THE INTERNATIONAL ASSOCIATION FOR THE PROPERTIES OF WATER AND STEAM

MEMBERS
Britain and Ireland
Canada
Czech Republic
Germany
Japan
Russia
Scandinavia (Denmark, Finland, Norway, Sweden)
United States of America

ASSOCIATE MEMBERS
Argentina and Brazil
Australia
France
Greece
New Zealand
Switzerland

EXECUTIVE SECRETARY

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Minutes of the Meetings

of the

Executive Committee

of the

International Association for the Properties of

Water and Steam

Stockholm, Sweden
29th June – 3rd July 2015

Prepared by: Barry Dooley

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Minutes of the Meetings
of the
Executive Committee
of the
International Association for the Properties of Water and Steam
held in
Stockholm, Sweden
29th June – 3rd July 2015

Plenary Session. Monday, 29th June 2015. 8:34am

The new President of IAPWS, Dr. David Guzonas, welcomed the Executive Committee (EC) and other IAPWS members to Stockholm for the Executive Committee and Working Group (WG) Meetings of IAPWS. The President officially opened the 2015 EC Meetings by introducing the National Delegates. Each of the Member countries of IAPWS was in attendance as well as Associate Members, Australia and New Zealand. In total there were 62 people assembled for the EC meeting.

The President asked the Chairman of SIAPWS, Mats Hellman, to welcome IAPWS and to provide a few details of the planned IAPWS week.

1. Adoption of Agenda

Provisional agendas had been posted on the IAPWS Website for all IAPWS members by the Executive Secretary. There were no further agenda suggestions from the EC. The agenda was then approved by the Heads of all National Delegations and forms Attachment 1 of these minutes.

2. IAPWS Business and Appointment of Committees

2.1 Releases, Advisory Notes, ICRNs and Technical Guidance Documents

The Executive Secretary indicated that eleven documents had been circulated to the National Committees during the year since the Moscow meeting for approval or final review prior to being approved during the current EC Meeting. The Executive Secretary reminded the EC of these documents:

- *Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use.* Distributed 21st August 2014. No comments or objections were received. Thus document was approved 24th November 2014.

- Four Revised Supplementary Releases for the four sets of "backward" equations that supplement IAPWS-IF97:

  * *Backward Equations p(h,s) for Region 3, Equations as a Function of h and s for the Region Boundaries, and an Equation Tsat(h,s) for Region 4 of IAPWS-IF97.*

  * *Backward Equations for p(h,s) for Regions 1 and 2 of IAPWS-IF97.*

  * *Backward Equations for T(p,h), v(p,h) and T(p,s), v(p,s) for Region 3 of IAPWS-IF97.*

  * *Backward Equations for v(p,T) for Region 3 of IAPWS-IF97.Thermodynamic Derivatives from IAPWS Formulations*.

  Distributed 25th July 2014. No comments or objections were received. Thus the documents were approved 24th October 2014.

- Three amended IAPWS Technical Guidance Documents:

  * *Technical Guidance Document – 2015 Revision: Instrumentation for monitoring and control of cycle chemistry for the steam-water circuits of fossil-fired and combined cycle power plants.*

  * *Technical Guidance Document – 2015 Revision: Phosphate and NaOH treatments for the steam-water circuits of drum boilers of fossil and combined cycle/HRSG power plants.*

  * *Technical Guidance Document – 2015 Revision: Volatile treatments for the steam-water circuits of fossil and combined cycle/HRSG power plants*

  Distributed on 24th February 2015. Other than a cross referencing correction by the Japan National Committee no objections or comments were received by 31st May 2015. The documents will be reviewed finally by the PCC working group during the week prior to approval at the Friday EC.

- Two draft IAPWS Guidelines:

  * *Guideline on Thermodynamic Properties of Supercooled Water*

  * *Guideline on a Virial Equation for the Fugacity of H_2O in Humid Air*.

  Distributed on 16th April 2015 for a postal ballot as agreed by the EC in Moscow. No comments or objections were received by 31st May 2015. The documents will be reviewed finally by the working groups during the week prior to approval at the Friday EC.

- One draft IAPWS Guideline:

  * *Guideline on Thermal Conductivity of Seawater*

  Distributed on 10th May 2015 for a postal ballot as agreed by the EC in Moscow. No comments or objections were received by 31st May 2015. The documents will be reviewed finally by the working groups during the week prior to approval at the Friday EC.

2.2 Press Release.

The President asked Thomsen and Cook to develop a Press Release on the IAPWS proceedings during the week. The Clerks of Minutes from each WG were asked to provide input. The Press Release is discussed in Minute 17.1 and is Attachment 11.

2.3 Evaluation Committee on International Collaboration.

The President indicated that no proposals had been received by the Executive Secretary prior to the meeting, and that any suggestions from WGs should be given to the Executive Secretary by the end of day. The President then reminded the EC that the Committee to review any proposals received would consist of the WG Chairmen, with the President and Executive Secretary as ex. officio members. A chairman would be chosen by the Committee. (See Minute15.1 for review of proposals received).

2.4 IAPWS Awards Committees

2.4.1 Helmholtz Award Committee

The President indicated that there was a Helmholtz Awardee this year. The Executive Secretary then reminded the EC that the Helmholtz Committee for the 2016 award would consist of a member from Czech Republic, Germany, Japan, Russia and SIAPWS. Czech Republic will provide the committee chairman. The President asked Czech Republic delegate Hruby to organize the committee and to report back to the EC on Friday with the names of the members of this committee (Minute 16.1).

2.4.2 Honorary Fellow Award Committee

The President requested that Kretzschmar (Chairman) and Friend form the Committee for 2016. The President would be ex. Officio.

2.5 IAPWS Associate Members.

The President reminded the EC of the discussions in Moscow regarding inactive Associate members and requested the Executive Secretary to provide an update. Following the Moscow meetings a postal ballot was sent to the National Committees of IAPWS with the motion: “Do you agree to keep the Associate Member in IAPWS?” All IAPWS Members voted on each Associate Member. The following results of this postal ballot were displayed to the EC:

1. Should Argentina / Brazil remain as an Associate Member of IAPWS? 4 Yes and 4 No votes.
2. Should France remain as an Associate Member of IAPWS? 8 Yes and 0 No votes.
3. Should Greece remain as an Associate Member of IAPWS? 7 Yes and 1 No votes.
4. Should Italy remain as an Associate Member of IAPWS? 3 Yes and 5 No votes.

There had been no futher correspondence with any of the Associate Members since the ballot. The President requested discussion. First, the relevant Section 3.2.1f) of the IAPWS Statutes was quoted: "*After a defaulting Member has been in Associate Member status for three years, its membership shall be terminated; under special circumstances this termination may be deferred by the Executive Committee on an annual basis"*. The postal ballot results led to much EC discussion which eventually resulted in three motions.

Motion 1: Following the IAWPS Statutes and based on the postal ballot, Italy should be removed as an Associate Member of IAPWS, and the Executive Secretary should notify the last known contact.

The EC voted unanimously to support this motion.

Motion 2: Following the IAWPS Statutes and based on the postal ballot, Argentina/Brazil should be removed as an Associate Member of IAPWS.

The EC voted 2 For and 6 Against this motion.

The Executive Secretary was then requested to contact the last head of the Argentina/Brazil Joint Committee to determine if there is any way to re-activate the committee.

Motion 3: Following the IAWPS Statutes and based on the postal ballot, the Executive Secretary should contact the last heads of the France and Greece National Committees to determine if there is any way to re-activate the committee.

The EC voted unanimously to support this motion.

The President finalized this item by indicating that the activities would be discussed again at the 2016 EC meetings.

2.6 Report on CCQM / CCT / BIPM Interfaces

The President reminded the EC that approval was provided at the 2014 EC meetings for travel expenses not to exceed $8,000USD for two people to attend WG meetings with BIPM to foster continuing relationships. He then asked Feistel to report on any activities over the last year. The interface with BIPM is going well and successful. There were not meetings for CCT and CCM over the last year, but Feistel attended a BIPM Workshop on Measurement Uncertainty on 15th and 16th June 2015 at BIPM, Sevres.

2.7 Cover Page of IAPWS Documents.

The President requested the chair of the Editorial Committee to address this item. Harvey reported that there were a few inconsistencies in the front page of IAPWS documents and that currently the President and Executive Secretary look like "authors" of each document. Also, these officers may be different when somebody looks at the document in the future. Harvey then presented the suggested changes for future documents:

- Consistency – cover page paragraph should just have the basic summary and that any detailed information about the process should be in an "Introduction" or similar section,
- Remove President and Executive Secretary from a prominent position on cover page but include the Executive Secretary and email address at end along with website address, and mention President with listing of Member countries, and
- Add a line to the cover page about how the document should be cited.

The EC voted unanimously to support these changes.

Following the vote the EC discussed whether IAPWS documents should have a document identifier. After much discussion without a consensus, the President requested that each WG and SC chair should discuss this item with their WG and report back to the EC on Friday.

2.8 Other Business Requiring Extensive Discusssions

No other business was raised by the EC.

3. EC Mandate to Working Groups and Membership

The President then provided the following mandates to the WG Chairmen for action during the week.

3.1 Releases, Guidelines and Certified Research Needs.

The Executive Secretary indicated that two ICRNs needed attention during the week: #22 on steam chemistry in the phase transition zone (PTZ) and #24 on thermal conductivity of water at low pressures and high temperatures. Two new ICRNs will also be worked on during the IAPWS week: #29 on uncertainties in coolant sampling for low concentration metals, and #30 on thermodynamic properties of supercooled water.

3.2 Working Group Directions.

The President emphasized that each WG Chairmen should only report to the EC on Friday about those activities that need approval or discussion by the EC.

4. Preview by the WG Chairmen of the Week's Activities

President Guzonas requested each WG Chairman to review briefly the main topics which would be covered in their WGs during the week. The details of the WG meetings are covered in detail in Minutes 7 to 11 (Attachments 4 to 8).

The President closed the opening session of the EC at 9:40 am.

Activities During the Week in Stockholm

The first day activities of the WGs and Executive Committee were followed by the separate and joint WG meetings on Monday, Tuesday and Thursday.

The full IAPWS program for the week is shown in Attachment 2.

The IAPWS Symposium was held on Wednesday, 1st July 2015 and the Symposium Program is shown in Attachment 3.

Executive Committee Meeting. Friday, 3rd July 2015

President Guzonas opened the continuation of the EC Meeting at 8:30 am. Each of the Member countries of IAPWS was in attendance as well as Associate Members Australia, New Zealand and Switzerland. In total there were 24 people assembled for the EC meeting. Guzonas first asked the EC if there were any additional items that should be added to the Agenda. None were suggested. The Executive Secretary showed the latest Agenda with additional items relating from the Monday EC Meeting.

5. Acceptance of Minutes of Previous Meeting

   President Guzonas asked for comments and changes to the minutes of the EC meeting held in Moscow, Russia in June 2014. No changes were noted, thus the 2014 Minutes were accepted.

6. President's Report

   President Guzonas indicated that it had been a very good year for IAPWS with many new documents being worked on and published. The activities within the Working Groups during the week had been exceptional. He was very pleased that the interfaces with BIPM had continued and will be strengthened further.

7. Report and Recommendations of the Thermophysical Properties of Water and Steam (TPWS) Working Group

   TPWS Chairman Harvey opened this item by indicating that he would report on the activities relating to TPWS although a number of joint meetings with IRS and SCSW had taken place during the week. Full Minutes and the Agenda for TPWS can be found in Attachment 4.

   7.1 The Working Group (jointly with SCSW) considered the "*Guideline on a Virial Equation for the Fugacity of H_2O in Humid Air*" The Evaluation Task Group gave a favorable report. TPWS and SCSW recommended that the Guideline be approved by the EC.

   The EC approved the Guideline Unanimously.

7.2 The Working Group (jointly with SCSW) considered the "*Guideline on Thermodynamic Properties of Supercooled Water*". The Evaluation Task Group report was favorable. TPWS and SCSW recommended that the Guideline be approved by the EC.

The EC approved the Guideline Unanimously.

7.3 The Working Group (jointly with PCAS) considered the "*Guideline on Thermal Conductivity of Seawater*". The Evaluation Task Group report was favorable. TPWS and PCAS recommended that the Guideline be approved by the EC.

The EC approved the Guideline Unanimously.

7.4 ICRNs. Chairman Harvey indicated the following activity on ICRNs relating to the WGs:

- ICRN 30. The Working Group (jointly with SCSW) considered a new ICRN on *Thermophysical Properties of Supercooled Water*. TPWS and SCSW approved the ICRN and request that the EC send it for postal ballot after the meeting by the procedure specified in the IAPWS By-Laws.
- ICRN 24. It was decided to allow ICRN 24 (*Thermal Conductivity of H_2O at Low Pressures and High Temperatures*) to expire. Harvey will prepare a closing statement.

The EC approved the Changes to the ICRNs Unanimously.

7.5 Chairman Harvey then informed the EC on the following four items of interest:

- A Task Group consisting of Wagner and Harvey was appointed to refine the uncertainty estimates for the isobaric heat capacity in IAPWS-95 based on new data.
- A Task Group including Friend, Feistel and Hrubý has been formed to come up with an opinion of whether the topic of differential evaporation of isotopic species of water is relevant for IAPWS.
- A Task Group consisting of Hellmuth, Hrubý, and Sengers was formed to work on a new ICRN for interfacial properties of supercooled water.
- Existing Task Groups continue to work toward new formulations for the thermodynamic and transport properties of heavy water, and for the surface tension of water.

7.6 TPWS Membership. Chairman Harvey requested EC approval for the following TPWS WG membership items:

Membership in TPWS should be terminated for Gernert and Spitzer. He also reported sadly that Dr. Ines Stöcker had recently passed away.

Two proposals were submitted for TPWS membership:

- Dr. Hiroyuki Miyamoto (Toyama Prefectural University, Japan)
- Prof. Dr. Ing. Karsten Meier (Helmut-Schmidt-University in Hamburg, Germany).

Both proposals were approved by the Working Group.

The EC approved these Membership Changes Unanimously.

8. Report and Recommendations of the Industrial Requirements and Solutions (IRS) Working Group

IRS Chairman Weber indicated that many of the activities of IRS during the week had been reported in the TPWS report. Minutes for IRS and the Agenda can be found in Attachment 5. He covered the following two items with the EC.

8.1 Proposed Guideline on the *Fast Calculation of Steam and Water Properties Using Spline Interpolation* (SBTL).

Weber reported that the Guideline document exists and there has been a successful evaluation of the technical content. Editorial changes are now required, and the IRS and TPWS working groups recommend adoption by EC. It is suggested that the Editorial Committee and the authors perform the editorial changes, and after the document has been finalized it is distributed to National Committees for Postal Ballot.

The EC approved the Process for this Guideline Unanimously.

8.2 Industrial Advisory Group. Weber indicated that an additional advisory note will be created (instead of an extension of Advisory Note #2). This will list all documents relevant for power industries and explanation of their interdependencies. The task group will prepare such a document for the 2016 meeting.

8.3 Informational item on discussions within IRS. Weber indicated that no further IRS products appear to be on the horizon after SBTL guideline and so the IRS working group discussed possible topics for future work within IRS. A few technical topics were identified, but either demand in industry does not exist or they were not in IRS scope.

Thus the IRS working group had discussed making itself dormant. Discussion will continue throughout the next year and at the 2016 meeting because of the danger of losing members due to missing justification for travel to meetings.

9. Report and Recommendations of the Sub-Committee on Seawater (SCSW)

SCSW Chairman Pawlowicz reported on the following items. Minutes for SCSW and the Agenda can be found in Attachment 6.

9.1 Highlights.

- Annual report of Joint SCOR/IAPWS/IAPSO Committee on the Properties of Seawater (JCS):
  - Two new members had been proposed: Wolf (PTB) for density, and Stoica (LNE) for pH replacing Spitzer (PTB)

  - Downloads of TEOS software and manuals had increased over last year
  - Many tasks that had been identified at the JCS workshops at the 16th ICPWS have now been completed, while others have made good progress
  - BIPM/IAPWS cooperation continues
- Metrologia article (now 4 articles) in review (#1 accepted 1st July)
- R. Feistel attended BIPM workshop on uncertainty (June 2015)
- Nine presentations providing updates on progress and plans with respect to seawater issues
- JCS proposed a formal procedure for updating TEOS-10 (and IAPWS documents related to TEOS-10); after discussion this was accepted by SCSW/TPWS.

9.2 Task Groups. The Chairman of SCSW informed the EC of the following Task Groups:

- Task Group to write an Advisory Note on TEOS-10 and the role of IAPWS documents within it (Feistel, Pawlowicz, Harvey)
- Task Group to write a Supplementary Release describing a simplified equation for the density of seawater for oceanographic use (Pawlowicz, McDougall, co-opted expert Barker), and evaluation group (Harvey and Feistel)
- Task Group on Providing Uncertainty in IAPWS products (Feistel, Seitz, Hruby, Friend, and Lovell-Smith)

9.3 Interface with BIPM.

The Chairman next requested IAPWS support to send a SCSW member to the April 2016 BIPM/CCT meeting (Paris) to continue working with BIPM on incorporation of Relative Humidity into SI. The estimated cost is 1000 Euros.

The Russian Delegate, Orlov, wanted to make sure that there would be a report distributed following the meeting.

The EC then approved this Request Unanimously.

9.4 Membership. Pawlowicz then requested that the EC approve the following three new members from National Center of Ocean Standards and Metrology in China for the SCSW:

Yongchao Pang. Director, Calibration and Testing Center
Chuan Zhang. Senior Engineer, Chemical Standards
Yanan Li. Engineer, CTD calibration

The EC approved these Membership Additions Unanimously.

10. Report and Recommendations of Physical Chemistry of Aqueous Systems Working Group (PCAS)

Chairman Anderko provided the PCAS Report to the EC. Full Minutes can be found in Attachment 7. He covered the following items with the EC:

10.1 *Guideline on Thermal Conductivity of Seawater*. Chairman Anderko indicated this collaborative effort with TPWS and SCSW had been reported and approved in the TPWS report (Minute 7.3).

10.2 Forthcoming Guidelines. Anderko reported that two other guidelines on *Self-diffusion in High Temperature Water* (Yoshida) and on the *Dissociation and Vapor-liquid Distribution of Amines* (Bellows) were under development. It is anticipated that both will be ready for the 2016 meeting.

10.3 PCAS Membership. Chairman Anderko requested that the following new member be approved:

Kaj Thomsen. Technical University of Denmark

The EC approved this Membership Addition Unanimously.

11. Report and Recommendations of Power Cycle Chemistry Working Group (PCC)

Chairman Rziha provided the PCC Report to the EC. Full Minutes can be found in Attachment 8 and PCC Nuclear Minutes in Attachment 8A. He covered the following items with the EC:

11.1 Technical Guidance Documents (TGD) for Approval. Chairman Rziha requested EC approval for the three amended TGD for Fast Start HRSGs delineated in Minute 2.1. These had received a final review by the PCC Working Group during the week.

The EC approved these Amended TGD Unanimously.

11.2 Technical Guidance Documents (TGD) under Development. Chairman Rziha informed the EC that the TGD Task Group (Chair: Dooley) had intiated the following activities during the week.

- Possible future TGD on Corrosion Product Monitoring in Cycling and Two-shifting Plants. A Task Group has been formed (Addison Chair) to develop a White Paper for review by PCC at the 2016 meeting with the possibility of developing a TGD following the meeting.
- New TGD proposed on "Ensuring the Integrity and Reliability of Demineralised Makeup Water Supply to the Unit Cycle". A Task Group has been formed (Joy Chair) to develop this TGD for approval at the 2016 meeting.
- New TGD proposed on "HRSG HP Evaporator Tube Sampling". A Task Group has been formed (Dooley Chair) to develop this TGD for approval at the 2016 meeting.
- New TGD proposed on "Film Forming Amines". A Task Group has been formed (Hater and Lendi Chairs) to develop this TGD for approval at the 2016 meeting.
- Possible future TGD on Geothermal Chemistry. A Task Group has been formed (Addison Chair) to develop a White Paper for review by PCC at the 2016 meeting with the possibility of developing a TGD following the meeting.

11.3 ICRNs. Rziha provided the EC with the following information for approval.

ICRN 17 on Amines. The PCC WG had decided that this ICRN will be closed because a Guideline and a TGD are under preparation.

ICRN 22 on Steam Chemistry in the Phase Transition Zone. It is requested that this ICRN is extended for two more years.

ICRN 29 on Uncertainties in Coolant Sampling for Low Concentration Metals. The ICRN will be sent for a final review to the PCC WG. The final version will be sent to the Editorial Committee for a light review. The PCC WG request that the EC then send it for postal ballot after the meeting by the procedure specified in the By-Laws.

The EC approved these ICRN Actions Unanimously.

11.4 PCC Membership. Rziha indicated that Thomsen has stepped down as a Vice Chairman of PCC and requested that Leidich become the second Vice Chairman of PCC. Rziha also requested that the following new members be approved:

Roger Lundberg (Sweden)
Nobuo Ishihara (Japan)
Keith Fruzzetti (USA)
Joung Hae Lee (Korea)

The EC approved these Membership Changes Unanimously.

11.5 Items Needing Discussion with EC. Chairman Rziha reported on the following discussions by PCC during the week.

- PCC asked for the status of creating an open and closed area on the OPAL webserver (EC minutes 2014). This item lead to discussion by the EC which indicated that the Opal site was a password protected location for Working Group documents, and that a site could be developed for open access on the IAPWS website. Finally a consensus was developed that the WG Chairman would provide approval of documents before placing them on the IAPWS website. A caveat would be added that these documents are not official IAPWS documents.

The EC approved this Unanimously.

- PCC proposed to create a kind of "yellow pages" of all PCC WG members, in order to know the individual fields of expertise (especially for new WG members). This also led to much discussion and then consensus by the EC. It was also agreed that the members contact details could also be on this file if the individual agrees.

- PCC proposed a "refurbishment" of the appearance of the IAPWS website. The content was considered satisfactory. This lead to discussion on whether the refurbishment required a budget for a web designer. Finally a proposal was developed that each WG would suggest somebody to Harvey as chair by October

2015 to constitute a Task Group which would investigate the possibilities of upgrading the IAPWS website and provide a budget. This would be prepared by March 2016 and circulated to the National Committees.

The EC approved this Motion Unanimously.

12. Editorial Committee Report

Editorial Committee Chairman Harvey reported that in the preceding year, the Editorial Committee had reviewed the following documents:

Minor Revision of IAPWS-95 Release
3 Amended Technical Guidance Documents
Guideline on Thermodynamic Properties of Supercooled Water
Guideline on a Virial Equation for the Fugacity of H_2O in Humid Air
Guideline on Thermal Conductivity of Seawater

Harvey then indicated that a large number of documents will need editorial review over the next year and requested early notification.

13. Membership and Associates

13.1 Member Dues.

The Executive Secretary indicated that all IAPWS Members have paid their 2015 dues.

13.2 Reports on Associate Members

The President reminded the EC that discussion had focused on Monday on the inactive Associate Members (Minute 2.5). The Executive Secretary then asked the recent associate members to provide an update on their activities towards membership.

