A5

Thermophysical Properties of Refrigerants

Nitin Goel
Intel Technology India Pvt. Ltd.

R-22 (Chlorodifluoromethane)
R-134a (1,1,12-Tetrafluoroethane)
R-404A [R-125/143a/134a (44/52/4)]
R-407C [R-32/125/134a (23/25/52)
R-410A [R-32/125 (50/50)]
Ammonia/Water
Water/Lithium bromide

The Montreal Protocol, signed in 1987 and later amended in 1990, 1992, 1997, and 1999 controls the production of ozone-depleting substances including refrigerants containing chlorine and/or bromine production chloro-fluoro-carbons (CFC). Pursuent to this treaty, refrigerants such as R-11 and R-12, ceased to exist in 1996 although continued use from existing stocks is permitted. In addition, hydrofluorocarbon (HCFCs) (such as R-22 and R-123) are being phased out, with complete cessation of production by January 1, 2030.

These refrigerants are being replaced by HFC refrigerants which have zero ozone depletion potential. Common HFC refrigerants are R-32, R-125, 134a, and R-143a and their mixtures, such as, R-404A, R-407C, and R-410A.

This appendix gives thermophysical properties of these HFC refrigerants and ammonia water and water–lithium bromide mixtures which are used in absorption refrigeration systems. Properties of R-22 are given to serve as a reference (Figure A5.1 through Figure A5.8).

