

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

**MEMBERS**

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

**ASSOCIATE MEMBERS**

Argentina and Brazil  
China  
Egypt  
France  
Greece  
India  
Israel  
Italy

**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**

**Turin, Italy  
4<sup>th</sup> and 8<sup>th</sup> September 2023**

**Prepared by Barry Dooley**



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**Minutes of the Meetings**  
of the  
Executive Committee  
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International Association for the Properties of Water and Steam

4<sup>th</sup> and 8<sup>th</sup> September 2023

**Plenary Session. Monday, 4<sup>th</sup> September 2023. 9:00am**

At 9:00am the new President of IAPWS, Dr. Dan Friend welcomed the Executive Committee (EC) and other IAPWS members to the EC Meeting. He first thanked the Chair of the Italian National Committee, Ms. Simona Lago, for hosting the 2023 IAPWS meetings. He then asked Mr. Vito Fericola, Senior Researcher and INRIM Board of Directors Member, to welcome the EC to Turin, Italy. Fericola thanked the sponsors of this IAPWS meeting. The President then officially opened the 2023 EC Meetings by introducing the National Delegates. All of the IAPWS Members were in attendance as well as the delegates from Associate Member countries Greece and Italy. In total there were 44 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 2023. There were no additions and 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 Rotorua, New Zealand, November 2022

The Executive Secretary reported that during the year since the last IAPWS EC Meeting in New Zealand no documents had been forwarded to IAPWS members for review or approval.

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. It was also suggested that a person from Italy assist in this development and in this regard Lago agreed to assist 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 9.

2.3 Evaluation Committee on International Collaboration.

The Executive Secretary indicated that no proposal 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.

2.4 IAPWS Awards Committees for 2024

2.4.1 Honorary Fellow Award Committee

A committee of Kretzschmar (Chairman) and Harvey were selected for the 2024 Honorary Fellow award with the President and Executive Secretary as ex. Officio members.

**Action: Nominations are due to the Executive Secretary by 31<sup>st</sup> January 2024.**

#### 2.4.2 Helmholtz Award Committee

The Executive Secretary reminded the EC that the Helmholtz Award selection committee for the 2024 award would consist of a member from Canada (Chair), Czech Republic, Germany/Switzerland, Japan and New Zealand. These countries were requested to provide the name of the member for this committee to Chairman Cook before the Friday EC meeting.

**Action: Nominations are due to the Executive Secretary by 31<sup>st</sup> January 2024.**

#### 2.4.3 Gibbs Award Committee

The President reminded the EC that the Gibbs Award is awarded about every five years at each ICPWS and asked the Chair of the Selection Committee to provide the results of the nomination committee. Okita indicated that the selection committee with one person from each Working Group had met electronically a number of times and had unanimously selected Dr. Rainer Feistel as the 2024 IAPWS Gibbs Awardee. Feistel had agreed to the selection and to provide the Gibbs Award lecture at the 18<sup>th</sup> ICPWS.

#### 2.5 Update Report on 18<sup>th</sup> ICPWS

The President, as co-chair of the 18<sup>th</sup> ICPWS, provided an update of the status of arrangements:

- The U.S. National Committee will host the ICPWS between 23<sup>rd</sup> and 28<sup>th</sup> June 2024 in Boulder, Colorado in conjunction with the triennial Symposium on Thermophysical Properties (STP).
- Harvey and Friend will be Co-Chairs.
- The call for papers was issued recently and the website for submissions is <https://na.eventscloud.com/eSites/759400/Homepage>
- Housing will be available on the Colorado University (CU) campus and at local hotels.
- There will be sessions for ICPWS, Symposium, and special joint sessions.
- Planning is still in progress for the IAPWS EC and General Meetings and the social events.
- Approximately 600 people are expected for the symposium and about 100 for ICPWS.

#### 2.6 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.**

#### 2.7 Dues Structure Task Group

The President reported that in response to the approval of the German-Swiss joint membership at the 2022 annual meeting a committee (Friend, Addison and Neilsen) had been formed to review the fairness and effectiveness of the current dues structure and to recommend changes, as appropriate. He then reviewed the history of the dues structure with the monetary standard of the Association being the Swiss franc. The Statutes and By-Laws indicate that the dues are apportioned according to the gross economic product of the member country. Dues for new Members are assessed on this principle using the scale of dues paid by existing Members and there is a minimum annual rate below which dues are not apportioned. The dues structure has been unchanged for 30 years. The committee reviewed various alternate calculation procedures and determined that the current system was fair and adequate and had been able to address any IAPWS expenditures, and thus suggested no change.

**The EC approved this unanimously.**

## 2.8 Registration and Other Fees Associated with an IAPWS Annual Meeting

The President reported that a number of IAPWS individual members had let the Executive Secretary know that the overall costs (registration, accommodation, etc.) of attending an annual IAPWS meeting had been increasing over the years. It had become more difficult for senior/retired persons to attend. The President indicated that these costs are the responsibility of the national committee organizing the annual meeting and that efforts are needed to keep the events as cheap as possible. He also mentioned that IAPWS does not support individual members to annual meetings.

## 2.9 Refreshment of IAPWS Website

The President indicated that the Executive Secretary had received notes indicating that the IAPWS Website was not secure (:https) and that the website could be upgraded to improve the “look and feel”. This led to some discussion from EC members which eventually resulted in the President proposing a Task Group to report back at the Friday EC meetings. The following members were selected: McCann (BIAPWS) as Chair, Cook (Canada), Addison (New Zealand) and McAllister (Australia).

## 2.10 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 Releases, Guidelines and 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 no ICRNs needed attention by the Working Groups during the week.

### 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 IAPWS Symposium on Wednesday 6<sup>th</sup> September 2023. The details are included in Attachment 2. 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 10:10 am.

### Activities During the Week

The first day activities of the Executive Committee were followed by Working Group meetings and the IAPWS Symposium. The schedule of the IAPWS week is shown in Attachment 3.

### Executive Committee Meeting. Friday, 8<sup>th</sup> September 2023

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 countries Greece and Italy. In total there were 22 people assembled for the EC meeting.

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 Rotorua, New Zealand in November 2022. No changes were noted; thus the 2022 Minutes were accepted.

6. President's Report

President Friend provided his report. This is provided in these minutes as Attachment 4.

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

Minutes of the TPWS WG conducted during the week are in Attachment 5. 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. The first step will be organization and evaluation of available experimental data. No responses were received to ICRN-31 on a call for experimental data. The task group was expanded by Lago (as a vice-chair), Albo and Kayukawa to motivate experimental work, and by Caupin to cover the metastable water region.

7.2 New Model for Thermodynamic Properties of Mixtures.

The Chair reported that Hrubý had proposed a new equation of state model for mixtures, which overcomes the problem of incorrectly represented composition dependence of virial coefficients. It requires that the metastable regions of the pure components (particularly of water) are properly represented.

7.3 Second Cross Virial Coefficients of Aqueous Gas Mixtures.

The Chair indicated that Hellmann had reported a new theoretically calculated second and third virial coefficients and transport properties for water-argon system. A Task Group will develop an IAPWS guideline providing enhancement factors for solubility of water vapor in important gases at elevated pressures. As a pilot project, one system (presumably water-argon) will be chosen.

7.4 Future of the Subcommittee on Seawater (SCSW).

TPWS Chair, Meier, reported that Seitz had written a Distress Flyer on the situation in the SCSW and distributed it to potentially interested public. Four positive responses were received. Friend suggested that presentations on seawater topics at 18<sup>th</sup> ICPWS could encourage the activity. Albo agreed to co-chair a conference session on sea water and Seitz agreed to assist.

Pawlowicz and Feistel remain formally Chair and Vice-chair respectively of SCSW.

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.

7.5 TPWS Membership and Officers.

The TPWS Chair informed the EC that there was no change in membership or officers.

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

The Chair and Vice 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 6.

## 8.1 Task Group Updates.

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

- Task Group on Categories of industrial requirements. Extend new topics such as hydrogen combustion, clouds micro and macrophysics related to aviation to be discussed to cooperate with ASME or other groups.
- Task Group on Wet Steam properties calculation. Connect expert for measurements in Škoda, Dr. Hoznedl, with Dr. Schatz. Consider cooperation and/or universities involvement. A new task group was formed on “Translation of IF97 Fortran routines into other programming languages” with members: Nový, di Mare, Harwood and Sachssendahl.
- Task Group on Wet Steam Data from operating turbines. The key is to understand the film forming on stator blade and droplets forming from the water film. The TG will search for all public available measurements worldwide.
- Task Group on ICRN for acid gas dew points. Possible TGD to maintain reliability was considered instead of an ICRN. Draft white paper for the TGD to be prepared by the next annual meeting. A new task group was formed on “A white paper for acid gas dew points” with members: Okita, Addison, Yoshida (+ one PCC member).
- Report of the joint Task Group on White paper on geothermal plant issues. A second draft is expected soon by PCC and possible approval of final document in 2024.

## 8.2 Future Direction of the IRS Working Group.

Okita next provided the EC with short-term and longterm directions. None needed EC approval.

### Short-term:

- Next industrial calculation needs for steam properties (for CFD etc.)
  - Translation of IF97 Fortran routines into other programming languages
  - Task Group set up for defining issues.
- ICRN for acid gas dew points
  - White paper toward TGD for reliable GTCC operation against corrosion.
- Discussion on wet steam data
  - Summarizing existing research and researchers.
- “Categories of industrial requirements or interests” to be focused on IAPWS documentation and cooperation with ASME for H<sub>2</sub> combustion.
  - Try again ASME Turbo Expo 2025 or other cooperation.

### Longterm:

- New calculation needs for mixture with H<sub>2</sub>O and other medium for geothermal or renewables including CO<sub>2</sub> cycle, H<sub>2</sub> combustion etc.
  - “EOS-CG” is one optional EOS to evaluate collaborated with TPWS on demand.
  - TG for formal guideline will be set up.

## 8.3 IRS Members.

The IRS Chair proposed one new WG member:

- Aurel Ranniste Sachssendahl, Siemens Energy, Germany

**The EC approved this WG member change unanimously.**

9. Sub-Committee on Seawater (SCSW)

Unfortunately, the SCSW Chair, Pawlowicz, could not be present for the EC meeting. The TPWS Working Group included SCSW activities.

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

Minutes of the PCAS WG conducted during the week are in Attachment 7.

IRS Chairman Yoshida discussed the following items with the EC:

10.1 New Task Group on Ionization of Water.

A PCAS Task Group to work on developing a revised formulation for the water ionization constant ( $K_w$ ) proposed by Arcis and Tremaine. There is the need for accurate water ionization constant formulation at near-critical and supercritical conditions for the purpose of future Advanced Modular Reactors (AMR) water cooling circuit chemistry modeling.

- New flow conductivity derived water ionization constant data have been reported under near-critical and supercritical conditions.
- To address possible systematic uncertainties, revised correlations for the limiting conductivity of fully ionized water have been derived based on a critical assessment of the literature.
- The flow conductivity derived water ionization constant data have been revised.
- $K_w$  database has been reevaluated, taking into account the new conductivity data.
- Parameters for Bandura and Lvov (IAPWS  $K_w$  release 2019) function have been revised.

The evaluation is planned to be carried out before the IAPWS Meeting in 2024 and the Evaluation Task Group members are: Harvey (Chair), Anderko and Corti.

- A new PCAS Task Group was proposed by Arcis and Tremaine on developing a revised formulation for the water ionization constant ( $K_w$ ). A joint PCAS/TPWS Evaluation Task Group is also proposed to first review the revised formulations derived to represent the limiting conductivity of ionized water, and second to evaluate the upcoming revised correlation for  $K_w$ . The following members were suggested: Harvey, Palmer, Corti and Wang.

10.2 Other On-going Activities.

The PCAS Chair informed the EC of the following activities:

- Guideline on self-diffusion coefficient. Led by Yoshida, in collaboration with TPWS. Development is underway and will be continued.
- White Paper on acid dew point. Collaboration with PCC and IRS. Development is underway and will be continued.
- White Paper on Geothermal. Collaboration with PCC and IRS. Development is underway and will be continued.
- ICRN on FFS. Collaboration with PCC. Development is underway and will be continued.
- Possibility of extending PCAS activities to radiation chemistry. Efforts to connect international young researchers and experts are progressing. PCAS is organizing the session “Nuclear Reactor and Fuel Cycle Chemistry” in the 18<sup>th</sup> ICPWS.

11. Power Cycle Chemistry Working Group (PCC).

Minutes of the PCC WG conducted during the week are in Attachment 8.

PCC Chairman Addison discussed the following items with the EC:

#### 11.1 Technical Guidance Documents (TGD).

The PCC Chair indicated that the following documents are in preparation:

1. Film Forming Substances for Nuclear Plants (has been delayed due to business and health pressures).
2. Monitoring Corrosion Products in Flexible (cycling and two-shifting) Plants. Updated draft white Paper including initial Proxy Processes and Decay Map was developed on 19<sup>th</sup> September 2019 (Dooley/Thomsen). The International Collaborative Projects (ICPs) on Monitoring for the Decay Map and Round Robin (2022 and 2023) were completed. Current Sub-Task Group (STG) (Dooley, Thomsen, Nielsen, Vepsalainen, Addison and McCann) with new members Skovbjerg, McAllister and Leidich will work on deciding what needs to be developed with a target of the end of October 2023.
3. Flue Gas Condensation First draft of White Paper (SIAPWS, March 2022) was reviewed by PCC. The STG (Fogh, Dooley and SIAPWS team plus new member Daal) will develop next stage of White Paper and then circulate again to PCC to determine if the white paper should be converted to a TGD.
4. Geothermal Steam Chemistry has ongoing work between NZAPWS and JAPWS – white paper draft for circulation soon.
5. Electrode Boiler Chemistry. Initial NZAPWS interface with SIAPWS expanded to make international. Proposal is to publish technical papers and move straight to basic TGD and identify possible ICRN areas. (STG: Addison, Nielsen and Dooley).
6. Dew Point of Low Sulphur Gas. Joint White Paper/TGD development with PCAS (Okita) with McCann and Addison providing PCC support.

#### 11.2 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 presented as PCC Keynote. The results will be used in the TGD revision project (Section 11.1).

#### 11.3 PCC Improvements and Process Changes.

The PCC Chair informed the EC that there was a need to improve the PCC reach to help with new members and awareness of IAPWS. There had been a PCC workshop to go over this and collate comments and thoughts. The key outcomes were:

- TGDs are a key part of PCC and key deliverable – critical to maintain quality.
- PCC is a great group – global collaborations, knowledge sharing, leading edge.
- But is very slow at producing TGDs which is a complex and difficult process.
- Time between productive meetings is long so it's hard to make progress in between.
- Hard for outsiders to know about and understand PCC.
- IAPWS PCC penetration into North America market is poor.
- Need to continue to grow PCC and be exposed to new members and new industries.

The Chair then made the following requests and comments:

- First Request is for PCC to have a PCC page on the IAPWS website providing more public background information on PCC and information on PCC functions and activities – to increase awareness. This led to much discussion by the EC with a final motion of: “A working group (WG) product could be on the WG Page within the IAPWS website as long as it had been approved by the WG and reviewed by the Editorial Committee”.

### **The EC Approved this Unanimously**

- PCC are going to hold four public webinars on the “best of PCC” leading up to ICPWS and will also provide information on IAPWS and PCC with 30-40 minutes on presentation and time for Q&A. Dooley will kick off these webinars.
- PCC internal action/status/progress calls will be held every two months to assist with support and encouraging progress on TGDs etc.
- PCC to try a little bit of LinkedIn to share information about IAPWS PCC and have a presence – to be managed by PCC officers.
- Second Request for EC to consider better IAPWS file sharing/collaborative work tools possibly as part of IAPWS website refreshment (discussed in Section 17.3).

#### 11.4 ICPWS 2024.

The PCC Chair outlined the plans for PCC activities at the 2024 meetings:

- PCC TGD work and administration will take place on the first Sunday after IAPWS EC meeting in focused session.
- Rest of ICPWS will be related presentations.
- PCC members to submit abstracts and solicit presentations.
- Need suitable meeting space as well as the Sunday at ICPWS. This will be discussed with the ICPWS committee.

#### 11.5 White Papers and International Collaboration Project (ICP) Report.

Chairman Addison raised the following items:

- These documents are outside of the normal IAPWS release process but in case of white papers critical to TGD development and need to circulate inside/outside of PCC for review/comment.
- The ICP reports are part of the ICP process but not currently published anywhere.
- White papers exist in a “behind the scenes” IAPWS space.
- As part of PCC webpage, the update is intended to include a short summary of draft white papers in a state to be circulated and ICP reports with contact to email for a copy.
- PCC (Addison/Dooley) also to draft “cover/template first page” for these documents including disclaimer about them not being guidance documents etc.
- In summary, the PCC Chair requested the EC that a proper process was needed to manage these documents going forward (see Section 17.3).

#### 11.6 PCC Membership and Officers.

The PCC Chair proposed the following new WG members:

- Mikko Vepsäläinen, Finland
- David De Vos, Belgium
- Antony Senecat, Belgium
- Ronny Wagner, Germany
- Antonios Thanos, Greece

**The EC approved these new WG member changes unanimously.**

The PCC Chair next indicated that Taro Ichihara, Japan was nominated by the PCC WG as a third PCC Vice Chair.

**The EC approved this new PCC officer arrangement unanimously.**

## 12 Editorial Committee Report

Editorial Committee Chairman Harvey reported that in the preceding year, the Editorial Committee (Harvey, Cook and Cooper) had not reviewed any IAPWS Documents prior to publication.

## 13. Membership and Associates

### 13.1 Report on Membership.

The Executive Secretary reported that only Canada had not paid the 2023 dues by the end of August 2023.

The Head of the Canada National Committee, Cook, indicated that because of internal budgeting at the sponsor of the Canadian National Committee the dues will be processed before the end of 2023.

