THERMOPHYSICAL PROPERTIES OF HFC-143a AND HFC-152a

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THERMOPHYSICAL PROPERTIES OF HFC-143a AND HFC-152a

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ABSTRACT

Numerous fluids have been identified as promising alternative refrigerants, but much of the information needed to predict their behavior as pure fluids and as components in mixtures does not exist. In particular, reliable thermophysical properties data and models are needed to predict the performance of the new refrigerants in heating and cooling equipment and to design and optimize equipment to be reliable and energy efficient. The objective of this project is to provide highly accurate, selected thermophysical properties data for refrigerants HFC-143a (CH_3CF_3) and HFC-152a (CH_3CHF_2) and to use these data to fit complex equations of state and detailed transport property models. The new data will fill gaps in the existing data sets and resolve problems and uncertainties that exist in and between the data sets. **This report describes progress during the third quarter of this twelve-month project, which was initiated on April 1, 1993.**

SCOPE

This project involves selected measurements of the thermodynamic properties of HFC-143a and HFC-152a and the development of high-accuracy modified Benedict-Webb-Rubin (MBWR) equations of state for each fluid. It also includes selected measurements of the transport properties (viscosity and thermal conductivity) of both HFC-143a and HFC-152a and the development of detailed correlations for same. The experimental thermodynamic property measurements will include, as appropriate, accurate determinations of the critical temperature, pressure, and density; vapor pressures and saturated densities; vapor-phase speed of sound and ideal-gas heat capacity; pressure-volume-temperature (PVT) behavior of the superheated vapor and compressed liquid; and isochoric heat capacity in the liquid and two-phase regions. The experimental transport property measurements will cover the one-phase and saturated liquid and vapor states over the temperature range of interest. Efforts during this third quarter focused on analyzing vapor pressures and on measuring vapor-phase PVT behavior and liquid-phase isochoric heat capacities of HFC-143a; on developing an interim MBWR equation of state for HFC-152a; and on measuring sound speeds and thermal conductivities for HFC-152a.

SIGNIFICANT RESULTS

HFC-143a

The Burnett apparatus has been used in the isochoric mode to determine the PVT relation for the vapor phase of HFC-143a at 121 state points. Isochores were completed ranging in density from 0.106 to 6.077 mol/L (0.56 to 31.87 lb_m/ft³), in pressure from 0.234 to 6.59 MPa (34 to 956 psia), and in temperature from 276.7 to 373 K (38 to 212°F). The results of these measurements are given in Table 1. A Burnett expansion was completed at 373.16 K (212.018°F) to establish the densities of the isochores. These isothermal results are shown in Table 2. The ranges of pressures and temperatures covered are shown in Figure 1.

In the last report the vapor pressures measured with the Burnett apparatus, as well as those measured with the ebulliometer, were presented. The data measured with the Burnett apparatus have been revised for a small air impurity, and adjusted results are given in Table 3. The adjustments were all less than 0.15% in pressure. All of the vapor pressure data have been represented with a Wagner-type equation,

$$\ln(P/P_c) = T_c/T(a_1\tau + a_2\tau^{1.5} + a_3\tau^{2.5} + a_4\tau^5) \quad (1)$$

with $\tau = (1-T/T_c)$, $a_1 = -7.34896$, $a_2 = 1.70066$, $a_3 = -2.02724$, $a_4 = -2.65228$, $T_c = 346.23$ K, and $P_c = 3.7904$ MPa. This equation is valid in the temperature range from 230 K (-46°F) to the critical temperature. Deviations of the data from Equation (1) are shown in Figure 2, and they are within $\pm 0.05\%$ in pressure.

An adiabatic calorimeter has been used to measure the molar heat capacity at constant volume (C_v) for HFC-143a. Measurements were conducted on samples in the liquid state and in the vapor + liquid two-phase region. In total, heat capacities at more than 250 state conditions were measured along a total of ten isochores. The temperatures ranged from 165 to 343 K (-163 to 158°F), with pressures up to 35 MPa (5100 psia). The preliminary results of the measurements are given in Tables 4 and 5 and in Figure 3 for the liquid phase and in Tables 6 and 7 and in Figure 4 for the two-phase region. In addition to the temperature-density-pressure (T, ρ, P) state conditions, the tables present estimated uncertainties of the measurements which lead to values of liquid heat capacity, C_v , or heat capacity of the saturated liquid, $C_{v\sigma}$. In Tables 4 and 5, calculated heat capacity ($C_{v,cal}$) values are presented that were estimated using an extended corresponding states model. Also given are the percentage differences ($\delta C_v, \%$) from the measured ($C_{v,exp}$) values. In Tables 6 and 7, the measured temperature (T) and its uncertainty (δT), the saturated liquid density (ρ_σ), and vapor pressure (P_σ) are given. The values of ρ_σ and P_σ were estimated using the extended corresponding states model. The uncertainties in the experimental measurements are propagated into the heat capacities. Estimates of the absolute uncertainties ($\delta C_v^{(2)}$ and $\delta C_{v\sigma}$) and percentage uncertainties ($\delta C_v^{(2)}, \%$ and $\delta C_{v\sigma}, \%$) of the heat capacities are also given.

HFC-152a

A cylindrical acoustic resonator has been used to measure the speed of sound (u) in HFC-152a along isotherms from 242.8 to 400.0 K (-22.7 to 260.3°F) at pressures between 35 and 1030 kPa (5 to 149.4 psia). The results are given in Table 8. The quantity $\delta u/u$ is the estimated fractional error in u . The ideal-gas heat capacity, C_p^0 , of HFC-152a has been obtained by analyzing the speed of sound measurements at low pressures. The results are given in Table 9. The following expressions for C_p^0 were obtained by fitting the data in Table 9.

$$C_p^0/R = a_0 + a_1T + a_2T^2 + a_3T^3$$

where

SI UNITS

a_0	=	7.6253 ± 0.0041
$a_1(^{\circ}\text{C}^{-1})$	=	0.02021 ± 0.00018
$a_2(^{\circ}\text{C}^{-2})$	=	$-2.626 \times 10^{-5} \pm 4.6 \times 10^{-6}$
$a_3(^{\circ}\text{C}^{-3})$	=	$1.035 \times 10^{-7} \pm 2.8 \times 10^{-8}$
R (gas constant)	=	$8.314471 \text{ J}/(\text{mol}\cdot\text{K})$

or

PI UNITS

a_0	=	7.251 ± 0.0054
$a_1(^{\circ}\text{F}^{-1})$	=	0.01180 ± 0.00014
$a_2(^{\circ}\text{F}^{-2})$	=	$-9.809 \times 10^{-6} \pm 1.5 \times 10^{-6}$
$a_3(^{\circ}\text{F}^{-3})$	=	$1.775 \times 10^{-8} \pm 4.8 \times 10^{-9}$
R (gas constant)	=	$0.01419457 \text{ Btu}/(\text{mol}\cdot^{\circ}\text{F})$

The second, third, and fourth acoustic virial coefficients (β_a , γ_a , δ_a) have been obtained by analyzing the pressure dependence of the speed of sound. The results are given in Table 10.

A 32-term MBWR equation of state for HFC-152a has been developed. It is valid at temperatures from the triple point of 155 K (-181°F) to 450 K (350°F), and appears to be reasonable upon extrapolation up to 500 K (440°F). The maximum pressure for the equation is 40 MPa (5800 psia), and it appears to be reasonable upon extrapolation up to 100 MPa (14500 psia). This equation was fit, using a multiparameter linear least squares routine, to the data measured under this contract as well as selected data reported in the literature. Data used in the fit include vapor pressures, saturated liquid and vapor densities, liquid and vapor phase pressure-volume-temperature (PVT) and speed of sound data, virial coefficients, and isochoric heat capacities at saturation and in the single-phase liquid. Table 11 gives the coefficients of the

equation of state; Tables 12 and 13 give the critical parameters and the coefficients of the auxiliary ideal gas heat capacity equation. The ideal gas heat capacity equation is based on the C_p° values measured in this work combined with selected literature data to extend the temperature range. Figures 5 and 6 show the deviations of the values calculated with the equation of state compared to the saturation boundary and experimental PVT data used in the fit. Table 14 tabulates the saturation properties calculated with the equation of state. The process of fitting a high-accuracy equation of state is iterative – at least, a preliminary equation of state is needed for the final analysis of the PVT and heat capacity data measured in this work. The equation of state presented here will be used for this final analysis. Also, the wide temperature range of the data has necessitated the development of an improved function to represent the saturated liquid density. For these reasons, this equation of state must be considered preliminary. This MBWR equation of state will be incorporated into a future version of the REFPROP computer package.

The low- and high-temperature transient hot-wire thermal conductivity instruments have been used to measure the thermal conductivity of HFC-152a in the vapor phase along isotherms at 300 and 425 K (80.3 and 305.3°F) and in the liquid phase along isotherms at 195, 230, 265, 300, and 335 K (-108.7, -45.7, 17.3, 80.3, and 143.3°F). Thermal conductivity measurements yet to be completed include those in the vapor phase at 225, 250, 275, 350, and 375 K (-54.7, -9.7, 35.3, 170.3, and 215.3°F), in the liquid phase at 370 K (206.3°F), and in the supercritical region at 410 K (278.3°F). The status of the thermal conductivity measurements and the location of the data are shown in Figure 7.

Figure 1. Plot of experimental temperatures and pressures for vapor phase PVT measurements for HFC-143a using Burnett apparatus.

Figure 2. Deviations of HFC-143a vapor pressure data from a correlation of the Burnett (•) and ebulliometric (o) vapor pressures.

Figure 3. Liquid phase isochoric heat capacities of HFC-143a.

Figure 4. Saturated liquid heat capacities of HFC-143a.

Figure 5. Deviations of MBWR equation of state for HFC-152a from ancillary functions for vapor pressure, saturated liquid density, and saturated vapor density.

Figure 6. Deviations of MBWR equation of state for HFC-152a from experimental pressure-volume-temperature data.

Figure 7. Range of temperatures and pressures for thermal conductivity measurements for HFC-152a.

APPENDIX A:
TABLES OF THERMOPHYSICAL PROPERTIES DATA

Table 1a. Isochoric Vapor Phase PVT Measurements using Burnett Apparatus for HFC-143a (SI Units).

T/K	P/MPa	$\rho/(\text{mol/dm}^3)$
348.207	3.9919	6.0768
353.212	4.4919	6.0755
358.141	5.0000	6.0742
363.151	5.5250	6.0730
373.163	6.5925	6.0704
368.153	6.0557	6.0717
363.152	5.5253	6.0730
358.144	5.0002	6.0742
353.165	4.4875	6.0755
323.123	2.3078	3.4136
333.144	2.8757	3.4121
343.185	3.5556	3.4107
353.205	4.1078	3.4093
363.149	4.6174	3.4078
373.174	5.1205	3.4064
328.137	2.5788	1.9151
333.167	2.8341	1.9147
338.179	2.9698	1.9143
342.824	3.0926	1.9139
348.169	3.2307	1.9135
353.167	3.3577	1.9131
358.146	3.4825	1.9127
363.159	3.6066	1.9123
368.164	3.7291	1.9119
373.154	3.8501	1.9115
318.150	1.9141	1.0751
323.176	1.9809	1.0749
328.050	2.0446	1.0746
332.632	2.1035	1.0744
338.156	2.1735	1.0742
343.180	2.2364	1.0740
348.147	2.2978	1.0737
353.142	2.3590	1.0735
358.133	2.4195	1.0733
363.134	2.4796	1.0731
368.185	2.5399	1.0728
373.155	2.5987	1.0726

Table 1a. Isochoric Vapor Phase PVT Measurements Using Burnett Apparatus for HFC-143a (SI Units) (continued).

