THERMOPHYSICAL PROPERTIES OF HCFC ALTERNATIVES

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THERMOPHYSICAL PROPERTIES OF HCFC ALTERNATIVES

ARTI MCLR Project Number 660-50800

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ABSTRACT

Numerous fluids and fluid mixtures have been identified as promising alternatives to the HCFC refrigerants, but, for many of them, reliable thermodynamic data do not exist. In particular, reliable thermodynamic 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 measure, with high accuracy, selected thermodynamic properties data for two pure refrigerants and nine refrigerant blends; these data will be used to fit equations of state and other property models which can be used in equipment design. The new data will fill in gaps in the existing data and resolve problems and differences that exist in and between existing data sets. Most of the studied fluids and blends are potential replacements for HCFC-22 and/or R502; in addition, one pure fluid and one blend are potential replacements for CFC-13 in low temperature refrigeration applications.

SCOPE

This project involves the measurement of primary thermodynamic data for eight binary mixtures and one ternary mixture (R125/134a; R32/143a; R125/143a; R143a/134a; R32/290; R125/290; R290/134a; R41/744; and R32/125/134a). These data will consist of simultaneous measurements of the coexisting liquid and vapor densities and coexisting liquid and vapor compositions as well as the bubble point pressures over wide ranges of temperature and composition. These data will be used to determine the mixing parameters, including any temperature and/or composition dependence, for the Carnahan-Starling-DeSantis (CSD) equation of state and the extended corresponding states (ECS) model. Primary data will also be measured for the pure fluid HFC-41. These measurements will include the determination of vapor pressure; liquid density; liquid, two-phase, and ideal gas heat capacities; vapor sound speeds and virial coefficients; and a determination of the critical point parameters. These data will cover wide ranges of temperature and pressure and will be used (together with available literature data) to fit equations of state and other models of the thermodynamic properties. The original proposal called for similar measurements of primary data for HFC-245ca; since work on this fluid has been funded by another sponsor, comprehensive mixture data for the binary system R125/143a will be substituted as recommended by the MCLR Advisory Committee. During the past quarter, preparation of standard reference mixtures for the R125/134a and R32/134a/125 systems and for the R290 and R143a series of systems for calibration of the gas chromatograph were completed. Vapor-liquid equilibria and coexisting density measurements were completed for the R125/290 and R32/143a systems. Measurements on the remaining R143a systems will be carried out during the next quarter.

Extensive comparisons were carried out for the R32/134a system (measured in the previous quarter). Isochoric PVT measurements were made along ten isochores from 200 to 400 K (-100 to 260°F) up to 35 MPa (5100 psia) for an equimolar mixture of HFC-143a and HFC-125.

SIGNIFICANT RESULTS

Primary mixture data for binary mixtures of relatively volatile components (R125/134a; R32/143a; R125/143a; R143a/134a; R32/290; R125/290; R134a/290)

In the previous quarter we had carried out measurements for the R32/290 and R134a/290 systems. In this quarter we completed eight isotherms from 280 to 364 K (45 to 196°F) for the R125/290 system and seven isotherms from 280 to 350 K (44 to 170°F) for R32/143a. Also, during this quarter, gas chromatograph calibrations were performed for the R32/290, R134a/290, R125/290, and R32/143a systems. Measurements have been initiated for the R134a/143a system. Preliminary data for the R32/290, R134a/290, and R125/290 are presented in Tables 1 through 3. The data for R32/143a will be presented in the next quarterly report. The isotherms for these systems are spaced at 15 K (27°F) intervals with additional isotherms in the critical region. Six to nine compositions are measured on each isotherm except near the critical line.

For the composition measurements, two standard reference mixtures have been prepared for each binary system. These mixtures are needed for the comprehensive gas chromatograph (GC) calibration procedure that has been developed to achieve high accuracy in the composition determination. Standard reference mixtures at mole fractions of 35 and 65 mole percent have been prepared for each binary system. Samples masses of 100 to 150 g (0.22 to 0.330 lb) were prepared in 5.9 L (0.21 ft³) cylinders for each mixture. The balance used for preparing the samples has a resolution of 1 mg (2.2×10^{-6} lb). Therefore, the uncertainty of the composition of the prepared mixtures is approximately 10^{-5} mole fraction. This is several orders of magnitude better than the accuracy of the sampling and analysis procedure used for the composition determination during the measurement process.

The binary systems, R32/134a and R32/125, are needed for thorough evaluation of the data for the ternary system R32/125/134a. These data have been obtained under DOE support. Preliminary data were reported for these binary systems in the last quarter. Final revised data are presented in Tables 4 and 5. We have also reported the compositions in units of mass fractions.

As part of the data evaluation, we compare our data to all available data to examine the data for consistency and agreement with other laboratories. The best available source for information on the R32/134a and R32/125 mixtures is the International Energy Agency (IEA) Annex 18 database. This database contains data from laboratories from many countries that are working together to determine the properties of the alternative refrigerants. Much of the data from the Annex 18 data base is preliminary and/or unpublished; it may be updated before publication.

We have completed comparisons for R32/134a and are currently doing similar comparisons for R32/125. We are using a preliminary extended corresponding states model (ECS) to intercompare the data sets. A refined version of the ECS model is currently being implemented in the REFPROP database, and will be an option for mixture calculations in

Version 5.0 of REFPROP, which is expected to be released in Spring 1995. The data from this project will be used to continually update and optimize the models in REFPROP. To calculate a state point at saturation with the ECS model, two quantities must be specified. The usual choices for mixtures are temperature and liquid composition. It is also possible to calculate saturation properties by specifying temperature and pressure; this makes use of the two-phase flash calculation in the ECS model and requires an initial guess for composition. The flash calculation then gives coexisting liquid and vapor compositions necessary to match the input temperature and pressure. Additional information can be obtained by comparing the data using both sets of independent variables. These comparisons also provide insight into determining which part of a state point measurement has the largest uncertainty. This is important since, for some references, the compositions were the least accurate measurement and, for others, the pressures were the least accurate measurement.

Figures 1 and 2 show the data for R32/134a from this study for bubble and dew point pressures, and for liquid and vapor densities. The smooth curves represent polynomial fits of the data. The figures show the range over which the data were collected and the general behavior between composition and the other parameters. An equation of state is needed to compare these results to data from the IEA Annex 18 database at different temperatures, pressures, and compositions. It should be noted that a preliminary version of the extended corresponding states model is used for comparisons. This model has not been optimized to recent experimental data. It is used to facilitate intercomparisons of different data sets and to provide insight into the general behavior of mixture properties. It is not intended as an absolute comparison of the model to experimental data. Comparisons in the critical region are not meaningful at this time, since the current model and the experimental data do not have the same critical line. This difference in the critical lines is not unexpected, since most models cannot give an accurate representation of both the critical region and the low temperature vapor-liquid equilibria.

