Chair: Mr. M. Sparrey, ABB Ltd., Oldends Lane, Stonehouse, Gloucestershire, UK
Vice-Chair: vacant
Secretary: Dr M. Robson, RWE npower, Laboratory Building, TSG Ferrybridge, Knottingley, UK
Treasurer: Mr H.W. Lloyd, UK

BIAPWS ANNUAL REPORT 2017

1 INTRODUCTION

The British and Irish Association for the Properties of Water and Steam (BIAPWS) is the UK and Ireland national committee of the International Association for the Properties of Water and Steam (IAPWS) and the representative body for Power Plant Chemistry in the UK and Ireland. BIAPWS is a not for profit organisation. This is the annual report of the activities of BIAPWS for the period from August 2016 to July 2017. A list of publications by BIAPWS members during this period is included in Appendix A. If you would like to know more about BIAPWS, please feel free to visit our web site www.biapws.org or e-mail BIAPWS at contact.us@biapws.co.uk.

2 BIAPWS MEMBERSHIP AND MEETINGS

BIAPWS membership remains strong, with current support provided by twenty-three industrial sponsors, six honorary members, five ordinary members and eleven corresponding members.

BIAPWS committee meetings are held three times a year and attendance at these continues to be good, typically with around thirty people present. A recent change has been to expand the technical sessions at BIAPWS committee meetings to add value to meeting attendance.
Industrial member's representatives are able to bring a colleague to the meetings to benefit from and contribute to the discussions.

3 BIAPWS POWER PLANT CHEMISTRY SYMPOSIUM

Each year, BIAPWS organises an annual symposia on power plant chemistry and water treatment. The 18th in this series of symposia was held at the University of Warwick, Coventry, on 14 – 15 June 2017. The symposium consists of introductory sessions on the fundamentals of power plant chemistry and water treatment, followed by more detailed technical presentations. The event remains well supported, with around 100 delegates and 13 exhibition spaces taken up in 2017.
A copy of the symposium programme is included in Appendix B. A paper summarising the proceedings of the 2017 event has been published in Power Plant Chemistry journal.

4 IAPWS ACTIVITIES

BIAPWS has continued to support IAPWS through its formal membership and participation in IAPWS activities. A number of BIAPWS committee members are represented on IAPWS working groups. At the 2017 IAPWS annual meeting in Kyoto, Japan, BIAPWS will be represented by M. Sparrey and Adam Caswell of EDF. In addition, BIAPWS is represented on the executive committee of IAPWS.

5 BIAPWS AWARDS

BIAPWS offers selected sponsorship opportunities for student placements and schools events that aim to raise the awareness and generate new interest amongst students in the areas of science and technology relevant to the properties of water and steam, including power plant chemistry. This initiative has in the past proven highly successful, with many previous winners of the BIAPWS Student Award going on to full time employment in power generation.

Over the last 12 months, BIAPWS received no opportunities for sponsorship in 2017.

6 BIAPWS WEBSITE

The public facing pages aim to promote a better understanding of what BIAPWS and IAPWS are and what our activities include. The member's area now includes a library of technical information for our members from BIAPWS meetings and symposia. Further developments are planned to include training resources.

7 BSI REPRESENTATION

BIAPWS is currently represented on the three British Standards and Euro Norm Committees listed below of relevance to power plant chemistry and water treatment. However, there have not been any significant developments in recent years.

- PVE/2: Water Tube and Shell Boilers. The UK standards committee has responsibility for BS EN 12952-12:2003: "Water-tube Boilers and Auxiliary Installations - Requirements for Boiler Feedwater and Boiler Water Quality" and BS EN 12953-10:2003: "Shell Boilers - Requirements for Feedwater and Boiler Water Quality".

- CII/62: Treatment of water for boilers. The UK standards committee also has responsibility for BS 2486:1997: "Recommendations for Treatment of Water for Steam Boilers and Water Heaters".
- EH/3/6: Water quality - sampling. The UK standards committee is responsible for BS 6068-6.7:1994 (ISO 5667-7:1993): "Guidance on Sampling of Water and Steam in Boiler Plants".

8 INTERACTION WITH PROFESSIONAL ORGANISATIONS

BIAPWS maintains correspondence with a number of professional bodies with the aim of sharing information and closer working.

- BIAPWS is represented on the Energy Sector Interest Group of the Royal Society of Chemistry by John Greene;
- BIAPWS is also represented on the Water Science Forum of the Royal Society of Chemistry by Eric Huff;
- Richard Hill, who is a committee member of the Institution of Chemical Engineers (IChemE) Water Subject Group, is also a Corresponding Member of BIAPWS.

Mike Sparrey
Chair, British & Irish Association for the Properties of Water and Steam
September 2017

APPENDIX A:

LIST OF UK AND IRELAND ORIGINATED REFERENCE PAPERS IN AREAS OF INTEREST. NO UPDATES CURRENTLY SUPPLIED IN 2017.

APPENDIX B:

WARWICK CONFERENCES
The University of Warwick, Coventry, CV4 7AL UK
http://www.warwickconferences.com/

Early bird registration fees are available until 31 March 2017

PROGRAMME

WEDNESDAY 14TH JUNE 2017, 12:00 – 17:00

INTRODUCTIONS TO POWER PLANT CHEMISTRY

12:00 Registration and Lunch

13:20 Welcome and introduction — Mike Sparrey, Chair, BIAPWS

13:30 Session 1: New Nuclear Update

Presenters: Ruth Oakley (EDF Energy Generation)

Presenter to be confirmed (Horizon Nuclear Power)

Chair: Andy Rudge (EDF Energy Generation)

15:00 Break

15:30 Session 2: Amine Chemistry

Presenters: Properties and Chemistry of Amines - Alan Pomfret (GE Water)

Film-Forming Amines using the IAPWS Guidelines - Andre deBache (Kurita Europe)

Chair: Andy Rudge (EDF Energy Generation)

17:00 Close

19:30 Evening meal and entertainment, Warwick Conferences

BRITISH AND IRISH ASSOCIATION FOR THE PROPERTIES OF WATER AND STEAM

A Member of the International Association for the Properties of Water and Steam

BIAPWS

www.biapws.org

THURSDAY 15TH JUNE 2017, 09:00 – 16:00

POWER PLANT CHEMISTRY AND CORROSION

08:30	Registration and Coffee	
09:00	Welcome and introduction	Mike Sparrey, Chair, BIAPWS
09:05	Exhibitor introductions	Mike Sparrey, Chair, BIAPWS
	Session 1	Chair: John Greene, Consultant
09:20	The Real Story on Steam Turbine Phase Transition Zone Damage	Barry Dooley, Structural Integrity Associates
09:50	CCGT Plant Preservation	Paul McCann, Uniper Technologies Ltd
10:20	Break	
10:50	Cation Conductivity Measurement by Electrodeionisation	Julie Gath, SWAN
11:20	Cooling Water pH Discharge Monitoring	Mark Robson, RWE Generation UK PLC
11:50	Open Discussion Session	
12:00	Lunch	
	Session 2	Chair: Eric Huff, BIAPWS
13:00	A Recent History of the Advanced Gas Reactor (AGR) Pod Boilers	Ellie Laney, EDF Energy Generation
13:30	Off-Load Corrosion in AGR Reheaters – Summary of Investigative Work	Adam Caswell, EDF Energy Generation
14:00	Break	
14:30	Four Years' Experience of Film-Forming Amine Treatment on a CCGT - The Analytical Chemistry Challenges and Achievements	Bill Smith, Uniper, and John Greene, Consultant
15:00	A Modern Approach to Monitoring and Controlling Boiler Chemistry	Andrew Mosley and Mark Robson, RWE Generation UK PLC
15:30	Open Discussion Session	
15:55	Closing Remarks	Mike Sparrey, Chair, BIAPWS
16:00	Close	

IAPWS Canadian National Committee

Annual Report 2017

Submitted to IAPWS EC, Kyoto, Japan, September 1, 2017

CNC Executive: *William Cook (Chair); Derek Lister; Peter Tremaine; Melonie Myszczyszyn; Rich Pawlowicz; Steve McGee (CANDU Owners Group Representative, Treasurer), Craig Stuart.*

1. Canadian National Committee: Dues for the Canadian National Committee (CNC) of IAPWS are supported by the National Research Council of Canada (NRC). This arrangement requires support and participation by a national organization representing industry. In 2004 the CANDU Owners Group took on this role on a trial basis, and in 2007 the CANDU Owners Group accepted this role for an initial five-year term, including travel support for the academic members of the CNC. In December 2012, COG agreed to another five-year term as the CNC's industrial sponsor (2013-2017). We are currently in the second year of an agreement with COG and the NRC for a third five-year term. Thanks to Steve McGee for ensuring the renewal proceeded smoothly.

