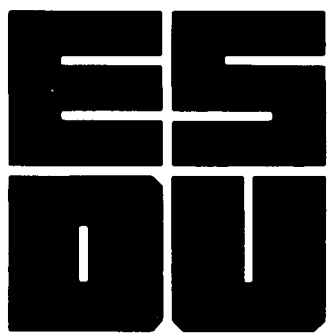


68023



Engineering Sciences Data
Item Number

68023

Approved for Issue
September 1978

Supersedes in part
Item Numbers 67031, 68008,
68009, 68010, 68011

SPONSORS

Institution of Chemical Engineers
Institution of Mechanical Engineers

Thermal conductivity, viscosity, heat capacity, density and Prandtl number of solid, liquid and gaseous heavy water

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ENGINEERING SCIENCES DATA ITEM No. 68023

Physical Data, Chemical Engineering Sub-series

Physical Data, Mechanical Engineering Sub-series

Engineering Sciences Data Items provide evaluated data and authoritative information for use in engineering design. The results of much valuable work, both theoretical and practical, are frequently not applied because they are not readily available or because the form in which they are available is not suitable for use directly in design. Accordingly, the Engineering Sciences Data Unit has for many years issued Data Sheets and Memoranda in numerous Sub-series. This work is sponsored by the following Institutions: the Royal Aeronautical Society, the Institution of Mechanical Engineers, the Institution of Chemical Engineers and the Institution of Structural Engineers. Crucial support for this work is provided voluntarily by industrial companies, government research laboratories, universities and others through the attendance at Technical Committees (see below) of their leading experts.

This Item collects together, and rationalises the presentation of, the data on the physical properties of heavy water that were originally in Item Nos 67031 and 68008 to 68011. Those Items are now being revised because new data have become available on the properties of ordinary water. The work of the permanent professional staff of the Engineering Sciences Data Unit on those Items was monitored and guided by the Fluid Mechanics and Thermodynamics Committee which had the following constitution:

Chairman	
Prof. A.J.Ede	— University of Aston in Birmingham
Vice-Chairman	
Mr E.C.Firman	— Central Electricity Generating Board
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Dr K.E.Bett	— Representing Physical Data and Reaction Kinetics Committee
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Mr A.Linford	— The British Hydromechanics Research Association
Mr G.J.F.Reid	— British Petroleum Co. Ltd
Miss B.Shilling	— Royal Aircraft Establishment.

The Items were accepted for inclusion in the Physical Data, Chemical Engineering Sub-series by the Physical Data and Reaction Kinetics Committee which at that time had the following constitution:

Chairman	
Mr D.P.Plummer	— Shell Refining Co. Ltd
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Dr J.M.Hoffman	— Courtaulds Ltd
Mr M.J.Larkin	— United Kingdom Atomic Energy Authority
Mr G.J.F.Reid	— Representing Fluid Mechanics and Thermodynamics Committee.

The initial assessment of the available information was undertaken by Dr E.A.Bruges at Glasgow University and the member of staff responsible for the final editing of the Items was Mr K.W.Reynard, Chemical Engineering Specialist.

(Continued on inside back cover)

THERMAL CONDUCTIVITY, VISCOSITY, HEAT CAPACITY, DENSITY AND PRANDTL NUMBER OF SOLID, LIQUID AND GASEOUS HEAVY WATER

1. NOTATION AND UNITS

c_p	specific heat capacity	kJ/kg K
Pr	Prandtl number, $c_p \eta / \lambda$	
p	absolute pressure	N/m^2
p_s	saturation pressure	N/m^2
t	temperature	$^{\circ}\text{C}$
η	dynamic viscosity*	N s/m^2
λ	thermal conductivity	W/m K
ρ	density	kg/m^3
<i>Subscripts</i>		
l	denotes saturated liquid	
g	denotes saturated vapour	

2. GENERAL INFORMATION

Critical temperature	371.5°C	700.7°F
Critical pressure	$218 \times 10^5 \text{ N/m}^2$	3162 lbf/in^2
Critical density	338 kg/m^3	21.1 lb/ft^3
Normal boiling point	101.4°C	214.5°F
Normal freezing point	3.8°C	38.8°F

3. CONVERSION FACTORS

1 W/m K	$= 0.8598$	$\text{kcal/m h}^{\circ}\text{C}$
	$= 2.3885 \times 10^{-3}$	$\text{cal/cm s}^{\circ}\text{C}$
	$= 0.5778$	$\text{Chu/ft h}^{\circ}\text{C}$
	$= 0.5778$	$\text{Btu/ft h}^{\circ}\text{F}$
	$= 6.9335$	$\text{Btu in /ft}^2 \text{ h}^{\circ}\text{F}$
10^5 N/m^2	$= 1$	bar
	$= 14.5038$	lbf/in^2
	$= 1.0197$	kgf/cm^2

* The symbol μ is often used for dynamic viscosity.

