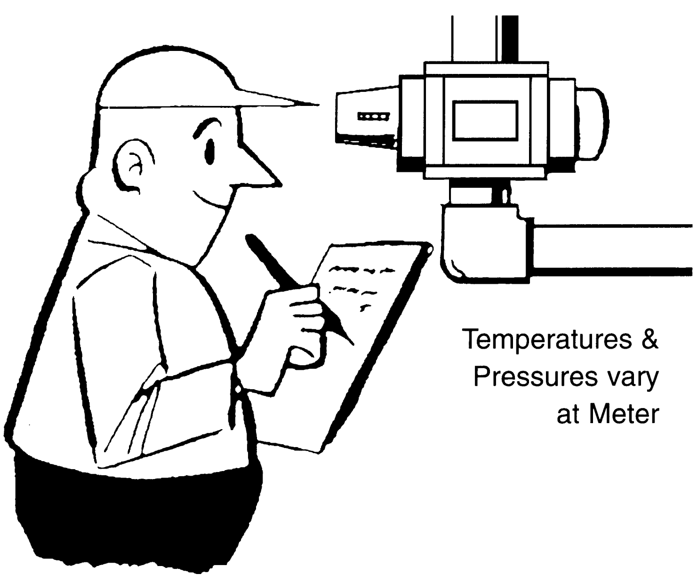
RM 135
(rev. 10/99)

The Application of Temperature and/or Pressure Correction Factors in Gas Measurement

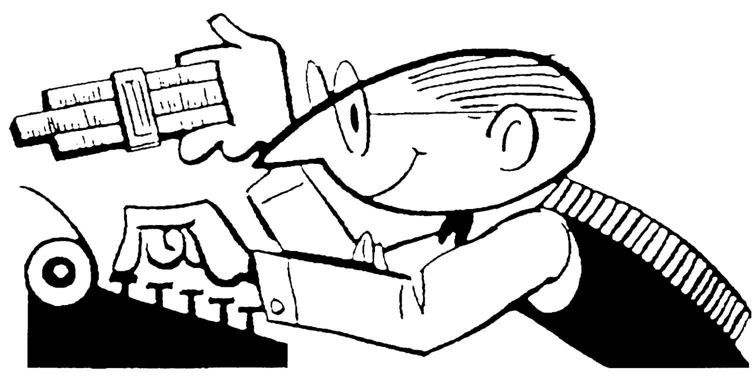
COMBINED BOYLE'S – CHARLES' GAS LAWS

To convert measured volume at metered pressure and temperature to selling volume at agreed base pressure and temperature

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$



Temperatures & Pressures vary at Meter



Readings must be converted to Standard conditions for billing

DRESSER DMD ROOTS™
A Halliburton Company

APPLICATION OF
CORRECTION FACTORS
FOR PRESSURE AND/OR TEMPERATURE

Introduction:

Most gas meters measure the volume of gas at existing line conditions of pressure and temperature. This volume is usually referred to as displaced volume or actual volume (Va). The value of the gas (i.e., heat content) is referred to in gas measurement as the standard volume (Vs) or volume at standard conditions of pressure and temperature.

Since gases are compressible fluids, a meter that is measuring gas at two (2) atmospheres will have twice the capacity that it would have if the gas is being measured at one (1) atmosphere. (Note: One atmosphere is the pressure exerted by the air around us. This value is normally 14.696 psi absolute pressure at sea level, or 29.92 inches of mercury.) This fact is referred to as Boyle's Law which states, "Under constant temperature conditions, the volume of gas is inversely proportional to the ratio of the change in absolute pressures". This can be expressed mathematically as:

$$P_1 V_1 = P_2 V_2 \quad \text{or} \quad \frac{P_1}{P_2} = \frac{V_2}{V_1} \; *$$

Charles' Law states that, "Under constant pressure conditions, the volume of gas is directly proportional to the ratio of the change in absolute temperature". Or mathematically,

$$\frac{V_1}{T_1} = \frac{V_2}{T_2} \quad \text{or} \quad V_1 T_2 = V_2 T_1 *$$

Gas meters are normally rated in terms of displaced cubic feet per hour. For gas equipment rated in B.T.U's, a simple conversion can be applied to the B.T.U./Hr. Rating to obtain SCFH (Standard Cubic Feet per Hour). The table below lists the most commonly used gases and their approximate conversion factors.

