2.39 CFC-152a(R152a)

All equations for CFC-152a(R152a) are based on the Table from Thermodynamic properties of refrigerants of ASHRAE[1],[2].

2.39.1 Temperature Scale

International practical temperature scale 1968 (IPTS-1968)

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

Name of Substance:	CFC-152a, R152a, Refrigerant 152a, Difluoroethane
Library File for UNIX:	libjr152a.a
Library File for DOS,Windows95/NT:	JR152A.LIB
Single Shot Program for UNIX:	r152a-ss
Single Shot Program for DOS,Windows95/NT:	R152A–SS.EXE

2.39.3 Important Constants and Others

Molecular Formula:	$C_2H_4F_2$
Relative Molecular Mass:	66.050
Gas Constant:	125.882 J/(kg·K)

Critical Constants:

Critical Pressure:	4.495×10^{6}Pa (44.95 bar)
Critical Temperature:	386.65 K (113.50 °C)
Critical Specific Volume:	2.7397×10^{-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.

2.39.4 Formula

Equation of State:

The Martin-Hou equation in reference [1] is used.

Vapor Pressure:

Equation (2.2.2) in reference [1].

Properties at Vapor-Liquid Equilibrium:

The saturated liquid density equation is obtained from Equation (2.2.4.d) in reference [1]. The saturated vapor density is obtained by the compatibility of the equation of state and vapor pressure equation. Isobaric specific heat c_p is obtained from individual in reference [2].

Transport Properties:

Thermal conductivity and viscosity from reference [2].

The Other Properties:

Surface tension from reference [5].

References

[1] Thermodynamic Properties of Refrigerants (1986), 33, ASHRAE
[2] Thermophysical Properties of Refrigerants (Inch-Pound Edition), (1993), 113, ASHRAE

Table II–2.39–1 R152a 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)		
8C	AKTD(T)		
8D	AKTDD(T)		
2	ALAPP(P)	ALAPP: Laplace Coefficient [m] P∗: Pressure [Pa], [bar]	$1.033\times10^3\leq P\leq0.22189\times10^6$ [Pa] $0.01033\leq P\leq2.2189$ [bar]
3	ALAPT(T)	ALAPT: Laplace Coefficient [m] T∗: Temperature [K], [°C]	$173.15\leq T\leq268$ [K] $-100\leq T\leq-5.15$ [°C]
4	ALHP(P)	ALHP: Latent Heat of Vaporization [J/kg] P∗: Pressure [Pa], [bar]	$1.033\times10^3\leq P\leq3.3832\times10^6$ [Pa] $0.01033\leq P\leq33.832$ [bar]
5	ALHT(T)	ALHT: Latent Heat of Vaporization [J/kg] T∗: Temperature [K], [°C]	$173.15\leq T\leq371.15$ [K] $-100\leq T\leq98$ [°C]
6	ALMPD(P)	ALMPD: Thermal Conductivity of Saturated Liquid [W/(m·K)] P∗: Pressure [Pa], [bar]	$9.71\times10^3\leq P\leq1.899\times10^6$ [Pa] $0.0971\leq P\leq18.99$ [bar]
7	ALMPDD(P)		
8	ALMPT(P,T)	ALMPT: Thermal Conductivity at Ordinary Pressure [W/(m·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	P=Dummy $273\leq T\leq473$ [K] $-0.15\leq T\leq199.85$ [°C]
9	ALMTD(T)	ALMTD: Thermal Conductivity of Saturated Liquid [W/(m·K)] T∗: Temperature [K], [°C]	$203.15\leq T\leq343.15$ [K] $-70\leq T\leq70$ [°C]
10	ALMTDD(T)		
11	AMUPD(P)	AMUPD: Coefficient of Viscosity of Saturated Liquid [Pa·s] P∗: Pressure [Pa], [bar]	$9.62\times10^3\leq P\leq0.6885\times10^6$ [Pa] $0.0962\leq P\leq6.885$ [bar]
12	AMUPDD(P)	AMUPDD: Coefficient of Viscosity of Saturated Vapor [Pa·s] P∗: Pressure [Pa], [bar]	$0.12486\times10^3\leq P\leq1.509\times10^6$ [Pa] $1.2486\leq P\leq15.09$ [bar]
13	AMUPT(P,T)	AMUPT: Coefficient of Viscosity at Ordinary Pressure [Pa·s] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	P=Dummy $248\leq T\leq423$ [K] $-25.15\leq T\leq149.85$ [°C]
14	AMUTD(T)	AMUTD: Coefficient of Viscosity of Saturated Liquid [Pa·s] T∗: Temperature [K], [°C]	$203\leq T\leq303$ [K] $-70.15\leq T\leq29.85$ [°C]
15	AMUTDD(T)	AMUTDD: Coefficient of Viscosity of Saturated Vapor [Pa·s] T∗: Temperature [K], [°C]	$253.15\leq T\leq333.15$ [K] $-20\leq T\leq60$ [°C]
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]	$9.71\times10^3\leq P\leq1.899\times10^6$ [Pa] $0.0971\leq P\leq18.99$ [bar]
17	CPPDD(P)	CPPDD: Isobaric Specific Heat of Saturated Vapor [J/(kg·K)] P∗: Pressure [Pa], [bar]	$17.81\times10^3\leq P\leq0.912\times10^6$ [Pa] $0.1781\leq P\leq9.12$ [bar]
18	CPPT(P,T)	CPPT: Isobaric Specific Heat at Ordinary Pressure [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	P=Dummy $248.15\leq T\leq473.15$ [K] $-25\leq T\leq200$ [°C]

