Orifice Plate Coefficient of Expansion for High dP Compressible Fluid Flow - refer Cunningham "Orifice Meters with Supercritical Compressible Flow - Transactions of the ASME - July 1951"

Air k **1.4**

Experimental (Cunningham)

Beta Nom	Beta Act	K Calc	KY Exp 1	KY Exp 0.63	KY Exp 0	Y Exp 1	Y Exp 0.63	Y Exp 0	Y Fig 7 1	Y Fig 7 0.63	Y Fig 7 0
0.15	0.1503	0.608212	0.5993			1	0.8916	0.671	1	0.8916	0.671
0.2	0.2035	0.608712	0.616	0.548	0.407	1.011973	0.900262	0.668625	1	0.89	0.664
0.3	0.3027	0.611484	0.616	0.548	0.407	1.007385	0.89618	0.665594	1	0.89	0.664
0.4	0.4047	0.619132	0.616	0.548	0.407	0.994941	0.88511	0.657372	1	0.89	0.664
0.5	0.5037	0.634714	0.634	0.562	0.413	0.998875	0.885438	0.650687	1	0.886	0.653
0.6	0.6119	0.666179	0.665	0.585	0.423	0.998229	0.878142	0.634964	1	0.88	0.638
0.7	0.7049	0.710461	0.719	0.624	0.445	1.012019	0.878303	0.626354	1	0.87	0.62
0.8	0.8071	0.784099	0.82	0.703	0.452	1.045786	0.89657	0.576458	1	0.86	0.56

using K = 0.608 + 0.415 x B^4

Formula (Cunningham)

Beta Nom	Beta Act	Formula	1	0.63	0	
0.15	0.1503	Y = 1.0 - (0.41 + 0.35 x B^4) x (1 - r) / k	1	0.891596	0.671033	Y = $Y_{0.63}$ - 0.3501 x (0.63 - r)
0.2			1	0.891495	0.661545	Y = $Y_{0.63}$ - 0.3650 x (0.63 - r)
0.3			1	0.890894	0.660944	Y = $Y_{0.63}$ - 0.3650 x (0.63 - r)
0.4			1	0.889275	0.659325	Y = $Y_{0.63}$ - 0.3650 x (0.63 - r)

k **1.4**

0.41	0.49
0.35	0.45

Calculated (D Kirk)

Beta Nom	Beta Act	1	0.63	0	Y ASME 1	Y ASME 0.63 / Y Kirk	0
0.15	0.1503	1	0.891596	0.670992	1	0.891596	0.670994
0.2	0.2035	1	0.891484	0.670637	1	0.891495	0.670671
0.3	0.3027	1	0.890866	0.668666	1	0.890894	0.668753
0.4	0.4047	1	0.889162	0.66323	1	0.889275	0.663591
0.5	0.5037	1	0.885689	0.652154	1	0.885862	0.652705
0.6	0.6119	1	0.878675	0.629786	1	0.879655	0.632911
0.7	0.7049	1	0.868805	0.598309	1	0.869434	0.600313
0.8	0.8071	1	0.852392	0.545964	1	0.853755	0.550311

Comparison of calculated and experimental values for Y

	0.999995	0.999989	0.999996	0.99999	0.999996	0.99999
	0.99025	1.003009	0.990262	1.003059	1.00168	1.010046
	0.99407	1.004616	0.994101	1.004747	1.001004	1.007159
	1.004578	1.008911	1.004706	1.009461	0.999185	0.999384
	1.000283	1.002254	1.000478	1.003102	0.999844	0.999549
	1.000607	0.991846	1.001723	0.996767	0.999608	0.992023
	0.989186	0.955225	0.989902	0.958425	0.999349	0.968247
	0.950725	0.947101	0.952245	0.954642	0.992738	0.982698
Average	99.12%	98.91%	99.17%	99.13%	99.92%	99.49%

Steam k **1.3**

Experimental (Cunningham)

Beta Nom	Beta Act	Y Fig 4 1	0.63	0
0.15	0.1514	1	0.884	0.664

Formula (Cunningham)

Beta Nom	Beta Act	Formula	1	0.63	0	
0.15	0.1514	Y = 1.0 - (0.41 + 0.35 x B^4) x (1 - r) / k	1	0.891594	0.672354	Y = $Y_{0.63}$ - 0.3480 x (0.63 - r)

k **1.3**

0.41	0.49
0.35	0.45

Calculated (D Kirk)

