

Thermal conductivity of liquids: Halogenated aliphatic hydrocarbons

Part 1. Halogenated methanes and azeotropic mixtures

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THERMAL CONDUCTIVITY OF LIQUIDS: HALOGENATED ALIPHATIC HYDROCARBONS

Part 1. Halogenated methanes and azeotropic mixtures

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Data sheets for each of the liquids are given in the following order:

Formula	Name	Alternative Name(s)
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MONOHALOMETHANES

1. CH ₃ F	Fluoromethane	Methyl fluoride	Refrigerant 41	7
2. CH ₃ Cl	Chloromethane	Methyl chloride	Refrigerant 40	8
3. CH ₃ Br	Bromomethane	Methyl bromide	Refrigerant 40B1	9
4. CH ₃ I	Iodomethane	Methyl iodide		10

DIHALOMETHANES

5. CH ₂ F ₂	Difluoromethane	Methylene difluoride	Methylene fluoride Refrigerant 32	11
6. CH ₂ ClF	Chlorofluoromethane	Methylene chlorofluoride	Refrigerant 31	12
7. CH ₂ Cl ₂	Dichloromethane	Methylene dichloride	Methylene chloride Refrigerant 30	13
8. CH ₂ BrCl	Bromochloromethane	Methylene bromochloride	Refrigerant 30B1	14

Formula Name Alternative Name(s)

9. CH₂Br₂ Dibromomethane Methylene dibromide Methylene bromide Refrigerant 30B2 15

10. CH₂I₂ Diiodomethane Methylene diiodide Methylene iodide 16

TRIHALOMETHANES

11. CHF₃ Trifluoromethane Fluoroform Refrigerant 23 17

12. CHClF₂ Chlorodifluoromethane Refrigerant 22 18

13. CHBrF₂ Bromodifluoromethane Refrigerant 22B1 20

14. CHF₂I Difluoroiodomethane 21

15. CHCl₂F Dichlorofluoromethane Refrigerant 21 22

16. CHBrFI Bromofluoroiodomethane 24

17. CHFI₂ Fluorodiiodomethane 25

18. CHCl₃ Trichloromethane Chloroform Refrigerant 20 26

19. CHCl₂I Dichloroiodomethane 28

20. CHClI₂ Chlorodiiodomethane 29

21. CHBr₃ Tribromomethane Bromoform Refrigerant 20B3 30

TETRAHALOMETHANES

22. CF₄ Tetrafluoromethane Carbon tetrafluoride Refrigerant 14 31

23. CClF₃ Chlorotrifluoromethane Refrigerant 13 32

24. CBrF₃ Bromotrifluoromethane Refrigerant 13B1 33

25. CCl₂F₂ Dichlorodifluoromethane Refrigerant 12 34

26. CBrClF₂ Bromochlorodifluoromethane Refrigerant 12B1 36

27. CBr₂F₂ Dibromodifluoromethane Refrigerant 12B2 37

28. CCl₃F Trichlorofluoromethane Refrigerant 11 38

29. CCl₂FI Dichlorofluoroiodomethane 40

30. CCl₄ Tetrachloromethane Carbon tetrachloride Refrigerant 10 41

31. CBrCl₃ Bromotrichloromethane Refrigerant 10B1 44

32. CBr₄ Tetrabromomethane Carbon tetrabromide Refrigerant 10B4 45

AZEOTROPIC MIXTURES

33. Refrigerant 500 60.6% mol R-12 + 39.4% mol R-152a Azeotrope 46

34. Refrigerant 502 63.0% mol R-22 + 37.0% mol R-115 Azeotrope 47

35. Refrigerant 503 50.0% mol R-13 + 50.0% mol R-23 Azeotrope 48

36. Refrigerant 31 + 114 75.4% mol R-31 + 24.6% mol R-114 Azeotrope 49

THERMAL CONDUCTIVITY OF LIQUIDS: HALOGENATED ALIPHATIC HYDROCARBONS

Part 1. Halogenated methanes and azeotropic mixtures

1. INTRODUCTION

This Item presents values of thermal conductivity at saturation pressure, in tabular form, for liquid halogenated methanes and azeotropic mixtures.

The data on which these recommended values of thermal conductivity are based are the most reliable available and the temperature range covered is from the melting temperature to approximately 0.9 of the critical temperature. Quantities are expressed in SI units and conversion factors to other units are provided in Section 3.