Table II–2.39–1 R152a Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
19	CPTD(T)	CPTD: Isobaric Specific Heat of Saturated Liquid [J/(kg·K)] T∗: Temperature [K], [°C]	203.15≤T≤343.15 [K] −70≤T≤70 [°C]
20	CPTDD(T)	CPTDD: Isobaric Specific Heat of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	213.15≤T≤313.15 [K] −60≤T≤40 [°C]
21	CRP('A')	CRP: Critical Constants H: 'A'='H': 0.4679×10^6 [J/kg] Specific Enthalpy P∗: 'A'='P': 4.495×10^6 [Pa], 44.95 [bar] Pressure S: 'A'='S': 1.7970×10^3 [J/(kg·K)] Specific Entropy T∗: 'A'='T': 386.65 [K], 113.50 [°C] Temperature V: 'A'='V': 2.7397×10^{-3} [m^3/kg] Specific Volume	one of 'H', 'P', 'S', 'T' and 'V'
7A	CVPD(P)		
76	CVPDD(P)		
77	CVPT(P,T)		
7B	CVTD(T)		
78	CVTDD(T)		
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': 66.050 Relative Molecular Mass R: 'A'='R': 125.882 [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]	1.033×10^3≤P≤3.3832×10^6 [Pa] 0.01033≤P≤33.832 [bar]
24	HPDD(P)	HPDD: Specific Enthalpy of Saturated Vapor [J/kg] P∗: Pressure [Pa], [bar]	1.033×10^3≤P≤3.3832×10^6 [Pa] 0.01033≤P≤33.832 [bar]
71	HPS(P,S)	HPS: Specific Enthalpy [J/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	10×10^3≤P≤3.0×10^6 [Pa] SPDD(P)≤S≤ SPT(P,453.15K) [J/(kg·K)] 0.1≤P≤30 [bar] SPDD(P)≤S≤ SPT(P,180°C) [J/(kg·K)] see Fig.II-2.39-3 for S
25	HPT(P,T)	HPT: Specific Enthalpy [J/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	10×10^3≤P≤3.0×10^6 [Pa] TSP(P)≤T≤453.15 [K] 0.1≤P≤30 [bar] TSP(P)≤T≤180 [°C] see Fig.II-2.39-1
26	HPX(P,X)	HPX: Specific Enthalpy of Mixture [J/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	1.033×10^3≤P≤3.3832×10^6 [Pa] 0.01033≤P≤33.832 [bar] 0≤X≤1.0 [–]
27	HTD(T)	HTD: Specific Enthalpy of Saturated Liquid [J/kg] T∗: Temperature [K], [°C]	173.15≤T≤371.15 [K] −100≤T≤98 [°C]
28	HTDD(T)	HTDD: Specific Enthalpy of Saturated Vapor [J/kg] T∗: Temperature [K], [°C]	173.15≤T≤371.15 [K] −100≤T≤98 [°C]
29	HTX(T,X)	HTX: Specific Enthalpy of Mixture [J/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	173.15≤T≤371.15 [K] −100≤T≤98 [°C] 0≤X≤1.0 [–]

