Name: Enrolment No:	UPES

UNIVERSITY OF PETROLEUM AND ENERGY STUDIES

End Semester Examination, May 2021

Programme Name: B. Tech. APE (Gas) Semester : IV
Course Name : Natural Gas Engineering Time : 03 hrs
Course Code : CHCE 3001 Max. Marks: 100
Nos. of page(s) : 23

Instructions:

- ✓ Draw diagrams wherever necessary
- ✓ Attempt questions in sequence
- ✓ Appendix with all the tables and graphs are attached at the end of the question paper

SECTION A (5 X 12= 60 Marks)

Answer all questions

S. No.		Marks	CO
1.	For the gas composition given below, calculate the following at 2000 psia and 60°F. a) the gas gravity b)pseudocritical pressure and pseudo critical temperature using kays mixing rule c)compressibility of gas Component / Mole %: Methane 85; Ethane 3; Propane 4; n-butane 4; CO2 2; H2S 2 **Note: The temperature has to be taken as T=60°F+ Roll Number** **Eg: If your roll no is 1 then the Temperature that needs to be considered will be 60+1= 61°F,** **if your roll no is 12 the temperature you need to consider will be 60+12=72°F** **If your roll no is 121 then the temperature you need to consider will be 60+121=181°F**	12M	CO1
2.	Explain the p-T phase diagrams for variable composition with an example. Is it possible to accurately predict the phase envelope? Justify	12M	CO2
3.	A gas is being compressed from 100 psia and 100°F to 2500 psia. Determine the ratio of specific heats for the natural gas composition given in the table below. Assume butanes to be all n-butane and C5+ fraction to be hexane.	12M	

Table for Question 1:

Component	Mole %
Methane	85
Ethane	3
Propane	4
n-butane	4
CO_2	2
H_2S	2

<table>
<tr><td></td><td>

Component	Mol fraction
Methane	0.8754
Ethane	0.0627
Propane	0.0374
Butanes	0.0138
Pentanes and above	0.0107

</td><td></td><td>CO3</td></tr>
<tr><td>4.</td><td>
Calculate the hourly flow rate of natural gas for the conditions given as follows:
Base Conditions: P_b=14.65 psia, T_b=60°F
Pipe Dimension: 4-in schedule 40 (D=4.026 –in ID), flange taps, static pressure measured upstream.
Orifice plate: stainless steel, orifice diameter d=1.5 in
Readings:
Elevation =500 ft
Latitude =66°
Atmospheric pressure: 14.4 psia
Flowing temperature=100°F
Gas specific gravity=0.6
Differential pressure =65 in . water column
Static pressure=641 psig
$$g = 3.2808 \times 10^{-2}(9.7801855 \times 10^{2} - 2.8247 \times 10^{-3}L + 2.029 \times 10^{-3}L^{2} - 1.5058 \times 10^{-5}L^{3} - 9.4 \times 10^{-5}H)$$
$L = latitude, deg.$
$H =$ elevation above the sea level, ft.
Neglect F_a.
</td><td>12M</td><td>CO4</td></tr>
<tr><td>5.</td><td>
A separator to be operated at 1000 psia, is required to handle a well stream with gas flow rate 8 MMsfcd at a GLR =40 bbl/MMscf. Determine the separator size required for a vertical separator, horizontal separator and a spherical separator. Assume a liquid density of 52 lbm/ft^3, ideal gas with gravity=0.80 an operating temperature equal to 100°F, a retention time t=3 min and half full of liquid conditions.
</td><td>12M</td><td>CO5</td></tr>
</table>

<table>
<tr><td></td><td>SECTION B (2 x 20=40 Marks)
Question 6 is compulsory. Internal choice in Q7.</td><td></td><td></td></tr>
<tr><td>6.</td><td>a) Explain the working of a reciprocating positive displacement compressor and the various steps in a reciprocating compressor cycle with a neat diagram?
b) A flow rate across a 3 in [2.9 in ID] pipeline is expected to be 1.5 MMSCFD. The line pressure is 200 psia. The gas gravity is 0.6 and the upstream temperature is 75°F . If the ideal range of differential pressure is 100 in of water and flange taps are used, what orifice plate diameter do we need to use? Assume Fr =Fpb=Ftb=Y=1, Neglect Fm , Fl and Fa. z factor at 200 psia and 75°F is 0.9682.
c) For a well stream having a composition shown as follows find the optimum second stage pressure for a three stage separation, if p_1=800 psia..Use the Whinery-campbell method.
<table>
<tr><td>Component</td><td>Mol fraction</td></tr>
<tr><td>C1</td><td>0.35</td></tr>
<tr><td>C2</td><td>0.25</td></tr>
<tr><td>C3</td><td>0.15</td></tr>
<tr><td>C4</td><td>0.10</td></tr>
<tr><td>C5</td><td>0.08</td></tr>
<tr><td>C6</td><td>0.04</td></tr>
<tr><td>C7+(C9)</td><td>0.03</td></tr>
</table></td><td>(6+7+7)
20M</td><td>CO3
&
CO4
&
CO5</td></tr>
<tr><td>7.</td><td>a) Determine the number of stages (n) required to compress 70 to 4310 kPa (gauge) with a compression ratio of 3:1, and calculate the exit temperature (T_2) if the compression is carried using a single stage if the gas enters first stage at 300K and the ratio of specific heats is 1.15.
b) Explain the orifice metering system in detail with neat diagrams.
c) A 0.7 gravity gas at 150°F is expanded through a choke, so that its pressure is reduced by 2000 psig..What is the temperature drop if the initial pressure is :1) 3500 psig and 2) 4500 psig 3) what is the final temperature if the gas is initially at 3000 psig and 170°F and the pressure is reduced to 200 psig..</td><td>(7+6+7)
20M</td><td>CO3
&
CO4
&
CO5</td></tr>
<tr><td></td><td>Or</td><td></td><td></td></tr>
</table>

7.	a) Estimate the brake horse power (BHP) needed to compress 35MMscfd of the gas from 10 to 625 psig. Assume the intake temperature (T_1) be 80°F, Z_1=1 and the ratio of specific heats is 1.15. b) Calculate the basic orifice factor, Reynolds number factor, Expansion factor and super compressibility factor (by specific gravity method) from a well with the following orifice meter information: Pipe diameter: 8-in nominal (8.071 in. ID) Orifice diameter =3.0 in. Gas specific gravity= 0.6 Flowing temperature =85° F Static pressure reading=110 psia Differential pressure reading = 175.5 in. water, Pipe taps downstream Assume base conditions of 14.73 psia and 60°F and that the gas has (in mole%): CO_2 =1.2, N_2 = 0.58. c) Explain the significance of low temperature separation?	(7+7+6) 20M	CO3 & CO4 & CO5

Appendix

Table 3-1
Physical Constants for Typical Natural Gas Constituents*

Compound	Molecular Weight	Critical Pressure (psia)	Critical Temp. (°R)	Crit. Comp. Factor (Z_c)	Acentric Factor (ω)	Eykman Mol Refraction** (EMR)
CH_4	16.043	667.8	343.1	0.289	0.0115	13.984
C_2H_6	30.070	707.8	549.8	0.285	0.0908	23.913
C_3H_8	44.097	616.3	665.7	0.281	0.1454	34.316
n-C_4H_{10}	58.124	550.7	765.4	0.274	0.1928	44.243
i-C_4H_{10}	58.124	529.1	734.7	0.283	0.1756	44.741
n-C_5H_{12}	72.151	488.6	845.4	0.262	0.2510	55.267
i-C_5H_{12}	72.151	490.4	828.8	0.273	0.2273	55.302
n-C_6H_{14}	86.178	436.9	913.4	0.264	0.2957	65.575
n-C_7H_{16}	100.205	396.8	972.5	0.263	0.3506	75.875
n-C_8H_{18}	114.232	360.6	1023.9	0.259	0.3978	86.193
n-C_9H_{20}	128.259	332.0	1070.4	0.251	0.4437	96.529
n-$C_{10}H_{22}$	142.286	304.0	1111.8	0.247	0.4902	106.859
N_2	28.013	493.0	227.3	0.291	0.0355	9.407
CO_2	44.010	1070.9	547.6	0.274	0.2250	15.750
H_2S	34.076	1306.0	672.4	0.266	0.0949	19.828
O_2	31.999	737.1	278.6	0.292	0.0196	8.495
H_2	2.016	188.2	59.9	0.304	− 0.2234	4.450
H_2O	18.015	3203.6	1165.1	0.230	0.3210	—