Beta Nom	Beta Act	1	0.63	0	Y ASME 1	Y ASME 0.63 / Y Kirk	0
0.15	0.1514	1	0.883255	0.645679	1	0.883257	0.645685
0.2	0.2035	1	0.883137	0.645301	1	0.883148	0.645338
0.3	0.3027	1	0.882471	0.643179	1	0.882501	0.643273
0.4	0.4047	1	0.880636	0.637324	1	0.880758	0.637713
0.5	0.5037	1	0.876895	0.625396	1	0.877082	0.62599
0.6	0.6119	1	0.869342	0.601308	1	0.870398	0.604673
0.7	0.7049	1	0.858713	0.56741	1	0.85939	0.569568
0.8	0.8071	1	0.841037	0.511038	1	0.842505	0.515719

$$Y = 1 - \left(0.41 + 0.35.\beta^4\right).\frac{\left(1 - \frac{P2}{P1}\right)}{k}$$

$$- for 1 > \frac{P2}{P1} > 0.63$$

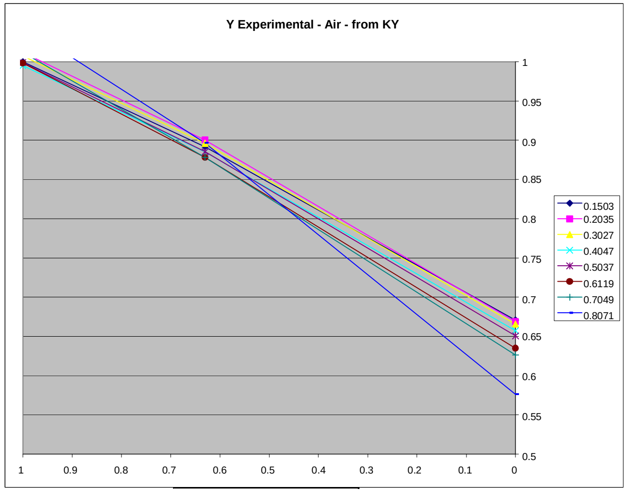
- the ASME Formula is valid down to P2/P1 = 0.63

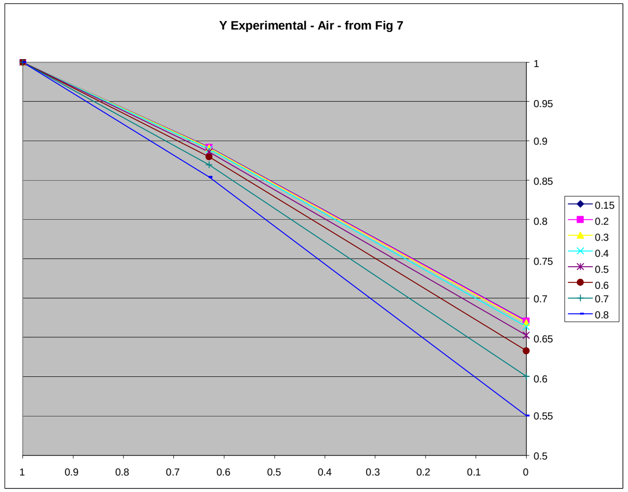
$$Y = Y_{0.63} - \left(0.49 + 0.45.\beta^4\right).\frac{\left(0.63 - \frac{P2}{P1}\right)}{k}$$

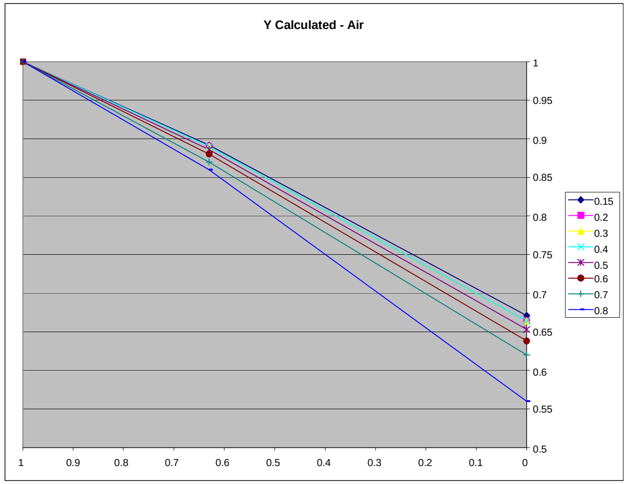
$$- for 0.63 > \frac{P2}{P1} > 0$$

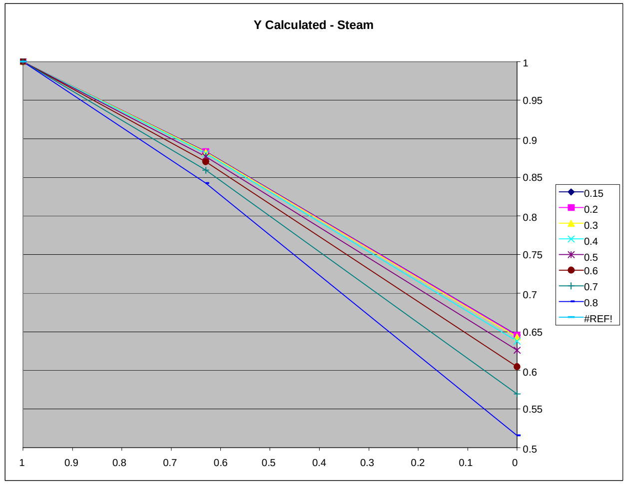
- $Y_{0.63}$ is Y from the ASME formula at P2/P1 = 0.63