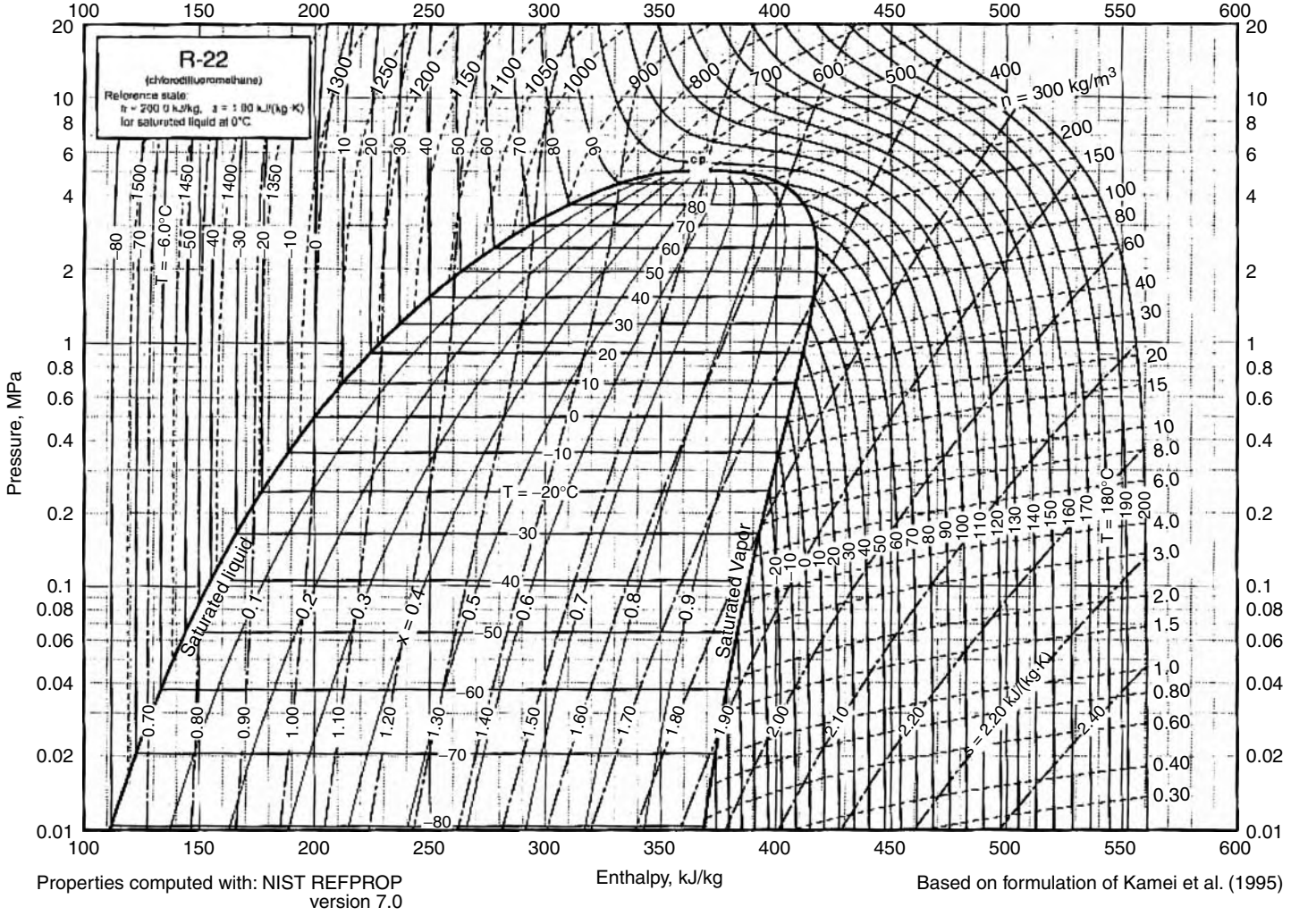


FIGURE A5.1 Pressure–enthalpy diagram for refrigerant R-22.

