THE INTERNATIONAL ASSOCIATION FOR THE PROPERTIES OF WATER AND STEAM

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

ASSOCIATE MEMBERS
Argentina and Brazil
China
Egypt
France
Greece
Italy
Switzerland

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Minutes of the Meetings

of the

Executive Committee

of the

International Association for the Properties of

Water and Steam

Prague, Czech Republic
2nd – 7th September 2018

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
Prague, Czech Republic
2nd – 7th September 2018

Plenary Session. Sunday, 2nd September 2018. 9:03am

The President of IAPWS, Professor Hans-Joachim Kretzschmar, welcomed the Executive Committee (EC) and other IAPWS members to Prague for the 17th ICPWS and the Executive Committee (EC) and Working Group (WG) Meetings of IAPWS. He first asked the Chair of the Czech National Committee, Dr. Tomáš Němec, to welcome the EC to Prague and introduce the Chairman of the 17th ICPWS, Dr. Jan Hruby. The President then officially opened the 2018 EC Meetings by introducing the National Delegates. All of the Member and Associate Member countries of IAPWS were in attendance with the exception of New Zealand, Argentina/Brazil, China, France and Greece. In total there were 26 people assembled for the EC meeting.

1. Adoption of Agenda

Provisional agendas had been posted on the IAPWS Website for all IAPWS members by the Executive Secretary in June 2018. There were a few additions and the final 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 IAPWS Business Since Last EC Meeting in Kyoto, Japan, August / September 2017

The Executive Secretary indicated that one document had been circulated to the National Committees during the year since the Kyoto meeting for final approval:

- *Release on the IAPWS Formulation 2017 for the Thermodynamic Properties of Heavy Water*. Kyoto EC Minute 7.1 indicated that the Release would have an Editorial Committee review after the Kyoto meeing. This was completed, and the document was circulated for a Postal Ballot on 8th December 2017. No objections were received by 9th March 2018, so the Release became an official IAPWS document (R16-17).

2.2 Press Release / IAPWS Highlights.

The President asked Cook to chair the development of the Highlights/Press Release on the IAPWS / ICPWS proceedings during the week. It was also suggested that Hruby and Němec assist in this development. The Clerks of Minutes from each WG were asked to provide input. The Press Release is discussed in Minute 18.1 and is Attachment 9.

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 Minute 15.1 for further discussion on International Collaborations).

2.4 IAPWS Awards Committees

2.4.1 Helmholtz Award Committee

The Executive Secretary reminded the EC that the Helmholtz Committee for the 2019 award would consist of a member from BIAPWS, Canada, Czech Republic, Germany and Japan. BIAPWS will provide the committee chairman. The President asked BIAPWS delegate, Sparrey, to organize the committee and to report back to the EC on Friday with the names of the members of this committee (see Minute 16.1).

2.4.2 Honorary Fellow Award Committee

The President requested that Nakahara (Chairman) and Harvey form the Committee for 2019. The President would be ex. Officio.

2.5 Preparation for the General Meeting. Host Country for 18th ICPWS

The Executive Secretary indicated that the next country in line to host the 18th ICPWS is the USA, and requested that the head of the US National Committee, Friend, discuss the possibility of holding the next conference with the US Committee and report back to the Executive Secretary by the end of 2018.

2.6 Discussion on Future ICPWS

The Exceutive Secretary indicated that there had been 17 ICPWS conferences and that the first one was in 1929. Since the 1989 11th ICPWS in Prague the format for the conferences had been the same. This year the number of attendees was reduced compared with previous conferences, and the President, Vice President and Executive Secreatry suggested to the EC that a small committee should be formed to review the format and frequency of the conferences and whether they should continue. After some discussion a committee was formed: Friend (Chair), Cook, Hruby, Henderson, Dooley and Rziha. They would meet during the week and report back to the EC at the Friday meeting (see Minute 18.3)

2.7 OPAL Website for IAPWS Documents and Presentations

The President reminded the EC of the Opal Website for storage of IAPWS Working Group files and presentations. This is a password protected site for use by the IAPWS Working Groups.

3. EC Mandate to Working Groups and Membership

The President introduced 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 one ICRN needed attention during the week. ICRN #22 on steam chemistry in the phase transition zone (PTZ) needed finalization by the PCC Working Group, brief review by the Editorial Committee and then a Postal Ballot.

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 Working Group (WG) Chairmen of the Week's Activities

President Kretzschmar 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 3 to 7).

Following this item, the President closed the opening session of the EC at 9:45am.

Activities During the Week in Prague

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

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

Executive Committee Meeting. Friday, 1st September 2017

President Kretzschmar opened the continuation of the EC Meeting at 8:32am. All of the Member and Associate Member countries of IAPWS were in attendance with the exception of Argentina/Brazil, France and Greece. In total there were 30 people assembled for the EC meeting.

The President then presented the 2018 IAPWS Honorary Fellow Award to Mr. Ingo Weber.

Kretzschmar then asked the EC if there were any additional items that should be added to the EC Agenda. None were suggested.

5. Acceptance of Minutes of Previous Meeting

President Kretzschmar asked for comments and changes to the minutes of the EC meeting held in Kyoto, Japan in 2017. No changes were noted, thus the 2017 Minutes were accepted.

6. President's Report

President Kretzschmar next provided his report and indicated that this was the same report as presented at the IAPWS General Meeting:

6.1 The President first wanted to thank the Czech National Committee for arranging the 17th ICPWS under the Chairmanship of Hruby.

6.2 Membership. Kretzschmar was very pleased to welcome Australia as a Member of IAPWS (Minute13.1).

6.3 Working Group (WG) Activities. The President indicated that the Working Group (WG) IRS was very important to IAPWS and encouraged them to include people from industry. The Technical Guidance Documents from the PCC WG were penetrating internationally and giving IAPWS a leadership position.

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 joint meeting with IRS and SCSW had taken place during the week. Full Minutes and the Agenda for TPWS can be found in Attachment 3.

7.1 The Working Group (WG) considered a *Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (IAPWS-95).* There had been some minor document updates to clarify some calculations and improve some uncertainty estimates; the formulation had not changed. The WG had voted to approve the draft revised Release. The WG Chairman requested the EC to authorize a Postal Ballot.

The EC approved this Request Unanimously.

7.2 The Working Group (WG) considered a *Revised Release on the IAPWS Formulation 2017 for the Thermodynamic Properties of Heavy Water.* The revision reflects an improved formulation, after the WG found some highly accurate liquid data had been omitted from the fit approved last year. The WG voted to approve the draft revised Release. The WG Chairman requested the EC to authorize a Postal Ballot after Editorial Committee approval.

The EC approved this Request Unanimously.

7.3 The Working Group (WG) considered a *Revised Advisory Note 3: Thermodynamic Derivatives from IAPWS Formulations.* The revision was needed to make it consistent with the new heavy water Release. The WG voted to approve the draft revised Advisory Note. The WG Chairman requested the EC to authorize a Postal Ballot after Editorial Committee approval.

The EC approved this Request Unanimously.

7.4 Harvey provided an informational item that a Task Group had been formed to prepare a *Guideline on the Diffusion Coefficient of Water*. The new membership of the Task Group will consist of: Yoshida, Harvey, Caupin and Hellmann. The WG also appointed an Evaluation Task Group: Meier (chair) and Orlov [also Anderko from PCAS].

7.5 ICRNs.

Harvey reported that ICRN-27 (properties of humid gases and CO_2-rich mixtures) was closed in 2014. Span and Harvey need to prepare closing statement. The first draft was prepared during the week and should be completed in 2018.

7.6 TPWS Membership.

Chairman Harvey requested EC approval for two new TPWS WG members who had been approved by the WG:

- Cornelia Breitkopf (Technical University Dresden, Germany)
- Robert Hellmann (University of Rostock, Germany)

Harvey also informed the EC that Henning Wolf had retired from PTB, Germany and had requested to be removed from membership.

The EC approved these Membership Changes Unanimously.

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

IRS Chairman Okita indicated that many of the activities of IRS had been reported in the TPWS report. Minutes for IRS and the Agenda can be found in Attachment 4. He then reported on the following informational items on IRS Task Groups:

- Task Group on Categories of Industrial Requirements will continue. The categories will be shared using the OPAL password protected site for the review by each WG.

- Task Group on Industrial Advisory Note will be terminated. The WG will consider reopening the Task Group after the categories have been prepared.

- Task Group on Wet Steam Properties Calculation will continue. The WG will contact ASME through the US Delegate, Friend, and any other specialists for assistance.

- Task Group on ICRN for Acid Gas Dew Points will continue. The WG suggests cooperation with the PCAS WG.

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 5.

9.1 Task Group on Surface Tension of Seawater

The Task Group will continue their work, which could result in a new Guideline by the IAPWS 2019 Meetings in Canada. Duska was added to the Evaluation Task Group.

Discussion was raised by the EC that this could be an area of cooperation with the PCC and PCAS WGs. There was agreement that a joint workshop would be arranged during the 2019 IAPWS meetings in Canada.

9.2 Information for EC.

The Chairman provided two informational items:

- During the week, the SCSW and JCS (Joint Committee on Seawater) organized four BIPM / IAPWS workshops on seawater topics (salinity / density, pH, relative humidity, and the future of JCS).
- In 2019, under the conditions of its formation, the Terms of Reference and the Executive for JCS will have to be re-approved by IAPWS. JCS talked about this during the week and developed a proposal. This will require approval by SCSW and then need to be presented to the EC at the 2019 EC meeting in Canada.

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 6.

10.1 Guidelines.

- Self-diffusion in High Temperature and Supercritical Water over Wide Density Ranges is in an advanced stage of development with Yoshida as Chair. An evaluation committee has been appointed.
- Volatility and Dissociation Constants of Amines and Amine Decomposition Products. Task Group consists of Bellows (Chair) and Anderko.

Discussion was raised by the EC for initiation of important work on Film Forming Substances (FFS). There was agreement that a joint PCAS / PCC workshop would be arranged during the 2019 IAPWS meetings in Canada. Also, it was suggested that an ICRN should be developed on FFS.

10.2 Membership

Chairman Anderko proposed Hugues Arcis (Guelph University, Canada) for membership additon for PCAS. He also indicated that he was stepping down as PCAS Chair after five years and proposed to the EC that Yoshida becomes the new Chair with Arcis as Vice-Chair

The EC approved these Membership Changes 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 7. The following items were covered:

11.1 Technical Guidance Documents (TGD).

The PCC working group had discussed extensively the TGD developments. The TGD Task Group (Chair: Dooley) activities can be summarized as follows.

- *Application of Film Forming Substances (FFS) in Industrial Plants*. The Task Group (Dooley, Hater and Lendi (Joint Chairs), Rziha, and Carvalho) have developed a draft TGD which has been circulated to the full TGD Task Group and the PCC WG. The document requires a few additions which will be added by the end of October, then will be circulated again for review to the PCC WG. The PCC Chairman requested that the document can be sent for a postal ballot following review by the Editorial Committee.

  The EC approved this Request Unanimously.

- *Air In-Leakage in Steam Water Cycles*. The Task Group (Carvalho (Chair), Dooley, Rziha and Thomsen) finalized the TGD in August 2018 after review by the TGD Task Group and the PCC WG. It is now being reviewed by the Editorial Committee. The PCC Chairman requested that the document can be sent for a postal ballot following this review.

  The EC approved this Request Unanimously.

- *Chemistry Management in Generator Water Cooling Systems*. The Task Group (Svoboda (Chair) and Dooley) will develop the new TGD for the 2019 Meeting.
- *Monitoring Corrosion Products in Flexible (cycling and two-shifting) Plants*. The Task Group (Addison and Thomsen (Joint Chairs), Cook, McCann, Dooley, Henderson, and Powalisz) will develop a White Paper for the 2019 Meeting. Extensive plant sampling and detailed evaluation is on-going and is the focus of an IAPWS International Collaborative Project.
- *Ensuring the Integrity and Reliability of Demineralised Makeup Water Supply to the Unit Cycle*. The Task Group (Joy, Chair) plan to develop the final TGD by the 2019 Meeting.
- *Application of Film Forming Substances (FFS) in Nuclear Plants*. The Task Group (Cook, Chair) will develop a White Paper by the 2019 Meeting.
- *Aspects of Geothermal Steam Chemistry*. The Task Group (Addison, Chair, plus representatives from Geothermal Countries) will finalize the White Paper for the 2019 Meeting.

- *Condensate Polishing for Combined Cycle / HRSG Plants.* The expanded task Group (Khalifa (Chair) met during the week and will develop a White Paper for the 2019 meeting.

11.2 PCC Membership.

The PCC Chairman requested that the following new members be approved:

- Joerg Fandrich (Framatome, Germany)
- Hayden Henderson (AGL, Australia)
- John Powalisz (Sentry Equipment, USA)
- Craig Stuart (CNL, Canada)

The Chairman also indicated that the WG proposes Addison to become an additional Vice Chairman.

The EC approved these Membership Additions Unanimously.

12. Editorial Committee Report

Editorial Committee Chairman Harvey reported that in the preceding year, the Editorial Committee (Harvey, Cook and Cooper) had reviewed the document in Minute 2.1. The Committee also has in progress review of the revised Advisory Note #3, revised Release on Heavy Water, and the TGD on Air In-leakage.

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 Application of Australia for IAPWS Membership

The outgoing Chair of AUSAPWS, Joy, indicated that this was a very significant day for Australia. AUSAPWS had been formed in 2010 and became an IAPWS Associate Member in 2011. He wished to thank a number of people for supporting the development: Dooley (from IAPWS), Mc Dougall (on the seawater side), NZIAPWS, and the past AUSAPWS officers. He then handed the presentation to the in-coming AUSAPWS Chair, Henderson, who provided the current status: a) 160 individual members from the power generation industry, Universities, industry service companies and consultants, and b) 15 companies have provided expressions of interest for Company membership. AUSAPWS also has collaborative support links with Australian Power Institute (API), Aurecon (now AmpControl), Australasian HRSG Users Group (AHUG) and AGL. He then introduced the current AUSAPWS committee, and indicated there are plans for future events, a newsletter, collaboration with other conferences, and expansion into other forums of IAPWS interest.

Henderson then requested EC that AUSAPWS become a full Member of IAPWS.

The EC approved AUSAPWS as a Member of IAPWS Unanimously.

13.2 Report on Membership and Member Dues.

The Executive Secretary indicated that only the Czech National Committee had not paid the 2018 IAPWS dues. Chairman Němec explained this had resulted from a change in the legal status of the Czech National Committee at the end of 2017. He assured the EC that they are actively seeking to pay the 2019 IAPWS dues.

13.3 Reports on Current Associate Members

Status Report on IAPWS Associate Member, China. The Executive Secretary provided a short presentation received from the four participants from China. Approved by China Electric Power Enterprise Federation, the China Electric Power Plant Chemical Standardization Technical Committee became the Associate member of IAPWS in May 2017. This committee is an academic group composed of nearly 40 experts from various research institutes in China and mainly carries out the formulation and revision of China's standards in Power Plant Chemistry, and also organizes some academic activities in Power Plant Chemistry. For example, they have just completed review of the criteria: 1) Technical requirements of stainless steel screen pipe for power plant water treatment equipment; 2) Evaluation of kinetic behavior of strongly basic anion exchange resin for water treatment in power plants; 3) Guideline for the acceptance of pleated filter element for water treatment in power plants; 4) Calibration procedures of trace total organic carbon analyzer in power plant; 5) Determination of the group percentage of chloride form, carbonate form and sulfate form in nuclear grade anion exchange resin; and 6) Determination of thermostability and anti-oxidation stability of strongly basic anion exchange resins for water treatment. Delegates from this committee have participated in the PCC WG activities, and personnel from the Marine Information Technology Research Institute have participated in the SCSW.

Status Report on IAPWS Associate Member, Egypt. Chairman Khalifa provided a short report on 2018 activities and plans for 2019. There are plans for expansion of Egypt's generating capacity to 80,000 MW by 2020, so improving the national capacity and capability is essential. Khalifa indicated that there have been many technical presentations about IAPWS to increase awareness about TGDs in the power generation community. PGESCo have confirmed their support of the national committee. There are still a few administrative and legal items to finalize, but the National Committee is hoping to hold a first meeting in the first quarter of 2019.

