2.48 Refrigerant 500

All equations for R500 are based on the Table from Thermophysical properties of refrigerants of ASHRAE[1].

2.48.1 Temperature Scale

International practical temperature scale 1968 (IPTS-1968)

2.48.2 The Names of Substance, Library File and Single Shot Program

Name of Substance:	R500, Refrigerant 500, Freon 500, Azeotrope of R12 and R152a, Azeotrope of CFC-12 and HFC-152a
Library File for UNIX:	libjr500.a
Library File for DOS,Windows95/NT:	JR500.LIB
Single Shot Program for UNIX:	r500-ss
Single Shot Program for DOS,Windows95/NT:	R500–SS.EXE

2.48.3 Important Constants and Others

Molecular Formula:	$CC\ell_2F_2$(72.8mass% +CH_3CHF_2(26.2mass%)
Relative Molecular Mass:	99.300
Gas Constant:	83.7312 J/(kg·K)

Critical Constants:

Critical Pressure:	4.4256×10^6Pa (44.256 bar)
Critical Temperature:	378.70 K (105.55 °C)
Critical Specific Volume:	$2.0121\times10^{-3}m^3$/kg

Reference State:

At 0°C, 1.0000 kJ/(kg·K) and 200.00 kJ/kg are assigned to the specific entropy and the specific enthalpy of saturated liquid, respectively.

2.48.4 Formula

Equation of State:

The Bender equation of state (II·3·1) in reference [1], which is in a function from of $Z = Z(\rho, T)$. Here Z=compressibility, ρ=density and T=temperature.

Vapor Pressure:

Equation (20) in reference [1].

Properties at Vapor-Liquid Equilibrium:

saturated state: The Bender equation of state is utilized to obtaining saturated specific volume by the aid of maxwell's criterion according to the author's recommendation. The Bender equation of state shows unreasonable behavior near the critical point. This temperature range is evaluated by $T_c \pm 1$ K. Therefore, in the temperature range and above the critical pressure, the values of u, h and s would include some uncertainity. Also, in the ranges of $p_{sat}(T_c - 1\ K) < p < p_{sat}(T_c + 1\ K)$ and $v'(T_c - 1\ K) < v < v''(T_c - 1\ K)$, the calculated values of p, v, T, c_p, c_v, isentropic exponent, Laplace coefficient, Prandtl number, velocity of sound and dryness fraction of wet vapor would have some uncertainity. Equations (2), (3), and (5) for specific enthalpy, specific entropy and isobaric specific heat respectively. However, the sign of the last integration term in u including in Equation (2) has been corrected to −.

Transport Properties:

Equation (3.28) in reference [2] and Eq.(3.27) in reference [3] for thermal conductivity and dynamic viscosity of saturated liquid respectively.

References

[1] B.Platzer, A.Polt and G.Maurer, Thermophysical Properties of Refrigerants (1990) ASHRAE
[2] JSME Data Book: Thermophysical Properties of Fluids, JSME (1983), 527