Table 1: Physical properties and critical constants

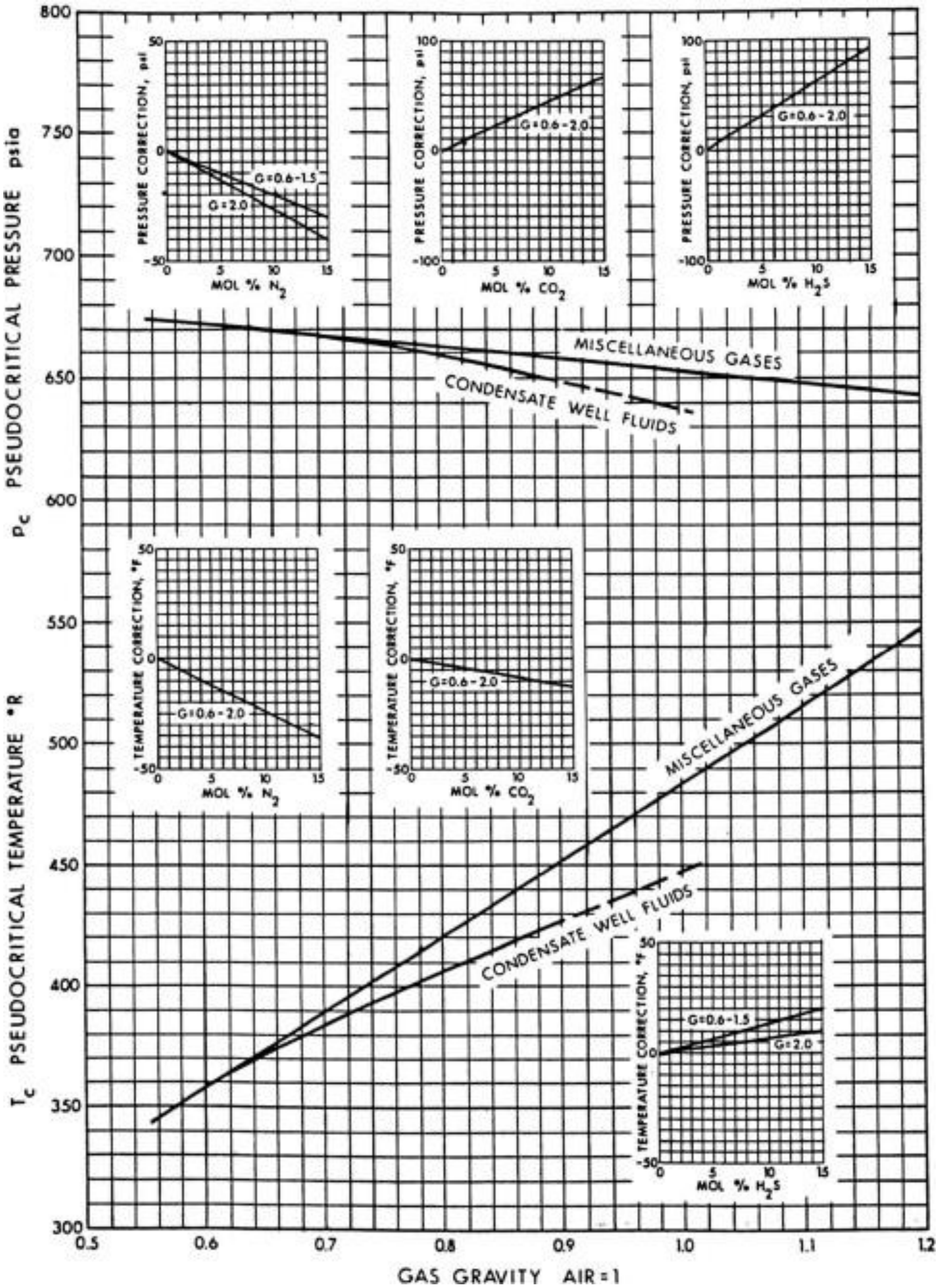
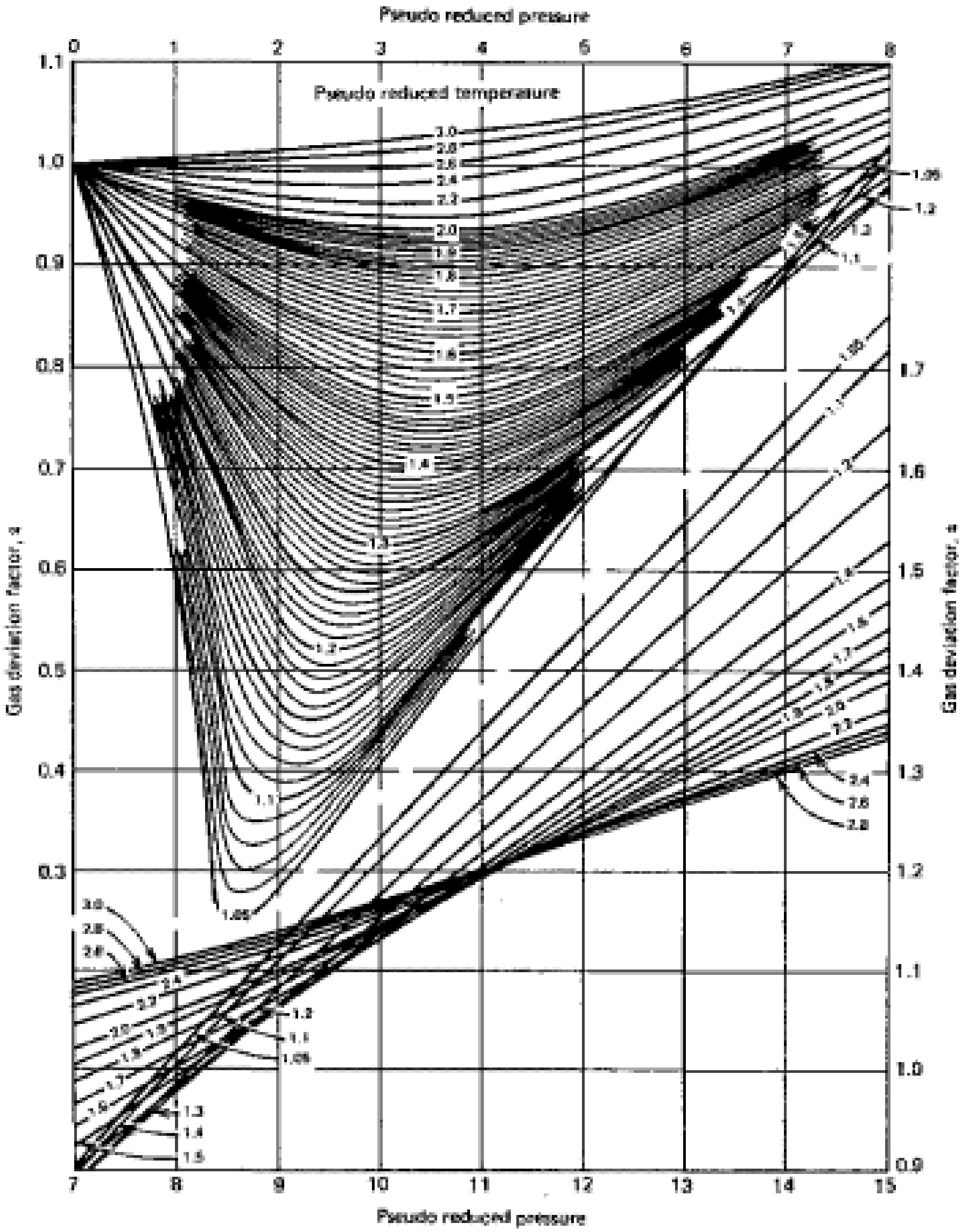


Fig 1: Browns Method chart


Pseudo reduced pressure
0
1
2
3
4
5
6
7
8
Pseudo reduced temperature
Gas deviation factor, z
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
7
8
9
10
11
12
13
14
15
Pseudo reduced pressure

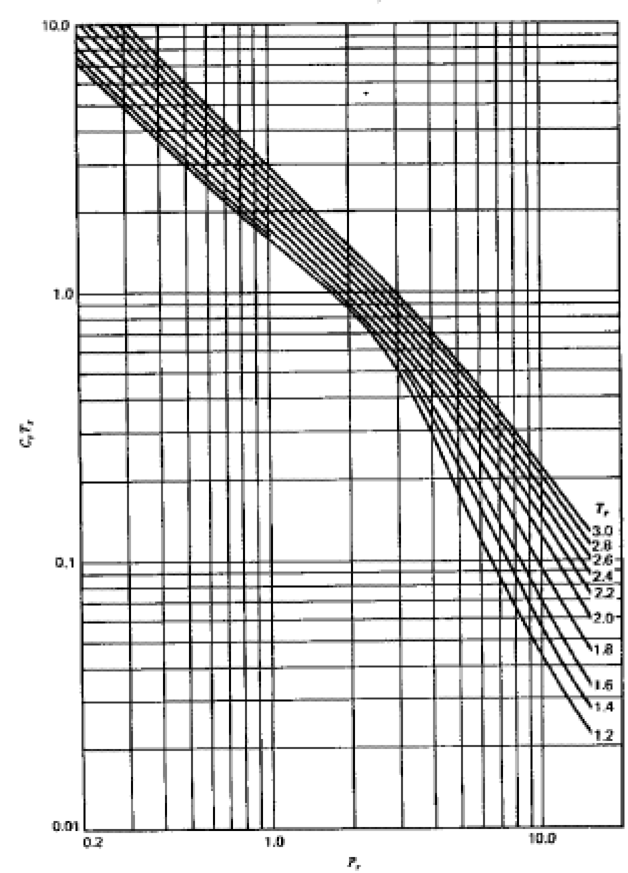


Fig. 2.9 Variation of $c_r T_r$ with reduced temperature and pressure ($1.4 \leq T_r \leq 3.0$; $0.2 \leq p_r \leq 15.0$). (After Mattar, Brar, and Aziz.)

