

**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
India
Italy
Switzerland

EXECUTIVE SECRETARY

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Minutes of the Meetings

of the

Executive Committee

of the

International Association for the Properties of

Water and Steam

Banff, Canada

30th September – 4th October 2019

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
Banff, Canada
30th September - 4th October 2019

Plenary Session. Monday, 30th September 2019. 9:00am

At 9:02 the President of IAPWS, Dr. Jan Hruby welcomed the Executive Committee (EC) and other IAPWS members to Banff for the Executive Committee (EC) and Working Group (WG) Meetings of IAPWS. He first asked the Chair of the Canada National Committee, Professor Willy Cook, to welcome the EC to Banff. Cook thanked the sponsors of this IAPWS meeting: CANDU Owners Group Inc., Canadian Nuclear Society, ChemTreat and OLI Systems Inc. The President then officially opened the 2019 EC Meetings by introducing the National Delegates. All of the Member and Associate Member countries of IAPWS were in attendance with the exception of Russia, Argentina/Brazil, Egypt, France and Greece. In total there were 45 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 2019. There were no 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 Prague, Czech Republic, September 2018

The Executive Secretary indicated that the following documents had been circulated to the National Committees during the year since the Prague meeting for postal ballot:

- *Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use.* Prague EC Minute 7.1 indicated that the Revised Release would have an Editorial Committee review after the Prague meeting. This was completed, and the document was circulated for a Postal Ballot on 16th September 2018. No objections were received by 21st December 2018, so the Revised Release became an official IAPWS document (R6-95(2018)).
- *Revised Release on the IAPWS Formulation 2017 for the Thermodynamic Properties of Heavy Water.* Prague EC Minute 7.2 indicated that the Revised Release would have an Editorial Committee review after the Prague meeting. This was completed, and the document was circulated for a Postal Ballot on 23rd September 2018. No objections were received by 23rd December 2018, so the Revised Release became an official IAPWS document (R16-17(2018)).
- *Revised Advisory Note No. 3, Thermodynamic Derivatives from IAPWS Formulations.* Prague EC Minute 7.3 indicated that the Advisory Note would have an Editorial Committee review after the Prague meeting. This was completed, and the document was circulated for a Postal Ballot on 25th September 2018. No objections were received by 25th October 2018, so the Revised Advisory Note became an official IAPWS document (AN3-07(2018)).
- *Technical Guidance Document: Air In-leakage in Steam – Water Cycles.* Prague EC Minute 11.1 indicated that the TGD would have an Editorial Committee

review after the Prague meeting. This was completed, and the document was circulated for a Postal Ballot on 26th October 2018. A few minor comments were received by 25th January 2019 and addressed, so the TGD became an official IAPWS document (TGD9-18).

- *Technical Guidance Document: Chemistry Management in Generator Water Cooling during Operation and Shutdown*. Prague EC Minute 11.1 indicated that the TGD would be developed following the Prague meeting. This was completed and the TGD had Working Group and Editorial Committee reviews. The document was then circulated for a Postal Ballot on 19th April 2019. A few minor comments were received by 1st August 2019 and addressed. So, the TGD is now ready for final PCC review and EC approval.
- *Revised Release on the Ionization Constant of H₂O*. The Revised Release had an Editorial Committee review after the Prague meeting and the document was circulated for a Postal Ballot on 23rd April 2019. No negative votes were received by 31st May 2019. So, the TGD is now ready for final TPWS review and EC approval.
- *Technical Guidance Document: Application of Film Forming Substances in Industrial Steam Generators*. Prague EC Minute 11.1 indicated that the TGD would be completed following the Prague meeting. This was completed and the TGD had Working Group and Editorial Committee reviews. The document was then circulated for a Postal Ballot on 22nd May 2019. A few minor comments were received by 23rd August 2019 and addressed. So, the TGD is now ready for final PCC review and EC approval.
- *Technical Guidance Document 2019 Revision: Application of Film Forming Substances in Fossil, Combined Cycle and Biomass Power Plants*. Prague EC Minute 11.1 indicated that the TGD would be completed following the Prague meeting. This was completed and the TGD had Working Group and Editorial Committee reviews. The document was then circulated for a Postal Ballot on 12th July 2019. A few minor comments were received by 12th August 2019 and addressed. So, the TGD is now ready for final PCC review and EC approval.

2.2 Press Release / IAPWS Highlights.

The President asked Cook to chair the development of the Highlights/Press Release on the IAPWS proceedings during the week. It was also suggested that Sparrey (BIAPWS) assist in this development. The Clerks of Minutes from each WG were asked to provide input. The Press Release is discussed in Minute 17.1 and is Attachment 11.

2.3 Evaluation Committee on International Collaboration.

The President indicated that no proposals had been received by the Executive Secretary prior to the meeting, and that any suggestions from WGs should be given to the Executive Secretary by the end of day. The President then reminded the EC that the Committee to review any proposals received would consist of the WG Chairmen, with the President and Executive Secretary as ex. officio members. A chairman would be chosen by the Committee. (See 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 2020 award would consist of a member from Czech Republic, Germany, Japan, New Zealand and SIAPWS. The Czech Republic will provide the committee chairman. The President

asked the Czech Republic delegate, Nemeč, 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 continue on the Committee for 2020. The President would be ex. Officio.

2.5 Report on 17th ICPWS and Host Country for 18th ICPWS

The President provided a short report and final financials on the 17th ICPWS held in Prague in 2018. There had been 140 participants from 27 countries. Although the conference budget had not been covered the Czech Republic National Committee returned £7,500.00GBP of the donation from IAPWS.

The President requested Friend (USA) to provide information on the 18th ICPWS. He indicated that the US National Committee have agreed in principal to host the next ICPWS but at this stage do not know the year, location or format. Also, in response to an EC request in Prague, Friend will chair a small committee during the week to discuss and formulate the format for future ICPWS. The committee will be: Friend (Chair), Hruby, Zohm (BIAPWS), Rziha and Henderson. See minute17.3.

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 IAPWS Certified Research Needs.

The Executive Secretary indicated that five ICRNs needed attention during the week:

- ICRN #16 on Thermophysical Properties of Seawater.
- ICRN #22 on Steam Chemistry in the Phase Transition Zone (PTZ)
- ICRN #25 on Corrosion Mechanisms Related to Contaminants
- ICRN #26 on Behaviour of Aluminum in Steam / Water Cycles
- ICRN #28 on Thermophysical Properties of Metastable Steam

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 Hruby 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 5 to 9).

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

Activities During the Week in Banff

The first day activities of the WGs and Executive Committee were followed by the separate and joint WG meetings on Monday, Tuesday and Thursday. The IAPWS Symposium was held on Wednesday, 2nd October 2019 and the Symposium Program is shown in Attachment 2.

The full IAPWS program for the week is shown in Attachment 3.

Executive Committee Meeting. Friday, 4th October 2019

President Hruby opened the continuation of the EC Meeting at 9:00 am. All of the Member and Associate Member countries of IAPWS were in attendance with the exception of Russia, Argentina/Brazil, Egypt, France and Greece. In total there were 30 people assembled for the EC meeting.

Hruby 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 Hruby asked for comments and changes to the minutes of the EC meeting held in Prague, Czech Republic in 2018. No changes were noted; thus the 2018 Minutes were accepted.

6. President's Report

President Hruby next provided his report and highlighted items of importance for the future for each Working Group. The full report is Attachment 4.

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

TPWS Chairman Harvey opened his report 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 5.

- 7.1 The WG had considered a draft ICRN: *New Thermodynamic Data for Ordinary Water*. The WG voted to approve the ICRN, subject to some editorial corrections and addition of an item on surface tension. The WG requested the EC to authorize a Postal Ballot for the ICRN, to be conducted after these small edits.

The EC approved this Request Unanimously.

- 7.2 Harvey next provided an informational item for the EC. A Task Group had presented a draft Release for viscosity of heavy water. An evaluation Task Group had been appointed (Meier (chair), Blahut and Kretzschmar). They will report by end of 2019 and are aiming for EC approval in 2020. A release on heavy water thermal conductivity may also be ready in time for a 2020 Postal Ballot.

- 7.3 The WG (along with PCAS) had considered a Revised Release on the Ionization Constant of H₂O as identified in Minute 2.1. The WG voted to approve the Revised Release, and Harvey requested the EC to approve the Revised Release, which was circulated to the EC in April/May.

The EC approved this Request Unanimously.

- 7.4 ICRN-28: *Thermophysical Properties of Metastable Steam and Homogeneous Nucleation*, will be allowed to expire in 2019. A Task Group was appointed (Hrubý and Senoo) to work toward a new ICRN focused on nucleation for 2020.

7.5 TPWS Membership.

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

- Alberto Giuliano Albo (INRIM, Italy).

Harvey also informed the EC that the WG had voted to elect Maier (Helmut Schmidt University, Hamburg) as Chair and Harvey (NIST) as Vice-Chair, effective 1st January 2020. He requested approval from the EC.

The EC approved these Membership Changes Unanimously.

The Chairman also indicated to the EC that it had been requested to remove two TPWS members from the WG: Patek (Czech Republic) and Levelt Sengers (USA). One member had deceased, Jacobsen.

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

8.1 IRS Task Groups. IRS Chairman Okita reported on four informational items from IRS Task Groups. Minutes for IRS and the Agenda can be found in Attachment 6.

- The Task Group “Categories of Industrial Requirements” will continue
- The Task Group “Wet Steam Properties Calculation” will continue
- The Task Group “Wet steam Data from Operating Turbines” will continue
- The Task Group on ICRN for Acid Gas Dew Points will continue

8.2 IRS Membership.

Chairman Okita indicated to the EC that the WG had approved removal of three members from the WG: Gachon (France), Le Neindre (France) and Parry (USA).

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 7.

9.1 Joint SCOR/IAPSO/IAPWS Committee on the Properties of Seawater

The Chairman proposed to the EC that the JSC sponsorship is renewed for another six years. There are no changes to the terms of reference. IAPSO and SCOR have already supported the renewal.

The EC approved this Request Unanimously.

9.2 Guideline on the Surface Tension of Seawater.

The new Guideline had been written by Nayar and Harvey. The Evaluation Task Group (Feistel and Duska) had reviewed the document. Now the joint WGs (TPWS and SCSW) propose it for a Postal Ballot once editorial changes have been completed.

The EC approved this Request Unanimously.

9.3 ICRN 16: Thermophysical Properties of Seawater.

The SCSW voted to close this ICRN in 2020 and a closing statement will be written, so that its closure coincides with the development of a new ICRN in the same general area but targeted more at the relevant parts of JCS aims. A Task Group has been formed: Pawlowicz (Chair), Feistel, Seitz, Camoes, Kayukawa and Harvey.

9.4 SCSW Membership.

The Chairman requested EC approval for one new SCSW WG member who had been approved by the WG:

- Alberto Giuliano Albo (INRIM, Italy).

The EC approved this Membership Addition Unanimously.

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

Chairman Yoshida provided the PCAS Report to the EC. Full Minutes can be found in Attachment 8.

10.1 Guidelines.

- Self-diffusion in High Temperature and Supercritical Water over Wide Density Ranges is in an advanced stage of development.
- Volatility and Dissociation Constants of Amines and Amine Decomposition Products. No progress over the last year so the WG voted to delete this from the list of guidelines under development.

10.2 Possible ICRNs

The chairman informed the EC that discussions had taken place on:

- Film forming substances (in collaboration with PCC). Task group members from PCAS are Yoshida and Tremaine.
- Replacement of Archer's model for aqueous NaCl solutions by incorporating the current formulation for the dielectric constant of water
- Dielectric constant of heavy water

10.3 PCAS Membership.

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

- Dr. Jane Ferguson, (University of New Brunswick, Canada)
- Dr. Václav Vinš, (Institute of Thermomechanics, Czech Republic)

The EC approved these Membership Additions Unanimously.

The Chairman also indicated to the EC that it had been requested to remove Levelt Sengers (USA) from the PCAS membership.

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 9. The following items were covered:

11.1 Technical Guidance Documents (TGD).

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

- *Application of Film Forming Substances (FFS) in Industrial Plants.* This TGD had received National Committee Approval (see Minute 2.1) and final review by the PCC during the week. Chairman Rziha requested EC final approval.

The EC approved this TGD Unanimously.

- *Technical Guidance Document 2019 Revision: Application of Film Forming Substances in Fossil, Combined Cycle and Biomass Power Plants.* This TGD had received National Committee Approval (see Minute 2.1) and final review by the PCC during the week. Chairman Rziha requested EC final approval.

The EC approved this TGD Unanimously.

- *Technical Guidance Document: Chemistry Management in Generator Water Cooling during Operation and Shutdown.* This TGD had received National Committee Approval (see Minute 2.1) and final review by the PCC during the week. Chairman Rziha requested EC final approval.

The EC approved this TGD Unanimously.

The Chairman informed the EC of the other TGD and White Papers under development:

- Application of Film Forming Substances in Nuclear Plants (White Paper). Attachment PCC B provides details of the sub-task group (STG)
- Monitoring Corrosion Products in Flexible (cycling and two-shifting) Plants (initial White Paper developed)
- Ensuring the Integrity and Reliability of Demineralized Makeup Water Supply to the Unit Cycle (TGD in Draft)
- Aspects of Geothermal Steam Chemistry (White Paper to be developed for 2020)
- Condensate Polishing for Combined Cycle Plants (No activity yet on White Paper)

- Flue Gas Condensation Proposed (New TGD to be developed in 2020)

11.2 International Collaborations (IC).

The chairman informed the EC of two IC:

- Corrosion Product Sampling, Analysis and Assessment. The PCC proposed this new IC which is shown in Attachment 10. The estimated budget is £25,000 (GBP). The PCC requested approval from the EC. The President indicated that this would be covered later in the EC agenda (see Minute 15.1).
- Examining the Effect of Combined Impurities (Chloride and Sulphate) on the Corrosion of Boiler Steels. The primary aim is to verify the boiler chemistry limits in the IAPWS TGD. The work is underway at the University of New Brunswick, Canada, and the apparatus has been built. Preliminary results were presented at ICPWS 17 in Prague. The project is on track and on budget.

11.3 ICRNs

The chairman informed the EC that discussions had taken place on the following ICRNs as instructed by the EC (Minute 3.1):

- ICRN 22 Steam Chemistry in the Phase Transition Zone. ICRN will be closed. Closing statement will be developed.
- ICRN 25 Corrosion Mechanisms related to the presence of contaminants in steam/water circuits, particularly in boiler water. Still ongoing as part of PCC IC project (Canada/NZ) (Minute 11.2). EC was asked for extension to 2024

The EC approved this ICRN Extension Unanimously.

- ICRN 26 Behaviour of Aluminium in the steam water cycle. Work has been completed. Results will be incorporated into a revision of the current TGD3-10(2015). The ICRN will be closed and a closing statement will be developed.

11.4 PCC Membership.

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

- Mr. Neil Fricke (Suncor, Canada)
- Dr. Tetsuya Sawatsubashi (Mitsubishi Heavy Industries, Japan)
- Mr. Shinichi Terada (Toshiba, Japan)
- Mrs. Arja Lehtikoinen (Valmet, Finland)
- Mr. Burkhard Zohm (Doosan Babcock, United Kingdom)

The EC approved these Membership Additions Unanimously.

The Chairman also indicated that one of the Vice Chairs, Leidich, has requested to step down from the position. The Chairman also informed the EC that he will continue as WG chair until 2021. In 2021 a transition to a new WG Chair will take place.

11.5 PCC Possible Future Sub-Committee.

The PCC Chairman wished to inform the EC that discussions had taken place concerning a possible future sub-committee in conjunction with the Canadian Water Treatment Development Centre and CRIN in regards initially to Oil and Gas processing.

12. Editorial Committee Report

Editorial Committee Chairman Harvey reported that in the preceding year, the Editorial Committee (Harvey, Cook and Cooper) had reviewed the documents in Minute 2.1.

13. Membership and Associates

13.1 Application of India for IAPWS Associate Membership

The Executive Secretary reminded the EC that the application documents for India to become an Associate Member had been forwarded to the Heads of National Committees on 10th September 2019. There was a quick review of the INDIAPWS Statutes, Minutes of the first Meeting, and IAPWS Application Form.

The Executive Secretary, on behalf of the Indian National Committee, then requested EC that INDIAPWS become an Associate Member of IAPWS.

The EC approved INDIAPWS as an Associate Member of IAPWS Unanimously.

13.2 Report on Membership and Member Dues.

The Executive Secretary indicated that all Members had paid the 2019 IAPWS dues.

13.3 Reports on Current Associate Members

Status Report on IAPWS Associate Member, China. The Chair of the China National Committee, Wang, provided a short status report on activities in China. He also indicated that the IAPWS Associate Member status of China Electric Power Plant Chemistry Standardization Technical Committee will expire in May 2020. In order to strengthen exchanges and cooperation between China and other countries, and to promote the internationalization of China power plant chemistry standard, he requested the EC for an extension of China's Associate Member status.

The EC approved an additional three years for China as an Associate Member of IAPWS Unanimously.

Status Report on IAPWS Associate Member, Egypt. The Head of the Egypt National Committee, Khalifa, unfortunately could not attend the IAPWS meetings in Banff. But he did provide a written report which can be seen as Attachment 15.

Status Report on IAPWS Associate Member, Italy. Italian Delegate Giuliano Alba provided a short report on activities of INRiM (Istituto Nazionale di Ricerca Metrologica) over the last year. He indicated that the Italian National Committee will need a little longer to become a full member of IAPWS and requested the EC for an extension of Italy's Associate Member status.

The EC approved an additional three years for Italy as an Associate Member of IAPWS Unanimously.

Status Report on IAPWS Associate Member, Switzerland. The Swiss delegate, Werder, provided a short report on the status of activities (see Attachment 20). Up to now, no team of sponsors to commit on mid- or longterm 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 2020 to find new participating institutions in Switzerland.

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 £67,00.00GBP in total in the UK and US bank accounts. The status as at 15th September 2019 in the bank accounts had been provided to each National Delegate prior to the EC meeting.

The Executive Secretary next reported that the 2018 financial statements had been forwarded to the IAPWS Auditors in January 2019. Professor Savarik in Czech Republic and Dr. Delfs 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 2020.

The EC Unanimously Agreed to this Proposal.

The Executive Secretary had also provided a rough estimate of the income and known planned expenditures for 2019 / 2020.

14.2 Time and Place of the 2020 and 2021 Meetings

2020 IAPWS Meetings. Italian Delegate Giuliano Alba indicated that the 2020 IAPWS meetings will be in Torino, Italy from 6th – 11th September 2020 at the Starhotel Majestic. There is a website for the meeting: <http://iapws2020.inrim.it/>

2021 IAPWS Meetings. The Head of the New Zealand National Committee indicated that the 2021 IAPWS meetings will be held in New Zealand. The dates and specific location details have not yet been worked out. The EC will be informed at the 2020 meetings in Torino.

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 Pawlowicz reported that one collaborative project had been proposed. An overview of the proposed project was provided in the PCC Report (Minute 11) and the proposal details are provided in Attachment 10. The Chairman indicated that the Committee would like to propose funding the project. At this point the US Delegate asked questions about the amount of additional data that would be required to provide validation of the decay map approach for a new TGD. He also questioned the price tag. This led to further discussion and finally a proposal to fund the project up to a maximum of £25,000 (GBP) with the possibility to request the EC for an amendment at the 2020 Meetings in Torino.

The EC Unanimously Approved this Proposal for the International Collaborative Project..

16. IAPWS Awards

16.1 IAPWS Helmholtz Award

The President reported that Dr. Václav Vinš from the Institute of Thermomechanics of CAS, Czech Republic had received the 2019 IAPWS Helmholtz Award and presented the Helmholtz lecture during the IAPWS Symposium.

The President asked the Czech Republic Delegate, Nemeč, for the names of the 2020 Helmholtz Award Committee. The 2020 Helmholtz Committee will consist of: Chairman Nemeč (Czech Republic), Kretzschmar (Germany), Yasouka (Japan), Lovell-Smith (New Zealand) and Jensen (SIAPWS).

Action: Nominations will be due to the Executive Secretary by 31st January 2020.

16.2 IAPWS Honorary Fellowships

The President reported that Mr. Michael Rziha from PPChem in Switzerland had received the 2019 IAPWS Honorary Fellow Award.

The President reminded the EC of the Awards Committee for 2020 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 2020.

17. New Business

17.1 Press Release

The President mentioned that Cook (Chair) and Sparrey 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 11. The President indicated that this release will be sent to all NCs and WGs of IAPWS and it should be distributed as widely as possible and sent to any journals and publications.

17.2 Canada National Committee Feedback on the 2019 EC and WG Meetings.

The Head of the Canadian National Committee, Cook, thought the IAPWS meetings had been a great success but it had been difficult to predict the number of attendees. There had been 62 full delegates from 16 countries and an additional 22 people attending for the symposium. This in total is about 15 to 20 people lower than historically. Cook suggested to the EC and to future organizers of IAPWS annual meetings that they will need to be proactive, and suggested that IAPWS WGs should develop informative agendas as early as possible so that local people not familiar with IAPWS will be able to review the technical topics in detail.

The IAPWS President thanked Cook and his extended team for organizing the IAPWS week in Banff. Applause from EC in appreciation.

17.3 Report on Committee for Future ICPWS

President Hruby asked Friend to provide the EC with feedback on the Committee's discussions during the week. Friend indicated this was a continuation of the Task Force formed in Prague (Friend (Chair), Dooley, Hruby, Henderson, Rziha and Zohm) and Minute 2.5. The Task Force had reviewed three options: a) no future ICPWS, b) reduced days for conference and c) keep ICPWS as historically. The overriding support was for a reduced ICPWS held within a normal IAPWS week of EC and WG meetings. There was also discussion on enhancing educational aspects and having virtual attendees.

Friend indicated to the EC that the US National Committee will report at the next meeting in Torino on how they plan to proceed. No dates have yet been discussed but Friend thought it could be 2023 or 2024.

17.4 Reports from National Committees.

Written reports on progress in member countries were not reported to the EC but were distributed to other members and the Executive Secretary electronically. They are attached to these minutes as follows:

Australia, AUSAPWS	Attachment 12
BIAPWS	Attachment 13
Czech Republic	Attachment 14
Egypt	Attachment 15
Germany	Attachment 16
Japan	Attachment 17
New Zealand	Attachment 18
SIAPWS	Attachment 19
Switzerland	Attachment 20
USA	Attachment 21

17.5 Participants

Attachment 22 provides a list of participants at the IAPWS EC and WG Meetings in Banff, Canada in September/October 2019.

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

18. 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 2019 EC meeting at 11:35 am.

