

IAPWS GUIDELINE STATEMENT, 1990

ELECTROLYTIC CONDUCTIVITY (SPECIFIC CONDUCTANCE)  
OF LIQUID AND DENSE SUPERCRITICAL WATER FROM 0°C TO 800°C  
AND PRESSURES UP TO 1000 MPa

Unrestricted publication allowed in all countries

Issued by the  
International Association for the Properties of Water and Steam

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This formulation of the electrolytic conductivity (specific conductance) of water has been authorized by the International Association for the Properties of Water and Steam (IAPWS) for issuance as an IAPWS Guideline. In the judgement of IAPWS, the formulation represents the best available at the final time of consideration (September, 1989, Prague, Czechoslovakia) and is recommended for use in the power industry with the understanding that new measurements or theoretical developments may lead to improved formulations.

This Guideline was prepared under the direction of Working Group A, "Properties of Steam and Aqueous Systems", under the chairmanship of J. M. H. Levelt Sengers, National Institute of Standards and Technology, USA, and has been reviewed and approved by the national committees of the members of IAPWS (Canada, Czechoslovakia, FRG, France, Japan, UK, USA, USSR, and associate member, Argentina). IAPS guidelines and releases can be obtained from the Executive Secretary, Dr. Barry Dooley, Electric Power Research Institute, 3412 Hillview Avenue, Palo Alto, California 94304 USA.

The dimensionless electrolytic conductivity ( $\bar{\kappa}$ ) of water is calculated from:

$$\bar{\kappa} = 10^{-3} \bar{\Lambda}_o \bar{K}_w^{1/2} \bar{\rho} \quad (1)$$

with dimensionless variables:

$$\begin{aligned} \bar{\kappa} &= \kappa / \kappa^\circ & \bar{\Lambda}_o &= \Lambda_o / \Lambda^\circ \\ \bar{K}_w &= K_w / K_w^\circ & \bar{\rho} &= \rho / \rho^\circ \end{aligned} \quad (2)$$

Here:

$\kappa$  is the electrolytic conductivity (specific conductance) of water

$K_w$  is the ion product of water

$\rho$  is the density of water

$\Lambda_o$  is the molar conductivity of  $H^+$  plus  $OH^-$  ions in water

The superscripts  $^\circ$  denote the following reference values:

$$\begin{aligned} \kappa^\circ &= 10^2 \text{ S m}^{-1} & \Lambda^\circ &= 10^{-4} \text{ m}^2 \text{ S mol}^{-1} \\ K_w^\circ &= 1 (\text{mol kg}^{-1})^2 & \rho^\circ &= 10^3 \text{ kg m}^{-3} \end{aligned} \quad (3)$$

In Eq. (1), the ion product of water ( $K_w$ ) at a given density and temperature, is obtained from the IAPWS release on the Ion Product of Liquid Water [May 1980]. The dimensionless molar conductivity ( $\Lambda_o$ ) is obtained from:

$$\bar{\lambda}_o = [\bar{\rho}_h - \bar{\rho}] \bar{\lambda}_{oo} / \bar{\rho}_h \quad (4)$$

with

$$\bar{\lambda}_{oo} = A_o - [A_1^{-1} + \sum_{i=0}^3 A_{(i+2)} \bar{t}^{(i+1)}]^{-1} \quad (5)$$

$$\bar{\rho}_h = B_o - [B_1^{-1} + \sum_{i=0}^2 B_{(i+2)} \bar{t}^{(i+1)}]^{-1} \quad (6)$$

with the dimensionless variable:

$$\bar{t} = (T - T^o) / t^o$$

Here:

$t$  is the Celsius temperature of water,  $t = T - T^o$ ,  
with  $T$  the absolute temperature.

The superscripts  $^o$  denote the following reference values:

$$t^o = 1^{\circ} \text{ C}$$

$$T^o = 273.15 \text{ K}$$

The dimensionless coefficients are listed in Table I. The range of application is:

for temperature

$$0^{\circ}\text{C} < t < 800^{\circ}\text{C}$$

and density

$$600 \text{ kg m}^{-3} < \rho < 1200 \text{ kg m}^{-3}$$

with a maximum pressure of 1000 MPa.

The uncertainty is estimated by the original author of the supporting document not to exceed 5% for liquid water temperatures up to 374°C; or 15% for temperatures from 374°C to 800°C and 1000 MPa. The range of applicability and corresponding uncertainty are shown in Fig. 1. Some values of the electrolytic conductivity, calculated from Eqs. 1-6, are given in Table II.