Figures 3 and 4 show comparisons of the data sets for R32/134a with temperature and pressure as the independent variables. Figure 3 shows the experimental liquid compositions compared to predictions from the ECS model. Our data are in general agreement with all of the data except for the data of Fujiwara *et al.* [Fujiwara, K., Momota, H., and Noguchi, M., 13th Japan Symposium Thermophysics Properties A116, 61 (1992)]. Our data follow the general trend of the data of Defibaugh [NIST, unpublished data]. The data of Higashi (Iwaki Meisei University, unpublished data) are in good agreement with our data at the higher temperatures. The data of Higashi and that from the current study cover a wide composition range and are lower than the ECS model predictions at low temperatures. However, our data and the data of Defibaugh are slightly higher than the data of Widiatmo *et al.* [Widiatmo, J.V., Sato, H., and Watanabe, K., Fluid Phase Equilibria 19, 199 (1994)], of Kleemiss [University of Hannover, unpublished data], and of Higashi. Defibaugh used a standard reference mixture prepared gravimetrically rather than determining the liquid composition by sampling and analysis. This technique should result in a relatively small uncertainty in the composition. For the other data sets, the liquid compositions were determined by a gas chromatographic (GC) analysis. As discussed below, we shall provide an analysis of possible problems in sampling and analysis that could account for the differences in composition when compared with the other data sets. The data of Widiatmo *et al.* are in general agreement with our data and the data of Higashi at the lowest temperature. At some of the higher temperatures, there are a few outliers in the data of Widiatmo *et al.* The data of Fujiwara *et al.* show large deviations compared to the other experimental data. Our data near the critical point show large deviations compared to the ECS model. It is not uncommon to observe large deviations for mixtures in the critical region; indeed, it is not unusual to observe large deviations for pure fluids in this region.

In Figure 4 the vapor compositions are intercompared using the ECS model predictions. The data from the current study tend to be somewhat higher than the other results except for those of Fujiwara *et al.* We will provide an explanation for the observed discrepancies, as discussed below. The vapor compositions of Fujiwara *et al.* are in general agreement with our data. Since his liquid compositions were not in agreement with the other experimental data, it is likely that his liquid composition sampling technique is characterized by a large uncertainty or a loss of material between when the sample was taken and when it was analyzed. His vapor compositions, pressures, and temperatures seem to generally agree with the other data sets. The data of Kleemiss for an equimolar mixture and the data of Higashi agree in the region of overlap. The vapor composition data of Higashi appear too low except at the highest two temperatures. From this we can deduce that he may have had a problem with his vapor sampling technique. His liquid compositions, pressures, and temperatures are in general agreement with the other data sets.

In Figures 5 and 6 the liquid composition and temperature are the independent variables, while examining the pressure and vapor composition deviations. In Figure 5 the experimental bubble point pressures are intercompared using the ECS model. Most of the data from the different laboratories seem to be in good agreement. The data from this work are in general agreement (slightly lower) with the other data sets. This is because the liquid composition was used as an independent variable. We have observed in Figure 2 that our liquid compositions are slightly higher compared to the other data sets. When the liquid composition is used as the independent variable, the difference between our bubble point pressures and the ECS model will be less than the other data sets. The data of Fujiwara *et al.* are significantly lower than the other results. This is not unexpected since we have observed that his liquid compositions show large deviations. If the liquid composition is used as an independent variable and has substantial error, the pressures calculated from his liquid compositions will be significantly different from the measured pressures. The lowest temperature point of Higashi seems high compared to all of the other data sets. A couple of the points of Widiatmo *et al.* also seem high compared to the majority of the data. One of our points on the 295 K (72°F) isotherm may have greater than expected error. As the critical point is approached, the deviations between our data and the ECS model increase, which is expected.

Figure 6 shows intercomparisons of the vapor compositions using the ECS model with the liquid composition and temperature as the independent variables. Our data look very similar to the results we presented in Figure 4. However, the vapor compositions of Higashi and of Kleemiss are not as low compared to our data as they were in Figure 4. This difference is again due to using the liquid composition as an independent variable. Their liquid compositions were lower than ours, and when the liquid composition is used as the independent variable, it will produce lower predicted vapor compositions. Therefore, the predicted vapor compositions are closer to the measured results. This result implies that the liquid compositions may be slightly low, because the vapor compositions predicted are significantly different than when using the pressure as an independent variable. A possible reason for the lower composition will be discussed below. For the vapor composition, the data of Fujiwara *et al.* are low compared to the other data sets. Again this is because the liquid composition was used as an independent variable, and we have already observed that his liquid compositions exhibited large differences.

Using the ECS model, Figure 7 intercompares the liquid densities for the small amount of available data for the R32/134a system. In Figure 7 our data are compared to the liquid densities of Widiatmo *et al.* The data are in general agreement over the region of overlap. The deviations of our data increase near the critical point, which is again expected.

There are significant differences among the data of the various laboratories when using the liquid composition as a basis for comparison. There are also small differences in the measured liquid compositions between the data sets and larger differences in the measured vapor compositions between the data sets. These differences may result from HFC-32 adsorption on stainless steel at temperatures below 340 K. We have been aware of this problem and have replaced the lines from our sampling valves to the GC with copper tubing. These lines should reach an equilibrium concentration of HFC-32 on the walls after the first sample is taken. The time it takes the HFC-32 to desorb under a vacuum at room temperature is several hours. We have verified the liquid sampling and analysis procedure in tests on a ternary mixture of R32/134a/125. This test involved a standard reference mixture that was injected directly into the GC. The apparatus was then completely filled with liquid condensed from the standard reference mixture sample cylinder. A liquid sample was taken using the same procedure as for normal mixture experiments and was compared to the tests where the standard reference mixture was injected directly into the GC. The measured compositions agreed with the composition of the standard reference mixture within the uncertainty of the measurement technique.

We have also verified our vapor sampling technique in the same manner that we used for the liquid sampling. We used four standard reference mixtures of R32/R134a and R32/R125. The samples were injected directly into the GC. Then the apparatus was filled with vapor from a standard reference mixture sample cylinder. A vapor sample was taken from the apparatus in the usual manner as for mixture experiments. The difference between the directly injected samples and the samples from the apparatus filled with the standard mixture were within the estimated uncertainty of the GC calibration. Thus, we feel confident in the technique we have used for obtaining vapor samples and in the subsequent analysis.

The apparatus of Higashi and of Kleemiss use trapped sampling for obtaining samples. This involves withdrawing the sample into a stainless steel bomb and diluting it with helium. Then, the diluted sample is injected into the GC. Usually a smaller sample of vapor compared to liquid samples is withdrawn from the system. This means a larger fraction of the HFC-32 could be adsorbed to the walls of the stainless steel bomb and would not be transferred to the GC. We do not have the details of the apparatus of Fujiwara *et al.*, but it may have a similar sampling procedure. This problem can also affect the liquid compositions depending on the size of the sample that is withdrawn. If the sample is sufficiently large compared to the amount of HFC-32 adsorbed on the walls of the stainless steel bomb, the composition measurement will not be significantly affected. We have tried to anticipate any sampling problems that may occur in our apparatus and have tested the sampling techniques using standard reference mixtures. We feel confident from our analysis of the existing data that our results are accurate within our estimated experimental uncertainties.

The same type of analysis that has been performed for R32/134a is necessary for all of the systems we measure. Comparisons will be performed for R32/125 and the propane systems in the next quarter. A literature search for data for the R143a systems will be initiated.