T/K	P/MPa	$\rho/(\text{mol/dm}^3)$
298.144	1.1521	0.6038
303.168	1.1862	0.6037
308.173	1.2195	0.6036
313.165	1.2523	0.6034
318.141	1.2845	0.6033
323.162	1.3167	0.6032
328.150	1.3485	0.6030
333.173	1.3800	0.6029
338.044	1.4105	0.6028
343.178	1.4421	0.6027
348.149	1.4727	0.6025
353.139	1.5032	0.6024
358.189	1.5338	0.6023
363.177	1.5638	0.6022
368.187	1.5938	0.6020
373.153	1.6233	0.6019
283.174	0.6763	0.3390
288.447	0.6947	0.3390
292.239	0.7078	0.3389
298.168	0.7279	0.3388
303.180	0.7448	0.3388
308.168	0.7614	0.3387
313.144	0.7778	0.3386
318.192	0.7943	0.3385
323.142	0.8105	0.3385
328.135	0.8267	0.3384
329.352	0.8306	0.3384
333.128	0.8429	0.3383
338.192	0.8591	0.3383
343.155	0.8731	0.3382
348.112	0.8906	0.3381
353.187	0.9065	0.3381
358.136	0.9221	0.3380
363.179	0.9379	0.3379
368.134	0.9534	0.3378
373.153	0.9690	0.3378
276.658	0.3969	0.1903
283.087	0.4085	0.1903
288.195	0.4176	0.1902

Table 1a. Isochoric Vapor Phase PVT Measurements Using Burnett Apparatus for HFC-143a (SI Units) (continued).

T/K	P/MPa	ρ /(mol/dm ³)
293.132	0.4264	0.1902
298.164	0.4353	0.1901
303.176	0.4440	0.1901
308.134	0.4527	0.1901
313.165	0.4614	0.1900
318.156	0.4701	0.1900
323.141	0.4786	0.1899
328.188	0.4872	0.1899
333.183	0.4957	0.1899
338.138	0.5041	0.1898
343.157	0.5126	0.1898
348.198	0.5210	0.1897
353.188	0.5293	0.1897
358.187	0.5377	0.1897
363.172	0.5461	0.1896
368.180	0.5544	0.1896
373.137	0.5626	0.1895
278.133	0.2338	0.1068
283.152	0.2386	0.1068
288.197	0.2434	0.1067
293.123	0.2480	0.1067
298.164	0.2528	0.1067
303.174	0.2576	0.1067
308.132	0.2622	0.1067
313.168	0.2668	0.1066
318.195	0.2715	0.1066
323.185	0.2761	0.1066
328.182	0.2807	0.1066
333.184	0.2853	0.1065
338.140	0.2899	0.1065
343.156	0.2946	0.1065
348.162	0.2991	0.1065
353.173	0.3038	0.1064
358.179	0.3083	0.1064
363.176	0.3129	0.1064
368.179	0.3174	0.1064
373.149	0.3220	0.1064

Table 1b. Isochoric Vapor Phase PVT Measurements using Burnett Apparatus for HFC-143a (PI Units).

T/°F	P/psia	ρ /(lb _m /ft ³)
167.103	578.99	31.8739
176.112	651.51	31.8672
184.984	725.20	31.8606
194.002	801.35	31.8539
212.023	956.18	31.8406
203.005	878.32	31.8473
194.004	801.39	31.8539
184.989	725.23	31.8606
176.027	650.87	31.8673
121.951	334.72	17.9049
139.989	417.09	17.8973
158.063	515.70	17.8898
176.099	595.80	17.8823
193.998	669.71	17.8748
212.043	742.68	17.8673
130.977	374.03	10.0452
140.031	411.06	10.0431
149.052	430.74	10.0410
157.413	448.55	10.0390
167.034	468.58	10.0368
176.031	487.00	10.0346
184.993	505.10	10.0326
194.016	523.10	10.0304
203.025	540.87	10.0283
212.007	558.42	10.0262
113.000	277.62	5.6390
122.047	287.31	5.6378
130.820	296.55	5.6367
139.068	305.09	5.6356
149.011	315.24	5.6343
158.054	324.37	5.6331
166.995	333.27	5.6319
175.986	342.15	5.6307
184.969	350.92	5.6296
193.971	359.64	5.6284
203.063	368.39	5.6272
212.009	376.92	5.6260
76.989	167.10	3.1671
86.032	172.05	3.1664
95.041	176.88	3.1658

Table 1b. Isochoric Vapor Phase PVT Measurements using Burnett Apparatus for HFC-143a (PI Units) (continued).

T/°F	P/psia	ρ/(lb_m/ft³)
104.027	181.63	3.1651
112.984	186.30	3.1644
122.022	190.97	3.1638
131.000	195.59	3.1631
140.041	200.16	3.1624
148.809	204.58	3.1618
158.050	209.16	3.1611
166.998	213.60	3.1605
175.980	218.02	3.1598
185.070	222.46	3.1591
194.049	226.81	3.1585
203.067	231.16	3.1578
212.005	235.44	3.1571
50.043	98.09	1.7784
59.535	100.75	1.7780
66.360	102.65	1.7777
77.032	105.57	1.7773
86.054	108.02	1.7769
95.032	110.43	1.7765
103.989	112.81	1.7761
113.076	115.21	1.7758
121.986	117.55	1.7754
130.973	119.90	1.7750
133.164	120.47	1.7749
139.960	122.25	1.7747
149.076	124.60	1.7743
158.009	126.63	1.7739
166.932	129.17	1.7735
176.067	131.48	1.7732
184.975	133.75	1.7728
194.052	136.03	1.7724
202.971	138.28	1.7721
212.005	140.54	1.7717
38.314	7.57	0.9982
49.887	59.25	0.9979
59.081	60.57	0.9977
67.968	61.85	0.9975
77.025	63.13	0.9973
86.047	64.40	0.9971
94.971	65.66	0.9969
104.027	66.92	0.9967

**Table 1b. Isochoric Vapor Phase PVT Measurements using Burnett Apparatus for HFC-143a
(PI Units) (continued).**

T/°F	P/psia	ρ/(lb_m/ft³)
113.011	68.18	0.9965
121.984	69.42	0.9963
131.068	70.66	0.9961
140.059	71.90	0.9958
148.978	73.12	0.9956
158.013	74.35	0.9954
167.086	75.56	0.9952
176.068	76.78	0.9950
185.067	77.99	0.9948
194.040	79.20	0.9946
203.054	80.42	0.9944
211.977	81.60	0.9942
40.969	33.90	0.5601
50.004	34.60	0.5600
59.085	35.30	0.5599
67.951	35.98	0.5598
77.025	36.66	0.5596
86.043	37.36	0.5595
94.968	38.03	0.5594
104.032	38.70	0.5593
113.081	39.37	0.5592
122.063	40.05	0.5591
131.058	40.71	0.5589
140.061	41.38	0.5588
148.982	42.05	0.5587
158.011	42.73	0.5586
167.022	43.39	0.5585
176.041	44.06	0.5583
185.052	44.72	0.5582
194.047	45.38	0.5581
203.052	46.04	0.5580
211.998	46.70	0.5579

Table 2a. Burnett Isothermal Vapor Phase PVT Measurements for HFC-143a (SI Units).

T/K	P/MPa	$\rho/(\text{mol/dm}^3)$
373.16	6.5923	6.0704
373.16	5.1199	3.4064
373.16	3.8498	1.9115
373.16	2.5982	1.0726
373.16	1.6236	0.6019
373.16	0.9686	0.3378
373.16	0.5627	0.1895
373.16	0.3219	0.1064

Table 2b. Burnett Vapor Phase PVT Isothermal Measurements for HFC-143a (PI Units).

T/°F	P/psia	ρ/(lb_m/ft³)
212.018	956.15	31.8406
212.018	742.90	17.8673
212.018	558.37	10.0262
212.018	376.84	5.6260
212.018	235.49	3.1571
212.018	140.49	1.7717
212.018	81.62	0.9942
212.018	46.69	0.5579

Table 3. Final Vapor Pressure Results for HFC-143a From Burnett Apparatus.

T/K	P/kPa	T/°F	P/psia
279.171	744.3	42.838	107.95
282.974	832.1	46.683	120.69
283.128	835.7	49.960	121.21
287.965	958.8	58.667	139.06
288.221	965.6	59.128	140.05
293.028	1101.9	67.780	159.82
293.173	1105.8	68.041	160.39
298.165	1262.0	77.027	183.04
298.173	1262.6	77.041	183.13
303.153	1434.3	86.005	208.03
303.155	1434.4	86.009	208.05
308.131	1623.1	94.966	235.41
308.177	1624.7	95.049	235.65
313.176	1833.1	104.047	265.87
318.118	2057.9	112.942	298.48
323.168	2309.0	122.032	334.90
323.264	2351.3	122.205	341.03
328.172	2581.2	131.040	374.38
333.162	2876.6	140.022	417.22
337.997	3188.8	148.725	462.50
343.190	3556.3	158.072	515.81

Table 4. Experimental Liquid Heat Capacity Data for HFC-143 (SI Units).

T	ρ	P	$C_{v,exp}$	$C_{v,cal}$	$\delta C_v, \%$	Run
K	mol dm ⁻³	MPa	J mol ⁻¹ K ⁻¹			
170.3281	15.6171	13.7273	72.10	77.04	-6.85	A
170.7989	15.6154	14.3789	70.17	77.06	-9.82	C
172.5565	15.6105	16.1155	68.56	77.08	-12.42	B
175.2451	15.6006	19.8705	68.78	77.12	-12.13	C
177.0298	15.5941	22.3525	68.92	77.12	-11.90	B
179.6599	15.5845	26.0074	69.37	77.09	-11.13	C
181.4563	15.5778	28.5012	69.50	77.05	-10.86	B
184.0426	15.5683	32.0694	69.75	76.98	-10.36	C
185.8380	15.5617	34.5416	69.97	76.92	-9.94	B
187.8542	15.5543	37.3102	70.49	76.86	-9.04	A
188.3914	15.5523	38.0468	70.37	76.84	-9.19	C
188.5298	15.1080	9.9379	73.13	75.36	-3.04	A
190.7988	15.1017	12.1929	69.70	75.30	-8.03	B
192.8861	15.0946	14.8228	69.85	75.27	-7.76	A
195.1668	15.0869	17.6944	70.44	75.25	-6.83	B
197.2441	15.0799	20.3057	70.29	75.23	-7.02	A
199.5162	15.0723	23.1557	70.89	75.21	-6.09	B
201.5735	15.0653	25.7314	70.86	75.19	-6.11	A
203.8414	15.0576	28.5638	71.31	75.18	-5.43	B
205.8816	15.0507	31.1068	71.54	75.17	-5.07	A
208.1183	15.0431	33.8893	71.88	75.17	-4.56	B
210.1512	15.0362	36.4133	72.31	75.17	-3.95	A
205.8928	14.6057	7.4907	74.26	74.09	0.23	A
208.0073	14.6003	9.3875	71.03	74.11	-4.32	B
210.2338	14.5933	11.9202	71.41	74.15	-3.84	A
212.3681	14.5867	14.3481	71.51	74.20	-3.77	B
214.5824	14.5799	16.8640	71.90	74.25	-3.27	A
216.6730	14.5734	19.2371	72.17	74.30	-2.96	B
218.8695	14.5692	21.7264	72.36	74.36	-2.75	A
220.9379	14.5601	24.0715	72.65	74.41	-2.41	B
223.1052	14.5534	26.5188	73.06	74.46	-1.92	A
225.1740	14.5470	28.8556	73.41	74.52	-1.51	B
227.3037	14.5404	31.2585	73.55	74.57	-1.39	A
229.3668	14.5339	33.5842	74.03	74.63	-0.81	B
231.4567	14.5274	35.9378	74.00	74.69	-0.92	A
225.1753	14.0162	5.6089	76.45	73.74	3.56	A
227.1426	14.0115	7.1672	72.90	73.82	-1.26	B
229.4664	14.0051	9.4998	73.29	73.94	-0.89	A
231.4525	13.9995	11.4944	73.37	74.04	-0.91	B
233.7754	13.9931	13.8272	73.73	74.15	-0.56	A
235.7224	13.9877	15.7818	74.01	74.24	-0.30	B
238.0428	13.9813	18.1106	74.44	74.34	0.13	A
239.9519	13.9760	20.0262	74.70	74.43	0.37	B
242.2762	13.9695	22.3580	75.10	74.53	0.75	A
244.1186	13.9644	24.2052	75.16	74.61	0.72	B
246.4717	13.9578	26.5647	75.69	74.72	1.28	A
248.2543	13.9528	28.3516	76.03	74.79	1.63	B
250.6216	13.9462	30.7245	76.08	74.90	1.56	A
252.3632	13.9413	32.4701	76.55	74.97	2.07	B
254.7225	13.9347	34.8343	76.58	75.08	1.96	A
256.4376	13.9298	36.5530	76.93	75.15	2.31	B
244.3347	13.4049	4.9226	77.80	74.35	4.43	A
246.3316	13.4006	6.3420	75.47	74.48	1.31	B
248.5641	13.3951	8.2937	75.47	74.62	1.12	A
250.6151	13.3900	10.0891	75.70	74.75	1.26	B

