

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

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Canada
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Germany
Japan
Russia
Scandinavia (Denmark, Finland, Norway, Sweden)
United States of America

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

**Moscow, Russia
23rd – 27th June 2014**

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
held in
Moscow, Russia
23rd – 27th June 2014

Plenary Session. Monday, 23rd June 2014. 9:00am

The President of IAPWS, Professor Tamara Petrova, welcomed the Executive Committee (EC) and other IAPWS members to Moscow and to the Moscow Power Engineering Institute (MPEI) for the Executive Committee (EC) and Working Group (WG) Meetings of IAPWS. The President officially opened the 2014 EC Meetings by introducing the National Delegates. Each of the Member countries of IAPWS was in attendance as well as Associate Member, New Zealand.

The President asked the MPEI Rector, Professor Nikolai Rogalev, to welcome IAPWS. The President then asked the Head of the Russian National Committee, Professore Konstantin Orlov to provide a few details of the planned IAPWS week.

1. Adoption of Agenda

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

2. IAPWS Business and Appointment of Committees

2.1 Releases, Advisory Notes, ICRNs and Technical Guidance Documents

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

- ICRN 25: *Corrosion Mechanisms that are Related to the Presence of Contaminants in Steam / Water Circuits, Particularly Boiler Water*. Distributed 29th April 2014. No comments had been received. The document will be reviewed by the PCC working group during the week prior to approval at the Friday EC.

- Revised Advisory Note Number 3: *Thermodynamic Derivatives from IAPWS Formulations*. Distributed 14th May 2014. No comments had been received. The document will be reviewed by the TPWS working group during the week prior to approval at the Friday EC.
- Revised IAPWS Release: *Surface Tension of Ordinary Water Substance*. Distributed on 8th May 2014. No comments had been received. The document will be reviewed by the TPWS working group during the week prior to approval at the Friday EC.
- Technical Guidance Document (TGD): *Corrosion Product Sampling and Analysis for Fossil and Combined Cycle Plants*. Distributed on 31st January 2014 for a postal ballot as agreed by the EC in Greenwich. A few comments had been received by 30th April 2014 and were dealt with by the PCC Task Group.

The respective Working Groups will report to the EC at the Friday meeting on any further changes prior to requesting approval.

2.2 Press Release.

The President asked McCann and Orlov to develop a Press Release on the IAPWS proceedings during the week. The Clerks of Minutes from each WG were asked to provide input. The Press Release is discussed in Minute 17.1 and is Attachment 8.

2.3 Evaluation Committee on International Collaboration.

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

2.4 IAPWS Awards Committees

2.4.1 Helmholtz Award Committee

The President indicated that there was a Helmholtz Awardee this year. The Executive Secretary then reminded the EC that the Helmholtz Committee for the 2015 award would consist of a member from BIAPWS, Canada, Czech Republic, Germany and Japan. BIAPWS will provide the committee chairman. The President asked delegate McCann to organize the committee and to report back to the EC on Friday with the names of the members of this committee (Minute 15.1).

2.4.2 Honorary Fellow Award Committee

The President requested that Bellows and Kretzschmar remain on the Committee with Bellows as the Chairman for 2015. The President would be ex. Officio.

2.5 IAPWS Website and Web Space for Working Group Documents.

2.5.1 IAPWS Website (Feedback from Greenwich Minutes 2.5 and 17.2)

The President requested Harvey to briefly report on the activities since Greenwich. First on the issue of improving the visibility of IAPWS documents in search engines, Harvey reported that suggestions had been made by an external consultant at NIST. These suggestions had been adopted in December 2013 and it appeared that there were improvements. He requested feedback and that the Working Groups should provide text on good keywords for each IAPWS Release and TGD.

Harvey then indicated that NIST had hosted the IAPWS Website since 1998 and was happy to continue. But a 2.5 week partial shutdown of the US Government in 2013 had precluded access. He suggested that alternatives would cost in the range of \$100 – 500USD per year.

2.5.2 Web Space for WG Documents

Kretzschmar reminded the EC that TPWS and IRS have used a password protected part of web space on OPAL located at Hochschule Zittau, and that PCC had also used the same site for WG presentations. The site is available for other WGs. This raised a question from the BIAPWS delegate on whether members of National Committess could also access this site. After some EC discussion an Action was placed on the PCC Chairman for the PCC to discuss during the week and provide feedback at the EC on Friday.

2.6 Report on CCQM / CCT / BIPM Interfaces and BIPM with IAPWS Working Groups

2.6.1 CCQM / CCT / BIPM Interfaces

The President reminded the EC that approval was provided at the 2013 EC meetings for travel of two SCSW Members to BIPM meetings. She then asked Hellmuth to provide a short update in the absence of Pawlowicz, the SCSW Chairman.

- Pawlowicz attended CCQM / EAWG (Electrochemical Working Group) and CCQM / plenary Meetings (April 2014, Sevres France). The topics discussed were salinity / density link and pH issues. The major outcomes were that there is a need for further discussion, and that the next step involves finalization of a common Metrologia position paper as a basis for further discussion.
- Feistel attended CCT / WG-6 and CCT / plenary Meetings (May 2014, Sevres France). The topic discussed was relative humidity (RH), and cooperation with IAPWS gives a boost to solving the problem with the RH definition and a joint position paper is considered as a 'milestone'. Feistel is now a confirmed member of BIPM CCT / WG – Humidity and new CCT Taskgroup “Environment”.

IAPWS is expected to prepare a document on calculation of fugacity of water in humid air.

2.6.2 Continuing CCQM / CCT / BIPM Interfaces for IAPWS

The report on the two interfaces with BIPM lead to two further discussion items. The first was raised by Cooper who requested that an item is added to the Friday EC agenda to discuss IAPWS's continuing interface with BIPM. The second item was raised by the US delegate, Friend, who requested that all the WGs discuss during the week whether there could be other interfaces with BIPM than those with the SCSW.

2.7 Cover Page of IAPWS Documents.

The President requested that the US Delegate address this item. Friend reported that there were a few inconsistencies in the front page of IAPWS documents. The President suggested that a small committee be appointed consisting of Harvey as the Chair of Editorial Committee and the WG Chairs and should report back to the EC on Friday (Minute 17.3).

2.8 Other Business Requiring Extensive Discussions

No other business was raised by the EC.

3. EC Mandate to Working Groups and Membership

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

3.1 Releases, Guidelines and Certified Research Needs.

The Executive Secretary indicated that seven ICRNs had either expired already or will expire in September 2014 and thus needed attention by the WGs during the week: #16 on thermophysical properties of seawater, #17 on amines, #20 on sensors for elevated temperatures, #22 on steam chemistry in the phase transition zone (PTZ), #26 on behavior of aluminium, #27 on thermodynamic properties of humid gases, and #28 on thermodynamic properties of metastable steam and homogeneous nucleation.

3.2 Working Group Directions.

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

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

President Petrova requested each WG Chairman to review briefly the main topics which would be covered in their WGs during the week. The details of the WG meetings are covered in detail in Minutes 7 to 10 (Attachments 4 to 7).

The President closed the opening session of the EC at 10:15am.

Activities During the Week in Moscow

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

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

The IAPWS Symposium was held on Wednesday, 3rd October 2012. The overall theme was on “*Water and Steam: Industrial and Scientific Application*”, and the Symposium Program is shown in Attachment 3.

Executive Committee Meeting. Friday, 27th June 2014

President Petrova opened the continuation of the EC Meeting at 8:30 am. Each of the Member and Associate Member countries of IAPWS was in attendance as well as Associate Member, New Zealand. In total there were 18 people assembled for the EC meeting. Petrova first asked the EC if there were any additional items that should be added to the Agenda. None were suggested. The Executive Secretary showed the latest Agenda with additional items relating from the Monday EC Meeting.

5. Acceptance of Minutes of Previous Meeting

President Petrova asked for comments and changes to the minutes of the EC meeting held in Greenwich, UK in 2013. No changes were noted, thus the 2013 Minutes were accepted.

6. President's Report

President Petrova indicated that the 16th ICPWS in Greenwich had been a huge success with over 250 scientists present from 25 countries. Over 150 papers had been presented on all aspects covered by IAPWS. She reported that 66 people from 13 countries had been in attendance during the Moscow meetings. She was very pleased with the interfaces that IAPWS has made with BIPM and hoped that this can be strengthened further.

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

TPWS Chairman Harvey opened this item by indicating that he would report on activities relating to joint meetings of TPWS, IRS and SCSW during the week. He then highlighted only those activities from the working sessions during the week which needed action by the EC or which he thought were of interest to the EC. He indicated that all of the TPWS WG activities had been conducted jointly with the exception of a separate meeting for IRS which is reported in Minute 8. Full Minutes and the Agenda for TPWS can be found in Attachment 4.

7.1 Revised Advisory Note Number 3: *Thermodynamic Derivatives from IAPWS Formulations*. As per Minute 2.1 this document had been circulated to National Committees prior to Moscow. The TPWS and IRS Working Groups (WG) and the SCSW had reviewed and approved the Advisory Note, and now recommend adoption by the Executive Committee (EC).

The EC approved Revised Advisory Note 3 Unanimously.

- 7.2 Metastable Water. A guideline is being prepared which is planned for approval in 2015. An evaluation Task Group has been formed (Hrubý (chair), Hellmuth, Feistel and Orlov) as well as a Task Group to prepare an ICRN (Hellmuth (chair), Holten, Hrubý and Sengers)
- 7.3 Revised IAPWS Release: *Surface Tension of Ordinary Water Substance*. The revision specifies that extrapolation is OK down to -25°C (based on new data from two laboratories in Czech Republic). The formulation remains unchanged. As per Minute 2.1 this document had been circulated to National Committees prior to Moscow. The TPWS Working Group had reviewed and approved the revised Release, and now recommend approval by the Executive Committee (EC).

The EC approved the Revised Release Unanimously.

Chairman Harvey then informed the EC that a Task Group has been appointed to conduct a complete reevaluation and revision of the release (Vinš (chair) Harvey, Hellmuth, Holten, Hrubý, Kalová and Mareš).

- 7.4 Revision of IAPWS-95 Release. Chairman Harvey indicated that there was no change in the formulation, but there were potential improvements in uncertainty estimates for the speed of sound and heat capacity based on recent experimental data. The TPWS WG approved the revision and request approval by EC for a postal ballot following a review by the Editorial Committee.

The EC approved a Postal Ballot for the Revised Release Unanimously.

- 7.5 Chairman Harvey then informed the EC on the following three items of interest:
- In supercooled water work, it has become clear that the melting curve of Ice Form III can be improved. A Task Group has been appointed (Holten, Harvey and Kretzschmar).
 - A new heavy water thermodynamic formulation is nearing completion. An Evaluation Task Group has been appointed (Duska, Kretzschmar, and co-opted expert Thomas Beuthe (AECL, Canada)).
 - A Task Group has been appointed for revision of heavy water transport properties (Assael, Sengers and co-opted expert M. Huber (NIST)).
- 7.6 ICRNs. Chairman Harvey indicated the following activity on ICRNs relating to the WGs:
- ICRN-16 (seawater thermophysical properties) was amended and renewed with a new expiration date of 2019. A separate ICRN on pH issues may be developed.
 - ICRN-27 (properties of humid gases and CO_2 -rich mixtures) will be closed. Span and Harvey will prepare a closing statement. A new ICRN on mixtures relevant for CCS may be prepared for next year.
 - ICRN-28 (metastable steam) was renewed without change with a new expiration date of 2019.

The EC approved the Changes to the ICRNs Unanimously.

7.7 Activities relating to the interface with BIPM. Chairman Harvey reported the following activities:

- Finalising of the common IAPWS / BIPM position paper on salinity, pH, and relative humidity (to be submitted to Metrologia) and of the Technical Report of the ICPWS 2013 Workshop on Humidity.
- Work on a draft guideline on virial equation for fugacity of water in humid air. An evaluation Task Group has been appointed (Cooper, Harvey and Kretzschmar).
- Ongoing development of a document to support BIPM / CCT WG, Relative Humidity decision process regarding Relative Humidity metrology.
- Feistel and Pawlowicz are involved in relevant working groups of CCT and CCQM.

Chairman Harvey then requested, on behalf of SCSW, that IAPWS provide funds to support two trips by IAPWS representatives to relevant BIPM working meetings.

The US Delegate suggested that this request should be reviewed after the IAPWS financial situation has been discussed (see Minute 17.2).

7.8 Miscellaneous. Chairman Harvey then reported on the following item which was raised at the WG meetings:

- TPWS member Ochkov has proposed to implement online calculations of IAPWS calculations for Knovel (owned by Elsevier publishing).
- He has requested an official IAPWS letter endorsing the project.
- The WGs considered that the project is OK and is welcomed by IAPWS without the need for any IAPWS letter as long as the formulations are attributed to IAPWS.
- However, the WGs were concerned about IAPWS endorsing such a project with one commercial entity, and wanted to raise the question to the EC of whether IAPWS should make many companies (not just one) aware of the possibility of using IAPWS formulations?

The EC considered that IAPWS products can be freely used as long as attribution is given to IAPWS, however a number of the delegates were not fully aware of the application proposed. After much further discussion, US Delegate Friend proposed that a small Group be formed to define the purpose of an IAPWS letter. It was suggested that the Group be composed of Orlov (Chair), Weber and Friend and that a document would be prepared within two months for circulation by the Executive Secretary.

The EC approved this Proposal Unanimously.

7.9 TPWS Membership. Chairman Harvey requested that the following new TPWS WG members are approved:

- S. Herrig (Ruhr-Universitaet Bochum, Germany).
- H. Wolf (Physikalisch-Technische Bundesanstalt, Germany).

The EC approved these Membership Additions Unanimously.

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

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

8.1 Proposed Revised Supplementary Releases on “Backwards” Equations for IAPWS-IF97.

- The following clarifications and editorial changes for Supplementary Releases are suggested:
 - Backward Equations $p(h,s)$ for Region 3, Equations as a Function of h and s for the Region Boundaries, and an Equation $T_{\text{sat}}(h,s)$ for Region 4 of IAPWS-IF97
 - Backward Equations for $p(h,s)$ for Regions 1 and 2 of IAPWS-IF97
 - Backward Equations for $T(p,h)$, $v(p,h)$ and $T(p,s)$, $v(p,s)$ for Region 3 of IAPWS-IF97
 - Backward Equations for $v(p,T)$ for Region 3 of IAPWS-IF97
- The WGs had accepted the proposed revisions.
- Review by the Editorial Committee will be required.

Chairman Weber then requested EC approval for a Postal Ballot.

The EC approved a Postal Ballot for the Revised Supplementary Releases Unanimously.

8.2 Proposed Guideline “Guideline on the Fast Calculation of Steam and Water Properties Using Spline Interpolation (SBTL)”.

A draft guideline has been developed and an Evaluation Task Group presented a report which indicated that additional evaluation is required. The next steps are to complete this evaluation and circulate it to WG members by the end of August 2014. An electronic vote by WG members will be conducted followed by an Editorial Committee review.

Chairman Weber then requested EC approval for a Postal Ballot.

The EC approved a Postal Ballot for the Proposed Guideline Unanimously.

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

Chairman Anderko provided the PCAS Report to the EC. Full Minutes can be found in Attachment 6. He covered the following items with the EC:

9.1 Amine Properties. Chairman Anderko indicated that a Task Group has been formed (Bellows (Chair) and Anderko) to evaluate liquid / vapor distribution, acid or base

dissociation constants, and amine decomposition products. The Task Group will create a plan for IAPWS Guidelines and ICRNs and hope to have the draft Guideline ready for review by the WG before Sweden 2015. The WG also proposed an Evaluation Task Group (Tremaine, Guzonas, and a member of PCC).

- 9.2 Guideline for Thermal Conductivity of Seawater. Chairman Anderko indicated that a complete multi-component thermal conductivity model has been developed which includes a simplified formulation as a function of salinity. The plan is to submit this for publication and development of a guideline. An evaluation task group was formed at the 2013 WG meeting.
- 9.3 PCAS Membership. Chairman Anderko requested that the following new member be approved:

K. Yoshida (University of Tokushima, Japan)

The EC approved this Membership Addition Unanimously.

10. Report and Recommendations of Plant Cycle Chemistry Working Group (PCC)

It was reported that PCC Chairman Rziha and PCC Vice Chairman Thomsen were not able to attend the Moscow meetings. The Executive Secretary had asked if PCC Member, Paul McCann could chair the PCC meetings during the week. McCann had enthusiastically accepted. He highlighted those activities that needed action / approval by the EC. A full written report of the PCC WG activities forms Attachment 7. He covered the following items with the EC

- 10.1 Technical Guidance Documents (TGD). Chair McCann provided the following information on TGD activities during the week.
- Amendments to three TGD will be made to cover the requirements of cycling and fast starts of HRSGs. A Task Group has been formed with Dooley as chair. This will address the small additions to each TGD for approval in Sweden in 2015.
 - New TGD proposed on “Ensuring the Integrity and Reliability of Demineralised Makeup Water Supply to the Unit Cycle”. A Task Group has been formed with Joy as Chair. This will develop the TGD for approval in Sweden in 2015.
 - New TGD proposed on “HRSG HP Evaporator Tube Sampling”. A Task Group has been formed with Dooley as Chair. The plan is to have this approved in Sweden in 2015.
 - TGD on Corrosion Product Sampling and Analysis. A number of the references in the new TGD will be updated. There are no content changes. A revised TGD will be sent to the Editorial Committee and the amended version will be placed on the IAPWS website.

10.2 ICRNs. McCann provided the EC with the following information for approval.

ICRN 17 on Amines. This ICRN will be closed and a Closing Statement prepared. A new ICRN will be prepared for approval in 2015.

ICRN 20 on Sensors for Use at Elevated Temperatures. This ICRN will be closed and a Closing Statement prepared.

ICRN 22 on Steam Chemistry in the Phase Transition Zone. It is requested that this ICRN is extended for one year to allow a more detailed review.

ICRN 25 on Corrosion Mechanisms that are related to the presence of contaminants in steam / water circuits, particularly in boiler water. As per Minute 2.1 this document had been circulated to National Committees prior to Moscow. The PCC WG reviewed the ICRN during the week and now request approval from the EC.

ICRN 26 on Aluminum. It is requested that this ICRN is extended for five years to 2019.

