

ERRATA

CRANE FLOW OF FLUIDS

THROUGH VALVES, FITTINGS AND PIPE

TECHNICAL PAPER NO. 410

METRIC VERSION

CONTACT

Please address questions and possible errata to solutions@flowoffluids.com

FRONT MATTER	CORRECTION PRINTED
<p>PAGE VI</p> <p>F_k should be F_γ</p> <p>“...individual gas constant...(J/kg·k)” should be “...(J/kg·K)”</p> <p>“...universal gas constant...(J/kg·k)” should be “...(J/k mol·K)”</p>	<p>08/2011</p> <p>10/2010</p> <p>10/2010</p>
TEXT	
<p>PAGE 2-7</p> <p>“...sum of the inverses of the individual resistance of each component:” should be “...sum of the square roots of the inverse of the individual...”</p> <p>Eq. 2-6 $\frac{1}{K_{Total}} = \frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_3} + \dots + \frac{1}{K_n}$ should be $\frac{1}{\sqrt{K_{Total}}} = \frac{1}{\sqrt{K_1}} + \frac{1}{\sqrt{K_2}} + \frac{1}{\sqrt{K_3}} + \dots + \frac{1}{\sqrt{K_n}}$</p>	<p>08/2011</p> <p>08/2011</p>
<p>PAGE 2-11</p> <p>Eq. 2-16 $K_1 = 0.5 \left(1 - \frac{d_1^2}{d_2^2}\right)^2$ should be $K_1 = 0.5 \left(1 - \frac{d_1^4}{d_2^4}\right)$</p> <p>Eq. 2-18 $K_1 = 0.5(1 - \beta^2)^2$ should be $K_1 = 0.5(1 - \beta^4)$</p> <p>Eq. 2-27 $K_2 = \frac{0.5 \sqrt{\sin^2 \frac{\theta}{2}} (1 - \beta^2)^2}{\beta^4}$ should be $K_2 = \frac{0.5 \sqrt{\sin^2 \frac{\theta}{2}} (1 - \beta^4)}{\beta^4}$</p>	<p>10/2010</p> <p>10/2010</p> <p>10/2010</p>
<p>PAGE 2-13</p> <p>“...expansion bend up of continuous 90 degree...” should be “...bend made up of...”</p>	<p>10/2010</p>

PAGE 2-15

Column for values of G added to table 2-3:

Angle (α)	G	H	J
0-60°	Table 2-4	1	2
$\alpha = 90^\circ$ at $\beta_{branch} \leq \frac{2}{3}$	1	1	2
$\alpha = 90^\circ$ at $\beta_{branch} = 1^*$	$G = 1 + 0.3 \left(\frac{Q_{branch}}{Q_{comb}} \right)^2$	0.3	0

Replace Tables 2-2 and 2-4:

Table 2-2: Values of C for Equation 2-35

		Q_{branch} / Q_{comb}	
		≤ 0.4	> 0.4
β_{branch}^2	≤ 0.35	$C = 1$	
	> 0.35	$C = 0.9 \left(1 - \frac{Q_{branch}}{Q_{comb}} \right)$	$C = 0.55$

