

**THE INTERNATIONAL ASSOCIATION
FOR THE PROPERTIES OF
WATER AND STEAM**

MEMBERS

Australia
Britain and Ireland
Canada
Czech Republic
Germany and Switzerland
Italy
Japan
New Zealand
NORDIC (Denmark, Finland, Norway, Sweden)
United States of America

ASSOCIATE MEMBERS

Argentina and Brazil
China
Egypt
France
Greece
India
Israel
The Netherlands

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

**Boulder, Colorado, USA
23rd and 28th June 2024**

Prepared by Barry Dooley



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23rd and 28th June 2024

Plenary Session. Sunday 23rd June 2024. 9:00am

At 9:00am the President of IAPWS, Dr. Dan Friend welcomed the Executive Committee (EC) and other IAPWS members to the EC Meeting. He first introduced Dr. Allan Harvey, Chair of the US National Committee and co-host of the IAPWS/ICPWS and STP (Symposium on Thermophysical Properties) conferences. The President then officially opened the 2024 EC Meeting by introducing the National Delegates. All of the IAPWS Members were in attendance but none of the Associate Member countries. In total there were 22 people assembled for the EC meeting.

1. Adoption of Agenda

Provisional agendas had been e-mailed to all IAPWS members by the Executive Secretary in April 2024. The final agenda forms Attachment 1 of these minutes.

2. IAPWS Business and Appointment of Committees

2.1 IAPWS Business Since Last EC Meeting in Turin, Italy, September 2023

The Executive Secretary reported that during the year since the last IAPWS EC Meeting in Turin only one document on the *Revised Release on the Ionization Constant of H₂O* had been forwarded to IAPWS members for review or approval. By the 6th June 2024 no comments or objections had been made so the Revised Release became an official IAPWS document and has been posted on the IAPWS website.

The Executive Secretary received a notice that SIAPWS had changed the name to NORDIC IAPWS with Denmark, Sweden, Finland and Norway as included countries. This would be reduced to NIAPWS.

2.2 IAPWS Highlights and Press Release

The President asked Cook to chair the development of the Highlights/Press Release on the IAPWS proceedings during the week. Cook indicated that he would be available but needed to travel to Florida in mid-week. It was also suggested that Harvey should be part of the team to work with Cook. The Clerks of Minutes from each WG were asked to provide input. The Press Release is discussed in Minute 17.1 and is Attachment 7.

2.3 Evaluation Committee on International Collaboration.

The Executive Secretary indicated that two early proposals had been received prior to the meeting, and that any suggestions from a Working Group (WG) 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. Final discussion is found in Minute 14.1.

2.4 IAPWS Awards Committees for 2025

2.4.1 Honorary Fellow Award Committee

This committee consists of two IAPWS Fellows and the President and Executive Secretary as ex. Officio members. At this time on the agenda there was some uncertainty as to availability of people so the President indicated that this would be finalized at the Friday EC meeting (Minute 15.2).

Action: Nominations are due to the Executive Secretary by 31st January 2025.

2.4.2 Helmholtz Award Committee

The Executive Secretary reminded the EC that the Helmholtz Award selection committee for the 2025 award would consist of a member from Germany/Switzerland (Chair), Japan, New Zealand, NORDIC and USA. These countries were requested to provide the name of the member for this committee to Chairman Kretzschmar before the Friday EC meeting (Minute 15.1).

Action: Nominations are due to the Executive Secretary by 31st January 2025.

2.5 Situation in Ukraine

The President indicated that there had not been any changes to the aggression and suggested to the EC that there were no reasons to change the suspended membership.

The EC approved this unanimously.

2.6 Refreshment of IAPWS Website

The President requested the chair of this committee to provide an update. McCann requested that the report should be delayed to the Friday EC meeting so the committee could meet during the week. The following were committee members: Cook (Canada), Addison (New Zealand) and McAllister (Australia). An approximate budget was needed to upgrade the IAPWS website. The Executive Secretary asked about the current security of the IAPWS website in regards to :http versus :https. This led to some discussion from EC members which eventually resulted in an agreement that the Executive Secretary and a member of the committee interface with godaddy as soon as possible to determine the action needed. Final discussion on the website is found in Minute 17.3.

2.7 Executive Secretary Succession

The President reminded the EC of the history from the EC meeting in 2023 when some criteria had been developed. Since then some people had responded. The president reviewed these responses from six people and indicated that none of these had been totally acceptable; he then opened up the floor for any other discussion. Vice President Nielsen made a motion that President Friend at the end of his tenure to take over the Executive Secretary position on an interim basis as deputy to the incumbent or vice versa. The Canadian delegate, Cook, seconded the proposal as a “stop gap measure”. It was suggested by the US delegate that this item should be left until the Friday EC to allow EC members to reflect. This is finalized in Minute 6.

2.8 Other Business Requiring Extensive Discussions

No other business was raised by the EC.

3. EC Mandate to Working Groups and Membership

The following mandates were discussed with the WG Chairmen for action during the week.

3.1 IAPWS Certified Research Needs.

The President indicated that one main purpose of the annual meetings was to produce documents (guidelines, Technical Guidance Documents, ICRNs, etc.) and urged the Working Groups to review the

strategy and provide a report at the Friday EC meeting on the schedule for production. The Executive Secretary indicated that three ICRNs needed attention by the Working Groups during the week: ICRNs 25, 28 and 31. Updates on these are included in the WG reports (Minutes 7 – 10).

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 of the IAPWS Week's Activities

President Friend indicated that there would be the ICPWS and STP conferences during the week. He then asked each WG Chair to provide an outline of activities during the week.

Following this item, the President closed the opening session of the EC at 10:20 am.

Activities During the Week

The first day activities of the Executive Committee were followed by Working Group meetings and the joint ICPWS/STP. The schedule of the IAPWS week is shown in Attachment 2.

Executive Committee Meeting. Friday, 28th June 2024

President Friend opened the continuation of the EC Meeting at 9:00 am. All of the IAPWS Members were in attendance as well as Associate Member country Italy.

Friend 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 Friend asked for comments and changes to the minutes of the EC meeting held in Turin, Italy in September 2023. No changes were noted; thus the 2023 Minutes were accepted.

6. President's Report and Remarks

President Friend indicated that he had given his report at the General Meeting on Thursday 25th June 2024 and wouldn't repeat it at this EC meeting.

The President returned to the important item of succession planning for the IAPWS Executive Secretary position. This item had been discussed at the Sunday EC meeting (Minute 2.7). He reminded the EC that a motion had been made by the NORDIC delegate and seconded by the Canadian delegate which was followed by a suggestion by the US delegate to delay further discussion until the Friday EC meeting. He then again expressed interest in the position and indicated that he had been involved with IAPWS since 1993 and was very familiar with IAPWS workings. He then left the room to allow the Vice President to lead any discussion. Nielsen repeated her motion to elect Friend on 1st January 2025 as Executive Secretary on an interim basis for three years with the current Executive Secretary acting as deputy. At the next EC meeting in Finland (June 2025) the process to find a new deputy will take place. Much discussion took place with numerous EC members concentrating on the need to have a procedure for the future to remove the risk of a single Executive Secretary. The Vice President asked for a vote by the EC.

The EC approved this process unanimously.

7. Thermophysical Properties of Water and Steam (TPWS) Working Group (WG)

Minutes of the TPWS WG conducted during the week are in Attachment 3. TPWS Chairman Meier discussed the following items with the EC:

7.1 Replacement of the IAPWS-95 Formulation.

Planning is beginning on what will be a large project to replace IAPWS-95. In the first step, the available experimental data will be organized and evaluated, and a preliminary EOS showing only a single van-der-Waals loop will be developed. No responses were received to ICRN-31 on a call for experimental data.

7.2 Industrial Formulation for the Thermodynamic Properties of Water and Steam.

The Chair reported that Kunick proposed to develop a new Industrial Formulation for the Thermodynamic Properties of Water and Steam based on the SBT method (look-up tables). It was discussed whether the splines should be based on IAPWS-95 or IAPWS-97 formulation. A task group will approach industry in explaining the pros and cons of the two options.

7.3 Future of the Subcommittee on Seawater (SCSW).

TPWS Chair, Meier, reported that Albo had organized a conference session on sea water during the week. But the future of the Subcommittee on Seawater could not be discussed because only two members of SCSW had attended the TPWS/SCSW meeting.

The TPWS Chair proposed that Pawlowicz and Feistel remain formally Chair and Vice-chair respectively of SCSW. This raised a few comments from the Executive Secretary on the availability of these officers and whether SCSW should now be dissolved. It was then proposed that Albo become the interim SCSW chair with Pawlowicz as vice chair.

The EC approved the new SCSW officers unanimously.

The TPWS working group thought that ICRN 16 (*Thermophysical Properties of Seawater*) should be reconsidered after a new SCSW Chair and Vice-chair have been elected.

7.4 ICRNs

For ICRN 16 (*Thermophysical Properties of Seawater*): TPWS Chair will ask Pawlowicz to write a concluding statement.

For ICRN 28 (*Thermophysical Properties of Metastable Steam and Homogeneous Nucleation*): Hrubý will prepare a concluding statement.

For ICRN 30 (*Thermophysical Properties of Supercooled Water*): TPWS Chair will ask Hellmuth to write a concluding statement.

For ICRN 31 (*New Thermodynamic Data for Ordinary Water*): Harvey and Hrubý will prepare an update of the release.

7.5 IAPWS Representative for CCT-WG-Hu

The TPWS Chair indicated that Harvey was appointed as an IAPWS representative for the Consultative Committee for Thermometry / Working Group on humidity (CCT-WG-Hu). The IAPWS President is asked to inform the Consultative Committee for Thermometry.

7.6 TPWS Membership and Officers.

The TPWS Chair informed the EC that there were no new members suggested but that Sengers resigned from TPWS and Miyagawa resigned from SCSW.

Hrubý was elected as the new TPWS Chair with Jäger and Meier being elected as new Vice-Chairs.

The EC approved these WG officer changes unanimously.

8. Industrial Requirements and Solutions (IRS) Working Group.

The Chair of IRS had not attended the meetings during the week, so past Chair Okita had stood in. Minutes of the IRS WG conducted during the week are in Attachment 4.

8.1 Task Group Updates.

Okita provided the EC with brief updates on six Task Groups. None needed EC approval.

8.2 New Task Group.

Okita next indicated that a new Task Group had been formed: *Proposal for the Development of an Industrial Formulation for the Thermodynamic Properties of Water and Steam based on SBTL*. The Task Group consists of di Mare, Kunick, Pawellek, Hruby, Kretzschmar and Okita.

8.3 IRS Members.

Okita indicated that Miyagawa was retiring from IRS. He also proposed two new WG members:

- Prof. Markus Schatz, Helmut Schmidt University / University of the Federal Armed Forces, Germany
- Mr. Benedikt Lea, Ruhr University/ Bochum, Germany

The EC approved these two new WG members unanimously.

9. Physical Chemistry of Aqueous Systems Working Group (PCAS)

Minutes of the PCAS WG conducted during the week are in Attachment 5.

PCAS Chairman Yoshida discussed the following items with the EC:

9.1 Task Group on Radiation Chemistry.

A joint PCAS-PCC Task Group has been formed to work on radiation chemistry and water radiolysis concepts of critical interest for irradiated aqueous systems such as those in nuclear reactors, proposed by Yakabuskie (CNL, Canada), Arcis (NNL, UK), Conrad (INL, USA) and Bachet (EdF, France). Radiation chemistry is an important concept for many aspects of the nuclear fuel cycle, with implications for reactor operation and chemistry control, severe accident modelling and development of mitigation plans, and waste management activities.

9.2 Task Group on Electric Conductivity.

A joint PCAS-TPWS (and possibly PCC) Task Group has been formed to work on literature survey and developing correlation functions of electric conductivities of aqueous electrolyte solutions at high temperatures. It is proposed that the Task Group is aimed at collecting literature and developing correlations, focusing on the required thermodynamic conditions for electrolytes needed in the field of hydrogen production using electrolysis. The initial members are Albo, Arcis, and Yoshida. Anyone interested in this project who can contribute is welcome to participate.

9.3 PCAS Membership.

The PCAS Chair informed the EC:

Dr. Kaj Thomsen (Technical University of Denmark, Denmark) was leaving PCAS and four people were proposed for membership:

Dr. Elizabeth Ploetz (Kansas State University, USA)

Professor Francesco Paesani (University of California San Diego, USA)

Dr. Martin Bachet (EdF, France)

Professor Greg Zimmerman (Commonwealth University of Pennsylvania, USA)

The EC approved these four new WG members unanimously.

10. Power Cycle Chemistry Working Group (PCC).

Minutes of the PCC WG conducted during the week are in Attachment 6.

PCC Chairman Addison discussed the following items with the EC:

10.1 Technical Guidance Documents (TGD).

The PCC Chair provided updates on the following TGD (Sub-Task Group chaired by Dooley):

- Film Forming Substances for Nuclear Plants. As this TGD has been delayed due to business and health pressures PCC will return to it in Finland in 2025.
- Monitoring Corrosion Products in Flexible (cycling and two-shifting) Plants. The white paper/draft TGD is almost ready for distribution to enable additional data collection for final TGD development. The PCC white paper format will be raised with the EC later.
- Flue Gas Condensation. Following presentation in Turin the draft is undergoing edits/review internally by PCC and will then be considered for a PCC white paper.
- Geothermal Steam Chemistry. Draft TGD in development with a goal for approval at IAPWS 2025.
- Electrode Boiler Chemistry. Expansion of working group to include Finnish and Norwegian plant operators. Goal is for draft TGD prior to IAPWS 2025 for presentation at Symposium.
- Dew Point of Low Sulphur Gas. This is an IRS led project with support from PCC. Draft white paper completed and presented at ICPWS 2024.

The Instrumentation TGD (IAPWS TGD2-09(2024)) has been amended and reviewed by the Editorial Committee. PCC requests EC approval for a postal ballot.

The EC approved the postal ballot unanimously.

10.2 International Collaboration Projects (ICP).

The PCC Chair informed the EC that no new collaborations had been proposed but indicated the status on the following two ICP:

- Boiler Corrosion – Canada/NZ – work continuing with expanded project.
- Corrosion Products. The two projects are completed, and the results were presented to PCC at previous meetings. The results have been used in the Corrosion Product white paper (Minute 10.1).

10.3 PCC Key Actions.

The PCC Chair informed the EC of the following key PCC actions:

- PCC technical description for IAPWS website completed and issued for uploading
- PCC LinkedIn Page completed and active for improved outreach
- Proposed PCC white paper format developed and approved by PCC
- Proposed IAPWS website location on PCC page.

At this stage the EC discussed the White Paper content and format. It was made clear that any WG can have a White Paper and that it is a WG document not an IAPWS document. The editorial committee will review the front page.

10.4 ICRNs.

The PCC Chair outlined the activities on ICRNs:

For ICRN 32. (Conductivity of electrolytes in aqueous solutions): This has had editorial review and will be sent for a PCC postal ballot.

For ICRN 25. PCC requests an extension to 2025.

The EC approved this extension unanimously.

For ICRNs 22 and 26. PCC requests that these be closed.

10.4 PCC Opal Files, File Storage and PCC Back-up Files.

Chairman Addison raised the following items:

- For IAPWS documents and file management there is a risk of loss of information and knowledge. IAPWS needs its own secure system (or subscription to cloud based system) for file and document storage. All WG and Task Group work should be stored on this system for access. The ICP reports are part of the ICP process but not currently published anywhere.
- PCC requests EC to investigate and considers a IAPWS file storage and document management system for all IAPWS WGs to use

Discussion by the EC led to the conclusion that these items would be dealt with through the on-going IT (Minute 17.3) discussion and would be put forward for a motion in 2025.