Table II–2.39–1 R152a 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': 'C2H4F2' Molecular Formula S: 'A'='S': 'R152A' 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]	$9.71 \leq P \leq 0.6885$ [Pa] $0.0971 \leq P \leq 6.885$ [bar]
86	PRPDD(P)		
81	PRPT(P,T)	PRPT: Prandtl Number at Ordinary Pressure [–] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	P=Dummy $273 \leq T \leq 423$ [K] $-0.15 \leq T \leq 149.85$ [°C]
87	PRTD(T)	PRTD: Prandtl Number of Saturated Liquid [–] T∗: Temperature [K], [°C]	$203.15 \leq T \leq 303$ [K] $-70 \leq T \leq 29.85$ [°C]
88	PRTDD(T)		
99	PSBT(T)		
30	PST(T)	PST∗: Saturation Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$173.15 \leq T \leq 371.15$ [K] $-100 \leq T \leq 98$ [°C]
72	PSTD(T)		
73	PSTDD(T)		
31	SIGP(P)	SIGP: Surface Tension [N/m] P∗: Pressure [Pa], [bar]	$1.033 \times 10^3 \leq P \leq 0.22189 \times 10^6$ [Pa] $0.01033 \leq P \leq 2.2189$ [bar]
32	SIGT(T)	SIGT: Surface Tension [N/m] T∗: Temperature [K], [°C]	$173.15 \leq T \leq 268$ [K] $-1000 \leq T \leq -5.15$ [°C]
33	SPD(P)	SPD: Specific Entropy of Saturated Liquid [J/(kg·K)] P∗: Pressure [Pa], [bar]	$1.033 \times 10^3 \leq P \leq 3.3832 \times 10^6$ [Pa] $0.01033 \leq P \leq 33.832$ [bar]
34	SPDD(P)	SPDD: Specific Entropy of Saturated Vapor [J/(kg·K)] P∗: Pressure [Pa], [bar]	$1.033 \times 10^3 \leq P \leq 3.3832 \times 10^6$ [Pa] $0.01033 \leq P \leq 33.832$ [bar]
35	SPT(P,T)	SPT: Specific Entropy [J/(kg·K)] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10 \times 10^3 \leq P \leq 3.0 \times 10^6$ [Pa] $TSP(P) \leq T \leq 453.15$ [K] $0.1 \leq P \leq 30$ [bar] $TSP(P) \leq T \leq 180$ [°C] see Fig.II-2.39-1
36	SPX(P,X)	SPX: Specific Entropy of Mixture [J/(kg·K)] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$1.033 \times 10^3 \leq P \leq 3.3832 \times 10^6$ [Pa] $0.01033 \leq P \leq 33.832$ [bar] $0 \leq X \leq 1.0$ [–]
37	STD(T)	STD: Specific Entropy of Saturated Liquid [J/(kg·K)] T∗: Temperature [K], [°C]	$173.15 \leq T \leq 371.15$ [K] $-100 \leq T \leq 98$ [°C]
38	STDD(T)	STDD: Specific Entropy of Saturated Vapor [J/(kg·K)] T∗: Temperature [K], [°C]	$173.15 \leq T \leq 371.15$ [K] $-100 \leq T \leq 98$ [°C]
39	STX(T,X)	STX: Specific Entropy of Mixture [J/(kg·K)] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	$173.15 \leq T \leq 371.15$ [K] $-100 \leq T \leq 98$ [°C] $0 \leq X \leq 1.0$ [–]
67	TLDP(P)		
69	TMLP(P)		