**AGENDA for the EXECUTIVE COMMITTEE of IAPWS
Banff, Canada. 29th September – 4th October 2019**

Monday, 30th September 2019. Opening Plenary Session (9:00 – 10:15 am)

- Opening Remarks, Welcome and Introductions by IAPWS President J. Hruby
1. Adoption of Agenda
 2. IAPWS Business and Appointment of Committees
 - 2.1 IAPWS Business since Last EC Meeting in Prague, September 2018
 - 2.2 IAPWS Highlights / Press Release
 - 2.3 Evaluation Committee on International Collaboration
 - 2.4 IAPWS Awards for 2020 (Honorary Fellow, Helmholtz)
 - 2.5 Reports on 17th ICPWS and Host Country for 18th ICPWS
Report by Chairman Friend on Format for Future 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, 4th October 2019. Executive Committee Meeting. (9:00am – 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 India for Associate Member
 - 13.2 Report on Membership. Including Members Defaulting on Dues.
 - 13.3 Reports of Current and Possible Associate Members
14. Executive Secretary's Report
 - 14.1 IAPWS Bank Accounts, Financials, Auditors and Dues
 - 14.2 Time and Place of 2020 (Italy) and 2021 (New Zealand) 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. New Business
 - 17.1 Press Release
 - 17.2 Canada National Committee feedback on 2019 Annual Meeting
 - 17.3 Future ICPWS
 - 17.4 Other items raised during the IAPWS week
18. Adjournment



Barry Dooley
14th September 2019

IAPWS Symposium
Chemistry and Mass Transport for Steam Generation
and Injection Processes
Wednesday October 2nd, 2019
Banff Centre for Arts and Creativity
Banff, Alberta, Canada

1.0		Symposium Opening	
9:00 – 9:10	1.1	Introductory Remarks	Jan Hrubý, IAPWS President, Institute of Thermomechanics of the Czech Academy of Sciences, Czech Republic
9:10 – 9:55	1.2	Helmholtz Lecture & Award Presentation: Surface Tension of Supercooled Water, Seawater and Aqueous Binaries at Low Temperatures including Metastable Supercooled	Dr. Václav Vinš, Institute of Thermomechanics of the Czech Academy of Sciences, Czech Republic
9:55 – 10:00	1.3	Welcome to IAPWS and the IAPWS Symposium	William Cook, Canadian National Committee of IAPWS, University of New Brunswick, Canada
2.0		Equations-of State for Water and Aqueous Fluid Mixtures	
10:00 – 10:25	2.1	Progress in Modeling Thermophysical Properties for H ₂ O and D ₂ O	Allan Harvey, National Institute of Standards and Technology, USA
10:25 – 10:50	Coffee Break		
10:50 – 11:15	2.2	Development of Equations of State for Seawater	Rich Pawlowicz, University of British Columbia, Canada
3.0		Oil and Gas (steam injection, amine-based gas processing, sour-gas fluids)	
11:15 – 11:40	3.1	Water Issues/Solutions in Oil & Gas – Once Through Steam Generator R&D Overview in Alberta	Basil Perdicakis, Suncor Sean Sanders, University of Alberta, Canada
11:40 – 12:05	3.2	Water Content of Sour Gases	Rob Marriott, University of Calgary, Canada

12:05 – 12:30	3.3	Small Modular Reactors for Oil Extraction Processes	Craig Stuart, Canadian Nuclear Laboratories, Canada
12:30 – 13:30	Lunch (provided)		
4.0	Modelling Hydrothermal Fluids for Nuclear, Thermal and Oil & Gas Applications		
13:30 – 13:55	4.1	Modeling Phase and Chemical Equilibria for Carbon Capture, Transportation and Storage	Andre Anderko, OLI Systems Inc., USA
13:55 – 14:20	4.2	Speciation of Boric Acid, Borate and Polyborates under PWR Primary Coolant Conditions by AC Conductivity and Raman Spectroscopy: Implications for Modelling Coolant Chemistry and Boron	Peter Tremaine, University of Guelph, Canada
14:20 – 14:45	4.3	Case Study - OLI Warm Lime Softening Lime and Magox Silicate Reactions Modelling	Subodh Peramanu, Canadian Natural Resources Limited, Canada
14:45 – 15:00	Coffee Break		
5.0	Film Forming Substances (FFS) for Power Cycle Applications		
15:00 – 15:25	5.1	Assessment of FFS Technology	Stephen Shulder, EPRI, USA
15:25 – 15:50	5.2	FFS Application for Nuclear Systems	Jörg Fandrich, Framatome, Germany
15:50– 16:15	5.3	FFS for Steam Cycle Applications	Ivan Morales, Integrated Sustainability, USA
16:15 – 16:30	5.4	Symposium Closing Discussion	All
Close of IAPWS Symposium			



Schedule of IAPWS Meetings
Banff, Canada. 29th September – 4th October 2019

(All technical meetings will be at the Banff Centre for Arts and Creativity)

Sunday 29 Sept.	7:00 pm	Welcome Reception and Registration Banff Centre for Arts and Creativity
Monday 30 Sept.	9:00 am	Executive Committee - Opening Plenary Session
	10:15 am	Coffee / Tea Break
	10:30 am	TPWS/IRS/SCSW Joint Meeting
		(To set agendas for the week and to conduct IAPWS Business, thus allowing remainder of week for technical matters)
	10:30 am	PCAS and PCC Separate Meetings
		(To conduct IAPWS Business, thus allowing remainder of week for technical matters)
	12:00 pm	Lunch
	1:30 pm.	TPWS/IRS/SCSW Joint Meeting
	1:30 pm.	PCC and PCAS Separate WG Meetings
Tuesday 1 Oct.	9:00 am	PCAS Workshop (other WG Members will be welcome)
	9:00 am	PCC Workshop (other WG Members will be welcome)
	9:00am	TPWS/IRS/SCSW Joint Working Group Meeting
	10:30 am	TPWS/IRS/SCSW Joint or Separate Meetings
	10:30 am	PCC and PCAS Separate Meetings
	12:00 pm	Lunch
	1:30 pm	TPWS/IRS/SCSW Joint Meeting.
	1:30 pm	PCC/PCAS Joint WG Meeting and Workshop
	3:30 pm	PCC and PCAS Separate Meetings
Wednes. 2 Oct.	9:00 am – 4:00 pm	IAPWS Symposium (Chemistry and Mass Transport for Steam Generation and Injection Processes)
Thursday 3 Oct.	9:00 am	IRS, SCSW and PCC Separate WG Meetings
	9:00 am	TPWS/PCAS Joint WG Meeting
	12:00 pm	Lunch
	1:30 pm	Separate meetings of Working Groups (If needed to prepare for Executive meeting)
	6:30 pm.	IAPWS Dinner/Banquet. (Brewster's Mount View Barbecue)
Friday 4 Oct.	9:00am	Executive Meeting (9:00am - 1: 00pm) (Will include at least one member from each National Delegation)

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

Barry Dooley
 9th June 2019

IAPWS President's Report at IAPWS Executive Committee Meeting in Banff, Canada, 4th October 2019

Dear Colleagues,

It is a great pleasure for me to talk to you here in Banff at the end of a successful 2019 IAPWS Meeting.

I would like to thank to the Canadian National Committee for their excellent organization of the meeting. Also I would like to thank to the chairs of the IAPWS Working Groups for organizing WG meetings. Finally I would like to thank to all participants for their active role in developing IAPWS deliverables: Releases, Guidelines, and Technical Guidance Documents.

In my speech I would like to turn our attention to future. We live in a time of rapid societal changes. Renewable energy became policy of many nations. While the reduction of fossil fuels has sound reasons, the farewell to nuclear energy that we see in some countries has reasons less rational. These societal changes have significant impact on our work. For example, it is difficult to get funding for research related to thermal power cycles, although there are still many unresolved questions and it is very likely that steam cycles will remain the backbone of power generation in near future. On the other hand, there are new technological challenges relevant to IAPWS, e.g., geothermal power, steam cycles for biomass fuel, and cycles with carbon capture and storage/utilization.

Besides these “external” driving forces acting on IAPWS, maybe even more important are “internal” driving forces, namely qualified and enthusiastic individuals willing to collaborate towards a valuable result. Thanks to this human potential, the Power Cycle Chemistry WG moves ahead very successfully, although it is right this WG which may feel the societal pressure the most.

I recognize two areas of IAPWS expertise, in which it is of vital importance to keep global leadership by producing and spreading documents containing cutting edge knowledge:

- i. Formulations of thermophysical properties and selected physico-chemical properties for water and aqueous systems important in technology, including seawater,
- ii. Guidance for all chemistry-related aspects of steam power cycle operation.

The first area of IAPWS expertise belongs to WG Thermophysical Properties of Water and Steam (TPWS), Subcommittee for Seawater (SCSW) and to WG Physical Chemistry of Aqueous Systems (PCAS). A very important step is starting the development of a new formulation for H₂O thermodynamics, replacing IAPWS-95. This new flagship formulation will become a basis for formulating thermodynamic properties of seawater and other aqueous systems, for formulations of other properties, as well as for algorithms for fast property calculations relevant to IRS. Development of a new equation for seawater using the new ordinary water formulation, and including desalination conditions, is also necessary. New formulations of seawater

properties, as well as clarification of metrological aspects related to salinity, are urgently needed for environmental modeling, in particular the global circulation models, as well as for new technological processes. Accurate formulation of properties of humid air is clearly within the expertise of IAPWS and highly important for applications in geophysics as well as in technology.

The second area of key IAPWS expertise belongs primarily to WG Power Cycle Chemistry (PCC) and partially to PCAS WG. Technical Guidance Documents (TGDs) became a highly important tool for power plant operators and a vehicle by which IAPWS expertise is effectively disseminated. PCC WG reached a leadership in the knowledge concerting Film Forming Substances (FFS) and works on their further spreading to industrial plants. A new TGD on Chemistry Management in Generator Water Cooling during Operation and Shutdown will be published at this EC meeting. PCC has shown that IAPWS platform can be used to organize specialized meetings or series thereof, such as IAPWS Conference on Film Forming Substances, European HRSG Forum and Australasian HRSG Forum organized by the IAPWS Executive Secretary. These activities proved to be tools for inviting new nations to IAPWS or revitalizing inactive national contacts.

The PCAS WG has an important role in supporting both main areas of IAPWS expertise. With TPWS WG it will develop formulations of physico-chemical properties of aqueous systems such as self-diffusion and static dielectric constant of ordinary water. On the other hand, it will support PCC WG by a more fundamental view on FFS, transport properties in nuclear systems etc.

While PCC WG is intimately connected with power plant public, the connection to application is less straightforward for TPWS and PCAS WGs. Here, the IRS WG serves as an important interface with industry. A specific interest of IRS are algorithms for fast calculations which can be used in Computational Fluid Dynamics (CFD).

It is of essential importance that IAPWS has some top researchers and engineers in its areas of excellence. It is of course not possible to attract all relevant persons, but they can also be invited as external collaborators for particular tasks. What can attract distinguished personalities to collaborate with IAPWS? I think that this is the discussion forum, place of friendly collaboration, increased publicity of the results, and the easy interface between industry and research.

Another activity requiring a continuous attention is communication with other standardizing bodies. IAPWS adopts relevant recommendations of other bodies. On the other hand, it is important to attempt that IAPWS top products are adopted by other internationally recognized organizations.

Jan Hrubý

IAPWS Thermophysical Properties of Water and Steam WG Banff, Canada, 30 September to 3 October 2019

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 Monday, September 30, 2019 by the TPWS Chair, Allan Harvey. An additional item 14.2 Discussion of expiring ICRN 28 - Thermophysical Properties of Metastable Steam and Homogeneous Nucleation was added to the agenda (Attachment A). The Chair noted that the 2018 Minutes had been circulated and approved by email shortly after the 2018 meeting. K. Meier was appointed Clerk of Minutes for TPWS.

3. Potential International Collaborative Projects

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 “Wet steam properties calculation”

4.3 Report of the Task Group “Wet Steam Data from Operating Turbines”

4.4 Requirements for CFD calculations.

5. Heavy Water Properties (joint with WG IRS)

5.1 Density of heavy water at low temperatures - validation of IAPWS standard against Prague experimental data (A. Blahut, J. Hykl, P. Peukert, V. Vinš, J. Hrubý)

A. Blahut reported on density measurements of super-cooled heavy water in the temperature range between 254 K and 298 K up to 100 MPa. The measurements were carried out with a two-capillary instrument developed by J. Hrubý's group in Prague. With the instrument, the density relative to the density on a reference isotherm is measured. The density on the reference isotherm was determined by the method of thermodynamic integration by using very accurate speed-of-sound data measured by Fehres and Rudtsch at PTB in Berlin and data of Wilson at pressures above 60 MPa from the literature as well as thermal expansion and second order thermal expansion coefficients derived from the experimental relative density data. The uncertainty in absolute density is 110 ppm.

Based on the new density measurements and data for density and other properties from the literature, an equation of state (EOS) formulated in Gibbs energy was developed for liquid heavy water that covers the temperature and pressure ranges of the measurements. The new EOS was compared with literature data for various thermodynamic properties and the current and previous IAPWS formulations for heavy water. The new EOS describes the density, isothermal compressibility at high pressure, and maximum of density in the studied region somewhat better than the current IAPWS formulation.

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

J. Sengers reported on the status of the work on the new formulations of the viscosity and thermal conductivity of heavy water. The development of both formulations was mainly carried out after the Release for new formulation for the thermodynamic properties of heavy water was approved in 2018. Available data in the literature for both transport coefficients have been collected, were critically evaluated, and separated in primary and secondary data. The experimental data for the viscosity cover the temperature range between 242 K and 778 K with pressures up to 964 MPa. The viscosity is formulated as a product of three contributions: the viscosity in the limit of zero density, the residual viscosity, and the critical enhancement, which resembles the theoretically well-founded multiplicative critical enhancement. The correlation for the viscosity in the limit of zero density is based on the theoretically calculated values of Hellmann and Bich. It covers the whole temperature range of the calculations between 250 K to 2500 K. The residual viscosity and critical enhancement contributions have the same functional form as for ordinary water. The exponents and correlation length of the critical enhancement are the same as for ordinary water. In the term for the crossover critical behavior, the wavenumber q_c is the same as for ordinary water, but q_d is different as obtained from the fit to the experimental data in the critical region. Only four data points close to the critical point are not represented within the uncertainty of 2%. J. Sengers remarked that the current IAPWS formulation for heavy water does not describe the physical behavior of the correlation length in critical region correctly. An auxiliary equation for the viscosity of heavy water as a function of temperature at ambient pressure was also developed. The uncertainty of the formulation is between 1% and 5% depending on the state point.

K. Meier recommended that more detailed figures with comparisons of the new formulation with experimental data are provided in the publication which e.g. show the representation of data in deviation plots along isotherms as is usually done when assessing the quality of an equation of state. J. Hrubý remarked that his group developed an equation of state for cold and supercooled liquid water which is somewhat more accurate in this region than the current IAPWS formulation for the thermodynamic properties of heavy water.

Subsequently, J. Sengers reported on the progress in the development of the formulation for the thermal conductivity. The primary and secondary data for the thermal conductivity of heavy water cover the temperature range between 270 K to 870 K up to 250 MPa. There are no data for the thermal conductivity of supercooled heavy water. The structure of the formulation is the same as for ordinary water. It is composed of the product of the thermal conductivity in the limit of zero density and the residual thermal conductivity, while the critical enhancement is added. As for the viscosity, the thermal conductivity in the limit of zero density is based on the theoretical values of Hellmann and Bich. The residual thermal conductivity and critical enhancement contributions have the same structure as for ordinary water. The parameters of the critical enhancement are the same as for ordinary water. The available experimental data in the critical region are described well. Next steps are the development of an auxiliary equation for the thermal conductivity at 0.1 MPa, the final assessment of the range of validity and uncertainty of the formulation, and to draft a Release and a manuscript for journal publication.

An evaluation Task Group for the evaluation of the Release for the new viscosity formulation was appointed, consisting of K. Meier (chair), A. Blahut, and H.-J. Kretzschmar. The evaluation of the Release for the viscosity formulation should be finished by the end of December 2019.

The evaluation of the Release for the thermal conductivity will be performed by the same Task Group. The time schedule for the evaluation of the Release for the thermal conductivity will be fixed after the evaluation of the viscosity Release has been completed.

A. Harvey mentioned that there was interest in the static dielectric constant of heavy water; he will look into the issue further before the 2020 meeting.

6. Possible Replacement of IAPWS-95

6.1 Report of Task Group (A. Harvey, D. Friend, J. Hrubý, N. Okita, K. Orlov, R. Span)

A. Harvey reported on behalf of the Task Group examining possible improvement of the IAPWS-95 formulation. His report was structured in three topics: deficiencies in performance of the IAPWS-95 formulation, new data that are not included in the IAPWS-95 formulation, and regions where additional data are needed.

R. Feistel commented that the sea water standard TEOS-10 is based on IAPWS-95 and there is no need to replace TEOS-10 because the changes in the new formulation will be outside of region of interest in oceanography. Moreover, the difference between confidence and prediction intervals should be considered in uncertainty analysis.

6.2 (Item not presented)

6.3 Discussion of proposed ICRN

A. Harvey presented the draft ICRN developed by the task group. It contains the points described in 6.1. J. Sengers suggested not to mention a time when IAPWS-95 is to be replaced. R. Feistel suggested to include investigations on the influence of isotopic composition on the properties of water. The general opinion was that this topic should be considered separately. A. Harvey will prepare this topic for the next meeting. **The WG voted to approve the ICRN with minor editorial changes and recommend that the EC then send it for Postal Ballot.**

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)

A. Harvey on behalf of J. Kalová reported on the surface tension of ordinary water. The current IAPWS formulation was approved in 1975. Several new data sets were published since then. The selection and analysis of data sets for a new formulation was discussed. A new equation for the surface tension of ordinary water based on Wegner's expansion was developed. The critical exponent was fixed to the theoretical value 1.26. A manuscript for a journal publication will be prepared before the 2020 meeting in Turin. J. Sengers commented that the Wegner expansion refers to the critical region only. It was decided that the Task Group should continue. A sentence will be added to the ICRN for the data needs for the new formulation of the thermodynamic properties of ordinary water stating the need for high-temperature surface tension data.

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 had been limited progress, but that he hoped he and V. Holten could have a Guideline prepared for next year's meeting in Turin.

NOTE: Items 9, 10, and 11 are reported on in the SC SW minutes.

9. Report of Task Group on Extension of Range of Formulation for Thermodynamic Properties of Sea Water (joint with WG IRS and SC SW) (R. Feistel)

10. Cooperation with other international bodies (joint with SC SW)

10.1 IAPWS/IAPSO/SCOR Joint Committee on Seawater, including updates to TEOS-10

11. Reports on seawater-related topics (joint with SC SW)

11.1 Proposed Guideline on Surface Tension of seawater (K. Nayar, A. Harvey)

11.2 Evaluation Report on proposed Guideline (R. Feistel, M. Duska)

11.3 Formal Working Group consideration of the Guideline

- 11.4 Density measurements of IAPSO standard seawater by single sinker hydrostatic weighing at atmospheric pressure (A. Giuliano Albo, S. Lago, Y. Kayukawa)
 - 11.5 Density of seawater at low temperatures (including supercooled seawater) and high pressures (A. Blahut, J. Hykl, P. Peukert, V. Vinš, J. Hrubý)
 - 11.6 Seawater Density Anomalies in the Eastern Central Atlantic (S. Weinreben, R. Feistel)
 - 11.7 Report on pH (S. Seitz)
 - 11.8 Progress towards pH Traceability (F. Camoes)
 - 11.9 Liquid Junction Potentials and pH (R. Pawlowicz)
 - 11.10 SI-Traceable Measurement of Relative Fugacity (R. Feistel, J. Lovell-Smith)
12. Reports on miscellaneous TPWS scientific topics (joint with WG IRS and SC SW)
- 12.1 Anomaly in virial expansion of IAPWS-95 at low temperatures (A. Harvey)

A. Harvey presented an investigation on the behavior of virial coefficients calculated with IAPWS-95. He showed that the calculated virial expansion does not show the correct physical behavior at low temperatures. This effect results from one term in IAPWS-95 with a temperature exponent of 50 causing the fourth virial coefficient to become very large in magnitude at low temperatures. The effect is small, but must be considered when IAPWS-95 is used to derive a virial expansion, which is e.g. done in humidity metrology. A manuscript that describes this investigation has been submitted to the International Journal of Thermophysics.
 - 12.2 (item not presented)
13. Joint session with WG PCAS
- 13.1 Report and official WG consideration of minor revision of Release on the Ionization Constant of H₂O (A. Harvey)

A. Harvey reported on a minor revision of the Release of the ionization constant of water. An error in the text of the definition of the ionization constant was corrected, the cover page was adopted to the current IAPWS standard, and the definition of activity was added to the nomenclature. The formulation has not changed. The revised document was circulated in both WGs a few months before the meeting, and was also circulated to the EC. **The WGs voted to approve the Revised Release and recommend that the EC give it final approval.**

- 13.2 Report on progress toward IAPWS Guideline on diffusivity of ordinary water (K. Yoshida, F. Caupin, A. Harvey, R. Hellmann, M. Huber)

K. Yoshida reported on behalf of the Task Group on the progress toward a formulation for the self-diffusion coefficient of ordinary water. Data were collected from the literature and separated into primary and secondary data sets. In summary, 951 data are available, 190 of which were discarded and 487 selected as primary data for preliminary fitting. The product of self-diffusion coefficient and density is formulated as a sum of the zero-density contribution and the residual contribution. Since the self-diffusion coefficient exhibits no anomaly at the critical point, there is no critical enhancement contribution. The functional form of the zero-density contribution is a product of the square root of temperature and a rational function in temperature with 7 adjustable parameters. It is fitted to R. Hellmann's theoretical zero-density values and represents them within 0.1%. The residual contribution is formulated as a product of the square root of temperature and a sum of 17 double polynomials in reduced density and temperature, which are formed with the critical temperature and density. The zero-density contribution does not represent all values derived from experimental data within their uncertainty. In order to assess this discrepancy, experimental viscosity data and theoretically calculated values for the viscosity of Hellmann and Vogel were converted to self-diffusion data by scaling them with the ratio of the cross sections of self-diffusion and viscosity and compared with the self-diffusion data. Based on this comparison, the zero-density contribution was shifted by +0.5%. The preliminary formulation represents the best literature data at high densities within -5% to +10%. Next steps are to improve the data selection and weighing, complete the literature survey, improve the fitting functions, and consider the use of H₂¹⁸O tracer diffusion data. Moreover, in the supercooled region densities according to the IAPWS Guideline for Supercooled Water will be considered.

In the discussion, K. Meier noted that the two experimental data sets for the product $D \cdot \rho$ in the limit of zero density show different dependences on temperature and that the scaling of viscosity to self-diffusion data is only a rough approximation.

- 13.3 Cross second virial coefficients for industrially and scientifically important mixtures of water vapor and simple gases from *ab initio* intermolecular potentials (R. Hellmann, K. Meier)

K. Meier on behalf of R. Hellmann presented *ab initio* calculations on the second cross virial coefficients of the mixtures water-nitrogen and water-carbon dioxide. Intermolecular potential functions were developed on the basis of state-of-the-art quantum chemical calculations of the interaction energies of the molecules. Using the intermolecular potentials, cross second virial coefficients were computed semiclassically with the Mayer-sampling Monte-Carlo method in a wide temperature range up to 2000 K. The calculated virial coefficients were represented by simple analytic functions. Comparisons with experimental data for thermal virial coefficients and Joule-Thomson virial coefficients as well as theoretical calculations of other authors show that the calculated cross virial coefficients agree well with the best experimental

data and are probably more accurate than previously calculated values. The work on water-carbon dioxide was published in Fluid Phase Equilibria and a manuscript on water-nitrogen has been submitted to the Journal of Chemical and Engineering Data. The project continues with calculations of second cross virial coefficients for further binary mixtures containing water. It was noted in discussion that the water-oxygen binary would be of particular interest to IAPWS for moist air calculations.