Status Report on IAPWS Associate Member, Italy. Chair person Lago provided a short report on activities of INRiM (Instituto Nazionale di Ricerca Metrologica), the recently formed European Metrology Network (EMN) on Climate and Ocean Observation, and on the interfaces with numerous professional organizations. In 2019 INRiM will insert on its website some information and links for National Industries and Companies sponsoring IAPWS activities.

Status Report on IAPWS Associate Member, Switzerland. The Secretary of the Swiss National Committee (SCPWS), Werder, provided a short report on activities (see Attachment 17). Up to now, no team of sponsors to commit on a mid- or long-term basis to a regular Swiss membership fee has yet been assembled. Activities were therefore

limited to a few individuals. The board of SCPWS is currently planning a small event in Spring 2019 to find new participating institutions in Switzerland.

Secretary Werder requested that the Associate Membership of SCPWS be extended for another term.

The EC approved this request Unanimously.

Activities of other Associate Members of IAPWS. The Executive Secretary provided short updates on Argentina/Brazil, France and Greece. The Gibbs Awardee, Fernandez-Prini, will try to reactivate discussion with his colleagues in Argentina. During the week the Executive Secretary and President met with four ICPWS attendees from France, who will try to determine interest across the country. The EC was requested to provide details on French contacts to the Executive Secretary. IAPWS will be supporting the European HRSG Forum (EHF2019) in Athens in May 2019, and will arrange an associated meeting to engage the Greece IAPWS community.

14. Executive Secretary's Report

14.1 IAPWS Bank Accounts, Financial, Auditors and IAPWS Dues

The Executive Secretary reported that IAPWS is on a sound financial footing with currently about £66,00.00GBP in total in the UK and US bank accounts. The status as at 24th August 2018 in the bank accounts had been provided to each National Delegate prior to the EC meeting.

The Executive Secretary next reported that the 2017 financial statements had been forwarded to the IAPWS Auditors in January 2018. Professor Savarik in Czech Republic and Dr. Hencke in Germany had reviewed and approved the financial statements. These 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 2019. He also mentioned that IAPWS By-Law #1 provided the basis of the dues structure, and that this would be used to assess the dues for Australia for the new membership in 2019.

The EC Unanimously Agreed to this Proposal.

The Executive Secretary had also provided a rough estimate of the income and known planned expenditures for 2018 / 2019.

14.2 Time and Place of the 2019, 2020 and 2021 Meetings

2019 IAPWS Meetings. The Head of the Canada National Committee, Cook, indicated that the the 2019 IAPWS meetings will be in Banff, Alberta from 29th September to 4th October 2019 at the Banff Centre for Arts and Creativity. A website (www.IAPWS2019.org) has been developed for the meetings.

2020 and 2021 IAPWS Meetings. The Executive Secretary informed the EC that New Zealand and Italy have been requested to consider hosting the 2020 and 2021 IAPWS meetings. Discussion by the EC resulted in a consensus that it was preferred to hold the 2020 meetings in Italy and the 2021 meetings in New Zealand. The NC heads of Italy (Lago) and New Zealand (Addison) agreed to review these requests with their committees and confirm with the Executive Secretary by the end of 2018. Further details on the 2020 meeting will be provided at the 2019 meetings in Canada.

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.

15.1 International Collaborative Project.

The President requested the Chairman of the 2019 International Collaboration Committee (WG and SC Chairs) to report on the findings of that committee during the week. Chairman Harvey reported that one collaborative project had been proposed. The following is an overview of the proposed project. The original proposal details are provided in Attachment 8:

The Effects of Combined Impurities (chloride and sulfate) on the Corrosion of Fossil and Combined Cycle / HRSG Boiler Tube Materials

The work proposed in this International Collaboration (IC) project will capitalize on the efforts from the previous collaboration to develop the experimental equipment and procedures. A Master's student (person yet to be determined) will be supported through this IC project to utilize the UNB (University of New Brunswick) test rig and electrochemical test system. A full scope of experiments to pin-point the progression of corrosion in boiler systems with individual and mixed contaminants will be conducted using the Linear Polarization method. This is well suited to identify the threshold for the onset of accelerated corrosion. The test plan will encompass typical IAPWS AVT(R) and AVT(O) chemistry conditions with a range of pH between 9.0 – 9.8, and chloride and sulfate concentrations between 0 – 1000 ppb. The proposal requests £18,000 (GBP) for student support and travel expenses.

Harvey indicated that the Evaluation Committee supported the proposal, that it was technically sound and contributed to the goals of IAPWS. There were a few discussion points for clarification: a) the student was expected to take about a year to conduct the experimental work, and b) it was preferred if an international student could be found. A question was raised by the US Delegate about the availability of sufficient funds within IAPWS; after some discussion the consensus of the EC was that this was an important project for IAPWS, and that the funding could be managed. A proposal was then developed by the SIAPWS Delegate for IAPWS to support the IC once a suitable

international student had been identified. The US Delegate added a caveat to the proposal that the funding should, if possible be staged across 2019 and 2020 to eleviate concerns about minimum balance in the IAPWS accounts. The EC, minus the Delegates from Canada and New Zealand, were then asked to vote.

The Collaborative Project was Approved Unanimously by the Remaining Members of the EC.

16. IAPWS Awards

16.1 IAPWS Helmholtz Award

The President reported that Dr. Hugues Arcis from Guelph University in Canada had received the 2018 IAPWS Helmholtz Award and presented the Helmholtz lecture during the ICPWS.

The President asked the BIAPWS Delegate, Sparrey, for the names of the 2019 Helmholtz Award Committee. The 2019 Helmholtz Committee will consist of: Chairman Sparrey (BIAPWS), Cook (Canada), Nemec (Czech Republic), Rziha (Germany) and Yoshida (Japan).

Action: Nominations will be due to the Executive Secretary by 31st January 2019.

16.2 IAPWS Honorary Fellowships

The President reported that Mr. Ingo Weber from Siemens in Germany had received the 2018 IAPWS Honorary Fellow Award.

The President reminded the EC of the Awards Committee for 2019 with Nakahara (Japan) as Chairman and Harvey (USA) as member with the IAPWS President as ex.-officio member.

Action: Nominations are due to the Executive Secretary by 31st January 2019.

17. Election of IAPWS Officers for 2019 and 2020

The Executive Secretary indicated that according to the Statutes, the election of the next Vice President should be made at the end of the EC meeting in even years. The President and Executive Secretary had checked the recent history, and suggest that the Japan National Committee should be asked to nominate one of their committee members for the position. The Executive Secretary asked the EC if there were any other suggestions or comments. None were suggested, so he then requested the EC to approve this selection.

The EC Unanimously Approved this Selection Process.

Action: The Japan National Committee should inform the Executive Secretary of their agreement to provide a nomination for Vice President after the next meeting of their committee, and before the end of December 2018.

18. New Business

18.1 Press Release

The President mentioned that Cook had been asked at the EC meeting on Sunday 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 9. 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.

18.2 Czech National Committee Feedback on the Prague ICPWS and EC Meetings.

The ICPWS Conference Chair, Hruby, thought the IAPWS meetings had been a great success. There had been 140 conference participants from 27 countries. Hruby gave the EC an initial financial summary and indicated that a full accounting would be provided to the Executive Secretary later in 2018.

The President thanked Hruby and his extended team for organizing the 17th ICPWS.

The Executive Secretary indicated that the Guidance Document for Organizing ICPWS conferences would be updated based on the experiences of the Czech National Committee in arranging the 17th conference.

18.3 Report on Committee for Future ICPWS

President Kretzschmar asked Friend to provide the EC with feedback on the Committee's discussions during the week. Friend presented the summary in Attachment 10. First, he reviewed the issues which had been raised, and then some possible options for future ICPWS. After much discussion by the EC, the consensus appeared to be moving to a variety of option 7, which could involve a shorter ICPWS (2 – 2.5 days) and 3 days of "normal" EC and WG meetings within a one week timeframe. There was also some discussion on more frequent shorter ICPWS conferences.

The US Chair indicated the US National Committee would report to the Executive Secretary by the end of 2018 on whether they would be willing to host the next ICPWS. They would consider the various options and provide further discussion at the 2019 IAPWS EC Meeting in Canada.

18.4 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:

Canada	Attachment 11
Czech Republic	Attachment 12

Germany	Attachment 13
Japan	Attachment 14
New Zealand	Attachment 15
SIAPWS	Attachment 16
Switzerland	Attachment 17
USA	Attachment 18

18.5 Participants

Attachment 19 provides a list of participants at the ICPWS, IAPWS EC and WG Meetings in Prague, Czech Republic in September 2018.

18.6 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 Prague Meetings. This will be forwarded electronically to the Head of each National Committee and the Working Group Chairs.

19. Closing Remarks and Adjournment

No further business was raised by the EC. The President thanked everybody for participating at this EC meeting. Then he formally closed the 2018 EC meeting at 12:10 pm.

AGENDA for the EXECUTIVE COMMITTEE of IAPWS

Prague, Czech Republic. 2nd – 7th September 2018

Sunday, 2nd September 2018. Opening Plenary Session (9:00 – 10:15 am)

Opening Remarks, Welcome and Introductions by IAPWS President H-J. Kretzschmar

1. Adoption of Agenda
2. IAPWS Business and Appointment of Committees
   - 2.1 IAPWS Business since Last EC Meeting in Kyoto, September 2017
   - 2.2 IAPWS Highlights / Press Release
   - 2.3 Evaluation Committee on International Collaboration
   - 2.4 IAPWS Awards for 2019 (Honorary Fellow, Helmholtz)
   - 2.5 Preparation for General Meeting
     - Host Country for 18th ICPWS
   - 2.6 Other business requiring special/extensive discussions
3. EC Mandate to Working Groups and Membership
   - 3.1 Releases, Guidelines and ICRNs
4. Preview of Week's WG Activities by WG Chairmen

Friday, 7th September 2018. Executive Committee Meeting. (8:30am – 1:00 pm)

5. Acceptance of Minutes of Previous Meeting
6. President's Report
7. Report and Recommendations of Joint TPWS, IRS and the Sub-Committee on Seawater
8. Report and Recommendations of Separate IRS Meetings
9. Report and Recommendations of Separate Sub-committee on Seawater Meetings
10. Report and Recommendations of PCAS
11. Report and Recommendations of PCC
12. Editorial Committee Report
13. Membership and Associates
    - 13.1 Application of Australia for IAPWS Membership
    - 13.2 Report on Membership. Including Members Defaulting on Dues.
    - 13.3 Report of Current Associate Members
14. Executive Secretary's Report
    - 14.1 IAPWS Bank Accounts, Financials, Auditors and Dues
    - 14.2 Time and Place of 2019 and 2020 Meetings.
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 Election of Officers for 2019 and 2020

18 New Business
   - 18.1 Press Release
   - 18.2 Czech Republic Committee feedback on 2018 IAPWS/ICPWS
   - 18.3 Report on Committee for Future ICPWS
   - 18.4 Other items raised during the IAPWS week

19. Adjournment

Barry Dooley
29th August 2018

Schedule
IAPWS Meetings and ICPWS
Prague, Czech Republic. 2nd – 7th September 2018

(ICPWS Sessions in Marriott Hotel, Prague, Czech Republic)

Sunday 2 Sept.	**9:00**	**EC Initial Meeting** (Marriott Hotel)
	11:00	TPWS/IRS Joint Meeting to 5:00pm
	11:00	SCSW Separate and Joint Meetings to 5pm
	11:00	PCAS Separate Meeting to 5:00pm
	11:00	PCC Separate Meeting to 5:00pm
	Registration for ICPWS will be open all day	
	18:00	IAPWS/ICPWS Welcome Reception (Marriott Hotel)
Monday 3 Sept.	8:30	Opening Plenary Session – ICPWS
	8:50	**IAPWS Gibbs Award Lecture**
	9:40	ICPWS Keynote Lectures
	12:00 - 14:00	Gibbs Award Luncheon (Location to be announced)
	14:00	ICPWS Symposia – Afternoon
	19:00 – 22:00	River Cruise / Dinner on Vltava River (See ICPWS Website)
Tuesday 4 Sept.	8:30	ICPWS Symposia All Day
	15;00	ICPWS Poster Session
	16:00	**IAPWS Helmholtz Award Lecture**
	17:30	**General Assembly Meeting of IAPWS** (Marriott Hotel)
Wed. 5 Sept.	8:30	ICPWS Symposia
	19:00	**17th ICPWS Banquet** (Letenský Zámeček) (See ICPWS Website)
Thursday 6 Sept.	8:30	ICPWS Symposia
	15:00 – 17:00	Three Technical Tours (See ICPWS Website)

Friday 7 Sept. **8:30am.** **IAPWS Executive Meeting** **(8:30 – 1:00pm)**
(Marriott Hotel)
(To include one member from each National Delegation)

TPWS - Thermophysical Properties of Water and Steam WG
IRS - Industrial Requirements and Solutions WG
SCSW - Sub-Committee Sea Water
PCAS - Physical Chemistry of Aqueous Solutions WG
PCC - Power Cycle Chemistry WG

Barry Dooley
29th August 2018

IAPWS Thermophysical Properties of Water and Steam WG
Prague, Czech Republic, 2 September 2018

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.

1-2. The meeting was opened on Sunday, September 2, 2018 by the TPWS Chair, Allan Harvey. The agenda (Attachment A) was adopted without additions. The Chair noted that the 2017 Minutes had been circulated and approved by email shortly after the 2017 meeting. K. Meier was appointed Clerk of Minutes for TPWS.

3. No new Collaborative Project was suggested at TPWS.

NOTE: Item 4 is reported on in the IRS minutes.

4. Industrial Requirements and Solutions for Steam Property Calculations (joint with WG IRS)

4.1 Report of the Task Group "Categories of industrial requirements"

4.2 Report of the Task Group "Industrial Advisory Note"

4.3 Report of the Task Group "Wet steam properties calculation"

4.4 Report of the Task Group "Wet Steam Data from Operating Turbines"

5. Minor Revisions to IAPWS Documents (joint with WG IRS)

5.1 Report on minor revision of IAPWS-95 Release (A. Harvey)

A. Harvey reported on the revision of the release on behalf of the Task Group. Additional explicit equations for the second virial coefficient $B(T)$ and third virial coefficient $C(T)$ obtained analytically from the IAPWS formulation were added. Furthermore, sentences were added to the captions of the figures for uncertainty stating that the uncertainties of the density, heat capacities, and speed of sound in the gas phase become much smaller at low pressures as the ideal gas limit is approached.

5.2 Report on evaluation of IAPWS-95 revision (K. Miyagawa, presented by A. Harvey)

A. Harvey presented the evaluation report on the Revised Release on behalf of K. Miyagawa. K. Miyagawa verified the equations for the virial coefficients, and recommends to accept the Revised Release. It was discussed whether a sentence should be added to the footnote in the list of symbols stating that the change to the new SI unit system in 2019 will have no impact on the formulation. It was decided to add such a note. The wording should be agreed upon by the Chair and the Vice-chairs. After the meeting, R. Span, S. Bell, and D. Friend were also included in this

decision and the sentence “This is unaffected by the revision to the SI system of units scheduled to go into effect in 2019.” was agreed upon.

5.3 Formal consideration of IAPWS-95 Revised Release

The WG voted to approve the revised Release and recommend that the EC send it for approval by Postal Ballot.

5.4 Report on minor revision of Advisory Note 3 on Thermodynamic Derivatives from IAPWS Formulations (H.-J. Kretzschmar)

H.-J. Kretzschmar presented the revision of the advisory note. The note provides equations for derivatives of the IAPWS Formulations for ordinary water, heavy water, and seawater, which are formulated as fundamental equations in terms of the Helmholtz or Gibbs energies. The note is intended to assist implementation of the IAPWS Formulations. The update became necessary because of the 2018 Release of the new IAPWS Formulation for heavy water.