10.5 PCC Membership.

The PCC Chair proposed the following new WG members:

- Mr. Ludwin Daal, BlueXPRT– The Netherlands
- Mr. Tapio Werder, PPChem – Switzerland

The EC approved these new WG member additions unanimously.

11. Editorial Committee Report

Editorial Committee Chairman Harvey reported that in the preceding year, the Editorial Committee (Harvey, Cook and Cooper) had reviewed two IAPWS Documents:

- TGD 2024 Revision on *Instrumentation for monitoring and control of cycle chemistry for the steam/water circuits of fossil-fired, combined cycle, and industrial power plants*. (IAPWS TGD2-09(2024))
- *Revised Release on the Ionization Constant of H₂O*. (IAPWS R11-24).

12. Membership and Associates

12.1 Report on Membership.

The Italian Delegate, Albo, proposed to the EC that the Italian National Committee, ITAPWS, become a full member of IAPWS. He would be the chair with Stefano Boggio (Nippon Gases) as the Secretary and Rajesh Nair (OGS) as Treasurer. He also outlined the Italian organizations, industries and universities interested in ITAPWS.

The EC approved ITAPWS as a new full member of IAPWS unanimously.

The Executive Secretary then reported that Australia and USA had not paid the 2024 dues by the end of May 2024.

The Head of the Australian National Committee, McAllister, indicated that this had been an oversight by the treasurer and the dues would be paid as soon as possible.

The Head of the U.S. National Committee, Harvey, provided some background on the U.S. Committee. Since the beginning of IAPWS/IAPS (and even before), U.S. representation has been provided through the American Society of Mechanical Engineers (ASME). The current U.S. representation to IAPWS is the Properties Subcommittee (Harwood as Chair) of the ASME Research and Technology Committee on Water and Steam in Thermal Systems. On 6th June 2024, the U.S. committee was informed that ASME will terminate these committees on 30th June 2024 and that the international work on “steam tables” and related topics will not be supported by ASME in the future. ASME will not pay the dues to IAPWS in the future. For 2024, the U.S. committee is trying to get ASME to pay the 2024 IAPWS dues, which were already approved and for which Committee money was allocated; the most recent information is that ASME have indicated they will now do so.

Harvey then informed the EC that after 30th June 2024 the U.S. Committee will not be able to meet the requirement of the IAPWS Statutes which indicates: *“In any country desiring to participate in the work of the Association, a National Organization or Committee, representative of interests in the properties of water, steam, aqueous systems, and power plant cycle chemistry shall be constituted or designated by a governmental, technical, or professional body”*. They expect to initiate some sort of “technical body” (such as a nonprofit U.S. organization) in the coming months. But currently there is no apparent source of funding to be able to pay dues after 2024 and for future planning, the EC should not assume dues payments from the U.S. after 2024.

12.2 Reports on Associate Members.

The representative of The Netherland, Ludwin Daal, proposed to the EC that The Netherlands become an associate member of IAPWS as the Dutch IAPWS (DIAPWS). He provided some background on the Dutch power industry and indicated that the “Dutch Ring of Power Plant Chemists” already exists and would take on the role of the National Committee. DIAPWS will have the following officers: Chair: Simon van Dijk (Uniper); Secretary: Ludwin Daal (BlueXPRT); and Treasurer: William Fleuren (DNV). He also noted that an existing financial mechanism is already in place through DNV (EPOS).

The EC approved DIAPWS as a new Associate Member of IAPWS unanimously.

The Executive Secretary reported on contacts with Associate Members on their IAPWS status.

Status Report on IAPWS Associate Member, Greece. Mr. Antony Thanos, Chair of HIAPWS, had provided a short report to the Executive Secretary. The National Committee is actively supporting IAPWS activities, establishing regular updates on IAPWS activities (documents, events etc.) to HIAPWS participants. Persons participating in HIAPWS also contribute to IAPWS WGs. The local legal (Tax, Public Administration) framework, as far as potential legal forms to be considered for the Association, has been explored with continued follow-up, but still a main obstacle for officially setting a committee is the lack of financing. A web symposium is under consideration for the early winter period.

Status Report on IAPWS Associate Member, Israel. The Executive Secretary reported that ISRAPWS continues to maintain an annual symposium for the members with information sharing and raising of problems through direct personal contacts and presentations sessions. The most recent symposium was in May 2024.

Status Report on IAPWS Associate Member, India. The Executive Secretary reported that INDIAPWS continues to hold virtual symposia for the members on topics of interest. The most recent symposium was in March 2024.

Status Report on IAPWS Associate Member, Argentina and Brazil. The Executive Secretary reported that as a follow-up to action imposed on him at the EC meeting in Turin, he had contacted the Head of the National Committee, Corti. He provided some information on the nuclear industry and CNEA but did not feel that Argentina could participate institutionally in IAPWS activities in the near future. He indicated that it had been a pleasure for him to collaborate with IAPWS as a reviewer of the Release on water Kw. The rest of the people who were involved in the Argentine Committee in the past, in CNEA or in power stations, are all retired.

13. Executive Secretary's Report

13.1 IAPWS Bank Accounts, Financial, Auditors and IAPWS Dues

The Executive Secretary reported that IAPWS is on a sound financial footing with currently about £83,000.00GBP in total in the UK and US bank accounts. The status as at 3rd June 2024 in the bank accounts had been provided to the Heads of each IAPWS Member country prior to the EC meeting.

The Executive Secretary next reported that the 2023 financial statements had been forwarded to the IAPWS Auditors in January 2024 (Professor Savarik in Czech Republic and Dr. Delfs of VDI in Germany). Both had reviewed and approved the financial statements which were provided to the EC. But Dr. Delfs had informed the Executive Secretary that he and VDI would not be able to remain as an IAPWS auditor. The Executive Secretary requested an IAPWS country to volunteer. When no response was received the IAPWS President mandated that each National Committee consider the situation and respond to him by the end of 2024 with a suggested auditor. These would be reviewed, and a decision made for the next audit cycle in January 2025.

Action Required: Each National Committee to respond to the IAPWS President by the end of 2024 with a suggestion of an auditor.

The Executive Secretary proposed that Professor Savarik remain as an IAPWS auditor.

The EC Approved this proposal Unanimously.

The Executive Secretary proposed to the EC that the dues structure for member countries remains unchanged for 2025.

The EC Approved this proposal Unanimously.

13.2 Time and Place of the 2025 and 2026 IAPWS Meetings.

2025 IAPWS Meetings. The Head of NORDIC IAPWS, Nielsen, briefly reviewed the details to host the meeting in Helsinki, Finland between 22 – 27 June 2025. The meetings will be held at Hanaholmen. As well as the normal IAPWS EC and WG activities there will be a Symposium on 25th June 2025 and a technical visit to VTT, Technical Research Center of Finland.

2026 and 2027 IAPWS Meetings. The Executive Secretary indicated that preliminary discussions have taken place with the Chairs of BIAPWS for 2026 and Australia for 2027. He requested the present BIAPWS Delegate, McCann, to review the situation with the BIAPWS executive and respond to the Executive Secretary by the end of 2024. He also requested the Australian Delegate, McAllister, to review the situation with the Australian executives and respond to the Executive Secretary by the end of 2024. It is expected that the location of the 2026 and 2027 annual IAPWS meetings will be consolidated by the next annual meeting in 2025.

14. Guidelines, Releases, Certified Research Needs, and International Collaboration Projects (ICP).

14.1 International Collaborations.

The President asked the chair of the evaluation committee to provide the results of the evaluation of the ICP. Addison indicated that there were three proposals received and the committee had reviewed and ranked them in the following order:

1. *Analysis of Film Forming Amine Coatings in High Temperature Water Loops.* Submitted by Yoshida for PCAS. The sponsors are Canada and Japan. The cost is £16,400.00GBP.
2. *Radiation Chemistry of Iodine Under Low Dose Rate Conditions Relevant to Design Basis Accidents in PWRs.* Submitted by Hugues Arcis for PCAS. The sponsors are Canada and UK. The cost is £15,300.00GBP.
3. *Guideline on Thermodynamic Properties of Metastable Water.* Submitted by Frédéric Caupin for TPWS. The sponsors are U.S., Czech Republic and France. Cost: \$32,400.00 USD which at the current rate of exchange is £25,622.00GBP.

Addison indicated that all three were acceptable and if the funds existed IAPWS should support each as they would be of benefit to IAPWS. Much EC discussion took place about the financial situation. Finally, the U.S. Delegate, Harvey proposed the motion: “IAPWS should fund the first proposal pending the financial report from ICPWS being in balance (no loss from ICPWS)”. Further discussion led to an additional motion: “If there is a surplus from ICPWS then the EC should consider funding the second proposal by email”.

The EC Approved these motions by majority with Canada abstaining.

15. IAPWS Awards

The President reported that there was a 2024 Helmholtz Awardee: Dr. Sebastian Herrmann.

The Helmholtz Award Committee for 2025 had been initially discussed in Minute 2.4 and would consist of the following members: Germany/Switzerland (Hellmann)(Chair), Japan (Kayukawa), NORDIC IAPWS (Jensen), USA (Anderko) and Australia (McAllister).

The President reported that Nobuo Okita had been awarded an Honorary Fellow Award for 2024.

The Honorary Fellow award committee for 2025 will be Hruby (Chair) and Okita.

The Gibbs Award had been awarded to Dr. Rainer Feistel at the ICPWS.

16. Future. Election of IAPWS Officers for 2027/2028 and 2029/30. Next ICPWS.

The Executive Secretary indicated that according to IAPWS By-Law 8, the election of the next Vice President should be made at the end of the EC meeting in even years. The Executive Secretary indicated that together with the IAPWS President the recent history had been checked which suggested that the Australian Committee should be asked to nominate one of their committee members for the position for 2027/2028. The Australian Chair, McAllister, had been contacted and was asked to provide his committee's decision by November 2024. The Executive Secretary also indicated that Canada was next in line and requested the Head of the Canada national committee to review with his committee about nominating a person for the 2029/2030 period.

The EC Unanimously Approved this Process.

The current President, Friend, will step down on 31st December 2024. The current Vice President, Nielsen, will become the President on 1st January 2025 and the new IAPWS Vice President will assume the position at the same time.

The Executive Secretary thanked Friend for his leadership over the last two years which had been a tremendously difficult period for IAPWS. The EC applauded.

With regards to the next ICPWS (19th) the next country in line is Canada and the Executive Secretary requested Cook to review the possibility with his national committee. The IAPWS President suggested that a Task Group be formed to review all aspects of holding another ICPWS. This committee should consist of Hruby (17th ICPWS), Harvey (18th ICPWS) and Cook as representative of the possible next ICPWS. There should be review of the product (book, CD, etc) which could ensue from the next ICPWS.

The EC Unanimously Approved this Task Group.

17. New Business

17.1 Press Release

The President mentioned that Cook (Chair) and Harvey had been asked at the EC meeting on Sunday to develop a Press Release. This was developed with input provided by each WG. Cook indicated that a document had been prepared. The final version is Attachment 7. 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 U.S. National Committee Feedback on the 2024 EC and General Meeting and ICPWS.

The Head of the U.S National Committee, Harvey, thought that combining ICPWS with the STP had been a great success and had allowed IAPWS members to experience a much wider range of activities. The financial report will be available in a couple of months.

The IAPWS President thanked the U.S. National Committee and requested any feedback from the EC. Applause from EC in appreciation.

17.3 IAPWS Website.

The President requested the chair of the Task Group, McCann, to provide the EC with the feedback.

McCann informed the EC that the desired outcomes were:

- * Improved collaborative and efficient working
- * Modernisation of graphics and branding
- * Provide information management and file storage.

McCann next indicated that the Task Group had worked with a professional designer and the review had indicated that the current IAPWS website is dated in appearance, navigational structure and development (not device friendly). The architecture is shallow with all links to sections and pages compiled in one long menu list which is unclear to work through and not practical for smaller screen devices. All content is text only which doesn't make it visually appealing. The proposed structure will include a revised homepage and interface conveying imagery and identity with an overview on what IAPWS is and what it covers. There would also be visual promos and links to upcoming seminars, meetings and events. McCann provided a possible website structure to include a homepage, technical guidance, meetings and working groups, and "about IAPWS".

McCann next provided the EC with three options:

1. Keep website as is and update security certificate to https.
2. Refresh existing graphics and architecture
3. Full update with filesharing capability.

He discussed the advantages and limitations of each and indicated that the TG preference is for Option 2 with a Stage 1 activity as follows to include refreshment of graphics and architecture and make device friendly:

- a. Currently exploring with the designer if they would be willing to support on this basis – depends if complete website redevelopment is required.
- b. If full website development is required, IAPWS will go out for three quotes from website design companies.
- c. Suggest that EC ringfences \$15k for website development.
- d. Request that each IAPWS WG and the EC provide 5-6 photographs/images with permission to go on the website that illustrates what IAPWS is and does.
- e. The Task Group expects it will take 3 months to come back with proposals to EC followed by a review process and timescale development
- f. Website redesign is then expected to take up to 2 years (possibly quicker but also depends on time needed for IAPWS review).

Following discussion from the EC a motion was developed for the EC: *"Is EC happy with proceeding with Option 2 but not currently authorizing any funding?"*. A second motion was also developed: *"A proposal will be developed in three months to include a scope and cost estimate. This will be sent to the Executive Secretary to arrange a Postal Ballot of one month"*.

The EC Unanimously Approved this Approach.

17.2 Reports from National Committees.

Written reports on progress in member countries provided during and after the EC meeting are attached to these minutes as follows:

Czech Republic	Attachment 8
Germany-Swiss	Attachment 9
Japan	Attachment 10
USA	Attachment 11

17.3 Participants

Attachment 12 provides a list of participants at the IAPWS Meetings in Boulder, USA in June 2024.

17.4 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 EC Meeting. 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. The 2024 EC meeting was closed at 1:14 pm.

**AGENDA for the EXECUTIVE COMMITTEE of IAPWS
Boulder, Colorado, USA. 23rd – 28th June 2024**

Sunday, 23rd June 2024. Opening Plenary Session (9:00 – 10:15 am). Room ECCR 105.

- Opening Remarks, Welcome and Introductions by IAPWS President D. Friend
1. Adoption of Agenda.
 2. IAPWS Business and Appointment of Committees
 - 2.1 IAPWS Business since Last EC Meeting September 2023
 - 2.2 IAPWS Highlights / Press Release
 - 2.3 Evaluation Committee on International Collaboration
 - 2.4 IAPWS Awards for 2025 (Honorary Fellow, Helmholtz)
 - 2.5 Situation in Ukraine
 - 2.6 Refreshment of IAPWS Website
 - 2.7 IAPWS Executive Secretary Succession
 - 2.8 Other business requiring special/extensive discussions.
 3. EC Mandate to Working Groups and Membership
 - 3.1 ICRNs.
 4. Preview of Week's WG Activities by WG Chairmen.

Friday, 28th June 2024. Executive Committee Meeting. (9:00am – 1:00 pm). DLC Building.

