2.10 Nitrogen

Equations for thermodynamic properties have been cited from the IUPAC Tables[1], those for transport properties from Stephan et al.[2], and those for other properties from Jacobsen et al.[3].

2.10.1 Temperature Scale

International practical temperature scale 1968 (IPTS-1968)

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

Name of Substance:	Nitrogen
Library File for UNIX:	libjn2.a
Library File for DOS,Windows95/NT:	JN2.LIB
Single Shot Program for UNIX:	n2-ss
Single Shot Program for DOS,Windows95/NT:	N2–SS.EXE

2.10.3 Important Constants and Others

Molecular Formula:	N_2
Relative Molecular Mass:	28.0134
Gas Constant:	296.8115 J/(kg·K)

Critical Constants:

Critical Pressure:	3.4000×10^{6}Pa (34.000 bar)
Critical Temperature:	126.20 K (−146.95°C)
Critical Specific Volume:	3.1847×10^{-3}m^3/kg

Triple Point:

Pressure:	0.01253×10^{6}Pa (0.1253 bar)
Temperature:	63.148 K (−210.002°C)

Reference State:
At 1.01325 bar(1 atm) and 25°C(298.15 K), 0 J/(kg·K) is assigned to the specific entropy of the ideal gas. At 25°C(298.15 K), 0 J/kg is assigned to the specific enthalpy of the ideal gas.

2.10.4 Formula

Equation of State:
Equation (9) in a function form of $P = P(\rho, T)$ in reference [1]. Here P=pressure, ρ=density and T=Temperature.

Vapor Pressure:
Equation (2) in reference [1].

Properties at Vapor-Liquid Equilibrium:
Equations (2) and (9) for specific volume, equation (12) for specific enthalpy, equation (15) for specific entropy and equation (19) for isobaric specific heat, respectively. All of these have been cited from reference [1]. However, the third term in the right side of equation (19),

$$C_p(\rho,T) = C_p^{id}(T) - R + R[\sum_{i=1}^{32} N_i(XC)_i]_0^w + \cdots$$

has been corrected to

$$C_p(\rho,T) = C_p^{id}(T) - R - R[\sum_{i=1}^{32} N_i(XC)_i]_0^w + \cdots$$

Pressure and Temperature on Melting Line:
Equation (1) in reference [1].

Transport Properties:
Viscosity and thermal conductivity from Equations (1) and (5) in reference [2], respectively.

The Other Properties:
Surface tension and static dielectric constant from equations (19) and (20) in reference [3], respectively.

References

[1] S.Angus, B.Armstrong and K.M.de Reuck, Nitrogen International Thermodynamic Table of the Fluid State-6, IUPAC, (1979).
[2] K.Stephan, R.Krauss and A.Laesecke, J. Phys. Chem. Ref. Data, 16–4, (1987), pp.993–1023.
[3] R.T.Jacobsen, R.B.Stewart, R.D.McCarty and H.J.M. Hanley, N.B.S. Technical Note 648, (December, 1973).