Table 2-4: Values of G for Equation 2-37

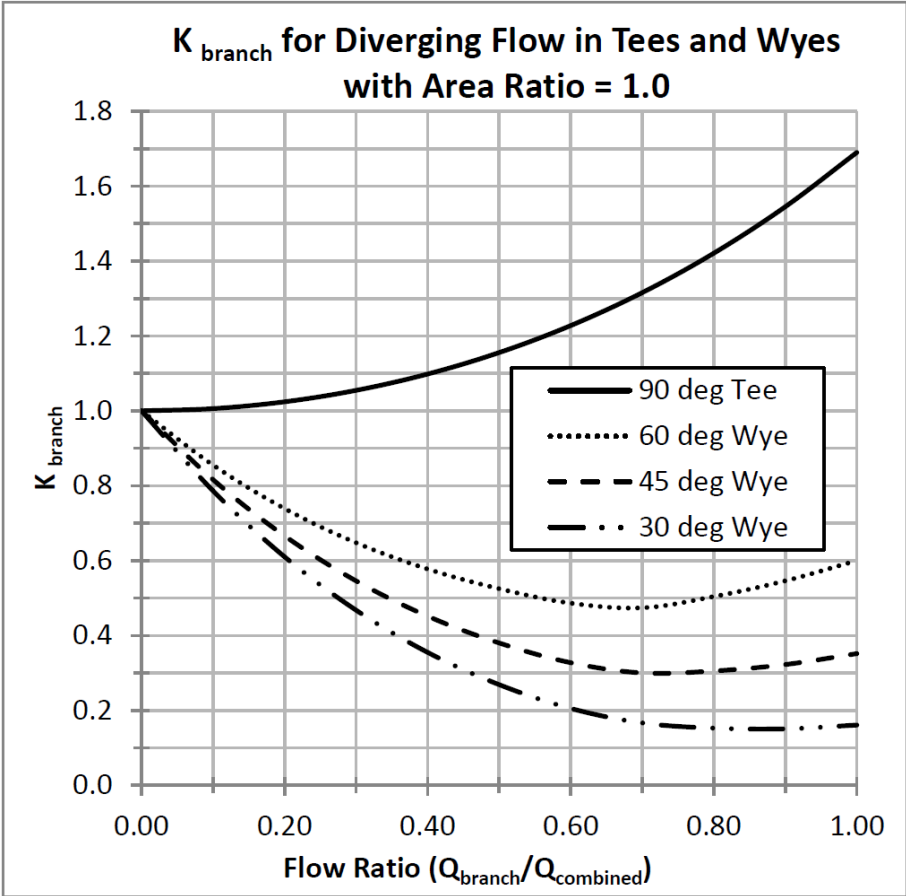
		Q_{branch} / Q_{comb}	
		≤ 0.4	> 0.4
β_{branch}^2	≤ 0.35	$G = 1.1 - 0.7 \frac{Q_{branch}}{Q_{comb}}$	$G = 0.85$
	> 0.35	$G = 1.0 - 0.6 \frac{Q_{branch}}{Q_{comb}}$	$G = 0.6$
		≤ 0.6	> 0.6
		Q_{branch} / Q_{comb}	

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PAGE 2-16
New Figure 2-16:



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PAGE 3-4

Footnote added: “*For use only with control valves per ANSI/ISA 75.01.01, for reducers in pipelines see page 2-11”

10/2010

PAGE 3-5

Eq. 3-13 Should be $Y = 1 - \frac{x}{3F_Y x_T}$

Definition of x should read: “x = pressure drop ratio = $\Delta P/P'_1$ ”

F_k should be F_Y

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PAGE 4-5

Eq. 4-7b $J = \left(\frac{19000\beta}{Re}\right)$ should read: $J = \left(\frac{19000\beta}{Re}\right)^{0.8}$

08/2011

PAGE 4-6

“The data is also plotted on page A-21 of this reference” should be “...page A-22”

04/2010

<p>“Equation 4-16 may be used for orifices...” should be “...Equation 4-14”</p> <p>“1. The specific heat ratio, k.” should be “1. The specific heat ratio, γ.”</p> <p>Eq. 4-15 should be:</p> $Y = 1 - (0.351 + 0.256\beta^4 + 0.93\beta^8) \left[1 - \left(\frac{P'_2}{P'_1} \right)^{\frac{1}{\gamma}} \right]$ <p>Eq. 4-16 should be:</p> $Y = \left\{ \frac{\gamma \left(\frac{P'_2}{P'_1} \right)^{\frac{2}{\gamma}}}{\gamma - 1} \left[\frac{1 - \beta^4}{1 - \beta^4 \left(\frac{P'_2}{P'_1} \right)^{\frac{2}{\gamma}}} \right] \left[\frac{1 - \left(\frac{P'_2}{P'_1} \right)^{\frac{\gamma-1}{\gamma}}}{1 - \left(\frac{P'_2}{P'_1} \right)} \right] \right\}^{0.5}$ <p>The paragraph beginning “The expansibility factor has been experimentally determined...” should have the following added at the end: “For the purposes of accurate metering, the expansibility factor equations should be limited to conditions when the pressure ratio is greater than 0.80 ($P'_2/P'_1 \geq 0.80$) per the ASME standard. There are some critical flow applications discussed in the next section where stringent metering accuracy is not a requirement, and therefore the charts on page A-22 reflect a greater range of pressure ratios.”</p> <p>The paragraph beginning “Values of k for some ...” shall have the terms “k” replaced with the terms “γ”.</p> <p>The paragraph beginning “The critical pressure ratio is the largest ratio...” shall be rewritten as follows: “The critical pressure ratio r_c is the largest ratio of downstream pressure to upstream pressure capable of producing sonic velocity. Values of critical pressure ratio which are a function of the ratio of nozzle diameter to upstream diameter as well as the specific heat ratio γ are plotted on page A-22, and are derived from the following relationship⁴⁶:</p> <p>Add Eq. 4-17:</p> $r_c^{\frac{1-\gamma}{\gamma}} + \left(\frac{\gamma-1}{2} \right) \beta^4 r_c^{\frac{2}{\gamma}} = \frac{\gamma+1}{2}$ <p>The paragraph beginning “Flow through nozzles and venturi meters...” shall be rewritten as follows: “Flow through nozzles and venturi meters is limited by the critical pressure ratio. Other applications which require the determination of a mass flow rate under critical conditions include equipment ruptures and pressure relief valves. In these cases, the stringent accuracy of metering applications is not required, and therefore the expansibility factors can be taken at pressure ratios below 0.80. Minimum values of Y to be used in Equation 4-14 for this condition, are indicated on the plots on page A-22 by the termination of the curves at $P'_2/P'_1 = r_c$.”</p>	<p>04/2010</p> <p>08/2011</p> <p>08/2011</p> <p>08/2011</p> <p>08/2011</p> <p>08/2011</p> <p>08/2011</p> <p>08/2011</p> <p>08/2011</p> <p>08/2011</p> <p>08/2011</p>
<p>PAGE 6-2</p> <p>Viscosity Conversion should be $\nu = \frac{\mu}{\rho'} = \frac{\mu}{S_{4^\circ\text{C}}} = \frac{1000\mu}{\rho}$</p>	<p>08/2011</p>