Australia. Chairman Joy provided a short presentation. The Australian National Committee (AUSAPWS) has continued to focus on the Power Cycle Chemistry area but is also developing a wider focus in seawater, carbon sequestration and thermodynamics. AUSAPWS now has about 60 members and has developed an initial Statutes. There were continuing challenges during 2015 in the Australian Electricity Generation industry due to profitability and proposed sales of State owned and private generators as well as plant shutdowns. Joy indicated that AUSAPWS is finalizing funding arrangements with API and also seeking further Company and individual membership and sponsorship to complete AUSAPWS funding. An Australian wide steering committee has been formed. Joy requested that the EC approves a second three year period for Associate Membership and indicated that they are planning to apply for IAPWS Membership at the next meeting in 2016 in Germany.

The EC approved the Continuing Associate Membership Unanimously.

New Zealand. Chairman Addison provided an update on NZAPWS. He indicated that the IAPWS TGD are heavily used in New Zelaland. They are currently working on a fee structure for individual member companies and have opened a bank account. NZAPWS

needs 15 paid members to become a non profit incorporated society in NZ. To accomplish these Addison requested that the EC approves a second three year period for Associate Membership and indicated that they are planning to apply for IAPWS Membership at the next meeting in 2016 in Germany.

The EC approved the Continuing Associate Membership Unanimously.

Switzerland. Chairman Lendi indicated that the Swiss National Committee had still not yet been able to acquire financial commitment, but that they plan a National Meeting in autumn 2015 to find new participant instituitions. Lendi requested that the EC approves a second three year period for Associate Membership.

The EC approved the Continuing Associate Membership Unanimously.

14. Executive Secretary's Report

14.1 Financial, Auditors and IAPWS Dues

The Executive Secretary reported that IAPWS is on a sound financial footing with currently about £70,000GBP in total in the UK and US bank accounts. The status as at 15th June 2015 in the bank accounts had been provided to each National Delegate prior to the EC meeting.

The Executive Secretary next reported that the 2014 financial statements had been forwarded to the IAPWS Auditors in January 2015. Both Dr. Hencke of VDI in Germany and Professor Savarik in Czech Republic had reviewed and approved the financial statements. Both approvals had also been provided to the Heads of all the National Delegates present prior to the EC meeting.

The Executive Secretary proposed that these organizations continue to act as auditors.

The EC Approved this Unanimously.

The Executive Secretary proposed to the EC that the dues structure for member countries remains unchanged for 2016.

The EC Unanimously Agreed to this Proposal.

The Executive Secretary had also provided a rough estimate of the income and known planned expenditures for 2015 / 2016.

14.2 Time and Place of the 2016, 2017 and 2018 Meetings

2016 IAPWS Meetings. The German Delegate, Kretzschmar, indicated that the German NC would like to invite IAPWS to Dresden on 11th to 16th September 2016. Arrangements have been made at the Steigenberger Hotel in a central location in Dresden. He indicated that a website will be developed for the meeting and this will be linked with the IAPWS website.

2017 IAPWS Meetings. The Japan Delegate, Nakahara, indicated that the Japan NC would like to invite IAPWS to Kyoto in the week starting Sunday 27th August 2017. Details will be available at the next meeting in Dresden in September 2016.

2018 IAPWS Meetings and the 17th ICPWS. The Head of the Czech Republic NC, Hruby, reported that the Czech Republic National Committee will support the 17th ICPWS in Prague. Much discussion by the EC on the dates suggested of 26th to 31st August 2018 led to the usual direction that the Host National Committee should make the final decision based on the inputs received. Hruby also quickly reviewed the possible conference fee structure, sponsors, hotel and internet services. Full details on the 17th ICPWS will be available at the next IAPWS meeting in Dresden in 2016 when the first meeting will take place between the local organizing committee (LOC) and the international program committee (IPC) to start planning the technical program. The final item was discussion on the IAPWS Donation to the Czech National Committee for the 17th ICPWS. Some discussion first took place on returning this donation to IAPWS before a motion was developed to provide a donation of up to £16,000 upon request to the Executive Secretary.

The EC Approved this Unanimously.

15. Guidelines, Releases, Certified Research Needs, and International Collaborations

The President indicated that the Releases and ICRNs had been discussed within the WG Reports so no further action was required by the EC. Two international collaborations had been suggested during the 2015 IAPWS meetings.

15.1 International Collaborative Projects.

The President requested the Chairman of the 2015 International Collaboration Committee (WG and SC Chairs) to report on the findings of that committee during the week. Chairman Anderko reported that two collaborative projects had been proposed. The following are overviews of the proposed projects. The details are provided in Attachments 9 and 10:

- *Towards an IAPWS Guideline for the Thermodynamic Properties of Supercooled Heavy Water.*
  The IAPWS sponsors are Anisimov (USA) and Hruby (Czech Republic). The young scientist (Michal Duška) will be from the Institute of Thermomechanics of the CAS. It is proposed that IAPWS funding of £17,490GBP would cover subsistence for 9 months at the University of Maryland. If approved, a report on the research will be presented at the 2017 IAPWS meetings.

- *High Temperature Data on the Effects of Combined Anion Contamination on the Corrosion of Boiler Materials.*
  The IAPWS sponsors are Cook (Canada) and Addison (New Zealand). The scientist is David Addison from Thermal Chemistry. A total budget of £ 9,600GBP is proposed for this project, to reside at UNB over six months (in 6-8 week periods) to assemble and commission a flow-through electrochemical cell and to conduct baseline tests. This would pay for the

travel and living expenses. If approved, a report on the research will be presented describing commissioning and preliminary baseline testing at the next annual meeting in Germany.

Anderko indicated that the Evaluation Committee supported both proposals and that the technical content was of interest to IAPWS. He indicated that the committee recommended to the EC that both are funded, but that if there are financial constraints then the committee ranked the Corrosion of Boiler Materials proposal as priority one as it related directly to a current ICRN. The President indicated that the IAPWS finances were in good condition and developed a motion to support both proposals as submitted.

The EC Approved the Motion to Fund Both Projects Unanimously.

16. IAPWS Awards

16.1 IAPWS Helmholtz Award

The President reported that the 2015 Helmholtz Award was to Dr. Vincent Holten of Cornell University but unfortunately he had not been able to present the Helmholtz Lecture at the IAPWS Symposium on Wednesday.

Guzonas then asked the Czech Delegate, Hruby, for the names of the 2016 Helmholtz Award Committee. The 2016 Helmholtz Committee will consist of: Chairman Vinš (Czech Republic), Wagner (Germany), Hirano (Japan), Orlov (Russia) and Jensen (SIAPWS),

Action: Nominations will be due to the Executive Secretary by 31st January 2016.

16.2 IAPWS Honorary Fellowships

The President reported that Professor Masaru Nakahara had been elected an Honorary IAPWS Fellow, following the established procedures and after unanimous approval through the postal ballot conducted by the Executive Secretary. The Fellowship Award had been presented to him at the IAPWS banquet by the IAPWS President.

Guzonas then reminded the EC of the Awards Committee for 2016 with Kretzschmar as Chairman and Friend as member with the IAPWS President as ex.-officio member.

Action: Nominations are due to the Executive Secretary by 31st January 2016.

17. New Business

17.1 Press Release

The President mentioned that Cook and Thomsen had been asked at the EC meeting on Monday to develop a Press Release. This was developed with input provided by each WG and SC. Cook indicated that a document had been prepared. The final version is Attachment 11. The President indicated that this release will be sent to all NCs and WGs of IAPWS and it should be distributed as widely as possible and sent to any journals and publications.

17.2 Numbering System for IAPWS Documents

The President now returned to this item from the Monday EC meeting and asked the Chairman of the Committee to report. Harvey indicated that the WG Chairs had met during the week. There was a desire from PCC to have the TGD with identifiers. As ICRNs already had numbers the committee suggests that this should be done for all IAPWS documents, and that this should be retroactive for the documents already published. The actual numbering system had not been discussed, and Harvey suggested that the Editorial Committee develop a proposal which will be circulated to the National Commitees by the end of 2015 for an administrative postal ballot.

The EC Approved this Suggestion Unanimously

17.3 SIAPWS National Committee Feedback on the Stockholm Meetings.

The SIAPWS Delegate, Hellman, thanked everybody for attending and indicated that everything appeared to have proceded very smoothly.

17.4 Other New Business

President Guzonas asked the EC if there was any further business. No other business was raised.

17.5 Reports from National Committees.

Written reports on progress in member countries were not reported to the EC but were either distributed to other members and the Executive Secretary during the IAPWS week, or sent to the Executive Secretary after the meetings. They are attached to these minutes as follows:

BIAPWS	Attachment 12
Canada	Attachment 13
Czech Republic	Attachment 14
Germany	Attachment 15
Japan	Attachment 16
Russia	Attachment 17
Switzerland	Attachment 18
USA	Attachment 19

17.6 Participants

Attachment 20 provides a list of participants at the IAPWS EC and WG Meetings in Stockholm, Sweden in June/July 2015.

17.7 List of Members

An up-dated list of members of the Executive Committee, Working Groups, and Honorary Fellows will be developed by the Executive Secretary following the Moscow Meetings. This will be forwarded electronically to the Head of each National Committee and the Working Group Chairs.

18. Closing Remarks and Adjournment

The President thanked everybody for participating at this EC meeting. Then he formally closed the 2015 EC meeting at 12:06pm.

AGENDA for the EXECUTIVE COMMITTEE of IAPWS

Stockholm, Sweden. 28th June – 3rd July 2015

Monday, 29th June 2015. Opening Session (8:30 – 10:00 am)

Opening Remarks and Welcome by IAPWS President, D. Guzonas

1. Adoption of Agenda
2. IAPWS Business and Appointment of Committees
   - 2.1 Releases, Advisory Note, ICRNs and Technical Guidance Documents
   - 2.2 Press Release
   - 2.3 Evaluation Committee on International Collaboration
   - 2.4 IAPWS Awards Committees for 2016 (Honorary Fellow, Helmholtz)
   - 2.5 IAPWS Associate Members (2014 Minute 12.2.2)
   - 2.6 Report on CCQM/CCT/BIPM Interfaces
   - 2.7 Cover Page of IAPWS Documents (2014 Minute 17.3)
   - 2.8 Other business requiring special/extensive discussions
3. EC Mandate to Working Groups and Membership
   - 3.1 Releases, Guidelines and ICRNs
   - 3.2 WG Directions
4. Preview of Week's WG Activities by WG Chairmen

Friday, 3rd July 2015. Executive Committee Meeting. (8:30am – 1:00 pm)

5. Acceptance of Minutes of Previous Meeting
6. President's Report
7. Report and Recommendations of TPWS
8. Report and Recommendations of IRS
9. Report and Recommendations of the Sub-committee on Seawater
10. Report and Recommendations of PCAS
11. Report and Recommendations of PCC
12. Editorial Committee Report
13. Membership and Associates
    - 13.1 Report on Membership. Including Members Defaulting on Dues.
    - 13.2 Report on Associate Members, Australia, New Zealand and Switzerland
14. Executive Secretary's Report
    - 14.1 Financial and Auditors
    - 14.2 Time and Place of 2016/2017/2018 Meetings.
      Includes Czech Republic on the 17th ICPWS in 2018
15. Guidelines, Releases, Certified Research Needs, and International Collaborations
    - 15.1 International Collaborations
16. IAPWS Awards
    - 16.1 Helmholtz Award Committee
    - 16.2 Honorary Fellowship
17. New Business
    - 17.1 Press Release
    - 17.2 Numbering of IAPWS Documents
    - 17.3 SIAPWS Committee feedback on 2015 Meetings and Symposium
    - 17.4 Other items raised during the IAPWS week
18. Adjournment

Schedule of IAPWS Meeting

Stockholm, Sunday, 28 June, to Friday, 3 July 2015

All meetings take place at the Scandic Ariadne Conference Hotel in Stockholm

Date	Time	Activity
Sunday, 28 June	7:00 pm	Informal get-together and registration
Monday, 29 June	8:30 am	Opening plenary session – Executive Committee
	10:00 am	TPWS/IRS/SCSW joint meeting PCAS meeting PCC meeting
	1:30 pm	TPWS/IRS/SCSW joint meeting PCAS meeting PCC meeting
Tuesday, 30 June	8:30 am	TPWS/IRS/SCSW joint meeting PCAS meeting PCC meeting
	10:00 am	TPWS/IRS/SCSW joint meeting PCAS workshop PCC workshop
	1:30 pm	TPWS/IRS/SCSW joint meeting and workshop PCAS & PCC joint WG meeting and workshop
	3:30 pm	TPWS/IRS/SCSW workshop PCAS workshop PCC workshop
Wednesday, 1 July	9:00 am	IAPWS Symposium Agenda under preparation
	16:30 pm (#1) 17:30 pm (#2)	Sightseeing – Stockholm by amphibious bus – two tours to accomodate everybody
Thursday, 2 July	8:30 am	IRS meeting SCSW meeting PCC workshop TPWS/PCAS joint meeting
	1:30 pm	Separate meetings of WG – preparation for EC meeting
	6:30 pm	Bus leaves for the IAPWS Dinner at Vasa Museum
Friday, 3 July	8:30	Executive Committee meeting
	1:00	Adjourn IAPWS meeting

TPWS Thermophysical Properties of Water and Steam WG
SCSW Subcommittee on Seawater
IRS Industrial Requirements and Solutions WG
PCAS Physical Chemistry of Aqueouos Solutions WG
PCC Power Cycle Chemistry WG

Activities marked with the light grey shading are pen to guests who register for the symposium. The idea is to group the workshop activities around the symposium to attract interest for the activities of the WGs.

Schedule of IAPWS Symposium

Stockholm, Wednesday, 1 July 2015

The meeting takes place at the Scandic Ariadne Conference Hotel in Stockholm

Block	Time	Activity
Energy planning and technical solutions	9:00	Energy/Environmental planning in Scandinavia, implications on technical solutions Speaker: Per Kallner, Vattenfall
	9:30	Production of power and heat based on biomass, heat production by means of flue gas condensation, water treatment of flue gas condensate Speaker: Fredrik Axby, Grontmij AB, Sweden
Pause	10:15	
Carbon Capture and Storage (CCS)	10:30	Thermodynamic modeling of CO_2 capture system with liquid-liquid phase split in addition to VLE and SLE Speaker: Professor Kaj Thomsen, Technical University of Denmark (DTU)
	11:00	The N_2O analogy in the CO_2 capture context Speaker: Professor Juliana Monteiro, Norwegian University of Science and Technology (NTNU)
	11:30	Carbon Dioxide Removal in Indirect Gasification Speaker: Professors Christian Hulteberg and Helena Svensson, Lund University (LTH)
Lunch	12:00	
IAPWS	13:00	Presentation of Helmholz Award speaker Helmholz Award presentation Speaker: To be disclosed
	13:30	Fundamental aspects of aqueous reactions of polysaccharides in relation to biomass Speaker: Professor Masaru Nakahara, Kyoto University
Pause	13:55	
IAPWS	14:05	Modeling Aqueous Electrolyte Systems: From Bulk Properties to Corroding Interfaces Speaker: Dr Andre Anderko, OLI Systems, Inc.
Nuclear power	14:30	MVSS (Multi Venturi Scrubber System) – An innovative solution to alleviate the consequences of a severe accident Speaker: Patrick Isaksson, Strålsäkerhetsmyndigheten (Swedish Radiation Safety Authority)
Thermal power	15:00	Efficient and clean thermal power plants for the future Speaker: Rudolph Blum, retired (former ELSAM, Denmark)
	ca 15:30	Paus
	The plant visit has been cancelled and replaced with a 50 minute sightseeing tour.	
Sightseeing first tour	16:30	We will experience Stockholm from both land and water in one single vehicle - an amphibious bus. The bus will pic us up just outside the hotel. There will be two tours to allow everyone to go.
Sightseeing second tour	17:30	

Minutes: IAPWS Thermophysical Properties of Water and Steam WG
Stockholm, Sweden, 29 June – 2 July 2015

NOTE: These Minutes include many items that were held jointly with the IRS Working Group and/or the Subcommittee on Seawater (SCSW). Items are listed according to their order on the TPWS agenda, which is Attachment A. **Bold print** denotes significant actions.

Obituary: H.-J. Kretzschmar reported that Dr. Ines Stöcker, member of TPWS, died in June at the age of 53. Ines Stöcker participated in several IAPWS projects: the development of IAPWS-IF97, four supplementary releases to IF-97, advisory notes No. 3 (Thermodynamic Derivatives) and 5 (Industrial Calculations for Seawater). She was involved in organizing the 15th ICPWS in Berlin. She attended many IAPWS Meetings and conferences starting from 1995 in Paris. The WGs observed a minute of silence in remembrance of Dr. Stöcker.

1-2. The meeting was opened on Monday, June 29 by the TPWS Chair, Allan Harvey. The agenda (Attachment A) was adopted after some additions. The Chair noted that the 2014 Minutes had been circulated and approved with shortly after the 2014 meeting. J. Hrubý was appointed Clerk of Minutes for TPWS. (Michael Hiegemann was appointed Clerk for SCSW and Anurag Singh for IRS)

3. Mathias Kunick informed about the OPAL Web Space for sharing the working material of WGs.

4. Collaborative project "Towards an IAPWS Guideline for the Thermodynamic Properties of Supercooled Heavy Water" was proposed by M. A. Anisimov and J. Hrubý. Besides developing a new formulation for the region of cold and supercooled heavy water, the project should also provide information for the present development of the fundamental equation of state of heavy water. **TPWS unanimously recommended the Project for being granted.**

5. Industrial Requirements and Solutions for Steam Property Calculations, joint with WG IRS

5.1 Report of the Task Group "Industrial Advisory Note" (M. Hiegemann, B. Rukes, A. Singh, A. Harvey) – see IRS Minutes

6. Proposal for an IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using Spline Interpolation, joint with WG IRS – see IRS Minutes

TPWS and IRS voted unanimously to approve the technical content of the IAPWS Guideline on the Fast Calculation of Water and Steam Properties in Computational Fluid Dynamics Using Spline Interpolation and to recommend that it be sent for Postal Ballot by the EC after editorial revisions.

7. Heavy Water Properties, joint with WG IRS

7.1 A. Harvey reported on behalf of the Task Group on Heavy Water Thermodynamic Properties (R. Span, A. Harvey, S. Herrig, E. Lemmon). An equation of state of heavy water has been developed with the aim of replacing the present formulation of thermodynamic properties of heavy water developed by Hill (1982, 1983). The new equation has only 24 terms and shows plausible extrapolation behavior. New data has been included (e.g., speed of sound by Wegge and Span). A further potential improvement would introduce new data for the ideal-gas properties (see item 17.4), and there may be additional vapor pressure and/or virial coefficient data. Because of the uncertainty of timing of new data, it is not clear when the equation will be finalized.

7.2 A. Harvey reported on behalf of the TG for Heavy Water Transport Properties (J. Sengers, M. Assael, M. Huber (co-opted expert), A. Harvey). Experimental data has been collected by M. Assael. R. Hellmann (Rostock) will calculate dilute-gas viscosity and thermal conductivity. Calculated values will be used together with experimental data. R. Perkins of NIST was approved by the TPWS and IRC WGs as another "Coopted Expert" for the Task Group.

8. V. Vinš reported on the progress of the Task Group on Surface Tension of Ordinary Water (joint with WG IRS and SC SW) (V. Vinš, A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, J. Kalová, R. Mareš). Review and analysis of both old and new literature data, further measurements for supercooled water. 2016 – revision of the uncertainty measurements, 2017 – development of a new correlation. V. Vinš further reported on new measurements of the surface tension of supercooled water. The new data agree with the IAPWS formulation, except for the lower temperature limit, where the measured values are about 0.2% higher (almost within the experimental uncertainty). J. Kalová reported on the values of surface tension at 20 and 25 °C.

9. W. Wagner reported on a study by himself and M. Thol on the behavior of IAPWS-95 from 250 K to 300 K and up to 400 MPa. The evaluation was based primarily on newly evaluated speed of sound data by Lin and Trusler. An improved equation was fitted to the speed of sound data. The results are in agreement with the equation by Holten et al. (proposed for IAPWS Guideline under Item 11). The evaluation enables to provide estimates for the uncertainty of the isobaric heat capacity close to the melting line at high pressures. **A task group (W. Wagner, A. Harvey) was formed to include the new estimates into the IAPWS-95 release.**

10. Humid Air Fugacity and Enhancement Factor, joint with SC SW.

10.1 R. Feistel reported on behalf of the proposers of "Guideline on a Virial Equation for the Fugacity of H_2O in Humid Air" (R. Feistel, O. Hellmuth, J. Lovell-Smith). The Guideline provides an explicit expression for the fugacity of water vapor in air which is based on literature correlations for the temperature dependency of virial coefficients of the water vapor – air system.

10.2 A. Harvey presented the Report of the Evaluation Task Group (A. Harvey, H.-J. Kretzschmar). They found that the Draft Guideline is correct and recommended it for approval.

10.3 **TPWS and SCSW unanimously recommended that the Guideline be approved by the EC.**

10.4 O. Hellmuth reported on behalf of a group (O. Hellmuth, R. Feistel, J. Lovell-Smith, J. Kalová, H.-J. Kretzschmar, S. Herrmann) suggesting next steps concerning the humid air properties. A virial approximation of the enhancement factor may be developed, and maybe a correlation based on structural optimization. Other topics discussed included an analytical approximation for the low-density water mole fraction in supercooled water (c.f. Item 11.1), an analytical correlation of the ratio of relative humidity to the relative fugacity, problems of metastable regions with respect to the suggested developments.

11. Metastable Water (joint with SC SW)

11.1 M. Anisimov presented on behalf of the proposers the background of supercooled water Guideline (V. Holten, M. Anisimov, J. Sengers). The formulation is based on an idea of two competing structures of liquid water which are represented in a quasi-chemical formalism. This view of the supercooled water has been partly confirmed by experiments. The formulation is valid up to 400 MPa and down to the homogeneous ice nucleation limit. It can be extrapolated to negative pressures down to -50 MPa.

11.2 J. Hrubý reported on behalf of the Evaluation Task Group on Supercooled Water Guideline. The formulation did not change since the Moscow meeting 2014, where a detailed report was presented including the issues of representation of experimental data, consistency with IAPWS-95 in the region of overlap, and physical correctness. Therefore, these issues were not re-iterated by the Task Group. Only formal changes have been suggested by the Task Group and they were adopted by the Proposers. The Task Group recommended the Guideline for adoption.

11.3 **TPWS and SCSW unanimously recommended the Guideline on Thermodynamic Properties of Supercooled Water for adoption by the EC.**

11.4 O. Hellmuth reported on behalf of the Task Group on Supercooled Water ICRN (O. Hellmuth, V. Holten, J. Sengers, J. Hrubý). The ICRN stimulates new experimental data for thermophysical properties of supercooled water.

