

# THERMAM 2014

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Izmir - Turkey



University of Rostock  
Institute of Technical Thermodynamics  
Rostock, Germany

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## Property Libraries and Software for Seawater, Steam, Water, Ice, Humid Air, and other Working Fluids for Calculating Desalination and Related Processes

Hans-Joachim Kretzschmar<sup>1</sup>, Sebastian Herrmann<sup>1</sup>, Matthias Kunick<sup>1</sup>, Ines Stoecker<sup>1</sup>,  
Mariana Nicke<sup>1</sup>

<sup>1</sup>Zittau/Goerlitz University of Applied Sciences, Zittau, Germany

E-mail: [hj.kretzschmar@hszg.de](mailto:hj.kretzschmar@hszg.de)

The program libraries for calculating the thermophysical properties for seawater, steam, water, ice, humid air, combustion-gas mixtures and other working fluids are designed for practical use by engineers who calculate desalination and related processes. The property libraries can calculate thermodynamic properties, transport properties, thermodynamic derivatives and inverse functions.

For simulating desalination processes at high temperatures, pressures, and salinities, the property library *LibSeaWa* for seawater can be used. It calculates thermodynamic and colligative properties from the IAPWS Industrial Formulation for Seawater. The range of validity in temperature and salinity of this property library is enlarged by using algorithms described by Hömig, Fichtner-Handbook [2]. So, the library *LibSeaWa* can be used at temperatures  $T$  from 261 K to 493 K, pressures  $p$  from 0.2 kPa to 100 MPa, and salinities  $S$  from 0 (pure water) to 200 g kg<sup>-1</sup>. All thermodynamic properties such as density  $\rho$ , specific volume  $v$ , specific enthalpy  $h$ , specific isobaric heat capacity  $c_p$ , and specific entropy  $s$ , transport properties such as thermal conductivity  $\lambda$  and dynamic viscosity  $\eta$ , thermodynamic derivatives, and inverse functions from given quantities  $(p,h,S)$  and  $(p,s,S)$  are computed. In addition, boiling temperature  $T_b$ , freezing temperature  $T_f$ , and properties for brine-vapor mixtures are calculable. Furthermore, the property libraries *LibIF97* for water and steam, *LibIF97\_META* for metastable steam, *LibICE* for ice including melting and sublimation, *LibHuAir* for humid air also at high temperatures and pressures, and *LibHuGas* for humid combustion-gas mixtures also at high pressures are available. In addition, property libraries for a number of other working fluids such as for ORC working fluids, refrigerants, absorption-refrigerant mixtures, gas mixtures, carbon dioxide, and hydrogen are offered. The libraries contain the most recent and accurate algorithms for calculating thermodynamic and transport properties.

The following software solutions will be presented:

Add-In *FluidEXLGraphics* for Excel<sup>®</sup>,

Add-On *FluidLAB* for MATLAB<sup>®</sup>,

Add-On *FluidMAT* for Mathcad<sup>®</sup>,

Add-On *FluidDYM* for Dymola<sup>®</sup> (Modelica) and SimulationX<sup>®</sup>,

Add-On *FluidVIEW* for LabVIEW<sup>™</sup>, and

Add-On *FluidEES* for the Engineering Equation Solver<sup>®</sup>.

The program *FluidDIA* was developed for calculating and plotting large-size and camera-ready thermodynamic charts.

Steam tables are available for iPhone, iPad and iPod touch, and for Android smart phones and tablets.

The property software on Texas Instruments<sup>®</sup>, Hewlett Packard<sup>®</sup>, and Casio<sup>®</sup> pocket calculators is particularly interesting for students.

The properties of several working fluids can be calculated at our website:

[www.thermodynamics-zittau.de](http://www.thermodynamics-zittau.de).

**Keywords:** Seawater, Thermophysical properties, Property libraries.