The EC approved the new ICRN 25 and the Changes to the other ICRNs Unanimously.

10.3 PCC Membership. McCann requested that the following new members be approved:

O. Yegoshina (MPEI, Russia)
P. Dyachenko (Aminotek, Russia)
A. Saeidipour (Siemens, Iran)
S. Hanawa (JAEA, Japan)

The EC approved these Membership Additions Unanimously.

10.4 IAPWS Website. Chair McCann reported on the following discussions by PCC during the week. PCC will provide short summaries for the website of the TGDs to include key words which hopefully will improve any search engine “hits” to identify the TGD to potential users. PCC members will “test” out the changes made to the IAPWS website as reported at the Monday EC meeting (Minute 2.5.1).

With regards to the OPAL web space for WG documents discussed at the Monday EC Meeting (Minute 2.5.2), PCC would like to use the OPAL website to hold Working Group presentations, white papers and TGDs. PCC developed two proposals for consideration by the EC:

First Proposal: PCC would like to request permission to provide access to all PCC Working Group members and National Committees. This effectively would make it a public website, so Password Protection may not be necessary.

Second Proposal: PCC would like to use the OPAL website to manage Task Sub-Group documents (white papers and early drafts), for which PCC would like to propose that folders with controlled access are set up.

Much discussion followed these two proposals. Finally US Delegate Friend proposed that the EC is happy to allow any WG to deposit any open documents such as presentations from meetings in a WG folder on the IAPWS Website, and that the WG folder on the OPAL website can be used for documents that need to be password protected such as working documents or drafts.

The EC approved this Proposal Unanimously with the caveat that each WG Chairman needs to approve any open documents before they are placed on the IAPWS website. Approval from the authors of presentations also will be required.

10.5 Front Page of IAPWS Documents. McCann informed the EC that the PCC WG had discussed this item as requested at the Monday EC (Minute 2.7), and that a proposal had been developed. The President suggested that this item be deferred until later on the agenda (see Minute 17.3).

11. Editorial Committee Report

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

- Revised Release on Surface Tension of Ordinary Water Substance
- Revised Advisory Note 3: Thermodynamic Derivatives from IAPWS Formulations
- 4 Revised Supplementary Releases for IAPWS-IF97 “backward” formulations
- Technical Guidance Document for Corrosion Product Sampling
- Informal Review of ICRN-25 (Corrosion related to contaminants)

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

12. Membership and Associates

12.1 Member Dues.

The Executive Secretary indicated that all IAPWS Members have paid their 2014 dues.

12.2 Reports on Associate Members

The Executive Secretary indicated that this year there were two items associated with Associate Members. The first addresses the recent associate members that are working towards membership. The second addresses those members that have been inactive for a number of years.

12.2.1 Recent Associate Members.

Australia. Chairman Joy provided a short presentation which Addison presented to the EC. The Australian National Committee (AUSAPWS) has continued to focus on the Power Cycle Chemistry area but has also tried to seek a wider focus in seawater, carbon sequestration and thermodynamics. AUSAPWS has 45 members and has developed an

initial Statutes. Discussions are taking place for AUSAPWS to link with API. An Australian wide steering committee has been formed. Joy indicated that they are planning to apply for IAPWS Membership at the Sweden Meeting in 2015.

New Zealand. Chairman Addison provided an update on NZAPWS. They intend to apply for full IAPWS Membership at the Sweden Meeting in 2015. NZAPWS members have been heavily involved in the development of the latest IAPWS TGD on Corrosion Products, and will be leading the PCC Sub-Task Group on Geothermal Chemistry.

Switzerland. The Executive Secretary had received a note from the Swiss NC Chairman, Svoboda, that there were seven members, but the committee had not yet been able to acquire financial commitment.

12.2.2 Inactive Associate Members.

The Executive Secretary was requested at the 2013 EC meetings in Greenwich to contact those Associate Members that have been inactive in IAPWS for a number of years. During the year the heads of the Argentina / Brazil, France and Greece National Committees were contacted. Each provided the current status. These were presented to the EC. These generated lots of discussion by EC members in relation to the IAPWS Statutes and By-Laws. As some alternate delegates were representing some IAPWS members, the EC was not happy to vote on membership at the meeting. So the following motion was proposed. The information provided by the Associate Members will be forwarded to the Heads of National Committees. Each IAPWS Member will be asked to vote on whether to keep the Associate Member within IAPWS. This will be a Postal Ballot for Administrative Details which requires a majority and if a member does not respond within the 45 day period then the vote is considered affirmative.

The EC approved the proposal Unanimously.

13. Executive Secretary's Report

13.1 Financial, Auditors and IAPWS Dues

The Executive Secretary reported that IAPWS is on a sound financial footing with currently over \$97,000 in the US bank account. The status as at 10th June 2014 in the bank account had been provided to each National Delegate present at the EC meeting.

The Executive Secretary next reported that the 2013 financial statements had been forwarded to the IAPWS Auditors in January 2014. Both Dr. Hencke of VDI in Germany and Professor Savarik in Czech Republic had reviewed and approved the financial statements. Both approvals had also been provided to the Heads of all the National Delegates present.

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

The EC Approved this Unanimously.

The Executive Secretary proposed to the EC that the dues structure for member countries remains unchanged for 2015.

The EC Unanimously Agreed to this Proposal.

The Executive Secretary had also provided a rough estimate of the income and known planned expenditures for 2014 / 2015.

In the final item of this section, the Executive Secretary confirmed to the EC that his business office and thus the IAPWS Secretary's office had been moved to the UK in February 2014. As part of this move the Executive Secretary reported that the IAPWS Bank account was also in the process of being moved to a UK bank and that with the assistance and help of the BIAPWS Chair the new bank account will have him as a second signatory. The immediate result of this move will be that the IAPWS dues in January 2015 will be translated from Swiss Francs into UK Pounds.

13.2 Time and Place of the 2015, 2016 and 2017 Meetings

2015 IAPWS Meetings. The Head of SIAPWS, Hellman, provided a short presentation and indicated that SIAPWS will host the 2015 meetings in Stockholm on 28th June to 3rd July 2015 at the Hotell Scandic Ariadne.

2016 IAPWS Meetings. The German Delegate, Weber, indicated that the German NC would like to invite IAPWS to Dresden on 11th to 16th September 2016. He requested that national committees review this date and provide information before 1st August 2014 if it overlaps with any other related events.

2017 and the 17th ICPWS. The Head of the Czech Republic NC, Hruby, had already indicated at the 2013 EC Meetings that the Czech Republic National Committee will support the 17th ICPWS.

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

The President indicated that the Releases and ICRNs had been discussed within the WG Reports so no further action was required by the EC. Also no international collaborations had been suggested during the 2014 IAPWS meetings.

15. IAPWS Awards

15.1 IAPWS Helmholtz Award

The President reported that the 2014 Helmholtz Award had been presented to Dr. Ken Yoshida of Tokushima University at the IAPWS Symposium on Wednesday.

Petrova then asked the British Delegate, McCann, for the names of the 2015 Helmholtz Award Committee. The 2015 Helmholtz Committee will consist of: Chairman Cooper (BIAPWS), Cook (Canada), Vinš (Czech Republic), Kretschmar (Germany) and Hirano (Japan).

Nominations will be due to the Executive Secretary by 1st January 2015.

15.2 IAPWS Honorary Fellowships

The Executive Secretary reported that the IAPWS President had been elected an Honorary IAPWS Fellow, following the established procedures and after unanimous approval through the postal ballot conducted by the Executive Secretary. The Fellowship Award had been presented to her at the IAPWS banquet by Friend as a past IAPWS president.

Petrova then reminded the EC of the Awards Committee for 2015 with Bellows as Chairman and Kretzschmar as member with the IAPWS President as ex.-officio member.

Nominations are due to the Executive Secretary by 1st January 2015.

16. Election of IAPWS Officers for 2015 and 2016

The Executive Secretary indicated that the President would step down at the end of 2014 and that Vice President Guzonas will assume the position of IAPWS President on 1st January 2015. According to the Statutes, the election of the next Vice President should be made at the end of the EC meeting in even years. The President and Executive Secretary had checked the recent history, and noted that it is 12 years since Germany has held the IAPWS Presidency and proposed that the German National Committee should be asked to nominate one of their committee members for the position. The Executive Secretary asked the EC if there were any other suggestions. None were suggested, so he then requested the EC to approve this selection.

The EC Unanimously Approved this Selection.

Action: The German National Committee should inform the Executive Secretary of their nomination for Vice President after the next meeting of their committee, and before the end of November 2014.

The Executive Secretary thanked the President for her leadership over the last two years, and indicated that her enthusiasm will continue under President Guzonas. The EC applauded Petrova.

17. New Business

17.1 Press Release

The President mentioned that McCann and Orlov had been asked at the EC meeting on Monday to develop a Press Release. This was developed with input provided by each WG and SC. McCann indicated that a draft document had been prepared. The Executive Secretary requested the Canadian Delegate, Cook, to review the document. The final version is Attachment 8. 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 IAPWS Continuing Interface with BIPM

The President now returned to the interface with BIPM covered in the TPWS Report (Minute 7.7). She requested US Delegate Friend to propose a motion on supporting IAPWS members to visit BIPM working groups. The following proposal was developed. The IAPWS EC will authorize travel expenses not to exceed \$8,000 US for two people to attend WG meetings with BIPM to foster continuing relationships. Each visit will require a detailed report and work plans for the next year of work. The Chair of SCSW will select the people for the two visits and inform the Executive Secretary accordingly.

The EC Approved this Proposal by Majority vote with Russia voting negatively.

17.3 Cover Page of IAPWS Documents

The President now returned to this item which was introduced in the PCC Report (Minute 10.5). She requested the Editorial Committee Chairman, Harvey, to provide discussion.

Harvey indicated that not all WGs were concerned about the cover page but it was recognized that the TGD should provide information that these documents represented a consensus of a large number of countries which are members of both IAPWS and PCC. Any changes will only apply to documents going forward. Some discussion by the EC took place of what information should be on the front page and what could be placed on a second page. It was also mentioned that there could be confusion about having the President's and Executive Secretary's names on the front page. Finally a proposal was developed to allow the Editorial Committee to develop a new front page for IAPWS documents which will be common to all documents developed. This will be sent to National Committees for review before the end of 2014 so that the new cover can be used for 2015 documents.

The EC Approved this Proposal Unanimously.

Harvey also indicated a statement on the ICRNs which could be confusing about IAPWS providing financial support. The Editorial Committee will also provide a suggestion for review.

17.4 Russian National Committee Feedback on the Moscow Meetings.

The Russian Delegate, Gotovtsev, thanked everybody for attending and indicated that there had been no problems which needed to be reported to the EC.

17.5 Other New Business

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

17.6 Reports from National Committees.

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

BIAPWS	Attachment 9
Canada	Attachment 10
Germany	Attachment 11
Japan	Attachment 12
Russia	Attachment 13
Switzerland	Attachment 14
USA	Attachment 15

17.7 Participants

Attachment 16 provides a list of participants at the IAPWS EC and WG Meetings in Moscow, Russia in June 2014.

17.8 List of Members

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

18. Closing Remarks and Adjournment

The President thanked everybody for participating at this EC meeting. Then she formally closed the 2014 EC meeting at 12:05pm.

AGENDA for the EXECUTIVE COMMITTEE of IAPWS

Moscow, Russia. 22nd – 27th June 2014

Monday, 23rd June 2014. Opening Session (9:00 – 10:30am)

- Opening Remarks and Welcome by IAPWS President, T. Petrova
1. Adoption of Agenda
 2. IAPWS Business and Appointment of Committees
 - 2.1 Releases, Advisory Note, ICRNs and Technical Guidance Documents
 - 2.2 Press Release
 - 2.3 Evaluation Committee on International Collaboration
 - 2.4 IAPWS Awards Committees for 2015 (Honorary Fellow, Helmholtz)
 - 2.5 IAPWS Website (2013 Minutes 2.5 and 17.2) + WG Documents
 - 2.6 Report on CCQM/CCT/BIPM Interfaces and BIPM with other WGs
 - 2.7 Cover page of TGD (US introduced item)
 - 2.8 Other business requiring special/extensive discussions
 3. EC Mandate to Working Groups and Membership
 - 3.1 Releases, Guidelines and ICRNs
 - 3.2 WG Directions
 4. Preview of Week's WG Activities by WG Chairmen

Friday, 27th June 2014. Executive Committee Meeting. (8:30am – 1:00pm)

5. Acceptance of Minutes of Previous Meeting
6. President's Report
7. Report and Recommendations of TPWS, IRS and the Sub-Committee on Seawater
8. Report and Recommendations of IRS
9. Report and Recommendations of PCAS
10. Report and Recommendations of PCC
11. Editorial Committee Report
12. Membership and Associates
 - 12.1 Report on Membership. Including Members Defaulting on Dues.
 - 12.2 Report on Associate Members, Australia, New Zealand and Switzerland
13. Executive Secretary's Report
 - 13.1 IAPWS Bank Account and Relocation of Executive Secretary
 - 13.2 Financial and Auditors
 - 13.3 Time and Place of 2015/2016/2017 Meetings.
14. Guidelines, Releases, Certified Research Needs, and International Collaborations
 - 14.1 International Collaborations
15. IAPWS Awards
 - 15.1 Helmholtz Award Committee
 - 15.2 Honorary Fellowship
16. Election of Officers for 2015 and 2016
17. New Business
 - 17.1 Press Release
 - 17.2 IAPWS Continuing Interface with BIPM
 - 17.3 Cover Page of IAPWS Documents
 - 17.4 Russian Committee feedback on 2014 Meetings and Symposium
 - 17.5 Other items raised during the IAPWS week
19. Adjournment

Schedule of IAPWS Meetings Moscow, Russia. 22nd – 27th June 2014

(All meetings will be in the Moscow, Lefortovo district)

Sunday 22 June	6:00 pm	Informal Get-together and Registration Krasnokazarmennaya street, 12S38, restaurant “Trapeznaya”
Monday 23 June	9:00 – 10:30 am	Opening Plenary Session – Executive Committee Krasnokazarmennaya Street 14, 4th Floor, room MAZ
	10:45 am	Coffee / Tea Break Krasnokazarmennaya Street 13, Building P (about 10 minutes’ walk from previous location)
	11:00 am	Working Group Meetings (same building for all WG Meetings: Krasnokazarmennaya Street 13, Building P)
	11:00 am	TPWS/IRS/SCSW Joint Meeting (To set agendas for the week and to conduct IAPWS Business, thus allowing remainder of week for technical matters)
	11:00 am	PCC Meeting
	11:00 am	PCAS Meeting
	12:00–1:00 pm	Lunch Krasnokazarmennaya street, 12S38, restaurant “Trapeznaya”
	1:00 pm	TPWS/IRS/SCSW Joint Meeting
	1:00 pm	PCC Meeting
	1:00 pm	PCAS Meeting
	2:30 pm	Coffee / Tea Break
Tuesday 24 June (Krasnokazarmennaya Street ulitsa 13, Building P)	8:30 am	PCAS Workshop (other WG Members will be welcome)
	8:30 am	PCC Workshop (other WG Members will be welcome)
	8:30 am	TPWS/IRS/SCSW Joint Working Group Meeting
	10:15 am	Coffee / Tea Break
	10:30 am	TPWS/IRS/SCSW Joint Meeting
	10:30 am	PCC Meeting
	10:30 am	PCAS Meeting
	12:00–1:00 pm	Lunch Krasnokazarmennaya street, 12S38, restaurant “Trapeznaya”
	1:00 pm	TPWS/IRS/SCSW Joint Meeting
	1:00 pm	PCC/PCAS Joint WG Meeting and Workshop
	2:30 pm	Coffee / Tea Break
	3:00 pm	PCC Meeting
	3:00 pm	PCAS Meeting
Wednesday 25 June	9:00 am – 4:30pm	IAPWS Symposium <i>Water and Steam: Industrial and Scientific Applications</i> Krasnokazarmennaya Street 14, 4th Floor, room MAZ
Thursday 26 June (Krasnokazarmennaya Street ulitsa 13, Building P)	8:30 am	IRS Meeting
	8:30 am	SCSW Meeting
	8:30 am	PCC Meeting
	8:30 am	TPWS/PCAS Joint WG Meeting WG Chairmen: A. Harvey and A. Anderko
	10:15 am	Coffee / Tea Break

	12:00–1:00 pm	Lunch Krasnokazarmennaya street, 12S38, restaurant “Trapeznaya”
	1:00 pm	TPWS Separate Meeting (if needed to prepare for Executive meeting)
	1:00 pm	PCC Separate Meeting (if needed to prepare for Executive meeting)
	1:00 pm	PCAS Separate Meeting (if needed to prepare for Executive meeting)
	4:30 pm	IAPWS Dinner/Banquet (starting point from “Lefortovo” hotel: 1-y Krasnokursanskiy proesd, 1/4)
Friday 27 June	8:30 am	Technical Excursion to Thermal Power Plant #27 of MosEnergo (starting point from “Lefortovo” hotel: 1-y Krasnokursanskiy proesd, 1/4)
	8:30 am	Executive Committee Meeting (Will include at least one member from each National Delegation) (Krasnokazarmennaya Street 13, Building P)
	10:30 am	Coffee / Tea Break
	1:00–2:00 pm	Lunch Krasnokazarmennaya street, 12S38, restaurant “Trapeznaya”
	2:00–5:00 pm	Excursion for EC (starting point: Krasnokazarmennaya Street 13, Building P)

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
 IAPWS – International Association for the Properties of Water and Steam

Location notes: Krasnokazarmennaya Street 13, Building P (WG Meetings location) is on opposite side of Krasnokazarmennaya street, 12S38, restaurant “Trapeznaya” (Lunches and Informal Get-together and Registration locations). Please be careful while crossing the street.