Gas	**Heating Value B.T.U.'s/Cu. Ft.**	**To Obtain SCF, Multiply B.T.U. Ratings of Equipment by**
Butane	3333	.00030
Ethane	1758	.00056
Methane	997	.00100
Natural Gas	965 to 1055	.00100
Propane	2529	.00040

*See Appendix A for combined formula and application.

The displaced capacity of the meter can be found on the meter nameplate or in the model designation where the "M" represents a multiplier of one thousand (1000). For example, a 3M175 meter has a displaced volume capacity of 3000 ACFH.

The "175" is the maximum working pressure in pounds per square inch gauge pressure (psig). If a 3M175 meter is installed on a 15 psig system (or 2 atmospheres), the meter will have a standard volume capacity of 6000 SCFH. This is true since the gas at two (2) atmospheres is compressed to one-half of its displaced volume or volume at standard conditions. The gas meter, however, will only measure the displaced volume and the counter on the meter will only register 3000 cubic feet in a one hour period (assuming gas flow is at the meter's maximum capacity).

For these reasons the counter reading or actual volume (V_A) must be corrected to standard volume (V_S) to obtain the real value of the gas that has passed through the meter.

Engineering Data Sheet RM-26 has a listing of gas pressure and temperature correcting factors. To determine the standard volume for a given period of time, simply subtract the initial counter reading from the final counter reading and multiply this difference by the appropriate factor for pressure (F_P) and, if desired, by the appropriate factor for temperature (F_T). There is an approximate 1% change in volume for every 5°F.

Note: If the gas meter being utilized is already temperature compensated (TC), then the temperature correcting factor should not be used.

Example: A 3M175 Counter Version ROOTS® Meter is installed inside on a 25 PSIG gas line. Calculate the standard volume of gas (corrected for both pressure and temperature) if the gas temperature is 75° F.

$$V_S = V_A \times F_p \times F_T$$

Period	Meter Counter Readings Final	Initial	Difference (V_A)	F_P *@ 25 PSIG	Volume Corrected for Pressure	F_T *@ 75° F.	Volume Corrected for Press. & Temp.
1	008200	000000	8200	2.675	21935	0.972	21321
2	017900	008200	9700	2.675	25948	0.972	25221
3	028400	017900	10500	2.675	28088	0.972	27301
4	031600	028400	3200	2.675	8560	0.972	8320

* See Data Sheet RM-26 for values.

If the temperature or pressure changes from one period to another, the factor for pressure (F_P) or temperature (F_T) can be adjusted before calculating the standard volume.

The values on the Data Sheet, RM-26, are for a base pressure of 14.73 psia, an assumed atmospheric pressure for 14.40 psia (or about 500 ft. above sea level elevation), and a base temperature of 60° F. For other base conditions, the formulae for calculating the factors for pressure and temperature are given below:

$$F_P = \frac{\text{Line Pressure (psig)} + \text{Atmospheric Pressure (psia)}}{\text{Contract Base Pressure (psia)}}$$

$$F_T = \frac{460 + \text{Base Temperature (°F)}}{460 + \text{Line Temperature (°F)}}$$

Note: The Base Pressure and Base Temperature values can normally be found in your contract with your gas supplier. The atmospheric pressure can be assumed based upon your elevation above sea level or by contacting your local weather station or airport facility. (See table below)

