

# The IAPWS Industrial Formulation for the Thermodynamic Properties of Seawater

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## **Abstract**

In 2008, the International Association for the Properties of Water and Steam (IAPWS) adopted a standard formulation for the thermodynamic properties of seawater as a sum of contributions to the Gibbs free energy from pure water and from dissolved sea salt. For pure water, the IAPWS formulation for general and scientific use (IAPWS-95) was used. However, for industrial uses such as desalination and seawater power-plant cooling, it is likely to be more convenient to use the computationally simpler IAPWS formulation for industrial use (IAPWS-IF97), which is standard in the steam power industry. This paper documents this approach, and gives formulas for calculating thermodynamic properties of seawater and steam (volume, enthalpy, isobaric heat capacity, etc.). The calculation of colligative properties (such as boiling and freezing points and osmotic pressure) is also described, as is the calculation of properties of two-phase states such as vapor-brine and brine-ice (sea ice). The computing speeds for these calculations are faster than those using IAPWS-95 by factors on the order of 100 to 200.

The use of IAPWS-IF97 instead of IAPWS-95 for industrial seawater calculations is endorsed in IAPWS Advisory Note No. 5: Industrial Calculation of the Thermodynamic Properties of Seawater. This use is valid for Standard Seawater with sea salt of the Reference Composition in specified regions inside the pressure, temperature, and salinity ranges of  $0.3 \text{ kPa} \leq p \leq 100 \text{ MPa}$ ,  $261 \text{ K} \leq T \leq 353 \text{ K}$ , and  $0 \leq S \leq 0.12 \text{ kg kg}^{-1}$ .