13.4 Nucleation in water vapor: Classical nucleation theory and molecular simulation (T. Němec) [joint with IRS]

T. Němec presented an investigation of homogeneous nucleation in steam by molecular dynamics simulations with the SPC/E and TIP4P/2005 models for water. An assessment of experimental and simulation data from the literature shows that there are often large discrepancies between these data and classical nucleation theory. In order to examine these differences, molecular dynamics simulations were performed to detect a single nucleation event. During the simulation the development of the largest cluster is monitored to determine the nucleation rate. Good agreement of the simulation results for the nucleation rate with classical nucleation theory was found. It was concluded that simulations should not be carried out in the NVT ensemble. Moreover, experiments must be carried out carefully so that the experimental conditions conform with the assumptions of classical nucleation theory.

14. IAPWS Certified Research Needs (ICRN)

14.1 Discussion of possible ICRN for acid gas dew points (N. Okita)

N. Okita presented the progress of a survey of models for the prediction of acid dew points in combustion gases. Available data from the literature were collected and compared with prediction methods implemented in the process simulation software ASPEN Plus. It was concluded that the presently available methods are not satisfactory. J. Hrubý noted that a better definition of the requirements for the applications is necessary. A Task Group for the development of an ICRN may be appointed in the 2020 meeting in Turin.

14.2 Discussion of expiring ICRN 28 - Thermophysical Properties of Metastable Steam and Homogeneous Nucleation

It is noted that the part of the ICRN about metastable properties is also contained in the new ICRN on the data needs for the thermodynamic properties of ordinary water. Therefore, it was decided to let the ICRN expire and set up a new ICRN about homogenous nucleation. A Task Group consisting of J. Hrubý and S. Senoo was formed to write the new ICRN before the 2020 meeting. Hrubý will write the closing statement for ICRN 28.

15. Reports on other TPWS activities

15.1 Guideline on Fundamental Constants (A. Harvey)

With the adoption of the new SI system in May 2019 and the 2018 CODATA adjustment, the values of some fundamental constants changed. Consequently, the Guideline must be updated. A. Harvey will prepare an update for the 2020 meeting.

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

No update is needed for this document at this time.

16. Other Business

16.1 Report on International Collaborative Projects

M. Duška worked with Prof. Anisimov on properties of supercooled water. The project was funded as an IAPWS Young Scientist Project. A written report describing the work was recently prepared. It can be accessed via the link: <https://arxiv.org/abs/1909.13468> [Duška, M., Water above spinodal, arXiv:1909.13468 [physics.chem-ph] (2019)]

17. Membership

Dr. Patek (Czech Republic) and Dr. J. M. H. Levelt Sengers (U.S.A.) should be removed from the TPWS membership. A. Giuliano Albo (Italy) was unanimously elected as a new TPWS member.

18. Election of Chair and Vice-Chair

K. Meier was elected as Chair, A. Harvey was elected as Vice-Chair, beginning 1 January 2020. H.-J. Kretzschmar on behalf of the WG thanked A. Harvey for serving as Chair of the WG during the last eight years.

19. Contribution to Press Release

The Chair was assigned to prepare the contribution to the Press Release.

20. 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.

21. Adjournment

The meeting was adjourned at 14:00 on Thursday, October 3.

**Agenda for the IAPWS Working Group
Thermophysical Properties of Water and Steam (TPWS)
Banff, Canada, Sept. 30 – Oct. 3, 2019**

1. Opening Remarks; Adoption of Agenda
2. Appointment of Clerk of Minutes
3. Potential International Collaborative Projects [Monday]
4. Industrial Requirements and Solutions for Property Calculations, joint with WG IRS
 - 4.1 Report of the Task Group “Categories of industrial requirements” (N. Okita, A. Nový, I. Weber, R. Span, A. Anderko, M. Rziha)
 - 4.2 Report of the Task Group “Wet steam properties calculation” (A. Nový, J. Hrubý, K. Orlov, R. Span, K. Meier)
 - 4.3 Report of the Task Group “Wet Steam Data from Operating Turbines” (N. Okita, A. Nový, I. Weber, S. Senoo)
 - 4.4 Requirements for CFD calculations
5. Heavy Water Properties (joint with WG IRS)
 - 5.1 Density of heavy water at low temperatures - validation of IAPWS standard against Prague experimental data (A. Blahut, J. Hykl, P. Peukert, V. Vinš, J. Hrubý)
 - 5.2 Report of TG for Heavy Water Transport Properties (J. Sengers, M. Assael, M. Huber, R. Perkins)
6. Possible Replacement of IAPWS-95
 - 6.1 Report of Task Group (A. Harvey, D. Friend, J. Hrubý, N. Okita, K. Orlov, R. Span)
 - 6.2 A brief review of density and speed of sound data at high temperatures and pressures (J. Hrubý)
 - 6.3 Discussion of proposed ICRN
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, F. Caupin) [presented by A. Harvey]
8. Metastable Water (joint with SC SW)
 - 8.1 Report on the vapor pressure of supercooled water (V. Holten, A. Harvey)
9. Report of Task Group on Extension of Range of Formulation for Thermodynamic Properties of Sea Water (joint with WG IRS and SC SW) (R. Feistel)
10. Cooperation with other international bodies (joint with SC SW)
 - 10.1 IAPWS/IAPSO/SCOR Joint Committee on Seawater, including updates to TEOS-10 (R. Pawlowicz)
11. Reports on seawater-related topics (joint with SC SW)
 - 11.1 Proposed Guideline on Surface Tension of seawater (K. Nayar, A. Harvey)
 - 11.2 Evaluation Report on proposed Guideline (R. Feistel, M. Duska)

- 11.3 Formal Working Group consideration of the Guideline
- 11.4 Density measurements of IAPSO standard seawater by single sinker hydrostatic weighing at atmospheric pressure (A. Giuliano Albo, S. Lago, Y. Kayukawa)
- 11.5 Density of seawater at low temperatures (including supercooled seawater) and high pressures (A. Blahut, J. Hykl, P. Peukert, V. Vinš, J. Hrubý)
- 11.6 Seawater Density Anomalies in the Eastern Central Atlantic (S. Weinreben, R. Feistel)
- 11.7 Report on pH (S. Seitz)
- 11.8 Progress towards pH Traceability (F. Camoes)
- 11.9 Liquid Junction Potentials and pH (R. Pawlowicz)
- 11.10 SI-Traceable Measurement of Relative Fugacity (R. Feistel, J. Lovell-Smith)
12. Reports on miscellaneous TPWS scientific topics (joint with WG IRS and SC SW)
 - 12.1 Anomaly in virial expansion of IAPWS-95 at low temperatures (A. Harvey)
 - 12.2 Cloud service for IAPWS formulations (K. Orlov, V. Ochkov)
13. Joint session with WG PCAS [Thursday morning]
 - 13.1 Report and official WG consideration of minor revision of Release on the Ionization Constant of H₂O (A. Harvey)
 - 13.2 Report on progress toward IAPWS Guideline on diffusivity of ordinary water (K. Yoshida, F. Caupin, A. Harvey, R. Hellmann, M. Huber)
 - 13.3 Cross second virial coefficients for industrially and scientifically important mixtures of water vapor and simple gases from *ab initio* intermolecular potentials (R. Hellmann, K. Meier)
 - 13.4 Nucleation in water vapor: Classical nucleation theory and molecular simulation (T. Němec) [joint with IRS]
14. IAPWS Certified Research Needs (ICRNs)
 - 14.1 Discussion of possible ICRN for acid gas dew points (N. Okita)
 - 14.2 Discussion of expiring ICRN 28 - Thermophysical Properties of Metastable Steam and Homogeneous Nucleation
15. Reports on other TPWS activities
 - 15.1 Guideline on Fundamental Constants (A. Harvey)
 - 15.2 Advisory Note 2 (J. Cooper, A. Harvey)
16. Other Business
 - 16.1 Report on International Collaborative Projects
17. Membership
18. Election of Chair and Vice-Chair
19. Contribution to Press Release
20. Preparation of the Formal Motion to the EC
21. Adjournment

Minutes of the IAPWS working group IRS, Banff, Canada, 29 September – 4 October 2019

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

1. The Chair, Nobuo Okita, opened the IRS joint at 10:30 am, 30. September 2019. Agenda was adopted without changes.
2. Appointed Shigeaki Senoo 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 member has joined the TG: K. Yoshida in place of A. Anderko (PCAS).

N. Okita summarized the progress since the last IAPWS meeting in 2018 briefly explained three examples of the requirements;

- 1) wet steam properties in steam turbines
- 2) Acid dew points under low sulfur contents for HRSG design.
- 3) Geothermal steam turbine cycle with non-condensable gas and Impurities.

Also explained added items into Group A and B of categories, then proposed industrial support documents as WG output and future direction in short and medium terms.

D. Friend asked the material has been uploaded?

N. Okita answered that not yet, but it will be uploaded in the IAPWS web.

A. Harvey asked what kind chemicals are involved in steam in geothermal power plant?

N. Okita answered that CO₂ is major but widely distributed from 2 to 10 %, others are H₂S, ammonia(some times) and so on.

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

Skip, because of absence of A. Nový and no progress so far.

4.3 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.

S. Senoo explained the research requirement of coarse droplets causing blade erosion in steam turbine.

The research goal is erosion reduction in steam turbine. The required data are number density distributions of coarse droplet size as a function of steam velocity and liquid mass flow rate. The requests to experts are measurement technologies in steam turbine and a physical and mathematical model for the number density distributions of coarse droplet size.

The following discussion:

Jan Hrubý informed visualization technique is developed by using a small camera in Czech technical university.

Richard Harwood informed EPRI developed such measurement technologies in 1980's.

Daniel Friend and Allan Harvey recommended the requirement will be an ICRN after TG clarifies the gap between current knowledge and the research goal, and TG summarizes an IAPWS guideline.

4.4 Requirements for CFD calculation (N. Okita, M. Kunick, F. di Mare, Hans-J. Kretzsmar)

N. Okita explained requirements to IAPWS IF-97 for applying to CFD calculation, especially an improvement of accuracy of metastable regions and inconsistencies at the region boundary.

IRS Discussion (including joint discussion with PCAS in the related agenda item)

[GOAL in the next few years]

Two ICNRs, but start with „ICRN for condensation“.

- 1) Wet Steam Data from Operating Turbines
- 2) Acid dew point under low sulfur contents for HRSG design

[TO DO]

a) Coarse droplets causing erosion in " Wet Steam Data from Operating Turbines "

a-1) Hans-Joachim Kretzschmar looks for reserachs and experts on two-phase flow in Germany, such as in Helmholtz institute, Fraunhofer institute, and thermodynamic and two-phase flow related conferences.

a-2) S. Senoo hears past research in EPRI from Barry Dooley during the IAPWS.

-> Barry Dooley answered that he does not have any EPRI materials any more and know no contact person.

a-3) Task member continue the literature survey to clarify the gap between the present knowledge and the reserach goal.

b) Categories of industrial requirements

b-1) N.Okita uploaded the presentation material with the updated full list.

(OPAL password protected site, in "File Transfer")

b-2) Promote TGs focusing on common issues so that many IAPWS members can contribute and IRS members would cooperate with other WGs.

c) Requirements for CFD calculations

c-1) Hans-Joachim Kretzschmar transfer the IAPWS discussion to Francesca di Mare in Ruhr-University Bochum and Matthias Knunick in Zittau/Goerlitz University of Applied Science, and introduce Francesca and Matthias to S.Senoo with N.Okita.

c-2) N.Okita and S.Senoo discuss the requirements for CFD calculations with Francesca and Matthias, including the SBTL (Spline-Based Table Look-up Method) and equation of state in metastable vapour.

c-3) confirm the new IAPWS scientific formulation to TPWS.

d) Wet steam properties calculation (no discussion due to absence of leader)

8-IRS/PCAS. (joint with WG PCAS)

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

N. Okita explained the purpose.

S. Senoo explained the research requirement of coarse droplets causing blade erosion in steam turbine as same as the item 4.3.

The following discussion:

M. Nakahara asked about theoretical approach. S. Senoo answers that Kelvin-Helmholtz and Rayleigh-Taylor instability theories have been applied to estimate Weber number for maximum or Suater mean droplet diameter. No theory, however, can produce the number density function.

M. Nakahara asked how the number distributions of droplet diameters and velocities in the slides were obtained. S. Senoo answered that the distributions were obtained by measurement based on Mie scattering theory in model steam turbines. The measurement technologies are not established yet.

P. Tremaine asked influences of chemicals and electric charge on erosion. S. Senoo answered that the impact shock would be dominant, but erosion associated with corrosion would be affected by chemicals and electric charge.

Tomas Nemecek asked the coarse droplet size. S. Senoo answered that it is exactly what we want to know. The coarse droplet diameter would be from 10 to 500 microns according to our literature survey.

8.2 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 member has joined the TG: K. Yoshida in place of A. Anderko (PCAS).

N. Okita summarized the progress since the last IAPWS meeting in 2018 briefly explained three examples of the requirements and proposed industrial support documents and future directions as same as the item 4.1.

The following discussion:

P. Tremaine asked the material has been uploaded. N. Okita answered that not yet, but it will be uploaded in the IAPWS web.

P. Tremaine asked about CO₂ influence on steam in geothermal steam turbine. He mentioned the REFPROP is accurate enough to resolve the issue. N.Okita answered the issue is related to solubility and equilibrium constant in the flusher.

P. Tremaine asked about dew point under low sulfur condition in HRSG. He mentioned the REFPROP could calculate the dew point even in binary gas with sulfur. N.Okita answered the measured dew point temperature under low sulfur region does not agree the temperature predicted by thermodynamic equilibrium calculation.

P. Tremaine asked whether SO₃ causes SCC. N.Okita answered SO₃ creates start points of condensation, then NO₂ is induced nitric acid condensation causing SCC.

[TO DO]

Both PCAS and IRS specialists send each other the related useful papers and/or information for understanding the gap between the present knowledge and the research goal.

10-IRS. Discussion on „wet Steam Data from Operating Turbines“

Covered by point 4.

15 IAPWS Certified Research Needs (ICRN)

15.1 Report of task Group on ICRN for acid gas dew points

N. Okita summarized the progress since the last IAPWS meeting in 2018 briefly explained acid dew points under low sulfur contents for HRSG design.

The discussion is covered by item 14.1 of TPWS minutes.

16-IRS. Discussion on “Categories of industrial requirements” and promotion of IRS activities.

Covered by point 4.

17-IRS. Other Business

No other business.

18-IRS. Membership

IRS members agree to remove from the list for the following three persons.

1) Dr. F. Gachon (EDF, France)

New job and request to remove from the list.

2) Dr. B. Le Neindre(LDPM, France)

As F. Gachon, wish to be removed from the list.

3) Mr. W. T. Parry (former GE, USA)

No more active (from US national committee)

19-IRS. Contribution to Press Release

20-IRS. Preparation of the Formal Motion to the EC

21-IRS. Adjournment

N. Okita closed meeting at 14:20, 3. October 2019.

Minutes of SCSW: Banff, Oct/2019

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. For other 2018 agenda items consult the minutes of the other WG.

9. Report of Task Group on Extension of Range of Formulation for Thermodynamic Properties of Sea Water: (R. Feistel)

Although more data are available, there does not yet appear to be a pressing immediate need for a new formulation that will be valid at high temperatures and high salinities. RF is transitioning to retirement and will not continue to work on a new formulation, but suggests that people from the desalination industry might be interested and should be contacted to see if they might continue to work on the topic. RF proposed that the taskgroup be closed until someone is found to lead work.

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

RP presented an update on the work of JCS, including the statistics of downloads from various items at www.teos-10.org. Results of the JCS workshops, held at the ICPWS in Prague last year, were also described. As per its terms of reference, JCS requires re-approval at 6 year intervals. JCS proposed that a) JCS continue, b) the JCS terms of reference remain unchanged for the next cycle, and c) the updated membership be approved. An SCSW/TPWS vote was held and this was approved unanimously for presentation to the Executive.

11.1 Proposed Guideline on Surface Tension of seawater (K. Nayar, A. Harvey)

The proposed guideline in the surface tension of seawater was presented

11.2 Evaluation Report on proposed Guideline (R. Feistel, M. Duska)

The Evaluation committee, after examining the proposed guideline, found no mathematical errors.

11.3 Formal Working Group consideration of the Guideline

A number of editorial points were raised, including the statement of uncertainties in Table 1, a definition of the coverage factor for the expanded uncertainty, a statement about pressure dependence, the relation to saturation conditions, and the location of Table 3 (in an Appendix or not). The WG voted to accept the guideline and move it forward to the EC, subject to editorial revision on these points.

11.4 Density measurements of IAPSO standard seawater by single sinker hydrostatic weighing at atmospheric pressure (A. Giuliano Albo, S. Lago, Y. Kayukawa)

Progress has been made in a cooperation between metrologists in Japan and Italy. Fundamentally, INRIM has still problems with measurement errors (bubbles, etc.) and the uncertainty is large. However, their measurement appear to suggest that SSW densities are larger than those predicted by TEOS-10, this is in contrast to recent vibrating tube densimeter measurements which appear to show SSW densities smaller than those predicted by TEOS-10.

(the following 4 items were presented out of order so that PCAS members could attend)

11.7 Report on pH (S. Seitz)

An update was given on work by SCOR WG 145 and their plans for a meeting in Feb 2020. SS also provided information about the new European Metrological Network for earth sciences, which includes ocean sciences.

11.8 Progress towards pH Traceability (F. Camoes)

A presentation was given on issues related to 'pH' and 'pH_T' scales.

11.9 Liquid Junction Potentials and pH (R. Pawlowicz)

RP presented work on calculated Liquid Junction Potentials using the MIN3P 'reactive mass transport' numerical code. This approach can potentially provide guidance to many issues, but in spite of its critical importance in potentiometric techniques for pH determination there are very few measurements available for comparison.

11.10 SI-Traceable Measurement of Relative Fugacity (R. Feistel, J. Lovell-Smith)

RF presented some recently published work that (in theory at least) allowed for a SI traceable measurement of relative fugacity using new carbon nanotube membranes which can pass water but block all other materials dissolved in water/

11.5 Density of seawater at low temperatures (including supercooled seawater) and high pressures (A. Blahut, J. Hykl, P. Peukert, V. Vinš, J. Hrubý)

Differential measurements of seawater density in a two-capillary-tube system in which the meniscus height was measured were presented,

11.6 Seawater Density Anomalies in the Eastern Central Atlantic (S. Weinreben, R. Feistel)

RF presented recently published measurements of density measurements in the tropical Atlantic. Measurements were lighter than TEOS-10, but no correlation could be found between the measurements and any oceanographic or technical variations. Samples in some years were analyzed on the vessel; in other years in the lab..

14.2 (Not in the Agenda)

It was pointed out that ICRN 16 "Thermophysical Properties of seawater" expires in 2019. This ICRN had originally been written in 2007, and renewed in 2011 and 2014. All agreed (by vote) that although the Research Need continues, changes to the text and an updating of references was needed. A discussion occurred as to whether it would be more helpful to just revise and extend the existing ICRN, or to close it and issue a new one.

By a majority vote it was concluded that a) the present ICRN should be closed at the 2020 meeting, when a closing statement would be issued, and b) that a new ICRN should be brought up for approval at that same date. A task group is formed (chair: Pawlowicz members: Feistel, Seitz, Camoes, Kayukawa, Harvey)

Issue to be considered: the new title and scope, proposal for scope: thermophysical properties and pH related issues, plus instrumental issues.

17. Membership

New member:

P. Alberto Giuliano Albo
Istituto Nazionale di Ricerca Metrologica
Strada delle Cacce 91, 10135 Torino, Italia
tel.:+39.011.3919.615 fax.:+39.011.3919.621
Email: a.albo@inrim.it

20. Preparation of the Formal Motion to the EC

21. Adjournment

Oct 4, 2019

R. Pawlowicz (Chair)

PCAS WG Minutes

Banff, Canada, September 29 – October 4, 2019

Present:

Ken Yoshida (chair)	yoshida.ken@tokushima-u.ac.jp
Masaru Nakahara	nakahara@scl.kyoto-u.ac.jp
Peter Tremaine	tremaine@uoguelph.ca
Andre Anderko (clerk of minutes)	aanderko@olisystems.com
Tomáš Němec	nemec@it.cas.cz
Jane Ferguson	jane.ferguson@unb.ca
Václav Vínš (TPWS, PCAS)	vins@it.cas.cz
Nobuo Okita (IRS)	nobuo.okita@toshiba.co.jp
Shigeki Senoo (IRS, PCAS)	shigeki1_senoo@mhi.co.jp
Glenn Pringle (PCC, PCAS)	glenn.pringle@candu.org

PCAS separate meeting, 09/30 morning

Clerk of minutes has been appointed: Andre Anderko

PCC/PCAS Joint meeting, 09/30 morning and afternoon.

The session focused on film-forming substances. The following presentations have been given: Barry Dooley – Introduction of Technical Guidance Documents (TGDs). 10 TGDs have been presented.

Wolfgang Hater – Durability of Protective OLDA Films

Hayden Henderson - The AGL experience with Film-Forming Substances

Kristine Liao - Film Forming Product Qualification at Darlington Nuclear Generation Station

PCAS separate meeting, 09/30 afternoon

Agenda has been approved with the addition of Tomáš Němec's presentation for Tuesday.

Minutes of the 2018 meeting have been approved.

The group members gave an overview of their PCAS-related research activities during the past year.

Possible ICRNs have been discussed. Peter Tremaine proposed the following two new ICRNs:

- (1) Development of an improved thermodynamic model for the NaCl-H₂O system that would incorporate the current formulation for the dielectric constant of H₂O and ultimately replace the well-known model of Donald Archer.
- (2) Development of an equation for the dielectric constant of D₂O. It has been noted that TPWS is working on a formulation for the viscosity of D₂O, but there is also a need for an analogous formulation for the dielectric constant.

No international collaborations have been proposed.

Joint session with TPWS, 09/30 afternoon

The following presentations have been given:

Allan Harvey – Revision of the IAPWS 95 EOS. A new ICRN (ICRN 31) is being created.

Jana Kalova, presented by Allan Harvey – Report of Task Group on Surface Tension of Ordinary Water

PCAS/IRS joint meeting, 10/01 morning

Nobuo Okita introduced the work of the task group on categories of industrial requirements. After the introduction, the following presentations have been made:

Shigeki Senoo - Report of the Task Group “Wet Steam Data from Operating Turbines” (N. Okita, A. Nový, I. Weber, S. Senoo). S. Senoo explained the research requirements for predicting the effects of coarse droplets on blade erosion in steam turbines. The research goal is the reduction of erosion in steam turbines.

