The International Association for the Properties of Water and Steam

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Revised Guideline on the Critical Locus of Aqueous Solutions of Sodium Chloride

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This guideline contains 6 pages, including this cover page.

This guideline has been authorized by the International Association for the Properties of Water and Steam (IAPWS) at its meeting in Boulder, Colorado, USA, 30 September to 5 October 2012, for issue by its Secretariat. The members of IAPWS are: Britain and Ireland, Canada, the Czech Republic, Germany, Japan, Russia, Scandinavia (Denmark, Finland, Norway, Sweden), and the United States of America. Associate members are Argentina and Brazil, Australia, France, Greece, Italy, New Zealand, and Switzerland.

This guideline replaces the "Guideline on the Critical Locus of Aqueous Solutions of Sodium Chloride", issued in 2000.

Further information concerning this guideline and other documents issued by IAPWS can be obtained from the Executive Secretary of IAPWS or from http://www.iapws.org.

This guideline presents equations for the critical temperature, the critical pressure, and the critical density of aqueous solutions of sodium chloride as a function of mole fraction x of NaCl. The proposed equations yield an accurate description of the experimental data for the critical parameters from the pure-water limit to the highest salt concentration ($x = 0.12$) for which data are available.

The supporting document for this guideline is: D.A. Fuentevilla, J.V. Sengers, and M.A. Anisimov, “Critical Locus of Aqueous Solutions of Sodium Chloride Revisited”, *Int. J. Thermophys.* **33**, 943-958 (2012); Erratum, *ibid.* **34**, 384 (2013).

Nomenclature

B, C: coefficients in Eqs. (4) and (5)

$f_1(x)$, $f_2(x)$: functions in Eq. (1)

P_c: critical pressure (MPa)

P_c^0: critical pressure of pure water (MPa)

p_1, p_2, p_3, p_4: coefficients in Eq. (8)

r_1, $r_{3/2}$, r_2, $r_{5/2}$, r_3, $r_{7/2}$, r_4: coefficients in Eq. (7)

T_c: critical temperature (K)

T_c^0: critical temperature of pure water (K)

$T_1(x)$, $T_2(x)$: functions in Eq. (1)

t_1, $t_{3/2}$, t_2: coefficients in Eq. (2)

$t'_1, t'_{3/2}, t'_2, t'_{5/2}, t'_3, t'_{7/2}, t'_4$: coefficients in Eq. (3)

x: mole fraction of NaCl

$\Delta T = T_c - T_c^0$

ρ_c: critical density (kg·m^{-3})

ρ_c^0: critical density of pure water (kg·m^{-3})

Critical parameters of pure water*:
$T_c^0 = 647.096\,\text{K}, \quad \rho_c^0 = 322.0\ \text{kg}\cdot\text{m}^{-3}, \quad P_c^0 = 22.064\ \text{MPa}.$

Equation for the critical temperature:

$$T_c(x) = f_1(x)T_1(x) + f_2(x)T_2(x), \tag{1}$$

with

$$T_1(x) = T_c^0\left(1 + t_1 x + t_{3/2}x^{3/2} + t_2 x^2\right), \tag{2}$$

$$T_2(x) = T_c^0\left(1 + t_1' x + t_{3/2}' x^{3/2} + t_2' x^2 + t_{5/2}' x^{5/2} + t_3' x^3 + t_{7/2}' x^{7/2} + t_4' x^4\right), \tag{3}$$

$$f_1(x) = \frac{1}{4}\left[\,|Bx - C - 1| - |Bx - C + 1|\,\right] + \frac{1}{2}, \tag{4}$$

$$f_2(x) = \frac{1}{4}\left[\,|Bx - C + 1| - |Bx - C - 1|\,\right] + \frac{1}{2}, \tag{5}$$

with

$$B = 10\,000, \quad C = 10. \tag{6}$$

Equation for the critical density:

$$\rho_c(x) = \rho_c^0\left[1 + r_1 x + r_{3/2}x^{3/2} + r_2 x^2 + r_{5/2}x^{5/2} + r_3 x^3 + r_{7/2}x^{7/2} + r_4 x^4\right]. \tag{7}$$