Table 4. Experimental Liquid Heat Capacity Data for HFC-143a (SI Units).
(continued)

T	ρ	P	$C_{v,exp}$	$C_{v,cal}$	$\delta C_v, \%$	Run
K	mol dm ⁻³	MPa	J mol ⁻¹ K ⁻¹			
252.8096	13.3847	12.0114	76.21	74.88	1.75	A
254.8377	13.3797	13.7912	76.00	75.00	1.32	B
257.0440	13.3743	15.7239	76.90	75.12	2.31	A
259.0325	13.3694	17.4688	76.97	75.23	2.26	B
261.2524	13.3639	19.4180	77.28	75.36	2.49	A
263.2223	13.3591	21.1480	77.62	75.47	2.78	B
265.4046	13.3537	23.0661	77.91	75.59	2.98	A
267.3757	13.3488	24.7987	78.22	75.70	3.23	B
269.5373	13.3435	26.6998	78.24	75.83	3.08	A
271.5082	13.3386	28.4337	78.55	75.94	3.32	B
273.6539	13.3333	30.3218	78.69	76.07	3.33	A
275.6050	13.3284	32.0390	79.08	76.20	3.65	B
277.7473	13.3230	33.9244	79.68	76.33	4.19	A
279.6657	13.3182	35.6127	79.99	76.46	4.41	B
281.8059	13.3129	37.4959	80.30	76.62	4.58	A
284.1113	12.7124	4.4465	80.03	75.86	5.21	A
286.3008	12.7082	5.8145	78.08	76.03	2.63	B
288.3500	12.7039	7.3261	78.14	76.17	2.51	A
270.5437	12.6992	8.9493	78.64	76.32	2.94	B
272.6139	12.6949	10.4804	78.72	76.46	2.86	A
274.7462	12.6904	12.0612	78.81	76.61	2.79	B
276.8307	12.6860	13.6089	79.36	76.75	3.28	A
278.9228	12.6816	15.1641	79.44	76.90	3.19	B
281.0129	12.6772	16.7210	80.03	77.05	3.72	A
283.0800	12.6728	18.2590	80.18	77.20	3.71	B
285.1712	12.6684	19.8179	80.48	77.36	3.88	A
287.2151	12.6640	21.3425	80.75	77.52	4.01	B
289.3142	12.6596	22.9094	81.06	77.69	4.17	A
291.3260	12.6553	24.4114	81.47	77.86	4.44	B
293.4552	12.6506	26.0716	81.59	78.04	4.35	A
295.4210	12.6465	27.4690	81.93	78.23	4.52	B
297.5759	12.6419	29.0777	81.88	78.44	4.21	A
299.4935	12.6378	30.5071	82.36	78.63	4.53	B
301.6745	12.6331	32.1341	82.83	78.86	4.79	A
303.5678	12.6291	33.5447	83.13	79.07	4.87	B
305.7566	12.6244	35.1731	83.63	79.33	5.15	A
307.6398	12.6203	36.5721	83.80	79.56	5.06	B
309.8085	12.6157	38.1803	84.35	79.83	5.35	A
283.3835	11.9420	3.9463	83.68	78.31	6.42	A
285.4336	11.9387	4.9974	80.97	78.49	3.06	B
287.6352	11.9348	6.3172	80.50	78.67	2.28	A
289.7480	11.9311	7.5874	81.29	78.83	3.03	B
291.8811	11.9273	8.8728	81.40	79.00	2.95	A
294.0396	11.9235	10.1765	81.62	79.18	2.98	B
296.1097	11.9199	11.4292	82.05	79.36	3.28	A
298.2870	11.9161	12.7489	82.24	79.55	3.28	B
300.3274	11.9126	13.9870	82.86	79.73	3.78	A
302.5247	11.9087	15.3225	83.39	79.94	4.13	B
304.5601	11.9051	16.5606	83.31	80.14	3.81	A
306.7747	11.9012	17.9086	83.66	80.37	3.94	B
308.7748	11.8976	19.1277	83.52	80.58	3.53	A
310.9964	11.8938	20.4808	83.96	80.82	3.74	B
312.9743	11.8934	20.0770	84.22	85.52	-1.54	A

Table 4. Experimental Liquid Heat Capacity Data for HFC-143a (SI Units).
(continued)

T	ρ	P	$C_{v,exp}$	$C_{v,cal}$	$\delta C_v, \%$	Run
K	mol dm ⁻³	MPa	J mol ⁻¹ K ⁻¹			
315.1688	11.8898	21.3062	84.71	85.73	-1.21	B
317.1429	11.8864	22.4123	84.74	85.92	-1.40	A
319.3687	11.8826	23.6590	85.29	86.13	-0.98	B
321.2830	11.8794	24.7211	85.31	86.31	-1.17	A
323.5440	11.8756	25.9813	85.66	86.52	-1.00	B
325.4079	11.8725	27.0188	86.04	86.69	-0.75	A
327.6870	11.8687	28.2856	86.53	86.89	-0.42	B
329.5205	11.8656	29.3033	86.57	87.05	-0.56	A
331.8295	11.8617	30.5829	87.13	87.26	-0.15	B
333.6453	11.8586	31.5877	87.04	87.42	-0.43	A
335.9567	11.8547	32.8646	87.38	87.62	-0.28	B
337.7613	11.8517	33.8599	87.27	87.77	-0.57	A
340.0821	11.8478	35.1377	87.60	87.97	-0.42	B
341.8592	11.8448	36.1150	88.11	88.12	-0.01	A
302.6082	11.0690	3.7624	83.59	81.91	2.02	A
304.9506	11.0657	4.8483	83.64	82.09	1.85	B
306.9944	11.0628	5.7996	83.86	82.26	1.92	A
309.3185	11.0595	6.8851	83.83	82.45	1.64	B
311.3876	11.0566	7.8545	84.94	82.63	2.72	A
313.6729	11.0550	8.0480	84.77	86.37	-1.88	B
315.7738	11.0522	8.9730	85.32	86.53	-1.42	A
318.0323	11.0491	9.9687	85.11	86.71	-1.88	B
320.1499	11.0463	10.9034	85.77	86.87	-1.29	A
322.3770	11.0433	11.8874	85.38	87.04	-1.94	B
324.5126	11.0404	12.8320	86.46	87.20	-0.86	A
326.7105	11.0374	13.8049	85.98	87.36	-1.61	B
328.8573	11.0345	14.7559	86.39	87.52	-1.31	A
331.0434	11.0315	15.7250	86.14	87.67	-1.78	B
333.1596	11.0286	16.6635	86.68	87.82	-1.32	A
335.3561	11.0256	17.6380	86.76	87.98	-1.40	B
337.4661	11.0228	18.5745	87.13	88.12	-1.14	A
339.6743	11.0198	19.5549	87.45	88.28	-0.95	B
341.7628	11.0169	20.4821	87.57	88.42	-0.97	A
322.6664	9.9901	3.6829	87.19	89.17	-2.27	A
323.8406	9.9889	4.0545	87.19	89.23	-2.34	B
325.0226	9.9877	4.4295	86.85	89.28	-2.80	D
326.2608	9.9864	4.8234	87.36	89.33	-2.25	C
327.1876	9.9854	5.1188	87.93	89.37	-1.64	A
328.3871	9.9842	5.5019	87.59	89.42	-2.09	D
329.5622	9.9829	5.8781	87.72	89.47	-1.99	B
330.8087	9.9816	6.2781	87.90	89.52	-1.85	C
331.7354	9.9807	6.5760	87.97	89.56	-1.81	A
332.9560	9.9794	6.9691	88.05	89.61	-1.77	D
334.1053	9.9782	7.3400	87.94	89.66	-1.95	B
335.3547	9.9769	7.7440	88.07	89.71	-1.86	C
336.2793	9.9759	8.0436	88.27	89.74	-1.67	A
337.5257	9.9746	8.4480	88.05	89.79	-1.98	D
338.6302	9.9735	8.8070	88.19	89.84	-1.86	B
339.8803	9.9722	9.2140	88.43	89.89	-1.65	C
340.8197	9.9712	9.5204	88.30	89.93	-1.84	A
342.0863	9.9699	9.9340	88.60	89.98	-1.55	D

Table 5. Experimental Liquid Heat Capacity Data for HFC-143a (PI Units).