Figure 2

Table 3-3*

Molal Heat Capacity (Ideal-Gas State), Btu/(lb mol-°R)**

Gas	Chemical formula	Mol wt	0°F	50°F	60°F	100°F	150°F	200°F	250°F	300°F
Methane	CH_4	16.043	8.23	8.42	8.46	8.65	8.95	9.28	9.64	10.01
Ethyne (Acetylene)	C_2H_2	26.038	9.68	10.22	10.33	10.71	11.15	11.55	11.90	12.22
Ethene (Ethylene)	C_2H_4	28.054	9.33	10.02	10.16	10.72	11.41	12.09	12.76	13.41
Ethane	C_2H_6	30.070	11.44	12.17	12.32	12.95	13.78	14.63	15.49	16.34
Propene (Propylene)	C_3H_6	42.081	13.63	14.69	14.90	15.75	16.80	17.85	18.88	19.89
Propane	C_3H_8	44.097	15.65	16.88	17.13	18.17	19.52	20.89	22.25	23.56
1-Butene (Butylene)	C_4H_8	56.108	17.96	19.59	19.91	21.18	22.74	24.26	25.73	27.16
cis-2-Butene	C_4H_8	56.108	16.54	18.04	18.34	19.54	21.04	22.53	24.01	25.47
trans-2-Butene	C_4H_8	56.108	18.84	20.23	20.50	21.61	23.00	24.37	25.73	27.07
iso-Butane	C_4H_{10}	58.124	20.40	22.15	22.51	23.95	25.77	27.59	29.39	31.11
n-Butane	C_4H_{10}	58.124	20.80	22.38	22.72	24.08	25.81	27.55	29.23	30.90
iso-Pentane	C_5H_{12}	72.151	24.94	27.17	27.61	29.42	31.66	33.87	36.03	38.14
n-Pentane	C_5H_{12}	72.151	25.64	27.61	28.02	29.71	31.86	33.99	36.08	38.13
Benzene	C_6H_6	78.114	16.41	18.41	18.78	20.46	22.45	24.46	26.34	28.15
n-Hexane	C_6H_{14}	86.178	30.17	32.78	33.30	35.37	37.93	40.45	42.94	45.36
n-Heptane	C_7H_{16}	100.205	34.96	38.00	38.61	41.01	44.00	46.94	49.81	52.61
Ammonia	NH_3	17.031	8.52	8.52	8.52	8.52	8.52	8.53	8.53	8.53
Air		28.964	6.94	6.95	6.95	6.96	6.97	6.99	7.01	7.03
Water	H_2O	18.015	7.98	8.00	8.01	8.03	8.07	8.12	8.17	8.23
Oxygen	O_2	31.999	6.97	6.99	7.00	7.03	7.07	7.12	7.17	7.23
Nitrogen	N_2	28.013	6.95	6.95	6.95	6.96	6.96	6.97	6.98	7.00
Hydrogen	H_2	2.016	6.78	6.86	6.87	6.91	6.94	6.95	6.97	6.98
Hydrogen sulfide	H_2S	34.076	8.00	8.09	8.11	8.18	8.27	8.36	8.46	8.55
Carbon monoxide	CO	28.010	6.95	6.96	6.96	6.96	6.97	6.99	7.01	7.03
Carbon dioxide	CO_2	44.010	8.38	8.70	8.76	9.00	9.29	9.56	9.81	10.05

* Courtesy of Gas Processors Suppliers Association

Table-2 Molal heat capacity

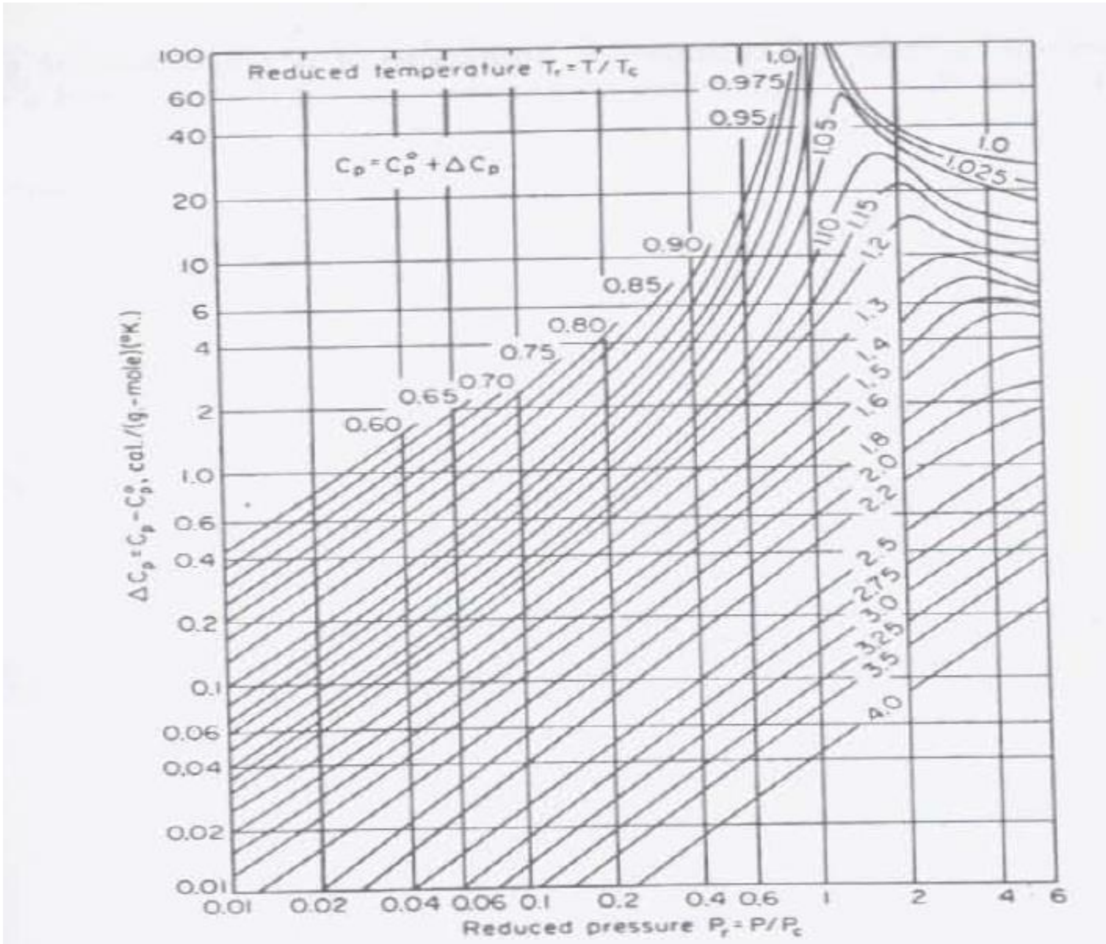

Reduced temperature $T_r = T/T_c$
$C_p = C_p^\circ + \Delta C_p$
$\Delta C_p = C_p - C_p^\circ$, cal./(g.-mole)(°K.)
Reduced pressure $P_r = P/P_c$
0.60
0.65
0.70
0.75
0.80
0.85
0.90
0.95
0.975
1.0
1.05
1.10
1.15
1.2
1.3
1.4
1.5
1.6
1.8
2.0
2.2
2.5
2.75
3.0
3.25
3.5
4.0
1.025
100
60
40
20
10
6
4
2
1.0
0.6
0.4
0.2
0.1
0.06
0.04
0.02
0.01
0.01
0.02
0.04
0.06
0.1
0.2
0.4
0.6
1
2
4
6

Figure 3

Temperature drop accompanying a given pressure drop

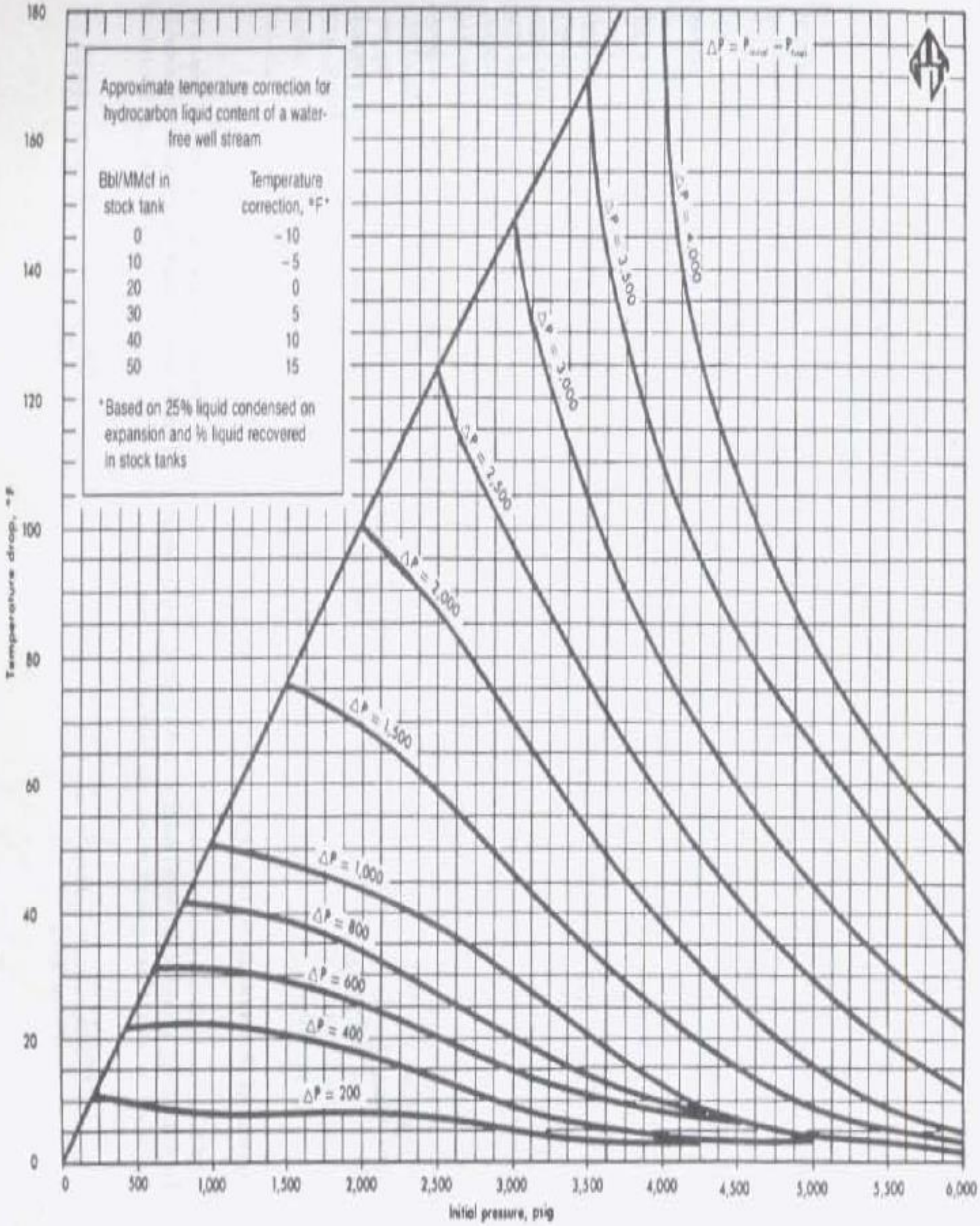


Table 10-2
Flange Taps—Basic Orifice Factors—F_b

Base temperature = 60°F Flowing temperature = 60°F $\sqrt{h_w p_f} = \infty$
Base pressure = 14.73 psia Specific gravity = 1.0 $h_w/p_f = 0$