Table II–2.39–1 R152a 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]	$10\times10^3\leq P\leq3.0\times10^6$ [Pa] HPDD(P)≤H≤ HPT(P,453.15K) [J/kg] 0.1≤P≤30 [bar] HPDD(P)≤H≤ HPT(P,180°C) [J/kg] see Fig.II-2.39-2 for H
6H	TPH2(P,H)		
65	TPS(P,S)	TPS∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$10\times10^3\leq P\leq3.0\times10^6$ [Pa] SPDD(P)≤S≤ SPT(P,453.15K) [J/(kg·K)] 0.1≤P≤30 [bar] SPDD(P)≤S≤ SPT(P,180°C) [J/(kg·K)] see Fig.II-2.39-3 for S
6S	TPS2(P,S)		
98	TPSEUP(P)		
70	TPV(P,V)	TPV∗: Temperature [K], [°C] P∗: Pressure [Pa], [bar] V: Specific Volume [m^3/kg]	$10\times10^3\leq P\leq3.0\times10^6$ [Pa] VPDD(P)≤V≤ VPT(P,453.15K) [m^3/kg] 0.1≤P≤30 [bar] VPDD(P)≤V≤ VPT(P,180°C) [m^3/kg]
41	TRPL('A')		
100	TSBP(P)		
40	TSP(P)	TSP∗: Saturation Temperature [K], [°C] P∗: Pressure [Pa], [bar]	$1.033\times10^3\leq P\leq3.3832\times10^6$ [Pa] 0.01033≤P≤33.832 [bar]
74	TSPD(P)		
75	TSPDD(P)		
42	UPD(P)	UPD: Specific Internal Energy of Saturated Liquid [J/kg] P∗: Pressure [Pa], [bar]	$1.033\times10^3\leq P\leq3.3832\times10^6$ [Pa] 0.01033≤P≤33.832 [bar]
43	UPDD(P)	UPDD: Specific Internal Energy of Saturated Vapor [J/kg] P∗: Pressure [Pa], [bar]	$1.033\times10^3\leq P\leq3.3832\times10^6$ [Pa] 0.01033≤P≤33.832 [bar]
79	UPS(P,S)	UPS: Specific Internal Energy [J/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy [J/(kg·K)]	$10\times10^3\leq P\leq3.0\times10^6$ [Pa] SPDD(P)≤S≤ SPT(P,453.15K) [J/(kg·K)] 0.1≤P≤30 [bar] SPDD(P)≤S≤ SPT(P,180°C) [J/(kg·K)] see Fig.II-2.39-3 for S
44	UPT(P,T)	UPT: Specific Internal Energy [J/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	$10\times10^3\leq P\leq3.0\times10^6$ [Pa] TSP(P)≤T≤453.15 [K] 0.1≤P≤30 [bar] TSP(P)≤T≤180 [°C] see Fig.II-2.39-1
45	UPX(P,X)	UPX: Specific Internal Energy of Mixture [J/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	$1.033\times10^3\leq P\leq3.3832\times10^6$ [Pa] 0.01033≤P≤33.832 [bar] 0≤X≤1.0 [–]
46	UTD(T)	UTD: Specific Internal Energy of Saturated Liquid [J/kg] T∗: Temperature [K], [°C]	173.15≤T≤371.15 [K] −100≤T≤98 [°C]