11.5 **TPWS and SCSW unanimously recommended the ICRN (ICRN 30: Thermophysical Properties of Supercooled Water) and requests that the EC send it to be voted on after the meeting by the procedure specified in the By-Laws.**

The topic of interfaces of supercooled water is important, but was excluded from this ICRN. **A Task Group on an ICRN for Interfacial Properties of Supercooled Water was appointed, consisting of O. Hellmuth, J. Hrubý, and J. Sengers.**

11.6 M. Duška reported on behalf of the group of J. Hrubý on the progress of measurements of density of supercooled water at elevated pressures. New apparatus for measurements of the density of supercooled liquids has been developed showing reproducibility of 0.01% in density. Preliminary data from -20 to 20°C and from 0.1 MPa to 100 MPa agrees well with data by Sotani and with the IAPWS Guideline.

11.7 H.-J. Kretzschmar left the Task Group on Superheated liquid water. The Task Group did not have any output. In a consequent discussion it was concluded that such a Task Group is needed. The remaining task group (J. Hrubý and R. Feistel) will continue.

11.8 A. Harvey reported on behalf of the Task Group on possible revision of IAPWS formulations for melting curves (V. Holten, A. Harvey, H.-J. Kretzschmar). Formulation is not yet available. In the discussion it has been confirmed that new formulations are needed as it is clear that better results can be achieved. The Task Group hopes to have a proposal for 2016.

12. Report of Task Group on Extension of Range of Formulation for Thermodynamic Properties of Sea Water, joint with WGs IRS and SC SW (R. Feistel) – see SCSW minutes

13. Cooperation with other international bodies, joint with SC SW – see SCSW minutes

14. Reports on seawater-related topics, joint with SCSW – see SCSW minutes

15. Proposed new IAPWS seawater-related documents (joint with SCSW) – see SCSW minutes

16. Reports on miscellaneous TPWS scientific topics (joint with WG IRS)

16.1 K. Meier reported on thermophysical property research at Helmut-Schmidt-University in Hamburg. Founded in 1973 as one of two universities of the armed forces, good conditions for performing experimental research. The research concerns thermophysical properties of fluids, mass transport across fluid interfaces, and heat transport in gas turbines. Experimental apparatuses include pulse-echo speed of sound instrument for liquids, automated vibrating tube densimeter, torsional crystal viscometer, combined vibrating wire viscometer and magnetic suspension balance densimeter for gases.

16.2 E. E. Ustyuzhanin reported on a comparative study of Ps(T) models for H_2O in the critical region (E. E. Ustyuzhanin, V. F. Ochkov). Cosiderations have been presented concerning the critical scaling of the two-phase heat capacity of water and the second derivative of the saturated vapor pressure with respect to temperature. Extrapolation of the IAPWS-IF97 equation for saturation vapor pressure towards the critical point was investigated.

16.3 V. Ochkov reported on the online calculation from IAPWS formulations (V. Ochkov, K. Orlov). Elsevier publishes reference books in the Knovel series enabling computations in their electronic editions. Online computations based on IAPWS computations have been implemented at the Knovel web site. A printed handbook for thermal computations is available.

16.4 M. Hiegemann suggested an innovative concept for fluid property approximations. He reviewed the current methodology for structural optimization of thermophysical property formulations. Slow evaluation, complex structure, non-generic – different structure for each fluid. Chebychev polynomials Clenshaw algorithm for a fast evaluation. Two variants for Semi-infinite transform have been presented. An application to the isobaric ideal gas heat capacity based on Woolley data enabled fitting within 0.02% in a range from 130 to 2000 K with 13 terms.

17. Joint session with WG PCAS

17.1 Report of Task Group on Transport Properties of Seawater, joint with SC SW and WG IRS

A. Anderko reported on behalf of the proposers of the Guideline on Thermal Conductivity of Seawater. The guideline is based on a correlation originally developed for atmospheric pressure, which has been extended by the pressure dependence. Originally, the formulation was expressed in terms of individual ionic species. Based on the previous Evaluation Task Group suggestions, the formulation was simplified such that the effect of solutes is expressed in terms of the absolute salinity.

17.2 R. Pawlowicz reported on behalf of the Evaluation Task Group for Seawater Thermal Conductivity. He reported about the tests performed. The Evaluation Task Group recommended to accept the Guideline.

17.3 **TPWS, SCSW, and IRS unanimously recommended the Guideline on Thermal Conductivity of Seawater to be approved by the EC.**

17.4 J. Hrubý reported on the progress toward improved ideal-gas properties of ordinary and heavy water (J. Hrubý, A. Harvey). Very accurate data for the partition function and related thermodynamic properties in the ideal gas state are available (Prof. A. Császár, Budapest) for the most abundant isotopologue $H_2{}^{16}O$, their uncertainties are being considered. Preliminary data for deuterated isotopologues have been provided. Deviations on the order of 1% from the present heavy water ideal-gas formulation have been observed (so this work will contribute to improving the new heavy water equation of state). In a discussion it was suggested that the differential evaporation of various isotopologues should be investigated. **A task group including D. Friend, R. Feistel and J. Hrubý has been formed to come up with an opinion of whether this topic is relevant for IAPWS.**

17.5 A. Harvey reported on the progress in the development of first-principles data to extend knowledge of the second virial coefficient of ordinary and heavy water (A. Harvey, G. Garberoglio, P. Jankowski, K. Szalewicz). Computations have been performed using newly developed potentials using classical, semi-classical, and full quantum, path integral approaches. The computed data enable to extend the temperature range for the 2nd virial coefficient for both H_2O and D_2O to lower and higher temperatures. Classical computations are in error already at quite high temperatures. Semi-classical computations provide correct second virial coefficients at least down to 300 K. This work will, among other things, provide 2nd virial coefficients to help the fit of the new formulation for thermodynamic properties for D_2O.

17.6 H. Miyamoto reported about modeling thermodynamic properties of mixtures of natural substances used as working fluids for heat pumps and organic Rankine cycle (H. Miyamoto, R. Akasaka, E. Lemmon). Four apparatuses were used to investigate thermophysical properties for isopentane. bellows volumeter 200 MPa, 600 K. Small sample, completely sealed.

18. IAPWS Certified Research Needs (ICRNs) – reported by A. Harvey

18.1 ICRN 27: Thermophysical Properties of Humid Gases and CO_2-Rich Mixtures - closing statement will be prepared by R. Span and A. Harvey. An ICRN on CCS-related research will be considered.

18.2 ICRN24: Thermal Conductivity of H_2O at Low Pressures and High Temperatures. New theoretical data have been prepared by R. Hellmann (Rostock). Since the IAPWS thermal conductivity formulation is finished, it was felt that there was no urgent need for further research, so the ICRN should be allowed to expire. A. Harvey will prepare a closing statement.

19. Reports on other TPWS activities

19.1 A. Harvey reported on the status of the Guideline on Fundamental Constants. No updates have been prepared. An update for the Vienna standard for ordinary water will possibly have an impact on the Guideline.

19.2 A. Harvey reported on the Advisory Note 2 (J. Cooper, A. Harvey). The Guidelines on supercooled water and on the spline-based table lookup method will be added and other aspects will be brought up to date.

20. Other Business

20.1 Report on International Collaborative Projects – no collaborative projects in the past year. See item 4 for a new proposal.

20.2 Discussion of IAPWS document numbering/designation. Various opinions have been expressed. Possibility of DOI numbering has been discussed. Editorial committee will prepare a suggestion.

20.3 Topics for 2018 ICPWS have been discussed. No new symposia have been suggested; members are encouraged to send ideas for sessions to J. Hrubý in the next few months. The conference will be prepared on the basis of 16th ICPWS in London.

21. Membership

Membership in TPWS has been terminated for Dr. Johannes Gernert (formerly of Ruhr Universität Bochum, Germany) because a change in his professional career does not allow him to follow the TPWS activities, and for Dr. Petra Spitzer who has retired from the PTB. Membership of Dr. Ines Stöcker ceased as she passed away.
Two proposals were submitted for TPWS membership: Dr. Hiroyuki Miyamoto (Toyama Prefectural University, Japan) and Prof. Dr. Ing. Karsten Meier (Helmut-Schmidt-University in Hamburg, Germany). Both proposals were unanimously approved by the Working Group.

22. Contribution to Press Release
The chair and the clerk of minutes were assigned to prepare the contribution to the Press Release.

23. Preparation of the Formal Motion to the EC
The chair and the clerk of minutes were assigned to prepare the Formal Motion to the EC.

24. Adjournment
The meeting was adjourned at 2:15 p.m. on Thursday, July 2.

Preliminary Agenda for the IAPWS Working Group: Thermophysical Properties of Water and Steam (TPWS)

Stockholm, Sweden, 29 June - 2 July 2015

1. Opening Remarks; Adoption of Agenda
2. Appointment of Clerk of Minutes
3. OPAL Web Space for Working Material for WGs TPWS, IRS, and SC SW, joint with WG IRS and SC SW (H.-J. Kretzschmar)
4. Potential International Collaborative Projects [Monday]
5. Industrial Requirements and Solutions for Steam Property Calculations, joint with WG IRS [Monday]
   - 5.1 Report of the Task Group "Industrial Advisory Note" (M. Hiegemann, B. Rukes, A. Singh, A. Harvey)
6. Proposal for an IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using Spline Interpolation, joint with WG IRS [Monday]
   - 6.1 Report of proposers (H.-J. Kretzschmar, M. Kunick, J. Hrubý, M. Duška, V. Vinš, F. di Mare, A. Singh)
   - 6.2 Report of Evaluation Task Group (A. Novy et al.)
   - 6.3 Formal consideration of the Guideline
7. Heavy Water Properties, joint with WG IRS [Monday]
   - 7.1 Report of Task Group on Heavy Water Thermodynamic Properties (R. Span, A. Harvey, S. Herrig)
   - 7.2 Report of TG for Heavy Water Transport Properties (J. Sengers, M. Assael, M. Huber; reported by A. Harvey)
8. Report of Task Group on Surface Tension of Ordinary Water (joint with WG IRS and SC SW) (V. Vinš, A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, J. Kalova, R. Mareš) [Monday]
9. Behavior of IAPWS-95 from 250 K to 300 K and up to 400 MPa: Evaluation Based on Recently Derived Property Data (W. Wagner, M. Thol) [Monday]
10. Humid Air Fugacity and Enhancement Factor, joint with SC SW
    - 10.1 Report of the proposers of "Guideline on a Virial Equation for the Fugacity of H_2O in Humid Air" (R. Feistel, O. Hellmuth, J. Lovell-Smith)
    - 10.2 Report of the Evaluation Task Group (A. Harvey, H.-J. Kretzschmar)
    - 10.3 Formal consideration of the Guideline by the Working Groups
    - 10.4 Next steps: Determination of the enhancement factor and saturated water vapor mole fraction (O. Hellmuth, R. Feistel, J. Lovell-Smith, J. Kalova, H.-J. Kretzschmar, S. Herrmann)
11. Metastable Water (joint with SC SW) [Tuesday]
    - 11.1 Background of supercooled water Guideline (V. Holten, M. Anisimov, J. Sengers)
    - 11.2 Report of Evaluation Task Group on Supercooled Water Guideline (J. Hrubý)

11.3 Formal consideration of the Guideline by the Working Group

11.4 Report on Task Group on Supercooled Water ICRN (O. Hellmuth, V. Holten, J. Sengers, J. Hrubý)

11.5 Formal consideration of Supercooled Water ICRN

11.6 Progress of measurements of density of supercooled water at elevated pressures (M. Duška, J. Hrubý)

11.7 Report of Task Group on Superheated liquid water, joint with WG IRS and SCSW (H.-J. Kretzschmar)

11.8 Report of Task Group on possible revision of IAPWS formulations for melting curves (V. Holten, A. Harvey, H.-J. Kretzschmar)

12. Report of Task Group on Extension of Range of Formulation for Thermodynamic Properties of Sea Water, joint with WGs IRS and SC SW (R. Feistel) [Tuesday]

13. Cooperation with other international bodies, joint with SC SW [Tuesday]

13.1 IAPWS/IAPSO/SCOR Joint Committee on Seawater, including updates to TEOS-10 (R. Pawlowicz)

13.2 Metrologia article on BIPM/IAPWS interaction (R. Feistel)

13.3 Cooperation with BIPM (Uncertainty Workshop) (R. Feistel)

13-IRS Separate IRS meeting for IRS future discussion (I. Weber).

14. Reports on seawater-related topics, joint with SCSW [Tuesday]

14.1 Best practices guide for density analysis (H. Wolf, S. Weinreben, H. Uchida, R. Pawlowicz)

14.2 The Conductance-Density Relation of Standard Seawater (Schmidt, Wolf)

14.3 Seawater Density Comparison (Schmidt, Wolf)

14.4 Nonlinearities in Seawater density measurements (Uchida)

14.5 Density anomalies in coastal waters (R. Pawlowicz, H. Uchida, F. Millero)

14.6 Update on GSW software toolbox (Feistel and Barker)

14.7 Update on seawater pH (Feistel and Camoes)

14.8 JCOMM intercomparison (Pang)

14.9 Density standards at Anton Paar (Laky)

15. Proposed new IAPWS seawater-related documents (joint with SCSW) [Tuesday]

15.1 Discussion on Guideline for Practical Salinity formula also covering the low salinity range.

15.2 Discussion on Supplementary Release for a simplified density equation for oceanographic use.

15.3 Appointment of Task Groups, if appropriate.

16. Reports on miscellaneous TPWS scientific topics (joint with WG IRS)

16.1 Thermophysical property research at Helmut-Schmidt-University in Hamburg (K. Meier)

16.2 A comparative study of $P_s(T)$ models for H_2O in the critical region (E. E. Ustyuzhanin, V. F. Ochkov)

16.3 Online calculation from IAPWS formulations (V. Ochkov, K. Orlov)

16.4 Innovative concept for fluid property approximations (M. Hiegemann)

17. Joint session with WG PCAS [Thursday morning]
    - 17.1 Report of Task Group on Transport Properties of Seawater, joint with SC SW and WG IRS (A. Anderko, A. Harvey)
    - 17.2 Report of Evaluation Task Group for Seawater Thermal Conductivity (R. Pawlowicz)
    - 17.3 Formal consideration of Guideline on Thermal Conductivity of Seawater
    - 17.4 Progress toward improved ideal-gas properties of ordinary and heavy water (J. Hrubý)
    - 17.5 Development of first-principles data to extend knowledge of the second virial coefficient of ordinary and heavy water (A. Harvey, G. Garberoglio, P. Jankowski, K. Szalewicz)
    - 17.6 Modeling thermodynamic properties of mixtures of natural substances used as working fluids for heat pumps and organic Rankine cycle (H. Miyamoto, R. Akasaka, E. Lemmon)
18. IAPWS Certified Research Needs (ICRNs)
    - 18.1 ICRN 27: Thermophysical Properties of Humid Gases and CO_2-Rich Mixtures (closing statement needed) (R. Span, A. Harvey)
    - 18.2 ICRN24: Thermal conductivity of water vapor
19. Reports on other TPWS activities
    - 19.1 Guideline on Fundamental Constants (A. Harvey)
    - 19.2 Advisory Note 2 (J. Cooper, A. Harvey)
20. Other Business
    - 20.1 Report on International Collaborative Projects
    - 20.2 Discussion of IAPWS document numbering/designation
    - 20.3 Topics for 2018 ICPWS
21. Membership
22. Contribution to Press Release
23. Preparation of the Formal Motion to the EC
24. Adjournment

Minutes of the IAPWS working group IRS, Stockholm, 29. June – 2. July 2015

(Numbering of topics follows TPWS agenda)

1. Ingo Weber opened the session for IRS at about 11 am, 29. June 2014. The agenda was adopted with an additional topic 13-IRS on the future of the WG.
2. Anurag Singh was appointed clerk of minutes.
3. Covered in TPWS / SCSW minutes.
4. Covered in TPWS / SCSW minutes.
5. Industrial Requirements and Solutions for Steam Property Calculations
   - Report of the Task Group "Industrial Advisory Note"

     Ingo Weber gave an overview on the "Industrial Advisory Note" and its brief history. Michael Hiegemann reported on the task. He suggested that either a document should be created that compiles all relevant existing documents in order to have a document that is specific and easy to refer to. The other option would be to extend the existing advisory notes #2 to reflect the relevant documents and revise it with a new title with separate sections for specific subjects that cover beyond thermodynamic properties => change to thermophysical properties. The WGs had a significant discussion on what kind of document to have in this regard. Final decision was not to make amendments to advisory note #2. Instead it was decided that a draft separate advisory note document for industrial needs specifically steam power industry will be created (Action item for the existing task group). Allan Harvey & Jeff Cooper will perform an updated to advisory note #2 to reflect current status.
6. Proposal for an IAPWS Guideline on the Fast Calculation of Steam and Water Properties Using Spline Interpolation (SBTL)

   6.1. Report of proposers

   Matthias Kunick gave a talk on the proposed guideline emphasizing on topics added since last years meeting, specifically the metastable region for application to IAPWS-IF97 and general application to the scientific formulation IAPWS-95. Questions on comparison of calculation time between SBTL applied to IAPWS-IF97 and SBTL applied to IAPWS-95, answer being that computing times are comparable. Michael Hiegemann commented that the method itself is generic.

   6.2. Report of Evaluation Task Group

   Adam Novy presented a report on validation/testing of SBTL. He reported that very convincing results came out of testing in various environments. It is the recommendation of the evaluation task group that the draft should be accepted.

   6.3. Formal consideration of Guideline

   Ingo Weber informed that the draft guideline had been distributed to the WGs members in February 2015. Comments were received on editorial topics of the guideline (e.g. structure of the document). The WGs voted and the technical content of the guideline was accepted unanimously. The document will be proposed to the EC for acceptance as an IAPWS guideline pending completion of the editorial changes. Ingo Weber thanked the authors for their extensive work on the topic.
7. Covered in TPWS / SCSW minutes.

8. Covered in TPWS / SCSW minutes.
11. Covered in TPWS / SCSW minutes.
12. Covered in TPWS / SCSW minutes.
11. IRS: Future of WG IRS

    Ingo Weber raised the question about the future of WG IRS because after acceptance of the SBTL guideline there will be no other product in the works. Discussion evolved on further topics for future work:

    - A few technical topics were identified (desalination, H2O-CO2 mixtures, erosion-corrosion on ST blades due to droplet formation, etc.) but either demand is not (yet) existing in industry or the topic is not within IRS scope.
    - It was discussed that for verification of IAPWS-IF97 software implementations a more extensive table of check points (more than currently available in the releases / supplementary releases) would be desirable.
    - Also the future of the industrial H2O properties standard was discussed. Probably no specific industrial formulation would be developed, rather a SBTL-type approach based on the scientific standard would be applied. However it currently seems that this topic is not valid unless there is a new scientific formulation.

    A potential proposal could also be to make WG IRS dormant for the time being. Danger with this is the loss of members due to missing justification for travel to meetings. The discussion will continue throughout the year and at the next meeting in 2016.

16. Covered in TPWS / SCSW minutes.
17. Covered in TPWS / SCSW minutes.
18. IAPWS Certified Research Needs (ICRNs)

    No ICRNs need WG IRS attention.

20. Other business:

    20.1. Report on International Collaborative Projects

    No International Collaborative Projects need WG IRS attention.

    20.2. Discussion on IAPWS document identification

    Covered in TPWS / SCSW minutes.

    20.3. Symposia for 17th ICPWS in Prague, 2018

    Covered in TPWS / SCSW minutes.

21. Membership:

    No changes in membership are necessary.

22. Contribution to Press release will be done by the WG chair
23. Formal motion to the EC will be prepared by the WG chair
24. Ingo Weber adjourned the meeting at about 14:30, 2. July 2015

Agenda for the IAPWS Working Group: Industrial Requirements and Solutions (IRS)

Stockholm, Sweden, 29 June - 2 July 2015

(Numbering of topics follows TPWS agenda)

1. Opening Remarks; Adoption of Agenda
2. Appointment of Clerk of Minutes
3. OPAL Web Space for Working Material for WGs TPWS, IRS, and SC SW, joint with WG TPWS and SC SW (H.-J. Kretzschmar)
4. Potential International Collaborative Projects
5. Industrial Requirements and Solutions for Steam Property Calculations, joint with WG TPWS
   - 5.1 Report of the Task Group "Industrial Advisory Note" (M. Hiegemann, B. Rukes, A. Singh, A. Harvey)
6. Proposal for an IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using Spline Interpolation, joint with WG TPWS
   - 6.1 Report of proposers (H.-J. Kretzschmar, M. Kunick, J. Hrubý, M. Duška, V. Vinš, F. di Mare, A. Singh)
   - 6.2 Report of Evaluation Task Group (A. Novy)
   - 6.3 Formal consideration of Guideline by the Working Groups
7. Heavy Water Properties, joint with WG TPWS
   - 7.1 Report of Task Group on Heavy Water Thermodynamic Properties (R. Span, A. Harvey, S. Herrig)
   - 7.2 Report of TG for Heavy Water Transport Properties
8. Report of Task Group on Surface Tension of Ordinary Water, joint with WG TPWS and SC SW (V. Vinš, A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, J. Kalova, R. Mareš)

11. Metastable Water, joint with WG TPWS and SC SW
    - 11.1 … 11.6 WG TPWS and SC SW topics
    - 11.7 Report of Task Group on Superheated liquid water, joint with WG TPWS and SCSW (H.-J. Kretzschmar)
    - 11.8 WG TPWS and SC SW topics
12. Report of Task Group on Extension of Range of Formulation for Thermodynamic Properties of Sea Water, joint with WGs TPWS and SC SW (R. Feistel)

13-IRS. Discussion on the future of WG IRS (I. Weber)

16. Reports on miscellaneous TPWS scientific topics, joint with WG TPWS
    16.1 Thermophysical property research at Helmut-Schmidt-University in Hamburg (K. Meier)
    16.2 A comparative study of $P_s(T)$ models for H2O in the critical region (E. E. Ustyuzhanin, V. F. Ochkov)
    16.3 Online calculation from IAPWS formulations (V. Ochkov, K. Orlov)
    16.4 Innovative concept for fluid property approximations (M. Hiegemann)

17. Joint session with WG TPWS and WG PCAS

    17.1 Report of Task Group on Transport Properties of Seawater, joint with SC SW and WG TPWS (A. Anderko, A. Harvey)

    17.2 … 17.6 WG TPWS and WG PCAS topics

18. IAPWS Certified Research Needs (ICRNs)

20. Other Business
    20.1 Report on International Collaborative Projects
    20.2 Discussion on IAPWS document identification
    20.3 Symposia for 17th ICPWS in Prague, 2018

21. Membership

22. Contribution to Press Release

23. Preparation of the Formal Motion to the EC

24. Adjournment

2015-June-29

Ingo Weber (Chair)

Minutes of the joint meeting of TPWS/IRS/SCSW

Michael Hiegemann, Stockholm, June 30th

1. The session was opened by Alan Harvey. The agenda was corrected with addition of item 14.8 concerning a JCOMM intercomparison test (Pang) and item 14.9 on density standards at Anton Paar (Laky). During the discussion of item 13 the IRS will be discussing on the future of IRS. The agenda was adopted by the working groups.
   Prof. Kretzschmar informed the attendees of Ines Stöcker, who passed away last week. Ines was involved in the preparation of several IAPWS papers and participated in several IAPWS meetings.

