THE INTERNATIONAL ASSOCIATION FOR THE PROPERTIES OF WATER AND STEAM

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Czech Republic
Denmark
France
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Japan
Russia
United States of America

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Minutes of the Meetings

of the

Executive Committee

of the

International Association for the Properties of

Water and Steam

Niagara Falls, Canada
18-23 July 2010

Prepared by: Barry Dooley

IAPWS

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Minutes of the Meetings
of the
Executive Committee
of the
International Association for the Properties of Water and Steam
held in
Niagara Falls, Canada
18-23 July 2010

Plenary Session. Monday, 19th July 2010. 8:30 am

The President of IAPWS, Friend, welcomed the Executive Committee (EC) and other IAPWS members to Niagara Falls for the EC and Working Group (WG) Meetings of IAPWS. The President officially opened the 2010 EC Meetings by introducing the National Delegates. Each of the Member and Associate Member countries of IAPWS was in attendance with the exception of Argentina/Brazil, France, Greece and Italy.

The President informed the EC of the sad news of the death of Dr. Howard White who had been the Executive Secretary of IAPWS for over 10 years prior to 1989. Dr. White was an IAPWS Honorary Fellow. Friend then asked for a few moments of silence to remember Howard.

The President asked the representative of Canada to provide some opening comments. Guzonas welcomed everybody to Niagara Falls and to the 2010 IAPWS meetings. He provided some background to the Canadian National Committee and wanted to recognize the support of the National Research Council (NRC) of Canada, the Candu Owners Group (COG), and Atomic Energy of Canada (AECL). He then introduced a few of the events which would take place during the week: the IAPWS Symposium, the IAPWS Dinner and and the various working group meetings. He particulary thanked the other members of the organizing committee: Tremaine, Hey, Lister and Cook.

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 Guidance Documents

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

- Technical Guidance Document: Volatile Treatments for the Steam-Water Circuits of Fossil and Combined Cycle/HRSG Power Plants. Distributed 25th May 2010. There had been two sets of comments from the Russian and Japanese National Committees which needed to be addressed by PCC during the week.

- Guideline on an Equation of State for Humid Air in Contact with Seawater and Ice, Consistent with the IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater. Distributed 3rd July 2010. This was the second circulation for this Guideline due to minor changes in the definition of "relative humidity. No objections had been received.

- ICRN 17. Distributed 4th March 2010. One objection had been received on the references. The US NC needs to address prior to EC approval.

- ICRN 21. Distributed 23rd January 2010. The Danish NC had suggested a minor change to the temperature and pressure ranges. This had been addressed and no further comments were received by 1st April 2010, so the ICRN is approved as an IAPWS document.

- ICRN 22. Distributed 4th March 2010. No comments received so the ICRN is approved as an IAPWS document.

- ICRN 24. Distributed 1st October 2009. No comments received so the ICRN is approved as an IAPWS document.

  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 Bellows and Tremaine to serve on this Committee. The Clerk of Minutes from each WG will also provide input. The Press Release is discussed in Minute 12 and Attachment 11.

2.3 Evaluation Committee on International Collaboration.

The President indicated that two proposal had been received by the Executive Secretary prior to the meeting, and that any further 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 the proposals would consist of the WG Chairmen, with the President and Executive Secretary as ex. officio members. A chairman would be chosen by the Committee. The discussion of this Committee is reported in Minute 15.1.

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 2011 award would consist of a member from BIAPWS, Canada, Czech Republic, Denmark and France. The President indicated that the BIAPWS would provide the committee chairman. The President asked delegate Bignold to organize the committee and to report back to the EC on Friday with the names of the members of this committee (Minute 16.1).

2.4.2 Honorary Fellow Award Committee

The Executive Secretary requested that Watanabe remain on the Committee as the Chairman for 2011 with Rukes as the other member. The IAPWS President would be ex. Officio.

2.5 IAPWS Bank Account and Future IAPWS Dues

The President indicated that the IAPWS Swiss Bank account had been forced to close in 2009. The Executive Secretary had transferred the funds in the Swiss account to the IAPWS US account. The member dues for 2010 had been formulated by conversion of the Swiss Franc amount, as required by the IAPWS Statutes. Dues were paid into the US Bank account. The President requested that a small committee of Svoboda and Tremaine review the ramifications of these events. The Executive Secretary and President would be ex officio members. (See Minute 14.2).

2.6 Committee on Keywords for Internet Access

The President reminded the EC of Doorwerth Minute 16.3 on ensuring that key words used on the Internet accessed PCC documents. Members of the committee, Svoboda and Harvey, indicated that a report would be provided at the EC meeting on Friday (see Minute 18.2).