IAPWS SYMPOSIUM

“WATER AND STEAM: INDUSTRIAL AND SCIENTIFIC APPLICATION”

- 9:00 The Core Scientific Activities of Moscow Power Engineering Institute Aimed at Utility Industry Progress
N.D. Rogalev
- 9:20 Self-diffusion in supercritical water: NMR and MD studies on dynamics of hydrogen bonds
K. Yoshida
- 10:15 Properties of amorphous ice and formation of gas hydrates
M.Z. Faizullin
- 10:45 Coffee break
- 11:00 Thermal Conductivity of Supercooled Water
J.W. Biddle, F. Bresme, J.V Sengers, M.A. Anisimov
- 11:30 Supercooled Aqueous Solutions: Offspring of Liquid-Liquid Transition in Water
W. Biddle, V. Holten, M.A. Anisimov
- 12:00 Lunch
- 13:00 Investigation of thermodynamic properties of dissociated water steam
R.Z. Aminov , A.A. Gudym, A.V. Portyankin
- 13:30 Dry lay-up of steam generators with film forming amines. Studies and field experiences (Presentation not given)
W. Hater, A. de Bache, T. Petrick
- 14:00 Specifics of water phase condensation from the wet natural gas (water, supercooled water, non-electrolyte aqueous solutions, ice, gas hydrates) to cooled surface
V.Istomin
- 14:30 Coffee break
- 14:50 Water-carbon dioxide system: solubility, hydrates, substitution of methane for carbon-dioxide gas in gas hydrates
V. Voronov, E. Gorodetskiy, B. Grigoriyev, A. Muratov
- 15:20 Water conditions and properties of natural hydrate systems for determination the character and dynamics of gas-hydrates development and decomposition
V. Buleyko, B. Grigoriyev
- 15:50 The properties of supercritical water under high-power heating
S.B. Rutin, P.V. Skripov

Minutes

IAPWS Thermophysical Properties of Water and Steam WG and Subcommittee on Seawater Moscow, Russia, 23-26 June 2014

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

1-2. The meeting was opened on Monday, June 23 by the TPWS Chair, Allan Harvey. The agenda (Attachment A) was adopted. The Chair noted that the 2013 Minutes had been circulated and approved with shortly after the 2013 meeting. J. Hrubý was appointed Clerk of Minutes for TPWS and SCSW. (R. Pawellek was appointed Clerk for IRS)

3. H.-J. Kretzschmar introduced the OPAL Web Space for sharing the working material of WGs. In a continuation of a discussion started at the EC Meeting, WG members expressed various opinions. Some favored abandoning the password protection following a philosophy that IAPWS work should be open to anybody; others suggested that the access should be limited to WG members in order that draft documents are not disseminated and unpublished work can be shared. The resulting opinion was to keep the current state, e.g. password-protected access with a freedom to pass the password to national committee members or other collaborators.

4. No collaborative projects were suggested in TPWS.

5. H.-J. Kretzschmar explained the Revised Advisory Note No. 3 on Thermodynamic Derivatives from IAPWS formulations. The reason for this revision was correcting an incorrect formula and adding formulae for the derivatives of the IAPWS formulation for liquid water for oceanographic use (2009 Release) and the IAPWS industrial formulation for seawater (2013 Advisory Note).

The Working Groups adopted the Revised Advisory Note 3 unanimously.

6. Revised Supplementary Releases on “Backward” equations for IAPWS-IF97 (joint with WG IRS) [See IRS Minutes for this item.]

7. Proposal for an IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using Spline Interpolation, joint with WG IRS [See IRS Minutes for this item].

8. Metastable Water (joint with SC SW)

8.1 V. Holten explained the background of the supercooled water formulation. The formulation has the form of a Gibbs function of a mixture of a high-density structure and a low-density structure. The equilibrium fraction of these “components” is found by minimizing the Gibbs function for a given pressure and temperature. The model is consistent with the hypothesis

of a liquid-liquid critical point. The range of validity of the model is from 300 K down to the homogeneous ice nucleation temperature and up to 400 MPa, which corresponds to the coverage by experimental data.

8.2 J. Hrubý reported on behalf of the Task Group on Supercooled Water formulation (chair J. Hrubý, V. Holten, M. Anisimov, R. Feistel, O. Hellmuth, K. Orlov). The formulation suggested by Holten et al. was found to represent all available experimental data. It was suggested that additional comparisons are performed for the saturation vapor pressure of supercooled water. While the “pure components” of the two-structure model exhibit negative compressibilities and heat capacities, it was explained that this does not indicate anything unphysical and the measurable properties of the “mixture” are correct. It was suggested that the preparation of the IAPWS Guideline for the thermodynamic properties of supercooled water be postponed until comparisons with new density data (cf. 8.4) and other new data are performed.

8.3 Report on Task Group on possible Supercooled Water ICRN. No ICRN has been developed. In a discussion, it was found desirable and **the previously established task group consisting of O. Hellmuth (chair), V. Holten, J. Hrubý, J. Sengers) was asked to prepare a draft ICRN by the end of August.**

8.4 M. Duška and J. Hrubý reported on the progress of measurements of density of supercooled water at elevated pressures. The measurements should cover cold and supercooled water up to 200 MPa. Present measurements up to 35 MPa have shown that uncertainty of 0.01% in density can be achieved. It is likely that the new data will be available before the next meeting.

8.5 In a discussion it was decided that the **IAPWS Guideline on thermodynamic properties of supercooled water will be prepared without waiting for additional data in order to be ready for adoption at the 2015 Meeting.** In a vote, this decision was approved unanimously. The proposers – V. Holten and M. Anisimov – were asked to prepare a draft of the IAPWS Guideline by the end of July. **The Evaluation TG (chair J. Hrubý, O. Hellmuth, R. Feistel, K. Orlov) will prepare an evaluation report by the end of September.**

8.6 Report of Task Group on Superheated liquid water, joint with WG IRS and SCSW (chair H.-J. Kretzschmar, R. Feistel, J. Hrubý, K. Orlov, and B. Rukes). The Task Group had no output. Nevertheless, it was found that this area is of importance and the mandate of the Task Group was continued until the next meeting. The TG should examine the behavior of IAPWS-95 in this region and its agreement with experimental data.

9. Surface Tension of Ordinary Water (joint with WG IRS and SC SW)

9.1 Report (J. Hrubý). Independent measurements of the surface tension of supercooled water have been performed by two laboratories, showing that the IAPWS equation for the surface tension can be safely extrapolated down to $-25\text{ }^{\circ}\text{C}$. The experimental results were presented by V. Vinš and R. Mareš at ICPWS in London and published; a more complete account of the measurements will be forthcoming.

9.2 A Revised Release on Surface Tension of Ordinary Water Substance was prepared, which includes a statement that the equation provides reasonably accurate values when

extrapolated into the supercooled region to temperatures as low as $-25\text{ }^{\circ}\text{C}$. The Draft Revised Release was circulated in the WG in February. **The Working Groups recommended the Revised Release for adoption by the EC.**

9.3 Appointment of Task Group for complete revision of formulation. J. Hrubý explained that there are reasons to completely revise the formulations: new data claim uncertainty at 20 and $25\text{ }^{\circ}\text{C}$ which is many times lower than the uncertainties stated by the Release. A noticeable deviation was observed for supercooled water below $-25\text{ }^{\circ}\text{C}$. An up-to-date value for the critical exponent should be used. **A Task Group was established, consisting of V. Vinš (chair), A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, J. Kalová, R. Mareš.** For the next meeting, the TG should prepare a report on the existing experimental data.

10. Possible Improvement of the Uncertainty Estimates of IAPWS-95

10.1 Report of Task Group (A. Harvey, W. Wagner, M. Trusler)

The main basis for reconsideration was the new data for the speed of sound by Lin and Trusler. It has been found that old data by Alexandrov and Larkin (1976) and Alexandrov and Kochetkov (1979, 1980) are of high quality. Based on the differences between IAPWS-95 and experimental data, it was possible to significantly reduce the uncertainties of IAPWS-95 in the speed of sound in some regions. The data situation for C_p at high pressures had not improved. Comparisons with the equation by Holten in the range of overlap show relatively high differences. Consequently, it was proposed that a region near the melting line, which previously was assigned an uncertainty of 6%, is left without uncertainty estimates. As a further improvement, the borders in the uncertainty graphs will be defined mathematically (not just graphically).

10.2 Discussion of density data in the range $0\text{-}150\text{ }^{\circ}\text{C}$ to 100 MPa (J. Hrubý, M. Duška). J. Hrubý presented a re-evaluation of the accurate density data by Kell and Whalley (1965, 1975), which is the main density data set in the region of liquid water up to 100 MPa. In their 1965 work, K&W used an erroneous value for the compressibility of stainless steel 304, which was the material of their measuring cell. When it became clear that their density data is not compatible with densities derived from speed of sound measurements, they decided to fit the compressibility of SS304 such that density at 100 MPa for given temperature is equal with density determined from the speed of sound data by Wilson (1959). In this way, K&W 1975 data are not an independent source. To improve this situation, reliable data for the compressibility of SS304 have been found and K&W 1975 data were corrected. The correction is small, its maximum value is about 15 ppm at 100 MPa and 273.15 K. Agreement with the equation by Holten et al. is improved at 273.15 K. It is not necessary to modify the uncertainty statement for IAPWS-95.

10.3 **It was voted to approve the suggestion of the Task Group of a Revised IAPWS-95 Release containing improved uncertainty estimates, and to request that (following Editorial Committee review) it be sent for Postal Ballot by the EC.**

11. Industrial Requirements and Solutions for Steam Property Calculations, joint with WG IRS [See IRS Minutes for this item.]

12. Report of Task Group on Extension of Range of Formulation for Thermodynamic Properties of Sea Water, joint with WGs IRS and SC SW (R. Feistel, presented by A. Harvey).

J. Safarov has performed measurements of density of seawater as function of pressure, temperature and salinity. Saturation vapor pressure of seawater was measured up to 50 °C. Solubility of CO₂ in seawater as function of salinity was determined. Measurement of vapor pressure up to 200 °C is under development. The Task Group will continue to monitor the data situation to see if new data are sufficient to expand the range of the seawater formulation.

13. Cooperation with other international bodies, joint with SC SW (O. Hellmuth)

13.1 IAPWS/IAPSO/SCOR Joint Committee on Seawater. Report by R. Pawlowicz was presented by O. Hellmuth. Structure of JCS: Chair: R. Pawlowicz, Vice Chairs: R. Feistel T. McDougall. Taskgroups: Salinity/Density (S. Seitz, H. Uchida, F. Millero, S. Weinreben, Y. Pang), Seawater pH (P. Spitzer, M.F. Camoes, A. Dickson), moist air RH (O. Hellmuth, J. Lovell-Smith, R. Feistel). Subgroups: Thermodynamics (Feistel), numerical modelling (McDougall), software (P. Barker), industry representatives. High number of downloads of TEOS-10 software. Ocean measurements of TEOS-10 salinity anomaly have been carried out. Realized workshop: linearity of the Anton Paar density meter using heavy water and NaCl solutions, definition of a plausible artificial seawater matrix (based on TEOS-10 Reference Composition) for pH measurements. Further plans: best practices for precision density measurements, collective experience about the chemical composition of standard sea water, inter-laboratory comparisons of density measurements, traceability of uncertainties in Pitzer-like models, tasks related to relative humidity (cf. item 14).

13.2 Cooperation with BIPM (CCQM and CCT) (R. Feistel, R. Pawlowicz, P. Spitzer). Pawlowicz attended CCQM/EAWG (Electrochemical Working Group) meetings and CCQM/plenary meetings (April 2014, Sevres, France). Comparisons of NMIs (National Metrology Institutes) for conductivity shows wide variation. Instrument design may be important in seawater practical salinity measurements. Not yet clear how to move forward on salinity/density; also pH issues not yet resolved. R. Feistel attended CCT/WG-6 (now WG-Humidity) and CCT/plenary meetings (May 2014, Sevres, France). When a draft paper on BIPM/IAPWS Cooperation (now under revision) is completed, it is expected that WG-6 will adopt the approach to RH recommended in this paper. R. Feistel is now a member CCT/WG-Humidity and CCT Task Group Environment. **IAPWS is expected to prepare a document on the calculation of fugacity of water in humid air.** CCT/IAPWS will work towards putting RH in the list of quantities with unit 1 in the updated SI brochure.

A motion to ask the EC for support of two people participating in BIPM meetings in the coming year was approved unanimously by SCSW.

14. Report on progress on topics following ICPWS13 Humidity Workshop, joint with SC SW (R. Feistel, J. Lovell-Smith, O. Hellmuth). All items were reported on by O. Hellmuth.

14.1 Virial equation for fugacity of water in humid air and determination of relative fugacity from this equation. ICPWS London workshop. “To support the acceptance of the intended new BIPM/CCT definition of relative humidity, CCT/WG RH is requesting IAPWS to develop a document on the calculation of fugacity and relative fugacity of water in humid air”. A draft Guideline has been prepared and a background article submitted (R. Feistel, J. Lovell-Smith, O. Hellmuth), but this only addresses the issue of fugacity in the vapor, not the relative fugacity. The formulation has the form of a virial expansion in terms of pressure and mole fraction which

is expressed using second and third virial coefficients for water by IAPWS-95, second and third coefficients for air by Lemmon et al. (2000), second air-water coefficient by Harvey and Huang (2007), third cross virial coefficients as estimated by Hyland and Wexler (1983).

14.2 Comparison of “relative fugacity” versus “relative humidity”. Relative humidity (RH) is defined as a ratio of the water vapor mole fraction to water vapor mole fraction at phase equilibrium for the same temperature and pressure (World Meteorological Organization – WMO). New concept: relative fugacity (RF) is defined as a ratio of fugacity to fugacity at the same temperature and pressure at phase equilibrium. A practical difficulty consists in the necessity of computing the mole fraction at the phase equilibrium. A preliminary approximation function was suggested for the atmospherically relevant range 234.15 K to 325.15 K and 100 hPa to 1060 hPa. Also a high-temperature and pressure (HTP) area was investigated, ranging between 273.15 K to 473.15 K and 1000 hPa to 10 MPa using a similar polynomial fit. A goal of virial formulation for RF was not reached. An eventual formulation needs to also cover the case of ice as the condensed phase. So far the issue of dissolved air in the liquid phase has not been considered, and it was unclear whether that omission is OK.

14.3 Discussion of possible IAPWS Guideline on a Virial Equation for the Fugacity of Water in Humid Air. In a discussion it was recommended that the proposed Guideline contains both equations for computation of fugacity and for computation of the vapor molar fraction at saturation. Also it was suggested that the formulation might be restricted to second virial coefficients to simplify the calculations and to avoid inconsistencies with third virial coefficients obtained from different sources. The proposers should ask CCT about the required ranges of temperatures and pressures, and clarify whether their request to IAPWS is only for the fugacity of water in the vapor phase or if it also includes calculation of relative fugacity. **An evaluation Task Group was established (A. Harvey, H.-J. Kretzschmar, J. Cooper).**

15. Reports on miscellaneous TPWS scientific topics

15.1 V. Holten reported on his investigation of the melting curve of Ice III. The present IAPWS formulation is based on Bridgman’s data which do not agree with newer data. V. H. based his computation on a simple model for the Gibbs energy of ice III and his formulation of properties of cold and supercooled water (cf. 8.1). Preliminary computations showed agreement with more recent experimental data including metastable regions corresponding to stable ices Ih and V. It has been recommended that a new correlation for this melting line is established. Discussion about the triple point (liquid, Ih, III): The current triple-point temperature and pressure are computed with IAPWS-95, which is not quite accurate in this region. It was recommended that new coordinates are computed using the new equation by V.H. **A Task Group was appointed consisting of V. Holten, A. Harvey, and H.-J. Kretzschmar to consider revision of the IAPWS Release that gives the melting curves of water with various ice forms.**

15.2 N. P. Romanov reported on a New Simple Formula for Saturated Water Steam Pressure from -40 to 350 °C for Liquid Water and from -100 to 0 °C for Ice. The equations are constructed as simple fits of partial ranges. Inverse computation is possible by solving a cubic equation using Cardano’s method.

16. Heavy Water Properties, joint with WG IRS

16.1 S. Herrig presented a Report of Task Group on Heavy Water Thermodynamic Properties (R. Span, A. Harvey, S. Herrig). The present formulation by Hill et al. (1982) was adopted in 1984 and adjusted to ITS-90 in 2005. The preliminary new equation has the form of

dimensionless Helmholtz energy, it contains 6 terms for ideal gas and 23 terms for the residual function. The equation is valid up to 825 K and 1000 MPa. It shows a plausible extrapolation behavior. The new equation represents much better the speed of sound. High-pressure pVT data by Jůza et al. were decided to be inaccurate based on other data. The ideal-gas part is based on data by Friedman and Haar (1954) who gave values between 0 and 5000 K. Potential improvements: additional measurements for vapor pressures at low temperatures may be performed at NIST if manpower can be made available; additional measurements for sound speeds are considered at University of Bochum. Ideal-gas properties based on recent spectroscopic data and quantum mechanical computations will be available soon (c.f. 17.2).

16.2 An Evaluation TG for Heavy Water Thermodynamic Properties was established including M. Duska, H.-J. Kretzschmar, and co-opted expert Thomas Beuthe (AECL, Canada). The TG Chair will be determined by the WG Chair later.

16.3 Appointment of TG for Heavy Water Transport Properties. Preliminary work started at NIST. A Task Group was formed incorporating J. Sengers and M. Assael and co-opted expert M. Huber (NIST). The TG Chair will be determined by the WG Chair later.

17. Joint session with WG PCAS [Thursday morning]

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

The recently developed equation for thermal conductivity of seawater (Wang Anderko 2012) is based on a model of a multicomponent salt solution. Thermal conductivity is expressed as a sum of the pure-water term and a contribution due to electrolytes, where the latter is a sum of contributions of individual ions and an interaction term, which depends on the ionic strength. The parameters of the model are based on a large amount of good quality experimental data for individual salts and for multicomponent systems. Most of the seawater data is not consistent. Comparison of existing seawater data with NaCl solution for the same molality shows an unexpected deviation increasing with pressure. Recent data by Sharqawy (2013) at atmospheric pressure are in an excellent agreement with the multicomponent model. Based on this model, a draft guideline has been proposed and reviewed. It has been found that the multicomponent approach is too complex for application to seawater, because the variability of the chemical composition of seawaters is small to produce noticeable effects in thermal conductivity. Therefore, a simple model in terms of pressure (p), temperature (T), and salinity (S) has been developed based on a matrix of data generated from the multicomponent model. It has been found that the difference from the pure-water thermal conductivity can be expressed as $a \cdot S^{(1+b)}$, where a and b are simple functions of pressure and temperature. The simplified model is prepared for publication.