### 13.2 Reports on Current Associate Members.

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, indicated that in 2022-2023 the effort for expanding interest on IAPWS activities in Greece was continued. Currently, there are 54 participants in the Hellenic Association including one from Cyprus. HIAPWS is exploring options for type and content of Statutes and By-Laws for the Greece national committee and are starting to consider options and opportunities for financing, such as sponsoring, closely related with the legal form of the Association. For these reasons, the Hellenic National Committee requests the IAPWS Executive Committee for an extension of the status of Greece as an Associate Member, for another 3 years, in order to properly shape Statutes and By Laws and to identify potential resources for financing the National Committee and, eventually, the participation of Greece as a Full Member of IAPWS.

#### **The EC Approved Unanimously the Extension of the Associate Membership.**

Status Report on IAPWS Associate Member, Italy. The delegate of the Italian National Committee, Ms. Simona Lago, reported that the Italian National Committee has contacted numerous organizations. They have experienced several administrative (and bureaucratic) issues, which did not allow them to complete the legal process for the constitution of the Italian Committee. Lago then requested the EC for an extension of one year as Associate Member before applying for IAPWS full Membership.

#### **The EC Approved Unanimously the Extension of the Associate Membership.**

Status Report on IAPWS Associate Member, Israel. The Head of ISRAPWS, (Yitzhak Nussbaum) could not be in Turin so sent a report to the Executive Secretary. He reported that ISRAPWS continue to maintain an annual symposium for the members with information sharing and raising of problems through direct personal contacts and presentations sessions. They hope to manage a strong committee and influence the community in the coming year with much more financial strength. Until then they request the EC to extend the Associate Membership for another three years.

#### **The EC Approved Unanimously the Extension of the Associate Membership.**

Status Report on IAPWS Associate Member, China. The new head of the China National committee (Long) had provided a Work Report to the Executive Secretary. This reported that the China electric power plant chemical standardization technical committee became an Associate member of IAPWS in May 2017. This group is composed of nearly 40 experts from various research institutes in China. It mainly carries out the formulation and revision of China's standards in Power plant chemistry and

organizes some academic activities of power plant chemistry. It had met twice since December 2022. A motion from the US Delegate, Harvey, was given to extend the Associate Membership of China for three years.

**The EC Approved Unanimously the Extension of the Associate Membership.**

Other IAPWS Associate Members. The Executive Secretary provided short status reports as follows:

- Egypt. The initial chair of this national committee, Mr. Moataz Khalifa, had moved jobs and country location. The new chair, Mr. Mohamed A. ElSherif, has been trying to reconvene the national committee.
- India. The initial chair of this national committee, Dr. Bikasendu Bhattacharya, had been killed in a road accident. The new contact, Mr. Aditya Kanetkar, has gradually been organizing officers for the national committee and planning a virtual meeting to reconvene the committee.
- France. A number of attempts have been made to reconstitute the national committee in France.

A motion from the US Delegate, Harvey, was given to extend these Associate Memberships for three years and for the Executive Secretary to provide continuing interface with each and report at the 2024 EC meeting.

**The EC Approved Unanimously the Extension of these Associate Memberships.**

- Argentina and Brazil. The Executive Secretary indicated that no contact had been made with Dr. Horacio Corti the last head of the national committee. However as indicated in Minute 10.1, Corti is a proposed member of a PCAS Task Group.

A motion from the US Delegate, Harvey, was given to extend this Associate Membership for one year for the Executive Secretary to contact Corti and report at the 2024 EC meeting.

**The EC Approved Unanimously the Extension of this Associate Membership.**

14 Executive Secretary's Report

14.1 IAPWS Bank Accounts, Financial, Auditors and IAPWS Dues

The Executive Secretary reported that IAPWS is on a sound financial footing with currently about £90,000.00GBP in total in the UK and US bank accounts. The status as at 30<sup>th</sup> August 2023 in the bank accounts had been provided to the Head of each IAPWS Member country prior to the EC meeting.

The Executive Secretary next reported that the 2022 financial statements had been forwarded to the IAPWS Auditors in January 2023 (Professor Savarik in Czech Republic and Dr. Delfs of VDI in Germany). Professor Savarik had reviewed and approved the financial statements. But Dr. Delfs was away from the office and had not reviewed the statements. The Head of the Germany-Swiss national committee had checked with Delfs who indicated that he would be able to review the statements soon and was prepared to remain as an IAPWS auditor.

The IAPWS President motioned that the second audit report should be forwarded to the heads of IAPWS members when available with a postal ballot vote for acceptance of the IAPWS financial situation.

**The EC Approved these Actions Unanimously.**

The Executive Secretary proposed that these organizations be re-appointed to act as auditors.

**The EC Approved this proposal Unanimously.**

The Executive Secretary proposed to the EC that the dues structure for member countries remains unchanged for 2024 as had been approved in Minute 2.7.

14.2 Time and Place of the 2024 and 2025 IAPWS Meetings.

2024 IAPWS Meetings. The annual meetings will be held in conjunction with the 18<sup>th</sup> ICPWS which was discussed in Minute 2.5.

2025 IAPWS Meetings. The Head of SIAPWS, Nielsen, briefly reviewed the initial 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 technical visit to VTT, Technical Research Center of Finland.

2026 IAPWS Meetings. The Executive Secretary indicated that preliminary discussions have occurred with three IAPWS countries. It is expected that the location of the 2026 annual IAPWS meetings will be consolidated by the next annual meeting in 2024.

14.3 Succession Planning for the IAPWS Executive Secretary Position.

President Friend informed the EC that the Executive Secretary had suggested that a succession plan should be developed for this IAPWS executive position. Friend indicated that this appeared sensible and could involve finding a deputy. All other WG officer positions had vice chairs. This led to much EC discussion with the President indicating that each national committee should deliberate with their committee members to provide a suggested path forward on succession for the Executive Secretary position. Suggestions and comment should be sent to the President and Executive Secretary. He then proposed a motion to appoint a Task Group consisting of the heads of IAPWS member national committees with the President as chair.

**The EC Approved this Motion Unanimously.**

The President indicated that he would send a note to the Heads of national committees to start the process and provide a timeframe.

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

The President indicated that ICRNs had been discussed within the WG Reports, so no further action was required by the EC. There had not been any International Collaborative Projects suggested. The President wanted to encourage everybody to think about collaborative projects for 2024 and that proposals should be submitted as early as possible before the annual meetings.

16. IAPWS Awards

The President reported that there was no 2023 Helmholtz Award which was very disappointing.

The Helmholtz Award Committee for 2024 had been initially discussed in Minute 2.4.2 and would consist of the following members: Canada (Cook as Chair), Czech Republic (Hruby), Germany/Switzerland (Hellmann), Japan (Kayukawa) and New Zealand (Addison).

There was also no Honorary Fellow Award for 2023. The committee for 2024 is found in Section 2.4.1.

The Gibbs Award had been discussed at the Monday EC meeting (Minute 2.4.3).

## 17. New Business

### 17.1 Press Release

The President mentioned that Cook (Chair) and Lago had been asked at the EC meeting on Monday 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 9. The President indicated that this release will be sent to all NCs and WGs of IAPWS and it should be distributed as widely as possible and sent to any journals and publications.

### 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:

Australia	Attachment 10
Czech Republic	Attachment 11
Germany-Swiss	Attachment 12
Japan	Attachment 13
New Zealand	Attachment 14
SIAPWS	Attachment 15
USA	Attachment 16

### 17.3 Refreshment of IAPWS Website.

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

McCann informed the EC on the following points:

- The IAPWS website works fine and it is relatively easy to find the basic information.
- It is hosted by GoDaddy and there are no indications of any problems supporting it.
- Harvey has administration rights.  
but.....
- The http domain is not secure and it may be blocked by modern IT security.
- Overall the website is out-of-date in terms of appearance and functionality.
- There is no possibility to use it for collaborative working.
- It provides the first interface with IAPWS for users and thus doesn't create the best impression.
- There is limited information about Working Groups.

McCann next provided three proposals for the EC to consider. Each was discussed in turn.

1. The existing website domain must be changed to https to ensure it remains compatible with modern IT security. This is an immediate priority and should be easy to do in conjunction with GoDaddy at minimum cost. But if not, then IAPWS needs a new website as proposed in proposal 3.

The President proposed to the EC that this item should proceed as soon as possible.

**The EC approved this activity unanimously.**

2. For the existing website, the PCC WG requested (Minute 11.3) its own webpage to provide public facing information about what the WG does. The other WGs were interested and in agreement. This is a short-term priority. These website changes can be addressed by Harvey within the existing structure before the next IAPWS meeting.

The President proposed to the EC to establish web pages for each WG and that each WG should provide descriptions of the content.

**The EC approved this activity unanimously.**

The President proposed that the descriptions should be available by the end of November 2023

3. The Task Group recommends that IAPWS has a new modern website developed to improve branding and enable collaborative working. The following are the desired outcomes and it is recognized that this may take up to two years.
  - Improves collaborative and efficient working.
  - Modernisation of graphics and branding.
  - Provide information management and file storage.
  - The cost is expected to be in the range of 3 - 6k USD by an external professional website designer.

The President developed the motion that a Task Group is established to scope the project and come back to the EC with a proposal at the next annual meeting in the US.

**The EC approved this proposal unanimously.**

The Task Group will consist of McCann, Addison, Harvey, McAllister and Albo. The President indicated that there is no current commitment from the EC for expenditure of IAPWS funds.

#### 17.4 Italy National Committee Feedback on the 2023 EC and WG Meetings.

The Head of the Italy National Committee, Lago, thought the IAPWS symposium had been a great success. There had been 72 people attending the meetings from 19 countries. It had been very difficult to predict the number of participants.

The IAPWS President thanked Lago for organizing the IAPWS week in Turin. Applause from EC in appreciation.

#### 17.4 Participants

Attachment 17 provides a list of participants at the IAPWS Meetings in Turin, Italy in September 2023.

#### 17.5 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.

### 19. Closing Remarks and Adjournment

No further business was raised by the EC. The President thanked everybody for participating at this EC meeting. The 2023 EC meeting was closed at 12:25 pm.

**AGENDA for the EXECUTIVE COMMITTEE of IAPWS  
Torino, Italy. 3<sup>rd</sup> – 8<sup>th</sup> September 2023**

**Monday, 4<sup>th</sup> September 2023. Opening Plenary Session (9:00 – 10:15 am)**

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 December 2022
  - 2.2 IAPWS Highlights / Press Release
  - 2.3 Evaluation Committee on International Collaboration
  - 2.4 IAPWS Awards for 2024 (Honorary Fellow, Helmholtz, Gibbs)
  - 2.5 Update Report on 18<sup>th</sup> ICPWS (ICPWS Chairman Friend)
  - 2.6 Situation in Ukraine
  - 2.7 Dues Structure Task Group (IAPWS 2022 Minutes 13.1)
  - 2.8 Registration Fees for IAPWS Annual Meetings
  - 2.9 Refreshment of IAPWS Website
  - 2.10 Other business requiring special/extensive discussions.
3. EC Mandate to Working Groups and Membership
  - 3.1 Releases, Guidelines and ICRNs.
4. Preview of Week's WG Activities by WG Chairmen.

**Friday, 8<sup>th</sup> September 2023. Executive Committee Meeting. (9:00am – 1:00 pm)**

5. Acceptance of Minutes of Previous IAPWS EC Meeting
6. President's Report
7. Report and Recommendations of Joint TPWS and IRS (including SCSW)
8. Report and Recommendations of Separate IRS Meetings
9. Report and Recommendations of Separate SCSW Meetings (if any)
10. Report and Recommendations of PCAS
11. Report and Recommendations of PCC
12. Editorial Committee Report
13. Membership and Associates
  - 13.1 Report on Membership and Members Defaulting on Dues
  - 13.2 Reports of Associate Members (China, Greece, Israel and Italy)
14. Executive Secretary's Report
  - 14.1 IAPWS Bank Accounts, Financials, Auditors and Dues
  - 14.2 Time and Place of 2024 (USA) and 2025 (Finland) Meetings.
15. Guidelines, Releases, Certified Research Needs, and International Collaborations
  - 15.1 International Collaborations (if any)
16. IAPWS Awards
  - 16.1 Helmholtz Award Committee
  - 16.2 Honorary Fellowship
  - 16.3 Gibbs Award
17. New Business
  - 17.1 Press Release
  - 17.2 Italy National Committee feedback on 2023 Annual Meeting
  - 17.3 IAPWS Website
  - 17.4 Other items raised during the IAPWS week.
18. Adjournment



Barry Dooley 7<sup>th</sup> September 2023

# IAPWS Symposium

6 September 2023

## “Underpinning the seawater science”

09:00 – 9:30

*Oceanic in situ long term O<sub>2</sub> times series: challenges & solution*

Dominique Lefèvre (Centre National de la Recherche, CNRS, France)

09:30 – 10:00

*Brief state of the art in density/absolute salinity measurements seawater*

Marc Le Menn (Service hydrographique et océanographique de la marine, SHOM, France)

10:00 – 10:30

The role of metrology into the value chain of ocean observations

Paola Fiscaro (Laboratoire National de Métrologie et d'Essais, LNE, France)

10:30 – 10:45

Coffee Break

10:45 – 11:15

In-situ measurement of seawater properties

Christoph Waldmann (University of Bremen, WMO member)

11:15 – 11:45

Ab initio calculation of virial coefficients: from noble gases to water

Giovanni Garberoglio (Fondazione Bruno Kessler-ECT, FBK-ECT, Italy)

Allan Harvey (National Institute of Standards and Technology, NIST, USA)

11:45 – 12:15

From concept definition to full scale prototype of a hybrid wave energy converter to produce fresh water and electricity

Marcello Rava (Politecnico di Torino, Italy)

12:15 – 12:25

Picture of IAPWS meeting participants

12:25 – 13:40

Lunch

13:40 – 14:10

On the measurement of the absolute salinity of seawater: state-of-the-art and emerging trends

Rajesh Nair (Istituto Nazionale di Oceanografia e di Geofisica Sperimentale, OGS, Italy)

14:10 – 14:35

INRiM activity in the field of metrology for the determination of CO<sub>2</sub> in atmosphere and seawater

Francesca Rolle (Istituto Nazionale di Ricerca Metrologica, INRiM, Italy)

14:35 – 15:00

Acoustic thermometry in the atmosphere and the ocean

Roberto Gavioso (Istituto Nazionale di Ricerca Metrologica, INRiM, Italy)



## Schedule of IAPWS Meetings Torino, Italy. 3<sup>rd</sup> – 8<sup>th</sup> September 2023

(All technical meetings will be at the Starhotels Majestic)

Sunday 3 Sept.	6:00 – 8:00 pm	Welcome Reception and Registration Starhotels Majestic
Monday 4 Sept.	9:00 am	<b>Executive Committee - Opening Plenary Session</b>
	10:15 am	Coffee / Tea Break
	10:30 am	TPWS/SCSW/IRS Joint Meeting
	(To set agendas for the week and to conduct IAPWS Business, thus allowing remainder of week for technical matters)	
	10:30 am	PCAS and PCC Separate Meetings
	(To conduct IAPWS Business, thus allowing remainder of week for technical matters)	
	12:00 pm	Lunch
	1:30 pm	TPWS/SCSW/IRS Joint Meeting
	1:30 – 3:15 pm	PCC and PCAS Joint Meeting
	3:30 pm	PCC and PCAS Separate Meetings
Tuesday 5 Sept.	9:00 am	PCAS and TPWS Joint Meeting
	9:00 am - Noon	PCC WG Meeting
	9:00 am	SCSW/IRS Joint Meeting
	10:30 am	PCAS Separate Meeting
	12:00 pm	Lunch
	1:30 pm	PCAS/PCC Joint Meeting.
	1:30 pm	TPWS/SCSW Joint Meeting
	3:30 pm	PCC, PCAS and IRS Separate Meetings
Wednes. 6 Sept.	9:00 – 3:30 pm	<b>IAPWS Symposium</b> “Underpinning the Seawater Science”
	4:00 - 5:30 pm	Egyptian Museum guided visit
	7:00 pm.	<b>IAPWS Dinner/Banquet.</b> (Stupinigi Palace)
Thurs. 7 Sept.	9:00 am	TPWS, SCSW and IRS Separate WG Meetings
	9:00 am	PCC and PCAS Separate WG Meetings
	12:00 - 1:00 pm	Separate meetings of Working Groups (if needed)
	1:00 pm	Lunch
	2:30 - 4 pm	<b>IAPWS Technical Visits to INRiM</b> (Humidity, Density & Speed of Sound, Acoustic Thermodynamics)
Friday 8 Sept.	9:00 am	<b>Executive Meeting (9:00am - 1:00pm)</b> (Will include at least one member from each National Member Delegation)

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

Barry Dooley  
2<sup>nd</sup> September 2023

**Report of IAPWS President Dan Friend to IAPWS Executive Committee.**

**8<sup>th</sup> September 2023**

Good morning again! (Buongiorno!) As usual, it's been a wonderful week at the IAPWS Annual Meeting: we've had two years in which all meetings were virtual, and now two years with in-person meetings. It seems that we're starting to get things done again—I'm looking forward to hearing the reports of our Working Groups, and learning of accomplishments, plans, and progress in a general sense. That said, I feel a sense of disappointment and concern that Barry has reported on Monday, that no IAPWS business was completed during the last year—no releases, TGDs, ICRNs—or anything. I hope we will do better in the coming year.

Firstly, and on behalf of all of IAPWS, I must thank the Italian delegation—Simona—for the wonderful hospitality and effective logistical arrangements. I expressed our appreciation at the Monday meeting, but now that the week is nearly concluded I can provide more sincere and well-founded thanks: the meeting details have been essentially flawless.

So we are here together in Italy. From my perspective, it seems obvious that the networking and personal connections (and pressures) of in-person meetings are more conducive to actions—to IAPWS accomplishments. This perception (of mine) is despite my awareness of the costs of travel—not so much financial, although that is certainly an important factor—see agenda item 2.8—but in terms of CO<sub>2</sub> costs to the planet.

And as I mention CO<sub>2</sub> I am brought back to Dr. Nakahara's Presidential report from last year in New Zealand—actually perhaps the subject of our concern for at least decades—that there is a relation between traditional electric energy production and global climate change.

