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Chris Haslego
President
Cheresources, Inc.

1422 Goswick Ridge Road
Midlothian VA 23114

Fax: 561-658-6489
Email: support@cheresources.com

Content Based
Chemical Engineering

COMPRESSIBLE FLUID FLOW find flow, pressure drop known

REFERENCES: CRANE TECHNICAL PAPER 410

LIMITATIONS: k = 1.3 or 1.4 ONLY; `**SK**' must be between 1.2 and 100.

NOTE: Always begin a new case by retrieving the original file. Direct entry of data in cells that originally contain table lookups could cause functions to be lost, or incorrect calculations. I format cells requiring entry colored **RED**; calculated values are black.

1.) Enter identification at [B4]
2.) Enter fluid at [C6], use [=], then go to fluid name in table (A51...D112) eg. [=A53] is AIR. k, and MW will be automatically looked up in the table, if the fluid is in table. If not, these have to be entered at [F6] and [F7]. Note: k MUST be 1.3 or 1.4!
3.) Enter the pipe ID at [C7], use [=], then go to pipe table, eg; [=G56] is the ID for 1 1/2" schd 40, or [=H56] metric (40 mm) or directly enter the size if it is not in table.
4.) Enter straight pipe length at [C8].
5.) Enter inlet pressure at [C9], the absolute pressure will be shown at [F9].
6.) Enter outlet pressure at [C10], and the absolute pressure will be shown at [F10].
7.) Enter temperature at [C11], again the absolute value will show at cell [F11].
8.) Enter the number of each type of valve & fitting just to their left.[A18]...[A25] and at [D18]...[D25].
9.) Enter the nomimal size,eg; "4/6" (100/150) mm or "6/4" (150/100) mm for (dia1/dia2) at [F27] and [F28] to determine the beta coefficient. The size change 'k' will be calculated and included via [C33] and [C34]. For cases of NO increasers or reducers F27 & F28 should have zeroed out C33 & C34.
10.) Enter the manufacturer's certified test value of K_R for the rupture disk in cell [F30], when available. When a disk is included, the calculated flow capacity in cell [E44] is decreased to compensate for the 10% capacity reduction required by the (ASME) Code. The new calculated flow capacity is shown in cell [E47]. If a manufacturer's certified test value is not available use the (ASME Code) default value of 2.4.
11.) Entrance and exit losses: normally 0.5 and 1.0, enter 0 at [C29] and[C30] as desired, or any value needed.
12.) Misc K: for any item where `K' is known, but not listed above. Enter the value at [C32]
13.) Misc additional pressure: for any item where `delta P' is known, but not listed above. Enter the value at [F34].
14.) The program automatically determines choked or non-choked conditiions, and indicates this at [B37].
15.) Compressibility `Y' is determined and shown at [B39].
Flow `W' is calculated and shown at [E44].

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Print out using direct EXCEL commands.

dmcoffman@aol.com

04/11/04

COMPRESSIBLE FLUID FLOW find flow, pressure drop known

PIPE: Example 4-20....Steam at Sonic Velocity, Crane Technical Paper 410, pg. 4-13

fluid:	STEAM		k:	1.3	
pipe ID:	2.067	in	MW:	18.02	mol. weight
length:	30	ft	v1:	2.6733	ft^3/lb
P1 - in:	155.3	psig	P1a:	170.0	psia
P2 - out:	0	psig	P2a:	14.7	psia
temp:	368.23871	°F	T1a:	828.2	°R
ΔP:	155.3	psi	ΔP/P1a:	0.9135	

