT (K) PLOT
Balanced Inline beta 0.650.xls

NOTE: PIPE ID = 1.5 INCH

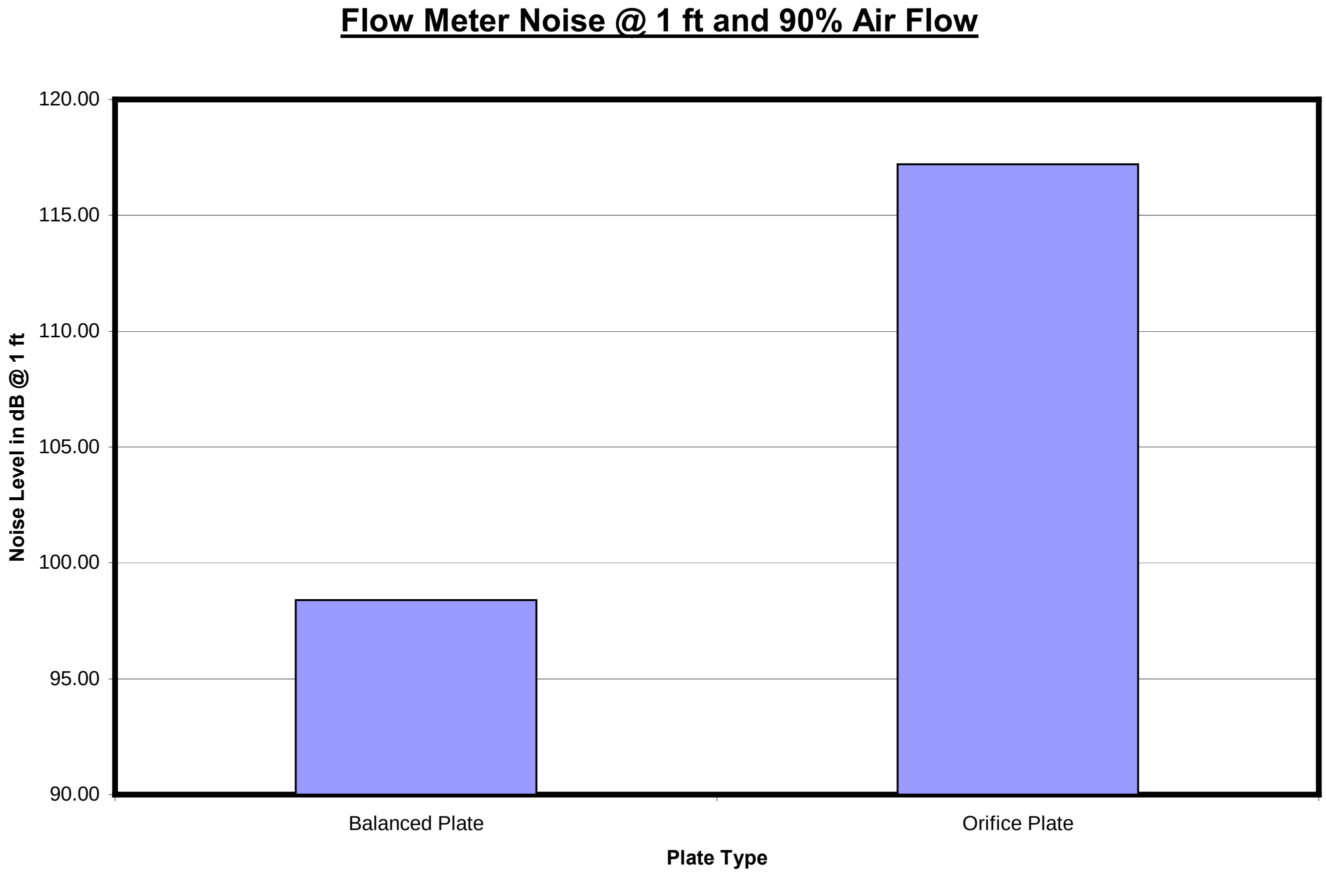
Experimental Results – con't

Pressure Recovery versus Flow



Experimental Results – con't

Acoustical Noise Levels

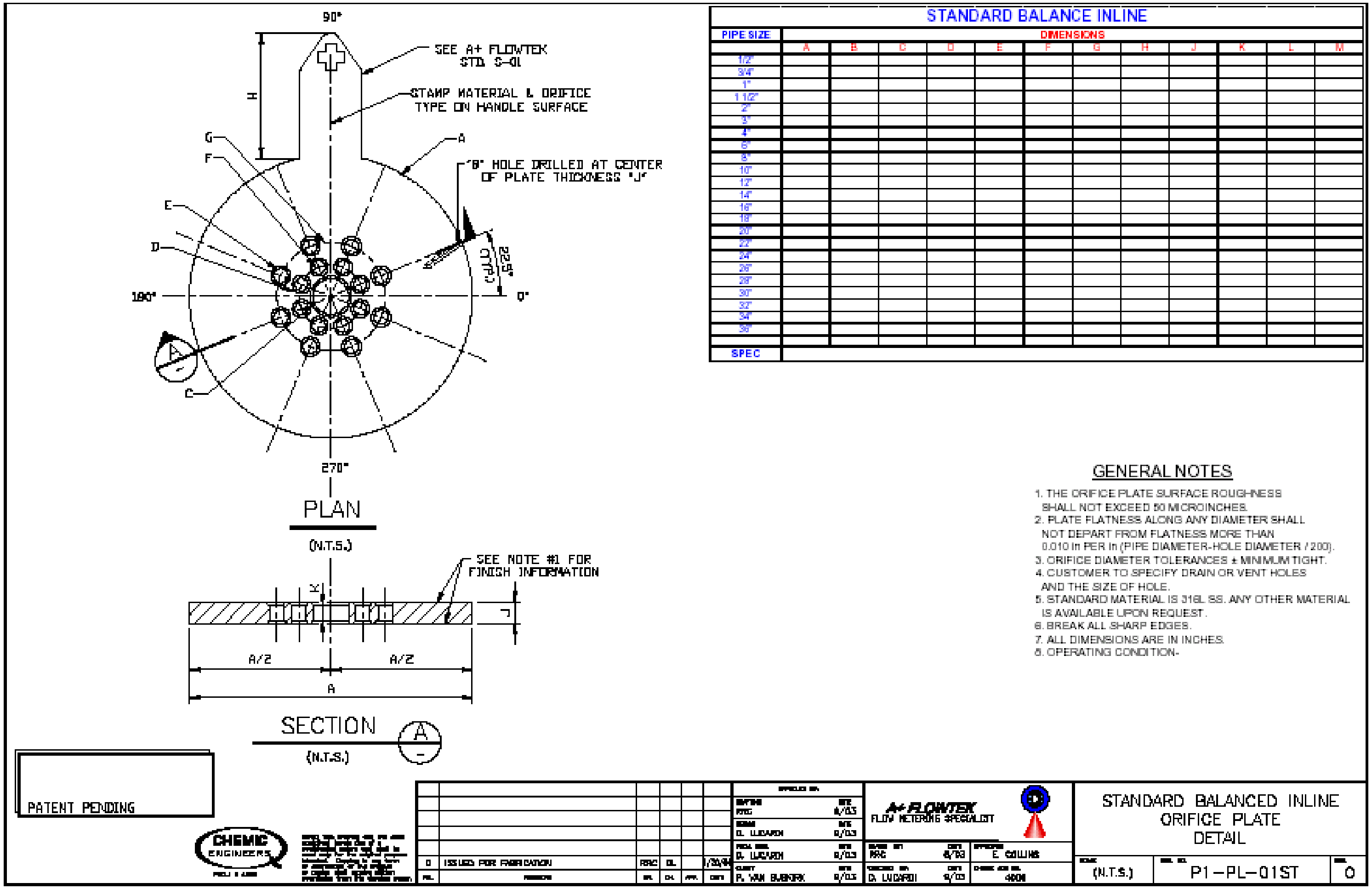


A+ FLOWTEK

Balanced Flow Meter

Patented 10 / 750,628

Design Details



STANDARD BALANCE INLINE												
PIPE SIZE	DIMENSIONS											
	A	B	C	D	E	F	G	H	J	K	L	M
1/2"												
3/4"												
1"												
1 1/2"												
2"												
3"												
4"												
6"												
8"												
10"												
12"												
14"												
16"												
18"												
20"												
22"												
24"												
26"												
28"												
30"												
32"												
34"												
36"												
SPEC												

