

REPORT

on IAPWS-related activities: May 2015 – May 2016

submitted by the

Czech National Committee for the Properties of Water and Steam (CZ NC PWS)
to the Executive Committee Meeting of 2016 IAPWS Meeting, Dresden, Germany, in September 2016

National Committee Contacts

CZ NC PWS
Institute of Thermomechanics of the CAS, v. v. i.
Dolejšková 1402/5, 182 00 Praha
Czech Republic
Fax: +420 2858 4695
E-mail: secr.czncpws@it.cas.cz
Committee Chairman: Dr. Jan Hrubý (hruby@it.cas.cz)

Participating institutions

The following Czech Institutions participated in the research of thermophysical properties and chemical processes between May 2015 and May 2016:

Institute of Thermomechanics of the CAS, v. v. i., (“IT CAS”), Department of Thermodynamics, Dolejšková 1402/5, CZ-182 00 Praha 8

Czech Technical University in Prague (“CTU”), Faculty of Mechanical Engineering, Department of Fluid Mechanics and Thermodynamics, and Department of Power Engineering, Technická 4, CZ-166 07 Praha

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

University of West Bohemia (“UWB”), Faculty of Mechanical Engineering, Department of Power System Engineering, Univerzitní 8, CZ-306 14 Plzeň

DOOSAN ŠKODA POWER, Plzeň, Inc., Tylova 57, CZ-316 00 Plzeň

Technical University of Liberec (“TUL”), Department of Chemistry, CZ-461 19 Liberec

SIGMA Research and Development Institute Ltd. (“SIGMA”), Jana Sigmunda 79, CZ-783 50 Lučín

University of South Bohemia (“USB”), Faculty of Science, Branišovská 31A, CZ-370 05 České Budějovice

The founder of the CZNCPWS is the Czech Academy of Sciences.

The activities described below were sponsored by the Czech Science Foundation (GAČR), DOOSAN ŠKODA POWER, Ministry of Education, Youth and Sport of the Czech Republic (MŠMT), and Ministry of Industry and Trade of the Czech Republic (MPO).

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

The project of IT CAS 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 CZNCPWS with IAPWS since 2016. The project support will end on 31/12/2017.

Dr. Hrubý and Dr. Vinš (IT CAS) and their collaborators from IT CAS continued their experimental investigation of surface tension of supercooled water [1,5,6,7] and density of supercooled water at elevated pressures [6,7]. In joint cooperation with the team of Prof. Roland Span from Ruhr-University Bochum they progressed in modeling of gas hydrates relevant to carbon capture and storage [3,4]. In addition, the vapor-liquid phase interface of water was studied using molecular dynamic simulations [2,7].

Prof. Mareš (UWB) and Dr. Kalová (USB) studied surface tension of water and water nanodroplets [8-9].

Dr. Němec (IT CAS) studied bubble nucleation in binary systems of liquid solvent and dissolved gas. His theoretical model enabled him to evaluate the influence of dissolved gas concentration in water on the process of bubble formation [10].

Assoc. Prof. Kolovratník (CTU) and Dr. Bartoš carried out pneumatic and optical measurements of a wet steam flow field upstream of the last stage of a nuclear power-station steam turbine. This unique measurement has produced useful new information for the manufacturer and operator of the steam turbine and valuable experimental data for phase transition modelling in wet steam flows [11].

Mr. Nový (DOOSAN ŠKODA POWER) and his collaborators studied the speed of sound in steam [12] and carried out numerical simulations of flow with condensation in nozzles based on homogeneous nucleation.

Dr. Sedlář (SIGMA) and his collaborators studied cavitation erosion in water pumps [13] and the problem of cavitation instabilities in hydrodynamic conditions [14-16].

The team of Prof. Šedlbauer investigated thermodynamic properties of H₂S-H₂O-NaCl solutions [17].

The team of Assoc. Prof. Hnědkovský (ICT-IPC) studied thermodynamic properties of aqueous solutes in water [18-25].

References

- [1] Vinš, V., Hošek, M., Hykl, J., Hrubý, J.: Improvements of the Experimental Apparatus for Measurement of the Surface Tension of Supercooled Liquids Using Horizontal Capillary Tube, EPJ Web of Conferences 114, 02135, 2016.

