

## **The IAPWS Industrial Formulation for the Thermodynamic Properties of Seawater for Calculating Desalination Processes**

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The development and operation of desalination plants require the knowledge of accurate thermodynamic properties of seawater and the ability to calculate them quickly. In 2013, the International Association for the Properties of Water and Steam (IAPWS) adopted the "Advisory Note No. 5: Industrial Calculation of the Thermodynamic Properties of Seawater" (IAPWS 2013) as an international standard for the calculation of the thermodynamic properties of seawater for industrial use. This standard contains an equation of state for the Gibbs free energy for seawater consisting of a part for pure liquid water and a part for dissolved sea salt. The water part is computed from the "IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam" (IAPWS-IF97) and the saline part from the "IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater" (IAPWS-08). The industrial formulation is valid for seawater at temperatures from  $-12^{\circ}\text{C}$  to  $80^{\circ}\text{C}$ , pressures from 0.0003 MPa to 100 MPa, and salinities up to  $120\text{ g kg}^{-1}$ , with some restrictions in certain regions. All thermodynamic properties and inverse functions can be computed. When using the industrial formulation IAPWS 2013, the uncertainties of the calculated seawater properties are slightly greater than those of the scientific formulation IAPWS-08. The difference results from the use of IAPWS-IF97 in the IAPWS 2013 industrial formulation and the use of the scientific formulation IAPWS-95 in the IAPWS-08 scientific formulation for the pure-water part. The computing speed of the industrial formulation IAPWS 2013 for seawater, however, is increased in the order of 100 to 200 depending on the property function in comparison with the use of the scientific formulation IAPWS-08. The industrial formulation IAPWS 2013 for seawater can be applied in calculations for analyzing, designing, simulating, operating, and optimizing desalination processes and for cooling processes with seawater in power plants.