Section 4 describes the procedure used to obtain the values of thermal conductivity presented and indicates the effect of pressure. Section 5 gives an explanation of the Tables and indicates the uncertainties in the values presented in them.

References to sources of supplementary information are given in Section 6. The data sources for each particular compound are listed on the appropriate data sheet.

2. NOTATION AND UNITS

The SI unit of thermal conductivity is the watt per metre kelvin (W/m K). A convenient submultiple SI unit for the range of thermal conductivity in this Item is the milliwatt per metre kelvin (mW/m K); hence that is the unit adopted here.

A	constant for each liquid in Equation (4.2)	mW/m K
A'	constant for each liquid in Equation (4.1)	mW/m K
B'	non-dimensional constant for each liquid in Equation (4.1)	—
B, C, D	non-dimensional constants for each liquid in Equation (4.2)	—
p	pressure	N/m ² (Pa)
T	kelvin temperature	K
t	Celsius temperature, $T - 273.15$	°C
λ	thermal conductivity	mW/m K

Subscripts

c	denotes value at the critical point
p	denotes value at pressure p
r	denotes reduced quantity, <i>e.g.</i> $T_r = T/T_c$.

3. CONVERSION FACTORS

$$\begin{aligned}
 1 \text{ mW/m K} &= 0.8598 \times 10^{-3} \text{ kcal/m h } ^\circ\text{C}^* \\
 &= 2.3885 \times 10^{-6} \text{ cal/cm s } ^\circ\text{C}^* \\
 &= 0.5778 \times 10^{-3} \text{ Chu/ft h } ^\circ\text{C}^* \\
 &= 0.5778 \times 10^{-3} \text{ Btu/ft h } ^\circ\text{F}^* \\
 &= 6.9335 \times 10^{-3} \text{ Btu in/ft}^2 \text{ h } ^\circ\text{F}^* \\
 10^5 \text{ N/m}^2 &= 1 \text{ bar} \\
 &= 14.5038 \text{ lbf/in}^2 \\
 &= 1.0197 \text{ kgf/cm}^2 \\
 &= 0.9869 \text{ atm} \\
 &= 750.062 \text{ mmHg}.
 \end{aligned}$$

* The values used for the calorie and British Thermal Unit are International Table values.

4. THERMAL CONDUCTIVITY

4.1 Thermal Conductivity at Saturation Pressure

In Reference 2 Riedel showed that the experimental data for the thermal conductivity of normal (that is unassociated) liquids along the saturation line could be represented by the equation:

$$\lambda = A'[1 + (20/3)(1 - T_r)^{2/3}].$$

For the liquids considered in this Item a better representation of the data is obtained, over a wide temperature range, from the modified equation which was used in some earlier ESDU Items:

$$\lambda = A'[1 + B'(1 - T_r)^{2/3}]. \quad (4.1)$$

The range of applicability of Equation (4.1) is limited for most compounds; recent data from several sources show that there may be marked deviations in the regions of the triple point and the critical point from extrapolations of Equation (4.1) fitted in the intermediate region.

For the liquids considered in this Item a good representation of the data* between the melting temperature and $T_r = 0.9$ is obtained from the equation:

$$\lambda = A[1 + B(1 - T_r)^{1/3} + C(1 - T_r)^{2/3} + D(1 - T_r)]. \quad (4.2)$$

Measurements of thermal conductivity have been made for relatively few liquids at $T_r > 0.9$ and so, because of the uncertain variation of thermal conductivity in the critical region, data are presented only for temperatures up to $T_r = 0.9$. The equation extrapolates in a physically realistic manner to within a few kelvin of the critical point.

The critical temperatures for these compounds have been taken from ESDU 90015, 90019 (References 8 and 9). In this Item, the critical temperatures should be regarded as correlating parameters only and should not be taken as a source of accurate values.

* Experimental data at temperatures below the normal boiling temperature, t_b , are often at 1 atm pressure. As indicated in Section 4.2 the difference between values of λ at 1 atm pressure and at saturation pressure below t_b is not significant.