2.7 WG Future Activities and Mission Statements

The President reminded the EC of Doorwerth Minute 16.4 where he had requested each Working Group to develop a Mission Statement which could be placed on the IAPWS Website. He suggested that each WG Chairman provide this in the WG reports on Friday.

2.8 New IAPWS WG

The President reminded the EC of Doorwerth Minute 16.5 where he had requested Bellows to explore with the ASME committee the possibility of forming a new IAPWS WG on Water Chemistry activites outside of the power cycle. Bellows and Harvey reported that no action had been taken. President Friend suggested that the item be deferred to the 2011 EC Meeting on Friday.

2.9 WG 127 and SCOR

The President mentioned that the collaboration between IAPWS and the oceanographic community could be strengthened further by moving to a more official level. To do this it had been suggested by the Chairman of SCSW, Feistel, that two letters be formulated and sent to IAPSO in relation to WG 127, and to SCOR. The President appointed a small committee to develop a letter with Feistel as Chair and Harvey as member.

2.10 Other business for General Meeting or Requiring Extensive Discusssions

No other business was raised by the EC.

3. EC Mandate to Working Groups and Membership

The President 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 six ICRNs had either expired in September 2009 or 2010 or will expire in August 2010 and thus needed attention by the WGs during the week: #10 on pH required collaboration by PCAS and SCSW, #16 on Seawater, #18 on Ion Exchange Resins, #19 on Sampling, #20 on Sensors. #23 to address comments from an HRSG Manufacturer.

3.2 Working Group Directions.

The President emphasized the WGs need to remain vibrant and active. He asked the WG Chairmen to only report to the EC on Friday, those activities that needed approval or discussion by the EC.

4. Preview by the WG Chairmen of the Weeks Activities

President Friend requested each WG Chairman to review briefly the main topics which would be covered in their WGs during the week. The details of the WG meetings are covered in detail in Minutes 7 to 11 (Attachments 4 to 8).

The President closed the opening session of the EC at 9:35am.

Activities During the Week

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

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

The IAPWS Symposium was held on Wednesday, 21st July 2010. The overall theme was on *The Role of Water in Energy Transition*, and the Symposium Program is shown in Attachment 3.

Executive Committee Meeting. Friday, 23rd July 2010

President Friend opened the continuation of the EC Meeting at 8:32am. All members of IAPWS were present except Argentina/Brazil, France, Greece, and Italy. Friend 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 Friend asked for comments and changes to the minutes of the EC meeting held in Doorwerth, The Netherlands in September 2009. No changes were noted, thus the 2009 Minutes were accepted.

6. President's Report

President Friend opened his report by indicating that IAPWS remains financially solvent, and that the Canadian National Committee and IAPWS were very pleased with the attendance at the 2010 meetings. The work conducted over the last year has been substantial with PCC working on Guidance Documents, TPWS/IRS continuing to address the important aspects in thermophysical properties, PCAS putting the WG on a firm footing, and the SCSW adding the oceanographic community which has allowed IAPWS to make a large contribution in this area. For the future, each working group and sub-committee will be developing Mission Statements to provide better visage of the IAPWS work externally. So there are real reasons to be very optimistic in addressing the local and global needs of the water and steam communities. IAWPS is setting the standard internationally where standards are needed. Finally the President thanked all the National delegates for bringing enthusiasm to the meeting.

7. Report and Recommendations of the Thermophysical Properties of Water and Steam (TPWS) and the Industrial Requirements and Solutions (IRS) Working Groups and the Subcommittee on Seawater (SCSW)

TPWS Chairman Kretzschmar opened this item by indicating that he would report on activities within TPWS and IRS during the week, and would also include some of the items from the Subcommittee on Seawater. 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 WG activities had been

conducted jointly with the exception of one separate meeting each for IRS and the Subcommittee on Seawater which are reported in Minutes 8 and 9. Full Minutes and the Agenda for TPWS can be found in Attachment 4.

7.1 Web Space for Working Material for WGs TPWS and IRS. A password-protected website for documents and presentations of the TPWS and IRS WGs and the SCSW has been arranged. The site is accessible from the Working Groups page on www.IAPWS.org.

7.2 International Collaborative Projects. The WG had proposed two projects. These are covered in Minute 15.1.

7.3 Guideline on an Equation of State for Humid Air in Contact with Seawater and Ice, Consistent with the IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater. This doucument had been circulated to the National Committees. The WG TPWS and the SC SW recommend the approval of the Guideline by the EC.

