2.14 Carbon Dioxide

Equations for thermodynamic properties have been cited from the IUPAC Table[1], those for transport properties from Altunin et al.[2][3], and one for surface tension from Miller et al.[4].

2.14.1 Temperature Scale

International practical temperature scale 1968 (IPTS-1968)

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

Name of Substance:	Carbon Dioxide
Library File for UNIX:	libjco2.a
Library File for DOS,Windows95/NT:	JCO2.LIB
Single Shot Program for UNIX:	co2-ss
Single Shot Program for DOS,Windows95/NT:	CO2–SS.EXE

2.14.3 Important Constants and Others

Molecular Formula:	CO_2
Relative Molecular Mass:	44.009
Gas Constant:	188.92 J/(kg·K)

Critical Constants:

Critical Pressure:	7.3825×10^{6}Pa (73.825 bar)
Critical Temperature:	304.21 K (31.06°C)
Critical Specific Volume:	2.1459×10^{-3}m^3/kg

Triple Point:

Pressure:	0.5185×10^{6}Pa (5.185 bar)
Temperature:	216.58 K (−56.57°C)

Reference State:

At the state of the perfect crystal at 0 K, 0 J/(kg·K) and 0 J/kg are assigned to the specific entropy and the specific enthalpy, respectively.

2.14.4 Formula

Equation of State:

Equation (14) in a function form of $P = P(\rho, T)$ in reference [1]. Here P=pressure, ρ=density and T=temperature.

Vapor Pressure:

Equation (3) in reference [1].

Properties at Vapor-Liquid Equilibrium:

Equations (4) and (5) for specific volume, equation (16) for specific entropy, and equation (18) for specific enthalpy, and equations (20) and (22) for isobaric specific heat, respectively. All of these have been cited from reference [1].

Pressure and Temperature on Melting Line:

Equation (2) in reference [1].

Transport Properties:

Equations (7) and (9) in reference [2] for viscosity. Equations (5) and (6) in reference [3] for thermal conductivity.

The Other Properties:
Surface tension from reference [4].

References

[1] S.Angus, B.Armstrong and K.M.de Reuck, International Thermodynamic Table of the Fluid State-3 Carbon Dioxide, IUPAC, vol.3, (1976).
[2] V.V.Altunin and M.A.Sakhabetdinov, Teploenergetika, 19–8, (1972), p.85.
[3] V.V.Altunin and M.A.Sakhabetdinov, Teploenergetika, 20–5, (1973), p.85.
[4] J.W.Miller Jr. and C.L.Yaws, Chem. Eng.,83–23, (1976), p.127.

Table II–2.14–1 Carbon Dioxide Function

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
1	AIPPT(P,T)		
94	AJTPT(P,T)	AJTPT: Joule-Thomson Coefficient [K/Pa] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $220 \leq T \leq 1100$ [K] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] $TMLP(P) \leq T \leq 1100$ [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] $TMLP(P) \leq T \leq 700$ [K] $0.1 \leq P < 5.185$ [bar] $-53.15 \leq T \leq 826.85$ [°C] $5.185 \leq P \leq 600$ [bar] $TMLP(P) \leq T \leq 826.85$ [°C] $600 < P < 1000$ [bar] $TMLP(P) \leq T \leq 426.85$ [°C]
8A	AKPD(P)		
8B	AKPDD(P)		
82	AKPT(P,T)	AKPT: Aidabatic Exponent [–] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $220 \leq T \leq 1100$ [K] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] $TMLP(P) \leq T \leq 1100$ [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] $TMLP(P) \leq T \leq 700$ [K] $0.1 \leq P < 5.185$ [bar] $-53.15 \leq T \leq 826.85$ [°C] $5.185 \leq P \leq 600$ [bar] $TMLP(P) \leq T \leq 826.85$ [°C] $600 < P < 1000$ [bar] $TMLP(P) \leq T \leq 426.85$ [°C]
8C	AKTD(T)		
8D	AKTDD(T)		
2	ALAPP(P)	ALAPP: Laplace Coefficient [m] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P < 7.3825 \times 10^6$ [Pa] $5.185 \leq P < 73.825$ [bar]
3	ALAPT(T)	ALAPT: Laplace Coefficient [m] T∗: Temperature [K], [°C]	$216.58 \leq T < 304.21$ [K] $-56.57 \leq T < 31.06$ [°C]
4	ALHP(P)	ALHP: Latent Heat of Vaporization [J/kg] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] $5.185 \leq P \leq 73.825$ [bar]
5	ALHT(T)	ALHT: Latent Heat of Vaporization [J/kg] T∗: Temperature [K], [°C]	$216.58 \leq T \leq 304.21$ [K] $-56.57 \leq T \leq 31.06$ [°C]
6	ALMPD(P)	ALMPD: Thermal Conductivity of Saturated Liquid [W/(m·K)] P∗: Pressure [Pa], [bar]	$1.286 \times 10^6 \leq P < 7.3825 \times 10^6$ [Pa] $12.86 \leq P < 73.825$ [bar]
7	ALMPDD(P)	ALMPDD: Thermal Conductivity of Saturated Vapor [W/(m·K)] T∗: Temperature [K], [°C]	$0.5185 \times 10^6 \leq P < 7.3825 \times 10^6$ [Pa] $5.185 \leq P < 73.825$ [bar]

