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A SURVEY OF CURRENT WORLDWIDE RESEARCH ON THE THERMOPHYSICAL PROPERTIES OF ALTERNATIVE REFRIGERANTS

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M. O. McLinden
W. M. Haynes
J. T. R. Watson*
K. Watanabe**

Thermophysics Division
Chemical Science and Technology Laboratory
National Institute of Standards and Technology
Boulder, Colorado 80303-3328

*Energy and Environment Centre
National Engineering Laboratory
Glasgow, United Kingdom

**Department of Mechanical Engineering
Keio University
Yokohama, Japan

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ABSTRACT

This survey represents an exhaustive compilation of the research activities throughout the world concerned with either measurements or correlations of the thermophysical properties of alternative refrigerants. The properties covered in this study include thermodynamic, transport, phase equilibria, and other properties such as dielectric constant and refractive index. This survey has included a wide range of fluids (including R23, R32, R125, R143a, R22, R134a, R152a, R134, R124, R142b, R123, R123a, R141b), along with mixtures containing at least one of these fluids. This report presents in tabular form summary information about each research activity; this survey does not present raw data or correlating equations.

Key words: hydrochlorofluorocarbons; hydrofluorocarbons; refrigerants; survey; thermodynamic properties; thermophysical properties; transport properties

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INTRODUCTION

The advent of the Montreal Protocol banning the future production of the fully halogenated chlorofluorocarbon (CFC) refrigerants, which are major contributors to the environmental problems of ozone depletion and greenhouse warming, has presented a major challenge to the refrigeration industry. The expected prospect of also phasing out hydrochlorofluorocarbons (HCFCs) sometime early in the next century adds to this challenge. There are a number of very promising fluids under study which may serve as substitutes, either as pure fluids, as constituents of mixtures, or both. These substitutions must not, however, be done at the expense of energy efficiency. In order to evaluate the performance (energy efficiency, capacity, etc.) of these fluids in any thermodynamic cycle, a knowledge of their thermophysical properties is required. Accurate values of these properties are essential to select, from a set of closely related fluids or fluid mixtures, the working fluid that will yield the highest energy efficiency in refrigeration and heat-pumping applications.

The results of a comprehensive survey of current worldwide research on the thermophysical properties of alternative refrigerants are reported here in tabular form. This work summarizes under a single cover an exhaustive compilation of these activities. Its objectives are (1) to assist in the coordination of existing research programs so as to expedite the acquisition of the required property data and to not unnecessarily duplicate research programs and (2) to serve as a guide for planning the future directions of research projects involving the thermophysical properties of alternative refrigerants.

The traditional approach to determining the thermophysical properties of a given fluid is an exacting, time-consuming, and specialized endeavor. In order to expedite the effort to achieve an accurate knowledge of the thermophysical properties of environmentally acceptable refrigerants, it was appropriate to establish an international collaborative effort to provide a forum for the exchange of information and data and for the coordination of activities. Toward this end, the Advanced Heat Pump Programme of the International Energy Agency established Annex 18: "Thermophysical Properties of the Environmentally Acceptable Refrigerants." The ultimate goal of this Annex is to provide property formulations that will become de facto international standards for the most promising candidates. The first step necessary to accomplish this goal is to identify the sources of experimental data and correlations. Therefore, this report of current research activities on the thermophysical properties of alternative refrigerants represents the first major task of Annex 18. This report presents in tabular form the results of this task; this survey will be updated as deemed necessary by the development of new research activities in this area.

This survey represents an exhaustive compilation of the research activities throughout the world concerned with either measurements or correlations of the thermophysical properties of alternative refrigerants. The properties covered in this study include thermodynamic, transport, phase equilibria, and other properties such as dielectric constant and refractive index. This survey has covered a wide range of fluids (including R23, R32, R125, R143a, R22, R134a, R152a, R134, R124, R142b, R123, R123a, R141b), along with mixtures containing at least one of these fluids. These fluids are listed with their molecular mass, normal boiling point, etc. in Table 1. This report presents in tabular form summary information about each research activity; this survey does not present raw data or correlating equations. Future IEA collaborative tasks include the measurement, compilation, and evaluation of experimental data for the most important alternatives, along with the development and recommendation of correlations.

Table 1—Summary of Alternative Refrigerants

Fluid number	formula	MW (g/mol)	NBP (°C)	T_c (°C)
R23	CHF_3	70.01	–82.1	25.9
R32	CH_2F_2	52.02	–51.8	78.4
R125	CF_3CHF_2	120.02	–48.6	66.3
R143a	CF_3CH_3	84.04	–47.4	73.1
R22	$CHClF_2$	86.47	–40.8	96.2
R134a	CF_3CH_2F	102.03	–26.1	101.1
R152a	CHF_2CH_3	66.05	–24.2	113.3
R134	CHF_2CHF_2	102.03	–19.4	119.0
R124	$CHClFCF_3$	136.48	–12.1	122.5
R142b	$CClF_2CH_3$	100.50	–9.3	137.1
R123	$CHCl_2CF_3$	152.93	27.9	183.8
R123a	$CHClFCClF_2$	152.93	29.8	185.8
R141b	CCl_2FCH_3	116.95	32.0	204.7

SURVEY PROCEDURE

The survey was conducted by Annex 18 participants from Japan, the United Kingdom, and the United States, with the U.S. participants acting as overall coordinators. A comprehensive survey form (Figure 1) was developed and in the early summer of 1990 was sent to over 120 research groups worldwide that were either known to be active in refrigerant research or that have fluid property expertise. Responses were received from more than 60 research groups in 15 countries. Additional responses were received but were not included in the summary presented here because the work fell outside the scope of the survey (e.g., heat transfer measurements on alternative refrigerants) or was proprietary and insufficient information was provided. Studies of refrigerant–oil solubility were not included here even though they were on the survey form; the very limited number of responses received were not felt to be representative of the extensive work in this area either because we did not query the appropriate research groups or because refrigerant–oil research is largely proprietary.

The focus of the survey is on current studies of refrigerant thermophysical properties. Also solicited in the survey and included here are recent work (i.e., work completed since 1988) and future work. Although the survey instructions specified that future work be included only if a definite commitment for funding had been established, many of the projects listed several years in the future, or simply as "planned," probably do not meet this criterion. References for published results during the past two years are also reported.

This report has been distributed to all participants in IEA Annex 18 as well as to all survey respondents. This will hopefully facilitate the objectives of this Annex.

Name ____________________ Institution ____________________

Project type: ❏ experimental measurement ❏ modeling/correlation

Fluid(s) studied:

❏ R23 ❏ R32 ❏ R125 ❏ R143a ❏ R22 ❏ R134a ❏ R152a
❏ R134 ❏ R124 ❏ R124a ❏ R142b ❏ R123 ❏ R123a ❏ R141b
❏ mixture--please list components and composition(s) ____________________
❏ other(s)--please list ____________________

sample purity ____________
❏ by own analysis ❏ by suppliers analysis ❏ estimated/unknown

Property(ies) measured/correlated (also indicate number of experimental points):

❏ vapor pressure (___) ❏ saturation density (___) ❏ critical parameters (___)
❏ P-V-T (___) ❏ surface tension (___) ❏ dielectric constant (___)
❏ heat capacity (___) ❏ sound speed (___) ❏ viscosity (___)
❏ thermal conductivity (___) ❏ refractive index (___) ❏ mixture V-L-E (___)
❏ refrigerant/oil solubility (___)
❏ other(s)--please list ____________________

Experimental technique/correlating equation employed:

____

____

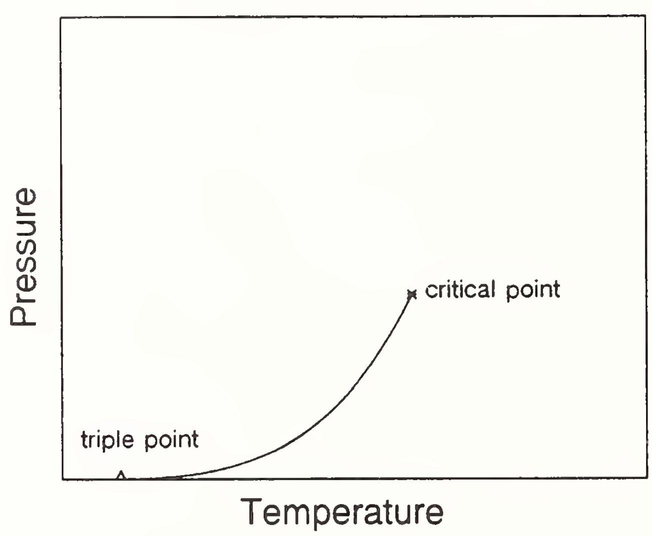
Estimated accuracy (experimental projects only)

____

Range of measurements/correlation (either indicate numerically or sketch below)

temperature: from ________ to ________
pressure: from ________ to ________
density: from ________ to ________
phase: ❏ saturated liquid ❏ saturated vapor ❏ critical region
❏ single-phase liquid ❏ single-phase vapor ❏ supercritical region

Single-phase properties



Saturation properties

property ____________

|————————|——————————————|

property ____________

|————————|——————————————|

property ____________

|————————|——————————————|

T_{tp} T_{nbp} T_c

Project status:

❏ completed--if paper or report is available please give reference:

____

____

❏ in progress beginning date ____________
❏ planned (i.e. funded) ending date ____________

Additional remarks:

____

____

Figure 1—Survey form

SUMMARY OF SURVEY RESULTS

A series of tables on the following pages presents the results of the survey in a compact format. Tables 2, 3, and 4 summarize the number of projects by fluid, type of property measured, and the country in which the work is being done. These tables tally the "number of projects" for a particular combination of fluid and country, or fluid and property. Each "project" represents one property studied for one fluid by one research group. A research program involving the measurement of a single property for several fluids, several different property measurements for one fluid, or a project being carried out by more than one laboratory would be counted multiple times in computing the entries in Tables 2–4. Similarly, a project measuring only a few data points is counted the same as an exhaustive set of measurements. Thus, the total quantity of work on the alternative refrigerants is considerably less than what might initially be inferred from Tables 2–4. These tables do, however, give an indication of the countries active in studying refrigerant thermophysical properties and the relative level of effort being expended for the various alternatives.

Following the summary tables, a series of tables, one for each fluid, present details of the responses. The fluids are listed in order of increasing normal boiling point; mixtures follow the pure components and are listed first in order of the normal boiling point of the more volatile component, and then by the normal boiling point of the other constituent(s). For a given fluid, the entries are further organized by property. The information presented for each entry are self-evident. Dashes indicate missing information or an item that is not applicable. The order of the entries reflects the sequence of their entry into the tables and has no other significance. Each entry is identified by the name of the person responding to the survey (usually the principal investigator), the organization, and the country. The final set of tables, organized by country, gives details on the research groups responding to this survey. Names, addresses, and telephone numbers of the principal investigator(s) and any other collaborators are given, as well as a brief listing of the techniques employed. The listing of techniques represents those that have been applied to the alternative refrigerants; in many cases these research groups have additional capabilities.

ACKNOWLEDGMENTS

We extend our sincere thanks to all of our colleagues from around the world who shared with us information on their work on the alternative refrigerants. The U.S. participation in this task was funded by the Office of Buildings and Community Systems of the United States Department of Energy.

Table 2—Summary of Research by Fluid and Property
(entries indicate number of projects)

	Fluid														
Property	23	32	125	143a	22	134a	152a	134	124	142b	123	123a	141b	mix	other	totals
vapor pressure	1		2	1	5	15	7	3	2	8	15	3	6	17	4	89
sat. liquid density	1		2	2	3	10	3	4	1	5	9	2	6	9	5	62
sat. vapor density			1		2	3		1		2	4		1	2	1	17
P-V-T	3	1	2	1	8	16	8	3	2	8	15	4	9	11	3	94
virial coefficients					1	1	1			1	1			3		8
critical parameters			1			7	3	2	1	5	7	1	3	5	3	38
triple point par.					1	1	1			1						4
heat capacity/calor.	1				1	5	2			1	2			6	2	20
speed of sound				2	2	6	2			4	6	1	3	1	1	28
dielectric constant	2		1		3	3	2	1	1	1	3	1	2			20
refractive index						1	2	2		2	2	1	1		1	12
surface tension					2	4	3	2		2	6	1	1		2	23
thermal conduct.			1	1	6	11	3	1	2	7	11	1	8	2		54
thermal diffusivity			1		5	5	3		1	5	5		2			27
viscosity	2	1	1	3	6	10	4			3	10	4	4	14	2	64
equation of state	4	4	3	3	6	9	5	4	4	4	3		2	11	1	63
ideal gas properties	2	2	2	2	2	2	2	2	2	2	2	2	2			26
mixture V-L-E														24		24
totals for fluid	16	8	17	15	53	109	51	25	16	61	101	21	50	105	25	673

Table 3—Summary of Research by Fluid and Country
(entries indicate number of projects)

	Fluid															
Country	23	32	125	143a	22	134a	152a	134	124	142b	123	123a	141b	mix	other	totals
Australia											2	2	2			6
Canada			3		3	3	1			2	3		2	8		25
China						5	2				5			5		17
Czechoslovakia						1		1								2
France						5				5	5		5	5		25
Germany	8	2	1	3	31	25	28	2	2	21	17	2	2	28	4	176
Greece					1	1					1					3
Italy						2					2					4
Japan	1			9	4	32	7	9	5	17	38	8	13	36	4	183
Korea								3			3					6
Portugal						3				3	3		3			12
Sweden	2	2			2	2	2			2				12		24
U.S.S.R		1														1
United Kingdom					1	4				1	2		2			10
United States	5	3	13	3	11	26	11	10	9	10	20	9	21	11	17	179
total for fluid	16	8	17	15	53	109	51	25	16	61	101	21	50	105	25	673

Table 4—Summary of Mixtures Research
(mixture specified by intersection of pure components; table entry indicates number of projects)

	R23	R32	R125	R143a	R22	R134a	R152a	R134	R124	R142b	R123	R123a	R141b
R32													
R125													
R143a													
R22	1			2									
R134a		2	1		2								
R152a		2			19	10							
R134						1	3						
R124			1										
R142b	1				27		3						
R123					1	2							
R123a													
R141b						1							
other	2				15		1				3		

projects on ternary mixtures:

R22/152a/124: 3

R22/152a/142b: 1

R22/152a/114: 1

DETAILED PROJECT INFORMATION

R23; CHF_3; trifluoromethane

Property /Investigator	phase	range of data T (K)	p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Vapor pressure								
Kruse; U. Hannover; FRG	l-v	--	-	--	--	--	9/89-8/91	
Saturated liquid density								
Kruse; U. Hannover; FRG	sl	--	-	--	--	--	9/89-8/91	
Pressure-volume-temperature								
Ström; Chalmers U. Tech.; Swe	l	258-323	0.5-2	--	0.15%	.99	planned	
Zollweg; Cornell U.; USA	l	126-332	sat-100	1300	0.1-0.4%	.999	comp	[Rb89]
Bier; U. Karlsrühe; FRG	v	333-423	0.2-58	128	0.02-0.14%	.999	comp	
Heat capacity/calorimetry								
Bier; U. Karlsrühe; FRG	v	233-473	0.1-12	163	0.2%	.999	comp	
Dielectric constant								
Makita; Kobe U.; Japan	l,v	283-323	0.1-17	126	0.01%	.9991	comp	
Franck; U. Karlsruhe; FRG	l,v	213-468	0.5-200	90	0.5-1.5%	.9995	comp	[Rt89]
Viscosity								
Ström; Chalmers U. Tech.; Swe	l	258-323	0.5-2	--	2%	.99	planned	
Kruse; U. Hannover; FRG	sl,sv	--	-	--	--	--	9/89-8/91	
Equation of State								
Maurer; U. Kaiserlautern; FRG	l,v	203-473	0-58	-	-	-	comp	[Pl90]
Huber; NIST; USA	l,v	all	all	-	-	-	in prog	[El90]
Fischer; ORNL; USA	l,v	-	-	-	-	-	comp	[Fs90]
Gallagher; NIST; USA	l,v	0.5-1.6 T_c	0-2 P_c	-	-	-	comp	[Gl90]
Ideal Gas Properties								
Lucas; U. Duisburg; FRG	-	100-500	0-0	-	1%	-	in prog	
Marsh; Texas A&M; USA	-	0-1500	0.1	-	--	-	comp	[TR90]

Notes and References

[El90] J. F. Ely and M. L. Huber, Proc. ASHRAE–Purdue CFC Conference, W. Lafayette, IN, USA, July, 1990, pp 383-392.

