the saturation curve near the critical point (29). By successive trials, the value of t_c for which $(d_l - d_g)$ showed the proper dependence on $(t_c - t)^{1/3}$ was determined to be 36.434° C. With this value of the critical temperature, the critical pressure was calculated from Equation 2 and the critical density was calculated from the rectilinear diameter given by Equation 4. The resulting critical properties of nitrous oxide are:

$$t_c = 36.434° \pm 0.005° \text{ C.}$$
$$P_c = 71.596 \pm 0.007 \text{ atm.}$$
$$d_c = 0.4525 \pm 0.001 \text{ gram per ml.}$$

These values are shown in comparison with the critical constants reported by other investigators in Table V.

Latent Heat of Vaporization. The observed latent heat values presented in Table IV were evaluated by use of the Clapeyron equation,

$$\Delta H_v = JT(v_g - v_L)(dP/dT) \qquad (6)$$

in conjunction with the smoothed orthobaric densities of Table IV and the vapor pressure relation given by Equation 2. In evaluating the slope of the vapor pressure curve, the residual term, r_p, was differentiated and smoothed graphically. This residual derivative, dr_p/dT, contributed a maximum of 1% to the slope of the vapor pressure curve calculated from Equation 2.

In smoothing the latent heat data, the observed values were fitted to the equation:

$$\Delta H_v = a(t_c - t)^b + c(t_c - t) + r_v \qquad (7)$$

Table V. Comparison of Critical Properties

Date	t_c, ° C.	P_c, Atm.	d_c, G./Ml.	Investigator
1956	36.434	71.596	0.4525	This work
1953	36.39	71.4	0.452	Cook (10)
1929	...	...	0.459	Quinn and Wernimont (27)
1912	36.50	71.65	...	Cardoso and Arni (6)
1895	36.0	71.9	...	Kuenen (24)
1894	38.8	77.5	0.454	Villard (33)
1886	...	...	0.41	Cailletet and Mathias (5)
1884	35.4	75.0	...	Dewar (13)
1878	36.4	73.07	...	Janssen (21)

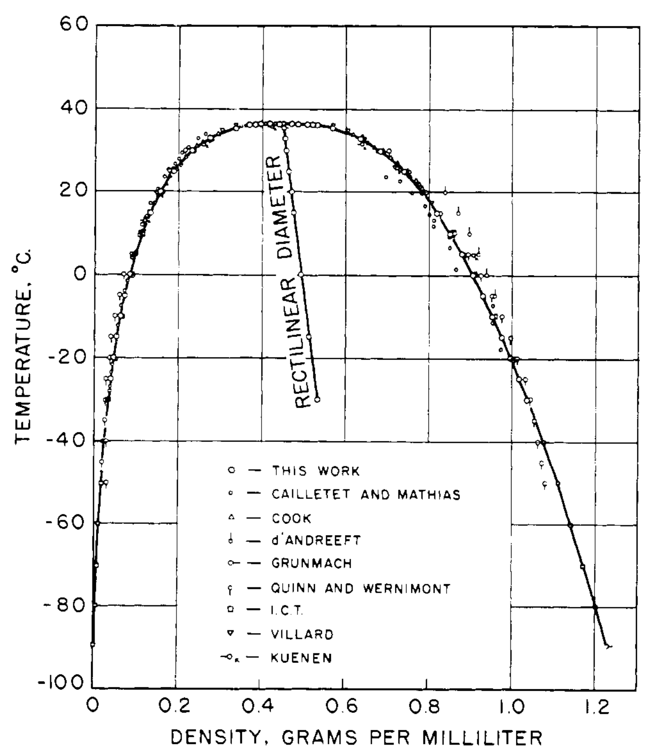

Figure 5. Orthobaric densities of nitrous oxide

where

$$a = 12.9922$$
$$c = -0.082167$$
$$b = 0.417796$$
$$t_c = 36.434° \text{ C.}$$

The residuals, r_v, were smoothed graphically and the smoothed latent heats calculated from Equation 7 are shown in Table IV. These latent heat data are considered to be reliable to 1% for temperatures below 35° C.

CONCLUSIONS

While the accuracy of the experimental *P-V-T* measurements is discussed above, a realistic estimation of the reliability of the derived quantities is difficult. In some cases, notably the orthobaric densities and latent heat values, the above tabulations contain more significant figures than the probable accuracy warrants. These additional figures have been retained not only as an indication of the internal consistency of the smoothed tabulations, but also with a view to the possible use of these data in subsequent thermodynamic calculations wherein differences and differential coefficients must be evaluated. In using the data as such, the limitations on their reliability should be borne in mind.