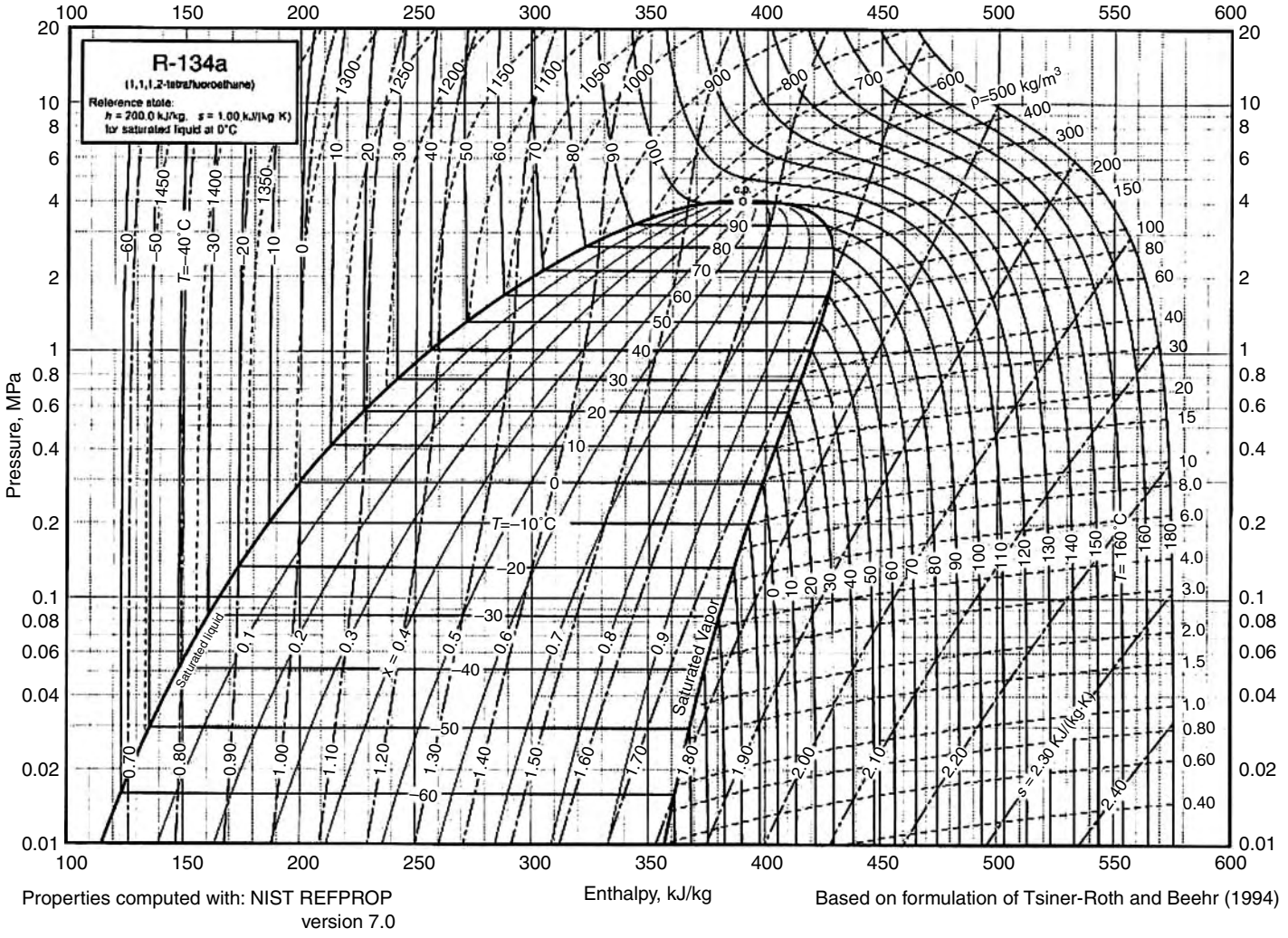


FIGURE A5.2 Pressure–enthalpy diagram for refrigerant R-134a.