Table II–2.48–1 Refrigerant 500 Function

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
1	AIPPT(P,T)		
94	AJTPT(P,T)		
8A	AKPD(P)		
8B	AKPDD(P)		
82	AKPT(P,T)	AKPT: Isentropic Exponent [–] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0.02\times10^6\leq P\leq5.85\times10^6$ [Pa] $300\leq T\leq470$ [K] $0.2\leq P\leq58.5$ [bar] $26.85\leq T\leq196.85$ [°C]
8C	AKTD(T)		
8D	AKTDD(T)		
2	ALAPP(P)		
3	ALAPT(T)		
4	ALHP(P)	ALHP: Latent Heat of Vaporization [J/kg] P∗: Pressure [Pa], [bar]	$0.77\times10^6\leq P\leq4.4256\times10^6$ [Pa] $7.7\leq P\leq44.256$ [bar]
5	ALHT(T)	ALHT: Latent Heat of Vaporization [J/kg] T∗: Temperature [K], [°C]	$298.15\leq T\leq378.7$ [K] $25\leq T\leq105.55$ [°C]
6	ALMPD(P)	ALMPD: Thermal Conductivity of Saturated Liquid [W/(m·K)] P∗: Pressure [Pa], [bar]	$PST(160K)\leq P\leq2.635\times10^6$ [Pa] $PST(-113.15°C)\leq P\leq26.35$ [bar]
7	ALMPDD(P)		
8	ALMPT(P,T)		
9	ALMTD(T)	ALMTD: Thermal Conductivity of Saturated Liquid [W/(m·K)] T∗: Temperature [K], [°C]	$100\leq T\leq320$ [K] $-173.15\leq T\leq46.85$ [°C]
10	ALMTDD(T)		
11	AMUPD(P)	AMUPD: Coefficient of Viscosity of Saturated Liquid [Pa·s] P∗: Pressure [Pa], [bar]	$PST(190K)\leq P\leq PST(332K)$ [Pa] $(\sim25\times10^3)$ $(\sim3.37\times10^6)$ $PST(-83.15°C)\leq P\leq PST(58.85°C)$ (∼0.25) (∼33.7) [bar]
12	AMUPDD(P)		
13	AMUPT(P,T)		
14	AMUTD(T)	AMUTD: Coefficient of Viscosity of Saturated Liquid [Pa·s] T∗: Temperature [K], [°C]	$190\leq T\leq332$ [K] $-83.15\leq T\leq58.85$ [°C]
15	AMUTDD(T)		
92	BPPT(P,T)		
90	BSPT(P,T)		
91	BTPT(P,T)		
93	BVPT(P,T)		
16	CPPD(P)	CPPD: Isobaric Specific Heat of Saturated Liquid [J/(kg·K)] P∗: Pressure [Pa], [bar]	$0.77\times10^6\leq P\leq4.4256\times10^6$ [Pa] $7.7\leq P\leq44.256$ [bar]
17	CPPDD(P)	CPPDD: Isobaric Specific Heat of Saturated Vapor [J/(kg·K)] P∗: Pressure [Pa], [bar]	$0.77\times10^6\leq P\leq4.4256\times10^6$ [Pa] $7.7\leq P\leq44.256$ [bar]
18	CPPT(P,T)	CPPT: Isobaric Specific Heat [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0.02\times10^6\leq P\leq5.85\times10^6$ [Pa] $300\leq T\leq470$ [K] $0.2\leq P\leq58.5$ [bar] $26.85\leq T\leq196.85$ [°C]
19	CPTD(T)	CPTD: Isobaric Specific Heat of Saturated Liquid [J/(kg·K)] T∗: Temperature [K], [°C]	$298.15\leq T\leq378.7$ [K] $25\leq T\leq105.55$ [°C]

Table II–2.48–1 Refrigerant 500 Function (cont'd)

No.	Name of Function	Function and Argum ent(s)	Range of Argument(s)
20	CPTDD(T)	CPTDD: Isobaric Specific Heat of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	298.15≤T≤378.7 [K] 25≤T≤105.55 [°C]
21	CRP('A')	CRP: Critical Constants H: 'A'='H': 0.3698×10^{6} [J/kg] Specific Enthalpy P∗: 'A'='P': 4.4256×10^{6} [Pa], 44.256 [bar] Pressure S: 'A'='S': 1.498×10^{3} [J/(kg·K)] Specific Entropy T∗: 'A'='T': 378.70 [K], 105.55 [°C] Temperature V: 'A'='V': 2.0121×10^{-3} [m^3/kg] Specific Volume	one of 'H', 'P', 'S', 'T' and 'V'
7A	CVPD(P)		
76	CVPDD(P)	CVPDD: Isochoric Specific Heat of Saturated Vapor [J/(kg·K)] P∗: Pressure [Pa], [bar]	0.77×10^{6}≤P≤4.4256×10^{6} [Pa] 7.7≤P≤44.256 [bar]
77	CVPT(P,T)	CVPT: Isochoric Specific Heat [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	0.02×10^{6}≤P≤5.85×10^{6} [Pa] 300≤T≤470 [K] 0.2≤P≤58.5 [bar] 26.85≤T≤196.85 [°C]
7B	CVTD(T)		
78	CVTDD(T)	CVTDD: Isochoric Specific Heat of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	298.15≤T≤378.7 [K] 25≤T≤105.55 [°C]
2A	EPSPD(P)		
2B	EPSPDD(P)		
22	EPSPT(P,T)		
2C	EPSTD(T)		
2D	EPSTDD(T)		
89	FC('A')	FC: Fundamental Constants M: 'A'='M': 99.30 Relative Molecular Mass R: 'A'='R': 83.7312 [J/(kg·K)] Gas Constant	one of 'M' and 'R'
9A	GAMPD(P)		
96	GAMPDD(P)		
95	GAMPT(P,T)		
9B	GAMTD(T)		
97	GAMTDD(T)		
23	HPD(P)	HPD: Specific Enthalpy of Saturated Liquid [J/kg] P∗: Pressure [Pa], [bar]	0.77×10^{6}≤P≤4.4256×10^{6} [Pa] 7.7≤P≤44.256 [bar]
24	HPDD(P)	HPDD: Specific Enthalpy of Saturated Vapor [J/kg] P∗: Pressure [Pa], [bar]	0.77×10^{6}≤P≤4.4256×10^{6} [Pa] 7.7≤P≤44.256 [bar]
71	HPS(P,S)	HPS: Specific Enthalpy [J/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	0.02×10^{6}≤P≤5.85×10^{6} [Pa] SPT(P,300K)≤S≤ SPT(P,470K) [J/(kg·K)] 0.2≤P≤58.5 [bar] SPT(P,26.85°C)≤S≤ SPT(P,196.85°C) [J/(kg·K)]
25	HPT(P,T)	HPT: Specific Enthalpy [J/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	0.02×10^{6}≤P≤5.85×10^{6} [Pa] 300≤T≤470 [K] 0.2≤P≤58.5 [bar] 26.85≤T≤196.85 [°C]
26	HPX(P,X)	HPX: Specific Enthalpy of Mixture [J/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	0.77×10^{6}≤P≤4.4256×10^{6} [Pa] 7.7≤P≤44.256 [bar] 0≤X≤1.0 [–]
27	HTD(T)	HTD: Specific Enthalpy of Saturated Liquid [J/kg] T∗: Temperature [K], [°C]	298.15≤T≤378.7 [K] 25≤T≤105.55 [°C]
28	HTDD(T)	HTDD: Specific Enthalpy of Saturated Vapor [J/kg] T∗: Temperature [K], [°C]	298.15≤T≤378.7 [K] 25≤T≤105.55 [°C]