The derived values of A , B , C and D given in Table 7.1 are a correlated set of values giving the best fit to the experimental data, not only as individual compounds but also as members of their chemical series. This method of correlating data for a series of compounds has been described in References 5 and 6. For the halogenated methanes and azeotropes in this Item, it was found that C and D are directly related to B^* , as was observed for other non-hydrogen-bonded compounds such as the alkanes. Correlated values of the constants A , B , C and D were used to estimate constants for liquids for which no experimental data exist. Using these values with the values of T_c given in Table 7.1, values of λ in mW/m K have been calculated for each compound from Equation (4.2) and are presented in the data sheets.

4.2 Effect of Pressure

At temperatures up to the normal boiling point, the effect of pressure from the saturation pressure to $50 \times 10^5 \text{ N/m}^2$ (up to 50 atm) is to increase the thermal conductivity by approximately 1 per cent and, for most practical purposes, values at saturation pressure may be taken as equal to those at atmospheric pressure.

Reference 1 gives measurements of thermal conductivity for a number of liquids up to $12\,000 \times 10^5 \text{ N/m}^2$ ($\approx 12\,000 \text{ atm}$) at 30°C and 75°C . A generalised correlation of these results is given in Reference 3, but a knowledge of the critical pressure of the substance is required for its use.

For pressures up to $500 \times 10^5 \text{ N/m}^2$ ($\approx 500 \text{ atm}$) between the melting temperature and the normal boiling point a very approximate relationship:

$$\lambda_p/\lambda \approx 1 + 0.2p \times 10^{-8}, \quad (4.3)$$

may be used where λ_p is the thermal conductivity at pressure p and λ is the thermal conductivity at a pressure of 10^5 N/m^2 ($\approx 1 \text{ atm}$), both at the same temperature.

5. EXPLANATION OF TABLES

The constants of Equation (4.2) are given in Table 7.1 and on the data sheets. Values of the thermal conductivity are given in the data sheets at 10 kelvin intervals in K and $^\circ\text{C}$, from within 10 kelvin of the melting temperature, or an appropriate starting temperature where the melting temperature is unknown, to a temperature corresponding with $T_r \approx 0.9$.

The sources are given in the data sheets and extrapolated values are indicated in parentheses.

For uniformity and ease of interpolation the data are presented and can be read to more significant digits than is warranted by their estimated accuracy.

The experimental data from the most reliable individual sources have a repeatability of about ± 1 per cent although differences in technique used by different workers (and possibly also in the purity of samples) can increase the uncertainty in the absolute values to about ± 2 per cent. However, such reliable data are not available for all the compounds considered, nor over the whole temperature range covered. Although it is considered that the correlation procedures adopted keep the errors in the values presented to a minimum, the user should in general allow for an uncertainty of ± 5 per cent unless the value in the data sheet is truncated to a whole number. Where whole numbers are given the uncertainty increases to ± 10 per cent.

Some fluids have poor thermal stability coupled with a high critical temperature. Values have been tabulated for all fluids up to $T_r \approx 0.9$ but many of these fluids will decompose at elevated temperatures. As most compounds will decompose rapidly at temperatures above about 300°C , uncertainties of greater than ± 10 per cent may occur for temperatures $\geq 573 \text{ K}$.

* $C = 1 - 3B$ and $D = 3B$.

6. REFERENCES

The references given are recommended sources of information supplementary to that in this Item.

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7. TABLES

TABLE 7.1 Constants for Equation (4.2)

