

German National Committee to IAPWS

Research Activities on the Thermodynamic Properties of Water and Steam Report "Research in Progress 2010"

Baltic Sea Research Institute, Warnemünde, Germany, Dr. rer. nat. habil. R. Feistel

1. Preparation of the Guideline on an Equation of State for Humid Air in Contact with Seawater and Ice, Consistent with the IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater (with H.J. Kretzschmar, A.H. Harvey, M. Miyagawa)
2. Preparation of the Revision of the Revised Release on the Pressure along the Melting and Sublimation Curves of Water (with W. Wagner, A.H. Harvey)
3. Proposal for Renewal of ICRN 16 on Thermophysical Properties of Seawater
4. other Publications:

Wright, D.G., Pawlowicz, R., McDougall, T.J., Feistel, R., Marion, G.M.: Absolute Salinity, "Density Salinity" and the Reference-Composition Salinity Scale: Present and Future Use in the Seawater Standard TEOS-10. Submitted to Ocean Science on 30 May 2010

Seitz, S., Feistel, R., Wright, D.G., Weinreben, S., Spitzer, P., de Bievre, P.: Metrological Traceability of Oceanographic Salinity Measurement Results. Submitted to Ocean Science on 28 May 2010

Feistel, R., Marion, G.M.M., Pawlowicz, R., Wright, D.G.: Thermophysical Property Anomalies of Baltic Seawater. Ocean Science, submitted 26 May 2010

Feistel, R.: Stochastic Ensembles of Thermodynamic Potentials. Accreditation and Quality Assurance, submitted 20 May 2010

Feistel, R., Labrenz, R.: Neuer Internationaler Meerwasserstandard. Schiff & Hafen, April 2010, Nr.4, 66-67

Wright, D., Pawlowicz, R., McDougall, T., Feistel, R.: Progress Report for the SCOR/IAPSO Working Group 127 on "Thermodynamics and Equation of State of Seawater" CNC/SCOR Newsletter, 49, March 30, 2010, p.1-4 <http://www.cmos.ca/scor/NL49Mar2010.pdf>

Wright, D., Pawlowicz, R., McDougall, T., Feistel, R.: Progress Report for the SCOR/IAPSO Working Group 127 on "Thermodynamics and Equation of State of Seawater". CMOS Bulletin, submitted 26 March 2010

Marion, G.M., Millero, F.J., Camoes, F., Spitzer, P., Feistel, R. Chen, C.-T.A.: pH and Acidity of Natural Waters. Marine Chemistry, submitted 19 Feb 2010

Wright, D.G., Feistel, R., Reissmann, J.H., Miyagawa, K., Jackett, D.R., Wagner, W., Overhoff, U., Guder, C., Feistel, A. and Marion, G.M.: Numerical Implementation and Oceanographic Application of the Thermodynamic Potentials of Water, Vapour, Ice, Seawater and Air. Part II: The Library Routines. Ocean Sci. Discuss., 7, 649-708, 2010. www.ocean-sci-discuss.net/7/649/2010/

Feistel, R., Wright, D.G., Jackett, D.R., Miyagawa, K., Reissmann, J.H., Wagner, W., Overhoff, U., Guder, C., Feistel, A. and Marion, G.M.: Numerical Implementation and Oceanographic Application of the Thermodynamic Potentials of Water, Vapour, Ice, Seawater and Air. Part I: Background and Equations. Ocean Sci. Discuss., 7, 521-647, 2010. www.ocean-sci-discuss.net/7/521/2010/

Feistel, R., Wright, D.G., Kretzschmar, H.-J., Hagen, E., Herrmann, S., Span, R.: Thermodynamic Properties of Sea Air. Ocean Science, 6, 91-141, 2010. <http://www.ocean-sci.net/6/91/2010/>

Feistel, R., Weinreben, S., Wolf, H., Seitz, S., Spitzer, P., Adel, B., Nausch, G., Schneider, B., Wright, D.G.: Density and Absolute Salinity of the Baltic Sea 2006-2009. *Ocean Science*, 6, 3-24, 2010.
www.ocean-sci.net/6/3/2010/

Safarov, J., Millero, F., Feistel, R., Heintz, A., Hassel, E.: Thermodynamic properties of standard seawater: extensions to high temperatures and pressures. *Ocean Science*, 5, 235-246, 2009, Internet: www.ocean-sci.net/5/235/2009/

Feistel, R.: Extended equation of state for seawater at elevated temperature and salinity. *Desalination* 250, 14–18, 2010.