ATMOSPHERIC PRESSURES AND BAROMETER READING AT DIFFERENT ALTITUDES

Altitude Above Sea Level Feet	Atmospheric Pressure PSIA	Barometer Reading Inches Hg	Altitude Above Sea Level Feet	Atmospheric Pressure PSIA	Barometer Reading Inches Hg
Sea Level	14.69	29.92	4,000	12.68	25.84
250	14.56	29.64	4,500	12.45	25.36
500	14.42	29.38	5,000	12.22	24.89
750	14.29	29.09	6,000	11.77	23.98
1,000	14.16	28.86	7,000	11.33	23.09
1,250	14.04	28.59	8,000	10.91	22.22
1,500	13.91	28.33	9,000	10.50	21.38
1,750	13.79	28.08	10,000	10.10	20.58
2,000	13.66	27.82	11,000	9.71	19.75
2,500	13.41	27.31	12,000	9.34	19.03
3,000	13.16	26.81	13,000	8.97	18.29
3,500	12.92	26.32	14,000	8.62	17.57

GAS PRESSURE CORRECTING FACTORS

Base Pressure = 14.73 psia   Atmospheric Pressure = 14.4 psia

Factors listed are directly usable to convert volume readings from displacement meters at various metering pressures into volumes at the standard base pressure and atmospheric pressure indicated above. For a 14.65 base pressure, use an additional multiplier of 1.006.