[Fs90] S. K. Fischer and J. Sand, Proc. ASHRAE–Purdue CFC Conference, W. Lafayette, IN, USA, July, 1990, pp 373-382.

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[TR90] TRC Thermodynamic Tables, Thermodynamics Research Center, Texas A&M University, continuously updated; also to be published in J. Phys. Chem. Ref. Data.

R32; CH_2F_2; difluoromethane

Property /Investigator	phase	range of data T (K)	p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Pressure-volume-temperature								
Ström; Chalmers U. Tech.; Swe	l	258-323	0.5-2	--	0.15%	.99	planned	
Viscosity								
Ström; Chalmers U. Tech.; Swe	l	258-323	0.5-2	--	2%	.99	planned	
Ideal Gas Properties								
Lucas; U. Duisburg; FRG	-	100-500	0-0	-	1%	-	in prog	
Marsh; Texas A&M; USA	-	0-1500	0.1	-	--	-	comp	[TR90]
Equation of State								
Los; Inst. Low Temp. Engr.; USSR	v	200-500	0-5	-	-	-	6/90-10/90	
Morgenstern; HFV Dresden; FRG	l,v	190-400	0-6	-	-	-	comp	
Huber; NIST; USA	l,v	all	all	-	-	-	in prog	[El90]
Fischer; ORNL; USA	l,v	-	-	-	-	-	comp	[Fs90]

Notes and References

[El90] J. F. Ely and M. L. Huber, Proc. ASHRAE–Purdue CFC Conference, W. Lafayette, IN, USA, July, 1990, pp 383-392.

[Fs90] S. K. Fischer and J. Sand, Proc. ASHRAE–Purdue CFC Conference, W. Lafayette, IN, USA, July, 1990, pp 373-382.

[TR90] TRC Thermodynamic Tables, Thermodynamics Research Center, Texas A&M University, continuously updated; also to be published in J. Phys. Chem. Ref. Data.

R125; CHF_2CF_3; pentafluoroethane

Property /Investigator	phase	range of data T (K)	p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Vapor pressure								
Holste; Texas A&M U.; USA	l-v	230-480	-	--	0.1%	--	9/90-10/91	
Morrison; NIST; USA	l-v	268-339	-	10	-	.993	comp	
Saturated liquid density								
Holste; Texas A&M U.; USA	sl	230-480	-	--	0.1%	--	9/90-10/91	
Morrison; NIST; USA	sl	268-339	-	10	-	.993	comp	
Saturated vapor density								
Holste; Texas A&M U.; USA	sv	230-480	-	--	0.1%	--	9/90-10/91	
Pressure-volume-temperature								
Holste; Texas A&M U.; USA	l,v	230-480	0-70	--	0.1%	--	9/90-10/91	
Morrison; NIST; USA	l	268-378	sat-7	60	0.1%	.993	comp	
Critical parameters								
Holste; Texas A&M U.; USA	T,P,ρ	-	-	-	0.1%	--	9/90-10/91	
Dielectric constant								
Morrison; NIST; USA	v	298-433	0.04-1.4	-	$3x10^{-6}$	.993	comp	[My90]
Thermal conductivity								
Venart; U. New Brunswick; Canada	l,v	203-393	0.1-70	--	1%	--	planned	
Thermal diffusivity								
Venart; U. New Brunswick; Canada	l,v	203-393	0.1-70	--	5%	--	planned	
Viscosity								
Snelson; NRC; Canada	sl	253-353	-	15	2.5-3.5%	-	3/91-10/91	
Equation of state								
Huber; NIST; USA	l,v	all	all	-	-	-	in prog	[El90]
Fischer; ORNL; USA	l,v	-	-	-	-	-	comp	[Fs90]
Gallagher; NIST; USA	l,v	0.5-1.6 T_c	0-2 P_c	-	-	-	comp	[Gl90]
Ideal Gas Properties								
Lucas; U. Duisburg; FRG	-	100-500	0-0	-	1%	-	in prog	
Marsh; Texas A&M; USA	-	0-1500	0.1	-	--	-	comp	[TR90]

Notes and References

[El90] J. F. Ely and M. L. Huber, Proc. ASHRAE–Purdue CFC Conference, W. Lafayette, IN, USA, July, 1990, pp 383-392.

[Fs90] S. K. Fischer and J. Sand, Proc. ASHRAE–Purdue CFC Conference, W. Lafayette, IN, USA, July, 1990, pp 373-382.

[Gl90] J. Gallagher, M. McLinden, and G. Morrison, National Institute of Standards and Technology, Standard Reference Data Base 23 (1990).

[My90] C. W. Meyer and G. Morrison, J. Phys. Chem. (in press).

[TR90] TRC Thermodynamic Tables, Thermodynamics Research Center, Texas A&M University, continuously updated; also to be published in J. Phys. Chem. Ref. Data.

R143a; CH_3CF_3; 1,1,1-trifluoroethane

Property Investigator	phase	range of data T (K)	 p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Vapor pressure								
Widiatmo; Keio U.; Japan	l-v	200-345	-	--	10kPa	--	7/90-3/91	
Saturated liquid density								
C. Yokoyama; Tohoku U.; Japan	sl	250-340	-	--	0.3%	.999	comp	
Widiatmo; Keio U.; Japan	sl	200-345	-	--	0.2%	--	7/90-3/91	
Pressure-volume-temperature								
Widiatmo; Keio U.; Japan	l	280-315	sat-2	--	0.2%	--	7/90-3/91	
Speed of sound								
Kohler; Ruhr U.;FRG	v	230-350	0.02-0.5	400	0.01%	.993	?/88-?/91	
Takagi; Kyoto Inst. Tech.; Japan	l	280-370	sat-75	100	0.2%	.9996	comp	
Thermal conductivity								
Tanaka; Kobe U.; Japan	v	293-353	0.1-sat	30	2%	.999	comp	[Tn90]
Viscosity								
Takahashi; Tohoku U.; Japan	v	298-423	0.1-9	107	0.3%	.999	comp	[Tk90]
Kumagai; Tohoku U.; Japan	sl	273-323	sat	6	0.5%	.999	comp	[Km90]
Tanaka; Kobe U.; Japan	v	283-323	0.1-0.1	5	1%	--	comp	[Ko89]
Equation of State								
Morgenstern; HFV Dresden; FRG	l,v	200-400	0-4	-	-	-	comp	
Huber; NIST; USA	l,v	all	all	-	-	-	in prog	[El90]
Fischer; ORNL; USA	l,v	-	-	-	-	-	comp	[Fs90]
Ideal Gas Properties								
Lucas; U. Duisburg; FRG	-	100-500	0-0	-	1%	-	in prog	
Marsh; Texas A&M; USA	-	0-1500	0.1	-	--	-	comp	[TR90]

Notes and References

[El90] J. F. Ely and M. L. Huber, Proc. ASHRAE–Purdue CFC Conference, W. Lafayette, IN, USA, July, 1990, pp 383-392.
[Fs90] S. K. Fischer and J. Sand, Proc. ASHRAE–Purdue CFC Conference, W. Lafayette, IN, USA, July, 1990, pp 373-382.
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[TR90] TRC Thermodynamic Tables, Thermodynamics Research Center, Texas A&M University, continuously updated; also to be published in J. Phys. Chem. Ref. Data.

R22; $CHClF_2$; chlorodifluoromethane

Property / Investigator	phase	range of data T (K)	p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Vapor pressure								
Blanke; PTB; FRG	l-v	113-369	-	18	0.1%	.9999	10/86-9/90	
Gorenflo; U. Paderborn; FRG	l-v	293-369	-	33	0.04%	.9999	comp	[Rt89]
Kohler; Ruhr U.; FRG	l-v	313-368	-	40	--	.9996	comp	[Kh90]
Straub; T.U. München; FRG	l-v	318-374	-	50	0.5-1.5%	.9998	comp	
Wagner; Ruhr U.; FRG	l-v	180-340	-	45	0.05%	.99995	comp	[Wg90]
Saturated liquid density								
Gorenflo; U. Paderborn; FRG	sl	293-366	-	16	0.04%	.9999	comp	[Rt89]
Wagner; Ruhr U.; FRG	sl	115-340	-	42	0.02%	.99995	comp	[Wg90]
Kruse; U. Hannover; FRG	sl	233-353	-	8	0.3%	--	comp	
Saturated vapor density								
Gorenflo; U. Paderborn; FRG	sv	293-366	-	16	0.2%	.9999	comp	[Rt89]
Wagner; Ruhr U.; FRG	sv	250-330	-	4	0.02%	.99995	comp	[Wg90]
Pressure-volume-temperature								
Blanke; PTB; FRG	l	113-470	sat-30	300	0.1%	.9999	10/86-9/90	
Kohler; Ruhr U.; FRG	l,v	250-500	0.1-60	280	0.05%	.9996	comp	[Kh90]
Straub; T.U. München; FRG	l,v	318-413	2-12	300	0.5-1.5%	.9998	comp	
Ström; Chalmers U. Tech.; Swe	l	258-323	0.5-2	--	0.15%	.99	planned	
Wagner; Ruhr U.; FRG	l,v	120-340	0-8	55	0.02%	.99995	comp	[Wg90]
Kubota; Kobe U.; Japan	v	348-423	0.1-11	56	0.4%	.999	comp	
Morrison; NIST; USA	l	268-378	sat-7	60	0.1%	--	comp	
Sandarusi; NIST; USA	l,v	318-473	1.4-40	400	0.1-0.3%	.999+	in prog	
Virial coefficients								
Schramm; Phys. Chem. Inst.; FRG	v	233-296	--	9	2%	--	comp	[Nt89]
Triple point temperature								
Blanke; PTB; FRG	-	-	-	-	--	.9999	10/86-9/90	
Heat capacity/calorimetry								
Sami; U. Moncton; Canada	l,v	283-353	0.5-1.4	-	2%	--	in prog	
Speed of sound								
Kohler; Ruhr U.; FRG	v	230-350	0.02-0.5	400	0.01%	.9996	?/88-?/91	
Leipertz; U. Erlangen-Nürnberg; FRG	l,v	240-450	<15	--	0.5%	--	4/90-->	
Dielectric constant								
Makita; Kobe U.; Japan	v	293-373	0.1-sat	31	0.01%	.9999	comp	
Franck; U. Karlsruhe; FRG	l,v	233-368	0.5-200	90	0.7%	.994	comp	[Um89]
Morrison; NIST; USA	v	298-433	0.04-1.0	-	$3x10^{-6}$	--	comp	[My90]
Surface Tension								
Straub; T.U. München; FRG	l-v	223-369	-	100	0.5%	.9998	planned	
Okada; Nagaoka U. Tech.; Japan	l-v	273-353	-	36	0.16mN/m	.9998	comp	[Ok88]

R22; $CHClF_2$; chlorodifluoromethane (continued)

Property Investigator	phase	range of data T (K)	p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Thermal conductivity								
Assael; Aristotle U.; Greece	l,v	230-370	<40	--	0.5%	--	6/89-?	
Hemminger; PTB; FRG	v	303-463	0.1-0.1	5	2.5%	.9999	comp	[Hm89]
Stephan/Taxis; U. Stuggart; FRG	v	273-423	<5	100	1%	.99996	-->9/91	
Johns; Nat'l. Eng. Lab; UK	v	298-423	1-30	--	0.5%	--	12/90-12/92	
Perkins; NIST; USA	l,v	130-405	0.1-70	800	1%	--	1/91-9/92	
Venart; U. New Brunswick; Canada	l,v	203-393	0.1-70	--	1%	--	in prog	
Thermal diffusivity								
Fiebig; Ruhr U.; FRG	l	273-363	1-8	--	1%	.995	comp	
Leipertz; U. Erlangen-Nürnberg; FRG	l,v	240-450	<15	--	1-2%	--	4/90-->	
Straub; T.U. München; FRG	l,v	318-413	2-12	300	0.5-1.5%	.9998	comp	
Perkins; NIST; USA	l,v	130-405	0.1-70	800	5%	--	1/91-9/92	
Venart; U. New Brunswick; Canada	l,v	203-393	0.1-70	--	5%	--	in prog	
Viscosity								
Mayinger; T. U. München; FRG	v	300-425	0.1-7.5	35	0.5%	.9995	comp	[Nb90]
Ström; Chalmers U. Tech.; Swe	l	258-323	0.5-2	--	2%	.99	planned	
Kumagai; Tohoku U.; Japan	sl	273-323	sat	6	0.5%	.999	comp	[Km90]
Kruse; U. Hannover; FRG	l	236-353	?-2.5	8	4%	.999	comp	
Diller; NIST; USA	l	120-320	sat-35	60	3%	--	comp	
Diller; NIST; USA	l,v	300-500	0.2-50	100	3%	--	10/90-10/91	
Equation of State								
Maurer; U. Kaiserslautern; FRG	l,v	253-473	0-35	-	-	-	comp	[Pl90]
Wagner; Ruhr U.; FRG	l,v	115-525	0-160	-	-	-	-->3/91	
Oellrich; U. Karlsrühe; FRG	l,v	-	-	-	-	-	?/89-?/92	
Huber; NIST; USA	l,v	all	all	-	-	-	in prog	[El90]
Fischer; ORNL; USA	l,v	-	-	-	-	-	comp	[Fs90]
Gallagher; NIST; USA	l,v	0.5-1.6 T_c	0-2 P_c	-	-	-	comp	[Gl90]
Beyerlein; U. Idaho; USA	l,v	-	-	-	-	-	comp	
Ideal Gas Properties								
Lucas; U. Duisburg; FRG	-	100-500	0-0	-	1%	-	in prog	
Marsh; Texas A&M; USA	-	0-1500	0.1	-	--	-	comp	[TR90]

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R134a; CH_2FCF_3; 1,1,1,2-tetrafluoroethane

Property Investigator	phase	range of data T (K)	p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Vapor pressure								
Baehr; U. Hannover; FRG	l-v	300-374	-	35	0.03%	.9993+	8/89-8/91	
Baroncini; U. Ancona; Italy	l-v	240-360	-	64	1%	.9998	comp	[Br90]
LeNeindre; U. Paris Nord; France	l-v	298-?	-	--	--	--	10/90-->	
Straub; T.U. München; FRG	l-v	318-374	-	50	0.5-1.5%	.999	1/89-8/90	
Oguchi; Kanagawa Inst. Tech.; Japan	l-v	243-374	-	37	0.5kPa	.999	comp	
Kubota; Kobe U.; Japan	l-v	253-373	-	25	3kPa	.998	comp	[Kb89]
Fukushima; Asahi Glass; Japan	l-v	262-374	-	41	5kPa	.9999	comp	
Maezawa; Keio U.; Japan	l-v	280-350	-	13	7kPa	.9999	comp	[Mz90]
Piao; Keio U.; Japan	l-v	300-374	-	51	2kPa	.995-.9999	comp	[Pi90]
Mingshan; Tsinghua U.; PRC	l-v	248-358	-	20	0.02%	.9998	comp	
Kruse; U. Hannover; FRG	l-v	--	-	--	--	--	9/89-8/91	
Howley; NIST; USA	l-v	180-360	-	19	0.03%	.9997	comp	[Hw90]
Bier; U. Karlsrühe; FRG	l-v	203-374	-	53	0.1%	.999	comp	[Bi90]
Weber; NIST; USA	l-v	313-374	-	22	0.01%	.9995	comp	[Wb89]
Morrison; NIST; USA	l-v	268-374	-	10	-	.9994	comp	[Mo90]
Saturated liquid density								
Baehr; U. Hannover; FRG	sl	293-373		9	0.1%	>.9993	8/89-8/91	
Yokoyama; Tohoku U.; Japan	sl	252-367	-	22	0.5%	.999	comp	[Yk88]
Oguchi; Kanagawa Inst. Tech.; Japan	sl	243-346	-	6	0.01-0.1%	.999	comp	
Fukushima; Asahi Glass; Japan	sl	244-374	-	16	0.2-0.3%	.9999	comp	
Maezawa; Keio U.; Japan	sl	200-370	-	25	0.2%	.9999	comp	[Mz90]
Piao; Keio U.; Japan	sl	313-372	-	7	0.15%	.995-.9999	comp	[Pi90]
Kabata; Keio U.; Japan	sl	354-374	-	11	0.5%	.995	comp	[Ka89]
Kruse; U. Hannover; FRG	sl	--	-	--	--	--	9/89-8/91	
Holste; Texas A&M U.; USA	sl	180-360	-	--	0.1%	.9997	comp	[Hl90]
Morrison; NIST; USA	sl	268-374	-	10	-	.9994	comp	[Mo90]
Saturated vapor density								
Kabata; Keio U.; Japan	sv	365-374	-	11	0.5%	.995	comp	[Ka89]
Fukushima; Asahi Glass; Japan	sv	271-374	-	8	$3kg/m^3$	.9999	comp	
Weber; NIST; USA	sv	320-365	-	5	0.02%	.9995	comp	[Wb89]