The CNC recruited Dr. Craig Stuart, Senior Scientist – CNL, as Dr. Dave Guzonas' replacement so that CNL and the Canadian nuclear industry's interests continue to be well represented within IAPWS.

2. CNC Member Activities

2.1 Activities at the University of New Brunswick (UNB)

Derek Lister

Heat exchanger fouling; the recirculating water loop built for studying deposit formation on heat-exchange surfaces has been refurbished with a new test section (including a simulated heat exchanger tube with a high heat-flux heater) and control system. A scoping study to assess the operation of the loop in sub-cooled boiling in the test section and the effect on magnetite particle deposition ended with heater burn-out; at the same time, the study using atomic-force microscopy to evaluate the forces between magnetite particles and bubble surfaces in water ended when the AFM became no longer available. Emphasis has switched to bench studies of adsorption of film-forming amines on magnetite with experiments on magnetite powder and sintered magnetite pellets.

Flow-accelerated corrosion (FAC); experiments on the effects of FFA on FAC are proceeding in two recirculating water loops. Under feedwater conditions at 140°C, a commercial product is being investigated for its efficiency in mitigating FAC with no pH additive in flows of different Reynolds numbers. The effect of the FFA on FAC in steam-water mixtures has been determined.

Modelling reactor primary circuit contamination; inserting FAC mechanisms and in-core effects into models for material transport has led to predictions of the transport of radioactive corrosion products in a CANDU primary coolant system. To translate the results to predictions of radiation field build-up, experiments are in progress to simulate and then verify by measurement the radiation field from radioactivated bundles of tubes in heat-exchanger configurations.
Developing a robust probe for measuring FAC in-situ in operating plant; three probes have been successively installed downstream of the boiler feed pump in a coal-fired power station. After analysis of the results from the first probe, refinements were made to the system before the second probe was installed. The third probe has been installed and removed while analysis of the results from the second has proved inconclusive because of the intermittent power production of the plant.

Verifying the effects of dissolved iron on FAC; experiments injecting iron into a coolant stream by promoting FAC upstream of an in-situ FAC probe are complete. The measured effects have been successfully described in terms of UNB's mechanistic model, indicating that the FAC rate is not directly proportional to the concentration of dissolved iron.
Measuring the effusion rate of hydrogen through steel; in a collaborative project with UNB's Centre for Nuclear Energy Research, the development of an in-situ probe (HEPro) for monitoring FAC by measuring the rate of effusion of corrosion hydrogen through pipe walls is being supported by investigating the details of hydrogen diffusion around the probe structure. Using a commercial CFD code, the pathways of diffusion into the probe have been visualised and the effect of the wall thickness of the probe evaluated. In collaboration with CNER, a project measuring the ingress of hydrogen into a steel undergoing FAC has already demonstrated that the phenomenon is different under reactor primary coolant conditions and feedwater conditions.

Electrochemical influences in FAC; an in-situ FAC probe in a high-temperature water loop is made the working electrode of a three-electrode system and the corrosion characteristics are separately investigated by electrochemical techniques. The project is currently investigating the phenomena in bent tubes.

Willy Cook
W. Cook has been Director of the Centre for Nuclear Energy Research (CNER), a research institute on UNB's campus, for the past two years. CNER has over two-decades of research / collaboration with the nuclear industry and has developed and patented online sensors for monitoring corrosion of plant piping in-situ, HEPro. Additional field trials to show the utility of the sensors for nuclear power plants are currently in preparation. CNER continues to grow its consulting expertise and provides services to Canada's nuclear industry including active engagement with local nuclear power generating stations and Canadian Nuclear Laboratories.

Experience with the use of CNER's HEPro has demonstrated that it is very sensitive and can measure changes in FAC rate of carbon steel with subtle changes in system chemistry conditions. A program is currently underway to investigate the effects of IX resin replacement on iron concentration in the CANDU heat transport system and what affect this may have on FAC of the carbon steel outlet feeder pipes.

Hydrogen control in CANDU cooling systems is a project initiated in 2014 in conjunction with industrial collaborators. Current CANDUs have several nuclear auxiliary light water systems that are exposed to intense radiation fields. Suppression of water radiolysis and mitigation of hydrogen production in these systems using alternate oxygen scavenging chemicals to hydrazine is a primary goal. The experimental program is now complete and results demonstrate that corrosion processes on carbon steel can significantly affect the reaction kinetics and production from water radiolysis.

W. Cook and David Addison (Thermal Chemistry Inc. – New Zealand) were awarded an IAPWS International Collaboration project 2015. The focus of the project was to establish capabilities at UNB / CNER's laboratories to measure, electrochemically, the effects of mixed contaminants on boiler materials. D. Addison again visited UNB / CNER in May 2017 and the test rig was redesigned, relocated and recommissioned.

3.2. Activities at the University of Guelph (Peter Tremaine)

In 2016, Peter Tremaine was appointed to a newly created NSERC/UNENE Senior Industrial Research Chair in High Temperature Aqueous Chemistry. The objective is to expand mission-oriented basic research and modelling expertise at Guelph in areas related to primary coolant chemistry, moderator chemistry, steam generator chemistry and nuclear waste management. Recruitment of a tenure-track junior faculty member to address succession planning issues is in the final stages. In addition to UNENE, the industrial

partners are the CANDU Owners Group, the Nuclear Waste Management Organization and the Electric Power Research Institute.

Other current and recent projects include (i) Solvation and Equilibria of Ions and Organic Solutes in Water up to Near-Critical Conditions (ii) CANDU Nuclear Reactor Chemistry: D_2O Isotope Effects on Acid-base Ionization and Metal Hydrolysis (UNENE/NSREC CRD Grant), (iii) Generation IV Nuclear Reactor Chemistry: Ion Pairs and Complexes in Sub-critical and Supercritical Water (NRCan/AECL/ NSERC CRD Grants), (iv) Carbon Capture and Sequestration by Novel Phase-Separating Solvents (NSERC International Strategic Grant with University Blaise Pascal, France)

3.3. Activities at the University of British Columbia (Rich Pawlowicz)

IAPWS-related activities continue to concentrate on investigations into the effect of chemical composition changes in seawater on its physical properties, and coordination of international activities in supporting and extending the seawater standard TEOS-10 through chairmanship of the Joint SCOR/IAPWS/IAPSO Committee on the Properties of Seawater (JCS).

Field measurements of "density anomaly": (1) Continued measurements of river anomalies were made in the Canadian Arctic Archipelago as part of a Canadian GEOTRACES rivers project (with H. Uchida and K. Brown)

3.4. CANDU Owner's Group (COG) Activities (Steve McGee)

COG is a not-for-profit corporation with voluntary funding from international CANDU-owning utilities and Canadian National Laboratories. The COG mission is to improve the performance of CANDU stations worldwide through member collaboration. COG Canadian R&D program members include Ontario Power Generation, Bruce Power Limited Partnership, New Brunswick Power and Canadian Nuclear Laboratories.

CANDU Industry-IAPWS Engagement
In September 2016, the COG Research and Development (R&D) Chemistry, Materials and Components Technical Committee members toured the laboratories of CNER and UNB which are instrumental in performing IAPWS research. Willy Cook and Peter Tremaine have participated in COG Chemistry Working Group meetings and COG workshops and have also provided input to the annual COG R&D planning process. W. Cook keeps the Working Group members informed of the Canadian IAPWS activities.

4. Activities Planned

The CNC activities over the next few years will continue the work that is currently ongoing, as described above.

An IAPWS CNC workshop for Canadian industry and academic stakeholders is in the planning stages for December 2017. The goal would be to raise the profile of the Canadian National Committee and IAPWS activities with researchers in Canada doing complementary research within the fossil and HRSG community. Topics included FFA/FFP use and modelling and simulation of aqueous energy production and extraction.

The CNC has started the planning process to host the 2019 IAPWS meetings. Preliminary scouting of locations has led to Banff, Alberta and we are now finalizing the dates, venue and arrangements.

Each of the CNC members and IAPWS-involved researchers in Canada are involved in industry-sponsored research with organizations such as EPRI and the CANDU Owners Group pertinent to topics of interest to IAPWS.

5. Select List of Publications

1. Pawlowicz, R., **Ocean Salinity,** Encyclopedia of Sustainable Technologies, Elsevier, 11pp, (accepted Dec/2016, in press).

2. H. Arcis, J. Ferguson, G. Zimmerman, L. Applegarth, C. Pye, S. Sasidharanpillai, J. Cox, D. Hussey, D. Wells and P. Tremaine, Speciation and Thermodynamic Stability of Boric Acid, Borate and Polyborates under PWR Primary Coolant Conditions by AC Conductivity and Raman Spectroscopy, Nuclear Plant Chemistry NPC 2016, Brighton, UK, Oct. 2 to 7 (2-16).