5.5 Report on evaluation of Revised Advisory Note 3 (K. Meier)

K. Meier reported on behalf of the Task Group about the Evaluation of the Revised Note. All revised equations were verified. Minor editorial changes were suggested. The equations in the Revised Note were provided in specific quantities whereas the equations in the IAPWS Release are given in molar quantities. To remove this inconsistency the calculated quantities are retained as specific quantities, while the molar density was replaced by the product of molar density and molar mass and the molar gas constant by the ratio of the universal gas constant to the molar mass in all equations for the heavy water formulation. This change resulted in a twofold use of the symbol R, for the universal gas constant in the equations for the heavy water formulation and for the specific gas constant in the equations of all other formulations. This ambiguity is acceptable. K. Meier recommends to approve the Revised Note by IAPWS.

5.6 Formal consideration of Revised Advisory Note 3

The WG voted to approve the revised Release and recommend that the EC send it for Postal Ballot following review by the Editorial Committee.

6. Heavy Water Properties (joint with WG IRS)

6.1 Report of Task Group on Heavy Water Thermodynamic Properties (R. Span, A. Harvey, S. Herrig)

S. Herrig reported on behalf of the Task Group on a revision of the Release of the IAPWS formulation for heavy water. An equation of state was presented at the 2017 Meeting in Kyoto, and the corresponding release became available online in 2018. During the publication process a further density data set (Kell, 1985) was found.

Since this density data set is more accurate than those to which the equation of state was fitted, it was decided to refit the equation. The fit resulted in a better representation of the Kell density data set and reduced uncertainties in the liquid phase density and a minor improvement in the uncertainties of the heat capacities and the speed of sound. Moreover, the saturated liquid density is represented much better, and the critical pressure is fitted within the uncertainty specified by IAPWS. The IAPWS release was updated for these points. A manuscript reporting the refitted equation of state has been submitted to the Journal of Physical and Chemical Reference Data.

6.2 Report of Evaluation Task Group for Revised Heavy Water Formulation (H.-J. Kretzschmar)

H.-J. Kretzschmar reported on behalf of the Task Group on the evaluation of the Revised Release. The revision resulted only in minor changes of the release. Especially the equations, the tables for the coefficients and figures for uncertainty were revised. The draft contains all required information. All equations were programmed and computationally verified. The document contains all necessary background information and relevant references. It is of excellent quality. H.-J. Kretzschmar recommends to adopt the revised Release by IAPWS. At the suggestion of D. Friend, a note will be added like that described in item 5.2 above.

6.3 Formal consideration of Revised Release for Heavy Water

The WG voted to approve the revised Release and recommend to the EC that it be sent for Postal Ballot following review by the Editorial Committee.

6.4 Report of TG for Heavy Water Transport Properties (J. Sengers, M. Assael, M. Huber, R. Perkins)

A. Harvey reported the status of the work on behalf of the Task Group. Available data in the literature for the viscosity of heavy water have been collected and were evaluated. Four new data sets have been published since the Release of the IAPWS 1984 formulation. F. Caupin measured the viscosity of subcooled heavy water at ambient pressure and has provided the data to the Task Group. The new formulation will be formulated as a product of the zero-density viscosity, the residual contribution, and the critical enhancement. The zero-density viscosity is based on the theoretical data of Hellmann and Bich and formulated as a ratio of two polynomials in temperature. The residual and critical enhancement contributions will be developed before the 2019 IAPWS Meeting in Banff. R. Hellmann remarked that the functional form chosen for the zero-density term does not represent the current state-of-the-art. It was recommended by the chairman that the Task Group should consult Robert Hellmann about how to fit the theoretical zero-density data in the best way.

7. Report of Task Group on Surface Tension of Ordinary Water (joint with WG IRS and SC SW) (J. Kalová, V. Vinš, A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, R. Mareš, J. Pátek, F. Caupin)

J. Kalová reported on the surface tension of ordinary water. She recalled the history of the surface tension of ordinary water in IAPWS. The IAPWS formulation is valid since 1975. Several new data sets have been published since then. With the introduction of the ITS-90 in 1990 the value of the critical temperature changed. The IAPWS formulation and the Pátek et al. correlation are lower than the IAPWS comparison formulation. A new fit to experimental data is required. A revised IAPWS Guideline should also include reference values at 20 °C and 25 °C.

R. Mareš reported on new measurements of the surface tension of supercooled water in the temperature range between −19.4 °C and −32 °C with a vertical capillary tube technique. The new measurements extend the range of previous measurements, which cover the range from +2 °C to −25 °C, down to −32 °C. The dependence of the surface tension of supercooled water on temperature is almost linear.

8. Metastable Water (joint with SC SW)

8.1 Report on the vapor pressure of supercooled water (V. Holten, A. Harvey)

A. Harvey reported that there are several correlations for the vapor pressure of supercooled water, most of which are extrapolated outside their valid range, and described different approaches to calculate the vapor pressure (correlations as a function of temperature and from thermodynamic potentials). A thermodynamic potential for supercooled water in terms of the Helmholtz energy was developed by Holten et al. (2014). Vapor pressures calculated with IAPWS-95 and the EOS of Holten et al. agree within 0.01%. Deviations are higher at low temperatures. There are two data sets for the isobaric heat capacity for supercooled water that are not consistent. This inconsistency has an influence on the uncertainty of the vapor pressure calculated with the equation of state. A. Harvey recommends to use the Holten et al. equation of state for vapor pressure calculation and to add the calculation of the vapor pressure to the IAPWS Guideline on the Thermophysical Properties of Supercooled Water. The uncertainty of the vapor pressure should be based on the uncertainty of the isobaric heat capacity. The draft revision of the Guideline should be circulated in time for adoption at the 2019 meeting in Banff.

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

A. Harvey reported on a possible revision of the IAPWS formulations for melting curves. The triple point for liquid water/ice I/ice III is not described accurately and this issue should be improved. There is no clear plan at this time for improving the formulation due to the unavailability of V. Holten to work on it.

NOTE: Items 9 and 10 are reported on in the SC SW minutes.

9. Cooperation with other international bodies (joint with SC SW)
   - 9.1 IAPWS/IAPSO/SCOR Joint Committee on Seawater, including updates to TEOS-10
   - 9.2 BIPM/IAPWS cooperation

10. Proposed new IAPWS seawater-related documents (joint with SC SW)
   - 10.1 Report on surface tension of seawater
   - 10.2 Appointment of Evaluation Task Group for seawater surface tension and setting of schedule for new IAPWS Guideline
   - 10.3 Report on preliminary work on viscosity of seawater

11. IAPWS Certified Research Needs (ICRNs)

   11.1 ICRN 27: Thermophysical Properties of Humid Gases and CO_2-Rich Mixtures (closing statement needed) (R. Span, A. Harvey)

   A. Harvey reported that the closing statement will be prepared soon; R. Span has just completed a first draft.

   11.2 Report of Task Group on ICRN for acid gas dew points (N. Okita, K. Orlov, R. Span)

   N. Okita reported on behalf of the Task Group on the status of the preparation of the ICRN. Different methods for dew point estimation were evaluated. It seems that the Abel function from 1946 is often used. It is the final goal to provide a recommendation for dew point estimation. Possibly the development of an estimation method can be supported by molecular simulations and/or simulations with ASPEN. A first draft of the ICRN will be presented at the 2019 meeting in Banff.

12. Reports on other TPWS activities

   12.1 Guideline on Fundamental Constants (A. Harvey)

   A. Harvey reported that there are no changes needing an update of the Guideline on Fundamental Constants.

   12.2 Advisory Note 2 (J. Cooper, A. Harvey)

   The Task Group was authorized to update this document to reflect the minor revisions to the IAPWS-95 Release.

   12.3 Report on progress toward IAPWS Guideline on diffusivity of ordinary water (A. Harvey, K. Yoshida)

   A. Harvey reported on behalf of the Task Group the status of the development of a correlation for the diffusivity of ordinary water. K. Yoshida measured the self-diffusion coefficient at high temperatures and published a correlation. The

correlation yields unphysical behavior in the zero-density limit when extrapolated to low temperature, where the calculated self-diffusion coefficient becomes negative. Therefore, it was decided to develop a new correlation. The zero-density contribution was fitted by M. Huber (NIST, Boulder) to the theoretical data of Hellmann and co-workers. Next steps are the collection and evaluation of experimental data and fitting of the residual part. The self-diffusion coefficient does not have a critical anomaly as the viscosity and thermal conductivity. Finally, the correlation will be published and established as an IAPWS formulation in a Guideline. **A. Harvey suggested to add M. Huber as an external expert and R. Hellmann to the Task Group; in subsequent discussions F. Caupin was also added to the Task Group. K. Meier resigned from the Task Group. An Evaluation Task Group (K. Meier, K. Orlov) was appointed (with possible additional membership from PCAS). The new members of Task Group and the Evaluation Task Group were unanimously approved.**

13. Other Business

It was discussed how the ICPWS conference series should be continued. R. Span pointed out that it is difficult to find funding for the research topics of interest to TPWS. He suggested to join the conference with other conferences or let it die and concentrate on the annual meetings. It was decided to postpone the discussion to the 2019 meeting in Banff and put the topic on the agenda for all working groups.

14. Membership

Dr. Robert Hellmann (University of Rostock, Germany) and Prof. Cornelia Breitkopf (Technical University Dresden, Germany) were unanimously elected as TPWS members. Henning Wolf (Germany) has retired and should be removed from TPWS membership.

15. Contribution to Press Release

The Chair and the Clerk of Minutes were assigned to prepare the contribution to the Press Release.

16. 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.

17. Adjournment

The meeting was adjourned at 17:20 on Sunday, September 2.

Agenda for the IAPWS Working Group
Thermophysical Properties of Water and Steam (TPWS)
Prague, Czech Republic, September 2, 2018

1. Opening Remarks; Adoption of Agenda
2. Appointment of Clerk of Minutes
3. Potential International Collaborative Projects
4. Industrial Requirements and Solutions for Steam Property Calculations (joint with WG IRS)
   - 4.1 Report of the Task Group "Categories of industrial requirements" (N. Okita, A. Nový, I. Weber)
   - 4.2 Report of the Task Group "Industrial Advisory Note" (M. Hiegemann, B. Rukes, A. Singh, A. Harvey) (N. Okita)
   - 4.3 Report of the Task Group "Wet steam properties Calculation" (A. Nový, J. Hrubý, K. Orlov, R. Span, K. Meier)
   - 4.4 Report of the Task Group "Wet Steam Data from Operating Turbines" (N. Okita, A. Nový, I. Weber, S. Senoo)
5. Minor Revisions to IAPWS Documents (joint with WG IRS)
   - 5.1 Report on minor revision of IAPWS-95 Release (A. Harvey)
   - 5.2 Report on evaluation of IAPWS-95 revision (K. Miyagawa, presented by A. Harvey)
   - 5.3 Formal consideration of IAPWS-95 Revised Release
   - 5.4 Report on minor revision of Advisory Note 3 on Thermodynamic Derivatives from IAPWS Formulations (H.-J. Kretzschmar)
   - 5.5 Report on evaluation of Revised Advisory Note 3 (K. Meier)
   - 5.6 Formal consideration of Revised Advisory Note 3
6. Heavy Water Properties (joint with WG IRS) [afternoon]
   - 6.1 Report of Task Group on Heavy Water Thermodynamic Properties (R. Span, A. Harvey, S. Herrig)
   - 6.2 Report of Evaluation Task Group for Revised Heavy Water Formulation (H.-J. Kretzschmar)
   - 6.3 Formal consideration of Revised Release for Heavy Water
   - 6.4 Report of TG for Heavy Water Transport Properties (J. Sengers, M. Assael, M. Huber, R. Perkins, presented by A. Harvey)
7. Report of Task Group on Surface Tension of Ordinary Water (joint with WG IRS and SC SW) (J. Kalová, V. Vinš, A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, R. Mareš, J. Pátek, F. Caupin)
8. Metastable Water (joint with SC SW)
   - 8.1 Report on the vapor pressure of supercooled water (V. Holten, A. Harvey)
   - 8.2 Report of Task Group on possible revision of IAPWS formulations for melting curves (V. Holten, A. Harvey, H.-J. Kretzschmar)

9. Cooperation with other international bodies (joint with SC SW)
   - 9.1 IAPWS/IAPSO/SCOR Joint Committee on Seawater, including updates to TEOS-10 (R. Pawlowicz)
   - 9.2 BIPM/IAPWS cooperation
10. Proposed new IAPWS seawater-related documents (joint with SCSW)
   - 10.1 Report on surface tension of seawater (V. Vins, A. Harvey, K. Nayar)
   - 10.2 Appointment of Evaluation Task Group for seawater surface tension and setting of schedule for new IAPWS Guideline.
   - 10.3 Report on preliminary work on viscosity of seawater (K. Nayar, presented by A. Harvey)
11. IAPWS Certified Research Needs (ICRNs)
   - 11.1 ICRN 27: Thermophysical Properties of Humid Gases and CO_2-Rich Mixtures (closing statement needed) (R. Span, A. Harvey)
   - 11.2 Report of Task Group on ICRN for acid gas dew points (N. Okita, K. Orlov, R. Span)
12. Reports on other TPWS activities
   - 12.1 Guideline on Fundamental Constants (A. Harvey)
   - 12.2 Advisory Note 2 (J. Cooper, A. Harvey)
   - 12.3 Report on progress toward IAPWS Guideline on diffusivity of ordinary water (A. Harvey, K. Yoshida)
13. Other Business
14. Membership
15. Contribution to Press Release
16. Preparation of the Formal Motion to the EC
17. Adjournment

Minutes of the IAPWS working group IRS, Prague, 2. – 7. September 2018

(Numbering of topics follows TPWS agenda, except where denoted "…-IRS")

1. The Chair, Nobuo Okita, opened the IRS joint at 11:15 am, 2. September 2018. Agenda was adopted without changes.
2. Appointed Adam Nový as a clerk of minutes
3. No potential collaborative projects reported
4. Industrial Requirements and Solutions for Steam Property Calculations [joint with WG TPWS]

4.1 Report of the Task Group "Categories of industrial requirements" (N. Okita, A. Nový, I. Weber, A. Anderko, M. Rziha, R. Span)

N. Okita reported the status of the TG as new members have joined the TG: A. Anderko (PCAS), M. Rziha (PCC) and R. Span (TPWS incl. SCSW). The presentation was done twice, once in the joint meeting with TPWS and then later afternoon joint with PCC and PCAS. N. Okita summarized the purpose, WG history and schedule of the task. It was presented the list of the possible interests which is ready to be circulated within the all IAPWS members. There were also examples from industry mentioned for better understanding. The categories are gathered and sorted in three ways: First the list of the items, second items in the hierarchical tree and the last form is the list grouped by the expected IAPWS output. In the separate IRS meeting it has been decided to keep the TG running on maintaining the list and incorporate the TPWS/SCSW, PCAS and PCC inputs.

The following discussion (summarized from IRS, TPWS and PCC/PCAS groups):

B. Dooley has noted that there is missing surface tension, T. Rziha mentioned the importance of film forming substances where is a lack of knowledge and also the high practical interest of the acid dew point. The conclusion of the separate IRS discussion was, that among IRS are unable judge which categories/topics are important so the help from other IAPWS members is necessary. It was also deiced to continue maintaining the categories lists and incorporate new information into the shared document.

TODO:

Distribute the categories to all IAPWS members and do the process of evaluating the distance to the IAPWS business. Proposed to share the categories document using the OPAL password protected site. Try to evaluate the importance of the categories regarding steam turbines and combined cycle with GT at first.

The progress will be reported at the next annual meeting.

4.2 Report of the Task Group "Industrial Advisory Note" (M. Hiegemann, B. Rukes, A. Singh, A. Harvey) (presented by N. Okita)

The report was given by N. Okita as M. Hiegemann is not active for now. There was proposed to terminate the TG and consider reopening after the categories are being prepared. This was unanimously accepted.