In the discussion it was suggested that a new Draft Guideline be prepared along with publishing the paper. The Draft Guideline will contain only the simplified approach (p,T,S). The evaluation task group as nominated in London (R. Feistel, R. Pawlowicz, K. Miyagawa) will review it such that the Guideline is prepared for adoption at the 2015 Meeting.

17.2 Progress toward improved ideal-gas properties of ordinary and heavy water (J. Hrubý). The ideal-gas parts of the formulations of thermodynamic properties for ordinary water is based on data by Woolley (1980) and for heavy water on data by Friedman and Haar (1954). In 2012, a loose collaboration was established with J. Tennyson (London) and A. Csaszar (Budapest) who participated in an IUPAC project to develop a comprehensive spectroscopic database for the 9

important water isotopologues (various combinations of isotopes H, D, ^{16}O , ^{17}O , and ^{18}O). This work has been recently finished. Based on the evaluated energy levels, the ideal-gas properties can be computed with a high accuracy. First data for C_p of H_2^{16}O in a limited temperature range were obtained in 2012. Consequent discussions concerned primarily the uncertainty of the results. For high temperatures (approximately above 1000 K), high energy levels become important which are not covered by spectroscopic data. These are presently being computed quantum mechanically. The temperature should range up to 6000 K or perhaps even higher as long as the uncertainty in C_p remains in useful limits (say 20%). It has been noted that below about 60 K it is necessary to distinguish the “ortho” and “para” states of the water molecule. Data relevant to heavy water should be delivered very soon (summer 2014).

18. IAPWS Certified Research Needs (ICRNs)

18.1 **ICRN-16 on Thermophysical Properties of Seawater (joint with SCSW) was extended until 2019.** The motion passed unanimously.

18.2 ICRN-27 on Humid Gases and CO_2 -Rich Mixtures (R. Span, A. Harvey)

It was decided to close this ICRN. R. Span and A. Harvey will prepare a closing statement. They will also consider the possibility of a new ICRN for properties relevant to carbon capture and sequestration.

18.3 ICRN-28 on Metastable Steam

J. Hrubý explained the importance of metastable steam for power generation. The situation in experimental data has not improved. Significant improvement is possible also from the side of molecular simulation of virial coefficients and the nucleation process. **The Working Group agreed to extend ICRN-28 to 2019 without modification.**

19. Reports on other TPWS activities

19.1 Guideline on Fundamental Constants (A. Harvey)

No new information relevant to IAPWS documents was found.

19.2 Advisory Note 2 on the Role of Various IAPWS Documents Concerning the Thermodynamic Properties of Ordinary Water Substance. (J. Cooper, A. Harvey). **Harvey and Cooper were authorized to make minor revisions to the Advisory Note to reflect recent updates.** When the SBTL Guideline is approved, a note on its role will be added.

19.3 IAPWS formulation on the Elsevier site (V. Ochkov)

On Tuesday, V. Ochkov presented plans for incorporating calculations based on IAPWS formulations via the SMath tool on the site of Knovel (owned by Elsevier) which provides web-based science and engineering information. It was requested that IAPWS endorse this project by letter. A copy of the letter was circulated. Further discussion on Thursday primarily concerned the question that the letter might be understood as promotion of a specific company, which would not be compatible with IAPWS Statutes. An option was suggested that IAPWS develops a general letter which can be sent to companies for such purposes. The letter would inform about the position of IAPWS, its main documents and would contain an offer for feedback. It has been recognized that the decision about the letter is a question for the EC, not for any Working Group. **The WG Chair will bring the question to the EC.**

20. Other Business

20.1 Report on International Collaborative Projects. Nothing to report

21. Membership

Two proposals were submitted for TPWS membership: Dr. Henning Wolf (PTB Braunschweig) and Mr. Stefan Herrig (Ruhr Universität Bochum). Both candidates were approved unanimously.

No proposal was submitted for SCSW membership.

22. Contribution to Press Release

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

23. Preparation of the Formal Motion to the EC

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

24. Adjournment

The meeting was adjourned at 11:10 a.m on Thursday, June 26.

Agenda for the IAPWS Working Group

Thermophysical Properties of Water and Steam (TPWS)

Moscow, Russia, 23-26 June 2014

1. Opening Remarks; Adoption of Agenda
2. Appointment of Clerk of Minutes
3. OPAL Web Space for Working Material for WGs TPWS, IRS, and SC SW, joint with WG IRS and SC SW (H.-J. Kretzschmar)
4. Potential International Collaborative Projects
5. Revised Advisory Note No. 3 on Thermodynamic Derivatives from IAPWS formulations, joint with WG IRS and SC SW
 - Report of the proposers (H.-J. Kretzschmar)
 - Formal consideration of the Revised Advisory Note by the Working Groups
6. Revised Supplementary Releases on “Backward” equations for IAPWS-IF97 (joint with WG IRS)
 - 6.1 Report of the proposers (H.-J. Kretzschmar)
 - 6.2 Formal consideration of the Revised Supplementary Releases by the Working Groups
7. Proposal for an IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using Spline Interpolation, joint with WG IRS (H.-J. Kretzschmar, M. Kunick, J. Hrubý, M. Duška, V. Vinš, F. di Mare, A. Singh)
 - 7.1 Report of Evaluation Task Group (A. Novy)
 - 7.2 Specification of path forward for Guideline
8. Metastable Water (joint with SC SW)
 - 8.1 Background of supercooled water formulation (V. Holten)
 - 8.2 Report of Task Group on Supercooled Water formulation (J. Hrubý)
 - 8.3 Report on Task Group on possible Supercooled Water ICRN (V. Holten, J. Sengers, O. Hellmuth)
 - 8.4 Progress of measurements of density of supercooled water at elevated pressures (M. Duška, J. Hrubý)
 - 8.5 Discussion of IAPWS path forward for supercooled water
 - 8.6 Report of Task Group on Superheated liquid water, joint with WG IRS and SCSW (H.-J. Kretzschmar)
9. Surface Tension of Ordinary Water (joint with WG IRS and SC SW)
 - 9.1 Report (J. Hrubý)
 - 9.2 Formal consideration of the Revised Release by the Working Groups

- 9.3 Appointment of Task Group for complete revision of formulation
10. Possible Improvement of the Uncertainty Estimates of IAPWS-95
 - 10.1 Report of Task Group (A. Harvey, W. Wagner, M. Trusler)
 - 10.2 Discussion of density data in the range 0-150 °C to 100 MPa (J. Hrubý, M. Duška)
 - 10.3 Discussion of next steps, including formal consideration of Revised Release
11. Industrial Requirements and Solutions for Steam Property Calculations, joint with WG IRS
 - 11.1 Report of the New Industrial Requirements Task Group (I. Weber)
 - 11.2 Report of the Task Group “Industrial Advisory Note” (M. Hiegemann, B. Rukes, A. Singh, A. Harvey)
12. Report of Task Group on Extension of Range of Formulation for Thermodynamic Properties of Sea Water, joint with WGs IRS and SC SW (R. Feistel)
13. Cooperation with other international bodies, joint with SC SW (O. Hellmuth)
 - 13.1 IAPWS/IAPSO/SCOR Joint Committee on Seawater (R. Pawlowicz)
 - 13.2 Cooperation with BIPM (CCQM and CCT) (R. Feistel, R. Pawlowicz, P. Spitzer)
14. Report on progress on topics following ICPWS13 Humidity Workshop, joint with SC SW (R. Feistel, J. Lovell-Smith, O. Hellmuth)
 - 14.1 Virial equation for fugacity of water in humid air and determination of relative fugacity from this equation
 - 14.2 Comparison of “relative fugacity” versus “relative humidity”
 - 14.3 Discussion of possible IAPWS Guideline on a Virial Equation for the Fugacity of Water in Humid Air
15. Reports on miscellaneous TPWS scientific topics
 - 15.1 Investigation of the melting curve of Ice III (V. Holten)
 - 15.2 A New Simple Formula for Saturated Water Steam Pressure from –40 to 350 °C for Liquid Water and from –100 to 0 °C for Ice (N.P. Romanov)
16. Heavy Water Properties, joint with WG IRS
 - 16.1 Report of Task Group on Heavy Water Thermodynamic Properties (R. Span, A. Harvey, S. Herrig)
 - 16.2 Appointment of Evaluation TG for Heavy Water Thermodynamic Properties
 - 16.3 Appointment of TG for Heavy Water Transport Properties
17. Joint session with WG PCAS [Thursday morning]
 - 17.1 Report of Task Group on Transport Properties of Seawater, joint with SC SW and WG IRS (A. Anderko, A. Harvey)
 - 17.2 Progress toward improved ideal-gas properties of ordinary and heavy water (J. Hrubý)
18. IAPWS Certified Research Needs (ICRNs)
 - 18.1 ICRN-16 on Thermophysical Properties of Seawater (joint with SCSW)
 - 18.2 ICRN-27 on Humid Gases and CO₂-Rich Mixtures (R. Span, A. Harvey)
 - 18.3 ICRN-28 on Metastable Steam (J. Hrubý)

19. Reports on other TPWS activities
 - 19.1 Guideline on Fundamental Constants (A. Harvey)
 - 19.2 Advisory Note 2 (J. Cooper, A. Harvey)
 - 19.3 IAPWS formulation on the Elsevier site (V. Ochkov) [Tuesday]
20. Other Business
 - 20.1 Report on International Collaborative Projects
21. Membership
22. Contribution to Press Release
23. Preparation of the Formal Motion to the EC
24. Adjournment

June 19, 2014

A.H. Harvey (Chair), J. Hrubý (Vice-Chair)

Minutes of the IAPWS working group IRS, Moscow, 23 - 26 June 2014 (Numbering of topics follows TPWS agenda)

1. Ingo Weber opened the session for IRS at about 11 am, 23. June 2014. The agenda was adopted unchanged.
2. Rainer Pawellek was appointed clerk of minutes.
3. Covered in TPWS minutes.
4. Covered in TPWS minutes.
5. Covered in TPWS minutes.
6. Revised Supplementary Releases on Backward equations for IAPWS-IF97
 - 6.1. Report of the proposers

H.-J. Kretzschmar explained that K. Orlov discovered a sentence in the description for the determination of the region that could be misinterpreted. This in total affects 4 advisory notes (S-01, S-03rev, S-04 and S-05). D. Friend asked for details of this change. Prof. Kretzschmar explained the change in one of the documents (a simple elimination of the problematic sentence). Additionally a few references were updated.
 - 6.2. Formal consideration of the Revised Supplementary Releases by the Working Group

I. Weber pointed out that all comments to the revision were included and asked for the approval by the Working Group. The result was: all votes in favor, no against, no abstentions.
I. Weber explained that – since the revised documents were not yet circulated to the National Committees - the EC will be asked for a Postal Ballot for adoption of these Revised Supplementary Releases.
7. Proposal for an IAPWS Guideline on the Fast Calculation of Steam and Water Properties Using Spline Interpolation (SBTL)
 - 7.1. Presentation of the Draft Guideline by the proposers

First, H.-J. Kretzschmar introduced the changed abbreviation SBTL – “Spline-based table lookup” – for this method. He illustrated the background, went through the chapters of the document and explained the highlights. He also explained the evaluation process: there were four packages delivered by M. Kunick to the evaluation group, with C++ source code for the SBTL functions (88 functions) and FORTRAN source code for the test programs and the IAPWS-IF97 packages from Bochum. He explained that the preparation of these program packages was a full time job for M. Kunick for 10 months. Therefore, an explicit reprogramming of the SBTL cannot be done in an evaluation task group. He emphasized the parallelism to the TTSE guideline in 2003 where IAPWS for the first time issued a numerical method as a guideline. After the presentation, D. Friend asked questions about

 - the boundaries. H.-J. Kretzschmar explained that the regions for SBTL are different from the regions of IAPWS-IF97, but the user does not have to care about the boundaries
 - time comparisons with TTSE. H.-J. Kretzschmar explained that they compared a couple of functions
 - a potential withdrawal of TTSE. I. Weber remembered that this issue already had been discussed last year and it was decided to keep both methods. J. Cooper remarked that Advisory Note #2 needed an update whenever SBTL was released as a Guideline. It was discussed that Advisory Note #2 then should contain a recommendation when to use which method.

- a comparison with CFD calculation times based on ideal gas behavior that were performed during the evaluation. H.-J. Kretzschmar explained that this was considered only for the steam phase for steam turbine calculations in TRACE.

7.2. Report of Evaluation Task Group

A. Novy presented the report of the evaluation task group that was distributed to the WG members. The task group consisted of A. Novy (chair), I. Weber, K. Miyagawa, R. Pawellek, F. Blangetti and A. Singh. The SBTL functions were tested only for the IAPWS-IF97 functions. A. Novy explained which functions were available and which tests were performed by whom. Subjects of the tests were the accuracy as well as the gain in calculation speed. K. Miyagawa evaluated the results given in the document. F. di Mare, A. Novy, R. Pawellek and I. Weber integrated the SBTL library in their company calculation tools. E.W. Lemmon performed a review of the method and compared the source code with the method. A. Novy closed his presentation with the question which product should be published: the SBTL method itself or its application (spline coefficient tables) for IAPWS-IF97 and IAPWS-95, respectively. It is the recommendation of the evaluation task group that the draft should be accepted.

7.3. Formal consideration of Guideline

There was an elaborated discussion among the WG members.

For the scope of the questions by A. Novy, I. Weber pointed to the discussion for TTSE. J. Hruby noted that for TTSE, it is easier to determine the coefficients and suggested to publish the tables of coefficients for SBTL. K. Orlov asked how many papers would be required for these tables. A. Novy explained that these tables can be published only electronically as the SBTL library has a size of 120 MB (compared to 0.5 MB of the Skoda library). H.-J. Kretzschmar added that the tables alone would not help without the software. I. Weber explained that it is not necessary to publish the tables because the SBTL is not the standard but an approximate method for the standard. IAPWS-IF97 is the standard, and it is up to the user what approximate method he uses.

O. Hellmuth asked whether the time ratios are related to the property calls only or the overall calculation time. The factor 6-10 for CFD really affects the whole calculation time, i.e. you need 1 day instead of 1 week for a calculation.

J. Cooper asked whether more functions may be required than the (u,v) and the (p,h) functions, especially for the calculation of steam generators. A. Novy explained that other functions are included, but not available in the interface. I. Weber noted that for the evaluation at Siemens, these functions were sufficient.

W. Wagner noted that it the method should not be limited to just these two sets of variables because the method is much more general. I. Weber points to possible future usages.

As the evaluation was performed for IAPWS-IF97 only, there was a discussion whether an evaluation for IAPWS-95 is required as well. Although the main interest from the industry is on IAPWS-IF97, there are results from IAPWS-95 in the Guideline document. Therefore, it is necessary that these results also have to be evaluated.

A. Novy asked whether an evaluation of the method itself would be possible. A. Harvey asked H.-J. Kretzschmar whether it would be possible at least for IAPWS-95 because this would be easier as problems with the regions do not have to be considered. H.-J. Kretzschmar estimates an effort of 1 – 2 full time years even for IAPWS-95 due to numerical challenges, coordinate transformations et al. As E. Lemmon compared the source code with the method, the agreement

in the results can be seen as an indication of the correctness of the method.

Finally, A. Harvey proposed that

1. the WG instructs the evaluation task group also to evaluate IAPWS-95 statements contained in the draft document. This proposal was accepted by all WG members without dissents or abstentions. As the work most efficiently could be done by Kiyoshi Miyagawa who is not attending the meeting, the time frame depends on his availability. End of August would be desirable.
2. the guideline will be published without the tables. This proposal was accepted with 2 dissents (from all present WGs) and 0 abstentions.
3. the review of the document by the WG members should be done in parallel to 1.) until end of August. This proposal was accepted by all WG members without dissents or abstentions.

It was determined that after completion of evaluation and review by WG members (latest by end of August 2014), the WG members will be asked to electronically vote for adoption within a time period of one month, i.e. by end of September. In parallel to that the editorial committee would be finalizing the Guideline also by end of September. Following the acceptance by the Working Groups the document will be transferred to EC for Postal Ballot.

Addendum:

Later in the week, prior to adjourning the IRS meeting, I. Weber informed the working group that K. Miyagawa had already performed the SBTL evaluation for IAPWS-95. There are only minor changes, and a new guideline draft is available. There was a discussion whether the time schedule could be accelerated. D. Friend noted that the guideline is quite long and that 6 weeks instead of 1 month would be appropriate to check the document. Ultimately there was an agreement that the time schedule should be left as proposed before. The updated evaluation report and the draft Guideline document will be distributed within one week after the meeting. A. Harvey noted that – if the WG review happens to be faster – the chairs of the WGs could also proceed faster. W. Wagner expressed his thanks to K. Miyagawa, quotation: “Kyoshi is a superman”.

8. Covered in TPWS minutes.
9. Covered in TPWS minutes.
11. Industrial Requirements and Solutions for Steam Property Calculations
 - 11.1. Report of the New Industrial Requirements Task Group
 - I. Weber explained that there is nothing to report from this task group and asked how to continue with this task group. As the task is not concrete enough, he suggested closing this task group. The WG agreed to this suggestion.
 - 11.2. Report of the Task Group “Industrial Advisory Note”
 - The task of this group is to compile an additional advisory note to have one document that encapsulates all documents relevant for industrial use. There was no progress during the last year, but there is still a document being worked on. I. Weber suggested postponing the task for one year. B. Rukes asked whether M. Hiegemann is still participating in IAPWS. I. Weber will check this. A. Harvey noted that I. Weber is authorized to appoint a new chair of the task group if M. Hiegemann would not be available any more.
20. Other business:
 - No International Collaborative Projects were proposed and no ICRNs need the WGs attention
21. Membership:
 - No changes in membership are necessary.
22. Contribution to Press release will be done by the WG chair

23. Formal motion to the EC will be prepared by the WG chair
24. Ingo Weber adjourned the meeting at about 11:30am, 26. June 2014

IAPWS Meeting
Moscow, Russia
June 23-26, 2014

PCAS WG Minutes

Present:

Andre Anderko (Chair)

Masaru Nakahara

Ken Yoshida

Milan Sedlar

James Bellows (Clerk of minutes)

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1. **Opening remarks.** Andre Anderko opened the meeting and presented the agenda. James Bellows was appointed the clerk of minutes.
2. Minutes of 2013 were approved
3. Agenda was approved.
4. A short round-table of scientific activities of the attendees was held.
5. **Task group on amine properties**

A task group on amine properties was appointed

Members: Andre Anderko and James Bellows

Task: To evaluate available data on liquid/vapor distribution and acid or base dissociation constants of amines and amine decomposition products; to create a plan of Guidelines and ICRN's; to attempt to have a guideline draft on an amine of the task group's choice available for working group approval in 2015.