Table II–2.14–1 Carbon Dioxide Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
8	ALMPT(P,T)	ALMPT: Thermal Conductivity [W/(m·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $220 \leq T \leq 1100$ [K] $0.5185 \times 10^6 \leq P \leq PST(240K)$ [Pa] $TSP(P) \leq T \leq 1100$ [K] $PST(240K) < P \leq 60 \times 10^6$ $240 \leq T \leq 1100$ [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] $240 \leq T \leq 700$ [K] $0.1 \leq P < 5.185$ [bar] $-53.15 \leq T \leq 826.85$ [°C] $5.185 \leq P \leq PST(-33.15°C)$ [bar] $TSP(P) \leq T \leq 826.85$ [°C] $PST(-33.15°C) < P \leq 600$ [bar] $-33.15 \leq T \leq 826.85$ [°C] $600 < P < 1000$ [bar] $-33.15 \leq T \leq 426.85$ [°C]
9	ALMTD(T)	ALMTD: Thermal Conductivity of Saturated Liquid [W/(m·K)] T∗: Temperature [K], [°C]	$240 \leq T < 304.21$ [K] $-33.15 \leq T < 31.06$ [°C]
10	ALMTDD(T)	ALMTDD: Thermal Conductivity of Saturated Vapor [W/(m·K)] T∗: Temperature [K], [°C]	$216.58 \leq T < 304.21$ [K] $-56.57 \leq T < 31.06$ [°C]
11	AMUPD(P)	AMUPD: Coefficient of Viscosity of Saturated Liquid [Pa·s] P∗: Pressure [Pa], [bar]	$1.286 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] $12.86 \leq P \leq 73.825$ [bar]
12	AMUPDD(P)	AMUPDD: Coefficient of Viscosity of Saturated Vapor [Pa·s] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] $5.185 \leq P \leq 73.825$ [bar]
13	AMUPT(P,T)	AMUPT: Coefficient of Viscosity [Pa·s] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $220 \leq T \leq 1100$ [K] $0.5185 \times 10^6 \leq P \leq PST(240K)$ [Pa] $TSP(P) \leq T \leq 1100$ [K] $PST(240K) < P \leq 60 \times 10^6$ $240 \leq T \leq 1100$ [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] $240 \leq T \leq 700$ [K] $0.1 \leq P < 5.185$ [bar] $-53.15 \leq T \leq 826.85$ [°C] $5.185 \leq P \leq PST(-33.15°C)$ [bar] $TSP(P) \leq T \leq 826.85$ [°C] $PST(-33.15°C) < P \leq 600$ [bar] $-33.15 \leq T \leq 826.85$ [°C] $600 < P < 1000$ [bar] $-33.15 \leq T \leq 426.85$ [°C]
14	AMUTD(T)	AMUTD: Coefficient of Viscosity of Saturated Liquid [Pa·s] T∗: Temperature [K], [°C]	$240 \leq T \leq 304.21$ [K] $-33.15 \leq T \leq 31.06$ [°C]
15	AMUTDD(T)	AMUTDD: Coefficient of Viscosity of Saturated Vapor [Pa·s] T∗: Temperature [K], [°C]	$216.58 \leq T \leq 304.21$ [K] $-56.57 \leq T \leq 31.06$ [°C]