Nobuo Okita - Report of the Task Group “Categories of industrial requirements” (N. Okita, A. Nový, I. Weber, A. Anderko, M. Rziha, R. Span). N. Okita summarized the progress since the last IAPWS meeting in 2018 and explained three examples of the requirements:

- 1) Wet steam properties in steam turbines
- 2) Acid dew points under low sulfur contents for HRSG design.
- 3) Geothermal steam turbine cycle with non-condensable gas and impurities

Discussion of future activities of PCAS: Progress on guidelines have been discussed. The guideline on self-diffusion coefficients of H₂O (led by K. Yoshida) is in an advanced stage. Work on the guideline on amines (led by J. Bellows) has not progressed since the last meeting and no update is available due to Jim Bellows' absence.

After the discussion, the following presentation has been made:

Andre Anderko - Modeling aqueous solution chemistry for water treatment applications. This presentation focused on the thermodynamic behavior of humic substances.

PCC/PCAS joint meeting, 10/01 afternoon

The meeting was focused on film-forming amines. The following presentation has been made:

Barry Dooley – Influences of FFS Films on Oxide Growth Mechanisms around Generating Cycles

PCAS separate meeting, 10/01 afternoon

The following presentation has been made:

Tomáš Němec – Catalyst Nanoparticle Synthesis by Spark Discharge

TPWS/PCAS joint meeting, 10/03 morning

The following presentations have been made:

A. Harvey - Report and official WG consideration of minor revision of Release on the Ionization Constant of H₂O

K. Yoshida - Report on progress toward IAPWS Guideline on diffusivity of ordinary water (K. Yoshida, F. Caupin, A. Harvey, R. Hellmann, M. Huber)

K. Meier - Cross second virial coefficients for industrially and scientifically important mixtures of water vapor and simple gases from ab initio intermolecular potentials (R. Hellmann, K. Meier)

T. Němec - Nucleation in water vapor: Classical nucleation theory and molecular simulation

PCAS separate meeting, 10/03 afternoon

The following presentation has been given to expand on Vaclav Vins's Helmholtz Award lecture:

Václav Vinš - Density and Surface Tension of Binary Aqueous Mixtures with Special Focus on Low Temperatures

PCAS Membership: Invitation has been extended to Vaclav Vins and Jane Ferguson to join PCAS. K. Yoshida informed the group that Anneke Levelt-Sengers will be unable to continue her membership in PCAS.

Preparation of report for the Executive Committee: The group discussed the report to the Executive Committee. The main parts of the report are (1) the preparation of guidelines and (2) membership. For the guidelines, it has been decided to defer further discussion of the amine guideline until James Bellows is able to comment on his progress.

Power Cycle Chemistry Working Group (PCC WG) Banff, Canada, September 30 – October 3, 2019

1. Amendments / Adoption of Agenda

Attendees were warmly welcomed by Rziha. The agenda was adopted with no changes. The agenda is attached as PCC Attachment A.

Need to check and update PCC members list and contact details - circulated

2. Appointment of Clerk of Minutes

David Addison (NZAPWS) was appointed as clerk.

3. Approval of Minutes of PCC WG in Prague, 2018

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

4. Review of Actions from last PCC WG Meeting

- Finalisation and approval of TGD's – air in leakage, FFS for industrial plants
- Review of current ICRNs to be done as part of the meeting
- Any new proposals for International Collaboration (IC) needs to be raised no later than midnight tonight.
 - One IC already received for continuation of corrosion product monitoring by Executive Secretary

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 (started in 2008). Highest level of guidance for fossil and biomass plants worldwide. The benefit of IAPWS documents is that they bring together both academia and industry to provide scientifically robust guidelines and form the basis of plant guidelines.

Dooley requested that the separate TGD WGs arrange to meet during the ICPWS week to progress activities.

- Need to get approval for latest TGDs
 - FFS for industrial plants – TGD
 - Discussed and no objections raised from PCC, approved to be sort from EC
 - Revision of FFS in Fossil and Combined Cycle – TGD
 - Discussed and no objections raised from PCC, approved to be sort from EC
 - Generator water cooling - TGD
 - Discussed and no objections raised from PCC, approved to be sort from EC
- Progress on draft TGDs
 - Demin Water – Draft TGD

- No progress in the last year. Table of contents drafted, wanting to progress in the next 12 months, need to revise STG. New member is Judy Weir (NZAPWS). Need to meet during week.
- Flue Gas Condensation – Proposed TGD
- Electrical boilers – Proposed TGD
- Need to progress on White Papers (Pre TGD Documents)
 - Corrosion product sampling for flexible plants – White paper
 - FFS in Nuclear – White paper
 - No progress in the last year, subcommittee to meet during meeting to work on project. See PCC Attachment B for minutes of this meeting.
 - Geothermal – White paper
 - Progress made, drafting
 - Condensate polishing – White paper
 - No progress

Need to have refreshment/review of existing TGDs.

- AVT – needs incorporation of aluminium specifically

5.1 Film Forming Substances (FFS) for Industrial Plants

TGD completed and final edits made for final approval. Discussed and no PCC objections. To be submitted to EC for final approval at EC meeting.

5.2 Film Forming Substances (FFS) for Nuclear Plants

Cook (STG chair) reported no progress in 2018/2019. Subcommittee to meet during meeting to continue work on white paper.

5.3 Demin Water Integrity

Henderson (new STG chair) reported no progress in 2018/2019 from Joy (previous STG chair) and project handed to him now and to be restarted. Judy Weir (Thermal Chemistry/NZAPWS) to working group to assist Henderson with writing. Current 2019 STG members – McCann, Buecher, Bellows, Hirano (Terada), Rziha, Khalifa, Shinotsuka, Ichihara, and Holl

5.4 Corrosion product (CP) sampling and analysing (white paper)

Thomsen (STG chair) provided an outline of the soon to be issued white paper – produced like a TGD. Will be provided to the PCC after the Banff meeting for review and comment. Need for more data from PCC members to help with data analysis.

A draft IAPWS ‘decay map’ has been produced for the white paper that could be used by sites to optimise preservation and start-up chemistry.

An international collaboration has been completed in 2018/2019 with field tests carried out by a student–Maja Skou Jensen (Aarhus University, Denmark) at multiple plants in Denmark, the UK and Australia. She did a great job and her work has been inputted into the white paper

- Use of proxy methods – filter iron, turbidity, particle counting/sizing to build data sets and understanding

- Operating chemistry and degree of optimisation is reflected in CPT on start up
- Layup and storage practices very important for CPT on start up (generation of more corrosion products)
- Key learning is particle size of iron corrosion products varies with operating conditions – total iron is extremely sensitive to variation in particle size
- Majority of particles detected < 2 microns. “Normal” commercial particle size analysers used in plants only detect down to 2 microns so miss the bulk of particles.
- Plants tested with FFS showed lower median particle size on the HRSG evaporator samples
- OT/AVT(O) tends to have ~ 1 micron median particle size detected
- Proxy methods can be used to track the CPT during start up and transient

Need particle counter – 0.5 to 30 micron range, cost effective design, field robust etc – challenge to instrument vendors to develop and provide such a instrument

More work needed for mixed metallurgy units – not covered in this project

Outline of additional field tests given – filtered iron, 0.45 micron filter, 1L of sample, then filter digestion and analysis. Matches to particle size analysis well.

- Question raised about using 0.2 micron filters – considered not much difference but project run out of time to test this
- Question about samples/iron drop out of solution on the bottles before filtration – was looked at, samples made up sitting for 1 to 10 to 20 days and no statistical difference noted in results once analysed.
- Question: Was different filter types looked at? Looked at cation exchange filters, found to be very high in iron so not used. Used the same Millipore type for all the testing.

Overall summary of the White Paper work

- Key questions from Dresden 2017 all answered based on the work done since then
- Close correlation between transients of FW bulk flow and spikes of particles
 - Useful for tracking CPT during transient loads
- Filtered iron method simple and correlates well with particle based proxy-methods – digestion then analysis
- Close correlation between CPT and bulk flow changes – change in turbulence in bulk flow brings solids into suspension
 - Sometimes seen (< 5% of incidents) during steady load conditions – something else going on.
- Iron oxide transport covered both corrosion products and exfoliated oxides from high alloyed steels in SH/RHs
- Proxy method – continuous FW/Boiler – trend is most important
- Using on condensate – measure of oxide exfoliation on start up
- Feedwater – start up – use of IAPWS “map” to guide plant
- IAPWS decay map – time starts at first fire, time from first fire, Fe and Cu on axis’s. Provides colour indication bands for data fit.
- White paper ready for PCC review and comments and additional data (standard spreadsheet and plant questioner)

- Want to test different types of plants and chemistry and design and metallurgy - good and bad examples
- Target to be ready in 2020

ACTION: Working group to meet and consider revision of current TGD to include new filter/digestion method. Addison/Dooley/Thomsen

Comment – Fandrich - issues also present with cycling nuclear plants. Be good to have a statement to say results/methods applicable also for Nuclear plants. Will review white paper and provide comment
Dooley presented on oxide growth and oxide behaviour in steam water cycles outlining research over the last 40 years on oxides and exfoliation. No influence from cycle chemistry

5.5 Geothermal (white paper)

Addison (STG chair) reported white paper drafting based on known (already covered under current TGDs)/and unknowns and TGD outlining underway along with drafting of possible ICRNs but progress slower than expected. Being driven by NZAPWS (Addison) and JAPWS (Nobuo). Considered critical task for 2019/2020 for NZAPWS and JAPWS so major push will be made. Need to include more members of JAPWS as well as other geothermal people in Indonesia, Philippines, Iceland, Turkey and Russia

5.6 Condensate Polishing for HRSG Plants (white paper)

No progress in 2018/2019, Khalifa (STG chair) not attending Banff 2019

5.7 Water Cooled Generator TGD

Completed by Svoboda (STG chair) with assistance from Dooley. TGD completed and final edits made for final approval. Discussed and no PCC objections. To be submitted to EC for final approval at EC meeting.

5.8 Flue Gas Condensation – Proposed TGD

5.9 Proposals for new TGDs

5.9.1 Cycle Chemistry for Oil Recovery Systems/Oil Refineries

Commonly found with very poor water/steam chemistry and no idea what to do – need for improved guidance.

Idea is to take a base line and then a set of customisation conditions – similar to the Industrial FFS TGD and spell out basic chemistry requirements

Robust discussion held around complexity of doing this and information already in IAPWS TGDs

Could possibly be done via a “IAWPS PCC Advisory Note” – advice on how to use the current TGDs for these plants – how to review and assess the plant then customise currently TGD knowledge to develop the plant specific advice for water/steam chemistry

ACTION: Consider development of an advisory note for this or a TGD. Task group to be formed to work on it. Dooley (Chair), Members – Addison, Thomson, West/Henderson, Fricke, Hater, Zohm, Myszczyzyn. To consider how this could be done and report back for IAPWS 2020

5.9.2 Laboratory Management and Instrument Validation

Nothing been done since raised in 2018 – possible add onto revised S&A TGD

5.9.3 Flue Gas Condensation

Nordic speciality with district heating – FGC can allow for up to 20% more heat to be extracted from the same fuel and produce extra potential make up water. Technology for water collection and treatment tricky.

Potential outline provided

- Flue Gas Cleaning Technology Options

- Treatment of condensate

- Design considerations

- Operation of plants

- Customisation section

- References

ACTION: Nordic STG set up – move to straight TGD drafting rather than white paper to target for next year (2020). Led by Nordic IAPWS members – Chair Thomsen

PCC Chair Comments – TGD should be supported, broadens IAPWS applicability and consistent with environmental changes in European industry

Dooley Comments – be good to add more international representation to the working group if possible. Perhaps other IAPWS members – Russia, Czech Republic etc

STATEMENT: PCC accepts and supports proposal for TGD development

ACTION: Thomsen to try to attract more international members

ACTION: Dooley to be added to STG

5.9.4 Smart Alarms

Raised as a possible – may be better to be added as a update to S&A TGD or as a possible “advisory note”. Could be added as “words” to the current TGD.

Need to clearly define terms as well

ACTION: Consider adding to currently TGD as a revision – description of smart alarms etc. Task group to be formed to work on it. Chair – Powalisz, Dooley, Buecher, Henderson, Jere Espo (SIAPWS). Need revision/draft by November 2019 to meet TGD timeline for a revision.

5.9.5 Electrical Boilers

Discussion of recent experiencers and issues with electrical boilers – both examples immersion electrode boilers – one for steam (NZ) and one for hot water under nitrogen pressure (Denmark)

ACTION: Form “Pre White Paper Working Group” with NZAWS and SIAPWS to share experiences and learnings – Addison, Thomson, Nielsen and report back at 2020 IAPWS re if worth a white paper/TGD

5.10 Revision of Currently Published TGDs

5.10.1 AVT

Aluminium management needs to be added

5.10.2 PT/CT

No changes needed

5.10.3 Sampling

Smart alarms to be possible added

5.10.4 CPS – base load conditions TGD

ACTION: New filter iron/digestion method to be added via separate paper to be published in PPChem then added to original TGD. Addison, Dooley, Thomson to developed to meet November 2019 timeframe for TGD revision

5.10.5 Steam Purity

No changes needed

5.10.6 Carryover

No changes needed

5.10.7 HRSG Evaporator Tubes

No changes needed

5.10.8 FFS

No changes needed

5.0 Joint PCAS and PCC WG Meeting

Update on FFS and Possible Influences on Oxide Growth Mechanisms around Generating Cycles – B Dooley

Influence of FFS on oxide growth mechanisms not well understood

ACTION: Need ICRN between PCAS and PCC re influence of FFS on oxide growth mechanisms and missing knowledge. To be developed Dooley, Lister, Yoshida, Tremaine, Wolfgang, Fandrich

5.0 Japan IAPWS discussion

New Japanese JAPWS PCC Chairperson introduced – Shinichi Terada (Toshiba) and the Japanese PCC process outlined.

Japan issues – historical IAPWS TGDs vs JIS information – specifically around the use of oxygen scavengers in all ferrous plants

ACTION: Need closer interaction between JAPWS PCC and other PCC working groups to further foster knowledge transfer and increased collaboration – specific focus for geothermal – NZAPWS/Addison to ensure closer collaboration in that area.

6.0 Canada Oil Sands Water/Steam related Discussions

Canada oil sand issues discussed and Water Treatment Development Centre and CRIN outlined. Clear advantage for them to have IAPWS involvement going forward related to water/steam issues - formation of IAPWS subcommittee related to Oil and Gas processing.

ACTION: Rziha and Dooley to coordinate the consideration of the formation of a subcommittee with Canada industry representatives

7.0 Progress Reports 2018/2019

Main activities are the further development of the TGDs as described above. Releases of new TGDs, FFS for Industrial plants, Generator Cooling etc

8.0 Future PCC Activities

As already outlined in current TGD progress/status as described above

Concept of TGD Advisory Notes as used by other IAPWS group raised
Thomson raised idea of an advisory note for Statistical Treatment of Corrosion Product Data. Dooley suggested this as better as an IAWPS guideline.

ACTION: Thomson to draft with support from McCann

9.0 International Collaboration

There are one current collaboration and one completed collaboration and one new collaboration for 2019:

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 ongoing. The preliminary data is promising was reported at ICPWS 2018. Schedule and budget is on track. Additional funding approved in 2018 for an additional student with funding to commence in 2019.

ACTION: Note to PCC to be issued by Cook asking for suitable IAPWS member country for student to undertake this work

Thomsen - Maja Skou Jensen (Aarhus University) has been completed now as of 2019 with results incorporated into the white paper and Maja's thesis

ACTION: Rziha to upload to PCC Maja's thesis and advise PCC when this is done

ACTION: Status to be reported to the EC – Thomson

New proposal in 2019 for CPS related IC “Application for International Collaboration: Corrosion Product Sampling, Analysis and Assessment– Thomson nominated IC and provided documentation. Continuation of the previous work to provide more data for the PCC CPS project.

ACTION: Rziha to submit to EC

10.0 ICRNs – Review and Possible New Additions

Status of ICRN#22 “Steam Chemistry in Turbine Phase Transition Zone” reviewed. ICRN to be closed and PCC to provide closing statement

ACTION: Dooley to produce closing statement

Status of ICRN#25 “Corrosion Mechanism, related to the presence of contaminants in steam/water circuits, particularly in boiler water” – Still ongoing as part of PCC IC project (Canada/NZ)
ACTION Rziha to request EC for extension to 2024

Status of ICRN#26 “Behaviour of Aluminium in the steam water cycle” – work has been completed on this and work recommended by Dooley to be incorporated in current AVT TGD. Can be closed
ACTION: Rziha to produce closing statement

New ICRNs for 2019

ACTION: Need ICRN between PCAS and PCC re influence of FFS on oxide growth mechanisms and missing knowledge. To be developed Dooley, Lister, Yoshida, Tremaine, Wolfgang, Fandrich

It is expected as part of the Geothermal working group that new ICRNs will be required as part of the white paper work

ACTION: Addison/Okita to draft and provide to PCC chair prior to 2020 IAPWS meeting

11.0 PCC Public Relations / Contribution to Press Release

The PCC WG has been active with various TGD production (FFS for industrial plants, air in leakage, generator cooling and with White Paper production (corrosion product sampling, geothermal etc). IAPWS has also supported various events worldwide to raise awareness of IAPWS. The conference on FFS in Heidelberg (3rd one) 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 2020 (10th to 12th March) in Strasburg, France. Another IAPWS event is the European HRSG forum, held in 2019 in Athens, Greece, 2020’s which had a excellent contribution from the Greek industry and hopefully assisted with the reanimation of the Greek IAPWS group. The next meeting will be in EHF in May 2020 in Strasburg (26-28 May). Another IAPWS support related meeting is the Australasians Boiler/HRSG user group held in Brisbane, Australia from the 30th October to the 1st of November 2019. All of these IAPWS support meetings/conferences have assisted with promoting IAPWS internationally and assisting the formation of National Committees

IAPWS sponsorship for relevant technical conferences can be obtained via applying via email to the IAPWS Executive Secretary for approval.

For the ICPWS, the press release will be prepared by Cook (University of New Brunswick).

12.0 Changes in PCC Membership and Election of Officers

The following WG members were elected and welcomed to PCC:

1. Neil Fricke, Suncor Energy, Canada
2. Tetsuya Sawatsubashi, Mitsubishi Heavy Industries, Japan
3. Shinichi Terada, Toshiba, Japan
4. Arja Lehtikoinen, Valmet, Finland
5. Burkhard Zohm, Doosan Babcock, United Kingdom

Michael has been PCC chair for 9 years. Discussion with Dooley and Addison at Banff re future. Suggested to remain until 2021 and then handover to Addison (to be elected via IAPWS process).

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

Frank-Udo Leidich wishes to step-down as vice-chair of PCC but wishes to stay as a corresponding member of the PCC

Nominations to be sort for a third vice chair to be elected at IAPWS 2020 -please send to Rziha.

13.0 Adjournment

ENDS

Summary of Actions from PCC 2019

Number	PCC Area	Action	Whom By	Due Date	Comment
1	Corrosion Product Sampling	Working group to meet and consider revision of current TGD to include new filter/digestion method.	Addison, Dooley, Thomsen	Prior to November 2019	
2	Corrosion Product Sampling	New filter iron/digestion method to be added via separate paper to be published in PPChem then added to original TGD	Addison, Dooley, Thomson	To developed to meet November 2019 timeframe for TGD revision	
	Corrosion Product Sampling	Development of a advisory note for Statistical Treatment of Corrosion Product Data.	Thomson to draft with support from McCann	Prior to IAPWS 2020	
3	Oil and Gas and Refinery Plants	Consider development of an advisory note for this or a TGD. Task group to be formed to work on it.	Dooley (Chair), Members – Addison, Thomson, West/Henderson, Fricke, Hater, Zohm, Myszczyzyn.	To consider how this could be done and report back for IAPWS 2020	
4	Flu Gas Condensation	Thomson to attract more international members to working group and commence work on drafting to TGD. Dooley to be added to	Thomson and task group	TGD ready for IAPWS 2020 approval as per normal TGD timeline	

		task group			
5	Smart Alarms	Consider adding to currently Instrumentation TGD as a revision – description of smart alarms etc. Task group to be formed to work on it.	Chair – Powalisz, Dooley, Buecher, Henderson, Jere Espo (SIAPWS).	Need revision/draft by November 2019 to meet TGD timeline for a revision.	
6	Electrical Boilers	Form “Pre White Paper Working/Task Group” with NZAWS and SIAPWS to share experiences and learnings	Addison, Thomson, Nielsen	Report back at 2020 IAPWS re learnings and if worth a white paper/TGD	
7	Oxides and Film Forming Substances	Need ICRN between PCAS and PCC re influence of FFS on oxide growth mechanisms and missing knowledge.	Dooley, Lister, Yoshida, Tremaine, Wolfgang, Fandrich	TBC	
8	JAPWS PCC Group and Closer Collaboration	Need closer interaction between JAPWS PCC and other PCC working groups to further foster knowledge transfer and increased collaboration – specific focus for geothermal	NZAPWS / Addison to ensure closer collaboration in that area.	Ongoing	

9	Canada oil sand water/steam issues	Coordinate the consideration of the formation of a subcommittee with Canada industry representatives to foster closer technical sharing of knowledge	Rziha and Dooley	Over the next 12 months	
10	IC – Boiler Corrosion	Note to PCC to be issued by Cook asking for suitable IAPWS member country for student to undertake this funded work	Cook	November 2019	
11	IC – Corrosion Product Sampling	Rziha to upload to PCC Maja’s thesis and advise PCC when this is done and Status to be reported to the EC – Thomson	Rziha and Thomson	October 2019	
12	IC – Corrosion Product Sampling	New proposal in 2019 for CPS related IC “Application for International Collaboration: Corrosion Product Sampling, Analysis and Assessment– Thomson nominated IC and provided documentation. Continuation of the previous work to provide more data for the PCC CPS project.	Rziha to submit to EC	October 2019	

13	Status of ICRN#22 “Steam Chemistry in Turbine Phase Transition Zone”	Completed and included Steam Purity TGD	Dooley to produce closing statement	November 2019	
14	Status of ICRN#25 “Corrosion Mechanism, related to the presence of contaminants in steam/water circuits, particularly in boiler water”	Project still in progress as IC project	Rziha to request EC for extension to 2024	October 2019	
15	Status of ICRN#26 “Behaviour of Aluminium in the steam water cycle”	Completed and to be included in update of AVT TGD	Rziha to produce closing statement		
16	Geothermal ICRNS	As part of White Paper work ICRNS expected	Addison/Okita to draft and provide to PCC chair prior to 2020 IAPWS meeting	IAPWS 2020	

Attachment: PCC WG Meeting Agenda



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Power Cycle Chemistry Working Group (PCC WG)

Banff, Canada 29th September – 4th October 2019

Sunday September 29th, 19:00 Welcome Reception and Registration

Monday, 30 Sept.

- 09:00 am Executive Committee – Opening Plenary Session
- 10:15 am Coffee / Tea Break

1) 10:30 – 12:00 – PCC WG Meeting

- a) Amendments / Adoption of Agenda
- b) Appointment of Clerk of Minutes
- c) Approval of Minutes of PCC WG in Prague, 2018
- d) Review of Actions from last PCC WG Meeting
- e) **IAPWS TGD's – (Barry Dooley)**
 - a) Final approval for the TGD Chemistry in Generator Cooling Water
 - b) TGD's Film Forming Substances (FFS)
 - (1) Wolfgang Hater - Investigations on the durability of the protective FFA film
 - (2) Hayden Henderson - The AGL experience with Film-Forming Substances
 - (3) Final approval for the TGD for Industrial Plants
 - c) Amended FFS TGD "Application of Film Forming Substances in Fossil, Combined Cycle, and Biomass Power Plants".