Evaluation committee: Peter Tremaine, David Guzonas and a member of PCC to be selected by the chair (see note at end). The task group is to obtain consent or substitute members.

6. **Report on thermal conductivity of sea water project.**
Andre Anderko presented a report on the progress of the project at a joint meeting with TPWS. The plan is to submit a paper for publication, hopefully in July, 2014, and prepare a draft release in parallel with a goal of approval at the 2015 meeting.
5. **Membership:** Dr. Ken Yoshida will be proposed to the EC as a PCAS working group member.

6. Minutes were reviewed and approved.

Note on evaluation committee: PCC suggested Wolfgang Hater, David Moed, and a person to be named from Japan (Dr. Hirano as contact.). David accepted on June 26, 2014.

8. Contribution to press release:

In collaboration with the Power Cycle Chemistry working group, the Physical Chemistry of Aqueous Solutions (PCAS) working group has formed a task group to provide formulations of the liquid/vapor distribution and of acid or base dissociation constants of amines and their acid decomposition products. Interested parties are invited to participate by contacting the chair at james.bellows@siemens.com. PCAS is continuing work on a Guideline on the Thermal Conductivity of Seawater.

IAPWS Power Cycle Chemistry (PCC) Working Group

Minutes of IAPWS PCC WG Meetings

Location: Moscow, Russia, June 23 - 27, 2014

Acting Chairman: Paul McCann
Members present: See PCC Attachment A

Monday 23rd June 2014

Chairman P. McCann welcomed the participants and working group members and passed on best wishes to M. Rziha for a speedy and full recovery from his current health issues.

Each participant was asked to briefly introduce him- or herself.

1. Agenda

1.1 Amendments / Adoption of Agenda

There were no amendments to the drafted agenda.

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

P. McCann described the proceedings for the WG meetings and summarized the overall schedule. The schedule for the PCC workshop presentations on Tuesday and Thursday was finalized.

A brief discussion was held regarding the distribution of PCC WG presentations following the meeting. It was decided that the OPAL webspace would be used and login credentials would be provided via email following the meeting.

Action: P. McCann to provide login instructions to secure webspace to the PCC members following the meeting.

2. Appointment of Clerk of Minutes

W. Cook was asked and agreed to act as the Clerk of Minutes.

3. Approval of Minutes of PCC WG meeting in Greenwich, UK, 2013

The minutes were approved with a minor correction required in section 7.2 – T. Ichihara should be H. Kido.

4. Progress Reports on PCC Activities 2013 / 2014

4.1 Review of Actions from last PCC WG Meeting

4.2.2 ICRN#17 on Amines: J. Bellows to prepare new ICRN and prepare text to close out ICRN#17 - 15th October 2013

Status: Ongoing.

4.2.3 ICRN on Film Forming Amines: S. Marais (task group leader) and W. Hater to prepare proposal and timeline for new ICRN during ICPWS16.
Status: Ongoing.

4.2.4 ICRN#25 on Impurities: W. Cook to circulate to PCC for approval and M. Rziha to bring to EC for approval.
Status: Complete. Ready for EC approval.

4.2.5 ICRN#22 on PTZ: Expired September 2013. M. Rziha to contact M. Stastny and A. Rudge.

Status: Complete (P. McCann) – Stastny and Rudge indicated ICRN is still relevant and current. It was suggested ICRN #22 be renewed with M. Stastny as the primary contact. There were no objections from the PCC WG. Further discussion included in Section 4.3 below.

4.2.7 ICRN for CP Sampling in cycling plants: P. McCann to lead task group to develop new ICRN.
Status: Ongoing - D. Addison mentioned that a year or two of feedback from experience with the current TGD may be useful and customizations for cycling plants may be a good amendment for future. Discussion added as agenda item to new ICRNs.

4.2.8 ICRN#26 on AI in Steam/Water Cycle: Expiring in September 2014. M. Rziha, G. Joy, F. Leidich to evaluate extension.
Status: B. Dooley still sees ICRN as relevant. Recommend extension to EC to September 2019. Further discussion required.

4.5.1 PCC Public Relations: M. Rziha and J. Bellows to assist A. Harvey examining improvements for IAPWS document visibility in search engines.
Status: A. Harvey completed preliminary review of options – presented at EC meeting Monday morning June 23, 2014. Better keywords required on IAPWS webpage, suggested short description of TGD should follow the title/link on the webpage.

4.5.2 PCC meeting highlight for PPChem: M. Rziha to prepare summary of PCC WG meeting for Power Plant Chemistry.
Status: Complete.

4.5.3 Press Release: P. McCann to prepare press release.
Status: Complete.

4.5.4 Indexing files/documents on IAPWS website: J. Bellows to improve searchability of documents on webpage by referencing filenames to authors etc.
Status: Ongoing.

7.2 PCC membership changes: M. Rziha to propose new members to EC.
Status: Complete – note H. Kido should be included in the minutes as a new PCC member, she was incorrectly recorded as T. Ichihara in last year's minutes.

7.3 Contact defunct PCC members: M. Rhiza and P. McCann to contact PCC members who have not been present or active for many years and inquire on their desire to remain on WG.
Status: Ongoing.

4.2 International Collaboration

No international collaborations are currently ongoing. P. McCann asked the PCC WG if there were any proposals for new collaborations, there were none.

4.3 ICRNs – Review and Possible New Additions

Current ICRNs

ICRN#17 on Amines – expired in September 2013. J. Bellows was to write close-out document and prepare new ICRN.

J. Bellows indicated two tasks for new ICRN on Amines: circulate current document through EPRI for comment (J. Matthews – complete); re-write document. B. Dooley suggested having ICRN#17 closing document.

Action: J. Bellows to write closing document for ICRN#17 – provide by end of WG meetings this week.

Action: J. Bellows to draft new ICRN on amines, suggested co-authorship with member from PCAS – provide draft ICRN for circulation to PCC by September 30, 2014.

ICRN#20 on Sensors for Elevated Temperatures – expires September 2014. S. Uchida recommends closure of this ICRN as it has helped with FAC sensors and H₂O₂ sensor development.

Action: S. Uchida to prepare closing document for ICRN#20 – provide by December 31, 2014.

ICRN#22 on Chemistry in the PTZ: Expired September 2013.

As above, it was suggested ICRN #22 be renewed for 1-year period with M. Stastny as the primary contact. There were no objections from the PCC WG. Suggested collaborative review of current document with A. Bartos and recommend changes (if any) to PCC for approval at 2015 meeting.

Action: M. Stastny / A. Bartos – provide amended ICRN#22 to PCC chairman by September 30, 2014

Action: P. McCann to recommend extension of ICRN#22 for one year to EC.

ICRN#25 on Impurities: Document complete, approved by Editorial Committee and circulated to NC's for comments. None have been received. Take to EC for approval.

Action: P. McCann to submit ICRN#25 to EC for approval.

ICRN#26 on AI in Steam/Water Cycle: Expiring in September 2014. B. Dooley, M. Rziha, G. Joy and F. Leidich still see ICRN as relevant. Recommend extension to EC to for 5-year period.

Action: P. McCann to request 5-year extension of ICRN#26 to EC.

Future ICRNs

P. McCann reviewed list of potential future PCC activities from the Greenwich meeting. The items selected for further PCC work include:

Film Forming Amines – discussion on the need to examine current literature and prepare a position paper. B. Dooley suggested W. Hater as lead for task group who will examine the relevant issues (effect on polishers, conductivity etc.).

Task group includes: W. Hater (lead), T. Petrova, W. Cook, M. Lendi

Action: task group to prepare white paper on film forming amines for next meeting – provide by April 30, 2015.

Corrosion Product Sampling for Cycling Plants – D. Addison suggested to wait and let comments percolate from current TGD to provide direction for what's needed for cycling plants and potentially include as a revision to current TGD. Suggested that task group struck in Greenwich identify the primary needs/requirements for cycling plants (sampling point locations, instrumentation etc.) and prepare “white paper” for release at next year's meeting.

Task group includes: D. Addison, P. McCann, W. Cook

Action: Task group to prepare white paper on CP sampling in cycling plants for next meeting – provide by April 30, 2015.

Geothermal Power Cycle Chemistry – D. Addison indicated every geothermal reservoir is different in its chemical makeup, likely not possible to provide TGD encompassing all plants. Likely several areas for ICRNs in the future.

Demineralized Make-up Water – discussion around TGD for supply of DM water for plant systems (see below).

Organics Effects and Removal – discussion around need for guidance in the industry, perhaps separate organics removal from their effects in plant systems.

Condensate Polishing for Plants with ACCs – potential white paper on water purification options in units with ACCs where the condensate temperature is greater than 60°C.

Other issues discussed as were suggested from open meeting in Greenwich included outage inspection guidelines for chemists, QA/QC, HRSG sample tubes, plant preservation, training, technical knowledge transfer. No immediate actions from the PCC WG were recommended on these items at this time.

4.4 Activities of Standard Organizations (e.g. VGB, EN 12952, IEC)

P. McCann asked the PCC WG members if there were any updates regarding work ongoing from standards organisations. W. Hater indicated VGB is in process of developing revised standards for plant conservation.

4.5 Technical Guidance Documents

B. Dooley presented background to TGD and how they are equivalent to IAPWS Releases for the TPS WG and are being recognized as the standard documents internationally. Discussion on the status of current TGDs, do they need revision? F. Gabrielli feels TGD on Carryover is fine for the moment. D. Addison mentioned several references that need to be amended in TGD for CP sampling. Discussion on other additions to CP Sampling TGD including modifications for cycling plants (see ICRN section above), adding Aluminium to CP monitoring, HRSG HP evaporator sampling. B. Dooley circulated a document from J. Cooper of some of the changes incorporated into the sampling TGD. Other potential TGDs discussed include Demin. Water quality, Open Gas Turbine water usage, Nuclear Plant Chemistry and Amines.

Action: P. McCann to mention at EC meeting the minor changes to references in TGD on CP Sampling

Demineralized Make-up Water – B. Dooley gave presentation from G. Joy about the need for a TGD on DMW purity monitoring. Proposed TGD on sampling requirements and locations that would overlap and re-iterate key concepts from other TGDs. This TGD would not include details on the normal operation and/or maintenance of water treatment plants. J. Bellows and Kirk Buecher felt document would be useful. P. McCann was concerned about the scope and utility of the proposed document. Task group struck to begin building the document.

Task Group: G. Joy (lead), P. McCann, K. Buecher, J. Bellows, H. Hirano

Action: Task group to prepare TGD for approval at next meeting – provide by March 31, 2015.

HRSG HP Evaporator sampling – Discussion identified emerging issues in HRSGs around deposition in HP evaporator tubes. Much work has already been published and could be readily turned into a TGD. PCC WG viewed this as important issue and suggested striking a task group to begin development.

Task Group: B. Dooley, P. McCann, D. Addison, T. Petrova, F. Gabrielli.

Action: Task group to prepare TGD for approval at next meeting – provide by March 31, 2015.

4.6 Discussion of Future PCC Activities and Task Groups

The PCC workshop on the morning of Tuesday 24th June 2014 included presentations on:

- Water Use in Gas Turbines – D. Addison
Discussion centred around the possibility of issuing an IAPWS TGD for water purity required for different applications in the gas turbine operation. F. Gabrielli cautioned about specifying requirements for turbines supplied by OEMs. B. Dooley commented that agreement from OEMs on water specs is not the mandate of IAPWS, also commented that our current knowledge on the topic needs more time to develop to the same level as current TGDs. Proposed drafting a white paper to poll current OEM specs and investigate potential areas for recommendations. Task group formed. Could be included in section of potential TGD on water demineralization (discussed above).

Task group: D. Addison (lead), B. Dooley, B. Svoboda, H. Kido (or rep from Japan)

- Sampling/Analytical Considerations for the Next Generation of Combined Cycle Plants – F. Gabrielli
Outlined key areas for IAPWS to contribute to cycling plants including recommending sampling locations next to drum, sensors in strategic locations (hot well) and chemistry control during layups and start-ups. B. Dooley commented that shut down chemistry is of prime importance to ensure conditions during quick start up. F. Gabrielli commented that continuous ammonia dosing during start ups would be beneficial to counteract carbonate pH depression from CO₂ ingress during shut down.

Discussion ensued about the preparation of an Advisory Note or a paper for PPChem. It was then suggested that several TGDs be amended to include guidance for cycling plants including the Instrumentation, AVT and Phosphate TGDs. Task group formed.

Task group: F. Gabrielli / B. Dooley, M. Hellman, H. Hirano, T. Petrova, K. Buecher

Action: Task group to draft amendments to these TGDs for PCC review and approval at 2015 meeting – provide drafts to PCC chair by September 30, 2014.

Action: Task group to draft paper for PPChem describing amendments to TGDs for cycling plants – provide to PPC chair by January 31, 2015.

The joint PCC/PCAS workshop in the afternoon of Tuesday 24th June 2014 included presentations on:

- Water Treatment in Swedish Power Plants – A. Fredrikson
- Film Forming Amines – W. Hater
The current state of R&D for FFAs was presented. Discussion on the need for reducing agents while using FFAs as well as the effect/benefit of FFAs on the corrosion of aluminium and copper alloys. PCAS members invited on to PCC task group developing white paper on FFAs.
- Research Needs for Amines – J. Bellows
The importance of sound and accessible database for the chemical properties of alkalizing amines used in power plants was presented. J. Bellows proposed PCAS issues “Guidelines” for the properties of amines for open distribution. Properties should include volatility, dissociation constants, complex stability and equivalent conductance all up to near critical temperature. W. Cook suggested interaction with the EPRI MultiEQ development team, perhaps P. Tremaine. A task group was formed.

Task group: A. Anderko, J. Bellows

Action: Task group to identify necessary ICRN(s) (if any) and prepare them for submission and approval at next year’s meeting. Goal to have Guideline documents for release in 2015.

- Overview to Geothermal Power Production – D. Addison
Introduction to the forms and challenges of geothermal production in the world. Scaling in the reinjection wells is one of the primary issues and may require literature search and/or more

experimental data to predict and mitigate. Suggested white paper be drafted examining geothermal issues and how IAPWS interaction and guidance could be of benefit.

Task group: D. Addison, A. Anderko, T. Petrova, M. Nakahara, M. Hellman

Action: Task group to solicit participation and input from experts in their respective countries and draft white paper for circulation to PCC.

The PCC workshop on the morning of Thursday 26th June 2014 included the following presentations:

- Reviewing the Status of the Revision of JIS B 8223 " Water Conditioning for Boiler Feed Water and Boiler Water – H. Hirano
B. Dooley pleased to see JIS is nearly identical to IAPWS TGDs. Commented to H. Hirano that Na spec. in steam is still too high, perhaps JIS would like to review.
- Advanced management of pipe wall thinning due to flow-accelerated corrosion – S. Uchida
- Turbidity measurement as trend monitor for particulate corrosion products – M. Lendi
Discussion around the utility of a continuous iron monitor, caution that turbidity is commonly misunderstood and misinterpreted when used in power plant systems. B. Dooley suggested that IAPWS may be able to support an International Collaboration examining turbidity measurements with different iron or copper oxides.
- Determining water chemistry conditions in nuclear reactor coolants – S. Uchida
Discussion around how IAPWS can contribute to chemistry control in nuclear power stations. Likely not feasible to issue TGD as each country and utility follows specific guidelines already (EPRI, EDF etc). Perhaps IAPWS could issue state-of-the-art summary or paper providing value to the nuclear industry. Task group to interface with key people involved with guidelines and report back to PCC at next meeting.

Task group: S. Uchida, D. Lister, W. Cook

- Development of a sensor for in-situ measurement of hydrogen peroxide in irradiation field by using Frequency dependent complex impedance analysis – S. Hanawa
- Development of Water Quality Simulator for Thermal Power Plants – H. Kido

4.7 PCC Public Relations

It is desirable to have IAPWS documents, including the PCC TGDs, be the first hit when people perform web searches on issues related to power cycle chemistry. Discussed again including brief summary of TGD directly on webpage to increase probably and ease of hits from search engines. It was suggested that outside professional help should be solicited to aid in promotion and visibility of IAPWS PCC and the TGDs.

Action: P. McCann to contact authors for the TGD for a brief summary to be included on the website. He will provide to A. Harvey to upload.

Action: P. McCann to write a summary of PCC WG meeting for Power Plant Chemistry. B. Dooley and W. Cook agreed to review.

Other Action List Items

No other items were presented requiring action by PCC WG members.

5. Priority List Review

Discussion proceeded surrounding the utility of maintaining a priority list. Suggestion to amalgamate Priority List with potential/current ICRNs and TGDs listed above.

Action: P. McCann to amalgamate Priority list with ICRN/TGD ideas.

6. Other Business

No other business added.

Thursday afternoon 26th June 2014 – PCC WG business

1. J. Bellows wanted PCC reviewers for ICRN/TGD drafts. The following people were proposed:

from PCC: D. Moed, W. Hater, H. Hirano

from PCAS: P. Tremaine & D. Guzonas

2. New Members and Election of PCC Officers

The following new members were proposed for the PCC WG:

Olga Yegoshina (MPEI, TWT Dept.) nominated: T. Petrova seconded: P. McCann

Philipp Dyachenko (Aminotek) nominated: T. Petrova seconded: P. McCann

Aref Saeidipour (Seimens) nominated: P. McCann seconded: F. Gabrielli

Satoshi Hanawa (JAEA) nominated: P. McCann seconded: S. Uchida

PCC unanimously accepted these new members.

Due to unforeseen circumstances, neither the PCC chair (M. Rziha) nor the two vice chairs (Karsten Thomsen and Marc DeWispelaere) were able to attend the WG meeting this year. P. McCann accepted to act as chair and was thanked for his efforts. It was noted that vice-chair M.