A new VLE and coexisting density apparatus that will be used for some of the measurements in this project has been constructed. This apparatus was described in a previous progress report. The two pressure transducers, two differential pressure transducers, the three platinum resistant thermometers, and the two densimeters are in the process of being calibrated. It is expected that this apparatus will give smaller uncertainties in the measured properties, especially related to temperature. Thus, we are attempting to get this apparatus into operation as soon as possible to carry out measurements on the systems that have not been tested in this project and to provide checks for the systems already measured.

Primary mixture data for a ternary mixture of relatively volatile components (R32/125/134a)

The GC calibration for this ternary system is similar to that required for the constituent binaries. For this system, three standard reference ternary mixtures, in addition to the six standard reference binary mixtures of the constituent binaries, will be used for the calibration procedure. These standard reference mixtures have been prepared. We have measured the bubble point pressures and liquid densities for a ternary mixture of 0.346 mole fraction HFC-32, 0.300 mole fraction HFC-125, and 0.354 mole fraction HFC-134a from 244 to 346 K (-20 to 163°F) for a project supported by ICI. These data will be included in our analysis of the ternary system. The Annex-18 database has provided some ternary data for comparison. Measurements on the ternary system will be initiated after completion of the HFC-143a systems.

Primary mixture data for a binary mixture of very low boiling components (R41/744)

As mentioned in the previous report, this system will be measured in a low temperature VLE apparatus that was recently used for measurements on binary mixtures of oxygen, nitrogen, and argon. A new GC column is needed to separate the GC peaks. We have high purity R744 available. A sample of R41 was obtained, but an analysis revealed that it had significant impurities and was not suitable for the planned measurements. We are currently pursuing two other possible suppliers in the U.S. and Germany. Standard reference mixtures will be prepared for the GC calibration.

Comprehensive data for the R143a/125 mixture

An isochoric PVT apparatus has been used to measure the density of 0.50004 (mole fraction) HFC-143a + 0.49996 HFC-125 at about 100 points in the temperature range from 200 to 400 K (-100 to 260°F) with pressures up to 35 MPa (5100 psia). At the time of this report, ten runs at different filling densities have been completed. These data are in the dense liquid and supercritical fluid phases. During the next reporting period, PVT measurements will be completed in the compressed gas phase at five filling densities. The final data set for this mixture will encompass temperatures between 200 and 400 K (-100 to 260°F) and pressures between 2 and 35 MPa (300 to 5100 psia).

COMPLIANCE WITH AGREEMENT

NIST has complied with all terms of the grant agreement modulo small shifts in the estimated level of effort from one property and/or fluid to another.

PRINCIPAL INVESTIGATOR EFFORT

Dr. W.M. Haynes is the NIST Principal Investigator for the MCLR program. During the first quarter of calendar year 1995, Dr. Haynes devoted approximately one week to planning this project, monitoring and reviewing the research, and preparing the report. The project involves multiple researchers and capabilities in Boulder, CO.

Figure 1: Experimental bubble point and dew point pressures for R32/134a measured along isotherms (x-experimental liquid data, *-experimental vapor data; smooth lines represent polynomial fits of the data)

Figure 2: Experimental liquid and vapor densities for R32/134a measured along isotherms (x-experimental liquid data, *-experimental vapor data; smooth lines represent polynomial fits of the data)

Figure 3: Comparison of liquid compositions for the R32/134a system; the baseline is a preliminary extended corresponding states (ECS) model, and temperature and pressure are the independent variables.

Figure 4: Comparison of vapor compositions for the R32/134a system; the baseline is a preliminary extended corresponding states (ECS) model, and temperature and pressure are the independent variables.

Figure 5: Comparison of bubble point pressures for the R32/134a system; the baseline is a preliminary extended corresponding states (ECS) model, and temperature and pressure are the independent variables.

Figure 6: Comparison of vapor compositions for the R32/134a system; the baseline is a preliminary extended corresponding states (ECS) model, and temperature and liquid composition are the independent variables.

Figure 7: Comparison of liquid densities for the R32/134a system; the baseline is a preliminary extended corresponding states (ECS) model.

APPENDIX A:
TABLES OF THERMOPHYSICAL PROPERTIES DATA

Table 1. Coexisting Densities and Bubble Point Pressures for R32/290 Mixtures from 280 to 365 K (44 to 197°F).
(LL indicates liquid-liquid immiscibility.)

Temperature K	x(R32) Liquid Mole Fraction	y(R32) Vapor Mole Fraction	Pressure MPa	Liquid Density kg/m ³	Vapor Density kg/m ³	Temperature °F	x(R32) Liquid Mass Fraction	y(R32) Vapor Mass Fraction	Pressure psia	Liquid Density lb/ft ³	Vapor Density lb/ft ³
280.00	0	0	0.5798	519.2	12.5	44.33	0	0	84.1	32.39	0.78
280.66	0.348	0.655	1.2545	619.2	33.7	45.51	0.386	0.691	181.9	38.62	2.10
280.25	0.366	0.643	1.2598	648.4	33.7	44.78	0.405	0.680	182.7	40.44	2.10
280.37	LL	0.686	1.2988	LL	36.0	44.99	LL	0.720	188.4	LL	2.25
280.39	LL	0.687	1.2928	LL	36.0	45.03	LL	0.721	187.5	LL	2.24
280.32	LL	0.687	1.2837	LL	35.4	44.90	LL	0.721	186.2	LL	2.21
280.26	0.843	0.739	1.2621	843.9	33.9	44.80	0.864	0.770	183.1	52.63	2.12
280.33	0.907	0.770	1.2424	880.0	34.3	44.92	0.920	0.798	180.2	54.88	2.14
280.31	0.935	0.790	1.2262	901.8		44.89	0.944	0.816	177.9	56.25	
280.49	0.978	0.890	1.1349	978.1	31.2	45.21	0.981	0.905	164.6	61.00	1.94
280.42	0.978	0.890	1.1340	979.3	30.7	45.08	0.981	0.905	164.5	61.08	1.92
281.53	0.997	0.910	1.1196	992.2	27.8	47.08	0.997	0.923	162.4	61.88	1.73
281.44	0.997	0.910	1.1169	991.9	27.8	46.92	0.997	0.923	162	61.87	1.73
280.00	1	1	1.0059	1029.0	27.4	44.33	1	1	145.9	64.18	1.71
294.80	0	0	0.8731	497.5	19.2	70.96	0	0	126.6	31.03	1.20
295.93	0.135	0.437	1.5334	531.5	38.2	73.01	0.156	0.478	222.4	33.15	2.38
294.46	0.337	0.622	1.7667	588.4	48.5	70.37	0.375	0.660	256.2	36.70	3.02
294.80	0.445		1.8464	614.1		70.96	0.486		267.8	38.30	
294.70	LL	0.700	1.8825	LL	54.6	70.78	LL	0.734	273	LL	3.40
293.15	0.857	0.778	1.7775	850.9		68.01	0.876	0.805	257.8	53.07	
293.01	0.857	0.778	1.7725	851.1		67.74	0.876	0.805	257.1	53.08	
295.82	0.935	0.869	1.6809	892.5	51.3	72.81	0.944	0.887	243.8	55.67	3.2
295.48	1	1	1.5748	971.2	44.6	72.19	1	1	228.4	60.58	2.78
309.49	0	0	1.2593	473.7	28.1	97.41	0	0	182.6	29.55	1.75
310.81	0.112	0.337	1.9159	488.8	47.9	99.79	0.130	0.375	277.9	30.48	2.98
310.24	0.306	0.428	2.4462	529.8	67.2	98.76	0.342	0.469	354.8	33.05	4.19
310.07	0.618	0.637	2.7100	597.2	80.3	98.46	0.656	0.674	393.1	37.25	5.01
310.16	0.127	0.347	1.9374	492.2	48.6	98.62	0.146	0.385	281	30.70	3.03
310.25	0.306	0.428	2.4483	529.6	67.5	98.78	0.342	0.469	355.1	33.03	4.21
310.10	0.667	0.694	2.7674	628.9	84.2	98.51	0.703	0.728	401.4	39.23	5.25
310.08	0.667	0.694	2.7672	629.1	84.3	98.48	0.703	0.728	401.4	39.24	5.26
310.84	0.707	0.713	2.7808	657.8	84.8	99.84	0.740	0.746	403.3	41.03	5.29