PSIG	Factor	PSIG	Factor	PSIG	Factor	PSIG	Factor	PSIG	Factor	PSIG	Factor
1	1.045	61	5.119	121	9.192	405	28.47	705	48.84	1005	69.20
2	1.113	62	5.187	122	9.260	410	28.81	710	49.18	1010	69.54
3	1.181	63	5.254	123	9.328	415	29.15	715	49.52	1015	69.88
4	1.249	64	5.322	124	9.396	420	29.49	720	49.86	1020	70.22
5	1.317	65	5.390	125	9.464	425	29.83	725	50.20	1025	70.56
6	1.385	66	5.458	130	9.803	430	30.17	730	50.54	1030	70.90
7	1.453	67	5.526	135	10.142	435	30.51	735	50.86	1035	71.24
8	1.521	68	5.594	140	10.482	440	30.85	740	51.22	1040	71.58
9	1.589	69	5.662	145	10.821	445	31.19	745	51.55	1045	71.92
10	1.656	70	5.730	150	11.161	450	31.53	750	51.89	1050	72.26
11	1.724	71	5.798	155	11.50	455	31.87	755	52.23	1055	72.60
12	1.792	72	5.866	160	11.84	460	32.21	760	52.57	1060	72.94
13	1.860	73	5.933	165	12.18	465	32.54	765	52.91	1065	73.28
14	1.928	74	6.001	170	12.52	470	32.88	770	53.25	1070	73.62
15	1.996	75	6.069	175	12.86	475	33.22	775	53.59	1075	73.96
16	2.064	76	6.137	180	13.20	480	33.56	780	53.93	1080	74.30
17	2.132	77	6.205	185	13.54	485	33.90	785	54.27	1085	74.64
18	2.200	78	6.273	190	13.88	490	34.24	790	54.61	1090	74.98
19	2.267	79	6.341	195	14.22	495	34.58	795	54.95	1095	75.32
20	2.335	80	6.409	200	14.55	500	34.92	800	55.29	1100	75.66
21	2.403	81	6.476	205	14.89	505	35.26	805	55.63	1105	75.99
22	2.471	82	6.544	210	15.23	510	35.60	810	55.97	1110	76.33
23	2.539	83	6.612	215	15.57	515	35 94	815	56.31	1115	76.67
24	2.607	84	6.680	220	15.91	520	36 28	820	56.65	1120	77.01
25	2.675	85	6.748	225	16.25	525	36.62	825	56.98	1125	77.35
26	2.743	86	6.816	230	16.59	530	36.96	830	57.32	1130	77.69
27	2.810	87	6.884	235	16.93	535	37.30	835	57.66	1135	78.03
28	2.878	88	6.952	240	17.27	540	37.64	840	58.00	1140	78.37
29	2.946	89	7.020	245	17.61	545	37.98	845	58.34	1145	78.71
30	3.014	90	7.088	250	17.95	550	38.32	850	58.68	1150	79.05
31	3.082	91	7.155	255	18.29	555	38.66	855	59.02	1155	79.39
32	3.150	92	7.223	260	18.63	560	39.00	860	59.36	1160	79.73
33	3.218	93	7.291	265	18.97	565	39.33	865	59.70	1165	80.07
34	3.286	94	7.359	270	19.31	570	39.67	870	60.04	1170	80.41
35	3.354	95	7.427	275	19.65	575	40.01	875	60.38	1175	80.75
36	3.422	96	7.495	280	19.99	580	40.35	880	60.72	1180	81.09
37	3.489	97	7.563	285	20.32	585	40.69	885	61.06	1185	81.42
38	3.557	98	7.631	290	20.66	590	41.03	890	61.40	1190	81.76
39	3.625	99	7.698	295	21.00	595	41.37	895	61.74	1195	82.10
40	3.693	100	7.766	300	21.34	600	41.71	900	62.08	1200	82.44
41	3.761	101	7.834	305	21.68	605	42.05	905	62.42	1210	83.12
42	3.829	102	7.902	310	22.02	610	42.39	910	62.76	1220	83.80
43	3.897	103	7.970	315	22.36	615	42.73	915	63.10	1230	84.48
44	3.965	104	8.038	320	22.70	620	43.07	920	63.44	1240	85.16
45	4.032	105	8.106	325	23.04	625	43.41	925	63.77	1250	85.84
46	4.100	106	8.174	330	23.38	630	43.75	930	64.11	1260	86.52
47	4.168	107	8.242	335	23.72	635	44.09	935	64.45	1270	87.20
48	4.236	108	8.310	340	24.06	640	44.43	940	64.79	1280	87.88
49	4.304	109	8.377	345	24.40	645	44.76	945	65.13	1290	88.55
50	4.372	110	8.445	350	24.74	650	45.10	950	65.47	1300	89.23
51	4.440	111	8.513	355	25.08	655	45.44	955	65.81	1310	89.91
52	4.507	112	8.581	360	25.42	660	45.78	960	66.15	1320	90.59
53	4.576	113	8.649	365	25.76	665	46.12	965	66.49	1330	91.27
54	4.644	114	8.717	370	26.10	670	46.46	970	66.83	1340	91.95
55	4.711	115	8.785	375	26.44	675	46.80	975	67.17	1350	92.63
56	4.779	116	8.853	380	26.78	680	47.14	980	67.51	1360	93.31
57	4.847	117	8.920	385	27.11	685	47.48	985	67.85	1380	94.66
58	4.915	118	8.988	390	27.45	690	47.82	990	68.19	1400	96.02
59	4.983	119	9.056	395	27.79	695	48.16	995	68.53	1420	97.38
60	5.051	120	9.124	400	28.13	700	48.50	1000	68.87	1440	98.74

GAS TEMPERATURE CORRECTING FACTORS

Factors listed are usable to convert gas volume readings from displacement meters at various temperatures to volumes at the standard base temperature of 60° F.