T	ρ	P	$C_{v,exp}$	$C_{v,cal}$	$\delta C_v, \%$	Run
$^{\circ}\text{F}$	lb ft^{-3}	psia	$\text{Btu lb}^{-1} ^{\circ}\text{F}^{-1}$			
-153.079	133.06	1991.0	0.12627	0.13492	-6.85	A
-152.232	133.04	2085.5	0.12289	0.13496	-9.82	C
-149.068	133.00	2337.4	0.12007	0.13499	-12.42	B
-144.229	132.92	2882.0	0.12045	0.13506	-12.13	C
-141.016	132.86	3242.0	0.12070	0.13506	-11.90	B
-136.282	132.78	3772.1	0.12148	0.13500	-11.13	C
-133.049	132.72	4133.8	0.12172	0.13493	-10.86	B
-128.393	132.64	4651.3	0.12215	0.13481	-10.36	C
-125.162	132.58	5009.8	0.12253	0.13471	-9.94	B
-121.532	132.52	5411.4	0.12344	0.13460	-9.04	A
-120.566	132.50	5518.2	0.12324	0.13457	-9.19	C
-120.316	128.72	1441.4	0.12807	0.13197	-3.04	A
-116.232	128.66	1768.4	0.12206	0.13187	-8.03	B
-112.475	128.60	2149.9	0.12234	0.13183	-7.76	A
-108.370	128.54	2566.4	0.12336	0.13178	-6.83	B
-104.631	128.48	2945.1	0.12311	0.13174	-7.02	A
-100.541	128.41	3358.5	0.12415	0.13171	-6.09	B
-96.838	128.35	3732.0	0.12410	0.13168	-6.11	A
-92.755	128.29	4142.8	0.12488	0.13166	-5.43	B
-89.083	128.23	4511.7	0.12529	0.13164	-5.07	A
-85.057	128.17	4915.2	0.12589	0.13164	-4.56	B
-81.398	128.11	5281.3	0.12664	0.13164	-3.95	A
-89.063	124.44	1086.4	0.13005	0.12975	0.23	A
-85.257	124.39	1361.5	0.12440	0.12978	-4.32	B
-81.249	124.33	1728.9	0.12507	0.12986	-3.84	A
-77.407	124.28	2081.0	0.12523	0.12995	-3.77	B
-73.422	124.22	2445.9	0.12592	0.13004	-3.27	A
-69.659	124.16	2790.1	0.12638	0.13012	-2.96	B
-65.705	124.13	3151.2	0.12673	0.13022	-2.75	A
-61.982	124.05	3491.3	0.12724	0.13031	-2.41	B
-58.081	123.99	3846.2	0.12795	0.13040	-1.92	A
-54.357	123.94	4185.2	0.12856	0.13050	-1.51	B
-50.523	123.88	4533.7	0.12880	0.13060	-1.39	A
-46.810	123.83	4871.0	0.12964	0.13070	-0.81	B
-43.048	123.77	5212.3	0.12960	0.13080	-0.92	A
-54.354	119.42	813.5	0.13389	0.12913	3.56	A
-50.813	119.38	1039.5	0.12767	0.12928	-1.26	B
-46.631	119.32	1377.8	0.12834	0.12949	-0.89	A
-43.056	119.27	1667.1	0.12849	0.12966	-0.91	B
-38.874	119.22	2005.5	0.12913	0.12985	-0.56	A
-35.370	119.17	2289.0	0.12962	0.13001	-0.30	B
-31.193	119.12	2626.7	0.13037	0.13020	0.13	A
-27.757	119.07	2904.6	0.13083	0.13035	0.37	B
-23.573	119.02	3242.8	0.13151	0.13053	0.75	A
-20.257	118.97	3510.7	0.13162	0.13067	0.72	B
-16.021	118.92	3852.9	0.13255	0.13085	1.28	A
-12.812	118.88	4112.1	0.13316	0.13099	1.63	B
-8.551	118.82	4456.2	0.13324	0.13117	1.56	A
-5.416	118.78	4709.4	0.13407	0.13130	2.07	B
-1.170	118.72	5052.3	0.13411	0.13148	1.96	A
1.918	118.68	5301.6	0.13473	0.13161	2.31	B
-19.867	114.21	714.0	0.13624	0.13021	4.43	A
-19.867	114.21	714.0	0.13624	0.13021	4.43	A
-12.255	114.12	1202.9	0.13217	0.13068	1.12	A
-12.255	114.12	1202.9	0.13217	0.13068	1.12	A
-4.613	114.04	1742.1	0.13347	0.13113	1.75	A

Table 5. Experimental Liquid Heat Capacity Data for HFC-143a (PI Units).
(continued)

T	ρ	P	$C_{v,exp}$	$C_{v,cal}$	$\delta C_v, \% \text{ Run}$	
$^{\circ}\text{F}$	lb ft^{-3}	psia	$\text{Btu lb}^{-1} ^{\circ}\text{F}^{-1}$			
-4.613	114.04	1742.1	0.13347	0.13113	1.75	A
3.009	113.95	2280.6	0.13467	0.13156	2.31	A
3.009	113.95	2280.6	0.13467	0.13156	2.31	A
10.584	113.86	2816.3	0.13534	0.13197	2.49	A
10.584	113.86	2816.3	0.13534	0.13197	2.49	A
18.058	113.77	3345.5	0.13645	0.13238	2.98	A
18.058	113.77	3345.5	0.13645	0.13238	2.98	A
25.497	113.69	3872.5	0.13702	0.13279	3.08	A
25.497	113.69	3872.5	0.13702	0.13279	3.08	A
32.907	113.60	4397.8	0.13781	0.13322	3.33	A
32.907	113.60	4397.8	0.13781	0.13322	3.33	A
40.275	113.51	4920.3	0.13954	0.13368	4.19	A
40.275	113.51	4920.3	0.13954	0.13368	4.19	A
47.581	113.42	5438.3	0.14062	0.13418	4.58	A
47.581	113.42	5438.3	0.14062	0.13418	4.58	A
15.730	108.31	644.9	0.14015	0.13286	5.21	A
19.671	108.27	843.3	0.13674	0.13315	2.63	B
23.360	108.24	1062.6	0.13684	0.13340	2.51	A
27.309	108.20	1298.0	0.13772	0.13366	2.94	B
31.035	108.16	1520.1	0.13786	0.13391	2.86	A
34.873	108.12	1749.3	0.13802	0.13417	2.79	B
38.625	108.08	1973.8	0.13898	0.13442	3.28	A
42.391	108.05	2199.4	0.13912	0.13467	3.19	B
46.153	108.01	2425.2	0.14015	0.13494	3.72	A
49.874	107.97	2648.2	0.14041	0.13520	3.71	B
53.638	107.93	2874.3	0.14095	0.13548	3.88	A
57.317	107.90	3095.5	0.14142	0.13575	4.01	B
61.096	107.86	3322.7	0.14197	0.13605	4.17	A
64.717	107.82	3540.6	0.14268	0.13635	4.44	B
68.549	107.78	3781.4	0.14289	0.13667	4.35	A
72.088	107.75	3984.1	0.14348	0.13700	4.52	B
75.967	107.71	4217.4	0.14340	0.13736	4.21	A
79.418	107.67	4424.7	0.14424	0.13770	4.53	B
83.344	107.63	4660.7	0.14505	0.13811	4.79	A
86.752	107.60	4865.3	0.14558	0.13848	4.87	B
90.692	107.56	5101.4	0.14647	0.13893	5.15	A
94.082	107.52	5304.3	0.14675	0.13933	5.06	B
97.985	107.48	5537.6	0.14772	0.13981	5.35	A
50.420	101.74	572.4	0.14655	0.13715	6.42	A
54.111	101.72	724.8	0.14181	0.13747	3.06	B
58.073	101.68	916.2	0.14098	0.13777	2.28	A
61.876	101.65	1100.5	0.14237	0.13806	3.03	B
65.716	101.62	1286.9	0.14256	0.13836	2.95	A
69.601	101.59	1476.0	0.14293	0.13867	2.98	B
73.328	101.56	1657.7	0.14369	0.13898	3.28	A
77.247	101.52	1849.1	0.14403	0.13931	3.28	B
80.919	101.49	2028.6	0.14512	0.13963	3.78	A
84.874	101.46	2222.3	0.14604	0.14000	4.13	B
88.538	101.43	2401.9	0.14591	0.14035	3.81	A
92.524	101.40	2597.4	0.14652	0.14074	3.94	B
96.125	101.37	2774.2	0.14627	0.14111	3.53	A
100.124	101.33	2970.5	0.14704	0.14153	3.74	B
103.684	101.33	2911.9	0.14750	0.14977	-1.54	A
107.634	101.30	3090.2	0.14836	0.15014	-1.21	B
111.187	101.27	3250.6	0.14840	0.15047	-1.40	A
115.194	101.24	3431.5	0.14937	0.15084	-0.98	B

Table 5. Experimental Liquid Heat Capacity Data for HFC-143a (PI Units).
(continued)

T	ρ	P	$C_{v,exp}$	$C_{v,cal}$	$\delta C_v, \% \text{ Run}$	
°F	lb ft ⁻³	psia	Btu lb ⁻¹ °F ⁻¹			
118.639	101.21	3585.5	0.14940	0.15115	-1.17	A
122.709	101.18	3768.3	0.15001	0.15152	-1.00	B
126.064	101.15	3918.8	0.15068	0.15181	-0.75	A
130.167	101.12	4102.5	0.15153	0.15217	-0.42	B
133.467	101.09	4250.1	0.15160	0.15246	-0.56	A
137.623	101.06	4435.7	0.15258	0.15281	-0.15	B
140.891	101.03	4581.4	0.15243	0.15309	-0.43	A
145.052	101.00	4766.6	0.15302	0.15344	-0.28	B
148.300	100.98	4911.0	0.15284	0.15371	-0.57	A
152.478	100.94	5096.3	0.15341	0.15406	-0.42	B
155.677	100.92	5238.0	0.15431	0.15432	-0.01	A
85.025	94.31	545.7	0.14640	0.14344	2.02	A
89.241	94.28	703.2	0.14648	0.14377	1.85	B
92.920	94.25	841.2	0.14687	0.14406	1.92	A
97.103	94.23	998.6	0.14681	0.14439	1.64	B
100.828	94.20	1139.2	0.14875	0.14470	2.72	A
104.941	94.19	1167.3	0.14846	0.15125	-1.88	B
108.723	94.16	1301.4	0.14942	0.15154	-1.42	A
112.788	94.14	1445.8	0.14906	0.15185	-1.88	B
116.600	94.11	1581.4	0.15020	0.15214	-1.29	A
120.609	94.09	1724.1	0.14953	0.15243	-1.94	B
124.453	94.06	1861.1	0.15141	0.15271	-0.86	A
128.409	94.04	2002.2	0.15057	0.15300	-1.61	B
132.273	94.01	2140.2	0.15129	0.15327	-1.31	A
136.208	93.99	2280.7	0.15086	0.15354	-1.78	B
140.017	93.96	2416.8	0.15180	0.15380	-1.32	A
143.971	93.94	2558.2	0.15194	0.15407	-1.40	B
147.769	93.91	2694.0	0.15259	0.15433	-1.14	A
151.744	93.89	2836.2	0.15314	0.15460	-0.95	B
155.503	93.86	2970.7	0.15336	0.15485	-0.97	A
121.130	85.11	534.2	0.15270	0.15617	-2.27	A
123.243	85.10	588.1	0.15269	0.15626	-2.34	D
125.371	85.09	642.5	0.15210	0.15635	-2.80	B
127.600	85.08	699.6	0.15300	0.15644	-2.25	C
129.268	85.07	742.4	0.15399	0.15651	-1.64	A
131.427	85.06	798.0	0.15340	0.15660	-2.09	D
133.542	85.05	852.6	0.15363	0.15669	-1.99	B
135.786	85.04	910.6	0.15394	0.15678	-1.85	C
137.454	85.03	953.8	0.15406	0.15684	-1.81	A
139.651	85.02	1010.8	0.15420	0.15693	-1.77	D
141.720	85.01	1064.6	0.15401	0.15701	-1.95	B
143.968	85.00	1123.2	0.15424	0.15710	-1.86	C
145.633	84.99	1166.6	0.15458	0.15717	-1.67	A
147.876	84.98	1225.3	0.15421	0.15725	-1.98	D
149.864	84.97	1277.3	0.15445	0.15733	-1.86	B
152.115	84.96	1336.4	0.15486	0.15742	-1.65	C
153.805	84.95	1380.8	0.15464	0.15748	-1.84	A
156.085	84.94	1440.8	0.15517	0.15757	-1.55	D

Table 6. Experimental Two-Phase Heat Capacity Data for HFC-143a (SI Units).