The EC Approved the Guideline Unanimously

7.4 Editorial changes to the Revised IAPWS-95 Release. The TPWS WG approved the editorial changes presented by Wagner and informs the EC of the editorial changes.

7.5 Revision of the Revised Release on the Pressure along the Melting and Sublimation Curves of Water. The WG TPWS approved the Revision suggestions by Wagner and informed the EC that after Editorial Committee review the document will be sent to the National Committees for Postal Ballot in the coming year.

7.6 Development of a new Release on Thermal Conductivity for Water. The TPWS Chairman reported that Sengers had presented a proposed new correlation for the thermal conductivity of ordinary water. The Evaluation Task Group consists of R. Mareš (Chair, responsible for evaluation of the scientific formulation), W. Parry (Co-Chair, responsible for evaluation of the industrial formulation), J. Hruby, K. Miyagawa and K. Orlov. The initial evaluation should be completed by the end of 2010 and the WG plans to have this formulation ready by the next IAPWS meeting in 2011.

7.7 Task Group on Metastable Steam and Nucleation. The Chairman informed the EC that a Task Group had been formed with Hruby as Chair and that this TG will modify the existing ICRN-15 on thermodynamic properties of metastable steam to include the possibility of calculation from molecular properties, and will work on a new ICRN on homogeneous nucleation of droplets from supersaturated steam and steam-inert gas mixtures. These will be prepared for the 2011 IAPWS meeting.

7.8 ICRN 14 on Thermodynamic Properties of Humid Air und Combustion-Gas Mixtures. Many of the items in this ICRN have been addressed since it was issued in 2002, so the WG will allow this ICRN to expire in 2011 and prepare a closing statement. A new ICRN will be prepared to include carbon capture and sequestration (CCS) and considered at the 2011 IAPWS meeting.

7.9 Update of Advisory Note # 2 on Roles of Various IAPWS Documents. A revision of Advisory Note 2 had been presented to the WG to reflect documents approved and/or revised in 2009. This was approved, subject to editorial review.

7.10 Educational Steam Tables. Kretzschmar reported on the educational Steam Tables for Excel and Pocket Calculators linked to the IAPWS website. There have been 773 downloads of the Excel product since June 2009, and 995 downloads of pocket calculator software since the 2009 IAPWS meeting.

7.11 Membership and TPWS Officers. Kretzschmar requested that the following new member is approved:

K. Orlov, Moscow Power Institute (Russia).

He also requested that following are removed from membership due to their request and/or lack of participation:

Professor Oguchi (Japan),
Professor Dittmann (Germany),
Professor Schiebener (Germany).

The EC approved these Membership Changes Unanimously.

Kretzschmar then announced his intention to step down as TPWS Chairman at the conclusion of the 2011 meeting. The current Vice-Chair, Harvey, will become Chair at that time. In addition, TPWS had voted to add an additional Vice-Chair, Hruby, which was requested to be effective immediately.

The EC approved these TPWS Officer Changes Unanimously.

7.12 TPWS Mission Statement. Chairman Kretzschmar reported that the TPWS WG had developed a Mission Statement which he shared with the EC. The text is within the TPWS minutes (Attachment 4). The President indicated that he will review the Mission Statements from all WGs and sub-committees with the Editorial Committee prior to them being put on the IAPWS Website.

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

IRS Chairman Parry indicated that many of the activities of IRS during the week had been reported in the TPWS report, but the IRS group had one separate meeting during the week. Minutes for IRS and the Agenda can be found in Attachment 5. He covered the following items with the EC.

8.1 Industrial Formulation IF-97. Chairman Parry indicated that Wagner had presented a brief history of the current Industrial Formulation, IF-97, which was followed by a discussion on the range of validity between 273.15 K and 273.16 K. Wagner had presented that the current description of this region as shown in the release is not correct and proposed new wording, and that the current Release does not give guidance on the estimate of uncertainties of specific enthalpy, and proposed adding a new sentence to the end of the subsection. Miyagawa's test report recommended to accept these proposed changes. The joint session of Working Groups IRS and TPWS had unanimously voted to recommend to the EC that the editorial changes be adopted.

8.2 Industrial Survey Task Group. The Chairman informed the EC that a new Task Group under his Chairmanship had been formed to develop a list of companies to include in an industrial survey to determine industrial needs and requirements, develop the industrial survey, develop IAPWS material to send with the survey, and then to send the survey to the identified companies and all of the IAPWS National Committees.