Pipe Sizes—Nominal and Published Inside Diameters, Inches

Orifice Diameter, in.		2			3				4
	1.689	1.939	2.067	2.300	2.626	2.900	3.068	3.152	3.438
0.250	12.695	12.707	12.711	12.714	12.712	12.708	12.705	12.703	12.697
0.375	28.474	28.439	28.428	28.411	28.393	28.382	28.376	28.373	28.364
0.500	50.777	50.587	50.521	50.435	50.356	50.313	50.292	50.284	50.258
0.625	80.090	79.509	79.311	79.052	78.818	78.686	78.625	78.598	78.523
0.750	117.09	115.62	115.14	114.52	113.99	113.70	113.56	113.50	113.33
0.875	162.95	159.56	158.47	157.12	156.00	155.41	155.14	155.03	154.71
1.000	219.77	212.47	210.22	207.44	205.18	204.04	203.54	203.33	202.75
1.125	290.99	276.20	271.70	266.35	262.06	259.95	259.04	258.65	257.63
1.250	385.78	353.58	345.13	335.12	327.39	323.63	322.03	321.37	319.61
1.375		448.57	433.50	415.75	402.18	395.80	393.09	391.97	389.03
1.500			542.26	510.86	487.98	477.36	472.96	471.14	466.39
1.625				623.91	586.82	569.65	562.58	559.72	552.31
1.750					701.27	674.44	663.42	658.96	647.54
1.875					834.88	793.88	777.18	770.44	753.17
2.000						930.65	906.01	896.06	870.59
2.125						1091.2	1052.5	1038.1	1001.4
2.250							1223.2	1199.9	1147.7
2.375									1311.7
2.500									1498.4

Orifice Diameter, in.	4			6				8	
	3.826	4.026	4.897	5.182	5.761	6.065	7.625	7.981	8.071
0.250	12.687	12.683							
0.375	28.353	28.348							
0.500	50.234	50.224	50.197	50.191	50.182	50.178			
0.625	78.450	78.421	78.338	78.321	78.296	78.287			
0.750	113.15	113.08	112.87	112.82	112.75	112.72			
0.875	154.40	154.27	153.88	153.78	153.63	153.56	153.34	153.31	153.31
1.000	202.20	201.99	201.34	201.19	200.96	200.85	200.46	200.39	200.38
1.125	256.69	256.33	255.31	255.08	254.72	254.56	253.99	253.69	253.87
1.250	318.03	317.45	315.83	315.48	314.95	314.72	313.91	313.78	313.74
1.375	386.45	385.51	382.99	382.47	381.70	381.37	380.25	380.06	380.02
1.500	462.27	460.79	456.93	456.16	455.03	454.57	453.02	452.78	452.72
1.625	545.89	543.61	537.77	536.64	535.03	534.38	532.27	531.95	531.87
1.750	637.84	634.39	625.73	624.09	621.79	620.88	618.02	617.60	617.50
1.875	738.75	733.68	721.03	718.69	715.44	714.19	710.32	709.77	709.64
2.000	849.41	842.12	823.99	820.68	816.13	814.41	809.22	808.50	808.34
2.125	970.95	960.48	934.97	930.35	924.07	921.71	914.79	913.86	913.64
2.250	1104.7	1089.9	1054.4	1048.1	1039.5	1036.3	1027.1	1025.9	1025.6
2.375	1252.1	1231.7	1182.9	1174.2	1162.6	1158.3	1146.2	1144.7	1144.3
2.500	1415.0	1387.2	1320.9	1309.3	1293.8	1288.2	1272.3	1270.3	1269.8
2.625	1595.6	1558.2	1469.2	1453.9	1433.5	1426.0	1405.4	1402.9	1402.3
2.750	1797.1	1746.7	1628.9	1608.7	1582.1	1572.3	1545.7	1542.5	1541.8
2.875		1955.5	1801.0	1774.5	1740.0	1727.5	1693.4	1689.3	1688.4
3.000		2194.9	1986.6	1952.4	1907.8	1891.9	1848.6	1843.5	1842.3
3.125			2187.2	2143.4	2086.4	2066.1	2011.6	2005.2	2003.8
3.250			2404.2	2348.8	2276.5	2250.8	2182.6	2174.6	2172.9
3.375			2639.5	2569.8	2479.1	2446.8	2361.8	2352.0	2349.9
3.500			2895.5	2808.1	2695.1	2654.9	2654.9	2537.7	2535.0

From *Orifice Metering of Natural Gas*, 1969; courtesy of AGA.

(table continued)

Table 10-3 Continued
"b" Values for Reynolds Number Factor F_r Determination—Flange Taps

Orifice Diameter in.	4		6				8		
	3.826	4.026	4.897	5.189	5.761	6.065	7.625	7.981	8.071
0.250	0.1047	0.1054							
0.375	0.0894	0.0907							
0.500	0.0763	0.0779	0.0836	0.0852	0.0880	0.0892			
0.625	0.0653	0.0670	0.0734	0.0753	0.0785	0.0801			
0.750	0.0561	0.0578	0.0645	0.0665	0.0701	0.0718			
0.875	0.0487	0.0502	0.0567	0.0587	0.0625	0.0643	0.0723	0.0738	0.0742
1.000	0.0430	0.0442	0.0500	0.0520	0.0557	0.0576	0.0660	0.0676	0.0680
1.125	0.0388	0.0396	0.0444	0.0462	0.0498	0.0517	0.0602	0.0619	0.0623
1.250	0.0361	0.0364	0.0399	0.0414	0.0447	0.0464	0.0549	0.0566	0.0571
1.375	0.0347	0.0344	0.0363	0.0375	0.0403	0.0419	0.0501	0.0518	0.0523
1.500	0.0345	0.0336	0.0336	0.0344	0.0367	0.0381	0.0457	0.0474	0.0479
1.625	0.0354	0.0338	0.0318	0.0322	0.0337	0.0348	0.0418	0.0435	0.0439
1.750	0.0372	0.0350	0.0307	0.0306	0.0314	0.0322	0.0383	0.0399	0.0403
1.875	0.0398	0.0370	0.0305	0.0298	0.0298	0.0303	0.0353	0.0366	0.0371
2.000	0.0430	0.0395	0.0308	0.0296	0.0287	0.0288	0.0327	0.0340	0.0343
2.125	0.0467	0.0427	0.0318	0.0300	0.0281	0.0278	0.0304	0.0315	0.0318
2.250	0.0507	0.0462	0.0334	0.0310	0.0281	0.0274	0.0286	0.0295	0.0297
2.375	0.0548	0.0501	0.0354	0.0324	0.0286	0.0274	0.0271	0.0278	0.0280
2.500	0.0589	0.0540	0.0378	0.0342	0.0295	0.0279	0.0259	0.0264	0.0265
2.625	0.0626	0.0579	0.0406	0.0365	0.0308	0.0287	0.0251	0.0253	0.0254
2.750	0.0659	0.0615	0.0436	0.0391	0.0324	0.0300	0.0246	0.0245	0.0245
2.875		0.0647	0.0468	0.0418	0.0343	0.0314	0.0244	0.0240	0.0240
3.000		0.0673	0.0500	0.0448	0.0366	0.0332	0.0245	0.0238	0.0237
3.125			0.0533	0.0479	0.0389	0.0353	0.0248	0.0239	0.0237
3.250			0.0564	0.0510	0.0416	0.0375	0.0254	0.0242	0.0240
3.375			0.0594	0.0541	0.0443	0.0400	0.0263	0.0248	0.0244
3.500			0.0620	0.0569	0.0472	0.0426	0.0273	0.0255	0.0251
3.625			0.0643	0.0597	0.0500	0.0452	0.0286	0.0265	0.0260
3.750				0.0621	0.0527	0.0479	0.0300	0.0274	0.0271
3.875				0.0640	0.0553	0.0505	0.0316	0.0289	0.0283
4.000					0.0578	0.0531	0.0334	0.0304	0.0297
4.250					0.0620	0.0579	0.0372	0.0338	0.0330
4.500						0.0618	0.0414	0.0386	0.0366
4.750							0.0457	0.0416	0.0405
5.000							0.0500	0.0457	0.0446
5.250							0.0539	0.0497	0.0487
5.500							0.0574	0.0535	0.0524
5.750								0.0569	0.0559
6.000									0.0588