Gas Compressibility Factors at Low Pressures

The pressure range of the gas compressibility factor isotherms is extended to pressures as low as 1 atm. over the temperature range −30° to 150° C. Also given are smoothed values of the second virial coefficient for nitrous oxide, parameters for use with the Lennard-Jones potential function which predicts values of the second virial coefficient, and fugacity coefficients for gaseous nitrous oxide for pressures up to 315 atm. over the temperature range from −30° to 150° C.

EXPERIMENTAL

Nitrous Oxide Purity. The nitrous oxide used is described above. It was further purified by cooling to −70° C. and then discharging gas from the vapor phase until the original weight was reduced by 10%.

Apparatus. The design, construction, and calibration of the Burnett apparatus used in this investigation are described by Silberberg, Kobe, and McKetta (30). The equipment was modified to extend the lower temperature limit to −30° C.

RESULTS

Compressibility. The compressibility factor is defined as

$$z = PV/RT \qquad (8)$$

The experimental data were treated graphically (30). Large scale plots of P_rN^r *vs.* P_r were made to determine P_o/z_o, the ordinate at zero pressure. On these plots ordinates could be read to 0.01 to 0.02% with commensurate precision for the abscissas. The compressibility factor, z_r, at each pressure, P_r, was calculated by dividing each P_rN^r by P_o/z_o.

Compressibility factor isotherms were measured at 15° C. intervals from −30° to 30° C. for pressures ranging from atmospheric to slightly below the vapor pressure. Between 50° and 150° C. the isotherm increment was 25° C. and pressures up to 65 atm. were measured. However, since the gas compressibility factors at the higher pressures agree so well with Couch's results (11), only the experimental data below 10 atm. are shown in Table VI.

The maximum error, including that from pressure and temperature, in the compressibility factor values of Table

VI is estimated to be 0.20% at −30° and −15° C., 0.25% at 0° C., 0.30% at 15° C., 0.75% at 30° C., 0.25% at 50° C., and 0.20% at 75°, 100°, 125°, and 150° C.

Second Virial Coefficients. The residual volume, α, was defined above as

$$\alpha = \frac{RT}{P} - V = \frac{RT}{P}(1 - z) \tag{1}$$

For each isotherm residual volumes were calculated from the experimental compressibility data by Equation 1 and plotted against pressure. Smoothed curves were drawn through the experimental points and extrapolated to zero pressure, where the intercept is the numerical value of the second virial coefficient with the sign reversed (*31*).

The experimental residual volume isotherms of nitrous oxide are shown in Figure 6 along with the values computed from Couch's results (*11*). The experimental second virial coefficients are presented in Table VII and plotted in Figure 7. Smoothed values of the second virial coefficient read from the curve in Figure 7 appear in Table VII. It is estimated that the error in the smoothed second virial coefficients does not exceed 0.025 liter per gram mole at −30° C. and decreases to 0.010 liter per gram mole at 150° C.

Fugacity Coefficients. Lewis (*26*) defined fugacity as:

$$RT(d \ln f) = VdP = dG \tag{9}$$

If Equation 9 is combined with Equation 1,

$$\int_0^P d \ln\left(\frac{f}{P}\right) = -\frac{1}{RT}\int_0^P \alpha\, dP \tag{10}$$

Integrating the left side of Equation 10,

$$\ln\left(\frac{f}{P}\right) = -\frac{1}{RT}\int_0^P \alpha\, dP + \ln\left(\frac{f}{P}\right)\Bigg|_{P=0} \tag{11}$$

By definition, $f/P = 1.0$ at $P = 0$. Therefore, the last term of Equation 11 is zero.

The value of α at $P = 0$ is not indeterminate, as Equation 11 might indicate. Experiment shows that α approaches a finite value at zero pressure (Figure 6).

The ratio of fugacity to pressure is termed the fugacity coefficient, ν, Equation 11 may be rewritten as

$$\nu = \frac{f}{P} = \exp.\left[-\frac{1}{RT}\int_0^P \alpha\, dP\right] \tag{12}$$

Fugacity coefficients for nitrous oxide were calculated by Equation 12. The experimental α values of Couch (*11*) and this work were plotted against pressure with temperature as a parameter. The scale of the plot permitted α to be read to 0.0001 liter per gram mole and the pressure to 0.02 atm. A smoothed curve was drawn through the data for each isotherm and residual volumes were read from the curve at intervals of 1.5 atm. The integration in Equation 12 was performed mathematically by calculating areas under the α *vs.* P curve at increments of 3 atm. using Simpson's rule.

