ERRATA
CRANE FLOW OF FLUIDS
THROUGH VALVES, FITTINGS AND PIPE
TECHNICAL PAPER NO. 410
U.S. VERSION

CONTACT

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

FRONT MATTER	CORRECTION PRINTED
No errata at this time	
TEXT	
PAGE 2-7 "...sum of the inverses of the individual resistance of each component:" should be "...sum of the square roots of the inverse of the individual..."	08/2011
Eq. 2-6 $\frac{1}{K_{Total}} = \frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_3} + \cdots \frac{1}{K_n}$ should be $\frac{1}{\sqrt{K_{Total}}} = \frac{1}{\sqrt{K_1}} + \frac{1}{\sqrt{K_2}} + \frac{1}{\sqrt{K_3}} + \cdots \frac{1}{\sqrt{K_n}}$	08/2011
PAGE 2-11 Eq. 2-16 $K_1 = 0.5\left(1 - \frac{d_1^2}{d_2^2}\right)^2$ should be $K_1 = 0.5\left(1 - \frac{d_1^2}{d_2^2}\right)$	10/2010
PAGE 2-13 "...expansion bend up of continuous 90 degree..." should be "...bend made up of..."	10/2010

PAGE 2-15

Column for values of G added to table 2-3: 10/2010

Table 2-3: Constants for K_{branch} in Equation 2-37			
Angle (α)	G	H	J
0-60°	Table 2-4	1	2
$\alpha = 90° \text{ at } \beta_{branch} \leq \frac{2}{3}$	1	1	2
$\alpha = 90° \text{ at } \beta_{branch} = 1$ *	$G = 1 + 0.3\left(\frac{Q_{branch}}{Q_{comb}}\right)^2$	0.3	0

Replace Tables 2-2 and 2-4: 08/2011

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

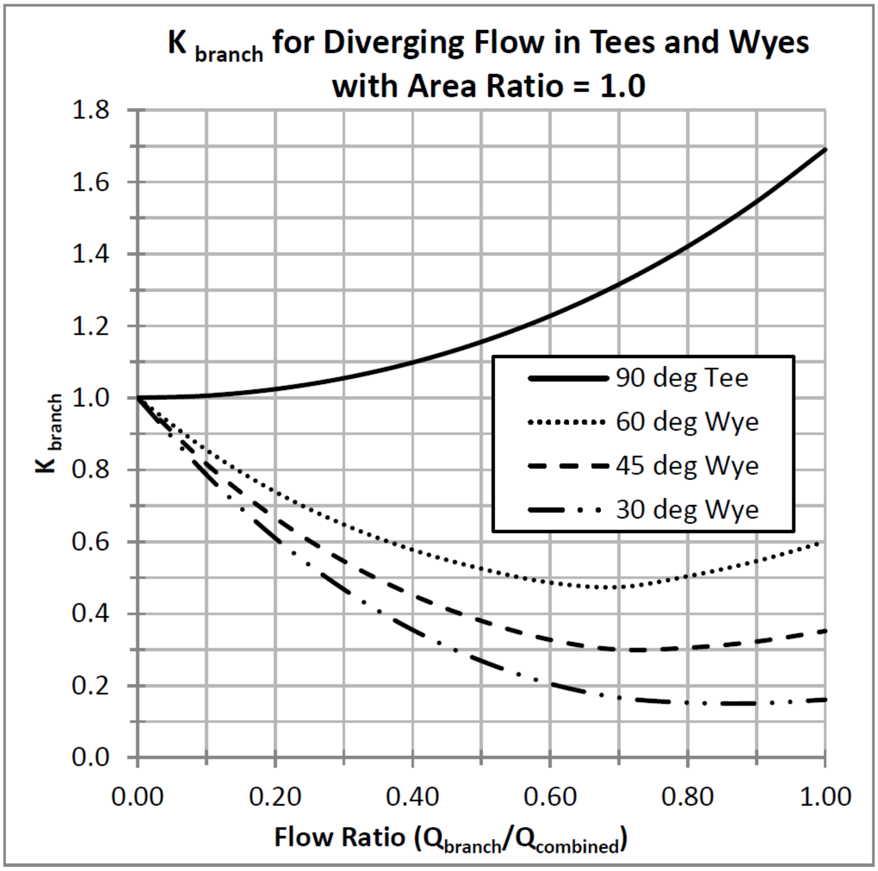
		Q_{branch} / Q_{comb} ≤ 0.4	Q_{branch} / Q_{comb} > 0.4
β^2_{branch}	≤ 0.35	$C = 1$	
β^2_{branch}	> 0.35	$C = 0.9\left(1 - \frac{Q_{branch}}{Q_{comb}}\right)$	$C = 0.55$