Table 1. Coexisting Densities and Bubble Point Pressures for R32/290 Mixtures from 280 to 365 K (44 to 197°F).
(LL indicates liquid-liquid immiscibility.) (continued)

Temperature K	x(R32) Liquid Mole Fraction	y(R32) Vapor Mole Fraction	Pressure MPa	Liquid Density kg/m ³	Vapor Density kg/m ³	Temperature °F	x(R32) Liquid Mass Fraction	y(R32) Vapor Mass Fraction	Pressure psia	Liquid Density lb/ft ³	Vapor Density lb/ft ³
310.79	0.707	0.713	2.7792	657.9	85.0	99.75	0.74	0.746	403.1	41.04	5.3
310.32	0.833	0.795	2.7216	754.1	82.8	98.91	0.855	0.821	394.7	47.03	5.17
309.83	0.93	0.887	2.513	836.8	74.2	98.03	0.94	0.903	364.5	52.19	4.63
309.98	1	1	2.2939	908.4	66.6	98.29	1	1	332.7	56.66	4.15
324.69	0	0	1.7749	445.7	40.9	124.77	0	0	257.4	27.80	2.55
325.13	0.112	0.290	2.5487	458.6	65.6	125.56	0.13	0.325	369.7	28.61	4.09
325.07	0.341	0.486	3.3527	489.6	100.1	125.46	0.379	0.527	486.3	30.54	6.24
324.39	0.559	0.604	3.7244	541.9	124.3	124.23	0.599	0.643	540.2	33.80	7.75
324.76	0.808	0.761	3.7944	652.6	131.5	124.90	0.832	0.79	550.3	40.71	8.2
325.22	0.914	0.860	3.6340	735.5	122.7	125.73	0.926	0.879	527.1	45.87	7.65
325.23	0.914	0.860	3.6377	735.1	122.6	125.74	0.926	0.879	527.6	45.85	7.65
324.98	1	1	3.2791	829.1	103.6	125.29	1	1	475.6	51.71	6.46
341.17	0	0	2.4926	408.8	61.0	154.44	0	0	361.5	25.5	3.81
340.31	0.163	0.302	3.6602	420.8	106.1	152.89	0.187	0.338	530.9	26.24	6.61
340.31	0.163	0.302	3.6602	420.4	103.9	152.89	0.187	0.338	530.9	26.22	6.48
340.33	0.224	0.366	4.0037	423.0	123.7	152.92	0.254	0.405	580.7	26.38	7.72
340.31	0.255	0.397	4.1670	422.8	129.8	152.89	0.288	0.437	604.4	26.37	8.09
340.09	0.202	0.397	3.8843	421.3		152.49	0.230		563.4	26.28	
340.30	0.255	0.397	4.1667	422.2	129.3	152.87	0.288	0.437	604.3	26.33	8.07
340.01	0.430		4.8108	429.5		152.35	0.471		697.8	26.79	
339.61	0.517	0.572	5.1089	440.3	225.8	151.63	0.558	0.612	741.0	27.46	14.08
339.66	0.711	0.73	5.2394	473.3	241.9	151.72	0.744	0.761	759.9	29.52	15.09
339.62	0.873	0.801	5.1400	550.7	222.4	151.65	0.890	0.826	745.5	34.35	13.87
339.76	0.918	0.876	4.9526	618.6	198.5	151.90	0.930	0.893	718.3	38.58	12.38
339.74	0.918	0.876	4.9526	617.5	203.0	151.86	0.930	0.893	718.3	38.51	12.66
339.96	1	1	4.5609	718.7	170.1	152.26	1	1	661.5	44.83	10.61
354.40	0	0	3.2110	369.0	87.0	178.25	0	0	465.7	23.01	5.43
354.56	0.091	0.137	3.8431	366.2	114.2	178.54	0.106	0.158	557.4	22.84	7.13
354.00	0.211	0.275	4.7874	325.6	180.7	177.53	0.24	0.309	694.4	20.31	11.27
360.14	0	0	3.5660	345.2	104.6	188.58	0	0	517.2	21.53	6.52
359.89	0.072	0.099	4.2840	348.3	162.4	188.13	0.084	0.115	621.3	21.72	10.13
360.02	0.223	0.232	5.2367	298.7	227.0	188.37	0.253	0.263	759.5	18.63	14.16
365.03	0	0	3.1197	317.2	127.4	197.38	0	0	452.5	19.78	7.94
364.78	0.172	0.182	5.2738	270.5	222.5	196.93	0.197	0.208	764.9	16.87	13.88

Table 2. Coexisting Densities and Bubble Point Pressures for R134a/290 Mixtures from 279 to 372 K (43 to 210°F).
(LL indicates liquid-liquid immiscibility.)