Values of the fugacity coefficient for gaseous nitrous oxide from −30° to 150° C. are presented in Table VIII and plotted in Figure 8. The maximum error in these values is estimated to be 0.20%.

DISCUSSION

Low pressure gas compressibility measurements at 0° C. and 1 atm. were reported by Batuecas (*1*), Cawood and Patterson (*8*), and Johnston and Weimer (*22*). The agreement of their results with those of this work ranges from 0.05 to 0.10%.

Second virial coefficients computed from the low pressure compressibility data of Batuecas (*1*), Bottomley, Massie,

Table VI. Nitrous Oxide Low Pressure Experimental Compressibility Isotherms

Pressure, Atm.	Volume, Liters/G. Mole	$z = PV/RT$
	−30° C.	
9.9066	1.7830	0.8853
7.2631	2.5233	0.9184
5.2663	3.5700	0.9424
3.7875	5.0511	0.9591
2.7088	7.1507	0.9706
1.9309	10.1163	0.9790
1.3730	14.3137	0.9851
8.4645	2.1310	0.9040
6.1674	3.0159	0.9321
4.4496	4.2665	0.9516
3.1929	6.0387	0.9663
2.2781	8.5445	0.9756
1.6218	12.0907	0.9828
1.1515	17.1071	0.9874
9.5308	6.0493	0.8903
6.9747	2.6372	0.9220
	−15° C.	
8.3072	2.3524	0.9228
6.0117	3.3298	0.9450
4.3174	4.7096	0.9603
3.0877	6.6684	0.9719
2.2003	9.4325	0.9800
1.5641	13.3499	0.9858
1.1094	18.8947	0.9895
10.3084	1.8566	0.9035
7.5104	2.6272	0.9315
5.4196	3.7169	0.9511
3.8861	5.2597	0.9651
2.7744	7.4451	0.9750
1.9754	10.5329	0.9824
1.4032	14.9050	0.9874
	0° C.	
8.2453	2.5483	0.9376
5.9366	3.6075	0.9553
4.2546	5.1048	0.9688
3.0348	7.2234	0.9778
2.1572	10.2198	0.9836
1.5318	14.4596	0.9884
1.0868	20.4673	0.9922
9.8028	2.1157	0.9253
7.0882	2.9934	0.9468
5.0916	4.2372	0.9623
3.6386	5.9953	0.9732
2.5932	8.4844	0.9814
1.8429	12.0034	0.9870
1.3068	16.9812	0.9904
	15° C.	
8.2859	2.7016	0.9467
5.9522	3.8237	0.9623
4.2565	5.4079	0.9738
3.0308	7.6565	0.9812
2.1535	10.8305	0.9866
1.5284	15.3251	0.9908
1.0841	21.6982	0.9945
10.2745	2.1489	0.9341
7.4117	3.0409	0.9535
5.3119	4.3046	0.9670
3.7910	6.0891	0.9766
2.6990	8.6173	0.9838
1.9161	12.1931	0.9884
1.3581	17.2573	0.9914
0.9622	24.4282	0.9938
9.1777	2.4280	0.9424
6.6021	3.4365	0.9593
4.7224	4.8617	0.9710
3.3669	6.8812	0.9796
2.3927	9.7320	0.9851
1.6988	13.7796	0.9898
1.2047	19.4842	0.9932