- [2] Vinš V., Celný D., Planková B., Němec T., Duška M., Hrubý J.: Molecular Simulations of the Vapor–Liquid Phase Interfaces of Pure Water Modeled with the SPC/E and the TIP4P/2005 Molecular Models, EPJ Web of Conferences 114, 02136, 2016.
- [3] Vinš V., Jäger A., Hrubý J., Span R.: Hydrate Model for CCS Relevant Gases Compatible with Highly Accurate Equations of State I. Parameter Study and Model Fitting, 19th Symposium on Thermophysical Properties, Boulder, 2015.
- [4] Vinš V., Jäger A., Hrubý J., Span R.: Hydrate Model for CCS Relevant Gases Compatible with Highly Accurate Equations of State I. Parameter Study and Model Fitting, 19th Symposium on Thermophysical Properties, Boulder, 2015.
- [5] Vinš V., Hošek J., Hykl J., Hrubý J.: Surface Tension of Supercooled Water Down to – 22 °C Measured with a Horizontal Capillary Tube, 19th Symposium on Thermophysical Properties, Boulder, 2015.
- [6] Hrubý J., Vinš V., Duška M., Hykl J., Peukert, P.: Experimental Investigations of the Properties of Supercooled Water: Surface Tension and Density at Moderate Pressure, 19th Symposium on Thermophysical Properties, Boulder, 2015.
- [7] Hrubý J., Vinš V., Duška M., Peukert P., Hykl J., Planková B.: New Measurements of the Surface Tension and Density of Supercooled Water and Simple Thermodynamic Models. WaterX – Exotic Properties of Water under Extreme Conditions, Nice, 2016.
- [8] Kalová, J., Mareš, R.: Reference Values of Surface Tension of Water, International Journal of Thermophysics, Volume 36, Issue 7, pp.1396-1404, 2015.
- [9] Kalová, J., Mareš, R.: Tolman Length of Water Nanodroplets, In : 15th Conference on Power System Engineering Thermodynamics & Fluid Flow, ES 2016, Pilsen, 2016.
- [10] Němec T.: Homogeneous Bubble Nucleation in Binary Systems of Liquid Solvent and Dissolved Gas, Chemical Physics, 467, pp.26-37, 2016
- [11] Kolovratník, M., Bartoš, O.: Experimental Investigation of the Steam Wetness in a 1000 MW Steam Turbine, In: EJP Web Conferences, 114, 02056, 2016
- [12] P.Šafařík, P., Nový, A., Hajšman, M., Jícha, D.: On the Speed of Sound in Steam, Acta Polytechnica, Vol. 55, No.6, pp.422-423, 2015
- [13] Sedlář, M., Krátký, T., Zima, P.: Numerical Analysis of Unsteady Cavitating Flow around Balancing Drum of Multistage Pump, International Journal of Fluid Machinery and Systems, Volume 9, pp.119-128, 2016.
- [14] Kozák, J., Rudolf, P., Sedlář, M., Habán, V., Hudec, M., Huzlík, R.: Numerical Simulation and Experimental Visualization of Separated Cavitating Boundary Layer over NACA2412, EJP Web Conferences, 92, 02037, 2015.
- [15] Zima, P., Fürst, T., Sedlář, M., Komárek, M., Huzlík, R.: Determination of Frequencies of Oscillations of Cloud Cavitation on 2D Hydrofoil from High-Speed Camera Observations, Journal of Hydrodynamics, Volume 28, No.2, pp.840-847, 2016,
- [16] Maršík, F.: Unstable Phenomena Induced by Cavitating Flow around Hydrofoil, In : 2015 Annual Meeting of IAPWS, Stockholm, 2015.
- [17] Akinfiyev, N.N., Majer, V., Shvarov, Y.V., Thermodynamic Description of H₂S–H₂O–NaCl Solutions at Temperatures to 573 K and Pressures to 40 MPa, Chemical Geology 424, pp.1-11, 2016.

- [18] Cibulka, I.: Partial Molar Volumes of Organic Solutes in Water. XXVI. 15-Crown-5 and 18-Crown-6 Ethers at Temperatures (298 to 573) K and Pressures up to 30MPa, *Journal of Chemical Thermodynamics*, Volume 80, pp.41-48, 2015.
- [19] Vataščin, E., Dohnal, V.: Thermophysical Properties of Aqueous Solutions of the 1-Ethyl-3-Methylimidazolium Tricyanomethanide Ionic Liquid, *Journal of Chemical Thermodynamics*, Volume 89, article No.4237, pp.169-176, 2015.
- [20] Baránková, E., Dohnal, V.: Effect of Additives on Volatility of Aroma Compounds from Dilute Aqueous Solutions, *Fluid Phase Equilibria*, Volume 407, pp.217-223, 2015
- [21] Unger, I., Hollas, D., Seidel, R., Thürmer, S., Aziz, E.F., Slavíček, P., Winter, B.: Control of X-Ray Induced Electron and Nuclear Dynamics in Ammonia and Glycine Aqueous Solution via Hydrogen Bonding, *Journal of Physical Chemistry B*, Volume 119 (33), pp.10750-10759, 2015.
- [22] Šmídová, D., Lengyel, J., Pysanenko, A., Med, J., Slavíček, P., Fárník, M.: Reactivity of Hydrated Electron in Finite Soze System : Sodium Pickup on Mixed N2O-Water Nanoparticles, *Journal of Physical Chemistry Letters*, Volume 6 (15), pp.2565-2869, 2015.
- [23] Klíčová, L., Muchová, E., Šebej, P., Slavíček, P., Klán, P.: Nature of CTAB/Water/Chloroform Reverse Micelles at Above- and Subzero Temperatures Studied by NMR and Molecular Dynamics Simulations, *Langmuir*, Volume 31 (30), pp.8284-8293, 2015.
- [24] Žák, M., Klepic, M., Štastná, L.Č., Sedláková, Z. Vychodilová, H., Hovorka, Š., Friess, K., Randová, A., Brožová, L., Jansen, J.C., Khydhayyer, M.R., Budd, P.M., Izák, P.: Selective Removal of Butanol from Aqueous Solution by Pervaporation with a PIM-1 Membrane and Membrane Aging, *Separation and Purification Technology*, Vol.151, pp.108-114, 2015.
- [25] Pluhařová, E., Slavíček, P., Jungwirth, P.: Modeling Photoionization of Aqueous DNA and Its Components, *Accounts of Chemical Research*, Volume 48 (5), pp.1209-1217, 2015.