Equation for the critical pressure:

$$P_c(x) = P_c^0\left[1 + p_1(\Delta T / \text{K}) + p_2(\Delta T / \text{K})^2 + p_3(\Delta T / \text{K})^3 + p_4(\Delta T / \text{K})^4\right]. \tag{8}$$

Equation (1) represents T_c with a standard deviation $\sigma = 0.019\%$ at $x \leqslant 0.0009$ and with a standard deviation $\sigma = 0.24\%$ at $0.0009 \leqslant x \leqslant 0.12$.

Equation (7) represents ρ_c with a standard deviation $\sigma = 0.6\%$.

Equation (8) represents P_c with a standard deviation $\sigma = 1.7\%$.

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*Release: *Values of Temperature, Pressure and Density of Ordinary and Heavy Water Substance at their Respective Critical Points* (IAPWS, 1992), available from http://www.iapws.org.

Table I. Coefficients in Eqs. (1) – (8) for the critical locus of aqueous solutions of NaCl up to a NaCl mole fraction of 0.12.

Critical temperature T_c (K)	
$T_1(x)$	$T_2(x)$
$t_1 = 2.30 \times 10^1$	$t'_1 = 1.757 \times 10^1$
$t_{3/2} = -3.30 \times 10^2$	$t'_{3/2} = -3.026 \times 10^2$
$t_2 = -1.80 \times 10^3$	$t'_2 = 2.838 \times 10^3$
	$t'_{5/2} = -1.349 \times 10^4$
	$t'_3 = 3.278 \times 10^4$
	$t'_{7/2} = -3.674 \times 10^4$
	$t'_4 = 1.437 \times 10^4$
Critical pressure P_c (MPa)	
$p_1 = 9.1443 \times 10^{-3}$	
$p_2 = 5.1636 \times 10^{-5}$	
$p_3 = -2.5360 \times 10^{-7}$	
$p_4 = 3.6494 \times 10^{-10}$	
Critical density ρ_c (kg·m^{-3})	
$r_1 = 1.7607 \times 10^2$	
$r_{3/2} = -2.9693 \times 10^3$	
$r_2 = 2.4886 \times 10^4$	
$r_{5/2} = -1.1377 \times 10^5$	
$r_3 = 2.8847 \times 10^5$	
$r_{7/2} = -3.8195 \times 10^5$	
$r_4 = 2.0633 \times 10^5$	

Table II. Critical temperature, density, and pressure calculated from Eqs. (1) – (8) at selected mole fractions of NaCl.†

x	T_c (K)	P_c (MPa)	ρ_c (kg·m^{-3})
0	647.096000	22.0640000	322.000000
0.0005	651.858942	23.0502156	341.467388
0.001	653.957959	23.5003231	355.403431
0.0015	656.214478	23.9942848	366.631874
0.002	658.266685	24.4522876	376.071640
0.003	661.792675	25.2578916	391.370335
0.004	664.850727	25.9748152	403.503882
0.005	667.640852	26.6429248	413.572545
0.006	670.274404	27.2851928	422.220364
0.007	672.818265	27.9158160	429.857769
0.008	675.314254	28.5438775	436.760441
0.009	677.789002	29.1752574	443.120149
0.01	680.259476	29.8137278	449.073533
0.02	705.710570	36.7725468	499.162456
0.03	731.830060	44.3508666	542.631406
0.04	757.383936	51.8585660	579.897786
0.05	782.719671	59.1490976	609.816085
0.06	809.415999	66.4909864	632.701609
0.07	839.687528	74.2862762	649.832063
0.08	875.954487	82.9284097	662.792131
0.09	920.557281	93.0389707	673.036769
0.1	975.571016	106.692174	681.662669
0.11	1042.68691	130.966478	689.331958
0.12	1123.13874	186.176548	696.300163

† The number of decimals quoted does not correspond to the estimated uncertainties, but is given for program verification.