2. As Clerk of minutes were nominated: Jan Hruby for TPWS, Anuragh Singh for IRS and Michael Hiegemann for SCSW.
3. A
4. A
5. A
6. A
7. A
8. a
9. a
10. Humid air fugacity and enhancement factor (joint with SCSW)

10.1 Rainer Feistel reported on the work on a "Guideline on a virial equation for the fugacity of H2O in humid air". The fugacity is the most promising candidate to determine the relative humidity. The coefficients of the virial equation are derived analytically from the equations of state of air and water. The guideline comes with an estimate of the uncertainties.

10.2 Alan Harvey presented the results of evaluation task group on the above mentioned guideline. All numerical data was recomputed and compared to the data given in the guideline, with complete coincidence of all figures given. The guideline is considered complete and correct in its description and thus being recommended by adoption by the IAPWS executive committee.

10.3 Olaf Hellmuth reported on the "Determination of the enhancement factor and the saturated vapor mole fraction". There is an interest in this entity due to its influence of the global warming. The enhancement factor is determined as a virial approximation. The set of equations developed can be evaluated also using parts of the industrial formulation IAPWS-IF97 as the limits of application have been defined accordingly. The enhancement factor needs to be computed iteratively, and the paper comprises a method to determine starting guesses.

10.4 Olaf Hellmuth reported on behalf of a group (O. Hellmuth, R. Feistel, J. Lovell-Smith, J. Kalová, H.-J. Kretzschmar, S. Herrmann) suggesting next steps concerning the humid air properties. A virial approximation of the enhancement factor should be developed. Other topics discussed included an analytical approximation for the low-density water mole fraction in supercooled water (c.f. Item 17.1), an analytical correlation of the ratio of relative humidity to the relative fugacity, problems of metastable regions with respect to the suggested developments.

11. (MH not participating)

12. Reiner Feistel presented the results of the task group on the "Extension of range of formulation for thermodynamic properties of sea water". The report is an update of his talk at the IAPWS 2013 meeting. Data measurements will be finished by David Safarov In autumn 2015. The development of a new speed of sound sensor has been finished by Christoph von Rhoden and first data at atmospheric pressure has been measured; however his contract has come to an end and plans for further data are uncertain. The existing data could be included in a new correlation. Work on this correlation could start in spring 2016.

13. Collaboration with other international bodies (joint with SCSW):
    13.1 Rich Pawlowicz talked about work of the IAPWS/IAPSO/SCOR Joint Committee on Properties of Seawater (JCS). He presented an updated org chart of governmental and non-governmental organizations in order to clarify where JCS could fit. The members and work groups of JCS are well defined. TEOS-10 is becoming a practically applied standard, indicated by the high number of software downloads and by the fact that there are several large climate models that have TEOS-10 support now. Ocean measurements are going on and focus on anomalies of salinity and of the chemical composition. The salinity/density subgroup are about to develop a best practice guide for high precision density measurements. The chemical composition of standard sea water is to be explored by pooling of experiences. The ph subgroup targets to write a more cook-book like document on the details of the creation of TRIS buffers. The Pitzer model is followed further. The relative humidity subgroup has written a technical report on the definition of Relative Humidity. The members of TPWS and SCSW support the directions taken by the work groups.

Reiner Feistel attended a Marine Instrument Workshop in China. Trevor McDougall was awarded the Australian Laureate Fellowship with a 2.7 AUS$ funding over 5 years for the further development of thermodynamic tools and other instruments, i.e. to support TEOS-10.

13.2 The BIPM/IAPWS collaboration is ongoing and was presented by Reiner Feistel. The collaboration was initially triggered by the wish to develop an SI traceable salinity standard. The collaboration is being institutionalized by a position paper submitted to Metrologia in February 2015. It was decided to split the paper, such that there is a series of four papers and a substantial supplementary appendix now. The papers express a strong relation to climate research.

13.3 Reiner Feistel reported on a workshop with BIPM on measurement uncertainty in June 2015. The workshop was predominantly covering Bayesian Methods for the estimation of uncertainties to be part of a Guide to the expression of Uncertainty in Measurement (GUM). Reiner Feistel et al. have written a respective article on the uncertainty of correlated equations. The approach includes the requirement to publish the covariance matrix in addition to the coefficients of a correlation to enable the calculation of the errors. The new requirement will urge authors to apply a more rigorous analysis of the data published.

14. Sea water related topics (joint with SCSW):

14.1 Rich Pawlowicz presented work on the task “Best practices guide for density analysis”. The guide shall encourage researchers to carry out more density measurements and is precise on all practical aspects from sample preparation to the execution of the measurement itself. There are some remaining issues on the sequence of measurements, concerning the linearity of the Anton-Paar measurement equipment and where to publish the document.

14.2 Hannes Schmidt explained the “Conductivity-density relation of standard seawater” in his talk. The uncertainty of the density measurement can be reduced by use of a substitution method in which alternating pure water and seawater samples are measured. This method is able to bring the uncertainty down to less than 2 g/m3 at atmospheric pressure and to less than 36 g/m3 for very high pressures. The measurement time is between 16 and 48 hours per point. The method is applicable from 5 to 35°C and up to pressures of 65 MPa. A number of possible sources of uncertainty were investigated.

14.3 The same speaker then reported on the “Seawater density comparison”, targeting to compare vibrating tube densitometer measurements delivered by 11 groups. Some four results were analyzed in more detail, and it was found that corrections for aeration and for isotopic compositions need to be carried out consistently. After the execution of the corrections the results compared very well with the reference value from PTB.

14.4 Hiroshi Uchida discussed “Nonlinearities in seawater density measurements”. Results of hydrostatic weighing are compared with calculated results from TEOS-10 and with measured results from the Anton Paar devices DMA5000M and DMA5000s (relative to pure water), where a correction for the results of the latter device has been recommended. There was a discussion about this nonlinearity correction, which Hannes had investigated thoroughly but found to be too small to worry about. However, the remaining alternative, that Standard Seawater had a density that differed from that described by TEOS-10, was not well received.

14.5 Rich Pawlowicz reported on “Density anomalies in coastal waters”. TEOS-10 allows for variations of the chemical composition of sea water. Different areas not being “open ocean” were discussed, with a focus on river salt input. There is no generalization about major ions in rivers possible, but salinity anomalies can be correlated. However, the scatter about predictions involving river water is large. These remaining differences are systematical, and could result from sulphate reduction processes that do occur in sediments on shelves. However, there is no definite conclusion yet.

14.6 Reiner Feistel showed some slides on the GSW software toolbox. Version 3.05 was released in May 2015 and contains plenty of new programs. New ice functions have been added as well as a new function of specific volume.

14.7 He then reported on the IUPAC project on sea water pH, which is particularly concerning the activity of the H+ ion, described by a Pitzer equation. There is still a difference between the activity measured and the current Pitzer equation.

14.8 Yanan Li presented the NCOSM institute and their certification process. NCOSM is a government-run marine measurements institute in China. They recently carried out a JCOMM salinity intercomparison project. Two different types of sea water samples were prepared and shipped to 17 (?) different partner institutes. Only a few of the reported results differed considerable from the reference values.

14.9 Barbara Laky reported on the accreditation of the Anton Paar GmbH as a calibration laboratory for reference standard for density according to ISO 17025. The company is now accredited for a scope of liquid densities from 650 to 1550 kg/m3 at 15 to 40°C and at 1 atm. The smallest uncertainty is 20 g/m3.

15. New IAPWS sea water related documents (joint with SCSW):
    15.1 Rich Pawlowicz, as chair of JCS, proposed the question "How do you maintain a standard?". The presentation contained information about proposed updates of the salinity anomaly algorithm and other algorithms in TEOS-10. Actually, TEOS-10 has changed in the past wrt the correction of errors and the replacement of some equations but the method for doing so was rather informal. A proposed formal procedure for implementing these improvements was sketched, resembling to practices in software engineering, reaching from paper publication, JCS involvement, formal agreement, beta version circulated to the JCS by an independent evaluator, and conversion of final beta to official version. Some changes to the initial proposal by Rich were included during the discussion in the meeting. There is a need for versioning and to archive older versions which are provided via the web page now. The formalization of the PSS-78 standard needs to be formalized and documented.

The formal procedure was then accepted by SCSW on behalf of IAPWS as the method by which TEOS-10 updates should be carried out.

15.2 Discussion on a supplementary release for a simplified density equation for oceanographic use. A task group was nominated, see below.

15.3 A task group headed by Rainer Feistel (further participants Rich Pawlowicz and Allan Harvey) was set up to list all IAPWS documents being part of TEOS-10, i.e. to describe the TEOS-10/IAPWS relationship, with the intention to write an Advisory Note. A further task group headed Rich Pawlowicz (further participants Trevor Mcdougall with co-opted expert Paul Barker) to prepare a supplementary release for a simplified equation of the density of water for oceanographic use. The respective evaluation task group is headed by Allan Harvey (further participants Rainer Feistel).

Finally, a discussion was held on the desirability of continuing cooperation between IAPWS and BIPM (leading to releases relevant to relative humidity problems) by meeting with the BIPM's CCT working group in Paris in April/May of 2016. The SCSW and TPWS WG agreed that a proposal should be put forward to the Executive to send an IAPWS representative from SCSW to this meeting, with an estimated cost of EUR1000.

Under new business was a continuation of item 13.3: A discussion between Reiner Feistel and Jan Hruby on the covariance method ended up in the proposal to set up a task group exploring the impacts of that method on IAPWS work. Members of the proposed task group are Reiner Feistel, Jan Hruby, Steffen Seitz, Jeremy Lovell-Smith, and Dan Friend.

PCAS WG Minutes

Present:

Andre Anderko (Chair)	aanderko@olisystems.com
Frantisek Marsik	marsik@it.cas.cz
Dave Guzonas	david.guzonas@cnl.ca
Masaru Nakahara	nakahara@scl.kyoto-u.ac.jp
Ken Yoshida	yoshida.ken@tokushima-u.ac.jp
Kaj Thomsen	kth@kt.dtu.dk
James Bellows (Clerk of minutes)	jcbellows2@aol.com

Andre Anderko opened the meeting. The agenda was approved with addition of David Guzonas' presentation. James Bellows was appointed clerk of minutes.

Minutes of 2014 were approved.

A short round-table of scientific work of attendees was held.

The committee read through the IAPWS Guidelines list and found that we should possibly examine: Guideline: "Solubility of Sodium Sulfate in Aqueous Mixtures of Sodium Chloride and Sulfuric Acid from Water to Concentrated Solutions, from 250°C to 350°C" (September 1994) (This is a revision of the 1990 Guideline). PCC considers this topic low priority.

Some of the antimony and lead work report by Dave Guzonas potentially leads to guidelines. Peter Tremaine is working on D_2O effects, which might also be possible guidelines.

We will maintain a list of long term projects, which includes matters that were not quite ready for action at the time.

Presentations were made:

- Ken Yoshida: Recent research trends in the conversion of carbohydrate biomass into value-added compounds in aqueous solutions
- Jim Bellows: Amine Project Progress Report
- Andre Anderko: Thermodynamic Modeling of Aqueous Systems Containing Amines and Hydrochlorides
- Dave Guzonas: Water Chemistry of Supercritical Water-cooled Reactors

Presentations at the joint TPWS-PCAS workshop:

- Andre Anderko, Report of Task Group on Transport Properties of Seawater
- R. Pawlowicz, Report of Evaluation Task Group for Seawater Thermal Conductivity
- J. Hruby, Progress toward improved ideal-gas properties of ordinary and heavy water
- A. Harvey, Development of first-principles data to extend knowledge of the second virial coefficient of ordinary and heavy water
- H. Miyamoto, Modeling thermodynamic properties of mixtures of natural substances used as working fluids for heat pumps and organic Rankine cycle.

Joint TPWS-PCAS Guideline on the Thermal Conductivity of Seawater is formally submitted to the Executive Committee for approval

Ken Yoshida will be working on a self-diffusion guideline.

Jim Bellows will be working on the amine guideline project; ethanolamine is the first one

Professor Kaj Thomsen was elected member of the working group.

Long term list

- Antimony solubility guideline
- Lead solubility guideline
- Solubility and deposition of corrosion products (to be split up into specific materials later)
- Review of sodium sulfate guideline of 1994
- Self-diffusion in high temperature and supercritical water
- Free energy of gases and organic materials
- Hydration of gases and other solutes—following work of Jana Ehlerova
- Reactivity of hydrogen, carbon dioxide, carbon monoxide, organic compounds etc. in high temperature and supercritical water—invited paper at next ICPWS

(Do we have presentations from previous meetings that should become guidelines?)

IAPWS
Power Cycle Chemistry (PCC) Working Group

Minutes of IAPWS PCC WG Meetings

Location: Stockholm, Sweden, June 29, 2015 – July 3, 2015

Acting Chairman: Michael Rziha
Members present: See PCC Attachment A

Monday 29th June 2015

Chairman M. Rziha welcomed all participants and working group members.

Agenda

Amendments / Adoption of Agenda

There were following changes and amendments to the drafted agenda:

- Adding "Numbering of Technical Guidance Documents" as third item to No 5 of PCC WG Meeting on Monday 29th June 2015
- Presentation of R. Blum "Efficient and clean thermal power plants for the future" was shifted from the joint PCC/PCAS WG Meeting on Tuesday to the IAWPS Symposium on Wednesday.
- Presentation of O. Yegoshina "Operative estimation of cycle chemistry at thermal power plants using statistical algorithms" was withdrawn.

Week program: split up of PCC for joint workshops and task groups.

M. Rziha described the proceedings for the WG meetings, summarized the overall schedule and gives an outlook of the upcoming meeting.

Appointment of Clerk of Minutes

A. Drexler was asked and agreed to act as the Clerk of Minutes.

Approval of Minutes of PCC WG in Moscow, 2014

The minutes were approved without any corrections.

Progress Reports on PCC Activities 2014/2015

Review of Actions from last PCC WG Meeting

Film-forming amine: Task group (W. Hater (chair), T. Petrova, W. Cook, M. Lendi) to prepare white paper on film forming amines for next meeting – provide by April 30, 2015.
Status: TGD on FFA is under preparation. Target is to have the TGD ready for EC approval by next year's IAPWS annual meeting (see also topic 5.4).

Corrosion Product Sampling for Cycling Plants: Task group includes: D. Addison (chair), P. McCann, W. Cook
Status: ongoing – task group will have the TGD ready for EC approval by next year's IAPWS annual meeting.

Demineralized Make-up Water. Task group includes Gary Joy (chair), Paul McCann, Kirk Buecher, Jim Bellow, H. Hirano and Michael Rziha
Status: ongoing – Task group have the TGD ready for EC approval by next year's IAPWS annual meeting

International Collaboration

No international collaborations are currently ongoing. B. Dooley asks the PCC WG members for proposal. W. Cook and D. Addison proposed an international collaboration regarding a 2-electrode and/or 3-electrode high temperature electrochemistry flow cell. The PCC WG members agreed to present this proposal of an international collaboration to the EC.

W. Cook and D. Addison to prepared a proposal for the EC decision.

IAWPS TGD – Status and future developments

Status of present and future development

B. Dooley gives a presentation of the background, content and target of the IAWPS TGDs. Currently 6 technical guidance documents are released (see http://www.iapws.org/techguide.html) and are being recognized as the standard documents internationally.

Approval on amendments of TGDs

The amendments for the TGD on instrumentation, as well as for the 2 TGD's on treatments (Volatile and Phosphate / Caustic) for cycling and fast start up plants had been finished and approved by PCC. Those are ready for approval by EC to be published now.
Instrumentation. F.-U. Leidich proposed to include a section regarding the pros and cons of the three available degassing techniques for measuring of degassed conductivity in the TGD amendment. After discussion PCC WG decided not to add an amendment, but to settle a small task group providing information on the next meeting.

Task Group: F.-U. Leidich (Chair), M. Lendi, M. Hellman, M. Rziha
Action: to summarize available public information for the next meeting in 2016.

Corrosion product sampling. There is need for support regarding load-follow operation.

A task group has been established to prepare a white paper

> Task Group: D. Addison (Chair), K. Tompson, F.-U. Leidich, M. Rziha, A. Whitney, D. Lister
> Action: to prepare a draft of the white paper until End of December 2015

Numbering of IAWPS Technical Guidance Documents

M. Rziha asked the WG members regarding the introduction of a numbering system of the TDGs. W. Hater and P. Mc Can supports such a system. W. Cook pointed out that such a system has to be consistent within all IAWPS working groups. M. Rziha proposed to add the year of revision. The WG members decided to support the development of a numbering system of the TGDs.

> Action: M. Rziha to inform the editorial committee about the decision.

Setting of new task groups

Film-forming amine. B. Dooley proposed to form a task group for preparing a TGD on film-forming amines as there are lot of uncertainties and open questions, i.e. no universal guideline is existing. He recommends the participation of all vendors of filming amines.

> Action: Task Group Members to prepare a skeleton of draft: M. Vermeersch, F. Dyachenko, P. Hattingh, A. Witney, A. Drexler, D. Lister, W. Hater (Chair), M. Lendi within this week

HRSG HP Evaporator Tube Sampling and Deposits analysis.

Task group members: P. James, P. McCann, B. Dooley, P. Hattingh

Demin Water. G. Joy gives an update regarding work have been done for the TGDs of demineralized make-up water, which could not be prepared.

Task Group: G. Joy, P. McCann, K., Bruecher, J. Bellow, H. Hirano, M. Rziha

> Action: Task group will prepare a skeleton within this week

TGDs and ICRN

Geothermal. D. Addison gives a presentation on the white paper. The white paper will be circulated reflecting New Zealand experience to all interested parties and PCAS to ask for feedback, comments etc. by end of 2015.

> Action: D. Addison circulated white paper

ICRNs – Review and possible new additions

Update Amine Guideline

Jim Bellows gave an overview of the current status of the work. He mentioned that there are might be potential for a future ICRN on acetic acid. The next steps will be discussed in 2016.

ICRN#17 Amines

The draft of the ICRN#17 was never be approved by the EC. M. Rziha proposed not to finalize the draft as J. Bellows is working on the amine guideline and a TGD on film-forming amine is being prepared. B. Dooley noted that the #17 will be never used for an ICRN in future, so there is no issue stopping the work on it. The WG group decided to stop any work on the ICRN#17.

ICRN#22 PTZ

The work on the ICRN#22 is not finished yet. Mr Stasny proposed to extent the ICRN for another 2 years. As A. Rudge has left the IAWPS, Mr. Stasny will remain the responsible alone.

> Action: M. Rziha will bring up this proposal to the EC for approval.

ICRN#29 Sampling

D. Lister prepared a draft on this ICRN, but due to misunderstandings it was missed in the minutes of meeting in Moscow. M. Rziha will circulate the proposal to the members of PCC WG and ask for comments within one month. Afterwards the proposal will be passed to the editorial committee.

> Action: M. Rziha will inform the EC regarding this procedure.

ICRN#26 Aluminum

M. Rziha reminds that the ICRN#26 is in place and asks for contribution.

> Action: G. Joy, F.-U. Leidich and M. Rziha will provide an overview presentation at the meeting 2016 in Dresden.

Chemical guidelines for solar thermal power plants

G. Joy raised the question of preparing a guideline for solar thermal power plants. M. Rziha mentioned that the interests in solar thermal power plants have been decreased in the last years according to his opinion. B. Dooley supports this and would put low priority on such a guideline. It was decided not to follow up this issue.

Need for new ICRNs

G. Joy proposed to set up a new ICRN regarding the behavior of condensate polishing plants on the unit cycle. M. Rziha mentioned that great work was conducted by K. Daucik in 1990s and also an ICRN on Decomposition of Ion Exchange Resins was in place (ICRN#18).

> Action: G. Joy will contact K. Daucik and probably prepare a draft for a new ICRN until the next meeting in 2016.

There were no further proposals for new ICRNs.

Activities of standard organizations

EN Standard 12952-12:2003 and 12953-10:2003

M. Rziha gave a presentation prepared by P. McCann who has left the meeting earlier dealing with the European Standards

- 12952-12:2003 (Water-tube boilers and auxiliary installations - Part 12: Requirements for boiler feedwater and boiler water quality) and
- 12953-10:2003 (Shell boilers - Part 10: Requirements for boiler feedwater and boiler water quality)

This PCC WG discussed how to proceed and how to approach the European standard committee for a contribution of IAWPS.

> Action: The national member should be approached the European standard committee via their national IAWPS committees.

> Action: G. Joy will contact ISO and gathering information which the target to send an IAWPS delegate to relevant international standards committees.

Technical Guidance Documents

TGD on film-forming amines

W. Hater presented the results of the Sub-Task Group meeting. The goal of the TGD is to provide guidance whether FFA can be used and are an option for particular fossil or combined cycle plant.

> Action: Sub-Task Group to provide a TGD until the upcoming meeting 2016.

S. Uchida noted that H. Hirano and K. Fruzzetti would like to participate also the sub-task group. After setup of the draft version of the TGD the nuclear group will discussed the preparation of an addendum.

> Action: W. Hater to distribute the draft version of the TGD to the nuclear group within PCC.

TGD on Monitoring of corrosion product sampling in cycling power plant

D. Addison gives an overview of the results gathered within this week. M. Rziha noted that start-up and shut-down of power plants are nowadays much faster than in the past, which has an influence on the corrosion products. D. Lister noted that the iron solubility change should be also considered

> Action: Task Group to prepare a white paper for the 2016 meeting.

TGD on Demin Water

G. Joy gives an update of the results of the task group meeting. B. Dooley remarked that the TGD should definitely include the nuclear plants. M. Rziha supported that by mentioning the similarity of demin water plants in nuclear and fossil plants.

Action: Task group to provide a TGD until the upcoming meeting 2016

Discussion of future PCC activities and task groups

The PCC WG agreed that no further task groups are needed. M. Rziha appreciated the huge process that PCC made since the last 10 years.

B. Dooley asked regarding the status of creating an open and closed area on the OPAL webserver. (see EC minutes of 2014).

Action: M. Rziha to address this issue at the EC meeting.

A member of the Swedish committee proposed to conduct a short introduction of each speaker prior their presentation.

Action: M. Rziha to conduct in the next meeting as proposed

F.U. Leidich proposed to create a kind of “yellow pages” of all PCC WG members.

Action: M. Rziha to present at the EC meeting.

PCC Public relations

The article published in the PowerPlant Chemistry Journal reporting about the annual meeting should be continued.

Action: M. Rziha to take care of provision of an article to Power Plant Chemistry Journal.

M Rziha encouraged the PCC WG members who are acting in an organizing committee of conference dealing with IAPWS issues to bring IAPWS in by using the logo etc.

D. Lister recommends using the well-known steam table as an argument to increase the awareness level of IAPWS. S. McGee brings up to establish a kind of an “IAPWS slogan”. W. Hater noted to update the Wikipedia IAPWS item.