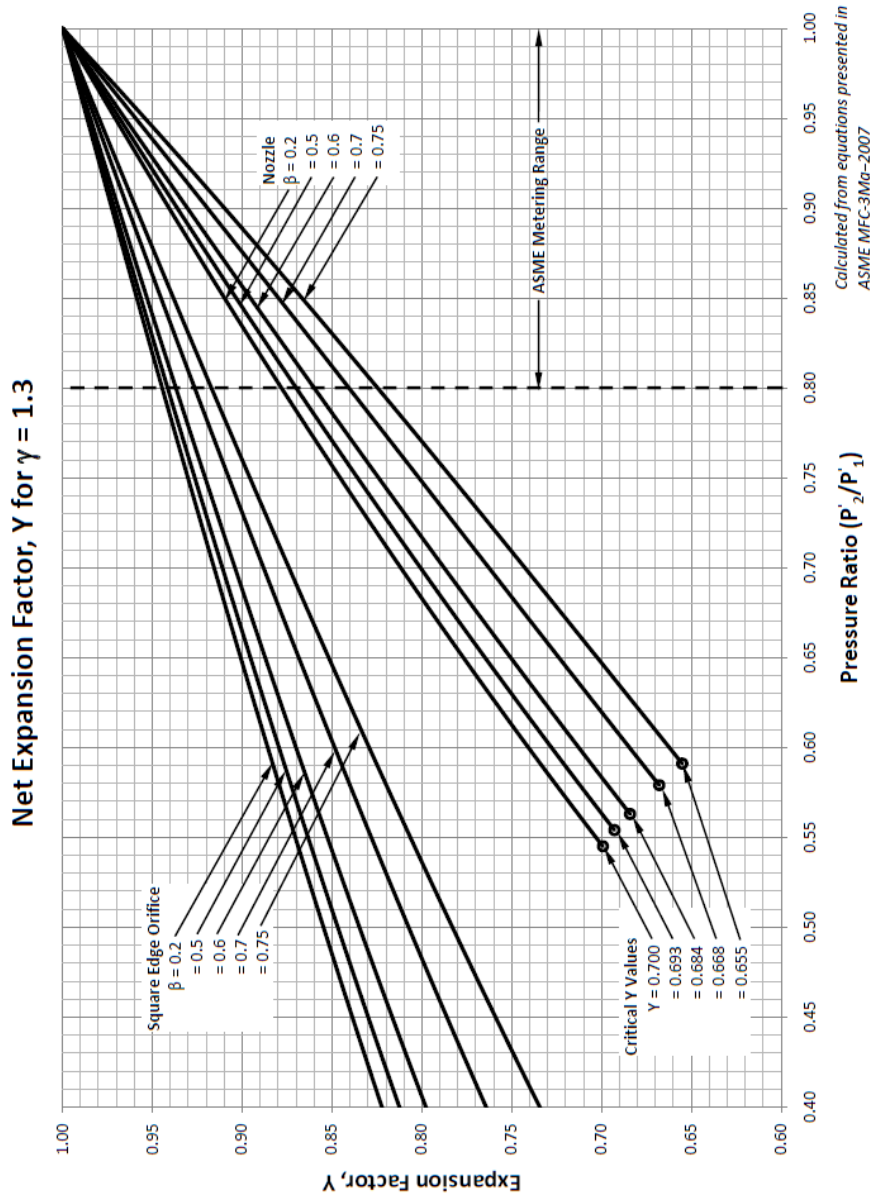
<p>PAGE 6-3</p> <p>Eq. 6-9 should be:</p> $\Delta P_{per\ metre} = 6.05 \times 10^{10} \frac{Q^{1.85}}{C^{1.85}d^{4.87}}$ $\Delta P = 6.05 \times 10^{10} \frac{LQ^{1.85}}{C^{1.85}d^{4.87}}$ $h_L = \frac{\Delta P}{\rho g} = 6.177 \times 10^6 \frac{LQ^{1.85}}{C^{1.85}d^{4.87}}$	<p>08/2011</p> <p>08/2011</p> <p>08/2011</p>
<p>PAGE 6-5</p> <p>Eq. 6-25 $\frac{1}{K_{Total}} = \frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_3} + \dots + \frac{1}{K_n}$ should be $\frac{1}{\sqrt{K_{Total}}} = \frac{1}{\sqrt{K_1}} + \frac{1}{\sqrt{K_2}} + \frac{1}{\sqrt{K_3}} + \dots + \frac{1}{\sqrt{K_n}}$</p> <p>Eq. 6-32 $q = YCA\sqrt{2gh_L} = YCA\sqrt{\frac{2g\Delta P}{\rho}}$ should be $q = YCA\sqrt{2gh_L} = YCA\sqrt{\frac{2\Delta P}{\rho}}$</p>	<p>08/2011</p> <p>08/2011</p>
<p>PAGE 6-6</p> <p>Eq. 6-38 should be corrected as follows:</p> $Y = 1 - \frac{x}{3F_\gamma x_T} \text{ without fittings}$ $Y = 1 - \frac{x}{3F_\gamma x_{TP}} \text{ with fittings}$ $F_\gamma = \frac{\gamma}{1.4} = \frac{c_p/c_v}{1.4}$ <p>Eq. 6-39 should be corrected as follows:</p> $x \geq F_\gamma x_T \text{ without fittings}$ $x \geq F_\gamma x_{TP} \text{ with fittings}$	<p>08/2011</p> <p>08/2011</p>
<p>PAGE 7-2</p> <p>Ex. 7-3 “for graphical solutions of steps 5 through 7, use pages A-31 & A-32” should be removed</p> <p>Ex. 7-3 5. Should be $C_V = 29.84 \frac{3.826^2}{\sqrt{2.475}} = 277.7$</p>	<p>08/2011</p>
<p>PAGE 7-6</p> <p>Ex. 7-10 “...as described in Example 6-4...” should be “...Example 7-4...”</p>	<p>10/2010</p>