☞ **12:00 – 13:30 Lunch**



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Power Cycle Chemistry Working Group (PCC WG)

2) 13:30 – ca. 17:00 PCC WG Meeting (Coffee Break will be announced separately)
Continuation IAPWS TGD

d) **Film Forming Substances (FFS) for Nuclear Plants**

- (1) Kristine Liao - Film Forming Product Qualification at Darlington Nuclear Generation Station

e) **Monitoring Corrosion Products in Flexible** (cycling and two-shifting) Plants
(white paper)

- (1) Karsten Thomsen - Presentation on field test of proxy-methods for CP monitoring
- (2) Karsten Thomsen - Update on field test based on Maja Skou Jensen's work
- (3) Karsten Thomsen - Round robin on analytical methods and the implications for the TGD recommendations
- (4) Karsten Thomsen - New knowledge/recommendations to be included in the present and new TGD
- (5) Barry Dooley – Oxide Growth and Oxide Behavior in Steam Water Cycles

Tuesday, 1 October

09:00 – 12:00 - PCC WG Meeting

Continuation IAPWS TGD

f) **Geothermal** (white paper)

- (6) David Addison -Geothermal reboiler chemistry issues – application of IAPWS TGD's to solve water/steam issues

g) **Proposals for new TGD's**

- I. Cycle Chemistry Guidance for Oil Recovery Systems
- II. Laboratory Management and Instrument Validation
- III. Flue Gas Condensation



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Power Cycle Chemistry Working Group (PCC WG)

- IV. Smart Alarms
- V. Revisions of Currently Published TGD

☞ **12:00 – 13:30 Lunch**

13:30 – 15:30 Joint PCAS & PCC WG Meeting

Discussion and presentation about film-forming substances

- (1) Barry Dooley – Influences of FFS Films on Oxide Growth Mechanisms around Generating Cycles
- (2) Additional presentations / speakers to be confirmed

15:30 – ca. 17:00 PCC WG Meeting

- (1) David Addison - Electrode boilers – water/steam chemistry considerations
- (2) Monica Nielsen - Trouble-shooting water chemistry in an electric boiler
- (3) Tetsuya Sawatubashi - Determination of the presence of Chlorides on Steel Surfaces

Wednesday, 2 October

☞ **09:00 16:00 IAPWS SYMPOSIUM**



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Power Cycle Chemistry Working Group (PCC WG)

Thursday, 3 October

09:00 – 12:00 - PCC WG Meeting

Presentations

- (1) Melonie Myszczyzyn - WTDC – water treatment development center – new water testing facility built in Fort McMurray
- (2) Adele Zenide- CRIN Water Theme – new water connectivity network initiative to connect entrepreneurs to water challenges to government research/funding

PCC WG Business:

- a) Progress Reports 2017/2018 and Future PCC Activities
- b) International Collaboration
- c) ICRNs – Review and Possible New Additions
- d) PCC Public Relations / Contribution to Press Release
- e) Changes in PCC Membership and Election of Officers
- f) Adjournment

☞ **12:00 – 13:30 Lunch**

☞ **18:30 IAPWS Dinner / Banquet**

Friday, 4 October Executive Meeting (09:00 – 13:00)



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Power Cycle Chemistry Working Group (PCC WG)

Minutes of Meeting

IAPWS PCC - Nuclear Subcommittee

Attendees: W. Cook (chair) C. Stuart
 D. Lister K. Liao
 W. Hater G. Pringle
 J. Fandrich P. Tremaine
 S. Shulder S. Weerakul

Date: October 1, 2019

Opening remarks – W. Cook

- Three questions for this sub-committee on FFS for nuclear plants document
 1. Is there still a need for this IAPWS white paper or TGD?
 2. What will be the scope and intent of the document?
 3. Who is going to help develop the document?

Comments on Question 1:

- JF indicated that this document is still highly needed to highlight the potential application for nuclear secondary systems but also to identify gaps in knowledge.
- Must highlight the differences between fossil and nuclear plants including:
 - o Qualification requirements
 - o Various steam generator configurations
 - o Potential degradation issues (thermal, radiation etc)
- KL suggested that the document would be useful for utilities considering FFS applications but it should include a summary of operating experience from the few applications that have been conducted
- DHL commented that most nuclear utilities already adhere to “guidance” documents from other organisations. Suggested this document is useful but perhaps should not be a “guidance” document.
- Discussion ensued with the result that everyone agreed the document is needed and that IAPWS can provide leadership in this area, even for nuclear plant applications.

Comments on Question 2:

- The document should not be an addendum to the current FFS TGDs, it must be a stand-alone document.
- The document should provide a summary of previous nuclear plant applications of FFS
- The document should be limited to application for preservation during lay-up conditions
- The document will emphasize key FFAs as per other IAPWS TGD and that the complete contents of any FFS for application in a nuclear plant must be disclosed, no proprietary compounds will be accepted for nuclear plant application.
- The document will highlight current knowledge gaps and acknowledge work ongoing in these areas.



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Power Cycle Chemistry Working Group (PCC WG)

- The document will describe some of the qualification activities needed to make application to nuclear regulator to approve their use.

Comment on Question 3:

- J. Fandrich will contribute significantly to the development of the document
- D. Lister will also contribute, sections to be determined
- W. Cook will oversee and administer the development of the document
- K. Liao, C. Stuart and W. Hater indicated they or someone from their organizations will assist with document review and editing.

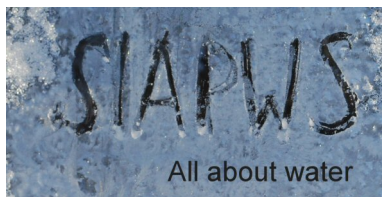
ACTION: W. Cook to develop skeleton of FFS for nuclear application document and to circulate to Jorg Fandrich by October 18th, 2019.

ACTION: W. Cook & J. Fandrich will finalize document skeleton and W.Cook will circulate to sub-committee and assign duties by October 31st, 2019.

ACTION: Sub-committee to write document sections and have prepared for review and comments by January 31, 2020.

Prepared by:
William Cook
Nuclear subcommittee chair

October 4th, 2019



19 October 2019

Application for International Collaboration Corrosion Product Sampling, Analysis and Assessment

Background

Since its release in 2013, the IAPWS TGD on corrosion product sampling and analysis has taken a leadership position for conventional and combined cycle plants worldwide. Not only does this TGD provide details on how and where to take samples and how to analyse them properly to determine total iron and copper levels, but it also provides limits for iron and copper, which illustrate optimized cycle chemistry according to the IAPWS treatment TGD for AVT, OT, PT and CT. These levels have become standards worldwide. However, it is recognised that for heavily flexibly operating plant (fast start, cycling and two-shifting) these limits may not provide a rugged assessment of the cycle chemistry or whether FAC is under control. Therefore, this Corrosion Product Sampling and Analysis TGD is under revision with new assessment methodology being developed. This first requires cooperation with a range of power plants applying a variety of chemistry conditions that already conduct or are willing to conduct the corrosion product monitoring campaigns with parallel measurements of both classical analysis (as defined by the IAPWS TGD) and on-line methods during flexible load conditions and start-ups. Several organisations have already taken part, but they often lack resources and the right setup of monitors to cover the demands fully. IAPWS in NZ/AU, UK/EI, and the Nordic countries have formulated an approach, which will use a young scientist supported by an IAPWS International Collaborative Project. The Young Scientist will work under the direction of Karsten Thomsen, SIAPWS, and Paul McCann, BIAPWS, assisted by the other members of the task group (Barry Dooley, Michael Rziha, Germany, and David Addison, New Zealand) and cooperate with host plants that will conduct the field tests. It is planned that the Young Scientist will spend two weeks at 3-4 host sites in other IAPWS member countries. This will involve organising monitoring campaigns focused on start-up and flexible load conditions, securing proper sampling conditions, applying and testing on-line instrumentation, and overseeing that the data acquired and submitted have the best possible quality. Most the equipment to conduct the tests and the analyses will be provided by the host site. All the analysis will be conducted and/or quality assured by the Young Scientist under the direction of the IAPWS mentor in SIAPWS, which will involve spending at least two weeks at a SIAPWS laboratory. This project will follow-up on the corresponding project granted in 2017 and performed by Maja Skou Jensen in 2018-19. This led to a successful cooperation with Assistant Professor Marianne Glasius at the Chemistry Department, Aarhus University, Denmark, and she is interested in further cooperation with IAPWS. Compared to the first project, the new one will focus more on monitoring of start-ups of both all-ferrous and mixed-metallurgy plants to help acquiring the knowledge and experience base necessary for the IAPWS guidance to be included in the new, extended TGD. The primary guidance will introduce a simple but systematic approach to optimize shutdown chemistry and preservation measures. The outcome of the measurements introduced will be graded relative to the international experience condensed in the IAPWS Corrosion Product Decay Map. The present project will be a key factor in establishing the decay map on a scientific base of broad international experience.



19 October 2019

Technical Aspects and Goals

This planned activity will keep IAPWS in the leadership position with regards to corrosion products monitoring and assessment. The final goal of the activity is to develop the IAPWS Corrosion Product Decay Map that will represent the first standardized method for quantification and comparison of the effects of operational and shutdown chemistry regimes. The field tests conducted to date have demonstrated that, provided correct sampling and subsequent sample handling, on-line measurements such as turbidity and particle number/distribution are useful and reliable means to follow particle levels and transport during start-up and flexible operation. The close relation between particle size distribution (PSD) and corrosion product (CP) distribution has been demonstrated both from basic principles and experimentally. Both PSD and CP distribution follow the log-normal distribution, and this new insight leads to a change in data processing of CP data and the use of new characteristic parameters to describe the level and variability of the CPs. These findings need to be further confirmed to cover all the different chemistries typically applied in various all-ferrous and mixed-metallurgy plants. The outcome of the project will be a master thesis and key reference for the final product: The extension to the present TGD covering sampling, analysis, and assessment of CPs for plants operating in flexible mode. This will allow further minimization of CP transport and the negative consequences during operation, but the most important guidance will be the systematic method to quantify CP transport during start-up and the IAPWS Decay Map defining the relevant guiding values. Of course, such values must be based on reliable and comparable data. Getting those within the next 1-1½ year is the focus of this project. There is a great demand for such guidance worldwide, because power plant operating in flexible mode are numerous, and the guidance so far has focused on plants in base load. The IAPWS Map will allow plants to determine whether both the operating and shutdown chemistry is optimized. For combined cycle plants, it will also link very closely with the IAPWS Map for HRSG HP Evaporator deposits (IAPWS TGD). The scientific content of the project will lead to a handful of publications describing the connection between the fundamental PSD and the levels and distribution of CPs measured, the application of on-line methods as valuable tools to optimise the layup and shutdown chemistry, and the new data model leading to a change in routine data processing of CP data. In many senses, new territory is discovered in this study.

Young Scientist

IAPWS has through SIAPWS contact to Dr. Marianne Glasius at the Chemistry Department of Aarhus University. The Chemistry Department will support this project by access to in-house instrumentation and laboratory facilities for analysis as well as supervision. SIAPWS will support the project both technically and financially, and the engineering company COWI will support it by employing the Young Scientist as student trainee during the project. The host facilities will support the project by the funds needed to do their part and by staff assistance and guidance to run the measurements optimally. Dr. Marianne Glasius will help finding a suitable candidate who will conduct the project for the master thesis. The candidate must be a promising person who has very good competences in physical and analytical chemistry. Besides that, we are looking for an open-minded and communicative person that will be able to adapt and cooperate under foreign conditions.



19 October 2019

Budget

Expenses to be covered:

1. Travel Scandinavia to UK and a Nordic country x 1 each
2. Travel to NZ/AU/JPN x 1
3. Travel to IAPWS meeting x 1
4. Living expenses during stays
5. Hire of scientific instrument for particle counting/particle size distribution

Additional analyses – the purpose is to supplement the analyses performed by/at the plants, such that all relevant measures are available for the evaluation in relation to the TGD development work. The young scientist will validate the relevant laboratory analysis at the Chemistry Department or at a SIAPWS Laboratory. Quality of the collected data will be a focus point, and only laboratories that are able to document appropriate quality assurance at least at the level of the current TGD will be used. Total budget as a rough initial estimate is 25.000 GBP. The budget will be further refined, once the precise extent of the field trials is known.

On behalf of IAPWS organisations in Australia, New Zealand, United Kingdom and Ireland, and the Nordic countries (Sweden, Norway, Denmark, Finland)

Karsten Thomsen, SIAPWS Chair, member of PCC and the TGD task group

Paul McCann, BIAPWS, member of PCC and the TGD task group

Contact Person:

Chair Karsten Thomsen
Mail: knth@cowi.dk
Phone: +45 2787 5744

The International Association for the Properties of Water and Steam

2019 Annual Meeting
September 29-October 4, 2019
The Banff Centre for Arts and Creativity, Banff, Alberta, Canada



Press Release

International Association for the Properties of Water and Steam (IAPWS) 2019 Executive Committee and Working Group Meetings

Banff, Canada, September 29th – October 4th, 2019

Between September 29th – October 4th, 2019, 92 scientists, engineers and guests representing 16 countries descended on the Banff Centre for Arts and Creativity in Banff, Alberta, Canada for the annual meeting of the IAPWS Executive Committee and Working Groups. This continues a series that began in 1929 in London, UK with the purpose to connect researchers and scientists with the engineers who use their work providing the researchers with guidance on topical problems within industry and providing the engineers with the latest research results. Areas of application include power cycle chemistry, high temperature aqueous technologies applicable to steam cycles and steam injection, the use of high temperature water and supercritical steam in chemical and metallurgical processes, supercritical synthesis of new materials and destruction of toxic wastes, hydrothermal geochemistry, hydrometallurgy, oceanography and global climate modelling, power cycles with CO₂ capture and storage systems and combined heat and power systems.

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

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 during the IAPWS Symposium, typically held on the Wednesday of the IAPWS working week. This year, the Helmholtz award was presented to Dr. Václav Vinš from the Institute of Thermomechanics of the Czech Academy of Sciences, Czech Republic for “achievements in the research of thermophysical properties of water and aqueous systems, in particular surface tension of metastable supercooled water and phase equilibria involving gas hydrates.”



During the IAPWS banquet that was held at the Brewster's Mountview Barbeque just outside of Banff, Michael Rziha from Germany was acknowledged as an IAPWS Honorary Fellow for leadership and service to the Power Cycle Chemistry working group.

IAPWS, through the various working groups, produces guidelines, technical guidance documents (TGD) and IAPWS certified research needs (ICRN). These can all be found for free download 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) received a new formulation for the viscosity of heavy water, consistent with the new equation of state for heavy water that was adopted in 2018. This will be evaluated in the coming year with the intention of official adoption by IAPWS in 2020. A corresponding formulation for the thermal conductivity of heavy water should follow soon after. TPWS is considering new information available since the 1995 adoption of the IAPWS formulation for the thermodynamics of ordinary water, with the intention of producing a new standard over the coming years. Toward that end, an IAPWS Certified Research Need (ICRN) was authorized to document the areas in which new thermodynamic data for water would be most useful.

The Subcommittee on Seawater (SCSW) met and discussed progress on the difficult problem of making absolute density measurements of Standard Seawater, and the slightly easier problem of making density measurements relative to the density of freshwater. A number of members also discussed issues related to pH and its measurement in high ionic strength liquids like seawater. Finally, a new IAPWS guideline on the viscosity of seawater was endorsed.

The main topics discussed in the Industrial Requirements and Solutions (IRS) Working Group were the engineering requirements for prevention of coarse-droplet erosion in wet steam flow and improvement of IAPWS formulations in metastable subcooled vapor for computation fluid dynamics (CFD) calculations. Some items, like proper methods or new models for estimating low sulfur dew point in GTCC and mixed properties of geothermal steam, are opening discussions on new methods and potential for new IAPWS releases to be worked on by a joint task group and liaison with other specialists.

The Physical Chemistry of Aqueous Systems (PCAS) working group discussed the self-diffusion of water and the development of a correlation function to model self-diffusion, theoretical and computational approaches to nucleation in water vapor, modeling of acid-base equilibrium for humic substances, and density and surface tension of aqueous mixtures at low temperatures. Development of an IAPWS guideline on the Self-Diffusion of Water is in progress and is currently at an advanced stage.

The Power Cycle Chemistry (PCC) working group had an extremely productive meeting with Technical Guidance Document (TGD) work including key areas such as air in-leakage, film forming substances (FFS) in industrial plants and chemistry management in generator water cooling. Several white papers and new TGDs are in progress including FFS for nuclear plants, corrosion product monitoring for cycling plants, demineralizer system integrity and reliability, geothermal steam chemistry and flue gas condensation. The number of TGDs continues to increase providing robust, practical and technically correct water and steam guidance to industry. As well as the new TGDs, existing TGDs are being reviewed and updated to ensure they are kept up to date and relevant. Additional PCC technical discussions were held, and work was started in the area of oil sands applications and electric boilers. PCC-related International Collaborations (IC) continue between Canada and New Zealand (corrosion of boiler steels in presence of mixed contaminants) and a new IC was approved related to Corrosion Product Sampling, Analysis and Assessment to provide more data to the PCC corrosion product sampling and analysis project.

The Executive Committee reviewed and approved all the above-mentioned working group activities and also approved and welcomed the Indian Association for the Properties of Water and Steam (INDIAPWS) as a new Associate Member.

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 Turin, Italy from 6th – 11th September 2020. 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. Barry Dooley, bdooley@iapws.org. People do not need to be citizens or residents of member countries to participate.



**Participants at the Annual IAPWS Meetings and Symposium
Banff Centre for Arts and Creativity, Banff, Alberta, Canada**



Australian Association for the Properties of Water and Steam (AUSAPWS) Annual Report

Date: 2 October 2019

Key Achievements:

1. AUSAPWS is in its first year of full membership of IAPWS. Achieved at ICPWS Prague, September 2019.
2. AUSAPWS has established a funding model, and sent a delegate to Banff as part of this model.
3. AUSAPWS now has over 60 members and continues to grow. Our membership primarily covers power generation but has expanded to industrial boilers.

Key Activities:

1. AUSAPWS held out first ever workshop, in April 2019. It was a free seminar held at the AGL Offices in Melbourne.
 - a. 45 Attendees came covering every state in Australia.
 - b. The Workshop was key noted by Michael Rziha and David Addison
 - c. Several key topics in power station chemistry were covered including, FFS, data analytics, cycle chemistry and water treatment.
2. AUSAPWS collaborated with SCIAPWS on the corrosion product monitoring in cycling operations work.
3. Hayden Henderson attended the IAPWS meeting in Banff.
4. AUSAPWS has established a LinkedIn group for discussing of chemistry topics.

AUSAPWS Awards

The AUSAPWS Awards were established to be awarded for services to chemistry in Australia, the first two AUSAPWS awards were awarded to:

- Gary Joy
- David Swainsbury

Publications:

No publications by AUSAPWS members in 2018/2019

Hayden Henderson
AUSAPWS Chairperson
Mobile + 61 499 021 436
Email: hhenderson@agl.com.au

BRITISH AND IRISH ASSOCIATION FOR THE PROPERTIES OF WATER AND STEAM

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

BIAPWS

www.biapws.org

Chair: Mr. M. Sparrey, ABB Ltd., Oldends Lane, Stonehouse, Gloucestershire, UK
Vice-Chair: vacant
Secretary: Mr B. Zohm, Doosan Babcock, Engineering & Technology, Porterfield Rd, Renfrew, UK
Treasurer: Mr H.W. Lloyd, UK

BIAPWS ANNUAL REPORT 2019

1 INTRODUCTION

The British and Irish Association for the Properties of Water and Steam (BIAPWS) is the UK and Ireland national committee of the International Association for the Properties of Water and Steam (IAPWS) and the representative body for Power Plant Chemistry in the UK and Ireland. BIAPWS is a not for profit organisation. This is the annual report of the activities of BIAPWS for the period from August 2018 to July 2019. A list of publications by BIAPWS members during this period is included in Appendix A. If you would like to know more about BIAPWS, please feel free to visit our web site www.biapws.org or e-mail BIAPWS at contact.us@biapws.co.uk.

2 BIAPWS MEMBERSHIP AND MEETINGS

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

BIAPWS committee meetings are held three times a year and attendance at these continues to be good, typically with around thirty people present. A recent change has been to expand the technical sessions at BIAPWS committee meetings to add value to meeting attendance.

Industrial member's representatives are able to bring a colleague to the meetings to benefit from and contribute to the discussions.

3 BIAPWS POWER PLANT CHEMISTRY SYMPOSIUM

Each year, BIAPWS organises an annual symposia on power plant chemistry and water treatment. The 20th in this series of symposia was held at the University of Warwick, Coventry, on 29 – 30 May 2019. The symposium consists of introductory sessions on the fundamentals of power plant chemistry and water treatment, followed by more detailed technical presentations. The event remains well supported, with around 90 delegates and 11 exhibition spaces taken up in 2019.

A copy of the symposium programme is included in Appendix B. A paper summarising the proceedings of the 2019 event has been published in Power Plant Chemistry journal.

BIAPWS

4 IAPWS ACTIVITIES

BIAPWS has continued to support IAPWS through its formal membership and participation in IAPWS activities. A number of BIAPWS committee members are represented on IAPWS working groups. At the 2020 IAPWS annual meeting in Kyoto, Japan, BIAPWS will be represented by M. Sparrey BIAPWS Chair and Burkhard Zohm BIAPWS Secretary. In addition, BIAPWS is represented on the executive committee of IAPWS.

5 BIAPWS AWARDS

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

Over the last 12 months, BIAPWS received no opportunities for sponsorship in 2018/2019

6 BIAPWS WEBSITE

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

7 BSI REPRESENTATION

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

- PVE/2: Water Tube and Shell Boilers. The UK standards committee has responsibility for BS EN 12952-12:2003: "Water-tube Boilers and Auxiliary Installations - Requirements for Boiler Feedwater and Boiler Water Quality" and BS EN 12953-10:2003: "Shell Boilers - Requirements for Feedwater and Boiler Water Quality".
- CII/62: Treatment of water for boilers. The UK standards committee also has responsibility for BS 2486:1997: "Recommendations for Treatment of Water for Steam Boilers and Water Heaters".
- EH/3/6: Water quality - sampling. The UK standards committee is responsible for BS 6068-6.7:1994 (ISO 5667-7:1993): "Guidance on Sampling of Water and Steam in Boiler Plants".

BIAPWS

8 INTERACTION WITH PROFESSIONAL ORGANISATIONS

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

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

Mike Sparrey
Chair, British & Irish Association for the Properties of Water and Steam
September 2019

APPENDIX A:

LIST OF UK AND IRELAND ORIGINATED REFERENCE PAPERS IN AREAS OF INTEREST.