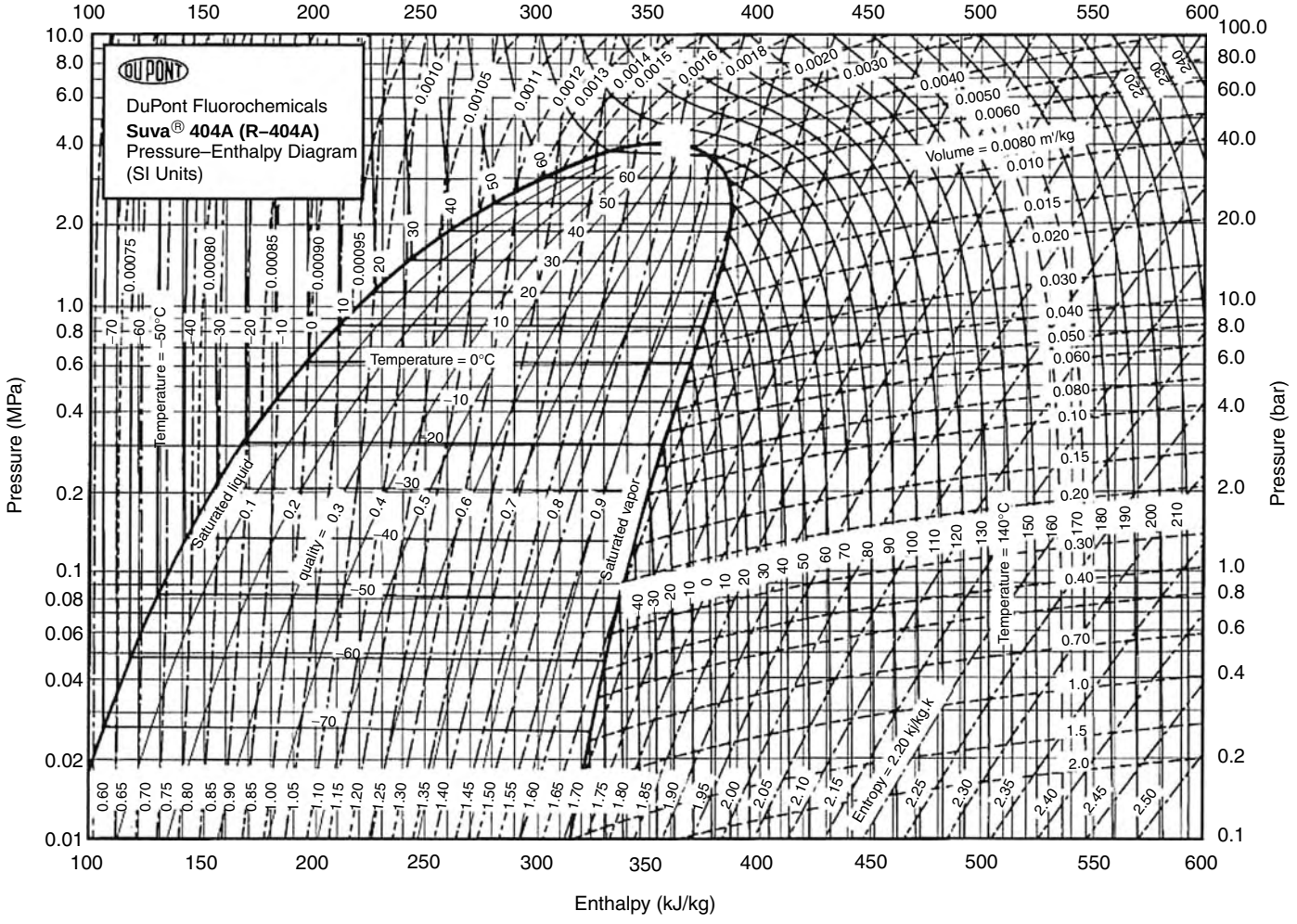


FIGURE A5.3 Pressure–enthalpy diagram for refrigerant R-404A.