3. H. Arcis, J.P. Ferguson, G.H. Zimmerman, and P.R. Tremaine, The Limiting Conductivity of the Borate Ion and its Ion-Pair Formation Constants with Sodium and Potassium under hydrothermal Conditions. *Phys. Chem. Chem. Phys*. **18**, 24081-24094 (2016).

4. H. Arcis, J.P. Ferguson, L.M.S.G.A. Applegarth, G. H. Zimmerman, and P. R. Tremaine, Ionization of Boric Acid in Water from 298 K to 623 K by AC Conductivity and Raman Spectroscopy. *J. Chem. Thermodyn.* **106** 187–198 (2017).

5. D.E. Nieto Roca, C.M. Romero and P.R. Tremaine, Ionization constants of DL-2-aminobutyric acid and DL-norvaline under hydrothermal conditions by UV-visible spectroscopy, *J. Solution Chem.* **46**, 388-423 (2017).

6. J.P. Ferguson, H. Arcis, G.H. Zimmerman, and P.R. Tremaine Ion-Pair Formation Constants of Lithium Borate and Lithium Hydroxide under Pressurized Water Nuclear Reactor Coolant Conditions, *Ind. Eng. Chem. Research.* **56**,8121-8132 (2017).

7. C. McGregor, O. Fandino, J.S. Cox, K. Ballerat-Busserolles and P.R. Tremaine Standard Partial Molar Heat Capacities and Volumes of Aqueous N-Methylpiperidine and N-Methylpiperidinium Chloride from 283 K to 393 K. *J. Chem. Thermodynamics* **113**, 377-387 (2017).

8. A.R. Lowe, J.S. Cox, P.R. Tremaine. Thermodynamics of Aqueous Adenine: Standard Partial Molar Volumes and Heat Capacities of Adenine, Adeninium Chloride, and Sodium Adeninate from T = 278.15 to 363.15 K. *J. Chem. Thermodynamics* **112**, 129-145 (2017).

9. L. Applegarth, C. Pye, J.S. Cox, P.R. Tremaine. A Raman Spectroscopic and Ab Initio Investigation of Aqueous Boric Acid, Borate and Polyborate Speciation from 25 to 80 °C. *Ind. Eng. Chem. Research*. (Submitted).

10. P. Tremaine, H. Arcis, L. Applegarth, J. Cox, J. Ferguson, C. Pye, S. Sasidharanpillai, G. Zimmerman; EPRI Project Managers D. Wells D. Hussey. Thermodynamic Properties and Structure of Boric Acid Species under PWR Coolant Conditions -Speciation of Aqueous Borate and Polyborates by AC Conductivity and Raman Spectroscopy up to 350°C *EPRI Technical Report* 3002008159 (2016)

11. Swift, R. and Cook, W.G., C. Bradley, R.C. Newman, *Validation of Constant Load C-ring Apex Stresses for SCC Testing in Supercritical Water*, Journal of Nuclear Engineering and Radiation Science, vol.3, no.2, pp. 021004-021004-7, March 2017.

12. Steeves, G. and Cook, W.G., *Development of Kinetic Models for the Long-term Corrosion Behaviour of Candidate Alloys for the Canadian SCWR*, Journal of Nuclear Engineering and Radiation Science, vol.3, no.3, pp. 031001-031000-7, July 2017.

13. Lyons, J., Cook, W., Stuart, C. and Gardner, E., *Synergistic Effects Between Radiation Chemistry and Carbon Steel Corrosion in the Calandria Vault and End Shield Cooling System of a CANDU Reactor*, Proceedings of the 2017 Canadian Nuclear Society Annual Student Conference, Niagara Falls, June 2017.

14. Cook, W., Brown, G., Smith, B. and Thompson, P., *Status Update: Evolution of Radiation Fields in the Point Lepreau CANDU Reactor Following Refurbishment*, Proceedings of the 2017 Canadian Nuclear Society Annual Conference, Niagara Falls, June 2017.

15. Cook, W., Brown, G., Smith, B. and Stuart, C., *Evolution of Radiation Fields in the Point Lepreau CANDU Reactor Following Refurbishment*, Nuclear Plant Chemistry Conference (NPC 2016), Brighton, UK, October 2016.

16. Stuart, C., Lee, J., Gardner, E. and Cook, W., *Steam Cycle Contamination and Remediation following the Refurbishment Outage at the Point Lepreau Generating Station*, Nuclear Plant Chemistry Conference (NPC 2016), Brighton, UK, October 2016.

17. Lyons, J., Cook, W., Stuart, C. and Gardner, E., *Synergistic Effects Between Radiation Chemistry and Carbon Steel Corrosion in the Calandria Vault and End Shield Cooling System of a CANDU Reactor*, Nuclear Plant Chemistry Conference (NPC 2016), Brighton, UK, October 2016.

18. S. Mahboubi, Y, Jiao, W. Cook, W. Zheng, D. Guzonas, G. Botton, J. Kish, Stability of Chromia (Cr2O3)-Based Scales Formed During Corrosion of Austenitic Fe-Cr-Ni Alloys in Flowing Oxygenated Supercritical Water, Corrosion, v 72, n 9, p 1170-1180, September 2016.

19. Uchida, S., Naitoh, M., Okada, H., Hanawa, S. and Lister, D.H. (2016). "Effects of Oxide Film on ECP and Corrosion of Steel." Proc. EUROCORR2016, Annual Congress European Federation of Corrosion, Montpellier, France, (September 11-15).

20. Lister, D.H. (2016). "Studies on Two-phase FAC; Modelling and Effects of Amine Breakdown Products". Power Cycle Chemistry Working Group, IAPWS 2016 Annual Meeting, Dresden, Germany, (Sept. 11-16).

21. Mohajery, K., Liu, L., Lister, D.H. and Uchida, S. (2016). "Flow-Accelerated Corrosion in Two-phase Steam-Water Flows: Experiments and Modelling". Proc. 20th International Conference on Water Chemistry of Nuclear Reactor Systems, Brighton, UK. Nucl. Inst. (October 2-7).

22. Palazhchenko, O.Y. and Lister, D.H. (2016) "The Impact of Crud Behaviour on the Predictions of Activity Transport in CANDU-6 Reactors", Proc. 20th International Conference on Water Chemistry of Nuclear Reactor Systems, Brighton, UK. Nucl. Inst. (October 2-7).

REPORT

on IAPWS-related activities: May 2016 – May 2017

submitted by the

Czech National Committee for the Properties of Water and Steam (CZ NC PWS)
to the Executive Committee Meeting of 2017 IAPWS Meeting, Kyoto, Japan, September 2017

National Committee | Contact

CZ NC PWS
Institute of Thermomechanics of the CAS, v. v. i.
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Committee Chairman: Dr. Tomáš Němec (nemec@it.cas.cz)

Participating institutions

The following Czech Institutions participated in the research of thermophysical properties and chemical processes between May 2016 and May 2017:

Institute of Thermomechanics of the CAS, v. v. i., ("IT CAS"), Department of Thermodynamics, Dolejškova 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 Lutín

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

The founder of CZ NC PWS 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. T. Němec
Dr. J. Hrubý
Prof. R. Mareš
Prof. P. Šafařík
Prof. J. Šedlbauer

List of IAPWS-Related Activities

The international collaboration between CZ NC PWS and IAPWS was funded from the project of IT CAS and TUL sponsored by MŠMT since 2016 (project no. LG15040). The project support will end on 31/12/2017.

Dr. Hrubý and Dr. Vinš (IT CAS) and their collaborators from IT CAS, UWB, USB and abroad continued their experimental investigation of surface tension of supercooled water [1,2].

Dr. Hrubý (IT CAS) has completed a multi-year collaborative project with a group of molecular spectroscopists and quantum chemists focused on calculation of properties of water molecules composed of ^{1}H [3] and deuterium ^{2}H [4] and three isotopes of oxygen, ^{16}O, ^{17}O, and ^{18}O. The resulting thermodynamic data replaces previous data that were several decades old. The uncertainty of the new data in the technically most relevant temperature range up to 1,000°C is much smaller than the uncertainty of any thinkable thermodynamic measurement. The new data has already been used for the development of the new IAPWS equation of state for heavy water.

Assoc. Prof. Kolovratník (CTU) and Dr. Bartoš (CTU/IT CAS) carried out pneumatic and optical measurements of a wet steam flow upstream of the last stage of a nuclear-power-station steam turbine [5-9]. On September 12-14, 2016, the Wet Steam Conference 2016 was held at the Faculty of Mechanical Engineering of Czech Technical University.

Prof. Šafařík (CTU) had a Keynote Lecture on the speed of sound in steam [10] and published a book on thermodynamics of moist air [11].

Dr. Sedlář (SIGMA) and his collaborators studied cavitation erosion in water pumps and the problem of cavitation instabilities under hydrodynamic conditions [12, 13].