Compound	T_c	A	B	C	D	Range of Applicability °C	
	K	mW/m K					
1. Fluoromethane	310.	107.6	2.5	-6.5	7.5	-140	to 10
2. Chloromethane	416.3	90.3	2.0	-5.0	6.0	-100	to 110
3. Bromomethane	463.	55.1	1.0	-2.0	3.0	-100	to 150
4. Iodomethane	527.	41.7	1.6	-3.8	4.8	-70	to 210
5. Difluoromethane	351.45	80.4	2.9	-7.7	8.7	-140	to 50
6. Chlorodifluoromethane	428.	65.3	2.7	-7.1	8.1	-140	to 120
7. Dichloromethane	510.	63.0	2.0	-5.0	6.0	-100	to 190
8. Bromochloromethane	560.	64.8	1.5	-3.5	4.5	-90	to 240
9. Dibromomethane	610.	47.7	1.45	-3.35	4.35	-50	to 280
10. Diiodomethane	750.	33.8	2.3	-5.9	6.9	0	to 410
11. Trifluoromethane	299.3	56.1	3.2	-8.6	9.6	-160	to 0
12. Chlorodifluoromethane	369.3	47.4	3.2	-8.6	9.6	-150	to 70
13. Bromodifluoromethane	413.	40.5	3.0	-8.0	9.0	-150	to 110
14. Difluoroiodomethane	472.	37.9	2.7	-7.1	8.1	-120	to 160
15. Dichlorodifluoromethane	451.25	45.4	2.85	-7.55	8.55	-140	to 140
16. Bromofluoroiodomethane	600.	39.5	2.4	-6.2	7.2	-70	to 270
17. Fluorodiiiodomethane	630.	37.9	2.7	-7.1	8.1	-70	to 300
18. Trichloromethane	536.5	50.5	2.0	-5.0	6.0	-60	to 220
19. Dichloroiodomethane	655.	42.5	1.4	-3.2	4.2	-70	to 320
20. Chlorodiiiodomethane	770.	34.1	2.6	-6.8	7.8	-50	to 430
21. Tribromomethane	685.	40.5	1.6	-3.8	4.8	10	to 350
22. Tetrafluoromethane	227.7	36.0	4.0	-11.0	12.0	-190	to -60
23. Chlorotrifluoromethane	302.15	33.9	3.9	-10.7	11.7	-180	to 10
24. Bromotrifluoromethane	340.15	33.5	2.85	-7.55	8.55	-170	to 40
25. Dichlorodifluoromethane	385.05	34.3	3.5	-9.5	10.5	-160	to 80
26. Bromochlorodifluoromethane	426.9	35.6	3.2	-8.6	9.6	-160	to 120
27. Dibromodifluoromethane	471.	34.7	2.0	-5.0	6.0	-140	to 160
28. Trichlorofluoromethane	471.15	36.5	3.0	-8.0	9.0	-110	to 160
29. Dichlorofluoroiodomethane	560.	40.5	2.2	-5.6	6.6	-100	to 240
30. Tetrachloromethane	556.3	43.5	2.0	-5.0	6.0	-20	to 240
31. Bromotrichloromethane	606.	37.6	1.9	-4.7	5.7	-10	to 280
32. Tetrabromomethane	740.	35.5	1.75	-4.25	5.25	90	to 400
33. Refrigerant 500	378.65	39.03	3.3	-8.9	9.9	-160	to 80
34. Refrigerant 502	363.15	37.47	3.3	-8.9	9.9	-170	to 60
35. Refrigerant 503	292.55	43.46	3.2	-8.6	9.6	-170	to 0
36. Refrigerant 31 + refrigerant 114	415.15	48.00	2.5	-6.5	7.5	-150	to 110

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CH₃F FLUOROMETHANE (METHYL FLUORIDE, REFRIGERANT 41)

$$\lambda = A[1 + B(1 - T_r)^{1/3} + C(1 - T_r)^{2/3} + D(1 - T_r)]$$

where

λ = thermal conductivity at saturation pressure (mW/m K)

$T_r = T/T_c$, T = temperature (K)

$T_c = 310. \text{ K}$

$A = 107.6$, $B = 2.5$, $C = -6.5$, $D = 7.5$

T K	λ mW/m K	T K	λ mW/m K	t °C	λ mW/m K	t °C	λ mW/m K
130	(314.)	210	(223.)	-140	(310.)	-60	(220.)
140	(302.)	220	(213.)	-130	(298.)	-50	(210.)
150	(290.)	230	(204.)	-120	(286.)	-40	(201.)
160	(278.)	240	(194.)	-110	(275.)	-30	(191.)
170	(267.)	250	(185.)	-100	(263.)	-20	(183.)
180	(256.)	260	(177.)	-90	(252.)	-10	(174.)
190	(245.)	270	(169.)	-80	(241.)	0	(167.)
200	(234.)	280	(162.)	-70	(231.)	10	(160.)