Temperature K	x(R134a) Liquid Mole Fraction	y(R134a) Vapor Mole Fraction	Pressure MPa	Liquid Density kg/m ³	Vapor Density kg/m ³	Temperature °F	x(R134a) Liquid Mass Fraction	y(R134a) Vapor Mass Fraction	Pressure psia	Liquid Density lb/ft ³	Vapor Density lb/ft ³
280.00	0	0	0.5798	519.2	12.5	44.33	0	0	84.1	32.39	0.78
279.22	0.088	0.275	0.7051	674.5	22.2	42.92	0.183	0.467	102.3	42.07	1.38
279.54	LL	0.342	0.7156	LL	24.2	43.50	LL	0.546	103.8	LL	1.51
279.88	LL	0.358	0.7171	LL	23.3	44.11	LL	0.563	104.0	LL	1.45
279.85	LL	0.358	0.7173	LL	23.4	44.06	LL	0.563	104.0	LL	1.46
279.42	0.692	0.437	0.6749	936	23.5	43.28	0.839	0.642	97.9	58.38	1.46
279.29	0.774	0.487	0.6464	1020.5	23.1	43.05	0.888	0.687	93.8	63.65	1.44
279.35	0.786	0.474	0.6475	1017.9	23.2	43.16	0.895	0.676	93.9	63.49	1.45
279.80	0.913	0.656	0.5349	1173.8	21.1	43.97	0.960	0.815	77.6	73.21	1.32
279.73	0.972	0.843	0.4378	1238.9	19.1	43.84	0.988	0.926	63.5	77.27	1.19
279.60	0.972	0.843	0.4368	1238.5	19.1	43.61	0.988	0.926	63.4	77.25	1.19
280.39	1	1	0.3790	1271.1	18.2	45.03	1	1	55.0	79.28	1.14
294.99	0	0	0.8777	497.2	19.3	71.32	0	0	127.3	31.01	1.20
295.33	0.262	0.308	1.0669	653.7	36.3	71.93	0.451	0.507	154.7	40.77	2.26
294.05	LL	0.359	1.0334	LL	36.2	69.61	LL	0.564	149.9	LL	2.26
293.99	LL	0.359	1.0362	LL	36.9	69.52	LL	0.564	150.3	LL	2.30
295.33	LL	0.354	1.0632	LL	36.3	71.93	LL	0.559	154.2	LL	2.26
294.85	0.602	0.494	1.0315	870.5	37.9	71.05	0.778	0.693	149.6	54.29	2.37
295.17	0.727	0.541	0.9858	980.8	38.3	71.63	0.860	0.732	143.0	61.18	2.39
294.33	0.872	0.724	0.7901	1134.2		70.13	0.940	0.859	114.6	70.74	
294.33	0.872	0.724	0.7881	1134.8	32.5	70.13	0.940	0.859	114.3	70.78	2.03
294.70	1	1	0.5962	1221.2	28.9	70.78	1	1	86.5	76.17	1.80
309.99	0	0	1.2742	472.9	28.4	98.31	0	0	184.8	29.49	1.77
310.70	0.200	0.267	1.5343	579.0	48.7	99.59	0.367	0.457	222.5	36.11	3.03
310.58	0.337	0.351	1.5750	649.9	54.2	99.38	0.540	0.556	228.4	40.54	3.38
310.63	0.450	0.423	1.5625	709.3	56.3	99.47	0.654	0.629	226.6	44.24	3.51
310.85	0.570	0.434	1.5355	791.5	58.1	99.86	0.754	0.640	222.7	49.37	3.62
310.76	0.671	0.518	1.4975	858.9	58.9	99.70	0.825	0.713	217.2	53.57	3.68
310.84	0.748	0.578	1.4526	918.5	59.0	99.84	0.873	0.76	210.7	57.29	3.68
309.31	1	1	0.9102	1165	45.1	97.09	1	1	132.0	72.66	2.81
324.99	0	0	1.7864	445.0	41.1	125.30	0	0	259.1	27.76	2.57
326.09	0.134	0.190	2.0764	510.6	62.9	127.28	0.264	0.352	301.2	31.85	3.93
325.14	0.364	0.380	2.2287	620.5	83.3	125.57	0.570	0.586	323.2	38.70	5.19

Table 2. Coexisting Densities and Bubble Point Pressures for R134a/290 Mixtures from 279 to 372 K (43 to 210°F).
(LL indicates liquid-liquid immiscibility.) (continued)

Temperature K	x(R134a) Liquid Mole Fraction	y(R134a) Vapor Mole Fraction	Pressure MPa	Liquid Density kg/m ³	Vapor Density kg/m ³	Temperature °F	x(R134a) Liquid Mass Fraction	y(R134a) Vapor Mass Fraction	Pressure psia	Liquid Density lb/ft ³	Vapor Density lb/ft ³
325.51	0.504	0.444	2.2012	697.4	87.4	126.24	0.702	0.649	319.3	43.50	5.45
325.93	0.603	0.48	2.1375	757.5	87.0	127.00	0.779	0.681	310.0	47.25	5.42
326.04	0.720	0.589	2.0691	834.1	88.2	127.19	0.856	0.768	300.1	52.02	5.50
324.50	1	1	1.3642	1094.9	71.2	124.42	1	1	197.9	68.29	4.44
339.98	0	0	2.4353	411.7	59.3	152.30	0	0	353.2	25.68	3.70
340.89	0.213	0.258	2.9553	496.4	107.9	153.94	0.385	0.446	428.6	30.96	6.73
341.17	0.290	0.311	3.0002	523.6	116.3	154.44	0.486	0.511	435.1	32.66	7.25
340.46	0.375	0.377	3.0021	560.6	124.3	153.16	0.581	0.583	435.4	34.97	7.75
340.37	0.457	0.437	3.0207	598.7		153.00	0.661	0.642	438.1	37.34	
340.71	0.610	0.555	2.8719	694.8	131.0	153.61	0.743	0.743	416.5	43.33	8.17
340.51	0.706	0.611	2.7863	757.8	131.7	153.25	0.847	0.784	404.1	47.26	8.21
340.16	1	1	1.9837	1013.7	109.4	152.62	1	1	287.7	63.23	6.82
354.98	0	0	3.2509	366.9	88.7	179.29	0	0	471.5	22.88	5.53
356.23	0.026	0.025	3.4207	368.5	101.3	181.54	0.058	0.056	496.1	22.99	6.32
356.21	0.175	0.209	3.9482	392.2	180.5	181.50	0.329	0.379	572.6	24.46	11.26
356.48	0.717	0.660	3.8141	516.2	239.8	181.99	0.854	0.818	553.2	32.20	14.95
356.52	0.778	0.720	3.6925	590.9	233.4	182.06	0.890	0.856	535.6	36.86	14.56
356.46	0.827	0.755	3.6077	716.7	229.0	181.95	0.917	0.877	523.3	44.70	14.29
356.47	0.842	0.754	3.6085	716.8	228.8	181.97	0.925	0.876	523.4	44.71	14.27
356.45	0.897	0.837	3.351	788.2	205.1	181.94	0.953	0.922	486.0	49.16	12.79
356.46	0.897	0.837	3.3609	788.3	205.6	181.95	0.953	0.922	487.5	49.17	12.82
355.02	1	1	2.7447	917.3	167.3	179.36	1	1	398.1	57.21	10.43
366.17	0	0	3.9865	264.5	140.3	199.44	0	0	578.2	16.49	8.75
366.18	0.086	0.089	4.3831	306.3	238.9	199.46	0.179	0.184	635.7	19.10	14.90
366.45	0.160	0.167	4.5815	327.8	305.6	199.95	0.306	0.317	664.5	20.44	19.06
366.42	0.748	0.739	4.388	365.8	322.9	199.88	0.873	0.868	636.4	22.81	20.14
371.55	0.816	0.805	4.6542	431.1	379.4	209.13	0.911	0.905	675.0	26.89	23.66
371.94	0.852	0.843	4.5418	463.5	372.8	209.83	0.930	0.926	658.7	28.91	23.26
371.97	1	1	3.8886	551.1	327.1	209.88	1	1	564.0	34.37	20.40

Table 3. Coexisting Densities and Bubble Point Pressures for R125/290 Mixtures from 280 to 364 K (45 to 196°F).