T	δT	ρ_G	P_G	$C_v^{(2)}$	$\delta C_v^{(2)}$	$\delta C_v^{(2)}, \%$	C_G	δC_G	$\delta C_G, \%$	Run
K		mol dm ⁻³	MPa	J mol ⁻¹ K ⁻¹						
164.8070	0.0029	15.564	0.0016	101.70	0.07	0.07	101.64	0.07	0.07	G
167.0908	0.0030	15.505	0.0019	102.07	0.07	0.07	102.00	0.07	0.07	H
169.5763	0.0029	15.441	0.0025	102.30	0.07	0.07	102.21	0.07	0.07	G
171.8324	0.0030	15.383	0.0030	102.46	0.07	0.07	102.36	0.08	0.08	H
174.2884	0.0029	15.319	0.0037	102.93	0.07	0.07	102.82	0.08	0.08	G
176.5223	0.0030	15.261	0.0045	103.09	0.07	0.07	102.96	0.08	0.08	H
178.9530	0.0029	15.197	0.0055	103.54	0.07	0.07	103.38	0.09	0.08	G
181.1703	0.0030	15.138	0.0066	103.59	0.07	0.07	103.41	0.09	0.09	H
183.5699	0.0029	15.074	0.0079	104.16	0.07	0.07	103.97	0.10	0.09	G
185.7765	0.0030	15.015	0.0094	104.34	0.07	0.07	104.12	0.10	0.10	H
188.1431	0.0030	14.951	0.0111	104.79	0.07	0.07	104.55	0.11	0.10	G
190.3388	0.0030	14.891	0.0130	105.12	0.07	0.07	104.85	0.12	0.11	H
192.6723	0.0029	14.827	0.0153	105.80	0.07	0.07	105.51	0.12	0.12	G
194.8503	0.0030	14.767	0.0177	105.84	0.08	0.07	105.52	0.13	0.12	H
197.1617	0.0029	14.702	0.0206	106.36	0.08	0.07	106.00	0.14	0.13	G
199.3215	0.0030	14.642	0.0237	106.60	0.08	0.07	106.21	0.15	0.14	H
201.6066	0.0029	14.577	0.0273	106.90	0.08	0.07	106.47	0.16	0.15	G
203.7498	0.0030	14.516	0.0311	107.34	0.08	0.07	106.88	0.17	0.16	H
206.0062	0.0030	14.451	0.0356	107.80	0.08	0.07	107.30	0.18	0.17	G
208.1359	0.0030	14.389	0.0402	108.23	0.08	0.07	107.70	0.20	0.18	H
210.3715	0.0030	14.324	0.0456	108.55	0.08	0.07	107.98	0.21	0.19	G
212.4839	0.0030	14.262	0.0513	109.11	0.08	0.07	108.51	0.22	0.20	H
214.6957	0.0029	14.196	0.0578	109.43	0.08	0.07	108.78	0.24	0.22	G
216.7947	0.0030	14.133	0.0645	109.77	0.08	0.08	109.09	0.25	0.23	H
218.9846	0.0030	14.067	0.0722	110.40	0.08	0.07	109.68	0.26	0.24	G
221.0647	0.0030	14.003	0.0802	110.44	0.08	0.08	109.68	0.28	0.25	H
223.2249	0.0029	13.936	0.0892	111.74	0.08	0.07	110.94	0.29	0.27	G
225.2965	0.0030	13.872	0.0986	111.47	0.08	0.08	110.63	0.31	0.28	H
227.4281	0.0030	13.805	0.1090	112.60	0.08	0.08	111.73	0.32	0.29	G
229.4981	0.0031	13.739	0.1199	112.74	0.09	0.08	111.84	0.34	0.30	H
231.6137	0.0029	13.671	0.1320	113.41	0.09	0.08	112.48	0.36	0.32	G
233.6641	0.0030	13.605	0.1445	113.59	0.09	0.08	112.62	0.37	0.33	H
235.7617	0.0030	13.536	0.1583	114.39	0.09	0.08	113.39	0.39	0.34	G
237.7949	0.0030	13.469	0.1726	114.80	0.09	0.08	113.78	0.40	0.36	H
239.8719	0.0030	13.400	0.1883	115.42	0.09	0.08	114.37	0.42	0.37	G
241.8978	0.0031	13.331	0.2045	115.80	0.09	0.08	114.73	0.44	0.38	H
243.9577	0.0030	13.261	0.2222	116.40	0.09	0.08	115.31	0.45	0.39	G
245.9631	0.0031	13.192	0.2405	117.03	0.09	0.08	115.93	0.47	0.40	H
248.0078	0.0030	13.120	0.2603	116.93	0.09	0.08	115.82	0.48	0.41	G
250.0022	0.0031	13.050	0.2808	118.19	0.10	0.08	117.06	0.49	0.42	H
252.0213	0.0030	12.978	0.3029	118.58	0.09	0.08	117.46	0.51	0.43	G
254.0127	0.0031	12.906	0.3258	118.91	0.10	0.08	117.79	0.52	0.44	H
256.0161	0.0030	12.833	0.3503	119.71	0.10	0.08	118.60	0.53	0.45	G
257.9869	0.0030	12.760	0.3757	120.18	0.10	0.08	119.08	0.55	0.46	H
259.9779	0.0030	12.685	0.4027	120.69	0.10	0.08	119.62	0.56	0.47	G
261.9411	0.0031	12.611	0.4308	121.12	0.10	0.08	120.07	0.57	0.47	H
263.9041	0.0030	12.536	0.4603	121.87	0.10	0.08	120.87	0.58	0.48	G
265.8598	0.0031	12.460	0.4912	122.21	0.10	0.08	121.25	0.59	0.49	H
267.8159	0.0030	12.382	0.5237	123.17	0.10	0.08	122.27	0.60	0.49	G
269.7587	0.0030	12.305	0.5575	123.43	0.10	0.08	122.59	0.60	0.49	H
271.6913	0.0030	12.227	0.5928	124.64	0.10	0.08	123.88	0.61	0.49	G
273.6242	0.0031	12.147	0.6297	124.81	0.10	0.08	124.13	0.62	0.50	H
275.5496	0.0030	12.067	0.6681	126.24	0.10	0.08	125.66	0.62	0.49	G
277.4786	0.0031	11.986	0.7084	126.07	0.11	0.08	125.60	0.62	0.50	H
279.3869	0.0030	11.904	0.7501	127.05	0.11	0.08	126.71	0.62	0.49	G
281.3024	0.0030	11.821	0.7937	127.51	0.11	0.08	127.32	0.62	0.49	H

Table 6. Experimental Two-Phase Heat Capacity Data for HFC-143a (SI Units).
(continued)

T	δT	ρ_g	P_g	$C_v^{(2)}$	$\delta C_v^{(2)}$	$\delta C_v^{(2)}, \%$	C_g	δC_g	$\delta C_g, \%$	Run
K		mol dm ⁻³	MPa	J mol ⁻¹ K ⁻¹						
283.1927	0.0030	11.737	0.8385	128.16	0.11	0.08	128.12	0.62	0.48	G
285.1039	0.0030	11.652	0.8858	128.95	0.11	0.09	129.09	0.62	0.48	H
286.9835	0.0030	11.566	0.9342	129.48	0.11	0.08	129.82	0.61	0.47	G
288.8803	0.0031	11.478	0.9850	130.11	0.11	0.09	130.67	0.61	0.46	H
290.7438	0.0030	11.390	1.0370	130.96	0.11	0.08	131.76	0.60	0.45	G
292.6233	0.0030	11.300	1.0914	131.77	0.11	0.09	133.27	0.47	0.36	H
294.4922	0.0030	11.208	1.1477	132.18	0.11	0.09	133.57	0.57	0.43	G
296.3541	0.0031	11.116	1.2058	132.79	0.12	0.09	134.50	0.56	0.42	H
298.2157	0.0030	11.021	1.2662	133.12	0.12	0.09	135.20	0.55	0.41	G
300.0538	0.0030	10.926	1.3280	134.69	0.12	0.09	137.19	0.52	0.38	H
301.9145	0.0030	10.827	1.3928	135.14	0.12	0.09	138.08	0.51	0.37	G
303.7437	0.0031	10.729	1.4588	135.62	0.12	0.09	139.04	0.50	0.36	H
305.5996	0.0031	10.626	1.5282	136.89	0.12	0.09	140.85	0.48	0.34	G
307.4036	0.0031	10.524	1.5980	136.74	0.13	0.09	141.30	0.47	0.33	H
309.2661	0.0030	10.416	1.6726	137.75	0.12	0.09	143.00	0.46	0.32	G
311.0452	0.0030	10.310	1.7463	138.64	0.13	0.09	144.62	0.47	0.32	H
312.8998	0.0030	10.279	1.8340	139.82	0.13	0.09	146.43	0.49	0.34	G
314.6675	0.0030	10.171	1.9124	140.02	0.13	0.09	147.52	0.51	0.35	H
304.0523	0.0031	10.712	1.4702	145.37	0.12	0.09	139.90	3.09	2.21	A
306.2426	0.0032	10.590	1.5528	146.26	0.13	0.09	141.10	3.15	2.23	B
308.3481	0.0031	10.469	1.6355	147.57	0.13	0.09	142.81	3.20	2.24	A
310.5285	0.0032	10.341	1.7246	149.94	0.14	0.09	145.67	3.24	2.23	B
312.6122	0.0032	10.296	1.8215	150.20	0.14	0.09	146.22	3.36	2.30	A
314.7920	0.0033	10.164	1.9180	152.00	0.14	0.09	148.70	3.40	2.29	B
316.8343	0.0031	10.035	2.0118	153.09	0.14	0.09	150.63	3.42	2.27	A
318.9845	0.0033	9.894	2.1144	152.90	3.07	2.01	151.39	4.63	3.06	B
321.0117	0.0032	9.756	2.2148	155.46	2.98	1.92	154.98	4.61	2.98	A
323.1489	0.0032	9.603	2.3245	159.40	0.15	0.10	160.34	3.55	2.21	B
325.1497	0.0032	9.453	2.4310	160.52	0.15	0.10	163.10	3.57	2.19	A
327.2932	0.0032	9.284	2.5492	163.01	0.16	0.10	167.75	3.58	2.13	B
329.2690	0.0031	9.118	2.6622	164.40	0.16	0.10	171.64	3.58	2.09	A
331.3935	0.0032	8.928	2.7881	167.21	0.16	0.10	177.86	3.59	2.02	B
333.3317	0.0032	8.741	2.9070	169.42	0.16	0.10	184.11	3.59	1.95	A
335.4371	0.0032	8.520	3.0409	172.69	0.17	0.10	193.27	3.61	1.87	B
337.3469	0.0031	8.298	3.1665	175.42	0.17	0.10	203.53	3.67	1.80	A
339.4069	0.0033	8.026	3.3071	180.19	0.18	0.10	220.22	3.90	1.77	B
341.2663	0.0032	7.739	3.4386	185.14	0.19	0.10	242.66	4.44	1.83	A
343.4200	0.0032	7.320	3.5967	167.17	0.16	0.10	265.40	6.27	2.36	B

Table 7. Experimental Two-Phase Heat Capacity Data for HFC-143a (PI Units).