Orifice Diameter, in.	10			12			16		
	9.564	10.020	10.136	11.376	11.938	12.090	14.688	15.000	15.250
1.000	0.0738								
1.125	0.0685	0.0701	0.0705						
1.250	0.0635	0.0652	0.0656	0.0698	0.0714	0.0718			
1.375	0.0588	0.0606	0.0610	0.0654	0.0671	0.0676			
1.500	0.0545	0.0563	0.0568	0.0612	0.0631	0.0635	0.0706	0.0713	
1.625	0.0504	0.0523	0.0527	0.0573	0.0592	0.0597	0.0670	0.0678	0.0684
1.750	0.0467	0.0485	0.0490	0.0536	0.0555	0.0560	0.0636	0.0644	0.0650

Table 10-4
Y_1 Expansion Factors—Flange Taps
Static Pressure Taken from Upstream Taps

$\frac{h_w}{P_n}$ Ratio	$\beta = \frac{d}{D}$ Ratio 0.1	0.2	0.3	0.4	0.45	0.50	0.52	0.54	0.56	0.58	0.60	0.61	0.62
0.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.1	0.9989	0.9989	0.9989	0.9988	0.9988	0.9988	0.9988	0.9988	0.9988	0.9988	0.9987	0.9987	0.9987
0.2	0.9977	0.9977	0.9977	0.9977	0.9976	0.9976	0.9976	0.9976	0.9975	0.9975	0.9975	0.9975	0.9974
0.3	0.9966	0.9966	0.9966	0.9965	0.9965	0.9964	0.9964	0.9963	0.9963	0.9963	0.9962	0.9962	0.9962
0.4	0.9954	0.9954	0.9954	0.9953	0.9953	0.9952	0.9952	0.9951	0.9951	0.9950	0.9949	0.9949	0.9949
0.5	0.9943	0.9943	0.9943	0.9942	0.9941	0.9940	0.9940	0.9939	0.9938	0.9938	0.9937	0.9936	0.9936
0.6	0.9932	0.9932	0.9931	0.9930	0.9929	0.9928	0.9927	0.9927	0.9926	0.9925	0.9924	0.9924	0.9923
0.7	0.9920	0.9920	0.9920	0.9919	0.9918	0.9916	0.9915	0.9915	0.9914	0.9913	0.9912	0.9911	0.9910
0.8	0.9909	0.9909	0.9908	0.9907	0.9906	0.9904	0.9903	0.9902	0.9901	0.9900	0.9899	0.9898	0.9897
0.9	0.9898	0.9897	0.9897	0.9895	0.9894	0.9892	0.9891	0.9890	0.9889	0.9888	0.9886	0.9885	0.9885
1.0	0.9886	0.9886	0.9885	0.9884	0.9882	0.9880	0.9879	0.9878	0.9877	0.9875	0.9874	0.9873	0.9872
1.1	0.9875	0.9875	0.9874	0.9872	0.9870	0.9868	0.9867	0.9866	0.9864	0.9863	0.9861	0.9860	0.9859
1.2	0.9863	0.9863	0.9862	0.9860	0.9859	0.9856	0.9855	0.9853	0.9852	0.9850	0.9848	0.9847	0.9846
1.3	0.9852	0.9852	0.9851	0.9849	0.9847	0.9844	0.9843	0.9841	0.9840	0.9838	0.9836	0.9835	0.9833
1.4	0.9841	0.9840	0.9840	0.9837	0.9835	0.9832	0.9831	0.9829	0.9827	0.9825	0.9823	0.9822	0.9821
1.5	0.9829	0.9829	0.9828	0.9826	0.9823	0.9820	0.9819	0.9817	0.9815	0.9813	0.9810	0.9809	0.9808
1.6	0.9818	0.9818	0.9817	0.9814	0.9811	0.9808	0.9806	0.9805	0.9803	0.9800	0.9798	0.9796	0.9795
1.7	0.9806	0.9806	0.9805	0.9802	0.9800	0.9796	0.9794	0.9792	0.9790	0.9788	0.9785	0.9784	0.9782
1.8	0.9795	0.9795	0.9794	0.9791	0.9788	0.9784	0.9782	0.9780	0.9778	0.9775	0.9772	0.9771	0.9769
1.9	0.9784	0.9783	0.9782	0.9779	0.9776	0.9772	0.9770	0.9768	0.9766	0.9763	0.9760	0.9758	0.9756
2.0	0.9772	0.9772	0.9771	0.9767	0.9764	0.9760	0.9758	0.9756	0.9753	0.9750	0.9747	0.9745	0.9744
2.1	0.9761	0.9761	0.9759	0.9756	0.9753	0.9748	0.9746	0.9744	0.9741	0.9738	0.9734	0.9733	0.9731
2.2	0.9750	0.9749	0.9748	0.9744	0.9741	0.9736	0.9734	0.9731	0.9729	0.9725	0.9722	0.9720	0.9718
2.3	0.9738	0.9738	0.9736	0.9732	0.9729	0.9724	0.9722	0.9719	0.9716	0.9713	0.9709	0.9707	0.9705
2.4	0.9727	0.9726	0.9725	0.9721	0.9717	0.9712	0.9710	0.9707	0.9704	0.9700	0.9697	0.9694	0.9692
2.5	0.9715	0.9715	0.9713	0.9709	0.9705	0.9700	0.9698	0.9695	0.9692	0.9688	0.9684	0.9682	0.9680
2.6	0.9704	0.9704	0.9702	0.9698	0.9694	0.9688	0.9686	0.9683	0.9679	0.9675	0.9671	0.9669	0.9667
2.7	0.9693	0.9692	0.9691	0.9686	0.9682	0.9676	0.9673	0.9670	0.9667	0.9663	0.9659	0.9656	0.9654
2.8	0.9681	0.9681	0.9679	0.9674	0.9670	0.9664	0.9661	0.9658	0.9654	0.9650	0.9646	0.9644	0.9641
2.9	0.9670	0.9669	0.9668	0.9663	0.9658	0.9652	0.9649	0.9646	0.9642	0.9638	0.9633	0.9631	0.9628
3.0	0.9658	0.9658	0.9656	0.9651	0.9647	0.9640	0.9637	0.9634	0.9630	0.9626	0.9621	0.9618	0.9615
3.1	0.9647	0.9647	0.9645	0.9639	0.9635	0.9628	0.9625	0.9622	0.9617	0.9613	0.9608	0.9605	0.9603
3.2	0.9636	0.9635	0.9633	0.9628	0.9623	0.9616	0.9613	0.9609	0.9605	0.9601	0.9595	0.9593	0.9590
3.3	0.9624	0.9624	0.9622	0.9616	0.9611	0.9604	0.9601	0.9597	0.9593	0.9588	0.9583	0.9580	0.9577
3.4	0.9613	0.9612	0.9610	0.9604	0.9599	0.9592	0.9589	0.9585	0.9580	0.9576	0.9570	0.9567	0.9564
3.5	0.9602	0.9601	0.9599	0.9593	0.9588	0.9580	0.9577	0.9573	0.9568	0.9563	0.9558	0.9554	0.9551
3.6	0.9590	0.9590	0.9587	0.9581	0.9576	0.9568	0.9565	0.9560	0.9556	0.9551	0.9545	0.9542	0.9538
3.7	0.9579	0.9578	0.9576	0.9570	0.9561	0.9556	0.9553	0.9548	0.9543	0.9538	0.9532	0.9529	0.9526
3.8	0.9567	0.9567	0.9564	0.9558	0.9552	0.9544	0.9540	0.9536	0.9531	0.9526	0.9520	0.9516	0.9513
3.9	0.9556	0.9555	0.9553	0.9546	0.9540	0.9532	0.9528	0.9524	0.9519	0.9513	0.9507	0.9504	0.9500
4.0	0.9545	0.9544	0.9542	0.9535	0.9529	0.9520	0.9516	0.9512	0.9506	0.9501	0.9494	0.9491	0.9487

From *Orifice Metering of Natural Gas*, 1969; courtesy of AGA.

Table 10-7
F_b Basic Orifice Factors—Pipe Taps

Basic temperature = 60°F Flowing temperature = 60°F $\sqrt{h_w pf} = \infty$
Base pressure = 14.73 psia Specific gravity = 1.0 $h_w/pf = 0$

Pipe Sizes—Nominal and Published Inside Diameters, Inches

Orifice Diameter, in.	2			3				4	
	1.689	1.939	2.067	2.300	2.626	2.900	3.068	3.152	3.430
0.250	12.850	12.813	12.800	12.782	12.765	12.753	12.748	12.745	12.737
0.375	29.359	29.097	29.005	28.882	28.771	28.710	28.682	28.669	28.634
0.500	53.703	52.816	52.401	52.019	51.591	51.353	51.243	51.196	51.064
0.625	87.212	84.919	84.083	82.922	81.795	81.142	80.835	80.703	80.332
0.750	132.23	126.86	124.99	122.45	120.06	118.67	118.00	117.70	116.86
0.875	192.74	181.02	177.08	171.92	167.23	164.58	163.31	162.76	161.17
1.000	275.45	251.10	243.27	233.30	224.56	219.76	217.52	216.55	213.79
1.125	391.93	342.98	327.98	309.43	293.79	285.48	281.66	280.02	275.42
1.250		465.99	437.99	404.52	377.36	363.41	357.12	354.45	347.03
1.375			583.96	524.68	478.68	455.82	445.74	441.48	429.83
1.500				679.10	602.45	565.79	549.94	543.31	525.40
1.625					755.34	697.43	672.95	662.81	635.76
1.750					946.99	856.37	819.05	803.77	763.51
1.875						1050.4	993.98	971.19	911.98
2.000						1290.7	1205.6	1171.8	1085.5
2.125							1465.1	1415.0	1289.7
2.250									1532.0
2.375									1822.8