Fitting Losses ··· fitting friction factor, f t : 0.0190

	valves	K		fittings	K
0	gate valve	0.000	0	thru `T'	0.000
1	globe valve	6.460	0	branch`T'	0.000
0	angle valve	0.000	1	scrwd 90°	0.570
0	ball valve	0.000	0	scrwd 45°	0.000
0	plug valve	0.000	0	short rad 90°	0.000
0	diaphragm valve	0.000	0	short rad 45°	0.000
0	butterfly valve	0.000	0	long rad 90°	0.000
0	swing chk valve	0.000	0	long rad 45°	0.000

valves total:	6.460	**size change**		
fittings total:	0.570	reducer:	0.000	$dia._1$ / $dia._2$
entrance loss:	0.500	increaser:	0.000	$dia._1$ / $dia._2$
exit loss:	1.000			
pipe : 12 ·f ·l'/d:	3.309	rupture disk:	0.0	K_R
misc. K:	0.000	misc equiv len:	0.0	feet
reducer, K:	0.000	final length, l':	30.0	feet
increaser, K:	0.000			
ΣK:	11.839	add'l equip. ΔP:	0	psig

···· flow is choked ····

Y = 0.711 velocity = 376 fps

--- Limited by sonic velocity; Actual delta P = 133.5 psi and desired flow was not achieved! ---

$$W := 1891 \cdot Y \cdot d^2 \cdot \sqrt{\left(\frac{\Delta P}{\Sigma K \cdot v_1}\right)} \quad = \quad 11795 \quad \text{lb/hr of steam}$$

04/11/04

COMPRESSIBLE FLUID FLOW find flow, pressure drop known

PIPE: Example 4-20....Steam at Sonic Velocity, Crane Technical Paper 410, pg. 4-13

fluid:	STEAM		k:	1.3	
pipe ID:	52.48	millimeter	MW:	18.02	mol. weight
length:	9.144	meter	v1:	0.1668878	m^3/kg
P1 - in:	1070756	Pa	P1a:	1172109	Pa..abs
P2 - out:	0	Pa	P2a:	101353	Pa..abs
temp:	186.79929	°C	T1a:	459.9	°K
ΔP:	1070756	Pa	ΔP/P1a:	0.9135	

Fitting Losses ··· fitting friction factor, f t : 0.0190

	valves	K		fittings	K
0	gate valve	0.000	0	thru `T'	0.000
1	globe valve	6.460	0	branch`T'	0.000
0	angle valve	0.000	1	scrwd 90°	0.570
0	ball valve	0.000	0	scrwd 45°	0.000
0	plug valve	0.000	0	short rad 90°	0.000
0	diaphragm valve	0.000	0	short rad 45°	0.000
0	butterfly valve	0.000	0	long rad 90°	0.000
0	swing chk valve	0.000	0	long rad 45°	0.000

valves total:	6.460		**size change**		
fittings total:	0.570		reducer:	0.000	$dia._1$ / $dia._2$
entrance loss:	0.500		increaser:	0.000	$dia._1$ / $dia._2$
exit loss:	1.000				
pipe : f ·l'/d:	3.311		rupture disk:	0.0	K_R
misc. K:	0.000		misc equiv len:	0.0	meter
reducer, K:	0.000		final length, l':	9.1	meter
increaser, K:	0.000				
ΣK:	11.841		add'l equip. ΔP:	0	Pa

···· flow is choked ····

Y = 0.711 velocity = 114.4 meter/sec

--- Limited by sonic velocity; Actual delta P = 920,710 Pa and desired flow was not achieved! ---

$$W := 1.11 \cdot Y \cdot d^2 \cdot \sqrt{\left(\frac{\Delta P}{\Sigma K \cdot v_1}\right)} = 1.483153738 \text{ kg/sec of steam}$$