Table II–2.10–1 Nitrogen 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]	$12.53\times10^3\leq P\leq10^9$ [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°C]
8A	AKPD(P)		
8B	AKPDD(P)		
82	AKPT(P,T)	AKPT: Isentropic Exponent [–] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$12.53\times10^3\leq P\leq10^9$ [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°C]
8C	AKTD(T)		
8D	AKTDD(T)		
2	ALAPP(P)	ALAPP: Laplace Coefficient [m] P∗: Pressure [Pa], [bar]	$12.53\times10^3\leq P<3.4\times10^6$ [Pa] 0.1253≤P<34 [bar]
3	ALAPT(T)	ALAPT: Laplace Coefficient [m] T∗: Temperature [K], [°C]	63.148≤T<126.2 [K] −210.002≤T<−146.95 [°C]
4	ALHP(P)	ALHP: Latent Heat of Vaporization [J/kg] P∗: Pressure [Pa], [bar]	$12.53\times10^3\leq P\leq3.4\times10^6$ [Pa] 0.1253≤P≤34 [bar]
5	ALHT(T)	ALHT: Latent Heat of Vaporization [J/kg] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]
6	ALMPD(P)	ALMPD: Thermal Conductivity of Saturated Liquid [W/(m·K)] P∗: Pressure [Pa], [bar]	$12.53\times10^3\leq P<3.4\times10^6$ [Pa] 0.1253≤P<34 [bar]
7	ALMPDD(P)	ALMPDD: Thermal Conductivity of Saturated Vapor [W/(m·K)] T∗: Temperature [K], [°C]	$12.53\times10^3\leq P<3.4\times10^6$ [Pa] 0.1253≤P<34 [bar]
8	ALMPT(P,T)	ALMPT: Thermal Conductivity [W/(m·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$12.53\times10^3\leq P\leq100\times10^6$ [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤1000 [bar] TMLP(P)≤T≤826.85 [°C]
9	ALMTD(T)	ALMTD: Thermal Conductivity of Saturated Liquid [W/(m·K)] T∗: Temperature [K], [°C]	63.148≤T<126.2 [K] −210.002≤T<−146.95 [°C]
10	ALMTDD(T)	ALMTDD: Thermal Conductivity of Saturated Vapor [W/(m·K)] T∗: Temperature [K], [°C]	63.148≤T<126.2 [K] −210.002≤T<−146.95 [°C]
11	AMUPD(P)	AMUPD: Coefficient of Viscosity of Saturated Liquid [Pa·s] P∗: Pressure [Pa], [bar]	$12.53\times10^3\leq P\leq3.4\times10^6$ [Pa] 0.1253≤P≤34 [bar]
12	AMUPDD(P)	AMUPDD: Coefficient of Viscosity of Saturated Vapor [Pa·s] P∗: Pressure [Pa], [bar]	$12.53\times10^3\leq P\leq3.4\times10^6$ [Pa] 0.1253≤P≤34 [bar]
13	AMUPT(P,T)	AMUPT: Coefficient of Viscosity [Pa·s] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$12.53\times10^3\leq P\leq100\times10^6$ [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤1000 [bar] TMLP(P)≤T≤826.85 [°C]
14	AMUTD(T)	AMUTD: Coefficient of Viscosity of Saturated Liquid [Pa·s] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]
15	AMUTDD(T)	AMUTDD: Coefficient of Viscosity of Saturated Vapor [Pa·s] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]

Table II–2.10–1 Nitrogen 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]	$12.53\times10^3\leq P\leq10^9$ [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°C]
90	BSPT(P,T)	BSPT: Isentropic Compressibility [1/Pa] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$12.53\times10^3\leq P\leq10^9$ [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°C]
91	BTPT(P,T)	BTPT: Isothermal Compressibility [1/Pa] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$12.53\times10^3\leq P\leq10^9$ [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°C]
93	BVPT(P,T)	BVPT: Pressure Coefficient [1/K] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$12.53\times10^3\leq P\leq10^9$ [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°C]
16	CPPD(P)	CPPD: Isobaric Specific Heat of Saturated Liquid [J/(kg·K)] P∗: Pressure [Pa], [bar]	$12.53\times10^3\leq P<3.4\times10^6$ [Pa] 0.1253≤P<34 [bar]
17	CPPDD(P)	CPPDD: Isobaric Specific Heat of Saturated Vapor [J/(kg·K)] P∗: Pressure [Pa], [bar]	$12.53\times10^3\leq P<3.4\times10^6$ [Pa] 0.1253≤P<34 [bar]
18	CPPT(P,T)	CPPT: Isobaric Specific Heat [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$12.53\times10^3\leq P\leq10^9$ [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°C]
19	CPTD(T)	CPTD: Isobaric Specific Heat of Saturated Liquid [J/(kg·K)] T∗: Temperature [K], [°C]	63.148≤T<126.2 [K] −210.002≤T<−146.95 [°C]
20	CPTDD(T)	CPTDD: Isobaric Specific Heat of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	63.148≤T<126.2 [K] −210.002≤T<−146.95 [°C]
21	CRP('A')	CRP: Critical Constants H: 'A'='H': 30.703×10^3 [J/kg] Specific Enthalpy P∗: 'A'='P': 3.4×10^6 [Pa], 34.0 [bar] Pressure S: 'A'='S': 4.2266×10^3 [J/(kg·K)] Specific Entropy T∗: 'A'='T': 126.2 [K], −146.95 [°C] Temperature V: 'A'='V': 3.1847×10^{-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]	$12.53\times10^3\leq P\leq3.4\times10^6$ [Pa] 0.1253≤P≤34 [bar]
77	CVPT(P,T)	CVPT: Isochoric Specific Heat [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$12.53\times10^3\leq P\leq10^9$ [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°C]
7B	CVTD(T)		
78	CVTDD(T)	CVTDD: Isochoric Specific Heat of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]