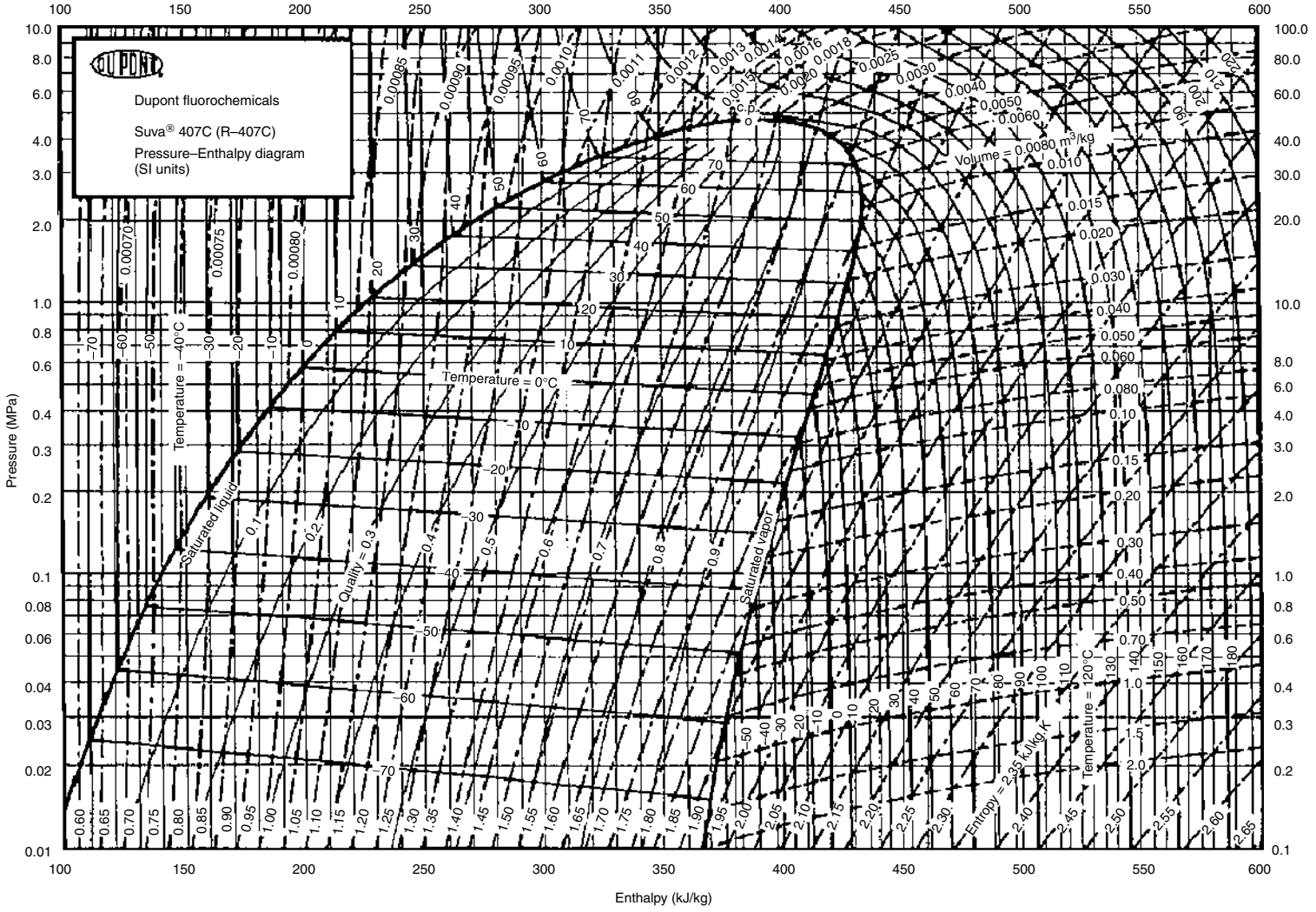


FIGURE A5.4 Pressure–enthalpy diagram for refrigerant R-407C.