FLUID PROPERITIES			
name	fluid	k	MW
ACETIC ACID	CH3COOH	1.30	60.05
ACETYLENE	C2H2	1.30	26.00
AIR		1.40	28.97
ALKYL BROM	C12H25Br	1.20	249.24
AMMONIA	NH3	1.30	17.03
ARGON	A	1.40	39.90
BENZENE	C6H6	1.30	78.11
BROMINE	Br2	1.30	159.83
BUTANE	C4H10	1.30	58.10
CARBON DIO	CO2	1.30	44.01
CARBON DIS	CS2	1.30	76.13
CARBON MO	CO	1.40	28.01
CHLORINE	CL2	1.30	70.91
CHLOROFOR	CHCl3	1.30	119.39
CYANOGEN	(CN)2	1.30	52.02
CYCLOHEXAN	C6H12	1.30	84.16
ETHANE	C2H6	1.30	30.00
ETHYL ALCO	C2H5OH	1.30	46.07
ETHYL CHLO	C2H5CL	1.30	64.50
ETHYL ETHE	(C2H5)2O	1.30	74.12
ETHYLENE	C2H4	1.30	28.00
FREON 11	F-11	1.30	137.40
FREON 114a	F-114a	1.30	170.90
FREON 12	R-12	1.30	120.93
FREON 22	R-22	1.30	86.48
FREON HFC-	CH2FCF3	1.30	102.03
FUEL OIL (#2)		1.30	96.00
GASOLINE		1.30	86.00
HELIUM	He	1.40	4.00
HEPTANE	C7H16	1.30	100.20
HEXANE	C6H14	1.30	86.17
HYDROCHLO	HCl	1.40	36.47
HYDROGEN	H2	1.40	2.02
HYDROGEN I	HBr	1.40	80.92
HYDROGEN (	HCl	1.40	36.47
HYDROGEN (	HCN	1.30	27.03
HYDROGEN I	HI	1.40	127.91
HYDROGEN S	H2S	1.30	34.08
IODINE	I2	1.30	253.84
ISOBUTANE	C4H10	1.30	58.10
ISOPENTANE	C5H12	1.30	72.10
MERCURY	Hg	1.40	200.60
METHANE	CH4	1.30	16.04
METHYL ACE	CH3COOCH2	1.30	74.08
METHYL ALC	CH3OH	1.30	32.04
METHYL CHL	CH3Cl	1.30	50.49
METHYL ETH	(CH3)2 O	1.30	46.07
NATURAL GA	typical	1.30	19.50
NEON	Ne	1.40	20.20
NITRIC OXID	NO	1.40	30.01
NITROGEN	N2	1.40	28.02
NITROUS OX	N2O	1.30	44.02
OCTANE	O2	1.30	114.22
OXYGEN	O2	1.40	32.00
PENTANE	C5H12	1.30	72.10
PHOSPHORO	P	1.30	30.97
POTASSIUM	K	1.40	39.10
PROPANE	C3H8	1.30	44.10
PROPENE	C3H6	1.30	42.10
SODIUM	Na	1.40	22.99
STEAM	H2O	1.30	18.02
SULPHUR DI	SO2	1.30	64.07
TOLUENE	C6H5CH3	1.30	92.13

Pipe Data Table			
nominal diameter	ID schd 10S	ID schd 40	ID schd 80
1/2	0.674	0.622	0.546
3/4	0.884	0.824	0.742
1	1.097	1.049	0.957
1 1/4	1.422	1.380	1.278
1 1/2	1.682	1.610	1.500
2	2.157	2.067	1.939
2 1/2	2.635	2.469	2.323
3	3.260	3.068	2.900
3 1/2	3.760	3.548	3.364
4	4.260	4.026	3.826
6	6.357	6.065	5.761
8	8.329	7.981	7.625
10	10.420	10.020	9.562
12	12.390	11.938	11.374
14	13.624	13.124	12.500
16	15.624	15.000	14.312
18	17.624	16.867	16.124
20	19.564	18.812	17.938
24	23.500	22.624	21.562

COPPER TUBING			
nominal diameter	inside diameter Type K	Type L	Type M
1/8	0.186	0.200	0.200
1/4	0.311	0.315	0.325
3/8	0.402	0.430	0.450
1/2	0.527	0.545	0.569
5/8	0.652	0.666	0.690
3/4	0.745	0.785	0.811
1	0.995	1.025	1.055
1 1/4	1.245	1.265	1.291
1 1/2	1.481	1.505	1.571
2	1.959	1.985	2.009
2 1/2	2.435	2.465	2.495
3	2.907	2.945	2.981
3 1/2	3.385	3.425	3.459
4	3.857	3.905	3.935
5	4.805	4.875	4.907
6	5.741	5.845	5.881
8	7.583	7.725	7.785