The team of Prof. Šedlbauer (TUL) published a paper [14] on chemical and biological process engineering and Prof. Majer (TUL) studied solubility data on correlation of solubility [15-16].

The team of Assoc. Prof. Hnědkovský (ICT-IPC) studied thermodynamic properties of aqueous solutes in water [17-24].

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[10] Šafařík P.: On Speed of Sound in Steam, Conference ANSYS 2017, Svratka, 2017 (in Czech)

[11] Šafařík P., Vestfálová M.: Thermodynamics of Moist Air, CTU – Publishing House, 2017 (in Czech)

[12] Sedlář, M., Ji, B., Krátký, T., Rebok, T., Huzlík, R.: Numerical and Experimental Investigation of Three-Dimensional Cavitating Flow around a Straight NACA2412 Hydrofoil. Ocean Engineering, 123, 2016, pp. 357-382.

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Report On Egyptian National Committee Status and Activities
Q4-2016 / Q3-2017

1. Purpose of the report

The purpose of this report is to present the status and activities of Egypt's national committee during 2017 as well as plans for 2018.

2. Importance of National Committee to Egypt

With the current expansion in power generating facilities in Egypt, building national capacity in the field of properties of water and steam specially the power cycle chemistry becomes mandatory in order to maintain and improve performance of this plants and to form a national forum for discussion and research. Egypt by 2020 will reach about 80,000 MW generating capacity, also there is a plan for coal fired complex and Nuclear power complex. We believe that the Egyptian NC will become the window for international collaboration in these fields.

3. Activities during 2017

After Dresden meeting we start to prepare a plan for promoting to our initiative of joining IAPWS and establishing our national committee. Communication started within electricity sector and a lot of correspondence and calls made to arrange for meeting and seminars.

It was decided to focus with Electricity sector to accelerate the start of NC and later will continue our initial plan for communicating other universities and research institutes.
Many seminars arranged to promote to NC and illustrate the initiative as well as provide technical sessions about selected IAPWS's TGDs. The following is a list of activities made during 2017:

a. <u>PGESCo seminar</u>
   - Location : Cairo
   - Date : 8th of May 2017
   - Attendance: 39 of Sector heads and plants mangers


EGYPTIAN IAPWS COMMITTEE
Moataz Khalifa
PGESCo


PGESCo

b. <u>UEEPC Seminar</u>

- Location : Kuriemat
- Date: 11th of July 2017
- Attendance: 29 of Plant's managers, chemists and operators within UEEPC

c. <u>WDEPC seminar</u>

- Location : Alexandria
- Date : 18th of July 2017
- Attendance : + 17 of Plant's managers, chemists and operators
- Attendees from power generation research department

d. <u>CEPC seminar</u>

- Location : Cairo North Power Station
- Date 25th July 2017
- Attendance : +29
- Plant's managers, chemists and operators

During all of the four seminars the following presentation is made:

- Introduction about IAPWS
- Initiative Of Obtaining IAPWS Membership For Building National Capability
- Egypt's IAPWS committee
- Technical discussion on TGD3-10(2015)
- Technical discussion on TGD4-11(2015)
- Technical discussion on TGD5-13
-

4. Plans for 2018

In 2018 we will continue our promoting effort and already arranged another two seminars to MDEPC and EDEPC.
Also we planned to list of activities in order to finalize establishment of NC in 2018 and to run it activities. The following list of planned activities:

- Conduct more seminars and travel to everyone has an interest of NC
- Prepare more technical session on IAPWS's TGDs
- Finalize an application form of national committee
- Finalize legal issues
- Maintain bank account
- Set a communication channel with members
- Arrange for the 1st meeting and announce of NC establishment

German National Committee to IAPWS Executive Committee

Research Activities on the Thermodynamic Properties of Water and Steam of the German National Committee in the Period 2016/2017

www.iapws.de

Chair: Ingo Weber, Siemens Power and Gas, Erlangen

Vice Chair: Prof. Dr. Hans-Joachim Kretzschmar, Zittau/Goerlitz University of Applied Sciences, Zittau

Annual Meeting of the German National Committee

The 2017 Annual Meeting of the German National Committee took place at the Helmut Schmidt University in Hamburg on 17th March 2017. 25 Colleagues attended this meeting. Six papers were presented in the scientific session.

In the following, activities of certain members of the German National committee are summarized.

Baltic Sea Research Institute, Warnemuende
Dr. Rainer Feistel

Projects

1. Development of a draft Advisory Note No. 6: "Relationship between Various IAPWS Documents and the International Thermodynamic Equation of Seawater – 2010 (TEOS-10)".
2. Preparation of a paper about Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air to be submitted to an international journal.
3. Preparation of a paper about unleashing empirical equations using nonlinear fitting & GUM tree calculator (published in Int. J. Thermophys.).
4. Preparation of a paper toward a fundamental definition on relative humidity (published in Metrologia).

Recent Publications

- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.: Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air.
  N.N. (2017), in preparation.
- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.: Digital Supplement to "Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air".
  N.N. (2017), in preparation.
- Lovell-Smith, J. W.; Saunders, P.; Feistel, R.:
  Unleashing Empirical Equations with “Nonlinear Fitting” and “GUM Tree Calculator”.
  Int. J. Thermophys. 38 (2017), 148.
  DOI 10.1007/s10765-017-2282-y

- Feistel, R.; Lovell-Smith, J. W.:
  Defining relative humidity in terms of water activity. Part 1: definition.
  Metrologia 54 (2017) 566-576.
  https://doi.org/10.1088/1681-7575/aa7083
- Feistel, R.:
  Salzgehalt des Meeres und relative Feuchte der Luft: Rolle im Klima-system und Probleme ihrer Definition. Vortrag in der Klasse für Naturwissenschaften und Technikwissenschaften am 10. 11. 2016.
  Zeitschrift der Leibniz-Sozietät e. V. Leibniz Online 25 (2017).
  https://leibnizsozietaet.de/wp-content/uploads/2017/01/Feistel.pdf
- Feistel, R.; Lovell-Smith, J. W.:
  Uncertainty propagation using dispersion matrices accounting for systematic error in least-squares regression.
  Metrologia 54 (2017), submitted.
- IAPWS:
  Relationship between Various IAPWS Documents and the International Thermodynamic Equation of Seawater – 2010 (TEOS-10).
  The International Association for the Properties of Water and Steam (2016).
  Available at http://www.iapws.org.

Highlight 2016 in the journal "Metrologia":

- Feistel, R.; Wielgosz, R.; Bell, S. A.; Camões, M. F.; Cooper, J. R.; Dexter, P.; Dickson, A. G.; Fisicaro, P.; Harvey, A. H.; Heinonen, M.; Hellmuth, O.; Kretzschmar, H.-J.; Lovell-Smith, J. W.; McDougall, T. J.; Pawlowicz, R.; Ridout, P.; Seitz, S.; Spitzer, P.; Stoica, D.; Wolf, H.:
  Metrological challenges for measurements of key climatological observables: Oceanic salinity and pH, and atmospheric humidity. Part 1: Overview.
  Metrologia 53 (2016), R1-R11, doi: 10.1088/0026-1394/53/1/R1.
- Lovell-Smith, J. W.; Feistel, R.; Harvey, A. H.; Hellmuth, O.; Bell, S. A.; Heinonen, M.; Cooper, J. R.:
  Metrological challenges for measurements of key climatological observables. Part 4: Atmospheric relative humidity.
  Metrologia 53 (2016), R40-R59, doi: 10.1088/0026-1394/53/1/R40.

German Aerospace Center (DLR), Cologne
Institute of Propulsion Technology
Prof. Dr. Francesca di Mare

Project

1. Implementation of the Fast Steam Property Algorithms Based on Spline Interpolation into the CFD Code TRACE.
   - The “IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using the Spline-Based Table Look-Up Method (SBTL)” has been implemented into the CFD code TRACE.
   - On this basis the implementation has been further improved, especially regarding the software architecture, solution algorithm and boundary treatment.

- The capability of the SBTL-method has been tested on Laval-nozzle and Cascade test cases. The calculation of a real steam engine configuration is targeted next.

Recent Publications

- Kunick, M.; Kretzschmar, H.-J.; Gampe, U.; di Mare, F.; Hrubý, J.; Duška, M.; Vinš, V.; Singh, A.; Miyagawa, K.; Weber, I.; Pawellek, R.; Novi, A.; Blangetti, F.; Wagner, W.; Friend, D. G.; Harvey, A. H.:
  Fast Calculation of Steam and Water Properties with the Spline-Based Table Look-Up Method (SBTL),
  J. Eng. Gas Turbines Power, in preparation.