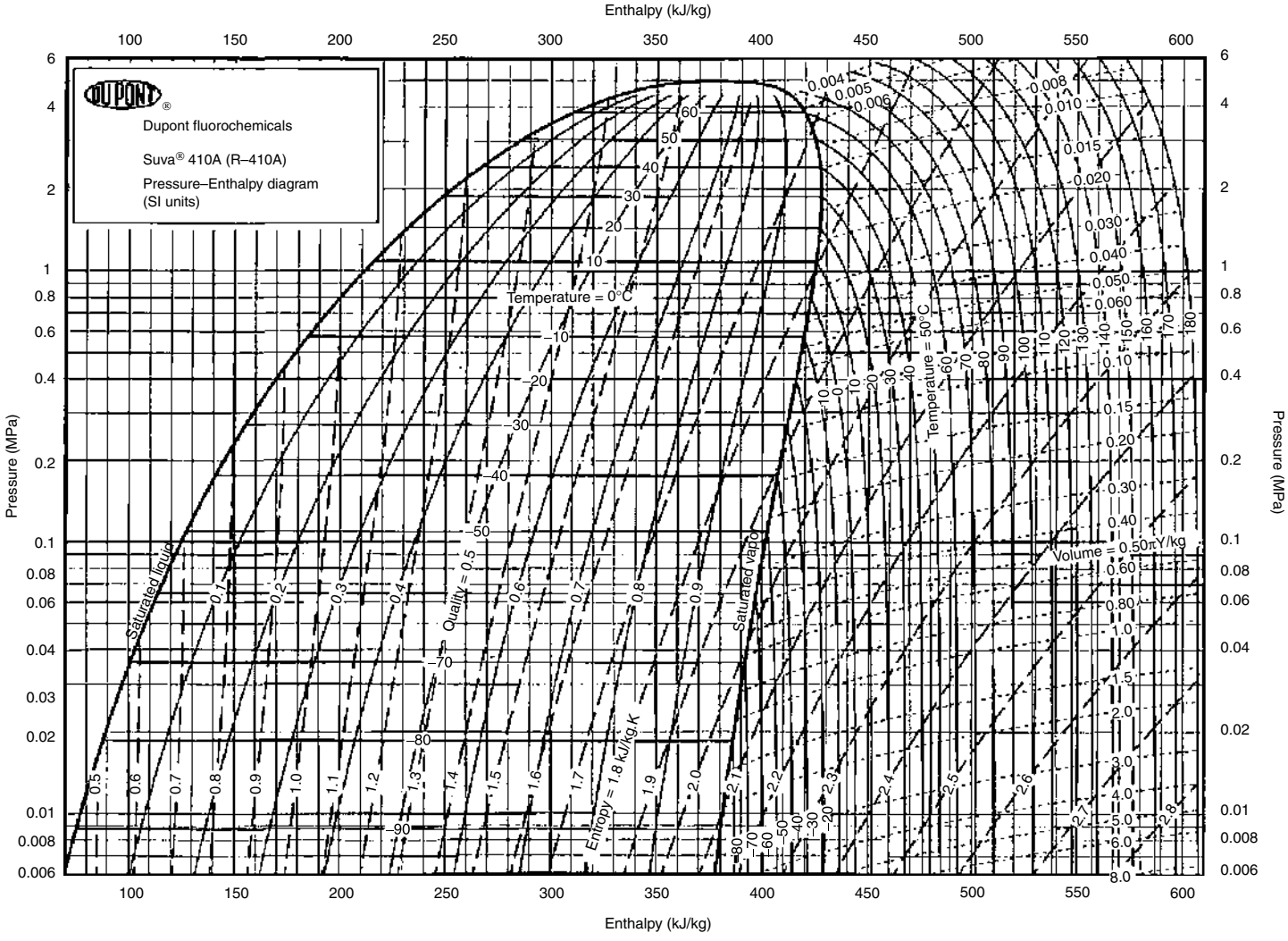


FIGURE A5.5 Pressure–enthalpy diagram for refrigerant R-410A.