Property Investigator	phase	range of data T (K)	 p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Pressure-volume-temperature								
Baehr; U. Hannover; FRG	l,v	293-433	0.1-16	500	0.1%	.9993+	8/89-8/91	
Baroncini; U. Ancona; Italy	v,sv	240-360	0.1-sat	46	1%	.9998	comp	[Br90]
LeNeindre; U. Paris; France	l,v	298-413	0.1-100	--	--	--	10/90-->	
Nieto de Castro; U. Lisbon; Por.	l,v	<T_c	<20	--	0.3%	.995	12/89-10/93	
Straub; T.U. München; FRG	l,v	318-423	2-12	300	0.5-1.5%	.999	1/89-8/90	
Ström; Chalmers U.Tech.; Swe.	l	258-323	0.5-2	120	0.15%	.99	--	
Vacek; Czech T.U.; Czech.	l	200-300	sat-55	--	0.1%	--	6/91-12/91	
Oguchi; Kanagawa Inst. Tech.; Japan	l	243-473	0.08-17	40	0.01%	.999	comp	
Matsuo; Kobe U.; Japan	l	293-353	sat-40	50	0.02%	.999	comp	
Fukushima; Asahi Glass; Japan	l,v	320-424	1-6	63	0.2%	.9999	comp	
Maezawa; Keio U.; Japan	l	280-350	sat-2	16	0.2%	.9999	comp	[Mz90]
Piao; Keio U.; Japan	l,v	300-425	0.7-12	159	0.15%	.995-.9999	comp	[Pi90]
Mingshan; Tsinghua U.; PRC	v	248-358	0.1-6	84	0.2%	.9998	comp	
Holste; Texas A&M U.; USA	l	180-380	sat-70	300	0.1%	.9997	comp	[Hl90]
Weber; NIST; USA	v	321-423	0-5.3	69	0.02%	.9995	comp	[Wb89]
Morrison; NIST; USA	l	268-378	sat-7	60	0.1%	.9994	comp	
Virial coefficients								
Schramm; Phys.-Chem. Inst.; FRG	v	233-296	--	9	2%	--	6/90-->	
Critical parameters								
LeNeindre; U. Paris; France				--	--	--	10/90-->	
Straub; T.U. München; FRG			-		0.5-1.5%	.999	1/89-8/90	
Fukushima; Asahi Glass; Japan	T,ρ		-		5mK,3kg/m^3	.9999	comp	
Piao; Keio U.; Japan	P		-		2kPa	.995-.9999	comp	[Pi90]
Kabata; Keio U.; Japan	T,ρ				10mK,0.5%	.995	comp	[Ka89]
Kubota; Kobe U.; Japan	T,P		-		50mK,3kPa	.998	comp	[Kb89]
Bier; U. Karlsrühe; FRG			-			.999	comp	[Bi90]
Triple point temperature								
Magee; NIST; USA	-	-	-	-	--	.9995	comp	[Mg91]
Heat capacity/calorimetry								
Wormald; U. Bristol; UK	l,v	233-473	0.1-10		1%	.99+	4/90-12/91	
Piao; Keio U.; Japan	--	--	-	2	--	.995-.9999	comp	[Pi90]
Saitoh; Keio U.; Japan	l	276-356	1-3	31	0.3%	.9997	comp	[St90]
Magee; NIST; USA	l	190-340	sat-35	400	0.5%	.9995	comp	[Mg91]
Magee; NIST; USA	l,v	320-500	0.1-20	--	0.4%	.9997	10/91-12/91	
Speed of sound								
Kohler; Ruhr U.; FRG	v	230-350	.025-.5	400	0.01%	--	?/88-?/91	
Leipertz; U. Erlangen-Nürnberg; FRG	l,v	240-450	<15	--	0.5%	--	4/90-->	
LeNeindre; U. Paris; France	l,v	298-523	0.1-100	--	--	--	10/90-->	
Mingshan; Tsinghua U.; PRC	v	248-358	0.1-1.5	--	0.15%	.9998	4/90-->	
Zollweg; Cornell U.; USA	l	180-380	sat-70	206	0.05%	.998	comp	[Zl90]
Goodwin; NIST; USA	v	233-340	0.02-.5*Psat	104	0.01%	.9994	comp	[Gd90]

Property Investigator	phase	range of data T (K)	p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Dielectric constant								
Nieto de Castro; U. Lisbon; Por.	l,v	<Tc	<20	--	0.5%	.995	12/89-10/93	
Makita; Kobe U.; Japan	v	298-348	0.1-sat	29	0.5%	.999	comp	
Morrison; NIST; USA	v	298-433	0.04-0.7	-	$3x10^{-6}$	.9994	comp	[My90]
Refractive index								
Straub; T.U. München; FRG	l,v	318-423	-	300	0.05%	.999	1/89-8/90	
Surface Tension								
Okada; Nagaoka U. Tech.; Japan	l-v	232-363		118	0.2mN/m	.9998	comp	[Ok90]
Mingshan; Tsinghua U.; PRC	l-v	263-358	-	--	--	.9998	4/90-->	
Straub; T.U. München; FRG	l-v	223-373	-	100	0.5%	.998	planned	
Schmidt; NIST; USA	l-v	263-368	-	29	0.15mN/m	.9995	comp	[Ch90]
Thermal conductivity								
Assael; Aristotle U.; Greece	l,v	230-370	<40	--	0.5%	--	6/89-?	
Gross/Hahne; U. Stuggart; FRG	l,v	262-354	0.1-8.0	71	1%	.998	?/88-?/92	[Gr90]
LeNeindre; U. Paris Nord; France	l,v	298-523	0.1-100	--	--	--	10/90-->	
Nieto de Castro; U. Lisbon; Por.	l,v	<T_c	<20	--	0.5%	.995	12/89-10/93	
Stephan/Taxis; U. Stuggart; FRG	v	273-423	<5	100	1%	.99+	-->9/91	
Wakeham; Imperial Col.; UK	sl,sv	260-370	sat	20	--	.999	comp	[Wk90]
Yata; Kyoto Inst. Tech.; Japan	l	250-350	sat-30	127	--	.995-.9995	comp	[Yt89]
Tanaka; Kobe U.; Japan	v	293-353	0.1-sat	33	2%	.999	comp	[Tn90]
Nagasaka; Keio U.; Japan	l	193-273	1-1	--	0.5%	.999	?/89-->	
Perkins; NIST; USA	l,v	180-410	0.1-70	800	1%	--	-->12/90	
Venart; U. New Brunswick; Canada	l,v	203-393	0.1-70	--	1%	--	planned	
Thermal diffusivity								
Fiebig; Ruhr U.; FRG	l	273-363	1-8	--	1%	--	1/91-->	
Leipertz; U. Erlangen-Nürnberg; FRG	l,v	240-450	<15	--	1-2%	--	4/90-->	
Straub; T.U. München; FRG	l,v	318-423	2-12	300	0.5-1.5%	.999	12/89-8/90	
Perkins; NIST; USA	l,v	180-410	0.1-70	800	5%	--	-->12/90	
Venart; U. New Brunswick; Canada	l,v	203-393	0.1-70	--	5%	--	planned	
Viscosity								
Matthews; Polytech. S.W.; UK	v	247-573	0.01-0.1	10	0.5%	--	1/90-->	
Mayinger; T.U. München; FRG	v	300-425	0.1-6.5	41	0.5%	.9994	comp	[My90]
Ström; Chalmers U.Tech.; Swe	l	258-323	0.5-2	--	2%	.99	--	
Takahashi; Tohoku U.; Japan	v	298-423	0.1-8.8	107	0.3%	.999	comp	[Tk90]
Kumagai; Tohoku U.; Japan	sl	273-343	sat	8	0.5%	.999	comp	[Km90]
Mingshan; Tsinghua U.; PRC	sl	263-358	sat	--	--	.9998	4/90-->	
Kruse; U. Hannover; FRG	sl,sv	--	sat	--	--	--	9/89-8/91	
Diller; NIST; USA	l	175-320	sat-35	60	3%	--	comp	
Diller; NIST; USA	l,v	300-500	0.2-50	100	3%	--	10/90-10/91	
Snelson; NRC; Canada	sl	253-353	-	15	2.5-3.5%	-	3/91-10/91	

Property Investigator	phase	range of data T (K)	p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Equation of State								
Piao; Keio U.; Japan	l,v	300-425	0-12	-	-	-	comp	[Pi90]
Maurer; U. Kaiserlautern; FRG	l,v	210-500	0-12	-	-	-	comp	[Pl89]
Wakeham; Imperial Col., UK	l,v	--	--	-	-	-	planned	
Sengers; U. Maryland; USA	l,v	356-450	3-12	-	-	-	comp	[Sn90]
Ely; NIST; USA	l,v	170-450	0-70	-	-	-	3/90-12/90	[El90]
Oellrich; U. Karlsrühe; FRG	l,v	-	-	-	-	-	?/89-?/92	
Huber; NIST; USA	l,v	all	all	-	-	-	in prog	[El90a]
Fischer; ORNL; USA	l,v	-	-	-	-	-	comp	[Fs90]
Gallagher; NIST; USA	l,v	0.5-1.6 T_c	0-2 P_c	-	-	-	comp	[Gl90]
Ideal Gas Properties								
Lucas; U. Duisburg; FRG	-	100-500	0-0	-	1%	-	in prog	
Marsh; Texas A&M; USA	-	0-1500	0.1	-	--	-	comp	[TR90]

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R152a; CH_3CHF_2; 1,1-difluoroethane

Property / Investigator	phase	range of data T (K)	p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Vapor pressure								
Baehr; U. Hannover; FRG	l-v	300-386	-	55	0.03%	.9995	7/89-6/91	
Blanke; PTB; FRG	l-v	156-386	-	18	0.1%	.9999	10/86-9/90	
Straub; T.U. München; FRG	l-v	330-386	-	50	0.5-1.5%	.9998	10/90-8/91	
Yin; Xi'an Jiaotong U.; PRC	l-v	242-293	-	21	1.5kPa	.9995	comp	[Yn90]
Kruse; U. Hannover; FRG	l-v	--	-	--	--	--	9/89-8/91	
Bier; U. Karlsrühe; FRG	l-v	203-386	-	--	0.1%	.998	comp	[Bi90]
Morrison; NIST; USA	l-v	268-383	-	10	-	.999	comp	
Saturated liquid density								
Baehr; U. Hannover; FRG	sl	293-383	-	10	0.1%	.9995	7/89-6/91	
Kruse; U. Hannover; FRG	sl	233-353	-	8	0.3%	--	comp	
Morrison; NIST; USA	sl	268-383	-	10	-	.999	comp	
Pressure-volume-temperature								
Baehr; U. Hannover; FRG	l,v	293-433	0.1-16	500	0.1%	.9995	7/89-6/91	
Blanke; PTB; FRG	l	156-470	sat-30	300	0.1%	.9999	10/86-9/90	
Straub; T.U. München; FRG	l,v	330-440	2-12	300	0.5-1.5%	.9998	10/90-8/91	
Ström; Chalmers U. Tech.; Swe	l	258-323	0.5-2	--	0.15%	.99	planned	
Kubota; Kobe U.; Japan	v	303-333	0.1-sat	30	3%	.9998	comp	
Kubota; Kobe U.; Japan	v	323-423	0.1-10	76	0.4%	.999	comp	
Majima; Keio U.; Japan	v	290-420	0.1-6	112	0.1%	.999	--	
Morrison; NIST; USA	l	268-378	sat-7	60	0.1%	.999	comp	
Virial coefficients								
Schramm; Phys. Chem. Inst.;FRG	v	233-296	-	4	1%	--	comp	
Critical parameters								
Yin; Xi'an Jiaotong U.; PRC	T,ρ	-	-	-	15mK,0.5%	.9997	comp	[Yn90]
Bier; U. Karlsrühe; FRG	-	-	-	-	-	-	comp	[Bi90]
Schmidt; NIST; USA	T,ρ	-	-	--	0.01g/cm^3	.9997	comp	[Ch90]
Triple point temperature								
Blanke; PTB; FRG	-	-	-	-	--	.9999	planned	
Heat capacity/calorimetry								
Nakagawa; Keio U.; Japan	l	--	--	--	0.4%	--	7/90-->	
Sami;U. Moncton; Canada	l,v	283-353	0.5-1.4	-	2%	--	in prog	
Speed of sound								
Kohler; Ruhr U.; FRG	v	230-350	0.02-0.5	400	0.01%	--	?/88-?/91	
Leipertz; U. Erlangen-Nürnberg; FRG	l,v	240-450	<15	--	0.5%	--	4/90-->	
Dielectric constant								
Lehmann; U. Rostock; FRG	v	373-423	0.2-3	20	2%	.993	1/90-6/91	
Morrison; NIST; USA	v	298-433	0.04-0.6	-	$3x10^{-6}$	.999	comp	[My90]

Property Investigator	phase	range of data T (K)	 p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Refractive index								
Straub; T.U. München; FRG	l,v	330-440	2-12	300	0.05%	.9998	10/90-8/91	
Schmidt; NIST; USA	l,v	296-384	sat	40	0.001	.9997	comp	[Ch90]
Surface Tension								
Straub; T.U. München; FRG	l-v	230-386	-	100	0.5%	.9998	10/90-8/91	
Okada; Nagaoka U. Tech.; Japan	l-v	273-373	-	126	0.2mN/m	.9999	comp	[Ok90]
Schmidt; NIST; USA	l,v	296-384	-	29	0.15mN/m	.9997	comp	[Ch90]
Thermal conductivity								
Gross/Hahne; U. Stuttgart; FRG	l,v	260-360	--	--	1%	--	?/90-?/92	
Hemminger; PTB; FRG	v	303-463	0.1-0.1	7	2.5%	.997+	comp	[Hm89]
Yata; Kyoto Inst. Tech.; Japan	l	250-350	sat-30	--	--	--	planned	
Thermal diffusivity								
Fiebig; Ruhr U.; FRG	l	293-353	2-8	--	1%	.98	comp	
Leipertz; U. Erlangen-Nürnberg; FRG	l,v	240-450	<15	--	1-2%	--	4/90-->	
Straub; T.U. München; FRG	l,v	330-440	2-12	300	0.5-1.5%	.9998	comp	
Viscosity								
Mayinger; T. U. München; FRG	v	300-425	0.1-7.5	--	0.5%	--	2/91-5/91	
Ström; Chalmers U. Tech.; Swe	l	258-323	0.5-2	--	2%	.99	planned	
Kumagai; Tohoku U.; Japan	sl	273-353	sat	8	0.5%	.999	comp	[Km90]
Kruse; U. Hannover; FRG	l	236-353	?-2.5	8	4%	.999	comp	
Equation of State								
Maurer; U. Kaiserlautern; FRG	l,v	164-470	0-50	-	-	-	comp	[Pl89]
Oellrich; U. Karlsrühe; FRG	l,v	-	-	-	-	-	?/89-?/92	
Huber; NIST; USA	l,v	all	all	-	-	-	in prog	[El90]
Fischer; ORNL; USA	l,v	-	-	-	-	-	comp	[Fs90]
Gallagher; NIST; USA	l,v	0.5-1.6 T_c	0-2 P_c	-	-	-	comp	[Gl90]
Ideal Gas Properties								
Lucas; U. Duisburg; FRG	-	100-500	0-0	-	1%	-	in prog	
Marsh; Texas A&M; USA	-	0-1500	0.1	-	--	-	comp	[TR90]

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R134; CHF_2CHF_2; 1,1,2,2-tetrafluoroethane

