

92018

Issued June 1992

Orthobaric densities and molar volumes of liquids

Halogenated Ethylenes

ESDU Copyright material. For current status contact ESDU.

Endorsed by
The Institution of Chemical Engineers



ESDU
Documents
International

ESDU DATA ITEM No.92018

ESDU DATA ITEMS

Data Items provide validated information in engineering design and analysis for use by, or under the supervision of, professionally qualified engineers. The data are founded on an evaluation of all the relevant information, both published and unpublished, and invariably supported by original work of ESDU staff engineers or consultants. The whole process is subject to independent review for which crucial support is provided by industrial companies, government research laboratories, universities and others from around the world through the participation of some of their leading experts on ESDU Technical Committees. This process ensures that the results of much valuable work (theoretical, experimental and operational), which may not be widely available or in a readily usable form, can be communicated concisely and accurately to the engineering community.

THE PREPARATION OF THIS DATA ITEM

The work on this particular Data Item was monitored and guided by the Physical Data and Reaction Kinetics Committee, which first met in 1966 and now has the following membership:

Chairman	
Dr D.T.Jamieson	— Independent
Vice-Chairman	
Mr C.F.Beaton	— Independent
Members	
Dr D.Ambrose†	— Independent
Dr E.Brunner*	— BASF AG, Ludwigshafen, West Germany
Dr M.W.Chase*	— National Institute of Standards and Technology, Gaithersburgh, USA
Dr J.R.Downey*	— Dow Chemical, Midland, USA
Dr B.Edmonds	— Infochem Computer Services Ltd
Dr G.Hobson	— Imperial Chemical Industries plc, Petrochemicals and Plastics Division
Jr A.E.Humphreys	— British Gas plc
Mr S.R.Knight	— Stone & Webster Engineering Ltd
Dr K.N.Marsh*	— Thermodynamics Research Center, USA
Mr J.T.R.Watson	— National Engineering Laboratory.

The technical work involved in the assessment of the available information and the construction and subsequent development of the Data Item was undertaken (under contract to ESDU) by

Mr J.Walton	— Independent
-------------	---------------

in consultation with Dr D.Ambrose.

The person with overall responsibility for the work in this subject area is Mr S.J.Pugh, Head of Thermofluids Group.

KEEPING UP TO DATE

We are constantly striving to develop new work and review data already issued. Any comments arising out of your use of our data, or any suggestions for new topics or information that might lead to improvements, will help us to provide a better service.

(Continued on inside back cover)

*Corresponding Member

†Emeritus Member

ORTHOBARIC DENSITIES AND MOLAR VOLUMES OF LIQUIDS
HALOGENATED ETHYLENES

CONTENTS

1.	INTRODUCTION	page 1
2.	NOTATION AND UNITS	page 2
3.	THE CRITICAL DENSITY	page 2
4.	EVALUATION AND CORRELATION	page 2
5.	UNCERTAINTIES	page 3
6.	REFERENCES	page 3
	COMPOUND NAME INDEX	page 5
	COMPOUND TABLES in the following order	

Sheet No.	Formula	Name	Alternative Name and Refrigerant No.
MONOHALOETHYLENES			
1.1	C_2H_3F	Fluoroethylene	Vinyl fluoride Refrigerant 1141
1.2	C_2H_3Cl	Chloroethylene	Vinyl chloride Refrigerant 1140
1.3	C_2H_3Br	Bromoethylene	Vinyl bromide Refrigerant 1140B1
DIHALOETHYLENES			
	$C_2H_2F_2$	1,1-Difluoroethylene (not issued)	
2.3a	$C_2H_2Cl_2$	1,1-Dichloroethylene	Vinylidene chloride Refrigerant 1130a
2.3b	$C_2H_2Cl_2$	cis-1,2-Dichloroethylene	Refrigerant 1130(cis)
2.3c	$C_2H_2Cl_2$	trans-1,2-Dichloroethylene	Refrigerant 1130(trans)
	$C_2H_2Br_2$	cis-1,2-Dibromoethylene (not issued)	
	$C_2H_2Br_2$	trans-1,2-Dibromoethylene (not issued)	
	$C_2H_2I_2$	cis-1,2-Diiodoethylene (not issued)	
	$C_2H_2I_2$	trans-1,2-Diiodoethylene (not issued)	
TRIALOETHYLENES			
3.2a	C_2HClF_2	Chloro-1,1-difluoroethylene	Refrigerant 1122
3.4	C_2HCl_3	Trichloroethylene	Refrigerant 1120
TETRAHALOETHYLENES			
	C_2F_4	Tetrafluoroethylene (not issued)	
4.2	C_2ClF_3	Chlorotrifluoroethylene	Refrigerant 1113
	$C_2Cl_2F_2$	1,2-Dichlorodifluoroethylene (not issued)	
4.5	C_2Cl_4	Tetrachloroethylene	Perchloroethylene Refrigerant 1110