SK	1.4			1.3			Pipe Friction Data - Crane TP-41		
	sonic vel	fig 6 - Y	Y vs SK	sonic vel	fig 5 - Y	Y vs SK	Nominal Size	Friction Factor, ƒt	Next Pipe Size
0.100	0.552	0.588	0.471	0.525	0.612	0.480			
1.200	0.552	0.588	0.590	0.525	0.612	0.613	0.125	0.034	0.250
1.500	0.576	0.606	0.602	0.550	0.631	0.623	0.250	0.032	0.500
2.000	0.612	0.622	0.617	0.593	0.635	0.637	0.500	0.027	0.750
3.000	0.662	0.639	0.638	0.642	0.658	0.655	0.750	0.025	1.000
4.000	0.697	0.649	0.652	0.678	0.670	0.668	1.000	0.023	1.500
6.000	0.737	0.671	0.672	0.722	0.685	0.685	1.500	0.021	2.000
8.000	0.762	0.685	0.684	0.750	0.698	0.697	2.000	0.019	2.500
10.000	0.784	0.695	0.693	0.773	0.705	0.707	2.500	0.018	3.000
15.000	0.818	0.702	0.705	0.807	0.718	0.718	3.000	0.018	4.000
20.000	0.839	0.710	0.710	0.831	0.718	0.718	4.000	0.017	6.000
40.000	0.883	0.710	0.710	0.877	0.718	0.718	6.000	0.015	8.000
100.000	0.926	0.716	0.710	0.920	0.720	0.718	8.000	0.014	10.000
							10.000	0.014	12.000
							12.000	0.013	14.000
							14.000	0.013	16.000
							16.000	0.013	18.000
							18.000	0.012	20.000
							20.000	0.012	24.000
							24.000	0.012	30.000
							30.000	0.011	36.000
							36.000	0.011	42.000
							42.000	0.010	48.000
							48.000	0.010	60.000

Factor "Y" Interpolation				
SK; actual	SK; next		SK	Y
0	0.1	Prior =	10	0.7065
0.1	1.2	Actual =	11.84	0.7107
1.2	1.5	Next =	15	0.7180
1.5	2.0	choking determination		
2.0	3.0	Prior =	10	0.7730
3.0	4.0	Actual =	11.84	0.7855
4.0	6.0	Next =	15	0.8070
6.0	8.0	1	flow is cho	DP/P1a = 0.9135294
8.0	10.0	test for actual DP =	133.54	psi
10.0	15.0	ASME Steam Table - 1967		
15.0	20.0	Applicable from 0 - 850 psig		
20.0	40.0	Pressure, psig :	155.3	
40.0	100.0	Pressure, psia :	170.0	
100.0	100.01	Temperature, °F :	368.2	
		Temperature, °R :	827.9	
		Steam Enth, btu/lb :	1195.9	
		Water Enth, btu/lb :	341.1	
		Evap Enth, btu/lb :	854.9	
		Stm Spec Vol, ft^3/lb :	2.6733	
		Stm Density, lb/ft^3 :	0.3741	
		Water Density, lb/ft^3 :	54.903	
		Wtr Spec Vol, ft^3/lb :	0.01821	
		Viscosity, cps :	0.01561	
		Ratio of Spec Heat, k :	1.299	

COMPRESSIBLE FLUID FLOW find pressure drop, flow known

PLEASE READ ITEM #14 BELOW IT IS MANDATORY FOR PROPER OPERATION OF THIS WORKSHEET !!!

REFERENCES: CRANE TECHNICAL PAPER 410

LIMITATIONS: k = 1.3 or 1.4 ONLY; `**SK**' must be between 1.2 and 100.