T	δT	ρ_G	P_G	$C_v^{(2)}$	$\delta C_v^{(2)}$	$\delta C_v^{(2)}, \%$	C_G	δC_G	$\delta C_G, \%$	Run
$^{\circ}F$		lb ft ⁻³	psia	Btu lb ⁻¹ $^{\circ}F^{-1}$						
-163.017	0.005	81.65	0.23	0.28924	0.00019	0.07	0.28906	0.00020	0.07	G
-158.907	0.005	81.35	0.28	0.29029	0.00020	0.07	0.29008	0.00021	0.07	H
-154.433	0.005	81.01	0.36	0.29094	0.00020	0.07	0.29069	0.00021	0.07	G
-150.372	0.005	80.71	0.44	0.29140	0.00021	0.07	0.29112	0.00023	0.08	H
-145.951	0.005	80.37	0.54	0.29274	0.00020	0.07	0.29240	0.00023	0.08	G
-141.930	0.005	80.06	0.65	0.29319	0.00020	0.07	0.29281	0.00024	0.08	H
-137.555	0.005	79.73	0.80	0.29445	0.00020	0.07	0.29402	0.00025	0.08	G
-133.563	0.005	79.42	0.95	0.29460	0.00021	0.07	0.29410	0.00026	0.09	H
-129.244	0.005	79.08	1.15	0.29624	0.00021	0.07	0.29568	0.00027	0.09	G
-125.272	0.005	78.77	1.36	0.29674	0.00021	0.07	0.29611	0.00029	0.10	H
-121.012	0.005	78.44	1.61	0.29802	0.00021	0.07	0.29732	0.00031	0.10	G
-117.060	0.005	78.12	1.89	0.29896	0.00021	0.07	0.29819	0.00033	0.11	H
-112.860	0.005	77.79	2.22	0.30090	0.00021	0.07	0.30005	0.00035	0.12	G
-108.939	0.005	77.47	2.57	0.30101	0.00022	0.07	0.30008	0.00037	0.12	H
-104.779	0.005	77.14	2.99	0.30249	0.00022	0.07	0.30146	0.00040	0.13	G
-100.891	0.005	76.82	3.43	0.30317	0.00022	0.07	0.30206	0.00043	0.14	H
-96.778	0.005	76.48	3.96	0.30402	0.00022	0.07	0.30281	0.00046	0.15	G
-92.920	0.005	76.16	4.51	0.30527	0.00022	0.07	0.30396	0.00049	0.16	H
-88.859	0.005	75.82	5.16	0.30657	0.00022	0.07	0.30516	0.00052	0.17	G
-85.025	0.005	75.49	5.83	0.30781	0.00023	0.07	0.30629	0.00056	0.18	H
-81.001	0.005	75.15	6.62	0.30870	0.00023	0.07	0.30708	0.00059	0.19	G
-77.199	0.005	74.82	7.44	0.31031	0.00023	0.07	0.30859	0.00063	0.20	H
-73.218	0.005	74.48	8.38	0.31120	0.00023	0.07	0.30936	0.00067	0.22	G
-69.440	0.005	74.15	9.36	0.31218	0.00023	0.08	0.31024	0.00071	0.23	H
-65.498	0.005	73.80	10.48	0.31398	0.00023	0.07	0.31193	0.00075	0.24	G
-61.754	0.005	73.47	11.63	0.31409	0.00024	0.08	0.31193	0.00079	0.25	H
-57.865	0.005	73.12	12.94	0.31778	0.00024	0.07	0.31551	0.00084	0.27	G
-54.136	0.005	72.78	14.29	0.31701	0.00024	0.08	0.31464	0.00088	0.28	H
-50.299	0.005	72.43	15.81	0.32022	0.00024	0.08	0.31774	0.00092	0.29	G
-46.573	0.006	72.08	17.39	0.32063	0.00025	0.08	0.31806	0.00097	0.30	H
-42.765	0.005	71.73	19.14	0.32254	0.00024	0.08	0.31988	0.00101	0.32	G
-39.075	0.005	71.38	20.96	0.32303	0.00025	0.08	0.32028	0.00106	0.33	H
-35.299	0.005	71.02	22.96	0.32532	0.00025	0.08	0.32248	0.00110	0.34	G
-31.639	0.005	70.66	25.04	0.32649	0.00026	0.08	0.32358	0.00115	0.36	H
-27.901	0.005	70.30	27.30	0.32826	0.00025	0.08	0.32528	0.00119	0.37	G
-24.254	0.006	69.94	29.67	0.32934	0.00026	0.08	0.32629	0.00124	0.38	H
-20.546	0.005	69.57	32.23	0.33102	0.00026	0.08	0.32793	0.00128	0.39	G
-16.936	0.006	69.21	34.88	0.33283	0.00027	0.08	0.32969	0.00133	0.40	H
-13.256	0.005	68.84	37.76	0.33256	0.00026	0.08	0.32938	0.00137	0.41	G
-9.666	0.006	68.47	40.73	0.33611	0.00027	0.08	0.33292	0.00141	0.42	H
-6.032	0.005	68.09	43.93	0.33724	0.00027	0.08	0.33405	0.00145	0.43	G
-2.447	0.006	67.71	47.26	0.33818	0.00028	0.08	0.33500	0.00149	0.44	H
1.159	0.005	67.33	50.80	0.34045	0.00027	0.08	0.33729	0.00152	0.45	G
4.706	0.005	66.94	54.48	0.34178	0.00028	0.08	0.33866	0.00156	0.46	H
8.290	0.005	66.55	58.41	0.34325	0.00027	0.08	0.34020	0.00159	0.47	G
11.824	0.006	66.16	62.48	0.34445	0.00028	0.08	0.34148	0.00162	0.47	H
15.357	0.005	65.77	66.76	0.34660	0.00028	0.08	0.34374	0.00165	0.48	G
18.878	0.005	65.37	71.24	0.34756	0.00029	0.08	0.34483	0.00167	0.49	H
22.399	0.005	64.96	75.95	0.35030	0.00028	0.08	0.34772	0.00170	0.49	G
25.896	0.005	64.56	80.86	0.35102	0.00029	0.08	0.34863	0.00172	0.49	H
29.374	0.005	64.15	85.97	0.35447	0.00029	0.08	0.35230	0.00174	0.49	G
32.854	0.005	63.73	91.33	0.35495	0.00030	0.08	0.35302	0.00175	0.50	H
36.319	0.005	63.31	96.91	0.35901	0.00029	0.08	0.35736	0.00176	0.49	G
39.792	0.006	62.88	102.75	0.35853	0.00030	0.08	0.35721	0.00177	0.50	H
43.226	0.005	62.45	108.79	0.36132	0.00030	0.08	0.36035	0.00177	0.49	G
46.674	0.005	62.02	115.11	0.36264	0.00031	0.08	0.36208	0.00177	0.49	H
50.077	0.005	61.58	121.62	0.36448	0.00031	0.08	0.36437	0.00177	0.48	G

Table 7. Experimental Two-Phase Heat Capacity Data for HFC-143a (PI Units).
(continued)

T	δT	ρ_g	P_g	$C_v^{(2)}$	$\delta C_v^{(2)}$	$\delta C_v^{(2)}, \%$	C_g	δC_g	$\delta C_g, \%$	Run
$^{\circ}F$		lb ft $^{-3}$	psia	Btu lb $^{-1}$ $^{\circ}F^{-1}$						
53.517	0.005	61.13	128.47	0.36673	0.00031	0.09	0.36714	0.00176	0.48	H
56.900	0.005	60.68	135.49	0.36824	0.00031	0.08	0.36921	0.00174	0.47	G
60.315	0.006	60.22	142.87	0.37003	0.00033	0.09	0.37163	0.00173	0.46	H
63.669	0.005	59.76	150.40	0.37243	0.00031	0.08	0.37472	0.00170	0.45	G
67.052	0.005	59.28	158.30	0.37476	0.00032	0.09	0.37901	0.00135	0.36	H
70.416	0.005	58.80	166.46	0.37592	0.00032	0.09	0.37988	0.00163	0.43	G
73.767	0.006	58.32	174.89	0.37765	0.00033	0.09	0.38250	0.00160	0.42	H
77.118	0.005	57.82	183.64	0.37860	0.00033	0.09	0.38449	0.00156	0.41	G
80.427	0.005	57.32	192.61	0.38305	0.00033	0.09	0.39018	0.00149	0.38	H
83.776	0.005	56.81	202.01	0.38434	0.00034	0.09	0.39268	0.00146	0.37	G
87.069	0.006	56.29	211.59	0.38571	0.00035	0.09	0.39542	0.00142	0.36	H
90.409	0.006	55.75	221.65	0.38930	0.00035	0.09	0.40057	0.00138	0.34	G
93.656	0.006	55.21	231.77	0.38888	0.00036	0.09	0.40185	0.00134	0.33	H
97.009	0.005	54.65	242.59	0.39175	0.00035	0.09	0.40668	0.00132	0.32	G
100.211	0.005	54.09	253.28	0.39427	0.00036	0.09	0.41128	0.00133	0.32	H
103.550	0.005	53.93	266.00	0.39764	0.00037	0.09	0.41644	0.00140	0.34	G
106.732	0.005	53.36	277.36	0.39820	0.00037	0.09	0.41953	0.00145	0.35	H
87.624	0.006	56.20	213.24	0.41342	0.00035	0.09	0.39786	0.00878	2.21	A
91.567	0.006	55.56	225.22	0.41594	0.00036	0.09	0.40129	0.00895	2.23	B
95.357	0.006	54.93	237.21	0.41969	0.00036	0.09	0.40614	0.00909	2.24	A
99.281	0.006	54.25	250.14	0.42641	0.00039	0.09	0.41427	0.00922	2.23	B
103.032	0.006	54.02	264.18	0.42717	0.00039	0.09	0.41585	0.00955	2.30	A
106.956	0.006	53.32	278.18	0.43228	0.00041	0.09	0.42290	0.00968	2.29	B
110.632	0.006	52.65	291.79	0.43538	0.00040	0.09	0.42838	0.00974	2.27	A
114.502	0.006	51.91	306.67	0.43484	0.00872	2.01	0.43055	0.01316	3.06	B
118.151	0.006	51.18	321.22	0.44212	0.00848	1.92	0.44075	0.01312	2.98	A
121.998	0.006	50.38	337.14	0.45333	0.00043	0.10	0.45601	0.01010	2.21	B
125.600	0.006	49.60	352.58	0.45652	0.00043	0.10	0.46384	0.01015	2.19	A
129.458	0.006	48.71	369.73	0.46359	0.00044	0.10	0.47706	0.01018	2.13	B
133.014	0.006	47.84	386.12	0.46756	0.00045	0.10	0.48812	0.01019	2.09	A
136.838	0.006	46.84	404.38	0.47555	0.00046	0.10	0.50583	0.01020	2.02	B
140.327	0.006	45.86	421.63	0.48182	0.00047	0.10	0.52361	0.01021	1.95	A
144.117	0.006	44.70	441.04	0.49111	0.00048	0.10	0.54966	0.01027	1.87	B
147.554	0.006	43.53	459.27	0.49887	0.00049	0.10	0.57884	0.01043	1.80	A
151.262	0.006	42.11	479.66	0.51246	0.00052	0.10	0.62630	0.01109	1.77	B
154.609	0.006	40.60	498.72	0.52653	0.00053	0.10	0.69010	0.01263	1.83	A
158.486	0.006	38.40	521.65	0.47543	0.00047	0.10	0.75480	0.01782	2.36	B

Table 8. Speed of Sound for HFC-152a.