Table II–2.14–1 Carbon Dioxide Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
92	BPPT(P,T)	BPPT: Volumetric Coefficient of Expansion [1/K] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $220 \leq T \leq 1100$ [K] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] TMLP(P)≤T≤1100 [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] TMLP(P)≤T≤700 [K] $0.1 \leq P < 5.185$ [bar] $-53.15 \leq T \leq 826.85$ [°C] $5.185 \leq P \leq 600$ [bar] TMLP(P)≤T≤826.85 [°C] 600<P<1000 [bar] TMLP(P)≤T≤426.85 [°C]
90	BSPT(P,T)	BSPT: Isentropic Compressibility [1/Pa] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $220 \leq T \leq 1100$ [K] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] TMLP(P)≤T≤1100 [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] TMLP(P)≤T≤700 [K] $0.1 \leq P < 5.185$ [bar] $-53.15 \leq T \leq 826.85$ [°C] $5.185 \leq P \leq 600$ [bar] TMLP(P)≤T≤826.85 [°C] 600<P<1000 [bar] TMLP(P)≤T≤426.85 [°C]
91	BTPT(P,T)	BTPT: Isothermal Compressibility [1/Pa] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $220 \leq T \leq 1100$ [K] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] TMLP(P)≤T≤1100 [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] TMLP(P)≤T≤700 [K] $0.1 \leq P < 5.185$ [bar] $-53.15 \leq T \leq 826.85$ [°C] $5.185 \leq P \leq 600$ [bar] TMLP(P)≤T≤826.85 [°C] 600<P<1000 [bar] TMLP(P)≤T≤426.85 [°C]
93	BVPT(P,T)	BVPT: Pressure Coefficient [1/K] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $220 \leq T \leq 1100$ [K] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] TMLP(P)≤T≤1100 [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] TMLP(P)≤T≤700 [K] $0.1 \leq P < 5.185$ [bar] $-53.15 \leq T \leq 826.85$ [°C] $5.185 \leq P \leq 600$ [bar] TMLP(P)≤T≤826.85 [°C] 600<P<1000 [bar] TMLP(P)≤T≤426.85 [°C]
16	CPPD(P)	CPPD: Isobaric Specific Heat of Saturated Liquid [J/(kg·K)] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P < 7.3825 \times 10^6$ [Pa] $5.185 \leq P < 73.825$ [bar]
17	CPPDD(P)	CPPDD: Isobaric Specific Heat of Saturated Vapor [J/(kg·K)] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P < 7.3825 \times 10^6$ [Pa] $5.185 \leq P < 73.825$ [bar]