We've all seen—in too many cases first hand--or at least heard about, the floods, the droughts, the wildfires; not to mention the pandemic, heat waves, weather extremes, climate migration, species extinction, overpopulation; and all the issues that could point to more horrors in this century. We do not really know how technological fixes will integrate with social needs and political realities. Every choice that is made to attempt to solve such issues will have consequences—risks—whether these are well known, unknown, or uncertain.

I'm not trying to dwell on catastrophe and depression; quite the opposite. Instead, I'm again emphasizing that we need to recognize, as did Dr. Nakahara, that there is an energy transition—and electric power generation remains a key part of that. Whether that means more geothermal as we saw in New Zealand or nuclear—or fusion even—or “all of the above” as we say, it puts this organization—IAPWS—near the center of things.

We used to speak of the “energy-water nexus,” a descriptive term from the mid 1970's--for those intricate connections between power generation and the entirety of our water infrastructure. Now we should more accurately talk about the “energy-water-climate nexus,” especially as we've added physical oceanography and humidity—the atmosphere—to our organizational scope. (And I will re-emphasize the importance of resurrecting the

Subcommittee on Seawater to our technical portfolio.) My conclusion here is that the International Association for the Properties of Water and Steam is central to the emerging science, engineering, and technology of this era. For more than 50 years, we have focused on harmonization of information on water and steam as key to progress in the electric power generation sector. Now, we should recognize the centrality and importance of IAPWS to a broader assortment of key global challenges of this century. This is the energy-water-climate nexus.

As individual scientists, engineers, technologists, and entrepreneurs we may look at fundamentals (perhaps aqueous physical chemistry or ab initio calculation of properties); or preservation of capital investments within a changing power grid—cycling of base load plants; or drivers of ocean currents, or whatever. But as an organization, we must continue to look at providing global harmonization of information, guidance, and documentation for the world (or at least our membership). We, as individuals, may play small roles, but IAPWS serves a core and vital mission with potentially unlimited opportunity and responsibility.

So where do we go from here. Initially, we'll listen to reports from our Working Groups and learn of the current activities, documents, and plans—as well as continue conducting the routine business of IAPWS.

Further, I urge you all to come to the conference next year and bring your delegations to share the technical progress and challenges with this international audience. As part of that, I'll suggest that we all try to think strategically and globally about how IAPWS can contribute to an understanding of the “energy-water-climate nexus,” and what activities should become new focusses for the organization. I was pleased to learn that this strategic planning process has been occurring during this year's Annual Meeting, and I suggest that we approach the ICPWS as a means to push the bounds of IAPWS in strategically important directions.

Thank you—Barry, delegates, and all.

***IAPWS Thermophysical Properties of Water and Steam WG  
Turin, Italy, 3-8 September 2023***

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 Monday, September 4 at approximately 10:30 by the TPWS Chair, Karsten Meier. TPWS Agenda was adopted (Attachment A). The 2022 Minutes had been circulated and approved by email shortly after the 2022 meeting. Jan Hrubý was appointed Clerk of Minutes for TPWS.
3. Potential International Collaborative Projects. No new project was suggested.
4. State of Development of a New Formulation for the Thermodynamic Properties of Ordinary Water (Replacement of IAPWS-95)
  - 4.1 Report of Task Group (A. Harvey, D. Friend, J. Hrubý, N. Okita, R. Span)  
Relevant ICRN 31 was adopted in 2019. A. Harvey reviewed the performance of IAPWS-95 with new existing data, starting needs of new data. Places for improvement: obsolete gas constant, problematic terms to mimic critical behavior, extrapolation to supercooled water. Oscillations in  $p(\rho)$  inside the binodal can distort mixture calculations and prohibit using in models of vapor-liquid phase interface. Fourth virial coefficient is unphysically large. In a discussion, it was suggested an option to develop an auxiliary equation valid in a neighborhood of the vapor-liquid critical point. R. Span mentioned that the accurate scaling behavior is not much important for application in technology, because at process conditions equilibrium is hardly established at near-critical conditions. K. Meier mentioned that new data from his laboratory is available for the speed of sound in liquid water in an extended temperature range. A. Harvey indicated that experimental results which will be used in the new equation should be available roughly within 5 years. R. Span stated that this allows only experiments with existing experimental facilities. **The task group was extended by S. Lago (as a vicechair), A. Giuliano Albo and Y. Kayukawa** to motivate experimental work **and by F. Caupin** to cover the metastable water region.
5. IAPWS Certified Research Needs (ICRNs)  
Decision about this ICRN 16 (Thermophysical Properties of Seawater) and ICRN 30 (Thermophysical Properties of Supercooled Water) was postponed to the 2024 meeting, where more seawater and supercooled water experts should be present.

6. Industrial Requirements and Solutions for Property Calculations (joint with WG IRS and SCSW) [Monday afternoon]  
NOTE: Item 6 is reported on in the IRS Minutes.
  - 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 Discussion on how to best exploit the work carried on last year by IRS WG (concerning industrial requirements)
  - 6.4 Report of the Task Group “Wet steam properties calculation” (A. Nový, J. Hrubý, R. Span, K. Meier, F. di Mare, S. Senoo, M. Kunick)
  - 6.5 Translation of IF-97 Fortran routines into other programming languages (A. Nový)
  
7. Report of Task Group on surface tension of ordinary water (joint with WG IRS and SC SW) (V. Vinš, A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, R. Mareš, F. Caupin)  
 J. Hrubý reported that the persisting problem is lack of experimental data at high temperatures (roughly above 100°C). Possibility of obtaining new data in this region is being evaluated. At present, it is possible to revise the uncertainties stated in R1-76(2014). With respect to present data, it is apparent that the uncertainties can be substantially reduced for the near-ambient temperature range.
  
8. Heavy Water Properties (joint with WG IRS)
  - 8.1 Thermodynamic property measurements for heavy water at metastable states (Y. Kayukawa, H. Miyamoto, and R. Akasaka) For computations of thermodynamic properties of mixtures using contemporary models, the properties of pure water are often needed at conditions of metastable liquid. To provide data for improving the equations of state in these regions, density and speed of sound measurements are developed for heavy water. In the discussion, it was pointed out that such experimental data would be needed for ordinary water, however with uncertainties comparable with those in the stable region.
  - 8.2 Progress on a formulation for the static dielectric constant of heavy water (J. Cox, A. Harvey, and P. Tremaine) The formulation is to be developed in two steps. In the first step, correlation for liquid heavy water valid in a limited temperature range will be developed. In a second step, correlation for the full range of parameters will be developed.
  
9. Reports on miscellaneous TPWS scientific topics (joint with IRS and PCAS)
  - 9.1 Multimodal CO<sub>2</sub>-transport - Current developments, the relevance of thermodynamic properties and open questions regarding the formation of corrosive phases (R. Span)  
 Recently, establishing CO<sub>2</sub> pipelines in Germany is considered, with storage sites in Norway, Netherlands, or UK. Possible EU development of CO<sub>2</sub> pipeline

backbone (parallel to the H<sub>2</sub> backbone) to connect states with limited approach to suitable storage locations. There is a need to balance costs of cleaning with costs of pipe material, which requires better knowledge of the behavior of CO<sub>2</sub> rich mixtures. Combination of pipeline with ship transport is considered (compressed gas in pipes, dense phase in ships). Standards for CO<sub>2</sub> compositions (H<sub>2</sub>O, H<sub>2</sub>S, CO, O<sub>2</sub>, SO<sub>x</sub>, NO<sub>x</sub>) are being developed. Expert Group of the CCUS-Forum outlined fundamentals for standards. Two phase flow should be avoided as much as possible. Formation of corrosive phases must be avoided. Health and safety impact of impurities should be smaller than that of CO<sub>2</sub> itself. Negotiable (such as N<sub>2</sub> and Ar non-condensables) and non-negotiable impurities (primarily due to health and safety) are distinguished. Instead of specifying detailed composition of non-condensable gases, it is possible to define a minimum boiling temperature for a given pressure. SO<sub>x</sub> problem – usually SO<sub>x</sub> is measured, but SO<sub>3</sub> reduces the dew point much stronger than SO<sub>2</sub>.

10. Joint session with WG PCAS [Tuesday morning]
  - 10.1 Cross second and third virial coefficients and dilute-gas transport properties of the water–argon system from first-principles calculations (R. Hellmann)  
New H<sub>2</sub>O-Ar and non-additive H<sub>2</sub>O-Ar-Ar potential energy surfaces based on ab initio calculations were developed. The computed data was fitted to analytical functions of temperature. The results for the cross-second virial coefficient are in good agreement with earlier computations by Hodges et al. (2002). Experimental data for virial coefficient and Joule-Thomson coefficient show much higher uncertainties. Shear viscosity and thermal conductivity depend on composition non-linearly even in the zero-density limit. In the discussion, it was pointed out that, for practical applications, H<sub>2</sub>O-Ar-Ar is much more important than H<sub>2</sub>O-H<sub>2</sub>O-Ar (which was not computed). The reason is that water is usually very dilute and the corresponding ternary interactions are statistically unimportant.
  - 10.2 Report of the Task Group on the enhancement factor of mixtures containing steam (K. Meier, R. Hellmann, A. Harvey, and V. Fericola). Goal is an IAPWS guideline providing enhancement factors for solubility of water vapor in important gases at elevated pressures. As a pilot project, one system (presumably water-argon) will be chosen.
  - 10.3 A new model for thermodynamic properties of mixtures based on Helmholtz energy formulations of the components yielding a proper composition dependence of virial coefficients. Preliminary results for water-gas systems. (J. Hrubý)  
Contemporary corresponding states-based method of modeling fluid mixtures with multi-component equations of state generates unphysical composition dependence of virial coefficients. The suggested model overcomes this problem. Predictive capabilities of the model were demonstrated with methane-propane system. Cross-second virial coefficients for water-gas systems (Ar, N<sub>2</sub>, H<sub>2</sub>) can be reproduced when a few model parameters are fitted. To be usable for the

- presented mixture model, the equations of state of pure components (in particular for water) must extrapolate well into the metastable region.
- 10.4 A Calibration facility for investigating trace water sensors in moist hydrogen in a wide range of gas pressure and water concentration (R. Nobakht, R. Cuccaro, R. Salerno, and V. Fernicola).  
Sensors like capacitance aluminum oxide, quartz crystal microbalance, infrared spectroscopy are affected by hydrogen. A transportable precision humidity generator was developed. Enhancement factor needs to be known for the calibration procedure. An experimental set up allowing to measure the enhancement factor in flow configuration is being developed. The measuring procedure, involving expansion to lower pressure reducing the non-ideal effects, was discussed.
- 10.5 Measurements of the surface tension of the binary mixtures water + ethylene glycol and water + methanol at temperatures down to -25 °C (V. Vinš, M. Součková, M. Čenský, O. Prokopová, A. Blahut and J. Hrubý)  
Experimental set up originally developed for measurement of surface tension of pure water at conditions of supercooled liquid were used to study selected aqueous solutions. Three variants of the capillary rise method were implemented. Evaluation of the surface tension requires knowledge of density, which was measured as function of temperature and composition using a vibrating tube densimeter. A correlation for the density of aqueous ethylene glycol was developed. At present, experiments focus on the surface tension for aqueous solutions of salts.
11. Reports on seawater-related topics (joint with SC SW) [Tuesday afternoon]
- 11.1 Present status of the absolute density measurements for sea-water (Y. Kayukawa)  
The goal of the development is improving the uncertainty of the equation of state to ppm level. Use is made of a silicon single crystal sphere and sinker manufactured for the purpose of kilogram re-definition. Hydrostatic weighing apparatus for seawater density was developed. The weighing mechanism is enclosed in a pressure-controlled containment to avoid effect of atmospheric pressure fluctuation. Yet some relation of the evaluated densities to atmospheric pressure was observed.
- 11.2 How (sea) water cooling water systems can remove nano- and micro-plastics from our marine environment (L. Daal).  
Nano- and micro-plastics are environmental pollutants receiving considerable attention in recent years. The water treatment facilities of existing powerplants can be used to remove plastics particles. Promising results of the cleaning process were presented.
- 11.3 Discussion on the future of the TEOS-10 equation: management and updating  
At present, TEOS10 continues to be maintained by Joint Committee on Seawater (JCS). Further discussion is postponed to the 2024 meeting.

- 11.4 Discussion on the future of the Subcommittee on Sea Water (SCCW).  
S. Seitz wrote a Distress Flyer on the situation in SCCW and distributed it to potentially interested public. Four positive responses were received. D. Friend suggested that presentations on seawater topics at 18<sup>th</sup> ICPWS could encourage the activity. A. Giuliano Albo agreed to co-chair a conference session on sea water. S. Seitz agreed to assist.
12. Joint session with WG PCAS  
NOTE: Item 12 is reported in PCAS minutes.
- 12.1 Reevaluation of the database and formulation for the water ionization constant ( $K_w$ ) (H. Arcis)

TPWS session [Thursday morning]

13. IAPWS Webpage  
IAPWS webpage was discussed. The present appearance is obsolete and more contents should be included, in particular description of TPWS aims and activities. **K. Meier will prepare a short document concerning the contents of webpage needed for TPWS.**
14. Discussion on the future activities of TPWS  
14.1 Active TPWS Task Groups were reviewed: Development of a New Formulation for the Thermodynamic Properties of Ordinary Water, Surface Tension of Ordinary Water, Enhancement Factor of Mixtures Containing Steam, Formulation for the Static Dielectric Constant of Heavy Water, Diffusivity of Ordinary Water, Possible Revision of IAPWS Formulations for Melting Curves. TPWS Chair is requested to contact the chairs of the TG and ask them for presentations of their outputs at 18<sup>th</sup> ICPWS.
- 14.2 Possible future areas of interest to TPWS: equation of state for ordinary water in the critical region, thermophysical properties of water-based heat transfer fluids, new formulation for ammonia-water, properties of geophysical fluids, radiation chemistry, equilibrium constants of reactions in aqueous solutions (particularly for power plant application).
15. Report on International Collaborative Projects.  
The TPWS Chair requested the group to remind the members of the possibility of establishing international collaborative projects.
16. Membership. There were no changes in TPWS membership.
17. Contribution to Press Release  
The Chair and Clerk of Minutes were assigned to prepare the contribution to the Press Release.

18. Preparation of the Formal Motion to the EC  
The chair and the clerk of minutes were assigned to prepare the Formal Motion to the EC.
  
19. Adjournment  
The meeting was adjourned at approximately 11:00 on Thursday, September 7.

**Agenda for the IAPWS Working Group  
Thermophysical Properties of Water and Steam (TPWS)  
Turin, Italy, Sept. 3 – Sept. 8, 2023**

1. Opening Remarks; Adoption of Agenda [Monday morning, joint with WG IRS and SCSW]
2. Appointment of Clerk of Minutes
3. Potential International Collaborative Projects
4. State of Development of a New Formulation for the Thermodynamic Properties of Ordinary Water (Replacement of IAPWS-95)
  - 4.1 Report of Task Group (A. Harvey, D. Friend, J. Hrubý, N. Okita, R. Span)
5. IAPWS Certified Research Needs (ICRNs)
  - 5.1 ICRN 16: Thermophysical Properties of Seawater (R. Pawlowicz)
  - 5.2 ICRN 30: Thermophysical Properties of Supercooled Water (O. Hellmuth)
6. Industrial Requirements and Solutions for Property Calculations (joint with WG IRS and SCSW) [Monday afternoon]
  - 6.1 Report of the Task Group “Wet steam properties calculation” (A. Nový, J. Hrubý, R. Span, K. Meier, F. di Mare, S. Senoo, M. Kunick)
  - 6.2 Translation of IF-97 Fortran routines into other programming languages (A. Nový)
  - 6.3 Report on a white paper for acid gas dew points (N. Okita)
  - 6.4 Report of the Task Group “Categories of industrial requirements” (N. Okita, chairs or representatives of other WG)
  - 6.5 Discussion on how to best exploit the work carried on last year by IRS WG (concerning industrial requirements)
7. Report of Task Group on surface tension of ordinary water (joint with WG IRS and SC SW) (V. Vinš, A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, R. Mareš, F. Caupin)
8. Heavy Water Properties (joint with WG IRS)
  - 8.1 Thermodynamic property measurements for heavy water at metastable states (Y. Kayukawa, H. Miyamoto, and R. Akasaka)
  - 8.2 Progress on a formulation for the static dielectric constant of heavy water (J. Cox, A. Harvey, and P. Tremaine)
9. Reports on miscellaneous TPWS scientific topics (joint with IRS and PCAS)
  - 9.1 Multimodal CO<sub>2</sub>-transport - Current developments, the relevance of thermodynamic properties and open questions regarding the formation of corrosive phases (R. Span)
10. Joint session with WG PCAS [Tuesday morning]
  - 10.1 Cross second and third virial coefficients and dilute-gas transport properties of the water–argon system from first-principles calculations (R. Hellmann)
  - 10.2 Report of the Task Group on the Enhancement Factor of Mixtures Containing Steam (K. Meier, R. Hellmann, A. Harvey, and V. Fericola)

- 10.3 A new model for thermodynamic properties of mixtures based on Helmholtz energy formulations of the components yielding a proper composition dependence of virial coefficients. Preliminary results for water-gas systems. (J. Hrubý)
  - 10.4 A Calibration facility for investigating trace water sensors in moist hydrogen in a wide range of gas pressure and water concentration (R. Nobakht, R. Cuccaro, R. Salerno, and V. Fericola)
  - 10.5 Measurements of the surface tension of the binary mixtures water + ethylene glycol and water + methanol at temperatures down to -25 °C (V. Vinš, M. Součková, M. Čenský, O. Prokopová, A. Blahut and J. Hrubý)
  11. Reports on seawater-related topics (joint with SC SW) [Tuesday afternoon]
    - 11.1 Present status of the absolute density measurements for sea-water (Y. Kayukawa)
    - 11.2 How (sea) water cooling water systems can remove nano- and micro-plastics from our marine environment (L. Daal)
    - 11.3 Discussion on the future of the TEOS-10 equation: management and updating
    - 11.4 Discussion on the future of the Subcommittee on Sea Water
  12. Joint session with WG PCAS
    - 12.1 Revaluation of the database and formulation for the water ionization constant ( $K_w$ ) (H. Arcis)
- TPWS session [Thursday morning]
13. IAPWS Webpage
  14. Discussion on Future Activities of TPWS
    - 14.1 Review of current TPWS task groups
    - 14.2 Possible future areas of interest to TPWS
  15. Report on International Collaborative Projects
  16. Membership
  17. Contribution to Press Release
  18. Preparation of the Formal Motion to the EC
  19. Adjournement

*September 4, 2023*

*K. Meier (Chair), J. Hrubý (Vice-Chair)*

## Minutes of the IAPWS working group IRS, Torino, Italy, Sep. 3 - 8, 2023

(Numbering of the topics follows IRS agenda)

### 1. Opening Remarks; Adoption of Agenda [Monday Morning]

N. Okita (on behalf of IRS Chair F. di Mare) opened the IRS (joint with TPWS) at 10:35 am, 4. September 2023 meeting for IRS. Agenda was adopted without changes.