<p>PAGE 7-7</p> <p>Ex. 7-12 7. $K_{orifice} = \left[\frac{\sqrt{1-\beta^4(1-c_d^2)}}{c_d\beta^4} - 1 \right]^2$ should be $K_{orifice} = \left[\frac{\sqrt{1-\beta^4(1-c_d^2)}}{c_d\beta^2} - 1 \right]^2$</p>	<p>10/2010</p>
<p>PAGE 7-10</p> <p>Ex. 7-17 1. should be: $t = \frac{9}{5} t_c + 32$ 2. should be: $t = \left(\frac{9}{5} \times 15.6 \right) + 32 = 60^\circ\text{F}$</p>	<p>08/2011 08/2011</p>
<p>PAGE 7-17</p> <p>Ex. 7-26 23. "f = 0.0155" should reference page A-25 rather than A-24</p>	<p>10/2010</p>
<p>PAGE 7-21</p> <p>Ex. 7-31 1. Should be $NRPD = \Delta P \left[\frac{\sqrt{1-\beta^4(1-c_d^2)}-c_d\beta^2}{\sqrt{1-\beta^4(1-c_d^2)}+c_d\beta^2} \right]$</p> <p>5. Should be $NRPD = 1.732 \left[\frac{\sqrt{1-0.395^4(1-0.982^2)}-0.982 \times 0.395^2}{\sqrt{1-0.395^4(1-0.982^2)}+0.982 \times 0.395^2} \right] = 1.272 \text{ psi}$</p>	<p>08/2011 08/2011</p>
<p>APPENDICES</p>	
<p>PAGE A-19</p> <p>Total Temp headings: 160, 180, 200, 220, 250, 300, 350, 400, 450, 550, 650</p> <p>Should be: 340, 360, 380, 400, 420, 440, 460, 500, 550, 600, 650</p>	<p>04/10</p>