W. Hater proposed that update the IAPWS Website with a new lay-out as of 2015 standard.

Action: M. Rziha to present these proposals at the EC meeting.

Priority list review

The priority list was not continuously renewed in the last years. M. Rziha ask shall we reanimate the priority list or to close the list and do not continue for future.

B. Dooley noted that the process is out of date, but the PCAS chairman should be informed if the list is withdrawn as the list was used in the past for collaboration between PCC and PCAS.

The priority list will be withdrawn.

Action: M. Rziha informs the PCAS Chairman.

Changes in the PCC Membership and Election of Officers

Election of Officers

K. Tompsson resigned as vice-chairman of the PCC working group. M. Rziha appreciated his contribution and work in the past. M. Rziha proposed F.-U. Leidich as vice-chairman. No objections were there.

S. Uchida has to step down from the IAWPS activities. M. Rziha thanks for his good contributions and very good contributions since many years. W. Cook will take over the chair of the nuclear group after the meeting this year.

Changes in the PCC Membership

- Roger Lundberg (Sweden) was proposed by M. Hellman and seconded by M. Rziha
- Nobuo Ishihara (Japan) was proposed by S. Uchida and seconded by D. Lister
- Keith Fruzzetti (USA) was proposed by S. Uchida and seconded by W. Cook
- Joung Hae Lee (Korea) was proposed by M. Rziha and seconded by M. Hellman

PCC unanimously accepted these new members.

Dates and venue of the next meeting

Annual Meeting 2016

The meeting in 2016 will be 11 – 16 September 2016 in Dresden (Germany).

17th ICPWS

Planning begin of September 2018 in Prague.

Action: M. Rziha will proposed late August instead of begin of September to the organizing committee due to probably conflict with NPC2018, EUROCORR, opening of university.

Proposed Topics / Suggestion of PCC WG:

- Water treatment by membrane techniques
- Recycle of water / zero liquid discharge
- Chemistry in cycling plants
- Geothermal chemistry
- Air cooled condenser ➔ operational chemical experience
- Experiences with USC plants
- Nuclear power
- Condensate Polishing
- Sampling and Instrumentation
- High Temperature oxidation
- Aluminum in water-steam cycle
- Seawater cooling and discharge
- Operational experience with new treatments chemicals (PAA, FFA, etc.)

Miscellaneous and Adjournment

M. Rziha asked for any further items of discussion, there were none.

M. Rziha thanks all working group member for the fruitful and productive meeting and appreciated their contribution.

Adjournment 14:30 hours.

IAPWS
Power Cycle Chemistry (PCC) – Nuclear Session

Minutes of IAPWS PCC Nuclear Session Meeting

Location: Stockholm, Sweden
Date: 30 June 2015, 10:30 – 12:00

Acting Chairman: S. Uchida (Japan)
Participants: Derek Lister (Canada), Willy Cook (Canada), Steve McGee (Canada), Keith Fruzzetti (USA), Andreas Drexler (Germany), Nobuo Ishihara (Japan), Hideo Hirano (Japan), Joung Hae Lee (Korea)

S. Uchida welcomed all participants.

IAPWS nuclear overview

S. Uchida gave an overview about IAPWS documents

- IAPWS certified research needs (ICRN) and
- IAPWS Technical guidance documents (TGD).

and the release process and timeline of those documents according to IAPWS statutes. He provided a list of ICRNs and TGDs and a few examples (see attachment).

The different objectives of Guidelines and Technical Guidance Documents were described.

Nuclear TGDs – Future possibilities

Issuing a technical guidance for e.g. instrumentation for nuclear is quite challenging due to the extending documents issued by many other institutes and organizations (EPRI, VGB others) that are working in this field.

K. Fruzzetti supports the ICRN from an EPRI perspective as an interesting and useful tool for deriving areas for R&D. IAPWS technical guidance documents on a high level (i.e. generic) are seen as complementary to existing guidelines.

The participants discussed possible topics which could be covered by TGDs. Two topics were mentioned:

(a) Film-forming amine technology.
It was agreed that it would be beneficial to add a separate section to the TGD on film-forming amines currently in preparation by the PCC task group. H. Hirano, K. Fruzzetti and A. Drexler announced their wish to take part in creating such a section.

(b) Sampling.
It was agreed to set up a new separate TGD for sampling in NPP in 2016. It was mentioned that due to increasing load follow operation of NPPs this topic is quite interesting for operators. N. Ishihara, K. Fruzzetti and A. Drexler announced their wish to take part in creating this TGD.

Contribution to the ICPWS

S. Uchida gave an overview about the last Conferences in Kyoto, Berlin and Greenwich and reminded on the upcoming conference in 2018 in Czech Republic. K. Fruzzetti noted that the Nuclear Plant Chemistry Conference in 2018 is planned to take place between mid-September and mid-October 2018 in US (San Francisco).

S. Uchida remarked on the next IAPWS annual meeting in 2016 (Dresden) and the following in 2017 (Kyoto).

Miscellaneous

The leadership of S. Uchida of the Nuclear Group is recognized and appreciated. W. Cook will take over the Chair within the PPC WG after the current meeting.

Proposal for Young Scientist IAPWS Fellowship Project

Towards an IAPWS Guideline for the Thermodynamic Properties of Supercooled Heavy Water

IAPWS Sponsors

Mikhail A. Anisimov
Institute for Physical Science and Technology
and Department of Chemical and Biomolecular Engineering
University of Maryland, College Park, MD 20742, USA

Jan Hrubý
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Young Scientist

Michal Duška
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Academy of Sciences of the Czech Republic
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Czech Republic

June 29, 2015

Abstract

Support is requested for an IAPWS Fellowship for a young scientist, Michal Duška, to pursue research "Towards an IAPWS guideline for the thermodynamic properties of heavy supercooled water"

1. Introduction

During the past decades considerable amount of experimental information for thermodynamic properties of supercooled heady water has become available. These experiments have revealed the anomalies similar to those observed in supercooled ordinary water. One theoretical possibility is the suggested presence of a metastable liquid-liquid critical point in supercooled water.

In a previous project supported by IAWPS a fundamental equation for the Gibbs energy as a function of temperature and pressure of state for cold and supercooled liquid H_2O (ordinary water substance) was developed in this guideline is a fundamental equation for the Gibbs energy as a function of temperature [1]. A draft of Guideline on Thermodynamic Properties of Supercooled Water, based on this equation, was presented to IAPWS for further consideration.

The project proposed will not only enable IAPWS to be actively engaged in a subject of considerable contemporary scientific interest , but it is also of direct relevance to IAPWS, since the equation of state of heavy water has been recently presented. We do think it should be possible to develop a reliable guideline for the thermodynamic properties of supercooled heavy water at least in the range of temperatures and pressures of direct relevance to an IAPWS.

2. Young investigator

We have found a young scientist, Michal Duška, from the Technical University Eindhoven who is uniquely qualified to pursue this research. The Curriculum Vitae of Michal Duška was provided.

3. Implementation of project

We request IAPWS support for a 9-months stay of Michal Duska at the University of Maryland from September 1 2016 till May 31, 2017. A report on the research to be completed under this project will be reported at the 2017 annual meeting of IAPWS and at the following Water Conference.

2. Budget (in £ GBP)

Subsistence for 9 months: IAPWS Young Scientist Grant..... £17,490

References

[1] Holten, V., Sengers, J.V., and Anisimov, M.A., Equation of state for supercooled water at pressures up to 400 MPa, *J. Phys. Chem. Ref. Data* **43**, 043101 (2014)

Attachment: Curriculum Vitae of Michal Duška

Proposal for IAPWS International Collaboration

D. Addison & W. Cook
New Zealand and Canada
29th June 2015

Overview:
IAPWS ICRN #25 [ref. 1] describes the need for high temperature data on the effects of combined anion contamination on the corrosion of boiler materials. Industry guidelines (i.e. IAPWS TGD's) specify administrative and action limits for Cl^-, SO_4^{2-}, etc. to prevent corrosion, impurity concentration and under-deposit corrosion; however, most of these limits are not fully validated by rigorous experimental evidence. The intent of this International Collaboration project would be to capitalize on previous development of electrochemical corrosion sensors (for example, see ref. 2) for use in simulated boiler/evaporator water and to establish and commission the facility and methods required to conduct targeted, long-term testing for materials in conventional boilers, HRSG's, industrial plants, and nuclear steam generators.

Scope:
Design and construct two-electrode and/or three-electrode high-temperature electrochemical flow-through cell. Similar to work conducted and described in reference 2. Collaborative effort between W. Cook and D. Addison – primarily through correspondence (first six month period).

Upgrade test loop at UNB, install and commission electrochemical test system. Run baseline testing to verify and validate experimental method. Collaborative effort between W. Cook and D. Addison. D. Addison to reside at UNB over six months (in 6-8 week periods) to assemble and commission flow-through electrochemical cell and to conduct base-line tests. (second six month period)

Deliverable: Report describing commissioning and preliminary baseline testing results from UNB high-temperature test rig with flow-through electrochemical cell. Intent is to have system and method ready for ongoing, long-term test program.

Budget:

Travel:	£ 4,600	
Accommodations:		£ 3,000
Incidentals:		£ 2,000
Total:		£ 9,600

References:

1. IAPWS ICRN#25, "*Corrosion mechanisms related to the presence of contaminants in steam/water circuits, particularly in boiler water*".
2. Victor Balashov, Mark Fedkin, Serguei Lvov, Barry Dooley, "*Experimental System For Electrochemical Corrosion Studies In High Temperature Aqueous Solutions*", NACE-07403, Corrosion 2007, March 2007.

Press Release

International Association for the Properties of Water and Steam

2015 ANNUAL MEETING, STOCKHOLM, SWEDEN

Continuing a series of conferences that began in 1929 in London, 88 scientists and engineers from 21 different countries, along with 14 accompanying persons, attended the annual meeting of the International Association for the Properties of Water and Steam (IAPWS). The Scandinavian National Committee of IAPWS (SIAPWS) hosted the meeting between 28th June and the 3rd July 2015 at the Scandic Ariadne hotel in Stockholm, Sweden. The highlights of the IAPWS working group sessions and other proceedings of the executive committee are summarised in this release.

The primary purpose of the annual IAPWS meeting is to connect researchers and scientists with the engineers who use their information. This information exchange provides the researchers with guidance on topical problems within industry and provides the engineers with the latest research results. Areas of application include power cycle chemistry, high temperature aqueous technologies applicable to steam cycles and fuel cells, the use of high temperature water and supercritical steam in chemical and metallurgical processes, supercritical synthesis of new materials and destruction of toxic wastes, hydrothermal geochemistry, hydrometallurgy, oceanography, power cycles with CO_2 capture and storage systems and combined heat and power systems including district heating.

IAPWS produces releases and guidelines on the recommended scientific formulations for physical and chemical properties of water in its various forms as well as technical guidance documents that are the concerted opinion of IAPWS members on best operating practices for power plant chemistry. IAPWS also documents certified research needs that represent the opinion of experts in their respective fields that research on a particular subject is greatly needed to fill a current gap in knowledge. All of this information is freely available and can be found on the IAPWS website at **www.iapws.org**.

In the Working Group on Thermophysical Properties of Water and Steam (TPWS), a new Guideline was approved on the thermodynamic properties of supercooled water. This new formulation provides the best available information for this important and scientifically interesting condition of water. New Guidelines were also approved on the fugacity of water and humid air (important in atmospheric science and humidity measurement) and on the thermal conductivity of seawater. Significant ongoing and new work includes efforts toward improved formulations for the surface tension of water, the thermodynamic properties of water in the ideal-gas state, and the thermodynamic properties of heavy water.

The Industrial Requirements and Solutions (IRS) working group finalized and approved the "IAPWS Guideline on the Fast Calculation of Steam and Water Properties with the Spline-Based Table Look-Up Method (SBTL)". The development of this guideline, which has occurred over the past several years, will allow for calculation of water and steam properties with substantially higher calculation speed while keeping the same accuracy as the current standard IAPWS-IF97. This method will be very beneficial for applications requiring extensive computation of H_2O properties such as Computational Fluid Dynamics, transient power cycle simulations, etc.

The Subcommittee on Seawater (SCSW) met during the week and discussed many issues related to the bulk properties of seawater, as measured in both the laboratory and in the field, and is continuing efforts to define a traceability chain between the TEOS-10 Seawater standard and the International System of Units (SI). A report was presented by the Joint SCOR/IAPWS/IAPSO Committee on the Properties of Seawater (JCS) which showed that worldwide use of the TEOS-10 Seawater Standard is increasing, with software and document downloads increasing each year. TEOS-10 is built around several IAPWS releases including the 1995 formulation on the Thermodynamic Properties of Ordinary Water Substance and the 2008 Release on the Thermodynamic Properties of Seawater.

In the meetings of the Power Cycle Chemistry (PCC) working group, major progress was achieved by finalizing amendments for the Technical Guidance Document (TGD) on instrumentation, as well as for two TGDs on chemical treatments (Volatile and Phosphate / Caustic) for providing guidance for cycling and fast start-up plants. All three amendments were submitted for approval to the Executive Committee and are ready for immediate release. Additional discussions and work undertaken was to begin the preparation of three new TGDs for planned release at the 2016 meeting. These include guidance on the use of film forming amines in water/steam cycles; guidance for HRSG HP evaporator tube sampling and deposit analysis; and, guidance for high purity demineralized makeup water integrity.

In collaboration with TPWS working group and SCSW, the Physical Chemistry of Aqueous Solutions (PCAS) working group has completed work on the Guideline for the thermal conductivity of seawater. The Guideline has been formally submitted to the Executive Committee for approval. Throughout the week, the working group discussed and identified topics for forthcoming Guidelines including providing IAPWS recommended formulations for the dissociation and vapor-liquid distributions of various amines used in the water/steam cycle and, for self-diffusion in high-temperature water.

IAPWS produces Certified Research Needs (ICRNs) as guidance for funding agencies and as an aid to people doing research in defining important research. To date, these have covered a variety of areas related to the properties of water and steam, seawater and the chemistry of power plants. A list of currently active ICRNs and closing statements on the progress made for those that have expired can be found on the IAPWS website.

A symposium entitled "Energy Planning and Technical Solutions" was held on Wednesday 1st July 2015**.** The symposium included several presentations focused on combined heat and power systems based upon biomass combustion systems that are prevalent in Sweden. Further presentations were given on the modeling of aqueous electrolyte systems including carbon capture and storage, aqueous reactions with biomass, corroding interfaces and mitigating the consequences of nuclear accidents. The IAPWS Helmholtz award lecture is traditionally the cornerstone of the IAPWS Symposium; unfortunately, this year's award

winner Dr. Vincent Holten, a Postdoctoral Associate at Cornell University, could not attend. His work and the planned topic of his presentation surround computational thermodynamics and statistical mechanics of aqueous solutions of hydrophobic substances. The IAPWS Helmholtz award is given annually to developing or early career scientists and engineers who are working in a field of interest to IAPWS. It includes an opportunity to attend the annual IAPWS meeting and to present the Helmholtz Award lecture.

The IAPWS Honorary Fellow award was conferred during the meeting banquet, which was held in the historic "Vasa Museum". The Honorary Fellow award is given in recognition of many years of contribution to the Association. At the 2015 meeting, the recipient of the IAPWS Honorary Fellow award was Professor Masaru Nakahara from Kyoto University in Japan in recognition of his outstanding contribution for sustained and exemplary service to IAPWS through the Working Group on Physical Chemistry of Aqueous Systems, leadership of the Japanese National Committee for IAPWS, and profound research results in the chemistry of aqueous solutions.

IAPWS welcomes scientists and engineers with interest in the thermophysical properties of water, steam, and aqueous systems and in the application of such information to industrial uses. The next IAPWS meeting will be in Dresden, Germany from 11^{th} – 16^{th} September 2016. Further information on meetings can be found at the IAPWS website (www.iapws.org) as it becomes available.

People interested in IAPWS documents and activities should contact the Chairs of their IAPWS National Committee (see the IAPWS website for contact details) or contact the IAPWS Executive Secretary, Dr. R. Barry Dooley, bdooley@structint.com. People do not need to be citizens or residents of member countries to participate in IAPWS activities.

	
SIAPWS Organizing Committee for the 2015 Annual Meeting in Stockholm, Sweden.	Participants of the SCSW working group during the annual meeting.

Group photo of the participants of the 2015 IAPWS meeting, Stockholm, Sweden.

2015 IAPWS dinner at the Vasa Museum, Stockholm, Sweden.

Professor Masaru Nakahara from Kyoto University, Japan, receives the 2015 IAPWS Honorary Fellow Award from IAPWS President, Dr. David Guzonas.

BIAPWS Annual Report 2015

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 2014 to July 2015. 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 twenty 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.

In April 2015, BIAPWS had to pass on the sad news of the death of Barry Hughes, who was a very keen and active member of BIAPWS and IAPWS for many years.

3 BIAPWS POWER PLANT CHEMISTRY SYMPOSIUM

Each year, BIAPWS organises an annual symposia on power plant chemistry and water treatment. The 16th in this series of symposia was held at the Village Hotel, Nottingham, on 12 - 13 May 2015. 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 90 delegates and 13 exhibition spaces taken up in 2015. A copy of the symposium programme is included in Appendix B. A paper summarising the proceedings of the 2014 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 2015 IAPWS annual meeting in Stockholm, Sweden, BIAPWS will be represented by P. McCann and J. Cooper. 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 sponsorship has supported student attendance at Royal Society of Chemistry (RSC) Energy Sector events through John Greene, one of our BIAPWS members, who is a member of the organising committees.

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On 11 November 2014, a one-day event on Chemistry in Nuclear Power Generation was held at the Manchester Conference Centre. The topics covered embraced the *Operational Experience and Research from Gas-Cooled and Light Water Reactors.* The event attracted nearly seventy delegates. Seventeen students were given free registration as a result of a BIAPWS sponsorship grant.

BIAPWS is also sponsoring student attendance at the 1st RSC Chemistry in Energy Conference, which will be held at Herriot-Watt University, Edinburgh, UK, on 20-22 July 2015. The purpose of this Conference is to bring together scientists and technologists from academia and industry with interests in the applications of Chemistry in the Energy Industry. The scope of the conference will be broad and will include all energy forms and technologies.

6 BIAPWS WEBSITE

The BIAPWS website has now been re-designed. The public facing pages aim to promote a better understanding of what BIAPWS and IAPWS are and what our activities include. The members 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.

Paul McCann
Chair, British & Irish Association for the Properties of Water and Steam
June 2015

APPENDIX A:

LIST OF UK AND IRELAND ORIGINATED REFERENCE PAPERS IN AREAS OF INTEREST TO IAPWS, PUBLISHED BETWEEN JUNE 2014 AND JULY 2015

Dooley, B., Rziha, M. and McCann, P., (2015), "IAPWS Technical Guidance on Power Cycle Chemistry Monitoring and Control for Frequently Cycling and Fast-Starting of HRSGs", PowerPlant Chemistry 2015, 17 (3).

Atkinson, C.M. and Jones, R.J., (2014), "Trial Results for the Control of Stator Cooling Water Dissolved Oxygen Concentrations Using Palladium-Doped Resin", PowerPlant Chemistry 2014, 16 (5).

McCann, P. and Robson, M., (2014), "Highlights of the BIAPWS 2014 Power Plant Chemistry Symposium", PowerPlant Chemistry 2014, 16 (4).

Spellissy, F., Griffin, F. and Stack, E., (2014), "Analyzing the Influence of Increased Ammonia Dosing to CCGT Condensate Systems", PowerPlant Chemistry 2014, 16 (4).

APPENDIX B:

PROGRAMME OF THE 16TH BIAPWS POWER PLANT CHEMISTRY SYMPOSIUM, 12-13 MAY, 2015

Introductions to Power Plant Chemistry & Water Treatment

Session 1: Fundamentals of Steam Turbine Corrosion

Presenters: Alan Turnbull (National Physical Laboratory) and Joerg Sperling (Alstom Power AG)

Session 2: Membrane Water Treatment Processes for Boiler Make-Up Water Productsion

Presenters: Justyna Warczok (Dow) and David Bennett/Steven Hughes (Veolia)

Environmental and Cycle Chemistry

Session 1: Environmental and Water Treatment Issues	
HSE and Local Authority Legionella Intervention Programme 2012-2014	Duncan Smith, Health & Safety Executive
Chlorine Dioxide as a Biocide for Cooling Water Treatment	Alistair Cameron, Scotmas
Demineralised Water Treatment Plant Monitoring and How This Should be Related to Resin Management	Brian Windsor, Purolite
Introduction to the UK Advanced Boiling Water Reactor and the Control of the Reactor Water Chemistry Regime to Minimise Corrosion and Dose Rates	Kathryn James, Horizon Nuclear Power
Session 2: Power Plant Chemistry and Corrosion	
Operating Experience of AREVA's Film Forming Amine Technology in the Water-Steam Cycle of Pressurised Water Reactors	Ute Ramminger, AREVA Gmbh
Managing the Risk of Off-Load Stress Corrosion Cracking in Stainless Steel Superheater Boiler Tubing by Feedwater Chemistry Control	James Meldrum, AMEC Foster Wheeler
Carryover Behaviour in Several CCGT Power Plants	John Greene, Consultant
The Relationship Between Ammonia Dosing and Corrosion Products in Dublin Bay Power HRSG	David Brazil, ESB

IAPWS Canadian National Committee
Annual Report 2015

Submitted to IAPWS EC, Stockholm, Sweden, July 3, 2015

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

1. Canadian National Committee: Dues for the Canadian National Committee (CNC) of IAPWS are supported by the National Research Council of Canada. 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 a 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).

After two years acting as the IAPWS Vice President, Dr. Dave Guzonas transitioned to the role of IAPWS President for 2015-2016.

2. NSERC/NRCan/AECL Generation IV Energy Technologies Program

A major university-based program to study water chemistry in support of the development of the Canadian Supercritical Water-cooled Reactor concept (NSERC/NRCan/AECL Generation IV Energy Technologies Program) is currently in the final year of its Phase II funding and includes seven water chemistry projects that cover two main themes: a) corrosion product transport and deposition, and b) water radiolysis. The goal is to develop chemistry control strategies for the SCWR as well as to recommend realistic chemistry conditions for corrosion testing for materials selection. The program also funds eight projects examining materials degradation phenomena (e.g., corrosion, stress corrosion cracking, creep, ageing) at temperatures up to 800 ºC.

The chemistry program is co-ordinated by D. Guzonas (CNL). Research on high-temperature water chemistry being funded by this program includes:

P. Tremaine (U. of Guelph): Aqueous chemistry of metals and fission product under SCWR conditions.
C. Pye (St. Mary's University): Ab initio calculations on ionic hydration and complexation.
W. Cook (U. of New Brunswick): Corrosion product transport and deposition under SCWR conditions.
I. Svishchev (Trent University): Water chemistry, pH control and particle formation process in an SCWR.
A. Anderson (St. F. X. University): Time-resolved investigations of metal oxide-water systems under conditions of extreme temperature, pressure and radiation.
P. Percival (Simon Fraser University) &: Reaction kinetics in SCW probed using muonium.
K. Ghandi (Mount Allison University)

J.-P. Jay-Gerin (U. of Sherbrooke): Computational modelling of water radiolysis in high temperature water (including SCW).
C. Wren (U. of Western Ontario): Water radiolysis effects on materials degradation in high temperature water (including SCW).