5. Acceptance of Minutes of Previous IAPWS EC Meeting
6. President's Report/Remarks
7. Report and Recommendations of Joint TPWS and IRS (including SCSW)
8. Report and Recommendations of Separate IRS Meetings
9. Report and Recommendations of PCAS
10. Report and Recommendations of PCC
11. Editorial Committee Report
12. Membership and Associates
 - 12.1 Report on Membership (Italy for full membership and US on funding) and Members Defaulting on Dues
 - 12.2 Application of The Netherlands for Associate Member
 - 12.3 Reports of Associate Members (Greece, India, Israel)
13. Executive Secretary's Report
 - 13.1 IAPWS Bank Accounts, Financials, Auditors and Dues
 - 13.2 Time and Place of 2025 (Finland) and 2026 Meetings.
14. Guidelines, Releases, Certified Research Needs, and International Collaborations
 - 14.1 International Collaborations
15. IAPWS Awards
 - 15.1 Helmholtz Award Committee
 - 15.2 Honorary Fellowship
16. Future. Election of IAPWS Officers for 2025 and 2026. Next ICPWS.
17. New Business
 - 17.1 Press Release
 - 17.2 US National Committee feedback on 2024 IAPWS and ICPWS
 - 17.3 IAPWS Website
 - 17.4 Other items raised during the IAPWS week.
18. Adjournment

IAPWS Meetings and ICPWS Boulder, Colorado, USA. 23rd – 28th June 2024

(IAPWS and ICPWS Sessions will be at the University of Colorado, Boulder, Colorado, U.S.A)
(The ICPWS is a combined conference with the 22nd Symposium on Thermophysical Properties [STP])

Sunday 23 Jun.	9:00 11:00 11:00 11:00 11:00	EC Initial Meeting (ECCR 105) TPWS/IRS Joint Meeting (ECCR 150) SCSW Separate and Joint Meetings (ECCR 108) PCAS Separate Meeting (ECCR 151) PCC Separate Meeting (ECCR 105)
	Registration will be open 4:00 – 8:00pm (UMC Ballroom)	
	4:00 – 8:00 9:00 – 11:00	ICPWS/STP Welcome Reception (UMC Ballroom) Evening Social (C4C Colorado Room/Patio)
Monday 24 Jun.	8:30 8:30 – 12:30 1:45 9:00 – 11:00	Opening Plenary Session – ICPWS/STP (Math 100) Plenary Lectures Including IAPWS Gibbs Award Lecture ICPWS/STP Symposia – Afternoon (Possible IAPWS WG Meetings at discretion of WG Chair) Evening Social (C4C Colorado Room/Patio)
Tuesday 25 Jun.	8:30 7:00 -8:30 9:00 – 11:00	ICPWS/STP Symposia All Day (Possible IAPWS WG Meetings at discretion of WG Chair) IAPWS Helmholtz Award Lecture and General Assembly Meeting of IAPWS (Math 100) Evening Social (C4C Colorado Room/Patio)
Wed. 26 Jun.	8:30 6:30	ICPWS/STP Symposia (Possible IAPWS WG Meetings at discretion of WG Chair) IAPWS Banquet (Chatauqua Dining Hall) (Bus departs at 6:00 pm (6:15 from Hotels))
Thursday 27 Jun.	8:30 6:00	ICPWS/STP Symposia (Possible IAPWS WG Meetings at discretion of WG Chair) ICPWS/STP Banquet (Stadium Club)
Friday 28 June.	9:00am. 8:30 – 12:30	IAPWS Executive Meeting (9:00 – 1:00pm)(DLC) (To include one member from each National Delegation) STP Symposia

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

Barry Dooley
30th June 2024



IAPWS Thermophysical Properties of Water and Steam WG

Boulder, USA, 23 June 2024

NOTE: These Minutes include some items that were held jointly with the IRS and/or PCAS Working Groups. Items are listed according to their order on the TPWS agenda, which is Attachment A. **Bold print** denotes significant actions.

1-2. The meeting was opened on Sunday, June 23, 2024 at 9:00 by the TPWS Chair, Karsten Meier. A modified Agenda was adopted (Attachment A). The 2023 Minutes had been circulated and approved by email shortly after the 2023 meeting. Jan Hrubý was appointed Clerk of Minutes for TPWS.

3. Tributes for deceased colleagues.

A. Harvey presented a brief tribute to Anneke Levelt Sengers (1929-2024). She joined IAPWS in 1968 at IAPWS Conference in Tokyo. She served as a leader of Working Group, IAPWS President, and U.S. national representative. She was IAPWS Honorary Fellow. She was also active in promoting women in science. The Chair led the Working Groups in a moment of silence.

4. Potential International Collaborative Projects

F. Caupin presented a Proposal for a collaborative project “Guideline on the Thermodynamic Properties of Metastable Water” (F. Caupin, M. Anisimov, J. Hrubý). The goal is developing a thermodynamic property formulation describing supercooled and stretched liquid water. The resulting Guideline should replace the present “Guideline on Thermodynamic Properties of Supercooled Water” (IAPWS G12-15), which does not cover the region of stretched liquid (liquid at negative pressures). The resulting equation would provide a constraint and support for the envisaged new fundamental formulation of thermodynamic properties of ordinary water. A draft of the Proposal was sent to the WG Chair before the TPWS meeting. TPWS endorsed submission of the proposal. The Proposal was formally completed and submitted to the Executive Secretary.

5. State of Development of a New Formulation for the Thermodynamic Properties of Ordinary Water (Replacement of IAPWS-95)

A. Harvey reported on behalf of Task Group (A. Harvey, A. Giuliano Albo, F. Caupin, D. Friend, J. Hrubý, Y. Kayukawa, S. Lago, N. Okita, R. Span). Brief justification of the need of IAPWS-95 replacement: Extrapolation, unphysical oscillations near critical point, oscillations of pressure vs. density isotherm inside the binodal (multiple van der Waals loop), existence of new data. Accuracy can be improved in several regions. So far, no serious activity was developed. In frame of the running International Collaborative Project, researchers from NIST, Ruhr Universität Bochum, and Institute of Thermomechanics, Prague, will work on two main tasks: (i) Organizing a database of experimental data, (ii) Principal development of EOS showing a single van der Waals loop, suitable for modeling mixtures and phase interfaces.

6. V. Vinš reported on behalf of Task group on surface tension of ordinary water (V. Vinš, A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, R. Mareš, F. Caupin). Sufficient data exists in the region of supercooled water. New accurate data is needed above 100 °C. Several correlations suggested. However, in absence of reliable high-temperature data it does not appear practical to

change the equation. The TG will prepare an improved definition of uncertainties as an update of the surface tension release.

7. IAPWS Certified Research Needs (ICRNs)

7.1 ICRN 16: Thermophysical Properties of Seawater (R. Pawlowicz), expired 2019
WG Chair will ask R. Pawlowicz to write a concluding statement.

7.2 ICRN 28: Thermophysical Properties of Metastable Steam and Homogeneous Nucleation (J. Hrubý), expired 2019

J. Hrubý will prepare a concluding statement.

7.3 ICRN 30: Thermophysical Properties of Supercooled Water (O. Hellmuth), expired 2020
WG Chair will ask O. Hellmuth to write a concluding statement.

7.4 ICRN 31: New Thermodynamic Data for Ordinary Water (A. Harvey and J. Hrubý), expires October 2024

A. Harvey and J. Hrubý will prepare an update of the release, in particular a more detailed description of needed molecular simulation data in the regions of supercooled steam and superheated/stretched liquid.

8. Industrial Requirements and Solutions for Property Calculations (joint with WG IRS, PCAS and SCSW, N. Okita) [afternoon]

8.1 Report on a white paper for acid gas dew points (N. Okita)

8.2 N. Okita reported on behalf of the Task Group “Categories of Industrial Requirements”. An extensive table of industrial requirements was presented.

8.3 Report of the Task Group “Wet steam properties calculation”: No progress, TG remains.

8.4 Translation of IF-97 Fortran routines into other programming languages: ongoing activity, task continues (A. Nový).

8.5 M. Kunick reported on a proposal for the development of a new industrial formulation for the properties of water and steam. It was suggested that a new industrial formulation is developed in the form of SBTL method (biquadratic spline polynomials). Computations with method are up to 270 times faster than IF-97 backward equations. It is intended to publish the tables of coefficients and interpolation algorithms. It was discussed whether the splines should be based on IAPWS-95 formulation or on IAPWS-97 formulation, the latter option being preferred with respect to the users in the industry. TG will approach the industry in explaining the pros and cons of the two options.

9. Heavy Water Properties (joint with WG IRS, PCAS and SCSW)

9.1 A. Harvey reported on progress on a formulation for the static dielectric constant of heavy water (J. Cox, A. Harvey, and P. Tremaine). The new formulation should improve the behavior in the low-temperature region.

10. A. Harvey reported on the activities concerning enhancement factor of mixtures containing steam. This problem was considered in a project the EU project PROMETH2O. Further activity of IAPWS in this direction will depend on the final reports of this project, which are not yet published.

A. Harvey was appointed as an IAPWS representative for Consultative Committee for Thermometry / Working Group on humidity (CCT-WG-Hu)

11. Reports on seawater-related topics

11.1 Discussion on the future of the Subcommittee on Sea Water: discussion did not take place because of missing SCSW members. It was indicated that sea water session might attract new members.

12. Discussion on Future Activities of TPWS

12.1 Review of current TPWS task groups:

- Task Group on the Development of a New Formulation for the Thermodynamic Properties of Ordinary Water (Replacement of IAPWS-95) (A. Harvey, F. Caupin (supercooled water), D. Friend, A. Giuliano Albo (motivation of experiments), J. Hrubý, Y. Kayukawa, S. Lago (vice-chair), A. Nový, N. Okita, R. Span)
- Task Group on Surface Tension of Ordinary Water (V. Vinš, A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, R. Mareš, F. Caupin)
- Task Group on the Enhancement Factor of Mixtures Containing Steam (K. Meier, R. Hellmann, A. Harvey, V. Fericola)
- Task Group on the Formulation for the Static Dielectric Constant of Heavy Water (A. Harvey, P. Tremaine)
- Task Group on the Diffusivity of Ordinary Water (K. Yoshida, F. Caupin, A. Harvey, R. Hellmann, M. Huber)
- Task Group on Possible Revision of IAPWS Formulations for Melting Curves (V. Holten, A. Harvey, H.-J. Kretzschmar)

12.2 Possible future areas of interest to TPWS, such as the description of the properties of H₂O and D₂O ice Ih, water electrolysis and hydrogen fuel cells were discussed.

13. Report on International Collaborative Projects

Running International Collaborative Project concerns preliminary work for a new fundamental formulation of thermodynamic properties of ordinary water, see Item 5.

14. Membership

J. Sengers left TPWS for the reason of his age. His long-term contributions are highly appreciated. A summary of his contributions to the transport properties of water, as written by him, is published as an annex to these Minutes.

15. Election of a new Chair and Vice-Chair

Jan Hrubý (Institute of Thermomechanics, Prague) was elected as a new TPWS Chair and Andreas Jäger (Technische Universität Dresden) was elected as a new TPWS Vice-Chair, both starting in January 2025. Present TPWS Chair Karsten Meier remains as second TPWS Vice-Chair for 2025.

16.-17. TPWS Chair will prepare a Contribution to Press Release and the Formal Motion to the EC

18. Adjournment

The meeting was adjourned at 16:04 on Sunday, June 23, 2024.

**DRAFT Agenda for the IAPWS Working Group
Industrial Requirements and Solutions (IRS)
Boulder, CO, USA, June 23rd – June 28th, 2024**

TPWS/IRS-1. Opening Remarks; Adoption of Agenda

TPWS/IRS-2. Appointment of Clerk of Minutes

TPWS/IRS-6. Industrial Requirements and Solutions for Property Calculations (joint with WG TPWS and SCSW)

- 6.1 Report on a white paper for acid gas dew points (N. Okita)
- 6.2 Report of the Task Group “Categories of industrial requirements” (N. Okita, chairs or representatives of other WG)
- 6.3 Report of the Task Group “Wet steam properties calculation” (A. Nový, J. Hrubý, R. Span, K. Meier, F. di Mare, S. Senoo, M. Kunick)
- 6.4 Translation of IF-97 Fortran routines into other programming languages (A. Nový)
- 6.5 Proposal for the Development of an Industrial Formulation for the Thermodynamic Properties of Water and Steam based on SBTL (M. Kunick)

PCC/PCAS/IRS-7.

- 7.1 Dew Point of Low Sulphur Exhaust Gas (N. Okita, same as 6.1)

IRS-8. International cooperations/projects/challenges for IRS (Francesca di Mare, N. Okita)

IRS-9. Status of each task of industrial Requirements and Solutions

- 9.1 Report of the Task Group “Categories of industrial requirements” (N. Okita, chairs or representatives of other WG)
- 9.2 Report of the Task Group “Wet steam properties Calculation” (A. Nový, J. Hrubý, K. Orlov, R. Span, K. Meier, Francesca di Mare, S. Senoo, M. Kunick)
- 9.3 Report of the joint Task Group “Wet Steam Data from Operating Turbines” (S. Senoo, N. Okita, A. Anderko) [Joint with PCAS]
- 9.4 Report of the joint Task Group on ICRN for acid gas dew points (N. Okita, S. Senoo, T. Němec) [Joint with PCAS]
- 9.5 Report of the joint Task Group “White paper on geothermal plant issues” (N. Okita, Francesca di Mare, D. Addison, S. Terada) [Joint with PCC]
- 9.6 Translation of IF-97 Fortran routines into other programming languages (A. Nový, jointly with TPWS)
- 9.7 Calculation of mixture properties of steam and non-condensable gases (N. Okita)
- 9.8 Proposal for the Development of an Industrial Formulation for the Thermodynamic Properties of Water and Steam based on SBTL (M. Kunick)

IRS-10. Other Business

IRS-11. Membership

IRS-12. Preparation of the Formal Motion to the EC

IRS-13. Adjournment

June, 17th, 2024

F. di Mare (Chair)

Minutes of the IAPWS working group IRS, Boulder, USA, June. 23 - 28, 2023

(Numbering of the topics follows IRS agenda)

TPWS/IRS-1. Opening Remarks; Adoption of Agenda [Sunday Morning]

N. Okita (on behalf of IRS Chair F. di Mare) opened the IRS (joint with TPWS) 23. June 2024 meeting for IRS. Agenda was adopted without changes.

TPWS/IRS-2. Appointed Richard Harwood as a clerk of minutes for IRS

TPWS/IRS-6. Industrial Requirements and Solutions for Property Calculations (joint with WG TPWS and SCSW)

6.1 Report on a white paper for acid gas dew points (N. Okita)

N. Okita presented a report on a white paper for acid gas dew points.

TODO:

Consult with PCC which is better, TGD or Guideline? Later, with PCC confirmed that firstly TG drafts a white paper then decides which is better (see 7.1)

6.2 Report of the Task Group “Categories of industrial requirements” (N. Okita, chairs or representatives of other WG)

N. Okita presented the current list of items. Some discussion and comments were raised.

TODO:

Some item should be considered to ICRN. The list itself should be internal use within IRS. Later, with PCC confirmed that white paper is considered an internal document within WG.

6.3 Report of the Task Group “Wet steam properties calculation” (A. Nový, J. Hrubý, R. Span, K. Meier, F. di Mare, S. Senoo, M. Kunick)

TG leader A. Nový is absent, then no updated.

6.4 Translation of IF-97 Fortran routines into other programming languages (A. Nový)

Some discussion regarding the verification values arose: every implementation must reproduce all figures and all digits. - no updates

TODO:

A. Nový's e-mail comment is to be considered as follows:
Activity aimed to provide validation tests and requirements to check that the custom specific IF-97 implementation fully complies to the IF-97 standard. This should require testing of sample values, limits and out of limits handling, error handling, backward functions consistency, regions boundaries behavior, etc.