Table 2-4: Values of G for Equation 2-37 08/2011

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

PAGE 2-16

New Figure 2-16: — 08/2011



PAGE 3-4

Eq. 3-6 $K_{reducer}^{outlet} = 1.0\left[1-\left(\frac{d_{nom}}{d_1}\right)^2\right]^2$ should be $K_{reducer}^{outlet} = 1.0\left[1-\left(\frac{d_{nom}}{d_2}\right)^2\right]^2$ — 10/2010

Eq. 3-7 $\sum K = 1.5\left[1-\left(\frac{d_{nom}}{d_1}\right)^2\right]^2$ should be $\sum K = 1.5\left[1-\left(\frac{d_{nom}}{d}\right)^2\right]^2$ — 10/2010

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 Definition of x should read: "x = pressure drop ratio = $\Delta P/P'_1$" — 04/2010

PAGE 4-5

Eq. 4-7b $J = \frac{19000\beta}{\mathrm{Re}}$ should read: $J = \left(\frac{19000\beta}{\mathrm{Re}}\right)^{0.8}$ — 08/2011

PAGE 4-6

"The data is also plotted on page A-21 of this reference" should be "…page A-22" — 04/2010

Updates to Errata available online at: http://www.flowoffluids.com/publications/crane-tp-410/errata.aspx

"Equation 4-16 may be used for orifices…" should be "…Equation 4-14 may…"	04/2010
"…termination of the curves at $\rho'_2/\rho'_1 - r_c$" …should be "…$\rho'_2/\rho'_1 = r_c$…"	08/2011
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."	08/2011
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 relationship[46]:"	08/2011
Add Eq. 4-17: $r_c^{\frac{1-k}{k}} + \left(\frac{k-1}{2}\right)\beta^4 r_c^{\frac{2}{k}} = \frac{k+1}{2}$	08/2011
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 $P'_2/P'_1 = r_c$."	08/2011
PAGE 6-2 Viscosity Conversion should be $\nu = \frac{\mu}{\rho'} = \frac{\mu}{S_{4°C}} = \frac{62.428\mu}{\rho}$	08/2011
PAGE 6-4 Eq. 6-23 $P = S\left(\frac{Q}{C_V}\right)^2$ should be $\Delta P = S\left(\frac{Q}{C_V}\right)^2$	08/2011
$C_V = Q\sqrt{\frac{S}{\Delta P}} = 1.266\,Q\sqrt{\frac{\rho}{\Delta P}}$… should be $C_V = Q\sqrt{\frac{S}{\Delta P}} = 0.1266\,Q\sqrt{\frac{\rho}{\Delta P}}$…	08/2011
PAGE 6-5 Eq. 6-25 $\frac{1}{K_{Total}} = \frac{1}{K_1} + \frac{1}{K_2} + \frac{1}{K_3} + \cdots \frac{1}{K_n}$ should be $\frac{1}{\sqrt{K_{Total}}} = \frac{1}{\sqrt{K_1}} + \frac{1}{\sqrt{K_2}} + \frac{1}{\sqrt{K_3}} + \cdots \frac{1}{\sqrt{K_n}}$	08/2011