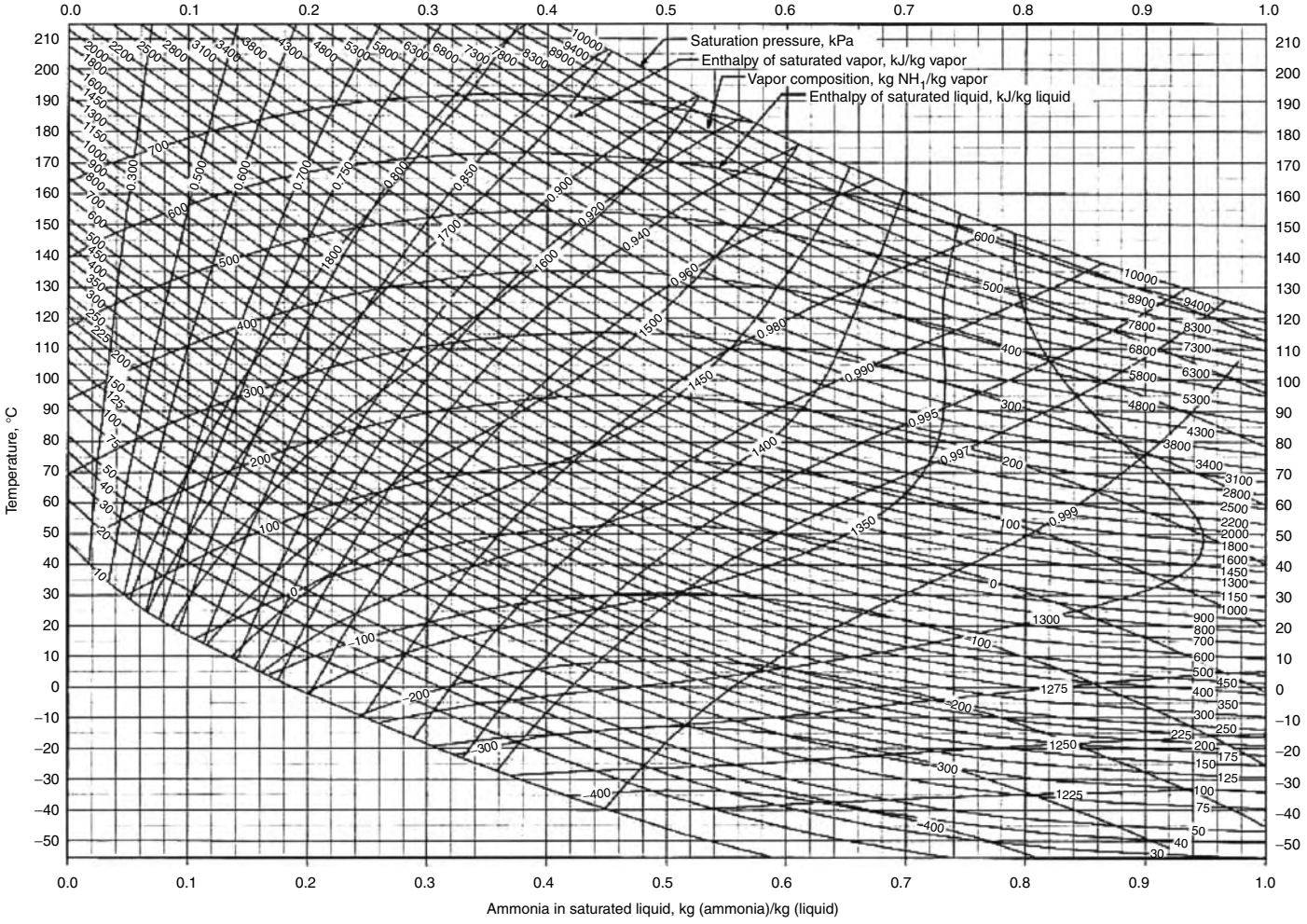
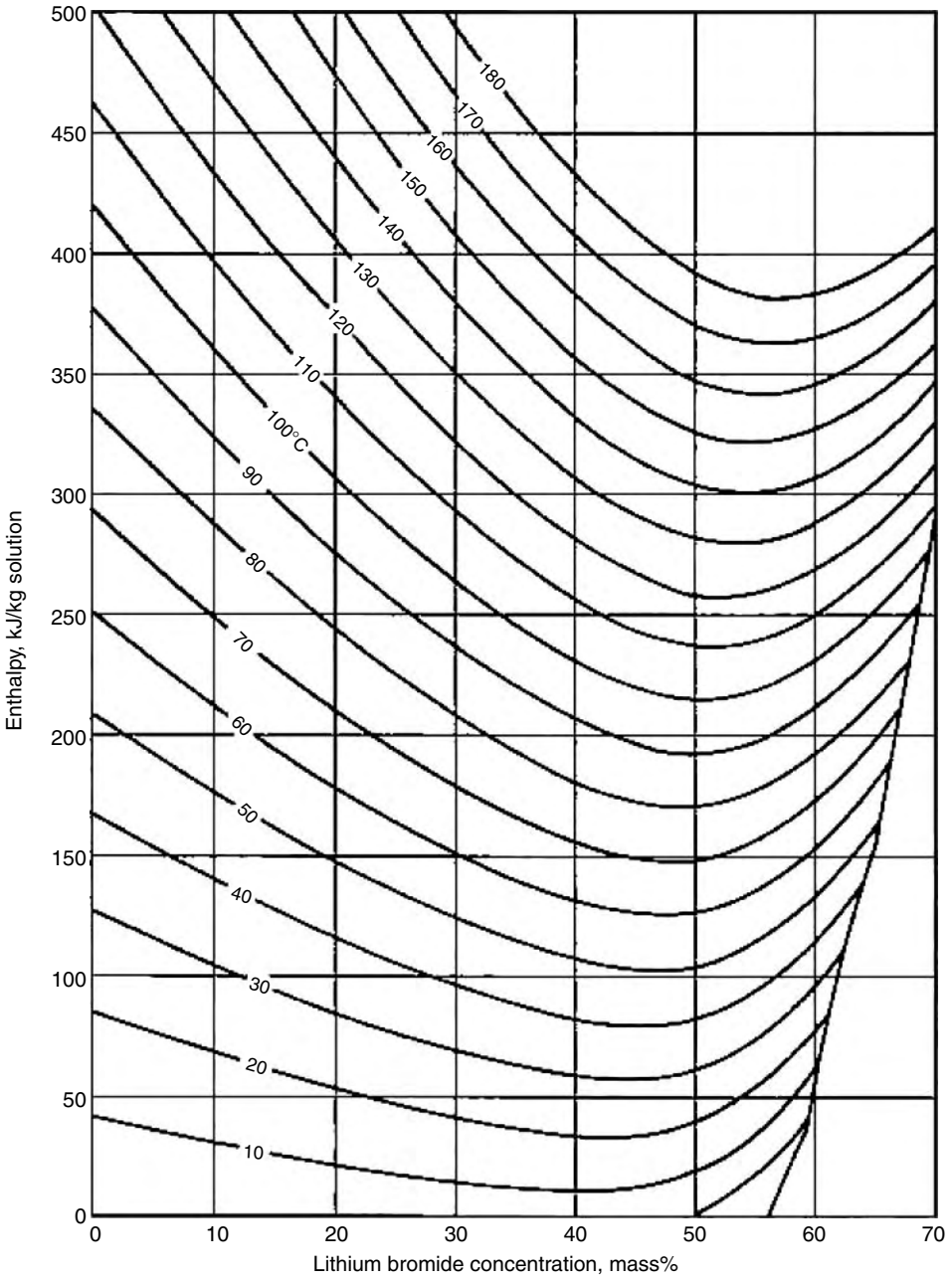