DeWispelaere has not been at a WG meeting in several years so it was proposed that he be replaced in this capacity by P. McCann, who accepted the nomination. The PCC was polled and P. McCann's appointment as vice-chair of PCC WG was unanimously accepted.

Action: P. McCann to advise EC of new PCC members and officers.

3. Technical Guidance Document and IAPWS cover pages

Suggested removing paragraph of text from IAPWS document cover pages and including this on the second page of the document so every IAPWS cover page looks essentially identical. PCC WG polled and agreed that this is a good approach.

Action: P. McCann to advise EC of PCC's recommendation.

4. Interface with BIPM

P. McCann explained the interfaces between TPS, particularly the subcommittee on seawater, and the BIPM. PCC members were asked to review the work and website of BIPM and advise at the meeting of potential interactions, if any.

5. Meeting Presentations

P. McCann indicated that the OPAL webspace would be used to circulate PCC presentations and login credentials would be provided via email following the meeting. P. McCann will investigate options for using OPAL or similar web-based system for use by PCC task groups' working documents.

Action: P. McCann

6. 2015 Meeting – Stockholm, Sweden

M. Hellman introduced the location of next year's EC and WG meetings from 28th June – 3rd July 2015.

7. 2016 Meeting – Dresden, Germany

P. McCann inquired if anyone knew of any conflicting conferences with the proposed dates for the 2016 meeting in Dresden, 11-16th September 2016. There were none at this time.

8. PCC WG Report for EC

P. McCann asked B. Dooley and W. Cook to review PCC WG report to EC following meeting.

9. Miscellaneous and Adjournment

P. McCann asked for any further items of discussion, there were none. P. McCann thanked MPEI and the Russian NC for organising an excellent meeting in Moscow and called the meeting closed.

Adjournment 14:00 hours.

PRESS RELEASE

INTERNATIONAL ASSOCIATION FOR THE PROPERTIES OF WATER AND STEAM

2014 ANNUAL MEETING, MOSCOW, RUSSIA

Continuing a series of conferences that started in 1929 in London, over 60 scientists and engineers from 12 different countries attended the annual meeting of the International Association for the Properties of Water and Steam (IAPWS) which was held on 22 - 27 June 2014 in Moscow, Russia. The meeting was hosted by the Russian National Committee of IAPWS at the Moscow Power Engineering Institute (MPEI). The highlights of the IAPWS working group sessions and other proceedings are summarized in this release.



The main purpose of the IAPWS meetings is to connect researchers with the engineers who use their information, providing the researchers with guidance on useful problems and the engineers with the latest research results. Areas of application include power cycle chemistry, high temperature aqueous technologies applicable to steam cycles and fuel cells, the use of high temperature water and supercritical steam in chemical and metallurgical processes, supercritical synthesis of new materials and destruction of toxic wastes, hydrothermal geochemistry, hydrometallurgy, oceanography, power cycles with carbon dioxide capture and the storage of carbon dioxide in aqueous environments.

IAPWS also produces guidelines and technical guidance documents, notably on power plant chemistry and also documents certified research needs that represent the considered opinion of experts in the field that research on a particular subject is needed. This information can be found on the IAPWS website at www.iapws.org.

The working group on Thermophysical Properties of Water and Steam (TPWS) continues to pursue a better knowledge of properties for scientific and industrial application. TPWS has made significant progress toward several new formulations that are expected to be finalized in the next year or two. These include an equation of state for the thermodynamic properties of heavy water to replace the existing standard that is now over 30 years old, work using new scientific insights to accurately describe the properties of supercooled liquid water and, additionally, an improved representation of the surface tension of water that takes advantage of new low temperature measurements performed in the Czech Republic. The latter two items will be especially important for atmospheric science, which is becoming an important constituency for IAPWS work.

The Industrial Requirements and Solutions (IRS) working group focused on the preparation of an IAPWS Guideline dealing with functions for the properties of water and steam applying spline interpolation methods. These functions will have a substantially higher calculation speed and

will be very beneficial for applications that require significant computing time, such as Computational Fluid Dynamics and extensive power cycle heat balance simulations.

The Sub-Committee on Seawater (SCSW) evaluated progress in the recently initiated collaboration between IAPWS and the International Bureau of Weights and Measures (BIPM) to develop standards relevant to environmental science and industry (<http://www.teos-10.org/JCS.htm>). The aim of current SCSW activities is to promote SI (international system of units) traceable definitions for ocean salinity and acidity (pH value) as well as for relative humidity (RH) in the atmosphere based on the Thermodynamic Equation of Seawater 2010 (TEOS-10). Based on the roadmaps that were developed with BIPM representatives during the 2013 IAPWS meeting in London and on the outcomes of several subsequent meetings held between BIPM and IAPWS in April and May 2014, the SCSW has continued to support work being undertaken by the BIPM Consultative Committee for Thermometry Working Group 'Relative Humidity' on the TEOS-10 compatible calculation of fugacity and relative fugacity of water vapour in humid air. The salinity and pH issues deserve further discussion between the SCSW and the BIPM Consultative Committee for Amount of Substances – Metrology in Chemistry (CCQM). A common IAPWS/BIPM position paper on salinity, pH and Relative Humidity definition is in preparation. The SCSW committee has also revised an IAPWS Certified Research Need on the thermophysical properties of seawater with the aim of promoting more research on extreme seawater conditions in hydrothermal vents in the deep ocean and on requirements for desalination and power plant cooling water systems.

In the proceedings of the Power Cycle Chemistry (PCC) working group, the need for improved industry guidance on chemical sampling and monitoring in cycling power plants was identified. This will be addressed by amendments to the existing suite of IAPWS Technical Guidance Documents (TGDs) on power plant chemistry. The Working Group also intends to develop TGDs on Heat Recovery Steam Generator boiler tube sampling for internal oxide condition assessment and on maintaining the integrity and reliability of boiler demineralized water treatment plant in response to industry recognized needs. A Task Group on Geothermal Power Plant Chemistry has also been established with the aim of promoting work towards improving the fundamental knowledge of potential causes of scaling and corrosion in these types of power plants.

In collaboration with the Power Cycle Chemistry working group, the Physical Chemistry of Aqueous Solutions (PCAS) working group has formed a task group to review and recommend standardized formulations of the liquid/vapor distribution and of acid/base dissociation constants of amines and their acid decomposition products, also in response to current gaps in industry knowledge. Interested parties are invited to participate by contacting the chair at james.bellows@siemens.com. PCAS is also continuing work on a Guideline on the Thermal Conductivity of Seawater.

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

During the meeting, a symposium was held on, “Water and Steam: Industrial and Scientific Application”. This included presentations on the the proprties of amporhous ice and formation of gas hydrates, the thermal conductivity of supercooled water and the properties of gas hydrates in systems based on water and carbon dioxide. The symposium included the IAPWS Helmholtz Award lecture “Self-Diffusion in Supercritical Water: NMR and MD studies on Dynamics of Hydrogen Bonds”, given by Dr. Ken Yoshida of the University of Tokushima, Japan. The IAPWS Helmholtz award is given annually to a developing or early career scientist or engineer who is working in a field of interest to IAPWS. It includes an opportunity to attend the IAPWS meeting to present the Helmholtz Award lecture.

The IAPWS Honorary Fellow award is conferred in recognition of many years of contribution to the Association. At the 2014 meeting, the recipient of the IAPWS Honorary Fellow award was Professor Tamara Petrova from the Moscow Power Engineering Institute in recognition of her outstanding contribution to the development of the understanding of power plant chemistry.

IAPWS welcomes scientists and engineers with interest in the thermophysical properties of water, steam, and aqueous systems and in the application of such information to industrial uses. The next IAPWS meeting will be in Stockholm, Sweden on 28 June - 3 July 2015. Further information on meetings can be found at the IAPWS website (www.iapws.org) as it becomes available.

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



Participants of the IAPWS 2014 annual meeting, which was held at the Moscow Power Engineering Institute, Russia.



Dr. Ken Yoshida from the University of Tokushima, Japan, presents the IAPWS Helmholtz Award lecture.



Professor Tamara Petrova from the Moscow Power Engineering Institute was the recipient of the 2014 IAPWS Honorary Fellow Award.

BIAPWS ANNUAL REPORT 2014

1 INTRODUCTION

The British and Irish Association for the Properties of Water and Steam (BIAPWS) is the UK and Ireland national committee of the International Association for the Properties of Water and Steam (IAPWS) and the representative body for Power Plant Chemistry in the UK and Ireland. BIAPWS is a not for profit organisation. This is the annual report of the activities of BIAPWS for the period from September 2013 to August 2014.

2013/14 has been another productive year for BIAPWS. Membership remains strong and BIAPWS meetings and our annual power plant chemistry symposium have been well supported. A major activity for BIAPWS was the successful co-hosting with the Institution of Mechanical Engineers (IMEchE) of the 16th International Conference on the Properties of Water and Steam (ICPWS16) at the University of Greenwich, 1-5 September 2013.

With our annual reports, IAPWS requests that National Committees provide a listing of relevant technical publications that have originated from the respective nations during the year in order to assist the dissemination of the international body of work being done on topics of interest to IAPWS and to IAPWS members. The list of publications for the UK and Ireland for the 2013/14 period is provided in the Appendix to this report.

If you would like to know more about BIAPWS, please feel free to contact one of the BIAPWS Officers listed above, visit our web site www.biapws.org or e-mail contact.us@biapws.co.uk.

2 BIAPWS MEMBERSHIP

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

3 BIAPWS ELECTION OF OFFICERS

Elections for BIAPWS officers were held in January 2014. The existing officers were re-elected, these being:

Chair:	P. McCann, E.ON Technologies (Ratcliffe) Limited
Vice-Chair:	G. Aspinall, AMEC
Secretary:	Dr M. Robson, RWE npower
Treasurer:	E.G. Huff

E. Huff (Treasurer) is planning to retire from this position at the end of the year. Therefore, H Lloyd is shadowing him during the year with a view to taking over the treasurer's position in 2015.

4 BIAPWS MEETINGS

BIAPWS committee meetings are held three times a year and attendance at these continues to be good, with typically around twenty people present. BIAPWS committee meetings are preceded by a technical session with presentations on areas of interest to BIAPWS members, which always generate a high level

of interest. Technical sessions during the 2013/14 meetings included presentations on chemical monitoring instrumentation, condensate polishing ion exchange resin kinetics, steam purity during HRSG start-ups and Legionella risk management. Industrial member's representatives are able to bring a colleague to the meetings to benefit from and contribute to the discussions.

5 BIAPWS POWER PLANT CHEMISTRY SYMPOSIUM

Each year, BIAPWS organises an annual symposia on power plant chemistry and water treatment. The 15th in this series of symposia was held at the Village Hotel, Nottingham, on 2 - 3 April 2014. This marked the return of the event after an absence in 2013 due to BIAPWS involvement in co-hosting ICPWS16.

The BIAPWS 2014 symposium consisted of introductory sessions on the fundamentals of Plant Preservation and Closed Circuit Cooling Water Chemistry, which were targeted at developing chemists and new entrants to the industry. This was followed by more detailed technical presentations on 'Power Plant Chemistry and Corrosion' and 'Environmental and Water Treatment Issues', which included a case study of poor steam quality as a result of boiler water carryover at a new plant, the application of film forming amines and the environmental consenting of a new build nuclear power plant in the UK.

Through contacts made via IAPWS, the opportunity was taken to invite guest speakers from across Europe to provide additional perspectives on power plant chemistry experiences and developments. Guest speakers were K. Thomsen (COWI A/S), D. Moed (TU Delft) and W. Hater (ICL Water Solutions).

The event was very well attended, with close to one hundred delegates. This demonstrated both the continued interest in developments in cycle chemistry and water treatment and the networking opportunities offered by the event. A summary of the proceedings of the symposium will be published in the Power Plant Chemistry journal.

6 IAPWS ACTIVITIES

BIAPWS has continued to support IAPWS through its formal membership and participation in IAPWS activities. A number of BIAPWS committee members are represented on IAPWS working groups, in particular Power Cycle Chemistry (PCC). At the 2014 IAPWS annual meeting in Moscow, Russia, BIAPWS will be represented by P. McCann and J. Cooper. In addition, BIAPWS is represented on the executive committee of IAPWS.

7 16TH INTERNATIONAL CONFERENCE ON THE PROPERTIES OF WATER AND STEAM

On 1 - 5 September 2013, the 16th International Conference on the Properties of Water and Steam (ICPWS16) was organised and hosted by BIAPWS and the Institution of Mechanical Engineers on behalf of IAPWS at the University of Greenwich. Around 230 delegates from 28 different countries attended what proved to be a very successful event. It had been over fifty years since the IAPWS conference was last held in the UK, so it was a welcome return to London, where the very first such conference was held in 1929. A press release on the Greenwich conference can be found on the IAPWS website at www.iapws.org.

The organisation of ICPWS16 represented a major undertaking for BIAPWS and we would like to gratefully acknowledge the ICPWS sub-group, comprising E. Huff, J. Cooper, H. Lloyd, P. Calver and P. McCann, and the IMechE, S. Love, H. Atkins and A. Duggal, for their considerable work, time and effort to make this important event for IAPWS a success. The input of A. Rudge and R. Harries in the organisation of the conference is also gratefully acknowledged.

8 BIAPWS AWARDS

BIAPWS offers selected sponsorship opportunities for student placements and schools events that aim to raise the awareness and generate new interest amongst students in the areas of science and technology relevant to the properties of water and steam, including power plant chemistry. This initiative has in the past proven highly successful, with many previous winners of the BIAPWS Student Award going on to full time employment in power generation. However, as student placements in most industrial companies are now arranged by in-house schemes, a BIAPWS sub group is currently reviewing the type and feasibility of student awards that BIAPWS could most beneficially offer in the future.

To encourage student awareness of BAPWS and IAPWS activities, four awards were presented by BIAPWS for the best student papers at ICPWS16 in memory of Dr Geoff Bignold. These were:

- Joachim Reimer, of the Paul Scherrer Institute, Switzerland, for his paper entitled “Biomass Related Salt Solutions at Hydrothermal Conditions: Investigations with Isochoric Differential Scanning Calorimetry.”
- David Moed, of TU Delft, Netherlands, for his paper entitled “Degradation kinetics of six alkalizing amines.”
- Masaki Hiratsuka, of Keio University, Japan, for his paper entitled “Ab initio calculations of vibrational spectra and guest-host interaction in clathrate hydrates.”
- Isabelle Bergonzi, of Universite d’Orleans, France, for her paper entitled “Thermodynamic properties of interfacial water from its infrared signatures.”

BIAPWS is also looking to support this year’s Royal Society of Chemistry (RSC) Energy Sector Nuclear symposium in Manchester by subsidising up to five student awards. One of our BIAPWS members, J. Greene, is part of the organising committee for the event.

For schools events, BIAPWS has continued to sponsor and judge prizes for energy related projects at a science fair in Hinckley, Leicestershire.

9 BIAPWS WEBSITE

The BIAPWS website is currently being re-designed. The public facing pages of the new site have been completed, with the members area currently being developed.

In developing the new website, the main aims were to promote a better understanding of what the aims of BIAPWS and IAPWS are and what our activities include and, importantly, to be a key point of reference for information on events and technical information of relevance to our members.

BIAPWS wishes to gratefully acknowledge the contribution of K McGrath in managing and maintaining our previous website for many years.

10 BSI REPRESENTATION

BIAPWS is currently represented on three British Standards and Euro Norm Committees of relevance to power plant chemistry and water treatment:

- PVE/2: Water Tube and Shell Boilers. The UK standards committee has responsibility for BS EN 12952-12:2003: “Water-tube Boilers and Auxiliary Installations - Requirements for Boiler Feedwater and Boiler Water Quality” and BS EN 12953-10:2003: “Shell Boilers - Requirements for Feedwater and Boiler Water Quality”. Whilst the European body responsible for these standards has agreed to their revision, there have not been any significant developments.
- CII/62: Treatment of water for boilers. The UK standards committee also has responsibility for BS 2486:1997: “Recommendations for Treatment of Water for Steam Boilers and Water Heaters”. Currently, this committee is not active.
- EH/3/6: Water quality - sampling. The UK standards committee is responsible for BS 6068-6.7:1994 (ISO 5667-7:1993): “Guidance on Sampling of Water and Steam in Boiler Plants”. The standard is due for revision, but even in its current state, it remains a technically sound and useful document.

11 INTERACTION WITH PROFESSIONAL ORGANISATIONS

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

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

BIAPWS also organised the 16th International Conference on the Properties of Water and Steam with the Power Industries Division of the IMechE on behalf of IAPWS.

Paul McCann
Chair, British & Irish Association for the Properties of Water and Steam
June 2014

APPENDIX: List of UK and Ireland Originated Reference Papers in areas of interest to IAPWS, published between September 2013 and June 2014

Spellissy, F., Hickey, W., Griffin, F. and Stack, E., (2014), “Analysing the Influence of Anions on After Cation Conductivity of HRSG Steam Samples during Start-Up Using Ion Chromatography”, *PowerPlant Chemistry* 2014, 16(1)



IAPWS Canadian National Committee

Annual Report 2014

Submitted to IAPWS EC, Moscow, Russia, June 27, 2014

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

1. Canadian National Committee: Dues for the Canadian National Committee (CNC) of IAPWS are supported by the National Research Council of Canada. This arrangement requires support and participation by a national organization representing industry. In 2004 the CANDU Owners Group took on this role on a trial basis, and in 2007 the CANDU Owners Group accepted this role for a five-year term, including travel support for the academic members of the CNC. In December 2012, COG agreed to another five-year term as the CNC's industrial sponsor (2013-2017).

Dr. Dave Guzonas has been the IAPWS vice-president since 2013. He will transition to IAPWS president for 2015-2016.

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

A major university-based program to study water chemistry in support of the development of the Canadian Supercritical Water-cooled Reactor concept (NSERC/NRCan/AECL Generation IV Energy Technologies Program) is currently in Phase II and includes seven water chemistry projects that cover two main themes: a) corrosion product transport and deposition, and b) water radiolysis. The goal is to develop chemistry control strategies for the SCWR as well as recommend realistic chemistry conditions for corrosion testing for materials selection. The program also funds eight projects examining materials degradation phenomena (e.g., corrosion, stress corrosion cracking, creep, ageing) at temperatures up to 850 °C. The yearly workshop for the program members will be held in Vancouver in August 2014 in conjunction with the Pacific Basin Nuclear Conference.