Property Investigator	phase	range of data T (K)	 p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Vapor pressure								
Maezawa; Keio U.; Japan	l-v	200-390	-	38	10kPa	.994-.998	comp	[Mz90]
Tamatsu; Keio U.; Japan	l-v	303-390	-	34	3kPa	.9998	3/90-8/90	
Morrison; NIST; USA	l-v	268-383	-	10	-	.994	comp	
Saturated liquid density								
Fukushima; Asahi Glass Co.; Japan	sl	245-293	-	7	0.3%	.9994	comp	
Maezawa; Keio U.; Japan	sl	200-390	-	38	0.2%	.994-.998	comp	[Mz90]
Tatoh; Keio U.; Japan	sl	364-391	-	10	0.1%	.998-.999	4/90-->	
Morrison; NIST; USA	sl	268-383	-	10	-	.994	comp	
Saturated vapor density								
Tatoh; Keio U.; Japan	sv	388-391	-	9	0.5%	.998-.999	4/90-->	
Pressure-volume-temperature								
Vacek; Czech T.U.; Czech.	l	200-300	sat-55	--	0.1%	--	6/91-12/91	
Maezawa; Keio U.; Japan	l	280-320	sat-2	5	0.2%	.994-.998	comp	[Mz90]
Tamatsu; Keio U.; Japan	l,v	345-443	0.1-10	67	0.1%	.9998	3/90-8/90	
Critical parameters								
Tatoh; Keio U.; Japan	T,ρ	-	-	-	10mK,0.5%	.998-.999	4/90-->	
Schmidt; NIST; USA	T,ρ	-	-	--	0.01g/cm^3	.994	comp	[Ch90]
Dielectric constant								
Morrison; NIST; USA	v	298-433	0.04-0.5	-	$3x10^{-6}$	.994	comp	[My90]
Refractive index								
Chae; Korea Std. Res. Lab.; Korea	l,v	230-456	0.1-5	--	1.0%	.99	planned	
Schmidt; NIST; USA	l,v	293-391	sat	22	0.001	.994	comp	[Ch90]
Surface Tension								
Chae; Korea Std. Res. Lab.; Korea	l-v	230-390	-	--	1.0%	.99	planned	
Schmidt; NIST; USA	l,v	293-391	-	17	0.15mN/m	.994	comp	[Ch90]
Thermal conductivity								
Chae; Korea Std. Res. Lab.; Korea	l,v	230-500	0.1-5	--	1.0%	.99	3/90-->	
Equation of State								
Morgenstern; HFV Dresden; FRG	l,v	220-480	0-4	-	-	-	comp	
Huber; NIST; USA	l,v	all	all	-	-	-	in prog	[El90]
Fischer; ORNL; USA	l,v	-	-	-	-	-	comp	[Fs90]
Gallagher; NIST; USA	l,v	0.5-1.6 T_c	0-2 P_c	-	-	-	comp	[Gl90]
Ideal Gas Properties								
Lucas; U. Duisburg; FRG	-	100-500	0-0	-	1%	-	in prog	
Marsh; Texas A&M; USA	-	0-1500	0.1	-	--	-	comp	[TR90]

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R124; $CHClFCF_3$; 1-chloro-1,2,2,2-tetrafluoroethane

Property	phase	range of data		no.	est.	sample	start/end	note
Investigator		T (K)	p (MPa)	points	accuracy	purity	dates	/ref.
Vapor pressure								
Fukushima; Asahi Glass Co.; Japan	l-v	--	-	--	5kPa	.9997	7/90-3/91	
Morrison; NIST; USA	l-v	273-373	-	25	-	.998	in prog	
Saturated liquid density								
Fukushima; Asahi Glass Co.; Japan	sl	250-310	-	8	0.3%	.9997	comp	
Pressure-volume-temperature								
Fukushima; Asahi Glass Co.; Japan	l,v	358-?	0.1-6	--	0.2%	.9997	7/90-3/91	
Sandarusi; NIST; USA	l,v	318-473	1.4-40	400	0.1-0.3%	.999+	planned	
Critical parameters								
Fukushima; Asahi Glass Co.; Japan	T,ρ	-	-	-	5mK,0.5%	.9997	6/90-12/90	
Dielectric constant								
Morrison; NIST; USA	v	298-433	0.04-0.4	-	$3x10^{-6}$	.998	comp	[My90]
Thermal conductivity								
Yata; Kyoto Inst. Tech.; Japan	l	250-350	sat-30	--	--	--	planned	
Perkins; NIST; USA	l,v	120-435	0.1-70	800	1%	--	1/91-9/92	
Thermal diffusivity								
Perkins; NIST; USA	l,v	120-435	0.1-70	800	5%	--	1/91-9/92	
Viscosity								
Snelson; NRC; Canada	sl	253-353	-	15	2.5-3.5%	-	3/91-10/91	
Equation of State								
Morgenstern; HFV Dresden; FRG	l,v	240-390	0-3.5	-	-	-	comp	
Huber; NIST; USA	l,v	all	all	-	-	-	in prog	[El90]
Fischer; ORNL; USA	l,v	-	-	-	-	-	comp	[Fs90]
Gallagher; NIST; USA	l,v	0.5-1.6 T_c	0-2 P_c	-	-	-	comp	[Gl90]
Ideal Gas Properties								
Lucas; U. Duisburg; FRG	-	100-500	0-0	-	1%	-	in prog	
Marsh; Texas A&M; USA	-	0-1500	0.1	-	--	-	comp	[TR90]

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R142b; $CClF_2CH_3$; 1-chloro-1,1-difluoroethane

Property / Investigator	phase	range of data T (K)	p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Vapor pressure								
Blanke; PTB; FRG	l-v	142-410	-	18	0.1%	.9999	planned	
LeNeindre; U. Paris Nord; France	l-v	298-?	-	--	--	--	10/90-->	
Straub; T.U. München; FRG	l-v	--	-	50	--	.9998	10/90-8/91	
Fukushima; Asahi Glass Co.; Japan	l-v	335-410	-	--	5kPa	.9998	4/90-10/90	
Maezawa; Keio U.; Japan	l-v	320-400	-	12	10kPa	.998	comp	[Mz90]
Kumagai; Keio U.; Japan	l-v	297-410	-	69	3kPa	.998-.9998	comp	[Km90]
Bier; U. Karlsrühe; FRG	l-v	203-410	-	--	0.1%	.999	comp	[Bi90]
Morrison; NIST; USA	l-v	268-383	-	10	-	--	comp	
Saturated liquid density								
Fukushima; Asahi Glass Co.; Japan	sl	252-410	-	--	0.2%	.9998	4/90-10/90	
Maezawa; Keio U.; Japan	sl	210-400	-	36	0.2%	.998	comp	[Mz90]
Tanikawa; Keio U.; Japan	sl	353-410	-	9	0.1%	.999	comp	
Kumagai; Keio U.; Japan	sl	346-410	-	7	0.1%	.998-.9998	comp	[Km90]
Morrison; NIST; USA	sl	268-383	-	10	-	--	comp	
Saturated vapor density								
Tanikawa; Keio U.; Japan	sv	395-410	-	9	0.5%	.999	comp	
Kumagai; Keio U.; Japan	sv	357-410	-	7	0.1%	.998-.9998	comp	[Km90]
Pressure-volume-temperature								
Blanke; PTB; FRG	l	142-470	sat-30	300	0.1%	.9999	planned	
LeNeindre; U. Paris Nord; France	l	298-413	0.1-40	--	--	--	comp	
Nieto de Castro; U. Lisbon; Por	l	290-420	0-20	50	1%	.995	comp	[Cs90]
Straub; T.U. München; FRG	l,v	360-460	2-12	300	--	.9998	10/90-8/91	
Ström; Chalmers U. Tech.; Swe	l	258-323	0.5-2	--	0.15%	.99	planned	
Fukushima; Asahi Glass Co.; Japan	l,v	335- >T_c	1-6	--	0.2%	.9998	4/90-10/90	
Maezawa; Keio U.; Japan	l	320-400	sat-2	6	0.2%	.998	comp	[Mz90]
Kumagai; Keio U.; Japan	l,v	345-443	0.3-9	70	0.1%	.998-.9998	comp	[Km90]
Virial coefficients								
Schramm; Phys.-Chem. Inst.; FRG	v	248-296	--	4	1%	--	comp	
Critical parameters								
LeNeindre; U. Paris Nord; France	--	-	-	--	--	--	10/90-->	
Fukushima; Asahi Glass Co.; Japan	T,ρ	-	-	--	10mK,0.1%	.9998	10/89-8/90	
Tanikawa; Keio U.; Japan	T,ρ	-	-	--	10mK,0.5%	.999	comp	
Bier; U. Karlsrühe; FRG	-	-	-	-	-	.999	comp	[Bi90]
Schmidt; NIST; USA	T,ρ	-	-	--	0.01g/cm^3	.9997	comp	[Ch90]
Triple point temperature								
Blanke; PTB; FRG	-	-	-	-	--	.9999	planned	
Heat capacity/calorimetry								
Nakagawa; Keio U.; Japan	l	276-340	1-3	19	0.4%	--	5/90-->	

Property Investigator	phase	range of data T (K)	 p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Speed of sound								
Kohler; Ruhr U.; FRG	v	230-350	0.025-0.5	400	0.01%	.999	?/88-?/91	
Leipertz; U. Erlangen-Nürnberg; FRG	l,v	240-450	<15	--	0.5%	--	4/90-->	
LeNeindre; U. Paris Nord; France	l	298-523	0.1-100	--	--	--	10/90-->	
Trusler; Imperial Col.; UK	v	--	0-4	50	0.005%	--	10/90-->	
Dielectric constant								
Nieto de Castro; U. Lisbon; Por	l,v	--	0-20	--	0.5%	.995	12/89-10/93	
Refractive index								
Straub; T.U. München; FRG	l,v	360-460	-	300	0.05%	.9998	10/90-8/91	
Schmidt; NIST; USA	l,v	296-409	sat	36	0.001	.9997	comp	[Ch90]
Surface Tension								
Straub; T.U. München; FRG	l-v	230-410	-	100	0.5%	.9998	10/90-8/91	
Schmidt; NIST; USA	l,v	296-409	-	39	0.15mN/m	.9997	comp	[Ch90]
Thermal conductivity								
LeNeindre; U. Paris Nord; France	l	298-523	0.1-70	--	1-2%	--	comp	
Nieto de Castro; U. Lisbon; Por	l,v	290-504	0-20	50	2%	.995	comp	[Cs90]
Stephan/Taxis; U. Stuggart; FRG	v	273-423	<5	100	1%	--	-->9/91	
Yata; Kyoto Inst. Tech.; Japan	l	250-350	sat-30	100	--	--	planned	
Tanaka; Kobe U.; Japan	v	293-353	0.1-sat	21	2%	.999	comp	[Tn90]
Perkins; NIST; USA	l,v	160-450	0.1-70	800	1%	--	-->12/90	
Venart; U. New Brunswick; Canada	l,v	203-393	0.1-70	--	1%	--	planned	
Thermal diffusivity								
Fiebig; Ruhr U.; FRG	l	293-353	2-8	--	--	.99	comp	
Leipertz; U. Erlangen-Nürnberg; FRG	l,v	240-450	<15	--	1-2%	--	4/90-->	
Straub; T.U. München; FRG	l,v	360-460	2-12	300	1-2%	.9998	10/90-8/91	
Perkins; NIST; USA	l,v	160-450	0.1-70	800	5%	--	-->12/90	
Venart; U. New Brunswick; Canada	l,v	203-393	0.1-70	--	5%	--	planned	
Viscosity								
Mayinger; T. U. München; FRG	v	300-384	0.1-2	28	0.5%	.9991	comp	[My90]
Ström; Chalmers U. Tech.; Swe	l	258-323	0.5-2	--	2%	.99	planned	
Kruse; U. Hannover; FRG	l	236-353	?-2.5	8	4%	.999	comp	
Equation of State								
Maurer; U. Kaiserlautern; FRG	v	257-427	0-4	-	-	-	comp	[Pl90]
Oellrich; U. Karlsrühe; FRG	l,v	-	-	-	-	-	?/89-?/92	
Huber; NIST; USA	l,v	all	all	-	-	-	in prog	[El90]
Gallagher; NIST; USA	l,v	0.5-1.6 T_c	0-2 P_c	-	-	-	comp	[Gl90]
Ideal Gas Properties								
Lucas; U. Duisburg; FRG	-	100-500	0-0	-	1%	-	in prog	
Marsh; Texas A&M; USA	-	0-1500	0.1	-	--	-	comp	[TR90]

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R123; $CHCl_2CF_3$; 1,1-dichloro-2,2,2-trifluoroethane

Property Investigator	phase	range of data T (K)	 p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Vapor pressure								
Baroncini; U. Ancona; Italy	l-v	240-360	-	--	0.5%	--	7/90-6-91	
Gorenflo; U. Paderborn; FRG	l-v	293-423	-	27	0.04%	.95-.97	--	
LeNeindre; U. Paris Nord; France	l-v	298-?	-	--	--	--	10/90-->	
Straub; T.U. München; FRG	l-v	360-460	-	50	0.5-1.5%	.998	7/90-12/90	
Oguchi; Kanagawa Inst. Tech.; Japan	l-v	243-456	-	45	0.5kPa	.998	comp	
Kubota; Kobe U.; Japan	l-v	273-457	-	38	3kPa	.995	comp	[Kb89]
Fukushima; Asahi Glass Co.; Japan	l-v	314-456	-	65	5kPa	.998-.999	comp	
Maezawa; Keio U.; Japan	l-v	280-350	-	8	7kPa	.9993	comp	[Mz90]
Piao; Keio U.; Japan	l-v	310-456	-	67	2kPa	.998-.9993	?/89-?/91	
Qian; Keio U.; Japan	l-v	310-420	-	36	1kPa	.996-.9994	5/90-7/90	
Mingshan; Tsinghua U.; PRC	l-v	248-358	-	20	0.02%	--	planned	
Magee; NIST; USA	l-v	166-400	-	--	0.01-0.05%	.9999	5/91-9/91	
Weber; NIST; USA	l-v	273457	-	64	0.05%	.9995	comp	[Wb90]
Morrison; NIST; USA	l-v	268-383	-	15	-	.9999	comp	[Mo90]
Morrison; NIST; USA	l-v	273-373	-	25	-	.9999	in prog	
Saturated liquid density								
Gorenflo; U. Paderborn; FRG	sl	295-423	-	27	0.04%	.95-.97	--	
Yokoyama; Tohoku U.; Japan	sl	248-423	-	24	0.2-0.3%	.996-.999	comp	[Yk88]
Oguchi; Kanagawa Inst. Tech.; Japan	sl	254-433	-	17	0.1%	.998	comp	
Fukushima; Asahi Glass Co.; Japan	sl	281-456	-	35	0.3%	.998-.999	comp	
Maezawa; Keio U.; Japan	sl	200-400	-	23	0.2%	.9993	comp	[Mz90]
Piao; Keio U.; Japan	sl	300-420	-	5	0.15%	.998-.9993	?/89-?/91	
Tanikawa; Keio U.; Japan	sl	401-456	-	10	0.1-0.5%	.998-.9999	comp	
Weber; NIST; USA	sl	300-457	-	-	0.05%	.9995	comp	[Wb90]
Morrison; NIST; USA	sl	268-383	-	10	-	.9999	comp	[Mo90]
Saturated vapor density								
Gorenflo; U. Paderborn; FRG	sv	293-423	-	27	0.2%	.95-.97	--	
Fukushima; Asahi Glass Co.; Japan	sv	352-456	-	27	0.3%	.998-.999	comp	
Tanikawa; Keio U.; Japan	sv	438-456	-	9	0.1-0.5%	.998-.9999	comp	
Weber; NIST; USA	sv	433-457	-	5	0.05%	.9995	comp	[Wb90]