4.3 Report of the Task Group "Wet steam properties Calculation" (A. Nový, J. Hrubý, K. Orlov, R. Span, K. Meier)

A. Nový reported preparation of three calculation models for the speed of sound in wet steam to be tested on measured data from last stages of nuclear power plant turbine by the end of 2018.

K. Mayer did some literature research and presented model from literature for calculating two phase flow speed of sound. It was mentioned, that the speed of sound depends on many parameters, for example the flow type and the flow speed.

The following discussion:

D. Friend mentioned the possible effect of the frequency of the soundwave to the speed of propagation. J. Hruby mentioned the work of Prof. Petr regarding the dispersion where for very high speed of flow the speed of sound was "frozen" and for low flow speed was "equilibrium". So more speeds of sound exists dependently on the flow speed. S. Senoo proposed also focus on measurement techniques.

TODO:

Continue the review of literature and test the calculation models on available measured data.

4.4 Report of the Task Group "Wet Steam Data from Operating Turbines" (N. Okita, A. Nový, I. Weber, S. Senoo)

N. Okita explained the purpose and plan. There was also cleared, stated, what data are being needed. The plan was to gather data, share it and finally make some output.
The following discussion:
A. Nový shared the result of internal company survey, that there is not possible to directly share the data because of legal issues and protection of know-how, but there is a possibility to test calculation models on the data within the company.
The following discussion:
Further discussion within the IRS led to the clearing out the purpose of the data being gathered. First is the problem of wetness losses and second, the erosion problem. For these purposes the simulation model and measurement technique are needed.
TODO: N. Okita will contact D. Friend for ASME or any other specialists for possible assistance with measurement of the droplets spectrum and velocity distribution. TPWS members should be contacted for reviewing existing calculation models of droplets forming. Investigate the possible form to be opened of sharing the data, try also to ask ASME for possible assistance in parallel.

5. Minor Revisions to IAPWS Documents [joint with WG TPWS]
5.1 Report on minor revision of IAPWS-95 Release (A. Harvey)
5.2 Report on evaluation of IAPWS-95 revision (K. Miyagawa, presented by A. Harvey)
5.3 Formal consideration of IAPWS-95 Revised Release
5.4 Report on minor revision of Advisory Note 3 on Thermodynamic Derivatives from IAPWS Formulations (H.-J. Kretzschmar)
5.5 Report on evaluation of Revised Advisory Note 3 (K. Meier)
5.6 Formal consideration of Revised Advisory Note 3
Items Covered by TPWS minutes

6-IRS/PCC/PCAS. Report of the Task Group "Categories of industrial requirements" (N. Okita, A. Nový, I. Weber)
Covered by point 4.1

6. Heavy Water Properties [joint with WG TPWS]
6.1 Report of Task Group on Heavy Water Thermodynamic Properties (R. Span, A. Harvey, S. Herrig)
6.2 Report of Evaluation Task Group for Heavy Water Formulation (H. -J. Kretzschmar)
6.3 Formal consideration of Revised Release for Heavy Water
6.4 Report of TG for Heavy Water Transport Properties (J. Sengers, M. Asseal, M. Huber, R. Perkins, presented by A. Harvey)
Items Covered by TPWS minutes

7. Report of Task Group on Surface Tension of Ordinary Water [joint with WG TPWS and SC SW]
(J. Kalová, V. Vinš, A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, , R. Mareš, J. Pátek, F. Caupin)
Covered by TPWS minutes

8-IRS. Discussion on "Wet Steam Data from Operating Turbines"
Covered by point 4.4

11. IAPWS Certified Research Needs (ICRNs) [joint with WG TPWS]
11.1 ICRN 27: Thermophysical Properties of Humid Gases and CO2-Rich Mixtures (closing statement needed) (R. Span, A. Harvey)
Covered by TPWS minutes

11.2 Report of Task Group on ICRN for acid gas dew points (N. Okita, K. Orlov, R. Span)
N. Okita presented the upgrade of the last year regarding dew point under low sulfur content related to HRSG for GTCC. Suggestion to IAPWS is to unify method for predicting dew point under low sulfur contents by theoretical approach using models and post/revise ICRN 23. Equilibrium calculation and modification of Otsuka equation and fitting recent data were tried to improve, but in vain due to lack of data for low sulfur.
Following discussion:

A question is raised by J. Hrubý whether kinetic or thermodynamic approach is necessary. It is beyond the knowledge at the moment. A. Harvey suggested cooperation with PCAS

12. IRS Discussion on "Categories of industrial requirements"
Covered by point 4.1
13-IRS Other Business: No other business.
14-IRS Membership: No changes in membership.
15-IRS Contribution to Press release will be done by the WG chair
16-IRS Formal motion to the EC will be prepared by the WG chair
17-IRS meeting was adjourned 2. September 2018, about 17:15.

Minutes of Joint Meeting with TPWS/SCSW: Prague, Sept/2018

Chair: R. Pawlowicz
Clerk of Minutes: S. Seitz.

NB: These minutes include agenda items in the joint TPWS/SCSW/IRS agenda that are specifically oriented to SCSW. A number of items that possibly should be been added to the agenda were not because of the short time available in an ICPWS year; the 2019 SCSW agenda should probably "mine" the 2017 as well as 2018 minutes. For other 2018 agenda items consult the minutes of the other WG.

9.1 SCOR/IAPWS/IAPSO Joint Committee on the Properties of Seawater (JCS). Pawlowicz reports Web site accesses and software downloads have reached a steady state. A discussion occurred on whether TEOS-10 was making a difference to oceanographic issues (a recent paper quantified the effect of TEOS-10 on meridional overturning circulation), and on whether the absolute density of seawater was correctly represented in TEOS-10 (some recent results with Anton-Paar densimeters by various groups had found densities about 5-15 ppm lower but not all groups have found this; the matter is still under investigation).

9.2 Report on BIPM/IAPWS collaboration – BIPM/IAPWS Workshops were occurring later that week as part of ICPWS. Unfortunately R. Feistel, the driving force behind this effort, is not able to attend this meeting due to health issues.

10.1 Report on Surface Tension of Seawater: V. Vins reports that new data has been acquired, its work-up is being finalized and a publication is being prepared.

10.2 Appointment of evaluation Task Group and scheduling of a Guideline. The Guideline should be relatively straightforward an A. Harvey was cautiously optimistic that such a guideline might be available by the next meeting. The evaluation task group (R. Feistel) was expanded with the addition of M. Duska.

10.3 Preliminary work on viscosity of seawater. K. Nayar was unable to attend but provided some slides on this work. A question was raised about whether precise knowledge of the viscosity was useful for oceanographers, R. Pawlowicz was unsure but did point out that correct evaluation of particle settling velocities required knowledge of the viscosity; it may also be useful in certain kinds of conductivity calculations.

14. Membership. No new members proposed for SCSW.

Rich Pawlowicz
6/Sep/2018

PCAS WG Minutes

Prague, Czech Republic, September 2, 2018

Present:

Masaru Nakahara	nakahara@scl.kyoto-u.ac.jp
James Bellows (clerk of minutes)	jcbellows2@aol.com
Ken Yoshida	yoshida.ken@tokushima-u.ac.jp
Peter Tremaine	tremaine@uoguelph.ca
Hugues Arcis	harcis@uoguelph.ca
Andre Anderko (chair)	aanderko@olisystems.com

Agenda approved
Clerk of Minutes: James Bellows
Minutes of 2017 were approved.

Dr. Yoshida gave a talk about the progress in the development of a guideline on self-diffusion coefficients of water. He explained that collection and evaluation of the experimental data have been almost completed and the fitting of the zero-density part of the data is successfully done by the correlation function planned to be employed. It was proposed to include Marcia Huber (NIST) as an outside expert for the Task Group who will work on the development of the correlation function and to appoint Evaluation Task Group, to start its work when Task Group prepares a draft Guideline, with a goal of 2019 approval. The attendees adopted this proposal unanimously.

Peter Tremaine described the Research Chair in High Temperature Aqueous Chemistry at the University of Guelph. The chair is funded by the nuclear industry. All research is to be published. Some of the topics of research are heavy water coolant chemistry, CANDU secondary chemistry and storing spent fuel.

Andre Anderko gave a presentation titled “Silicate chemistry in water treatment.” This presentation outlined thermodynamic research at OLI Systems to develop of comprehensive solution chemistry and solid-liquid equilibrium model for various calcium, magnesium, zinc, and aluminum silicates, which may precipitate over various time scales.

James Bellows will attempt to have density-based plots by February for ETA as a start on the Amine Guideline Project.
Attendance was discussed and more emphasis on joint meetings with PCC and TPWS. A quorum should be defined (perhaps 10 people or 6 six organizations). If quorum is not achieved, it has been proposed that the meeting would consist of an approximately 2-hour business meeting.

Summary of guidelines under development:

- Self-diffusion of water (Ken Yoshida; in an advanced stage of preparation)
- Volatility and dissociation constants of amines and amine decomposition products (James Bellows; work has been initiated)

Power Cycle Chemistry Working Group (PCC WG)

Prague, Czech Republic, September 2, 2018
11:00 – 17:00

1. Amendments / Adoption of Agenda

Attendees were welcomed by Rziha. The agenda was adopted with no changes.

2. Appointment of Clerk of Minutes

Paul McCann was appointed as clerk.

3. Approval of Minutes of PCC WG in Kyoto, 2017

The Kyoto minutes circulated previously by Rziha were accepted with no changes.

4. Review of Actions from last PCC WG Meeting

The only actions were related to the IAPWS TGDs. These are covered in the next section. Rziha noted that the TGDs are being increasing accepted worldwide as international standards.

5. IAPWS TGDs

This session was chaired by Dooley. Dooley provided background on the purpose of the TGDs which is to be the basis of guidelines worldwide. The benefit of IAPWS documents is that they bring together both academia and industry to provide scientifically robust guidelines. Dooley requested that the separate TGD WGs arrange to meet during the ICPWS week to progress activities.

5.1. Air in-leakage in Steam-Water Cycles

A draft TGD has been written and circulated to the full TGD Task Group and PCC WG for review with comments back now addressed. Input was also received from Anderko and Fernandez-Prini from IAPWS for input on thermodynamic principles. The draft TGD is currently at Editorial Review.

Action Rziha: To request EC to send the draft TGD to National Committees for postal ballot for final approval. This is to avoid delaying approval to the 2019 IAPWS meeting.

5.2. Film Forming Substances (FFS) for Industrial Plants

This is a complimentary document to go with the existing TGD for fossil plants. A draft document is largely finished but input is still needed from the industrial sub-task group (STG). The document proposes to introduce the term film-forming substances (FFS) as suitable nomenclature to cover the range of chemicals available. The STG will meet during the ICPWS to discuss how to progress and to agree a timeline for activities.

5.3. Film Forming Substances (FFS) for Nuclear Plants

Fandrich (Framatome) has joined the STG. The aim is initially to produce a white paper. A skeleton document has been produced and the STG will meet during the ICPWS to assign writing tasks. Although Dooley noted that only ODA has been used in nuclear plants to date, Cook (STG chair) confirmed that the

IAPWS document will not be product specific so should be of wide benefit. STG membership: McGee (Candu Owners Group) is no longer participating; Stuart (Canadian Nuclear Laboratories) has joined.

5.4. Demin Water Integrity

Joy (STG chair) reported that a skeleton for the TGD has been developed and drafts have been written for 6 out of 15 sections. Hirano has done much work and will present this during the ICPWS. Christiana Holl (Hydro Engineering) has joined the STG to contribute writing. Bellows is no longer participating. The STG will meet during the ICPWS to progress.

5.5. Corrosion product (CP) sampling and analysing (white paper)

Thomsen (STG chair) provided an update on developing the existing TGD to cover flexible plants. Initial planning was done in Dresden to identify gaps, particularly for field sampling, analysis and benchmarking. Since then, much work has been done on load transients at plants using conventional chemistries.

An international collaboration has been set up to conduct further field tests and a student appointed – Maja Skou Jensen (Aarhus University, Denmark) - who will be supervised by Thomsen. Further work is planned to qualify proxy measurement methods and to benchmark CP decay rates at startups.

The aim is that a 'decay map' could be produced that could be used by sites to optimise preservation and startup chemistry. The aim is to update the CP TGD for the 2019 IAPWS meeting. A draft white paper has been prepared with suggested updated contents list for the revision.

Dooley requested that the STG consider if CP levels at plants using FFS should be included as the scientific understanding of FFS still needs to be developed and also if guidance for CP monitoring for flexible plant should be covered under a new TGD. Rziha noted that spalling of oxides from superheater stages also requires guidance as this is a mechanical (not chemical) effect but can be an important cause of particle erosion at startups.

Henderson (AUSAPWS) requested that CP decay rates are included in the TGD revision and consideration given to guidance on the corrective actions this could promote.

Witney (GE) and Powalisz (Sentry) requested to join the STG.

5.6. Geothermal (white paper)

Addison (STG chair) reported that significant work has been done on steam purity and information will be consolidated into a White Paper in 2018. For subsequent TGD updates on steam purity and sampling, the PCC WG recommended that a separate standalone TGD be produced for geothermal plants.

5.7. Condensate Polishing for HRSG Plants (white paper)

Khalifa reported that a skeleton document has been produced with 15 sections and that draft text had been written for initial STG review. Due to the amount of work required, additional members were requested to help writing. The initial aim is to produce a white paper to discuss if the topic is worth developing into a TGD. For STG membership, Witney will deputise for Leidich (GE) and Henderson will replace Joy (AUSAPWS). Dooley noted that the purpose of the document is to provide technical guidance on how to apply condensate polishing at HRSG plants, not to produce a design document.

5.8. Proposals for new TGDs

A new TGD has been proposed by Svoboda and Dooley on "Chemistry Management in Generator Water Cooling during Operation and Shutdown" (Svoboda chair). A first skeleton has been written. Henderson and Witney volunteered to join the STG. The intention is to publish in 2019.

Henderson proposed a new TGD in laboratory management and instrument validation following feedback from AUSAPWS.

A TGD on chemical cleaning was discussed. It was felt that guidance on general cleaning procedures was not within IAPWS remit. However, possible guidance on when to clean supercritical boilers with duplex oxides could be considered in the future.

Action Henderson: To provide a skeleton of possible content for a TGD on laboratory management for the PCC WG to consider.

5.9. Updating Published TGDs

The additional of modern guidance on control of aluminium for plants with Heller air-cooled condensers was proposed by Dooley for the Volatile TGD.

6. Short joint session of IRS/PCC/PCA on Report of the Task Group "Categories of industrial requirements"

Okita (Toshiba, TG chair) provided a brief explanation about the purpose of the task group which is to collect, sort and categorise possible items of IAPWS interest, e.g. requirements for wetness measurements for wet steam properties in steam turbines; in HRSGs, measuring acid dew points in flue gas with low sulphur content. Items have been categorised and sorted with a potential IAPWS output. Other topics suggested by the PCC WG included the effect of FFS products on droplet surface tension in steam turbines as this is a field in which there is little data.

7. Progress Reports 2017/2018 and Future PCC Activities

Main activities are the further development of the TGDs as described above.

8. International Collaboration

There are two current collaborations:

Cook/Addison – Test rig at the University of New Brunswick (Canada) on corrosion of boiler steels in presence of mixed contaminants (chloride, sulphate). The aim of the work is to verify or adjust boiler limits. The test rig has been set up and experiments completed. The preliminary data is promising and will be reported at the ICPWS. Schedule and budget is on track. Consideration will be given to proposing a student placement to expand the work.

Thomsen - Maja Skou Jensen (Aarhus University) has been appointed. This will form a 1 year Masters degree project. A preliminary programme has been drawn up and will be finalised at the ICPWS.

There were no proposals for new collaborations.

9. ICRNs – Review and Possible New Additions

Action Rziha: Status of ICRN#22 “Steam Chemistry in Turbine Phase Transition Zone” to be confirmed.

No new ICRNs were proposed.