Table II–2.48–1 Refrigerant 500 Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
29	HTX(T,X)	HTX: Specific Enthalpy of Mixture [J/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	298.15≤T≤378.7 [K] 25≤T≤105.55 [°C] 0≤X≤1.0 [–]
84	IDENTF('A')	IDENTF: CHARACTER TYPE FUNCTION for Package Identification (Length 20) C: 'A'='C': 'CCL2F2+CH3CHF2' Molecular Formula S: 'A'='S': 'REFRIGERANT 500' Name of Substance V: 'A'='V': '10.1' Version Number	one of 'C', 'S' and 'V'
66	PLDT(T)		
68	PMLT(T)		
85	PRPD(P)	PRPD: Prandtl Number of Saturated Liquid [–] P∗: Pressure [Pa], [bar]	25×10^3≤P≤2.635×10^6 [Pa] 0.25≤P≤26.35 [bar]
86	PRPDD(P)		
81	PRPT(P,T)		
87	PRTD(T)	PRTD: Prandtl Number of Saturated Liquid [–] T∗: Temperature [K], [°C]	190≤T≤320 [K] −83.15≤T≤46.85 [°C]
88	PRTDD(T)		
99	PSBT(T)		
30	PST(T)	PST∗: Saturation Pressure [Pa], [bar] T∗: Temperature [K], [°C]	298.15≤T≤378.7 [K] 25≤T≤105.55 [°C]
72	PSTD(T)		
73	PSTDD(T)		
31	SIGP(P)		
32	SIGT(T)		
33	SPD(P)	SPD: Specific Entropy of Saturated Liquid [J/(kg·K)] P∗: Pressure [Pa], [bar]	0.77×10^6≤P≤4.4256×10^6 [Pa] 7.7≤P≤44.256 [bar]
34	SPDD(P)	SPDD: Specific Entropy of Saturated Vapor [J/(kg·K)] P∗: Pressure [Pa], [bar]	0.77×10^6≤P≤4.4256×10^6 [Pa] 7.7≤P≤44.256 [bar]
35	SPT(P,T)	SPT: Specific Entropy [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	0.02×10^6≤P≤5.85×10^6 [Pa] 300≤T≤470 [K] 0.2≤P≤58.5 [bar] 26.85≤T≤196.85 [°C]
36	SPX(P,X)	SPX: Specific Entropy of Mixture [J/(kg·K)] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	0.77×10^6≤P≤4.4256×10^6 [Pa] 7.7≤P≤44.256 [bar] 0≤X≤1.0 [–]
37	STD(T)	STD: Specific Entropy of Saturated Liquid [J/(kg·K)] T∗: Temperature [K], [°C]	298.15≤T≤378.7 [K] 25≤T≤105.55 [°C]
38	STDD(T)	STDD: Specific Entropy of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	298.15≤T≤378.7 [K] 25≤T≤105.55 [°C]
39	STX(T,X)	STX: Specific Entropy of Mixture [J/(kg·K)] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	298.15≤T≤378.7 [K] 25≤T≤105.55 [°C] 0≤X≤1.0 [–]
67	TLDP(P)		
69	TMLP(P)		
64	TPH(P,H)	TPH∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] H: Specific Enthalpy [J/kg]	0.02×10^6≤P≤5.85×10^6 [Pa] HPT(P,300K)≤H≤ HPT(P,470K) [J/kg] 0.2≤P≤58.5 [bar] HPT(P,26.85°C)≤H≤ HPT(P,196.85°C) [J/kg]