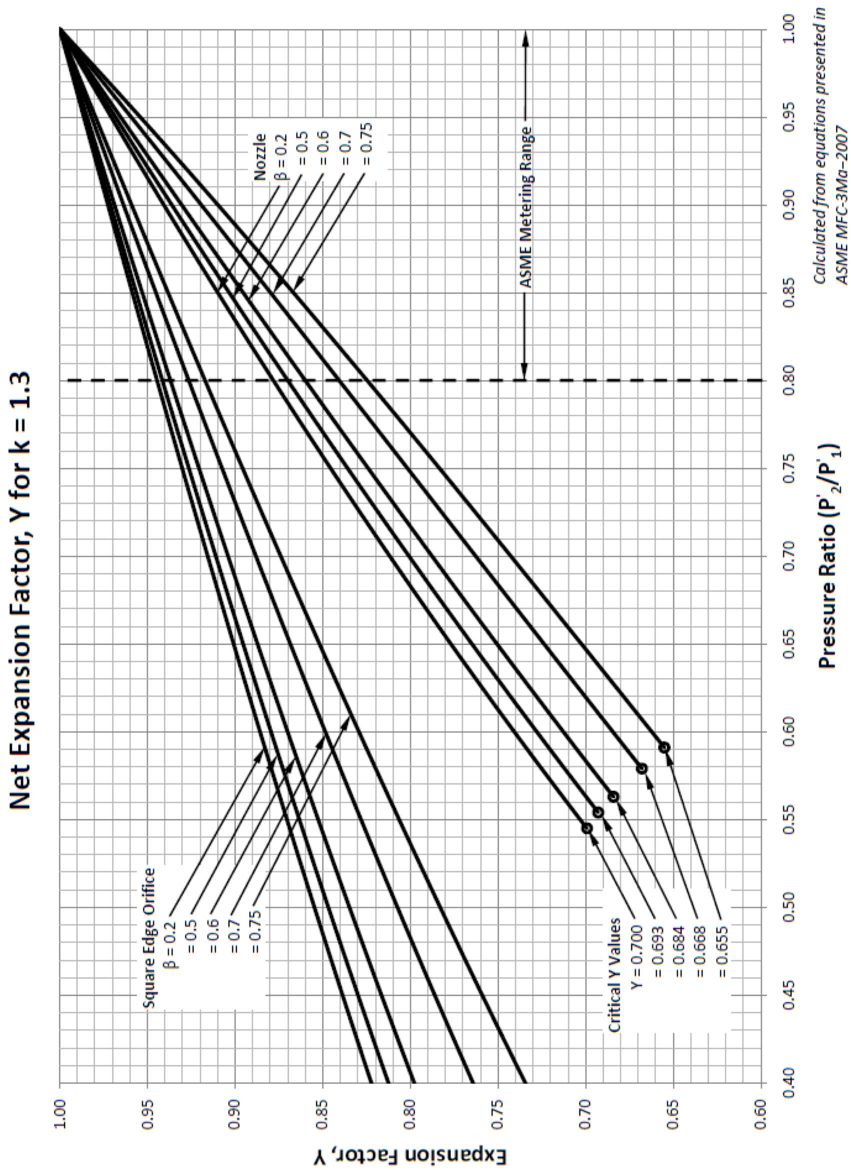
PAGE 7-2 Ex. 7-3 3. "$f_{T=0.016}$" should be "f_T = 0.0165 page A-26" 4. should read k = 150 x 0.0165 = 2.475 5. In the denominator 2.40 should be 2.475 The result 282.0 should be 277.4 6. L/D = 2.475/0.0165 = 150 7. Remove text "for graphical solution of step 5 through 7, use pages A-31&A-32" Ex. 7-4 3. "f_T = 0.015" should reference A-26 rather than A-27	10/2010 10/2010
PAGE 7-3 Ex. 7-6 "200 feet – 3" Schedule go pipe" should be "...Schedule 40..."	10/2010
PAGE 7-6 Ex. 7-10 "...6" Schedule 8o pipe..." should be "...Schedule 80..." "...as described in Example 6-4..." should be "...Example 7-4..." 4. "$\overline{V} = 1.430$" should be "$\overline{V} = 1.217$" "f_T = 0.015" should reference A-26 rather than A-27 8. should be: $\Delta P = \frac{2.799 \times 10^{-7} \times 16 \times 9^2 \times 10^8 \times 1.217}{5.761^4}$ $\Delta P = 40.1$	 10/2010 10/2010 08/2011 10/2010 08/2011 08/2011
PAGE 7-7 Ex. 7-12 10. "∴ use β = 0.68" should be "∴ use β = 0.665" 11. "Orifice size ≌ 11.938 x 0.68 = 8.1" should be "...x 0.665 = 7.94"	04/2010 04/2010
PAGE 7-14 Ex. 7-21 7. Should read: $\Delta P = 0.657 \times P_1' = 0.657 \times 139.7 = 91.8$	 08/2011
PAGE 7-17 Ex. 7-26 23. "f = 0.0155" should reference page A-25 rather than A-24	10/2010
PAGE 7-18 Ex. 7-27 6. C_v in the formula is 114 should be 78.98 7. Calculated C_v is 89.6 should be 80.02 8. "will be throttled to a C_v = 89.6" should be "C_v = 80.02"	10/2010 10/2010 10/2010