Table II–2.14–1 Carbon Dioxide Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
18	CPPT(P,T)	CPPT: Isobaric Specific Heat [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $220 \leq T \leq 1100$ [K] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] $TMLP(P) \leq T \leq 1100$ [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] $TMLP(P) \leq T \leq 700$ [K] $0.1 \leq P < 5.185$ [bar] $-53.15 \leq T \leq 826.85$ [°C] $5.185 \leq P \leq 600$ [bar] $TMLP(P) \leq T \leq 826.85$ [°C] $600 < P < 1000$ [bar] $TMLP(P) \leq T \leq 426.85$ [°C]
19	CPTD(T)	CPTD: Isobaric Specific Heat of Saturated Liquid [J/(kg·K)] T∗: Temperature [K], [°C]	$216.58 \leq T < 304.21$ [K] $-56.57 \leq T < 31.06$ [°C]
20	CPTDD(T)	CPTDD: Isobaric Specific Heat of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	$216.58 \leq T < 304.21$ [K] $-56.57 \leq T < 31.06$ [°C]
21	CRP('A')	CRP: Critical Constants H: 'A'='H': 636.64×10^3 [J/kg] Specific Enthalpy P∗: 'A'='P': 7.3825×10^6[Pa], 73.825 [bar] Pressure S: 'A'='S': 3.5579×10^3 [J/(kg·K)] Specific Entropy T∗: 'A'='T': 304.21 [K], 31.06 [°C] Temperature V: 'A'='V': 2.1459×10^{-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]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] $5.185 \leq P \leq 73.825$ [bar]
77	CVPT(P,T)	CVPT: Isochoric Specific Heat [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $220 \leq T \leq 1100$ [K] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] $TMLP(P) \leq T \leq 1100$ [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] $TMLP(P) \leq T \leq 700$ [K] $0.1 \leq P < 5.185$ [bar] $-53.15 \leq T \leq 826.85$ [°C] $5.185 \leq P \leq 600$ [bar] $TMLP(P) \leq T \leq 826.85$ [°C] $600 < P < 1000$ [bar] $TMLP(P) \leq T \leq 426.85$ [°C]
7B	CVTD(T)		
78	CVTDD(T)	CVTDD: Isochoric Specific Heat of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	$216.58 \leq T \leq 304.21$ [K] $-56.57 \leq T \leq 31.06$ [°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': 44.009 Relative Molecular Mass R: 'A'='R': 188.92 [J/(kg·K)] Gas Constant	one of 'M' and 'R'
9A	GAMPD(P)		
96	GAMPDD(P)	GAMPDD: Ratio of Specific Heats of Saturated Vapor [–] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] $5.185 \leq P \leq 73.825$ [bar]

Table II–2.14–1 Carbon Dioxide Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
95	GAMPT(P,T)	GAMPT: Ratio of Specific Heats [–] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $220 \leq T \leq 1100$ [K] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] TMLP(P)≤T≤1100 [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] TMLP(P)≤T≤700 [K] 0.1≤P<5.185 [bar] −53.15≤T≤826.85 [°C] 5.185≤P≤600 [bar] TMLP(P)≤T≤826.85 [°C] 600<P<1000 [bar] TMLP(P)≤T≤426.85 [°C]
9B	GAMTD(T)		
97	GAMTDD(T)	GAMTDD: Ratio of Specific Heats of Saturated Vapor [–] T∗: Temperature [K], [°C]	216.58≤T≤304.21 [K] −56.57≤T≤31.06 [°C]
23	HPD(P)	HPD: Specific Enthalpy of Saturated Liquid [J/kg] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] 5.185≤P≤73.825 [bar]
24	HPDD(P)	HPDD: Specific Enthalpy of Saturated Vapor [J/kg] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] 5.185≤P≤73.825 [bar]
71	HPS(P,S)	HPS: Specific Enthalpy [J/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] SPT(P,220K)≤S≤ SPT(P,1100K) [J/(kg·K)] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] SPT(P,TMLP(P))≤S≤ SPT(P,1100K) [J/(kg·K)] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] SPT(P,TMLP(P))≤S≤ SPT(P,700K) [J/(kg·K)] 0.1≤P<5.185 [bar] SPT(P,−53.15°C)≤S≤ SPT(P,826.85°C) [J/(kg·K)] 5.185≤P≤600 [bar] SPT(P,TMLP(P))≤S≤ SPT(P,826.85°C) [J/(kg·K)] 600<P<1000 [bar] SPT(P,TMLP(P))≤S≤ SPT(P,426.85°C) [J/(kg·K)]
25	HPT(P,T)	HPT: Specific Enthalpy [J/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $220 \leq T \leq 1100$ [K] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] TMLP(P)≤T≤1100 [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] TMLP(P)≤T≤700 [K] 0.1≤P<5.185 [bar] −53.15≤T≤826.85 [°C] 5.185≤P≤600 [bar] TMLP(P)≤T≤826.85 [°C] 600<P<1000 [bar] TMLP(P)≤T≤426.85 [°C]
26	HPX(P,X)	HPX: Specific Enthalpy of Mixture [J/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] 5.185≤P≤73.825 [bar] 0≤X≤1.0 [–]
27	HTD(T)	HTD: Specific Enthalpy of Saturated Liquid [J/kg] T∗: Temperature [K], [°C]	216.58≤T≤304.21 [K] −56.57≤T≤31.06 [°C]