NOTE: Always begin a new case by retrieving the original file. Direct entry of data in cells that originally contain table lookups could cause functions to be lost, or incorrect calculations. I format cells requiring entry colored **RED**; calculated values are black.

1.) Enter identification at [B5].
2.) Enter fluid at [C7], use [=], then go to fluid name in table (A55...D115) eg. [=A57] is AIR. k, and MW will be automatically looked up in the table, if the fluid is in table. If not, these have to be entered at [F7] and [F8]. Note: k MUST be 1.3 or 1.4!
3.) Enter the pipe ID at [C8], use [=], then go to pipe table, eg; [=G60] is the ID for 1 1/2" schd 40, or [=H60] metric (40 mm) or directly enter the size if it is not in table.
4.) Enter straight pipe length at [C9].
5.) Enter inlet pressure at [C10], the absolute pressure will be shown at [F10].
6.) Enter the gas temperature at [C11], and the absolute temperature will be shown at [F11].
7.) Enter the target flow rate at [C12].
8.) Enter the number of each type of valve & fitting just to their left.[A19]...[A26] and at [D19]...[D26].
9.) Enter the nomimal size,eg; "4/6" (100/150) mm or "6/4" (150/100) mm for (dia1/dia2) at [F28] and [F29] to determine the beta coefficient. The size change 'k' will be calculated and included via [C34] and [C35]. For cases of NO increasers or reducers F28 & F29 should have zeroed out C34 & C35.
10.) In the case of a Rupture Disk enter the manufacturer's certified test value of K_R value in cell [F31]. When the manufacturer's certified test value is not available use the (ASME Code) default value of 2.4. If a disk is included, the flow rate input in cell [C12] is increased to compensate for the 10% capacity reduction required by the (ASME) Code. The new target flow rate is shown in cell [C14].
11.) Entrance and exit losses: normally 0.5 and 1.0, enter 0 at [C30] and [C31] as desired, or any value needed.
12.) Misc K: for any item where `K' is known, but not listed above. Enter the value at [C33].
13.) Misc additional pressure: for any item where `delta P' is known, but not listed above. Enter the value at [F35].
14.) This worksheet MUST be run in **MANUAL RECALCULATION MODE.** This mode is set by a macro each time DARCY2 is used. The original configuration of EXCEL is returned after exiting.
15.) The program automatically determines choked or non-choked conditiions, and indicates this at [B39]. Compressibility `Y' is determined and shown at [B41]. Pressure drop `(del P)' is calculated and shown at [E45]. Note: If the calculated pressure drop exceeds availiable, an ERROR flag will show at [A42]. Outlet pressure `P2' is calculated and shown at [E48].

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dmcoffman@aol.com

COMPRESSIBLE FLUID FLOW find pressure drop, flow known

WARNING: SET IN MANUAL RECALCULATION MODE; USE THE {CALC; F9} KEY TO CALCULATE!!

PIPE: Example 4-20...Steam at Sonic Velocity, Crane Technical Paper 410

fluid:	STEAM		k:	1.3	
pipe ID:	2.067	in	MW:	18.02	mol. weight
length:	30	ft	v1:	2.6732869	ft³/lb
P1 - in:	155.3	psig	P1a:	170	psia
temperature:	368.24	°F	T1a:	828.2387	°R
flow:	11780	lb/hr			

Fitting Losses ··· fitting friction factor, f_t : 0.0190

	valves	**K**		**fittings**	**K**
0	gate valve	0.000	0	thru `T'	0.000
1	globe valve	6.460	0	branch`T'	0.000
0	angle valve	0.000	1	scrwd 90°	0.570
0	ball valve	0.000	0	scrwd 45°	0.000
0	plug valve	0.000	0	short rad 90°	0.000
0	diaphragm valve	0.000	0	short rad 45°	0.000
0	butterfly valve	0.000	0	long rad 90°	0.000
0	swing chk valve	0.000	0	long rad 45°	0.000

valves total:	6.460		**size change**		
fittings total:	0.570		reducer:	0.00	$dia._1$ / $dia._2$
entrance loss:	0.500		increaser:	0.00	$dia._1$ / $dia._2$
exit loss:	1.000				
pipe : 12 ·f ·l'/d:	3.309		rupture disk:	0.0	K_R
misc. K:	0.000		misc equiv len:	0.0	feet
reducer, K:	0.000		final length, l':	30	feet
increaser, K:	0.000				
ΣK:	11.839		add'l equip. ΔP:	0	psig