Research on high-temperature water chemistry being funded by this program includes:

P. Tremaine (U. of Guelph): Aqueous chemistry of metals and fission product under SCWR conditions.

C. Pye (St. Mary's University): Ab initio calculations on ionic hydration and complexation.

W. Cook (U. of New Brunswick): Corrosion product transport and deposition under SCWR conditions.

I. Svishech (Trent University): Water chemistry, pH control and particle formation process in an SCWR.

A. Anderson (St. Francis Xavier University): Time-resolved investigations of metal oxide-water systems under conditions of extreme temperature, pressure and radiation.

P. Percival (Simon Fraser University), K. Ghandi (Mount Allison University): Reaction kinetics in SCW probed using muonium.

J.-P. Jay-Gerin (U. of Sherbrooke): Computational modelling of water radiolysis in high temperature water (including SCW).

C. Wren (U. of Western Ontario): Water radiolysis effects on materials degradation in high temperature water (including SCW).

The chemistry program is co-ordinated by D. Guzonas (AECL).

3. Activities at the University of New Brunswick

D. Lister

Heat exchanger fouling; examining the effects of surfactants on magnetite deposition during boiling heat transfer (collaboration with AECL). Preliminary studies developed an accurate way of measuring local deposit thicknesses ex-situ and measured the effects of surfactants and film-forming amines on deposition.

Flow-accelerated corrosion (FAC); predicting the characteristics of scallops (the sculpting of surfaces undergoing FAC). Correlating the pattern of FAC recorded in many laboratory experiments and field measurements at different conditions of flow, pH, etc. lead to greater understanding of the FAC phenomenon in general.

Modelling reactor primary circuit contamination. Inserting FAC mechanisms and in-core effects into models for material transport lead to predictions of radiation fields.

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

Characterising the effects of film-forming amines on FAC in two-phase flow. Scoping studies in single-phase flow are complete and similar experiments under two-phase flow at 200°C are almost complete.

Developing a robust probe for measuring FAC in-situ in operating plant. A probe has been designed and an agreement negotiated with a power utility to install it in a coal-fired station.

Verifying the effects of dissolved iron on FAC. Experiments injecting iron into a coolant stream by promoting FAC upstream of an in-situ FAC probe are almost complete. The measured effects are being modelled for incorporation into a commercial code.

W. Cook

W. Cook has been asked by the University of New Brunswick to become the Director of the Centre for Nuclear Energy Research (CNER), a research institute on UNB's campus. CNER has over two-decades of research / collaboration with the nuclear industry and has developed and patented online sensors for monitoring corrosion of plant piping in-situ. Efforts will be undertaken to facilitate more field trials to show the utility of the sensors for nuclear power plants. Additional research programs in power cycle chemistry and corrosion will be launched from the CNER Institute over the next year.

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

Hydrogen control in CANDU cooling systems is a new project being undertaken in conjunction with industrial collaborators. Current CANDUs have conducted successful trials injecting hydrazine into the shield cooling system, which acts to suppress the water radiolysis reactions to keep the coolant in a reducing condition. Alternate chemical additives are being examined to duplicate the effect, eliminating the need for hydrazine use in this system.

Electrowinning of metals from solutions is an additional industrial project of note. Modelling and experimental work was undertaken on zinc, indium and manganese production. A series of electrowinning tests for manganese production, using ion-exchange membranes as the compartment separator, was undertaken to validate and improve upon process efficiency. Optimization of the winning process and associated modelling of the system involves use of the PCAS thermodynamic models.

4. Activities at the University of Guelph (Prof. Peter Tremaine)

Research Themes

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

Current and Recent Funders

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

Specific Projects

Solvation and Equilibria of Ions and Organic Solutes in Water up to Near-Critical Conditions

Origins of Life: Pre-Biotic Chemistry under Deep Ocean Hydrothermal Vent Conditions

CANDU Nuclear Reactor Chemistry: D₂O Isotope Effects on Acid-base Ionization and Metal Hydrolysis (UNENE/NSREC CRD Grant)

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

Carbon Capture and Sequestration by Novel Phase-Separating Solvents (NSERC International Strategic Grant with University Blaise Pascal, France)

5. Activities Planned to next ICPWS (2017/18)

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

The possibility of organizing an “IAPWS” session at a national conference such as those organized by the Chemical Institute of Canada or by the processed water industry surrounding the Alberta oil sands development was discussed. The goal would be to raise the profile of the Canadian National Committee and IAPWS activities with researchers in Canada doing complementary research.

Each of the CNC members and IAPWS-involved researchers in Canada are involved in industry-sponsored research with organizations such as EPRI and the CANDU Owners Group pertinent to topics of interest to IAPWS.

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

6. Select List of Publications

1. D.A. Guzonas, R. Novotny, “Supercritical Water-cooled Reactor Materials – Summary of Research and Open Issues”, *Progress in Nuclear Energy* (2014), <http://dx.doi.org/10.1016/j.pnucene.2014.02.008>.
2. L. M. Alrehaily, J. M. Joseph, A. Y. Musa, D. Guzonas, J. C. Wren, “Gamma-radiation Induced Formation of Chromium Oxide Nanoparticles from Dissolved Dichromate”, *Phys. Chem. Chem. Phys.*, **15** (2013) 98.
3. X. Huang, D. Guzonas “Characterization of Ni–20Cr–5Al Model Alloy in Supercritical Water”, *Journal of Nuclear Materials* 445 (2014) 298–307.
4. F. Barrett, X. Huang, D. Guzonas, “Characterization of TiO₂ Doped Yttria Stabilized Zirconia (YSZ) for Supercritical Water-Cooled Reactor Insulator Application”, *Journal of Thermal Spray, Journal of Thermal Spray Technology*, 22 (2013) 734-743.
5. Z. Dong, W. Chen, W. Zheng, D. Guzonas, “Effect of Yttria Addition on the Stability of Porous Chromium Oxide Ceramics in Supercritical Water”, *Journal of Nuclear Materials* 432 (2013) 466–474.
6. I. M. Svishchev, R.A.Carvajal-Ortiz, K.I.Choudhry, D.A.Guzonas “Corrosion Behavior of Stainless Steel 316 in Sub- and Supercritical Aqueous Environments: Effect of LiOH Additions”, *Corrosion Science* 72 (2013) 20–25.
7. D. Guzonas “Extreme Water Chemistry – How GEN IV Water Chemistry Research Improves GEN III Water-cooled Reactors, 19th Pacific Basin Nuclear Conference (PBNC 2014), Vancouver, Canada, 2014 August 24-28.

8. S. Sanguanmith, J. Meesungnoen, D.A. Guzonas C.R. Stuart and J.-P. Jay-Gerin “Low-LET Radiation Chemistry of Supercritical Water at 400 °C: A Re-analysis of the Water Density Dependence of the Spur Lifetime and the “Escape” e-aq Yield”, *Recent Res. Devel. Physical Chem.* 11 (2013) 1-14.
9. D.Guzonas “The Physical Chemistry of Corrosion in a Supercritical Water-cooled Reactor”, *Proceedings of the 16th Int. Conf on the Properties of Water and Steam*, 1-5 September 2013, University of Greenwich, London, UK.
10. L. Qiu, D.A. Guzonas, J. Qian “Dissolution of Silicon Nitride in High Temperature Alkaline Solutions”, *Proceedings of the 16th Int. Conf on the Properties of Water and Steam*, 1-5 September 2013, University of Greenwich, London, UK.
11. L.M.S.G.A. Applegarth, C.R. Corbeil, D.J.W. Mercer, C.C. Pye and P. R. Tremaine, A Raman and Ab Initio Investigation of Aqueous Cu(I) Chloride Complexes from 25 to 80°C. *J. Phys. Chem. B* 118, 204-214 (2014).
12. L. Applegarth and P. Tremaine, Boiling Points and Speciation of Aqueous Electrolyte Solutions Under “Hideout” Conditions in Supercritical Water-cooled Reactor Coolant by Raman Spectroscopy, *Proc. 19th Pacific Basin Nuclear Conf.* (Vancouver, Aug. 24-28, 2014) (Submitted).
13. C. Pye, Liwei Cheng, and P.R. Tremaine, Metal Speciation under Supercritical Water-Cooled Reactor Coolant Conditions by Ab Initio Calculations, Spectroscopy and Conductivity Measurements, *Proc. 19th Pacific Basin Nuclear Conf.* (Vancouver, Aug. 24-28, 2014) (Submitted).
14. Non-Complexing Anions for Physico-Chemical Studies by Raman Spectroscopy under Hydrothermal Conditions L.M.S.G.A. Applegarth, C. Alcorn, K. Bissonnette, J. Noel and P.R. Tremaine, *Proc. 16th Int. Conf. Properties of Water and Steam (IAPWS & Inst. Mech. Eng.; Greenwich, U.K., Sept. 1 - 5, 2013)*
15. Ion Pair Formation Constants and Transport Properties for Aqueous Strontium Complexes up to 350°C at 20 MPa by Flow AC Conductance, H. Arcis, G.H. Zimmerman‡ and P.R. Tremaine†,**Proc. 16th Int. Conf. Properties of Water and Steam (IAPWS & Inst. Mech. Eng.; Greenwich, U.K., Sept. 1 - 5, 2013).*
16. Uchida, S., Naitoh, M., Okada, H., Suzuki, H., Koshizuka, H. and Lister, D.H. (2013). “Contribution of Probabilistic Risk Evaluation of Flow-Accelerated Corrosion to System Safety Analysis of Aging NPPs”. *Proc.16th Intern. Conf. Props. Water and Steam*, Greenwich, London, UK. Sept. 1st-6th.
17. Addison, D., Lister, D. and Thomsen, K. (2013). “Monitoring and Analysing Total Iron and Copper in Fossil and Combined Cycle Plants – Technical Guidance Document”. *Proc.16th Intern. Conf. Props. Water and Steam*, Greenwich, London, UK. Sept. 1st-6th.

18. Srisukvatananan, P., Lertsurasakda, C., Lister, D. and Mathews, J. (2013). "Sampling Amines from Flowing Steam-Water Mixtures". Proc.16th Intern. Conf. Props. Water and Steam, Greenwich, London, UK. Sept. 1st-6th.
19. Lister, D., Srisukvatananan, P. and Uchida, S. (2013). "Sampling Nuclear Reactor Coolant Systems". Proc.16th Intern. Conf. Props. Water and Steam, Greenwich, London, UK. Sept. 1st-6th.
20. Lister, D.H. and Khumsa-Ang, K. (2013). "Oxide Particle Deposition under Low-Temperature Cooling Water Conditions: Experiments under Subcooled Boiling at High pH". Heat Trans. Eng., 34, Issues 8-9 (April-May).
21. Lertsurasakda, C., Srisukvatananan, P., Liu, L., Lister, D. and Mathews, J. (2013). "The Effects of Amines on Flow-Accelerated Corrosion in Steam-Water Systems". Power Plant Chem., 15 (3), 181-189.
22. Suzuki, H., Uchida, S., Naitoh, M., Okada, H., Koikara, S., Hasegawa, K., Kojima, F., Koshizuka, S. and Lister, D.H. (2013). "Risk Evaluation of Flow-Accelerated Corrosion Based on One-Dimensional FAC Code". Nuclear Technology, 183, 194-209.
23. Suzuki, H., Uchida, S., Naitoh, M., Okada, H., Koikara, S., Nagaya, Y., Nakamura, A., Koshizuka, S. and Lister, D.H. (2013). "Verification and Validation of One-Dimensional Flow Accelerated Corrosion Evaluation Code". Nuclear Technology, 183, 62-74.
24. Lister, D.H. and Uchida, S. (2014). "Determining Water Chemistry Conditions in Nuclear Reactor Coolants". J. Nucl. Sci. Techn. Invited Review for 50th Anniversary Edition, in press (April 10).
25. Uchida, S., Koshizuka, S. and Lister, D.H. (2014). "Evaluation of the Effects of pH and Oxygen on Mitigation of Wall Thinning of Carbon Steel due to Flow-Accelerated Corrosion." Proc. EUROCORR 2014, Pisa, Italy. September 8-12.
26. Cook, W.G., Stuart, C.R. and Gardner, E., *Secondary System Return to Service Following the Refurbishment Outage at the Point Lepreau Generating Station*, Oral presentation accepted to NPC 2014 - Nuclear Plant Chemistry 2014, Sapporo, Japan, October 2014.
27. Stuart, C.R., Cook, W.G. and Gardner, E., *Primary Heat Transport System Return to Service Following the Refurbishment Outage at the Point Lepreau Generating Station*, Oral presentation accepted to NPC 2014 - Nuclear Plant Chemistry 2014, Sapporo, Japan, October 2014.
28. Cook, W. and Olive, R., *Corrosion Product Transport and Deposition in a Supercritical Water-Cooled Reactor*, ICPSW16, Greenwich, UK, September 2013.
29. Cook, W. and Olive, R., *Predicting Corrosion Product Solubility in Supercritical Water using Revisited HKF-model Parameters and Thermodynamic Modelling*, ICPSW16, Greenwich, UK, September 2013.

German National Committee to IAPWS

Research Activities on the Thermodynamic Properties of Water and Steam

Report "Research in Progress 2014"

Baltic Sea Research Institute, Warnemuende

Dr. Rainer Feistel

Projects

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

Book Publications

Feistel, R., Tailleux, R., McDougall, T. (Eds.):

Thermophysical Properties of Seawater. Ocean Science Special Issue.

Copernicus Publications, Göttingen (2013), ISSN 1812-0784

Hellmuth, O., Khvorostyanov, V.I., Curry, J.A., Shchekin, A.K., Schmelzer, J.W.P.,

Feistel, R., Djikaev, Y.S., Baidakov, V.G.: Selected Aspects of Atmospheric

Ice and Salt Crystallisation. Review Series on Selected Topics of Atmospheric Sol

Formation, Volume 1. Nucleation Theory and Applications, Joint Institute for

Nuclear Research, Dubna, Russia (2013), ISBN 978-5-9530-0349-0

Papers

Feistel, R., Lovell-Smith, J. (proposers): Guideline on a Virial Equation for the Fugacity of H₂O in Humid Air. The International Association for the Properties of Water and Steam, Greenwich, UK, September 2013, submitted

Safarov, J., Berndt, S., Millero, F., Feistel, R., Heintz, A., Hassel, E. (2013):

(p,rho,T) Properties of seawater at brackish salinities: Extensions to high

temperatures and pressures. Deep-Sea Research I, 78 (2013) 95–101

German Aerospace Center (DLR), Cologne

Institute of Propulsion Technology

Prof. Dr. Francesca di Mare

Project

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

- The draft "IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using the Spline-Based Table Look-Up Method (SBTL)" has been implemented into the CFD code TRACE.

Leibniz Institute for Tropospheric Research, Leipzig
Dr. Olaf Hellmuth

Project

Preparation of the comprehensive paper for the Journal Metrologia:
Metrological challenges for measurements of key climatological observables: Oceanic salinity and pH,
and atmospheric humidity.

Book Publication

Hellmuth, O., Khvorostyanov, V.I., Curry, J.A., Shchekin, A.K., Schmelzer, J.W.P.,
Feistel, R., Djikaev, Y.S., Baidakov, V.G.: Selected Aspects of Atmospheric
Ice and Salt Crystallisation. Review Series on Selected Topics of Atmospheric Sol
Formation, Volume 1. Nucleation Theory and Applications, Joint Institute for
Nuclear Research, Dubna, Russia (2013), ISBN 978-5-9530-0349-0

Papers:

Shchekin, A.K., Shabaev, I.V., Hellmuth, O.,
Thermodynamic and kinetic theory of nucleation, deliquescence and efflorescence transitions in the
ensemble of droplets on soluble particle,
J. Chem. Phys. 138, 054704 (2013); doi: 10.1063/1.4789309

PTB Braunschweig
Dr. Petra Spitzer

Project

Preparation of the comprehensive paper for the Journal Metrologia:
Metrological challenges for measurements of key climatological observables: Oceanic salinity and pH,
and atmospheric humidity.

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

The group chaired by Prof. Span has been actively involved in a number of research projects related to
CO₂-rich mixtures as are typical for power generation with carbon capture and storage (CCS), to hydrate
formation and to heavy water. The work of Prof. Span primarily addresses the

- improvement of the experimental data base available for CCS-relevant mixtures. Experimental
programs are financed by BIGCCS (Norwegian Science Foundation) and IMPACTS (EU).
Measurements include density, speed of sound and dew point of CO₂ rich mixtures and other relevant
binary systems. In September 2013 the corresponding experimental equipment was moved into new,
modern laboratories in a new building. Though this new environment is a remarkable improvement,
complications related mostly to the air conditioning of the new laboratories have not been completely
yet. Much work has had to be invested into the new laboratories.
- improvement of accurate models available for CCS-relevant mixtures. The main foci of this work have
been the development of improved mixing models and a consistent description of complex phase
equilibria [1], including the formation of hydrates and other solid phases. This work is linked to close

co-operations with the group of Dr. J. Hruby at the Czech Academy of Sciences and with Dr. E. W. Lemmon at NIST in Boulder.

- a chapter in a book on CCS [2] has been written to raise the awareness of thermodynamic property-related issues in CCS.
- development of a new reference equation of state for heavy water. This work is linked to an IAPWS grant awarded in 2012 and to a close cooperation with Dr. A. Harvey and Dr. E. W. Lemmon at NIST in Boulder. Work on the new equation of state is proceeding slowly. New experimental data are expected for the vapor pressure of heavy water (from NIST) and for speed of sound in liquid heavy water (from Bochum's speed of sound laboratory). Once these data are available the equation of state can be finalized.

Many aspects of the work on CCS-relevant mixtures are closely related to work on properties of natural gases, particularly in conjunction with LNG processing. However, this work is not considered within the primary scope of IAPWS.