Pressure, Atm.	Volume, Liters/G. Mole	$z = PV/RT$
	30° C.	
10.3712	2.2639	0.9440
7.4627	3.2055	0.9614
5.3329	4.5358	0.9722
3.7997	6.4158	0.9802
2.7013	9.0806	0.9861
1.9171	12.8535	0.9903
9.1635	2.5827	0.9512
6.5720	3.6526	0.9653
4.6943	5.1716	0.9757
3.3415	7.3139	0.9828
2.3736	10.3525	0.9879
1.6826	14.6558	0.9910
1.1925	20.7255	0.9938
8.1798	2.9103	0.9568
5.8551	4.1179	0.9691
4.1768	5.8243	0.9782
2.9719	8.2477	0.9850
2.1082	11.6631	0.9887
1.4958	16.5087	0.9927
	50° C.	
8.0016	3.2029	0.9665
5.7136	4.5324	0.9766
4.0644	6.4139	0.9831
2.8868	9.0761	0.9881
2.0474	12.8424	0.9916
9.9677	2.5479	0.9578
7.1362	3.6054	0.9703
5.0900	5.1022	0.9794
3.6187	7.2199	0.9853
2.5682	10.2167	0.9895
1.8207	14.4562	0.9926
8.9511	2.8498	0.9620
6.3966	4.0327	0.9728
4.5573	5.7068	0.9808
3.2382	8.0750	0.9861
2.2983	11.4267	0.9904
1.6289	16.1693	0.9933
	75° C.	
10.0417	2.7527	0.9676
7.1621	3.8951	0.9765
5.0969	5.5120	0.9834
3.6203	7.7996	0.9884
2.5668	11.0376	0.9917
	100° C.	
8.6398	3.4614	0.9767
6.1473	4.8982	0.9834
4.3685	6.9313	0.9889
3.0957	9.8079	0.9916
2.1934	13.8788	0.9942
10.3202	2.8871	0.9731
7.3534	4.0853	0.9811
5.2246	5.7809	0.9864
3.7068	8.1810	0.9904
2.6271	11.5758	0.9932
	125° C.	
7.9811	4.0255	0.9834
5.6682	5.6964	0.9883
4.0172	8.0603	0.9911
2.8473	11.4066	0.9941
2.0157	16.1399	0.9958
	150° C.	
8.1284	4.2106	0.9857
5.7692	5.9583	0.9900
4.0878	8.4320	0.9927
2.8967	11.9317	0.9954
2.0520	16.8840	0.9978
9.7801	3.4928	0.9838
6.9447	4.9428	0.9886
4.9243	6.9947	0.9920
3.4873	9.8971	0.9940
2.4711	14.0050	0.9967
1.7492	19.8187	0.9984

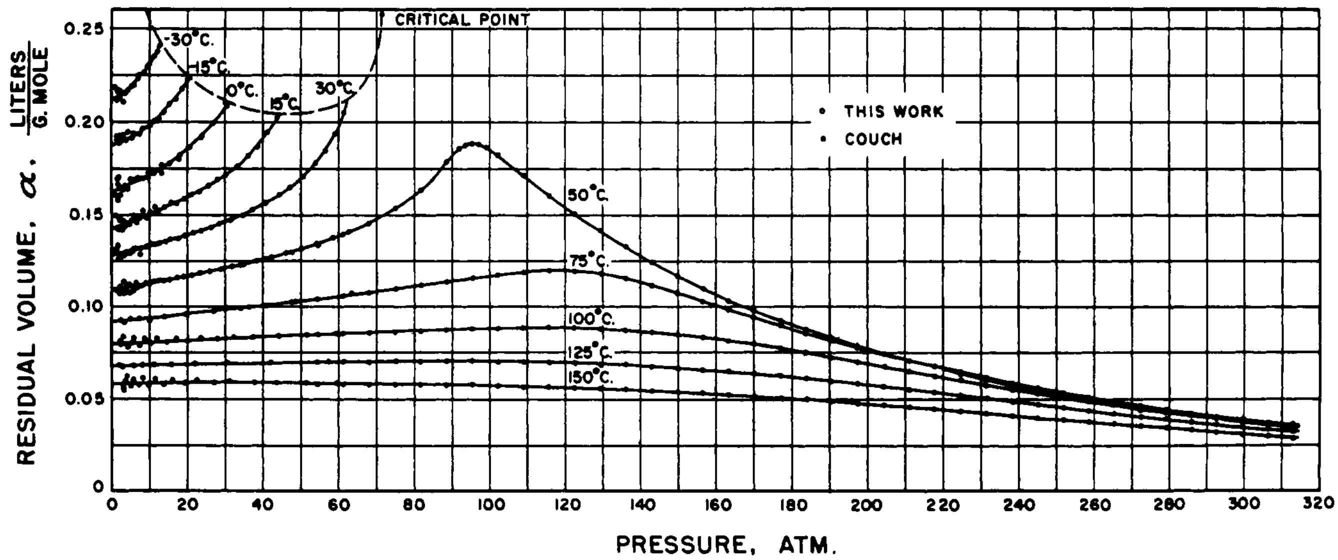

Figure 6. Residual volume isotherms of nitrous oxide

and Whytlaw-Gray (*3*), Cawood and Patterson (*8*), Johnston and Weimer (*22*), Leduc and Sacerdote (*25*), and Rayleigh (*28*) appear in Figure 7 along with the experimental values of the present work. The ICT value (*20*) was calculated from Rayleigh's work. Smoothed second virial coefficients obtained in this study agree with the work of these other investigators within the estimated experimental accuracy, 0.025 liter per gram mole.