Helmholtz Centre for Environmental Research – UFZ, Magdeburg
PD Dr. Bertram Boehrer

Project

1. Properties of limnic waters and effect on circulation of lakes.

Recent Publications

- Moreira, S., Schultze, M., Rahn, K., Boehrer, B.:
  A practical approach to lake water density from electrical conductivity and temperature.
  Hydrol. Earth Syst. Sci. 20 (2016), 2975-2986.
  doi: 10.5194/hess-20-2975-2016

Leibniz Institute for Tropospheric Research, Leipzig
Dr. Olaf Hellmuth

Projects

1. Investigation on Virial Approximation for Humid Air
2. Preparation of a Paper about Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air
3. Preparation of Three Further Volumes on New Particle Formation in the Earth Atmosphere

Recent Publications

- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.:
  Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air.
  N.N. (2017), in preparation.
- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.:
  Digital Supplement to "Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air".
  N.N. (2017), in preparation.

Physikalisch-Technische Bundesanstalt Braunschweig und Berlin, Braunschweig
Dr. Henning Wolf

Highlight 2016 in the journal "Metrologia":

- Feistel, R.; Wielgosz, R.; Bell, S. A.; Camões, M. F.; Cooper, J. R.; Dexter, P.; Dickson, A. G.; Fisicaro, P.; Harvey, A. H.; Heinonen, M.; Hellmuth, O.; Kretzschmar, H.-J.; Lovell-Smith, J. W.; McDougall, T. J.; Pawlowicz, R.; Ridout, P.; Seitz, S.; Spitzer, P.; Stoica, D.; Wolf, H.:
  Metrological challenges for measurements of key climatological observables: Oceanic salinity and pH, and atmospheric humidity. Part 1: Overview.
  Metrologia 53 (2016), R1-R11, doi: 10.1088/0026-1394/53/1/R1.R

Ruhr University Bochum
Faculty of Mechanical Engineering, Department of Thermodynamics
Prof. Dr. Roland Span

Projects:

1. Improvement of accurate models available for CCS-relevant mixtures. Within this project humid mixtures are of particular interest, since existing models from the GERG-2008 package for natural gases are not designed for higher concentrations of water. A first version of this new-mixture model was published in Journal of Chemical Thermodynamics (Gernert and Span, 2016). Software enabling the application of the latest version of our property models has been made available and is by now used by more than 80 groups worldwide (both in academia and in industry). Current work addresses an improved description of less well measured minor mixtures. In conjunction with the Norsk Research Center on CCS (NCCS) a project has been granted, which will provide funding for continued work on this subject.
2. The work on models describing hydrate formation has been continued in cooperation with Dr. V. Vinš and Dr. J. Hruby. S. Hielscher continues the work at RUB as Ph.D. candidate. Andreas Jäger has changed to TU Dresden, where he involves the institute of Technical Thermodynamics headed by Prof. Cornelia Breitkopf into the work on hydrates. Three journal articles describing the latest status of the hydrate model in detail were published (Vinš *et al.*, 2016, 2017; Jäger *et al.*, 2016).
3. Development of a new reference equation of state for heavy water. This work is linked to an IAPWS grant awarded in 2012 and to a close cooperation with Dr. A. H. Harvey and Dr. E. W. Lemmon at NIST in Boulder, CO. The work on the new equation of state has largely been finished. A draft release will be submitted to the evaluation task group and will be presented at the 2017 IAPWS meeting in Kyoto.

Recent Publications

- Gernert, J.; Span, R.:
  EOS−CG: A Helmholtz energy mixture model for humid gases and CCS mixtures.
  J. Chem. Thermodyn. 93 (2016), 274-293.
- Vinš, V.; Jäger, A.; Span, R.; Hrubý, J.:
  Model for gas hydrates applied to CCS systems part I. Parameter study of the van der Waals and Platteeuw model.
  Fluid Phase Equilib. 427 (2016), 268-281.

- Vinš, V.; Jäger, A.; Hrubý, J.; Span, R.:
  Model for gas hydrates applied to CCS systems part II. Fitting of parameters for models of hydrates of pure gases.
  Fluid Phase Equilib. 435 (2017), 104-117.
- Jäger, A.; Vinš, V.; Span, R.; Hrubý, J.:
  Model for gas hydrates applied to CCS systems part III. Results and implementation in TREND 2.0.
  Fluid Phase Equilib. 429 (2016), 55-66.

Ruhr University Bochum
Faculty of Mechanical Engineering, Chair of Thermodynamics
Prof. em. Dr. Dr. e. h. Wolfgang Wagner

Project

1. Preparation of the 3rd edition of the book "International Steam Tables".

Recent Publications

- Kunick, M.; Kretzschmar, H.-J.; Gampe, U.; di Mare, F.; Hrubý, J.; Duška, M.; Vinš, V.; Singh, A.; Miyagawa, K.; Weber, I.; Pawellek, R.; Novi, A.; Blangetti, F.; Wagner, W.; Friend, D. G.; Harvey, A. H.:
  Fast Calculation of Steam and Water Properties with the Spline-Based Table Look-Up Method (SBTL),
  J. Eng. Gas Turbines Power, in preparation.

Siemens Energy Solutions, Erlangen
Michael Rziha

Projects

1. Development of new Technical Guidance Documents:
   - Application of Film Forming Amines in Fossil, Combined Cycle, and Biomass Power Plants – Released 2016 in Dresden
   - HRSG High Pressure Evaporator Sampling for Internal Deposit Identification and Determining the Need to Chemical Clean – Released 2016 in Dresden
2. Developing of drafts for a new technical guidance documents
   - Monitoring Corrosion Products in Flexible (cycling and two-shifting) Plants. White paper is developed for presentation at the 2017 Meeting. TGD will be further developed based on this input.
   - Ensuring the Integrity and Reliability of Demineralized Makeup Water Supply to the Unit Cycle. Skeleton and list of contents is finalized. Further progress will be discussed during 2017 meeting.
   - Air In-Leakage in Steam Water Cycles. White paper in preparation.
   - Film Forming Products. Following the release of the IAPWS TGD on FFP for Fossil and Combined Cycle Plants and the IAPWS International Conference on FFP in Lucerne, IAPWS will be developing two new TGD on FFP:
     a) Application of Film Forming Products in Nuclear Plants. The Task Group will have a working session during the Kyoto week.

b) Application of Film Forming Products in Industrial Plants.

- Aspects of Geothermal Steam Chemistry. A White Paper for the 2017 Meeting is in preparation. This will be used to determine if a TGD can be developed.

Siemens Energy Solutions, Erlangen
Ingo Weber, Stefan Bennoit, Julien Bonifay

Projects

1. Implementation of the fast steam property spline-interpolation algorithms into the heat cycle simulation code KRAWAL
   - The "IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using the Spline-Based Table Look-Up Method (SBTL)" has been implemented into the heat cycle code KRAWAL which is used worldwide by Siemens.
   - The computing time consumption of KRAWAL has been significantly reduced.
2. Implementation of the fast steam property spline-interpolation algorithms into the non-stationary power-plant simulation code DYNAPLANT
   - The "IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using the Spline-Based Table Look-Up Method (SBTL)" has been implemented into the non-stationary power-plant simulation code DYNAPLANT.
   - The computing time consumption of DYNAPLANT has been significantly reduced.

Recent Publications

- Kunick, M.; Kretzschmar, H.-J.; Gampe, U.; di Mare, F.; Hrubý, J.; Duška, M.; Vinš, V.; Singh, A.; Miyagawa, K.; Weber, I.; Pawellek, R.; Novi, A.; Blangetti, F.; Wagner, W.; Friend, D. G.; Harvey, A. H.: Fast Calculation of Steam and Water Properties with the Spline-Based Table Look-Up Method (SBTL), J. Eng. Gas Turbines Power, in preparation.

STEAG Energy Services, Zwingenberg
Dr. Reiner Pawellek, Dr. Tobias Löw

Project

1. Implementation of the fast steam property spline-interpolation algorithms into the heat cycle simulation code EBSILON
   - The "IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using the Spline-Based Table Look-Up Method (SBTL)" has been implemented into the heat cycle code EBSILON which is used worldwide by the power industry.
   - The computing time consumption of EBSILON has been significantly reduced.

Recent Publications

- Kunick, M.; Kretzschmar, H.-J.; Gampe, U.; di Mare, F.; Hrubý, J.; Duška, M.; Vinš, V.; Singh, A.; Miyagawa, K.; Weber, I.; Pawellek, R.; Novi, A.; Blangetti, F.; Wagner, W.; Friend, D. G.; Harvey, A. H.: Fast Calculation of Steam and Water Properties with the Spline-Based Table Look-Up Method (SBTL), J. Eng. Gas Turbines Power, in preparation.