10. PCC Public Relations / Contribution to Press Release

The PCC WG has been active with TGD production. IAPWS has also supported various events worldwide to raise awareness of IAPWS. The conference on FFS in Prague was highlighted as being particularly successful. The presentations are not directly available to IAPWS members but can be purchased from the PowerPlant Chemistry journal for half of the registration cost. The next FFS will be held in March 2019 in Heidelberg, Germany. For the ICPWS, the press release will be prepared by Cook (University of New Brunswick).

11. Changes in PCC Membership and Election of Officers

The following WG members were elected:

Hayden Henderson (AGL / AUSAPWS)
Luke Mosele (AUSAPWS)
Craig Stuart (Canadian Nuclear Laboratories)
John Powalisz (Sentry)
Joerg Fandrich (Framatome)

Michael Rziha was elected to continue as WG chair. There are two vice-chairs: Paul McCann continues; David Addison was elected as new.

12. Adjournment

ENDS

Proposal for IAPWS International Collaboration

W. Cook & D. Addison
Canada and New Zealand
2nd September 2018

Overview:
Over the past three-years, David Addison (New Zealand) and Willy Cook (Canada) have worked together through an International Collaboration Project focused on examining the effects of combined impurities (chloride and sulfate) on the corrosion of boiler steels. The work was initiated from two IAPWS ICRN's, #25 – Corrosion mechanisms related to the presence of contaminants in steam/water circuits, particularly in boiler water and; #20 – Sensors for use at Elevated Temperature in the Plant Cycle of the Power Industry. The primary objectives of the previous International Collaboration were:

- Design and construct two-electrode and/or three-electrode high-temperature electrochemical flow-through cell
- Upgrade test loop at UNB, install and commission electrochemical test system.
- Run baseline testing to verify and validate experimental method.

The intent was to have the system and methods ready for an ongoing, long-term test program and this intent has now been completed. The test rig and electrochemical cell is now ready for implementing a full experimental test program, which is the focus of the present International Collaboration proposal.

Scope:
The work proposed in this International Collaboration project will capitalize on the efforts from the previous collaboration. A Master's student (person yet to be determined) will be supported through this IC project to utilize the UNB test rig and electrochemical test system. A full scope of experiments to pin-point the progression of corrosion in boiler systems with individual and mixed contaminants will be conducted. As demonstrated through the commissioning and initial testing, the Linear Polarization method is well suited to identify the threshold for the onset of accelerated corrosion. The test plan will encompass typical AVT(R) and AVT(O) chemistry conditions with a range of pH between 9.0 – 9.8 and chloride and sulfate concentrations between 0 – 1000 ppb. In addition, the Canadian Nuclear Laboratories (CNL) has begun to take an interest in this test program and there is agreement that this work may be further supported through CNL with potential parallel experimental work to be conducted at the Chalk River Laboratories.

Deliverable: Report describing results of the test program with potential for incorporating the results into a future revision of the PCC Technical Guidance Documents.

Budget:

Student Support (student yet to be identified):	£ 12,000
Travel Support (UNB to CRL; attend IAPWS meetings):	£ 6,000
Total:	**£18,000**

References:

1. IAPWS ICRN#25, "*Corrosion mechanisms related to the presence of contaminants in steam/water circuits, particularly in boiler water*".
2. IAPWS ICRN#20, "*Sensors for use at Elevated Temperature in the Plant Cycle of the Power Industry*".

Press Release

17th International Conference on the Properties of Water and Steam (ICPWS) and International Association for the Properties of Water and Steam (IAPWS) 2018 Executive Committee and Working Group Meetings

Prague, Czech Republic, September 2nd – 7th, 2018

Between September 2nd – 7th, 2018, 140 scientists and engineers representing 27 countries convened in Prague, Czech Republic for the 17th International Conference on the Properties of Water and Steam (ICPWS) and the annual meetings of the IAPWS Executive Committee and Working Groups. The ICPWS conferences began in 1929 in London, UK and are typically held every fourth or fifth year in conjunction with the annual IAPWS meetings. The purpose of the conference is to connect scientists with the engineers who use their information, providing the researchers with guidance on useful problems and the engineers with the latest research results.

During the conference, over 100 papers were given on the thermodynamic and transport properties of pure water and steam, including aqueous solutions at extreme conditions, the use of film forming substances (FFS) in power systems, the properties of sea water and the properties of heavy water. Areas of application included power cycle chemistry, district heating with condensate recycle, geothermal systems and other high temperature aqueous technologies applicable to steam cycles, and climate modelling.

The IAPWS Gibbs Award is the most prestigious award given by IAPWS and is typically presented at the ICPWS for a distinguished career body of work of interest to IAPWS. This year, the IAPWS Gibbs award was presented to Dr. Roberto Fernandez-Prini from the Instituto de Quimica Fisico del los Materiales, Argentina for "pioneering experimental and modeling work in the thermodynamics of aqueous systems at high temperatures, particularly in systems of interest for power generation".

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 IAPWS meeting to present the Helmholtz Award lecture. The award was presented to Dr. Hugues Arcis from the University of Guelph, Canada for "expanding the understanding of high temperature aqueous electrolytes and particularly for measurements of the solubility and heat of mixing of CO_2 in aqueous amine solutions".

Dr. Ingo Weber from Germany was acknowledged as an IAPWS Honorary Fellow for advancing the use of IAPWS formulations in the power industry, and for leadership of the IAPWS Working Group Industrial Requirements and Solutions.

IAPWS, through the various working groups, produces guidelines, technical guidance documents (TGD) and IAPWS certified research needs (ICRN). This information can be found on the IAPWS website at www.iapws.org. Throughout the week, the working groups progressed their activities, which are reported below.

The Working Group on Thermophysical Properties of Water and Steam (TPWS) continues to pursue better knowledge of properties for scientific and industrial applications. This year, the group finalized a new formulation for the thermodynamic properties of heavy water, a fluid of significant practical and scientific interest, replacing the previous IAPWS standard that was developed over 35 years ago. Work is now in progress to replace the similarly old correlations for heavy water transport properties. Additional projects are moving forward on the surface tension of ordinary water and of seawater, and on the self-diffusion coefficient of water over the full range of conditions of interest to science and industry. Sessions of the ICPWS oriented toward thermophysical properties reported, among other things, progress in understanding various scientifically interesting properties of super-cooled water, the use of molecular-level calculations to provide gas-phase properties in aqueous systems, and the use of flexible mixing rules for multi-parameter equations of state to describe vapor-liquid equilibrium in aqueous systems.

The Subcommittee on Seawater (SCSW) continued their aim of deepening ties between IAPWS and the International Bureau of Weights and Measures (BIPM) by holding a series of workshops in which ocean scientists, engineers, and metrologists came together to develop a vision in which key ocean variables would be defined in a consistent and long-term stable manner. The Scientific Committee on Ocean Research (SCOR), the International Association for the Physical Sciences of the Oceans (the two primary non-governmental oceanic science organizations), and IAPWS organized a meeting where JCS members and others came together for the first time since 2013 to discuss strategies for the next five years. Important topics included the development of salinity and oceanic pH definitions that could be linked to the seven variables of the SI (International System of Units), as well as a consistent definition of relative humidity. The meeting was attended by members of the BIPM including Suzanne Picard, the Executive Director of the BIPM's Consultative Committee on Thermometry (a keynote speaker at the conference) and important members of the BIPM's Electrochemical and Relative Humidity working groups.

The main topics of the Industrial Requirements Working Group were CFD calculation using IAPWS formulations, droplet in wet steam flow and engineering requirements. Some items, like measurement technique of wet steam data and new models for low sulfur dew point, are keeping discussion on IAPWS outputs by joint task with other working groups and liaison with other specialists.

The Working Group on Physical Chemistry of Aqueous Systems (PCAS) had discussions on the self-diffusion of water, nuclear power cycle chemistry and silicate chemistry in water treatment. An IAPWS guideline on the Self-Diffusion of Water is in an advanced stage of preparation and

another on the volatility and dissociation constants of amines and amine decomposition products, which is of particular interest to the power generating industry, is in the early stages of preparation.

The Power Cycle Chemistry (PCC) working group continues to work intensively on a number of new Technical Guidance Documents (TGDs) and white papers. To complement the existing eight TGDs, four new documents are in the final draft form and are expected to be released within the next year. These include Guidance for Air In-leakage, Guidance for the use of FFS for Industrial Plants, Guidance on Chemistry in the Generator Cooling System and Guidance for Ensuring the Integrity and Reliability of Demineralized Make-up Water Supply. Additionally, the PCC working group is preparing several white papers that will eventually become TGDs. These include the Use of FFS for Nuclear Plants, Steam Chemistry for Geothermal Plants, Corrosion Products in Flexible (Cycling, two shifting) Plants and, Guidance for HRSG Condensate Polishing Plants.

IAPWS produces Certified Research Needs (ICRN) as guidance for funding agencies and as an aid to people doing research in defining important research. While no new ICRNs were issued this year, eight remain active in a variety of areas related to the properties of water and steam, the properties of sea water and the chemistry of power plants.

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 Banff, Canada from 29th September – 4th October 2019. 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 chairman of their IAPWS National Committee (see website) or 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.

ICPWS Options for Future

Task Group: Friend (Chair), Rziha, Cook, Henderson, Hrubý, Dooley, Kretzschmar

Issues:

- Participation has decreased
- Burden on IAPWS finances
- Limits IAPWS "business" during conference
- Timing of conference
- Advertising for conference (social media)
- Cost of conference: registration/hotel
- Decreased research budgets in power generation industry
- Trends in steam power cycle deployment
- Spreads IAPWS message more broadly
- Hence increases participation in regular annual meetings
- Increased numbers of competing conferences
- Research trends are not reflected in conference format
- Sustainability of IAPWS (not ICPWS) is real goal

Options:

1. End ICPWS Series
2. Irregular depending on IAPWS breakthrough/requirement for input
3. Decrease frequency (6-10 years)
4. Focused (e.g., seawater; cycle chemistry; sub-area of IAPWS)
5. Pair with established conference (e.g., IWC, Thermophysical Properties, …)
6. Pair with smaller conference (e.g., humidity, calorimetry, JCS ? …)
7. Smaller conference within IAPWS week (e.g., 2 days)
8. Plan for smaller size
9. Increase frequency (2-3 years)
10. Status Quo—continue as established

IAPWS Canadian National Committee

Annual Report 2018

Submitted to IAPWS EC, Prague, Czech Republic, September 7, 2018

CNC Executive: *William Cook (Chair); Derek Lister; Peter Tremaine; Melonie Myszczyszyn; Rich Pawlowicz; Craig Stuart; Luis Carvahlo; Olga Palazhchenko; Sarita Weeraku, Hugues Arcis*

1. Canadian National Committee: Dues for the Canadian National Committee (CNC) of IAPWS are supported by the National Research Council (NRC) of Canada. This arrangement requires support and participation by a national organization representing industry. We are currently in the third year of an agreement with the CANDU Owners Group (COG) and the NRC for a third five-year term.

The CNC recruited Luis Carvalho, Olga Palazhchenko, Sarita Weerakul, Hugues Arcis to the committee to help with preparations to host the 2019 IAPWS Annual Meeting to be held in Banff, Canada.

2. CNC Activities

2.1 CNC Workshop 2017
The CNC hosted an IAPWS workshop on December 13, 2017 at the offices of COG in the heart of downtown Toronto that attracted 33 participants. The workshop, web-cast across Canada and with invited presenters from the USA, included presentations from all working groups and showed the breadth of IAPWS's work and its relevance. The goal was to raise the profile of the Canadian National Committee and IAPWS activities with scientists and engineers in Canada doing complementary research within the fossil and HRSG community. The list of presentations is included at the end of this report.

2.2 Activities at the University of New Brunswick (UNB)
Derek Lister
Under the title of UNB Nuclear, the Research Chair in Nuclear Engineering at UNB continues with traditional funding from the CANDU Owners Group and the Natural Sciences and Engineering Research Council, supplemented with contracts from the Electric Power Research Institute and companies such as Kurita Japan.

Heat exchanger fouling; the damaged atmospheric-pressure water loop has been repaired and a program for studying magnetite particle transport with additions of film-forming amines (FFAs) is being initiated. Bench studies of adsorption of film-forming amines on magnetite, with experiments on magnetite powder and sintered magnetite pellets, have provided preliminary data on the adsorption kinetics.

Flow-accelerated corrosion (FAC); experiments on the effects of an FFA on FAC in a recirculating water loop are underway. Under two-phase steam-water conditions at 200°C, the durability of FFA films adsorbed on carbon steel is being tested by exposing them to different shear-stress conditions by varying the average velocities of the fluid. Other FAC-related studies are providing data on the magnetite dissolution rate constant under conditions of reducing chemistry in feedwater systems and are developing a neural network scheme for predicting FAC rates by learning from the wealth of experimental data collected at UNB Nuclear over the years.

Modelling reactor primary circuit contamination; in collaboration with UNB's Centre for Nuclear Energy Research (CNER), progress has been made in developing a comprehensive model for activity transport in the Point Lepreau primary coolant. In parallel, studies in a high-temperature water loop under CANDU primary coolant conditions have provided preliminary values of the magnetite precipitation constant, to be reinforced later with values from radiotracer experiments.

Measuring the effusion rate of hydrogen through steel; in a collaborative project with CNER, the development of an in-situ probe (HEPro) for monitoring FAC by measuring the rate of effusion of corrosion hydrogen through pipe walls is being supported by investigating with computational fluid dynamics the details of hydrogen diffusion around the probe structure. At the same time, experiments have measured rates of effusion of hydrogen through carbon steel piping under various conditions and the results are being modelled.

Investigating the corrosion of aluminium alloy under the conditions of reactor coolant released during a severe loss-of-coolant accident; during a LOCA, corrosion products released from aluminium components in containment can block the sump strainers and impede access of the emergency core cooling system (ECCS) to the reactor fuel. The rates of release of Al species to typical reactor coolant have been measured under a range of possible LOCA conditions and the dependence on chemistry and flow rate determined. In parallel, the corrosion of 3-D printed components is compared with that of the standard cast alloy.

Willy Cook

As Director of UNB's CNER Institute (Centre for Nuclear Energy Research), W. Cook continues to expand CNER's consulting expertise and services to Canada's nuclear industry. Activities include engagement with local nuclear power generating stations and the Canadian Nuclear Laboratories, the Candu Owners Group and other utilities.

CNER has recently partnered with the provincial government and several advanced nuclear reactor designers and vendors with the intention of establishing a Small Modular Reactor Research Cluster within the Province.

CNER's HEPro has continued to demonstrate its utility and sensitivity for measuring changes in FAC rate of carbon steel. Several COG programs are now in progress and additional installation of HEPro for feeder pipe and feed water pipe monitoring are being planned for 2019.

W. Cook and D. Addison (Thermal Chemistry Inc. – New Zealand) have completed the first phase of an IAPWS International Collaboration project that was initiated in 2015. The focus of the project was to establish capabilities at UNB / CNER's laboratories to measure, electrochemically, the effects of mixed contaminants on boiler materials. D. Addison again visited UNB / CNER in June 2018 to carry out some of the experimental testing.

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

The NSERC/UNENE Senior Industrial Research Chair in High Temperature Aqueous Chemistry was awarded to Professor Peter Tremaine at the University of Guelph in 2016. The purpose of the Chair is to expand mission-oriented basic research and modelling expertise in areas related to the primary coolant chemistry, moderator chemistry, and steam-generator chemistry of the CANDU reactor fleet, as well as in areas related to the geological storage of nuclear spent fuel. The funding model is new for a UNENE IRC, in that support has been provided by three other industrial partners, in addition to UNENE: the CANDU Owner's Group (COG), the Nuclear Waste Management Organization (NWMO) and the Electric Power

Research Institute (EPRI). Additional support from NSERC and the University of Guelph is also being provided, including the recruiting a tenure-track assistant/associate professor in an area of research related to the IRC activities.

2.4. 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).

2.5. CANDU Owner's Group (COG) Activities

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
Craig Stuart (CNL) is chair of the COG Chemistry Working Group. Willy Cook and Peter Tremaine have participated in the Chemistry Working Group meetings and other COG workshops and have also provided input to the annual COG R&D planning process. W. Cook keeps the Working Group members informed of the Canadian IAPWS activities.