### 2. Appointed Adam Nový as a clerk of minutes for IRS

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

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

A. Nový reported no progress in theoretical level regarding the wet steam properties calculation and informed about expected progress in Doosan Škoda wet steam measurement nozzle. The complete readiness for measurements is to be reported by September 2023. K. Meier reported that he is personally in touch with Prof. Schatz, who is also willing to restart measuring at Helmut-Schmidt-Universität.

##### The following discussion:

D. Friend and A. Harvey discussed and explained the possibilities of IAPWS funding forms and that IAPWS can support only smaller measurements like students exchanges stays. For larger project the funding is about to be found on the base of EU and/or national grants. There was also discussed possibility to form ICRN with specified regions and properties to be measured (for example: speed of sound in range of wet steam, where steam turbines operate). A. Albo asked for the typical wet steam parameters in the steam turbines. From the general debate emerged, that it would be helpful to consider creating ICRN to support/encourage wet steam measurements.

##### **TODO:**

A. Nový should report the status of test rig in Doosan Škoda. Specify the typical operational envelope in wet steam for steam turbines. K. Meier to suggest to Prof. Schatz join in Boulder 2024.

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

A. Nový introduced and explained new problem raised by R. Harwood. This new topic is about helping those users of IF97 with transition from Fortran routines to other languages to support validation of newly created IF97 libraries.

##### The following discussion

D. Friend mentioned the “Nifbench”, which was used for measuring speed and also mentioned, that there was in the past done comparison between IF97 and IAPWS95 for both precision and speed. D. Friend and H.J. Kretzschmar also commented, that there should exist former Fortran routines for IF97 but it will be hard to find. H.J.Kretzschmar suggested, that there are summarised test within the Wagners Steam tables book and that also extensive test were done when creating SBTL. A. Nový mentioned, that existing checkpoints available in the IF97 releases are only for checking specific functions not the library as a complex and that in real usage are the functions combined between each other. H.J.Kretzschmar also suggested to contact K.Miyagawa, as he was also doing the IF97 tests. After the discussion there has been agreed to create new TG “Translation of IF-97 Fortran routines into other programming languages” which should at first gather and summarize all existing validation mechanisms and then continue to enhance the basic tests and also add some real more complex calculation tests (for example whole power plant cycle calculation). The TG setup was unanimously accepted at separate IRS meeting. Members of TG are A. Nový, F.di Mare,R.Harwood, A. R. Sachssendahl,

##### **TODO:**

Gather existing validation mechanisms. Suggest the validation scheme.

#### **6.3 Report on a white paper for acid gas dew points (N. Okita)**

N. Okita reported updates on the ongoing topic. Described the connection among deposits, exhaust temperature and wall surface temperature. The actual expected output is to form Whitepaper for reliable GTCC operation and shutdowns and revised Mueller’s curve. Some details regarding SO<sub>2</sub> and SO<sub>3</sub> concentrations should be included in the white paper.

##### The following discussion:

D.F. commented thermodynamical aspects. K. Meier asked about ASPEN regarding the data used K. Meier asked about the whitepaper meaning and it was answered, that it is intended as document until final TGD

##### **TODO:**

Prepare whitepaper draft until the next meeting.

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

N. Okita reported status and new updates/directions. Also reported that presence at ASME 2023 was good but not as effective because of not much time for preparation. New topic Metal Ion Complexation, close to PCC, has been added to the list. The H<sub>2</sub> combustion and atmospheric micro/macro physics is the most hot topic for future aviation propulsions to be focused next year.

The following discussion:

S. Senoo commented the presence at ASME 2023 on Power Generation panel discussion. K. Maier and A. Harvey mentioned that the mixtures problem and geothermal steam is most close to TPWS. Regarding the mixtures P. A. Albo suggested to check the “EOS-CG” (Combustion Gases). K. Meier commented that there is TPWS mixtures TG.

#### **TODO:**

ASME 2024 with stronger presence and preparation, attract industry around H<sub>2</sub> aviation propulsions and other hot topics like different H<sub>2</sub>O mixtures respectively.

Check the “EOS-CG”.

Find way to effectively share categories with other WGs.

#### **6.5 Discussion on 6.4 how to exploit it to outputs**

D. Friend mentioned that everything, that is about to be published needs EC approval. H. J. Kretzschmar reported that OPAL is still operational but not “actively” maintained and its future is uncertain. A. Harvey answered, that for sharing the outputs it would be good to use the renewed webpages of IAPWS but actually nobody within IAPWS is able to extend webpages and funding is limited.

#### **7.1 Dew Point of Low Sulphur Exhaust Gas (N. Okita, same as 6.3 but joint PCC/PCAS/IRS)**

The same topic as 6.3 but presented within PCC/PCAS by N. Okita (See PCC minutes)

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

No international cooperations/projects/challenges to be reported.

Instead, next step and future direction of IRS-WG was discussed and summarized for EC report.

#### **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 6.4

##### **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)**

A. Nový reported no progress in theory and progress in testing rig to be reported during end of September. Also it has been confirmed contact with Dr Schatz provided by K. Meier.

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

S. Senoo reported the need of measurements to adjust models for droplets-condensation. Reported, that were collected measurements available within Japan and the next step will be to collect published measurements worldwide.

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

Task group on “A white paper for acid gas dew points” was setup. Members of TG are N. Okita, D. Addison, K. Yoshida and one more PCC member (McCann).

##### **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]**

N. Okita reported limited progress since the last meeting in Rotorua, 2<sup>nd</sup> draft is waiting for PCC input regarding the concentrations limits for IRS review.

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

The issue was presented by A. Nový at the joint session, here just the basic motivation for such a activity was reminded. There was unanimously agreed to setup new TG “Translation of IF-97 Fortran routines into other programming languages (A. Nový, F. di.Mare, R. Harwood, A. R. Sachssendahl).

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

Two simple approaches, to use just IF97 or use IF97 with partial pressure at equilibrium.  
R. Pawellek commented, that Ebsilon uses functions prepared by Zittau functions“ and/or REFPROP for mixtures and also added that customers nowadays require methanol as medium.

**10. Other Business**

No other business

**11. Membership**

It has been unanimously confirmed to propose new IRS member, Aurel Ranniste Sachssendahl from Siemens Energy.

**12. Preparation of the Formal Motion to the EC**

Report new TG: “Translation of IF97 Fortran routines into other programming languages“  
Report new TG: „A white paper for acid gas dew points“  
Report new IRS member: Aurel Ranniste Sachssendahl  
Report: „Next steps“ of each TG/WG

**13. Adjournment**

Adjourned at about 16:45 September 4, 2023

## PCAS WG Minutes

Torino, Italy, September 4 – September 7, 2023

Present:

Ken Yoshida (chair)	yoshida.ken@tokushima-u.ac.jp
Hugues Arcis (vice-chair)	hugues.arcis@uknnl.com
Masaru Nakahara	nakahara@scl.kyoto-u.ac.jp
Milan Sedlár	m.sedlar@sigma.cz

### PCAS separate meeting, 9/4 morning

- (1) Agenda approved
- (2) H. Arcis appointed as the clerk of minutes
- (3) Minutes of the 2022 meeting approved
- (4) PCAS members in attendance each gave introduction and overview of their PCAS related research activities
- (5) Possibility of ICRNs  
None planned at the moment.
- (6) International collaboration  
No updates to date on International Collaboration Projects (ICP) [J. Conrad (INL, USA) and H. Arcis (NNL, UK) on the impact of metal ion complexation on the radiation chemistry of acetohydroxamic acid in aqueous solutions]
- (7) Discussion of future activities of PCAS

### PCC/PCAS joint session, 9/4 afternoon.

The following presentations were given:

Nobuo Okita, Toshiba, Dew Point of Low Sulphur Exhaust Gas

Ken Yoshida, Tokushima University, Reaction pathways and mechanisms of alkylamines in supercritical water as studied by NMR spectroscopy

It was recognized this is one of the only labs that can support the development of basic knowledge understanding for FFS kinetics – Recommendation for IAPWS Japan/NZ international collaboration project

David Addison (PCC), Ken Yoshida (PCAS) to prepare proposal for international collaboration project

Hal Stansfield, Waltron, FFA fouling of analytical instruments and mitigations

David Addison/Barry Dooley –Outline of FFS unknowns draft ICRN

Folmer Fogh, Ørsted Bioenergy & Thermal Power-Flue Gas Condensation White Paper/Draft TGD

B. Dooley, Technical guidance documents – status at September 2023

### **TPWS/PCAS joint session, 9/4 afternoon**

The following presentations were given:

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.

Multimodal CO<sub>2</sub>-transport - Current developments, the relevance of thermodynamic properties and open questions regarding the formation of corrosive phases (R. Span)

### **TPWS/PCAS joint session, 9/5 morning**

The following presentations were given:

Cross second and third virial coefficients and dilute-gas transport properties of the water–argon system from first-principles calculations (R. Hellmann)

A new model for thermodynamic properties of mixtures based on Helmholtz energy formulations of the components yielding a proper composition dependence of virial coefficients. Preliminary results for water-gas systems. (J. Hrubý)

A Calibration facility for investigating trace water sensors in moist hydrogen in a wide range of gas pressure and water concentration (R. Nobakht, R. Cuccaro, R. Salerno, V. Fernicola)

Measurements of the surface tension of the binary mixtures water + ethylene glycol and water + methanol at temperatures down to -25 °C (V. Vinš, M. Součková, M. Čenský, O. Prokopová, A. Blahut and J. Hrubý)

### **PCAS separate session, 9/5 morning**

(8) Discussion of the possibility of releases and guidelines

Potential new release on formulation for the ionization constant of light water

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

H. Arcis reported that the formation of a radiolysis group is in progress, H. Arcis has contacted researchers in that field but not ready yet for proposal to the EC.

### **TPWS/PCAS joint session, 9/5 afternoon**

The following presentation was given:

Reevaluation of the database and formulation for the water ionization constant ( $K_w$ ) (H. Arcis)

**IAPWS Symposium, 9/6**

**PCAS separate session, 9/7 morning**

The following presentation was given:

Comparison of experimental and calculated ionization constants for subcritical/supercritical water (M. Nakahara, K. Yoshida)

Thermal effects of cavitation in water (M. Sedlář)

(9) PCAS New Membership

None. Limited member attendance has been raised as a challenge. Efforts are being continued to recruit new members.

(10) Planning activities for 2023/2024

Possible new release on the ionization constant of water. Comments of evaluation task group (A. Harvey, A. Anderko) expected to be received before 2024 meeting.

PCAS expects to attract new members with the upcoming symposium session “Nuclear Reactor and Fuel Cycle Chemistry” at the 2024 meeting and accelerate the efforts towards the possibility of organizing a new group of radiation chemistry. Efforts to reach out to interested researchers in the field are still ongoing.

PCAS will coordinate with PCC to understand how they could support FFA/FFS and which academics could be invited to join PCAS.

Preparation of report for Executive meeting

It was decided to report to the EC that member Don Palmer of the Evaluation Task Group on  $K_w$  of water would be replaced by member Andre Anderko.

The wording of the EC slides was confirmed as appropriate, and some minor changes were made.

Members approved wording of draft press release of PCAS activities.

**Power Cycle Chemistry Working Group (PCC WG)  
Turin, Italy, September 3<sup>rd</sup> – 8<sup>th</sup> 2023**

**Revision 1.0**

**Monday 4<sup>th</sup> September: 10:30 – 12:00 Session**

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**1. Introduction to PCC 2023 WG meeting**

IAPWS 2023 PCC WG members were welcomed by David Addison who reviewed the schedule / agenda for the week

**2. Adoption of Agenda and Minutes Approval**

- The agenda was adopted and attached as PCC Attachment A.
- Minutes from PCC 2022 were approved with no changes.

**3. Appointment of PCC WG Clerk of Minutes**

Willy Cook (Canada) was appointed as clerk.

**4. Approval of Minutes**

No comments, omissions or changes suggested. Minutes approved.

**5. Review of Actions from last PCC WG Meeting**

From PCC-2022, 17 actions reviewed. Outstanding actions captured for follow up.

**6. Willy Cook made brief presentation in memoriam for Professor Derek Lister**

**7. Mads Skovbjerg – Update on Int'l Collaboration Project on corrosion product transport during transient load conditions**

- Filtered samples preferred for plant application – provide low-level Fe monitoring
- Correlation established between turbidity measurement and [Fe]/[Cu]
- Colour map needs to be updated to better represent plant data;
- need to include plant specific metrics such as feedwater flow rate and/or surface area to normalize the data
- Discussion followed presentation

**8. IAPWS TGD Updates**

**Corrosion Product Transport**

- Change white paper into TGD with following items further addressed

- New TGD or addition to current TGD?
- Are colour boundaries okay?
- Starting point of decay? Startup, first fire, load change?
- How to improve decay profile – operator / chemistry actions and procedures?
- Keep decay curves for both Fe and Cu?
- STG for white paper (Dooley, Thomsen, Nielsen, Vepsalainen – plus Addison, McCann)
  - New STG members for TGD development in addition to original STG
    - Skovbjerg, McAllister, Leidich

**FFS in Nuclear Plants (deferred to Monday PM)**

**Flue Gas Condensation (covered in PCC / PCAS joint session, Monday PM)**

**Geothermal Plants (deferred to Monday PM)**

**Monday 4<sup>th</sup> September: 1:00 – 15:15**

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**Joint PCAS and PCC WG Meeting**

**a) Nobuo Okita (Toshiba): Dew Point of Low Sulphur Exhaust Gas**

- Update on work presented in NZ last meeting.
- New practical H<sub>2</sub>S limits identified for inclusion in white paper
- Framework for potential TGD presented

*Questions on SO<sub>2</sub> to SO<sub>3</sub> conversion in model*

**Task Group for White Paper / TGD development: Okita, McCann, Addison**

**ACTION: Addison to discuss with Andy (GE) for addition to TG**

**b) Ken Yoshida (Tokushima University): Reaction pathways and mechanisms of alkylamines in supercritical water as studied by NMR spectroscopy.**

- Interested in FFA thermal degradation pathways investigated.
- Use of model amines (ETA, OctA) with isotope tracers to simulate FFA's
- Reaction products include the alcohol, ethene (for ETA) and isomers of octene (for OctA) that reach near equilibrium concentrations based upon modelling comparisons – different behaviour exhibited for the protonated vs neutral amine

**ACTION: Suggestion to draft ICRN project on FFS decomposition products.**

**c) Hal Stansfield (Waltron): FAA fouling of analytical instruments and mitigations**

- Loss of instrument response and accuracy due to fouling with FFS
- Tests on Na-electrode showed degraded response after a week of operation but still passes calibration – Common cleaning / regeneration not fully successful
- No apparent issues with O<sub>2</sub> analyzers

*Suggestion to use non-ionic surfactant to remove FFS.*

*What products were used for the testing? FFA's mainly (commercial OLA mixture used), no FFP's tested to date.*

*What other instruments have been investigated? ... working toward other technologies ...*

**Work needs to continue be published ASAP.**

**Suggestion to draft ICRN project to begin immediately.**

**d) David Addison (PCC WG): Outline of FFS unknowns draft ICRN**

- Key areas of interest (14) presented

**e) Folmer Fogh (Ørsted Bioenergy & Thermal Power): Water Treatment of Flue Gas Condensate White Paper | TGD**

- Development of white paper outlined and described
- Initial draft completed in March 2022 and circulated for comments.
- No work done since ...

Next steps:

- some feedback has already been collected
- Original STG to revise white paper and circulate to PCC
- Publish in PPChem

**Flue Gas Condensation TDG Discussion (Barry Dooley)**

- Change white paper into TGD with following items further addressed
  - Reformat for TGD
  - Add roadmaps and optimizations
  - Include customization
  - Needs international experience and review
  - Unify nomenclature
- STG members for TGD
  - Same members as white paper, plus

- Additional members: Ludwin Daal (Netherlands)

**Monday 4<sup>th</sup> September: 15:45 – 16:30**

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**IAPWS TGD Updates, Barry Dooley (con'd from AM session)**

**FFS in Nuclear Plants (deferred to Monday PM)**

STG: Fandrich (Chair), Dooley, Cook, Stuart, Duncanson

New STG members: Bobby Svoboda

White paper development for lay-up applications with draft ready by end of 2023.

**Geothermal Plants**

STG: Addison (chair), Richardson, Nobu

Draft circulated for review, some comments from Japanese committee – revisions needed

**Electrode Boiler Chemistry**

STG: Addison (chair), Dooley, Nielsen

New STG members: Vepsäläinen, Rziha

Recent applications in USA and Ireland

White paper in development and requires international input

- Distinction between volatile and NaOH or TSP
- Needed instrumentation?
- Relation between conductivity and corrosion
- FFS use?
- Makeup requirements

STG to meet during IAPWS week to begin activities.