Property / Investigator	phase	range of data T (K)	p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Pressure-volume-temperature								
Baroncini; U. Ancona; Italy	v	240-360	0.1-sat	--	0.5%	--	7/90-6-91	
LeNeindre; U. Paris Nord; France	l,v	298-413	0.1-100	--	--	--	10/90-->	
Nieto de Castro; U. Lisbon; Por.	l,v	$<T_c$	<20	--	0.3%	.995	12/89-10/93	
Straub; T.U. München; FRG	l,v	360-460	0.7-12	300	0.5-1.5%	.998	7/90-12/90	
Oguchi; Kanagawa Inst. Tech.; Japan	l	243-493	0.07-16	27	0.01%	.998	comp	
Matsuo; Kobe U.; Japan	l	293-323	sat-40	68	0.04%	.999	comp	[Ko90]
Matsuo; Kobe U.; Japan	l	293-353	sat-40	44	0.02%	.999	comp	[Ko88]
Fukushima; Asahi Glass Co.; Japan	l,v	352-484	1-5	59	0.2%	.998-.999	comp	
Maezawa; Keio U.; Japan	l	280-340	sat-2	16	0.2%	.9993	comp	[Mz90]
Piao; Keio U.; Japan	l,v	310-525	0.5-12	134	0.15%	.998-.9993	?/89-?/91	
Qian; Keio U.; Japan	v	310-420	0.1-sat	65	0.2-0.7%	.996-.9994	5/90-7/90	
Woolf; Australian Nat. U.; Aus.	l	273-338	sat-400	--	0.1-0.5%	--	8/90-->	
Mingshan; Tsinghua U.; PRC	v	248-358	0.1-6	80	0.2%	--	planned	
Morrison; NIST; USA	l	268-378	sat-7	60	0.1%	.9999	comp	
Weber; NIST; USA	v	338-453	0-sat	75	0.05%	.9995	comp	[Wb90]
Virial coefficients								
Schramm; Phys.-Chem. Inst.; FRG	v	268-296	--	2	5%	--	comp	
Critical parameters								
LeNeindre; U. Paris Nord; France	--	-	-	--	--	--	10/90-->	
Straub; T.U. München; FRG	--	-	-	--	0.5-1.5%	.998	7/90-12/90	
Kubota; Kobe U.; Japan	T,P		-		50mK,3kPa	.995	comp	[Kb89]
Fukushima; Asahi Glass Co.; Japan	T,ρ	-	-		25mK	.998-.999	comp	
Piao; Keio U.; Japan	P	-	-	-	2kPa	.998-.9993	?/89-?91	
Tanikawa; Keio U.; Japan	T,ρ	-	-	-	10mK,0.5%	.998-.9999	comp	
Weber; NIST; USA	T,P,ρ	-	-	-	0.05%	.9995	comp	[Wb90]
Heat capacity/calorimetry								
Nakagawa; Keio U.; Japan	l	276-440	sat-3	80	0.4%	.9982	comp	
Magee; NIST; USA	l	166-340	sat-35	--	0.5%	.9999	5/91-9/91	
Speed of sound								
Leipertz; U. Erlangen-Nürnberg; FRG	l,v	240-450	<15	--	0.5%	--	4/90-->	
LeNeindre; U. Paris Nord; France	l,v	298-523	0.1-100	--	--	--	10/90-->	
Trusler; Imperial Col.; UK	v	--	0-4	50	0.005%	--	10/90-->	
Takagi; Kyoto Inst. Tech.; Japan	l	280-370	sat-75	170	0.2%	.998	comp	
Mingshan; Tsinghua U.; PRC	v	248-358	0.1-1.5	--	0.2%	--	planned	
Goodwin; NIST; USA	v	260-335	0.02-0.07	49	0.01%	.9995	in prog	
Dielectric constant								
Nieto de Castro; U. Lisbon; Por.	l,v	<Tc	<20	--	0.5%	.995	12/89-10/93	
Tanaka; Kobe U.; Japan	l	298-313	sat-35	32	1%	.999	--	[Ko90]
Morrison; NIST; USA	v	298-433	0.04-0.1	-	$3x10^{-6}$	.9999	comp	[Me90]

R123; $CHCl_2CF_3$; 1,1-dichloro-2,2,2-trifluoroethane (continued)

Property Investigator	phase	range of data T (K)	 p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Refractive index								
Straub; T.U. München; FRG	l,v	360-460	0.7-12	300	0.05%	.998	7/90-12/90	
Chae; Korea Std. Res. Lab.; Korea	l,v	230-456	0.1-5	--	1.0%	.99	planned	
Surface Tension								
Straub; T.U. München; FRG	l-v	223-457	-	100	0.5%	.998	planned	
Higashi; Iwaki Meisei U.; Japan	l-v	273-290	-	21	0.4mN/m	.9984	in prog	
Okada; Nagaoka U. Tech.; Japan	l-v	237-443		186	0.2mN/m	.9984	comp	[Ok90]
Chae; Korea Std. Res. Lab.; Korea	l-v	230-456	-	--	1.0%	.99	planned	
Mingshan; Tsinghua U.; PRC	l-v	263-358	-	--	--	--	planned	
Schmidt; NIST; USA	l-v	253-423	-	22	0.15mN/m	.995	comp	[Ch90]
Thermal conductivity								
Assael; Aristotle U.; Greece	l,v	230-370	<40	--	0.5%	--	6/89-?	
Gross/Hahne; U. Stuggart; FRG	l,v	260-364	0.1-8.0	65	1%	.995	?/88-?/92	[Gr90]
LeNeindre; U. Paris Nord; France	l,v	298-523	0.1-100	--	--	--	10/90-->	
Nieto de Castro; U. Lisbon; Por.	l,v	$<T_c$	<20	--	0.5%	.995	12/89-10/93	
Yata; Kyoto Inst. Tech.; Japan	l	250-350	sat-30	127	--	.995-.9995	comp	[Yt89]
Tanaka; Kobe U.; Japan	l	283-323	sat-200	36	1.0%	.999	comp	[Tn88]
Matsuo; Kobe U.; Japan	l	298-323	sat-100	33	1%	.999	in prog	
Nagasaka; Keio U.; Japan	l	273-353	sat-40	--	0.5%	.998	?/89-->	
Chae; Korea Std. Res. Lab.; Korea	l,v	230-500	0.1-5	--	1.0%	.99	3/90-->	
Perkins; NIST; USA	l,v	180-450	0.1-70	800	1%	--	1/91-9/92	
Venart; U. New Brunswick; Canada	l,v	203-393	0.1-70	--	1%	--	in prog	
Thermal diffusivity								
Fiebig; Ruhr U.; FRG	l	273-363	1-8	--	1%	--	8/90-12/90	
Leipertz; U. Erlangen-Nürnberg; FRG	l,v	240-450	<15	--	1-2%	--	4/90-->	
Straub; T.U. München; FRG	l,v	360-460	0.7-12	300	0.5-1.5%	.998	7/90-12/90	
Perkins; NIST; USA	l,v	180-450	0.1-70	800	5%	--	1/91-9/92	
Venart; U. New Brunswick; Canada	l,v	203-393	0.1-70	--	5%	--	in prog	
Viscosity								
Matthews; Polytech. S.W.; UK	v	301-573	0.01-0.1	10	0.5%	--	1/90-->	
Mayinger; T.U. München; FRG	v	300-425	0.1-2.1	28	0.5%	.999	comp	[My90]
Takahashi; Tohoku U.; Japan	v	323-423	0.1-sat	48	0.3%	.996	comp	[Tk90]
Kumagai; Tohoku U.; Japan	sl	273-353	sat	9	0.5%	.996	comp	[Km90]
Tanaka; Kobe U.; Japan	l	293-313	sat-100	12	2%	.999	--	
Nagashima; Keio U.; Japan	l	233-418	sat-20	--	--	.9977	?/89-->	
Woolf; Austrlian Nat. U.; Aus.	l	273-338	sat-400	--	0.1-0.5%	--	8/90-->	
Mingshan; Tsinghua U.; PRC	sl	263-358	-	--	--	--	planned	
Diller; NIST; USA	l	170-320	sat-35	60	3%	--	comp	
Snelson; NRC; Canada	sl	253-353	-	15	2.5-3.5%	-	3/91-10/91	

Property Investigator	phase	range of data T (K)	 p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Equation of State								
Maurer; U. Kaiserlautern; FRG	v	288-368	0-0.7	-	-	-	--	
Huber; NIST; USA	l,v	all	all	-	-	-	in prog	[El90]
Gallagher; NIST; USA	l,v	0.5-1.6 T_c	0-2 P_c	-	-	-	comp	[Gl90]
Ideal Gas Properties								
Lucas; U. Duisburg; FRG	-	100-500	0-0	-	1%	-	in prog	
Marsh; Texas A&M; USA	-	0-1500	0.1	-	--	-	comp	[TR90]

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R123a; $CHClFCClF_2$; 1,2-dichloro-1,2,2-trifluoroethane

Property Investigator	phase	range of data T (K)	 p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Vapor pressure								
Otake; Tohoku U.; Japan	l-v	297-447	-	20	0.1kPa	.998	comp	[Ot89]
Kubota; Kobe U.; Japan	l-v	303-458	-	32	3kPa	.998	comp	[Kb89]
Morrison; NIST; USA	l-v	268-383	-	10	-	.991	comp	
Saturated liquid density								
Yokoyama; Tohoku U.; Japan	sl	247-422	-	31	0.3%	.998-.999	comp	[Yk88]
Morrison; NIST; USA	sl	268-383	-	10	-	.991	comp	
Pressure-volume-temperature								
Otake; Tohoku U.; Japan	v	374-465	0.5-5	19	0.5%	.998	comp	[Ot89]
Matsuo; Kobe U.; Japan	l	293-333	sat-40	44	0.04%	.999	comp	[Ko89a]
Woolf; Australian Nat. U.; Aus.	l	273-338	sat-400	--	0.1-0.5%	--	8/90-->	
Morrison; NIST; USA	l	268-378	sat-7	60	0.1%	.991	comp	
Critical parameters								
Schmidt; NIST; USA	T,ρ	-	-	--	$0.01 g/cm^3$	.991	comp	[Ch90]
Speed of sound								
Goodwin; NIST; USA	v	260-300	0.004-0.06	18	0.01%	-	in prog	
Dielectric constant								
Morrison; NIST; USA	v	298-433	0.04-0.1	-	3×10^{-6}	.991	comp	[My90]
Refractive index								
Schmidt; NIST; USA	l,v	297-460	sat	40	0.001	.991	comp	[Ch90]
Surface tension								
Schmidt; NIST; USA	l,v	297-460	sat	29	0.15mN/m	.991	comp	[Ch90]
Thermal conductivity								
Hemminger; PTB; FRG	v	303-463	0.1-0.1	7	2.5%	.997	comp	[Hm89]
Viscosity								
Takahashi; Tohoku U.; Japan	v	323-423	0.1-sat	47	0.3%	--	comp	[Tk90]
Kumagai; Tohoku U.; Japan	sl	273-353	sat	9	0.5%	.998	comp	[Km90]
Tanaka; Kobe U.; Japan	l	298-323	sat-120	39	2%	.999	comp	[Ko89]
Woolf; Australian Nat. U.; Aus.	l	273-338	sat-400	--	0.1-0.5%	--	8/90-->	
Ideal Gas Properties								
Lucas; U. Duisburg; FRG	-	100-500	0-0	-	1%	-	in prog	
Marsh; Texas A&M; USA	-	0-1500	0.1	-	--	-	comp	[TR90]

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[Yk88] C. Yokoyama, Proc., 29th High Pressure Conference of Japan, p. 116 (1988).

R141b; CCl_2FCH_3; 1,1-dichloro-1-fluoroethane

Property Investigator	phase	range of data T (K)	 p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Vapor pressure								
LeNeindre; U. Paris Nord; France	l-v	298-480	-	--	--	--	10/90-->	
Kubota; Kobe U.; Japan	l-v	278-373	-	24	3kPa	.999	comp	
Maezawa; Keio U.; Japan	l-v	200-400	-	37	10kPa	.988	comp	[Mz90]
Holste; Texas A&M U.; USA	l-v	250-400	-	--	0.1%	--	9/90-10/91	
Weber; NIST; USA	l-v	273-418	-	39	0.05%	.9994	comp	
Morrison; NIST; USA	l-v	268-383	-	10	-	.9994	comp	
Saturated liquid density								
Kumagai; Tohoku U.; Japan	sl	273-353	-	9	0.2%	.995	comp	[Km90]
Fukushima; Asahi Glass Co.; Japan	sl	245-369	-	--	0.3%	.9947	comp	
Maezawa; Keio U.; Japan	sl	200-400	-	37	0.2%	.988	comp	[Mz90]
Holste; Texas A&M U.; USA	sl	250-400	-	--	0.1%	--	9/90-10/91	
Morrison; NIST; USA	sl	268-383	-	10	-	.9994	comp	
Morrison; NIST; USA	sl	273-373	-	25	-	.9994	in prog	
Saturated vapor density								
Holste; Texas A&M U.; USA	sv	250-400	-	--	0.1%	--	9/90-10/91	
Pressure-volume-temperature								
LeNeindre; U. Paris Nord; France	l,v	298-413	0.1-100	--	--	--	10/90-->	
Nieto de Castro; U. Lisbon; Por.	l,v	$<T_c$	<20	--	0.3%	.995	12/89-10/93	
Matsuo; Kobe U.; Japan	l	293-348	sat-100	111	0.05%	.999	comp	[Ko90]
Kubota; Kobe U.; Japan	l,v	298-323	0.1-200	63	0.1-0.3%	.999	?/89-->	
Maezawa; Keio U.; Japan	l	280-400	sat-2	24	0.2%	.988	comp	[Mz90]
Woolf; Australian Nat. U.; Aus.	l	273-338	sat-400	--	0.1-0.5%	--	8/90-->	
Holste; Texas A&M U.; USA	l,v	250-400	0-70	--	0.1%	--	9/90-10/91	
Weber; NIST; USA	v	329-418	0-sat	50	0.05%	.9994	comp	
Morrison; NIST; USA	l	268-378	sat-7	60	0.1%	.9994	comp	
Critical parameters								
LeNeindre; U. Paris Nord; France	-	-	-	--	--	--	10/90-->	
Holste; Texas A&M U.; USA	T,P,ρ	-	-	--	0.1%	--	9/90-10/91	
Schmidt; NIST; USA	T,ρ	-	-	--	0.01g/cm^3	.9995	comp	[Ch90]
Speed of sound								
LeNeindre; U. Paris Nord; France	l,v	298-523	0.1-100	--	--	--	10/90-->	
Trusler; Imperial Col.; UK	v	--	0-4	50	0.005%	--	10/90-->	
Goodwin; NIST; USA	v	260-315	0.004-0.05	45	0.01%	.9994	in prog	
Dielectric constant								
Nieto de Castro; U. Lisbon; Por.	l,v	<Tc	<20	--	0.5%	.995	12/89-10/93	
Morrison; NIST; USA	v	298-433	0.04-0.1	-	$3x10^{-6}$	.9994	comp	[My90]
Refractive index								
Schmidt; NIST; USA	l,v	323-476	sat	40	0.001	.9995	comp	[Ch90]

Property Investigator	phase	range of data T (K)	 p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
Surface tension								
Schmidt; NIST; USA	l,v	323-476	-	28	0.15mN/m	.9995	comp	[Ch90]
Thermal conductivity								
LeNeindre; U. Paris Nord; France	l,v	298-523	0.1-100	--	--	--	10/90-->	
Nieto de Castro; U. Lisbon; Por.	l,v	$<T_c$	<20	--	0.5%	.995	12/89-10/93	
Wakeham; Imperial Col.; UK	sl,sv	260-370	sat	20	--	.999	comp	[Wk90]
Yata; Kyoto Inst. Tech.; Japan	l	250-350	sat-30	--	--	.995-.9995	--	
Tanaka; Kobe U.; Japan	v	293-353	0.1-0.1	4	2%	.999	comp	[Tn90]
Matsuo; Kobe U.; Japan	l	298-313	sat-60	13	1%	.999	in prog	
Perkins; NIST; USA	l,v	180-450	0.1-70	800	1%	--	1/91-9/92	
Venart; U. New Brunswick; Canada	l,v	203-393	0.1-70	--	1%	--	planned	
Thermal diffusivity								
Perkins; NIST; USA	l,v	180-450	0.1-70	800	5%	--	1/91-9/92	
Venart; U. New Brunswick; Canada	l,v	203-393	0.1-70	--	5%	--	planned	
Viscosity								
Kumagai; Tohoku U.; Japan	sl	273-353	sat	9	0.5%	.995	comp	[Km90]
Tanaka; Kobe U.; Japan	l	298-323	sat-120	39	2%	.999	comp	
Woolf; Australian Nat. U.; Aus.	l	273-338	sat-400	--	0.1-0.5%	--	8/90-->	
Diller; NIST; USA	l	180-320	sat-35	60	3%	--	comp	
Equation of State								
Morgenstern; HFV Dresden; FRG	l,v	273-520	0-4	-	-	-	comp	
Huber; NIST; USA	l,v	all	all	-	-	-	in prog	[El90]
Ideal Gas Properties								
Lucas; U. Duisburg; FRG	-	100-500	0-0	-	1%	-	in prog	
Marsh; Texas A&M; USA	-	0-1500	0.1	-	--	-	comp	[TR90]

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[Mz90] Y. Maezawa, submitted to J. Chem. Eng. Data (1990)

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[TR90] TRC Thermodynamic Tables, Thermodynamics Research Center, Texas A&M University, continuously updated; also to be published in J. Phys. Chem. Ref. Data.