3. CNC Member Activities

3.1 Activities at the University of New Brunswick

Derek Lister

Heat exchanger fouling; analysing the adsorption/desorption of film-forming amines (FFAs) on the surfaces of bench-scale apparatus and high-temperature water loops under single- and two-phase flow conditions has provided kinetic constants that can be used to plan experiments examining the effects of FFAs on the deposition of corrosion products on heat-exchange surfaces (in collaboration with CNL).

Flow-accelerated corrosion (FAC); predicting the characteristics of scallops (the sculpting of surfaces undergoing FAC). Computational-fluid-dynamic analysis of characteristic scallop shapes has provided insights into the mechanisms of flow-accelerated corrosion.

Modelling reactor primary circuit contamination. Inserting FAC mechanisms and in-core effects into models for material transport has led to predictions of radioactivity transport. The resulting model been applied to the Point Lepreau CANDU to estimate the effect of the core refurbishment and the associated equipment lay-up on the development of fields due to common corrosion products.

Sampling high-temperature water systems; modelling hold-up of corrosion products in coolers and introducing precipitation kinetics provide information relevant to the IAPWS technical guidance document.

Characterising the effects of film-forming amines on FAC in two-phase flow. Scoping studies in single-phase flow are complete and similar experiments under two-phase flow at 200ºC have also been completed. The results show the effect of the multi-layer nature of the FFA on FAC as its concentration is varied.

Developing a robust probe for measuring FAC in-situ in operating plant. A probe has been designed and an agreement negotiated with a power utility to install it in a coal-fired station. The probe has been manufactured and is awaiting bench trials before installation in 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 almost complete. The measured effects have been described in terms of UNB's mechanistic model preliminary to its incorporation into a commercial code.

Measuring the dissolution kinetics of coolant-system corrosion products. The rate of dissolution of magnetite under a range of coolant conditions has been measured and the kinetic constants derived. Under the conditions of power-system coolants, the dissolution is much slower than mass transfer, indicating that the conventional description of flow-accelerated corrosion is invalid. Similar measurements have been made on nickel ferrite, indicating that nickel release from steam generators is not via dissolution of the in-situ oxide film.

Willy Cook

W. Cook has been acting as the Director of the Centre for Nuclear Energy Research (CNER), a research institute on UNB's campus. 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. Additional field trials to show the utility of the sensors for nuclear power plants are currently in preparation. CNER is growing its consulting expertise and continues to provide service to Canada's nuclear industry, most recently in evaluating post-refurbishment radiation fields at the Point Lepreau CANDU through detailed analysis of plant data and predictions of activity transport by modifications to UNB's corrosion product and activity transport model.

Involvement in the Generation IV Technologies Program for development of the SCWR. The major focus is corrosion-product transport and deposition in the core of a SCWR where both experimental techniques and modeling are employed to elucidate material corrosion and the deposition kinetics of the "fall-out" from solution that occurs upon traversing the critical point.

Hydrogen control in CANDU cooling systems is a project initiated last year 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 scavaging chemical to hydrazine is the primary goal.

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

Research Themes

1. Ions and Organic Solutes in Very High Temperature Water
2. Origins of Life: Pre-Biotic Chemistry under Deep Ocean Hydrothermal Vent Conditions
3. CANDU Nuclear Reactor Chemistry: the Next Generation
4. Thermal Power Generation, Carbon Capture, and Hydrogen Co-Generation

Current and Recent Funders

The following companies and granting agencies contributed to our research during the past five years: NSERC, Atomic Energy of Canada Ltd. (now Canadian Nuclear Laboratories – CNL), Ontario Power Generation Ltd., The Electric Power Research Institute (EPRI), Inco, IAPWS, UNENE, Natural Resources Canada.

Specific Projects

Solvation and Equilibria of Ions and Organic Solutes in Water up to Near-Critical Conditions
Origins of Life: Pre-Biotic Chemistry under Deep Ocean Hydrothermal Vent Conditions

CANDU Nuclear Reactor Chemistry: D_2O Isotope Effects on Acid-base Ionization and Metal Hydrolysis (UNENE/NSREC CRD Grant)

Generation IV Nuclear Reactor Chemistry: Ion Pairs and Complexes in Sub-critical and Supercritical Water (NRCan/AECL/ NSERC CRD Grants):

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) Interpretation of measurements undertaken Feb 2014 in the North-East Pacific as part of the Canadian Department of Fisheries and Ocean "Line-P" program, in collaboration with JCS member Frank J. Millero (U. Miami), continues now that more comprehensive (independent) chemical analyses of the seawater samples are available. (2) Measurements were taken in Oct 2014 in the Salish Sea in collaboration with H. Uchida (JAMSTEC). Upcoming activities include (1) measurements taken in Arctic coastal areas, in collaboration with H.

Uchida and K. Brown (WHOI), and (2) measurements of highly supersaturated gas concentrations in the anoxic ancient seawater of Powell Lake, B.C.

Numerical modelling of "density anomaly" effects when river waters are mixed with seawaters has been published. This work will continue by extending this work to investigate effects of composition variations from hydrothermal vent plumes.

A major milestone for JCS was the submission of 4 linked papers to the journal Metrologia. These papers discuss proposed plans for developing traceability of seawater salinity, salinity pH, and relative humidity to the International System of Units (SI).

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
The presentation "International Association for the Properties of Water and Steam" was made by Dr. William Cook at the CANDU Chemistry Workshop in June 2015. This presentation informed the audience of approximately 65 CANDU industry chemists about IAPWS and the available IAPWS information.

Dr. Peter Tremaine, Dr. William Cook and Dr. Derek Lister have participated in the COG R&D Chemistry Working Group meetings and have informed Working Group members of the research activities at the University of Guelph and the University of New Brunswick. IAPWS activities and their benefits have been presented to the COG Chemistry Working Group by Dr. Tremaine, Dr. Cook, Dr. Lister and also by Dr. Dave Guzonas who is a member of this Working Group.

The COG R&D Chemistry Working Group has made a five-year commitment to fund the University of Guelph Industrial Research Chair in the field of "High Temperature Aqueous Chemistry". COG members are also funding the Collaborative Research and Development Grant "Chemistry and Corrosion in Nuclear and Conventional Power System Coolants" at the University of New Brunswick for the next five years. Plans are under development to formally incorporate university research programs with the COG industry Working Groups, which should further integrate and leverage the value of IAPWS activities with the COG R&D program.

CANDU Industry-Technology Implementation
COG members are actively implementing technologies presented at IAPWS conferences. An example is the presentation "Optimized pH Strategy Combined with Application of Film-Forming Amine for Improved Water Chemistry Treatment in Steam-Water Cycle of PWR" made by Dr. Andreas Drexler (Areva) at the 16th International Conference on the Properties of Water and Steam in London-Greenwich 2013.

There is ongoing research at Chalk River Laboratories to investigate the thermal resistances and fouling rates prior to and after the application of the Areva Film-Forming Amine. This project is to provide an independent technical basis for using Areva Film-Forming Amine during the upcoming CANDU station refurbishment outages. COG Joint Project 4494 "Qualification of Film Forming Amine (FFA) Preservation of Steam Generators" is underway to qualify the process for the participating CANDU stations. A presentation about implementing the Areva Film-Forming Amine process were made at the June 2015 CANDU Chemistry Workshop by Dennis Moghul (OPG) (Film Forming Amine Application for Darlington Refurbishment Lay-up Protection).

3.5 Activities within Canadian Natural Resources Ltd. (Melonie Myszczyszyn)
Melonie Myszczyszyn is a regular participant and session chair at the annual ASME International Water Conference, specifically for the produced water sessions. She also participates as chair of the Task Group within the ASME for the development of the produced water consensus document with 60 participants from Canada and USA. She filed two patents on 8th April 2015 with CNRL (#45353-201 and #45353-202) for treating Polymer Flood Produced Water specifically for use during polymer flooding, alkaline surfactant polymer flooding, and future Steam Assisted Gravity Drainage after polymer flooding applications.

4. Activities Planned to Next ICPWS (2017/18)

The CNC activities over the next few years will continue the work that is currently ongoing, as described above. The supercritical water-cooled reactor project is a focus for much of the current research activities of the CNC. This university-government-industry program focused on fundamental research will conclude Phase II in 2016 but may have more focused research beginning in Phase III.

A workshop on the IAPWS TGD's to Canadian industry and academic stakeholders is in the planning stages for October 2015. The goal would be to raise the profile of the Canadian National Committee and IAPWS activities with researchers in Canada doing complementary research and within the HRSG community.

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.

The CNC identified that the reformulation of the properties of heavy water is still of great interest to Canada and provided contacts with the CANDU community to support the work.

5. Select List of Publications

1. D. Guzonas; W. Cook, "Chemistry Control Strategy for the Canadian SCWR Concept", Canadian Nuclear Laboratories report 217-127120-REPT-001, Revision 0, February 2015
2. V. Subramanian; J.M. Joseph; H. Subramanian; J.J. Noël; D.A. Guzonas; J.C. Wren "Steady-State Radiolysis of Supercritical Water: Model Development, Predictions and Validation", 7th International Symposium on Supercritical Water-Cooled Reactors (ISSCWR-7), 2015 March 15-18, Helsinki, Finland.
3. D.T Kallikragas; A. Yu. Plugatyr; D.A. Guzonas; I.M. Svishchev "Effect of Confinement on the Hydration and Diffusion of Chloride at High Temperatures", J. of Supercritical Fluids 97, 22–30.
4. D. Guzonas, "Extreme Water Chemistry – How Gen IV Water Chemistry Research Improves Gen III Water-Cooled Reactors", The 19th Pacific Basin Nuclear Conference (PBNC 2014), Hyatt Regency Hotel, Vancouver, British Columbia, Canada, August 24-28, 2014.
5. D. Guzonas; W. Cook "Water Chemistry Specifications for the Canadian Supercritical Water-Cooled Reactor Concept", The 7th International Symposium on Supercritical Water-Cooled Reactors (ISSCWR-7), 15-18 March 2015, Helsinki, Finland
6. D. Guzonas; M. Edwards; W. Zheng, "Assessment of Candidate Fuel Cladding Alloys for the Canadian Supercritical Water-cooled Reactor Concept", The 7th International Symposium on Supercritical Water-Cooled Reactors (ISSCWR-7), 15-18 March 2015, Helsinki, Finland
7. D. Guzonas; L. Qiu; S. Livingstone; S. Rousseau, "Fission Product Release under Supercritical Water cooled Reactor Conditions", The 7th International Symposium on Supercritical Water-Cooled Reactors (ISSCWR-7), 15-18 March 2015, Helsinki, Finland

8. O.S. Bakai; D.A. Guzonas; V.M. Boriskin; A.M. Dovbnya; S.V. Dyuldya "Combined Effect of Irradiation, Temperature, and Water Coolant Flow on Corrosion of Zr–, Ni–Cr-, and Fe–Cr-based Alloys" The 7th International Symposium on Supercritical Water-Cooled Reactors (ISSCWR-7), 15-18 March 2015, Helsinki, Finland
9. M. Briggs & D. Lister, "Mechanistic Modelling of Flow-Accelerated Corrosion", 11th International Conference on Cycle Chemistry in Fossil and Combined Cycle Plants with Heat Recovery Steam Generator, St. Louis, USA, 2015.
10. Palazhchenko, O.Y. and Lister, D.H., "Modelling the Transport of Corrosion Products and Radionuclides in the CANDU Primary Heat Transport System," 35th Annual CNS Conference, Saint John, NB, May 31-June 3, 2015.
11. Palazhchenko, O.Y. and Lister, D.H., "Modelling Material and Radioactivity Transport in the Primary Circuit of CANDU Reactors," Proceedings of the International Nuclear Plant Chemistry Conference, Sapporo, Japan, October 27-31, 2014.
12. M. Jack, S. Weerakul, D.H. Lister, "The interaction of a film-forming amine with surfaces of a recirculating experimental water loop", International Conference on Heat Exchanger Fouling and Cleaning XI, Dublin, Ireland, 2015.
13. Uchida, S., Koshizuka, S. and Lister, D.H., "Evaluation of the Effects of pH and Oxygen on Mitigation of Wall Thinning of Carbon Steel due to Flow-Accelerated Corrosion." Proc. EUROCORR 2014, Pisa, Italy, September 8-12.
14. Lister, D.H. and Uchida, S., "Determining Water Chemistry Conditions in Nuclear Reactor Coolants". J. Nucl. Sci. Techn. Invited Review for 50th Anniversary Edition, vol. 52, no. 4, pp. 451-466, June 2015.
15. Solution Calorimetry Under Hydrothermal Conditions, P.R. Tremaine and H.Arcis, . Rev. Mineralogy Geochem. Vol 76, Chapt. 7 (Geochem Soc. & Mineral. Soc. Amer., 2013).
16. A Raman and Ab Initio Investigation of Aqueous Cu(I) Chloride Complexes from 25 to 80 ºC. L.M.S.G.A. Applegarth, C.R. Corbeil, D.J.W. Mercer, C.C. Pye and P. R. Tremaine, J. Phys. Chem. B 118, 204−214 (2014).
17. Ion-Pair Formation in Aqueous Strontium Chloride and Strontium Hydroxide Solutions under Hydrothermal Conditions by AC Conductivity Measurements, H. Arcis, G.H. Zimmerman and P.R. Tremaine, Chem. Phys. Phys. Chem. 16, 17688-17704 (2014).
18. Standard Partial Molar Heat Capacities and Enthalpies of Formation of Aqueous Aluminate under Hydrothermal Conditions from Integral Heat of Solution Measurements. Y. Coulier and P. R. Tremaine, J. Chem. Thermodynamics 78, 79-92 (2014).
19. Limiting Conductivities of Univalent Cations and the Chloride Ion in H_2O and D_2O under Hydrothermal Conditions, J. Plumridge, H. Arcis and P. R. Tremaine, J. Solution Chem. (Special issue honouring Prof. R.H. Wood). 44,1062–1089 (2015).
20. Non-complexing Anions for Quantitative Speciation Studies by Raman Spectroscopy in Fused-silica High Pressure Optical Cells under Hydrothermal Conditions. L.M.S.G.A Applegarth, C. Alcorn, K. Bissonette, J. Nöel, P. Tremaine. Appl. Spectroscopy (In Press, MS Number 14-07825).
21. Theoretical Study of Deuterium Isotope Effects on Acid-Base Equilibria under Ambient and Hydrothermal Conditions, N. Mora-Diez, Y Egorova, H. Plommer, P. R. Tremaine, JCS Advances 5, 9097-9108 (2015).
22. Thermodynamics of the Sodium–Iron–Phosphate–Water System Under Hydrothermal Conditions: The Gibbs Energy of Formation of Sodium Iron(III) Hydroxy Phosphate, $Na_3Fe(PO_4)_2{\cdot}(Na_4/3H_2/3O)$, from Solubility Measurements in Equilibrium with Hematite at 498–598 K, S. Quinlan, D. Chvedov, L.N. Trevani and P. R. Tremaine, J. Solution Chem. 44, 1121–1140 (2015).

23. Boiling Points and Speciation of Aqueous Electrolyte Solutions Under "Hideout" Conditions in Supercritical Water-cooled Reactor Coolant by Raman Spectroscopy, L. Applegarth and P. Tremaine, Proc. 19th Pacific Basin Nucl. Conf. (Can. Nucl. Soc., Vancouver, Aug. 24-28, 2014).

24. Overview on Investigation of Metal Speciation under Supercritical Water-Cooled Reactor Coolant Conditions by Ab Initio Calculations, Spectroscopy, and Conductivity Measurements, C.C. Pye, L. Cheng, P.R. Tremaine, Proc. 19th Pacific Basin Nuclear Congress (Vancouver, BC, Canada, August 24-28, 2014).

25. Validity Range of the Meissner Activity Coefficient Model used in MULTEQ. S. Dickinson, M. Bachet, R. Eaker, J. Henshaw, C. Marks, P. Tremaine, D. Wells. Proc. Nuclear Plant Chemistry Conference 2014 (NPC2014), (Sapporo, Japan, October 26-31, 2014)

26. Pawlowicz, R., "The Absolute Salinity of seawater diluted by riverwater". Deep Sea Research I, 101, 71-79 (2015)

27. Jiao, Y. Zheng, W., Guzonas, D. and Cook, W., Kish, J., "Effect of Thermal Treatment on the Corrosion Resistance of Type 316L Stainless Steel in Supercritical Water", Journal of Nuclear Materials, vol. 464, pp. 356-364, September 2015.

28. Swift, R. and Cook, W.G., "Validation of Constant Load C-ring Apex Stresses for SCC Testing in Supercritical Water", Proceedings ISSCWR7, Helsinki, Finland, March 2015.

29. Steeves, G. and Cook, W.G., "Development of Kinetic Models for the Long-term Corrosion Behaviour of Candidate Alloys for the Canadian SCWR", Proceedings ISSCWR7, Helsinki, Finland, March 2015.

30. Cook, W.G., Gardner, E., Lee, J., and Stuart, C.R., "Secondary System Return to Service Following the Refurbishment Outage at the Point Lepreau Generating Station", Proceedings NPC 2014 - Nuclear Plant Chemistry 2014, Sapporo, Japan, October 2014.

31. Stuart, C.R, Cook, W.G. and Gardner, E., "Primary Heat Transport System Return to Service Following the Refurbishment Outage at the Point Lepreau Generating Station", Proceedings NPC 2014 - Nuclear Plant Chemistry 2014, Sapporo, Japan, October 2014.

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:

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

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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 CZNCPWS 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.: Callibration 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., Ziková, 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 Enviroment.. 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 Engineeting, 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 Borid 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 to 343) 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 to 343) 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 Recommende ..., 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., Slavíček, 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

German National Committee to IAPWS

Research Activities on the Thermodynamic Properties of Water and Steam

Report "Research in Progress 2015"

Baltic Sea Research Institute, Warnemuende
Dr. Rainer Feistel

Projects

1. Development of a draft “IAPWS Guideline on a Virial Equation for the Fugacity of H2O in Humid Air”.
2. Leading preparation of the comprehensive paper for the Journal Metrologia:
   Metrological challenges for measurements of key climatological observables: Oceanic salinity and pH, and atmospheric humidity.

Publications:

- R Feistel, J W Lovell-Smith, P Saunders and S Seitz:
  Uncertainty of Empirical Correlation Equations.
  Submitted to Metrologia, 26 May 2015.
- R Feistel, R Wielgosz, S A Bell, M F Camões, J R Cooper, P Dexter, A G Dickson, P Fisicaro, A H Harvey, M Heinonen, O Hellmuth, H-J Kretzschmar, J W Lovell-Smith, T J McDougall, R Pawlowicz, P Ridout, S Seitz, P Spitzer, D Stoica and H Wolf:
  Metrological challenges for measurements of key climatological observables:
  Oceanic salinity and pH, and atmospheric humidity. Part 1: Overview.
  REVIEW PAPER. Submitted to Metrologia, 18 May 2015.
- R Pawlowicz, R Feistel, T J McDougall, P Ridout, S Seitz, H Wolf:
  Metrological challenges for measurements of key climatological observables, Part 2:
  Oceanic salinity. To be submitted to Metrologia.
- A G Dickson, M F Camões, P Spitzer, P Fisicaro, D Stoica, R Pawlowicz and R Feistel:
  Metrological challenges for measurements of key climatological observables, Part 3:
  Seawater pH. To be submitted to Metrologia.
- J W Lovell-Smith, R Feistel, A H Harvey, O Hellmuth, S A Bell, M Heinonen, J R Cooper:
  Metrological challenges for measurements of key climatological observables, Part 4:
  Atmospheric relative humidity. To be submitted to Metrologia.
- Feistel, R., Lovell-Smith, J.W., Hellmuth, O. (Proposers):
  Guideline on a Virial Equation for the Fugacity of H2O in Humid Air.
  The International Association for the Properties of Water and Steam.
  Stockholm, Sweden, July 2015, to be adopted.
- Feistel, R. (2015):
  Salinity and relative humidity: climatological relevance and metrological needs.
  Acta Imeko, in press.
- Feistel, R., Lovell-Smith, J.W., Hellmuth, O. (2015):
  Virial Equation for the Fugacity of Water in Humid Air.
  International Journal of Thermophysics 36, Issue 1, pp. 44-68.
- Rainer Feistel, Jeremy W. Lovell-Smith, Olaf Hellmuth (2015):
  Erratum to: Virial Approximation of the TEOS-10 Equation for the Fugacity of Water in Humid Air.
  International Journal of Thermophysics 36, Issue 1, p. 204

- Kretzschmar, H.-J., Herrmann, S., Feistel, R., Wagner, W.:
  The International IAPWS Formulation for the Thermodynamic Properties of Seawater for Desalination Processes.
  The International Desalination Association World Congress on Desalination and Water Reuse 2015, San Diego, CA, USA, Accepted (2015).
- Kretzschmar, H.-J., Feistel, R., Wagner, W., Miyagawa, K., Harvey, A.H., Cooper, J.R., Hiegemann, M., Blangetti, F.L., Orlov, K.A., Weber, I., Singh, A. Herrmann, S.:
  The IAPWS Industrial Formulation for the Thermodynamic Properties of Seawater.
  Desalination and Water Treatment xx, 1–23, doi: 10.1080/19443994.2014.925838,
  Published online (2014).
- Trevor J. McDougall, Paul M. Barker, Rainer Feistel, Ben K. Galton-Fenzi:
  Melting of ice and sea ice into seawater, and frazil ice formation.
  Journal of Physical Oceanography 44, 1751-1775, DOI: 10.1175/JPO-D-13-0253.1 (2014).

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

Project

Implementation of the Fast Steam Property Algorithms Based on Spline Interpolation into the CFD Code TRACE

- The draft "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, cf. [1].
- 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.

Paper

- Kunick, M., Kretzschmar, H.-J., di Mare, F., Gampe, U.:
  CFD Analysis of steam turbines with the IAPWS standard on the Spline-Based Table Look-Up Method (SBTL) for the fast calculation of real fluid properties.
  In *Turbine Technical Conference and Exposition: Proceedings of ASME Turbo Expo 2015*, 2015.