COG is the primary sponsor for the CNC to host the 2019 IAPWS Annual Meeting. Financial support has be received to secure our booking at the Banff Centre for the Arts and Creativity and COG's willingness to back the CNC to secure this venue is much appreciated.

2.6 Oil Industry Activities (Melonie Myszczyszyn, Canadian Natural Resources Ltd.)

M. Myszczyszyn is participating in multiple industry driven water initiatives with the goal to resolve oil and gas related water scaling and corrosion mechanisms.

Initiative # 1) WTDC (water treatment development centre) is being built up at the Suncor Firebag facility in Fort McMurray and will operate from 2018 to 2024 onwards. This test facility will be used to live feed stream test produced water with various water treatment technologies to find better ways to soften, de-oil, heat exchange, and make steam for oil and gas operations. Goal to advance the technologies used to treat produced water and make steam for thermal injection oil recovery method. Melonie is the WTDC Mancomm project manager for CNRL shares in the WTDC.

Initiative #2) Other spinoffs from the WTDC larger facility trial system is the development of the NAIT and SAIT and U of C laboratory testing trial facilities being created for doing smaller sized water to steam generation scale and corrosion investigations. These spinoff lab testing projects are being done by COSIA water and championed by Suncor oil and gas company and other oil and gas operators. Melonie is providing her OTSG (once through steam generator) knowledge in the design of these lab testing smaller OTSG version test trials.

Initiative #3) CRIN water theme – Melonie is the CNRL representative in this theme – CRIN water theme is a Canadian initiative to link all water related entities, create water connectivity roadmaps to show water entrepreneurs all the water links that exist and connect them to the research/academic communities like

IAPWS for water and governmental funding opportunities W. Cook attended the recent CRIN water theme meeting and will participate on behalf of IAPWS and share IAPWS capabilities with the other water entities.

Initiative #4) linking COSIA in-situ and mining entity with IAPWs by extending the invitation for the 2019 IAPWS Banff Conference to the industry operators that attend COSIA. Shared information about IAPWS with COSIA water contacts John Brogly and Chris Godwaldt. The hope is that the oil and gas industry operators within Alberta will be able to attend this 2019 IAPWS conference in Banff as is located close to Calgary, Alberta.

In November (28-29), at the 6th Water Management Initiative Canada 2018, Melonie is scheduled to give a presentation on "advancements in technologies and new initiatives for treating produced water for recycling & reuse".

4. Activities Planned

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

The CNC is now in the full planning stages for hosting the 2019 IAPWS meetings. The venue and dates have been finalized and the meeting will take place at the Banff Centre for Arts and Creativity between Sunday September 29 – Friday October 4, 2019.

5. Select List of Publications

1. Applegarth, L., Pye, C., Cox, J. S., & Tremaine, P. R. (2017). A Raman Spectroscopic and Ab Initio Investigation of Aqueous Boric Acid, Borate and Polyborate Speciation from 25 to 80 °C. *Industrial & Engineering Chemistry Research, 56*, 13983-13996, doi: 10.1021/acs.iecr.7b03316.
2. McGregor, C., Fandino, O., Cox, J. S., Ballerat-Busserolles, K., & Tremaine, P. R. (2017). Standard Partial Molar Heat Capacities and Volumes of Aqueous N-Methylpiperidine and N-Methylpiperidinium Chloride from 283 K to 393 K. Journal of Chemical Thermodynamics, 113, 377-387, doi: 10.1016/j.jct.2017.05.033.
3. Ferguson, J. P., Arcis, H., Zimmerman, G. H., & Tremaine, P. R. (2017). Ion-Pair Formation Constants of Lithium Borate and Lithium Hydroxide under Pressurized Water Nuclear Reactor Coolant Conditions. Journal of Chemical Thermodynamics, 56, 8121-8132, doi: 10.1021/acs.iecr.7b01015.
4. Nieto Roca, D. E., Romero, C. M., & Tremaine, P. R. (2017). Ionization constants of DL-2-aminobutyric acid and DL-norvaline under hydrothermal conditions by UV-visible spectroscopy. Journal of Solution Chemistry, 46, 388-423, doi: 10.1007/s10953-017-0569-z.
5. Lowe, A. R., Cox, J. S., & Tremaine, P. R. (2017). Thermodynamics of Aqueous Adenine: Standard Partial Molar Volumes and Heat Capacities Of Adenine, Adeninium Chloride and Sodium Adeninate from T = 283.15 K to 363.15 K. Journal of Chemical Thermodynamics, 112, 129-145, doi: 10.1016/j.jct.2017.04.005.

6. Arcis, H., Ferguson, J. P., Applegarth, L. M., Zimmerman, G. H., & Tremaine, P. R. (2017). Ionization of Boric Acid in Water from 298 K to 623 K by AC Conductivity and Raman Spectroscopy. Journal of Chemical Thermodynamics, 106, 187-198, doi: 10.1016/j.jct.2016.11.007.
7. Alcorn, C., Cox, J., Applegarth, L., & Tremaine, P. R. (2017). Quantitative Raman Investigation of Uranyl Sulfate Complexation under Hydrothermal Conditions. *Proc. 37rd CNS Student Conf.*
8. Ferguson, J., Arcis, H., Hussey, D., Wells, D., & Tremaine, P. R. (2017). Boric Acid Ionization Constants and Triborate Formation Constants under PWR Primary Coolant Conditions by AC Conductivity. *Proc. 37rd CNS Student Conf.*
9. Palazhchenko, O.Y., Cook, W.G and Taylor, D., *UNB CANDU-6 Primary Heat Transport System Code: Development and Validation of a Thermal-Hydraulic Expansion,* Accepted to the 2018 Canadian Nuclear Society Annual Conference, Saskatoon, SK, June 2018.
10. Steeves, G. and Cook, W.G., *Development of Kinetic Models for the Long-term Corrosion Behaviour of Candidate Alloys for the Canadian SCWR,* Journal of Nuclear Engineering and Radiation Science, vol.3, no.3, pp. 031001-031000-7, July 2017.

IAPWS - CANADIAN NATIONAL COMMITTEE WORKSHOP
(CNC-IAPWS)

December 13, 2017
Korea Room, COG Office
17th Floor, 655 Bay Street, Toronto, ON

FINAL AGENDA

	1.0	Introduction to IAPWS	
8:30 – 8:40	1.1	Welcome and Introduction	Willy Cook (UNB)
8:40 – 9:00	1.2	Background on IAPWS and the CNC-IAPWS	Willy Cook (UNB)
9:00 – 9:30	1.3	Current IAPWS Activities	Barry Dooley (Structural Integrity)
9:30 – 10:00	1.4	Candu Owners Group (COG) – IAPWS synergies between the nuclear and fossil industries	Steve McGee (COG)
10:00 – 10:15	Coffee break		
	2.0	Cycle Chemistry and Use of Film Forming Amines and Film Forming Products	
10:15 – 10:45	2.1	Optimum Cycle Chemistry for Fossil and Combined Cycle Plants	Barry Dooley (Structural Integrity)
10:45 – 11:15	2.2	COG FFA Programs	John Krasznai (COG)
11:15 – 11:45	2.3	Adsorption of FFPs and Effects on FAC (some of the studies at UNB Nuclear)	Derek Lister (UNB)
11:45 – 12:15	2.4	FFA use in Water Systems in the Oil & Gas Industry	Ivan Morales (Devon Canada)
12:15 – 12:45	2.5	IAPWS White Paper on FFA/FFP use in Nuclear Plants	Willy Cook (UNB)
12:45 – 1:30	Lunch		
	3.0	Modelling of Aqueous Systems in Harsh Environments	
1:30 – 2:00	3.1	Introduction to OLI Models and Case Studies	Andre Anderko (OLI)
2:00 – 2:30	3.2	Introduction to MultEQ and Uses	Dan Wells (EPRI)
2:30 – 3:00	3.3	Modelling Seawater Properties and their Implications for Industrial Systems	Rich Pawlowicz (UBC)
3:00 – 3.30	3.4	Case Studies of Modelling in Oil & Gas Processing	Subodh Peramanu (CNRL)
3:30 – 3:45	Coffee break		
	4.0	Emerging Issues & Technologies for the Use of Water and Steam	
3:45 – 4:15	4.1	High Temperature Reverse Osmosis Membranes	Basil Perdicakis (Suncor)
4:15 – 4:30	4.2	Generation Capacity and Trends in Ontario	Brian Townes (OPG-Lennox)
4:30 – 4:50	4.3	Group Discussion on Future Technologies / Activities	all
	5.0	Closing Discussion	
4:50 – 5:00	5.1	New CNC-IAPWS initiatives and membership	all
5:00	5.2	Workshop wrap-up	Willy Cook
5:30	5.3	Dinner at local establishment	

Czech Society for the Properties of Water and Steam

2018 Annual Report

Submitted to IAPWS Executive Committee in Prague, Czech Republic, September 2018

Because of a change of legislation, the Czech National Committee for the Properties of Water and Steam (CZNCPWS) was replaced by the Czech Society for the Properties of Water and Steam (CZPWS) by the end of 2017. On the contrary to CZNCPWS, which has been one of numerous committees embedded in the structure of the Czech Academy of Sciences, CZPWS is a standalone legal entity (Registered Association). All active members of the former CZNCPWS became CZPWS members. The seat of CZPWS is again the Institute of Thermomechanics of the Academy of Sciences of the Czech Republic (IT CAS) in Prague.

Steering board of CZPWS
Chair: Tomáš Němec (IT CAS, nemec@it.cas.cz), Vice-Chair: Josef Šedlbauer (Technical University of Liberec), Secretary: Jan Hrubý (IT CAS), Member: Radim Mareš (University of West Bohemia), Member: Milan Sedlář (SIGMA Research and Development Institute).

CZPWS Meetings
CZPWS was established at a constituent meeting on October 27, 2017, at IT CAS. Here, the CZPWS Statutes have been adopted. Consequently, the legal status of a Registered Association has been approved on December 4, 2017.
The first annual meeting of the CZPWS was held on June 20, 2018. Strategies to ensure CZPWS funding have been adopted. Activities of IAPWS WGs have been discussed. A significant activity was organizing the 17th ICPWS in Prague.

RESEARCH ACTIVITIES
Surface tension of supercooled water was studied at IT CAS in Prague and at the University of West Bohemia (UWB) in Pilsen.

Measurements of pure water under supercooled conditions conducted at IT CAS were finalized [1]. The measurements with the horizontal capillary tube imitating original method employed by P.T. Hacker [NACA TN 2510 (1951)] did not confirm the second inflection point anomaly down to -23 °C. The new data are in good agreement with the previous measurements conducted with the capillary rise technique employed in the extrapolation of the IAPWS standard [Hrubý et al., J. Phys. Chem. Lett. 5 (2014) 425 and Vinš et al., J. Phys. Chem. B 119 (2015) 5567]. The experimental apparatus has been further modified and is being used for the measurements of supercooled aqueous mixtures. Preliminary data for the surface tension of binary mixtures of water with methanol, ethanol, and propanol were presented at the international conference EFM 2017 [6]. Currently, the new measurements with supercooled seawater are carried out in order to verify extrapolation of the seawater correlation by Nayar et al. [J. Phys. Chem. Ref. Data 43 (2014)] in the supercooled region. For the needs of the task group, V. Vinš wrote an internal report “Surface tension of seawater at low temperatures including supercooled region down to –25 °C”.

At UWB, R. Mareš continued in surface tension measurements in the supercooled region down to -32°C (mentioned in Kyoto 2017). J. Kalová and R. Mareš tested a new equation for the surface tension of water

(results will be presented in Prague, ICPWS17th in Prague). J. Kalová and R. Mareš also published a work on the mean field equation of state for supercooled water [7].

At IT CAS, additional measurements for the density of supercooled water have been performed and a new data set on the density of supercooled seawater has been recorded [8].

In an international collaboration of the Ruhr-Universität Bochum, the Technische Universität Dresden and IT CAS, a thermodynamic model for eight pure gas hydrates relevant mostly for CCS (Carbon Capture and Storage) applications was successfully extended to hydrate mixtures. The complex phase equilibrium algorithms developed for various fluid phases, gas hydrates, and pure solid phases (ices) were thoroughly revised in order to model multicomponent systems with mixed hydrates. The results were published in Fluid Phase Equilibria [5] and presented at a German national conference [9].

Researchers from IT CAS (J. Hrubý, M. Duška, T. Němec) and M. Kolovratník from the Czech Technical University in Prague published a study on nucleation in steam and water vapor – carrier gas mixtures, including data from steam nozzles, turbines, classical nucleation data, and molecular simulations, including own simulations with TIP4P/2005 force field [2]. A team from the Institute of Chemical Process Fundamentals and IT CAS finalized a study of nucleation in mixtures of sulfuric acid and water vapors using a new experimental method [3].

At SIGMA Research and Development Institute and the Centre of Hydraulic Research, M. Sedlář and coworkers were developing models of cavitation erosion during the hydrodynamic cavitation and models of cavitation instabilities in hydrodynamic pumps [10]. In cooperation with ITCAS, the Moscow Power Engineering Institute, the Technical University of Liberec, and the Wuhan University, experimental and numerical modelling of unsteady cavitation phenomena in water has continued in the framework of internal grant projects. Recent research is devoted to the influence of real water properties including the content of undissolved air on the pressure pulses excited by cavitation [4].

At Doosan Škoda Power, P. Rudasová was concerned with the implementation of IAPWS guidelines for operating blocks. The implementation of IAPWS Technical Guidance Documents in Czech power plants is difficult, most personnel adhere to outdated national technical standards.

Publications

1. Vinš V., Hošek J., Hykl J., Hrubý J.: *Surface tension of supercooled water: Inflection point-free course down to 250 K confirmed using a horizontal capillary tube*, J Chem Eng Data 62 (2017) 3823-3832.
2. Hrubý J., Duška M., Němec T., Kolovratník T.: *Nucleation rates of droplets in supersaturated steam and water vapour–carrier gas mixtures between 200 and 450K.* J Power and Energy 232 (2018) 536–549.
3. Trávníčková T., Škrabalová L., Havlica J., Krejčí P, Hrubý J., Ždímal V. *Laboratory study of H2SO4/H2O nucleation using a new technique – a laminar co-flow tube*, Tellus B Chem Phys Meteorol 70 (2018) 1446643.
4. Sedlar, M., Soukal, J., Komarek, M., Volkov, A.V. and Ryzhenkov, A.V.: *Numerical Simulation of Interaction between Fluid and Vapor Structures in Multiphase Flow around Hydrofoil*. Journal of Applied Mathematics and Physics, 2018, under review
5. Hielscher S., Vinš V., Jäger A., Hrubý J. Breitkopf C., Span R.: *A new approach to model mixed hydrates*, Fluid Phase Equilibria 459 (2018) 170-185.

Conference Presentations

6. Vinš V., Hykl J., Nikl Z., Čenský M., Hrubý J.: *Surface tension of aqueous binary mixtures under the supercooled conditions – Development of the measuring technique and preliminary data for water + lower alcohols*, international conference Experimental Fluid Mechanics 2017, Mikulov (Czech Rep.), November 21-24, 2017.

7. Kalová J., Mareš R.: *Mean-Field Equation of State of Supercooled Water and Vapor Pressure Approximations,* AIP Conference Proceedings 1889, 020016 (2017)

8. A. Blahut, M. Duška, J. Hykl, P. Peukert, V. Vinš, M. Čenský, J. Hrubý, *Dual-Capillary Apparatus for Accurate Density Measurements of Supercooled Water*, Twentieth Symposium on Thermophysical Properties, Boulder (CO, USA), June 24-29, 2018.

9. Hielscher S., Jäger A., Vinš V., Breitkopf C., Hrubý J., Span R.: *Modellierung gemischter Gashydrate konsistent zu vielparametrigen Zustandsgleichungen*, Thermodynamik Kolloquium 2017, Dresden (Germany), September 27-29, 2017.