Zittau/Görlitz University of Applied Sciences
Department of Technical Thermodynamics
Prof. Dr. Hans-Joachim Kretzschmar, Dr. Sebastian Herrmann, Matthias Kunick

Projects

1. Development of fast property calculation algorithms based on spline interpolation
   - The Spline-Based Table Look-Up Method (SBTL) is being applied to the mixture humid air.
2. Application of the developed SBTL method for calculating thermodynamic properties

   The developed spline-based property libraries have been implemented into the following process simulation codes:
   - Non-stationary thermo-hydraulic codes SubChanFlow and TwoPorFlow of the Karlsruhe Institute of Technology KIT
   - Non-stationary thermo-hydraulic code RELAP-7 of the Idaho National Laboratory INL
   - Heat-cycle simulation program EBSILON of STEAG Energy Services
   - Heat-cycle simulation program KRAWAL of Siemens Energy Solutions
   - Non-stationary heat-cycle simulation program DYNAPLANT of Siemens Energy Solutions.
3. Development of algorithms for the transport properties of moist air, ASHRAE Research Project 1767.
4. Preparation of a new ASHRAE standard for calculating moist air properties, ASHRAE Project SPC 213P.
5. Reworking on the 3rd edition of the book "International Steam Tables".

Recent Publications

- Kunick, M.; Berry, R. A.; Martineau, R. C.; Kretzschmar, H.-J.; Gampe, U.:
  Application of the new IAPWS Guideline on the fast and accurate calculation of steam and water properties with the Spline-Based Table Look-Up Method (SBTL) in RELAP-7.
  Kerntechnik 82/3 (2017), 264-279.
- Herrmann, S.; Kretzschmar, H.-J.; Gatley, D. P.:
  In: 2017 ASHRAE HANDBOOK FUNDAMENTALS, SI and I-P Editions, Chapter 1 PSYCHROMETRICS, Table 2 Thermodynamic Properties of Moist Air at Standard Atmospheric Pressure. Table 3 Thermodynamic Properties of Water at Saturation.
  American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA (2017), ISBN 978-1-939200-58-0.
  www.ashrae.org
- Kunick, M.; Kretzschmar, H.-J.; Gampe, U.; di Mare, F.; Hrubý, J.; Duška, M.; Vinš, V.; Singh, A.; Miyagawa, K.; Weber, I.; Pawellek, R.; Novi, A.; Blangetti, F.; Wagner, W.; Friend, D. G.; Harvey, A. H.:
  Fast Calculation of Steam and Water Properties with the Spline-Based Table Look-Up Method (SBTL).
  J. Eng. Gas Turbines Power, in preparation.
- Kunick, M.:
  Fast Calculation of Thermophysical Properties in Extensive Process Simulations with the Spline-Based Table Look-Up Method (SBTL).
  Fortschritt-Berichte VDI, in preparation.

- Vogel, E., Herrmann, S.:
  New Formulation for the Viscosity of Propane.
  J. Phys. Chem. Ref. Data 45 (2016), 043103.
- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.:
  Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air.
  N.N. (2017), in preparation.
- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.:
  Digital Supplement to "Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air".
  N.N. (2017), in preparation.

Current Status of Research Activities in Japan
Submitted to the Executive Committee Meeting, IAPWS, Kyoto, Japan, August 2017

Japanese National Committee, Chaired by Professor Masaru Nakahara
International Association for the Properties of Water and Steam
c/o The 139th Committee on Steam Properties
Japan Society for the Promotion of Science (JSPS)
5-3-1, Kojimachi, Chiyoda-ku
Tokyo 102-0083, Japan

I. Overview:

The Japan National Committee, supported by JSPS, of IAPWS continues to endeavor to make closer and innovative interactions between engineering and academic groups with respect to the international and domestic energy-related issues. The key points are cleaner, greener, and more sustainable energy as well as high efficiency and safety. We are discussing about the science and engineering of fuels, boilers, turbines, and water-treatment. Now we take it into account the power generation from geothermal and biomass energies. Our activities in the publication are shown below.

II. Recent Publications:

Nakahara, Masaru
Professor Emeritus of Kyoto University, Institute for Chemical Research
email: nakahara@scl.kyoto-u.ac.jp

[1] Nakahara, M.; Yoshida K.; "Chronological Scientific Tables 2017", pp.502-509, 514-517, Maruzen Publishing Co., Ltd., Tokyo, ISBN 978-4-621-30096-1 (2016).
[2] Yoshida, K.; Matubayasi, N.; Nakahara, M.; Uosaki, Y.; "Effect of Rotation on Vibrational Spectrum of Supercritical Water: Analysis of Dependencies on Density and Hydrogen Isotopes", *The Review of High Pressure Science and Technology*, **26**, 323-332 (2016).
[3] Nakahara, M.; Yoshida K.; "Handbook of Scientific Tables", Maruzen Publishing Co., Ltd., Tokyo and World Scientific Publishing Co, Singapore, in press.

Hirano, Hideo
Retired Senior Research Scientist, Central Research Institute of Electric Power Industry
e-mail: hhirano0879@jcom.home.ne.jp

[1] Hirano, H.; Shimokado, T; Kamisasa, M; "Trend of The Water Conditioning for Boiler Water : Application of New Volatile Treatments AVT(LO) and AVT(O)" , Boiler Yearbook, 2016 year editions, Japan Boiler Association, pp. 44-54 (2016). (In Japanese)

[2] Hirotaka, K.; Hirano, H.; Katsumura, Y; et al., "BWR Water Chemistry Guidelines and PWR Primary Water Chemistry Guidelines in Japan – Purpose and Technical Background", *Nuclear Engineering and Design*, 309, 161-174 (2016).

Yasuoka, Kenji
Professor, Department of Mechanical Engineering, Keio University
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URL: http://www.yasuoka.mech.keio.ac.jp

[1] Doi, H.; Okuwaki, K.; Mochizuki, Y.; Ozawa, T.; Yasuoka, K.; "Dissipative Particle Dynamics (DPD) Simulations With Fragment Molecular Orbital (FMO) Based Effective Parameters for 1-Parmitoyl-2-Oleoyl Phosphatidyl Choline (POPC) Membrane", *Chem. Phys. Lett.*, **684**, 427-432 (2017). DOI : 10.1016/j.cplett.2017.07.032

[2] Winarto; Yamamoto, E.; Yasuoka, K.; "Water Molecules in a Carbon Nanotube Under an Applied Electric Field at Various Temperatures and Pressures", *Water*, **9**, 473 (2017). (14 pages) DOI : 10.3390/w9070473

[3] Doi, H.; Yasuoka, K.; "Replica Exchange Molecular Simulation of Lennard-Jones Particles in a Two-Dimensional Confined System", *AIP Advances*, **7**, 055018 (2017). (9 pages) DOI : 10.1063/1.4984815

[4] Tomobe, K.; Yamamoto, E.; Yasui, M.; Yasuoka, K.; "Effects of Temperature, Concentration, and Isomer on The Hydration Structure in Monosaccharide Solutions", *Phys. Chem. Chem. Phys.*, **19**, 15239-15246 (2017). DOI : 10.1039/C7CP02392H

[5] Shibuya, T.; Yasuoka, K.; Mirbt, S.; Sanyal, B.; "Subsurface Polaron Concentration as a Factor in The Chemistry of Reduced TiO2 (110) Surfaces", *J. Phys. Chem. C*, **121**, 11325-11334 (2017). DOI : 10.1021/acs.jpcc.7b00935

[6] Tomobe, K.; Yamamoto, E.; Kholmurodov, K.; Yasuoka, K.; "Water Permeation Through the Internal Water Pathway in Activated GPCR Rhodopsin", *PLOS ONE*, **12**, e0176876 (2017). DOI : 10.1371/journal.pone.0176876

[7] Nomura, K.; Kaneko, T.; Bai, J.; Francisco, J. S.; Yasuoka, K.; Zeng, X. C.; "Evidence of Low-Density and High-Density Liquid Phases and Isochore End Point for Water Confined to Carbon Nanotube", *PNAS*, **114**, 4066-4071 (2017). DOI : 10.1073/pnas.1701609

[8] Yamamoto, E.; Akimoto, T.; Kalli, A. C.; Yasuoka, K.; Sansom, M. S. P.; "Dynamic Interactions Between a Membrane Binding Protein and Lipids Induce Fluctuating Diffusivity", *Science Advances*, **3**, e1601871 (2017). (6 pages) DOI : 10.1126/sciadv.1601871

[9] Takahashi, K. Z.; Nishimura, R.; Yasuoka, K.; Masubuchi, Y.; "Molecular Dynamics Simulations for Resolving Scaling Laws of Polythylene Melts", *Polymers*, **9**, 24 (2017). (12 pages) DOI : 10.3390/polym9010024

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New Zealand Association for the Properties of Water and Steam (NZAPWS) Annual Report

Date: 28 August 2017

Key Achievements:

1. NZAPWS is now a full member country of IAPWS[1]

2. NZAPWS is now fully funded via a industry sponsorship model with contrubutions from generating utilities, industrial steam users and water/steam related chemical vendors providing sufficient funding to:
    a. Pay our annual IAPWS full country membership fees (Paid 22 June 2017)
    b. Provide travel funding assistance to NZAPWS members to attend IAPWS meetings/conferences – for 2017 – Jeremy Lovell-Smith to represent New Zealand
    c. Provide funding to undertake an annual NZAPWS meeting/conference in NZ
    d. Provide a source of funds for future related research.