CH₃Cl CHLOROMETHANE (METHYL CHLORIDE, REFRIGERANT 40)

$$\lambda = A[1 + B(1 - T_r)^{1/3} + C(1 - T_r)^{2/3} + D(1 - T_r)]$$

where

λ = thermal conductivity at saturation pressure (mW/m K)

$$T_r = T/T_c, \quad T = \text{temperature (K)}$$

$$T_c = 416.3 \text{ K}$$

$$A = 90.3, \quad B = 2.0, \quad C = -5.0, \quad D = 6.0$$

T K	λ mW/m K	T K	λ mW/m K	t °C	λ mW/m K	t °C	λ mW/m K
170	(244.)	280	177.7	-100	(242.)	10	175.9
180	(238.)	290	172.2	-90	(236.)	20	170.5
190	(231.)	300	166.8	-80	(229.)	30	165.1
200	(225.)	310	(161.)	-70	(223.)	40	(160.)
210	(219.)	320	(156.)	-60	(217.)	50	(155.)
220	(213.)	330	(151.)	-50	(211.)	60	(150.)
230	(207.)	340	(147.)	-40	(205.)	70	(145.)
240	(201.)	350	(142.)	-30	(199.)	80	(140.)
250	(195.)	360	(137.)	-20	(193.)	90	(136.)
260	189.	370	(133.)	-10	187.2	100	(132.)
270	183.3	380	(129.)	0	181.5	110	(128.)

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CH₃Br BROMOMETHANE (METHYL BROMIDE, REFRIGERANT 40B1)

$$\lambda = A[1 + B(1 - T_r)^{1/3} + C(1 - T_r)^{2/3} + D(1 - T_r)]$$

where

λ = thermal conductivity at saturation pressure (mW/m K)

$$T_r = T/T_c, \quad T = \text{temperature (K)}$$

$$T_c = 463. \text{ K}$$

$$A = 55.1, \quad B = 1.0, \quad C = -2.0, \quad D = 3.0$$

T K	λ mW/m K	T K	λ mW/m K	t °C	λ mW/m K	t °C	λ mW/m K
170	(126.)	300	(97.3)	-100	(125.)	30	(96.6)
180	(123.5)	310	(95.1)	-90	(122.8)	40	(94.5)
190	(121.3)	320	(93.0)	-80	(120.6)	50	(92.4)
200	119.0	330	(91.0)	-70	118.3	60	(90.3)
210	116.8	340	(88.9)	-60	116.1	70	(88.2)
220	114.6	350	(86.8)	-50	113.9	80	(86.2)
230	112.4	360	(84.8)	-40	111.7	90	(84.2)
240	110.2	370	(82.8)	-30	109.5	100	(82.1)
250	108.0	380	(81.)	-20	107.3	110	(80.)
260	105.8	390	(79.)	-10	105.2	120	(78.)
270	103.7	400	(77.)	0	103.0	130	(76.)
280	101.5	410	(75.)	10	100.8	140	(74.)
290	99.4	420	(73.)	20	98.7	150	(72.)

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CH₃I IODOMETHANE (METHYL IODIDE)

$$\lambda = A[1 + B(1 - T_r)^{1/3} + C(1 - T_r)^{2/3} + D(1 - T_r)]$$

where

λ = thermal conductivity at saturation pressure (mW/m K)

$T_r = T/T_c$, T = temperature (K)

$T_c = 527. \text{ K}$

$A = 41.7$, $B = 1.6$, $C = -3.8$, $D = 4.8$

T K	λ mW/m K	T K	λ mW/m K	t °C	λ mW/m K	t °C	λ mW/m K
200	(108.)	350	(79.)	-70	(107.)	80	(78.)
210	(106.)	360	(77.)	-60	(105.)	90	(76.)
220	(103.)	370	(75.)	-50	(103.)	100	(75.)
230	(102.)	380	(73.)	-40	(101.)	110	(73.)
240	(100.)	390	(72.)	-30	(99.)	120	(71.)
250	(98.)	400	(70.)	-20	(97.)	130	(70.)
260	(96.)	410	(68.)	-10	(95.0)	140	(68.)
270	(93.7)	420	(67.)	0	(93.0)	150	(66.)
280	(91.7)	430	(65.)	10	(91.1)	160	(65.)
290	(89.8)	440	(64.)	20	89.2	170	(63.)
300	(87.9)	450	(62.)	30	(87.3)	180	(62.)
310	(86.1)	460	(61.)	40	(85.5)	190	(60.)
320	(84.2)	470	(59.)	50	(83.6)	200	(59.)
330	(82.)	480	(58.)	60	(82.)	210	(57.)
340	(81.)			70	(80.)		