8.3 Advisory Note Task Group. This Task Group also under Parry's Chairmanship will investigate whether the current Industrial Release, IF-97, and the associated releases for transport properties provide adequate documentation to ensure that all users will use the entire package of Industrial Formulations correctly and consistently.

8.4 IRS Mission Statement. Chairman Parry reported that the IRS WG had developed a Mission Statement which he shared with the EC. The text is within the IRS minutes (Attachment 5). The President indicated that he will review the Mission Statements from all WGs and sub-committees with the Editorial Committee prior to them being put on the IAPWS Website.

8.5 Membership and IRS Officers. Chairman Parry indicated that he had retired from GE and would be stepping down as IRS Chairman. Vice Chairman Weber was elected as the new chairman of IRS. N. Okita was elected as the new vice-chairman. It is proposed that these changes take effect at the conclusion of the annual meeting.

The EC approved these IRS Officer Changes Unanimously.

The President thanked Parry for his excellent leadership of IRS. The EC applauded.

Parry requested that the following new members be approved:

P. Murphy (US)
A. Novy (Czech Republic)
M. Hiegemann (Switzerland)

The EC approved these Membership Changes Unanimously.

9 Report and Recommendations on the new IAPWS Subcommittee on Seawater

Subcommittee Chairman Feistel provided a report on the activities of the Subcommittee. Full minutes are in Attachment 6. He covered the following items with the EC.

9.1. Further cooperation between IAPWS, SCOR and IAPSO. The Chairman indicated that letters have been drafted from IAPWS to the Presidents of IAPSO and SCOR inviting continuing cooperation in some form of a joint task group. The President asked for comments and indicated that he will review and send out before the SCOR annual meeting which is in September 2010.

9.2 Feistel indicated that no progress had been made on the Advisory Note describing the use of IAPWS-IF97 in industrial calculations with seawater within the limits of validity of the current seawater formulation (which will exclude some applications). This document will be prepared on a schedule allowing for approval at the 2011 IAPWS meeting. A Task Group was formed in Doorwerth and an Evaluation Task Group has also been formed.

9.3 Modeling of the thermal conductivity of seawater had been presented to SCSW. The results are good for well-defined systems; the limited data available for seawater are scattered and sometimes not physically reasonable. The Task Group on Transport Properties appointed in item 6 of the 2009 SCSW minutes was encouraged to continue: a) developing a final formulation, which will become an IAPWS Guideline, and b) interacting with the effort to produce a new pure water thermal conductivity correlation so that the new seawater correlation will meet this pure water limit.

9.4 Modeling of the electrical conductivity of natural waters and seawater had been presented to SCSW. While for seawater the model is not nearly as accurate as good conductivity measurements, it may be possible to use the model to look at composition variations. In combination with existing measurements of seawater conductivity, a progress report on the work for a future IAPWS formulation on the electrical conductivity of seawater will be prepared for the 2011 IAPWS Meetings by the Task Group.

9.5 ICRN 16 on Thermophysical Property for Seawater had been discussed. Feistel had suggested that some numbers in the ICRN should change to reflect the industrial requirements. The ICRN was reviewed by the SCSW, adjustments had been made, and revised ICRN 16 was approved with a new expiration date of 2013.

9.6 SCSW Mission Statement. Chairman Feistel reported that the SCSW had developed a Mission Statement which he shared with the EC. The text is within the SCSW minutes (Attachment 6). The President indicated that he will review the Mission Statements from all WGs and sub-committees with the Editorial Committee prior to them being put on the IAPWS Website.

9.7 Membership and SCSW Officers. Chairman Feistel indicated to the EC that SCSW has voted to add McDougall as an additional Vice-Chair for SCSW, effective immediately, to guide the ongoing activities regarding TEOS-10 and related oceanographic issues.

The EC approved this SCSW Officer Change Unanimously.

Feistel requested that the following new member be approved:

R. Pawlowicz (Canada)

The EC approved this Membership Addition Unanimously.

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

Chairman Nakahara provided the PCAS Report to the EC. He indicated that a number of very useful workshops had been held during the week with PCAS members and joint with PCC and with TPWS/SCSW. Full Minutes can be found in Attachment 7. He covered the following items with the EC:

10.1 International Collaboration and Future Guideline Development. Chairman Nakahara indicated that this discussion was based on the joint IAPWS/IUPAC project "Establishing Recommended Data on Thermodynamic Properties of Hydration for Selected Organic Solutes and Gases" with Sedlbauer as the project coordinator. Originally, this project was supposed to result in the publication of a book. However, the plans have changed and a new method of disseminating the results needs to be established. Ehlerova had presented some options at the PCAS meeting regarding the publication of the results either as an Excel format or a web-based application. A report is scheduled for September 2010. Ehlerova had distributed the current version of the report in an electronic form. A draft for one journal paper is almost completed and it was agreed by PCAS to also publish the high temperature data in Chemosphere. Chairman Nakahara informed the EC of the need to develop a schedule for finalizing this project on hydration.