**Amending TGDs**

Refreshment of published TGDs:

- Volatile and boiler alkali treatments (Int'l Collaboration Project NZ / Canada)
  - Discuss after review of Cook presentation
- Addition of Al in volatile TGD
- Carryover as function of load changes (small addition, develop section 8 / customization)
  - Dooley, Rziha, Svoboda to revise

- Instrumentation TGD
  - o add some proxy measurements
  - o tables at back need clarifying / cleaning up
  - o TGD covers fossil / biomass – should include electrode boilers? Likely better to include in the plant-
  - o Dooley, Stansfield, Nogales, Buchner, Addison, McCann
  - o Group to meet early in IAPWS week
- Film forming substances TGDs
  - o Update with new information from IAPWS FFS conferences
- Steam purity TGD
  - o Incorporate customization per new VGB guidance
  - o Leidich, Dooley, Svoboda

## Monday 4<sup>th</sup> September: 16:30 – 17:30

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### PCC Discussions Around a Future Industrial Steam / Heat TGD

Potential to align IAPWS guidance with industrial boiler systems

#### Gaps:

- Low pressure boilers / hot-water systems
- Non-demin make-up plants
  - o Common lingo means IX demin plant – need to be very clear and specific on what is meant by demin
  - o Conductivity < 0.1, silica < 30 ppb
- Condensate return
- Low heat flux biomass
- Electrode boilers
- Reboilers
- Instrumentation requirements

Does PCC want to cover some of these areas?

- Guiding principles for industrial steam plants:
  - o All ferrous
  - o No reducing agents
  - o Don't add alkalizing agents known to fail boiler tubes
  - o Measure corrosion products
  - o Instrumentation
  - o Don't add boiler chemicals in condensate or feedwater

Discussion ensued about need and value of new TGDs vs updates.

**Action: flag to discuss again at IAPWS 2025 in Finland. D. Addison to provide preliminary information for PCC to review prior to IAPWS 2025.**

## **Additional PCC Presentations**

### **a) Monika Nielsen – SIAPWS Electrode Boiler Update**

- Demonstrated phosphate hide-out and conversion to iron-phosphate
- H<sub>2</sub> identified in boiler water with potential of H<sub>2</sub> explosion

### **b) David Addison – NZAPWS Electrode Boiler Update**

- Standardize on SWAS for NZ electrode boilers
- H<sub>2</sub> monitored in steam – and seen regularly – accumulation risk identified and high points vented

### **c) David Addison – ODA Emergency Application in a 8 MW Electrode Boiler**

- ODA dosed to mitigate corrosion issues from poorly functioning deaerator

**Tuesday 5<sup>th</sup> September: 09:00 – 10:30**

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## **Future of PCC Workshop – Led by Paul McCann – PCC Vice Chair**

- a) Paul McCann (Vice Chair) introduced session and provided background on need for PCC rejuvenation.
- b) Questions for breakout groups (NA, SIAPWS, Central Europe, Pacific Rim, German-Suisse):
- What does PCC WG do well at the moment?
  - What does PCC WG not do well at the moment? Have you any suggestions how this could be addressed?
  - What do you want PCC to do in the future?
  - What areas should PCC focus on and/or develop?
    - Plant types, e.g. fossil, nuclear, geothermal, industrial, other;
    - Activities, e.g. TGD development, training, webinars;
    - Suggestions for TGDs – new documents, missing info, need for revision.

	1 – Canada/USA	2 - SIAPWS	3 – Central Europe	4 – NZAPWS/AUSAPWS/JAIPWS	5 – Germany etc
1. Well	<ul style="list-style-type: none"> <li>- Collaborative working. Technical excellence</li> <li>- TGD output and quality, input from ICRNs and other WG's</li> </ul>	<ul style="list-style-type: none"> <li>- Same as Canada/USA +</li> <li>- Open discussions</li> <li>- Very informal</li> <li>- Great support</li> </ul>	<ul style="list-style-type: none"> <li>- Knowhow is free, easily available, international recognised group</li> <li>- Good way to keep up to date with what is new etc</li> </ul>	<ul style="list-style-type: none"> <li>- Right people in PCC</li> <li>- TGDs – focused documents, need to publish recognised as priority</li> </ul>	<ul style="list-style-type: none"> <li>- Same as others!</li> <li>- Global collaboration</li> <li>- Cross over of users/designers/R&amp;D etc</li> <li>- Open and non competitive discussions</li> </ul>
2. Not well	<ul style="list-style-type: none"> <li>- Communicating what IAPWS is and what IAPWS does</li> <li>- Training, mentoring, bringing in the next generation for PCC</li> <li>- Mainly focused on ultra pure water</li> </ul>	<ul style="list-style-type: none"> <li>- Timelines very long for TGDs etc</li> <li>- Hard to get things done between annual meetings</li> <li>- Unclear of how PCC functions/planning etc</li> <li>- Integration of new people</li> </ul>	<ul style="list-style-type: none"> <li>- Communication about what PCC is and what its done</li> <li>- Difficult to know how to join and take part in PCC and what is going on</li> </ul>	<ul style="list-style-type: none"> <li>- No clear metric for the success of the TGDs, numbers downloaded, access, who, where?</li> <li>- Communication within PCC is irregular</li> <li>- Relevance of PCC to the North American market</li> <li>- Value of IAPWS/PCC to new people in industry not clear</li> </ul>	<ul style="list-style-type: none"> <li>- Visibility of IAPWS/PCC limited</li> <li>- How to get more and new members and what is the benefit of IAPWS/PCC for the companies etc</li> </ul>
3. Future	<ul style="list-style-type: none"> <li>- Webinars, LinkedIn, website, knowledge transfer, mentorship</li> </ul>	<ul style="list-style-type: none"> <li>- webinars, how to advertise/awareness ?</li> <li>- Start small with webinars – intro to PCC</li> <li>- Podcasts</li> </ul>	<ul style="list-style-type: none"> <li>- Webinars, LinkedIn, more industry/vendor people, more diversity of members</li> <li>- Focus on sharing knowledge</li> <li>- Maybe consider a name change away from "Power Cycle Chemistry"</li> <li>- Need to retain knowledge</li> </ul>	<ul style="list-style-type: none"> <li>- Better coms, more regular coms, quarterly action update calls</li> <li>- Better technology for collaborative working</li> <li>- IAPWS associated research organisations / labs / experts</li> <li>- Is Water/Steam Cycle better name for PCC?</li> </ul>	<ul style="list-style-type: none"> <li>- Relook/redesign IAPWS/PCC website</li> <li>- Make very clear the benefits of IAPWS/PCC</li> <li>- Increase efforts of public relations – LinkedIn etc</li> <li>- Make members of PCC more visible</li> <li>- Translate TGDs into – Spanish/Chinese etc?</li> </ul>
4i. Plant	<ul style="list-style-type: none"> <li>- Look outside into more industrial applications</li> <li>- SMRs, CCS, water reuse, hydrogen</li> </ul>	<ul style="list-style-type: none"> <li>- Move beyond just fossil</li> <li>- SMR, CCS, eBlrs, industrial</li> </ul>	<ul style="list-style-type: none"> <li>- SMR, cooling systems</li> </ul>	<ul style="list-style-type: none"> <li>- Keep primary focus on what is in commercial use + track emerging industries and issues</li> </ul>	<ul style="list-style-type: none"> <li>- Steam/Water cycle still needed</li> <li>- Supercritical water/steam systems</li> </ul>
4ii. Activities	<ul style="list-style-type: none"> <li>- Webinars, LinkedIn, website, knowledge transfer, mentorship</li> </ul>	<ul style="list-style-type: none"> <li>- Advertising for PCC/raise awareness</li> <li>- Sharing of national group experiences/processes</li> </ul>	<ul style="list-style-type: none"> <li>- Need to retain knowledge</li> </ul>	<ul style="list-style-type: none"> <li>- More public outreach, webinars, IAPWS 101/TGDs, making them then available on YouTube etc</li> </ul>	<ul style="list-style-type: none"> <li>- Training/Webinars (issues with costs/commercials etc)</li> <li>- Take care of existing TGDs/revisions</li> </ul>
4iii. TGDs			<ul style="list-style-type: none"> <li>- Boiler chemical cleaning</li> </ul>	<ul style="list-style-type: none"> <li>- TGD "Management of Water/Steam Chemistry" – road map to use TGDs</li> </ul>	<ul style="list-style-type: none"> <li>- Supercritical water/steam systems</li> <li>- Plant preservation/issues</li> </ul>

**Tuesday 5<sup>th</sup> September: 11:00 – 12:00**

**Hydrogen Production and Water Related Issues – Led by Kirk Buecher (PCC Vice Chair)**

- a) **David Addison – Potential Water Chemistry issues in the large scale hydrogen production space introduction**
- b) **Kirk Buecher – Hydrogen Generation/Industry Space and Potential Cross Over with IAPWS PCC and other Working Groups**
  - Overview of H<sub>2</sub> generation technology
  - Emphasis on water quality for PEM electrolyzers (ASTM Type I, II etc)

*What can PCC contribute? TGD on PEM water quality?*

*Include topical area for ICPWS 2024? Invite presentations in the electrochem / corrosion stream.*

*Discuss with electrolyzer industry, develop relationship and identify potential issues + ICRN*

**ACTION: Addison, Cook, Dooley, Nielsen – coordinate for electrolyzer water session at ICPWS 2024**

**Tuesday 5<sup>th</sup> September: 1:00 – 15:15**

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**PCC Task Group Meeting/Working Time**

**Tuesday 5<sup>th</sup> September: 1:00 – 15:45**

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**TGD-Related PCC Presentations/Updates**

- a) **Taro Ichihara – Hydrogen damage in a power boiler: Correlations between damage distribution and thermal-hydraulic properties**
- b) **Ludwin Daal – BlueXPRT Netherlands Experience with Corrosion Product Sampling and Analysis**
- c) **Basil Perdicakis – Canadian Oil Sands Water/Steam Chemistry Related Changes and Improvements Since IAPWS 2019 in Banff, Canada**
- d) **Mar Nogales – Possible Updates for the IAPWS Instrumentation TGD**
- e) **Willy Cook – Boiler Electrochemical Corrosion Studies Test Rig Results Update: IAPWS Canada/NZ International Collaboration Project**

## **Thursday 7<sup>th</sup> September: 09:00 – 09:30**

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### **PCC Discussions Around ICPWS 2024 – led by David Addison**

#### General Information:

- June 23-28, 2024
- Call for papers close 19<sup>th</sup> November
- PCC areas
  - Power Cycle Chemistry
  - Electrochem & Corrosion
- Time for regular PCC business – Sunday prior to conference
  - EC meeting for 1.5 hrs +
  - PCC meeting (all PCC business)
- Remainder of week for ICPWS, IAPWS General Meeting
- EC meeting on the Friday

#### Key focus areas:

- Chemistry, FSS, water-steam analysis

## **Thursday 7<sup>th</sup> September**

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### **Dedicated PCC Task Group Meeting/Working Time**

Not needed, groups have meet and plans highlighted below.

## **Thursday 7<sup>th</sup> September: 09:30 – 10:30**

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### **IAPWS TGD's Updates (led by Barry Dooley) – progress updates from IAPWS 2023 activities and plans from Task Group Chairs**

#### Steam purity:

- has met and methodology determine
- Frank Udo to submit to Bobby & Barry
- Perhaps new TGD emerges for updated data analysis

#### FFS in Nuclear:

- Fandrich to complete draft by year end

#### FFS in fossil:

- ICRN has been discussed and new items to be added

## Corrosion products:

- still uncertainty if enough information has been collected to solidify a TGD
- Agreed to review Mads thesis, white paper 2019 and Barry's presentation
  - o e.g. what is the starting point for the decay curve, may include all
  - o what are the operating features and/or shutdown conditions that give "green" area
- All will agree path forward in next month, virtual meeting to be scheduled
- Determine who will write necessary new text
- Maintain it as a unique document
- Paul to collate comments and set

**ACTION: STG to comment on path forward and set meeting by end of October 2023**

## Geothermal Steam:

- Addison & Nobou have meet
- Plan for "consequence table" inserted into White Paper
- Target ICPWS 2024 for approval of TGD

## Flue Gas Condensation:

- Convert current white paper to TGD format
- Target ICPWS 2024 for approval of TGD

## Electrode Boilers:

- Addison & Nielsen have met
- Short, concise TGD to be drafted
- Circulate pre-TGD to operators / vendors over the next year for input
- Target IAPWS 2025 for approval of TGD

## Instrumentation:

- STG has met and it's already an excellent document
- Targeting minor updates
- Review by end of October and provide suggestions to STG
- Include monitoring of condensate return from process steam systems?

**ACTION: STG review and send comments / additions by end of October 2023**

## White Papers:

- Potentially included white paper activity descriptions on new IAPWS PCC website
- Contact WG Chair for information on white papers
- Some concern about this process depending upon the area of application
- Should have PCC WG approval prior to release
- Need to develop a white paper policy

**ACTION: Addison & Dooley to discuss and draft a policy for development and release of PCC white papers prior to ICPWS 2024.**

## International Collaboration Reports:

- Several reports are being completed. All currently “live” on the computer of the IAPWS Exec. Secretary
- Where do these “live” and who has access (OPAL terminal)
- Process to be similar to release of white papers

**ACTION: Addison & Dooley to discuss and draft a policy for development and release of PCC International Collaborations prior to ICPWS 2024.**

## Barry Dooley comments on Future of PCC Workshop

### What IAPWS PCC could do:

- Evaluation of water wall deposition loadings – do the boilers need to be chemically cleaned.
  - o Developed in ‘80s Based upon loading / thickness and incorrectly applied
  - o HRSG TGD has been developed
  - o Gap with supercritical units
    - New understanding based upon voidage of the native oxide
    - Introduce TGD?
  - o Chemical Cleaning for fossil plants
    - What could be done simply?
- IAPWS is the leading org in the world for ...
  - o FFS – based upon the international conference series
  - o HRSGs – again, based upon the international conference series
  - o Perhaps more conference series are needed
    - Corrosion products?
    - PTZ / steam turbines
- Internal organization of IAPWS
  - o 1990 Argentina – framework of IAPWS work activities developed, working groups developed
  - o Structure needs to be re-examined and how collaborative works are initiated
    - Interface between PCC and PCAS needs mending

**ACTION: PCC WG Chair to discuss with PCAS Chair**

**Thursday 7<sup>th</sup> September: 11:00 – 12:30**

**PCC WG Business**

Added presentation:

**Frank Udo Leidich – Oxidation and corrosion behavior of steel alloys in supercritical water**

**a) Progress Reports 2022/2023 and Future PCC Activities**

- Review of outstanding actions and new actions from 2023
- ICRN 32 – needs to go to editorial committee

**b) Future direction of PCC discussions summary – proposals for future management of PCC**

- Update website to add PCC information
- PCC LinkedIn page to be launched and monitored
  - o Comments that this should be done professionally and properly
  - o Dooley not overly excited about LinkedIn
- Host four webinars before ICPWS 2024
  - o Dooley to start with TGD Overview
  - o Rziha + two more
- Move to bi-monthly PCC virtual meetings via MS Teams or Zoom

PCC Chairman asked for PCC agreement on this approach. There was no objection from the PCC group in attendance.

**c) Proposals for new TGD's summary**

No additional discussion.

**d) International Collaboration Projects**

No ICPs currently ongoing, a few could be established within are of FFS and jointly between PCC and PCAS.

Process for reporting and access to ICP reports to be drafted (Action 23-10)

**e) ICRNs – Review and Possible New Additions**

ICRN 32 approved in 2022 needs to move to EC and Editorial Committee

FFS ICRN

Electrode Boiler ICRN – hydrogen generation

These can be drafted and passed out to national committees for review, comment and approval via postal ballot.

**f) PCC Public Relations / Contribution to Press Release**

**g) Changes in PCC Membership and Election of Officers**

New membership to PCC:

Nikko Vepsäläinen, Finland

David De Vos, Belgium

Antony Senecat, Belgium

Ronny Wagner, Germany

Antonios Thanos, Greece

New PCC Vice-Chair:

Taro Ichihara, Japan

**h) Adjournment**

IAPWS President made address to PCC and provided comments on planning for ICPWS 2024 and encouraged everyone to attend.

Meeting adjourned 12:15 PM September 7<sup>th</sup>, 2023.