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CH₂F₂ DIFLUOROMETHANE

(METHYLENE DIFLUORIDE, METHYLENE FLUORIDE, REFRIGERANT 32)

$$\lambda = A[1 + B(1 - T_r)^{1/3} + C(1 - T_r)^{2/3} + D(1 - T_r)]$$

where

λ = thermal conductivity at saturation pressure (mW/m K)

$$T_r = T/T_c, \quad T = \text{temperature (K)}$$

$$T_c = 351.45 \text{ K}$$

$$A = 80.4, \quad B = 2.9, \quad C = -7.7, \quad D = 8.7$$

T K	λ mW/m K	T K	λ mW/m K	t °C	λ mW/m K	t °C	λ mW/m K
130	(266.)	230	180.9	-140	(263.)	-40	178.5
140	(256.9)	240	173.3	-130	(254.0)	-30	171.0
150	247.8	250	166.0	-120	245.0	-20	163.8
160	238.9	260	158.9	-110	236.2	-10	156.8
170	230.2	270	152.1	-100	227.4	0	150.1
180	221.5	280	145.7	-90	218.8	10	143.7
190	213.1	290	140.	-80	210.4	20	138.
200	204.7	300	(134.)	-70	202.2	30	(132.)
210	196.6	310	(128.)	-60	194.1	40	(127.)
220	188.6	320	(123.)	-50	186.2	50	(122.)

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CH₂ClF CHLOROFLUOROMETHANE (METHYLENE CHLOROFLUORIDE, REFRIGERANT 31)

$$\lambda = A[1 + B(1 - T_r)^{1/3} + C(1 - T_r)^{2/3} + D(1 - T_r)]$$

where

λ = thermal conductivity at saturation pressure (mW/m K)

$T_r = T/T_c$, T = temperature (K)

$T_c = 428. \text{ K}$

$A = 65.3$, $B = 2.7$, $C = -7.1$, $D = 8.1$

T K	λ mW/m K	T K	λ mW/m K	t °C	λ mW/m K	t °C	λ mW/m K
130	(226.)	270	148.4	-140	(224.)	0	146.9
140	(219.7)	280	143.5	-130	(217.8)	10	142.0
150	(213.8)	290	138.7	-120	(212.0)	20	137.2
160	(208.0)	300	(134.1)	-110	(206.2)	30	(132.6)
170	(202.2)	310	(129.5)	-100	200.4	40	(128.1)
180	196.5	320	(125.0)	-90	194.7	50	(123.7)
190	190.9	330	(120.7)	-80	189.1	60	(119.4)
200	185.3	340	(117.)	-70	183.6	70	(115.)
210	179.8	350	(113.)	-60	178.1	80	(111.)
220	174.4	360	(109.)	-50	172.7	90	(108.)
230	169.0	370	(105.)	-40	167.4	100	(104.)
240	163.8	380	(102.)	-30	162.1	110	(101.)
250	158.6	390	(99.)	-20	156.9	120	(98.)
260	153.5			-10	151.9		

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CH₂Cl₂ DICHLOROMETHANE

(METHYLENE DICHLORIDE, METHYLENE CHLORIDE, REFRIGERANT 30)

$$\lambda = A[1 + B(1 - T_r)^{1/3} + C(1 - T_r)^{2/3} + D(1 - T_r)]$$

where

λ = thermal conductivity at saturation pressure (mW/m K)

$T_r = T/T_c$, T = temperature (K)

$T_c = 510. \text{ K}$

$A = 63.0$, $B = 2.0$, $C = -5.0$, $D = 6.0$

T K	λ mW/m K	T K	λ mW/m K	t °C	λ mW/m K	t °C	λ mW/m K
170	(185.)	320	131.4	-100	(183.)	50	130.4
180	180.9	330	(128.)	-90	179.7	60	(127.)
190	177.2	340	(125.)	-80	176.0	70	(124.)
200	173.5	350	(122.)	-70	172.3	80	(121.)
210	169.8	360	(119.)	-60	168.6	90	(118.)
220	166.1	370	(116.)	-50	165.0	100	(115.)
230	162.5	380	(113.)	-40	161.4	110	(112.)
240	158.9	390	(110.)	-30	157.8	120	(109.)
250	155.3	400	(107.)	-20	154.2	130	(106.)
260	151.8	410	(104.)	-10	150.7	140	(103.)
270	148.3	420	(101.)	0	147.2	150	(100.)
280	144.8	430	(99.)	10	143.8	160	(98.)
290	141.4	440	(96.)	20	140.4	170	(95.)
300	138.0	450	(94.)	30	137.0	180	(93.)
310	134.7	460	(91.)	40	133.7	190	(90.)

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