

GUIDELINE

**The International Association for the Properties of Water and
Steam**

Guideline on the Critical Locus of Aqueous Solutions of Sodium Chloride

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Based on a careful evaluation of the available experimental data reported in the literature, 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 the salt mass fraction. The proposed equations yield an accurate description of the experimental data for the critical parameters from the pure-water limit to the highest salt mass fraction (30 per cent of sodium chloride by mass) for which data are available.

The supporting document for this Guideline is: A.A. Povodyrev, M.A. Anisimov, J.V. Sengers, W. L. Marshall, and J.M.H. Levelt Sengers, "Critical Locus of Aqueous Solutions of Sodium Chloride", *Int. J. Thermophys.* **20**, 1529-1545, (1999).

DEFINITION OF SYMBOLS

p_c : critical pressure (MPa).

$p_c^{\text{H}_2\text{O}}$: critical pressure of pure water (MPa).

p_i ($i = 1, \dots, 4$): coefficients in Eq. (2) ($\text{MPa} \cdot \text{K}^{-i}$).

r_i ($i = 1, \dots, 3$): coefficients in Eq. (3) ($\text{kg} \cdot \text{m}^{-3}$).

T_c : critical temperature (K).

$T_c^{\text{H}_2\text{O}}$: critical temperature of pure water (K).

T_i ($i = 1, \dots, 6$): coefficients in Eq. (1) (K).

w : per cent of sodium chloride by mass.

w_1, w_2 : dimensionless parameters in Eq. (1).

ρ_c : critical density ($\text{kg} \cdot \text{m}^{-3}$).

$\rho_c^{\text{H}_2\text{O}}$: critical density of pure water ($\text{kg} \cdot \text{m}^{-3}$).

Critical point properties of pure water *:

$$T_c^{\text{H}_2\text{O}} = 647.096 \text{ K}, \quad p_c^{\text{H}_2\text{O}} = 22.064 \text{ MPa}, \quad \rho_c^{\text{H}_2\text{O}} = 322.0 \text{ kg}\cdot\text{m}^{-3}.$$

Equation for the critical temperature:

$$T_c = \frac{f_1}{2} \{ \tanh[w_1 (w_2 - w)] + 1 \} + \frac{f_2}{2} \{ \tanh[w_1 (w - w_2)] + 1 \}, \quad (1)$$

with

$$\begin{aligned} f_1 &= T_c^{\text{H}_2\text{O}} + T_1 w + T_2 w^2, \\ f_2 &= T_3 + T_4 w + T_5 w^2 + T_6 w^3. \end{aligned}$$

Equation for the critical pressure:

$$p_c = p_c^{\text{H}_2\text{O}} + p_1 \Delta T + p_2 (\Delta T)^2 + p_3 (\Delta T)^3 + p_4 (\Delta T)^4, \quad (2)$$

where $\Delta T = T_c - T_c^{\text{H}_2\text{O}}$.

Equation for the critical density:

$$\rho_c = \rho_c^{\text{H}_2\text{O}} + r_1 \psi + r_2 \psi^2 + r_3 \psi^3 w^2, \quad (3)$$

where $\psi = \ln(w + 1)$.

Equation (1) represents T_c at salt concentrations up to $w = 1.7\%$ with a standard deviation $\sigma = 0.017\%$ and at salt concentrations up to $w = 30\%$ with a standard deviation $\sigma = 0.3\%$.

Equation (2) represents p_c with a standard deviation $\sigma = 1.7\%$.

Equation (3) represents ρ_c with a standard deviation $\sigma = 1.5\%$.

*From IAPWS' Release on the Values of Temperature and Density of Ordinary and Heavy Water Substances at their Respective Critical Points.

Table I.

Parameters in Eqs. (1)-(3) for the Critical Locus of NaCl-H₂O Solutions up to 30 Per Cent
of NaCl by Mass

Critical temperature T_c			
$T_1 = 38.688$	$T_2 = -53.982$	$T_3 = 651.093$	$T_4 = 10.900$
$T_5 = -0.398\,21$	$T_6 = 0.016\,880$	$w_1 = 17.034$	$w_2 = 0.375\,87$
Critical pressure p_c			
$p_1 = 0.201\,76$	$p_2 = 1.1393 \times 10^{-3}$	$p_3 = -5.5960 \times 10^{-6}$	$p_4 = 8.0521 \times 10^{-9}$
Critical density ρ_c			
$r_1 = 66.868$	$r_2 = 13.668$	$r_3 = -6.3107 \times 10^{-4}$	

Table II.

Critical Temperature, Pressure, and Density Calculated from Eqs. (1)-(3)
at Selected Mass Percent Values of Sodium Chloride. [†]

w (%)	T_c (K)	p_c (MPa)	ρ_c (kg·m ⁻³)
0	647.096	22.0640	322.000
0.2	652.676	23.2243	334.646
0.4	654.946	23.7153	346.047
0.6	657.490	24.2780	356.447
0.8	659.567	24.7466	366.026
1	661.612	25.2160	374.916
1.2	663.629	25.6864	383.219
1.4	665.619	26.1574	391.016
1.6	667.583	26.6289	398.371
1.8	669.521	27.1004	405.336
2	671.435	27.5717	411.955
4	689.402	32.2408	464.982
6	705.804	36.7989	503.707
8	721.450	41.3101	534.482
10	737.152	45.9160	560.062
12	753.719	50.7860	581.901
14	771.963	56.0834	600.860
16	792.692	61.9375	617.492
18	816.717	68.4216	632.167
20	844.849	75.5545	645.148
22	877.898	83.3683	656.623
24	916.673	92.1443	666.733
26	961.986	103.007	675.582
28	1014.65	119.224	683.251
30	1075.46	148.807	689.801

[†]The number of decimals quoted do not correspond to the estimated uncertainties, but are given for program verification.