6.5 Proposal for the Development of an Industrial Formulation for the Thermodynamic Properties of Water and Steam based on SBTL (M. Kunick)

M. Kunick presented paper with results. The Task Group “Proposal for the Development of an Industrial Formulation for the Thermodynamic Properties of Water and Steam based on SBTL” was set up. The task group members are di Mare, Kunick, Pawellek, Hruby, Kretschmar and Okita.

TODO:

Evaluate whether IAPWS-95 or IAPWS IF-97 should be used as a basis for a new industrial formulation for water and steam. IAPWS-95 is generally preferred, but the calibration of models in the steam power industry should be avoided, which also renders IF-97 an option. Heat cycle calculations need to be performed for this purpose with IF-97 and IAPWS-95. Once a basis is chosen, SBTL property functions shall be developed and evaluated.

PCC/PCAS/IRS-7**7.1 Dew Point of Low Sulphur Exhaust Gas (N. Okita, same as 6.1)**

The same topic as 6.1. N. Okita provided status of tasks and what are PCC tasks and received commitment from PCC for support to complete the White Paper. The type of output (TGD or Guideline) will be discussed once after the white paper is finished.

TODO:

One month to review of the white paper within TG, then circulate in the PCC-WG for review. The discussion of the type of output will be followed.

8. International cooperations/projects/challenges for IRS (Francesca di Mare, N. Okita)

No international cooperations/projects/challenges to be reported.

9. Status of each task of industrial Requirements and Solutions

9.1 Report of the Task Group “Categories of industrial requirements” (N. Okita, chairs or representatives of other WG)

See 6.2

9.2 Report of the Task Group “Wet steam properties Calculation” (A. Nový, J. Hrubý, K. Orlov, R. Span, K. Meier, Francesca di Mare, S. Senoo, M. Kunick)

See 6.3

9.3 Report of the joint Task Group “Wet Steam Data from Operating Turbines” (S. Senoo, N. Okita, A. Anderko) [Joint with PCAS]

TG leader S. Senoo is absent, then no updated.

9.4 Report of the joint Task Group on ICRN for acid gas dew points (N. Okita, S. Senoo, T. Němec) [Joint with PCAS]

Same as 6.1

9.5 Report of the joint Task Group “White paper on geothermal plant issues” (N. Okita, Francesca di Mare, D. Addison, S. Terada) [Joint with PCC]

No update. See PCC minutes.

9.6 Translation of IF-97 Fortran routines into other programming languages (A. Nový, jointly with TPWS)

Same as 6.4.

9.7 Calculation of mixture properties of steam and non-condensable gases (N. Okita)

No update. Later, discussion with Ian Bell, NIST during the ICPWS confirmed that EOS-CG is a new model of GERG-2008. REFPROP could be used for EOS-CG substituting parameters.

TODO:

Confirm REFPROP can calculate by ECS-CG parameters substituting GERG-2008 parameters.

10. Other Business

No other business

11. Membership

It has been unanimously confirmed to propose new IRS members, Prof. Markus Schatz, Helmut Schmidt University and Mr. Benedikt Lea, Ruhr University.

12. Preparation of the Formal Motion to the EC

Prepared by N. Okita

13. Adjournment

Adjourned at about 12:00 July 23, 2024

PCAS WG Minutes

Boulder, US, June 23 – 28, 2024

Present:

Ken Yoshida (chair)

Hugues Arcis (vice-chair)

Andre Anderko

Sarita Weerakul

yoshida.ken@tokushima-u.ac.jp

hugues.arcis@uknml.com

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PCAS separate meeting, June, 23 morning

- (1) Agenda approved
- (2) H. Arcis appointed as the clerk of minutes
- (3) Minutes of the 2023 meeting approved
- (4) PCAS members in attendance each gave introduction and overview of their PCAS related research activities
- (5) Possibility of ICRNs
Creation of an ICRN on FFS led by PCC WG is one of possible ICRNs to which PCAS can contribute.
- (6) International collaboration
Two International Collaboration Projects (ICP) have been submitted (Iodine radiolysis by Arcis and Stuart, and FFA characterization by Yoshida and Cook). Both proposals were endorsed by PCAS, and Andre Anderko was appointed as the PCAS representative for the evaluation IAPWS Committee.
- (7) Discussion of future activities of PCAS
One of PCAS's main challenges is expanding its active membership. To address this, we decided to invite participants at this year's ICPWS who showed interest in PCAS activities to join PCAS. We made these announcements at the start of each session. This approach proved successful, resulting in productive conversations with interested participants and recommendations for new members.
- (8) Discussion of the possibility of releases and guidelines
Major revision to release on formulation for the ionization constant of light water (complete)
K. Yoshida reported that development of guidelines for the self-diffusion of water is ongoing, not at a stage yet to circulate guidelines, but making progress, and will continue to update in coming years
A joint PCAS-PCC Task Group to work on radiation chemistry and water radiolysis concepts of critical interest for irradiated aqueous systems such as those in nuclear reactors, has been proposed by Dr. Pam Yakabuskie (CNL, Canada), Dr. Hugues Arcis (NNL, UK) Dr. Jacy Conrad (INL, USA) and Dr. Martin Bachet (EdF, France). It has been identified that there is a need to re-establish access to, and continue the building of the worldwide database for reactions of water radiolysis products with impurities, and particularly to expand the database to include reaction rate constants at higher temperatures. This data forms the basis for fundamental development of radiolysis models for primary circuit chemistry and waste management streams. Radiation chemistry is an important concept for many aspects of the nuclear fuel cycle, with implications for reactor operation and chemistry control, severe accident modelling and development of mitigation plans, and waste management activities

TPWS/PCAS joint session, June, 23 afternoon.

The following presentations were given:

- Categories of Industrial Requirements and sulfuric acid dew points (N. Okita).
- Proposal for the development of a new industrial formulation for the properties of water and steam (M. Kunick) (joint with WG IRS, PCAS and SCSW) [afternoon]
- Progress on a formulation for the static dielectric constant of heavy water (J. Cox, A. Harvey, and P. Tremaine) – no progress due to staff moving to new positions; possible progress expected in 2024.
- IAPWS representative for Consultative Committee for Thermometry / Working Group on humidity (CCT-WG-Hu) – A. Harvey has volunteered pending there are virtual arrangements for the meetings in Paris (France).

ICPWS plenary session, June 24

IAPWS Gibbs Award Lecture: Thermodynamics of Water in the “Steam Engine” Climate – Rainer Feistel

ICPWS/PCAS session, June 24***Physical Chemistry of Aqueous Systems 1: Thermodynamics and Transport Properties – Chair K. Yoshida***

A Revised Formulation for the Ionization Constant of Water over a Wide Range of Temperatures and Densities, Including Near-Critical Conditions – Hugues Arcis

Improvements in Internal Consistency of Inorganic Thermodynamic Data at 298.15 K – Darrell Nordstrom

The Observation of Molecular Symmetry Evolutions in Extremely Supersaturated Aqueous Solution – Yong Chan Cho

Equilibria of Aqueous Solutions of Disodium Terephthalate, Terephthalic Acid, and Compressed Carbon Dioxide for Separations – Trevisan Melfi

Protein Diffusion in Aqueous Solution for Revealing Spectrally Silent Conformation Change – Masahide Terazima

Physical Chemistry of Aqueous Systems 2: High Temperatures-High Pressures, Electrochemistry, and Corrosion – Chair A. Anderko

High Pressure, High Temperature Rotating Cylinder Electrode for Electrochemical Corrosion Studies in Flowing Systems – Andrei Yermalayeu

Electrochemical and Fluid Properties of Electrolyte Solutions in All-Vanadium Redox Flow Batteries – Jana Heiß

Microscopic Investigations Towards the Practical Implementation of Film Forming Amines as Corrosion Inhibitors in High-Temperature Aqueous Systems – Ken Yoshida

Gibbs Energy Local Basis Function Representations for Aqueous NaCl and Ammonia-Water Solutions to 10 GPa and 2000 K – J. Michael Brown

Physical Chemistry of Aqueous Systems 3: Thermodynamic Modeling – Chair H. Arcis

A Novel Standard Gibbs Energy of Formation Model for High-Enthalpy Water Systems – Derek Hall

Modeling Speciation and Phase Equilibria of Aqueous Boric Acid and Metal Borates from Ambient to Hydrothermal Conditions – Andre Anderko

A Thermodynamically Sound and Numerically Robust Modelling Framework for Mixed Aqueous Electrolyte Solutions and for Redefining pH – Eric May

Quantifying Ion-Ion Association in Mixed Electrolyte Systems Using Bulk Thermodynamic Experimental Data – Elizabeth Ploetz

ICPWS/PCAS session, June 25, morning

Physical Chemistry of Aqueous Systems 4: Aqueous Solution Chemistry – Chair K. Yoshida

MB-pol Data-Driven Many-Body Potential: Realistic Simulations of Water Across All Phases – Francesco Paesani

Structure and Dynamics of Water-in-Salt LiTFSI Electrolytes from First-Principles Molecular Dynamics Simulations – Ilja Siepmann

Ion Dehydration Under Operating Conditions for Brine Treatment – Nathanael Schwindt

Optimization of the Route to Produce Magnetic Nanofluids – Matthias Buschmann

PCC/PCAS joint session, June, 25 afternoon.

The following presentations were given:

- Future of PCC Workshop – Paul McCann
- Electrode Boiler update – David Addison
- EPRI Nuclear Activities – Ian Duncanson
- Possibilities of Future PCC/PCAS Collaboration – David Addison
 - K. Yoshida pointed out that the work on updating the TGDs on FFS could serve as a model for collaborative efforts between PCC and PCAS.

ICPWS evening session, June, 25.

- ICPWS/STP - IAPWS Helmholtz Award Lecture & General Meetings of IAPWS

ICPWS/PCAS session, June 26, afternoon

Nuclear Reactor and Fuel Cycle Chemistry – Chairs J. Conrad & H. Arcis

Impact of KOH Primary Coolant Chemistry on Pressurized Water Reactor's Operating with Fuel Crud – Hugues Arcis

Phase Behavior and Thermodynamic Solubility Constants for Novel Nickel Sulfate Phases Formed Under Secondary Coolant Hideout Conditions – Maryanne Stones

A Re-evaluation of the Boric Acid Thermodynamics for PWR Systems – Hugues Arcis

A Simple Model for Salting In or Out in Reactor Conditions – Martin Bachet

In-situ High Temperature Radiation-Induced Metal Cation Redox Chemistry – Jacy K. Conrad

PCAS separate session, June 27 morning

PCAS New Membership proposed at the Friday EC meeting:

- Dr. Elizabeth Ploetz (Kansas State University, USA)
- Prof. Francesco Paesani (University of California San Diego, USA)
- Dr. Martin Bachet (EdF, France)
- Prof. Greg Zimmerman (Commonwealth University of Pennsylvania, USA)

**Power Cycle Chemistry Working Group (PCC WG)
Boulder, CO, 23rd to 28th June 2024**

Revision 1.1

Sunday 23 June: 11:00 – 16:00 Session

1. Introduction to PCC 2024 WG meeting

IAPWS 2024 PCC WG members were welcomed by David Addison who reviewed the schedule / agenda for the week with ICPWS sessions of interest to the WG and separate PCC WG meetings.

2. Adoption of Agenda and Minutes Approval

There were approximately 18 attendees at the PCC meeting. The agenda was adopted with the final version from the week attached as PCC Attachment A. Minutes from PCC 2024 were approved with no changes. IAPWS 2023 meeting presentations were noted as missing from the OPAL website.

Action: Addison to follow up and determine what the delay is and address.

3. Appointment of PCC WG Clerk of Minutes

Paul McCann (BIAPWS) was appointed as clerk.

4. Review of Actions from last PCC WG Meeting

See list below. The following points arising from the actions were also discussed:

22-3 ICRNs:

The formal procedure for ICRN approval was asked about which is as follows: Review by WG → review by National Committees → submit to EC for approval at meeting or by postal ballot → uploaded to IAPWS website.

22-7 International collaborations (ICs):

Barry Dooley noted that the intention of ICs is to encourage the participation of young scientists and preferably linked directly to WG activities. For PCC, electrode boiler chemistry could be a possibility to develop an IC for in 2025 due to common worldwide issues – work is in progress to consolidate issues. UNB may be able to explore small-scale electrode boiler installations; VTT (Finland) may also have this possibility.

22-16 Future PCC directions: Radiation chemistry and radiolysis collaboration.

Pam Yakabuskie stated that the IC proposed by PCAS requires an update before EC submission. The possibility of a radiolysis WG has been discussed but is currently on hold – this is linked to future PCAS/PCC collaboration opportunities.

5. IAPWS TGD Updates

An update was provided by Dooley on activities since 2023. Dooley emphasized that the main focus of PCC should be on developing and updating TGDs with the participation of WG members. The TGDs have had tremendous use and penetration around the world. The onus is on

PCC to keep the documents refreshed with latest understanding. The eleven TGDs were presented and some of the history described.

TGDs developments in progress:

- **Instrumentation** – There has been extensive work by all sub-task group (STG) members with the revision now completed and approved by editorial committee. The updated TGD will be submitted to EC for postal ballot at the 2024 meeting.
- **Corrosion products** – There has been extensive STG work including two complete revisions of the initial draft White Paper (WP). The latest draft WP includes proxy processes and the introduction of the IAPWS decay map with example applications; there is also extensive description about how to address non-optimum chemistries and shutdown protection. The new IAPWS Decay Map was presented and noted that the intention is for users to work with operators to understand the cause of any peaks in order to inform what improvements may be possible. The STG will meet during the week to finalise then circulate to PCC members. To progress to a TGD, the examples presented need to be expanded to include complete cases, i.e. to show decay profiles before and after improvement actions have been taken. Plants that have applied the draft procedure have reported favorably.
- **Film-forming substances (FFS) in nuclear plants** – This has been delayed due to external circumstances with no recent contact from the lead author. There had been discussion with steam turbine manufacturers where steam purity was frequently discussed for FFS application. Part of a skeleton was written in 2020 by Willy Cook. It was discussed whether to cancel the activity or put on-hold for the short-term. Instead a potential option for the Canadian Nuclear Laboratory (CNL) to pick up was identified following work on CANDU applications though with commercial sensitivity noted.

Action: Yakabuskie to see if CNL would take on TGD development.

- **Flue gas condensation** – The first draft of the WP was discussed. Written language needs reviewing and ideally the WP needs redrafting to make more international. It was agreed that the document can be issued as a WP after the language has been reviewed. It was also proposed to publish as a PPChem article which could be done by PPChem editors.

Action: Ben Loder to review for EN language then Nielsen to format for possible issue.

- **Geothermal** – Significant work has been done in New Zealand to validate data. The plan is to proceed straight to a draft TGD after review by Japanese manufacturers with the data considered robust enough for this. Geothermal plant in Iceland will also be contacted which also presents an opportunity to link with Nordic IAPWS.
- **Electrode boilers** – It was proposed to write a basic TGD as a first step to make knowledge available. Task Group to discuss how to progress during the meeting.
- **Dew point of low sulphur fuel gas** – This is being led by PCAS (Nobou Okita).

TGDs that may need refreshment:

- **Volatile and alkali** – Possible addition to cover knowledge now gained about use with aluminium materials, especially Heller dry cooling systems.
- **Carryover** – Addition to include measurement during load changes.
- **Steam purity** – Frank-Udo Leidich has previously suggested comments on customization as per VGB guidance.
- **Film-forming substances** – Update with knowledge gained after seven FFS conferences, e.g. possible non-commercial updates on instrumentation.