Appendices	
Page A-18 Total Temp headings: 350, 400, 500, 600, 700, 800, 900, 1000, 1100, 1300, 1500 Should be: 500, 600, 700, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500	04/2010
Page A-19 Total Temp headings: 350, 400, 500, 600, 700, 800, 900, 1000, 1100, 1300, 1500 Should be: 650, 700, 750, 800, 900, 1000, 1100, 1200, 1300, 1400, 1500	04/2010

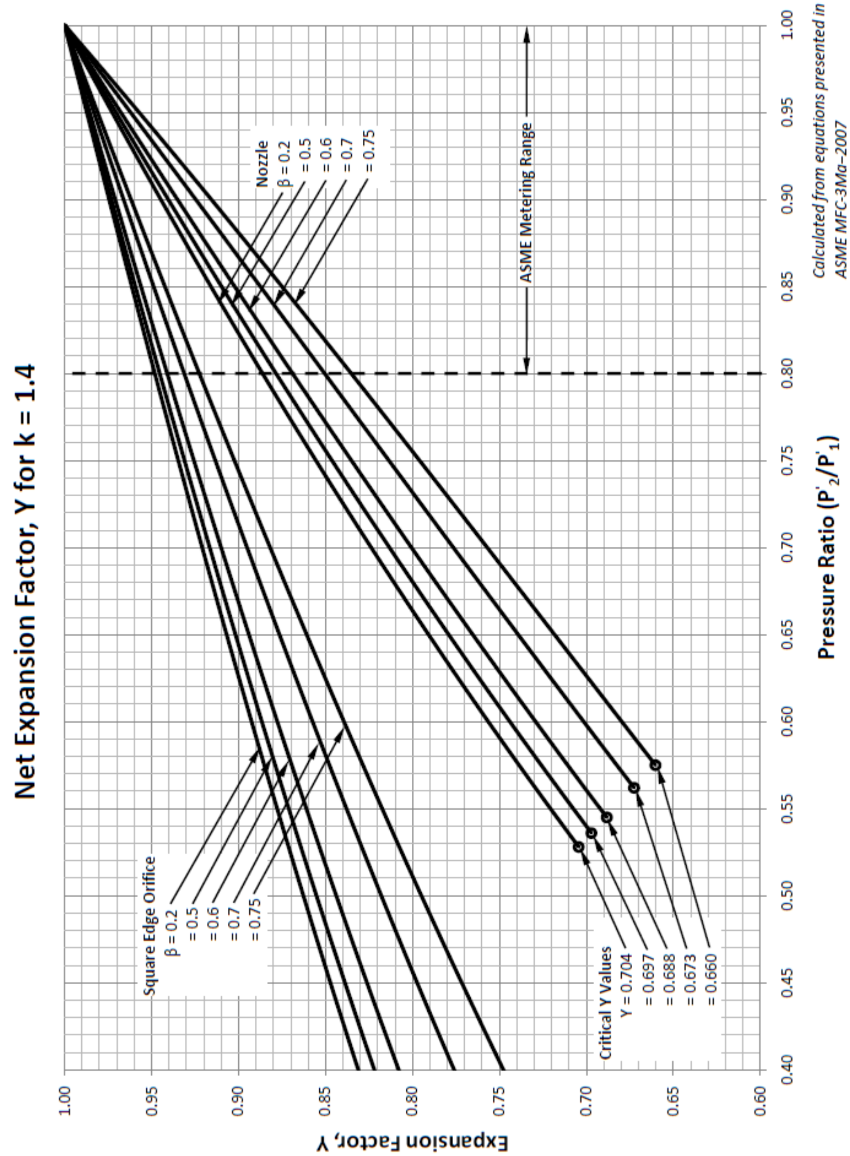
PAGE A-22

Page title should cite reference 27 and also 46 — 08/2011

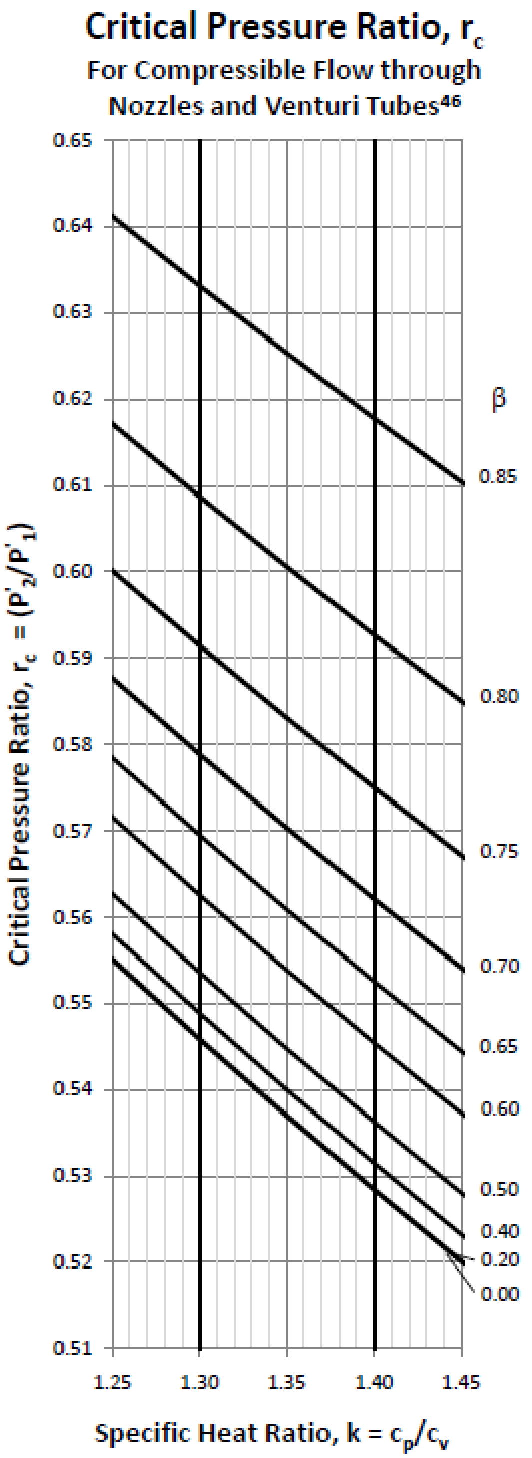
Graphs should change to the following:



08/2011


Net Expansion Factor, Y for k = 1.4
Nozzle
β = 0.2
= 0.5
= 0.6
= 0.7
= 0.75
ASME Metering Range
Square Edge Orifice
β = 0.2
= 0.5
= 0.6
= 0.7
= 0.75
Critical Y Values
Y = 0.704
= 0.697
= 0.688
= 0.673
= 0.660
Calculated from equations presented in
ASME MFC-3Ma–2007
Pressure Ratio (P'2/P'1)
Expansion Factor, Y
0.40
0.45
0.50
0.55
0.60
0.65
0.70
0.75
0.80
0.85
0.90
0.95
1.00

08/2011

	08/2011
PAGE A-30 Under STANDARD TEES AND WYES delete “For Converging or Diverging Flow:”	10/2010