GENERAL NOTES

1. THE ORIFICE PLATE SURFACE ROUGHNESS SHALL NOT EXCEED 50 MICROINCHES.
2. PLATE FLATNESS ALONG ANY DIAMETER SHALL NOT DEPART FROM FLATNESS MORE THAN 0.010 in PER in (PIPE DIAMETER-HOLE DIAMETER / 200).
3. ORIFICE DIAMETER TOLERANCES ± MINIMUM TIGHT.
4. CUSTOMER TO SPECIFY DRAIN OR VENT HOLES AND THE SIZE OF HOLE.
5. STANDARD MATERIAL IS 316L SS. ANY OTHER MATERIAL IS AVAILABLE UPON REQUEST.
6. BREAK ALL SHARP EDGES.
7. ALL DIMENSIONS ARE IN INCHES.
8. OPERATING CONDITION-

0 ISSUED FOR FABRICATION RRC DL 1/20/04

RRC 8/03
D. LUCARDI 9/03
D. LUCARDI 9/03
P. VAN BUSKIRK 9/03
RRC 8/03
D. LUCARDI 9/03
E. COLLINS
4006

STANDARD BALANCED INLINE
ORIFICE PLATE
DETAIL

(N.T.S.)
P1-PL-01ST
0

A+ FLOWTEK

Balanced Flow Meter

A+ FlowTek Patented 10 / 750,628

Fluid Flow Metering Specialists

Balanced Plate General Specifications

No	By	Date	Rev	Sheet		of	
				Spec No.		Revision	
				Project No.		Date	
Client Information:				P.O:			
				By	Chk'd	Approved	

BALANCED ORIFICE PLATES			ORIFICE FLANGES			
1 In-Line			7 Taps:	Flange Pipe Vena Other:		
2 Staggered			8 Tap Size:		9 Thread Type:	
3 In-Line & Staggered			10 Type:	Weld Neck Slip On Threaded		
4 Material:	316 Other:		11 Material:	Steel 304 316 Other:		
5 Reference Dwg.			12 Tap Orientation:	Top Bottom Other:		
6 Part No. / Ser No.			13 Flange Rating:	150# 300# Other:		

BASIC DATA	14	Tag Number		
	15	Service		
	16	Sizing Option	1 2 3 4 Other:	1 2 3 4 Other:
FLUID AND PROC DATA	17	Fluid		
	18	Fluid State	Gas Liquid 2-Phase	Gas Liquid 2-Phase
	19	Temperature		
	20	Pressure		
	21	Standard or Actual Flow		
	22	Min Flow		
	23	Normal Flow		
	24	Max Flow		
	25	Tap DP @ Max Flow		
	26	Fluid Composition (attach list)		
	27	Phase	Gas Liquid 2-Phase	Gas Liquid 2-Phase
	28	Fouling	High Medium Low	High Medium Low
	29	Specific Gravity at Base		
	30	Operating Spec. Gravity		
	31	Super Compressibility Factor		
	32	Base Press. Base Temp.		
PLATE AND PIPE DATA	29	Installation Type	Replacement New Design	Replacement New Design
	30	Pressure Recovery	High Nominal	High Nominal
	31	Accuracy	High Nominal	High Nominal
	32	Noise Level	N/A Medium Low	N/A Medium Low
	33	Plate Thickness	1/4 3/8 1/2 Other:	1/4 3/8 1/2 Other:
	34	Clearance to Pipe Wall	Min Nominal	Min Nominal
	35	Pipe Schedule		
	36	Pipe Nominal Diameter		
	37	Pipe ID		
	38	Insulation Thickness		
	39	Flange Schedule		
	40	Flange Rating		
	41	Matl of Construction Plate	316 Other:	316 Other:
	42	Matl of Construction Pipe	Steel Other:	Steel Other:
	43	Tap Types	Flange Center Other:	Flange Center Other:
	44	Tap Orientation	Top Bottom Other:	Top Bottom Other:
	45	Flow Loop Gain Factor	1.5 Other:	1.5 Other:
	46	Calibration Requirements	Yes No	Yes No
NOTES:				

Balanced Flow Meter

by

A+ FlowTek

Fluid Flow Metering Specialists

www.APlusFlowTek.com