

REPORT

on IAPWS-related activities: May 2014 – May 2015

submitted by the

Czech National Committee for the Properties of Water and Steam (CZ NC PWS)

to the Executive Committee Meeting of 2015 IAPWS Meeting, Stockholm, Sweden in June 2015

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Participating institutions

The following Czech Institutions participated in the research of thermophysical properties and chemical processes between May 2014 and May 2015:

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Institute of Chemical Technology, Prague (“ICT”), Department of Power Engineering (“ICT-DPE”) and Department of Physical Chemistry (“ICT-DPC”), Technická 5, CZ-166 28 Praha 6

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Board of CZ NC PWS for 2014-2017:

Dr. J. Hrubý
Prof. R. Mareš
Dr. T. Němec
Prof. P. Šafařík
Prof. J. Šedlbauer

List of IAPWS-Related Activities

Information about new documents adopted and authorized by IAPWS have been published on the CZ NC PWS website.

The joint project of IT CAS and TUL sponsored by the Ministry of Education, Youth and Sports of the Czech Republic has been the source of financial support for the international collaboration of CZNC PWS with IAPWS since 2013. The project support will end on 31/12/2016.

The research team of Dr. Hrubý (IT CAS) focused on the experimental investigation of the surface tension of supercooled pure water, the development of thermodynamic models for gas hydrates (in joint cooperation with the team of prof. Roland Span from the Ruhr-University Bochum), molecular simulations of the vapor-liquid interfacial properties and nucleation of water droplets, development of an experimental apparatus for the measurement of density of supercooled water [1-8].

Prof. Mareš (UWB) and Dr. Kalová (USB) studied surface tension of water and investigated a theoretical approach to the velocity of motion of the liquid column in the capillary [9-11].

Prof. Maršík (IT CAS) and his research team developed a thermodynamic theory of mixtures and formulated the generalized exergy analysis [12-13].

Dr. Němec (IT CAS) studied nucleation of bubbles theoretically and a scaling law for bubble nucleation data [14].

Assoc. Prof. Kolovratník (CTU) and his collaborators investigated binary homogeneous nucleation and wet steam energy losses in LP steam turbines and measured the heterogeneous particles in the superheated steam in turbines and the wet steam liquid phase structure in the 1000 MW LP steam turbine [15-22].

Mr. Nový (DOOSAN ŠKODA POWER) and his collaborators studied the speed of sound in steam and developed a data reduction method for reference parameters of steam flow fields [23-26].

Dr. Sedlář (SIGMA) and his collaborators studied the risk of cavitation erosion in hydrodynamic cavitation and cavitation instabilities in hydrodynamic pumps [27-31]. The team collaborates on the project entitled "Experimental Research and Mathematical Modelling of Unsteady Phenomena Induced by Hydrodynamic Cavitation" funded by the Czech Science Foundation.

Mr. Jiříček (ICT-DPE) and his collaborators studied corrosion in power engineering, water treatment for power engineering and environments, and renewable resources of energy. ICT-DPE organized the CHEO10 Conference on Chemistry of Power Plant Cycles in September 2014 [32-37].

Dr. Hnědkovský (ICT-IPC) and his collaborators studied the properties of organic solutes in water [38-49].

Prof. Šťastný (UWB) and his co-workers tested a numerical model of steam flow in a nozzle and in turbine blade cascades with NaCl binary nucleation and condensation and applied it to the solution of thermodynamic losses in turbine cascades [50-51].