Orifice Diameter, in.	4		6				8		
	3.826	4.026	4.897	5.189	5.761	6.065	7.625	7.981	8.071
0.250	12.727	12.722							
0.375	28.598	28.584							
0.500	50.936	50.886	50.739	50.705	50.652	50.628			
0.625	79.974	79.835	79.436	79.349	79.217	79.162			
0.750	116.05	115.73	114.81	114.61	114.32	114.20			
0.875	159.57	158.94	157.11	156.71	156.13	155.89	155.10	154.99	154.96
1.000	211.03	209.91	206.62	205.91	204.84	204.41	203.00	202.80	202.75
1.125	270.90	269.10	263.71	262.51	260.71	259.98	257.62	257.28	257.20
1.250	339.87	337.05	328.73	326.85	324.02	322.86	319.10	318.56	318.44
1.375	418.79	414.51	402.06	399.30	395.08	393.33	387.62	386.81	386.62
1.500	508.76	502.38	484.20	480.23	474.20	471.69	463.39	462.19	461.92
1.625	611.11	601.80	575.73	570.14	561.73	558.24	546.61	544.92	544.53
1.750	727.54	714.16	677.38	669.63	658.08	653.33	637.51	635.19	634.65
1.875	860.17	841.19	789.99	779.40	763.77	757.39	736.34	733.23	732.52
2.000	1011.7	985.04	914.57	900.28	879.38	870.93	843.34	839.29	838.35
2.125	1185.3	1148.4	1052.3	1033.2	1005.6	994.52	958.78	953.58	952.38
2.250	1385.4	1334.4	1204.7	1179.4	1143.2	1128.8	1083.0	1076.4	1074.9
2.375	1617.2	1547.3	1373.4	1340.2	1293.1	1274.6	1216.3	1208.0	1206.1
2.500	1887.6	1792.3	1560.5	1517.2	1456.4	1432.7	1359.2	1348.8	1346.5
2.625	2206.0	2075.9	1768.3	1712.3	1634.3	1604.3	1512.0	1499.2	1496.3
2.750		2407.0	1999.8	1927.6	1828.3	1790.3	1675.4	1659.7	1656.1
2.875			2258.5	2165.9	2039.9	1992.2	1849.9	1830.6	1826.3
3.000			2548.6	2430.2	2271.2	2211.6	2036.0	2012.7	2007.3
3.125			2875.2	2724.4	2524.3	2450.1	2234.7	2206.4	2199.9
3.250			3244.8	3052.8	2801.8	2709.9	2446.5	2412.4	2404.7
3.375			3665.6	3420.9	3106.9	2993.3	2672.5	2631.6	2622.3
3.500				3835.7	3443.0	3303.0	2913.7	2864.7	2853.7
3.625				4305.7	3914.4	3642.3	3171.1	3112.7	3099.6
3.750					4226.3	4014.8	3446.0	3376.6	3361.0
3.875					4684.9	4425.1	3739.9	3657.6	3639.2
4.000					5197.7	4878.4	4054.2	3957.0	3935.2

From *Orifice Metering of Natural Gas*, 1969; courtesy of AGA.

Table 10-8
"b" Values for Reynolds Number Factor F_r Determination—Pipe Taps

$$F_r = 1 + \frac{b}{\sqrt{h_w p_f}}$$

Pipe Sizes—Nominal and Published Inside Diameters, Inches

Orifice Diameter, in.	2			3				4	
	1.689	1.939	2.067	2.300	2.626	2.900	3.068	3.152	3.438
0.250	0.1105	0.1091	0.1087	0.1081	0.1078	0.1078	0.1080	0.1081	0.1084
0.375	0.0890	0.0878	0.0877	0.0879	0.0888	0.0898	0.0905	0.0908	0.0918
0.050	0.0758	0.0734	0.0729	0.0728	0.0737	0.0750	0.0758	0.0763	0.0778
0.625	0.0693	0.0647	0.0635	0.0624	0.0624	0.0634	0.0642	0.0646	0.0662
0.750	0.0675	0.0608	0.0586	0.0559	0.0546	0.0548	0.0552	0.0555	0.0568
0.875	0.0684	0.0602	0.0570	0.0528	0.0497	0.0488	0.0488	0.0489	0.0496
1.000	0.0702	0.0614	0.0576	0.0522	0.0473	0.0452	0.0445	0.0443	0.0443
1.125	0.0708	0.0635	0.0595	0.0532	0.0469	0.0435	0.0422	0.0417	0.0407
1.250		0.0650	0.0616	0.0552	0.0478	0.0434	0.0414	0.0406	0.0387
1.375			0.0629	0.0574	0.0496	0.0443	0.0418	0.0408	0.0379
1.500				0.0590	0.0518	0.0460	0.0431	0.0418	0.0382
1.625					0.0539	0.0482	0.0450	0.0435	0.0392
1.750					0.0553	0.0504	0.0471	0.0456	0.0408
1.875						0.0521	0.0492	0.0477	0.0427
2.000						0.0532	0.0508	0.0495	0.0448
2.125							0.0519	0.0509	0.0467
2.250									0.0483
2.375									0.0494

Orifice Diameter, in.	4		6				8		
	3.826	4.026	4.897	5.189	5.761	6.065	7.625	7.981	8.071
0.250	0.1087	0.1091							
0.375	0.0932	0.0939							
0.500	0.0799	0.0810	0.0850	0.0862	0.0883	0.0895			
0.625	0.0685	0.0697	0.0747	0.0762	0.0789	0.0802			
0.750	0.0590	0.0602	0.0655	0.0672	0.0703	0.0718			
0.875	0.0513	0.0524	0.0575	0.0592	0.0625	0.0642	0.0716	0.0730	0.0733
1.000	0.0453	0.0461	0.0506	0.0523	0.0556	0.0573	0.0652	0.0668	0.0662
1.125	0.0408	0.0412	0.0448	0.0464	0.0495	0.0512	0.0592	0.0609	0.0613
1.250	0.0376	0.0377	0.0401	0.0413	0.0442	0.0458	0.0538	0.0555	0.0560
1.375	0.0358	0.0353	0.0363	0.0373	0.0397	0.0412	0.0489	0.0506	0.0510
1.500	0.0350	0.0340	0.0334	0.0340	0.0360	0.0372	0.0445	0.0462	0.0466
1.625	0.0351	0.0336	0.0313	0.0315	0.0329	0.0339	0.0404	0.0421	0.0425
1.750	0.0358	0.0340	0.0300	0.0298	0.0304	0.0311	0.0369	0.0384	0.0388
1.875	0.0371	0.0349	0.0293	0.0287	0.0285	0.0290	0.0338	0.0352	0.0355
2.000	0.0388	0.0363	0.0292	0.0281	0.0273	0.0273	0.0311	0.0323	0.0327
2.125	0.0407	0.0360	0.0297	0.0281	0.0265	0.0262	0.0288	0.0298	0.0301
2.250	0.0427	0.0398	0.0305	0.0285	0.0261	0.0258	0.0268	0.0277	0.0280
2.375	0.0445	0.0417	0.0316	0.0293	0.0262	0.0253	0.0252	0.0259	0.0261
2.500	0.0460	0.0435	0.0330	0.0304	0.0267	0.0254	0.0239	0.0244	0.0246
2.625	0.0472	0.0450	0.0345	0.0317	0.0274	0.0258	0.0230	0.0232	0.0233
2.750		0.0462	0.0362	0.0331	0.0264	0.0265	0.0224	0.0224	0.0224
2.875			0.0379	0.0347	0.0295	0.0274	0.0220	0.0218	0.0218
3.000			0.0395	0.0364	0.0308	0.0285	0.0219	0.0214	0.0213

From *Orifice Metering of Natural Gas*, 1969; courtesy of AGA.

Table 10-10
Y_2 Expansion Factors—Pipe Taps
Static Pressure, Taken from Downstream Taps