10. Sedlář, M.: *Cavitation phenomena in balancing drums of high-performance feed pumps.* PCC/PCAS/IRS Joint WG Meeting and Workshop, IAPWS Meeting, Kyoto, 2017.

German National Committee to IAPWS Executive Committee

Research Activities on the Thermodynamic Properties of Water and Steam of the German National Committee in the Period 2017/2018

www.iapws.de

Chair: Ingo Weber, Siemens Power and Gas, Erlangen

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

Annual Meeting of the German National Committee

The 2018 Annual Meeting of the German National Committee took place at the Leibniz Institute for Tropospheric Research in Leipzig on 9th March 2018. 23 Colleagues attended this meeting. Six papers were presented in the scientific session.

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

Baltic Sea Research Institute, Warnemuende
Dr. Rainer Feistel

Recent Publications

- Feistel, R.:
  Thermodynamic Properties of Seawater, Ice and Humid Air: TEOS-10, Before and Beyond.
  Ocean Sci., 14, 471–502 (2018), https://doi.org/10.5194/os-14-471-2018
- Burchard, H.; Bolding, K.; Feistel, R.; Gräwe, U.; Klingbeil, K.; MacCready, P.; Mohrholz, V.; Umlauf, L.; van der Lee, E.:
  The Knudsen theorem and the Total Exchange Flow analysis framework applied to the Baltic Sea, Progress in Oceanography.
  Volume 165, July–August 2018, Pages 268-286 (2018).
  https://doi.org/10.1016/j.pocean.2018.04.004, in press
- Feistel, R.; Lovell-Smith, J.W.:
  Implementing systematic error in the weight matrix of generalized least-squares regression.
  published online (2018) https://doi.org/10.13140/RG.2.2.25098.16320
- Hellmuth, O.; Shchekin, A.K.; Feistel, R.; Schmelzer, J.W.P.; Abyzov, A.S.:
  Physical Interpretation of Ice Contact Angels, Fitted to Experimental Data on Immersion Freezing of Kaolinite Particles.
  Interfacial Phenomena and Heat Transfer, 2017 (in press).
- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.:
  Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air.
  N.N. (2018), in preparation.
- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.:
  Digital Supplement to "Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air".
  N.N. (2018), in preparation.

Baltic Sea Research Institute, Warnemuende
Dr. Stefan Weinreben

Projects

1. Measurements of density and practical salinity in the Baltic Sea to determine the absolute salinity anomaly
2. Preparation of a paper about measurements of the density-anomaly in the Atlantic Ocean.
3. We got the ILAC-accreditation for the calibration laboratory of the IOW for the calibration of oceanographic devices for electrical conductivity, temperature and pressure.

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

Project

1. Implementation of the Fast Steam Property Algorithms Based on Spline Interpolation into the CFD Code TRACE.
   - The "IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using the Spline-Based Table Look-Up Method (SBTL)" has been implemented into the CFD code TRACE.
   - On this basis the implementation has been further improved, especially regarding the software architecture, solution algorithm and boundary treatment.
   - The capability of the SBTL-method has been tested on Laval-nozzle and Cascade test cases. The calculation of a real steam engine configuration is targeted next.

Recent Publications

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

Leibniz Institute for Tropospheric Research, Leipzig
Dr. Olaf Hellmuth

Projects

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

Recent Publications

- Hellmuth, O.; Shchekin, A.K.; Feistel, R.; Schmelzer, J.W.P.; Abyzov, A.S.:
  Physical Interpretation of Ice Contact Angels, Fitted to Experimental Data on Immersion Freezing of Kaolinite Particles.
  Interfacial Phenomena and Heat Transfer, 2017 (in press).

- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.:
  Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air.
  N.N. (2018), in preparation.
- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.:
  Digital Supplement to "Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air".
  N.N. (2018), in preparation.

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

Projects:

1. Development of a new reference equation of state for heavy water. This work is linked to an IAPWS grant awarded in 2012 and to a close cooperation with Dr. A. H. Harvey and Dr. E. W. Lemmon at NIST in Boulder, CO. The work on the new equation of state has largely been finished. A draft release will be submitted to the evaluation task group and were presented at the 2017 IAPWS meeting in Kyoto.
2. The work on a new mixed gas hydrate model consistent to reference equations of state continues. This work started as a collaboration of Ruhr-Universität Bochum (Prof. Dr. Roland Span, Dr. Andreas Jäger) and the Institute of Thermomechanics of the CAS (Dr. Jan Hrubý, Dr. Václav Vinš). The work is now carried on as a collaboration of Ruhr-Universität Bochum (Prof. Dr. Roland Span, Sebastian Hielscher), the Institute of Thermomechanics of the CAS (Dr. Jan Hrubý, Dr. Václav Vinš), and TU Dresden (Prof. Dr. Cornelia Breitkopf, Dr. Andreas Jäger). The model for CCS-relevant pure hydrate formers was recently successfully modified in order to allow the calculation of mixed gas hydrates, which resulted in a publication by Hielscher et al. (2018) and another planned publication for this year.

Recent Publications

- Herrig, S.; Thol, M.; Harvey, A.H.; Lemmon, E.W.:
  A Reference Equation of State for Heavy Water,
  J. Phys. Chem. Ref. Data (2018), submitted.
- Hielscher, S.; Vinš, V.; Jäger, A.; Hrubý, J.; Breitkopf, C.; Span, R.:
  A New Approach to Model Mixed Hydrates,
  Fluid Phase Equilib. 459 (2018), 170–185.

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

Project

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

Recent Publications

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

Siemens Energy Solutions, Erlangen
Michael Rziha

Projects

1. Development of new Technical Guidance Documents:
   - Air In-Leakage in Steam Water Cycles. Finally developed, so that the release can be expected in 2018
   - Ensuring the Integrity and Reliability of Demineralized Makeup Water Supply to the Unit Cycle. TGD is drafted, but still some work needs to be done. Release is expected by 2019
   - Film Forming Products. Following the release of the IAPWS TGD on FFP for Fossil and Combined Cycle Plants and the IAPWS International Conference on FFP in Lucerne and a 2nd conference in Prague in spring 2018, IAPWS will be developing two new TGD on FFP:
     a) Application of Film Forming Products in Nuclear Plants.
     b) Application of Film Forming Products in Industrial Plants.
   - Both TGD's are progressing, however still some work to be done, so release is not expected before 2019.
2. Developing of white papers as basis for future technical guidance documents
   - Monitoring Corrosion Products in Flexible (cycling and two-shifting) Plants. White paper is developed for presentation at the 2017 Meeting. TGD will be further developed based on this input.
   - Aspects of Geothermal Steam Chemistry. A White Paper for the 2017 Meeting is in preparation. This will be used to determine if a TGD can be developed.

Highlight:

- IEC has finally agreed to withdraw their standard IEC 61370 Ed 1.0: 2002 Steam turbines - Steam purity in favor of IAPWS TGD5-13, due to the fact that the IAPWS TGD on steam purity is the most modern, state of the art and international accepted guidance on this topic. This is underlining once more the huge international leadership of IAPWS on aspects of high-temperature steam, water and aqueous mixtures relevant to thermal power cycles.
- A so called category C liaison (which is some sort of loose liaison, just for exchange of information) between IEC - MT12 and IAPWS PCC Working Group will be established.

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

Projects

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

Recent Publications

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

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

Project

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

Recent Publications

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

Technical University of Dresden
Institute of Power Engineering, Faculty of Mechanical Science and Engineering, Thermodynamics
Prof. Dr. Cornelia Breitkopf
Dr. Andreas Jäger, Dr. Tommy Lorenz, Erik Mickoleit

Projects:

1. The work on a new mixed gas hydrate model consistent to reference equations of state continues. This work started as a collaboration of Ruhr-Universität Bochum (Prof. Dr. Roland Span, Dr. Andreas Jäger) and the Institute of Thermomechanics of the CAS (Dr. Jan Hrubý, Dr. Václav Vinš). The work is now carried on as a collaboration of Ruhr-Universität Bochum (Prof. Dr. Roland Span, Sebastian Hielscher), the Institute of Thermomechanics of the CAS (Dr. Jan Hrubý, Dr. Václav Vinš), and TU Dresden (Prof. Dr. Cornelia Breitkopf, Dr. Andreas Jäger). The model for CCS-relevant pure hydrate formers was recently successfully modified in order to allow the calculation of mixed gas hydrates, which resulted in a publication by Hielscher et al. (2018) and another planned publication for this year.
2. Molecular simulations of volumetric properties and cage occupancies of gas hydrates in different crystal structures have been conducted and are ongoing work (Dr. Tommy Lorenz, Dr. Andreas Jäger). Properties of gas hydrate formers in structures that these hydrate formers do not form, if they are in a binary mixture with water, are important for the development of a model for mixed hydrates. As these quantities cannot be obtained experimentally, simulations are a viable option. First results will be presented on the 17th ICPWS in Prague (2018).
3. A new predictive mixing rule for the multi-fluid mixture model was developed and published (Jäger et al. (2018)). The new mixture model involves a theoretically based departure function, which allows for the combination of the multi-fluid mixture model with excess Gibbs energy models, like UNIFAC or COSMO-SAC. The application of this new model to mixtures containing water is ongoing work (Dr. Andreas Jäger, Erik Mickoleit). Results of the new model will be presented on the 17th ICPWS in Prague (2018).

Recent Publications

- Hielscher, S.; Vinš, V.; Jäger, A.; Hrubý, J.; Breitkopf, C.; Span, R.:
  A New Approach to Model Mixed Hydrates.
  Fluid Phase Equilib. 459, 170–185 (2018).
- Jäger, A.; Bell, I.H.; Breitkopf, C.:
  A theoretically based departure function for multi-fluid mixture models, Fluid Phase Equilib. 469, 56–69 (2018).

University of Rostock, Rostock
Institute of Chemistry, Department of Physical Chemistry
Dr. Robert Hellmann

Project

1. *Ab-initio* Calculations for Transport Properties of Water and Aqueous Mixtures.

Recent Publications

- Hellmann, R.:
  Cross Second Virial Coefficient and Dilute Gas Transport Properties of the (H2O+CO2) System from First-Principals Calculations,
  Fluid Phase Equilib. (2018), submitted.

VGB PowerTech e.V., Essen
Dr. Andreas Wecker

Project

1. *Development of a new VGB- standard*: Chemical Feeding and Feed Systems for Water/Steam Circuits.
   - This VGB-Standard supplements the VGB Standards for "Feed Water, Boiler Water and Steam Quality for Power Plants / Industrial Plants" and VGB-Standard "Sampling and Physico-Chemical Monitoring of Water and Steam Cycles" and contains recommendations for the correct location, design and instrumentation as well as operation and maintenance of chemical feed equipment in the water/steam circuit. It was published in July 2018.
   -

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

Projects

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

   The developed spline-based property libraries have been implemented into the following process simulation codes:
   - Non-stationary thermo-hydraulic code ATHLET of the German Society of Global Research for Safety GRS
   - Non-stationary thermo-hydraulic codes SubChanFlow and TwoPorFlow of the Karlsruhe Institute of Technology KIT
   - Non-stationary thermo-hydraulic code RELAP-7 of the Idaho National Laboratory INL
   - Heat-cycle simulation program EBSILON of STEAG Energy Services
   - Heat-cycle simulation program KRAWAL of Siemens Energy Solutions
   - Non-stationary heat-cycle simulation program DYNAPLANT of Siemens Energy Solutions.

3. Development of algorithms for the transport properties of moist air, ASHRAE Research Project 1767.
4. Preparation of a new ASHRAE standard for calculating moist air properties, ASHRAE Project SPC 213P.
5. Reworking on the 3rd edition of the book "International Steam Tables".

Recent Publications

- Kunick, M.; Kretzschmar, H.-J.; Gampe, U.; di Mare, F.; Hrubý, J.; Duška, M.; Vinš, V.; Singh, A.; Miyagawa, K.; Weber, I.; Pawellek, R.; Novi, A.; Blangetti, F.; Wagner, W.; Friend, D. G.; Harvey, A. H.:
  Fast Calculation of Steam and Water Properties with the Spline-Based Table Look-Up Method (SBTL).
  J. Eng. Gas Turbines Power, in preparation.
- Kunick, M.:
  Fast Calculation of Thermophysical Properties in Extensive Process Simulations with the Spline-Based Table Look-Up Method (SBTL).
  Fortschritt-Berichte VDI, Reihe 6 Energietechnik, Nr. 618 (2018).
- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.:
  Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air.
  N.N. (2018), in preparation.
- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.:
  Digital Supplement to "Virial Approximation of the TEOS-10 Equation for the Enhancement Factor of Water in Humid Air".
  N.N. (2018), in preparation.

Current Status of Research Activities in Japan
Submitted to the Executive Committee Meeting, IAPWS, Prague, Czech Republic, September 2018

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

I. Overview:

The Japan National Committee, supported by JSPS, of IAPWS continues to endeavor to make closer and innovative interactions between engineering and academic groups with respect to the international and domestic energy-related issues. We have the successfully organized IAPWS Annual Meetings in the last summer, 2017 and reported the international cooperation achievements; see the IAPWS website. Some of our members are active as the members of the IAPWS Working Groups and making efforts in each working group. The key points of our attention are cleaner, greener, and more sustainable energy as well as high efficiency and safety. We are discussing about the science and engineering of fuels, boilers, turbines, and water-treatment. Now we take it into account the power generation from geothermal and biomass energies. Our activities in the publication are shown below.

II. Recent Publications:

Nakahara, Masaru
Professor Emeritus of Kyoto University, Institute for Chemical Research
email: nakahara@scl.kyoto-u.ac.jp
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Hirano, Hideo
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[9] Takahashi, K. Z.; Nishimura, R.; Yasuoka, K.; Masubuchi, Y.; "Molecular Dynamics Simulations for Resolving Scaling Laws of Polythylene Melts", Polymers, 9, 24 (2017). (12 pages) DOI: 10.3390/polym9010024

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

Date: 27 August 2018

Key Achievements:

1. NZAPWS is now into its second year of full IAPWS membership

2. NZAPWS has robust funding in place and has gained additional sponsors for the 2018/2019 year and is in a good financial position

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

Key Activities:

1. A very successful technical seminar was held in May 2018 in Rotorua, NZ with 60 attendees and a wide ranging program of technical presentations covering;
    a. Geothermal steam chemistry
    b. Industrial steam chemistry
    c. Humidity
    d. Water and steam chemical analysis
    e. Cooling water systems
    f. Steam heat transfer
    g. IAPWS related research and Technical Guidance Documents

This seminar was expanded out to a 2 day program based on NZAPWS member demands and included a NZAPWS networking dinner.

Bobby Svoboda and Derek Lister attended as invited IAPWS members both presenting on their IAPWS related work and areas of interest and Bobby presented a ½ day steam turbine deposits and corrosion technical seminar. This was hugely successful.

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

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

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

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

Publications:

1. *P.A Siratovich , M.C. Villeneuve, S. Mordenskym I. Richardson, Acid Solubility Testing of Greywacke Core and Implications for Well Permeability Enhancement, New Zealand Geothermal Workshop, 2017*

2. *T. A. Clark and I. M. Richardson, Hydrogen Peroxide as a Geothermal Cooling Water Biocide, New Zealand Geothermal Workshop, 2017*

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1 September 2018

SIAPWS annual report for 2017

The annual meeting 2017 took place at Brista CHP north of Stockholm and was successful with around 20 participants, good discussion and interesting presentations. It was interesting to learn about Brista's steps towards a flue gas condensate rinsing process that could actually fulfil the demanding environmental limits and to visit the plant afterwards. The discussion focused on the continued introduction of the SIAPWS Water Chemistry Network.

This network has been the focus point of many EC meetings during the year. We have tried to promote it best possible, but with somewhat limited success. The first on-line courses on the interconnection between corrosion and water chemistry was held in late spring and repeated in September. On both occasions, a handful participants took part and there was room for more. The evaluation of the course was good, so we believe that the content and the form of it was OK.