References

- [1] Vinš, V., Fransen, M., Hykl, J., Hrubý, J.: Surface Tension of Supercooled Water Determined by Using a Counterpressure Capillary Rise Method, *Journal of Physical Chemistry B*, Vol. 119, pp. 5567-5575, 2015.
- [2] Hošek, J., Vinš, V., Hykl, J.: Influence of the Light Source on the Liquid Optical Element Planarity Measurement, In : *Optics and Measurement Conference 2014, Proceedings of SPIE Vol. 9442 (SPIE, Bellingham, WA, 2015), 94420E, 2014.*
- [3] Vinš, V., Hošek, J., Hykl, J., Hrubý, J.: An Apparatus with a Horizontal Capillary Tube Intended for Measurement of the Surface Tension of Supercooled Liquids, *EPJ Web of Conferences 92, 02108, 2015.*
- [4] Duška, M., Němec, T., Hrubý, J., Vinš, V., Planková, B.: Molecular Dynamics Simulation of Vapour-Liquid Nucleation of Water with Constant Energy, *EPJ Web of Conferences 92, 02013, 2015.*
- [5] Planková, B., Vinš, V., Hrubý, J., Duška, M., Němec, T., Celný, D.: Molecular Simulation of Water Vapor-Liquid Phase Interfaces Using TIP4P/2005 Model, *EPJ Web of Conferences 92, 02071, 2015.*
- [6] Peukert, P., Duška, M., Hykl, J., Sladký, P., Nikl, Z., Hrubý, J.: Calibration of Capillaries for Density Measurement of Supercooled Water, *EPJ Web of Conferences 92, 02067, 2015.*
- [7] Jäger, A., Vinš, V., Span, R., Hrubý, J.: The Lattice Parameter of Gas Hydrates – a New Model and Its Influence on van der Waals and Platteeuw Type Hydrate Models, *Thermodynamik-Kolloquium 2014, Stuttgart, 2014.*
- [8] Fransen, M.A.L.J., Hrubý, J., Smeulders, D.M.J., van Dongen, M.E.H.: On the Effect of Pressure and Carrier Gas on Homogeneous Water Nucleation. *Journal Chemical Physics*, Vol. 142, 164307, 2015.
- [9] Kalová, J., Mareš, R.: Size Dependences of Surface tension, *International Journal of Thermophysics*, 2015.
- [10] Mareš, R., Kalová, J.: Some Notes on Surface Tension Measurements of Supercooled Water, *EPJ WPC*, Vol.92, 02050, 2015.
- [11] Kalová, J., Mareš, R.: Some Notes on Surface Tension of Water. In : *13th Conference on Power System Engineering, Thermodynamics & Fluid Flow, 2014.*
- [12] Pavelka, M., Maršík, F., Klika, V.: Consistent Theory of Mixtures on Different Levels of Description, *International Journal of Engineering Science*, Vol.78, pp.192-217, 2014.
- [13] Pavelka, M., Klika, V., Vágner, P., Maršík, F.: Generalization of Exergy Analysis, *Applied Energy*, Vol.137, pp.158-172, 2015.

- [14] Němec T.: Scaled Nucleation Theory for Bubble Nucleation of Lower Alkanes. *European Physical Journal E*, 37 (11), 111, 2014.
- [15] Petr, V., Kolovratník, M.: The Assessment of the Effect of Binary Homogeneous Nucleation on Wet Steam Energy Loss in a Low Pressure Steam Turbine. *Proceedings the Institution of Mechanical Engineers, Part A: Journal of Power and Energy*, Vol. 228(5), pp. 525–535, 2014
- [16] Kolovratník, M., Hrubý, J., Ždímal, V., Bartoš, O., Jiříček, I., Moravec., Zíková, N.: Nanoparticles Found in Superheated Steam - A Quantitative Analysis of Possible Heterogeneous Condensation Nuclei. *Proceedings of the Institution of Mechanical Engineers Part A - Journal of Power and Energy*. Vol. 228, No. 2, pp. 186-193, 2014.
- [17] Bartoš, O., Cai, X.: The New Approach to Measure the Coarse Droplets in the Steam Turbine. Post-doctoral thesis. Shanghai University for Science and Technology, 2015.
- [18] Bartoš, O., Cai, X., Kolovratník, M.: A Detection of the Coarse Water Droplets in Steam Turbines. In : *Experimental Fluid Mechanics 2013*, Technical University of Liberec, Vol. 67, No. 02005, 2014.
- [19] Hrubý, J., Kolovratník, M., Bartoš, O.: A Method of Sample Extraction and Solution for Further Analysis. Sample Extraction from the Gas Environment.. Industrial Property Office, Patent 304783, 2014. (in Czech)
- [20] Kolovratník, M., Bartoš, O.: CTU Optical Probes for Liquid Phase Detection in the 1000 MW Steam Turbine. In : *Proceedings of the International Conference Experimental Fluid Mechanics 2014*, Liberec, pp. 273-277, 2014.
- [21] Kolovratník, M., Bartoš, O.: A Determination of the Wet Steam Liquid Phase Structure in the Steam Turbine 1078 MW. Research Report No. Z-586/2014, CTU Faculty of Mechanical Engineering, Prague, 2014. (in Czech)
- [22] Kolovratník, M., Bartoš, O.: Wet Steam Wetness Measurement in a 10 MW Steam Turbine. In : *Experimental Fluid Mechanics 2013*, Technical University of Liberec, Vol. 67, No. 02055, 2014.
- [23] P.Šafařík, P., Nový, A., Hajšman, M., Jícha, D.: Range of Valid Arguments for Data Reduction Method in the Steam Flow Fields, pp.245-249. In : *The Application of Experimental and Numerical Methods in Fluid Mechanics and Energy 2014*, Proceedings of the International Conference, Liptovský Ján, 2014
- [24] Jícha, D., Nový, A., Šafařík, P., Hajšman, M.: Some Remarks on Speed of Sound in Steam, SKMTaT 2014 Conference, Prague, 2014
- [25] Nový, A., Jícha, D., Šafařík, P., Hajšman, M.: Data Reduction Method for Steam Flow Fields, In : *XXII Biannual Symposium on Measurement Techniques in Turbomachinery*, Lyon, 2014
- [26] Nový, A., Šafařík, P. Jícha, D., Hajšman, M.: On Evaluation of Steam Flow Parameters from Experimental or Numerical Data Distribution on Traverse Plane, pp.151-158. In : *Topical Problems of Fluid Mechanics 2015*, Proceedings, Prague, 2015
- [27] Sedlář, M., Zima, P., Komárek, M.: Numerical Prediction of Erosive Potential of Unsteady Cavitating Flow around Hydrofoil, *Applied Mechanics and Materials*, No.565, 2014, pp. 156–163.
- [28] Komárek, M., Sedlář, M., Vyroubal, M., Zima, P., Müller, M., Pálka, T.: Preparation of Experimental and Numerical Research on Unsteady Cavitating Flow around Hydrofoil. *EJP Web of Conferences*, 92,