Temperature K	x(R125) Liquid Mole Fraction	y(R125) Vapor Mole Fraction	Pressure MPa	Liquid Density kg/m ³	Vapor Density kg/m ³	Temperature °F	x(R125) Liquid Mass Fraction	y(R125) Vapor Mass Fraction	Pressure psia	Liquid Density lb/ft ³	Vapor Density lb/ft ³
280.47	0	0	0.5902	518.0	12.9	45.17	0	0	85.6	32.31	0.80
280.83	0.204	0.413	0.9160	673.0	36.9	45.82	0.411	0.657	132.9	41.98	2.30
280.82	0.293	0.511	0.9788	787.8	44.2	45.80	0.530	0.740	142.0	49.14	2.76
280.87	0.293	0.511	0.9778	791.1	44.1	45.89	0.530	0.740	141.8	49.34	2.75
280.75	0.407	0.562	0.9952	858.7	47.2	45.68	0.651	0.777	144.3	53.56	2.95
280.74	0.434	0.580	1.0006	881.0	48.0	45.66	0.676	0.79	145.1	54.95	2.99
280.82	0.505	0.624	1.0031	893.1	48.9	45.80	0.735	0.819	145.5	55.70	3.05
280.17	0.505	0.624	1.0022	896.3	50.6	44.63	0.735	0.819	145.4	55.91	3.16
280.29	1	1	0.8302	1286.8	52.1	44.85	1	1	120.4	80.26	3.25
294.80	0	0	0.8731	497.5	19.2	70.96	0	0	126.6	31.03	1.20
294.74	0.219	0.389	1.3057	632.9	52.3	70.87	0.433	0.634	189.4	39.47	3.26
294.64	0.219	0.389	1.2988	638.6	52.2	70.67	0.433	0.634	188.4	39.83	3.26
293.92	0.347	0.478	1.3450	721.6	60.4	69.38	0.591	0.714	195.1	45.01	3.77
293.21	0.347	0.478	1.3328	725.0	60.2	68.12	0.591	0.714	193.3	45.22	3.76
293.82	0.470	0.520	1.3979	748.7	66.9	69.20	0.707	0.747	202.8	46.70	4.17
293.23	0.568	0.599	1.4097	834.9	70.6	68.14	0.782	0.803	204.5	52.07	4.40
293.55	0.731	0.609	1.4348	888.4	77.2	68.71	0.881	0.809	208.1	55.41	4.81
295.23	1	1	1.2719	1208.1	82.7	71.75	1	1	184.5	75.35	5.16
309.49	0	0	1.2593	473.7	28.1	97.41	0	0	182.6	29.55	1.75
310.74	0.263	0.397	1.8976	611.4	82.4	99.66	0.493	0.642	275.2	38.13	5.14
310.74	0.263	0.397	1.8969	611.5	82.0	99.66	0.493	0.642	275.1	38.14	5.11
310.83	0.294	0.438	1.9904	641.3	91.7	99.83	0.531	0.680	288.7	40.00	5.72
311.62	0.376	0.470	2.1058	673.3	103.8	101.25	0.621	0.707	305.4	42.00	6.47
311.82	0.376	0.470	2.1050	672.4	103.2	101.61	0.621	0.707	305.3	41.94	6.44
309.76	0.472	0.548	2.1013	731.4	110.6	97.90	0.709	0.767	304.8	45.62	6.90
309.83	0.529	0.575	2.0953	757.5	114.6	98.03	0.754	0.786	303.9	47.24	7.15
310.22	0.604	0.620	2.1401	804.0	122.6	98.73	0.806	0.816	310.4	50.15	7.64
310.61	1	1	1.8876	1107.4	132.3	99.43	1	1	273.8	69.07	8.25
324.69	0	0	1.7749	445.7	40.9	124.77	0	0	257.4	27.80	2.55
324.85	0.263	0.397	2.5306	559.4	111.7	125.05	0.493	0.642	367.0	34.89	6.97
324.95	0.315	0.423	2.6308	580.8	124.5	125.23	0.556	0.666	381.6	36.23	7.76
325.61	0.483	0.547	2.9687	497.1	182.1	126.42	0.718	0.767	430.6	31.01	11.36

Table 3. Coexisting Densities and Bubble Point Pressures for R125/290 Mixtures from 280 to 364 K (45 to 196°F). (continued)

Temperature K	x(R125) Liquid Mole Fraction	y(R125) Vapor Mole Fraction	Pressure MPa	Liquid Density kg/m ³	Vapor Density kg/m ³	Temperature °F	x(R125) Liquid Mass Fraction	y(R125) Vapor Mass Fraction	Pressure psia	Liquid Density lb/ft ³	Vapor Density lb/ft ³
325.61	0.574	0.597	3.0296	678.6	202.6	126.42	0.786	0.801	439.4	42.33	12.64
324.99	0.615	0.603	2.9781	697.1	197.7	125.30	0.813	0.805	431.9	43.48	12.33
324.60	0.730	0.714	2.9440	769.2	111.8	124.60	0.880	0.872	427.0	47.97	6.97
324.89	1	1	2.6364	983.7	209.5	125.12	1	1	382.4	61.36	13.07
341.17	0	0	2.4936	408.8	61.0	154.44	0	0	361.7	25.50	3.81
340.64	0.146	0.225	3.1476	459.4	128.3	153.49	0.318	0.441	456.5	28.65	8.00
340.57	0.243	0.320	3.4696	481.6	174.9	153.36	0.466	0.562	503.2	30.04	10.91
340.54	0.327	0.391	3.7372	492.1	243.2	153.31	0.569	0.636	542.0	30.69	15.17
340.55	0.501	0.504	4.0359	528.4	387.8	153.33	0.732	0.734	585.4	32.96	24.19
339.38	1	1	3.6290	571.9	571.9	151.22	1	1	526.3	35.67	35.67
347.99	0	0	2.8477	389.9	72.9	166.71	0	0	413.0	24.32	4.55
348.56	0.166	0.220	3.7004	423.5	171.8	167.74	0.351	0.434	536.7	26.41	10.71
348.54	0.166	0.220	3.6989	423.4	171.4	167.70	0.351	0.434	536.5	26.41	10.69
348.42	0.133	0.198	3.6146	422.4	157.0	167.49	0.295	0.402	524.3	26.35	9.79
348.40	0.353	0.365	4.3022	365.1	320.1	167.45	0.598	0.610	624.0	22.77	19.96
355.73	0	0	3.2967	364.1	90.7	180.64	0	0	478.1	22.71	5.66
356.42	0.098	0.119	3.8899	298.3	164.6	181.88	0.228	0.269	564.2	18.60	10.27
356.43	0.165	0.188	4.1753	283.9	207.6	181.90	0.350	0.387	605.6	17.71	12.95
356.43	0.165	0.188	4.1779	278.9	208.6	181.90	0.350	0.387	606.0	17.39	13.01
363.52	0	0	3.7920	327.0	118.8	194.66	0	0	550.0	20.40	7.41
363.78	0.003	0.014	3.8991	319.9	139.1	195.13	0.008	0.037	565.5	19.96	8.68
364.16	0.107	0.126	4.2993	215.1	186.1	195.81	0.246	0.282	623.6	13.41	11.61

Table 4. Coexisting Densities and Bubble Point Pressures for R32/134a Mixtures from 280 to 370 K (44 to 206°F).