BIAPWS

APPENDIX B:

PROGRAMME AND REGISTRATION INFORMATION

20th BIAPWS POWER PLANT CHEMISTRY SYMPOSIUM WEDNESDAY 29th AND THURSDAY 30th MAY 2019 WARWICK CONFERENCES

Scarman Meeting and Conference Centre, Scarman Road, The University
of Warwick, Coventry, CV4 7SH, UK
(see map at end)

PROGRAMME

WEDNESDAY 29TH MAY 2019, 12:00 – 17:00

MANAGEMENT OF COOLING WATER SYSTEMS

12:00 Registration and Lunch - Vendor exhibitions open

13:20 Welcome and introduction

Mike Sparrey, Chair, BIAPWS

13:30 Session 1

Presenters: Biofilm Formation in Water Systems

Katherine Fish, University of
Sheffield

Cooling Water Chemical Treatment

Anthony Matthews, SUEZ

Chair: Eric Huff, Consultant

15:00 Break

15:30 Session 2

Presenters: Life Management of Wooden Cooling
Tower Systems

Phil O'Leary, Exova

Progress with the HSE's Cooling Tower
Intervention Program

Duncan Smith, Health and Safety
Executive

Chair: Eric Huff, Consultant

17:00 Close

19:30 Evening meal, Warwick Conferences

BIAPWS

**BRITISH AND IRISH ASSOCIATION FOR
THE PROPERTIES OF WATER AND STEAM**

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the Properties of Water and Steam

BIAPWS

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THURSDAY 30TH MAY 2019, 09:00 – 16:00

POWER PLANT CHEMISTRY AND CORROSION

08:30	Registration and Coffee	
09:00	Welcome and introduction	Mike Sparrey, Chair, BIAPWS
09:05	Exhibitor introductions	Mike Sparrey, Chair, BIAPWS
	Session 1	Chair: Adam Caswell EDF Energy
09:20	Operational Experience of Intermittent Biocide Dosing for Marine Fouling Control	Carl Atkinson, EDF Energy Generation
09:50	Options to Decrease the Scaling Potential and Increase the Recovery Rate of a Reverse Osmosis Process	Uli Dölchow, LANXESS
10:20	Break	
10:50	Assessing the Atmospheric Corrosion Risk for the Storage of Spent Nuclear Fuel at Sizewell B Power Station	Peilong Dong, Imperial College
11:20	Film-Forming Amines for Closed Cooling/Heating Water Systems	Wolfgang Hater, Kurita Europe GmbH
11:50	Open Discussion Session	
12:00	Lunch	

BIAPWS

Session 2		Chair: Paul McCann, Uniper
13:00	Oxide Growth and Exfoliation (OGE) of Superheater and Reheater Tube Materials in Steam	Barry Dooley, Structural Associates
13:30	Field Tests of Proxy Methods for Monitoring Iron Transport at Plants Operating Under Flexible Load Conditions	Karsten Thomsen (COWI) and Maja Skou Jensen (Aarhus University)
14:00	Break	
14:30	Grain CCGT Power Station: Upgrade of Water-Steam Cycle On-Line Monitoring for Flexible Operation	Sarah Gerry, Uniper, Grain Power Station
15:00	Optimisation of the Secondary Circuit Chemical Conditioning at Hinkley Point C	Ruth Oakley and Laurence Vu-Do, EDF
15:30	Open Discussion Session	
15:55	Closing Remarks	Mike Sparrey, Chair, BIAPWS
16:00	Close	

Czech Society for the Properties of Water and Steam Annual Report 2019

Submitted to IAPWS Executive Committee in Banff, Canada, September 30, 2019

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 Meeting

Annual meeting of the CZPWS was held on June 26, 2019. A significant part of the meeting was devoted to CZPWS funding, in particular to ensuring the membership payments to IAPWS. Payment for 2018 has been granted by an anonymous individual. CZPWS expressed its gratitude. Payments for 2019, 2020, and 2021 are ensured by means of an international-cooperation grant by the Czech Ministry of Education, Youth and Sports led by T. Němec. Despite significant efforts, long-term funding of IAPWS membership has not yet been ensured.

Research Activities

Surface tension and density of aqueous systems under supercooled conditions have been investigated at the Institute of Thermomechanics of the Czech Academy of Sciences. The experimental apparatus for the measurement of **surface tension** of supercooled aqueous mixtures [6] has been used to collect new data for the surface tension of seawater [1] and binary aqueous mixtures with sodium chloride and ethylene glycol [7]. The new data for seawater are in good agreement with the correlation by Nayar et al. [J. Phys. Chem. Ref. Data 43 (2014)] extrapolated into the supercooled region down to $-25\text{ }^{\circ}\text{C}$, which is planned to become a new IAPWS standard for the surface tension of seawater. **Density** of cold and supercooled aqueous systems was investigated using a recently developed apparatus enabling high-accuracy density determinations up to pressure of 200 MPa [9]. Density of heavy water has been finalized [2]. Slight differences in isobaric expansivity from values computed from the recent IAPWS formulation (R16-17(2018)) have been found.

The problems studied in the SIGMA Research and Development Institute and the Centre of Hydraulic Research in the period June 2017 – May 2018 have been related mainly to the application of models of cavitation erosion during the hydrodynamic **cavitation** and models of cavitation instabilities to the problems of hydrodynamic pumps [5]. In cooperation with the Institute of Thermomechanics of the Czech Academy of Sciences, 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 been continued in the framework of international 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].

Thermodynamics of steam with special attention to supersaturated conditions has been studied by molecular simulations using polarizable force fields. Higher virial coefficients have been computed [3] and cluster distributions in steam have been studied [8].

Publications

1. Vinš V., Hykl J., Hrubý J.: *Surface tension of seawater at low temperatures including supercooled region down to $-25\text{ }^{\circ}\text{C}$* , Marine Chemistry 213 (2019) 13-23.
2. Blahut A., Hykl J., Peukert P., Vinš V., Hrubý J.: *Relative density and isobaric expansivity of cold and supercooled heavy water from 254 to 298 K and up to 100 MPa*. J. Chem. Phys. 151 (2019) 034505.

3. Rouha M., Nezbeda I., Hrubý J., Moučka F.: *Higher virial coefficients of water*. J. Mol. Liq. 270 (2018) 81–86.
4. Sedlář, M., Soukal, J., Komárek, M., Volkov, A.V. and Ryzhenkov, A.V.: *Numerical Simulation of Interaction between Fluid and Vapor Structures in Multiphase Flow around Hydrofoil*. J. Appl. Math. Phys., in review.

Conference Presentations

5. Sedlář, M.: *Cavitation phenomena in balancing drums of high-performance feed pumps*. PCC/PCAS/IRS Joint WG Meeting and Workshop, IAPWS Meeting, Kyoto, 2017.
6. Vinš V., Hykl J., Hrubý J., Hošek J., Fransen M., Šmíd B., Nikl Z.: *Seven years of measurement of the surface tension of supercooled water and aqueous mixtures at IT CAS*, 17th International Conference on the Properties of Water and Steam, Prague (Czech Republic), September 2-6, 2018.
7. Vinš V., Hykl J., Čenský M., Hrubý J.: *Surface tension of supercooled aqueous mixtures: Preliminary data for mixtures with alcohols and sodium chloride and for seawater*, 20th Symposium on Thermophysical Properties, Boulder (USA) June 24-29, 2018.
8. Hrubý J., Moučka F., Nezbeda I.: *Cluster distribution and nucleation in steam over a broad temperature range*. 17th International Conference on the Properties of Water and Steam, Prague (Czech Republic), September 2-6, 2018.
9. Blahut A., Duška M., Hykl J., Peukert P., Vinš V., Čenský M., Hrubý J.: *Measurements of density for supercooled ordinary water, heavy water, and seawater at high pressures*. . 17th International Conference on the Properties of Water and Steam, Prague (Czech Republic), September 2-6, 2018.



THE INTERNATIONAL ASSOCIATION FOR
PROPERTIES OF WATER AND STEAM (IAPWS)

**REPORT ON STATUS OF EGYPT'S
NATIONAL COMMITTEE**

Banff 2019

1. Purpose

The purpose of this presentation is to present the activities and plans of Egypt's national committee during 2019 and plans for 2020.

2. Importance of National Committee

- Expansion of Egypt's generating capacity reaching about 80,000 MW (by 2020).
- More than 75 power plants.
- By 2020 Egypt will become in the top 20 list of countries by generating capacity.
- Coal power plants will be added.
- Nuclear Power plants will be added.
- Egypt's national committee will be the channel to international collaboration.
- Opportunity to join forces of national individuals
- To form a national forum to discuss issues and improve performance.
- Platform to define research needs and start a research program to improve capabilities.
- So improving national capacity and capability is essential.

3. Activities in 2019

- Continue to focus with Electric generation sector.
- Prepared an awareness presentations about IAPWS and the initiative of Egypt's national committee.
- Prepared various sessions about some of IAPWS's TGDs
- Prepared application procedures and send to all individual attended seminars.
- Presented many technical presentations about selected IAPWS-TGDs to increase awareness about TGDs in power generation society.
- Maintaining PGESCo support to the initiative.

4. Plans for 2020

- Prepare more seminars at different power plants to allow more people of being involved.
- Prepare more technical sessions about IAPWS's TGDs
- Finalize membership application (some problems).
- Finalize legal form of the NC (still a problem)
- Maintain bank account (after Legal steps)
- Set a communication channel (started)
- Prepare for the 1st meeting.
- Set NC goals and working activities
- Promote in universities and research institutes

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 2018/2019**

www.iapws.de

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

Vice Chair: Ingo Weber
Siemens Power and Gas, Erlangen

Annual Meeting of the German National Committee

The 2019 Annual Meeting of the German National Committee took place at Siemens AG Power and Gas Division in Erlangen on 15th March 2019. 24 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.:
Distinguishing between Clausius, Boltzmann and Pauling Entropies of Frozen Non-equilibrium States.
Entropy (2019), submitted.
- Ebeling, W.; Feistel, R.; Krienke, H.:
On statistical calculations of individual ionic activity coefficients of electrolytes and seawater. I.
Online preprint 14 Apr 2019.
DOI: 10.13140/RG.2.2.18591.20640
- Feistel, R.:
Defining relative humidity in terms of water activity. Part 2: relations to osmotic pressures.
Metrologia 56, 015015 (2019).
<https://doi.org/10.1088/1681-7575/aaf446>
- Hellmuth, O.; Shchekin, A. K.; Feistel, R.; Schmelzer, J. W. P.; Abyzov, A. S.:
Physical interpretation of ice contact angles, fitted to experimental data on immersion freezing of kaolinite particles.
Interfac. Phenom. Heat Transfer 6, 37-74 (2018).
DOI: 10.1615/InterfacPhenomHeatTransfer.2018026166
- Hellmuth, O., Feistel, R.; Foken, T.:
Technical Note: A Look-up-Table of the TEOS-10 Based Mass Density of Humid Air for Quick-

Look Applications.

Atmos. Chem. Phys. (2019), to be submitted.

- 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 165, 268-286 (2018).
<https://doi.org/10.1016/j.pocean.2018.04.004>
- 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>

GFZ German Research Centre for Geosciences

Section 4.8 - Geoenergy

Dr. Harald Milsch, Ulrike Hoffert

Projects

1. Commissioning and optimization of a capillary-type high pressure-high temperature viscometer for aqueous electrolyte solutions at up to 50 MPa and 473 K.
2. Measurements of viscosity of pure and mixed NaCl, CaCl₂, and MgCl₂ aqueous solutions at up to 40 MPa and 353 K.

Publications

- Hoffert, U., Milsch, H.:
A modified flow-through apparatus for high pressure viscosity measurements of salt solutions.
17th International Conference on the Properties of Water and Steam – ICPWS17, Prague, Czech Republic (2018).
- Hoffert, U. and Milsch, H.:
Methods for measuring the density and viscosity of saline geothermal fluids under reservoir conditions.
Proceedings World Geothermal Congress 2020, Reykjavik, Iceland, Paper 13131 (2019).

Helmut Schmidt University / University of the Federal Armed Forces Hamburg**Institute of Thermodynamics
Prof. Dr. Karsten Meier, Dr. Robert Hellmann**

Projects

1. Thermophysical properties of mixtures of water vapor and simple gases from first-principles calculations.
2. Measurements of the speed of sound in water and derived thermodynamic properties of water.

Recent Publications

- Hellmann, R.:
Cross second virial coefficient and dilute gas transport properties of the (H₂O + CO₂) system from first-principles calculations.
Fluid Phase Equilib. 485, 251-263 (2019).
- Hellmann, R.:
First-Principles Calculation of the Cross Second Virial Coefficient and the Dilute Gas Shear Viscosity, Thermal Conductivity, and Binary Diffusion Coefficient of the (H₂O + N₂) System.
J. Chem. Eng. Data (2019), submitted.
- El Hawary, A.; Meier, K.:
Highly Accurate Densities and Isobaric and Isochoric Heat Capacities of Compressed Liquid Water Derived from New Speed-of-Sound Measurements.
N.N. (2019), in preparation.

Leibniz Institute for Tropospheric Research, Leipzig**Dr. Olaf Hellmuth**

Recent Publications (published, submitted, in preparation)

- Hellmuth, O.; Shchekin, A. K.; Feistel, R.; Schmelzer, J. W. P.; Abyzov, A. S.:
Physical interpretation of ice contact angles, fitted to experimental data on immersion freezing of kaolinite particles.
Interfac. Phenom. Heat Transfer 6, 37-74 (2018).
DOI: 10.1615/InterfacPhenomHeatTransfer.2018026166.
- Foken, T.; Hellmuth, O.; Huwe, B.; Sonntag, D.:
Chapter 6: Physical Quantities.
In: T. Foken (ed.): Springer Handbook of Atmospheric Measurements. Springer (in preparation).
Chapter accepted.
- Sonntag, D.; Foken, T.; Vömel, H.; Hellmuth, O.:
Chapter 9: Humidity Sensors.
In: T. Foken (ed.): Springer Handbook of Atmospheric Measurements. Springer (in preparation).
Chapter accepted.

- Görner, Ch.; Franke, J.; Kronenberg, R.; Hellmuth, O.; Bernhofer, Ch.:
Multivariate non-parametric Euclidean distance model for hourly disaggregation of daily climate data.
Theoretical and Applied Climatology (2019), submitted.
- Hellmuth, O.; Schmelzer, J. W. P.; Feistel, R.:
Ice-crystal nucleation in water: Thermodynamic driving force and surface tension.
Entropy, Special Issue “Crystallization Thermodynamics” (2019), submitted.
- Hellmuth, O.; Feistel, R.; Foken, T.:
Technical Note: TEOS-10 based mass density for quick-look applications.
Atmos. Chem. Phys. (2019), submitted.
- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.:
Real-Gas Effects in Humid Air: Possible Implications of the Advanced Seawater Standard TEOS-10 for Hygrometry at Atmospheric Pressure. **Part I:** Thermostatic Foundation.
In preparation for “Wiss. Mitteil. Inst. f. Meteorol. Univ. Leipzig”.
- Hellmuth, O.; Feistel, R.; Lovell-Smith, J. W.; Kalová, J.; Kretzschmar, H.-J.; Herrmann, S.:
Real-Gas Effects in Humid Air: Possible Implications of the Advanced Seawater Standard TEOS-10 for Hygrometry at Atmospheric Pressure. **Part II:** Performance of Enhancement Factor and Relative Fugacity.
In preparation for “Wiss. Mitteil. Inst. F. Meteorol. Univ. Leipzig”.
- Hellmuth, O.; Feistel, R.:
Real-Gas Effects in Humid Air: Possible Implications of the Advanced Seawater Standard TEOS-10 for Hygrometry at Atmospheric Pressure. **Part III:** Effects on Radiative Warming and Cooling in the Water-Vapour Absorption Bands and on the Surface Energy Balance.
In preparation for “Wiss. Mitteil. Inst. F. Meteorol. Univ. Leipzig”.

Ruhr University Bochum

Faculty of Mechanical Engineering, Chair of Thermal Turbomachines and Aeroengines

Prof. Dr. Francesca di Mare

Project:

1. Implementation of the Fast Steam Property Algorithms Based on Spline Interpolation into the in-house code Shar-C for high-fidelity calculation of unsteady, turbulent flow of condensing steam in low-pressure turbines.
 - The in-house, density-based CFD solver Shar-C accounts for complex thermodynamics, including non-equilibrium condensation and two-phase flow based on tabulation techniques. The two-phase flow is treated by means of the mono-dispersed Source-Term Euler-Euler model and the non-equilibrium condensation effects are modeled based on the classical theory of droplet nucleation and droplet growth. The solver is equipped with a high-resolution, low-dissipation spatial discretization, whilst a 4th – order explicit scheme is employed for time integration. Both a finite-volume and a finite-difference version of the code are available. Classic RANS turbulence models (e.g. k- ω SST, Spalart-Allmaras) as well as scale-resolving models (Wall-Adaptive Large Eddy Simulation) have been implemented and validated. The accuracy of the discretization schemes has

been demonstrated in a Direct Numerical Simulation of decaying, isotropic turbulence also in combination with non-ideal gas properties.

Recent Publications

- Post, P.; di Mare, F.:
Highly efficient Euler-Euler approach for condensing steam flows in turbomachines, GPPS-NA-2018-106.
Proceedings of GPPS Forum 18, Global Power and Propulsion Society, Montreal, 7th-9th May 2018.
- Post, P.; Sembritzky, M.; di Mare, F.:
Towards scale resolving computations of condensing wet steam flows.
ASME Paper GT2019-91269, Proceedings of ASME Turbo Expo 2019: Turbine Technical Conference and Exposition GT2019, June 17 – 21, 2019, Phoenix, Arizona, USA.
- Post, P.; di Mare, F.:
Highly efficient Euler-Euler approach with source-term tabulation for condensing wet steam flows.
Proceedings of the 2nd International Workshop on non-ideal compressible fluid dynamics (NICFD2018), Bochum, Germany, 4th-5th October, 2018.
- Iseni, S.; Post, P.; Sembritzky, M.; di Mare, F.:
Numerical analysis of the influence of air humidity on a transonic compressor stage.
Proceedings of the IGTC 2019 Conference, 17th-22nd November, 2019, Tokyo, Japan.
- Post, P.; Winhart, B.; di Mare, F.:
Large eddy simulation of a condensing flow in a steam turbine cascade.
Proceedings of the IGTC 2019 Conference, 17th-22nd November, 2019, Tokyo, Japan.
- 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.

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

Projects:

1. The work on the new reference equation of state for heavy water (D₂O) has been completed. The release published in 2017 has been revised to account for the last changes. The revised release was adopted by IAPWS on the 2018 annual meeting and was subsequently published on the IAPWS website (<http://www.iapws.org/relguide/Heavy.html>). Details on the new equation of state were published in the Journal of Physical and Chemical Reference Data.
2. The work on a new mixed gas hydrate model consistent to reference equations of state comes into its final phase. This work started as a collaboration of Ruhr University 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 University Bochum (Prof. Dr. Roland Span, Dr. Sebastian Hielscher), the Institute of Thermomechanics of the CAS (Dr. Jan Hrubý, Dr. Václav Vinš), and TU Dresden (Prof. Dr. Cornelia Breitung, Dr. Andreas Jäger). Recently, Dr. Sebastian Hielscher was promoted Dr.-Ing. based on his work on hydrates. Further work will likely address hydrogen hydrates and hydrate types that are stable only in mixed hydrates.

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 47, 043102 (2018).
- Hielscher, S.; Semrau, B.; Jäger, A.; Vinš, V.; Breitung, C.; Hrubý, J.; Span, R.:
Modification of a model for mixed hydrates to represent double cage occupancy,
Fluid Phase Equilibria 490, 48-60 (2019).

Ruhr University Bochum

Faculty of Mechanical Engineering, Chair of Thermodynamics

Prof. em. Dr. Dr. e. h. Wolfgang Wagner

Project

1. Completion of the 3rd edition of the book "International Steam Tables".
2. Preparation of the Chapter "Thermophysikalische Stoffwerte von Wasser (Thermophysical properties of Water)" for the VDI-Wärmeatlas (VDI-Heat Atlas) 2018.

Recent Publications

- Kretzschmar, H.-J.; Wagner, W.:
International Steam Tables – Properties of Water and Steam based on the Industrial Formulation IAPWS-IF97.
Springer-Verlag, Berlin (2019).
- Kretzschmar, H.-J.; Wagner, W.:
Thermophysikalische Stoffwerte von Wasser.
In: P. Stephan et al. (Hrsg.), Springer Reference Technik, VDI-Wärmeatlas, 12. Auflage. VDI Springer Reference (2019).
- 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 Power and Gas, Erlangen / PPCHEM AG

Michael Rziha

Activities

- New TGD on Air In Leakage (AIL)
- New TGD on film forming substances (FFS) for industrial plants.
- New TGD Chemistry Management in Generator Water Cooling during Operation and Shutdown
- Revision of TGD8-16 on Application of FFS in Fossil, Combined Cycle and Biomass Plants

Beside that also white papers are in preparation with the perspective becoming in near future also a TGD. Those are in particular a white paper about FFS application in nuclear plants and a white paper about corrosion product sampling and monitoring for cycling plant. This white on corrosion product monitoring was also part of the international collaboration, which was and is excellently progressing with important results.

Also for the elaboration of the white paper on chemistry for geothermal plants is in progress further.

With respect to promoting IAPWS, there had been numerous activities and events recently making IAPWS more and more known to the entire world. Just a few highlights:

- The 3rd IAPWS conference on FFS in Heidelberg this year was a great success with increasing number of participants (attracted more than 70 participants from 22 countries)
- The 6th IAPWS conference EHF (European HRSG Forum) in Athens was also extremely well visited, also with more than 70 participants from around the globe. Straight after this EHF a 1 day symposium of the "re-animated" Greek IAPWS (HIAPWS) was held and also this was a real highlight, since the HIAPWS seems now coming really back to the scene and showed a strong willingness and motivation to do that.
- Australia and New Zealand had also organized very successful meetings this year. In both events around 50 participants from each country had been present and both events demonstrated a great motivation and interest for a stronger and intensive collaboration with IAPWS. Also in both events it was demonstrated that the IAPWS TGD have taken over a leading role as the number 1 reference and guiding documents for all power plant chemistry applications and questions.
- Another superb example for the leading role of IAPWS and the TGD of PCC are that the IEC have withdrawn their standard on steam purity (which was in place since many decades) in favor of the IAPWS TGD 5-13 and so this TGD is now THE worldwide standard on steam purity for all kind of turbines.

Projects

Development of new Technical Guidance Documents:

1. FFS in Industrial Plants – Release in Banff 2019
2. Chemistry Management in Generator Water Cooling – Release in Banff 2019
3. Film Forming Substances (FFS) for Nuclear Plants – "White Paper is in preparation"
4. Demin Water Integrity – Final Draft will be discussed in Banff, 2019.
5. Corrosion product (CP) sampling and analysing – "White Paper" is in preparation. Excellent results by Int. Collaboration gained so far and those will be integrated into this white paper.
6. Chemistry in Geothermal Plant – "White Paper" will be introduced in Banff

Siemens Power and Gas, Erlangen

Ingo Weber

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, Chair of Technical Thermodynamics

Prof. Dr. Cornelia Breitkopf, Dr. Andreas Jäger, Erik Mickoleit

Projects:

1. The work on a new model for mixed gas hydrates 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 mixed hydrates has been modified in a way that double occupancy is now also taken into account. This resulted in a publication by Hielscher et al. (2019).