- [29] Sedlář, M., Komárek, M., Rudolf, P., Kozák, P., Huzlík, R.: Numerical and Experimental Research on Unsteady Cavitating Flow around NACA 2412 Hydrofoil. IOP Conference Series: Material Science and Engineering, 72, 022014. 2015.
- [30] Sedlář, M., Šoukal, J., Krátký, T., Vyroubal, M.: Numerical Prediction of Impacts of Cavitation in Pumps for Power Generation. Thermal Engineering, 62, pp. 408-413, 2015.
- [31] Sedlář, M., Zima, P., Němec, T.: New Grant Project on Cavitation Modelling and Measurements. Presentation IAPWS Annual Meeting, Moscow, 2014.
- [32] Parschová, H., Ryšavá, E., Mištová, E., Jelínek, L.: Removal of Cobalt Ions from Aqueous Solutions. CHEO10 Conference Prague, 2014 (in Czech)
- [33] Jiříček, I., Rudasová, P., Hásl, T., Farták, J.: Impurities in Steam Parts of Cycles and Degradation of Turbines, CHEO10 Conference Prague, 2014 (in Czech)
- [34] Němeček M., Parschová, H.: Sorption and Desorption of Chromates by the Sorbents with Aminomethyl Functional Group. CHEO10 Conference Prague, 2014 (in Czech)
- [35] Mištová, E., Houšťava, M., Gordyatskaya, Y., Parschová, H., Jelínek L.: Sorption of Cesium Ions on Clinoptilolite, CHEO10 Conference Prague, 2014 (in Czech)
- [36] Kůs, P., Bártová, Š., Parschová, H., Kunešová, K., Novotná, M., Jelínek, L.: Selective Sorption of Vanadium (V) and Molybdenum (VI) on Selective Sorbent with Dial Groups. CHEO10 Conference Prague, 2014 (in Czech)
- [37] Kůs, P., Bártová, Š., Kunešová, K., Skala, M., Moucha, T., Škoda, A., Fára, V., Martykán, M., Kopa, R.: The Preconcentration of Boric Acid by means of Reverse Osmosis. CHEO10 Conference Prague, 2014 (in Czech)
- [38] Purchala, A., Cibulka, I.: Partial Molar Volumes and Partial Molar Isentropic Compressions of Four Aliphatic Linear Polyethers at Infinite Dilution in Water at Temperatures $T = (278 \text{ to } 343) \text{ K}$ and Atmospheric Pressure, Journal of Chemical and Engineering Data, Vol.59, Issue 12, pp.4205-4216, 2014
- [39] Cibulka, I.: [Partial Molar Volumes and Partial Molar Isentropic Compressions of 15-Crown-5 and 18-Crown-6 Ethers at Infinite Dilution in Water at Temperatures \$T = \(278 \text{ to } 343\) \text{ K}\$ and Atmospheric Pressure](#), Journal of Chemical and Engineering Data, Vol.59, Issue 6, pp.2075-2086, 2014
- [40] Martins, M.A.R., Ferreira, O., Hnědkovský, L., Cibulka, I., Pinho, S.P. : Partial Molar Volumes of Glycine and DL-Alanine in Aqueous Ammonium Sulfate Solutions at 278.15, 288.15, 298.15 and 308.15 K, Journal of Solution Chemistry, Vol. 43, Issue 5, pp.972-988, 2014
- [41] Cibulka, I.: Partial Molar Volumes of Organic Solutes in Water. XXV. Branched Aliphatic Diols at Temperatures (298 to 573) K and Pressures up to 30 MPa, Journal of Chemical Thermodynamics, Vol. 71, pp. 19-26, 2014
- [42] Mota, P.C., Ferreira, O., Hnědkovský, L., Pinho, S.P., Cibulka, I.: Partial Molar Volumes of L-Serine and L-Threonine in Aqueous Ammonium Sulfate Solutions at (278.15, 288.15, 298.15, and 308.15) K, Journal of Solution Chemistry, Vol. 43, Issue 2, pp.283-297, 2014
- [43] Fenclova, D., Blahut, A., Vrbka, P., Dohnal, V., Böhme, A.: Temperature Dependence of Limiting Activity Coefficients, Henry's Law Constants, and Related Infinite Dilution Properties of C4-C6 Isomeric n-Alkyl Ethanoates/Ethyl n-Alkanoates in Water. Measurement, Critical Compilation, Correlation, and Recommendation ..., Fluid Phase Equilibria, Vol. 375, pp.347-359, 2014.