Table II–2.39–1 R152a 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]	173.15≤T≤371.15 [K] −100≤T≤98 [°C]
48	UTX(T,X)	UTX: Specific Internal Energy of Mixture [J/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	173.15≤T≤371.15 [K] −100≤T≤98 [°C] 0≤X≤1.0 [–]
49	VPD(P)	VPD: Specific Volume of Saturated Liquid [m^3/kg] P∗: Pressure [Pa], [bar]	1.033×10^3≤P≤3.3832×10^6 [Pa] 0.01033≤P≤33.832 [bar]
50	VPDD(P)	VPDD: Specific Volume of Saturated Vapor [m^3/kg] P∗: Pressure [Pa], [bar]	1.033×10^3≤P≤3.3832×10^6 [Pa] 0.01033≤P≤33.832 [bar]
80	VPS(P,S)	VPS: Specific Volume [m^3/kg] P∗: Pressure [Pa], [bar] S: Specific Entropy[J/(kg·K)]	10×10^3≤P≤3.0×10^6 [Pa] SPDD(P)≤S≤ SPT(P,453.15K) [J/(kg·K)] 0.1≤P≤30 [bar] SPDD(P)≤S≤ SPT(P,180°C) [J/(kg·K)] see Fig.II-2.39-3 for S
51	VPT(P,T)	VPT: Specific Volume [m^3/kg] P∗: Pressure [Pa], [bar] T∗: Temperature [K], [°C]	10×10^3≤P≤3.0×10^6 [Pa] TSP(P)≤T≤453.15 [K] 0.1≤P≤30 [bar] TSP(P)≤T≤180 [°C] see Fig.II-2.39-1
52	VPX(P,X)	VPX: Specific Volume of Mixture [m^3/kg] P∗: Pressure [Pa], [bar] X: Dryness Fraction [–]	1.033×10^3≤P≤3.3832×10^6 [Pa] 0.01033≤P≤33.832 [bar] 0≤X≤1.0 [–]
53	VTD(T)	VTD: Specific Volume of Saturated Liquid [m^3/kg] T∗: Temperature [K], [°C]	173.15≤T≤371.15 [K] −100≤T≤98 [°C]
54	VTDD(T)	VTDD: Specific Volume of Saturated Vapor [m^3/kg] T∗: Temperature [K], [°C]	173.15≤T≤371.15 [K] −100≤T≤98 [°C]
55	VTX(T,X)	VTX: Specific Volume of Mixture [m^3/kg] T∗: Temperature [K], [°C] X: Dryness Fraction [–]	173.15≤T≤371.15 [K] −100≤T≤98 [°C] 0≤X≤1.0 [–]
8E	WPD(P)		
8F	WPDD(P)		
83	WPT(P,T)		
8G	WTD(T)		
8H	WTDD(T)		
56	XPH(P,H)	XPH: Dryness Fraction [–] P∗: Pressure [Pa], [bar] H: Specific Enthalpy of Mixture [J/kg]	1.033×10^3≤P<3.3832×10^6 [Pa] 0.01033≤P<33.832 [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)]	1.033×10^3≤P<3.3832×10^6 [Pa] 0.01033≤P<33.832 [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]	1.033×10^3≤P<3.3832×10^6 [Pa] 0.01033≤P<33.832 [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]	1.033×10^3≤P<3.3832×10^6 [Pa] 0.01033≤P<33.832 [bar] VPD(P)≤V≤VPDD(P) [m^3/kg]

Table II–2.39–1 R152a Function (cont'd)

No.	Name of Function	Function and Argument(s)	Range of Argument(s)
60	XTH(T,H)	XTH: Dryness Fraction [–] T∗: Temperature [K], [°C] H: Specific Enthalpy of Mixture [J/kg]	173.15≤T<371.15 [K] −100≤T<98 [°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)]	173.15≤T<371.15 [K] −100≤T<98 [°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]	173.15≤T<371.15 [K] −100≤T<98 [°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]	173.15≤T<371.15 [K] −100≤T<98 [°C] VTD(T)≤V≤VTDD(T) [m^3/kg]