Table II–2.48–1 Refrigerant 500 Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
6H	TPH2(P,H)		
65	TPS(P,S)	TPS∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$0.02\times10^6\leq$P$\leq5.85\times10^6$ [Pa] SPT(P,300K)≤S≤ SPT(P,470K) [J/(kg·K)] 0.2≤P≤58.5 [bar] SPT(P,26.85°C)≤S≤ SPT(P,196.85°C) [J/(kg·K)]
98	TPSEUP(P)		
6S	TPS2(P,S)		
70	TPV(P,V)	TPV∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] V: Specific Volume [m^3/kg]	$0.02\times10^6\leq$P$\leq5.85\times10^6$ [Pa] VPT(P,300K)≤V≤ VPT(P,470K) [m^3/kg] 0.2≤P≤58.5 [bar] VPT(P,26.85°C)≤V≤ VPT(P,196.85°C) [m^3/kg]
41	TRPL('A')		
100	TSBP(P)		
40	TSP(P)	TSP∗: Saturation Temperature [K], [°C] P∗: Pressure [Pa], [bar]	$0.77\times10^6\leq$P$\leq4.4256\times10^6$ [Pa] 7.7≤P≤44.256 [bar]
74	TSPD(P)		
75	TSPDD(P)		
42	UPD(P)	UPD: Specific Internal Energy of Saturated Liquid [J/kg] P∗: Pressure [Pa], [bar]	$0.77\times10^6\leq$P$\leq4.4256\times10^6$ [Pa] 7.7≤P≤44.256 [bar]
43	UPDD(P)	UPDD: Specific Internal Energy of Saturated Vapor [J/kg] P∗: Pressure [Pa], [bar]	$0.77\times10^6\leq$P$\leq4.4256\times10^6$ [Pa] 7.7≤P≤44.256 [bar]
79	UPS(P,S)	UPS: Specific Internal Energy [J/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$0.02\times10^6\leq$P$\leq5.85\times10^6$ [Pa] SPT(P,300K)≤S≤ SPT(P,470K) [J/(kg·K)] 0.2≤P≤58.5 [bar] SPT(P,26.85°C)≤S≤ SPT(P,196.85°C) [J/(kg·K)]
44	UPT(P,T)	UPT: Specific Internal Energy [J/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0.02\times10^6\leq$P$\leq5.85\times10^6$ [Pa] 300≤T≤470 [K] 0.2≤P≤58.5 [bar] 26.85≤T≤196.85 [°C]
45	UPX(P,X)	UPX: Specific Internal Energy of Mixture [J/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$0.77\times10^6\leq$P$\leq4.4256\times10^6$ [Pa] 7.7≤P≤44.256 [bar] 0≤X≤1.0 [–]
46	UTD(T)	UTD: Specific Internal Energy of Saturated Liquid [J/kg] T∗: Temperature [K], [°C]	298.15≤T≤378.7 [K] 25≤T≤105.55 [°C]
47	UTDD(T)	UTDD: Specific Internal Energy of Saturated Vapor [J/kg] T∗: Temperature [K], [°C]	298.15≤T≤378.7 [K] 25≤T≤105.55 [°C]
48	UTX(T,X)	UTX: Specific Internal Energy of Mixture [J/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	298.15≤T≤378.7 [K] 25≤T≤105.55 [°C] 0≤X≤1.0 [–]
49	VPD(P)	VPD: Specific Volume of Saturated Liquid [m^3/kg] P∗: Pressure [Pa], [bar]	$0.77\times10^6\leq$P$\leq4.4256\times10^6$ [Pa] 7.7≤P≤44.256 [bar]