2. The multi-fluid mixture model was combined with different versions of the predictive excess Gibbs energy model COSMO-SAC [Jäger et al. (2019)]. Results of the new model for water have been presented on the 17th ICPWS in Prague (2018).
3. 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). A paper is in preparation.

Recent Publications

- Hielscher, S.; Semrau, B.; Jäger, A.; Vinš, V.; Bretkopf, C.; Hrubý, J.; Span, R.:
Modification of a model for mixed hydrates to represent double cage occupancy.
Fluid Phase Equilib. 490, 48-60 (2019).
- Jäger, A.; Mickoleit, E.; Bretkopf, C.:
A combination of multi-fluid mixture models with COSMO-SAC.
Fluid Phase Equilib. 476, 147-156 (2018).

University of Rostock, Rostock

Institute of Chemistry, Chair of Technical Thermodynamics

Dr. Javid Safarov

Project

1. Thermophysical Properties of Sea- and geothermal waters, aqueous salt solutions
Thermophysical Properties of Sea- and geothermal waters, aqueous salt solutions, seawater over a wide range of temperatures, pressures and concentration were reported.
An equation of state (EOS) for fitting of the (p, ρ, T) data has been developed as a function of pressure, temperature and molality. Various thermophysical properties were calculated.

Recent Publications

- Mirzaliyev, A.; Safarov, J.; Hassel, E.:
Thermophysical properties of Thessaloniki Aegean seawater.
Journal of Scientific Works of Azerbaijan Technical University 4, 30-36 (2018).
- Mirzaliyev, A.; Safarov, J.; Hassel, E.:
Viscosity of the Caspian Seawater.
Journal of Scientific Works of Azerbaijan Technical University 2, 39-45 (2018).
- Ziraman, D. U.; Safarov, J. T.; Doğan, Ö. M.; Hassel, E. P.; Uysal, B. Z.:
Apparent molar volumes V_ϕ of calcium acetate $(\text{Ca}(\text{CH}_3\text{COO})_2 (\text{aq}))$ at $T=(273.15 \text{ to } 353.15) \text{ K}$ and pressures up to 100 MPa.
Journal of the Serbian Chemical Society 83, 1005-1016 (2018).
- Mirzaliyev, A.; Safarov, J.; Hassel, E.:
Chemical and thermophysical properties of Bosphorus Seawater.
“Transactions” of Pedagogical University of Azerbaijan. Mathematical and Natural Sciences Series 2, 67-75 (2018).

- Talibov, M. A.; Safarov, J. T., Hassel, E.; Abdulagatov, I. M.:
High-Pressure and High-Temperature Density and Vapor-Pressure Measurements and Derived Thermodynamic Properties of Natural Waters of Yardimli District of Azerbaijan. High Temperature – High Pressure 47, 223-255 (2018).
- Ahmadov, A.; Safarov, J.; Bashirov, M.; Hassel, E.:
Density of geothermal energy resources of Gabala region of Azerbaijan at high pressures and wide range of temperatures. Monitoring, Science and technology (*Nauka i texnologiya*), Maxachkala, Russian Federation 4, 56-61 (2017).
- Gilbert, W. J. R.; Safarov, J.; Minnick, D. L.; Rocha, M. A.; Hassel, E.; Shiflett, M.:
Density, Viscosity, and Vapor Pressure Measurements of Water + Lithium bis(trifluoromethylsulfonyl) imide Solutions. J. Chem. Eng. Data 62, 2056-2066 (2017).
- Safarov, J.; Mammadova, E.; Shahverdiyev, A.; Hassel, E.:
Thermodynamic properties of the Arkivan-Seyfeddin (Masalli, Azerbaijan) geothermal water. Monitoring, Science and technology (*Nauka i texnologiya*), Maxachkala, Russian Federation 2, 82-91 (2017).

Zittau/Goerlitz University of Applied Sciences

Faculty of Mechanical Engineering / KCE-ThermoFluidProperties, Dresden

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), Garching
 - Non-stationary thermo-hydraulic code RELAP-7 of the Idaho National Laboratory (INL)
 - Heat-cycle simulation software KRAWAL of Siemens Power and Gas, Erlangen
 - Heat-cycle simulation software EBSILON of STEAG Energy Services, Zwingenberg
 - Process simulation software of Fraunhofer UMSICHT, Oberhausen

3. Development of algorithms for the transport properties of moist air, ASHRAE Research Project RP-1767.
4. Development of a new ASHRAE standard for calculating thermodynamic properties of moist air, ASHRAE Project SPC-213P.
5. Completion of the 3rd edition of the book "International Steam Tables".
6. Preparation of the Chapter "Thermophysikalische Stoffwerte von Wasser (Thermophysical properties of Water)" for the VDI-Wärmeatlas (VDI-Heat Atlas) 2018
7. Preparation of Chapter 1 for the ASHRAE Handbook of Fundamentals

Recent Publications

- Kretzschmar, H.-J.; Wagner, W.:
International Steam Tables – Properties of Water and Steam based on the Industrial Formulation IAPWS-IF97.
Springer-Verlag, Berlin (2019).
- Kretzschmar, H.-J.; Wagner, W.:
Thermophysikalische Stoffwerte von Wasser.
In: P. Stephan et al. (Hrsg.), Springer Reference Technik, VDI-Wärmeatlas, 12. Auflage.
VDI Springer Reference (2019).
- Kunick, M.:
Fast Calculation of Thermophysical Properties in Extensive Process Simulations with the Spline-Based Table Look-Up Method (SBTL).
Fortschritt-Bericht VDI, Reihe 6, Energietechnik, Nr. 618 (2018).
- Herrmann, S.; Kretzschmar, H.-J.; Aute, V. C.; Gatley, D. P.; Vogel, E.:
Transport Properties of Real Moist Air, Dry Air, Steam, and Water.
Report ASHRAE RP-1767, ASHRAE, Atlanta, GA (2019).
- Kretzschmar, H.-J.; Herrmann, S.; Schneider, M.; Jaehne, I.:
Learning System Thermopr@ctice for the Calculation of Exercises with Mathcad.
In: Proceedings of the Congress INFORINO, Trudi Mehdunarodny Nauchno-Metodichesky Konferenzy, Isdatjelstvo, Moscow Power Engineering Institute, Moskva (2018).
- Herrmann, S.; Vogel, E.:
New Formulation for the Viscosity of n-Butane.
J. Phys. Chem. Ref. Data 47, 013104 (2018).
- Herrmann, S.; Hellmann, R.; Vogel, E.:
Update: Reference Correlation for the Viscosity of Ethane [J. Phys. Chem. Ref. Data 44, 043101 (2015)].
J. Phys. Chem. Ref. Data 47, 023103 (2018).
- 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.
- Herrmann, S.; Kretzschmar, H.-J.; Aute, V. C.; Gatley, D. P.; Vogel, E.:
Transport Properties of Real Moist Air, Dry Air, Steam, and Water.
Science and Technology for the Built Environment, in preparation.

**Current Status of Research Activities in Japan
Submitted to the Executive Committee Meeting, IAPWS,
Banff, Canada, September–October 2019**

**Japanese National Committee, Chaired by Professor Kenji Yasuoka
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),
Chaired by Professor Masaru Nakahara
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. Since we organized IAPWS Annual Meetings in 2017, we have further promoted international cooperation as can be seen in minutes and documents at 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 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

Self-diffusion of water-cyclohexane mixtures in supercritical conditions as studied by NMR and molecular dynamics simulation.

Yoshida K, Nakahara M

The Journal of chemical physics 150(17) 174505 May 2019

Handbook of Scientific Tables

Nakahara, M., Yoshida K.

Maruzen Publishing Co., Ltd., Tokyo and World Scientific Publishing Co, Singapore, in press.

Yasuoka, Kenji

Professor, Department of Mechanical Engineering, Keio University

email: yasuoka@mech.keio.ac.jp

URL: <http://www.yasuoka.mech.keio.ac.jp>

Cage occupancies, lattice constants, and guest chemical potentials for structure II hydrogen clathrate hydrate from Gibbs ensemble Monte Carlo simulations

Brumby P., Yuhara D., Hasegawa T., Wu D., Sum A., Yasuoka K.
Journal of Chemical Physics 150(13) Apr 2019

Ordering in clusters of uniaxial anisotropic particles during homogeneous nucleation and growth

Nozawa T., Brumby P., Ayuba S., Yasuoka K.
Journal of Chemical Physics 150(5) Feb 2019

A fast and accurate computational method for the linear-combination-based isotropic periodic sum

Takahashi K., Nozawa T., Yasuoka K.
Scientific Reports 8(1) Dec 2018

Effect of central longitudinal dipole interactions on chiral liquid-crystal phases

Nozawa T., Brumby P., Yasuoka K.
International Journal of Molecular Sciences 19(9) Sep 2018

Molecular Dynamics Simulation of Ice Crystal Growth Inhibition by Hexadecyl-trimethyl-ammonium Bromide

Shimazu N., Takaiwa D., Suh D., Kawaguchi T., Fuse T., Kaneko T., Yasuoka K.
Langmuir 34(31) 9330-9335 Aug 2018

Kinetic analysis of homogeneous droplet nucleation using large-scale molecular dynamics simulations

Ayuba S., Suh D., Nomura K., Ebisuzaki T., Yasuoka K.
Journal of Chemical Physics 149(4) Jul 2018

Phase behaviors of deeply supercooled bilayer water unseen in bulk water

Kaneko, T., Bali J., Akimoto T., Francisco J. S., Yasuoka K., and Zeng X. C.
Proceedings of the National Academy of Sciences of USA 115(19) 4839-4844 May 2018

Analysis of three-phase equilibrium conditions for methane hydrate by isometric-isothermal molecular dynamics simulations

Yuhara, D., Brumby, P. E., Wu, D., Sum, A. K., Yasuoka, K.
J. Chem. Phys. 148(18) 184501 (9 pages) May 2018

Density functional theory study of atomic and electronic properties of defects in reduced anatase TiO₂ nanocrystals

Morita K., Yasuoka K.
AIP Advances 8(3) 035119 (14 pages) Mar 2018

Detection of Anomalous Dynamics for a Single Water Molecule

Tomobe, K., Yasuoka, K.
J. Chem. Theory Comput. 14(3) 1177-1185 Mar 2018

Critical test of isotropic periodic sum techniques with group-based cut-off schemes

Nozawa, T., Yasuoka, K., Takahashi, K. Z.
Scientific Reports 8(1) 4185 (9 pages) Mar 2018

Heterogeneous cavitation and crystallisation with an impurity by molecular dynamics

Suh, D., and Yasuoka, K.
Molec. Simul. 44(7) 530-533 Mar 2018

Structural determinants in the bulk heterojunction

Acocella, A., Hofinger, S., Haunshmid, E., Pop, C., S., Narumi, T., Yasuoka, K., Yasui, M., Zerbetto, F.
Phys. Chem. Chem. Phys. 20(8) 5708-5720 Feb 2018

Multi-step time series generator for molecular dynamics

Endo K., Tomobe K., Yasuoka K.
32nd AAAI Conference on Artificial Intelligence, AAAI 2018 2192-2199 2018

Oxygen vacancy-originated highly active electrocatalysts for the oxygen evolution reaction

Hirai S., Morita K., Yasuoka K., Shibuya T., Tojo Y., Kamihara Y., Miura A., Suzuki H., Ohno T., Matsuda T., Yagi S.
Journal of Materials Chemistry A 6(31) 15102-15109 2018

Recent advances in clathrate hydrates research using molecular simulations

Yuhara D., Hiratsuka M., Yasuoka K.
Review of High Pressure Science and Technology/Koatsuryoku No Kagaku To Gijutsu 28(2) 102-112 2018

Self-assembly of peptide amphiphiles by vapor pressure osmometry and dissipative particle dynamics

Seki T., Arai N., Suh D., Ozawa T., Shimada T., Yasuoka K., Hotta A.
RSC Advances 8(47) 26461-26468 2018

Theoretical analyses on water cluster structures in polymer electrolyte membrane by using dissipative particle dynamics simulations with fragment molecular orbital based effective parameters

Okuwaki K., Mochizuki Y., Doi H., Kawada S., Ozawa T., Yasuoka K.
RSC Advances 8(60) 34582-34595 2018

Yoshida, Ken

Associate Professor, Department of Applied Chemistry, Graduate School of Technology,
Industrial and Social Sciences, Tokushima University

email: yoshida.ken@tokushima-u.ac.jp

URL: <http://pub2.db.tokushima-u.ac.jp/ERD/person/189117/work-en.html>

Self-diffusion of water-cyclohexane mixtures in supercritical conditions as studied by NMR and molecular dynamics simulation.

Yoshida K, Nakahara M

The Journal of chemical physics 150(17) 174505 May 2019

High-Pressure and High-Temperature NMR Observation of Synthetic Polymers: High-Resolution Measurement Taking Advantage of Motional Narrowing in Sub-Critical Fluids

Tomohiro Hirano, Ken Yoshida, Miyuki Oshimura, Koichi Ute

The Review of High Pressure Science and Technology Vol.28(No.2) 95-101 Jul 2018

Chronological Scientific Tables 2019

Yoshida K.

pp.513-520, 525-528, Maruzen Publishing Co., Ltd., Tokyo, ISBN 978-4621302187 Nov 2018

Handbook of Scientific Tables

Nakahara, M., Yoshida K.

Maruzen Publishing Co., Ltd., Tokyo and World Scientific Publishing Co, Singapore, in press.

Matubayasi, Nobuyuki

Professor, Graduate School of Engineering Science, Osaka University

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

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

Local viscoelasticity at resin-metal interface analyzed with spatial-decomposition formula for relaxation modulus.

Mori H, Matubayasi N

The Journal of chemical physics 151(11) 114904 Sep 2019

Consistency of geometrical definitions of hydrogen bonds based on the two-dimensional potential of mean force with respect to the time correlation in liquid water over a wide range of temperatures.

Kikutsuji T, Kim K, Matubayasi N

J. Mol. Liq. 294 111603 Sep 2019

Spatially-Decomposed Free Energy of Solvation Based on the Endpoint Density-Functional Method.

Ishii Y, Yamamoto N, Matubayasi N, Zhang BW, Cui D, Levy RM

Journal of chemical theory and computation 15(5) 2896-2912 May 2019

Bridging the gap between molecular dynamics and hydrodynamics in nanoscale Brownian motions.

Mizuta K, Ishii Y, Kim K, Matubayasi N

Soft matter 15(21) 4380-4390 May 2019

Diffusion dynamics of supercooled water modeled with the cage-jump motion and hydrogen-bond rearrangement.

Kikutsuji T, Kim K, Matubayasi N

The Journal of chemical physics 150(20) 204502 May 2019

Free-energy analysis of the hydration and cosolvent effects on the β -sheet aggregation through all-atom molecular dynamics simulation.

Masutani K, Yamamori Y, Kim K, Matubayasi N

The Journal of chemical physics 150(14) 145101 Apr 2019

Structure and Dynamics of the Hydration Shell: Spatially Decomposed Time Correlation Approach.

Pluhařová E, Jungwirth P, Matubayasi N, Marsalek O

Journal of chemical theory and computation 15(2) 803-812 Feb 2019

The mechanism of salt effects on starch gelatinization from a statistical thermodynamic perspective

Nicol Thomas W. J., Isobe Noriyuki, Clark James H., Matubayasi Nobuyuki, Shimizu Seishi

FOOD HYDROCOLLOIDS 87 593-601 Feb 2019

Refining evERdock: Improved selection of good protein-protein complex models achieved by MD optimization and use of multiple conformations

Shinobu Ai, Takemura Kazuhiro, Matubayasi Nobuyuki, Kitao Akio

JOURNAL OF CHEMICAL PHYSICS 149(19) 195101 Nov 2018

Statistical thermodynamics of regular solutions and solubility parameters

Matubayasi Nobuyuki, Shimizu Seishi

J. Mol. Liq. 273 626-633 Oct 2018

Spatial-Decomposition Analysis of Electrical Conductivity.

Matubayasi N

Chemical record (New York, N.Y.) Oct 2018

Resin filling into nano-sized pore on metal surface analyzed by all-atom molecular dynamics simulation over a variety of resin and pore sizes

Mori Hodaka, Matubayasi Nobuyuki

POLYMER 150 360-370 Aug 2018

Free-energy analysis of physisorption on solid-liquid interface with the solution theory in the energy representation

Yamamoto Naoki, Nakakuki Ippei, Matubayasi Nobuyuki

JOURNAL OF CHEMICAL PHYSICS 149(1) 014504 Jul 2018

How do hydrogen bonds break in supercooled water?: Detecting pathways not going through saddle point of two-dimensional potential of mean force

Kikutsuji Takuma, Kim Kang, Matubayasi Nobuyuki

JOURNAL OF CHEMICAL PHYSICS 148(24) 244501 Jun 2018

Structure and permeability of ionomers studied by atomistic molecular simulation combined with the theory of solutions in the energy representation

Kawakami Tomonori, Shigemoto Isamu, Matubayasi Nobuyuki
JOURNAL OF CHEMICAL PHYSICS 148(21) 214903 Jun 2018

Statistical thermodynamic foundation for mesoscale aggregation in ternary mixtures

Shimizu Seishi, Matubayasi Nobuyuki
PHYSICAL CHEMISTRY CHEMICAL PHYSICS 20(20) 13777-13784 May 2018

The Excess Chemical Potential of Water at the Interface with a Protein from End Point Simulations

Zhang Bin W., Cui Di, Matubayasi Nobuyuki, Levy Ronald M.
JOURNAL OF PHYSICAL CHEMISTRY B 122(17) 4700-4707 May 2018

Free-Energy Analysis of Peptide Binding in Lipid Membrane Using All-Atom Molecular Dynamics Simulation Combined with Theory of Solutions

Mizuguchi Tomoko, Matubayasi Nobuyuki
JOURNAL OF PHYSICAL CHEMISTRY B 122(13) 3219-3229 Apr 2018

Probabilistic analysis for identifying the driving force of protein folding

Tokunaga Yoshihiko, Yamamori Yu, Matubayasi Nobuyuki
JOURNAL OF CHEMICAL PHYSICS 148(12) Mar 2018

Binding free energy analysis of protein-protein docking model structures by evERdock

Takemura Kazuhiro, Matubayasi Nobuyuki, Kitao Akio
JOURNAL OF CHEMICAL PHYSICS 148(10) Mar 2018

Spatial-decomposition analysis of viscosity with application to Lennard-Jones fluid

Tu Kai-Min, Kim Kang, Matubayasi Nobuyuki
JOURNAL OF CHEMICAL PHYSICS 148(9) Mar 2018

Ion hydration: linking self-diffusion and reorientational motion to water structure

Shimizu Seishi, Matubayasi Nobuyuki
PHYSICAL CHEMISTRY CHEMICAL PHYSICS 20(8) 5909-5917 Feb 2018

A unified perspective on preferential solvation and adsorption based on inhomogeneous solvation theory

Shimizu Seishi, Matubayasi Nobuyuki
PHYSICA A-STATISTICAL MECHANICS AND ITS APPLICATIONS 492 1988-1996 Feb 2018

The Role of Interfacial Water in Protein-Ligand Binding: Insights from the Indirect Solvent Mediated Potential of Mean Force

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Mori Hodaka, Matubayasi Nobuyuki

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Uchida, Hiroshi

Research Scientist, Physical and Chemical Oceanography Research Group, Global Ocean Observation Research Center, Japan Agency for Marine-Earth Science and Technology

email: huchida@jamstec.go.jp

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Hirano, Hideo

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

email: hhirano0879@jcom.home.ne.jp

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Progress in Nuclear Energy, Vol. 114, July 2019, pp 121-137

Okazaki, Susumu

Professor, Department of Materials Chemistry, Nagoya University
email:okazaki@apchem.nagoya-u.ac.jp,
URL: <http://simulo.apchem.nagoya-u.ac.jp/index.html>

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POLYMER 178 Sep 2019

Adschiri, Tadafumi

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email: tadafumi.ajiri.b1@tohoku.ac.jp

URL: http://www.wpi-aimr.tohoku.ac.jp/ajiri_lab/

Atomic-Scale Valence State Distribution inside Ultrafine CeO₂ Nanocubes and Its Size Dependence

XD.Hao, A.Yoko, CL.Chen,K.Inoue, M.Saito, GY.Seong, S.Takami, T.Adschiri, Y.Ikuhara

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Y.Abe, I. Satou, T. Aida, T. Adschiri

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T. Adschiri, A.Yoko

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Tsuchiya, Noriyoshi

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email: tsuchiya@mail.kankyotohoku.ac.jp

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Kometani, Noritsugu

Professor, Department of Applied Chemistry & Bioengineering, Graduate School of
Engineering, Osaka City University
email: kometani@eng.osaka-cu.ac.jp
URL: http://www.a-chem.eng.osaka-cu.ac.jp/kometani_group/index.html

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Uchida, Shunsuke

Research consultant, Reactor Safety Research Center, Japan Atomic Energy Agency
email: uchida.shunsuke@jaea.go.jp

Improvement of plant reliability based on combination of prediction and inspection on crack growth due to intergranular stress corrosion cracking

Uchida S., Chimi Y., Kasahara S., Hanawa S., Okada H., Naitoh N., Kojima M., Kikura H., Lister DH.,

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The corrosion of aluminum alloy in containment after a loss-of-coolant accident: Implications for clogging of sump strainers

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NEW ZEALAND
Association for the Properties of
WATER & STEAM



Tō AOTEAROA
Ranga mō ngā Āhuatanga o te
WAI ME TE MAMA OA

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

Date: 27 September 2019

Key Achievements:

4. NZAPWS is now into its third year of full IAPWS membership
5. NZAPWS has robust funding in place and has gained additional sponsors for the 2019/2020 year and is in a good financial position
6. 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
7. NZAPWS have developed and rolled out a dedicated website – www.nzapws.org.nz to provide relevant information and to manage meetings for NZAPWS

Key Activities:

1. A very successful technical seminar was held in May 2019 in Rotorua, NZ with 50 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

The 2-day seminar was based on NZAPWS member demands and included a NZAPWS networking dinner with the seminar fostering knowledge sharing and collaboration between different water/steam users, vendors

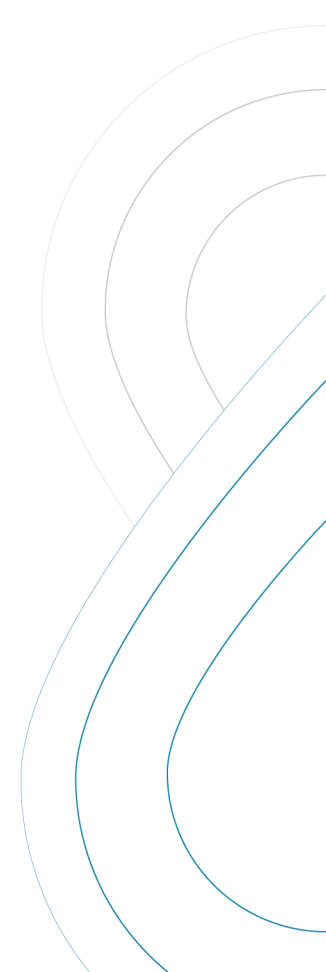
Michael Rziha from PPChem attended and presented on the activities of PCC and also ran a technical ½ day seminar on layout and storage of steam generating plants. This was hugely successful and of value to the NZ water/steam community. Other NZAPWS seminar highlights include more involvement of university researchers.