FIGURE A5.6 Enthalpy–concentration diagram for ammonia/water solutions prepared by Kwang Kim and Keith Herold, Centre for Environmental Energy Engineering, University of Maryland at Colleage Park.



Equations Concentration range 40 < x < 70% LiBr Temperature range 15 < t < 165°C

$h = \Sigma_0^4 A_n X^7 + r\Sigma_0^4 B_n X^n + r^2\Sigma_0^4 C_p X^n$ in kJ/kg, where t = °C and X = %LiBr

A_0 = –2024.33	B_0 = 18.2829	C_0 = –3.7008214 E-2
A_1 = 163.309	B_1 = –1.1691757	C_1 = 2.8877666 E-3
A_2 = –4.88161	B_2 = 3.248041E-2	C_2 = –8.1313015 E-5
A_3 = 6.302948 E-2	B_3 = –4.034184 E-4	C_3 = 9.9116628 E-7
A_4 = –2.913705 E-4	B_4 = 1.8520569 E-6	C_4 = –4.4441207 E-9

FIGURE A5.7 Enthalpy–concentration diagram for water/lithium bromide solutions.

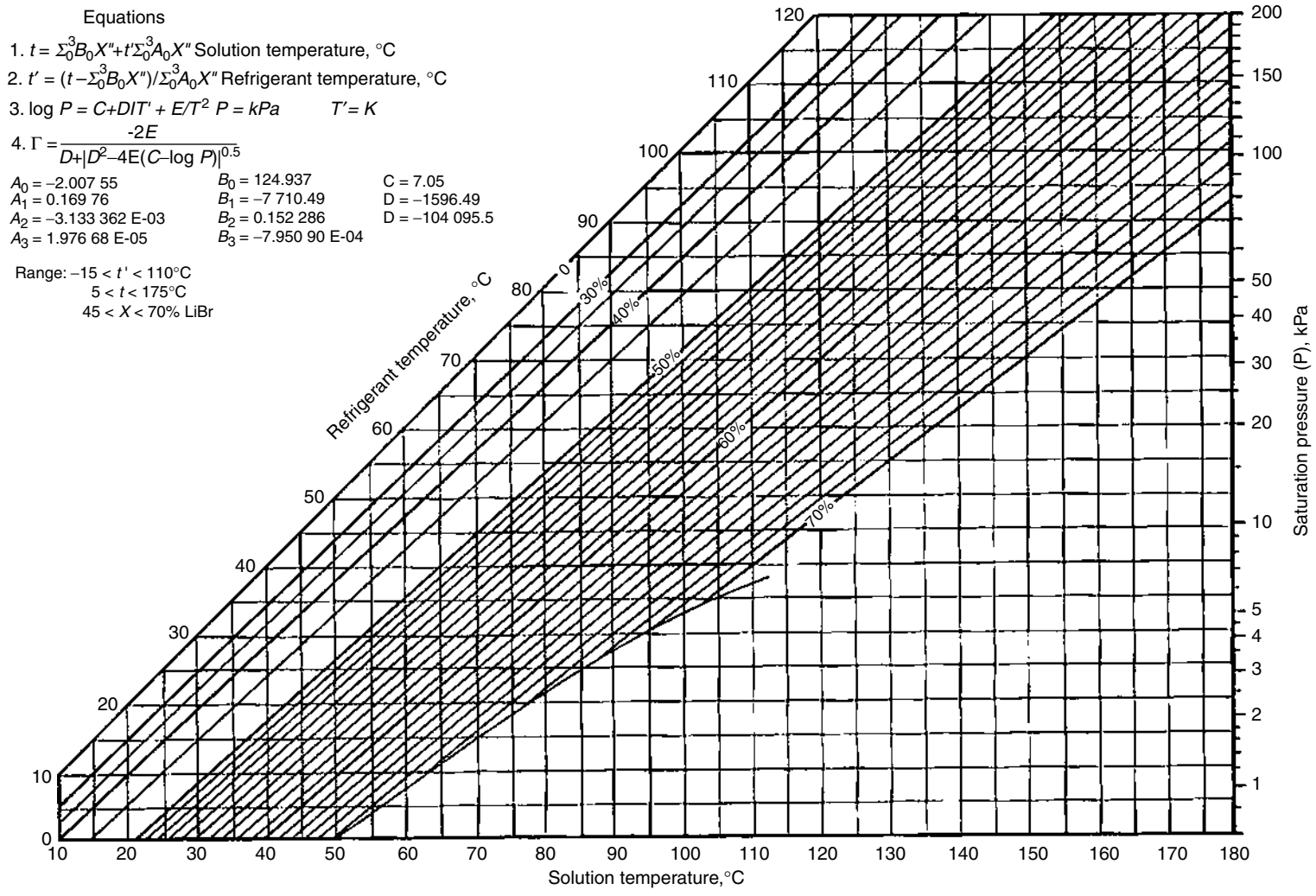


FIGURE A5.8 Equilibrium chart for aqueous lithium bromide solutions reprinted by permission of Carrier Corp.