Table II–2.10–1 Nitrogen Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
2A	EPSPD(P)		
2B	EPSPDD(P)		
22	EPSPT(P,T)	EPSPT: Static Dielectric Constant [–] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$12.53\times10^3\leq P\leq10^9$ [Pa] TMLP(P)≤T≤1000 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤726.85 [°C]
2C	EPSTD(T)		
2D	EPSTDD(T)		
89	FC('A')	FC: Fundamental Constants M: 'A'='M': 28.0134 Relative Molecular Mass R: 'A'='R': 296.8115 [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]	$12.53\times10^3\leq P\leq3.398\times10^6$ [Pa] 0.1253≤P≤33.98 [bar]
95	GAMPT(P,T)	GAMPT: Ratio of Specific Heats [–] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$12.53\times10^3\leq P\leq10^9$ [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°C]
9B	GAMTD(T)		
97	GAMTDD(T)	GAMTDD: Ratio of Specific Heats of Saturated Vapor [–] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]
23	HPD(P)	HPD: Specific Enthalpy of Saturated Liquid [J/kg] P∗: Pressure [Pa], [bar]	$12.53\times10^3\leq P\leq3.4\times10^6$ [Pa] 0.1253≤P≤34 [bar]
24	HPDD(P)	HPDD: Specific Enthalpy of Saturated Vapor [J/kg] P∗: Pressure [Pa], [bar]	$12.53\times10^3\leq P\leq3.4\times10^6$ [Pa] 0.1253≤P≤34 [bar]
71	HPS(P,S)	HPS: Specific Enthalpy [J/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$12.53\times10^3\leq P\leq10^9$ [Pa] SPT(P,TMLP(P))≤S≤ SPT(P,1100K) [J/(kg·K)] 0.1253≤P≤10000 [bar] SPT(P,TMLP(P))≤S≤ SPT(P,826.85°C) [J/(kg·K)]
25	HPT(P,T)	HPT: Specific Enthalpy [J/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$12.53\times10^3\leq P\leq10^9$ [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°C]
26	HPX(P,X)	HPX: Specific Enthalpy of Mixture [J/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$12.53\times10^3\leq P\leq3.4\times10^6$ [Pa] 0.1253≤P≤34 [bar] 0≤X≤1.0 [–]
27	HTD(T)	HTD: Specific Enthalpy of Saturated Liquid [J/kg] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]
28	HTDD(T)	HTDD: Specific Enthalpy of Saturated Vapor [J/kg] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]
29	HTX(T,X)	HTX: Specific Enthalpy of Mixture [J/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C] 0≤X≤1.0 [–]

Table II–2.10–1 Nitrogen Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
84	IDENTF('A')	IDENTF: CHARACTER TYPE FUNCTION for Package Identification (Length 20) C: 'A'='C': 'N2' Molecular Formula S: 'A'='S': 'NITROGEN' 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]	63.148≤T≤190.4 [K] −210.002≤T≤−82.75 [°C]
85	PRPD(P)	PRPD: Prandtl Number of Saturated Liquid [–] P∗: Pressure [Pa], [bar]	12.53×10^3≤P<3.4×10^6 [Pa] 0.1253≤P<34 [bar]
86	PRPDD(P)	PRPDD: Prandtl Number of Saturated Vapor [–] P∗: Pressure [Pa], [bar]	12.53×10^3≤P<3.4×10^6 [Pa] 0.1253≤P<34 [bar]
81	PRPT(P,T)	PRPT: Prandtl Number [–] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	12.53×10^3≤P≤100×10^6 [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤1000 [bar] TMLP(P)≤T≤826.85 [°C]
87	PRTD(T)	PRTD: Prandtl Number of Saturated Liquid [–] T∗: Temperature [K], [°C]	63.148≤T<126.2 [K] −210.002≤T<−146.95 [°C]
88	PRTDD(T)	PRTDD: Prandtl Number of Saturated Vapor [–] T∗: Temperature [K], [°C]	63.148≤T<126.2 [K] −210.002≤T<−146.95 [°C]
99	PSBT(T)		
30	PST(T)	PST∗: Saturation Pressure [Pa], [bar] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]
72	PSTD(T)		
73	PSTDD(T)		
31	SIGP(P)	SIGP: Surface Tension [N/m] P∗: Pressure [Pa], [bar]	12.53×10^3≤P≤3.4×10^6 [Pa] 0.1253≤P≤34 [bar]
32	SIGT(T)	SIGT: Surface Tension [N/m] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]
33	SPD(P)	SPD: Specific Entropy of Saturated Liquid [J/(kg·K)] P∗: Pressure [Pa], [bar]	12.53×10^3≤P≤3.4×10^6 [Pa] 0.1253≤P≤34 [bar]
34	SPDD(P)	SPDD: Specific Entropy of Saturated Vapor [J/(kg·K)] P∗: Pressure [Pa], [bar]	12.53×10^3≤P≤3.4×10^6 [Pa] 0.1253≤P≤34 [bar]
35	SPT(P,T)	SPT: Specific Entropy [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	12.53×10^3≤P≤10^9 [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°C]
36	SPX(P,X)	SPX: Specific Entropy of Mixture [J/(kg·K)] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	12.53×10^3≤P≤3.4×10^6 [Pa] 0.1253≤P≤34 [bar] 0≤X≤1.0 [–]
37	STD(T)	STD: Specific Entropy of Saturated Liquid [J/(kg·K)] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]
38	STDD(T)	STDD: Specific Entropy of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]
39	STX(T,X)	STX: Specific Entropy of Mixture [J/(kg·K)] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C] 0≤X≤1.0 [–]
67	TLDP(P)		
69	TMLP(P)	TMLP∗: Temperature on Melting Curve [K], [°C] P∗: Pressure [Pa], [bar]	12.53×10^3≤P≤10^9 [Pa] 0.1253≤P≤10000 [bar]