···· flow is choked ····

velocity = 375.2 fps

Y = 0.711

--- Limited by sonic velocity; desired flow of W = 11,780 was not achieved! ---

$$\Delta P := \Sigma K \cdot v_1 \cdot \left(\frac{W}{1891 \cdot Y \cdot d^2} \right)^2 = 133.20 \text{ psig}$$

$P_2 = P_1 - \Delta P$ = 22.10 psig

36.80 psia

COMPRESSIBLE FLUID FLOW find pressure drop, flow known

WARNING: SET IN MANUAL RECALCULATION MODE; USE THE {CALC; F9} KEY TO CALCULATE!!

PIPE: Example 4-20...Steam at Sonic Velocity, Crane Technical Paper 410

fluid:	STEAM		k:	1.3	
pipe ID:	52.48	millimeter	MW:	18.02	mol. weight
length:	9.144	meter	v1:	0.1669	m^3/kg
P1 - in:	1070756	Pa	P1a:	1172109	Pa..abs
temperature:	186.80	°C	T1a:	459.9	°K
flow:	1.48426	kg/sec			

Fitting Losses ··· fitting friction factor, ft : 0.0190

	valves	**K**		**fittings**	**K**
0	gate valve	0.000	0	thru `T'	0.000
1	globe valve	6.460	0	branch`T'	0.000
0	angle valve	0.000	1	scrwd 90°	0.570
0	ball valve	0.000	0	scrwd 45°	0.000
0	plug valve	0.000	0	short rad 90°	0.000
0	diaphragm valve	0.000	0	short rad 45°	0.000
0	butterfly valve	0.000	0	long rad 90°	0.000
0	swing chk valve	0.000	0	long rad 45°	0.000

valves total:	6.460		**size change**		
fittings total:	0.570		reducer:	0.00	$dia._1$ / $dia._2$
entrance loss:	0.500		increaser:	0.00	$dia._1$ / $dia._2$
exit loss:	1.000				
pipe : f ·l'/d:	3.311		rupture disk:	0.0	K_R
misc. K:	0.000		misc equiv len:	0.0	meter
reducer, K:	0.000		final length, l':	9.144	meter
increaser, K:	0.000				
ΣK:	11.841		add'l equip. ΔP:	0	Pa

···· flow is choked ····

velocity = 114.4 meter/sec

Y = 0.711

--- Limited by sonic velocity; desired flow of W = 1.48426 was not achieved! ---

$$\Delta P := \Sigma K \cdot v_1 \cdot \left(\frac{W}{1.11 \cdot Y \cdot d^2} \right)^2 = 920709.82 \text{ Pa}$$