°F	Factor	°F	Factor	°F	Factor	°F	Factor
-20	1.1818	20	1.0833	60	1.0000	100	0.9286
-19	1.1791	21	1.0811	61	0.9981	101	0.9269
-18	1.1765	22	1.0788	62	0.9962	102	0.9253
-17	1.1738	23	1.0766	63	0.9943	103	0.9236
-16	1.1712	24	1.0744	64	0.9924	104	0.9220
-15	1.1685	25	1.0722	65	0.9905	105	0.9204
-14	1.1659	26	1.0700	66	0.9886	106	0.9187
-13	1.1633	27	1.0678	67	0.9867	107	0.9171
-12	1.1607	28	1.0656	68	0.9848	108	0.9155
-11	1.1581	29	1.0634	69	0.9830	109	0.9139
-10	1.1556	30	1.0612	70	0.9811	110	0.9123
-9	1.1530	31	1.0591	71	0.9793	111	0.9107
-8	1.1504	32	1.0569	72	0.9774	112	0.9091
-7	1.1479	33	1.0548	73	0.9756	113	0.9075
-6	1.1454	34	1.0526	74	0.9738	114	0.9059
-5	1.1429	35	1.0505	75	0.9720	115	0.9043
-4	1.1404	36	1.0484	76	0.9701	116	0.9028
-3	1.1379	37	1.0463	77	0.9683	117	0.9012
-2	1.1354	38	1.0442	78	0.9665	118	0.8997
-1	1.1329	39	1.0421	79	0.9647	119	0.8981
0	1.1304	40	1.0400	80	0.9630	120	0.8966
1	1.1280	41	1.0379	81	0.9612	121	0.8950
2	1.1255	42	1.0359	82	0.9594	122	0.8935
3	1.1231	43	1.0338	83	0.9576	123	0.8919
4	1.1207	44	1.0317	84	0.9559	124	0.8904
5	1.1184	45	1.0297	85	0.9541	125	0.8889
6	1.1159	46	1.0277	86	0.9524	126	0.8874
7	1.1135	47	1.0256	87	0.9506	127	0.8859
8	1.1111	48	1.0236	88	0.9489	128	0.8844
9	1.1087	49	1.0216	89	0.9472	129	0.8829
10	1.1064	50	1.0196	90	0.9455	130	0.8814
11	1.1040	51	1.0176	91	0.9437	131	0.8799
12	1.1017	52	1.0156	92	0.9420	132	0.8784
13	1.0994	53	1.0136	93	0.9403	133	0.8769
14	1.0970	54	1.0117	94	0.9386	134	0.8754
15	1.0947	55	1.0097	95	0.9369	135	0.8739
16	1.0924	56	1.0077	96	0.9353	136	0.8725
17	1.0901	57	1.0058	97	0.9336	137	0.8710
18	1.0879	58	1.0039	98	0.9319	138	0.8696
19	1.0856	59	1.0019	99	0.9302	139	0.8681

APPENDIX A

Combining Boyle's Law and Charles' Law gives the relationship:

$$\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$$

This equation states that the volume of a given mass of gas will vary inversely with the absolute pressure and directly with the absolute temperature. By solving this equation for V_2 (selling volume at agreed base pressure and temperature), the value of the gas can be calculated:

$$V_2 = \frac{P_1 V_1 T_2}{P_2 T_1} \quad \text{or} \quad V_2 = V_1 \times \frac{P_1}{P_2} \times \frac{T_2}{T_1}$$

Note: Values indicated by subscript "2" are standard conditions. Values indicated by subscript "1" are existing line conditions. All pressures and temperatures must be expressed in terms of absolute.

For example, find the standard volume (or selling volume) which has passed through a meter given the following information:

V_2 = Selling or Standard Cubic Feet Volume (SCF), unknown.

V_1 = Final Counter Reading - Initial Counter Reading
= 1,862,900 - 1,743,600 = 119,300 Actual Cubic Feet (ACF).

P_1 = 18 PSI Gauge Pressure + 14.4 psi (Average Atmospheric Pressure)
= 32.40 psi Absolute Pressure.

T_1 = 80° F + 460°

T_1 = 80° F + 460° F = 540° R   Absolute Temperature

P_2 = 14.73 psi Absolute Contract Base Pressure

T_2 = 60°F + 460°F = 520°R Contract Base Temperature

$$V_2 = V_1 \times \frac{P_1}{P_2} \times \frac{T_2}{T_1} = 119{,}300 \times \frac{32.40}{14.73} \times \frac{520}{540}$$

$$V_2 = 119,\ 300 \times 2.2 \times .963 = 252{,}749 \text{ SCF}$$

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