Table II–2.48–1 Refrigerant 500 Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
50	VPDD(P)	VPDD: Specific Volume of Saturated Vapor [m^3/kg] P∗: Pressure [Pa], [bar]	$0.77\times10^6\leq P\leq4.4256\times10^6$ [Pa] $7.7\leq P\leq44.256$ [bar]
80	VPS(P,S)	VPS: Specific Volume [m^3/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$0.02\times10^6\leq P\leq5.85\times10^6$ [Pa] SPT(P,300K)≤S≤ SPT(P,470K) [J/(kg·K)] $0.2\leq P\leq58.5$ [bar] SPT(P,26.85°C)≤S≤ SPT(P,196.85°C) [J/(kg·K)]
51	VPT(P,T)	VPT: Specific Volume [m^3/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0.02\times10^6\leq P\leq5.85\times10^6$ [Pa] $300\leq T\leq470$ [K] $0.2\leq P\leq58.5$ [bar] $26.85\leq T\leq196.85$ [°C]
52	VPX(P,X)	VPX: Specific Volume of Mixture [m^3/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$0.77\times10^6\leq P\leq4.4256\times10^6$ [Pa] $7.7\leq P\leq44.256$ [bar] $0\leq X\leq1.0$ [–]
53	VTD(T)	VTD: Specific Volume of Saturated Liquid [m^3/kg] T∗: Temperature [K], [°C]	$298.15\leq T\leq378.7$ [K] $25\leq T\leq105.55$ [°C]
54	VTDD(T)	VTDD: Specific Volume of Saturated Vapor [m^3/kg] T∗: Temperature [K], [°C]	$298.15\leq T\leq378.7$ [K] $25\leq T\leq105.55$ [°C]
55	VTX(T,X)	VTX: Specific Volume of Mixture [m^3/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	$298.15\leq T\leq378.7$ [K] $25\leq T\leq105.55$ [°C] $0\leq X\leq1.0$ [–]
8E	WPD(P)		
8F	WPDD(P)		
83	WPT(P,T)	WPT: Velocity of Sound [m/s] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$0.02\times10^6\leq P\leq5.85\times10^6$ [Pa] $300\leq T\leq470$ [K] $0.2\leq P\leq58.5$ [bar] $26.85\leq T\leq196.85$ [°C]
8G	WTD(T)		
8H	WTDD(T)		
56	XPH(P,H)	XPH: Dryness Fraction [–] P∗: Pressure [Pa], [bar] H: Specific Enthalpy of Mixture [J/kg]	$0.77\times10^6\leq P<4.4256\times10^6$ [Pa] $7.7\leq P<44.256$ [bar] HPD(P)≤H≤HPDD(P) [J/kg]
57	XPS(P,S)	XPS: Dryness Fraction [–] P∗: Pressure [Pa], [bar] S: Specific Entropy of Mixture [J/(kg·K)]	$0.77\times10^6\leq P<4.4256\times10^6$ [Pa] $7.7\leq P<44.256$ [bar] SPD(P)≤S≤SPDD(P) [J/(kg·K)]
58	XPU(P,U)	XPU: Dryness Fraction [–] P∗: Pressure [Pa], [bar] U: Specific Internal Energy of Mixture [J/kg]	$0.77\times10^6\leq P<4.4256\times10^6$ [Pa] $7.7\leq P<44.256$ [bar] UPD(P)≤U≤UPDD(P) [J/kg]
59	XPV(P,V)	XPV: Dryness Fraction [–] P∗: Pressure [Pa], [bar] V: Specific Volume of Mixture [m^3/kg]	$0.77\times10^6\leq P<4.4256\times10^6$ [Pa] $7.7\leq P<44.256$ [bar] VPD(P)≤V≤VPDD(P) [m^3/kg]
60	XTH(T,H)	XTH: Dryness Fraction [–] T∗: Temperature [K], [°C] H: Specific Enthalpy of Mixture [J/kg]	$298.15\leq T<378.7$ [K] $25\leq T<105.55$ [°C] HTD(T)≤H≤HTDD(T) [J/kg]
61	XTS(T,S)	XTS: Dryness Fraction [–] T∗: Temperature [K], [°C] S: Specific Entropy of Mixture [J/(kg·K)]	$298.15\leq T<378.7$ [K] $25\leq T<105.55$ [°C] STD(T)≤S≤STDD(T) [J/(kg·K)]
62	XTU(T,U)	XTU: Dryness Fraction [–] T∗: Temperature [K], [°C] U: Specific Internal Energy of Mixture [J/kg]	$298.15\leq T<378.7$ [K] $25\leq T<105.55$ [°C] UTD(T)≤U≤UTDD(T) [J/kg]
63	XTV(T,V)	XTV: Dryness Fraction [–] T∗: Temperature [K], [°C] V: Specific Volume of Mixture [m^3/kg]	$298.15\leq T<378.7$ [K] $25\leq T<105.55$ [°C] VTD(T)≤V≤VTDD(T) [m^3/kg]