## ACTION LIST

#	PCC Area	Action	Owner	Due Date	Status
<b>Summary of Actions carried forward</b>					
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 <sup>nd</sup> 2022	In progress
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
22-5	Future PCC directions	Assess scope and cross-over of hydrogen generation space with PCC	Beucher	Turin 2023	Discussion later in PCC program

		and other WGs' mandates. To present his findings in Turin			
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
22-7	International collaborations	Submit plans or paperwork for desired upcoming international collaborations	PCC Members	Before Turin 2023	Issued – none received
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
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.
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		Not complete ... need to follow up
<b>Summary of New Actions from PCC 2023</b>					
23-1	Dew Point at low sulphur	Addison to discuss with Andy (GE) for addition to TG	Addison		
23-2	FFA decomposition products	Int'l Collaboration Project draft for EC submission	Yoshida		
23-3	FFA fouling on instrumentation	Int'l Collaboration Project draft for EC submission	Stansfield Cook		
23-4	Flue gas condensate	Submit white paper for publication + begin TGD draft	Fogh		
23-5	FFS in nuclear	Complete white paper draft for review	Fandrich	Dec2023	
23-6	Water use in hydrogen electrolyzers	Contact and coordinate papers for PEM / SOEC for sessions at ICPWS 2024	Addison Beucher Cook Dooley		

			Neilsen		
23-7	Corrosion products TGD	STG to review current comments and meet virtually to plan additions required	STG	Oct2023	
23-8	Instrumentation TGD	STG review and circulate comments / additions	STG	Oct2023	
23-9	White paper & Int'l Collaborations	Develop policy and process for promotion and release of these unofficial documents	Addison Dooley		
23-10	Internal structure of PCC and PCAS	Close collaboration needs to be reestablished and working relationship strengthened - discussion between WG Chairs needed	Addison		

### List of Current IAPWS Special Task Groups (STG) for Technical Guidance Document Development Led by PCC

**Task Group Name** Corrosion Product Sampling  
**New TGD** Intended but not at this stage  
**Revised TGD** No  
**New White Paper** Yes  
**STG Lead** Dooley  
**STG Members** Dooley, Thomsen, Nielsen, Vepsalainen – plus Addison, McCann. New members Skovbjerg, McAllister, Leidich

**Task Group Name** Flu Gas Condensation  
**New TGD** Intended but not at this stage  
**Revised TGD** N/A  
**New White Paper** Yes  
**STG Lead** Fogh  
**STG Members** Dooley, Thomsen, new member Daal

**Task Group Name** Geothermal Steam Chemistry  
**New TGD** Intended but not at this stage  
**Revised TGD** N/A  
**New White Paper** Yes

**STG Lead** Addison  
**STG Members** Okita, Richardson

**Task Group Name** Electrode Boiler Chemistry  
**New TGD** Yes  
**Revised TGD** N/A  
**New White Paper** N/A  
**STG Lead** Addison/ Nielsen  
**STG Members** Dooley, Vepsäläinen, Rziha

**Task Group Name** FFS for Nuclear Plants  
**New TGD** Intended but not at this stage  
**Revised TGD** N/A  
**New White Paper** Yes  
**STG Lead** Fandrich  
**STG Members** Cook, Dooley, Stuart, Hater, Pringle, Ichihara, Hirano, Bengtsson, Duncanson

**Task Group Name** Instrumentation  
**New TGD** No  
**Revised TGD** Yes  
**New White Paper** No  
**STG Lead** Dooley  
**STG Members** Stansfield, Nogales, Buchner, Addison, McCann

**Task Group Name** Steam Purity  
**New TGD** No  
**Revised TGD** Yes  
**New White Paper** No  
**STG Lead** Dooley  
**STG Members** Svoboda, Leidich

**Task Group Name** Film Forming Substances  
**New TGD** No  
**Revised TGD** Yes  
**New White Paper** No  
**STG Lead** Dooley  
**STG Members** Addison, TBC

**Task Group Name** Carryover  
**New TGD** No  
**Revised TGD** Yes  
**New White Paper** No  
**STG Lead** Dooley  
**STG Members** Svoboda, Rziha

**PCAS Led TGD Work with Support from PCC**

**Task Group Name** Dew Point of Low Sulphur Gas  
**New TGD** Intended but not at this stage  
**Revised TGD** N/A  
**New White Paper** Yes  
**STG Lead** Okita  
**STG Members** Addison, McCann



## Press Release – IAPWS 2023

### Executive Committee and Working Group Meetings

Between September 3<sup>rd</sup> – 8<sup>th</sup>, 2023, 62 scientists, engineers and guests representing 20 countries converged in Turin, Italy at the Star Hotel Majestic for the annual meetings of the IAPWS Executive Committee and Working Groups. This continues a series of meetings that began in 1929 in London, UK with the purpose to connect scientists and researchers with the industry operators, engineers and managers who use their work. Collaboration and engagement across these varied groups provides guidance to the researchers on topical problems within industry and provides the engineers with the latest research results for direct application in their facilities.

The main meetings included discussions around power cycle chemistry, high temperature aqueous technologies applicable to steam cycles and hydrogen generation, oceanography and global climate modelling, geothermal steam, electrode boilers, power cycles with CO<sub>2</sub> capture and storage systems and combined heat and power systems.

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

As traditionally held during the middle of the annual IAPWS meeting, the 2023 IAPWS Symposium entitled “Underpinning the Seawater Science” was focused on oceanographic research and climate modelling. Nine presentations intrigued the IAPWS delegates and additional Symposium attendees from diverse areas of ocean science including state-of-the-art measurements for carbon dioxide and dissolved oxygen in sea water, aspects of physical properties such as sea water density and salinity, acoustic thermometry



in oceanic environments and emerging technology including hybrid ocean-wave power conversion systems. No Helmholtz award was presented this year. Following the Symposium, the delegates were treated to a private tour of the Egyptian Museum where exhibits from various epochs of antiquity enlightened the group. The IAPWS banquet was held at the magnificent Stupinigi Palace where the delegates were treated to stunning architecture and Italian hospitality.



IAPWS, through the various working groups, produces releases and guidelines, technical guidance documents (TGD) and IAPWS certified

research needs (ICRN). These can be found for free download on the IAPWS website at [www.iapws.org](http://www.iapws.org).

The Thermophysical Properties of Water and Steam (TPWS) working group is developing an IAPWS guideline to provide enhancement factors for the solubility of water vapor in important gases at elevated pressures. As a pilot project, one system (presumably water-argon) will be chosen. Initial work involving new, theoretically calculated second and third virial coefficients and transport properties for the water-argon system were reported at the meeting.

The Industrial Requirements and Solutions (IRS) working group proposed a white paper as a progression toward development of a TGD on estimating low sulfur dew point in GTCCs to prevent acid corrosion and discussed future directions of IRS. A task group was established to define issues in industrial calculation needs for steam properties involving the translation of IF97 Fortran routines into other programming languages. There is on-going activity on wet steam properties, new calculation needs for mixtures with H<sub>2</sub>O and other medium for geothermal or renewables including CO<sub>2</sub> cycle and H<sub>2</sub> combustion to establish IAPWS formal guidelines in future.

The Physical Chemistry of Aqueous Systems (PCAS) working group discussed reactions of alkyl amines in water at high temperatures with the goal of understanding reactions of film-forming amines (FFA). Re-evaluation of the database and formulation for the ionization constant of water and the comparison of experimental and computational results were discussed with the goal to develop a new guideline. Thermal effects of cavitation in water were also discussed. These topics are all relevant to the basic understanding of corrosion processes.

The Power Cycle Chemistry (PCC) working group had a productive week with a focus on progressing and completing TGDs that are currently in progress via ongoing white paper development. Areas of active work include corrosion product transport in cycling plants, flue gas condensate use or reuse and dew point of low sulfur exhaust gas. An open and robust review of the future of PCC was conducted and resulted in topics to develop an action plan to enhance the reach of PCC in the future including new areas of interest such as hydrogen production and use.

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 the 18<sup>th</sup> International Conference on the Properties of Water and Steam (ICPWS) to be held in Boulder, USA from the 23<sup>rd</sup> – 28<sup>th</sup> June 2024. Further information on meetings can be found at the IAPWS website ([www.iapws.org](http://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](mailto:bdooley@iapws.org). People do not need to be citizens or residents of member countries to participate.





## AUSAPWS Report to IAPWS Executive Committee 2023

AUSAPWS held a three-day symposium in Melbourne from 14-16 August 2023. This was the first in-person event since 2019 and attracted more than 70 delegates from power stations, major industry, sponsors and vendors. Of particular interest to attendees was the IAPWS workshop on film-forming substances presented by David Addison.

Membership of AUSAPWS has grown to almost 100 active members (centered on power generation) and we expect to reach 150 members during 2024. Involvement with AUSAPWS is gaining recognition amongst managers and employers as an effective source of practical training and professional development for technical staff.

Alongside this increase in activity AUSAPWS has restarted its sponsorship and fundraising activities (paused in 2020) which will allow support for more frequent events for members.

Strategies goals for AUSAPWS in 2024 are:

1. To attract new members from academic and research sectors and explore ways to support basic research of interest to our members
2. To build an Australian presence in IAPWS Working Groups beyond the PCC
3. To support the hosting of satellite meetings of AUSAPWS members and build toward the next multi-day symposium in 2025
4. To maintain a healthy financial position that supports innovation in the services provided to members

**Czech Society for the Properties of Water and Steam  
Annual Report 2023**

Submitted to IAPWS Executive Committee, November 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 16, 2023. 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 2023 and 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 Prof. Jiří Kolafa, Prof. Josef Šedlbauer, Dr. Ondřej Bartoš, and Dr. Jan Hrubý. Ad-hoc lecture on nucleation of gas hydrates were organized at IT CAS in connection with a visit of Dr. Bernd Rathke (Univ. Bremen). A one-day symposium on thermophysical properties was organized at IT CAS with guests from TU Dresden, TU Chemnitz and Univ. Bochum).

Research

Recent data on surface tension of aqueous mixtures including the temperature range under the metastable supercooled state were presented on two international events [1,2]. The Prague team collected new data on systems with ethylene glycol and is currently performing measurements of low-concentration mixtures with methanol exhibiting a rapid drop in surface tension with increasing methanol concentration. The results of joined collaboration with the Ruhr University Bochum and the Technical University Dresden on the modeling of gas hydrates were introduced at the Prague conference held under the Czech Presidency of the Council of the European Union [3]. Research of nucleation of droplets in gaseous mixtures of water with various gases continued by a study with a sequence of gases with increasing number of atoms in the molecule: argon, nitrogen, and nitrous oxide[4] Jan Hrubý collaborated with Allan Harvey and Karsten Meier on the review paper of IAPWS activities concerning thermophysical properties of water [5].

References

1. Vinš, Václav - Součková, Monika - Čenský, Miroslav - Prokopová, Olga - Aminian, Ali - Blahut, Aleš - Hrubý, Jan: Surface tension of binary aqueous mixtures with ethylene glycol and sodium chloride including metastable supercooled state. 13th Asian Thermophysical Properties Conference (ATPC2022), pp. 202. September 26. to 30. 2022, Sendai (Japan).
2. Vinš, Václav - Součková, Monika - Blahut, Aleš - Čenský, Miroslav - Prokopová, Olga - Aminian, Ali - Hrubý, Jan: Surface tension and density of aqueous systems under the

supercooled metastable state. WORKSHOP - RESEARCH TRAINING GROUP 2430 – Interactive Fiber Rubber Composite, November 8. and 9. 2022, Lingnerschloss, Dresden (Germany).

3. Vinš, Václav - Jäger, A. - Fiedler, F. - Hrubý, Jan - Čenský, Miroslav - Span, R.: Phase Behavior of CO<sub>2</sub>-Rich Mixtures Involving Gas Hydrates and Ices as a Challenge for the Design of CCS/U Technologies. DECARB 2022 – Decarbonisation of Energy Intensive Industries – Conference under the Czech Presidency of the Council of the European Union. 10. & 11.11.2022, Prague (Czechia).
4. Lukianov, Mykola – Lukianova, Tetiana – Hrubý, Jan: Homogeneous water nucleation in argon, nitrogen, and nitrous oxide as carrier gases  
J. Chem. Phys. 158, 124301 (2023) <https://doi.org/10.1063/5.0138794>
5. Harvey, Allan - Hrubý, Jan - Meier, Karsten: Improved and Always Improving: Reference Formulations for Thermophysical Properties of Water.  
Journal of Physical and Chemical Reference Data 5 (2023) 011501  
<https://doi.org/10.1063/5.0125524>

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 2021/2023**

<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 Founding Assembly of the German-Swiss Association for the Properties of Water and Steam (GSAPWS) took place at the German Research Centre for Geosciences (GFZ) in Potsdam, Germany on 1 April 2022.

The second general meeting and the annual meeting of the association and took place at SWAN Analytical Instruments AG and PPCHEM AG in Hinwil, Switzerland on 20 and 21 April, 2023.

In the following, activities of certain members of the German-Swiss Association for the Properties of Water and Steam in the years 2021 to 2023 are summarized.

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

Recent Publications

- Hellmuth, O.; Feistel, R.; Foken, Th.:  
Intercomparison of different state-of-the-art formulations of the mass density of humid air.  
Bulletin of Atmospheric Science and Technology 2, 13 (2021),  
<https://doi.org/10.1007/s42865-021-00036-7>.
- Feistel, R.; Hellmuth, O.:  
Relative Humidity: A control valve of the steam engine climate.  
Journal of Human, Earth, and Future 2, 139-182 (2021),  
<http://dx.doi.org/10.28991/HEF-2021-02-02-06>.
- Feistel, R.; Hellmuth, O.; Lovell-Smith, J.:  
Defining relative humidity in terms of water activity: III. Relations to dew-point and frost-point temperatures.  
Metrologia 59 (2022) 045013 (27pp),  
<https://doi.org/10.1088/1681-7575/ac7185>.
- Feistel, R.; Hellmuth, O.:

Thermodynamics of evaporation from the ocean surface. *Atmosphere* 14 (2023), 560 (32pp), <https://www.mdpi.com/journal/atmosphere>.

- Feistel, R.; Hellmuth, O.:  
Non-equilibrium entropy and enthalpy of seawater evaporation. Short Note. ResearchGate Preprint, dated 11 April 2023
- Hellmuth, O.; Spänkuch, D.; Feistel, R.; Görsdorf, U.; Schwartz, S. E.:  
Microphysical, optical, and thermodynamic constraints defining a warm cloud. A contribution to the discussion "What is a cloud?".  
In preparation.
- Feistel, R.; Hellmuth, O.:  
Irreversible Thermodynamics of Seawater Evaporation.  
To be submitted to the Journal of Marine Science and Engineering
- Ebeling, W.; Feistel, R.; Krienke, H.:  
Statistical theory of individual ionic activity coefficients of electrolytes with multiple – charged ions including seawater.  
*Journal of Molecular Liquids* 346 (2022) 117814,  
<https://doi.org/10.1016/j.molliq.2021.117814>.
- Ebeling, W.; Feistel, R.; Grigo, M.:  
Onsager - Fuoss' matrix theory of conductivity of electrolytic mixtures applied to seawater. (*Dedicated to the 120th anniversary of Lars Onsager*).  
In preparation.
- 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.  
(*Zum Leibniztag 2023 dem Andenken an Lutz-Günther Fleischer (1938 – 2023) gewidmet, der einer der ersten Dozenten für irreversible Prozesse in Deutschland und langjähriger Vizepräsident der Leibniz – Sozietät war*).  
Submitted to Leibniz Online, August 2023.
- Hagen, E.; Feistel, R.:  
Sub-surface current meanders along the Namibian shelf. *Deep-Sea Research I*, 167, (2021), 103432,  
<https://doi.org/10.1016/j.dsr.2020.103432>.
- Feistel, R.:  
On the Evolution of Symbols and Prediction Models. *Biosemiotics* April 2023,  
<https://doi.org/10.1007/s12304-023-09528-9>.

**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, CaCl<sub>2</sub> 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 is in preparation for publication in *Geothermal Energy* (see below).

2. 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, CaCl<sub>2</sub>, and KCl. To evaluate the error in density and viscosity that comes with neglecting the minor constituents of natural fluids, three 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

- Hoffert, U., Milsch, H., Lassin, A., Guignot, S., André, L., Sass, I.: Density of pure and mixed NaCl and CaCl<sub>2</sub> aqueous solutions at 20-80°C and 0.1 MPa. (2023) in preparation.
- Milsch, H., Hoffert, U., Kummerow, J., Lassin, A., André, L.: The H2020 REFLECT project: Deliverable D2.4 - Thermophysical properties of highly saline geothermal fluids. Potsdam: GFZ German Research Centre for Geosciences, p. 47 (2022) <https://doi.org/10.48440/gfz.4.8.2022.008>

### **Helmholtz Centre for Environmental Research, Magdeburg Dr. Bertram Boehrer**

#### Project

Extending the solubility of noble gases for tracing natural waters and applying noble gas thermometry. (In collaboration with the Ruprecht-Karls University Heidelberg)

We measured solubility of noble gases from the atmosphere against temperature over the range from 25°C to 80°C and combined these measurements with previously available solubilities (0°C to 35°C). This we can provide a consistent curve for helium, neon, argon, krypton and xenon over the entire range from 0°C to 80°C at an accuracy of 2% to 3% depending on the separate noble gases.

This facilitates tracing of natural waters and noble gas thermometry in natural waters. We applied these new functions to the deep waters of Lake Kivu.

#### Recent Publications

- Schwenk, C.; Freundt, F.; Aeschbach, W.; Boehrer, B.: Extending Noble Gas Solubilities in Water to Higher Temperatures for Environmental Application. *J. Chem. Eng. Data* 2022, 67, 5, 1164–1173, <https://doi.org/10.1021/acs.jced.2c00009>.
- Schwenk, C.; Negele, S.; Balagizi, C. M.; Aeschbach, W.; Boehrer, B.: High temperature noble gas thermometry in Lake Kivu, East Africa. *Science of The Total Environment*, 837, 155859.

**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

- Hellmann, R.; Harvey, A. H.:  
First-Principles Diffusivity Ratios for Atmospheric Isotope Fractionation on Mars and Titan.  
J. Geophys. Res. Planets 126, e2021JE006857 (2021).
- El Hawary, A.; Meier, K.:  
Highly Accurate Densities and Isobaric and Isochoric Heat Capacities of Compressed Liquid Water Derived from New Speed-of-Sound Measurements.  
Int. J. Thermophys., to be submitted (2023).
- Hellmann, R.:  
Cross Second Virial Coefficient of the H<sub>2</sub>O–CO System from a New *Ab Initio* Pair Potential. Int. J. Thermophys. 43, 25 (2022).
- Huber, M. L.; Perkins, R. A.; Assael, M. J.; Monogenidou, S. A.; Hellmann, R.; Sengers, J. V.:  
New International Formulation for the Thermal Conductivity of Heavy Water.  
J. Phys Chem. Ref. Data 51, 013102 (2022).
- Harvey, A. H.; Hrubý, J.; Meier, K.:  
Improved and Always Improving: Reference Formulations for Thermophysical Properties of Water.  
J. Phys Chem. Ref. Data 52, 011501 (2023).
- Hellmann, R.:  
Cross Second Virial Coefficients of the H<sub>2</sub>O–H<sub>2</sub>S and H<sub>2</sub>O–SO<sub>2</sub> Systems from First Principles.  
J. Chem. Eng. Data 68, 108–117 (2023).
- Hellmann, R.:  
Cross Second Virial Coefficients of the H<sub>2</sub>O–H<sub>2</sub> and H<sub>2</sub>S–H<sub>2</sub> Systems from First Principles.  
J. Chem. Eng. Data, in press (2023).