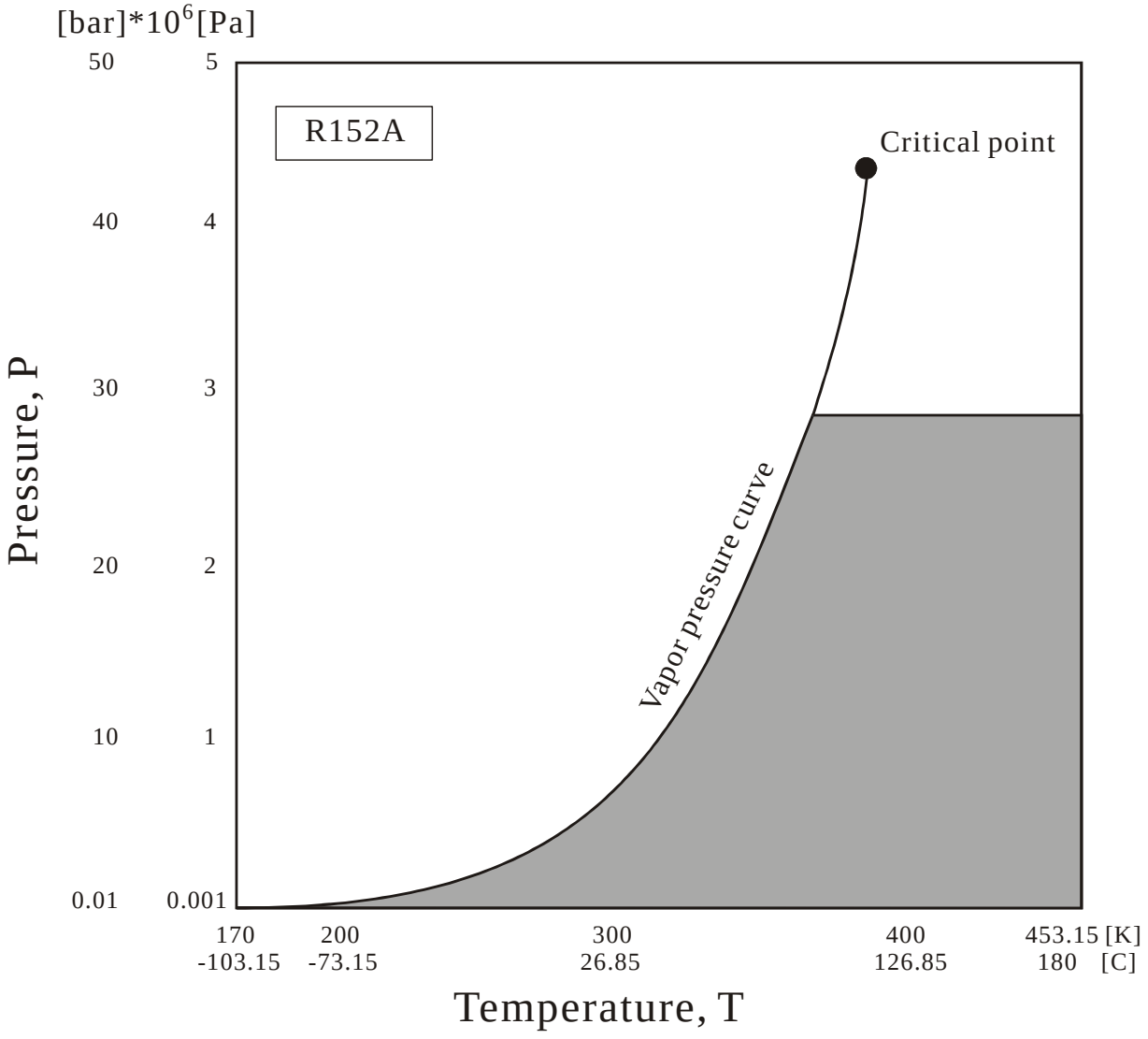

Fig.II–2.39–1 Range of Arguments(P,T) for AKPT(P,T),CPPT(P,T),CVPT(P,T),HPT(P,T), SPT(P,T),UPT(P,T) and VPT(P,T).