German Research Centre for Geosciences GFZ
Section 4.1 - Reservoir Technologies
Dr. Harald Milsch, Ulrike Hoffert

Projects

1. Measurements of density, viscosity and electrical conductivity of pure and mixed NaCl and $CaCl_2$ aqueous solutions at 0.1 MPa and 20-80°C
2. Evaluation of mixing rules for thermophysical properties of ternary NaCl-$CaCl_2$ aqueous solutions
3. Set-up and evaluation of a capillary-type high pressure-high temperature viscometer for aqueous electrolyte solutions at up to 50 MPa and 200°C

Publications

- Milsch, H., Hoffert, U., Hofmann, H. (2015): Data Gaps in Thermophysical Fluid Data for Geothermal Applications. Proceedings World Geothermal Congress, Melbourne, Australia, Paper 16028
- Hoffert, U. and Milsch, H. (2015): Experimental Investigations on the Thermophysical Properties of Synthetic Geothermal Fluids. Proceedings World Geothermal Congress, Melbourne, Australia, Paper 16030

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

Project

Density and electrical conductivity in limnic waters:

- A practical approach to lake water density from electrical conductivity and temperature
- Calculating conductance of acidic lake waters
- Accuracy of lake water density calculated from molar volumes: RHOMV

Book Publication

- Boehrer B.: Chapter 3.1 Physical properties of acidic pit lakes IN: Geller W., Schultze M., Kleinmann R., Wolkersdorfer C.:
  In: Acidic pit lakes.
  Springer, Heidelberg, 23-42 (2013)

Leibniz Institute for Tropospheric Research, Leipzig
Dr. Olaf Hellmuth

Publications

- Hellmuth, O., R. Feistel, J. Lovell-Smith and J. Kalova, 2015:
  Metrological Aspects of Humidity: State of Discussion on Common Positions, Challenges, and Needs.
  Technical Report of the Joint BIPM, CCT-WG6/CCQM and JCS Workshop on Hygrometry, held during the 16th International Conference on the Properties of Water and Steam 2013 (ICPWS 2013), Greenwich, UK. Online available:
  http://www.teos-10.org/pubs/ICPWS2013_WS_TechnicalReport_Humidity_20150211primo.pdf
- Feistel, R., Lovell-Smith, J.-W., O. Hellmuth:
  Virial Approximation of the TEOS-10 Equation for the Fugacity of Water in Humid Air.
  Int J Thermophys (2015) 36:44–68, DOI 10.1007/s10765-014-1784-0
- Hellmuth, O., Shchekin, A. K.: Determination of interfacial parameters of a soluble particle in a nonideal solution from measured deliquescence and efflorescence humidities.
  Atmos. Chem. Phys., 15, 3851-3871, 2015
  www.atmos-chem-phys.net/15/3851/2015/, doi:10.5194/acp-15-3851-2015
- R Feistel, R Wielgosz, S A Bell, M F Camões, J R Cooper, P Dexter, A G Dickson, P Fisicaro, A H Harvey, M Heinonen, O Hellmuth, H-J Kretzschmar, J W Lovell-Smith, T J McDougall, R Pawlowicz, P Ridout, S Seitz, P Spitzer, D Stoica and H Wolf:
  Metrological challenges for measurements of key climatological observables: Oceanic salinity and pH, and atmospheric humidity. Part 1: Overview.
  Revised version, submitted for publication in Metrologia

- J W Lovell-Smith, R Feistel, A H Harvey, O Hellmuth, S A Bell, M Heinonen, J R Cooper:
  Metrological challenges for measurements of key climatological observables, Part 4:
  Atmospheric relative humidity
  Revised version, submitted for publication in Metrologia

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 recently submitted to the Journal of Chemical Thermodynamics and will be published soon. Software enabling the application of the latest version of our property models has been made available and is by now used by more than 50 groups worldwide (both in academia and in industry).
2. The work on models describing hydrate formation has been continued in cooperation with Dr. V. Vins and Dr. J. Hruby. The Ph.D. thesis of A. Jäger has been completed. Three journal articles describing the latest status of the hydrate model in detail will be submitted within the next few weeks. S. Hielscher will continue this work at RUB; funding for this important project has been granted by the German Science Foundation (DFG).
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. Harvey and Dr. E. W. Lemmon at NIST in Boulder. The work on the new equation of state is still proceeding. It is enhanced by new highly accurate measurements of the speed of sound in the liquid phase. The experiments were performed by means of the single-burst pulse-echo technique in the speed of sound laboratory at RUB. The current status of the new equation of state as well as the speed of sound measurements has been presented at the 19th Symposium on Thermophysical Properties in Boulder, Colorado. The new equation of state will be validated over the next months.

Publications

- Gernert, J.; Span, R.:
  EOS-CG: A Helmholtz energy mixture model for humid gases and CCS mixtures.
  J. Chem. Therm., In press (2015)

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

Projects

1. Working for the article “Behavior of IAPWS-95 from 250 K to 300 K and Pressures up to 400 MPa: Evaluation Based on Recently Derived Property Data.”
2. Working for the report “Behavior of IAPWS-95 from 250 K to 300 K and Pressures up to 400 MPa: Evaluation Based on Recently Derived Property Data.” The results will be presented at the IAPWS Annual Meeting in Stockholm 2015.

Publications

- Wagner, W., Thol, M.:
  Behavior of IAPWS-95 from 250 K to 300 K and Pressures up to 400 MPa: Evaluation Based on Recently Derived Property Data.
  Submitted to J. Phys. Chem. Ref. Data (2015).
- Kretzschmar, H.-J. Feistel, R., Wagner, W., Miyagawa, K., Harvey, A. H., Cooper, J. R., Hiegemann, M. Blangetti, F. L., Orlov, K. A., Weber, I., Singh, A., Herrmann, S.:
  The IAPWS Industrial Formulation for the Thermodynamic Properties of Seawater.
  Desalination and Water Treatment (2014), 1-23.
- Kretzschmar, H.-J., Herrmann, S., Feistel, R., Wagner, W.:
  The International IAPWS Formulation for the Thermodynamic Properties of Seawater for Desalination Processes.
  The International Desalination Association World Congress on Desalination and Water Reuse 2015, San Diego, CA, USA. Accepted (2015)

Siemens Energy Solutions, Erlangen
Michael Rziha

Projects

1. Amendments and Revisions of the following three Technical Guidance Documents:
   - Technical Guidance Document – 2015 Revision:
     Instrumentation for monitoring and control of cycle chemistry for the steam-water circuits of fossil-fired and combined cycle power plants
   - Technical Guidance Document – 2015 Revision:
     Phosphate and NaOH treatments for the steam-water circuits of drum boilers of fossil and combined cycle/HRSG power plants
   - Technical Guidance Document – 2015 Revision:
     Volatile treatments for the steam-water circuits of fossil and combined cycle/HRSG power plants.

   All three documents are ready to be adopted by the EC in Stockholm.
2. Developing of a draft for a new technical guidance document "HRSG HP Evaporator Sampling for Internal Deposit Determination", which will be discussed within PCC Working Group during the Stockholm meeting.

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 draft “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 draft "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.

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

Project

Implementation of the fast steam property spline-interpolation algorithms into the heat cycle simulation code EBSILON

- The draft "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.

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

Projects

1. Development of fast property algorithms based on spline interpolation
   - Spline property algorithms were developed for functions of the variables specific volume and specific internal energy (v,u) and related inverse functions for water and steam based on the scientific formulation IAPWS-IF95.
   - The range of validity of the spline-property functions based on IAPWS-IF97 has been expanded to metastable subcooled steam and metastable superheated liquid water.
   - Spline property algorithms have been developed for functions of the variables specific volume an specific enthalpy (v,h) as well as for the related inverse functions for water and steam based on the industrial formulation IAPWS-IF97.
   - The draft "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 expanded to IAPWS-95 and the metastable subcooled steam region of IAPWS-IF97
   - The evaluation by the IAPWS Evaluation Task Group has been supported.
2. Application of the developed spline algorithms for calculating thermodynamic properties

   The developed spline property algorithms have been implemented into the following process simulation codes:
   - Non-stationary thermo-hydraulic cycle program RELAP-7 of the Idaho National Institute INL
   - Heat cycle simulation program EBSILON of STEAG Energy Services
   - Heat cycle simulation program KRAWAL of Siemens Energy Solutions
   - Non-stationary heat cycle program DYNAPLANT of Siemens Energy Solutions.

Recent Publications

- Kunick, M.; Kretzschmar, H.-J.; di Mare, F.; Gampe, U.:
  CFD Analysis of steam turbines with the IAPWS standard on the Spline-Based Table Look-Up Method (SBTL) for the fast calculation of real fluid properties.
  In: Turbine Technical Conference and Exposition: Proceedings of ASME Turbo Expo (2015).
- Kunick, M.; Kretzschmar, H.-J.; Gampe, U.; di Mare, F.:
  Simulation instationärer Prozesse und CFD in Dampfturbinen mithilfe eines neuen Spline-basierten Stoffwert-Berechnungsverfahrens (Simulation of non-stationary processes and CFD in steam turbines using the new spline-based property calculation method).
  In: Kraftwerkstechnik 2014, Eds. Beckmann, M. und Hurtado, A., Verlag Saxonia, Freiberg, S. 515-526 (2014)
- Kretzschmar, H.-J.; Feistel, R.; Wagner, W.; Miyagawa, K.; Harvey, A. H.; Cooper, J. R.; Hiegemann, M.; Blangetti, F. L.; Orlov, K. A.; Weber, I.; Singh, A.; Herrmann, S.:
  The IAPWS Industrial Formulation for the Thermodynamic Properties of Seawater.
  Desalination and Water Treatment, 2014, 1-23.
- Kretzschmar, H.-J.; Herrmann, S.; Feistel, R.; Wagner, W.:

  The International IAPWS Formulation for the Thermodynamic Properties of Seawater for Desalination Processes.

  In Proceedings of the International Desalination Association World Congress on Desalination and Water Reuse, San Diego CA, Accepted (2015).
- Kraft, I.; Kretzschmar, H.-J.:
  Reale Fluide und Grundlagen der Wärmeübertragung, Lernheft THD101: Grundlagen der Technischen Thermodynamik (Real fluids and the basics of heat transfer, Learning booklet THD101: Basics of Technical Thermodynamics).
  AKAD, Bildungsgesellschaft mbH, Art.-Nr. 10880 (2014).
- Kraft, I.; Kretzschmar, H.-J.:
  Gasgemische und feuchte Luft, Lernheft THD102: Grundlagen der Technischen Thermodynamik (Gas mixtures and humid air, Learning booklet THD102: Basics of Technical Thermodynamics).
  AKAD, Bildungsgesellschaft mbH (2014). Art.-Nr. 11112 (2014).
- Kraft, I.; Kretzschmar, H.-J.:
  Verbrennungsrechnung, Lernheft THD103: Grundlagen der Technischen Thermodynamik (Combustion calculation, Learning booklet THD103: Basics of Technical Thermodynamics).
  AKAD, Bildungsgesellschaft mbH, Art.-Nr. 11113, (2014).
- Kretzschmar, H.-J.; Stoecker, I.; Kunick, M.; Herrmann, S.; Nicke, M.:
  Calculation of Thermodynamic Properties on Pocket Calculators, Smart Phones, Tablets, Notebooks, and Online.
  In: Proceedings of the Congress INFORINO, Trudi Mechdunarodny Nauchno-Metodichesky Konferenzy, Isdatjelstvo, Moskva 2014, PP. 179-182 (2014), ISBN.: 978-5-7046-1535-4.
- 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.

Revised version, submitted for publication in Metrologia.

Current Status of Research Activities in Japan

Submitted to the Executive Committee Meeting, IAPWS, Stockholm, Sweden, June-July 2015

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:

Recently we focus on the contribution to the activities of IAPWS for the development of such the documents as TGD guidance, guidelines, releases etc. Also our efforts are directed to the effective distribution and bilingual availability of the internationally standardized references among our colleagues. Some fundamental research activities on water and aqueous systems, relevant closely or in future to IAPWS, are actively carried out all over our country as can be seen in the publication list below. They can be characterized by key words, such as water, hydrothermal, solvothermal, solvation, interfacial, organic, ionic, and reactions as well as the traditional. Some of them are presented by our colleagues in the IAPWS annual meeting in Stockholm, Sweden. Updated publication references can be obtained also from them. We often open the national meeting to exchange a wide range of information on the science and technology related to power generation. Industrial and academic people are collaborating in a stimulating manner to seek the present or future problems. Our members cover a variety of IAPWS-related areas and make efforts to seriously consider the improvement of our power cycle systems and operation and safety engineering including the outlet gas treatment to avoid the public nuisance such as air/water/soil pollution. One of the J-Power members, JPE, has been developing "Regenerative Activated Coke Technology as one of the eminent front runners. Now we have begun to prepare the annual meeting of IAPWS in 2017.

II. Recent Publications:

Hirano, Hideo

Retired Senior Research Scientist, Central Research Institute of Electric Power Industry,

e-mail: hhirano0879@jcom.home.ne.jp

[1] Hirano, H.; Usui, N.; Kitajima, H.; Kawamura, H.; Fukabori, Y.; Suzuki, J.; Kawai, N.; Yamaguchi, T.; Uemura, S.; Onodera, S.; Hisamune, K.; Ueyama, Y.; and Urata, H. "BWR Water Chemistry Guidelines in Japan", Proceedings of Nuclear Plant Chemistry Conference 2014 Sapporo, Paper No.10179, October 26-31, Sapporo, Japan (2014)

[2] Kawamura, H.; Shoda, Y.; Tsuzuki, Y.; Hirano, H.; Watanabe, Y.; Takeda, K.; Terachi, T.; Ishihara, N.; Takahashi, A.; Hisamune, K.; Nakano, Y.; and Nishimura, T.; "Primary Water Chemistry Guidelines for Japanese PWR Plants", Proceedings of Nuclear Plant Chemistry Conference 2014 Sapporo, Paper No.10155, October 26-31, Sapporo, Japan (2014)

Kometani, Noritsugu

Associate Professor, Department of Applied Chemistry & Bioengineering, Osaka City University

email: kometani@a-chem.eng.osaka-cu.ac.jp,

URL: http://www.a-chem.eng.osaka-cu .ac.jp/kometani_group/index.html

[1] Kometani, N.; Nakao, K.; and Honda, H.; "Catalytic Effects of Copper Oxides on the Decomposition of Chlorophenolby the Hydrothermal Oxidation", J. Soc. Mater. Sci. Jpn., **63**, 674-678 (2014). DOI:10.2472/jsms.63.674

[2] Kometani, N.; Tai, A. "High Pressure Study of Rotational Dynamics of Perylene and Sodium 8-Methoxypyrene-1,3,6-triulfonate in Imidazolium-Based Ionic Liquids", J. Solution Chem., **43**, 1529-1538 (2014). DOI:10.1007/s10953-014-0166-3

[3] Su, L.; Wang, Z.; Yang, K.; Minamikawa, Y.; Kometani, N.; and Nishinari K. "In situ observation of heat-and pressure-induced gelation of methylcellulose by fluorescence measurement", Int. J. Biol. Macromol., **64**, 409-414 (1014). DOI:10.1016/j.ijbiomac.2013.12.021

Matubayasi, Nobuyuki

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email: nobuyuki@cheng.es.osaka-u.ac.jp

URL: http://www.cheng.es.osaka-u.ac.jp/matubayasi/english/index.html

[1] Yoshidome, T.; Ekimoto, T.; Matubayasi, N.; Harano, Y.; Kinoshita, M.; Ikeguchi, M. "An accurate and efficient computation method of the hydration free energy of a large, complex molecule", J. Chem. Phys., **142**, 175101 (11 pages) (2015). DOI: 10.1063/1.4919636

[2] Mizuguchi, T.; Ishizuka, R.; Matubayasi, N. "Effect of diffuseness of micelle boundary on the solute distribution upon solubilization" Chem. , Phys. Lett., **624**, 19-23 (2015). DOI: 10.1016/j.cplett.2015.02.001

[3] Ishizuka, R.; Matubayasi, N.; Tu, K.-M.; Umebayashi, Y. "Energetic Contributions from the Cation and Anion to the Stability of Carbon Dioxide Dissolved in Imidazolium-Based Ionic Liquids", J. Phys. Chem., B **119**, 1579-1587 (2015). DOI: 10.1021/jp5101957

[4] Ekimoto, T.; Matubayasi, N.; Ikeguchi, M. "Finite-Size Effect on the Charging Free Energy of Protein in Explicit Solvent", J. Chem. Theory Comput., **11**, 215-223 (2015). DOI: 10.1021/ct5008394

[5] Tu, K.-M., Ishizuka, R., Matubayasi, N. "Spatial-decomposition analysis of electrical conductivity in ionic liquid", J. Chem. Phys., **141**, 244507 (11 pages) (2014). DOI: 10.1063/1.4904382

[6] Shimizu, S.; Matubayasi, N. "Gelation: The Role of Sugars and Polyols on Gelatin and Agarose", J. Phys. Chem., B **118**, 13210-13216 (2014). DOI: 10.1021/jp509099h

[7] Yoshida, K.; Matubayasi, N.; Uosaki, Y.; Nakahara, M. "Effect of Rotational Couplings on Vibrational Spectrum Line Shape of the Bending Mode in Low-Density Supercritical Water: Density and Hydrogen Isotopes Dependencies", J Solution Chem., **43**, 1499-1508 (2014). DOI: 10.1007/s10953-014-0220-1

[8] Shimizu, S.; Matubayasi, N. "Hydrotropy: Monomer-Micelle Equilibrium and Minimum Hydrotrope Concentration", J. Phys. Chem., B **118**, 10515-10524 (2014). DOI: 10.1021/jp505869m

[9] Tu, K.-M.; Ishizuka, R.; Matubayasi, N. "Spatial-decomposition analysis of electrical conductivity in concentrated electrolyte solution", J. Chem. Phys., **141**, 044126 (9 pages) (2014).DOI: 10.1063/1.4890741

[10] Sakuraba, S.; Matubayasi, N. "ERmod: Fast and Versatile Computation Software for Solvation Free Energy with Approximate Theory of Solutions", J. Comput. Chem., **35**, 1592-1608 (2014). DOI: 10.1002/jcc.23651

[11] Okazaki, Y.; Taniuchi, T.; Mogami, G.; Matubayasi, N.; Suzuki, M. "Comparative Study on the Properties of Hydration Water of Na- and K-Halide Ions by Raman OH/OD-stretching Spectroscopy and Dielectric Relaxation Data", J. Phys. Chem., A **118**, 2922–2930 (2014). DOI : 10.1021/jp412804d

[12] Shimizu, S.; Matubayasi, N. "Preferential Solvation: Dividing Surface vs Excess Numbers", J. Phys. Chem., B **118**, 3922–3930 (2014). DOI : 10.1021/jp410567c

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[1] Ito, T.; Nagata, Y.; Miyamoto, H. "Measurement of the (*p, ρ, T*) Properties for Pure Hydrocarbons at Temperatures up to 600 K and Pressures up to 200 MPa", Int. J. Thermophys., **35**, 1636-1646 (2014). DOI:10.1007/s10765-012-1383-x

[2] Miyamoto, H. "(*p, ρ, T*, *x*) properties of CO_2/propane binary mixtures at 280 to 440 K and 3 to 200 MPa", Int. J. Thermophys., **35**, 1647-1660 (2014). DOI: 10.1007/s10765-012-1370-2

[3] Muromachi, S.; Shijima, A.; Miyamoto, H.; Ohmura, R. "Experimental measurements of carbon dioxide solubility in aqueous tetra-n-butylammonium bromide solutions", J. Chem. Thermodyn., **85**, 94-100 (2015). DOI:10.1016/j.jct.2015.01.008

[4] Nakano, S.; Chang, Kwang-Hyeon; Shijima, A.; Miyamoto, H.; Sato, Y.; Noto, Y.; Ha, Jin-Yong; Sakamoto, M. "A usage of CO_2 hydrate: Convenient method to increase CO_2 concentration in culturing algae", Bioresource Technol., **172**, 444-448 (2014). DOI:10.1016/j.biortech.2014.09.019

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[1] Yoshida, Ken, Matubayasi, Nobuyuki, Uosaki, Yasuhiro, Nakahara, Masaru, "Effect of Rotational Couplings on Vibrational Spectrum Line Shape of Bending Mode in Low-Density Supercritical Water: Density and Hydrogen Isotopes Dependencies", J. Solution Chem., **43**, No.9-10, pp.1499-1508 (2014). (DOI: 10.1007/s10953-014-0220-1)

[2] Kimura, Hiroshi, Hirayama, Masaki, Yoshida, Ken, Uosaki, Yasuhiro, Nakahara, Masaru, "Effect of Water on Hydrolytic Cleavage of Non-Terminal Glycosidic Bonds in Cyclodextrins to Generate Monosaccharides and Their Derivatives in a Dimethyl Sulfoxide Water Mixture", J. Phys. Chem. A, **118**, No.8, pp.1309-1319 (2014). (DOI: 10.1021/jp412628y)

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[1] Yamada, A.; Kojima, H.; Okazaki, S. "A molecular dynamics study of intramolecular proton transfer reaction of malonaldehyde in solutions based upon mixed quantum-classical approximation. I. Proton transfer reaction in water", J. Chem. Phys. **141**, 084509, 1-15(2014). DOI: 10.1063/1.4893933

[2] Yagasaki, T.; Matsumoto, M.; Andoh, Y.; Okazaki, S.; Tanaka, H. "Effect of bubble formation on the dissociation of methane hydrate in water: A molecular dynamics study", J. Phys. Chem. B **118**, 1900-1906(2014). DOI: 10.1021/jp412692d

[3] Yagasaki, T.; Matsumoto, M.; Andoh, Y.; Okazaki, S.; Tanaka, H.; "Dissociation of Methane Hydrate in Aqueous NaCl Solutions", J. Phys. Chem. B **118**, 11797-11804(2014). DOI: 10.1021/jp507978u

[4] Andoh, Y.; Yoshii, N.; Yamada, A.; Fujimoto, K.; Kojima, H.; Mizutani, K.; Nakagawa, A.; Nomoto, A.; Okazaki, S. "All-atom molecular dynamics calculation study of entire poliovirus empty capsids in solution", J. Chem. Phys. **141**, 165101, 1-11(2014). DOI: 10.1063/1.4897557

[5] Kojima, H.; Yamada, A.; Okazaki, S. "A molecular dynamics study of intramolecular proton transfer reaction of malonaldehyde in solutions based upon mixed quantum-classical approximation. II. Proton transfer reaction in neon", J. Chem. Phys. 142, 174502, 1-11(2015). DOI: 10.1063/1.4919635

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[1] Miyajima, M.; Tsubakizaki, S.; Yoshida, M.; Takaku, H.; Tokunou, K. "Effects of Dissolved Oxygen and Others on Flow Accelerated Corrosion", THE THERMAL AND NUCLEAR POWER, 65, pp. 654-664 (2014).

[2] Miyajima, M.; Fujiwara, K.; Tsubakizaki, S.; Ishihara, T.; Takaku, H.; Tokunou, K. "The Results and Optimization about Water Treatments of HRSGs in GTCC", THE THERMAL AND NUCLEAR POWER, 65, pp. 580-589 (2014).

[3] Miyajima, M.; Nishino, M.; Minami, T.; Yoshida, M.; Takaku, H. "Suppresion Effect of the Steam Oxidation Growth by Pre-filming with Amine-carboxylate for Steam Pipes", THE THERMAL AND NUCLEAR POWER, 64, pp. 320-328 (2013).

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[1] Uchida, S. "Corrosion of Structural Materials and Electrochemistry in High Temperature Water of Nuclear Power Systems", *Nuclear Safety and Simulation*, **5** (1), 11-22 (2014).