3. NZAPWS has an active membership covering the following areas:
    a. Fossil power generation
    b. Industrial steam production and use for dairy product production
    c. Geothermal power generation (subsurface and surface operations)
    d. Humidity research and services
    e. Water/steam analytical services
    f. Water/steam chemical treatment and services

Key Activities:

1. A very successful technical seminar was held in May 2017 in Rotorua, NZ with 45 attendees and a wide ranging program of technical presentations covering;
    a. Geothermal steam chemistry
    b. Industrial steam chemistry
    c. Humidity
    d. Water and steam chemical analysis
    e. Cooling water systems
    f. Steam heat transfer
    g. IAPWS related research and Technical Guidance Documents

2. Formation of a new NZAPWS committee taking NZAPWS forward

3. David Addison has had ongoing involvement in the PCC Corrosion Product Sampling working group

[1] Once again showing our superiority to Australia by achieving full IAPWS membership status first.

4. David Addison has had ongoing involvement in a PCC IAPWS International Collaboration project with the University of New Brunswick (DR Willy Cook) working on high temperature electrochemical corrosion monitoring

5. David Addison and Ian Richardson have continued working on geothermal related aspects for a IAPWS white paper

6. Jeremy Lovell-Smith has contributed to (a) TPWS through continuing investigation into the use of Generalised Least Squares (GLS) to propagate input data covariance into the IAPWS equation parameters and to (b) JCS through work on the definition of relative humidity.

Publications:

1. E. Buscarlet, I. Richardson, S. Addison, H. Moon, J. Quinao; *Geochemical Modelling of Plant and Reservoir Processes at the Ngatamariki Geothermal Field* New Zealand Geothermal Workshop, 2016

2. I.M. Richardson, D.R. Addison, S.J. Addison, T.J. Gresham and R.J. Lawson; *Online Steam Purity Analysis for Geothermal Power Generation;* New Zealand Geothermal Workshop, 2016
3. R. Lawson, T. Gresham, I. Richardson, F. Siega, S. Addison; *Long Run Polymerization Experiments at the Kawerau Geothermal Limited Power Plant*; New Zealand Geothermal Workshop, 2016

4. J. Weir, D. Addison; *Ion Exchange Challenges in a Dairy Product Processing Factory Cogeneration Plant;* PPChem, 2017, 19(3)

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7. C. Morris, E Mroczek, *Geothermal Turbine Scaling*, PPChem 2016 (18(3)

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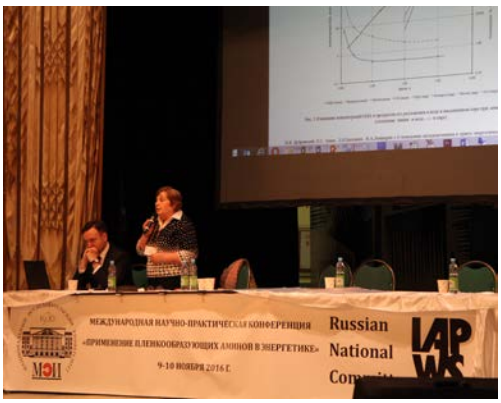
International Association for the Properties of Water and Steam
Russian National Committee (RNC)
Report Second Half-Year of 2016 – First Half-Year of 2017

Russian National Committee of IAPWS and National Research University "MPEI" held International Conference «Using Film Forming Amines in Power Industry» 9-10 November 2016, Moscow, MPEI. Registered participants: 188, active participants: 146.



Titles of presentations:

1. IAPWS TGDs for water chemistry in power industry;
2. IAPWS TGD for the water chemistry with film-forming amines;
3. The use of ODA in the Russian power industry;
4. Summarizing the experience of protection against atmospheric corrosion of power equipment of TPP and NPP by at ODACON conservation technology;
5. Perspective directions of use of film-forming amines in the power industry;
6. Experience of water chemistry with the use of complex reagents on the example of Vologda CCPP with 100 MW capacity;
7. FFAP treatment during abnormal operations;
8. Experience of polyamines in power plants;
9. Experience in the application of FFA for pre-cleaning and preservation of HGST in CCPP;
10. A review of studies on the use of film-forming amines for correctional water treatment;
11. The influence of complex reagents on the basis of PA sensors on automatic analysers in the system of chemical control at TPP;
12. The results of operation of power units of Zhambyl GRES with a water-based complex reagents with POA;
13. The use of reagents based on FFA for water chemistry at "Sitienergo" power plant;

14. The use of reagents based on FFA for water chemistry at Kaliningradskaya TPP-2 with 450 MW capacity;
15. Experience with the use of reagents on the basis of FFA at the Ivanovo CCPP.

List of other activities

- RNC active participation in organization of next seminars for engineers and technology specialist from Russian power engineering companies:

16. Cycle chemistry at power plants;
17. Today technologies for cycle chemistry monitoring systems;
18. Today experience of water treatment systems operation;
19. Water treatment and cycle chemistry for combine cycle power plants.

- Two meetings of RNC have been held.

Publications list

Books

1. Ochkov V., Orlov K., Voloshchuk V. Thermal Engineering Studies with Excel, Mathcad and Internet. Springer, ISBN 978-3-319-26673-2 (in English).
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Articles

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SIAPWS annual report for 2016

The annual meeting 2016 was successful with 16 participants at the event that was hosted by Nordjyllandsværket in Denmark. The workshop was interesting with good presentations and discussion afterwards, and the meeting ended with a visit to the ultrasupercritical plant NJV3 and the laboratory, which is specialised in tribology and water chemistry. The discussion at the meeting lead to a decision that the Executive Committee (EC) should focus on improving the exchange of information and experiences across SIAPWS in the coming year, especially with attention on transfer of knowledge to the younger members.

The EC took the task up and discussed several ideas that came together in SIAPWS Water Chemistry Network, a Facebook and web-based network intended for fast transfer of experience, registration and organisation of lasting information, and course activities covering the main aspects of the SIAPWS work field. The main idea is that you should be able to participate from your desk and pc and only occasionally travel to meet your colleagues physically.

The Matarvattenkonferensen in November was the setting for the first presentation of the network and invitation of our colleagues to take part. The first months of the network has seen a slow start, but the EC hopes that colleagues will join as they learn more about the network. The demand that only members of SIAPWS (company or personal) have the full access to the information may be an obstacle. This is necessary of several reasons – access to both IAPWS/PCC and SIAPWS website demands login, and the IAPWS materials is restricted to members only.

The annual IAPWS meeting took place in Dresden this year. As usual, it was an intensive week with workshops, presentations, and discussions. The work in the Power Cycle Chemistry (PCC) group during the year led to release of two new Technical Guidance Documents (TGDs) on criteria for chemical cleaning of Heat Recovery Steam Generators (HRSGs) and application of film forming amines for feed water conditioning. The last one is the first international guide describing the basic chemicals and application of these compounds in the water-steam circuit – *pro et contra*.

The upcoming revision of the TGD on Corrosion Product Sampling and Analysis was another hot topic. The driver for the revision is the wish of many users for guidance regarding plants that operate in flexible mode with frequent load changes and start/stops. This work is well under way, and currently a number of field trials are performed to cover missing knowledge with respect to corrosion product formation and transport under start-up and flexible conditions.

The work on a new TGD on air in-leakage in water-steam circuits has been initiated. This is a common disturbance, the source is often not easy to reveal, and it is costly since the plant efficiency decreases. The intention of the TGD is give systematic guidance on how to test for air in-leakage and methods to locate the source/leak.

SIAPWS takes part in both of the task groups working with the TGD’s mentioned here, and several members contribute to the field trials.

Executive Committee

Chair	Karsten Thomsen	Cashier	Kaj Thomsen
Vice-chair, secretary	Jørgen Peter Jensen	Coordinator	Roger Lundberg

The Swiss National Committee
International Association for the Properties of Water and Steam

Report on IAPWS related activities – September 2016 / August 2017

Submitted to the EC Meeting of IAPWS, Kyoto, Japan – August 2017.