The SIAPWS delegation at the IAPWS annual meeting in 2017 in Kyoto, Japan, consisted of three persons. It was an interesting week both from the cultural and technical viewpoint. The Japanese hosts did a splendid job and proved great hospitality. The Power Cycle Chemistry (PCC) workshops were focused on the Technical Guidance Documents (TGDs), but some presentations were of more general interest.

In the fall, the SIAPW Chair (Karsten) was on a promotion tour in Finland to tell about the work in SIAPWS and IAPWS and invite the Finnish colleagues to become a part of this cooperation. The occasion was a meeting in the Finnish VGB Chemistry Group, and the members present were positive towards SIAPWS.

At the Matarvattenkonferensen in November in Stockholm, SIAWS gave two presentations, one informing about the activities and the other of more general character.

The membership has increased with 5 companies in 2017, and at least 6 will join 2018 leading to nearly 30 in total.

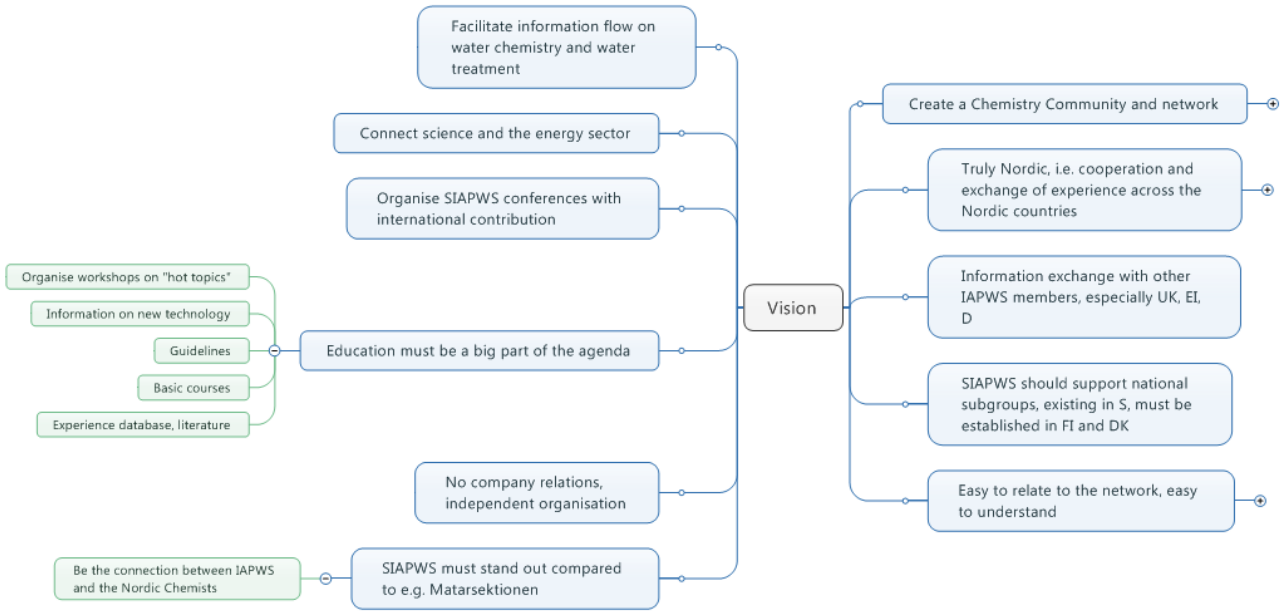
In the spring of 2018, SIAPWS has organised two on-line courses in component failures / plant inspection and plant preservation. We had 10-15 participants on both occasions and again enjoyed good critic afterwards, so this was very satisfactory.

The annual meeting 2018 was hosted by Igelstaverket in Södertälje. We had around 20 participants again, and it was interesting to learn about the very precise fuel (wood chips from forest and waste wood) management at the plant. This is due to rather limited space for fuel storage. The discussion at this SIAPWS annual meeting focused on the future of SIAPWS. The general feeling was that even though we had taken many initiatives during the last couple of years, the full impact has yet to come. The exchange of experience within the field between the Nordic countries is still rudimentary, and the somewhat low attendance to the first SIAPWS on-line courses shows that many do not see themselves as a natural part of the network. Thus, there is a need to rethink the role of SIAPWS.

In May in Helsinki, the newly elected Executive Committee (EC) met for a workshop with that focus and had a couple of productive days with many ideas and discussions. The outcome is a plan transforming SIAPWS to a truly Nordic organisation with national groups in the three countries Sweden, Finland and Denmark.

Matarvattensektionen continues to be the natural representative of the Swedish energy chemists, whereas SIAPWS will initiate national groups in Finland and Denmark. This recognises that many colleagues feel more comfortable speaking and listening in their own language, but still opens for Nordic and international experience exchange through meetings and communication in English. Easily understandable and efficient communication must be in focus both on national and Nordic level. This also calls for organising Nordic conferences with international contribution.

Main purposes of SIAPWS continue to be the link between the Nordic and the international energy chemistry society in IAPWS, to offer education on-line for a modest cost, and to organise work¬shops for current topics. The new vision of SIAPWS is summarised in the mindmap below.



Executive Committee

Chair	Karsten Thomsen	Secretary/cashier	Monika Nielsen
Vice-chair, coordinator	Roger Lundberg	Member	Arja Lehikoinen

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The Swiss National Committee

International Association for the Properties of Water and Steam

Report on IAPWS related activities – September 2017 / August 2018

Submitted to the EC Meeting of IAPWS, Prague, Czech Republic – September 2018.

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

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

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

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

Research activities in the reporting period:

No new projects were reported

Contributions to current IAPWS activities:

Vice-chairman of Subcommittee on Sea-Water: M. Hiegemann
Vice-chairman of PCC Sub-Task Group on Film Forming Amines (FFA): Marco Lendi
Chairman of PCC Sub-Task Group: Technical Guidance Document Chemistry Management in Generator Water Cooling during Operation and Shutdown: Robert Svoboda

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 currently planning a smaller event in Spring 2019 to find new participating institutions in Switzerland.
- It is therefore requested to extend the Associate Membership for another term.

M. Lendi, September 2018

U.S. National Committee to IAPWS
2018 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 collaboration with the Ruhr University of Bochum (Germany), we completed a new reference equation of state for the thermodynamic properties of heavy water. A paper describing the EOS has been submitted to the *Journal of Physical and Chemical Reference Data*. Work is beginning on a related IAPWS project, in collaboration with Marc Assael (Aristotle University, Greece) and Jan Sengers (University of Maryland), to develop new transport property correlations for heavy water.

- In collaboration with K. Yoshida of the University of Tokushima, work has begun on developing an IAPWS formulation for the self-diffusion coefficient of water. So far, the low-density limit has been developed, meeting correct boundary conditions and extrapolating reasonably to high and low temperatures. Dr. Yoshida has prepared a comprehensive collection of experimental data, and a preliminary classification into primary and secondary sources has been made.

- In collaboration with researchers at Fondazione Bruno Kessler (Italy), Nicolaus Copernicus University (Poland), and the University of Delaware (USA), two state-of-the-art flexible models for the water pair potential have been used to calculate second virial coefficients $B(T)$ for both H_2O and D_2O. The calculations use the path-integral Monte Carlo method, which fully accounts for both intermolecular and intramolecular quantum effects. The results agree with experimental data, but cover a wider range of temperatures; the best quantitative accuracy is achieved with the CCpol-8sf flexible model. The effect of molecular flexibility is small, but it is still significant in comparison to the uncertainty of the calculations and of the experimental data, implying that the rigid models often used for water are insufficient if the best quantitative accuracy is desired. The results for D_2O served as input for the new IAPWS EOS for heavy water.

  Path-integral calculations were also performed for the third virial coefficient $C(T)$ for both H_2O and D_2O, which requires state-of-the-art 3-body potentials (calculations with only the pair potential are qualitatively incorrect for water). Both flexible and rigid 3-body potentials were employed. While qualitative agreement with experiment was obtained, it was concluded that existing 3-body potentials are not adequate to enable quantitative prediction of $C(T)$.

  A paper describing these quantum virial calculations has been accepted in *Faraday Discussions*, DOI: 10.1039/C8FD00092A.

- Members of the Division were organizers and played major roles in the 20th Symposium on Thermophysical Properties held in Boulder in June of 2018. The conference included a number of sessions on *Properties of Aqueous Systems* organized by IAPWS Working Group members, and technical reports of potential interest to IAPWS in other sessions. The full technical program is at www.thermosymposium.nist.gov/program.html.

Communicated from the University of Maryland, College Park

- Prof. Jan Sengers continues work on the viscosity of heavy water as leader of the IAPWS task group and in conjunction with International Association for Transport Properties. A progress report will be presented at the 2018 IAPWS meeting.

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

Work has continued on an update to the document: *Consensus on Operating Practices for the Control of Feedwater and Boiler Water Chemistry in Modern Industrial Boilers.* We have also continued working on the steam/water cycle equipment inspection guidelines series. The project will consist of a series of guideline pamphlets each focused on a specific piece of equipment in the steam/water cycle and will provide the user with information on how to plan for, conduct, and interpret the results of inspections. The guidelines are aimed at power plant and industrial boiler house staff and aiding those persons in planning for inspections, working with the certified inspector, and understanding the results of the inspection reports.

The committee continues to sponsor sessions at the International Water Conference. In 2018 the conference is in Scottsdale Arizona and the session titles are 1. *Water Treatment for Combined Cycle Plants* and 2. *Controlling Corrosion and Impurities in Steam and Process Condensate for Industrial Cogeneration Plants.*

Communicated from OLI Systems

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

OLI Systems continued its participation in the Department of Energy's Critical Materials Institute (CMI). OLI's work is focused on modeling the properties of aqueous systems containing rare earth elements and providing simulation support to other members of CMI in the research on diversifying the supply, recycling, and developing substitutes for critical materials. Recent work focused on the properties of aqueous systems and solid phases containing sulfates, phosphates, chlorides, carbonates and organic complexes of rare earth elements. The recent work has been published in the following papers:

> G. Das, M.M. Lencka, A. Eslamimanesh, A. Anderko, and R.E. Riman, "Rare-Earth Elements in Aqueous Chloride Systems: Thermodynamic Modeling of Binary and Multicomponent Systems in Wide Concentration Ranges," Fluid Phase Equilibria, 452 (2017) 16-57
>
> P. Kim, A. Anderko, A. Navrotsky, R. Riman, "Trends in Structure and Thermodynamic Properties of Normal Rare Earth Carbonates and Rare Earth Hydroxycarbonates," Minerals, 8(3) (2018) 106

- **Aqueous chemistry for carbon capture technologies**

In collaboration with SRI International, OLI worked on developing simulation technology for CO_2 capture using mixed-salt (i.e., $NH_3 + K_2CO_3 + H_2O$) working fluids. A thermodynamic model has been constructed and, subsequently, process simulation studies have revealed the advantages of this technology with respect to energy requirements. This work has been summarized in the following paper:

> I. Jayaweera, P. Jayaweera, P. Kundu, A. Anderko, K. Thomsen, G. Valenti, D. Bonalumi, and S. Lilla, "Results from Process Modeling of the Mixed-Salt Technology for CO_2 Capture from Post-Combustion Related Applications," Energy Procedia, 114 (2017) 771-780.

List of Participants at ICPWS and IAPWS 2018

Title	Last Name	First Name	Country	Institution/Company
Mr.	Fernandez-Prini	Roberto	Argentina	N/A
Dr.	Barker	Paul	Australia	University of New South Wales
Prof.	McDougall	Trevor	Australia	University of New South Wales
Mr.	Mosele	Luke	Australia	Newgen Power
Mr.	Joy	Gary	Australia	Australian Association for the Properties of Water and Steam
Mr.	Henderson	Hayden	Australia	AGL Energy
Ms.	De Meyer	Evelyn	Belgium	Ghent University
Ms.	Xue	Yu	Belgium	Ghent University
Mr.	Senécat	Anthony	Belgium	Engie Laborelec
Dr.	Palazhchenko	Olga	Canada	University of New Brunswick
Prof.	Lister	Derek	Canada	University of New Brunswick
Prof.	Cook	William	Canada	University of New Brunswick
Dr.	Arcis	Hugues	Canada	University of Guelph
Prof.	Tremaine	z	Canada	University of Guelph
Prof.	Pawlowicz	Rich	Canada	University of British Columbia
Mr.	Moghul	Dennis	Canada	Ontario Power Generation Inc.
Mr.	Carvalho	Luis	Canada	ChemTreat International
Dr.	Stuart	Craig	Canada	Canadian Nuclear Laboratories
Dr.	Qiu	Liyan	Canada	Canadian Nuclear Laboratories
Mr.	Musil	Petr	Czechia	Vyncke
Prof.	Mares	Radim	Czechia	University of West Bohemia
Dr.	Kalová	Jana	Czechia	University of South Bohemia, Faculty of Science
Dr.	Macák	Jan	Czechia	University of Chemistry and Technology
Prof.	Šedlbauer	Josef	Czechia	Technical University of Liberec
Dr.	Sedlar	Milan	Czechia	SIGMA Research and Development Institute
Dr.	Blahut	Aleš	Czechia	Institute of Thermomechanics of the CAS, v. v. i.
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Mr.	Kapic	Miroslav	Czechia	Doosan Škoda Power
Mr.	Nový	Adam	Czechia	Doosan Škoda Power
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Ms.	Nielsen	Monika	Denmark	Ørsted Bioenergy & Thermal Power A/S
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Ms.	Maja Skou	Jensen	Denmark	Aarhus University
Mr.	Khalifa	Moataz	Egypt	Veolia
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Dr.	Le Menn	Marc	France	SHOM

Title	Last Name	First Name	Country	Institution/Company
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Mrs.	Picard	Susanne	France	Intenrnational Bureau for Weights and Measures
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Mr.	Sünder	Martin	Germany	Zittau/Goerlitz University of Applied Sciences
Mr.	Ronny	Freudenreich	Germany	Zittau/Goerlitz University of Applied Sciences
Prof.	Kretzschmar	Hans-Joachim	Germany	Zittau/Goerlitz University of Applied Sciences
Mr.	Wecker	Andreas	Germany	VGB PowerTech e.V.
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Dr.	Rathke	Bernd	Germany	Universität Bremen
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Mr.	Span	Roland	Germany	Ruhr-University Bochum
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Dr.	Hirano	Hideo	Japan	(Former) Central Research Institute of Electric Power Industry
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Mrs.	Kenneth	Martina	Netherlands	Sloe Centrale B.V.
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Prof.	Petrova	Tamara	Russian Federation	MPEI
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Mr.	Fredrikson	Anders	Sweden	Tekniska Verken i linköping AB
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Mr.	Winge	Niclas	Sweden	Eurowater AB
Mr.	Werder	Tapio	Switzerland	Waesseri GmbH
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Mr.	McCann	Paul	United Kingdom	Uniper Technologies Limited
Dr.	Culshaw	Jamie	United Kingdom	Office for Nuclear Regulation
Dr.	Bell	Stephanie	United Kingdom	Natinal Physical Laboratory
Dr.	Dooley	Barry	United	IAPWS

Title	Last Name	First Name	Country	Institution/Company
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Mr.	Sparrey	Mike	United Kingdom	ABB Ltd
Mr.	Trusler	Martin	United Kingdom	Imperial College London
Mr.	Powalisz	John	USA	Sentry Equipment Corp
Dr.	Anderko	Andre	USA	OLI Systems Inc.
Dr.	Harvey	Allan	USA	National Institute of Standards and Technology
Dr.	Friend	Daniel	USA	National Institute of Standards and Technology
Mr.	Buecher	Kirk	USA	Mettler Toledo Thornton
Dr.	Woosley	Ryan	USA	Masschusetts Institute of Technology
Dr.	Bellows	James	USA	James Bellows and Associates
Dr.	Kunick	Matthias	USA	Idaho National Laboratory
Dr.	Witney	Andy	USA	General Electric
Mr.	Hughes	Arni	USA	N/A
Prof.	Dickson	Andrew	USA	USC San Diego