McDougall, T.J., Feistel, R., Wright, D.G., Pawlowicz, R., Millero, F.J., Jackett, D.R., King, B.A., Marion, G.M., Seitz, S., Spitzer, P., Chen, C.-T.A. (proposers):
 IOC, SCOR and IAPSO: The international thermodynamic equation of seawater - TEOS-10: Calculation and use of thermodynamic properties. Intergovernmental Oceanographic Commission, Manuals and Guides No. 56, UNESCO (English), 182 pp., Paris, 2010. www.teos-10.org

University of Applied Sciences Zittau/Görlitz, Faculty of Mechanical Engineering,
 Department of Technical Thermodynamics, Prof. Dr.-Ing. habil. H.-J. Kretzschmar

1. Development of Fast Property Algorithms Based on Spline Interpolation
 - The algorithms for fast spline-interpolation methods were developed and applied to the calculation of thermodynamic properties of steam and carbon dioxide.
 - An algorithm for the generation of data grids with optimized data density for the user requirements range of state and accuracy is being developed.
3. Thermodynamic Properties of Humid Air
 - The results of the research project RP-1485 "Thermodynamic Properties of Real Moist Air, Dry Air, Steam, Water, and Ice" for the American Society of Heating, Refrigerating, Air-Conditioning Engineers (ASHRAE) were published in the journal "HVAC&R Research".
 - A comprehensive article on the properties of moist air was prepared for the "Journal of Engineering for Gas Turbines and Power".
 - The property library LibHuAirProp for calculating thermodynamic and transport properties for real moist Air, steam, water and ice was completed.
4. Thermodynamic Properties of Seawater and Sea Air
 - The property library LibSeaWa for calculating thermodynamic and transport properties of seawater was completed.
 - A comprehensive article on the properties of sea air was prepared for the Journal "Ocean Science".

Recent Publications

- Herrmann, S.; Kretzschmar, H.-J.; Gatley, D.P.: Thermodynamic Properties of Real Moist Air, Dry Air, Steam, Water, and Ice. *HVAC&R Research*, 15 (2009), pp. 961-986
- Feistel, R.; Kretzschmar, H.-J.; Span, R.; Hagen, E.; Wright, D. G.; and Herrmann, S.: Thermodynamic Properties of Sea Air. *Ocean Sci.* (2010) 6, pp. 91-141
- Herrmann, S.; Kretzschmar, H.-J.; Gatley, D.P.:
 Table 2 Thermodynamic Properties of Moist Air at Standard Atmospheric Pressure
 Table 3 Thermodynamic Properties of Water at Saturation
 In: 2009 ASHRAE HANDBOOK FUNDAMENTALS, Chapter PRINCIPLES, SI and I-P Editions,
 ASHRAE (2009), ISBN 978-1-933742-55-7

1. Editorial changes for the Revised Release on the Industrial Formulation IAPWS-IF97

Editorial changes were made for the correction of the “Notes” in the subsections “Range of validity” for Eq. (7) [region 1 of IAPWS-IF97], page 9, and for Eq. (15) [region 2 of IAPWS-IF97], page 17. In the current Notes, the range of validity of IAPWS-IF97 in the temperature range between 273.15 K and 273.16 K is not correctly described and was correspondingly corrected. In addition, in Section 12 “Estimates of uncertainties” a hint is given where to find estimates of the uncertainty in enthalpy, namely in the IAPWS Advisory Note No. 1 given as Ref. [15].

2. Editorial changes for the Revised Release on the IAPWS-95 Formulation

In Section 6 “Estimates of uncertainties” a hint is given where to find estimates of the uncertainty in enthalpy, namely in the IAPWS Advisory Note No. 1 given as Ref. [9].

3. Revision of the Revised Release on the Pressure along the Melting and Sublimation Curves of Ordinary Water Substance

The revision refers to a new estimation of the uncertainty in sublimation pressure. This new estimation is based on a comprehensive physically founded consideration performed by Rainer Feistel with input from Allan Harvey and Wolfgang Wagner.

4. Steam Tables for the VDI-Heat Atlas 2010

The work on Section D2.1 “Properties of Water and Steam” of the VDI-Heat Atlas 2010 was finished and corresponding steam tables were calculated based on the Industrial Formulation IAPWS-IF97. These steam tables are the main part of this section. Prof. H.-J. Kretzschmar is co-author of this contribution.