German National Committee to IAPWS

Research Activities on the Thermodynamic Properties of Water and Steam

Report "Research in Progress 2011"

Baltic Sea Research Institute, Warnemuende
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Recent Publications

- W. Wagner, T. Riethmann, R. Feistel, A.H. Harvey (2011):
  New Equations for the Sublimation Pressure and Melting Pressure of H2O Ice Ih.
  J. Phys. Chem. Ref. Data, under review at NIST, to be submitted before the Pilsen meeting
- Feistel, R. (2011):
  Thermodynamic Properties of Seawater.
  EOLSS 2-03-07, submitted June 2011, http://www.eolss.net/
- Feistel, R. (2011):
  TEOS-10: A New International Oceanographic Standard for Seawater, Ice, Fluid Water and Humid Air.
  International Journal of Thermophysics, DOI: 10.1007/s10765-010-0901-y
  http://www.springerlink.com/content/p4834412420n5j61/
- Wright, D.G., Pawlowicz, R., McDougall, T.J., Feistel, R., Marion, G.M. (2011):
  Absolute Salinity, "Density Salinity" and the Reference-Composition Salinity Scale: Present and Future Use in the Seawater Standard TEOS-10.
  Ocean Science, 7, 1–26, www.ocean-sci.net/7/1/2011/, doi:10.5194/os-7-1-2011
- Seitz, S., Feistel, R., Wright, D.G., Weinreben, S., Spitzer, P., de Bievre, P. (2011):
  Metrological Traceability of Oceanographic Salinity Measurement Results.
  Ocean Sci., 7, 45–62. www.ocean-sci.net/7/45/2011/
- Feistel, R., Marion, G.M.M., Pawlowicz, R., Wright, D.G. (2010):
  Thermophysical Property Anomalies of Baltic Seawater.
  Ocean Sci., 6, 949-981, www.ocean-sci.net/6/949/2010/
- Feistel, R. (2011):
  Stochastic Ensembles of Thermodynamic Potentials.
  Accreditation and Quality Assurance, 16, 225-235
- Marion, G.M., Millero, F.J., Camoes, F., Spitzer, P., Feistel, R., Chen, C.-T.A. (2011):
  pH of Seawater.
  Marine Chemistry, doi:10.1016/j.marchem.2011.04.002, in press

Zittau/Goerlitz University of Applied Sciences, Faculty of Mechanical Engineering, Department of Technical Thermodynamics
Prof. Dr. Hans-Joachim Kretzschmar

1. Development of Fast Property Algorithms Based on Spline Interpolation
   - The algorithms for fast spline-interpolation methods are being developed and applied to the calculation of thermodynamic properties of different fluids.
   - An algorithm for generating spline-interpolation data grids with optimized data density for the user requirements ‘range of state’ and ‘accuracy’ is being developed.

2. Thermodynamic Properties of Humid Air
   - The property library LibHuAirProp of the American Society of Heating, Refrigerating, Air-Conditioning Engineers (ASHRAE) for calculating thermodynamic and transport properties for real moist air, steam, water and ice has been completed.
3. Property Libraries for Calculating Heat Cycles
   - The property library LibIF97 for steam and water has been extended to include sublimation and melting pressures and ice properties.
   - The property libraries for steam, water, ice, seawater, humid combustion gases, humid air, ammonia/water mixtures and water/lithium bromide mixtures have been connected to DYMOLA (Modelica) for non-stationary process calculations.

Recent Publications

- Wagner, W.; Kretzschmar, H.-J.:
  Chapter 2.1 Properties of Water and Steam.
  In: *VDI Heat Atlas*, 2nd ed., Springer (2010), ISBN: 978-3-540-77876-9
- Herrmann, S.; Kretzschmar, H.-J.; Teske, V.; Vogel, P.; Ulbig, P.; Span, R.; Gatley, D.P.:
  Properties of Humid Air for Calculating Power Cycles.
  Journal of Engineering for Gas Turbines and Power, 132 (2010), pp. 093001: 1-8
- Feistel, R.; Wright, D. G.; Kretzschmar, H.-J.; Hagen, E.; Herrmann, S.; Span, R.:
  Thermodynamic Properties of Sea Air.
  Ocean Science, pp. 91-141, 6 (2010)
- Kretzschmar, H.-J., Stöcker, I.:
  Mollier h,s-Diagramm von Wasserdampf (*Mollier h-s* Diagram for Steam).
  Annex in: Zahoransky, R.: *Energietechnik* (*Power Engineering*), 5th Ed.
  Vieweg Verlag, Wiesbaden (2010), ISBN 978-3-8348-1207-0

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Department of Thermodynamics
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1 Article “New Equations for the Melting Pressure and Sublimation Pressure of H2O Ice Ih”

The manuscript for the background article for the “IAPWS Revised Release on the Pressure along the Melting and Sublimation Curves of Ordinary Water Substance” was written. The reference for this article reads: *Wagner, W., Riethmann, T., Feistel, R., and Harvey, A. H.* New Equations for the Melting Pressure and Sublimation Pressure of H_2O Ice Ih. Submitted to *J. Phys. Chem. Ref. Data*.

2 Stoffwerte für Wasser und Wasserdampf (Steam Tables for Water and Steam),VDI Wärme Atlas 2012

Section D2.1 “Stoffwerte für Wasser und Wasserdampf” (Properties of Water and Steam) of the VDI-Wärme Atlas 2012 (VDI-Heat Atlas), 11th German Edition, is being worked on. The corresponding steam tables are calculated based on the Industrial Formulation IAPWS-IF97 and the current equations for the transport properties and other properties based on the corresponding IAPWS Releases. The reference for this publication reads: *Wagner, W. and Kretzschmar, H.-J.*, Stoffwerte von Wasser und Wasserdampf, VDI-Wärmeatlas, 11. Auflage, Abschnitt D2.1, pp. 1-15, Springer-Verlag, Berlin, 2012.