[2] Lister, D. H.; Uchida, S. "Determining water chemistry condition in nuclear reactor coolant", *J. Nucl. Sci. Technol*.,**52** (4) 451-466 (2014).

[3] Okada, H.; Uchida, S.; Naitoh, M.; Suzuk, H.; Koshizuka, S.; Lister, D. H. L., "System safety analysis of aging NPPs based on probabilistic risk evaluation of flow-accelerated corrosion", *Int. Conf. On Water Chemistry of Nuclear power Systems, NPC2014*, Oct. 26-30, 2014, Sapporo, Japan, AESJ (2014).

[4] Shirai, S.; Uchida, S.; Naitoh, M.; Suzuki, H.; Okada, H. "Water chemistry control to meet the advanced design and operation of light water reactors", *Int. Conf. On Water Chemistry of Nuclear power Systems, NPC2014*, Oct. 26-30, 2014, Sapporo, Japan, AESJ (2014).

[5] Uchida, S.; Naitoh, M.; Suzuki, H.; Okada, H.; Konishi, S. "Evaluation of Accumulated Fission Products in the Contaminated Water at the Fukushima Dai-ichi Nuclear Power Plant", *Nucl. Technol*., 188(3), 252-265 (2014).

[6] Uchida, S.; Naitoh, M.; Okada, H.S.; Lister, D. H. "Evaluation of the effects of pH and oxygen on mitigation of wall thinning of carbon steel due to flow-accelerated corrosion", *EUROCORRF 2014*, Sep 8-12, 2014, Pisa, Italy, European Federation of Corrosion (2014) (in CD).

[7] *Achilli, A.; Cattadori, G.; Rigamonti, M.; Araneo, L.; Ninokata, H.; Ricotti, M.;* Pellegrini, M.; Naitoh, M.; Uchida, S. "Suppression pool testing at the SIET laboratory (1) Experimental Investigation of Critical Phenomena Expected in the Fukushima Daiichi Suppression Chamber", *Proc. 10th International Topical Meeting on Nuclear Thermal Hydraulics, Operation and Safety (NUTHOS-10)*, Dec. 14-18, Okinawa, Japan (2014).

[8] *Uchida, S.;* Naitoh, M.; Pellegrini, M.; *Achilli, A.; Hanamoto, Y.; Sasaki, H. "*Suppression pool testing at the SIET laboratory (4) Release of fission products into the environment under severe accident conditions", *Proc. 10th International Topical Meeting on Nuclear Thermal Hydraulics, Operation and Safety (NUTHOS-10)*, Dec. 14-18, Okinawa, Japan (2014).

[9] Uchida, S.; Naitoh, M.; Suzuki, H.; Okada, H.; "Latest Activities of the AESJ Investigation Committee on the Nuclear Accident at the Fukushima Daiichi NPP", *Int. Conf. On Water Chemistry of Nuclear Power Systems, NPC2014*, Oct. 26-30, 2014, Sapporo, Japan, AESJ (2014).

[10] Uchida, S.; Naitoh, M.; Suzuki, H.; Okada, H.;" Evaluation of long and short term fission product sources based on the trend of contaminated water at the Fukushima Daiichi NPP", *Int. Conf. On Water Chemistry of Nuclear power Systems, NPC2014*, Oct. 26-30, 2014, Sapporo, Japan, AESJ (2014).

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[1] Winarto, Takaiwa, D.; Yamamoto, E.; Yasuoka, K. "Structures of water molecules in carbon nanotubes under electric fields", J. Chem. Phys., 142, 124701 (2015). (9 pages) DOI : 10.1063/1.4914462 :Selected as a cover

[2] Yamamoto, E.; Akimoto, T.; Yasui, M.; Yasuoka, K. "Origin of 1/f Noise in Hydration Dynamics on Lipid Membrane Surfaces", Sci. Rep., 5, 8876 (2015). (6 pages) DOI : 10.1038/srep08876

[3] Nomura, K.; Oikawa, M.; Kawai, A.; Narumi, T.; Yasuoka, K. "GPU-Accelerated Replica Exchange Molecular Simulation on Solid-Liquid Phase Transition Study of Lennard-Jones Fluids", Molec. Simul., in press. DOI : 10.1080/08927022.2014.954572

[4] Kojić, D.; Tsenkova, R.; Tomobe, K.; Yasuoka, K.; Yasui, M. "Water confined in the local field of ions", ChemPhysChem, 15, 4077-4086 (2014). (10 pages) DOI : 10.1002/cphc.201402381

[5] Grim, R. G.; Barnes, B. C.; Lafond, P. G.; Kockelmann, W. A.; Keen, D. A.; Soper, A. K.; Hiratsuka, M.; Yasuoka, K.; Koh, C. A.; Sum, A. K. "Observation of Interstitial Molecular Hydrogen in Clathrate Hydrates", Angew. Chem. Int. Ed., 53, 10710-10713 (2014). DOI : 10.1002/anie.201406546

[6] Goto, Y.; Tanaki, M.; Okusa, Y.; Shibuya, T.; Yasuoka, K.; Matoba, M.; Kamihara, Y. "Effects of the Cu off-stoichiometry on transport properties of wide gap p-type semiconductor, layered oxysulfide LaCuSO", App. Phys. Lett., 105, 022104 (2014). (4 pages) DOI : 10.1063/1.4890302

[7] Kaneko, T.; Bai, J.; Yasuoka, K.; Mitsutake, A.; Zeng, X. "Liquid-solid and solid-solid phase transition of monolayer water: High-density rhombic monolayer ice", J. Chem. Phys., 140, 184507 (2014). (7 pages) DOI : 10.1063/1.4874696

[8] Shibuya, T.; Yasuoka, K.; Mirbt, S.; Sanyal, B. "Bipolaron Formation Induced by Oxygen Vacancy at Rutile TiO2(110) Surfaces", J. Phys. Chem. C, 118, 9429-9435 (2014). DOI : 10.1021/jp410596d

[9] Yamamoto, E.; Akimoto, T.; Yasui M.; Yasuoka, K. "Origin of subdiffusion of water molecules on cell membrane surfaces", Sci. Rep., 4, 4720 (2014). (7 pages) DOI : 10.1038/srep04720 :Selected as a featured article in Nature Japan

[10] Yamamoto, E.; Akimoto, T.; Hirano, Y.; Yasui M.; Yasuoka, K. "1/f fluctuations of amino acids regulate water transportation in aquaporin 1", Phys. Rev. E., 89, 022718 (2014). (6 pages) DOI : 10.1103/PhysRevE.89.022718

[11] Shibuya, T.; Goto, Y.; Kamihara, Y.; Matoba, M.; Yasuoka, K.; Burton, L.A.; Walsh, A. "From kesterite to stannite photovoltaics: stability and band gaps of the Cu2(Zn,Fe)SnS4 alloy", App. Phys. Lett., 104, 021912 (2014). (4 pages) DOI : 10.1063/1.4862030

[12] Arai, N.; Akimoto, T.; Yamamoto, E.; Yasui M.; Yasuoka, K. "Poisson property of the occurrence of flip-flops in a model membrane", J. Chem. Phys., 140, 064901 (2014). (8 pages) DOI : 10.1063/1.4863330 :Selected as a cover

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[1] Hirano, Tomohiro, Miyamoto, Yuya, Amano, Shinya, Tatsumi, Kazuya, Anmoto, Takuya, Kimura, Hiroshi, Yoshida, Ken, Oshimura, Miyuki, Ute, Koichi, "Hydrogen-bond-assisted isotactic-specific radical polymerization of N-vinyl-2-pyrrolidone with tartrate additives in toluene at low temperatures: high-resolution ^{1}H NMR analysis", *RSC Advances*, **4**, No.95, pp.53079-53089 (2014). (DOI: 10.1039/C4RA08743G)

[2] Yoshida, Ken, Matubayasi, Nobuyuki, Uosaki, Yasuhiro, Nakahara, Masaru, "Effect of Rotational Couplings on Vibrational Spectrum Line Shape of Bending Mode in Low-Density Supercritical Water: Density and Hydrogen Isotopes Dependencies", *J. Solution Chem.*, **43**, No.9-10, pp.1499-1508 (2014). (DOI: 10.1007/s10953-014-0220-1)

[3] Kimura, Hiroshi, Hirayama, Masaki, Yoshida, Ken, Uosaki, Yasuhiro, Nakahara, Masaru, "Effect of Water on Hydrolytic Cleavage of Non-Terminal Glycosidic Bonds in Cyclodextrins to Generate Monosaccharides and Their Derivatives in a Dimethyl Sulfoxide Water Mixture", *J. Phys. Chem. A*, **118**, No.8, pp.1309-1319 (2014). (DOI: 10.1021/jp412628y)

International Association for the Properties of Water and Steam

Russian National Committee (RNC)

Report Second Half-Year of 2014- First Half-Year of 2015

1. RNC active participation in organization of next seminars for engineers and technology specialist from Russian power engineering companies:
    1. Cycle chemistry at power plants;
    2. Today technologies for cycle chemistry monitoring systems;
    3. Today experience of water treatment systems operation;
    4. Water treatment and cycle chemistry for combine cycle power plants.
2. Three meetings of RNC have been held. Current problems are investigated.

Publications list

1. Pokrovski G.S., Akinfiev N.N., Borisova A.Y., Zotov A.V., Kouzmanov K. Gold speciation and transport in geological fluids: insights from experiments and physical-chemical modelling. From: Garofalo, P. S., Ridley, J. R. (eds) Gold-Transporting Hydrothermal Fluids in the Earth's Crust. Geological Society, London, Special Publications, 402, pp. 9 – 70, 2014, doi: 10.1144/SP402.4

2. Hall D.M., Akinfiev N.N., LaRow E.G., Schatz R.S., Lvov S.N. Thermodynamics and efficiency of a CuCl(aq)/HCl(aq) electrolyzer. Electrochimica Acta 143 (2014) 70-82 (http://dx.doi.org/10.1016/j.electacta.2014.08.018)

3. Akinfiev N.N., Plyasunov A.V., Pokrovski G.S. An equation of state for predicting the thermodynamic properties and vapour–liquid partitioning of aqueous $Ge(OH)_4$ in a wide range of water densities. Fluid Phase Equilibria 392 (2015) 74-83. (doi:10.1016/j.fluid.2015.02.010)

4. Petrova T.I., Selesnev L.I., Bogatireva Yu.V. Flow-accelerated corrosion in heat recovery steam generation at combine-cycle power plants. // New in Russian power engineering. 2015 №2 – p -14 – 24.

5. OchkovV.F., Orlov K.A., Aleksandrov A.A., Ochkov A.V. Properties of Water and Steam: Network, Open, and Interactive IT Resources // Thermal Engineering, 2015, Vol. 62, No. 5, pp. 378-387.

6. OchkovV.F., Ustujanin E.E., Djo Ko Ko, Voloshuk V.A. Information and engineering support for thermal, nuclear and industrial power engineering // Energy saving and water treatment. No. 1, pp. 57-61.

7. Thermal technique etudes with Exel, Mathcad and Internet. Book. Ed. OchkovV.F. 2015 – 336 p.

8. OchkovV.F. Formulas in scientific publications, problems and answers// Cloud in Science. Vol.1 No. 3, pp. 421-456.

9. OchkovV.F., Orlov K.A., Djo Ko Ko. “Cloud” functions and patterns of engineering calculations for NPP // Thermal Engineering, 2014, No. 10, pp. 68-72.

10. Egoshina O.V., Voronov V.N., Nazarenko M.P., Tabakov I.A., Kolushnicina S.A. Development and organization of cycle chemistry monitoring systems at thermal power plants // Power engineer. No. 1, pp. 14-17.

11. Egoshina O.V., Voronov V.N., Rogov A.S., Aye Min Lagg. Experimental research of dynamic properties of water chemistry analyzers//Thermal Engineering, 2015, No. 5, pp. 63-66.

12. Egoshina O.V., Petrova T.I., Voronov V.N., Nazarenko M.P., Aye Min Lagg. Experimental unit for investigation of corrosion processes and scaling formation processes on heat-exchange surfaces under the high thermodynamic parameters // Industrial power engineering. 2015, No. 5, pp. 43-46.

13. Larin B.M., Larin A.B. The state of the technology of treatment of aqueous working medium at Russian thermal power stations. // Thermal Engineering, 2014, No. 1, pp. 68-72.

14. Yuzbasheva, E.Y., Gotovtsev, P.M., *et al*. Biodiesel production via enzymatic catalysis (2014) Applied Biochemistry and Microbiology, 50 (8), pp. 737-749.

15. Reshetilov A.N., Kitova A.E., Ivahnenko A.A., Gotovtsev P.M., Vasilov R.G., Gutorov M.A. Accumulation of electrical energy from biofuel cell. // Ovchinnikov bulletin of biotechnology and physical and chemical biology.2014 V10 №4 p. 27 – 32

16. Badranova G.U., Gotovtsev P.M. *et al*. Devices for medical implants energy supply and materials for their construction. // Ovchinnikov bulletin of biotechnology and physical and chemical biology.2014 V10 №4 p. 54 – 66

17. Gotovtsev, P.M., Yuzbasheva, E.Y., *et al*. Immobilization of microbial cells for biotechnology industry applications. Current state and perspective technologies. // Biotechnologia 2015 №2 p. 8 – 21

18. Egoshina O.V., Voronov V.N., Yarovoy V.O. Analysis if operation of cycle chemistry controlling systems at combine-cycle power plants. Water treatment and cycle chemistry at thermal power plants. Conference proceedings. 26-28 May 2015 pp. 61-68

19. Egoshina O.V., Kuzina K.E. Characteristics of pH measurements in highly diluted solutions. National congress in power engineering. Conference proceedings. September 2014 pp. 127 – 131

20. Egoshina O.V., Makarishiva N.A. Comparison analysis of dynamic characteristics of automatic analyzers of oxydgen. National congress in power engineering. Conference proceedings. September 2014 pp. 304 – 309

21. Egoshina O.V., Makarishiva N.A., Aye Min Lagg. Investigation of dynamics of automated ammonia dosing systems in laboratory conditions. Current state and perspectives of electrical and thermal power engineering. Conference proceedings. 2015.

22. Egoshina O.V., Makarishiva N.A., Stoliarova E.A., Aye Min Lagg. Calculation of anionic compounds in clarified water based on electrical conductivity measurements. 3d All-Russian scientific and technical conference pf post graduate, graduate students and young scientists. Conference proceedings. 22 – 23 May 2015 pp. 956 – 960

23. OchkovV.F., Ustujanin E.E. Analysis of Internet resources about thermophysical properties of substances. XIV All-Russian conference on thermophysical properties of substances. Conference proceedings. 2014 – pp. 195-198

24. OchkovV.F. Modern progress in publication of data bases about thermodynamical properties of substances. XIV All-Russian conference on thermophysical properties of substances. Conference proceedings. 2014 – pp. 15-16

25. OchkovV.F., Djo Ko Ko. On-line calculation, cloud functions and patterns on thermodynamic properties of substances. XIV All-Russian conference on thermophysical properties of substances. Conference proceedings. 2014 – pp. 179-180

26. OchkovV.F., Ustujanin E.E., Djo Ko Ko. Data extrapolation of water in critical ares IAPWS-IF95 – density and pressure. All-Russian conference on thermophysical properties of substances. Conference proceedings. 2014 – pp. 198-201

27. Lazukin A.V., Krivov S.A., Gotovtsev P.M., *et al*. Application of surface discharge as a basis of autonomous high-voltage electro-technical units. Conference proceedings. XV International conference "Electromechanics, electrotechnology, electrotechnical materials and components. Conference proceedings. 2014 – pp. 246-247

The Swiss National Committee

International Association for the Properties of Water and Steam

Report on IAPWS related activities – September 2014 / June 2015

Submitted to the EC Meeting of IAPWS, Stockholm, Sweden - June 2015.

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SCPWS Swiss Committee for the Properties of Water and Steam
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Following Institutions participated in the research into the thermophysical properties and chemical processes:

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Research activities in the reporting period:

No new projects were reported

Contributions to current IAPWS activities:

Vice-chairman of Subcommittee on Sea-Water: M. Hiegeman

Preliminary research for the new 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. The board of SCPWS is planning a national meeting in autumn 2015 to find new participating institutions.

- It is requested to extend the Associate Membership for another term.

Recent Publications:

Svoboda, R., Review of Alkaline Treatment for Generator Stator Cooling Water Systems, *PowerPlant Chemistry* **2014**, 16(6), 352.

Svoboda, R., The EPRI Steam Turbine Generator Workshop: Discussions on Alkaline Treatment, *PowerPlant Chemistry* **2014**, 16(6), 392.

Lendi, M., Continuous Photometric Determination of Film-Forming Amines, *PowerPlant Chemistry* **2015**, 17(1), 24.

Svoboda, R., et al., Loss of Alkalization in an Alkaline Treated Stator Cooling Water System, *PowerPlant Chemistry* **2015**, 17(3), 181.

U.S. National Committee to IAPWS
2015 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 continue to work on an IAPWS project for an equation of state for the thermodynamic properties of heavy water. A preliminary equation has been developed, and is being refined and augmented by some new data.

  Work is beginning on a related IAPWS project to develop new transport property correlations for heavy water.

- In a collaboration with researchers at Fondazione Bruno Kessler (Italy), Nicolaus Copernicus University (Poland), and the University of Delaware (USA), a state-of-the-art flexible model for the water pair potential has 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. Some weaknesses in the current potential at larger distortions are being addressed, after which the calculations will be repeated and uncertainties will be estimated.

- In NIST's Sensor Science Division (Gaithersburg, MD), a gravimetric apparatus has been used to measure the saturation concentration of water as a function of temperature and pressure in compressed gaseous carbon dioxide (equivalent to a dew-point measurement) at pressures up to 5 MPa. These data are important for the design of systems for compression and transportation of CO_2 for carbon capture and sequestration. Data have been obtained for six isotherms at approximately 10 °C, 21.7 °C, 30 °C, 40 °C, 60 °C and 80 °C. The data have been processed to yield cross second virial coefficients, which are found to agree with theoretical predictions. A paper on the work is in press: C.W. Meyer and A.H. Harvey, Dew-point measurements for water in compressed carbon dioxide, *AIChE Journal*, in press (2015) doi: 10.1002/aic.14818.

- NIST, in partnership with ASME, AIChE, and the University of Colorado-Boulder, recently hosted the 19th Symposium on Thermophysical Properties. The meeting included seven oral sessions plus a number of posters devoted to aqueous systems: see http://thermosymposium.nist.gov for information and abstracts of the presentations.

Communicated from the University of Maryland, College Park

- Research on supercooled water:

V. Holten, J. V. Sengers, and M. A. Anisimov, "Equation of state for supercooled water at pressures up to 400 MPa", J. Phys. Chem. Ref. Data **43** (4) 043101-0431024 (2014).

- Research on aqueous solutions:

M. B. Taraban, L. Yu, Y. Feng, E. V. Jouravleva, M. A. Anisimov, Z.-X. Jiang, and Y. B. Yu, "Conformational transition of a non-associative fluorinated amphiphile in aqueous solution" RSC Adv., **4**, 54565-54575 (2014).

A. E. Robertson (high-school senior), D. H. Phan (undergraduate student), J. E. Macaluso (undergraduate student), V. N. Kuryakov (graduate student), E. V. Jouravleva, C. E. Bertrand, I. K. Yudin, M. A. Anisimov, "Mesoscale solubilization and critical phenomena in binary and quasi-binary solutions of hydrotropes", Fluid Phase Equilibrium (special issue, to be published, 2015).

- Guideline on Thermodynamic Properties of Supercooled Water:

To be considered at the Annual Meeting of the International Association for the Properties of Water and Steam, Stockholm, Sweden, June 20-July 3, 2015

Communicated from OLI Systems

- Aqueous solution chemistry of rare-earth elements. OLI Systems is a member of the Department of Energy's Critical Materials Institute, which has been established to address the U.S. needs for critical materials, with particular emphasis on rare earth metals. OLI Systems provides simulation tools for rare earth metals in aqueous environments. In a recently completed project, we provided simulation tools for optimizing electrochemical recycling of rare earth elements. This work has been published in:

  T.E. Lister, P. Wang, and A. Anderko, "Recovery of critical and value metals from mobile electronics enabled by electrochemical processing", Hydrometallurgy, 149 (2014) 228-237

  Work is in progress on analyzing phosphogypsum-related systems as an alternative source of rare-earth elements.

- Aqueous CO2-H2S systems. The following paper has been published about a comprehensive model for systems containing water, carbon dioxide, hydrogen sulfide, and common salts:

  R.D. Springer, P. Wang, and A. Anderko, "Modeling the Properties of H2S – CO2 – Salt – Water Extreme Environments", SPE Journal, in press,
  DOI: http://dx.doi.org/10.2118/173902-PA.

- Thermal conductivity of seawater. A revised model for the thermal conductivity of seawater has been published:

P. Wang and A. Anderko, "Revised Model for the Thermal Conductivity of Multicomponent Electrolyte Solutions and Seawater", Int. J. Thermophysics, 36 (2015) 5-24

Based on this model, a simple formulation has been proposed as an IAPWS Guideline for seawater thermal conductivity.

- Aqueous solution chemistry of actinides. Work is in progress on developing a comprehensive model for the thermodynamic behavior of uranium, plutonium, neptunium, americium, and curium in multicomponent aqueous solutions.

Communicated from Scripps Institution of Oceanography

- Researchers from the U.S. contributed to two large review papers related to metrology for physical oceanography, with substantial Scripps involvement in Part 1 and Part 3,

  Metrological challenges for measurements of key climatological observables: Oceanic salinity and pH, and atmospheric humidity. Part 1: Overview by Feistel, Rainer; Wielgosz, Robert; Bell, Stephanie; Camoes, Maria; Cooper, Jeff; Dexter, Peter; Dickson, Andrew; Fisicaro, Paola; Harvey, Allan; Heinonen, Martti; Hellmuth, Olaf; Kretzschmar, Hans-Joachim; Lovell-Smith, J; McDougall, Trevor; Pawlowicz, Rich; Ridout, Paul; Seitz, Steffen; Spitzer, Petra; Stoica, Daniela; Wolf, Henning Article reference: MET-100397.R1

  Metrological challenges for measurements of key climatological observables, Part 3: Seawater pH by Dickson, Andrew; Camoes, Filomena; Spitzer, Petra; Stoica, Daniela; Fisicaro, Paola; Pawlowicz, Rich; Feistel, Rainer Article reference: MET-100472

- Scripps also continues involvement in SCOR Working Group (WG-145) that will — in part — address the need for a suitable activity coefficient model for seawater that can be used to further the goal of establishing a suitable seawater pH definition that is metrologically traceable. This group has met once, and is now planning its future work.

Delegate List

IAPWS ANNUAL MEETING 2015 IN STOCKHOLM

Title	Surname	First Name	Company	Country
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Dr.	Allan	Harvey	NIST	US
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Mr.	Hattingh	Jared	Anodamine	US
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