The virial form of the Berthelot equation of state may be used to calculate second virial coefficients. The expression for B derived from the Berthelot equation is

$$B = \frac{9RT_c}{128P_c}\left[1 - \frac{6}{T_R^2}\right] \quad (13)$$

Couch's critical constants (*11*) were used in Equation 13 to calculate values of B from −30° to 150° C. (Table VII). The maximum deviation of the calculated second virial coefficients from the smoothed values of this work is 0.007 liter per gram mole.

Another theoretical relation for computing the second virial coefficients of nonpolar gases is the Lennard-Jones "6–12" potential function described by Hirschfelder, Curtiss, and Bird (*16*). Hirschfelder's suggested parameters (*17*) for nitrous oxide were used—e/k = 189° K. and b_0 = 0.122 liter per gram mole. The maximum difference between the calculated second virial coefficients (Table VII) and the smoothed values is 0.016 liter per gram mole at −30° C., which is within the experimental accuracy of this work.

Other values for the parameters in the Lennard-Jones function, such as e/k = 195°, 180°, and 175° K. and b_0 = 0.120, 0.145, and 0.149 liter per gram mole, led to calculated second virial coefficients which gave larger deviations from the experimental results than Hirschfelder's values.

For polar gases, the Stockmayer potential function usually gives good predictions of the second virial coefficient. The Stockmayer function depends not only of the reduced temperature but also on the dipole moment of the gas. For nitrous oxide the dipole moment is so small (0.14 debye) that the function $(T^*/t^*)B^*$ (*16*) cannot be evaluated. Consequently, the Stockmayer potential function is not satisfactory for predicting the second virial coefficients of nitrous oxide, a relatively nonpolar gas.

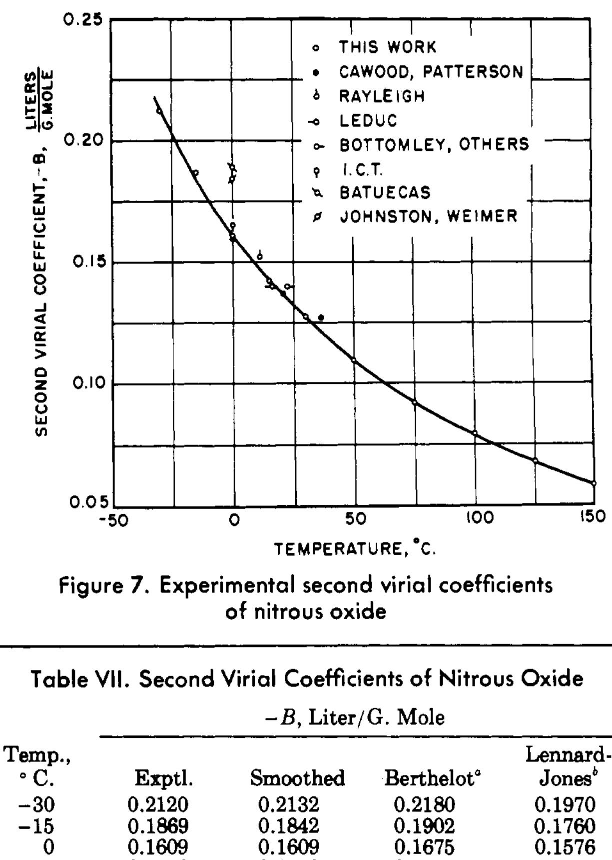

Figure 7. Experimental second virial coefficients of nitrous oxide

Table VII. Second Virial Coefficients of Nitrous Oxide

Temp., °C.	−B, Liter/G. Mole Exptl.	Smoothed	Berthelot[a]	Lennard-Jones[b]
−30	0.2120	0.2132	0.2180	0.1970
−15	0.1869	0.1842	0.1902	0.1760
0	0.1609	0.1609	0.1675	0.1576
15	0.1423	0.1423	0.1477	0.1418
30	0.1278	0.1272	0.1312	0.1276
50	0.1091	0.1095	0.1134	0.1113
75	0.0920	0.0920	0.0944	0.0939
100	0.0794	0.0788	0.0790	0.0791
125	0.0680	0.0688	0.0650	0.0666
150	0.0582	0.0582	0.0548	0.0560

[a] From Equation 13.
[b] Parameters. e/k = 189° K., b_0 = 0.122 liter/g. mole.