[Wk90] W. Wakeham, data presented in proprietary report (1990).

Other Pure Fluids

Fluid/Investigator/ /Property	phase	range of data T (K)	p (MPa)	no. points	est. accuracy	sample purity	start/end dates	note /ref.
R227								
Gorenflo; U. Paderborn; FRG								
vapor pressure	l-v	293-375	-	17	0.04%	.995	in prog	
sat. liquid density	sl	293-370	-	17	0.04%	.995	in prog	
sat. vapor density	sv	293-370	-	17	0.2%	.995	in prog	
R124a								
Morgenstern; HFV Dresden; FRG								
equation of state	l,v	243-450	0-3.5	-	-	-	comp	[Mr90]
R225ca								
Widiatmo; Keio U.; Japan								
vapor pressure	l-v	T_{tp}-400	-	--	10kPa	--	7/90-3/91	
saturation density	sl	T_{tp}-400	-	--	0.2%	--	7/90-3/91	
pressure-volume-temperature	l	280-400	sat-2	--	0.2%	--	7/90-3/91	
Higashi; Iwaki Meisei U.; Japan								
surface tension	l-v	273-320	-	--	0.2mN/m	--	in prog	
bis-difluoromethylether								
Gillis; NIST; USA								
sound speed	v	255-330	0.01-.2	-	0.01%	.998	in prog	
Schmidt; NIST; USA								
critical parameters	T,ρ	-	-	-	0.01g/cm^3	-	in prog	
density	sl	T_{nbp}-T_c	sat	41	-	-	in prog	
refractive index	sl,sv	T_{nbp}-T_c	sat	41	0.001	-	in prog	
surface tension	l-v	T_{nbp}-T_c	-	74	0.15mN/m	-	in prog	
2-, 3-, and 4-carbon fluoro- and hydrofluoroethers								
Adcock; U. Tennessee; USA								
vapor pressure	l-v	T_{nbp}-T_c	-	--	2%	.9998	8/88-2/92	[Ad90]
saturation density	sl	T_{nbp}-T_c	-	--	2%	.9998	8/88-2/92	[Ad90]
pressure-volume-temperature	--	--	--	6	2%	.9998	8/88-2/92	[Ad90]
critical parameters	--	-	-	--	--	.9998	8/88-2/92	[Ad90]
heat capacity	--	T_{nbp}-T_c	-	--	2%	.9998	8/88-2/92	[Ad90]
viscosity	sl	T_{nbp}-T_c	-	--	2%	.9998	8/88-2/92	[Ad90]
3- and 4-carbon hydrofluorocarbons and hydrochlorofluorocarbons								
DesMarteau; Clemson U.; USA								
vapor pressure	l-v	T_{nbp}-T_c	-	--	2%	.98+	8/88-8/91	[Hw90]
saturation density	sl	T_{nbp}-T_c	-	--	2%	.98+	8/88-8/91	[Hw90]
pressure-volume-temperature	--	--	--	6	2%	.98+	8/88-8/91	[Hw90]
critical parameters	--	-	-	--	--	.98+	8/88-8/91	[Hw90]
heat capacity	--	T_{nbp}-T_c	-	--	2%	.98+	8/88-8/91	[Hw90]
viscosity	sl	T_{nbp}-T_c	-	--	2%	.98+	8/88-8/91	[Hw90]

Notes and References

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Mixture/Investigator/ /Property	phase	range of data T (K)	p (MPa)	x	no. points	est. accuracy	start/end dates	note /ref.
R14/23								
Maurer; U. Kaiserlautern; FRG								
equation of state	l,v	203-473	0-58	--	-	-	comp	[P190]
R23/13								
Maurer; U. Kaiserlautern; FRG								
equation of state	l,v	203-473	0-58	--	-	-	comp	[P190]
R23/22								
Morrison; NIST; USA								
bubble point pressure	l-v	268-T_c	-	50	10	-	comp	
R23/142b								
Morrison; NIST; USA								
bubble point pressure	l-v	268-T_c	-	50	10	-	comp	
R32/134a								
Holste; Texas A&M U.; USA								
vapor-liquid equilibria	l-v	175-T_c	-	50	--	0.1%	6/91-12/91	
P-V-T-x	l,v	175-400	0-70	50	--	0.1%	6/91-12/91	
R32/152a								
Holste; Texas A&M U.; USA								
vapor-liquid equilibria	l-v	175-T_c	-	50	--	0.1%	1/92-6/92	
P-V-T-x	l,v	175-400	0-70	50	--	0.1%	1/92-6/92	
R125/134a								
Snellson; NRC; Canada								
viscosity	sl	253-353	-	0-100	50	2.5-3.5%	3/91-10/91	
R125/124								
Snellson; NRC; Canada								
viscosity	sl	253-353	-	0-100	50	2.5-3.5%	3/91-10/91	
R143a/22								
Tanaka; Kobe U.; Japan								
viscosity	v	293-313	0.1-0.1	0-100	15	1%	comp	[Ko90]
Kubota; Kobe U.; Japan								
vapor-liquid equilibria	l-v	273-338	-	--	114	1.5%	comp	
R22/12								
Takahashi; Tohoku U.; Japan								
viscosity	v	298-398	0.1-6	43-79	207	0.3%	comp	[Tk89]

Mixture/Investigator/ /Property	phase	range of data T (K)	p (MPa)	x	no. points	est. accuracy	start/end dates	note /ref.
R22/134a								
Tanaka; Kobe U.; Japan								
viscosity	v	293-313	0.1-0.1	0-100	15	1%	comp	[Ko90]
Yoshida; Matsushita Elec.; Japan								
vapor-liquid equilibria	l-v	273-323	-	--	--	0.4mol%	comp	
R22/152a								
Kruse; U. Hannover; FRG								
viscosity	l	243-353	?-2.5	0-100	--	4%	comp	
saturated liquid density	sl	233-353	--	0-100	76	0.3%	comp	
Mayinger; T. U. München; FRG								
viscosity	v	300-425	0.1-6.5	25-75	--	0.5%	7/91-10/91	
Schramm; Phys. Chem. Inst.; FRG								
second virial coefficient	v	233-296	-	--	4	2%	comp	
Ström; Chalmers U. Tech.; Swe								
vapor-liquid equilibria	l-v	--	0.1-2	--	--	0.3mol%	comp	
P-V-T-x	l	258-323	0.5-2	--	--	0.15%	comp	
heat capacity	l	253-313	sat-2	--	--	0.5%	in prog	
viscosity	l	258-323	0.5-2	--	--	2%	comp	
Kubota; Kobe U.; Japan								
vapor-liquid equilibria	l-v	263-323	-	--	114	1.7%	comp	
P-V-T-x	v	348-423	0.1-4	30-70	26	0.4%	comp	
Maezawa; Keio U.; Japan								
bubble point pressure	l-v	280-380	-	10-90	66	20kPa	comp	[Mz90c]
saturated liquid density	sl	280-380	-	10-90	66	0.3%	comp	[Mz90c]
vapor-liquid equilibria	l-v	280-380	-	10-90	66	0.1%	comp	[Mz90c]
Wang; Xi'an Jiaotong U.; PRC								
saturation density	sl,sv	323-T_c	--	0-100	210	0.5%	comp	
Canren; Tianjin U.; PRC								
equation of state	v	--	--	--	-	-	--	
Bier; U. Karlsrühe; FRG								
critical parameters	T,P,ρ	-	-	0-100	-	0.05K; 6kPa	comp	[Bi90]
Oellrich; U. Karlsrühe; FRG								
equation of state	l,v	-	-	-	-	-	?/89-?/92	
Sami; U. Moncton; Canada								
heat capacity	l,v	283-353	0.5-1.4	-	-	2%	in prog	
LaRue; CRIQ; Canada								
bubble point pressure	l-v	.65-.85 T_c	-	0-100	-	1%	comp	[Lr90]
R22/152a/142b								
Maezawa; Keio U.; Japan								
bubble point pressure	l-v	280-390	-	(6 comp)	71	20kPa	comp	[Mz90]
saturated liquid density	sl	280-390	-	(6 comp)	71	0.2%	comp	[Mz90]
vapor-liquid equilibria	l-v	280-390	-	(6 comp)	71	0.2%	comp	[Mz90]
R22/152a/114								
Sami; U. Moncton; Canada								
heat capacity	l,v	283-353	0.5-1.4	-	-	2%	in prog	

Mixture/Investigator/ /Property	phase	range of data T (K)	p (MPa)	x	no. points	est. accuracy	start/end dates	note /ref.
R22/142b								
Kruse; U. Hannover; FRG								
viscosity	l	237-353	?-2.5	0-100	72	4%	comp	
LeNeindre; U. Paris Nord; France								
vapor pressure	l-v	298-?	-	40/60	--	--	10/90-->	
P-V-T-x	l,v	298-413	0.1-100	40/60	--	--	10/90-->	
critical parameters	-	-	-	40/60	--	--	10/90-->	
sound speed	l,v	298-523	0.1-100	40/60	--	--	10/90-->	
thermal conductivity	l,v	298-523	0.1-100	40/60	--	--	10/90-->	
Mayinger; T. U. München; FRG								
viscosity	v	300-425	0.1-6.5	25-75	--	0.5%	9/90-12/90	
Schramm; Phys. Chem. Inst.; FRG								
second virial coefficient	v	248-296	-	--	4	1%	comp	
Stephan/Taxis; U. Stuttgart; FRG								
thermal conductivity	v	273-423	?-5	--	100	1%	-->9/91	
Ström; Chalmers U. Tech.; Swe								
vapor-liquid equilibria	l-v	--	0.1-2	--	--	0.3mol%	comp	
P-V-T-x	l	258-323	0.5-2	--	--	0.15%	comp	
heat capacity	l	253-313	sat-2	--	--	0.5%	in prog	
viscosity	l	258-323	0.5-2	--	--	2%	comp	
Tanaka; Kobe U.; Japan								
viscosity	v	298-323	0.1-0.1	0-100	11	1%	comp	[Ko89]
Kubota; Kobe U.; Japan								
vapor-liquid equilibria	l-v	263-338	-	--	174	1.5%	comp	
Yoshida; Matsushita Elec.; Japan								
vapor-liquid equilibria	l-v	273-323	-	--	--	0.4mol%	comp	
Maezawa; Keio U.; Japan								
bubble point pressure	l-v	280-400	-	20-80	46	20kPa	comp	[Mz90b]
saturated liquid density	sl	280-400	-	20-80	46	0.2%	comp	[Mz90b]
vapor-liquid equilibria	l-v	280-400	-	20-80	46	0.1%	comp	[Mz90b]
Kumagai; Keio U.; Japan								
vapor-liquid equilibria	l-v	321-T_c	-	20-80	31	0.1%	comp	[Km90]
P-V-T-x	l,v	297-443	0.5-10	20-80	445	0.1%	comp	[Km90]
Yujun; Zhejiang U.; PRC								
vapor-liquid equilibria	l-v	243-373	-	0-100	--	0.5mol%	5/90-9/90	
Canren; Tianjin U.; PRC								
equation of state	v	--	--	--	-	-	--	
Bier; U. Karlsrühe; FRG								
critical parameters	T,P,ρ	-	-	0-100	-	0.05K; 6kPa	comp	[Bi90]
Oellrich; U. Karlsrühe; FRG								
equation of state	l,v	-	-	-	-	-	?/89-?/92	
LaRue; CRIQ; Canada								
bubble point pressure	l-v	.65-.85 T_c	-	0-100	-	1%	comp	[Lr90]
Morrison; NIST; USA								
bubble point pressure	l-v	268-383	-	50	10	-	comp	

Mixture/Investigator/ /Property	phase	T (K)	range of data p (MPa)	x	no. points	est. accuracy	start/end dates	note /ref.
R22/152a/124								
Yujun; Zhejiang U.; PRC								
vapor-liquid equilibria	l-v	243-373	-	0-100	--	0.5mol%	2/91-7/91	
R22/114								
Mayinger; T. U. München; FRG								
viscosity	v	300-425	0.1-5.3	25-75	--	0.5%	comp	[Nb90]
Ström; Chalmers U. Tech.; Swe								
vapor-liquid equilibria	l-v	--	0.1-2	--	--	0.3mol%	comp	
P-V-T-x	l	258-323	0.5-2	--	--	0.15%	comp	
heat capacity	l	253-313	sat-2	--	--	0.5%	in prog	
viscosity	l	258-323	0.5-2	--	--	2%	comp	
Higashi; Iwaki Meisei U.; Japan								
V-L-E correlation	sl,sv	230-T_c	-	--	--	--	comp	[Hg89]
critical region correlation	-	-	-	--	-	-	comp	[Hg89a]
Kubota; Kobe U.; Japan								
vapor-liquid equilibria	l-v	253-338	-	0-100	158	0.3%	comp	[Kb90a]
Gorenflo; U. Paderborn; FRG								
vapor pressure	l-v	293-T_c	-	0-89	95	0.2%	comp	[Rt89]
sat. liquid density	sl	293-T_c	-	0-89	95	0.2%	comp	[Rt89]
sat. vapor density	sv	293-T_c	-	0-89	95	0.8%	comp	[Rt89]
critical parameters	-	-	-	0-89	9	--	comp	[Rt89]
Sami; U. Moncton; Canada								
heat capacity	l,v	283-353	0.5-1.4	-	-	2%	in prog	
LaRue; CRIQ; Canada								
bubble point pressure	l-v	.65-.85 T_c	-	0-100	-	1%	comp	[Lr90]
R22/123								
Schramm; Phys. Chem. Inst.; FRG								
second virial coefficient	v	268-296	-	--	2	3%	comp	
R134a/152a								
Baehr; U. Hannover; FRG								
vapor-liquid equilibria	l-v	300-373	-	25-75	40	0.1%	7/89-6/91	
P-V-T-x	l,v	293-433	0.1-16	25-75	500	0.1%	7/89-6/91	
Tamatsu; Keio U.; Japan								
vapor-liquid equilibria	l-v	300-T_c	-	20-80	--	0.1%	8/90-->	
P-V-T-x	l,v	300-443	0.5-10	20-80	--	0.1%	8/90-->	
Holste; Texas A&M U.; USA								
vapor-liquid equilibria	l-v	180-T_c	-	50	--	0.1%	1/91-6/91	
P-V-T-x	l,v	180-400	0-70	50	--	0.1%	1/91-6/91	
Bier; U. Karlsrühe; FRG								
vapor pressure	l-v	203-T_c	-	0-100	-	0.1%	comp	[Bi90]
critical parameters	-	-	-	-	-	-	comp	[Bi90]
Oellrich; U. Karlsrühe; FRG								
equation of state	l,v	-	-	-	-	-	?/89-?/92	
Morrison; NIST; USA								
bubble point pressure	l-v	268-T_c	-	50	10	-	comp	

Mixture/Investigator/ /Property	phase	range of data T (K)	p (MPa)	x	no. points	est. accuracy	start/end dates	note /ref.
R134a/134								
Morrison; NIST; USA								
bubble point pressure	l-v	268-T_c	-	50	10	-	comp	
R134a/123								
Kubota; Kobe U.; Japan								
vapor-liquid equilibria	l-v	288-333	-	--	--	0.1%	?/89-->	
Nakaiwa; Nat. Chem. Lab; Japan								
equation of state	--	313-363	0.2-3.2	--	--	--	comp	[Nk90]
R134a/141b								
Kubota; Kobe U.; Japan								
vapor-liquid equilibria	l-v	278-333	-	--	76	0.1%	comp	[Kb90]
R152a/134								
Maezawa; Keio U.; Japan								
bubble point pressure	l-v	280-380	-	20-80	44	20kPa	comp	[Mz91]
saturated liquid density	sl	280-380	-	20-80	44	0.2%	comp	[Mz91]
vapor-liquid equilibria	l-v	280-380	-	20-80	44	0.1%	comp	[Mz91]
Morrison; NIST; USA								
bubble point pressure	l-v	268-383	-	50	10	-	comp	
R152a/142b								
Maezawa; Keio U.; Japan								
bubble point pressure	l-v	280-400	-	20-80	48	20kPa	comp	[Mz90a]
saturated liquid density	sl	280-400	-	20-80	48	0.2%	comp	[Mz90a]
vapor-liquid equilibria	l-v	280-400	-	20-80	48	0.1%	comp	[Mz90a]
R152a/114								
Higashi; Iwaki Meisei U.; Japan								
V-L-E correlation	sl,sv	230-T_c	-	--	--	--	comp	[Hg89]
R227/123								
Gorenflo; U. Paderborn; FRG								
bubble-point pressure	l-v	293-423	-	(3 comp)	--	--	9/90-->	
saturated liquid density	sl	293-423	-	(3 comp)	--	--	9/90-->	
saturated vapor density	sv	293-423	-	(3 comp)	--	--	9/90-->	