Table II–2.14–1 Carbon Dioxide Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
28	HTDD(T)	HTDD: Specific Enthalpy of Saturated Vapor [J/kg] T∗: Temperature [K], [°C]	216.58≤T≤304.21 [K] −56.57≤T≤31.06 [°C]
29	HTX(T,X)	HTX: Specific Enthalpy of Mixture [J/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	216.58≤T≤304.21 [K] −56.57≤T≤31.06 [°C] 0≤X≤1.0 [–]
84	IDENTF('A')	IDENTF: CHARACTER TYPE FUNCTION for Package Identification (Length 20) C: 'A'='C': 'CO2' Molecular Formula S: 'A'='S': 'CARBON DIOXIDE' Name of Substance V: 'A'='V': '10.1' Version Number	one of 'C', 'S' and 'V'
66	PLDT(T)		
68	PMLT(T)	PMLT∗: Pressure on Melting Curve [Pa], [bar] T∗: Temperature [K], [°C]	216.58≤T≤237 [K] −56.57≤T≤−36.15 [°C]
85	PRPD(P)	PRPD: Prandtl Number of Saturated Liquid [–] P∗: Pressure [Pa], [bar]	1.286×10^6≤P<7.3825×10^6 [Pa] 12.86≤P<73.825 [bar]
86	PRPDD(P)	PRPDD: Prandtl Number of Saturated Vapor [–] P∗: Pressure [Pa], [bar]	0.5185×10^6≤P<7.3825×10^6 [Pa] 5.185≤P<73.825 [bar]
81	PRPT(P,T)	PRPT: Prandtl Number [–] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	10000≤P<0.5185×10^6 [Pa] 220≤T≤1100 [K] 0.5185×10^6≤P≤PST(240K) [Pa] TSP(P)≤T≤1100 [K] PST(240K)<P≤60×10^6 240≤T≤1100 [K] 60×10^6<P<100×10^6 [Pa] 240≤T≤700 [K] 0.1≤P<5.185 [bar] −53.15≤T≤826.85 [°C] 5.185≤P≤PST(−33.15°C) [bar] TSP(P)≤T≤826.85 [°C] PST(−33.15°C)<P≤600 [bar] −33.15≤T≤826.85 [°C] 600<P<1000 [bar] −33.15≤T≤426.85 [°C]
87	PRTD(T)	PRTD: Prandtl Number of Saturated Liquid [–] T∗: Temperature [K], [°C]	240≤T<304.21 [K] −33.15≤T<31.06 [°C]
88	PRTDD(T)	PRTDD: Prandtl Number of Saturated Vapor [–] T∗: Temperature [K], [°C]	216.58≤T<304.21 [K] −56.57≤T<31.06 [°C]
99	PSBT(P)		
30	PST(T)	PST∗: Saturation Pressure [Pa], [bar] T∗: Temperature [K], [°C]	216.58≤T≤304.21 [K] −56.57≤T≤31.06 [°C]
72	PSTD(P)		
73	PSTDD(P)		
31	SIGP(P)	SIGP: Surface Tension [N/m] P∗: Pressure [Pa], [bar]	0.5185×10^6≤P≤7.3825×10^6 [Pa] 5.185≤P≤73.825 [bar]
32	SIGT(T)	SIGT: Surface Tension [N/m] T∗: Temperature [K], [°C]	216.58≤T≤304.21 [K] −56.57≤T≤31.06 [°C]
33	SPD(P)	SPD: Specific Entropy of Saturated Liquid [J/(kg·K)] P∗: Pressure [Pa], [bar]	0.5185×10^6≤P≤7.3825×10^6 [Pa] 5.185≤P≤73.825 [bar]
34	SPDD(P)	SPDD: Specific Entropy of Saturated Vapor [J/(kg·K)] P∗: Pressure [Pa], [bar]	0.5185×10^6≤P≤7.3825×10^6 [Pa] 5.185≤P≤73.825 [bar]