$P_2 = P_1 - \Delta P =$ 150046.18 Pa

251399.18 Pa..abs

FLUID PROPERITIES				PIPE					COPPER TUBING			
name	fluid	k	MW	nominal diameter		inside diameter			nominal			
ACETIC ACID	CH3COOH	1.30	60.05	millimeter	inch	schd 10S	std wt	schd 80	diameter	Type K	Type L	Type M
ACETYLENE	C2H2	1.30	26.00	15 mm	1/2	17.08	15.76	13.84	3	4.724	5.080	5.080
AIR		1.40	28.97	20 mm	3/4	22.48	20.96	18.88	6	7.899	8.001	8.255
ALKYL BROM	C12H25Br	1.20	249.24	25 mm	1.00	27.86	26.64	24.30	10	10.211	10.922	11.430
AMMONIA	NH3	1.30	17.03	32 mm	1-1/4	36.66	35.08	32.50	15	13.386	13.843	14.453
ARGON	A	1.40	39.90	40 mm	1-1/2	42.76	40.94	38.14	18	16.561	16.916	17.526
BENZENE	C6H6	1.30	78.11	50 mm	2.00	54.76	52.48	49.22	20	18.923	19.939	20.599
BROMINE	Br2	1.30	159.83	65 mm	2-1/2	66.90	62.68	58.98	25	25.273	26.035	26.797
BUTANE	C4H10	1.30	58.10	80 mm	3.00	82.80	77.92	73.66	32	31.623	32.131	32.791
CARBON DIO	CO2	1.30	44.01	90 mm	3-1/2	95.50	90.12	85.44	40	37.617	38.227	39.903
CARBON DIS	CS2	1.30	76.13	100 mm	4.00	108.20	102.26	97.18	50	49.759	50.419	51.029
CARBON MO	CO	1.40	28.01	150 mm	6.00	161.50	154.08	146.36	65	61.849	62.611	63.373
CHLORINE	CL2	1.30	70.91	200 mm	8.00	211.58	202.74	193.70	80	73.838	74.803	75.717
CHLOROFOR	CHCl3	1.30	119.39	250 mm	10.00	264.72	254.56	242.98	90	85.979	86.995	87.859
CYANOGEN	(CN)2	1.30	52.02	300 mm	12.00	314.76	304.84	289.00	100	97.968	99.187	99.949
CYCLOHEXAN	C6H12	1.30	84.16	350 mm	14.00	342.90	336.54	317.50	125	122.047	123.825	124.638
ETHANE	C2H6	1.30	30.00	400 mm	16.00	393.70	387.34	363.58	150	145.821	148.463	149.377
ETHYL ALCO	C2H5OH	1.30	46.07	450 mm	18.00	444.50	438.14	409.60	200	192.608	196.215	197.739
ETHYL CHLO	C2H5CL	1.30	64.50	500 mm	20.00	495.30	488.94	455.62				
ETHYL ETHE	(C2H5)2O	1.30	74.12	600 mm	24.00	596.90	590.54	547.72				
ETHYLENE	C2H4	1.30	28.00	SK	1.4			1.3			Pipe Friction Data - Crane TP-41	
FREON 11	F-11	1.30	137.40	SK	sonic vel	fig 6 - Y	Y vs SK	sonic vel	fig 5 - Y	Y vs SK	Nominal Size	Friction Factor, ƒt	Next Pipe Size
FREON 114a	F-114a	1.30	170.90	0.100	0.552	0.588	0.471	0.525	0.612	0.480			
FREON 12	F-12	1.30	120.90	1.200	0.552	0.588	0.590	0.525	0.612	0.613	15.000	0.027	20.000
FREON 22	F-22	1.30	86.50	1.500	0.576	0.606	0.602	0.550	0.631	0.623	20.000	0.025	25.000
FUEL OIL (#2)		1.30	96.00	2.000	0.612	0.622	0.617	0.593	0.635	0.637	25.000	0.023	32.000
GASOLINE		1.30	86.00	3.000	0.662	0.639	0.638	0.642	0.658	0.655	32.000	0.022	40.000
HELIUM	He	1.40	4.00	4.000	0.697	0.649	0.652	0.678	0.670	0.668	40.000	0.021	50.000
HEPTANE	C7H16	1.30	100.20	6.000	0.737	0.671	0.672	0.722	0.685	0.685	50.000	0.019	65.000