Other discussion points raised were as follows:

Addison raised the possibility of improving collaborative working within IAPWS using modern document management systems to improve work flow and management of revisions and comments plus record keeping of IAPWS documents (this is currently reliant on lead authors holding master copies).

Action: McCann / Addison to consider filesharing / collaborative working options during IAPWS website re-design.

White Papers – A clear approach is needed for the format and issuing of WPs. It was proposed to keep WPs on individual IAPWS WG website pages as they are WG products not formal IAPWS products so should not need formal review and approval by the Editorial Committee. A standard IAPWS WP template is needed which needs to be clearly different to the TGD format and would need EC approval (cont'd in later item).

Potential **future TGDs** were discussed with two suggestions to discuss further at the 2025 meeting:

- Industrial boiler chemistry guidance for steam raising plant is becoming increasingly important especially as energy markets become move diverse. Plant design is also a significant limitation that may make writing generic guidance difficult.
- BIAPWS has suggested that basic guidance is provided on how to apply the suite of TGDs. It was proposed to develop a basic roadmap for application though not as an immediate WG priority.

The need to have a **routine periodic TGD review process** was discussed. Dooley commented on the status of knowledge of each of the TGDs and noted that the majority of the TGD content remains current. The HP HRSG HP evaporator TGD may be possible to extend to boiler plant based on developing knowledge of boiler waterwall scale morphologies. Currently there is not considered to be enough data for this – more information is needed on morphology on heat transfer surfaces to understand conditions at which concentration effects can start.

The next IAPWS meeting for TGD approvals is 22-June 2024 (Helsinki meeting). To meet this date for issue, draft TGDs would need to be circulated to PCC WG members for comment by Feb-2025.

Tuesday 25th June: 1:30 – 16:00

PCC WG Meeting

a) Future Direction – PCC WG and IAPWS

Possible future directions for the PCC WG and IAPWS were discussed by McCann.

At the 2024 Turin meeting, possible technical areas of interest identified by the PCC WG were reminded as industrial plant, small modular reactors, carbon capture and storage, hydrogen products, electrode boilers and water re-use. The general consensus at Turin was that the WG should keep the focus on the water-steam cycle but move beyond fossil, focusing on plant in commercial use and tracking emerging industries and issues.

For wider IAPWS participation, McCann noted that the numbers attending meetings is declining. The power market is rapidly changing with more fragmentation of companies that makes routine attendance at annual meetings more difficult. It is also difficult to maintain engagement if a meeting is missed. Issues for IAPWS were generally characterized as 1. communication and visibility, 2. maintaining engagement with WG members and 3. lack of future strategy.

For the PCC WG, there are already new technical directions being developed and plans to improve visibility (e.g. webinars, LinkedIn). Dooley noted that WG priorities should be to maintain the TGDs as the leading worldwide guidance on power plant chemistry and that there remains a need for an FFS TGD. Future attendance could also be helped by ensuring that IAPWS plans annual meetings with the aim of limiting costs for participants (e.g. hold in easy locations to access, venue costs). If key gaps in industry knowledge are identified, it is possible to form IAPWS sub-groups to work to address.

b) Electrode Boiler WG (Addison)

The WG was established in Turin in 2023 following worldwide boiler problems. The WG main focus are immersion, electrode type, high voltage – no spray type boilers are used in Europe or NZ. A list of current issues was presented that includes: hot water boilers – generation and build up of corrosion products, hydrogen generation, explosions on shutdowns, electrode damage. There are similar issues at steam producing boilers and also other issues include arcing damage and trips. Hydrogen and oxygen are forming in the process with levels related to boiler startup, load and boiler water conductivity. The boilers use an AC power supply so hydrogen should not be generated and the mechanism for formation is not understood. Corrosion mechanisms have been inhibited by the use of film-forming amines, e.g. ODA. The WG plans to expand to include other users, consolidate issues and known answers, ideally with vendor engagement. It is also intended to publish technical papers to raise awareness. A subsequent stage will be to draft a possible TGD.

c) Report on a White Paper for Acid Gas Dewpoints - Nobuo Okita (Toshiba):

Significant work has been done by Okita to develop estimations of sulphuric acid dewpoints at low gas path temperatures at the outlet of HRSGs. This has been done by extending the data from conventional coal and oil plants and available literature to improve calculations. Three dewpoint curves and calculation formulas have been developed for the range of expected

sulphur concentrations (1 ppb to 1 ppm SO₃, 5 - 15%v H₂O) and water content in flue gases; the data has also been tabulated which may be more accurate. Error ranges have been estimated within $\pm 2-3K$. A draft WP has been prepared and circulated to Task Group members. This needs support from PCC in reviewing and providing input on reliable shutdown methods.

Action: McCann to review draft WP for EN language.

d) Filming Product Application for Use in PWRs/PHWRs - Iain Duncanson (EPRI)

Iain Duncanson (EPRI Nuclear) joined the meeting to provide an update on their filming product (FP) program. FPs have potential value in nuclear plant to reduce metal corrosion and minimise FAC. There has only been multiple applications so far using only ODAICON® (first at the Almaraz NPP in Spain). Candidate vendor products have been reviewed and a laboratory testing program is in progress and nearly complete using ODAICON, Steamate PAS6079 and PowerFilm 10000 as amine and non-amine products. No particular positive or negative impacts on general corrosion were identified. The neat amine-based solutions have a detrimental effect on elastomers; there were no significant impacts from dilute solutions. Overall the laboratory tests have shown no significant detrimental effects but also no significant drivers for application. A portable field test is being developed for the detection of an amine film on surfaces. No issues have been raised with occupational safety related to amine films on system surfaces which has been questioned in some fossil plant applications.

e) PCAS, IRS and PCC Joint Discussion

PCC current priority gaps in knowledge relate mainly to FFS (fundamentally how do they work) and electrode boiler chemistry. The electrode boiler issues described by Addison were expected to be of interest to PCAS electrochemistry specialists. The FFS TGD update would also be of significant PCAS interest. It was agreed to routinely include joint sessions at future IAPWS meetings.

Actions:

1. Addison to include joint PCC/PCAS/IRS sessions at future meetings.
2. Addison / Ken Yoshida (PCAS) to develop a list of priority topics to assist collaboration.

Wednesday 26th June: 13:30 – 15:00

PCC WG Meeting (cont'd)

a) IAPWS Website

The PCC WG will shortly have its own new page on the website. The WG description has been written and submitted to Allan Harvey. WPs will be held on the PPC website page.

b) WP Template

A draft WP template as a “TGD Draft Format” was developed by Addison with comment from other PCC members. This was approved by WG attendees for submission to the IAPWS Executive Committee (EC) for approval

Action: Addison to submit template to EC with proposal for holding on the WG website pages.

c) Corrosion Product WP

It was agreed that once the corrosion product WP was finalized and available on the IAPWS website, a summary article should be published by PPCHEM.

Action: Addison and Tapio Werder to arrange the PPCHEM publication.

d) Introducing Dutch IAPWS (Ludwin Daal)

Ludwin Daal introduced the Dutch power industry electricity production and organization in advance of formally applying for IAPWS membership. This is being done with full support of the asset owners. Members have various power plants including coal/biomass, CCGT, combined heat and power plants and one nuclear power plant. The power market is dynamic with plants cycling and mothballing and a range of water-steam cycle chemistries. Each year, the power plant chemists meet three times to discuss operating experience (two in person and one online). One meeting will be changed to an open invite to IAPWS members. The group already organizes round robin sampling campaigns and undertakes collaborative projects with a financing mechanism in place for these, e.g. TOC online measurement campaign; developing practical guidelines for condenser leak management; assessing future water use in the industry as the power market transitions away from fossil plant.

e) Hydrogen Generation and Future PCC Areas of Interest (Kirk Buecher)

Buecher provided an outlook on hydrogen generation and potential future areas of interest for the PCC WG. Gas turbines burning hydrogen can generate excess NO_x which may require water or steam injection with increased demineralized water use. Electrolysers for hydrogen production are currently either alkaline or proton exchange membrane (PEM) types. Alkaline electrolysers require temperature and conductivity control. PEM electrolysers have exotic materials for electrodes and expensive stacks that should last 5 - 7 years though the lifespan is heavily influenced by water quality (impurities blocking membrane pores and salts forming bridges). Current water quality requirements are usually either ASTM Type I or II unless manufacturers provide their own specification. Possible PCC interests include water quality requirements, corrosion mechanisms and behaviour of electrode materials. Green methanol and e-methane production was also described with various projects noted that are being developed in Finland. Water quality requirements and monitoring for electrolysers could be a potential future area for PCC. Steam generators are also often used in biofuel plants where chemistry guidance could be of value.

Action: Nielsen to explore contact with projects in Finland about possible needs.

Thursday 26th June: 09:00 – 15:00

PCC WG Meeting (cont'd)

a) PPC WG ICRNs**Conductivity of Electrolytes in Aqueous Solutions**

The draft ICRN has been reviewed. Comments received have been addressed and the ICRN will be submitted for postal ballot.

FFS

Addison has updated a draft ICRN on knowledge gaps identified from the series of FFS conferences. This will be submitted for postal ballot in the near future.

Action: Complete and submit the FFS ICRN (Addison).

Possible future ICRNs could be related to electrode boilers and corrosion and deposition processes in hydrogen electrolysers.

List of Active ICRNs

ICRN22 Turbine phase transition zone chemistry – this is already closed.

Action: Addison to request that EC confirms closed and to be moved off website.

ICRN25 Corrosion mechanisms related to contaminants in boiler water.

Action: Addison to request EC to extend to 2027.

ICRN26 Aluminium in steam-water cycles.

Action: Addison to confirm closure with EC.

b) Possible PCC Related Future International Collaborations (ICs)

Possible PCC IC opportunities were discussed. The UNB project on boiler water corrosion was described as a good example where funding provided a means of starting a project (funding equipment and setup) and also the ICs on corrosion product transport monitoring and assessment by Mads Skovbjerg and Maja Skou Jensen which also promoted student participation. These have provided good value to the PCC WG in recent years (though it was noted that overall IAPWS funds for ICs are limited). PCAS is submitting an IC on radiolysis. There were no current PCC suggestions for ICs.

c) PCC Communications

LinkedIn

Addison set up a PCC WG LinkedIn page during the meeting. Super-administrators are Addison, Nielsen, McCann and McAllister.

Webinars

The CCJ has agreed to host PCC webinars. The intention is to have the first webinar on the IAPWS TGDs and then to expand to deliver a program on power plant chemistry fundamentals. These will be recorded and made available on YouTube as training resources and to enhance PCC visibility and communications.

d) IAPWS 2025 Meeting – Helsinki, Finland, June 22 – 27 (Nielsen)

Nielsen introduced the next IAPWS meeting to be held in Helsinki, Finland (Hanaholmen / Hanasaari) on June 22 - 27. The conference hotel is ca. 7.5 km from Helsinki. Shuttles will also be put on from the city. Registration fees are ca. 800 EUR pp for the full week and 350 EUR for the symposium. Hotel room costs are ca. 144 - 164 EUR per night. The conference is being arranged with Mecca Concepts who have also supported recent IAPWS meetings. The symposium will include sessions on flue gas condensate water treatment, electrode boilers and industrial boilers.

e) AUSAPWS Update (McAllister)

The 2nd biennial AUSAPWS conference will be held on 25 – 27 March 2025 in Noosa, Queensland. The meeting is a technical event to share experiences also with workshops. Previous topics have included sessions on film-forming substances based on the latest understanding.

f) Presentations

Presentations from PCC members during the meeting were requested to be sent to Addison for uploading to the OPAL website.

g) TGD Final Updates at Meeting End

- Corrosion products – Expected to be 2-3 months to circulate as a WP as it is close to TGD status. Additional data is needed to complete the process but the majority of the document is otherwise close to TGD suitable content.
- Flue gas condensation – No further updates.
- Geothermal – It is close to being able to be issued as a TGD with submission expected with suitable timescales for approval at the Helsinki meeting.
- Electrode boiler chemistry – No further updates.
- Application of FFS in Nuclear Plants – No further updates.
- Instrumentation – Final document to be requested for postal ballot.
- Steam purity, FFS in fossil/biomass plant and Carryover – No further updates.

The definition of an IAPWS WP was extensively discussed. It was agreed to submit the corrosion product document once it is completed as this is of suitable quality by any possible definition and to review again in 2025. To canvas opinion, almost all PCC WG attendees voted in favor of making WPs available in ‘rough and ready’ format as opposed to having to develop all documents to near-TGD status.

h) Collaborative Working Practices and Tools

There is a risk related to the management of IAPWS documents without a centralized storage system. Addison recommended that the final versions of all TGDs are stored on the OPAL website subject to EC approval.

For longer-term secure document storage, Addison proposed that IAPWS considers using a Sharepoint system. This could also be used for collaborative working and potentially supported by a code of conduct for working together. This would require IAPWS purchasing a licence.

Actions:

1. Addison to recommend to EC that a copy of each of the final TGDs is held on the OPAL website.

2. Addison to recommend to EC that IAPWS considers a Sharepoint system for document management.

PCC WG Business

a) Progress Reports 2023/2024 and Future PCC Activities

Radiolysis – PCAS and PCC members met during the week to discuss how to progress. It was agreed to form a sub-task group which will be proposed to the EC.

Small Modular Reactors – Cook reported that a discussion was had about possible areas of IAPWS interest. This was recommended by Cook as an area to track. Nielsen commented that Mikko Vepsäläinen (VTT) is working on new technologies and will be invited to present on these next year.

Addison requested that any relevant interests from National Committees are fed up to the WG. It is intended to compile a priority list for PCC activities at the 2025 meeting.

b) PCC Public Relations / Contribution to Press Release

A PCC meeting highlights summary was prepared by Addison and submitted to the Editorial Committee.

c) Proposals for new TGDs summary

No additional discussion.

d) International Collaboration Projects

No ICs currently proposed.

e) ICRNs – Review and Possible New Additions

ICRN 32 to take to EC and Editorial Committee as stated previously.

FFS ICRN to be drafted by end-July for PCC circulation as stated previously.

f) Changes in PCC Membership and Election of Officers

New members voted into PCC:

- Tapio Werder, Switzerland/Germany
- Ludwin Daal, Netherlands

g) Other Business

McCann asked member to consider any photographs or images that be used on the new IAPWS website to illustrate IAPWS business and activities.

h) Adjournment

Meeting adjourned 15:20 PM June 27th, 2024.

ACTION LIST

#	PCC Area	Action	Owner	Due Date	Status	2024 update
Summary of Actions carried forward						
22-3	ICRN 32	Circulate ICRN to national committees during the week so decision can be made by EC at end of week	Addison	Before Dec. 2 nd 2022	In progress	Comments have been addressed. To be submitted to Editorial Committee.
22-4	Future PCC directions	Organize two webinars	Addison	Webinar 1: Q1 of 2023 and Webinar 2: Q3 of 2023	On hold till 2023/2024 – discussion later in PCC program	On-going. Presentation mechanism now available.
22-5	Future PCC directions	Assess scope and cross-over of hydrogen generation space with PCC and other WGs' mandates. To present his findings in Turin.	Beucher	Turin 2023	Discussion later in PCC program	Complete. Further presentations by de Vos and Buecher in 2024 meeting.
22-6	Future PCC directions	Draft future PCC document for circulation to PCC for further comment/review	Addison	Before Turin 2023	On hold till 2023/2024 – discussion later in PCC program	Superseded.
22-7	International collaborations	Submit plans or paperwork for desired upcoming international collaborations	PCC Members	Before Turin 2023	Issued – none received	Complete.
22-8	PCC description on IAPWS website	Update IAPWS website with more details and a refresh on the mandate of PCC	Addison	Before Turin 2023	Still in progress	Complete. PCC information submitted at the 2024 meeting.
22-16	Future PCC directions: radiation chemistry and radiolysis collaboration	Interface with PCAS on existing radiation chemistry activities and will propose a collaboration specific to radiolysis.	Yakabuskie	Prior to Turin 2023 meeting	Follow up with Dr. Yakabuskie.	Complete.