Temperature K	x(R32) Liquid Mole Fraction	y(R32) Vapor Mole Fraction	Pressure MPa	Liquid Density kg/m ³	Vapor Density kg/m ³	Temperature °F	x(R32) Liquid Mass Fraction	y(R32) Vapor Mass Fraction	Pressure psia	Liquid Density lb/ft ³	Vapor Density lb/ft ³
280.39	0	0	0.3791	1268.5	18.2	45.03	0	0	55.0	79.12	1.14
280.03	0.216	0.454	0.5234	1234.7	19.4	44.38	0.123	0.298	75.9	77.01	1.21
279.76	0.366	0.600	0.6213	1197.5	21.3	43.90	0.227	0.433	90.1	74.69	1.33
279.85	0.519	0.782	0.6981	1169.8	22.5	44.06	0.355	0.647	101.2	72.96	1.40
279.72	0.752	0.91	0.8473	1108.9	25.0	43.82	0.607	0.838	122.9	69.17	1.56
280.00	1	1	1.0061	1029.5	27.4	44.33	1	1	145.9	64.21	1.71
294.69	0	0	0.5962	1217.7	29.0	70.78	0	0	86.5	75.95	1.81
294.10	0.214	0.419	0.7911	1180.6	31.5	69.72	0.122	0.269	114.7	73.64	1.96
294.68	0.566	0.736	1.0902	1106.8	36.5	70.76	0.399	0.587	158.1	69.03	2.28
294.16	0.639	0.831	1.1839	1088.3	37.7	69.83	0.474	0.715	171.7	67.88	2.35
294.29	0.731	0.874	1.2826	1060.3	39.4	70.06	0.581	0.780	186.0	66.13	2.46
294.11	0.807	0.928	1.3806	1036.9		69.74	0.681	0.868	200.2	64.67	
295.48	1	1	1.5748	971.2	44.6	72.20	1	1	228.4	60.58	2.78
309.31	0	0	0.913	1161.7	45.3	97.09	0	0	132.4	72.46	2.83
309.36	0.161		1.1161	1130.6		97.18	0.089		161.9	70.52	
309.23	0.214	0.379	1.1917	1124.7	49.3	96.95	0.122	0.237	172.8	70.15	3.08
309.34	0.291		1.2610	1111.0		97.14	0.173		182.9	69.29	
309.39	0.498	0.668	1.5360	1062.8	55.9	97.23	0.336	0.506	222.8	66.29	3.49
309.33	0.571	0.728	1.6371	1045.8	57.4	97.13	0.404	0.577	237.4	65.23	3.58
309.80	0.789	0.839	1.9419	987.3	62.1	97.97	0.656	0.727	281.6	61.58	3.87
309.37	0.873	0.936	2.0846	958.7	64.5	97.20	0.778	0.882	302.3	59.80	4.02
309.99	1	1	2.2940	908.4	66.6	98.31	1	1	332.7	56.66	4.16
324.50	0	0	1.3670	1094.9	71.3	124.42	0	0	198.3	68.29	4.45
324.54	0.130	0.22	1.5872	1070.3	74.6	124.50	0.071	0.126	230.2	66.76	4.65
325.11	0.236	0.373	1.8025	1040.6	79.7	125.52	0.136	0.233	261.4	64.90	4.97
325.23	0.387	0.527	2.0439	1014.0	84.1	125.74	0.244	0.362	296.4	63.25	5.25
325.18	0.658	0.765	2.5600	944.2	93.9	125.65	0.495	0.624	371.3	58.89	5.85
325.13	0.815	0.879	2.8703	900.4	99.7	125.56	0.692	0.787	416.3	56.16	6.22
325.15	0.923	0.956	3.1151	858.0	103.4	125.59	0.859	0.917	451.8	53.51	6.45
324.99	1	1	3.2791	829.1	103.6	125.31	1	1	475.6	51.71	6.46
340.16	0	0	1.9863	1013.2	109.7	152.62	0	0	288.1	63.20	6.84
340.08	0.140	0.227	2.3017	983.2	114.3	152.48	0.077	0.130	333.8	61.32	7.13
340.02	0.241	0.352	2.5291	963.6	119.5	152.37	0.139	0.217	366.8	60.10	7.45

Table 4. Coexisting Densities and Bubble Point Pressures for R32/134a Mixtures from 280 to 370 K (44 to 206°F). (continued)

Temperature K	x(R32) Liquid Mole Fraction	y(R32) Vapor Mole Fraction	Pressure MPa	Liquid Density kg/m ³	Vapor Density kg/m ³	Temperature °F	x(R32) Liquid Mass Fraction	y(R32) Vapor Mass Fraction	Pressure psia	Liquid Density lb/ft ³	Vapor Density lb/ft ³
339.88	0.461	0.577	3.0169	910.8	130.2	152.12	0.304	0.410	437.5	56.81	8.12
339.99	0.592	0.693	3.3473	867.3	139.0	152.32	0.425	0.535	485.5	54.10	8.67
339.91	0.760	0.838	3.8140	816.0	151.0	152.17	0.618	0.725	553.2	50.90	9.42
339.92	0.924	0.947	4.2884	754.4	165.9	152.19	0.861	0.901	622.0	47.05	10.35
339.98	1	1	4.5611	718.7	170.1	152.30	1	1	661.5	44.83	10.61
355.02	0	0	2.7471	914.4	168.5	179.36	0	0	398.4	57.03	10.51
354.66	0.214	0.282	3.3143	862.1	183.1	178.72	0.122	0.167	480.7	53.77	11.42
354.83	0.262	0.340	3.4586	850.3	188.8	179.02	0.153	0.208	501.6	53.03	11.78
354.71	0.541	0.643	4.4488	753.8	231.2	178.81	0.375	0.479	645.2	47.02	14.42
354.71	0.541	0.643	4.4529	754.1	230.7	178.81	0.375	0.479	645.8	47.04	14.39
354.74	0.662	0.799	5.1084	700.5	275.9	178.86	0.500	0.670	740.9	43.69	17.21
354.95	0.717	0.831	5.3147	674.8	301.9	179.24	0.564	0.715	770.8	42.09	18.83
359.85	0	0	3.0665	870.3	192.7	188.05	0	0	444.7	54.28	12.02
359.94	0.192	0.241	3.5564	826.8	214.6	188.22	0.108	0.139	515.8	51.57	13.38
359.72	0.243	0.312	3.7290	815.9	216.2	187.82	0.141	0.188	540.8	50.89	13.49
359.72	0.358	0.43	4.0919	772.5	235.5	187.82	0.221	0.278	593.5	48.18	14.69
364.68	0	0	3.3856	818.5	235.3	196.75	0	0	491.0	51.05	14.68
365.16	0.226	0.286	4.1255	751.1	275.4	197.61	0.130	0.170	598.3	46.85	17.18
365.04	0.376	0.452	4.7246	686.1	331.0	197.39	0.235	0.296	685.2	42.80	20.65
369.94	0	0	3.7667	743.6	305.1	206.23	0	0	546.3	46.38	19.03
369.80	0.085	0.139	4.0863	735.6	322.5	205.98	0.045	0.076	592.6	45.88	20.12

Table 5. Coexisting Densities and Bubble Point Pressures for R32/125 Mixtures from 280 to 352 K (43 to 173°F).