NB. To allow for the future issue of omitted compounds sheet numbers are not always consecutive.

ORTHOBARIC DENSITIES AND MOLAR VOLUMES OF LIQUIDS
HALOGENATED ETHYLENES

1. INTRODUCTION

This Data Item presents orthobaric densities and molar volumes of the halogenated ethylenes arranged in the order shown on the Contents page. The Compound Name Index lists alternative names of the compounds with, in bold, the first name used for each compound on the Contents page and at the head of each Sheet.

The values of density and molar volume for each compound have been obtained by calculation from the equation given, with its numerical coefficients, at the top of each Sheet. This equation was fitted to the data that had been selected after critical assessment of all the data. The value of the critical temperature for each compound was taken from Item 91006, which gives the vapour pressures. For completeness all the critical parameters of each compound are given in the Tables which also show the density at 298.15 K, where applicable, and for convenience, the approximate normal boiling and melting points.

The table of Data at Specified Temperatures for each compound gives the density, the molar volume and their derivatives with respect to temperature. In addition this table also gives an assessment of the data quality indicated, in decreasing order, by one of the letters 'A', 'B' or 'C', at each temperature. Brackets enclose the data at those temperatures which are outside the range of supporting experimental data. The estimated uncertainties in density and molar volume are shown below each letter in the units of density and molar volume rounded to 1, 2 or 5 times a power of 10.

In the main tables the uncertainties in the tabulated values of density and molar volume are shown for each value. The number of decimal places in each value is adjusted to be consistent with the uncertainty. Data quality and uncertainties are discussed at greater length in Section 5 and in Section 4 of the Introductory Data Item, Reference 4.

The sources of information which give liquid density or liquid molar volume data for the compound considered are listed on the reverse side of each sheet. Those sources that were used to derive the critical density and the coefficients of the liquid density/molar volume equation are shown together with the temperature ranges (ambient, low, medium, high or critical) of their data. These arbitrary temperature ranges are defined more precisely in Section 2 of the Introductory Data Item, Reference 4.

2. NOTATION AND UNITS

All temperatures are based on the International Temperature Scale (ITS-90).

b_1, b_2, b_3, b_4 non-dimensional coefficients of the density/molar volume equation

d liquid density

q $(1-T/T_c)^{1/3}$

T kelvin temperature

t Celsius temperature ($T-273.15$)

V liquid molar volume

Note. The UNITS of temperature, density and molar volume are shown in each table.

Subscripts

b denotes value at normal boiling point

c denotes value at critical point

m denotes value at normal melting point

3. THE CRITICAL DENSITY

In the absence of experimental measurements, the critical density of each liquid was obtained by fitting the latest form of Rackett equation, see References 1, 2 and 3, to the experimental liquid density data. This equation does not represent these data over a long range of temperature as satisfactorily as does the equation used in this Item. However, it does yield reliable values of the critical density for a wide variety of compounds, provided the critical temperature and the critical pressure of each compound are reliably known.

For this Item, the critical temperature was optimised in conjunction with the assessment of the vapour pressure and the critical density was initially taken as the value given by the modified Rackett equation and, where necessary, slightly adjusted to give a smooth variation between compounds. Where comparison was possible, this value was found to be in good agreement with the reported critical densities.