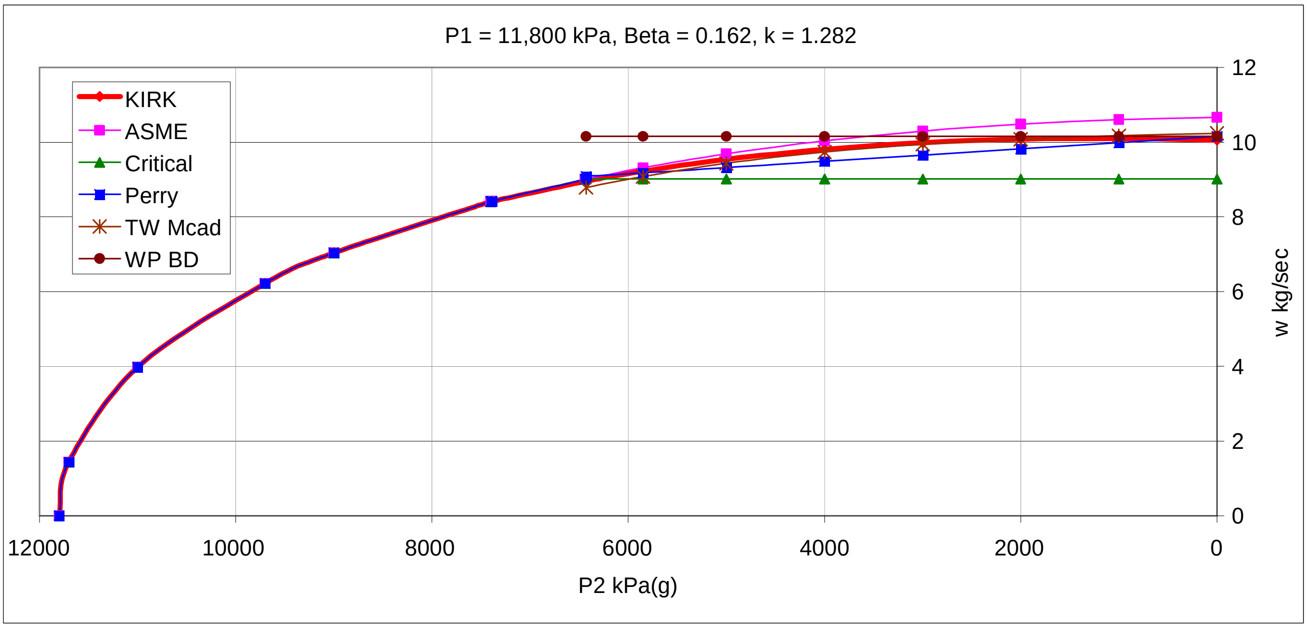
- use this formula for P2/P1 < 0.63

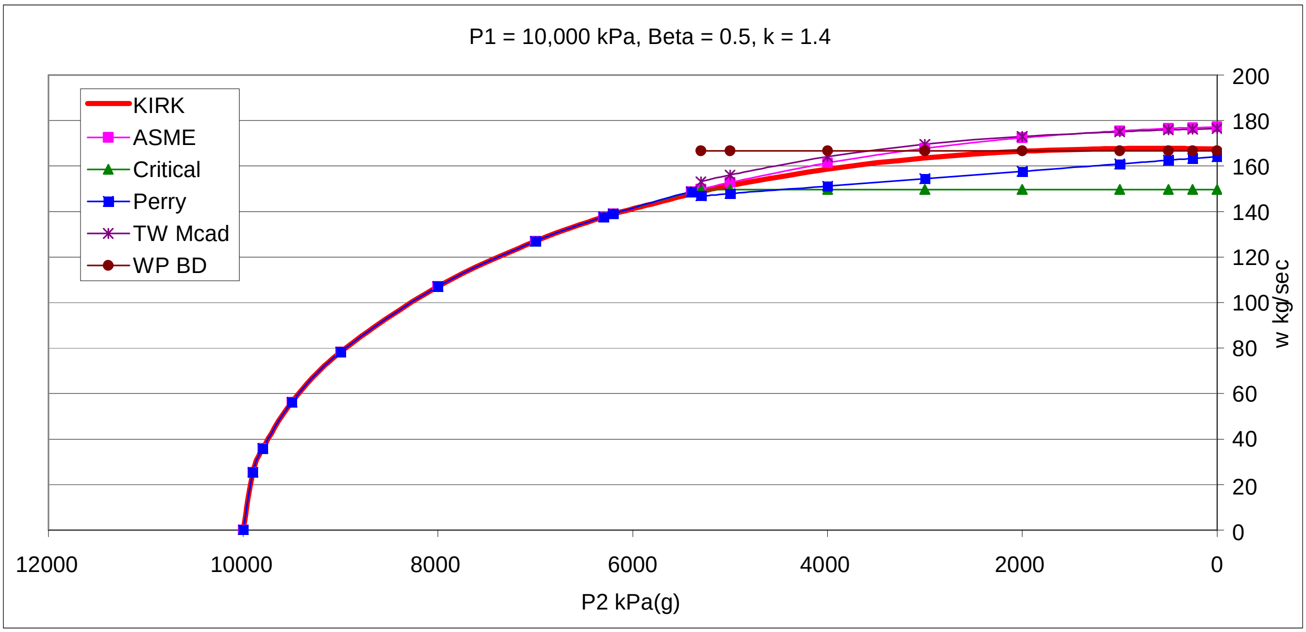


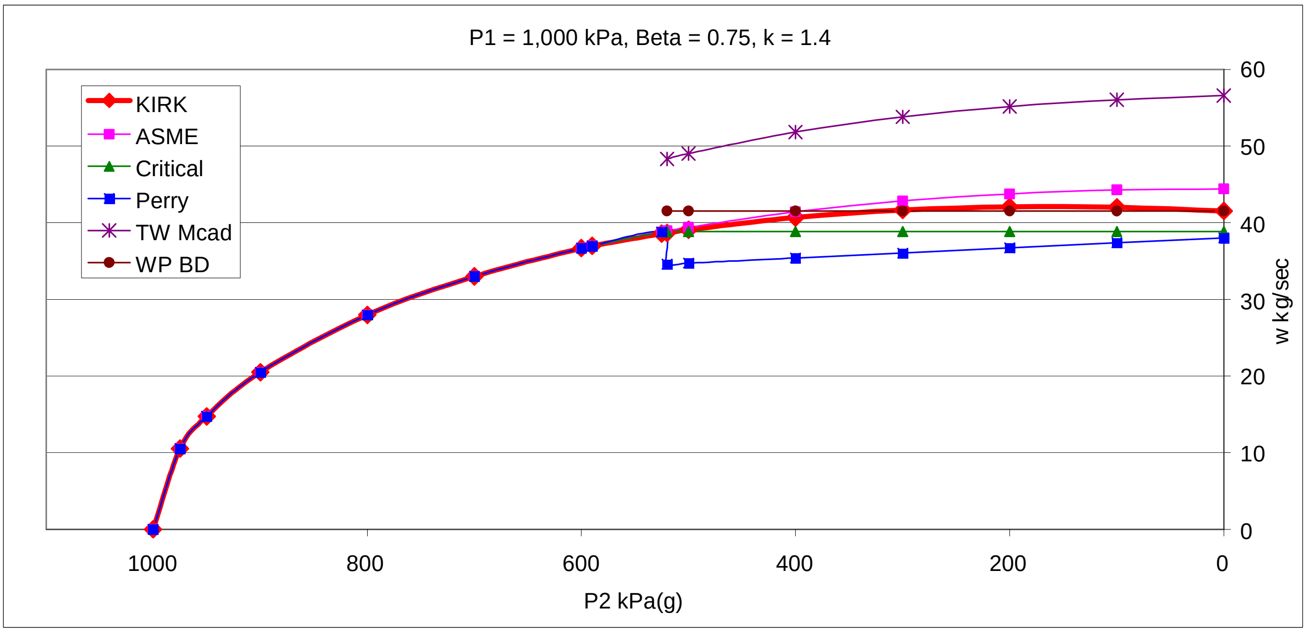







P1 = 11,800 kPa, Beta = 0.162, k = 1.282
KIRK
ASME
Critical
Perry
TW Mcad
WP BD
P2 kPa(g)
w kg/sec


P1 = 10,000 kPa, Beta = 0.5, k = 1.4
KIRK
ASME
Critical
Perry
TW Mcad
WP BD
P2 kPa(g)
w kg/sec


P1 = 1,000 kPa, Beta = 0.75, k = 1.4
KIRK
ASME
Critical
Perry
TW Mcad
WP BD
P2 kPa(g)
w kg/sec