PAGE A-22

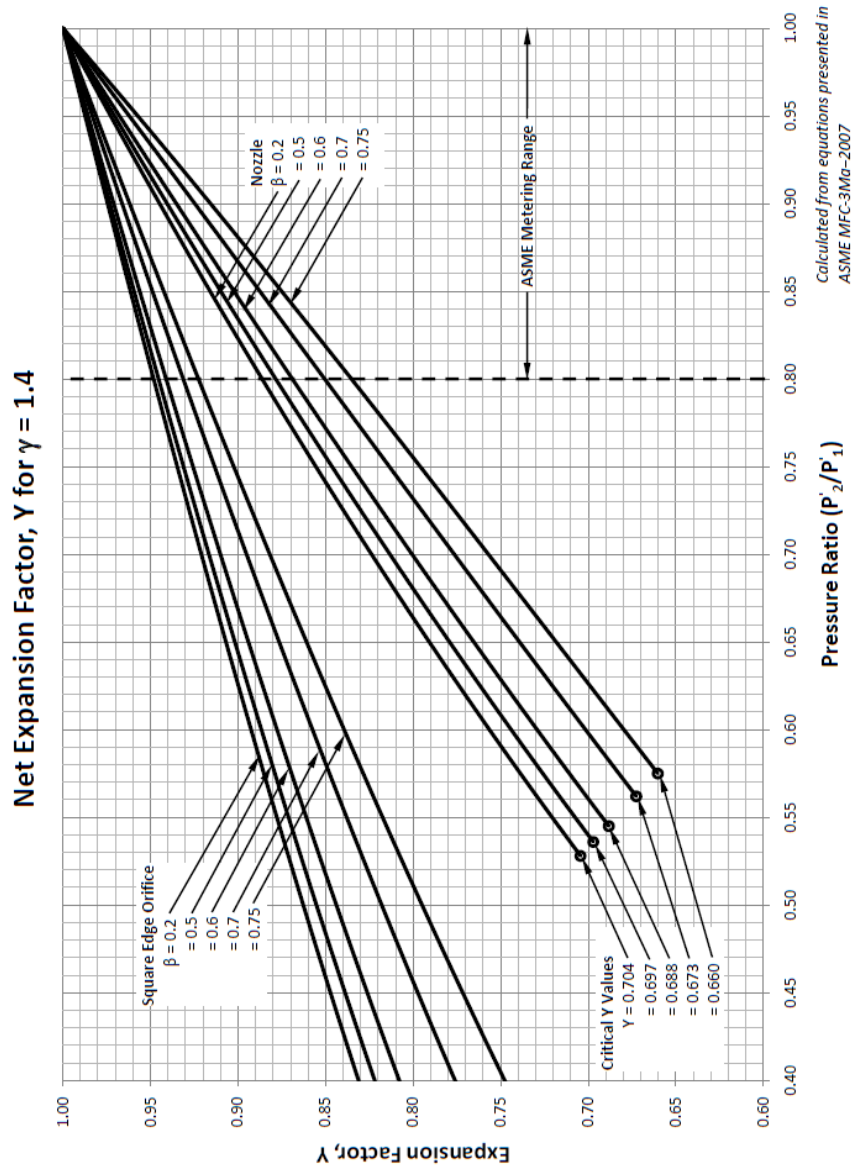
Page title should cite reference 27 and also 46

Graphs should change to the following:



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<p style="text-align: center;">Critical Pressure Ratio, r_c For Compressible Flow through Nozzles and Venturi Tubes⁴⁶</p> <p style="text-align: center;">Critical Pressure Ratio, $r_c = (P_2/P_1)$</p> <p style="text-align: center;">Specific Heat Ratio, $\gamma = c_p/c_v$</p>	<p>08/2011</p>
<p>PAGE A-30 Under STANDARD TEES AND WYES delete "For Converging or Diverging Flow:"</p>	<p>10/2010</p>