Table II–2.10–1 Nitrogen Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
64	TPH(P,H)	TPH∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] H: Specific Enthalpy [J/kg]	$12.53\times10^3\leq P\leq10^9$ [Pa] HPT(P,TMLP(P))≤H≤ HPT(P,1100K) [J/kg] 0.1253≤P≤10000 [bar] HPT(P,TMLP(P))≤H≤ HPT(P,826.85°C) [J/kg]
6H	TPH2(P,H)		
65	TPS(P,S)	TPS∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$12.53\times10^3\leq P\leq10^9$ [Pa] SPT(P,TMLP(P))≤S≤ SPT(P,1100K) [J/(kg·K)] 0.1253≤P≤10000 [bar] SPT(P,TMLP(P))≤S≤ SPT(P,826.85°C) [J/(kg·K)]
6S	TPS2(P,S)		
98	TPSEUP(P)	TPSEUP: Pseudo Boiling Point [K], [°C] T∗: Temperature [K], [°C]	$3.4\times10^6<P\leq100\times10^6$ [Pa] 34<P≤1000 [bar]
70	TPV(P,V)	TPV∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] V: Specific Volume [m^3/kg]	$12.53\times10^3\leq P\leq10^9$ [Pa] VPT(P,TMLP(P))≤V≤ VPT(P,1100K) [m^3/kg] 0.1253≤P≤10000 [bar] VPT(P,TMLP(P))≤V≤ VPT(P,826.85°C) [m^3/kg]
41	TRPL('A')	TRPL∗: Properties at Triple Point P∗: 'A'='P': 12.53×10^3 [Pa], 0.1253 [bar] Pressure T∗: 'A'='T': 63.148 [K], −210.002 [°C] Temperature	one of 'P' and 'T'
100	TSBP(P)		
40	TSP(P)	TSP∗: Saturation Temperature [K], [°C] P∗: Pressure [Pa], [bar]	$12.53\times10^3\leq P\leq3.4\times10^6$ [Pa] 0.1253≤P≤34 [bar]
74	TSPD(P)		
75	TSPDD(P)		
42	UPD(P)	UPD: Specific Internal Energy of Saturated Liquid [J/kg] P∗: Pressure [Pa], [bar]	$12.53\times10^3\leq P\leq3.4\times10^6$ [Pa] 0.1253≤P≤34 [bar]
43	UPDD(P)	UPDD: Specific Internal Energy of Saturated Vapor [J/kg] P∗: Pressure [Pa], [bar]	$12.53\times10^3\leq P\leq3.4\times10^6$ [Pa] 0.1253≤P≤34 [bar]
79	UPS(P,S)	UPS: Specific Internal Energy [J/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$12.53\times10^3\leq P\leq10^9$ [Pa] SPT(P,TMLP(P))≤S≤ SPT(P,1100K) [J/(kg·K)] 0.1253≤P≤10000 [bar] SPT(P,TMLP(P))≤S≤ SPT(P,826.85°C) [J/(kg·K)]
44	UPT(P,T)	UPT: Specific Internal Energy [J/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$12.53\times10^3\leq P\leq10^9$ [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°C]
45	UPX(P,X)	UPX: Specific Internal Energy of Mixture [J/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$12.53\times10^3\leq P\leq3.4\times10^6$ [Pa] 0.1253≤P≤34 [bar] 0≤X≤1.0 [–]
46	UTD(T)	UTD: Specific Internal Energy of Saturated Liquid [J/kg] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]