#	PCC Area	Action	Owner	Due Date	Status	2024 update
22-17	Future PCC directions: radiation chemistry and radiolysis collaboration	Circulate existing PCAS proposal submission on radiation chemistry task group to PCC	Addison or Dooley			Submission to be made to EC at 2024 meeting.
23-1	Dew Point at low sulphur	Addison to discuss with Andy (GE) for addition to TG	Addison			Complete.
23-2	FFA decomposition products	Int'l Collaboration Project draft for EC submission	Yoshida			Complete. IC submitted by PCAS at 2024.
23-3	FFA fouling on instrumentation	Int'l Collaboration Project draft for EC submission	Stansfield Cook			Stansfield now retired. Interest in a round-robin test program. Addison to contact Waltron to see if interest in continuing.
23-4	Flue gas condensate	Submit white paper for publication + begin TGD draft	Fogh			Superseded.
23-5	FFS in nuclear	Complete white paper draft for review	Fandrich	Dec2023		Superseded.
23-6	Water use in hydrogen electrolyzers	Contact and coordinate papers for PEM / SOEC for sessions at ICPWS 2024	Addison Beucher Cook Dooley Neilsen			Complete.
23-7	Corrosion products TGD	STG to review current comments and meet virtually to plan additions required	STG	Oct2023		On-going.
23-8	Instrumentation TGD	STG review and circulate comments / additions	STG	Oct2023		Complete.
23-9	White paper & Int'l Collaborations	Develop policy and process for promotion and release of these unofficial documents	Addison Dooley			Superseded.
23-10	Internal structure of PCC and	Close collaboration needs to be reestablished and	Addison			On-going. Discussions continuing.

#	PCC Area	Action	Owner	Due Date	Status	2024 update
	PCAS	working relationship strengthened - discussion between WG Chairs needed				Need to include all WGs.

Summary of New Actions from PCC 2024						
#	PCC Area	Action	Owner	Due Date	Status	
24-1	IAPWS meeting presentations on OPAL website	Raise at EC meeting that presentations from 2023 still need uploading. To confirm current procedure	Addison	June2024	Completed and resolved	
24-2	TGD on FFS in nuclear power plant	Ask if CNL can take this on.	Yakabuskie	June2025		
24-3	WP on flue gas condensation	Review draft WP for language.	Loder	Dec2024		
24-4	IAPWS website redesign	Check possibility to include fileshare system	McCann / Addison	June2025		
24-5	IAPWS WP proforma	Propose a common WP template to EC and recommend holding WPs on WG website pages.	Addison	Sept2024		
24-6	WP on sulphuric acid dewpoint	Review draft WP for language.	McCann	Aug2024		
24-7	PCC/PCAS joint sessions	Include a session in future annual meetings.	Addison / Yoshida	On-going		
24-8	PCC/PCAS priorities	PCC to develop a list of priority topics.	Addison / Yoshida	On-going		
24-9	Corrosion product WP	Publish a summary article in PPCHEM after the WP has been issued.	Addison / Werder	June-2025		
24-10	Hydrogen projects in Finland	Make contact with projects about possible areas of IAPWS interest.	Nielsen	June2025		
24-11	FFS ICRN	Complete and	Addison	July2024		

		submit to Editorial Committee.			
24-12	ICRN22	Request EC to close and move off website.	Addison	June2024	
24-13	ICRN25	Request EC to extend to 2027.	Addison	June2024	
24-14	ICRN26	Request EC to close.	Addison	June2024	
24-15	PCC TGD storage	Request EC that a final copy of TGDs are held on the OPAL website.	Addison	June2024	
24-16	IAPWS document storage	Request EC to consider a secure document management system, e.g. Sharepoint.	Addison	June2024	
24-17	New website images	Request for members to consider photos / images for the new IAPWS website	All members	June2025	

IAPWS Highlights 2024

18th International Conference on the Properties of Water and Steam (ICPWS) & Annual Executive Committee and Working Group Meetings

Continuing a series of conferences started in 1929, the 18th International Conference on the Properties of Water and Steam (ICPWS) was held in Boulder, Colorado on June 23-28, 2024. The Conference is organized by the International Association for the Properties of Water and Steam (IAPWS) and for the first time was combined with another conference: the 22nd Symposium on Thermophysical Properties (STP). The STP is held in the U.S. every three years and brings together experts in the theory, modeling, and measurement of thermophysical properties of fluids and solids. The joint meeting allowed a wider community of researchers to be exposed to the work of IAPWS and gave people from IAPWS the opportunity to learn about leading-edge research and applications in fields outside water and steam. The combined conference attracted 440+ attendees from 29 countries.

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 (TGDs) 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.

A primary highlight of the ICPWS is the awarding of the IAPWS Gibbs Award for outstanding technical achievements in an area of interest to IAPWS. The Gibbs Award is only given every four to five years in conjunction with the ICPWS and this year was awarded to Dr. Rainer Feistel (Germany) for exceptional IAPWS contributions to the creation of the international seawater standard, TEOS-10; establishment and leadership of the IAPWS Subcommittee on Seawater, SCSW; and leadership in building a broad international consensus on standards for seawater thermodynamics. Dr. Feistel accepted his award and provided the keynote lecture entitled



“Thermodynamics of Water in the “Steam Engine” Climate” to kick-off the joint conference. Also, during the IAPWS General Assembly, Dr. Sebastian Herrmann (Germany) presented the Helmholtz lecture *“From Accurate Viscosity Measurements to Wide-ranging Viscosity Formulations including the Near-critical Region Applying a Structural-optimization Method”* and received the Helmholtz Award. This is given annually to an early-career researcher and this year was given for high precision measurements of the viscosity of gases and successful application of the structural-optimization method on the correlation of viscosity formulations including the critical enhancement with outstanding accuracy which is accepted worldwide.

The IAPWS banquet was held in the historic Chautauqua Dining Hall. The Boulder Chautauqua, in a beautiful location against the foothills of the Rocky Mountains, is one of the best-preserved examples of the Chautauqua movement for culture and education that swept the United States around the year 1900. During the banquet, Nobuo Okita (Japan) was given the IAPWS Honorary Fellow Award for advancing the use of IAPWS formulations in the power industry, and for leadership of the IAPWS Working Group on Industrial Requirements and Solutions.



Given the busy schedule of the combined conferences, the annual meetings of the IAPWS Executive Committee and Working Groups began on Sunday June 23rd and continued sporadically throughout the week with the following highlights from each groups' activities.

The Thermophysical Properties of Water and Steam (TPWS) working group will examine the feasibility of a new industrial formulation in form of the SBTL method (biquadratic spline polynomials). Computations with the method are up to 270 times faster than the IF-97 backward equations. It is intended to publish the tables of coefficients and interpolation algorithms based upon the IAPWS-97 formulation, which is preferred by some industrial users. A task group will approach the industry to explain the drawbacks and benefits. Another task group is defining the path for eventual replacement of the standard reference equation of state for water and steam known as IAPWS-95.

The Industrial Requirements and Solutions Working Group (IRS) prepared a white paper on accurate estimation of low sulfur dew point in gas turbine combined-cycle plants for efficient operation to avoid acid corrosion. Furthermore, it was proposed that the SBTL method for fast calculation of the properties of water and steam to become a standard and a task group has been established for its review. Other task groups have been established to define verification standards for the "Translation of IF97 Fortran routines into other programming languages" and examining the requirements for industrial calculations and data. Finally, IRS offers the warmest congratulations to Nobuo Okita for his IAPWS Honorary Fellow award.

The Physical Chemistry of Aqueous Systems (PCAS) working group prepared two proposals for IAPWS International Collaboration projects, one concerning the effect of radiation on iodine chemistry under low dose rate conditions and the other regarding the effect of film-forming amines on flow-accelerated corrosion. In collaboration with the TPWS working group, PCAS contributed to a Revised Release on the Ionization Constant of H₂O, based on a re-evaluation of the data including new near-critical and supercritical conductivity data. PCAS had 17 presentations from 6 countries during the ICPWS and at a joint meeting with Power Cycle Chemistry (PCC) working group, there was an exchange of information on available literature and research needs related to film forming substances and electrode boilers.

The Power Cycle Chemistry (PCC) working group has revised the Instrumentation TGD that is now ready for approval and has completed a new white paper on corrosion product transport in cycling plants. The white paper introduces a new IAPWS corrosion product decay map to assist the practical interpretation of plant chemistry performance, especially during shutdown and start-up operation. A key new area is the water/steam/corrosion issues in electrode boilers and

investigating the water chemistry requirements for hydrogen generation plants. Other areas of active work include boiler corrosion thresholds, geothermal steam purity and dew point of low sulfur exhaust gas. An ongoing strategy is in place to increase the outreach and profile of PCC internationally with PCC webinars to commence soon.

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 held in Helsinki, Finland from the 22nd – 27th June 2025. Further information on meetings can be found at the IAPWS website (www.iapws.org) as it becomes available. People interested in IAPWS documents and activities should contact the chairman of their IAPWS National Committee (see website) or the IAPWS Executive Secretary, Dr. R. Barry Dooley, bdooley@iapws.org. People do not need to be citizens or residents of member countries to participate.

Czech Society for the Properties of Water and Steam
Annual Report 2024

Submitted to IAPWS Executive Committee, June 2023

Steering board of CZPWS

Chair: Jan Hrubý (Institute of Thermomechanics of the Czech Academy of Sciences - IT CAS, hruby@it.cas.cz), Vice-Chair: Milan Sedlář (SIGMA Research and Development Institute), Secretary: Ondřej Bartoš (Czech Technical University in Prague), Member: Adam Nový (Doosan Škoda Power, s. r. o.), Member: Vladimír Majer (Technical University of Liberec).

CZPWS Meetings

Annual meeting of the CZPWS was held on June 18, 2024. The form of the meeting was hybrid. CZPWS members were informed about the activities of CZPWS Chair and approved CZPWS Financial Statements. CZPWS is a member of the Council of Scientific Societies of the Czech Republic (CSSCR). Member fee for 2024 and, expectedly, future CZPWS Member Dues to IAPWS will be paid based on the CZPWS membership in CSSCR. The meeting was followed by a symposium with scientific presentations by Aleš Blahut, Václav Vinš, and Jan Hrubý.

Research

In collaboration with the Ruhr University Bochum and the Technical University Dresden, the van der Waals and Platteeuw model for gas hydrates combined with the multiparameter EoSs, including IAPWS-95 formulation for water, has been successfully extended to account for a multiple cage occupancy of water cavities by gas molecules [1]. This is important especially for accurate modeling of hydrogen hydrates showing up to quadruple occupancy of the large cavities in the crystal structure sII. At 22nd European Conference on Thermophysical Properties, the IT CAS team has presented new experimental data for the surface tension of aqueous mixtures with methanol including the temperature range under the metastable supercooled state [2].

At IT CAS, Jan Hrubý continued in the development of a new mixture model, applicable to contemporary Helmholtz energy models, which is consistent with the rigorous mixing rules for virial coefficients. Published results [3] include general formulation of the model, virial expansion up to 4th degree, and finding that a simple variant of the model gives identical results when applied to a two-parameter cubic equation of state as the standard approach using van der Waals mixing rules. Further work (to be reported at 18th ICPWS in Boulder) included predictive computations of thermodynamic properties and phase equilibria for simple fluid mixtures, which proved to be successful. It turned out, however, that modeling vapor-liquid phase equilibria (VLE) and states close VLE requires that the equations of state show single van der Waals loop between saturated vapor and saturated liquid densities. The present multiparameter equations of state, including IAPWS-95, exhibit multiple van der Waals loops. Consequently, it appears highly desirable that the future fundamental formulation of the properties of ordinary water shows a single van der Waals loop and it is as much as possible supported by experimental data and molecular simulations in the metastable vapor and liquid regions.

The problems studied in the SIGMA Research and Development Institute and the Centre of Hydraulic Research in the period of June 2023 – June 2024 have been related mainly to the modelling of cavitation erosion during the hydrodynamic cavitation and to the thermal effects of

cavitation and the exact description of water and water vapour properties during the cavitation flows. In cooperation with the Institute of Physics/Czech Academy of Sciences, the tests of cavitation resistance of steel samples treated with Laser Shock Peeling (LSP) and 3D printed samples with different surface patterns have continued from the last two years. The cavitation erosion stand has been reconstructed for higher speeds and equipped with the transparent lid enabling continuous monitoring by cameras. These tests have been accompanied by advanced numerical simulations. Some experimental and simulation results will be presented in the 5th International Symposium on Thermal-Fluid Dynamics (ISTFD 2024), Xi'an, China, July 26 – 29, 2024 [4]. Concerning the thermal effects of cavitation, a new hot water cavitation tunnel (Venturi type) has been designed and put into the production phase. It is equipped with two sapphire windows which will enable to measure in the infra-red spectrum. Supporting simulations of cavitating flow in the temperature range of 25 – 175 °C have been performed to confirm the functionality and design parameters.

Adam Nový (Doosan-Skoda Power) continued in activities relevant to RIS WG, in particular:

- validation procedure for IF97 implementations in other programming languages than Fortran,
- discussion on future steam properties formulation,
- discussion of strategy to support proposal of Spline-Based Table Look-Up Method (SBTL) as new IAPWS release.

References

1. Fiedler, F., Vinš, V., Jäger, A., Span, R.: Modification of the van der Waals and Platteeuw model for gas hydrates considering multiple cage occupancy. *Journal of Chemical Physics*. Roč. 160, č. 9 (2024), č. článku 094502. ISSN 0021-9606. E-ISSN 1089-7690.
2. Vinš, V., Součková, M., Čenský, M., Prokopová, O., Hrubý, J., Blahut, A., Aminian, A.: Surface tension of low-concentration aqueous mixtures with methanol and ethylene glycol including metastable supercooled state. *22nd European Conference on Thermophysical Properties /22./*. 10.09.2023-13.09.2023, Venice, s. 255-255. ISBN 9791221042207.
3. Hrubý, J: A General Model for Thermodynamic Properties of Fluid Mixtures Based on Helmholtz Energy Formulations for the Components. Virial Expansion and Reduction to van der Waals Mixing Rules. *Int J Thermophys* 44, 130 (2023).
4. Sedlář, M., Koutný, A., Krátký, T., Komárek, M., Fulín, M.: Prediction of Cavitation Erosion Using CFD and Bubble Dynamics Model. *Extended Abstract of 5th International Symposium on Thermal-Fluid Dynamics (ISTFD 2024)*, to be published in August 2024.

GSAPWS to IAPWS Executive Committee
**Research Activities on the Properties of Water and Steam
of the German-Swiss Association for the Properties of Water and Steam (GSAPWS)
e.V.
in the Period 2023/2024**

<https://gsapws.org>

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

Second Chair: Michael Rziha
PPCHEM AG, Hinwil, Switzerland

Deputy Chair: Prof. Dr. Karsten Meier
Helmut Schmidt University, Hamburg, Germany

Deputy Chair: Tapio Werder
PPCHEM AG, Hinwil, Switzerland

The 2024 General Meeting and the Annual Meeting of the German-Swiss Association for the Properties of Water and Steam (GSAPWS) took place at the Dresden University of Technology on 14 and 15 March, 2024.