1 Standard atmosphere	$\equiv 1.01325 \times 10^5$	N/m ²
	$\equiv 760.000$	mmHg
	$\equiv 14.696$	lbf/in ²
1 N s/m ² = 1 kg/m s	$\equiv 10$	g/cm s
	$\equiv 10$	dyn s/cm ²
	$\equiv 10$	poise
	$\equiv 0.6720$	lb/ft s
	$\equiv 0.6720$	pdl s/ft ²
	$\equiv 20.885 \times 10^{-3}$	slug/ft s
	$\equiv 20.885 \times 10^{-3}$	lbf s/ft ²
	$\equiv 0.10197$	kgf s/m ²
4.1868 J	$\equiv 1$	cal
1 kJ/kg K	$\equiv 0.2388$	kcal/kg°C
	$\equiv 0.2388$	Btu/lb°F
	$\equiv 0.2388$	Chu/lb°C
	$\equiv 277.78 \times 10^{-6}$	kWh/kg°C
1 kg/m ³	$\equiv 10^{-3}$	g/cm ³
	$\equiv 10^{-3}$	kg/dm ³
	$\equiv 62.428 \times 10^{-3}$	lb/ft ³
	$\equiv 10.0224 \times 10^{-3}$	lb/UKgal
	$\equiv 8.3454 \times 10^{-3}$	lb/USgal

4. THERMAL CONDUCTIVITY

4.1 Solid Deuterium Oxide

The thermal conductivity of solid heavy water may be expressed by the equation (Derivation 10)

$$\lambda = \frac{455.12}{t + 273.15} - 0.1266 \quad (1)$$

from which the values in the following table have been calculated.

t °C	λ W/m K	t °C	λ W/m K
0	1.54	-100	2.50
-20	1.67	-120	2.85
-40	1.83	-140	3.29
-60	2.01	-160	3.90
-80	2.23		

4.2 Liquid Deuterium Oxide

The thermal conductivity of liquid heavy water is given in Table I along the saturation line (Derivations 4, 6 and 8) and in Table II for temperatures from 80 to 260 °C and pressures from 100×10^5 N/m² to 500×10^5 N/m² (Derivations 4, 6, 8 and 11).

4.3 Gaseous Deuterium Oxide

The thermal conductivity of gaseous heavy water at 10^5 N/m^2 is given in the following table (Derivation 7).

t °C	λ W/m K	t °C	λ W/m K
100	0.0234	350	0.0494
150	0.0278	400	0.0558
200	0.0326	450	0.0625
250	0.0378	500	0.0695
300	0.0434		

5. DYNAMIC VISCOSITY

5.1 Liquid Deuterium Oxide

The dynamic viscosity of liquid heavy water is given in Table I along the saturation line (Derivation 5) and in Table IV for temperatures from 5 to 100 °C and pressures from 10^5 to 10^9 N/m^2 (Derivation 12).

5.2 Gaseous Deuterium Oxide

The dynamic viscosity of gaseous heavy water is given in Table III at one atmosphere pressure (Derivations 2 and 3).

6. SPECIFIC HEAT CAPACITY

6.1 Solid Deuterium

The data of Derivation 1 for the specific heat capacity of solid heavy water may be represented by the equation

$$c_p = 2.223 + 7.0527 t \times 10^{-3} - 4.9757 t^2 \times 10^{-6} \quad (2)$$

where c_p in kJ/kg K and t in °C. The values in the following table have been calculated from this equation except for the value at -273.15 °C.

t °C	c_p kJ/kg K	t °C	c_p kJ/kg K	t °C	c_p kJ/kg K
0	2.223	-100	1.468	-200	0.613
-10	2.152	-110	1.387	-210	0.523
-20	2.080	-120	1.305	-220	0.431
-30	2.007	-130	1.222	-230	0.338
-40	1.933	-140	1.138	-240	0.244
-50	1.858	-150	1.053	-250	0.149
-60	1.782	-160	0.967	-260	0.053
-70	1.705	-170	0.880	-273.15	0
-80	1.627	-180	0.792		
-90	1.548	-190	0.703		