## Dr. Olaf Hellmuth

### Recent Publications

- Hellmuth, O.; Feistel, R.; Foken, Th.:  
Intercomparison of different state-of-the-art formulations of the mass density of humid air.  
Bulletin of Atmospheric Science and Technology 2, 13 (2021),  
<https://doi.org/10.1007/s42865-021-00036-7>.
- Feistel, R.; Hellmuth, O.:  
Relative Humidity: A control valve of the steam engine climate.  
Journal of Human, Earth, and Future 2, 139-182 (2021),  
<http://dx.doi.org/10.28991/HEF-2021-02-02-06>.
- Foken, T.; Hellmuth, O.; Huwe, B.; Sonntag, D.:  
Chapter 5: Physical Quantities. In: Foken, T. (Ed.): Springer Handbook of Atmospheric Measurements.  
Springer International Publishing. Hardcover, ISBN 978-3-030-52170-7, DOI 10.1007/978-3-030-52171-4 (2021).
- Sonntag, D.; Foken, T.; Vömel, H.; Hellmuth, O.:  
Chapter 8: Humidity Sensors. In: Foken, T. (Ed.): Springer Handbook of Atmospheric Measurements. Springer International Publishing. Hardcover ISBN 978-3-030-52170-7, DOI 10.1007/978-3-030-52171-4 (2021).
- Spänkuch, D., O. Hellmuth, U. Görzdorf:  
What is a cloud? Toward a more precise definition. Bull. Am. Met. Soc., E1894-E1929 (2021),  
<https://doi.org/10.1175/BAMS-D-21-0032.1>.
- Feistel, R.; Hellmuth, O.; Lovell-Smith, J.:

Defining relative humidity in terms of water activity: III. Relations to dew-point and frost-point temperatures.

Metrologia 59 (2022) 045013 (27pp),  
<https://doi.org/10.1088/1681-7575/ac7185>.

- Feistel, R.; Hellmuth, O.:

Thermodynamics of evaporation from the ocean surface. Atmosphere 14 (2023), 560 (32pp), <https://www.mdpi.com/journal/atmosphere>.

- Feistel, R.; Hellmuth, O.:

Non-equilibrium entropy and enthalpy of seawater evaporation. Short Note. ResearchGate Preprint, dated 11 April 2023.

- Hellmuth, O.; Egerer, U.; Siebert, H.; Hellmuth, O.; Sorensen, L.:

PAMARCMiP Contribution: An analytical model companion based on observations: The role of low-level jets in the advection of passive tracers in the high Arctic.

Zenodo, March 1, 2023,

<https://doi.org/10.5281/zenodo.7689308>.

- Egerer, U.; Siebert, H.; Hellmuth, O.; Sorensen, L. L.:

The role of a low-level jet for stirring the stable atmospheric surface layer in the Arctic. Submitted to Atmos. Chem. Phys.

- Hellmuth, O.; Spänkuch, D.; Feistel, R.; Görndorf, U.; Schwartz, S. E.:

Microphysical, optical, and thermodynamic constraints defining a warm cloud. A contribution to the discussion "What is a cloud?".

In preparation.

## **PPCHEM AG, Hinwil**

### **Tapio Werder, Michael Rziha**

Following Technical Guidance Documents (TGDs) are presently in development:

- Chemistry in Geothermal plants (White Paper)
- Corrosion Product Sampling, Monitoring for Flexible and Fast Starting Plants (White Paper)
- Water Treatment of Flue Gas Condensate (White Paper and Draft TGD)
- Chemistry for Electrode Boilers (White Paper)
- FFS application in Nuclear Plants (White paper)

In 2023, all current TGDs will be reviewed. Based on this, the documents are updates/revised.

### **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 to improve the traceability of pH<sub>T</sub> measurements of seawater, a quantity needed to monitor ocean acidification due to anthropogenic CO<sub>2</sub> emissions. Empirical equations with associated uncertainties will be developed describing pH<sub>T</sub> in dependence of salinity and temperature over ranges relevant in oceanography.
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 will be used by 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.

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 3.13 establishes a measurement and calibration set-up for high pressure salinity measurements.

Publication:

- Waldmann, C.; Fischer, P. F.; Seitz, S.; Köllner, M.; Fischer, J.-G.; Bergenthal, M.; Brix, H.; Weinreben, S.; Huber, R.:  
A Methodology to Uncertainty Quantification of Essential Ocean Variables. *Frontiers in Marine Science* 15 (2022), Sec Ocean Observation, 9 (2022), <https://doi.org/10.3389/fmars.2022.1002153>.

**Ruhr University Bochum**

**Faculty of Mechanical Engineering, Chair of Thermal Turbomachines and Aeroengines**

**Prof. Dr. Francesca di Mare**

Projects:

1. Implementation of the Spline Based Table Lookup Method (SBTL) into the in-house code SharC for high-fidelity, scale-resolving calculations of unsteady, turbulent, condensing wet steam flows at arbitrary Wilson point pressures.  
The in-house, density-based CFD solver SharC is specifically optimized for the computation of thermodynamically complex flows as, e.g., non-equilibrium condensing wet steam (SBTL based), real gas and real gas mixtures (SBTL and Peng-Robinson based) in turbomachines and, generally, complex technologically relevant devices.
  - Extension of the non-equilibrium condensation model in terms of nucleation, droplet growth and constitutive surface tension model to predict spontaneous condensation at arbitrary Wilson point pressures.
  - Generalization of the multiphase treatment in terms of arbitrarily condensable single species gas flows to investigate potential non-equilibrium condensation in the inducer region of radial compressors for closed loop supercritical CO<sub>2</sub>-Brayton cycles.
2. Implementation of the IAPWS-IF97 for the usage in in-house codes to calculate the thermophysical properties of water and steam on CPU’s as well as highly parallel GPU’s.
- 3 Investigation the use of Physics Informed Artificial Neural Networks for the Physics Recovery to advance the state of condensation Modeling.

Previous research with the flow solver SharC has focused on two-phase flow in combination with non- equilibrium condensation in wet steam at low Wilson point pressures. Preliminary results demonstrate that the monodispersed source term model is now able to calculate two-phase flow and condensation at high Wilson point pressures for wet steam and sCO<sub>2</sub>. A journal publication is currently under preparation.

**Ruhr University Bochum**  
**Faculty of Mechanical Engineering, Department of Thermodynamics Prof.**  
**Dr. 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, has produced some first results. The consideration of hydrogen requires an extension of the hydrate model to account for multiple occupation of cavities with up to five hydrogen molecules in large SII cavities. Preliminary results were presented at the annual GSAPWS meeting; a journal publication is under preparation. However, the performance of the hydrate model greatly benefits from accurate models of the fluid phases.  
 Thus, the current water-hydrogen mixture model of the GERG-2008 is being revised with colleagues of the National Institute of Standards and Technology. A multiparameter equation of state in terms of the Helmholtz energy for tetrahydrofuran, one of the most popular promoters of hydrogen hydrates, has been developed and is submitted to an international journal [1].
2. Our work in the area of property models for CCS technologies and in particular for transport of CO<sub>2</sub>-rich mixtures resulted in a broad involvement in processes attempting to specify characteristics of CO<sub>2</sub>-rich mixtures for multimodal CO<sub>2</sub>-transport. The aim is to develop a European CO<sub>2</sub>-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 and DVGW and a chair position in the expert group on CO<sub>2</sub> characteristics implemented by the European Commission. The results of this expert group will soon be published as Annex to the upcoming Vision Paper on CO<sub>2</sub> infrastructure.

Recent Publication:

- [1] Fiedler, F.; Karog, J.; Lemmon, E.W.; Thol, M.:  
 A fundamental equation of state for fluid tetrahydrofuran.  
 Submitted to Int. J. Thermophysics (2023).

**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.
2. Within the project “Optisyskom”, heat transfer coefficients in annular cavities in the casing of steam turbines are investigated experimentally and theoretically. A test rig is being set up for this purpose and in a first step, experiments will be performed with air and transferred to steam by using the concept of similitude. In a second step, the results will be validated by directly using steam.

Recent Publications:

Paulick, O.; Eschmann, G.; Jäger, A.; Gampe, U. (2022): Test Rig Setup for the Experimental Investigation of Heat Transfer Coefficients in Annular T-shaped Cavities in Industrial Steam Turbines.  
34th Workshop Turbomachinery, September 2022, Gdansk, Poland.

**Zittau/Goerlitz University of Applied Sciences Faculty of Mechanical Engineering /  
KCE-ThermoFluidProperties, Dresden**

**Prof. Dr. Matthias Kunick, Prof. Dr. Hans-Joachim Kretzschmar, Dr.  
Sebastian Herrmann**

Projects

1. Development of fast property-calculation algorithms for water and steam in thermo-hydraulic process simulations
  - Development of the property library LibSBTL95 for water and steam considering special requirements of the thermo-hydraulic code ATHLET, developed by the German Society of Global Research for Safety (GRS), Garching. Fluid properties are extrapolable beyond physical boundaries in order to satisfy the demands of the solver algorithm in ATHLET. The library is based on IAPWS-95 and the Spline- Based Table Look-Up Method (SBTL) in order to provide high accuracy and computational efficiency.
  - Implementation and verification of the property library LibSBTL95 in ATHLET.
2. 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, CO<sub>2</sub>, He, H<sub>2</sub>, N<sub>2</sub>, and O<sub>2</sub>. 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.
3. 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).
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 the IAPWS Formulation 2011 for the thermal conductivity of water are being incorporated into the 2025 ASHRAE Handbook of Fundamentals.

Recent Publications

- Kretzschmar, H.-J.; Kraft, I.:  
Kleine Formelsammlung Technische Thermodynamik, 6. aktualisierte Auflage (Short Collection of Technical Thermodynamic Formulae, 6th Revised edition.)  
Carl Hanser Verlag München (2022).  
ISBN 978-3-446-47028-6, E-Book-ISBN 978-3-446-47321-8.
- Herrmann, S.; Kretzschmar, H.-J.; Aute, V. C.; Gatley, D. P.; Vogel, E.:  
Transport Properties of Real Moist Air, Dry Air, Steam, and Water.  
Science and Technology for the Built Environment, 27 (2021), pp. 393 -  
401. DOI: 10.1080/23744731.2021.1877519.
- Herrmann, S.; Kretzschmar, H.-J.; Gatley, D.P.:  
In: 2021 ASHRAE HANDBOOK FUNDAMENTALS, SI and I-P Editions, Chapter 1  
PSYCHROMETRICS,  
Table 2 Thermodynamic Properties of Moist Air at Standard Atmospheric Pressure.  
Table 3 Thermodynamic Properties of Water at Saturation.  
Table 5 Transport Properties of Moist Air at Standard Atmospheric  
Pressure. Table 6 Transport Properties of Water at Saturation.  
American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta,  
GA (2021)  
I-P-Version: ISBN: 978-1-947192-89-8, ISSN: 1523-7222  
SI-Version: ISBN: 978-1-947192-90-4, ISSN: 1523-7230
- Kunick, M.; Kretzschmar, H.-J.; Gampe, U.; di Mare, F.; Hrubý, J.; Duška, M.; Vinš, V.; Singh, A.;  
Miyagawa, K.; Weber, I.; Pawellek, R.; Novi, A.; Blangetti, F.; Wagner, W.;  
Friend, D. G.; Harvey, A. H.:  
Fast Calculation of Steam and Water Properties with the Spline-Based Table Look-Up  
Method (SBTL).  
J. Eng. Gas Turbines Power, in preparation.

**Current Status of Research Activities in Japan  
Submitted to the Executive Committee Meeting, IAPWS,  
September, 2023**

**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](mailto:yasuoka@mech.keio.ac.jp)  
URL: [https://k-ris.keio.ac.jp/html/100011311\\_en.html](https://k-ris.keio.ac.jp/html/100011311_en.html)

Report on IAPWS Annual Meeting 2022

K. Yoshida, K. Yasuoka  
The Thermal and Nuclear Power, (in press, in Japanese)

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., in press. (12 pages) DOI : 10.1039/D2NH00563H

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, in press. (12 pages) DOI : 10.1021/acsami.2c16366

Prediction of Water Diffusion in Wide Varieties of Polymers with All-Atom Molecular Dynamics Simulations and Deep Generative Models

R. Kawada, K. Endo, K. Yasuoka, H. Kojima, N. Matubayasi  
J. Chem. Inf. Model., 63, 76-86, 2022

MD-GAN with multi-particle input: the machine learning of long-time molecular behavior from short-time MD data

R. Kawada, K. Endo, D. Yuhara, K. Yasuoka,  
Soft Matter, 18, 8446-8455, 2022

Correlation between ordering and shear thinning in confined OMCTS liquids

Y. Kobayashi, N. Arai, K. Yasuoka  
J. Chem. Phys., 157, 114506 (10 pages), 2022

Impact of free energy of polymers on polymorphism of polymer-grafted nanoparticles

M. Ishiyama, K. Yasuoka, M. Asai  
Soft Matter, 18, 6318-6325, 2022

Optimal Replica-Exchange Molecular Simulations in Combination with Evolution Strategies

A. Kowaguchi, K. Endo, P. E. Brumby, K. Nomura, K. Yasuoka  
J. Chem. Inf. Model., 62, 6544-6552, 2022

Differences in ligand-induced protein dynamics extracted from an unsupervised deep learning approach correlate with protein-ligand binding affinities

I. Yasuda, K. Endo, E. Yamamoto, Y. Hirano, K. Yasuoka  
Commun. Biol., 5, 481 (9 pages), 2022

A stochastic Hamiltonian formulation applied to dissipative particle dynamics

L. Peng, N. Arai, K. Yasuoka  
Appl. Math. Comput., 426, 127126 (13 pages), 2022

Efficient Monte Carlo Sampling for Molecular Systems Using Continuous Normalizing Flow

K. Endo, D. Yuhara, K. Yasuoka  
J. Chem. Theory Comput., 18, 1395-1405, 2022

Natural quantum reservoir computing for temporal information processing

Y. Suzuki, Q. Gao, K. C. Pradel, K. Yasuoka, N. Yamamoto  
Sci. Rep., 12, 1353 (15 pages), 2022

An Efficient Random Number Generation Method for Molecular Simulation

K. Okada, P. E. Brumby, K. Yasuoka  
J. Chem. Inf. Model., 62, 71-78, 2022

### **Matubayasi, Nobuyuki**

Professor, Graduate School of Engineering Science, Osaka University

email: [nobuyuki@cheng.es.osaka-u.ac.jp](mailto:nobuyuki@cheng.es.osaka-u.ac.jp)

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

Chain-Increment Approach to the Mutual Miscibility of Polymers with All-Atom Molecular Simulation

K. Yamada, N. Matubayasi

Macromolecules, 56, 3857-3872, 2023

Understanding Sorption Mechanisms Directly from Isotherms

S. Shimizu, N. Matubayasi

Langmuir, 39, 6113-6125, 2023

Revealing the hidden dynamics of confined water in acrylate polymers: Insights from hydrogen-bond lifetime analysis

K. Shikata, T. Kikutsuji, N. Yasoshima, K. Kim, N. Matubayasi,

J. Chem. Phys., 158, 174901 (10 pages), 2023

Arylazopyrazole-Based Photoswitchable Inhibitors Selective for *Escherichia coli* Dihydrofolate Reductase

H. S. Sarkar, T. Mashita, T. Kowada, S. Hamaguchi, T. Sato, K. Kasahara, N. Matubayasi, T. Matsui, S. Mizukami,

ACS Chem. Biol., 18, 340-346, 2023

Hyper-mobile Water and Raman 2900  $\text{cm}^{-1}$  Peak Band of Water Observed around Backbone Phosphates of Double Stranded DNA by High-Resolution Spectroscopies and MD Structural Feature Analysis of Water

M. Suzuki, A. Tsuchiko, Y. Tanaka, N. Matubayasi, G. Mogami, N. Uozumi, S. Takahashi,

J. Phys. Chem. B, 127, 285-299, 2023

Prediction of Water Diffusion in Wide Varieties of Polymers with All-Atom Molecular Dynamics Simulations and Deep Generative Models

R. Kawada, K. Endo, K. Yasuoka, H. Kojima, N. Matubayasi,

J. Chem. Inf. Model., 63, 76-86, 2023

Diffusion theory of molecular liquids in the energy representation and application to solvation dynamics

K. Okita, K. Kasahara, N. Matubayasi,

J. Chem. Phys., 157, 244505 (14 pages), 2022

Cooperative Sorption on Heterogeneous Surfaces,

O. P. L. Dalby, S. Abbott, N. Matubayasi, S. Shimizu

Langmuir, 38, 13084-13092, 2022

Molecular dynamics study of the interactions between a hydrophilic polymer brush on graphene and amino acid side chain analogues in water

T. Yagasaki, N. Matubayasi

Phys. Chem. Chem. Phys., 24, 22877-22888, 2022

Constructing a Memory Kernel of the Returning Probability to Efficiently Describe Molecular Binding Processes

K. Kasahara, R. Masayama, Y. Matsubara, N. Matubayasi

Chem. Lett., 51, 823-827, 2022

Crystal Growth of Urea and Its Modulation by Additives as Analyzed by All-Atom MD Simulation and Solution Theory

S. Tanaka, N. Yamamoto, K. Kasahara, Y. Ishii, N. Matubayasi  
J. Phys. Chem. B, 126, 5274-5290, 2022

Surface Area Estimation: Replacing the Brunauer-Emmett-Teller Model with the Statistical Thermodynamic Fluctuation Theory

S. Shimizu, N. Matubayasi  
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Y. Ishii, N. Matubayasi, H. Washizu  
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N. Yasoshima, T. Ishiyama, N. Matubayasi  
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R. Matsuba, H. Kubota, N. Matubayasi  
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T. Kikutsuji, Y. Mori, K. Okazaki, T. Mori, K. Kim, N. Matubayasi  
J. Chem. Phys., 156, 154108 (8 pages), 2022

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S. Hervø-Hansen, J. Heyda, M. Lund, N. Matubayasi  
Phys. Chem. Chem. Phys., 24, 3238-3249, 2022

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K. Takemoto, Y. Ishii, H. Washizu, K. Kim, N. Matubayasi  
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Ensemble transformation in the fluctuation theory

S. Shimizu, N. Matubayasi  
Physica A, 585, 126430 (14 pages), 2022; Physica A, 605, 127987 (1 pages), 2022

**Yoshida, Ken**

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

Report on IAPWS Annual Meeting 2022  
K. Yoshida, K. Yasuoka  
The Thermal and Nuclear Power, (in press, in Japanese)

Nuclear Magnetic Resonance Analysis of Hydrothermal Reactions of Ethyl- and Octylamine in  
Sub- and Supercritical Water  
K. Yoshida, A. Doi, H. Yoshioka, T. Hirano, M. Nakahara  
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Significant role of counterion for lead(II) ion adsorption on carbon pore surface  
T. Horikawa, M. Okamoto, A. Kuroki-Matsumoto, K. Yoshida  
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Structure and Formation Mechanism of Protective Coatings on Steam Piping Composed of Film-  
Forming Amines  
K. Yoshida  
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Microscopic Structure and Binding Mechanism of the Corrosion-Protective Film of  
Oleylpropanediamine on Copper in Hot Water  
H. Yoshioka, K. Yoshida, N. Noguchi, T. Ueki, K. Murai, K. Watanabe, M. Nakahara  
J. Phys. Chem. C, 126, 6436-6447, 2022

### **Nakahara, Masaru**

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Nuclear Magnetic Resonance Analysis of Hydrothermal Reactions of Ethyl- and Octylamine in  
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J. Phys. Chem. C, 126, 6436-6447, 2022

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Observation Research Center, Research Institute for Global Change, Japan Agency for Marine-  
Earth Science and Technology (JAMSTEC)  
Email: [huchida@jamstec.go.jp](mailto:huchida@jamstec.go.jp)

Volume transport of the Kuroshio south of Japan estimated from repeated full-depth hydrographic surveys and current measurements

S. Imawaki, H. Uchida, H. Ichikawa, M. Fukasawa, S. Umatani, H. Yoritaka

J. Oceanogr. 79, 175-183, 2022

Source analysis of dissolved methane in Chukchi Sea and Bering Strait during summer – autumn of 2012 and 2013

K. Kudo, S. Toyoda, K. Yamada, N. Yoshida, D. Sasano, N. Kosugi, A. Murata, H. Uchida, S. Nishino

Mar. Chem., 243, 104119, 2022

**Miyamoto, Hiroyuki**

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email: [miyamoto@pu-toyama.ac.jp](mailto:miyamoto@pu-toyama.ac.jp)

Measurements and Modeling of the Vapor–Liquid Equilibrium Properties of Low-Global-Warming-Potential Refrigerant R32/R1234yf/R1123 Ternary Mixtures

H. Miyamoto, Y. Nakamura, K. Minai, T. Yamada

Fluid Phase Equilib., 558, 113440 (11 pages), 2022

**Sawatsubashi, Tetsuya**

Team Manager, Research & Innovation Center, Mitsubishi Heavy Industries, Ltd.