National Committee Contacts:
President: Marco Lendi, E-mail: marco.lendi@swan.ch
Secretary: Tapio Werder, E-mail: tapio.werder@waesseri.com

Following Institutions participated in the research into the thermophysical properties and chemical processes:

Prof. Dr. Horst-Michael Prasser, Institute of Energy Technology, Swiss Federal Institute of Technology, Zürich, E-Mail: prasser@lke.mavt.ethz.ch
Dr. Michael Hiegemann, General Electric (Switzerland) GmbH, Baden, Switzerland, E-Mail: michael.hiegemann@ge.com
Dr. Robert Svoboda, Svoboda Consulting, Wettingen, E-Mail: r.svoboda@swissonline.ch

Marco Lendi, Swan Analytical Instruments, Hinwil, E-Mail: marco.lendi@swan.ch
Tapio Werder, PowerPlant Chemistry Journal, Hinwil, E-Mail: tapio.werder@waesseri.com

Research activities in the reporting period:
No new projects were reported

Contributions to current IAPWS activities:
Vice-chairman of Subcommittee on Sea-Water: M. Hiegemann
Vice-chairman of PCC Sub-Task Group on Film Forming Amines (FFA): Marco Lendi

Status of Associate Membership to IAPWS:
Up to now, no team of sponsors to commit on mid- or long-term to a regular Swiss membership fee has yet been assembled. Activities were therefore limited to few individuals. SCPWS hosted the First International Conference on Film Forming Amines and Products in April 2017 in Lucerne, Switzerland. The organization of this conference was the main activity of the board of SCWPS in the past year. The conference in Lucerne was intended to serve to promote SCPWS within Switzerland and to find new participating institutions. Although the conference found wide international acceptance, in regard to finding new participating institutions, the goal was not achieved. The board of SCPWS is currently planning a smaller event in Spring 2018 to find new participating institutions in Switzerland.
- It is therefore requested to extend the Associate Membership for another term.

M. Lendi, August 2017

U.S. National Committee to IAPWS
2017 Report on Activities of Potential Interest to IAPWS

Communicated from the Applied Chemicals and Materials Division, National Institute of Standards and Technology, Boulder, CO:

- In a collaboration with the Ruhr University of Bochum (Germany), we completed a new reference equation of state for the thermodynamic properties of heavy water. This EOS is now undergoing testing by an IAPWS Evaluation Task Group, and a paper is being drafted.
- Work is beginning on a related IAPWS project to develop new transport property correlations for heavy water.

- In collaboration with researchers at Fondazione Bruno Kessler (Italy), Nicolaus Copernicus University (Poland), and the University of Delaware (USA), two state-of-the-art flexible models for the water pair potential have been used to calculate second virial coefficients $B(T)$ for both H_2O and D_2O. The calculations use the path-integral Monte Carlo method, which fully accounts for both intermolecular and intramolecular quantum effects. The results agree with experimental data, but cover a wider range of temperatures. The effect of molecular flexibility is found to be significant in comparison to the uncertainty of the calculations and of the experimental data, implying that the rigid models often used for water are insufficient if the best quantitative accuracy for virial coefficients is desired. The results for D_2O served as input for the new IAPWS EOS for heavy water.

- Calculations are in progress for the third virial coefficient $C(T)$ for both H_2O and D_2O, which requires state-of-the-art 3-body potentials. We have discovered that the only high-quality flexible 3-body model has too many "holes" to be useful in virial calculations, so we are using a better-behaved rigid potential for the 3-body contribution.

Communicated from the University of Maryland, College Park

In 2017 we have published four papers relevant to IAPWS activities, including the last two supported by the Young Scientist IAPWS Fellowship Project *Towards an IAPWS Guideline for the Thermodynamic Properties of Supercooled Heavy Water*.

- John W. Biddle, Rakesh S. Singh, Evan M. Sparano, Francesco Ricci, Miguel A. González, Chantal Valeriani, José L. F. Abascal, Pablo G. Debenedetti, Mikhail A. Anisimov, and Frédéric Caupin, *Two-structure thermodynamics for the TIP4P/2005 model of water covering supercooled and deeply stretched regions*, J. Chem. Phys. **146**, 034502 (2017).
- Andrei A. Novikov, Anton P. Semenov, Viviana Monje-Galvan, Vladimir N. Kuryakov, Jeffery B. Klauda, and Mikhail A. , *Action of Hydrotropes at the Water/Oil Interface*, J. Phys. Chem. C (2017) DOI:10.1021/acs.jpcc.7b05156
- Mikhail A. Anisimov, Michal Duška, Frédéric Caupin, Lauren E. Amrhein, Amanda Rosenbaum, Richard J. Sadus, *Thermodynamics of Fluid Polyamorphism*, arXiv:1708.03573 [cond-mat.stat-mech]
- Michal Duška, Jan Hrubý, Frédéric Caupin, Mikhail A. Anisimov *Communication: Two-structure thermodynamics unifying all scenarios for water anomalies* arXiv:1708.04054 [cond-mat.stat-mech]

Communicated from the ASME Research & Technology Committee on Water and Steam in Thermal Systems

The Water Technology Subcommittee has published the *Consensus on Pre-Commissioning Stages for Cogeneration and Combined Cycle Power Plants* (ASME, 2017 ISBN**:** 9780791861264). Work continues on an update to the document: *Consensus on Operating Practices for the Control of Feedwater and Boiler Water Chemistry in Modern Industrial Boilers.* We have also started working on a new project – the steam/water cycle equipment inspection guidelines series. The project will consist of a series of guideline pamphlets each focused on a specific piece of equipment in the steam/water cycle and will provide the user with information on how to plan for, conduct, and interpret the results of inspections. The guidelines are aimed at power plant and industrial boiler house staff and aiding those persons in planning for inspections, working with the certified inspector, and understanding the results of the inspection reports. Work has started on the first 3 guidelines: deaerators, fire tube boilers, and drum style water tube boilers.

Communicated from OLI Systems

- **Aqueous solution chemistry of actinides**

OLI has finalized a comprehensive model for predicting the properties of actinide species in aqueous solutions. The model is based on the previously developed Mixed-Solvent Electrolyte (MSE) thermodynamic framework. It provides a detailed treatment of speciation and solubility of U(IV, VI), Np(IV, V, VI), Pu(III, IV, V, VI), Am(III), and Cm(III) in various environments including salt, acid and base solutions in wide ranges of temperatures. The model has been designed for applications in nuclear waste management, environmental studies of radionuclide behavior and nuclear fuel processing. The work has been published in:

P. Wang, A. Anderko, J.J. Kosinski, R.D. Springer, and M.M. Lencka, “Modeling Speciation and Solubility in Aqueous Systems Containing U(IV, VI), Np(IV, V, VI), Pu(III, IV, V, VI), Am(III), and Cm(III) in Wide Concentration Ranges,” J. Solution Chem., 46 (2017) 521-588

- **Aqueous solution chemistry of rare-earth elements**

OLI Systems participates in the Department of Energy’s Critical Materials Institute as a provider of simulation tools for solution chemistry and thermodynamic properties. Recently, the work has been focused on the properties of aqueous systems and solid phases containing chlorides, sulfates, and carbonates of rare earth elements. The recently completed work has been published in the following papers:

> R. Shivaramaiah, W. Lee, A. Navrotsky, D. Yu, P. Kim, H. Wu, Z. Hu, R. Riman, and A Anderko, “Location and Stability of Europium in Calcium Sulfate and its Relevance to Rare Earth Recovery from Phosphogypsum Waste,” American Mineralogist, 101 (2016) 1854-1861
>
> S.G. Srinivasan, R. Shivaramaiah, P.R.C. Kent, A.G. Stack+, R. Riman, A. Anderko, A. Navrotsky, V.S. Bryantsev, “A Comparative Study of Surface Energies and Water Adsorption on Ce-Bastnästite, La-Bastnästite, and Calcite via Density Functional Theory and Water Adsorption Calorimetry,” Physical Chemistry Chemical Physics, 19 (2017) 7820-7832.

- **Corrosion chemistry**

A major effort has been devoted to investigating the effect of solution chemistry on corrosion phenomena. The MSE model has been applied to model the behavior of corrosion products in environments containing carbon dioxide, hydrogen sulfide and salts. Preliminary results of this work have been published in:

S. Smith, A. Anderko, and P. Wang, "Effects of Non-Ideal Chemistry on Corrosion Testing," Materials Performance, 56 (2017) 44-47

- **Other topics**

As continuation of our work on modeling natural aqueous environments, we focused on the behavior of systems containing hydrocarbons, carbon dioxide and hydrogen sulfide. A small part of this work has been published in:

> J. Loring, D. Bacon, R. Springer, A. Anderko, S. Gopinath, C. Yonkofski, C. Thompson, B. McGrail, K. Rosso, and H. Schaef, "Water Solubility at Saturation for CO2-CH4 Mixtures at 50 °C and 90 bar," J. Chem. Eng. Data, 62 (2017) 1608-1614

Also, we have completed a project on simulating the behavior of calcium, magnesium, and zinc silicates in aqueous systems. This project has been designed to address the need to predict phenomena associated with SAGD (steam-assisted gravity drainage) processes.