- [1] *J. Gernert, A. Jäger, R. Span: Calculation of Phase Equilibria for Multi-Component Mixtures Using Highly Accurate Helmholtz Energy Equations of State. Fluid Phase Equilibria, 2014.*
- [2] *K. Görner (Ed.): CO₂: Abtrennung, Speicherung, Nutzung. Springer (2014).*

Related Papers

- [3] *R. Span, J. Gernert, A. Jäger: Accurate Thermodynamic-Property Models for CO₂-Rich Mixtures. Energy Procedia, 2013.*
- [4] *H.G. Jacob Stang, J.P. Jakobsen, Ø. Wilhelmsen, R. Span: CO₂ Mix Project: Experimental Determination of Thermo Physical Properties of CO₂-Rich Mixtures. Energy Procedia, 2013.*

Ruhr University Bochum

Faculty of Mechanical Engineering, Chair of Thermodynamics

Prof. em. Dr. Wolfgang Wagner

Projects

1. Working for the report "Possible Improvements of the Uncertainty Estimates of IAPWS-95" within the Task Group "Uncertainty Estimates of IAPWS-95" for the Working Group "Thermophysical Properties of Water and Steam." The results will be presented at the IAPWS Annual Meeting in Moscow 2014.
2. Preparatory work for the article "Behavior of the IAPWS-95 Formulation for Temperatures from 253 K to 303 K at Pressures up to 400 MPa."

Publications

- Wagner, W., Dauber, F., Kretschmar, H.-J., Mareš, R., Miyagawa, K., Span, R. Extended equation for region 5 of the Industrial Formulation IAPWS-IF97. Proceedings of the International Conference on the Properties of Water and Steam, September 2013, University of Greenwich, London, UK, Institution of Mechanical Engineers, London SW1H 9JJ, UK.
- Kretschmar, H.-J. Feistel, R., Wagner, W., Miyagawa, K., Harvey, A. H., Cooper, J. R., Hiegemann, M. Blangetti, F. L., Orlov, K. A., Weber, I., Singh, A., Herrmann, S. The IAPWS Industrial Formulation for the Thermodynamic Properties of Seawater. Accepted for publication in *Desalination and Water Treatment* (2014).

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

Project

Implementation of the Fast Steam Property Algorithms Based on Spline Interpolation into the Heat Cycle Code KRAWAL

- The draft “IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using the Spline-Based Table Look-Up Method (SBTL)” has been implemented into the heat cycle code KRAWAL.

STEAG Energy Services, Zwingenberg
Reiner Pawellek

Project

Implementation of the Fast Steam Property Algorithms Based on Spline Interpolation into the Heat Cycle Code EBSILON

- The draft “IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using the Spline-Based Table Look-Up Method (SBTL)” has been implemented into the heat cycle code EBSILON.

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

Projects

1. Development of Fast Property Algorithms Based on Spline Interpolation
 - The algorithms for the fast spline-interpolation method have been developed and applied to the calculation of thermodynamic properties of steam and water in CFD and non-stationary calculations.
 - The draft “IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using the Spline-Based Table Look-Up Method (SBTL)” has been completed and evaluated.
2. Industrial Calculation of the Thermodynamic Properties for Seawater
 - The paper "The IAPWS Industrial Formulation for the Thermodynamic Properties of Seawater" has been completed and submitted to the Journal Desalination and Water Treatment.

Recent Publications

- Wagner, W., Dauber, F., Kretzschmar, H.-J., Mareš, R., Miyagawa, K., Span, R. Extended equation for region 5 of the Industrial Formulation IAPWS-IF97. Proceedings of the International Conference on the Properties of Water and Steam, September 2013, University of Greenwich, London, UK, Institution of Mechanical Engineers, London SW1H 9JJ, UK.
- Kretzschmar, H.-J., Feistel, R., Wagner, W., Miyagawa, K., Harvey, A. H., Cooper, J. R., Hiegemann, M., Blangetti, F. L., Orlov, K. A., Weber, I., Singh, A., Herrmann, S. The IAPWS Industrial Formulation for the Thermodynamic Properties of Seawater. Accepted for publication in Desalination and Water Treatment (2014).

Recent Publication Activities in Japan

**Submitted to the Executive Committee Meeting, IAPWS,
Moscow, Russia, June 2014**

Japanese National Committee of IAPWS
c/o The 139th Committee on Steam Properties
Japan Society for the Promotion of Science (JSPS)
5-3-1, Kojimachi, Chiyoda-ku
Tokyo 102-0083, Japan

ADSCHIR Tadafumi,

Professor, WPI-AIMR, Tohoku University; email: ajiri@tagen.tohoku.ac.jp,
URL: <http://www.tagen.tohoku.ac.jp/modules/laboratory/index.php?laboid=49>

- [1] Lu, J.F., Minami, K., Takami, S., Adschiri, T., "Rapid and continuous synthesis of cobalt aluminate nanoparticles under subcritical hydrothermal conditions with in-situ surface modification", Chem. Eng.Sci., in press. DOI : 10.1016/j.pcrygrow.2011.10.006.
- [2] Taguchi M., Takami, S., Adschiri, T., Nakane, T., Sato, K., Naka,T., "Simple and rapid synthesis of ZrO₂ nanoparticles from Zr(OEt)₄ and Zr(OH)₄ using a hydrothermal method ", Cryst Eng Comm., 14,2117(2012). DOI : 10.1039/C2CE06408A.
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- [5] Rangappa, D ., Ohara, S., Takami, S., Naka, T., Kondo, A, Ishii, M., Kobayashi, T., Adschiri, T., "Preparation of aqueous dispersible styrene-maleic amide encapsulated CoAl₂O₄ nanocrystals using supercritical water flow type apparatus", Mater. Res Innov., 16, 30(2012). DOI : 10.1179/1433075X11Yj.0000000017.
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- [8] Sahraneshin,A., Takami,S., Hojo,D., Minami,K., Arita,T., Adschiri,T., "Synthesis of shape-controlled and organic-hybridized hafnium oxide nanoparticles under sub- and supercritical hydrothermal conditions", J. Supercrit. Fluid, 62, 190(2012). DOI : 10.1016/j.supflu.2011.10.019.
- [9] Lu, J.F., Minami,K., Takami,S., Shibata,M., Kaneko,Y., Adschiri,T., "Supercritical Hydrothermal Synthesis and In situ Organic Modification of Indium Tin Oxide Nanoparticles Using Continuous-Flow Reaction System", ACS Applied Materials & Interfaces, 4, 351(2012). DOI : 10.1021/am2014234.

- [10] Li,H., Arita,T., Takami,S., Adschiri, T., "Rapid Synthesis Of Tin-Doped Indium Oxide Microcrystals In Supercritical Water Using Hydrazine As Reducing Agent", *Progress in Crystal Growth and Characterization of Materials*, 57,117(2011). DOI : 10.1016/j.pcrysgrow.2011.10.006.
- [11] Seong,G.M.,Takami,S., Arita,T., Minami,K., Hojo,D., Yavari,A.R., Adschiri, T., " Supercritical hydrothermal synthesis of metallic cobalt nanoparticles and its thermodynamic analysis", *J. Supercrit. Fluid*, 60,113(2011). DOI : 10.1016/j.supflu.2011.05.003.
- [12] Ohara,S., Hatakeyama, Y., Umetsu,M., Tan, Z.Q., Adschiri, T., " Fabrication of Pd-DNA and Pd-CNT hybrid nanostructures for hydrogen sensors", *Adv. Powder Tech.*, 22, 559(2011). DOI : 10.1016/j.appt.2011.05.006.
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- [20] Arita,T., Yoo J.W., Adschiri, T., "Relation between the Solution-State Behavior of Self-Assembled Monolayers on Nanoparticles and Dispersion of Nanoparticles in Organic Solvents", *J.phys.Chem.C*, 115, 3899(2011). DOI : 10.1021/jp110172s.
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International Association for the Properties of Water and Steam

Russian National Committee (RNC)

Report Second Half-Year of 2013- First Half-Year of 2014

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

Publications list

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

Report on IAPWS related activities – September 2013 / June 2014
Submitted to the EC Meeting of IAPWS, Moscow, RU - June 2014.

National Committee Contacts:

SCPWS Swiss Committee for the Properties of Water and Steam
Head: Dr. Robert Svoboda, E-mail: r.svoboda@swissonline.ch

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

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Dr. Michael Hiegemann, Dr. Francisco Blangetti; Alstom, Baden, Switzerland, e-mail: michael.hiegemann@power.alstom.com, francisco.blangetti@power.alstom.com

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Research activities in the reporting period:

No new projects were reported

Contributions to current IAPWS activities:

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

Co-authorship and reviewers of the following paper in the journal “Desalination and Water Treatment”:

H.J. Kretzschmar, R. Feistel, W. Wagner, K. Miyagawa, A.H. Harvey, J.R. Cooper, M.Hiegemann, F.L. Blangetti, K.A. Orlov, I. Weber, A. Singh, S. Herrmann. “The IAPWS Industrial Formulation for the Thermodynamic Properties of Seawater”.

Status of Associate Membership to IAPWS:

Industry climate and the ensuing activities at universities do presently not favor engagement in traditional science of water and steam in Switzerland. The major power plant supplier (Alstom) is presently undergoing change of ownership and possibly split-up; the major steam based electricity producers are nuclear power plants that plan phase out of their plants.

Up to now, no team of sponsors to commit on mid- or long-term to a regular Swiss membership fee has yet been assembled. Activities were therefore limited to few individuals. - It is requested to extend the Associate Membership for another term.

Recent Publications:

None

R.Svoboda, June 19, 2014

U.S. National Committee to IAPWS 2014 Report on Activities of Potential Interest to IAPWS

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

- In a collaboration with the Ruhr University of Bochum, we have made substantial progress on an IAPWS project for development of an equation of state for the thermodynamic properties of heavy water. A young researcher from Bochum spent several months in Boulder in 2013, collecting and evaluating the experimental database and developing preliminary fits for the EOS. A preliminary equation has been developed, and will be refined in the coming months, possibly augmented by some new data.
- In NIST's Sensor Science Division (Gaithersburg, MD), a gravimetric apparatus has been used to measure the saturation concentration of water as a function of temperature and pressure in compressed gaseous carbon dioxide (equivalent to a dew-point measurement) at pressures up to 5 MPa. These data are important for the design of systems for compression and transportation of CO₂ for carbon capture and sequestration. Data have been obtained on six isotherms at approximately 10 °C, 21.7 °C, 30 °C, 40 °C, 60 °C and 80 °C. The apparatus is currently being modified to take more data at conditions (in the same temperature range) with relatively high water vapor contents.
- The Properties Subcommittee of the ASME Research and Technology Committee on Water and Steam in Thermal Systems (which is the U.S. National Committee to IAPWS) completed the Third Edition of the book *ASME International Steam Tables for Industrial Use*, which was published in early 2014. This book documents and provides tables and charts (in both SI and U.S. customary units) based on IAPWS-IF97 and other IAPWS "industrial" recommendations. The main update for the Third Edition was the incorporation of the recently revised IAPWS thermal conductivity formulation.

Communicated from the University of Maryland

- Research on supercooled water:
V. Holten, J.C. Palmer, P.H. Poole, P.G. Debenedetti, and M.A. Anisimov, "Two-state thermodynamics of the ST2 model for supercooled water", *J. Chem. Phys.* **140**, 104502 (2014).
F.W. Bresme, J.W. Biddle, J.V. Sengers, and M.A. Anisimov, "Communication: Minimum in the thermal conductivity of supercooled water", *J. Chem. Phys.* **140**, 161104 (2014).
V. Holten, J.V. Sengers, and M.A. Anisimov, "Equation of state for supercooled water at pressures up to 400 MPa", submitted to *J. Phys. Chem. Ref. Data*.
- Research on aqueous solutions:
D. Subramanian, C.T. Boughter, J.B. Klauda, B. Hammouda, and M.A. Anisimov, "Mesoscale inhomogeneities in aqueous solutions of small amphiphile molecules", *Faraday Discussions* **167**, 217-238 (2013).
J. Leys, D. Subramanian, E. Rodenzo, B. Hammouda, and M.A. Anisimov, "Mesoscopic properties in solutions of 3-methylpyridine, heavy water, and an antagonistic salt", *Soft Matter* **9**, 9326-9334 (2013).
M.A. Anisimov, "Mesostructures and dynamics in liquids and solutions", Sections D and E, *Faraday Discussions* **167**, 1-23 (2013).

- D. Subramanian and M.A. Anisimov, "Mesoscale solubilization and phase behavior in aqueous solutions of hydrotopes", *Fluid Phase Equilibria* **362**, 170-176 (2014).
- D. Subramanian, J.B. Klauda, P.J. Collings, and M.A. Anisimov, "Mesoscale phenomena in ternary solutions of tertiary butyl alcohol, water, and propylene oxide", *J. Phys. Chem. B* **118**, 5994-6006 (2014).
- Review on transport properties near the critical point including H₂O: J.V. Sengers and R.A. Perkins, "Fluids near critical points", in: *Transport Properties of Fluids: Advances in Transport Properties*, M.J. Assael, R.H. Goodwin, V. Vesovic, and W.A. Wakeham, eds. (IUPAC, RSC Publishing, Cambridge, 2014), pp. 337-361.

Communicated from OLI Systems

- Within the framework of the Department of Energy's Critical Materials Institute, OLI Systems has initiated a project to develop a comprehensive thermodynamic model for rare earth metals in aqueous environments. This model is expected to provide a computational tool for designing and optimizing emerging processes related to recycling rare earth metal-containing products, broadening the supply of rare earth metals from unconventional sources and developing substitutes.
- A comprehensive model has been developed for systems containing water, carbon dioxide, hydrogen sulfide, and common chloride salts. The objective of this model is to predict both phase equilibria and speciation including pH.
- A previously developed model for the thermal conductivity of electrolyte systems including seawater (P. Wang and A. Anderko, *Int. J. Thermophysics*, 2002, 33, 235-258) has been revised to incorporate new experimental data, optimize the concentration dependence of species-species interaction terms, and create a simple formulation for seawater in terms of salinity, temperature, and pressure.

List of Participants at IAPWS 2014

N	Title	Name	Family	Organization	Country
1	Mr.	Reiner	Pawellek	STEAG Energy Services	Germany
2	Dr.	Barry	Dooley	Structural Integrity Associates	UK
3	Mr.	Paul	McCann	E.ON New Build & Technology	UK
4	Dr.	Allan	Harvey	NIST	United States
5	Mr.	David	Guzonas	Atomic Energy of Canada Limited	Canada
6	Dr.	Daniel	Friend	NIST	USA
7	Mrs.	Pavla	Rudasova	Doosan Skoda Power	Czech Republic
8	Mr.	Derek	Lister	University of New Brunswick	Canada
9	Mr.	Andrzej	Anderko	OLI Systems Inc.	USA
10	Mr.	Olaf	Hellmuth	TROPOS Leibniz Institute for Tropospheric Research	Germany
11	Dr.	Hideo	Hirano	CRIEPI (Central Research Institute of Electric Power Industry)	Japan
12	Mr.	Ingo	Weber	Siemens Energy	Germany
13	Mr.	William	Cook	University of New Brunswick	Canada
14	Mr.	Shunsuke	Uchida	Institute of Applied Energy	Japan
15	Mr.	Jan	Sengers	University of Maryland	USA
16	Mr.	Jeffery	Cooper	Queen Mary University of London	UK
17	Mr.	Mats	Hellman	Hellman Vatten AB	Sweden
18	Mr.	Aref	Asl Saedi Pour	Siemens	Iran
19	Mr.	David	Addison	Thermal Chemistry Limited	New Zealand
20	Mr.	Adam	Novy	Doosan Skoda Power	Czech Republic
21	Mr.	Michal	Duška	Institute of Thermomechanics AS CR, v. v. i.	Czech Republic
22	Mr.	Jan	Hrubý	Institute of Thermomechanics AS CR, v. v. i.	Czech Republic
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24	Mr.	Wolfgang	Hater	BK Giuliani GmbH	Germany
25	Mr.	Masaru	Nakahara	Kyoto University	Japan
26	Ms.	Jana	Kalova	University of South Bohemia, Faculty of Science	Czech Republic
27	Mr.	Ken	Yoshida	University of Tokushima	Japan
28	Dr.	Wolfgang	Wagner	Ruhr-University Bochum, Chair of Thermodynamics	Germany
29	Mr.	Vincent	Holten	University of Maryland, College Park	Netherlands
30	Dr.	James	Bellows	Siemens Energy, Inc.	USA
31	Mr.	Milan	Sedlár	CENTRUM HYDRAULICKÉHO VÝZKUMU, spol. s r. o.	Czech Republic
32	Mr.	Bert	Rukes	Siemens AG	Germany

N	Title	Name	Family	Organization	Country
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36	Mr.	Mikhail	Anisimov	University of Maryland	USA
37	Mr.	Anders	Fredriksson	Tekniska Verken	Sweden
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41	Dr.	Mars	Faizullin	Institute of Thermal Physics UB RAS	Russia
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45	Prof.	Valeriy	Ochkov	Moscow Power Engineering Institute	Russia
46	Prof.	Tamara	Petrova	Moscow Power Engineering Institute	Russia
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48	Mr.	Marco	Lendi	SWAN Analytical Instruments AG	Switzerland
49	Mr.	Oleg	Tzvetkov	University of information technologies, mechanics & optics	Russia
50	Mr.	Nikolay	Romanov	Research and Production Association 'Typhoon'	Russia
51	Mrs.	Galina	Kondakova	Organizer	Russia
52	Mr.	Vsevolod	Znamenskiy	Organizer	Russia
53	Mr.	Aleksey	Ochkov	Organizer	Russia
54	Prof.	Nikolay	Rogalev	Moscow Power Engineering Institute	Russia
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56	Ms.	Yulia	Bogatyreva	Organizer	Russia
57	Ms.	Asya	Miskimova	Organizer	Russia
58	Mr.	Pavel	Gotovtcev	Moscow Power Engineering Institute	Russia
59	Mr.	Frank	Gabrielli	Alstom	USA
60	Mr.	Philipp	Dyachenko	Aminotek	Russia
61	Dr.	Olga	Yegoshina	Moscow Power Engineering Institute	Russia
62	Prof.	Vladimir	Istomin	Gazprom VNIIGAZ JSC	Russia
63	Prof.	Valeriy	Buleiko	Gazprom VNIIGAZ JSC	Russia
63	Prof.	Boris	Grigoryev	Gazprom VNIIGAZ JSC	Russia