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Semi-Quantitative Microfluidic Paper-Based Analytical Device for Ionic Silica Detection

M. Ogawa, A. Katoh, R. Matsubara, H. Kondo, M. Otsuka, T. Sawatsubashi, Y. Hiruta, D. Citterio

Anal. Sci., DOI: 10.1007/s44211-023-00345-1, 2023

Semi-quantitative Microfluidic Paper-based Analytical Device for Ionic Silica Detection

M. Ogawa, A. Katoh, R. Matsubara, H. Kondo, M. Otsuka, T. Sawatsubashi, Y. Hiruta, D. Citterio

Royal Society of Chemistry Tokyo International Conference 2022 (RSC-TIC2022)

**Ichihara, Taro**

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Email: [taro.ichihara.jp@mhi.com](mailto:taro.ichihara.jp@mhi.com)

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

T. Ichihara, Y. Amano, M. Machida

Eng. Fail. Anal., 143, 106842, 2023

Hydrogen Damage in a Power Boiler: Correlations between Damage Distribution and Thermal-Hydraulic Properties

T. Ichihara, R. Koike, Y. Watanabe, Y. Amano, M. Machida  
Eng. Fail. Anal., 146, 107120, 2023

Study of Hydrogen Damage in Boiler Evaporator Tube: Damage Selectivity and Conditions  
T. Ichihara  
Chiba University, Ph. D. thesis, 2023 (in Japanese)

**Nakatsuchi, Yuta**

Deputy Manager, Research & Innovation Center, Mitsubishi Heavy Industries, Ltd.  
Email: [yuta.nakatsuchi.mc@mhi.com](mailto:yuta.nakatsuchi.mc@mhi.com)

Novel Identification Method of Seawater Contamination into Steam-Water Circuit Including  
Carbon Dioxide of Power Plants based on pH, Specific Conductivity, and Cation Conductivity Y.  
Nakatsuchi, A. Hamasaki, H. Kido, T. Iwato  
J. Chem. Eng. Japan, in press

New Proposal of Water Quality Management for Gas Turbine Combined Cycle Plant  
Y. Nakatsuchi, A. Hamasaki, H. Kido, T. Iwato  
Therm. Nucl. Power, 73, 869-876, 2022 (in Japanese)

Novel Prediction Model Based on Two-Film Theory for Ammonia Distribution Coefficient in  
Heat Recovery Steam Generator of Gas Turbine Combined Cycle Power Plants  
Y. Nakatsuchi, H. Kido, A. Hamasaki, S. Fujimoto  
J. Chem. Eng. Japan, 55, 281-289, 2022

**III. Presentations at JPAPWS General Meetings:**

**FY2022 1st General Meeting, May 31, 2022**

Radiation chemistry in reactor water of boiling water reactors  
Youichi Wada (Hitachi, Ltd.)

Status of Geothermal Power Generation in the World  
Shigeto Yamada (Fuji Electric Co.,Ltd.)

**FY2022 2nd General Meeting, October 21, 2022**

Hydrogen Damage in Power Boiler: A Study of Damage Selectivity and Conditions  
Taro Ichihara (Mitsubishi Heavy Industries Power IDS, Ltd.)

Strategies to improve criteria on steam for steam turbine  
Shin-ichi Terada (Toshiba Energy Systems & Solutions Corporation)

Crystal Growth of Urea and Its Modulation by Additives as Analyzed by All-Atom MD Simulation and Free-Energy Calculation  
Nobuyuki Matubayasi (Osaka University)

Research Trends and Issues Concerning Film-Forming Amines  
Ken Yoshida (Tokushima University)

**FY2022 3rd General Meeting, January 27, 2023**

Global Trends for Film-forming Corrosion Inhibitors in Water-steam Cycle  
Shuichi Tachibana (Aquas Co., Ltd.)

**FY2022 4th General Meeting, March 20, 2023**

Innovative Next-Generation Reactors and Hydrogen Production Technology toward Carbon Neutrality  
Takeshi Matsuo (Mitsubishi Heavy Industries, Ltd.)

**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)

**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)

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

NEW ZEALAND  
*Association for the Properties of*  
WATER & STEAM



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

Date: 7 September 2023, Rev 1.1

## Key Achievements:

1. NZAPWS is now into its seventh year of full IAPWS membership
2. Successfully arranged and hosted the 2022 IAPWS in person meeting in Rotorua, New Zealand from 27<sup>th</sup> to 2<sup>nd</sup> December 2022. The Symposium attracted over 60 attendees and the Workshop over 113 with full week attendees numbering 33. The meeting was financially successful covering all NZAPWS expenses.



3. NZAPWS has robust funding in place and has gained additional sponsors for the 2022/2023 year as part of the IAPWS2022 and is in a good financial position
4. NZAPWS has an active membership covering the following areas:
  - a. Fossil power generation
  - b. Industrial steam production and use for dairy product production
  - c. Geothermal power generation (subsurface and surface operations)
  - d. Humidity research and services
  - e. Water/steam analytical services
  - f. Water/steam chemical treatment and services
  - g. Electrode/electrical resistance boilers (**Note:** new area of interest for NZ and IAPWS as these plants have started to be installed in NZ to replace existing industrial coal boilers and have presented significant water/steam issues)

5. NZAPWS have a dedicated website – [www.nzapws.org.nz](http://www.nzapws.org.nz) to provide relevant information and to manage meetings for NZAPWS

**Key Activities:**

1. IAPWS 2022 NZ meeting very successful
2. NZAPWS have been supporting the AUSAPWS 2023 meeting
3. Next NZAPWS meeting to be in 2024 (skipped 2023)
4. David Addison has had ongoing involvement in a PCC IAPWS International Collaboration project with the University of New Brunswick (DR Willy Cook) working on high temperature electrochemical corrosion monitoring – Covid has prevented any follow up visits to UnB
5. David Addison and Ian Richardson have continued working on geothermal related aspects for a IAPWS white paper along with Nobuo Okita (Toshiba) of Japan. Work is ongoing
6. David Addison has worked on electrode boiler water/steam chemistry issued in conjunction with SIAPWS members (Karsten Thompson and Monica Nielsen) sharing experiences and learnings with various different electrode boiler makes and models
7. Jeremy Lovell-Smith has had ongoing involvement in TPWS and SCW and intends to continue to be actively involved (but unable to attend IAPWS 2023)

**Publications:**

None for 2023 at this stage

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NZAPWS Chairperson  
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Scandinavian International Association on the Properties of Water and Steam

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## SIAPWS Report to IAPWS Executive Committee 2023

SIAPWS consists of one Nordic Executive Committee bringing the Nordic countries together around the topic of water and steam and in each country Denmark, Sweden and Finland national groups are formed. In both Denmark and Finland, we have around 40 company members and in Sweden around 120 company members, so in total around 200 members.

Our members are among others from the following industries:

- a. Fossil / biomass power generation
- b. Boiler manufactures.
- c. Waste incineration
- d. Industrial steam production (pulp and paper)
- e. Water treatment suppliers
- f. Suppliers of analytical instruments
- g. Consulting companies
- h. Electrode/electrical resistance boiler manufactures.
- i. Laboratories
- j. Universities and Institutes

In March 2022 we held the annual general meeting and workshop in Uppsala, Sweden attracting around 30 people for a 1½ day workshop and plant visit.

Each National group have their own annual meetings and workshops during the year.

Next year the SIAPWS Nordic annual meeting and workshop will be held in Oslo, Norway on the 14.-15. March 2024. SIAPWS only have very few members from Norway, and the aim of the event is to attract more members from Norway and in the end to create a national group in Norway. The topics for this meeting will be general around IAPWS and introducing the working groups of IAPWS and the Releases, Guidelines and ICRNs and some technical presentations.

In 2023 up until now, SIAPWS has hosted three webinars on the topics: FAC, SWAS systems and Dosing System. In the Fall another three webinars are planned for September, October, and November on the topics: Chemical cleaning of new boilers, Experiences with the counter current flushed MBR and Industrial wastewater treatment. We typically have between 30-40 participants at these webinars.

SIAPWS EC has been in Helsinki in August 2023 where we started the planning of the IAPWS Annual Meeting in 2025.

In the Danish National Group, we are working on understanding the chemistry in electrical boilers and we have established a Danish Electrical Boiler Working Group which meet every or every second year for exchange of experience. This year we are meeting on September 12 and this time we have invited the electrical boiler manufactures in Denmark.

Monika Nielsen, SIAPWS Chair

## U.S. National Committee to IAPWS 2023 Report on Activities of Potential Interest to IAPWS

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

A collaboration between NIST and the group of Prof. Tremaine at the University of Guelph has the objective of developing a standard formulation for the static dielectric constant of heavy water. Thus far, we have gathered the available data and made preliminary comparisons based on the existing H<sub>2</sub>O correlation in order to see where there are gaps in the data that might need to be filled in based on H<sub>2</sub>O behavior. It is hoped that a new formulation will be ready before the 2024 IAPWS meeting.

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. This includes the electronic and vibrational polarizabilities, the dipole moment, and the rotational quantum effects that cause the dielectric behavior to deviate from the classical Debye expression. A paper is pending (G. Garberoglio, C. Lissoni, L. Spagnoli, and A.H. Harvey, "Comprehensive Quantum Calculation of the First Dielectric Virial Coefficient of Water," in preparation (2023)).

A review article has been published on the thermophysical properties of water, with an emphasis on IAPWS formulations: A.H. Harvey, J. Hrubý, and K. Meier, "Improved and Always Improving: Reference Formulations for Thermophysical Properties of Water," *Journal of Physical and Chemical Reference Data* **52**, 011501 (2023).

### Communicated from OLI Systems Inc., Parsippany, NJ:

#### *Aqueous chemistry of critical materials*

Under the auspices of the Department of Energy's Critical Materials Institute, OLI Systems continued its work on the aqueous chemistry of critical materials including rare earth elements and lithium-ion battery cathode materials. The recent work was focused on (1) development of simulation methodology to predict the behavior of rare earths in the presence of inorganic and organic ligands and (2) modeling the thermodynamics of reactive systems used for the recovery of metals from spent lithium-ion battery cathodes using biological media. The results of the work on project (1) have been published in the following paper:

G. Das, M.M. Lencka, J. Liu, A. Anderko, R.E. Riman, and A. Navrotsky, "Modeling phase equilibria and speciation in aqueous solutions of rare earth elements with hydroxide and organic ligands," *J. Chem. Thermodynamics* **186** (2023) 107125.

The results of project (2) have been summarized in the following paper, which has been submitted for publication in *Resources, Conservation and Recycling*:

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."

*Aqueous chemistry of boric acid and borates up to high temperatures*

In collaboration with Professor Tremaine of the University of Guelph, we have completed a comprehensive study of the speciation and solubility of boric acid and various borates (i.e., lithium, sodium, potassium, calcium, magnesium and zinc borates) ranging from ambient to high temperatures. While the low- and moderate-temperature behavior of these systems is important for the supply and separation of materials in the mining industry, the high-temperature behavior is important for nuclear power generation. The work has been described in the following paper, which has been submitted for publication:

P. Wang, A. Anderko, and P.R. Tremaine, "Speciation and phase equilibria of aqueous boric acid and alkali metal borates from ambient to hydrothermal conditions: a comprehensive thermodynamic model."

**Communicated from Idaho National Laboratory, Idaho Falls, ID:**

Successful demonstration of a custom-built high temperature (up to 200 °C) titanium cell for cobalt-60 irradiations of aqueous solutions with *in-situ* UV-Vis spectroscopy via coupled fiber optics was achieved. This custom-made device was used for monitoring the high temperature radiation-induced behavior of key alloying metal ions (chromium and iron) in aqueous solutions in real time. To my knowledge, these are the first *in-situ* irradiation studies of this kind to be performed, and they provide important data for benchmarking multiscale models of these chemical systems.

## Participants at IAPWS 2023

Nationality	Surname	Nome	Registration
AUSTRALIA	McAllister	Duncan	Meeting Participant
	Rodman	David	Meeting Participant
AUSTRIA	Svoboda	Robert	Meeting Participant
CANADA	Cook	William	Meeting Participant
	Perdicakis	Basil	Meeting Participant
CINA	Li	Ying	Meeting Participant
	Li	Ming	Meeting Participant
	Min	Zhuang	Meeting Participant
	Peng	Xiang	Meeting Participant
	Song	Yunlong	Meeting Participant
	Yujuan	Lyu	Meeting Participant
	Zhang	Ying	Meeting Participant
DANIMARCA	Fogh	Folmer	Meeting Participant
	Nielsen	Monika	Meeting Participant
	Skovbjerg	Mads	Meeting Participant
FINLANDIA	Huhtiniemi	Sami	Meeting Participant
	Lehikoinen	Arja	Meeting Participant
	Vepsäläinen	Mikko	Meeting Participant
FRANCIA	Fisicaro	Paola	Relatore
	Lefèvre	Dominique	Relatore
	Le Menn	Marc	Relatore
	Senécat	Anthony	Meeting Participant
GERMANIA	Hellmann	Robert	Meeting Participant
	Kretzschmar	Hans-Joachim	Meeting Participant
	Leidich	Frank Udo	Meeting Participant
	Meier	Karsten	Meeting Participant
	Pawellek	Reiner	Meeting Participant
	Ranniste Sachssendahl	Aurel	Meeting Participant
	Schweitzer	Daniel	Meeting Participant
	Seitz	Steffen	Meeting Participant
	Span	Roland	Meeting Participant
	Wagner	Ronny	Meeting Participant
	Waldmann	Christoph	Relatore
GIAPPONE	Ichihara	Taro	Meeting Participant
	Kayukawa	Yohei	Meeting Participant
	Okita	Nobuo	Meeting Participant
	Senoo	Shigeki	Meeting Participant
	Yasuoka	Kenji	Meeting Participant
	Yoshida	Ken Yoshida	Meeting Participant

Nationality	Surname	Nome	Registration
GRECIA	Thanos	Antonios	Meeting Participant
NUOVA ZELANDA	Addison	David	Meeting Participant
	Fillary	Thomas	Meeting Participant
PAESI BASSI	Daal	Ludwin	Meeting Participant
REGNO UNITO	Arcis	Hugues	Meeting Participant
	Dooley	Barry	Meeting Participant
	McCann	Paul	Meeting Participant
REPUBBLICA CECA	Hruby	Jan	Meeting Participant
	Novy	Adam	Meeting Participant
	Sedlář	Milan	Meeting Participant
	Vinš	Václav	Meeting Participant
SERBIA	Vidojkovic	Sonja	Meeting Participant
SPAGNA	Nogales Lopez	Maria del Mar	Meeting Participant
STATI UNITI D' AMERICA	Buecher	Kirk	Meeting Participant
	Friend	Daniel	Meeting Participant
	Harvey	Allan	Meeting Participant
	Stansfield	Harold	Meeting Participant
SUD AFRICA	De Vos	David	Meeting Participant
SVIZZERA	RZIHA	Michael	Meeting Participant
	Werder	Tapio	Meeting Participant
TURCHIA	Turan	Ekrem	Meeting Participant
ITALIA	Albo	Alberto Giuliano	INRIM
	Beltramino	Giulio	INRIM
	Cavuoto	Giuseppe	INRIM
	Cuccaro	Rugiada	INRIM
	De Luca	Paolo	INRIM
	Denasi	Sandra	INRIM
	Fernicola	Vito	INRIM
	Gabrielli	Frank	Meeting Participant
	Garberoglio	Giovanni	Relatore
	Gavioso	Roberto	INRIM
	Lago	Simona	INRIM
	Melli	Elisabetta	INRIM
	Nair	Rajesh	Relatore
	Nobakht	Rezvaneh	INRIM
	Rava	Marcello	Relatore
	Rolle	Francesca	INRIM
Romeo	Raffaella	INRIM	
Rosso	Lucia	INRIM	