$\frac{h_w}{p_{f2}}$ Ratio	$\beta = \frac{d}{D}$ Ratio									
	0.1	0.2	0.3	0.4	0.45	0.50	0.52	0.54	0.56	0.58
0.0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
0.1	1.0008	1.0008	1.0006	1.0003	1.0002	1.0000	0.9999	0.9998	0.9997	0.9996
0.2	1.0017	1.0015	1.0012	1.0007	1.0004	1.0000	0.9999	0.9997	0.9995	0.9993
0.3	1.0025	1.0023	1.0018	1.0010	1.0006	1.0000	0.9998	0.9995	0.9992	0.9989
0.4	1.0034	1.0030	1.0024	1.0014	1.0008	1.0001	0.9997	0.9994	0.9990	0.9986
0.5	1.0042	1.0038	1.0030	1.0018	1.0010	1.0001	0.9997	0.9992	0.9988	0.9982
0.6	1.0051	1.0045	1.0036	1.0021	1.0012	1.0001	0.9996	0.9991	0.9985	0.9979
0.7	1.0059	1.0053	1.0041	1.0025	1.0014	1.0002	0.9996	0.9990	0.9983	0.9975
0.8	1.0068	1.0060	1.0047	1.0028	1.0016	1.0002	0.9995	0.9988	0.9980	0.9972
0.9	1.0076	1.0068	1.0053	1.0032	1.0018	1.0002	0.9995	0.9987	0.9978	0.9969
1.0	1.0085	1.0075	1.0059	1.0036	1.0021	1.0003	0.9994	0.9986	0.9976	0.9965
1.1	1.0093	1.0083	1.0065	1.0039	1.0023	1.0003	0.9994	0.9984	0.9974	0.9962
1.2	1.0102	1.0091	1.0071	1.0043	1.0025	1.0004	0.9994	0.9983	0.9972	0.9959
1.3	1.0110	1.0098	1.0077	1.0047	1.0027	1.0004	0.9994	0.9982	0.9970	0.9956
1.4	1.0119	1.0106	1.0083	1.0051	1.0030	1.0004	0.9993	0.9981	0.9968	0.9953
1.5	1.0127	1.0113	1.0089	1.0054	1.0032	1.0005	0.9993	0.9980	0.9966	0.9950
1.6	1.0136	1.0121	1.0096	1.0058	1.0034	1.0006	0.9993	0.9979	0.9964	0.9947
1.7	1.0144	1.0128	1.0102	1.0062	1.0036	1.0006	0.9992	0.9978	0.9962	0.9944
1.8	1.0153	1.0136	1.0108	1.0066	1.0039	1.0007	0.9992	0.9977	0.9960	0.9941
1.9	1.0161	1.0144	1.0114	1.0070	1.0041	1.0008	0.9992	0.9976	0.9958	0.9938
2.0	1.0170	1.0151	1.0120	1.0073	1.0044	1.0008	0.9992	0.9975	0.9956	0.9935
2.1	1.0178	1.0159	1.0126	1.0077	1.0046	1.0009	0.9992	0.9974	0.9954	0.9932
2.2	1.0187	1.0167	1.0132	1.0081	1.0048	1.0010	0.9992	0.9973	0.9952	0.9929
2.3	1.0195	1.0174	1.0138	1.0085	1.0051	1.0010	0.9992	0.9972	0.9950	0.9927
2.4	1.0204	1.0182	1.0144	1.0089	1.0053	1.0011	0.9992	0.9971	0.9949	0.9924
2.5	1.0212	1.0189	1.0150	1.0093	1.0056	1.0012	0.9992	0.9971	0.9947	0.9921
2.6	1.0221	1.0197	1.0156	1.0097	1.0058	1.0013	0.9992	0.9970	0.9945	0.9919
2.7	1.0229	1.0205	1.0162	1.0101	1.0061	1.0014	0.9992	0.9969	0.9944	0.9916
2.8	1.0238	1.0212	1.0169	1.0104	1.0063	1.0014	0.9992	0.9968	0.9942	0.9914
2.9	1.0246	1.0220	1.0175	1.0108	1.0066	1.0015	0.9992	0.9968	0.9941	0.9911
3.0	1.0255	1.0228	1.0181	1.0112	1.0068	1.0016	0.9993	0.9967	0.9939	0.9908
3.1	1.0264	1.0235	1.0187	1.0116	1.0071	1.0017	0.9993	0.9966	0.9938	0.9906
3.2	1.0272	1.0243	1.0193	1.0120	1.0074	1.0018	0.9993	0.9966	0.9936	0.9904
3.3	1.0280	1.0250	1.0199	1.0124	1.0076	1.0019	0.9993	0.9965	0.9935	0.9901
3.4	1.0289	1.0258	1.0206	1.0128	1.0079	1.0020	0.9994	0.9965	0.9933	0.9899
3.5	1.0298	1.0266	1.0212	1.0133	1.0082	1.0021	0.9994	0.9964	0.9932	0.9896
3.6	1.0306	1.0273	1.0218	1.0137	1.0084	1.0022	0.9994	0.9964	0.9931	0.9894
3.7	1.0314	1.0281	1.0224	1.0141	1.0087	1.0024	0.9994	0.9963	0.9929	0.9892
3.8	1.0323	1.0289	1.0230	1.0145	1.0090	1.0025	0.9995	0.9963	0.9928	0.9890
3.9	1.0332	1.0296	1.0237	1.0149	1.0093	1.0026	0.9995	0.9963	0.9927	0.9888
4.0	1.0340	1.0304	1.0243	1.0153	1.0095	1.0027	0.9996	0.9962	0.9926	0.9885

From *Orifice Metering of Natural Gas*, 1969; courtesy of AGA.

Table 10-11a
Supercompressibility Pressure Adjustments, Δp
(Based on Specific Gravity Method)

Pressure Adjustment Index, I_{pa}	Pressure, psig															
	0	200	400	600	800	1000	1200	1400	1600	1800	2000	2200	2400	2600	2800	3000
−0.7	0	−11.32	−22.65	−33.97	−45.30	−56.62	−67.94	−79.27	−90.59	−101.92	−113.24	−124.56	−135.89	−147.21	−158.54	−169.86
−0.6	0	−10.50	−21.00	−31.49	−41.99	−52.49	−62.99	−73.49	−83.98	−94.48	−104.98	−115.48	−125.98	−136.47	−146.97	−157.47
−0.5	0	−9.67	−19.33	−29.00	−38.66	−48.33	−58.00	−67.66	−77.33	−86.99	−96.66	−106.33	−115.99	−125.66	−135.32	−144.99
−0.4	0	−8.83	−17.65	−26.48	−35.30	−44.13	−52.96	−61.78	−70.61	−79.43	−88.26	−97.09	−105.91	−114.74	−123.56	−132.39
−0.3	0	−7.98	−15.96	−23.93	−31.91	−39.89	−47.87	−55.85	−63.82	−71.80	−79.78	−87.76	−95.74	−103.71	−111.69	−119.67
−0.2	0	−7.12	−14.25	−21.37	−28.50	−35.62	−42.74	−49.87	−56.99	−64.12	−71.24	−78.36	−85.49	−92.61	−99.74	−106.86
−0.1	0	−6.26	−12.52	−18.78	−25.04	−31.30	−37.56	−43.82	−50.08	−56.34	−62.60	−68.86	−75.12	−81.38	−87.64	−93.90
0	0	−5.39	−10.78	−16.17	−21.56	−26.95	−32.34	−37.73	−43.12	−48.51	−53.90	−59.29	−64.68	−70.07	−75.46	−80.85
+0.1	0	−4.51	−9.02	−13.54	−18.05	−22.56	−27.07	−31.58	−36.10	−40.61	−45.12	−49.63	−54.14	−58.66	−63.17	−67.68
+0.2	0	−3.63	−7.25	−10.88	−14.50	−18.13	−21.76	−25.38	−29.01	−32.63	−36.26	−39.89	−43.51	−47.14	−50.76	−54.39
+0.3	0	−2.73	−5.46	−8.20	−10.93	−13.66	−16.39	−19.12	−21.86	−24.59	−27.32	−30.05	−32.78	−35.52	−38.25	−40.98
+0.4	0	−1.83	−3.66	−5.49	−7.32	−9.15	−10.98	−12.81	−14.64	−16.47	−18.30	−20.13	−21.96	−23.79	−25.62	−27.45
+0.5	0	−0.92	−1.84	−2.76	−3.68	−4.60	−5.52	−6.43	−7.35	−8.27	−9.19	−10.11	−11.03	−11.95	−12.87	−13.79
+0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
+0.7	0	0.93	1.86	2.78	3.71	4.64	5.57	6.49	7.42	8.35	9.28	10.20	11.13	12.06	12.99	13.91
+0.8	0	1.86	3.73	5.59	7.46	9.32	11.18	13.05	14.91	16.78	18.64	20.50	22.37	24.23	26.10	27.96
+0.9	0	2.81	5.62	8.42	11.23	14.04	16.85	19.66	22.46	25.27	28.08	30.89	33.70	36.50	39.31	42.12
+1.0	0	3.76	7.52	11.29	15.05	18.81	22.57	26.33	30.10	33.86	37.62	41.38	45.14	48.91	52.67	56.43
+1.1	0	4.73	9.45	14.18	18.90	23.63	28.36	33.08	37.81	42.53	47.26	51.99	56.71	61.44	66.16	70.89
+1.2	0	5.70	11.40	17.09	22.79	28.49	34.19	39.89	45.58	51.28	56.98	62.68	68.38	74.07	79.77	85.47
+1.3	0	6.68	13.36	20.04	26.72	33.40	40.08	46.76	53.44	60.12	66.80	73.48	80.16	86.84	93.52	100.20
+1.4	0	7.67	15.34	23.01	30.68	38.35	46.02	53.69	61.36	69.03	76.70	84.37	92.04	99.71	107.38	115.05
+1.5	0	8.67	17.34	26.01	34.68	43.35	52.02	60.69	69.36	78.03	86.70	95.37	104.04	112.71	121.38	130.05
+1.6	0	9.68	19.36	29.04	38.72	48.40	58.08	67.76	77.44	87.12	96.80	106.48	116.16	125.84	135.52	145.20
+1.7	0	10.70	21.40	32.10	42.80	53.50	64.20	74.90	85.60	96.30	107.00	117.70	128.40	139.10	149.80	160.50
+1.8	0	11.73	23.46	35.19	46.92	58.65	70.38	82.11	93.84	105.57	117.30	129.03	140.76	152.49	164.22	175.95
+1.9	0	12.77	25.54	38.31	51.08	63.85	76.62	89.39	102.16	114.93	127.70	140.47	153.24	166.01	178.78	191.55
+2.0	0	13.82	27.64	41.46	55.28	69.10	82.92	96.74	110.56	124.38	138.20	152.02	165.84	179.66	193.48	207.30

Note: factors for intermediate values of pressure adjustment index and pressure should be interpolated.

From *Orifice Metering of Natural Gas*, 1969; courtesy of AGA.