Table I  
Coefficients

$A_0:$	+1850.	$B_0:$	+16.0
$A_1:$	+1410.	$B_1:$	+11.6
$A_2:$	$+2.16417 \times 10^{-6}$	$B_2:$	$+3.26 \times 10^{-4}$
$A_3:$	$+1.81609 \times 10^{-7}$	$B_3:$	$-2.30 \times 10^{-6}$
$A_4:$	$-1.75297 \times 10^{-9}$	$B_4:$	$+1.10 \times 10^{-8}$
$A_5:$	$+7.20708 \times 10^{-12}$		

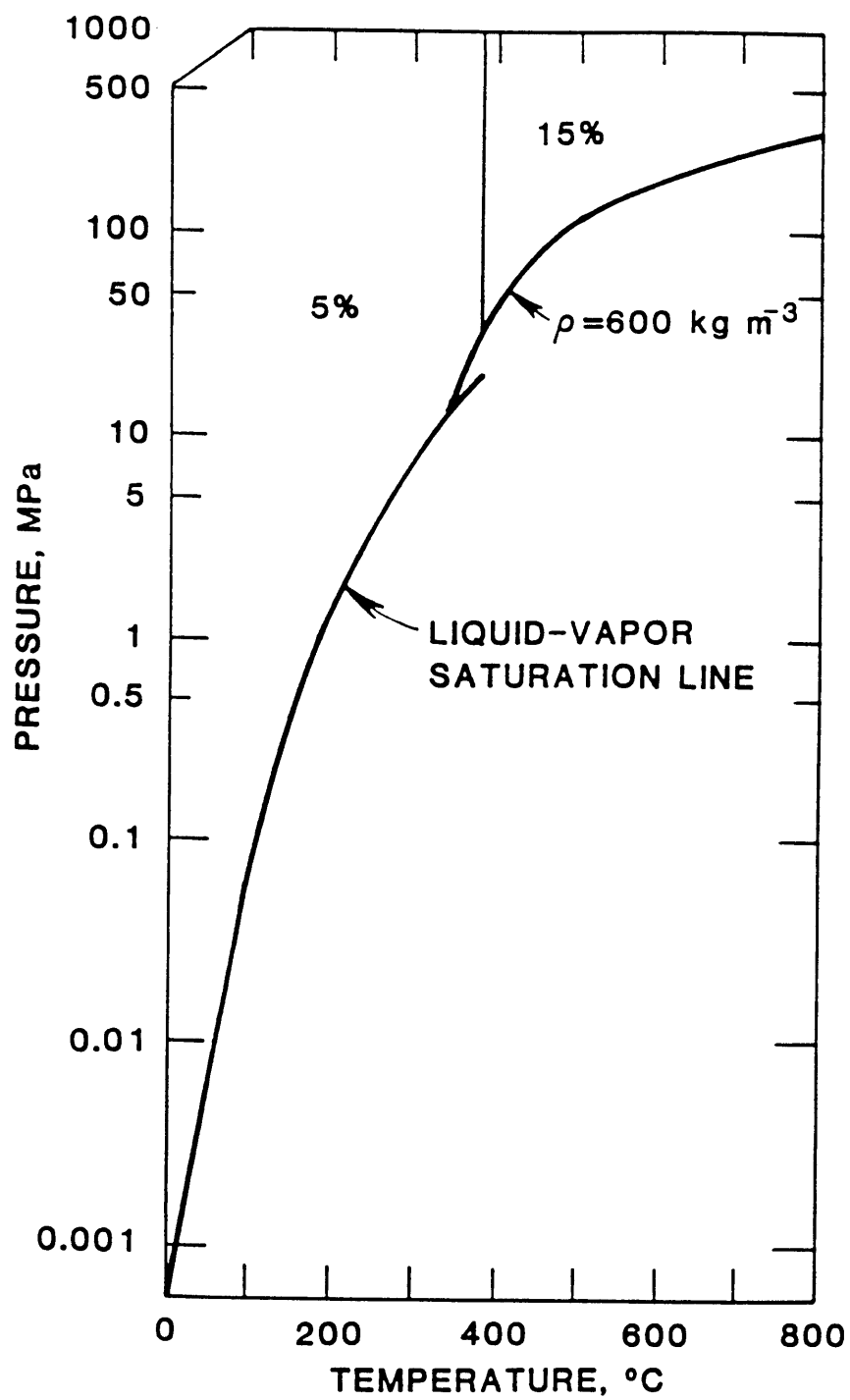
Table II

Dimensionless Electrolytic Conductivity ( $\bar{\kappa}$ ) times  $10^{+6}$  Calculated for Selected Values of Temperature and Density

$\bar{\rho}$ : $\bar{t}$	Saturated Liquid	0.60	0.80	0.90	1.00	1.10
0.01	0.0115					0.0333
25.	0.0550					0.153
100.	0.765				1.13	2.71
200.	2.99			4.19	10.2	22.8
300.	2.41		6.19	16.1	37.7	81.6
400.		1.57	15.4	39.2	90.2	
600.		5.30	49.6	124.	280.	
800.		11.2	103.			

The supporting document for the Guideline is:

W. L. Marshall, "Electrical Conductance of Liquid and Supercritical Water Evaluated from 0°C and 0.1 MPa to High Temperatures and Pressures. Reduced State Relationships", J. Chem. Eng. Data, 1987, 32, 221-226. All published works contributing to the Guideline are referenced and discussed in this document.



**Fig. 1. Range of Application and Corresponding Uncertainty**