Table II–2.14–1 Carbon Dioxide Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
35	SPT(P,T)	SPT: Specific Entropy [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $220 \leq T \leq 1100$ [K] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] $TMLP(P) \leq T \leq 1100$ [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] $TMLP(P) \leq T \leq 700$ [K] $0.1 \leq P < 5.185$ [bar] $-53.15 \leq T \leq 826.85$ [°C] $5.185 \leq P \leq 600$ [bar] $TMLP(P) \leq T \leq 826.85$ [°C] $600 < P < 1000$ [bar] $TMLP(P) \leq T \leq 426.85$ [°C]
36	SPX(P,X)	SPX: Specific Entropy of Mixture [J/(kg·K)] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] $5.185 \leq P \leq 73.825$ [bar] $0 \leq X \leq 1.0$ [–]
37	STD(T)	STD: Specific Entropy of Saturated Liquid [J/(kg·K)] T∗: Temperature [K], [°C]	$216.58 \leq T \leq 304.21$ [K] $-56.57 \leq T \leq 31.06$ [°C]
38	STDD(T)	STDD: Specific Entropy of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	$216.58 \leq T \leq 304.21$ [K] $-56.57 \leq T \leq 31.06$ [°C]
39	STX(T,X)	STX: Specific Entropy of Mixture [J/(kg·K)] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	$216.58 \leq T \leq 304.21$ [K] $-56.57 \leq T \leq 31.06$ [°C] $0 \leq X \leq 1.0$ [–]
67	TLDP(P)		
69	TMLP(P)	TMLP∗: Temperature on Melting Curve [K], [°C] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P \leq 100 \times 10^6$ [Pa] $5.185 \leq P \leq 1000$ [bar]
64	TPH(P,H)	TPH∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] H: Specific Enthalpy [J/kg]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] $HPT(P,220K) \leq H \leq$ $HPT(P,1100K)$ [J/kg] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] $HPT(P,TMLP(P)) \leq H \leq$ $HPT(P,1100K)$ [J/kg] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] $HPT(P,TMLP(P)) \leq H \leq$ $HPT(P,700K)$ [J/kg] $0.1 \leq P < 5.185$ [bar] $HPT(P,-53.15°C) \leq H \leq$ $HPT(P,826.85°C)$ [J/kg] $5.185 \leq P \leq 600$ [bar] $HPT(P,TMLP(P)) \leq H \leq$ $HPT(P,826.85°C)$ [J/kg] $600 < P < 1000$ [bar] $HPT(P,TMLP(P)) \leq H \leq$ $HPT(P,426.85°C)$ [J/kg]
6H	TPH2(P,H)		

Table II–2.14–1 Carbon Dioxide Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
65	TPS(P,S)	TPS∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] SPT(P,220K)≤S≤ SPT(P,1100K) [J/(kg·K)] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] SPT(P,TMLP(P))≤S≤ SPT(P,1100K) [J/(kg·K)] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] SPT(P,TMLP(P))≤S≤ SPT(P,700K) [J/(kg·K)] 0.1≤P<5.185 [bar] SPT(P,−53.15°C)≤S≤ SPT(P,826.85°C) [J/(kg·K)] 5.185≤P≤600 [bar] SPT(P,TMLP(P))≤S≤ SPT(P,826.85°C) [J/(kg·K)] 600<P<1000 [bar] SPT(P,TMLP(P))≤S≤ SPT(P,426.85°C) [J/(kg·K)]
6S	TPS2(P,S)		
98	TPSEUP(P)	TPSEUP: Pseudo Boiling Point [K], [°C] P∗: Pressure [Pa], [bar]	$7.3825 \times 10^6 < P \leq 30 \times 10^6$ [Pa] 73.825<P≤300 [bar]
70	TPV(P,V)	TPV∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] V: Specific Volume [m^3/kg]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] VPT(P,220K)≤V≤ VPT(P,1100K) [m^3/kg] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] VPT(P,TMLP(P))≤V≤ VPT(P,1100K) [m^3/kg] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] VPT(P,TMLP(P))≤V≤ VPT(P,700K) [m^3/kg] 0.1≤P<5.185 [bar] VPT(P,−53.15°C)≤V≤ VPT(P,826.85°C) [m^3/kg] 5.185≤P≤600 [bar] VPT(P,TMLP(P))≤V≤ VPT(P,826.85°C) [m^3/kg] 600<P<1000 [bar] VPT(P,TMLP(P))≤V≤ VPT(P,426.85°C) [m^3/kg]
41	TRPL('A')	TRPL∗: Properties at Triple Point P∗: 'A'='P': 0.5185×10^6 [Pa], 5.185 [bar] Pressure T∗: 'A'='T': 216.58 [K], −56.57 [°C] Temperature	one of 'P' and 'T'
100	TSBP(P)		
40	TSP(P)	TSP∗: Saturation Temperature [K], [°C] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] 5.185≤P≤73.825 [bar]
74	TSPD(P)		
75	TSPDD(P)		
42	UPD(P)	UPD: Specific Internal Energy of Saturated Liquid [J/kg] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] 5.185≤P≤73.825 [bar]
43	UPDD(P)	UPDD: Specific Internal Energy of Saturated Vapor [J/kg] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] 5.185≤P≤73.825 [bar]