T/K	T/°F	P/kPa	P/psia	u/(m/s)	u/(ft/s)	10 ⁶ δu/u
242.776	-22.672	69.297	10.051	184.3142	604.7054	26.7
		65.179	9.453	184.5916	605.6155	27.6
		62.954	9.131	184.7403	606.1033	32.9
		59.212	8.588	184.9874	606.9140	12.1
		55.685	8.076	185.2171	607.6677	12.0
		51.438	7.460	185.5013	608.6000	7.1
		48.384	7.018	185.7121	609.2917	22.6
257.973	4.682	124.900	18.115	187.6295	615.5823	34.8
		118.774	17.227	187.9597	616.6657	32.2
		108.555	15.745	188.5042	618.4521	28.8
		99.302	14.403	188.9914	620.0505	26.4
		88.901	12.894	189.5343	621.8317	22.4
		78.928	11.448	190.0498	623.5230	25.7
		70.300	10.196	190.4913	624.9714	24.2
		59.873	8.684	191.0191	626.7031	19.5
		50.735	7.358	191.4783	628.2097	34.5
		40.717	5.905	191.9704	629.8242	67.5
273.130	31.964	208.589	30.253	189.8258	622.7881	88.9
		194.016	28.140	190.5045	625.0148	78.6
		175.289	25.424	191.3685	627.8494	64.7
		154.413	22.396	192.3131	630.9485	58.0
		136.215	19.756	193.1260	633.6155	41.7
		117.452	17.035	193.9511	636.3225	27.5
		97.204	14.098	194.8286	639.2014	13.0
		79.143	11.479	195.5989	641.7287	12.1
		59.463	8.624	196.4277	644.4479	4.3
		40.717	5.905	197.2149	647.0305	77.2
289.946	62.233	379.117	54.986	190.1302	623.7867	100.9
		344.600	49.980	191.5789	628.5397	100.2
		292.273	42.391	193.6657	635.3862	100.7
		264.481	38.360	194.7467	638.9327	100.8
		238.982	34.661	195.7270	642.1490	100.7
		218.133	31.638	196.5001	644.6854	104.7
		163.244	23.677	198.5477	651.4032	48.1
		133.592	19.376	199.6279	654.9472	27.1
		94.865	13.759	201.0189	659.5109	18.4
		89.182	12.935	201.2145	660.1525	8.5
		79.229	11.491	201.5665	661.3074	2.3
		73.751	10.697	201.7396	661.8753	11.8
		66.392	9.629	202.0156	662.7808	29.5
		60.029	8.706	202.2418	663.5230	25.0
		53.590	7.773	202.4391	664.1703	90.6
		47.994	6.961	202.6631	664.9052	25.0
		40.674	5.899	202.9477	665.8389	33.9

Table 8. Speed of Sound for HFC-152a (continued).

T/K	T/°F	P/kPa	P/psia	u/(m/s)	u/(ft/s)	$10^4 \delta u/u$
300.013	80.354	473.878	68.730	191.3815	627.8921	90.3
		438.842	63.649	192.7164	632.2717	58.0
		398.755	57.835	194.2023	637.1467	49.6
		359.025	52.072	195.6401	641.8639	48.2
		314.274	45.582	197.2253	647.0646	43.8
		268.528	38.947	198.8068	652.2532	38.9
		226.974	32.920	200.2116	656.8622	41.1
		185.610	26.920	201.5855	661.3698	31.6
		145.986	21.173	202.8757	665.6027	28.6
		125.632	18.221	203.5322	667.7565	26.4
		125.681	18.228	203.5311	667.7529	25.6
		108.776	15.777	204.0708	669.5236	24.9
		101.681	14.748	204.2917	670.2484	26.9
		101.674	14.747	204.2929	670.2523	27.3
		98.766	14.325	204.3903	670.5718	31.4
		95.643	13.872	204.4852	670.8832	26.0
		89.645	13.002	204.6795	671.5207	33.7
		87.597	12.705	204.7393	671.7169	28.7
		80.936	11.739	204.9494	672.4062	30.0
		77.140	11.188	205.0752	672.8189	29.7
		74.313	10.778	205.1559	673.0837	23.4
		68.326	9.910	205.3501	673.7208	16.1
		61.727	8.953	205.5569	674.3993	13.1
		54.897	7.962	205.7593	675.0633	34.6
		47.172	6.842	206.0082	675.8799	4.9
		40.813	5.919	206.2073	676.5331	12.4
309.991	98.313	667.796	96.856	189.4653	621.6053	83.0
		611.372	88.672	191.5241	628.3599	96.7
		501.479	72.733	195.3295	640.8448	25.0
		480.440	69.682	196.0509	643.2116	86.0
		419.400	60.829	198.0611	649.8068	84.4
		362.511	52.578	199.8834	655.7855	80.8
		232.548	33.728	203.8814	668.9022	57.0
		163.940	23.777	205.9122	675.5649	43.1
		98.955	14.352	207.7979	681.7516	33.2
		93.354	13.540	207.9572	682.2743	24.1
		86.932	12.608	208.1385	682.8691	1.2
		80.312	11.648	208.3246	683.4797	1.7
		56.316	8.168	209.0094	685.7264	37.2
		50.699	7.353	209.1726	686.2618	25.0
		46.742	6.779	209.2865	686.6355	63.2
		41.971	6.087	209.4214	687.0781	25.0
		38.785	5.625	209.5130	687.3786	25.0

Table 8. Speed of Sound for HFC-152a (continued).

T/K	T/°F	P/kPa	P/psia	u/(m/s)	u/(ft/s)	10 ⁶ δu/u
329.945	134.232	1029.783	149.357	188.8217	619.4938	59.5
		821.186	119.103	195.3172	640.8044	77.0
		631.811	91.636	200.7613	658.6657	77.5
		557.900	80.917	202.7786	665.2841	72.1
		454.698	65.948	205.5165	674.2667	74.2
		368.364	53.427	207.7353	681.5463	61.2
		276.417	40.091	210.0353	689.0922	47.7
		185.203	26.861	212.2585	696.3862	29.6
		120.131	17.424	213.8180	701.5026	7.9
		103.515	15.014	214.1945	702.7379	36.7
		96.548	14.003	214.3604	703.2822	3.7
		89.409	12.968	214.5391	703.8684	3.9
		86.322	12.520	214.6048	704.0840	0.4
		75.979	11.020	214.8480	704.8819	8.7
		75.633	10.970	214.8626	704.9297	10.3
		65.189	9.455	215.1126	705.7500	5.8
		63.256	9.175	215.1555	705.8907	17.9
		58.083	8.424	215.2718	706.2723	23.0
		51.742	7.505	215.4213	706.7628	42.9
		45.643	6.620	215.5659	707.2372	51.7
		39.973	5.798	215.6944	707.6588	34.9
349.990	170.312	1014.575	147.152	200.5890	658.1004	119.8
		913.799	132.535	203.0093	666.0410	83.5
		766.833	111.220	206.3374	676.9600	263.3
		693.330	100.559	207.9909	682.3849	220.3
		531.155	77.038	211.6543	694.4039	71.0
		449.681	65.221	213.3834	700.0768	92.6
		363.687	52.748	215.1891	706.0010	71.2
		309.614	44.906	216.2950	709.6293	58.0
		182.801	26.513	218.8805	718.1119	14.7
		93.872	13.615	220.6438	723.8970	3.5
		93.918	13.622	220.6364	723.8727	2.9
		87.436	12.682	220.7666	724.2999	1.3
		82.225	11.926	220.8704	724.6404	13.4
		74.760	10.843	221.0172	725.1220	15.8
		68.065	9.872	221.1496	725.5564	16.4
		50.945	7.389	221.4993	726.7037	2.6
		50.923	7.386	221.5091	726.7359	32.1
		46.673	6.769	221.5952	727.0184	25.0
		34.704	5.033	221.8563	727.8750	25.0

Table 8. Speed of Sound for HFC-152a (continued).

T/K	T/°F	P/kPa	P/psia	u/(m/s)	u/(ft/s)	$10^6 \delta u/u$
369.985	206.303	1016.462	147.425	210.1440	689.4488	54.0
		799.807	116.002	214.2621	702.9597	66.8
		611.982	88.760	217.6876	714.1982	79.7
		445.385	64.598	220.6314	723.8563	95.7
		189.751	27.521	225.0360	738.3071	61.6
		104.789	15.198	226.4667	743.0010	0.2
		98.457	14.280	226.5765	743.3613	3.3
		94.527	13.710	226.6414	743.5742	6.5
		87.668	12.715	226.7576	743.9554	8.7
		82.416	11.953	226.8511	744.2621	17.7
		76.485	11.093	226.9479	744.5798	16.0
		69.414	10.068	227.0641	744.9609	11.6
		62.278	9.033	227.1885	745.3691	56.6
		56.502	8.195	227.2844	745.6837	35.2
		47.642	6.910	227.4317	746.1670	48.4
		41.067	5.956	227.5493	746.5528	25.0
399.959	260.256	1005.176	145.788	222.7795	730.9039	58.1
		955.631	138.603	223.4874	733.2264	62.6
		947.797	137.466	223.6012	733.5997	67.1
		947.770	137.462	223.5994	733.5938	57.1
		947.642	137.444	223.6024	733.6037	53.5
		820.092	118.944	225.4018	739.5072	76.3
		505.233	73.278	229.7674	753.8300	70.2
		459.746	66.681	230.3910	755.8760	62.2
		375.462	54.456	231.5337	759.6250	54.1
		335.836	48.709	232.0694	761.3825	50.0
		204.089	29.601	233.8379	767.1848	16.1
		107.554	15.599	235.1222	771.3983	2.6
		106.925	15.508	235.1329	771.4334	6.8
		97.359	14.121	235.2617	771.8560	9.0
		92.530	13.420	235.3286	772.0754	5.5
		87.856	12.742	235.3933	772.2877	16.2
		82.236	11.927	235.4686	772.5348	17.1
		82.082	11.905	235.4734	772.5505	12.3

Table 9. Ideal-Gas Heat Capacity, C_p° , of HFC-152a.

T/K	T/°F	C_p°/R	$\sigma(C_p^\circ)/R$
242.776	-22.672	6.97240	0.012
257.973	4.682	7.31965	0.011
273.130	31.964	7.62731	0.006
289.946	62.233	7.97092	0.019
300.013	80.354	8.15861	0.007
309.991	98.313	8.32217	0.008
329.945	134.232	8.70200	0.008
349.990	170.312	9.05906	0.012
369.985	206.303	9.44295	0.007
399.959	260.256	9.97502	0.005

Table 10a. Acoustic Virial Coefficients for HFC-152a (SI Units).

T K	$10^6 \beta_a$ m^3/mol	$10^9 \gamma_a$ $\text{m}^3/(\text{mol} \cdot \text{Pa})$	$10^{17} \delta_a$ $\text{m}^3/(\text{mol} \cdot \text{Pa}^2)$
242.776	-1392.40 $\pm$ 4.9	-	-
257.973	-1044.15 $\pm$ 6.1	-0.4400 $\pm$.035	-
273.130	-951.01 $\pm$ 1.6	-0.2736 $\pm$.015	-
289.946	-797.76 $\pm$ 6.6	-0.1307 $\pm$.018	-
300.013	-736.65 $\pm$ 2.4	-0.0606 $\pm$.010	-8.45 $\pm$ 1.3
309.991	-683.93 $\pm$ 2.6	-0.0358 $\pm$.009	-6.24 $\pm$ 0.8
329.945	-583.73 $\pm$ 1.2	-0.0313 $\pm$.003	-2.25 $\pm$ 0.2
349.990	-531.30 $\pm$ 4.1	-0.0366 $\pm$.011	-1.38 $\pm$ 0.3
369.985	-451.95 $\pm$ 1.8	-0.0054 $\pm$.004	-
399.959	-370.38 $\pm$ 0.6	-0.0035 $\pm$.001	-

Table 10b. Acoustic Virial Coefficients for HFC-152a (PI Units).