- [44] Ondo, D., Dohnal, V.: solITC: A Rapid Method to Determine Solubility Products and Heats of Solution of Hydrophobic Ionic Liquids from in situ Synthesis in Isothermal Titration Calorimeter, *Journal of Chemical Thermodynamics*, Vol. 75, pp. 86-95, 2014
- [45] Svoboda, O., Slaviček, P.: Is Nitrate Anion Photodissociation Mediated by Singlet-Triplet Absorption?, *Journal of Chemistry Letters*, Vol. 5, Issue 11, pp. 1958-1962, 2014
- [46] Kolafa, J.: Residual Entropy of Ices and Clathrates from Monte Carlo Simulation, *Journal of Chemical Physics*, Vol. 140, Issue 20, 2014
- [47] Strejc, M., Řehák, K., Beier, P., Morávek, P.: Liquid-Liquid Equilibria in Ternary Systems of Hexafluoroisopropanol plus Perfluorocarbon plus Water or Methanol at 298.15 K, *Journal of Chemical and Engineering Data*, Vol. 59, Issue 11, pp. 3510-3516, 2014.
- [48] Křížek, T., Kubíčková, A., Hladilková, J., Coufal, P., Heyda, J., Jungwirth, P.: Electrophoretic Mobilities of Neutral Analytes and Electroosmotic Flow Markers in Aqueous Solutions of Hofmeister Salts, *Electrophoresis*, Vol. 35, Issue 5, pp. 617-624, 2014
- [49] Werner, J., Wernersson, E., Ekholm, V., et al.: Surface Behavior of Hydrated Guanidinium and Ammonium Ions: A Comparative Study by Photoelectron Spectroscopy and Molecular Dynamics, *Journal of Physical Chemistry B*, Vol. 118 Issue 25, pp. 7119-7127, 2014
- [50] Šťastný, M., Šejna, M.: Thermodynamic Losses of Hetero and Homogeneous Condensation in Turbine Cascades, *Journal of Power and Energy*, 2014 (UK)
- [51] Šťastný, M., Šejna, M.: Thermodynamic Loss of Condensation in Steam Turbine Cascade, *Computational Mechanics*, Špičák, 2014