Temperature K	x(R32) Liquid Mole Fraction	y(R32) Vapor Mole Fraction	Pressure MPa	Liquid Density kg/m ³	Vapor Density kg/m ³	Temperature °F	x(R32) Liquid Mass Fraction	y(R32) Vapor Mass Fraction	Pressure psia	Liquid Density lb/ft ³	Vapor Density lb/ft ³
280.29	0	0	0.8302	1284.2	52.2	44.85	0	0	120.4	80.10	3.25
279.89	0.250	0.335	0.8957	1245.9	46.1	44.13	0.126	0.179	129.9	77.71	2.88
279.52	0.494	0.520	0.9459	1203.2	41.5	43.47	0.297	0.320	137.2	75.04	2.59
280.02	0.797	0.831	1.0116	1114.2	34.9	44.37	0.630	0.681	146.7	69.49	2.18
280.01	0.875	0.908	1.0185	1092.3	31.7	44.35	0.752	0.811	147.7	68.13	1.98
279.59	0.946	0.956	1.0131	1060.9	30.4	43.59	0.884	0.904	146.9	66.17	1.90
280.00	1	1	1.0076	1033.0	27.4	44.33	1	1	146.1	64.43	1.71
295.23	0	0	1.2720	1206.6	84.7	71.74	0	0	184.5	75.26	5.28
294.35	0.237	0.324	1.3484	1174.8	72.9	70.16	0.119	0.172	195.6	73.28	4.55
294.08	0.460	0.570	1.4293	1135.7	63.9	69.67	0.270	0.365	207.3	70.84	3.98
293.98	0.801	0.809	1.5001	1057.0	53.6	69.49	0.636	0.647	217.6	65.93	3.35
293.89	0.801	0.824	1.5001	1055.3		69.33	0.636	0.670	217.6	65.82	0.00
293.92	0.875	0.890	1.5173	1030.6	49.8	69.39	0.752	0.778	220.1	64.28	3.11
293.96	0.945	0.947	1.5249	1003.7	46.5	69.46	0.882	0.886	221.2	62.60	2.90
293.99	1	1	1.5152	980.5	41.1	69.51	1	1	219.8	61.16	2.56
310.61	0	0	1.8904	1107.8	133.3	99.43	0	0	274.2	69.10	8.31
309.82	0.270	0.333	2.0089	1083.6	116.2	98.01	0.138	0.178	291.4	67.59	7.25
310.96	0.509	0.564	2.2267	1032.2	108.6	100.06	0.310	0.359	322.9	64.38	6.77
310.50	0.745	0.793	2.2992	980.8	89.4	99.23	0.559	0.624	333.5	61.17	5.57
310.67	0.803	0.847	2.3220	969.5	84.6	99.54	0.639	0.706	336.8	60.47	5.27
309.85	0.873	0.881	2.2956	954.6	80.7	98.06	0.749	0.762	332.9	59.54	5.03
310.04	0.910	0.916	2.3019	941.1	76.6	98.40	0.814	0.825	333.9	58.70	4.78
309.96	0.952	0.940	2.3078	927.7	71.7	98.26	0.896	0.872	334.7	57.86	4.48
310.51	1	1	2.3288	905.9	68.6	99.25	1	1	337.8	56.50	4.28
324.89	0	0	2.6390	984.4	213.2	125.13	0	0	382.7	61.40	13.30
324.99	0.323	0.396	2.9689	950.3	183.6	125.31	0.171	0.221	430.6	59.27	11.45
325.60	0.456	0.551	3.1281	925.7	171.4	126.41	0.267	0.347	453.7	57.74	10.69
325.37	0.755	0.780	3.2705	883.0	143.0	126.00	0.572	0.606	474.3	55.08	8.92
325.81	0.804	0.816	3.3028	870.6	138.9	126.79	0.640	0.658	479.0	54.30	8.66
325.54	0.867	0.870	3.3239	859.8	130.1	126.30	0.739	0.744	482.1	53.63	8.11
325.48	0.915	0.916	3.3150	851.6	121.9	126.19	0.824	0.825	480.8	53.12	7.60
325.49	1	1	3.3179	828.5	104.2	126.21	1	1	481.2	51.68	6.50
339.38	0	0	3.6291	571.9	571.9	151.21	0	0	526.3	35.67	35.67

Table 5. Coexisting Densities and Bubble Point Pressures for R32/125 Mixtures from 280 to 352 K (43 to 173°F). (continued)

Temperature K	x(R32) Liquid Mole Fraction	y(R32) Vapor Mole Fraction	Pressure MPa	Liquid Density kg/m ³	Vapor Density kg/m ³	Temperature °F	x(R32) Liquid Mass Fraction	y(R32) Vapor Mass Fraction	Pressure psia	Liquid Density lb/ft ³	Vapor Density lb/ft ³
339.72	0.312	0.392	4.0557	697.5	318.4	151.83	0.164	0.218	588.2	43.51	19.86
340.19	0.485	0.570	4.3079	724.2	299.0	152.67	0.290	0.365	624.8	45.17	18.65
340.74	0.744	0.796	4.5809	723.6	263.9	153.66	0.558	0.628	664.4	45.13	16.46
340.46	0.873	0.876	4.6060	722.0	221.1	153.16	0.749	0.754	668.0	45.03	13.79
340.21	0.898	0.898	4.5948	724.5	213.3	152.71	0.792	0.792	666.4	45.19	13.31
340.14	0.913	0.916	4.5979	723.9	197.8	152.58	0.820	0.825	666.8	45.15	12.34
340.08	1	1	4.5717	715.7	172.8	152.47	1	1	663.0	44.64	10.78
343.22	0.426	0.476	4.5640	652.8	440.1	158.13	0.243	0.283	661.9	40.72	27.45
343.83	0.746	0.797	4.8968	673.8	326.4	159.22	0.560	0.630	710.2	42.03	20.36
343.35	0.874	0.873	4.9016	680.5	265.9	158.36	0.750	0.749	710.9	42.44	16.59
343.27	0.900	0.898	4.9050	679.9	250.2	158.22	0.796	0.792	711.4	42.41	15.61
343.28	1	1	4.8904	684.4	196.6	158.23	1	1	709.3	42.69	12.26
346.66	0.745	0.788	5.2034	613.2	421.4	164.32	0.559	0.617	754.7	38.25	26.28
346.65	0.828	0.828	5.2354	618.4	400.3	164.30	0.676	0.676	759.3	38.57	24.97
346.29	0.914	0.902	5.2328	637.3	297.1	163.65	0.822	0.800	758.9	39.75	18.53
346.28	0.870	0.874	5.2173	627.4	320.6	163.63	0.744	0.750	756.7	39.13	20.00
346.13	1	1	5.1922	643.9	227.8	163.36	1	1	753.0	40.16	14.21
349.34	0.870	0.872	5.4926	556.3	357.8	169.14	0.744	0.747	796.6	34.70	22.32
349.16	0.910	0.899	5.5550	573.1	382.2	168.82	0.814	0.794	805.7	35.75	23.84
349.18	1	1	5.5388	589.1	276.1	168.85	1	1	803.3	36.74	17.22
351.54	1	1	5.8302	428.5	428.5	173.10	1	1	845.6	26.73	26.73