T °F	$10^4 \beta_a$ Btu/(psi·mol)	$10^6 \gamma_a$ Btu/(mol·psi ²)	$10^9 \delta_a$ Btu/(mol·psi ³)
-22.672	-91.054	-	-
4.682	-68.281	-19.84 $\pm$ 1.6	-
31.964	-62.190	-12.34 $\pm$ 0.7	-
62.233	-52.168	-5.893 $\pm$ 0.8	-
80.354	-48.171	-2.732 $\pm$ 0.4	-26.3 $\pm$ 4.0
98.313	-44.725	-1.614 $\pm$ 0.4	-19.4 $\pm$ 2.5
134.232	-38.172	-1.411 $\pm$ 0.1	-6.99 $\pm$ 0.6
170.312	-34.744	-1.650 $\pm$ 0.5	-4.29 $\pm$ 0.9
206.303	-29.555	-0.243 $\pm$ 0.2	-
260.256	-24.220	-0.158 $\pm$ 0.04	-

Table 11. Coefficients to the MBWR Equation of State for HFC-152a (units are K, bar, L, mol).

$$p = \sum_{n=1}^9 a_n \rho^n + \exp(-\rho^2/\rho_c^2) \sum_{n=10}^{14} a_n \rho^{2n-17}$$

$$\begin{aligned} a_1 &= RT \\ a_2 &= b_1 T + b_2 T^{0.5} + b_3 + b_4 / T + b_5 / T^2 \\ a_3 &= b_6 T + b_7 + b_8 T + b_9 / T^2 \\ a_4 &= b_{10} T + b_{11} + b_{12} / T \\ a_5 &= b_{13} \\ a_6 &= b_{14} / T + b_{15} / T^2 \\ a_7 &= b_{16} / T \\ a_8 &= b_{17} / T + b_{18} / T^2 \\ a_9 &= b_{19} / T^2 \\ a_{10} &= b_{20} / T^2 + b_{21} / T^3 \\ a_{11} &= b_{22} / T^2 + b_{23} / T^4 \\ a_{12} &= b_{24} / T^2 + b_{25} / T^3 \\ a_{13} &= b_{26} / T^2 + b_{27} / T^4 \\ a_{14} &= b_{28} / T^2 + b_{29} / T^3 \\ a_{15} &= b_{30} / T^2 + b_{31} / T^3 + b_{32} / T^4 \end{aligned}$$

i	b _i	i	b _i
1	-0.653136507982 x 10 ⁻¹	17	-0.794945128529 x 10 ⁻³
2	0.544321046717 x 10	18	-0.160859940054
3	-0.121313765605 x 10 ³	19	0.617842740721 x 10 ⁻²
4	0.181868177534 x 10 ⁵	20	-0.139263903722 x 10 ⁶
5	-0.239916316821 x 10 ⁷	21	-0.533789127839 x 10 ³
6	0.131295183149 x 10 ⁻²	22	-0.906702054774 x 10 ⁴
7	-0.314050283774 x 10	23	0.548206634459 x 10 ⁹
8	0.140782204781 x 10 ⁴	24	-0.938326147547 x 10 ²
9	0.292826206065 x 10 ⁶	25	0.149565454607 x 10 ⁵
10	-0.244847072578 x 10 ⁻³	26	-0.467011142163
11	0.700647777825	27	-0.627534795462 x 10 ⁵
12	-0.274357889230 x 10 ³	28	-0.943343184078 x 10 ⁻²
13	-0.151880734084 x 10 ⁻¹	29	0.432157310903 x 10
14	0.206277213827	30	-0.192348324842 x 10 ⁴
15	-0.365615951970 x 10	31	-0.129433862772 x 10 ⁻³
16	0.238408634477 x 10 ⁻¹	32	-0.233185722528 x 10

Table 12. Critical Parameters for HFC-152a for Use with the MBWR Equation of State.

T_c	386.44 K
P_c	45.20 bar
ρ_c	5.57145 mol/L

Table 13. Ideal Gas Heat Capacity Auxiliary Equation and its Coefficients for HFC-152a.
 [(Units are K and J/(mol·K)].

$$C_p^o = c_0 + c_1T + c_2T^2 + c_3T^3$$

i	c_i
0	27.12550
1	9.220968×10^{-2}
2	2.189067×10^{-4}
3	-2.514364×10^{-7}

Table 14a. Properties of Saturated Liquid and Saturated Vapor HFC-152a (SI Units).

Temp* °C	Pressure MPa	Density kg/m ³ liq	Volume m ³ /kg vap	Enthalpy kJ/kg		Entropy kJ/(kg·K)		Specific Heat, C _p kJ/(kg·K)		C _p /C _v vap	Vel of Sound m/s	
				liq	vap	liq	vap	liq	vap		liq	vap
-118.59a	0.00006	1192.2	304.01604	13.79	419.41	0.1128	2.7372	1.505	0.692	1.223	1435.	154.
-110.00	0.00019	1177.1	107.99322	26.62	425.41	0.1936	2.6379	1.486	0.711	1.216	1374.	158.
-100.00	0.00058	1159.2	37.69066	41.48	432.56	0.2820	2.5407	1.490	0.734	1.209	1308.	162.
-90.00	0.00153	1141.1	15.06985	56.45	439.89	0.3660	2.4596	1.504	0.758	1.202	1247.	166.
-80.00	0.00359	1122.7	6.74478	71.58	447.34	0.4465	2.3919	1.522	0.783	1.197	1190.	170.
-70.00	0.00766	1103.9	3.31700	86.90	454.90	0.5238	2.3353	1.541	0.811	1.193	1135.	173.
-60.00	0.01503	1084.8	1.76552	102.42	462.52	0.5983	2.2878	1.561	0.841	1.191	1081.	177.
-50.00	0.02748	1065.2	1.00449	118.12	470.15	0.6703	2.2478	1.580	0.873	1.190	1029.	180.
-40.00	0.04732	1045.2	0.60461	134.04	477.75	0.7399	2.2142	1.600	0.909	1.190	977.	182.
-30.00	0.07735	1024.7	0.38170	150.16	485.28	0.8075	2.1858	1.622	0.947	1.193	926.	184.
-24.07b	0.10133	1012.2	0.29628	159.83	489.68	0.8467	2.1710	1.635	0.972	1.196	895.	185.
-20.00	0.12091	1003.6	0.25092	166.51	492.67	0.8733	2.1616	1.645	0.990	1.199	874.	186.
-10.00	0.18180	981.8	0.17070	183.11	499.88	0.9373	2.1411	1.671	1.037	1.206	823.	187.
0.00	0.26428	959.3	0.11955	200.00	506.86	1.0000	2.1234	1.700	1.088	1.217	771.	187.
10.00	0.37301	935.9	0.08581	217.20	513.55	1.0614	2.1080	1.734	1.146	1.232	720.	187.
20.00	0.51303	911.5	0.06287	234.76	519.87	1.1219	2.0944	1.773	1.210	1.252	669.	186.
30.00	0.68976	885.8	0.04685	252.74	525.76	1.1815	2.0821	1.819	1.285	1.278	618.	185.
40.00	0.90896	858.7	0.03539	271.21	531.10	1.2406	2.0705	1.876	1.372	1.314	566.	182.
50.00	1.17682	829.7	0.02702	290.26	535.75	1.2995	2.0592	1.947	1.479	1.362	514.	179.
60.00	1.49995	798.3	0.02076	310.02	539.55	1.3585	2.0475	2.039	1.614	1.430	462.	175.
70.00	1.88555	763.7	0.01601	330.69	542.21	1.4182	2.0346	2.168	1.799	1.532	409.	169.
80.00	2.34166	724.5	0.01230	352.57	543.28	1.4793	2.0193	2.361	2.077	1.698	353.	162.
90.00	2.87759	678.2	0.00935	376.23	541.93	1.5432	1.9995	2.699	2.566	2.008	296.	154.
100.00	3.50521	618.6	0.00688	402.96	536.21	1.6131	1.9702	3.497	3.745	2.789	233.	143.
110.00	4.24382	518.1	0.00448	438.61	517.38	1.7039	1.9095	9.191	12.088	8.421	157.	129.
113.29c	4.52000	368.0	0.00272	477.16	477.16	1.7896	1.7896	.inf	.inf	.inf	0.	0.

*temperatures are on the ITS-90 scale

a triple point; b boiling point; c critical point

Table 14b. Properties of Saturated Liquid and Saturated Vapor HFC-152a (PI Units).

Temp* °F	Pressure psia	Density lb/ft ³ liq	Volume ft ³ /lb vap	Enthalpy BTU/lb		Entropy BTU/(lb·°F)		Specific Heat, C _p BTU/(lb·°F)		C _p /C _v vap	Vel of Sound ft/s	
				liq	vap	liq	vap	liq	vap		liq	vap
-181.46a	0.009	74.43	4869.8696	-51.732	122.772	-0.14988	0.47736	0.3598	0.1654	1.2227	4709.	506.
-180.00	0.010	74.34	4390.2078	-51.206	123.013	-0.14800	0.47494	0.3590	0.1658	1.2220	4690.	507.
-160.00	0.041	73.11	1197.6993	-44.083	126.370	-0.12340	0.44540	0.3550	0.1717	1.2134	4435.	523.
-140.00	0.131	71.87	395.6157	-36.964	129.822	-0.10040	0.42134	0.3574	0.1779	1.2057	4201.	538.
-120.00	0.361	70.60	152.5005	-29.772	133.357	-0.07858	0.40167	0.3619	0.1845	1.1993	3985.	552.
-100.00	0.871	69.31	66.6796	-22.483	136.953	-0.05774	0.38555	0.3669	0.1916	1.1943	3782.	565.
-80.00	1.888	67.99	32.3355	-15.093	140.589	-0.03775	0.37229	0.3720	0.1993	1.1910	3586.	577.
-60.00	3.739	66.64	17.0804	-7.600	144.238	-0.01853	0.36137	0.3771	0.2078	1.1897	3395.	588.
-40.00	6.863	65.25	9.6849	0.000	147.872	0.00000	0.35235	0.3824	0.2172	1.1905	3206.	598.
-20.00	11.815	63.82	5.8248	7.713	151.464	0.01792	0.34487	0.3882	0.2275	1.1938	3018.	605.
-11.32b	14.696	63.19	4.7460	11.097	153.002	0.02552	0.34203	0.3908	0.2324	1.1961	2936.	608.
0.00	19.261	62.35	3.6793	15.549	154.984	0.03530	0.33864	0.3945	0.2390	1.2000	2830.	611.
20.00	29.976	60.83	2.4210	23.522	158.404	0.05221	0.33340	0.4016	0.2517	1.2096	2643.	614.
40.00	44.827	59.24	1.6480	31.650	161.689	0.06871	0.32896	0.4098	0.2660	1.2234	2456.	615.
60.00	64.774	57.59	1.1537	39.956	164.803	0.08489	0.32513	0.4194	0.2822	1.2426	2269.	613.
80.00	90.855	55.84	0.8264	48.469	167.703	0.10080	0.32174	0.4309	0.3008	1.2688	2082.	608.
100.00	124.192	53.99	0.6028	57.227	170.332	0.11653	0.31862	0.4451	0.3230	1.3049	1895.	600.
120.00	165.989	52.00	0.4457	66.283	172.618	0.13217	0.31561	0.4632	0.3503	1.3559	1706.	589.
140.00	217.549	49.84	0.3326	75.710	174.457	0.14784	0.31251	0.4874	0.3858	1.4304	1515.	573.
160.00	280.299	47.42	0.2491	85.620	175.689	0.16370	0.30905	0.5223	0.4360	1.5469	1321.	553.
180.00	355.848	44.63	0.1857	96.201	176.040	0.18002	0.30483	0.5781	0.5163	1.7496	1119.	527.
200.00	446.121	41.22	0.1359	107.834	174.942	0.19732	0.29905	0.6882	0.6767	2.1813	903.	494.
220.00	553.751	36.42	0.0938	121.632	170.706	0.21715	0.28935	1.0542	1.2206	3.7051	661.	452.
235.92c	655.571	22.97	0.0435	147.617	147.617	0.24563	0.24563	.inf	.inf	.inf	0.	0.

*temperatures are on the ITS-90 scale
a triple point; b boiling point; c critical point

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