Table II–2.14–1 Carbon Dioxide Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
79	UPS(P,S)	UPS: Specific Internal Energy [J/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] SPT(P,220K)≤S≤ SPT(P,1100K) [J/(kg·K)] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] SPT(P,TMLP(P))≤S≤ SPT(P,1100K) [J/(kg·K)] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] SPT(P,TMLP(P))≤S≤ SPT(P,700K) [J/(kg·K)] 0.1≤P<5.185 [bar] SPT(P,−53.15°C)≤S≤ SPT(P,826.85°C) [J/(kg·K)] 5.185≤P≤600 [bar] SPT(P,TMLP(P))≤S≤ SPT(P,826.85°C) [J/(kg·K)] 600<P<1000 [bar] SPT(P,TMLP(P))≤S≤ SPT(P,426.85°C) [J/(kg·K)]
44	UPT(P,T)	UPT: Specific Internal Energy [J/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \leq P < 0.5185 \times 10^6$ [Pa] 220≤T≤1100 [K] $0.5185 \times 10^6 \leq P \leq 60 \times 10^6$ [Pa] TMLP(P)≤T≤1100 [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] TMLP(P)≤T≤700 [K] 0.1≤P<5.185 [bar] −53.15≤T≤826.85 [°C] 5.185≤P≤600 [bar] TMLP(P)≤T≤826.85 [°C] 600<P<1000 [bar] TMLP(P)≤T≤426.85 [°C]
45	UPX(P,X)	UPX: Specific Internal Energy of Mixture [J/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] 5.185≤P≤73.825 [bar] 0≤X≤1.0 [–]
46	UTD(T)	UTD: Specific Internal Energy of Saturated Liquid [J/kg] T∗: Temperature [K], [°C]	216.58≤T≤304.21 [K] −56.57≤T≤31.06 [°C]
47	UTDD(T)	UTDD: Specific Internal Energy of Saturated Vapor [J/kg] T∗: Temperature [K], [°C]	216.58≤T≤304.21 [K] −56.57≤T≤31.06 [°C]
48	UTX(T,X)	UTX: Specific Internal Energy of Mixture [J/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	216.58≤T≤304.21 [K] −56.57≤T≤31.06 [°C] 0≤X≤1.0 [–]
49	VPD(P)	VPD: Specific Volume of Saturated Liquid [m^3/kg] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] 5.185≤P≤73.825 [bar]
50	VPDD(P)	VPDD: Specific Volume of Saturated Vapor [m^3/kg] P∗: Pressure [Pa], [bar]	$0.5185 \times 10^6 \leq P \leq 7.3825 \times 10^6$ [Pa] 5.185≤P≤73.825 [bar]