Table 10-11b
Supercompressibility Temperature Adjustments, ΔT
(Based on Specific Gravity Method)

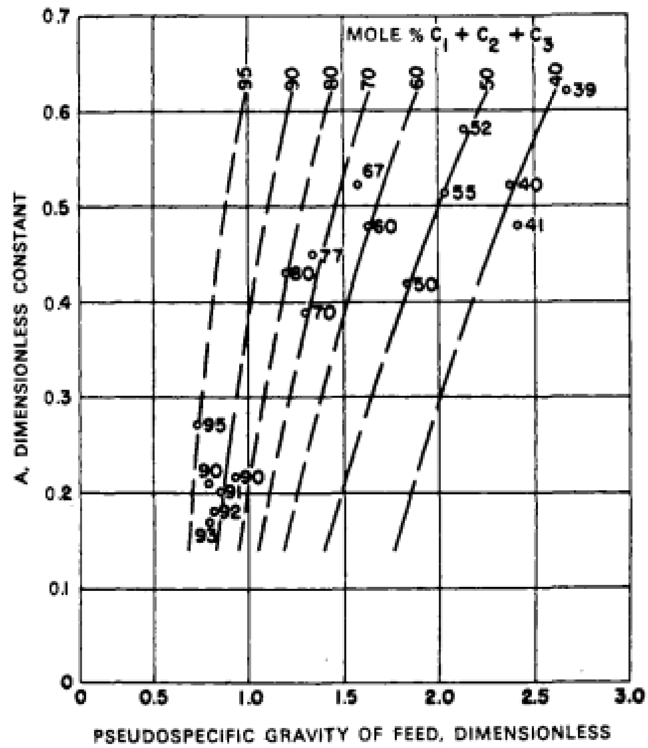
Temperature Adjustment Index, f_{tr}	Temperature, °F										
	0	20	40	60	80	100	120	140	160	180	200
0.45	75.16	78.43	81.70	84.97	88.24	91.50	94.77	98.04	101.31	104.58	107.84
0.46	69.41	72.43	75.45	78.47	81.49	84.50	87.52	90.54	93.56	96.58	99.59
0.47	63.76	66.53	69.30	72.07	74.84	77.62	80.39	83.16	85.93	88.70	91.48
0.48	58.24	60.77	63.30	65.83	68.36	70.90	73.43	75.96	78.49	81.02	83.56
0.49	52.81	55.10	57.40	59.70	61.99	64.29	66.58	68.88	71.18	73.47	75.77
0.50	47.52	49.58	51.65	53.72	55.78	57.85	59.91	61.98	64.05	66.11	68.18
0.51	42.33	44.17	46.01	47.85	49.69	51.53	53.37	55.21	57.05	58.89	60.73
0.52	37.25	38.87	40.48	42.10	43.72	45.34	46.96	48.58	50.20	51.82	53.44
0.53	32.26	33.67	35.07	36.47	37.88	39.28	40.68	42.08	43.49	44.89	46.29
0.54	27.38	28.57	29.76	30.95	32.14	33.33	34.52	35.71	36.90	38.09	39.28
0.55	22.60	23.58	24.56	25.54	26.52	27.51	28.49	29.47	30.45	31.44	32.42
0.56	17.90	18.68	19.46	20.23	21.01	21.79	22.57	23.35	24.12	24.90	25.68
0.57	13.29	13.87	14.45	15.03	15.61	16.18	16.76	17.34	17.92	18.50	19.07
0.58	8.78	9.16	9.54	9.92	10.30	10.68	11.07	11.45	11.83	12.21	12.59
0.59	4.35	4.54	4.73	4.92	5.10	5.29	5.48	5.67	5.86	6.05	6.24
0.60	0	0	0	0	0	0	0	0	0	0	0
0.61	−4.27	−4.45	−4.64	−4.82	−5.01	−5.19	−5.38	−5.57	−5.75	−5.94	−6.12
0.62	−8.45	−8.82	−9.19	−9.56	−9.93	−10.29	−10.66	−11.03	−11.40	−11.76	−12.13
0.63	−12.57	−13.11	−13.66	−14.21	−14.75	−15.30	−15.85	−16.39	−16.94	−17.48	−18.03
0.64	−16.61	−17.33	−18.05	−18.77	−19.49	−20.22	−20.94	−21.66	−22.38	−23.10	−23.83
0.65	−20.57	−21.47	−22.36	−23.25	−24.15	−25.04	−25.94	−26.83	−27.73	−28.62	−29.52
0.66	−24.47	−25.53	−26.60	−27.66	−28.72	−29.79	−30.85	−31.91	−32.98	−34.04	−35.11
0.67	−28.29	−29.52	−30.76	−31.99	−33.22	−34.45	−35.68	−36.91	−38.14	−39.37	−40.60
0.68	−32.06	−33.45	−34.84	−36.24	−37.63	−39.03	−40.42	−41.81	−43.21	−44.60	−46.00
0.69	−35.75	−37.30	−38.86	−40.41	−41.97	−43.52	−45.08	−46.63	−48.19	−49.74	−51.30
0.70	−39.38	−41.10	−42.81	−44.52	−46.23	−47.95	−49.66	−51.37	−53.08	−54.80	−56.51
0.71	−42.95	−44.82	−46.69	−48.56	−50.42	−52.29	−54.16	−56.03	−57.90	−59.76	−61.63
0.72	−46.46	−48.48	−50.50	−52.52	−54.54	−56.56	−58.58	−60.60	−62.62	−64.64	−66.66
0.73	−49.91	−52.08	−54.25	−56.42	−58.59	−60.76	−62.93	−65.10	−67.27	−69.44	−71.61
0.74	−53.31	−55.63	−57.95	−60.27	−62.59	−64.90	−67.22	−69.54	−71.86	−74.18	−76.49
0.75	−56.67	−59.14	−61.60	−64.06	−66.53	−68.99	−71.46	−73.92	−76.38	−78.85	−81.31

Note: Factors forintermediate values of temperature adjustment index and temperture should be interpolated.

From *Orifice Metering of Natural Gas*, 1969; courtesy of AGA.

TABLE A.35(a) (Continued)
F_{pv} Supercompressibility Factors
Base Data—0.6 Specific Gravity Hydrocarbon Gas

p_f	Temperature °F												
psig	60	65	70	75	80	85	90	95	100	105	110	115	120
0	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.000	1.000	1.0000	1.000	1.0000
20	1.0016	1.0015	1.0014	1.0014	1.0014	1.0013	1.0013	1.0012	1.0012	1.0012	1.0011	1.0011	1.0010
40	1.0032	1.0031	1.0030	1.0029	1.0028	1.0027	1.0027	1.0026	1.0025	1.0024	1.0023	1.0022	1.0022
60	1.0047	1.0046	1.0045	1.0043	1.0042	1.0040	1.0039	1.0038	1.0037	1.0036	1.0035	1.0033	1.0032
80	1.0064	1.0062	1.0061	1.0058	1.0056	1.0054	1.0052	1.0051	1.0049	1.0047	1.0046	1.0044	1.0043
100	1.0080	1.0078	1.0075	1.0073	1.0071	1.0068	1.0066	1.0064	1.0061	1.0059	1.0058	1.0056	1.0055
120	1.0097	1.0094	1.0091	1.0088	1.0085	1.0082	1.0079	1.0076	1.0073	1.0071	1.0069	1.0067	1.0065
140	1.0112	1.0109	1.0105	1.0102	1.0099	1.0095	1.0092	1.0088	1.0085	1.0083	1,0080	1.0078	1.0076
160	1.0129	1.0125	1.0121	1.0117	1.0112	1.0108	1.0105	1.0101	1.0098	1.0095	1.0092	1.0089	1.0087
180	1.0145	1.0140	1.0136	1.0131	1.0126	1.0122	1.0118	1.0114	1.0111	1.0107	1.0103	1.0100	1.0098
200	1.0162	1.0156	1.0151	1.0146	1.0140	1.0135	1.0131	1.0127	1.0123	1.0119	1.0115	1.0111	1.0108
220	1.0178	1.0172	1.0166	1.0160	1.0154	1.0149	1.0145	1.0140	1.0136	1.0131	1.0126	1.0122	1.0119
240	1.0194	1.0188	1.0181	1.0175	1.0168	1.0163	1.0158	1.0153	1.0148	1.0143	1.0138	1.0133	1.0129
260	1.0211	1.0204	1.0197	1.0190	1.0183	1.0177	1.0171	1.0165	1.0160	1.0155	1.0150	1.0144	1.0139
280	1.0228	1.0220	1.0212	1.0205	1.0197	1.0191	1.0185	1.0178	1.0173	1.0167	1.0162	1.0155	1.0150
300	1.0244	1.0236	1.0228	1.0220	1.0212	1.0205	1.0199	1.0192	1.0185	1.0179	1.0173	1.0167	1.0162
320	1.0261	1.0252	1.0243	1.0235	1.0227	1.0219	1.0212	1.0205	1.0198	1.0191	1.0185	1.0178	1.0173
340	1.0277	1.0267	1.0258	1.0249	1.0241	1.0233	1.0225	1.0217	1.0209	1.0203	1.0196	1.0189	1.0183
360	1.0294	1.0284	1.0273	1.0264	1.0256	1.0247	1.0238	1.0230	1.0222	1.0215	1.0207	1.0200	1.0194
380	1.0311	1.0300	1.0289	1.0279	1.0270	1.0261	1.0252	1.0243	1.0234	1.0227	1.0219	1.0211	1.0204
400	1.0328	1.0317	1.0305	1.0294	1.0285	1.0275	1.0265	1.0256	1.0246	1.0238	1.0230	1.0223	1.0215
420	1.0345	1.0333	1.0321	1.0309	1.0299	1.0289	1.0279	1.0269	1.0259	1.0250	1.0242	1.0234	1.0226
440	1.0361	1.0349	1.0336	1.0324	1.0313	1.0302	1.0292	1.0281	1.0272	1.0262	1.0253	1.0244	1.0236



MOLE % $C_1 + C_2 + C_3$
A, DIMENSIONLESS CONSTANT
PSEUDOSPECIFIC GRAVITY OF FEED, DIMENSIONLESS

Temperature drop accompanying a given pressure drop