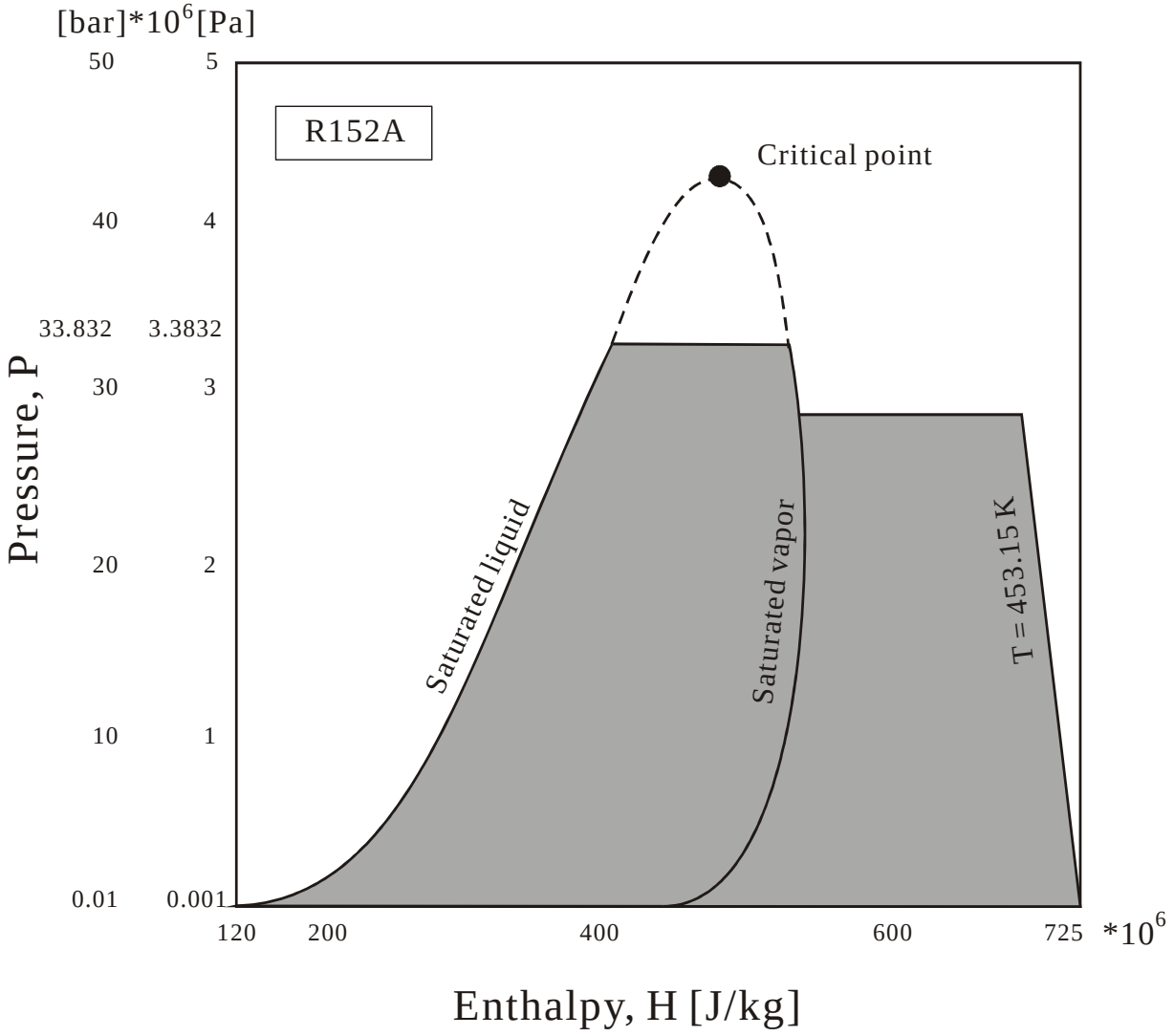

Fig.II–2.39–2 Range of Arguments(P,H) for TPH(P,H).