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 along with Nobuo Okita (Toshiba) of Japan
5. Jeremy Lovell-Smith is contributing to (a) TPWS via continued investigations into the use of Generalised Least Squares (GLS) to propagate input data covariance into empirical equations, and to (b) JCS through work on the definition of relative humidity. He presented a paper ‘Updating the Greenspan “Functional equations” for the water vapour enhancement factor’ at TEMPMEKO 2019 in Chengdu, China.
6. Initial planning has commenced for IAPWS 2021 in New Zealand, likely location will be Rotorua in September 2021 to allow attendees to experience the geothermal wonders of New Zealand.

Publications:

No publications by NZAPWS members in 2018/2019

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Scandinavian IAPWS Committee
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20 September 2019



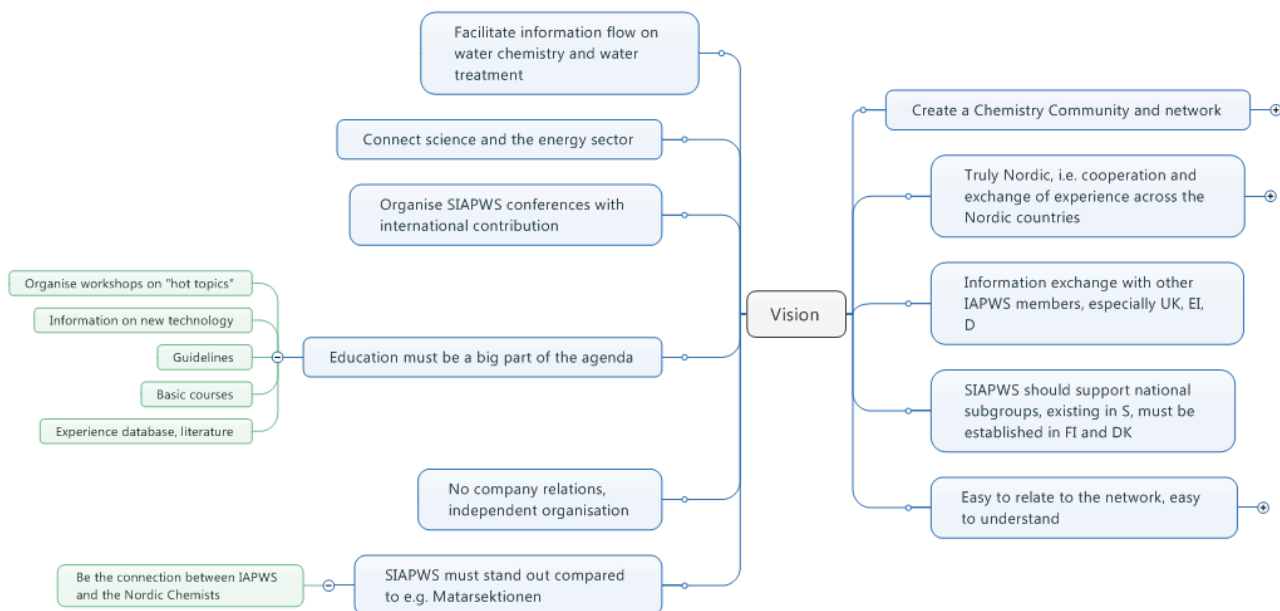
SIAPWS Annual Report for 2018

The discussion at the 2018 SIAPWS annual meeting in March in Södertälje 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 had yet to come. The exchange of experience in the field between the Nordic countries was still rudimentary, and the poor attendance to the first SIAPWS on-line courses showed that many did not see themselves as a natural part of the network. Thus, there was a need to rethink the role of SIAPWS.

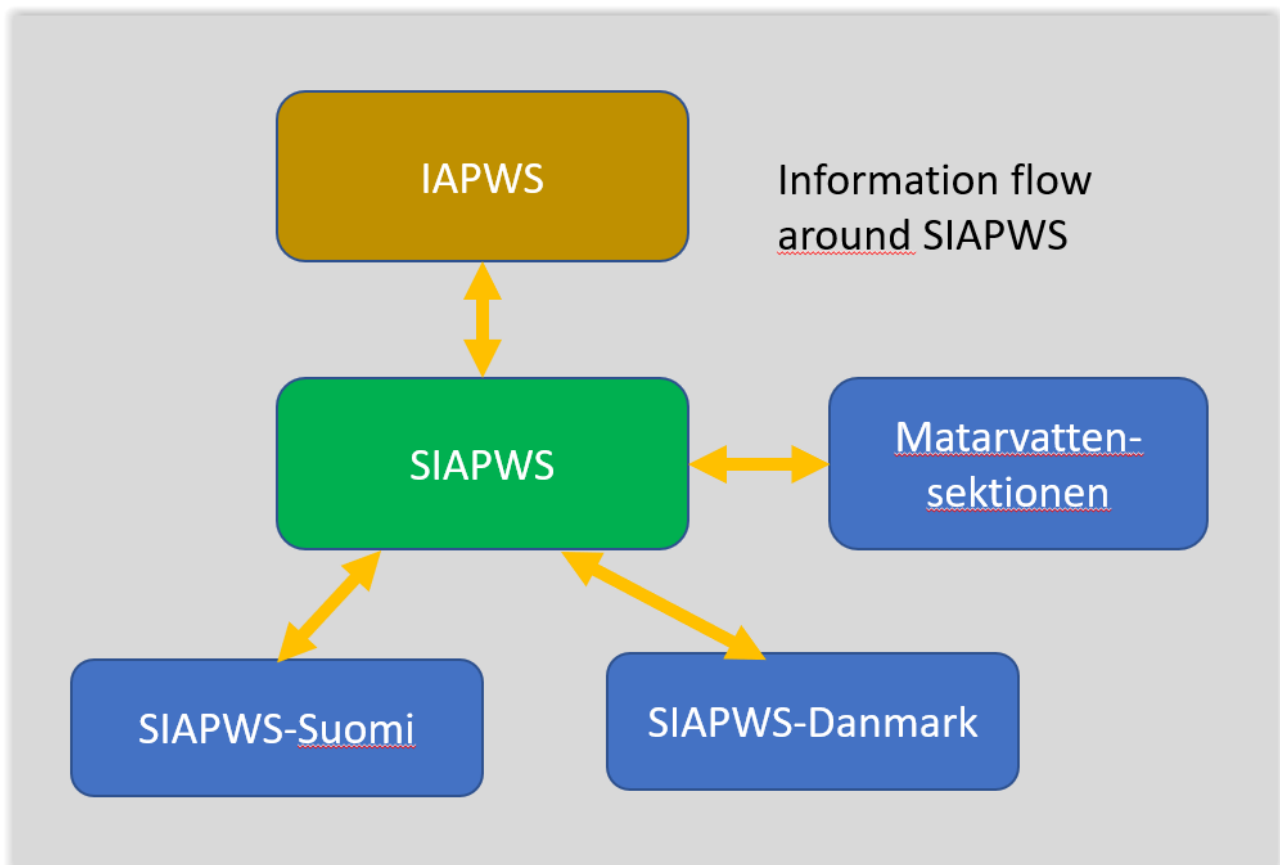
In May 2018 in Helsinki, the newly elected Executive Committee (EC) met for a workshop with this focus and had a couple of productive days with many ideas and discussions. The outcome was a plan transforming SIAPWS to a truly Nordic organisation with national groups in the three countries Sweden, Finland and Denmark. Matarvattensektionen should continue to be the natural representative of the Swedish energy community, whereas SIAPWS would 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 setup also calls for organising Nordic conferences with international contribution.

Main purposes of SIAPWS continue to link the Nordic and the international energy chemistry society in IAPWS, to offer education on-line for a modest cost, and to to organise workshops in current topics.

The new vision of SIAPWS is summarised in the mindmap below.



The new mode of operation of SIAPWS is an important change, and the EC will work hard to make a success out of it. The idea is shown in the figure, in which SIAPWS, as usual, relates to the international organization, IAPWS, but also to three national organizations in Sweden, Finland, and Denmark. The two groups in Finland and Denmark are newcomers and have been started in late 2018 and early 2019, whereas Matarvattensektionen takes the national role in Sweden. The national groups will live their own life with an organizing committee, their own meetings and workshops, and members that pay a fee to participate. On top of that, SIAPWS will organize exchange of information and experiences across the national organizations and to and from IAPWS. All members of the national groups are automatically members of SIAPWS also and have access to all information passing through that level. We have so much in common in the Nordic energy industry that it certainly will be of common interest to share experience and knowledge between the groups. The base will be the national groups that make events primarily for their countrymen and in the national language. On top of that everybody is welcome and invited to participate on the Nordic and international level where the language will be English. Those who do so will be the messengers between the national and the international levels. The main objective is to penetrate much more widely into the energy industry and relay valuable information within the Nordic countries and internationally. Both the Finnish and Danish groups have been started up successfully with around 25 companies as registered members. Matarvattensektionen continues to be "big brother" in the organization with a little more than 100 companies as members. These are now direct members of SIAPWS instead of the secondary membership through Matarvattensektionen.



The on-line education evolved in 2018 with 8-15 participants in the later courses on corrosion, preservation, and water-steam chemistry. This means that we have achieved an economical balance where the participant fees pay for the preparation of the courses.

A major highlight in 2018 was the international conference in Prague, ICPWS-17, with a record-high number of participants from the Nordic countries. SIAPWS organized two sessions on the flue gas condensation and re-use of condensate. These turned out successfully with many attendants and large interest for the new green technology that saves fuel costs and water resources while improving the flue gas cleaning at the same time.

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

Report on IAPWS related activities – September 2018 / September 2019
Submitted to the EC Meeting of IAPWS, Banff, Alberta, Canada – September 2019

National Committee Contacts:

President: Marco Lendi, E-mail: marco.lendi@swan.ch
Secretary: Tapio Werder, E-mail: tapio.werder@ppchem.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. Robert Svoboda, Svoboda Consulting, Wettingen, E-Mail: r.l.svoboda@swissonline.ch
- Dr. Michael Hiegemann, General Electric (Switzerland) GmbH, Baden, Switzerland, E-Mail: michael.hiegemann@ge.com
- Michael Rziha, PPCHEM AG Hinwil, E-Mail: michael.rziha@ppchem.com
- Marco Lendi, Swan Analytical Instruments, Hinwil, E-Mail: marco.lendi@swan.ch
- Tapio Werder, PPCHEM AG, Hinwil, E-Mail: tapio.werder@ppchem.com

Research activities in the reporting period:

No new projects were reported

Contributions to current IAPWS activities:

Chairman PCC Working Group: Michael Rziha
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 2020 to find new participating institutions in Switzerland.
- It is therefore requested to extend the Associate Membership for another term.

M. Lendi, September 2019

U.S. National Committee to IAPWS 2019 Report on Activities of Potential Interest to IAPWS

17 September 2019

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

A paper (in conjunction with the Ruhr-University Bochum) describing the new reference equation of state for the thermodynamic properties of heavy water was published:

- *A Reference Equation of State for Heavy Water*, S. Herrig, M. Thol, A. H. Harvey, and E. W. Lemmon; *J. Phys. Chem. Ref. Data* **47**, 043102 (2018) <https://doi.org/10.1063/1.5053993>

In a related IAPWS project, in collaboration with Marc Assael (Aristotle University, Greece) and Jan Sengers (University of Maryland and NIST), a new viscosity correlation for heavy water has been developed, and work is underway on a new thermal conductivity correlation.

Analysis was performed on the low-density behavior of IAPWS-95, discovering that its virial expansion behaves in unexpected ways near 300 K due to an unphysically large increase in magnitude of the 4th virial coefficient with decreasing temperature. This has implications for attempts to simplify descriptions of fugacity in vapor systems. A paper is in press in the *International Journal of Thermophysics*.

Work performed last year to describe the second and third virial coefficients of H₂O and D₂O from high-quality intermolecular potentials, in collaboration with researchers at Fondazione Bruno Kessler (Italy), Nicolaus Copernicus University (Poland), and the University of Delaware (USA), has been published:

- *Fully quantum calculation of the second and third virial coefficients of water and its isotopologues from ab initio potentials*, G. Garberoglio, P. Jankowski, K. Szalewicz, and A. H. Harvey; *Faraday Discuss.* **212**, 467-497 (2018) <https://doi.org/10.1039/c8fd00092a>

The History and Heritage Committee of the American Society of Mechanical Engineers (ASME) has approved the nomination of *Standardized Steam Property Tables* as an Historic Mechanical Engineering Landmark. Historic Mechanical Engineering Landmarks are artifacts or systems representing a significant mechanical engineering technology. ASME has designated over 250 landmarks through its History and Heritage Landmarks Program since the program began in 1971; more information can be found at <https://www.asme.org/about-asme/engineering-history/landmarks>. In this case, the designation will be a “virtual” landmark, since no corresponding physical object or site exists. A brochure about the Landmark will be prepared that explains its significance, and once that brochure is completed (sometime in 2020) the Landmark will be officially added on the ASME website.

Communicated from the University of Maryland, College Park

Prof. Mikhail Anisimov notes work on the pattern of property extrema in water's atomistic models and on recent work on thermodynamics of real supercooled water (revisited by including negative pressures and new compressibility data obtained below homogeneous ice nucleation temperatures).

- *Pattern of property extrema in supercooled and stretched water models and a new correlation for predicting the stability limit of the liquid state*, Betul Uralcan, Folarin Latinwo, Pablo G. Debenedetti, and Mikhail A. Anisimov; *J. Chem. Phys.* **150**, 064503 (2019) <https://doi.org/10.1063/1.5078446>

- *Thermodynamics of supercooled and stretched water: Unifying two-structure description and liquid-vapor spinodal*, Frédéric Caupin and Mikhail A. Anisimov; J. Chem. Phys. **151**, 034503 (2019) <https://doi.org/10.1063/1.5100228>

Prof. Jan Sengers reports on Casimir pressures in liquids under shear, noting that Couette flow experiments are commonly done with liquid water. We have found that shear-induced pressure enhancements in such experiments cannot be interpreted in terms of currently available computer simulations. The reason is that in such experiments pressure enhancements due to viscous heating are many orders of magnitude larger than observed in computer simulations that impose isothermal flow conditions.

- *Nonequilibrium Casimir pressures in liquids under shear*, J.M. Ortiz de Zárate, T.R. Kirkpatrick, and J.V. Sengers, Eur. Phys. J. E **42**, 106 (2019) <https://doi.org/10.1140/epje/i2019-11868-9>

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

Work on the technical content appears to have been completed and the relevant task group is in the formatting/editing process prior to formal vote for the document on *Consensus on Operating Practices for the Control of Feedwater and Boiler Water Chemistry in Modern Industrial Boilers*.

The ASME deaerator inspection guide is nearing completion in the Committee. This document provides the user with information on how to plan for, conduct, and interpret the results of inspections. The document is 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 2019 the conference is in Orlando, Florida, and the committee organized and chairs the following two sessions:

- *Communicating Lessons Learned from Operating Steam Generating Systems*
- *Preventing and Remediating Damage Caused by Chemical Excursions in Industrial Boiler Water*

Communicated from OLI Systems

Aqueous chemistry of rare-earth elements

Under the auspices of the Department of Energy's Critical Materials Institute (CMI), OLI Systems continued to work on the properties of aqueous systems containing rare earth elements in existing and emerging processes associated with diversifying the supply of rare earths and recycling rare earth-containing waste products. Recent work focused on (1) developing a comprehensive model for the behavior of rare earths in sulfate systems and (2) modeling the leaching of rare earths from synthetic phosphogypsum (a high-volume waste containing small concentrations of rare earths) using both mineral acids and biolixiviants. The recent work has been published in the following two papers:

- *Rare earth sulfates in aqueous systems: Thermodynamic modeling of binary and multicomponent systems over wide concentration and temperature ranges*, G. Das, M. M. Lencka, A. Eslamimanesh, P. Wang, A. Anderko, R.E. Riman, and A. Navrotsky; J. Chem. Thermodynamics, **131** 49 (2019) <https://doi.org/10.1016/j.jct.2018.10.020>
- *Bio- and mineral acid leaching of rare earth elements from synthetic phosphogypsum*, P.J. Antonick, Z. Hu, Y. Fujita, D.W. Reed, G. Das, L. Wu, R. Shivaramaiah, P. Kim, A. Eslamimanesh, M.M. Lencka, Y. Jiao, A. Anderko, A. Navrotsky, and R.E. Riman, J. Chem. Thermodynamics, **132** 491 (2019) <https://doi.org/10.1016/j.jct.2018.12.034>

Aqueous chemistry for carbon capture and transportation technologies

OLI Systems continues working on developing simulation methods to help in the optimization of advanced CO₂ capture technologies. In collaboration with SRI International, OLI is working on transformational CO₂ capture process based on a combination of mixed-salt and amine-based working fluids.

In collaboration with the Institute for Energy Technology (Norway), OLI is developing a predictive methodology to evaluate the corrosivity in CO₂ transportation systems. The corrosivity is due to reactions between various impurities, which may, under certain conditions, induce the formation of elemental sulfur and mineral acids (sulfuric and nitric).

IAPWS 2019 List of Participants

David Addison, Thermal Chemistry, New Zealand
P. Alberto Giuliano Albo, Istituto Nazionale di Ricerca Metrologica, Italy
Andre Anderko, OLI Systems Inc., USA
Arnel Angeles, Southern Alberta Institute of Technology, Canada
Joseph Apawan, Southern Alberta Institute of Technology, Canada
Aleš Blahut, Institute of Thermomechanics, Czech Academy of Sciences, Czech Republic
JC Bourgeois, Canadian Natural Resources Limited, Canada
Kirk Buecher, Mettler Toledo, USA
Maria Filomena Camões, University of Lisbon, Portugal
Dorthe Christensen, Guest of Karsten Normann Thomsen, Denmark
Stephanie Cook, Guest of Willy Cook, Canada
Willy Cook, University of New Brunswick, Canada
Barry Dooley, Structural Integrity Associates, Inc., United Kingdom
Diane Dooley, Guest of Barry Dooley, United Kingdom
Jörg Fandrich, Framatome GmbH, Germany
Rainer Feistel, Baltic Sea Research Institute, Germany
Sabine Feistel, Guest of Rainer Feistel, Germany
Jane Ferguson, University of New Brunswick, Canada
Anders Fredrikson, Tekniska verken AB, Sweden
Neil Fricke, Suncor Energy, Canada
Daniel Friend, National Institute of Standards and Technology, USA
John Gallagher, NIST, USA
Martin Godfrey, Ecolab, USA
Chris Graham, Chris Graham Consulting Inc., Canada
Allan Gray, Purolite, Canada
Allan Harvey, National Institute of Standards and Technology, USA
Paula Harvey, Guest of Allan Harvey, USA
Richard Harwood, Siemens, USA
Wolfgang Hater, Kurita Europe GmbH, Germany
Hayden Henderson, AGL, Australia
Jan Hrubý, Institute of Thermomechanics, Czech Academy of Sciences, Czech Republic
Taro Ichihara, Mitsubishi Hitachi Power Systems Industries, Japan
Sammy Isawode, ALS Global, Canada
Maryam Jafari, Baymag, Canada
Nelia Julca, Southern Alberta Institute of Technology, Canada
Yohei Kayukawa, NMIJ/AIST, Japan
Hans-Joachim Kretzschmar, Zittau/Goerlitz University of Applied Sciences, Germany
Jia Lee, Guest of Joung Hae Lee, Korea
Joung Hae Lee, Korea Research Institute of Standards and Science, Korea
Arja Lehtikoinen, Valmet Technologies, Finland
Kristine Liao, Ontario Power Generation, Canada
Derek Lister, University of New Brunswick, Canada
Rogelio Lozano, Southern Alberta Institute of Technology, Canada

Rakan Maksoud, Advisian, Canada
Ron Maltman, Ecolab, Canada
Robert Marriott, University of Calgary, Canada
Vita Martez, Southern Alberta Institute of Technology, Canada
Tom McCartney, Clean Harbors, Canada
Karsten Meier, Institute for Thermodynamics, Germany
Ivan Morales, Integrated Sustainability, USA
Melonie Myszczyzyn, Canadian Natural Resources Limited, Canada
Masaru Nakahara, Kyoto University, Japan
Tomáš Němec, Institute of Thermomechanics, Czech Academy of Sciences, Czech Republic
Monika Nielsen, Orsted A/S, Denmark
Marlon Norona, Southern Alberta Institute of Technology, Canada
Nobuo Okita, Toshiba Energy Systems & Solutions Corporation, Japan
Olga Palazhchenko, University of New Brunswick, Canada
Rich Pawlowicz, University of British Columbia, Canada
Subodh Peramanu, Canadian Natural Resources Limited, Canada
Basil Perdicakis, Suncor Energy, Canada
Steve Portelance, Advisian - A Division of Worley, Canada
John Powalisz, Sentry Equipment Corp, USA
Glenn Pringle, CANDU Owners Group, Canada
Corbin Ralph, Ecolab, Canada
Vineeth Ram, OLI Systems Inc., USA
Tom Reinders, Canadian Natural Resources Limited, Canada
Michael Rziha, PPCHEM AG, Switzerland
Nabel Sadek, Canadian Nuclear Safety Commission, Canada
Sean Sanders, University of Alberta, Canada
Tetsuya Sawatsubashi, Mitsubishi Heavy Industries, Japan
Steffen Seitz, PTB, Germany
Jan Sengers, University of Maryland, USA
Shigeki Senoo, Mitsubishi Heavy Industries, Japan
Stephen Shulder, EPRI, USA
Mike Sparrey, ABB Ltd., United Kingdom
Craig Stuart, Canadian Nuclear Laboratories, Canada
Yaping Sun, Huaneng Shandong Shidao Bay Nuclear Power Co. Ltd., China
Shinichi Terada, Toshiba, Japan
Karsten Normann Thomsen, COWI A/S, Denmark
Karin Tremaine, Guest of Peter Tremaine
Peter Tremaine, University of Guelph, Canada
Sarah Tripp, Southern Alberta Institute of Technology, Canada
Václav Vinš, Institute of Thermomechanics, Czech Academy of Sciences, Czech Republic
Deliang Wang, Xi'an Thermal Power Research Institute Co., Ltd., China
Sarita Weerakul, University of New Brunswick, Canada
Tapio Werder, PPCHEM AG, Switzerland
Hongmeng Yao, Huaneng Shandong Shidao Bay Nuclear Power Co. Ltd., China
Kenji Yasuoka, Keio University, Japan
Min Sook Yoon, Guest of Joung Hae Lee, Korea

Ken Yoshida, University of Tokushima, Japan

Guiquan Zhang, Xi'an Thermal Power Research Institute Co., Ltd., China

Burkhard Zohm, Doosan Babcock, United Kingdom