NOMENCLATURE

- B = second virial coefficient
- b_0 = parameter in Lennard-Jones and Stockmayer potential functions
- d = density, g./ml.
- e/k = parameter in Lennard-Jones and Stockmayer potential functions
- f = fugacity
- G = molal free energy

Table VIII. Fugacity Coefficients for Gaseous Nitrous Oxide

Pressure, Atm.	Temperature, ° C. −30	−15	0	15	30
	Fugacity Coefficient, $v = f/P$				
0	1.0000	1.0000	1.0000	1.0000	1.0000
3	0.9683	0.9740	0.9784	0.9819	0.9847
6	0.9372	0.9482	0.9570	0.9639	0.9694
9	0.9063	0.9226	0.9357	0.9460	0.9542
12	0.8752	0.8970	0.9144	0.9281	0.9391
13.052	0.8642[a]				
15		0.8712	0.8931	0.9102	0.9240
18		0.8456	0.8721	0.8924	0.9089
20.559		0.7864[a]			
21			0.8508	0.8746	0.8939
24			0.8295	0.8568	0.8789
27			0.8081	0.8390	0.8639
30			0.7864	0.8212	0.8489
30.786			0.7806[a]		
33				0.8033	0.8340
36				0.7853	0.8190
39				0.7672	0.8041
42				0.7487	0.7891
44.438				0.7334[a]	
45					0.7740
48					0.7589
51					0.7436
54					0.7281
57					0.7124
60					0.6961
62.359					0.6828[a]