In the following, activities of certain members of the German-Swiss Association for the Properties of Water and Steam in the years 2023 to 2024 are summarized.

**Baltic Sea Research Institute, Warnemuende Dr.
Rainer Feistel**

Recent Publications

- McDougall, T.J., Barker, P.M., Feistel, R., Roquet, F.:
A thermodynamic potential of seawater in terms of Absolute Salinity, Conservative Temperature, and in situ pressure.
Ocean Sci. 19(2023), 1719–1741. <https://doi.org/10.5194/os-19-1719-2023>
- Ebeling, W., Feistel, R., Haß, E.-C., Plath, P.:
Zu Problemen der mechanisch-chemisch-elektrischen Energiewandlung und des Transports hochwertiger Energie im Kontext des Klimawandels.
Leibniz Online 50 (2023), <https://doi.org/10.53201/LEIBNIZONLINE50>
- Feistel, R.:
On the Evolution of Symbols and Prediction Models.
Biosemiotics 16 (2023), 311–371, <https://doi.org/10.1007/s12304-023-09528-9>
- Feistel, R. (2023):
Self-Organisation of Prediction Models.
Entropy 25 (2023), 1596. <https://doi.org/10.3390/e25121596>
- Feistel, R., Hellmuth, O.:
Thermodynamics of Evaporation from the Ocean Surface.
Atmosphere 14 (2023), 560. <https://doi.org/10.3390/atmos14030560>
- Feistel, R., Hellmuth, O.:

Irreversible Thermodynamics of Seawater Evaporation.
 J. Mar. Sci. Eng. 12 (2024), 166. <https://doi.org/10.3390/jmse12010166>

- Feistel, R., Hellmuth, O.:
 TEOS-10 Equations for the Lifted Condensation Level (LCL) and Climatic Feedback of Marine Clouds.
 Preprints 2024031171 (2024). <https://doi.org/10.20944/preprints202403.1171.v1>
 submitted to "Oceans", under review
- Feistel, R.:
 TEOS-10 and the Climatic Relevance of Ocean-Atmosphere Interaction.
 EGUshere (2024), <https://doi.org/10.5194/egusphere-2024-1243>

GFZ German Research Centre for Geosciences

Section 4.8 – Geoenergy, Potsdam

Dr. Harald Milsch, Ulrike Hoffert

Projects

In the framework of the EU-H2020 Project “REFLECT” thermophysical investigations are performed on highly saline geothermal fluids:

1. In the past, aqueous solutions of NaCl, CaCl₂ and defined mixtures thereof were parameterized for density up to saturation, at temperatures between 293 K and 353 K, and ambient pressure. In cooperation with BRGM, France, the resulting original (ca. 550) new data points were compared with density predictions from numerical modelling using the PHREESCALE geochemical code (Lach et al., 2016; 2017) yielding a satisfying match for geothermal applications within an error band of approximately 1%. A publication of these findings was submitted to *Geothermal Energy* (Springer; Hoffert et al., 2024a; see below).
2. For the same set of samples at the mentioned conditions, viscosity was determined yielding a full parameterization of the extended Jones-Dole-Equation. A publication of these findings is currently in preparation and will also be submitted to *Geothermal Energy* (Springer; Hoffert et al., 2024b; see below).
3. Geothermal fluids display a huge variability in chemical composition and salinity. The approach that is pursued at GFZ is to fill the existing data gaps systematically by determining the properties of synthetic fluids containing the main salts only, i.e. typically NaCl, CaCl₂, and KCl. To evaluate the error in density and viscosity that comes with neglecting the minor constituents of natural fluids, four European geothermal sites are selected that span a huge variability in salt concentration and composition. For each site, four synthetic samples are prepared and parameterized, one containing the main salts only and three others containing two dominant minor salts as pure and mixed additions to the base solution. This study is ongoing and the results will be published after completion.

Recent Publications

- Ulrike Hoffert, Laurent André, Guido Blöcher, Sylvain Guignot, Arnault Lassin, Harald Milsch, Ingo Sass (2024a): Density of pure and mixed NaCl and CaCl₂ aqueous solutions at 293 K to 353 K and 0.1 MPa: An integrated comparison of analytical and numerical data. *Geothermal Energy*, under review.

- Ulrike Hoffert, Guido Blöcher, Stefan Kranz, Harald Milsch, Ingo Sass (2024b): Viscosity of pure and mixed NaCl and CaCl₂ aqueous solutions at 293 K to 353 K and 0.1 MPa: A parameterization of the extended Jones-Dole Equation with original analytical data. Geothermal Energy, in preparation.

**Helmut Schmidt University / University of the Federal Armed Forces Hamburg,
Institute of Thermodynamics**

Prof. Dr. Karsten Meier, Dr. Robert Hellmann

Project

1. Thermophysical properties of mixtures of water vapor and simple gases from first-principles calculations.

Recent Publications

- **A. El Hawary, K. Meier:**
Highly Accurate Densities and Isobaric and Isochoric Heat Capacities of Compressed Liquid Water Derived from New Speed of Sound Measurements
Int. J. Thermophys. 44, 180 (2023) (Open Access).
- Hellmann, R.:
Cross Second and Third Virial Coefficients and Dilute Gas Transport Properties of the (H₂O + Ar) System from First-Principles Calculations.
J. Chem. Eng. Data 69, 942-957 (2024).

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

Recent Publications

- Feistel, R., Hellmuth, O.:
Thermodynamics of Evaporation from the Ocean Surface.
Atmosphere 14 (2023), 560. <https://doi.org/10.3390/atmos14030560>
- Feistel, R., Hellmuth, O.:
Irreversible Thermodynamics of Seawater Evaporation.
J. Mar. Sci. Eng. 12 (2024), 166. <https://doi.org/10.3390/jmse12010166>
- Feistel, R., Hellmuth, O.:
TEOS-10 Equations for the Lifted Condensation Level (LCL) and Climatic Feedback of Marine Clouds.
Preprints 2024031171 (2024). <https://doi.org/10.20944/preprints202403.1171.v1>
submitted to "Oceans", under review

PPCHEM AG, Hinwil

Tapio Werder, Michael Rziha

The activities for the PCC WG were limited only to a minor contribution for the amendment / revision of the existing TGD2-09 Instrumentation for monitoring and control of cycle chemistry for the steam/water circuits of fossil-fired, combined cycle and industrial power plants.

**PTB German National Metrology Institute
Working Group 3.13, Electrochemistry Dr.
Steffen Seitz**

Projects:

1. The working group 3.13 'Electrochemistry' (WG 3.13) of PTB is led by Dr. Seitz. It is part of the European metrology research project "SApHTIES". The project aims has established traceability for spectrophotometric measurements of the pH_T of seawater, a quantity needed to monitor ocean acidification due to anthropogenic CO_2 emissions. WG 3.13 has developed empirical equations with associated uncertainties which can be used to assign pH_T values to primary artificial seawater standards from Harned cell measurements in dependence of salinity and temperature over ranges relevant in oceanography. A respective publication is in preparation.
2. Furthermore, WG 3.13 is associated with SCOR Working Group 145. The aim of WG 145 is to develop a user-friendly comprehensive chemical speciation model of seawater and related natural waters. WG 3.13 has, together with the metrology institutes of the US, France and Japan, carried out new potentiometric measurements, that have been used by other partners in WG145 to characterize the thermodynamic properties and speciation in the major and minor components of seawater, and in the aqueous buffers used to calibrate instruments for measuring pH, which includes working on an uncertainty analysis of currently available data and "Pitzer" speciation models. The speciation model has been published by the partners. Another publication, including the evaluation of PTB's measurement data is in preparation.
3. WG 3.13 is part of the European Horizon 2020 Project MINKE. MINKE (Metrology for Integrated Marine Management and Knowledge-Transfer Network) is an Horizon 2020/INFRAIA project that brings together 16 key European marine metrology research infrastructures to coordinate their use and development and propose an innovative framework of 'quality of oceanographic data' for the different European actors in charge of monitoring and managing the EOVs (Essential Ocean Variables) and marine ecosystems. MINKE includes also research activities to some extent. In this regard, WG 31.3 establishes a measurement and calibration set-up for high pressure salinity measurements. Furthermore, PTB has contributed to establish links between MINKE and the European Metrology Network for Climate and Ocean Observation (see <https://www.euramet.org/climate-and-ocean-observation>)

Ruhr University Bochum

**Faculty of Mechanical Engineering, Chair of Thermal Turbomachines and Aeroengines
Prof. Dr. Francesca di Mare**

Projects:

1. Extension of the in-house code SharC for investigations of the flow in radial turbines including its disc cavities using the Spline Based Table Lookup Method (SBTL) applied for the Span-Wagner reference equation of state.
 - a. Interfaces between adjacent blade rows and between the main channel and the cavities are modeled in a highly conservative and efficient manner by using the

SBTL to compute primitive variables, such as pressure, from the enthalpy flux across cell boundaries.

- b. Within the AG Turbo project DigITecT AP2.2b the extended version of the CFD solver was applied to assess the performance of a newly developed turbine stage, the role of non-ideal thermodynamic effects in the flow field and the axial thrust acting on the impeller wheel. The results will be presented on the ASME Turbo Expo 2024 in London and published in the conference proceedings¹.

Recent Publication:

- [1] Lea, B.; Franz, H.; di Mare, F.:
 Numerical Investigation of the axial thrust load of a prototype radial turbine for supercritical CO₂ cycles.
 Proceedings of ASME Turbo Expo 2024: Turbine Technical Conference and Exposition. Paper No. GT2024-123806 (accepted).

Ruhr University Bochum

Faculty of Mechanical Engineering, Chair of Thermodynamics

Prof. Dr. Dr. h.c. Roland Span

Projects:

1. Our project on hydrate formation of hydrogen and its mixtures, which is carried out in cooperation with colleagues from the Institute of Thermomechanics of the Czech Academy of Sciences in Prague and from TU Dresden, is approaching the end of the first project phase. The consideration of hydrogen required an extension of the hydrate model to account for multiple occupation of cavities with up to five hydrogen molecules in large SII cavities. A Journal publication explaining the way how this can be treated numerically has been published end of 2023 [1]. The performance of the hydrate model greatly benefits from accurate models of the fluid phases; a new Helmholtz mixture model for the system water / hydrogen is under development.
2. Our work in the area of property models for CCS technologies and in particular for transport of CO₂-rich mixtures resulted in a broad involvement in processes attempting to specify characteristics of CO₂-rich mixtures for multimodal CO₂-transport. The aim is to develop a European CO₂-backbone with discrimination free access for all emitters (for which emissions can hardly be avoided in different ways). The work includes memberships in the corresponding committees of ISO, DIN, DVGW, CEN and in the expert group on CO₂ characteristics implemented by the European Commission. The results obtained by this expert group in 2023 have been published as a report by the European Commission [2]. The latest version of our mixture model for CO₂-rich mixtures, EOS-CG-2021, has been published [3].

Recent Publication:

- [1] Fiedler, F.; Vinš, V.; Jäger, A.; Span, R.:
 Modification of the van der Waals and Platteeuw Model for Gas Hydrates Considering Multiple Cage Occupancy.
 Journal of Chemical Physics (2024), 160 (9), 094502.
<https://doi.org/10.1063/5.0189555>.

- [2] An Interoperable CO₂ Transport Network – Towards Specifications for the Transport of Impure CO₂. Report of the CCUS Forum Expert Group on CO₂ Specifications. <https://zeroemissionsplatform.eu/wp-content/uploads/An-Interoperable-CO2-Transport-Network.pdf>
- [3] Neumann, T.; Herrig, S.; Bell, I.; Beckmüller, R.; Lemmon, E.W.; Thol, M.; Span, R.: EOS-CG-2021: A Mixture Model for the Calculation of Thermodynamic Properties of CCS Mixtures. *Int. J. Thermophysics* (2023), 44. <https://doi.org/10.1007/s10765-023-03263-6>

SWAN Analytische Instrumente AG, Hinwil (Switzerland)

Mar Nogales

Following Technical Guidance Document (TGD) is presently in revision:

- TGD2-09(2015) Instrumentation for monitoring and control of cycle chemistry for the steam-water circuits of fossil-fired and combined cycle power plants

During 2023 and 2024, this TGD will be reviewed. Based on this, the document is updated/revised.

Technical University of Dresden

Institute of Power Engineering, Thermal Power Machinery and Plants

Dr. Andreas Jäger

Projects:

1. The cooperation regarding the establishment of gas hydrate models, in particular hydrogen hydrates, with colleagues from the Institute of Thermomechanics of the Czech Academy of Sciences in Prague and from Ruhr-University Bochum is continued. TU Dresden is supporting the work, which is mainly carried out within a DFG-project by Ruhr-University Bochum with Dr. Václav Vinš from the Czech Academy of Sciences being a “Mercator Fellow” of the project. Results of the common work concerning the modification of the van der Waals and Platteeuw model in order to consider multiple cage occupancy for hydrogen hydrates have been published in a joint publication at the beginning of this year [1].
2. Within the project “Optisyskom”, heat transfer coefficients in annular cavities in the casing of steam turbines are investigated experimentally and theoretically. The first experimental campaign with air is finished and the results have been presented and published at the AG Turbo Statusseminar in Cologne [2].

Recent Publications:

- [1] Fiedler, F.; Vinš, V.; Jäger, A.; Span, R.:
Modification of the van der Waals and Platteeuw Model for Gas Hydrates Considering Multiple Cage Occupancy.
Journal of Chemical Physics (2024), 160 (9), 094502.
<https://doi.org/10.1063/5.0189555>.
- [2] Paulick, O.; Jäger, A.; Eschmann, G.; Uffrecht, W.; Worlitz, N.:
Thermofluidodynamik in Gehäuseseitenräumen mit Dampfzufuhr und -entnahme im lastflexiblen Betrieb von Industriedampfturbinen.
In Tagungsband 18. Statusseminar AG Turbo; Cologne (2024).

**Zittau/Goerlitz University of Applied Sciences, Faculty of Mechanical Engineering,
Zittau / KCE-ThermoFluidProperties, Amberg**
**Prof. Dr. Matthias Kunick, Prof. Dr. Hans-Joachim Kretzschmar,
Dr. Sebastian Herrmann**

Projects

1. Development of fast property-calculation algorithms for gaseous mixtures of water with non- condensable gases in thermo-hydraulic process simulations:
 - Development of computationally efficient algorithms for the properties of gaseous mixtures of water vapor with Ar, CO, CO₂, He, H₂, N₂, and O₂. The mixture model combines the ideal mixing of real fluids with a residual part obtained from a virial-mixing approach or a one-fluid model.
 - Implementation and verification of the property library LibSBTL95 in ATHLET.
2. Application of the Spline-Based Table Look-Up Method (SBTL) to humid air
 - SBTL functions have been developed for water and steam as well as for dry air and the enhancement factor. These SBTL functions have been implemented into a new property library for humid air which is successfully applied at the Fraunhofer UMSICHT, Oberhausen, for the simulation of Advanced Adiabatic Compressed Air Energy Storages (AA-CAES).
 - Implementation and verification in the software KRAWAL of Siemens
3. Application of the Spline-Based Table Look-Up Method (SBTL) to ammonia-water mixtures
 - SBTL functions have been developed for the vapor-liquid phase equilibrium of ammonia-water mixtures. The phase equilibrium is calculable from (p, T) , (p, ξ) , (p, ξ_v) , (T, ξ) , and (T, ξ_v) inputs. These functions guarantee convergence and drastically increase the computing speed.
 - Three dimensional SBTL functions are being developed in order to demonstrate the method for three independent input variables as in $T(p, h, \xi)$.
4. Development of a new ASHRAE standard for calculating thermodynamic properties of moist air, ASHRAE Project SPC 213P: Method for Calculating Moist Air Thermodynamic Properties.
 - The vapor pressure and saturation temperature equations of the IAPWS-IF97 Industrial Formulation and the melting pressure equation of the IAPWS Formulation 2011 are being incorporated into the new ASHRAE Standard, Method for Calculating Moist Air Thermodynamic Properties.
5. Preparation of Chapter 1 Psychrometrics for the 2025 ASHRAE Handbook of Fundamentals.
 - Tables with values of thermodynamic properties calculated from the IAPWS-IF97 Industrial Formulation and of transport properties calculated from the IAPWS Formulation 2008 for the viscosity and from the IAPWS Formulation 2011 for the thermal conductivity of water are being incorporated into the 2025 ASHRAE Handbook of Fundamentals.