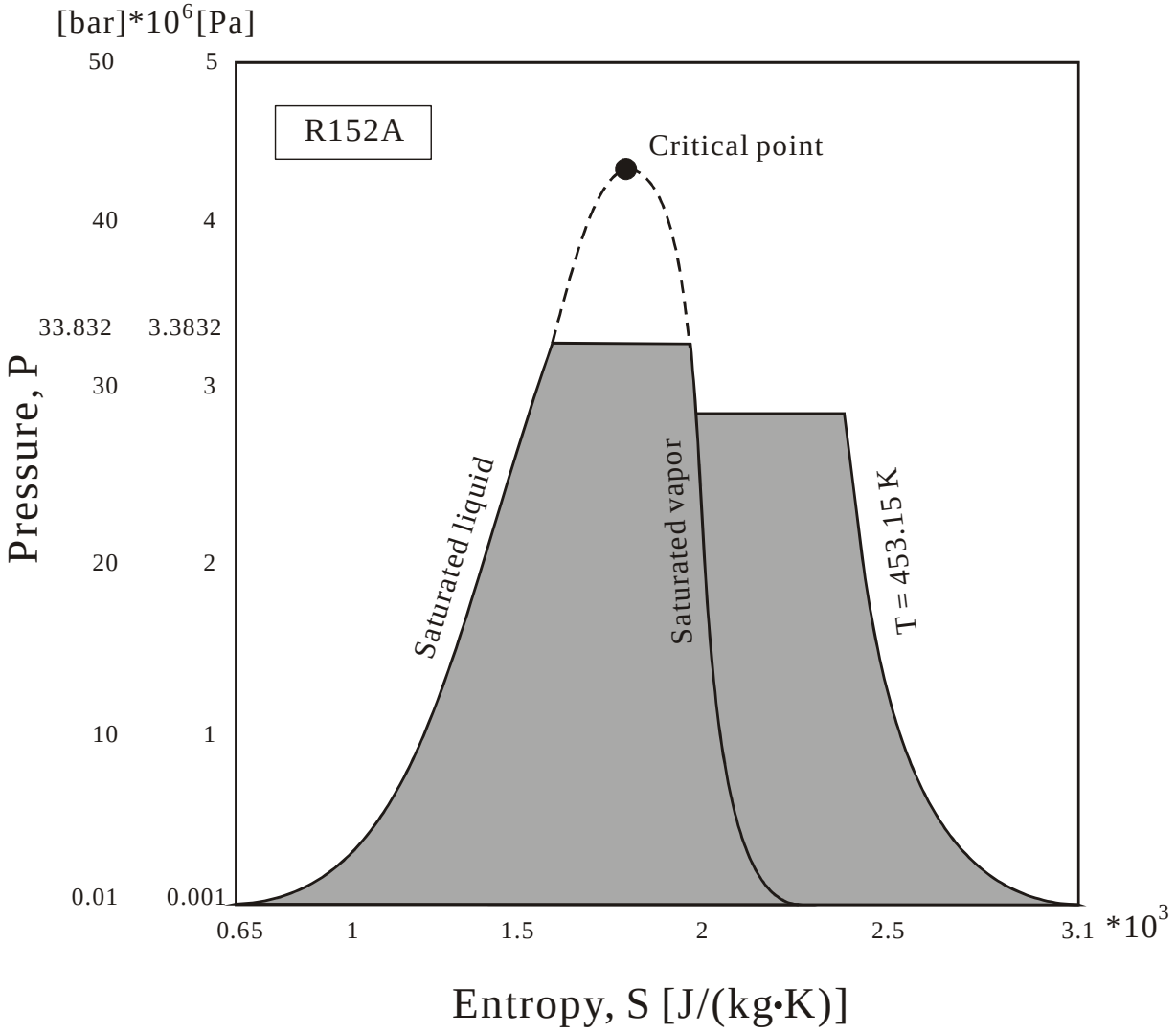

Fig.II–2.39–3 Range of Arguments(P,S) for HPS(P,S),TPS(P,S),UPS(P,S) and VPS(P,S).