HEXANE	C6H14	1.30	86.17	8.000	0.762	0.685	0.684	0.750	0.698	0.697	65.000	0.018	80.000
HYDROCHLO	HCl	1.40	36.47	10.000	0.784	0.695	0.693	0.773	0.705	0.707	80.000	0.018	100.000
HYDROGEN	H2	1.40	2.02	15.000	0.818	0.714	0.705	0.807	0.728	0.718	100.000	0.017	125.000
HYDROGEN B	HBr	1.40	80.92	20.000	0.839	0.730	0.710	0.831	0.735	0.718	125.000	0.016	150.000
HYDROGEN C	HCl	1.40	36.47	40.000	0.883	0.742	0.710	0.877	0.746	0.718	150.000	0.015	200.000
HYDROGEN C	HCN	1.30	27.03	100.000	0.926	0.756	0.710	0.920	0.759	0.718	200.000	0.014	250.000
HYDROGEN I	HI	1.40	127.91								250.000	0.014	300.000
HYDROGEN S	H2S	1.30	34.08	Wchoked =	1.47433	kg/sec		calculated ΔP/P1a =	0.7855		300.000	0.013	350.000
IODINE	I2	1.30	253.84								350.000	0.013	400.000
ISOBUTANE	C4H10	1.30	58.10	choking determination				SK	Y		400.000	0.013	450.000
ISOPENTANE	C5H12	1.30	72.10	Prior =	10	0.7730	Prior =	10	0.7065		450.000	0.012	525.000
MERCURY	Hg	1.40	200.60	Actual =	11.84	0.7855	Actual =	11.84	0.7107		525.000	0.012	600.000
METHANE	CH4	1.30	16.04	Next =	15	0.8070	Next =	15	0.7180		600.000	0.012	600.000
METHYL ACE	CH3COOCH2	1.30	74.08	choked	1	ASME Steam Table - 1967 (Keenan & Keyes)							
METHYL ALC	CH3OH	1.30	32.04	Factor "Y" Interpolation		Applicable from 0 - 850 psig			Imperial	Metric			
METHYL CHL	CH3Cl	1.30	50.49	SK; actual	SK; next	Pressure, gauge :		psi | Pa	155.3	1070756.0			
METHYL ETH	(CH3)2 O	1.30	46.07	0	0.1	Pressure, abs :		psi | Pa	170.0	1172081.0			
NATURAL GA	typical	1.30	19.50	0.1	1.2	Temperature :		°F | °C	368.2	186.8			
NEON	Ne	1.40	20.20	1.2	1.5	Temperature, abs :		°R | °K	827.9	459.9			
NITRIC OXID	NO	1.40	30.01	1.5	2.0	Steam Enthalpy :		btu/lb|kJ/kg	1195.9	5007.1			
NITROGEN	N2	1.40	28.02	2.0	3.0	Water Enthalpy :		btu/lb|kJ/kg	341.1	1427.9			
NITROUS OX	N2O	1.30	44.02	3.0	4.0	Evap Enthalpy :		btu/lb|kJ/kg	854.9	3579.2			
OCTANE	O2	1.30	114.22	4.0	6.0	Steam Specific Volume :		$ft^3/lb\|m^3/kg$	2.6733	0.1669			
OXYGEN	O2	1.40	32.00	6.0	8.0	Steam Density :		$lb/ft^3\|kg/m^3$	0.3741	5.9920			
PENTANE	C5H12	1.30	72.10	8.0	10.0	Water Density :		$lb/ft^3\|kg/m^3$	54.903	879.465			
PHOSPHORO	P	1.30	30.97	10.0	15.0	Water Specific Volume :		$ft^3/lb\|m^3/kg$	0.01821	0.00114			
POTASSIUM	K	1.40	39.10	15.0	20.0	Viscosity :		cps|Pa.s	0.01561	0.00002			
PROPANE	C3H8	1.30	44.10	20.0	40.0	Ratio of Spec Heat :		Cp/Cv	1.299	1.299			
PROPENE	C3H6	1.30	42.10	40.0	100.0								
SODIUM	Na	1.40	22.99	100.0	100.01								
STEAM	H2O	1.30	18.02										
SULPHUR DI	SO2	1.30	64.07										
TOLUENE	C6H5CH3	1.30	92.13										