Pressure, Atm.	Temperature, ° C. 50	75	100	125	150
	Fugacity Coefficient, $v = f/P$				
0	1.0000	1.0000	1.0000	1.0000	1.0000
3	0.9876	0.9904	0.9923	0.9938	0.9950
6	0.9754	0.9808	0.9846	0.9876	0.9901
9	0.9631	0.9712	0.9770	0.9815	0.9852
12	0.9509	0.9616	0.9694	0.9753	0.9803
15	0.9387	0.9521	0.9618	0.9693	0.9755
18	0.9266	0.9426	0.9542	0.9632	0.9706
21	0.9145	0.9332	0.9467	0.9572	0.9658
24	0.9024	0.9238	0.9392	0.9512	0.9610
27	0.8903	0.9144	0.9318	0.9452	0.9563
30	0.8783	0.9050	0.9243	0.9393	0.9515
33	0.8663	0.8956	0.9169	0.9334	0.9468
36	0.8544	0.8863	0.9095	0.9275	0.9421
39	0.8424	0.8770	0.9022	0.9216	0.9375
42	0.8305	0.8678	0.8948	0.9158	0.9330
45	0.8186	0.8585	0.8876	0.9100	0.9284
48	0.8067	0.8493	0.8803	0.9043	0.9238
51	0.7948	0.8402	0.8731	0.8985	0.9192
54	0.7830	0.8310	0.8659	0.8928	0.9146
57	0.7711	0.8220	0.8588	0.8872	0.9100
60	0.7592	0.8129	0.8517	0.8815	0.9055
63	0.7474	0.8039	0.8446	0.8759	0.9010
66	0.7355	0.7950	0.8376	0.8703	0.8965
69	0.7235	0.7860	0.8306	0.8648	0.8920
72	0.7115	0.7771	0.8236	0.8592	0.8876
75	0.6994	0.7683	0.8167	0.8538	0.8832
78	0.6871	0.7594	0.8098	0.8483	0.8788
81	0.6784	0.7506	0.8030	0.8428	0.8744
84	0.6622	0.7419	0.7962	0.8374	0.8701
87	0.6500	0.7332	0.7894	0.8321	0.8658
90	0.6377	0.7245	0.7827	0.8268	0.8615
93	0.6245	0.7158	0.7760	0.8214	0.8572
96	0.6114	0.7072	0.7694	0.8162	0.8530
99	0.5986	0.6986	0.7628	0.8110	0.8488
102	0.5862	0.6901	0.7563	0.8058	0.8446
105	0.5744	0.6816	0.7498	0.8006	0.8405
108	0.5631	0.6732	0.7434	0.7955	0.8364
111	0.5523	0.6649	0.7370	0.7904	0.8323
114	0.5420	0.6566	0.7306	0.7854	0.8282
117	0.5322	0.6484	0.7243	0.7804	0.8242
120	0.5228	0.6403	0.7181	0.7754	0.8202
123	0.5139	0.6323	0.7119	0.7705	0.8162
126	0.5054	0.6245	0.7058	0.7656	0.8123
129	0.4972	0.6168	0.6998	0.7608	0.8084
132	0.4895	0.6092	0.6938	0.7560	0.8045
135	0.4820	0.6018	0.6870	0.7512	0.8007
138	0.4749	0.5946	0.6820	0.7465	0.7969
141	0.4680	0.5876	0.6763	0.7419	0.7931
144	0.4615	0.5807	0.6706	0.7373	0.7894
147	0.4552	0.5740	0.6650	0.7328	0.7857
150	0.4492	0.5675	0.6594	0.7283	0.7820
153	0.4434	0.5612	0.6540	0.7238	0.7784
156	0.4378	0.5551	0.6486	0.7195	0.7748
159	0.4324	0.5491	0.6434	0.7151	0.7712
162	0.4273	0.5433	0.6382	0.7108	0.7677
165	0.4223	0.5377	0.6331	0.7066	0.7643
168	0.4175	0.5323	0.6281	0.7024	0.7608
171	0.4128	0.5270	0.6233	0.6983	0.7574
174	0.4084	0.5219	0.6185	0.6943	0.7541
177	0.4041	0.5170	0.6138	0.6903	0.7507
180	0.3999	0.5122	0.6092	0.6863	0.7474
183	0.3959	0.5075	0.6047	0.6824	0.7442
186	0.3920	0.5030	0.6003	0.6786	0.7410
189	0.3882	0.4986	0.5960	0.6748	0.7379
192	0.3846	0.4943	0.5918	0.6712	0.7348
195	0.3811	0.4902	0.5876	0.6675	0.7317
198	0.3777	0.4862	0.5836	0.6639	0.7286
201	0.3744	0.4823	0.5796	0.6604	0.7256
204	0.3712	0.4785	0.5758	0.6569	0.7227
207	0.3681	0.4748	0.5720	0.6535	0.7198
210	0.3651	0.4712	0.5683	0.6502	0.7169
213	0.3622	0.4677	0.5647	0.6469	0.7141
216	0.3594	0.4643	0.5612	0.6437	0.7113
219	0.3567	0.4610	0.5578	0.6405	0.7085
222	0.3540	0.4578	0.5544	0.6374	0.7058
225	0.3515	0.4547	0.5511	0.6343	0.7032
228	0.3490	0.4517	0.5479	0.6313	0.7005
231	0.3466	0.4488	0.5448	0.6284	0.6979
234	0.3442	0.4459	0.5418	0.6255	0.6954
237	0.3419	0.4431	0.5388	0.6226	0.6929
240	0.3397	0.4404	0.5358	0.6198	0.6904
243	0.3375	0.4378	0.5330	0.6171	0.6880
246	0.3354	0.4352	0.5302	0.6144	0.6856
249	0.3333	0.4327	0.5275	0.6118	0.6832
252	0.3313	0.4302	0.5248	0.6092	0.6809
255	0.3294	0.4278	0.5223	0.6067	0.6786
258	0.3275	0.4255	0.5197	0.6042	0.6764
261	0.3256	0.4233	0.5172	0.6018	0.6742
264	0.3238	0.4211	0.5148	0.5994	0.6720
267	0.3221	0.4189	0.5125	0.5971	0.6699
270	0.3204	0.4168	0.5102	0.5948	0.6678
273	0.3187	0.4148	0.5079	0.5926	0.6657
276	0.3171	0.4128	0.5057	0.5904	0.6637
279	0.3156	0.4108	0.5035	0.5882	0.6617
282	0.3140	0.4089	0.5014	0.5861	0.6598
285	0.3125	0.4071	0.4994	0.5841	0.6578
288	0.3110	0.4053	0.4974	0.5820	0.6560
291	0.3096	0.4035	0.4954	0.5801	0.6541
294	0.3082	0.4018	0.4935	0.5781	0.6523
297	0.3069	0.4002	0.4916	0.5762	0.6505
300	0.3056	0.3985	0.4898	0.5744	0.6488
303	0.3043	0.3969	0.4880	0.5725	0.6471
306	0.3030	0.3954	0.4862	0.5708	0.6454
309	0.3018	0.3938	0.4845	0.5690	0.6437
312	0.3006	0.3924	0.4829	0.5673	0.6421
315	0.2995	0.3909	0.4812	0.5656	0.6406

[a] Value at saturation.