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RESPONDING ORGANIZATIONS

AUSTRALIA

Australian National University
Research School of Physical Sciences
Canberra, A.C.T. 26

principal investigator:	
L. A. Woolf	61-6-249-2400
facsimile:	61-6-249-1884
other researcher:	
R. K. Malhotra	
apparatus and techniques employed:	
pressure-volume-temperature:	bellows volumometer; vibrating tube densimeter
viscosity:	not specified
sample purity analysis:	supplier's analysis

CANADA

Centre de Recherche Industrielle du Québec
333 rue Franquet
Case Postale 9038
Sainte-Foy, Québec G1V 4C7

principal investigator	
Mr. Michel Boulanger	1-418-659-1550
Paul Larue	1-418-659-1550
facsimile	1-418-652-2251
apparatus and techniques employed:	
vapor-liquid equilibria	variable volume cell

University of Moncton
Department of Mechanical Engineering
Moncton, New Brunswick E1A 3E9

principal investigator:	
Prof. Samuel Sami	1-506-858-4194
facsimile	1-506-858-4585
other researchers:	
W. Leblanc	1-506-858-6916
L. Fang	1-506-858-4871
J. Schnotale	1-506-858-4871

National Research Council of Canada
Low Temperature Laboratory
Montreal Road
Ottawa, Ontario K1A 0R6

principal investigators:

W. Keith Snelson	1-613-993-4892
Jeff Linton	
facsimile	1-613-954-1235

apparatus and techniques employed:

viscosity	falling ball viscometer

University of New Brunswick
P.O. Box 4400
Fredericton, New Brunswick E3B 5A3

principal investigator:

Prof. James Venart	1-506-453-4509
facsimile	1-506-453-5025

other researchers:
R. C. Prasad
G. H. Wang

apparatus and techniques employed:

thermal conductivity/diffusivity	transient hot wire

Tianjin University
Thermal Energy Research Institute
Tianjin 300072

principal investigator:
Prof. Lu Canren 86-33-3704-3451
facsimile: 86-33-318329

other researchers:
Dr. Ma Yitai 86-33-3704-2821
Prof. He Zhimai

techniques employed:	
equation of state:	Redlich-Kwong-Soave and Martin-Hou equations

Tsinghua University
Department of Thermal Engineering
Beijing, 100084

principal investigator:
Zhu Mingshan 86-1-2561141 x2987
facsimile: 86-1-2562768

other researchers:
Wang Bu-Xuan
Lin Zhao-Zhuang
Han Li-Zhong

apparatus and techniques employed:	
vapor pressure:	constant volume method
saturation density:	magnetic suspension densimeter
pressure-volume-temperature:	Burnett method
sound speed:	accoustic method
surface tension:	capillary rise method
thermal conductivity:	steady-state method
viscosity:	capillary method
sample purity analysis:	supplier's analysis

Xi'an Jiaotong University
Department of Power Machinery Engineering
Xi'an, Shaanxi Province 710049

principal investigator:
J. M. Yin — cc+32911-727
facsimile: — cc+029-335471

other researchers:
J. X. Guo
L. C. Tan
Z. Y. Zhao

apparatus and techniques employed:

vapor pressure:	constant volume method
saturation density:	not specified
critical parameters:	observation of meniscus for temperature and density
sample purity analysis:	not specified

Zhejiang University
Laboratory of Chemical Engineering Thermodynamics
Department of Chemical Engineering
Hangzhou, 310027

principal investigator:
Prof. Hou Yujun — cc+572244-2921
telex: — 35040 ZUFAO CN

other researchers:
Prof. Wu Zhaoli — cc+572244-3246
Dr. Chen Guangming — cc+572244-2621
Li Changsen — cc+572244-2621

apparatus and techniques employed:

mixture V-L-E:	Rose-William cell; vapor circulation technique;Martin-Hou equation of state
sample purity analysis:	own analysis

CZECHOSLOVAKIA

Czech Technical University
College of Mechanical Engineering
Technikká 4
166 07 Prauge 6

principal investigator:

Dr. Václav Vacek	cc+332-2581
facsimile	cc+311-2768

other researchers:
Jiri Petrak

apparatus and techniques employed

pressure-volume-temperature:	constant volume piesometer
sample purity analysis:	own analysis

FRANCE

Universite Paris Nord
Laboratoiré d'Ingénierie des Materiaux et Hautes Pressions
Avenue J. B. Clément
93430 Villetaneuse

principal investigator:

Dr. B. LeNeindre	33-1-49-40-34-38
facsimile	33-1-49-40-33-33

other researchers:

apparatus and techniques employed

vapor pressure:	not specified
pressure-volume-temperature:	vibrating tube densimeter
critical parameters:	not specified
sound speed:	not specified
thermal conductivity:	coaxial cylinder
sample purity analysis:	supplier's analysis

Universität Duisburg
Fachgebiet Thermodynamik
Lotharstraße 1
4100 Duisburg

principal investigator:
Prof. Dr.-Ing. Klaus Lucas 49-2031-379-3355

other researchers:
U. Delfs

apparatus and techniques employed

ideal gas properties:	statistical thermodynamics

Universität Erlangen-Nürnberg
Lehrstuhl Für Technische Thermodynamik
Am Weichselgarten 9
8520 Erlangen

principal investigator:
Prof. Dr.-Ing. A. Leipertz 49-9131-699-162
facsimile 49-9131-699-161

apparatus and techniques employed

sound speed:	photon correlation spectroscopy
thermal diffusivity:	photon correlation spectroscopy
sample purity analysis:	not specified

Universität Hannover
Institut für Kältetechnik und Angewandte Wärmetechnik
Welfengarten 1a
D-3000 Hannover 1

principal investigator:
Prof. Dr.-Ing. H. Kruse 49-511-762-2358
facsimile 49-511-762-5203

apparatus and techniques employed

vapor pressure:	not specified
saturated liquid density:	pycnometer
viscosity:	falling ball viscometer
sample purity analysis:	own analysis
predictive methods:	functional group methods

Universität Hannover
Institut für Thermodynamik
Callinstraße 36
D-3000 Hannover 1

principal investigator:

Prof. Dr.-Ing. H. D. Baehr	49-511-762-2277
facsimile	49-511-762-3456

apparatus and techniques employed

vapor pressure:	not specified
saturated liquid density:	vibrating tube densimeter
pressure-volume-temperature:	Burnett apparatus; vibrating tube densimeter
mixture V-L-E	VLE apparatus
sample purity analysis:	own analysis

Universität Gesamthochschule Paderborn
Laboratorium für Wärme- und Kältetechnik
Pohlweg 55
D-4790 Paderborn

principal investigator:

Prof. Dr.-Ing D. Gorenflo	49-5251-60-2393
facsimile	49-5251-60-3207 or -2519

other researchers:

W. Rott	49-5251-60-2391
H. Schömann	49-5251-60-2391
S. Caplanis	49-5251-60-2390
G. Herres	49-5251-60-2394

apparatus and techniques employed

vapor pressure:	static equilibrium cell
saturation density:	static equilibrium cell with vibrating tube densimeter
sample purity analysis:	own analysis

Universität Kaiserslautern
Lehrstuhl für Technische Thermodynamik
Erwin-Schrödinger-Straße
Postfach 3049
D-6750 Kaiserslautern

principal investigator:

Prof. Dr.-Ing. G. Maurer	49-631-205-2311
facsimile	49-631-205-3055

other researchers:

Dipl.-Ing. B. Platzer	49-631-205-2410

apparatus and techniques employed

equation of state:	Bender equation of state

Universität Karlsrühe
Institute für Physikalische Chemie und Elektrochemie
Kaiserstraße 12, Postfach 6380
7500 Karlsruhe 1

principal investigator:

Prof. Dr. E. U. Franck	49-721-608-2101
facsimile	49-721-696-324

apparatus and techniques employed

dielectric constant:	capacitance technique

Universität Karlsrühe
Institute für Technische Thermodynamik und Kältetechnik
Postfach 6980
7500 Karlsruhe 1

principal investigator:

Prof. Dr. K. Bier	49-721-608-2321
Prof. Dr.-Ing. L. Oellrich	49-721-608-2332
facsimile	49-721-66-1874

apparatus and techniques employed

vapor pressure:	static equilibrium cell
pressure-volume-temperature:	Burnett apparatus
critical parameters:	static equilibrium cell
heat capacity:	adiabatic flow calorimeter
sample purity analysis:	own analysis & supplier's analysis
equation of state:	not specified

Technische Universität München
Lehrstuhl A für Thermodynamik
Archisstraße 21
8000 München 2

principal investigators:

Prof. Dr.-Ing. J. Straub	49-89-2105-3438
Prof. Dr.-Ing. F. Mayinger	49-89-2105-3435
facsimile	49-89-2105-3451

other researchers:

Dipl.-Ing. B. Kruppa	49-89-2105-3452
Dr.-Ing. H. Nabizadeh	49-89-2105-3436

apparatus and techniques employed

pressure-volume-temperature:	not specified
critical parameters:	not specified
surface tension:	capillary rise
thermal diffusivity:	dynamic light scattering
refractive index:	not specified
viscosity:	oscillating disk viscometer
sample purity analysis:	supplier's analysis

Physikalisch-Chemisches Institut der Universität
Im Neuenheimer Feld 253
D-6900 Heidelberg

principal investigator:
Prof. B. Schramm 49-6221-563456

apparatus and techniques employed
pressure-volume-temperature: measurement of second virial coefficients
sample purity analysis: supplier's analysis

Physikalisch-Technische Bundesanstalt
Heat Division
Bundesallee 100
D-3300 Braunschweig

principal investigators:
Dr. W. Blanke 49-531-592-3100
Dr. W. Hemminger 49-531-592-3010
facsimile 49-531-592-4006

other researchers:
Dr. R. Weiß 49-531-592-3110
Dr. U. Hammerschmidt 49-531-592-3211

apparatus and techniques employed
vapor pressure: constant volume method
pressure-volume-temperature: constant volume method
triple point temperature: not specified
thermal conductivity: guarded hot plate
sample purity analysis: supplier's analysis

Universität Rostock
Sektion Chemie
WB Physikalische Chemie
Hermannstraße 14
Rostock 1, O-2500

principal investigators:
Dr. J. K. Lehmann 37-81-25509
Doz. Dr. J. Millat 37-81-25509
facsimile 37-81-369-666

apparatus and techniques employed
dielectric constant: cyclic expansion method
sample purity analysis: own analysis

Ruhr Universität Bochum
Institüt für Thermodynamik
Postfach 10 21 48
D-4630 Bochum 1

principal investigator:
Prof. Dr.-Ing. W. Wagner 49-234-700-3030
facsimile 49-234-700-2541

other researchers:

apparatus and techniques employed

vapor pressure:	single- and dual-sinker densimeters
saturated liquid density:	single- and dual-sinker densimeters
saturated vapor density:	single- and dual-sinker densimeters
pressure-volume-temperature:	single- and dual-sinker densimeters
sample purity analysis:	supplier's analysis
equation of state:	multi-property fit

Ruhr Universität Bochum
Institüt für Thermo- und Fluiddynamik
P.O. Box 10 2148
D-4630 Bochum 1

principal investigator:
Prof. F. Kohler 49-234-700-6389
facsimile 49-234-700-2541

other researchers:
R. Kohlen

apparatus and techniques employed

vapor pressure:	isochoric PVT
pressure-volume-temperature:	isochoric PVT; Burnett apparatus
sound speed	spherical resonator
sample purity analysis:	own analysis

Ruhr Universität Bochum
Thermo- und Fluiddynamik
Wärme und Stoffübertragung
Universitätstraße 150
D-4630 Bochum 1

principal investigator:

M. Fiebig	49-234-700-3083
facsimile	49-234-700-2000

other researchers:

M. Ibreighith	49-234-700-6680
G. Wu	49-234-700-6680
J. Wang	49-234-700-6680

apparatus and techniques employed

thermal diffusivity:	photon correlation spectroscopy
sample purity analysis:	supplier's analysis

Universität Stuttgart
Institut für Techniche Thermodynamik und Thermische Verfahrenstechnik
Pfaffenwaldring 9
D-7000 Stuttgart 80

principal investigator:

Prof. Dr.-Ing. K. Stephan	49-711-685-6102
facsimile	49-711-685-6140

other researchers:

R. Krauss	49-711-685-6566
Dipl.-Ing. B. Taxis	49-711-685-6113

apparatus and techniques employed

thermal conductivity:	transent hot wire
sample purity analysis:	supplier's analysis
data base project	

Universität Stuttgart
Institut für Thermodynamik und Wärmetechnik
Pfaffenwaldring 6
7000 Stuttgart 80

principal investigators:

Dr. U. Gross	49-711-685-3536
Prof. E. Hahne	49-711-685-3536
facsimile	49-711-685-3280

apparatus and techniques employed

thermal conductivity:	transient hot wire
sample purity analysis:	not specified

Hochschule für Verkehrswesen
Friedrich-List-Platz 1
Dresden, O-8010

principal investigator:
Dipl.-Ing. J. Morgenstern 37-51-462-2592

other researchers:
Dr. I. Ebinger
Dr. J. Senst

apparatus and techniques employed
equation of state: Redlich-Kwong-Soave equation; incremental methods (Lydersen, Riedel, Westmeier, etc.)

GREECE

Aristotle University
Chemical Engineering Department
University Box 453
GR54001 Thessaloniki

principal investigator:

Prof. Marc J. Assael	30-31-991532
facsimile:	30-31-206138

other researchers:
Mr. L. Karagiannidis

apparatus and techniques employed:

thermal conductivity:	transient hot wire
viscosity:	vibrating wire
sample purity analysis:	not specified

INDIA

Indian Institute of Science
Instrumentation and Services Unit
Bangalore 560-012

principal investigator:

K. Srinivasan	91-812-344411 x2249
facsimile:	91-812-341683

technique employed:

equation of state:	corresponding states

Universita di Ancona
Dipartimento di Energetica
Via Brecce Bianche
I-60100 Ancona

principal investigator:
Carlo Baroncini 39-71-5893765
facsimile 39-71-894677

other researchers:
Marco Pacetti 39-71-894780
Fabio Polonara 39-71-5893765
Giuliani Giuliano 39-71-5893766

apparatus and techniques employed

vapor pressure:	constant volume technique
pressure-volume-temperature:	constant volume technique
sample purity analysis:	own analysis

Asahi Glass Company, Ltd.
10, Goikaigan, Ichihara-shi, Chiba 290

principal investigator:
M. Fukushima 81-436-23-3151
facsimile: 81-436-23-3164

other researchers:
N. Watanabe
T. Kaminura

apparatus and techniques employed:

vapor pressure:	constant volume method
saturation density:	buoy method; constant volume method
pressure-volume-temperature:	constant volume method
critical parameters:	visual observation of meniscus for density and temperature
sample purity analysis:	own analysis

Iwaki Meisei University
5-5-1 Iino, Chuodai, Iwaki 970

principal investigator:
Y. Higashi 81-246-29-5111
facsimile 81-246-28-5415

apparatus and techniques employed

surface tension:	Wilhelmy method
mixture V-L-E:	original correlation

Kanagawa Institute of Technology
Shimo-ogino 1030, Atsugi, 243-02

principal investigator:
Dr. K. Oguchi 81-462-41-1211
facsimile: 81-462-42-3737

other researchers:
Y. Takaishi
N. Yada

apparatus and techniques employed

vapor pressure:	constant volume method
saturation density:	buoy method; constant volume method
pressure-volume-temperature	constant volume method
equation of state:	extended Bennedict-Webb-Rubin

Keio University
Thermodynamics Laboratory
Faculty of Science and Technology
3-14-1, Hiyoshi, Kohoku-ku, Yokohama 223

principal investigators:

Prof. Koichi Watanabe	81-45-563-1141 x3127
Dr. Haruki Sato	81-45-563-1141 x3106
facsimile	81-45-563-3421

graduate students and other collaborators:

N. Ehara	Y. Hayakawa	Y. Higashi
T. Hori	A. Hoshi	Y. Kabata
K. Kumagai	Y. Maezawa	T. Majima
H. Miyahara	T. Naito	S. Nakagawa
A. Ogino	S. Okazaki	C. C. Piao
Z. Y. Qian	A. Saitoh	S. Sakakibara
N. Sezaki	T. Shimokawa	T. Tamatsu
S. Tanakawa	J. Tatoh	J. V. Widiatomo

apparatus and techniques employed

vapor pressure:	magnetic densimeter; constant volume method; Burnett method
saturated liquid density:	magnetic densimeter; visual critical point cell; constant volume method
saturated vapor density:	visual critical point cell
pressure-volume-temperature:	magnetic densimeter; constant volume method; Burnett-isochoric method
critical parameters:	visual cell for temperature and density
heat capacity:	flow calorimeter
sample purity analysis:	supplier's analysis
equation of state:	25-term virial

Keio University
3-14-1, Hiyoshi, Kohoku-ku, Yokohama 223

principal investigators:

A. Nagashima	81-44-63-1141
Y. Nagasaka	81-44-63-1141
facsimile:	81-44-62-7625

apparatus and techniques employed

thermal conductivity:	transient hot wire
viscosity:	capillary viscometer
sample purity analysis:	supplier's analysis

Kobe University
Department of Chemical Engineering
Rokkodai, Nada, Kobe 657

principal investigators

Prof. T. Makita	81-78-881-1212
Dr. Y. Tanaka	81-78-881-1212
Dr. S. Matsuo	81-78-881-1212
Dr. H. Kubota	81-78-881-1212
facsimile:	81-78-802-3564

apparatus and techniques employed

vapor pressure:	constant volume method
pressure-volume-temperature	vibrating-tube densimeters (commercial and modified); constant volume method; Burnett method; high-pressure Burnett method
critical parameters:	observation of meniscus
heat capacity:	flow calorimeter
mixture V-L-E	vapor liquid circulation method
dielectric constant:	frequency counting method; LCR meter
thermal conductivity:	stationary coaxial cylinder; transient hot wire
viscosity:	rolling ball viscometer; falling cylinder viscometer
sample purity analysis:	supplier's analysis

Kyoto Institute of Technology
Department of Chemical Engineering
Faculty of Engineering and Design
Matsugasaki, Sakyoku, Kyoto 606

principal investigators

T. Takagi	81-75-791-3211
J. Yata	81-75-791-3211
facsimile:	81-75-711-9843

other researchers:

- M. Hori
- T. Minamiyama
- C. Kawashima

apparatus and techniques employed

sound speed:	sing-around method
thermal conductivity:	transient hot wire
sample purity analysis:	supplier's analysis

Matsushita Electric Industrial Company, Ltd.
Living Environmental Systems Research Lab
3-15 Yagumo-Nakamachi, Moriguchi, Osaka 570

principal investigator
Yuji Yoshida 81-6-906-4844
facsimile: 81-6-906-4590

other researchers:
Koji Arita
Masami Funakura

apparatus and techniques employed
mixture V-L-E static V-L-E method
sample purity analysis: supplier's analysis

Nagaoka University of Technology
Department of Mechanical Engineering
1603-1, Kamitomioka, Nagaoka, Niigata 940-21

principal investigator
Masaaki Okada 81-258-46-6000 x7143
facsimile 81-258-46-6972

other collaborators:
M. Hattori
K. Watanabe

apparatus and techniques employed
surface tension: single and differential capillary rise
sample purity analysis: supplier's analysis

National Chemical Laboratory for Industry
Chemical Systems Division
1-1, Higashi, Tsukuba-shi 305
Ibaraki

principal investigator
T. Akiya 81-298-54-4661
facsimile: 81-298-54-4487

other researcher:
M. Nakaiwa

apparatus and techniques employed:
mixture V-L-E: not specified
sample purity analysis: own analysis

Tohoku University
Chemical Research Institute of Non-Aqueous Solutions
2-1-1 Katahira, Aoba-ku, Sendai 980

principal investigators:

S. Takahashi	81-22-227-6200 x3446
C. Yokoyama	81-22-227-6200 x3447

other researchers:

A. Kumagai	81-22-227-6200 x3448
K. Otake	81-22-227-6200 x3447
M. Takahashi	81-22-227-6200 x3448
facsimile	81-22-223-8956

apparatus and techniques employed

vapor pressure:	static method
pressure-volume-temperature:	isochoric method
saturated liquid density:	pycnometer
viscosity:	oscillating-disk viscometer; capillary viscometer
sample purity analysis:	supplier's analysis

Ajou University
Department of Mechanical Engineering
5 Won Chon Dong
Suwon 440-380

principal investigator:

Youngmoo Park	82-2-231-7121 x646
facsimile:	82-331-33-5158

techniques employed:

equation of state:	Carnahan-Starling equation

Korea Standards Research Institute
Temperature Laboratory
P.O. Box 3
Taedok Science Town
Taejou

principal investigator:

Dr. Hee-Baik Chae	82-2-820-5199
facsimile:	82-2-231-6813

apparatus and techniques employed:

surface tension:	capillary rise technique
refractive index:	optical method
thermal conductivity:	transient hot wire
sample purity analysis:	supplier’s analysis

Seoul National University
Department of Mechanical Engineering
Seoul 151-742

principal investigator:

Sung Tack Ro	82-2-883-7111
facsimile:	82-2-883-0179

apparatus and techniques employed:

thermal conductivity:	transient hot wire
sample purity analysis:	supplier's analysis
equation of state:	not specified

PORTUGAL

Universidade de Lisboa
Departamento de Química
Campo Grande, Bloco C1
1700 Lisboa

principal investigator:

Prof. Dr. Carlos Nieto de Castro	351-1-7583141
facsimile	351-1-7599404

other researchers:
U. V. Mardolcar
J. M. N. A. Fareleira

apparatus and techniques employed

pressure-volume-temperature:	vibrating tube densimeter
dielectric constant:	capacitance measurement
thermal conductivity:	concentric cylinder method; transient hot wire
sample purity analysis:	supplier's analysis

SPAIN

Universidad Politecnica de Canarias
Cátedra de Termodinámica Escuela
Escuela Superior de Ingenieros Industriales
Tafira Baja, 35071-Las Palmas
Canary Islands

principal investigator:

Prof. Juan Ortega Saavedra	34-28-353500
facsimile	34-28-353900

other researchers:
Dr. Santiago Matos
Dr. Juan A. Peña
Dr. Salvador Galván

apparatus and techniques employed

vapor pressure:	not specified
saturated liquid density:	not specified
heat capacity:	not specified
refractive index:	not specified
sample purity analysis:	not specified

SWEDEN

Chalmers University of Technology
Department of Chemical Engineering Design
S-412 96 Göteborg

principal investigators:

Dr. Krister Ström	46-31-722946
facsimile	46-31-167194

apparatus and techniques employed

pressure-volume-temperature:	vibrating tube densimeter
heat capacity:	Setaram BT calorimeter
mixture V-L-E	Jones circulation unit
viscosity:	Höppler viscometer
sample purity analysis:	supplier's analysis

U.S.S.R

The Institute of Low Temperature and Power Engineering
270057, Odessa
ul. Petra Velikugo, 1/3

principal investigators:

V. J. Los	cc+209-170
A. V. Los	cc+209-112

techniques employed:

equation of state:	virial equation

University of Bristol
School of Chemistry
Cantock's Close
Bristol BS8 1TS

principal investigator:
Dr. C. J. Wormald — 44-272-303-030 x4719
facsimile — 44-272-250-612

apparatus and techniques employed

enthalpy:	flow calorimeter
sample purity analysis:	supplier's analysis

Imperial College
Department of Chemical Engineering
Prince Consort Road
London SW7 2BY

principal investigators:
Prof. J. P. M. Trusler — 44-71-589-5111 x4358
Prof. W. A. Wakeham — 44-71-225-8300
Dr. K. M. DeReuck
facsimile — 44-71-584-1170

other researchers:
V. Vesovic
R. Craven
S. B. Cha

apparatus and techniques employed

sound speed:	spherical resonator
thermal conductivity	transient hot wire
viscosity	vibrating wire
sample purity analysis:	supplier's analysis
equation of state:	Wagner algorithm

National Engineering Laboratory
Energy and Environment Centre
East Kilbride
Glasgow G75 0QU

principal investigator:
Dr. J. T. R. Watson — 44-3552-20222
Dr. A. I. Johns — 44-3552-20222
facsimile — 44-3552-63398

other researchers:
W. Gaskill

apparatus and techniques employed

pressure-volume-temperature:	single sinker magnetic suspension densimeter
thermal conductivity:	transient hot wire
sample purity analysis:	supplier's analysis

Polytechnic South West
Department of Environmental Sciences
Drake Circus, Plymouth
Devon PL4 8AA

principal investigator:
Dr. G. P. Matthews — 44-752-233021
facsimile — 44-752-232293

other researchers:
D. C. Dowdell

apparatus and techniques employed

viscosity:	gas phase capillary flow viscometry
sample purity analysis:	not specified

Clemson University
Department of Chemistry
Clemson, South Carolina 29634-1905

principal investigator:
Prof. Darryl D. DesMarteau

other researchers:
Dr. Adolph L. Beyerlein
Sun Hee Hwang

apparatus and techniques employed

vapor pressure:	not specified
critical parameters:	not specified
sample purity analysis:	own analysis

Cornell University
School of Chemical Engineering
377 Olin Hall
Ithaca, New York 14853-5201

principal investigator:

Dr. John A. Zollweg	1-607-255-7101
facsimile	1-607-255-9166

apparatus and techniques employed

pressure-volume-temperature:	gas expansion technique
speed of sound:	pulse-echo-overlap technique
sample purity analysis:	supplier's analysis

University of Idaho
Center for Applied Thermodynamic Studies
Moscow, Idaho 83843

principal investigators:

Prof. Richard T. Jacobsen	1-208-885-6479
Dr. Steven Penoncello	1-208-885-7245
Dr. Steven Beyerlein	1-208-885-7245
facsimile	1-208-885-6645

apparatus and techniques employed

equation of state:	fundamental EOS, MBWR, selection algorithm

University of Maryland
Institute for Physical Science and Technology
College Park, Maryland 20742

principal investigator:

Prof. Jan V. Sengers	1-301-405-4805
facsimile	1-301-314-9404

other researchers:
S. Tang

apparatus and techniques employed

equation of state:	renormalization theory for critical region

National Institute of Standards and Technology
Thermophysics Division
325 Broadway, Mail Stop 838
Boulder, Colorado 80303-3328

principal investigators:

Dr. W. M. Haynes	1-303-497-3247
Dr. James F. Ely	1-303-497-5467
Dr. Tom Bruno	1-303-497-5158
Mr. Dwain Diller	1-303-497-3255
Mr. John Howley	1-303-497-5607
Dr. Marcia L. Huber	1-303-497-5252
Dr. Joe Magee	1-303-497-3298
Dr. Mark McLinden	1-303-497-3580
Dr. Vicki Niesen	1-303-497-5614
Ms. Stephanie Outcalt	1-303-497-5786
Dr. Richard Perkins	1-303-497-5499
Dr. Jamal Sandarusi	1-303-497-3437
facsimile	1-303-497-5224

apparatus and techniques employed

vapor pressure:	isochoric apparatus; V-L-E apparatus
saturated liquid density:	isochoric apparatus; V-L-E apparatus; magnetic suspension densimeter
saturated vapor density:	isochoric apparatus; V-L-E apparatus
pressure-volume-temperature:	isochoric apparatus; magnetic suspension densimeter; vibrating tube densimeter
heat capacity:	adiabatic isochoric calorimeter
thermal conductivity:	transient hot wire
viscosity:	torsionally oscillating quartz crystal
sample purity analysis:	gas chromatography/mass spectrometry; infrared and ultraviolet spectrometry; Karl Fisher moisture analysis
equation of state:	Jacobsen-Stewart BWR; Schmidt-Wagner; extended corresponding states; Carnahan-Starling-DeSantis

National Institute of Standards and Technology
Thermophysics Division
Building 226; Room A-105
Gaithersburg, Maryland 20899

principal investigators:

Dr. Richard F. Kayser	1-301-975-2483
Dr. Michael R. Moldover	1-301-975-2459
Mr. Dana Defibaugh	1-301-975-2471
Mr. John Gallagher	1-301-975-2455
Dr. Keith Gillis	1-301-975-2468
Dr. Anthony R. H. Goodwin	1-301-975-2443
Dr. Christopher W. Meyer	1-301-975-2473
Dr. Graham Morrison	1-301-975-2450
Dr. James Schmidt	1-301-975-2458
Dr. Lloyd A. Weber	1-301-975-2462
facsimile	1-301-869-4020

apparatus and techniques employed

vapor pressure:	variable volume cell; Burnett-isochoric apparatus; ebulliometer
saturated liquid density:	variable volume cell; vibrating-tube densimeter; visual cell
saturated vapor density:	variable volume cell; Burnett-isochoric apparatus; vibrating tube densimeter
pressure-volume-temperature:	Burnett-isochoric apparatus; vibrating-tube densimeter
critical parameters:	visual cell; variable volume cell
sound speed:	spherical acoustic resonator
surface tension:	differential capillary rise technique
dielectric constant:	capacitance technique
sample purity analysis:	NIST-Boulder
equation of state:	Carnahan-Starling-DeSantis

Oak Ridge National Laboratory
Energy Division
P.O. Box 2009
Oak Ridge, Tennessee 37831

principal investigators:

Dr. James R. Sand	1-615-574-5819
S. K. Fischer	
facsimile	1-615-574-9338

apparatus and techniques employed:

equation of state:	Lee-Kessler-Plöcker

University of Tennessee-Knoxville
Department of Chemistry
Knoxville, Tennessee 37996-1600

principal investigator:

Prof. James L. Adcock	1-615-974-3391
facsimile	1-615-974-3454

other researchers:
Prof. W. Alexander Van Hook
Bao-Hai Wang
Shyam B. Mathur

apparatus and techniques employed

vapor pressure:	isochoric apparatus
saturated liquid density:	vibrating tube densimeter
pressure-volume-temperature:	vibrating tube densimeter; isochoric apparatus
critical parameters:	visual cell
sample purity analysis:	capillary gas-liquid chromatography

Texas A&M University
Department of Chemical Engineering
College Station, Texas 77843-3122

principal investigators:

Prof. James C. Holste	1-409-845-3384
Prof. K. R. Hall	1-409-845-3357
facsimile	1-409-845-6446

apparatus and techniques employed

vapor pressure:	isochoric apparatus
pressure-volume-temperature:	isochoric apparatus; Burnett apparatus; continuously weighed pycnometer; vibrating tube densimeter
critical parameters:	visual cell
sample purity analysis:	supplier's analysis

Texas A&M University
Thermodynamics Research Center
College Station, Texas 77843-3111

principal investigators:

Prof. K. N Marsh	1-409-845-4940
Prof. B. E. Gammon	1-409-845-2930
facsimile	1-409-845-6446

apparatus and techniques employed

ideal gas properties:	statistical mechanics
fluid property database:	wide variety of compounds including refrigerants

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M.O. McLinden, W.M. Haynes, J.T.R. Watson*, and K. Watanabe **

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*Energy and Environment Centre, National Engineering Laboratory, Glasgow, United Kingdom
**Department of Mechanical Engineering, Keio University, Yokohama, Japan

11. ABSTRACT (A 200-WORD OR LESS FACTUAL SUMMARY OF MOST SIGNIFICANT INFORMATION. IF DOCUMENT INCLUDES A SIGNIFICANT BIBLIOGRAPHY O[R] LITERATURE SURVEY, MENTION IT HERE.)

This survey represents an exhaustive compilation of the research activities throughout the world concerned with either measurements or correlations of the thermophysical properties of alternative refrigerants. The properties covered in this study include thermodynamic, transport, phase equilibria, and other properties such as dielectric constant and refractive index. This survey has included a wide range of fluids (including R23, R32, R125, R143a, R22, R134a, R152a, R134, R124, R142b, R123, R123a, R141b) along with mixtures containing at least one of these fluids. This report presents in tabular form summary information about each research activity; this survey does not present raw data or correlating equations.

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