Table II–2.10–1 Nitrogen Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
47	UTDD(T)	UTDD: Specific Internal Energy of Saturated Vapor [J/kg] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]
48	UTX(T,X)	UTX: Specific Internal Energy of Mixture [J/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C] 0≤X≤1.0 [–]
49	VPD(P)	VPD: Specific Volume of Saturated Liquid [m^3/kg] P∗: Pressure [Pa], [bar]	12.53×10^3≤P≤3.4×10^6 [Pa] 0.1253≤P≤34 [bar]
50	VPDD(P)	VPDD: Specific Volume of Saturated Vapor [m^3/kg] P∗: Pressure [Pa], [bar]	12.53×10^3≤P≤3.4×10^6 [Pa] 0.1253≤P≤34 [bar]
80	VPS(P,S)	VPS: Specific Volume [m^3/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	12.53×10^3≤P≤10^9 [Pa] SPT(P,TMLP(P))≤S≤ SPT(P,1100K) [J/(kg·K)] 0.1253≤P≤10000 [bar] SPT(P,TMLP(P))≤S≤ SPT(P,826.85°C) [J/(kg·K)]
51	VPT(P,T)	VPT: Specific Volume [m^3/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	12.53×10^3≤P≤10^9 [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°C]
52	VPX(P,X)	VPX: Specific Volume of Mixture [m^3/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	12.53×10^3≤P≤3.4×10^6 [Pa] 0.1253≤P≤34 [bar] 0≤X≤1.0 [–]
53	VTD(T)	VTD: Specific Volume of Saturated Liquid [m^3/kg] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]
54	VTDD(T)	VTDD: Specific Volume of Saturated Vapor [m^3/kg] T∗: Temperature [K], [°C]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°C]
55	VTX(T,X)	VTX: Specific Volume of Mixture [m^3/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	63.148≤T≤126.2 [K] −210.002≤T≤−146.95 [°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]	12.53×10^3≤P≤10^9 [Pa] TMLP(P)≤T≤1100 [K] 0.1253≤P≤10000 [bar] TMLP(P)≤T≤826.85 [°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]	12.53×10^3≤P<3.4×10^6 [Pa] 0.1253≤P<34 [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)]	12.53×10^3≤P<3.4×10^6 [Pa] 0.1253≤P<34 [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]	12.53×10^3≤P<3.4×10^6 [Pa] 0.1253≤P<34 [bar] UPD(P)≤U≤UPDD(P) [J/kg]

Table II–2.10–1 Nitrogen Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
59	XPV(P,V)	XPV: Dryness Fraction [–] P∗: Pressure [Pa], [bar] V: Specific Volume of Mixture [m^3/kg]	$12.53\times10^3 \le P < 3.4\times10^6$ [Pa] $0.1253 \le P < 34$ [bar] $VPD(P) \le V \le VPDD(P)$ [m^3/kg]
60	XTH(T,H)	XTH: Dryness Fraction [–] T∗: Temperature [K], [°C] H: Specific Enthalpy of Mixture [J/kg]	$63.148 \le T < 126.2$ [K] $-210.002 \le T < -146.95$ [°C] $HTD(T) \le H \le HTDD(T)$ [J/kg]
61	XTS(T,S)	XTS: Dryness Fraction [–] T∗: Temperature [K], [°C] S: Specific Entropy of Mixture [J/(kg·K)]	$63.148 \le T < 126.2$ [K] $-210.002 \le T < -146.95$ [°C] $STD(T) \le S \le STDD(T)$ [J/(kg·K)]
62	XTU(T,U)	XTU: Dryness Fraction [–] T∗: Temperature [K], [°C] U: Specific Internal Energy of Mixture [J/kg]	$63.148 \le T < 126.2$ [K] $-210.002 \le T < -146.95$ [°C] $UTD(T) \le U \le UTDD(T)$ [J/kg]
63	XTV(T,V)	XTV: Dryness Fraction [–] T∗: Temperature [K], [°C] V: Specific Volume of Mixture [m^3/kg]	$63.148 \le T < 126.2$ [K] $-210.002 \le T < -146.95$ [°C] $VTD(T) \le V \le VTDD(T)$ [m^3/kg]