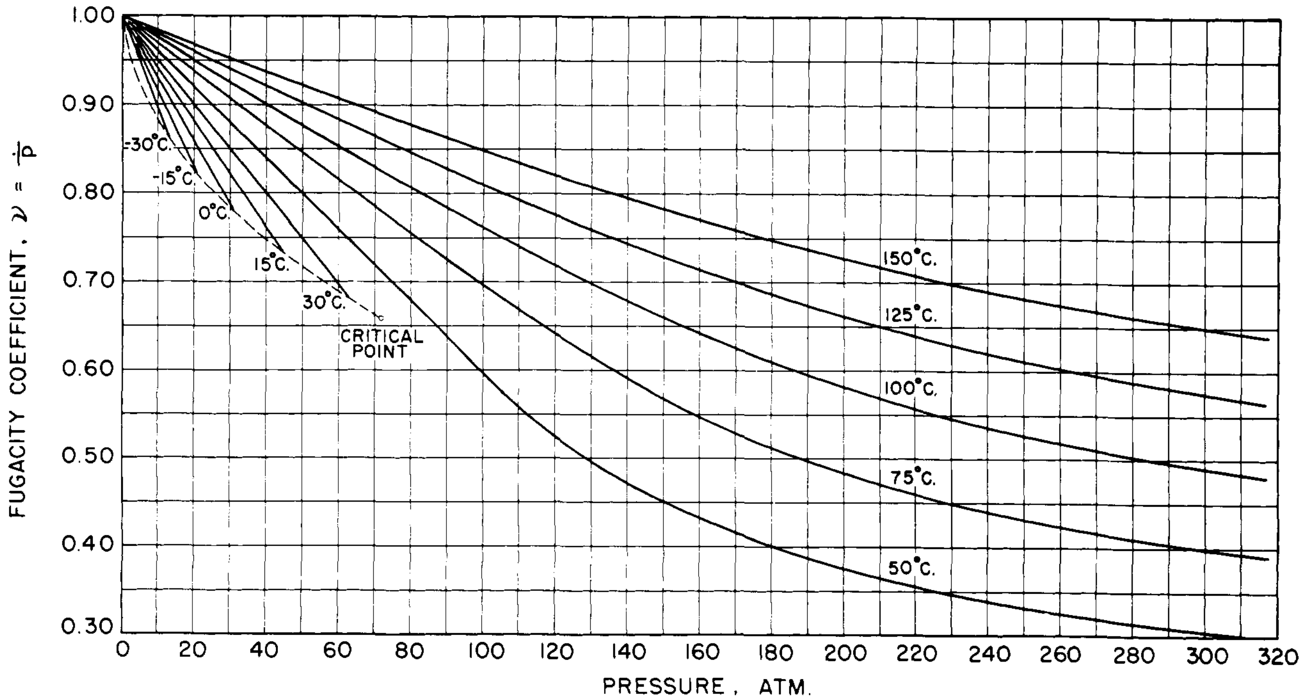

Figure 8. Fugacity coefficients for gaseous nitrous oxide

ΔH_v = latent heat of vaporization, cal./g.
J = mechanical equivalent of heat, 0.0242179 cal./ml. atm.
M = molecular weight (44.016 for nitrous oxide)
N = Burnett apparatus constant
P = absolute pressure, atm.
R = gas constant, 0.0820545 liter atm./g. mole ° K.
r_d = density residual, g./ml.
r_e = density residual, g./ml.
r_p = logarithmic vapor pressure residual
r_v = residual latent heat of vaporization, cal./g.
T = absolute temperature, ° K. (ice point = 273.16° K.)
t = temperature, ° C.
V = molal volume, liter/g. mole
v = specific volume, ml./g.
z = compressibility factor, $z = PV/RT$
α = residual volume, liter/g. mole
ν = fugacity coefficient, f/p

Subscripts

c = critical state
g = saturated gas phase
L = saturated liquid phase
o = initial state of a run
r = number of the expansion

Superscript

* = parameter in Stockmayer potential function

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