4. EVALUATION AND CORRELATION

Reliable data up to the critical point are available for two of the compounds considered here. Reliable data for the remainder of the compounds are mainly confined to medium reduced temperatures. Thus as there were insufficient compounds with data extensive and reliable enough to form a density correlation for haloethylenes in particular, the density correlation for haloethanes, see Item 92009, was used to derive the density/molar volume equations of the compounds considered here.

5. UNCERTAINTIES

At any temperature, the estimated uncertainties in the tabulated values of density and molar volume are dependent upon the rates of change of these properties with temperature and the quality of the experimental or estimated data upon which they are based. The table of Data at Specified Temperatures shows these derivatives, the assessed data quality (indicated by one of the letters 'A', 'B' or 'C') and the corresponding uncertainties at various points of the liquid range.

At low and medium reduced temperatures average quality data, denoted by the letter 'B', have uncertainties varying from 0.1 to 1 per cent, increasing to between 1 and 10 per cent at the critical point. Data with lower or higher uncertainties than these bands are graded 'A' and 'C' respectively. When the data quality is 'C' it will be appreciated that the uncertainties are necessarily rather speculative and that for some compounds they may be underestimated.

For those compounds for which the data quality at the critical pressure is denoted by 'C' the values of critical temperature and critical density given in the Tables should be regarded only as correlating parameters.

6. REFERENCES

1. RACKETT, H.G. Equation of state for saturated liquids. J. Chem. Eng. Data, Vol.15, No.4, pp.514-517, 1970.
2. SPENCER, C.F.,
DANNER, R.P. Improved equation for prediction of saturated liquid density. J. Chem. Eng. Data, Vol.17, No.2, pp.236-241, 1972.
3. CAMPBELL, S.W.
THODOS, G. Prediction of saturated-liquid densities and critical volumes for polar and non-polar substances. J. Chem. Eng. Data, Vol.30, No.1, pp.102-111, 1985.
4. ESDU Orthobaric densities and molar volumes of liquids. Introduction to Data Items issued after July 1989. Item No. 89018, ESDU ESDU International, 1989.
5. TRC TRC Thermodynamic Tables - Non-Hydrocarbons. Thermodynamics Research Center, Texas A & M University System, College Station, Texas, USA. Loose leaf data sheets extant 1991.

COMPOUND NAME INDEX

The first name given for each compound on the Contents page and at the head of each Sheet is in bold type

Name		Sheet No.
Bromoethylene		1.3
Chloro-1,1-difluoroethylene		3.2a
Chloroethylene		1.2
Chlorotrifluoroethylene		4.2
1,1-Dichloroethylene		2.3a
cis-1,2-Dichloroethylene		2.3b
trans-1,2-Dichloroethylene		2.3c
Fluoroethylene		1.1
Perchloroethylene	see Tetrachloroethylene	4.5
Tetrachloroethylene		4.5
Trichloroethylene		3.4
Vinyl bromide	see Bromoethylene	1.3
Vinyl chloride	see Chloroethylene	1.2
Vinyl fluoride	see Fluoroethylene	1.1
Vinylidene chloride	see 1,1-Dichloroethylene	2.3a

Refrigerant Number Index

Refrigerant	Name	Sheet No.
Refrigerant 1110	see Tetrachloroethylene	4.5
Refrigerant 1113	see Chlorotrifluoroethylene	4.2
Refrigerant 1120	see Trichloroethylene	3.4
Refrigerant 1122	see Chloro-1,1-difluoroethylene	3.2a
Refrigerant 1130(cis)	see cis-1,2-Dichloroethylene	2.3b
Refrigerant 1130(trans)	see trans-1,2-Dichloroethylene	2.3c
Refrigerant 1130a	see 1,1-Dichloroethylene	2.3a
Refrigerant 1140	see Chloroethylene	1.2
Refrigerant 1140B1	see Bromoethylene	1.3
Refrigerant 1141	see Fluoroethylene	1.1