Table II–2.14–1 Carbon Dioxide Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
80	VPS(P,S)	VPS: Specific Volume [m^3/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$10000 \le P < 0.5185 \times 10^6$ [Pa] SPT(P,220K)≤S≤ SPT(P,1100K) [J/(kg·K)] $0.5185 \times 10^6 \le P \le 60 \times 10^6$ [Pa] SPT(P,TMLP(P))≤S≤ SPT(P,1100K) [J/(kg·K)] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] SPT(P,TMLP(P))≤S≤ SPT(P,700K) [J/(kg·K)] 0.1≤P<5.185 [bar] SPT(P,−53.15°C)≤S≤ SPT(P,826.85°C) [J/(kg·K)] 5.185≤P≤600 [bar] SPT(P,TMLP(P))≤S≤ SPT(P,826.85°C) [J/(kg·K)] 600<P<1000 [bar] SPT(P,TMLP(P))≤S≤ SPT(P,426.85°C) [J/(kg·K)]
51	VPT(P,T)	VPT: Specific Volume [m^3/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \le P < 0.5185 \times 10^6$ [Pa] 220≤T≤1100 [K] $0.5185 \times 10^6 \le P \le 60 \times 10^6$ [Pa] TMLP(P)≤T≤1100 [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] TMLP(P)≤T≤700 [K] 0.1≤P<5.185 [bar] −53.15≤T≤826.85 [°C] 5.185≤P≤600 [bar] TMLP(P)≤T≤826.85 [°C] 600<P<1000 [bar] TMLP(P)≤T≤426.85 [°C]
52	VPX(P,X)	VPX: Specific Volume of Mixture [m^3/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$0.5185 \times 10^6 \le P \le 7.3825 \times 10^6$ [Pa] 5.185≤P≤73.825 [bar] 0≤X≤1.0 [–]
53	VTD(T)	VTD: Specific Volume of Saturated Liquid [m^3/kg] T∗: Temperature [K], [°C]	216.58≤T≤304.21 [K] −56.57≤T≤31.06 [°C]
54	VTDD(T)	VTDD: Specific Volume of Saturated Vapor [m^3/kg] T∗: Temperature [K], [°C]	216.58≤T≤304.21 [K] −56.57≤T≤31.06 [°C]
55	VTX(T,X)	VTX: Specific Volume of Mixture [m^3/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	216.58≤T≤304.21 [K] −56.57≤T≤31.06 [°C] 0≤X≤1.0 [–]
8E	WPD(P)		
8F	WPDD(P)		
83	WPT(P,T)	WPT: Velocity of Sound [m/s] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10000 \le P < 0.5185 \times 10^6$ [Pa] 220≤T≤1100 [K] $0.5185 \times 10^6 \le P \le 60 \times 10^6$ [Pa] TMLP(P)≤T≤1100 [K] $60 \times 10^6 < P < 100 \times 10^6$ [Pa] TMLP(P)≤T≤700 [K] 0.1≤P<5.185 [bar] −53.15≤T≤826.85 [°C] 5.185≤P≤600 [bar] TMLP(P)≤T≤826.85 [°C] 600<P<1000 [bar] TMLP(P)≤T≤426.85 [°C]
8G	WTD(T)		
8H	WTDD(T)		

Table II–2.14–1 Carbon Dioxide Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
56	XPH(P,H)	XPH: Dryness Fraction [–] P∗: Pressure [Pa], [bar] H: Specific Enthalpy of Mixture [J/kg]	$0.5185\times10^6 \le P < 7.3825\times10^6$ [Pa] $5.185 \le P < 73.825$ [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)]	$0.5185\times10^6 \le P < 7.3825\times10^6$ [Pa] $5.185 \le P < 73.825$ [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]	$0.5185\times10^6 \le P < 7.3825\times10^6$ [Pa] $5.185 \le P < 73.825$ [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]	$0.5185\times10^6 \le P < 7.3825\times10^6$ [Pa] $5.185 \le P < 73.825$ [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]	$216.58 \le T < 304.21$ [K] $-56.57 \le T < 31.06$ [°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)]	$216.58 \le T < 304.21$ [K] $-56.57 \le T < 31.06$ [°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]	$216.58 \le T < 304.21$ [K] $-56.57 \le T < 31.06$ [°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]	$216.58 \le T < 304.21$ [K] $-56.57 \le T < 31.06$ [°C] VTD(T)≤V≤VTDD(T) [m^3/kg]