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.; 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.; Vogel, E.:
Viscosity Measurements on Natural Gas: Re-evaluation.
Int. J. Thermophys. 44, 177 (2023).
<https://doi.org/10.1007/s10765-023-03280-5>

**Current Status of Research Activities in Japan
Submitted to the Executive Committee Meeting, IAPWS,
June, 2024**

**Japanese National Committee, Chaired by Professor Kenji Yasuoka
International Association for the Properties of Water and Steam
c/o The Japan Association for the Properties of Water and Steam
Chaired by Professor Kenji Yasuoka
3-14-1 Hiyoshi, Kohoku-ku,
Yokohama 223-8522, Japan**

I. Overview:

The Japan National Committee of IAPWS continues to endeavor to make closer and innovative interactions between engineering and academic groups with respect to the international and domestic energy-related issues. The key points 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:

Yasuoka, Kenji

Professor, Department of Mechanical Engineering, Keio University

email: yasuoka@mech.keio.ac.jp

URL: https://k-ris.keio.ac.jp/html/100011311_en.html

Novel approach for designing order parameters of clathrate hydrate structures by graph neural network

S. Ishiai, K. Endo, P. E. Brumby, A. K. Sum, K. Yasuoka

J. Chem. Phys., 160, 064504 (11 pages), 2024

Graph-Neural-Network-Based Unsupervised Learning of the Temporal Similarity of Structural Features Observed in Molecular Dynamics Simulations

S. Ishiai, I. Yasuda, K. Endo, K. Yasuoka

J. Chem. Theory Comput., 20, 819-831, 2024

Unsupervised deep learning for molecular dynamics simulations: a novel analysis of protein–ligand interactions in SARS-CoV-2 Mpro

J. Mustali, I. Yasuda, Y. Hirano, K. Yasuoka, A. Gautieri, N. Arai

RSC Adv., 13, 34249-34261, 2023

Pre-Smectic Ordering and the Unwinding Helix in Monte Carlo Simulations of Cholesteric Liquid-Crystals

P. E. Brumby, A. Kowaguchi, T. Nozawa, K. Yasuoka, H. Wensink

J. Phys. Chem. B, 127, 7194-7204, 2023

Graph neural networks classify molecular geometry and design novel order parameters of crystal and liquid

S. Ishiai, K. Endo, K. Yasuoka
J. Chem. Phys., 159, 064103 (16 pages), 2023

Report on IAPWS Annual Meeting 2022

K. Yoshida, K. Yasuoka
The Thermal and Nuclear Power, 74, 46-52, 2023

Learned pseudo-random number generator: WGAN-GP for generating statistically robust random numbers

K. Okada, K. Endo, K. Yasuoka, S. Kurabayashi
PLOS One, 18, e0287025 (19 pages), 2023

Wetting hysteresis induces effective uni-directional water transport through a fluctuating nanochannel

N. Arai, E. Yamamoto, T. Koishi, Y. Hirano, K. Yasuoka, T. Ebisuzaki
Nanoscale Horiz., 8, 652-661, 2023

Combining molecular dynamics and machine learning to analyze shear thinning for alkane and globular lubricants in the low shear regime

I. Yasuda, Y. Kobayashi, K. Endo, Y. Hayakawa, K. Fujiwara, K. Yajima, N. Arai, K. Yasuoka,
ACS Appl. Mater. Interfaces, 15, 8567-8578, 2023

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>

Solvation dynamics on the diffusion timescale elucidated using energy-represented dynamics theory

K. Okita, N. Ito, N. Morishita-Watanabe, H. Umakoshi, K. Kasahara, N. Matubayasi
Phys. Chem. Chem. Phys., 26, 12852-12861, 2024

How ATP suppresses the fibrillation of amyloid peptides: analysis of the free-energy contributions

T. M. Do, D. Horinek, N. Matubayasi
Phys. Chem. Chem. Phys., 26, 11880-11892, 2024

Biased Bowl-Direction of Monofluorosumanene in the Solid State

Y. Yakiyama, M. Li, D. Zhou, T. Abe, C. Sato, K. Sambe, T. Akutagawa, T. Matsumura, N. Matubayasi, H. Sakurai
J. Am. Chem. Soc., 146, 5224-5231, 2024

Actual Amount Adsorbed as Estimated from the Surface Excess Isotherm

S. Shimizu, N. Matubayasi
Langmuir, 40, 1666-1673, 2024

Free-energy decomposition of salt effects on the solubilities of small molecules and the role of excluded-volume effects,

S. Hervø-Hansen, D. Lin, K. Kasahara, N. Matubayasi
Chem. Sci., 15, 477-489, 2024

Replacing the Langmuir Isotherm with the Statistical Thermodynamic Fluctuation Theory
S. Shimizu, N. Matubayasi
J. Phys. Chem. Lett., 15, 3683-3689, 2024

Unraveling the Glass-like Dynamic Heterogeneity in Ring Polymer Melts: From Semiflexible to Stiff Chain
S. Goto, K. Kim, N. Matubayasi
ACS Polym. Au, 3, 437-446, 2023

Elucidating protein-ligand binding kinetics based on returning probability theory
K. Kasahara, R. Masayama, K. Okita, N. Matubayasi
J. Chem. Phys., 159, 134103 (15 pages), 2023

Cooperativity in Sorption Isotherms
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Nuclear Magnetic Resonance Analysis of Hydrothermal Reactions of Ethyl- and Octylamine in
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K. Yoshida, A. Doi, H. Yoshioka, T. Hirano, M. Nakahara
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Nuclear Magnetic Resonance Analysis of Hydrothermal Reactions of Ethyl- and Octylamine in
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Earth Science and Technology (JAMSTEC)
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Turbulence across the Antarctic Circumpolar Current in the Indian Southern Ocean: Micro-
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Ichihara, Taro

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Hydrogen Damage in Power Boiler: A Study of Damage Selectivity and Conditions

T. Ichihara, Y. Amano, M. Machida
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Study of Hydrogen Damage in Boiler Evaporator Tube: Damage Selectivity and Conditions

T. Ichihara
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Nakatsuchi, Yuta

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Study of Novel Water Quality Management System in the Steam-Water Circuit of Gas Turbine Combined Cycle Power Plants

Y. Nakatsuchi
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Novel Identification Method of Seawater Contamination into Steam-Water Circuit Including Carbon Dioxide of Power Plants based on pH, Specific Conductivity, and Cation Conductivity
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Big Data Factorial Analysis using Plant Operational Data for Dose Rate Reduction
N. Ishihara, Y. Mukai, S. Yamazaki, A. Maeda
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III. Presentations at JPAPWS General Meetings:

FY2024 1st General Meeting, May 28, 2024

Development of Novel Water Quality Management method for Water-Steam Circuits of Gas Turbine Combined Cycle Power Plants
Yuta Nakatsuchi (Mitsubishi Heavy Industries, Ltd.)

Adsorption Behavior of OLDA and the Effect of Adsorbed OLDA on Contact Angle
Yuta Nakatsuchi (Mitsubishi Heavy Industries, Ltd.)

Cage Occupancy Analysis and Phase Diagram Prediction in Clathrate Hydrates through Monte Carlo Simulations
Hirotaka Kishimoto (Keio University)

FY2023 5th General Meeting, March 11, 2024

Energy Process Research Institute (EPRI), National Institute of Advanced Industrial Science and Technology
Saneshiro Muromachi (AIST)

Revealing the hidden dynamics of confined water in acrylate polymers: Insights from hydrogen-bond lifetime analysis
Kokoro Shikata (Osaka University)

FY2023 4th General Meeting, January 30, 2024

Retro-technology, Electric Thermal Energy Storage realizes economic de-carbonized society
Toru Okazaki (The Institute of Applied Energy)

Molecular dynamics study on the surface structure of alcohol-water mixture
Mayu Hirose (University of Toyama) , Tatsuya Ishiyama (University of Toyama)

FY2023 3rd General Meeting, December 7, 2023

Hydrogen damage in a power boiler - Correlations between damage distribution and thermal-hydraulic properties

Taro Ichihara (Mitsubishi Heavy Industries Power IDS, Ltd.)

FY2023 2nd General Meeting, July 25, 2023

NMR analysis of hydrothermal reactions of ethylamine and octylamine

Ken Yoshida (Tokushima University)

Comparison of experimental and calculated ionization constants for subcritical/supercritical water

Masaru Nakahara (Kyoto University), Ken Yoshida (Tokushima University)

Present status of the absolute density measurements for sea-water

Yohei Kayukawa (AIST)

FY2023 1st General Meeting, May 30, 2023

Research background and the current status of the JPAPWS research grant: Thermodynamic properties evaluation on metastable state for heavy water

Yohei Kayukawa (AIST)

**U.S. National Committee to IAPWS
2024 Report on Activities of Potential Interest to IAPWS**

Communicated from the National Institute of Standards and Technology, Boulder, CO and Gaithersburg, MD:

In collaboration with G. Garberoglio (Italy), calculations have been performed with state-of-the-art surfaces from the literature to characterize the different contributions to the first dielectric virial coefficient of water (and heavy water). This includes the electronic and vibrational polarizabilities, the dipole moment, and the rotational quantum effects that cause the dielectric constant to deviate from the classical Debye expression. The work has been published: G. Garberoglio, C. Lissoni, L. Spagnoli, and A.H. Harvey, “Comprehensive quantum calculation of the first dielectric virial coefficient of water,” *J. Chem. Phys.* **160**, 024309 (2024). This work will provide boundary conditions for future IAPWS formulations for the dielectric constant of water and of heavy water, and can support proposed capacitance-based measurements for humidity.

High-accuracy refractivity measurements have been performed on water vapor (and heavy water vapor) between 293 K and 433 K at an optical frequency, and at 303 K at a frequency in the near infrared. Comparison with the IAPWS formulation for the refractive index of ordinary water indicates that there is some room for improvement, with about a 2% discrepancy in the low-density limit. References: P.F. Egan and Y. Yang, “Optical $n(p, T_{90})$ measurement suite 2: H₂O and D₂O,” *Int. J. Thermophys.* **45**, 89 (2024); P.F. Egan and Y. Yang, “Optical $n(p, T_{90})$ measurement suite 3: Results at $\lambda = 1542$ nm,” *Int. J. Thermophys.*, in preparation.

Communicated from OLI Systems Inc., Parsippany, NJ:

Aqueous chemistry of critical materials

OLI Systems continued its participation in the Department of Energy’s Critical Materials Innovation Hub (CMI). OLI’s work focuses on developing thermodynamic models for predicting chemical and phase equilibria in systems containing rare earth elements, nickel, cobalt, lithium, and other critical materials. In the past year, the work was focused on (1) developing thermodynamic models for rare earth carbonates, fluorocarbonates, oxyfluorides, and oxychlorides, (2) finalizing a model for optimizing the recovery of metals from end-of-life lithium ion battery cathodes using gluconic acid as an environmentally benign, biologically-sourced lixiviant, (3) finalizing a model for the crystallization of cobalt and nickel in the form of Tutton salt crystals, (4) studying the recovery of cadmium and tellurium from end-of-life solar panels and (5) initiating research on modeling solvent extraction of rare earths. The results of project (2) have been published in the following paper:

M. Alipanah, H. Jin, Q. Zhou, C. Barboza, D. Gazzo, V. Thompson, Y. Fujita, J. Liu, A. Anderko, and D. Reed, “Sustainable Bioleaching of Lithium-ion Batteries for Critical Materials Recovery: Process Optimization through Design of Experiments and Thermodynamic Modeling,” *Resources, Conservation & Recycling* **199** (2023) 107293.

Modeling aqueous nuclear power chemistry

OLI has completed a collaborative project with the University of Guelph on developing a comprehensive model for the behavior of aqueous systems containing boric acid and borates of lithium, sodium, and potassium. The work was based on the recent experimental results from the

University of Guelph, which elucidated speciation of borates at high temperatures. The work has been published in the following paper:

P. Wang, A. Anderko, and P. Tremaine, "Speciation and phase equilibria of aqueous boric acid and alkali metal borates from ambient to hydrothermal conditions: a comprehensive thermodynamic model," *Ind. Eng. Chem. Res.* **62** (2023) 20875–20898

IAPWS and Related Attendees, 18th ICPWS, 2024

David	Addison	New Zealand
Ryo	Akasaka	Japan
Andre	Anderko	United States
Mikhail	Anisimov	United States
Hugues	Arcis	United Kingdom
Martin	Bachet	France
Aleš	Blahut	Czechia
J. Michael	Brown	United States
Kirk	Buecher	United States
Matthias	Buschmann	Germany
Frédéric	Caupin	France
Elen	Clayton	United Kingdom
Jacy	Conrad	United States
William	Cook	Canada
Ludwin	Daal	Netherlands
David	De Vos	Belgium
Barry	Dooley	United Kingdom
Iain	Duncanson	United States
Rainer	Feistel	Germany
Daniel	Friend	United States
John	Gallagher	United States
P. Alberto	Giuliano Albo	Italy
Claudia	Goy	Germany
Allan	Harvey	United States
Richard	Harwood	United States
Robert	Hellmann	Germany
Sebastian	Herrmann	Germany
Jan	Hrubý	Czechia
Taro	Ichihara	Japan
Andreas	Jäger	Germany
Vegard Gjeldvik	Jervell	Norway
Baptiste	Journaux	United States
Yohei	Kayukawa	Japan
Hans-Joachim	Kretschmar	Germany
Matthias	Kunick	Germany
Simona	Lago	Italy
Benjamin	Loder	Canada
Duncan	McAllister	Australia
Paul	McCann	United Kingdom
Karsten	Meier	Germany
Hiroyuki	Miyamoto	Japan
Phillip	Nguyen	United States
Monika	Nielsen	Denmark
Nobuo	Okita	Japan
Reiner	Pawellek	Germany
Basil	Perdicakis	Canada
Naoya	Sakoda	Japan
Steffen	Seitz	Germany
Jan	Sengers	United States

Roland	Span	Germany
Maryanne	Stones	Canada
Shinichi	Terada	Japan
Martin	Trusler	United Kingdom
Václav	Vinš	Czechia
Sarita	Weerakul	Canada
Tapio	Werder	Switzerland
Jintao	Xie	China
Pam	Yakabuskie	Canada
Kenji	Yasuoka	Japan
Ken	Yoshida	Japan
Guoliang	Yu	China
Xinzi	Zhou	China
Greg	Zimmerman	United States
Jana	Zimmermann	Germany