10.2 ICRNs. The Chairman reported that discussion had taken place in PCAS during the week on the following ICRNs: 10, 17, 20, 21, 22, 25, and 26. None required any action by the EC and each is covered in the PCAS minutes (Attachment 7).

10.3 The future of PCAS. Chairman Nakahara continued the discussion on the future of PCAS that he had introduced at the 2009 EC Meeting. He indicated that the low turnout at PCAS meetings remains a concern. Discussion at the PCAS meetings during the week resulted in a suggestion to consider converting PCAS to

a subcommittee and/or holding only joint workshops and working meetings with other working groups. PCAS feels that the current model of presenting the majority of talks in joint workshops is a step in the right direction but that more focus is needed. The Chairman indicated that PCAS would also like to preserve a separate PCAS workshop. This is partially due to the fact that PCAS's mission is to solve fundamental problems, which differentiates it from the other groups.

The President suggested that PCAS should remain as a WG of IAPWS, but adopt the suggestions for more joint meetings with the other IAPWS WGs. He asked the EC for comments and suggestions. The Chairman of PCC, Svoboda, indicated that PCAS is most important to PCC and particularly for the development of future Technical Guidance Documents, and that there will be no problem in arranging joint sessions. The Chairman of TPWS, Kretzschmar, supported having one joint meeting with TPWS/IRS but that certain items needed to remain in exclusive PCAS workshops.

The President thanked Chairman Nakahara for raising this issue to improve the overall operation of IAPWS. He concluded this item by suggesting that at the next annual meetings in 2011, the WG Chairmen needed to be more proactive than in the past in putting together agendas earlier for their WG sessions. This would encourage more interaction.

10.4 PCAS Membership. Chairman Nakahara raised the issue of PCAS membership of persons who have not participated in the activities of PCAS for a long time and indicated that he plans to contact all the current members and will review with PCAS in 2011.

10.5 PCAS Mission Statement. Chairman Nakahara reported that PCAS had developed a Mission Statement which he shared with the EC. The text is within the PCAS minutes (Attachment 7). The President indicated that he will review the Mission Statements from all WGs and sub-committees with the Editorial Committee prior to them being put on the IAPWS Website.

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

Chairman Svoboda highlighted those activities that needed action/approval by the EC. A full written report of the PCC WG activities forms Attachment 8. He covered the following items with the EC

11.1 Technical Guidance Documents. Chairman Svoboda reminded the EC that the first Guidance Document had been approved in 2008. This was on *The Measurement of Carryover of Boiler Water and Steam*. The second document which is entitled *Instrumentation for Monitoring and Control of Cycle Chemistry in Fossil and Combined Cycle/HRSG Plants* was approved in 2009. Svoboda reported that these documents are already getting much use in the industry worldwide and are being used in the development of guidelines worldwide. The third document has been prepared over the last year and is entitled *Volatile Treatments for the Steam-Water Circuits of Fossil and Combined Cycle/HRSG*

Power Plants. The document had been circulated to the National Committees. Two sets of comments from the Japanese and Russian committees had been been addressed within the PCC WG during the week. Chairmen Svoboda requested that the EC approve this document which would receive final Editorial Review.

The EC approved the Technical Guidance Document Unanimously

Svoboda informed the EC that a number of further Guidance Documents will be prepared over the next year for approval at the EC in September 2011. He then indicated that the world needs truly international guidance on cycle chemistry, which can be the foundation for guidelines in each country and for manufacturers and other organizations worldwide. IAPWS has a unique place in the world with so many international members and specialists plus the expertise from the other WGs.

11.2 ICRNs. The Chairman reported that discussion had taken place in PCC during the week on the following ICRNs: 17, 19, 21, 22, 25, and 26. None required any action by the EC and each is covered in the PCC minutes (Attachment 8). ICRNs 19 and 20 will be extended and updated during 2010.

11.3 PCC Membership. The Chairman informed the EC that two PCC members had withdrawn from membership:

J. Izumi (Japan)
M. Zmitko (Czech Republic)

11.4 PCC Mission Statement. Chairman Svoboda reported that PCC had developed a Mission Statement which he shared with the EC. The text is within the PCC minutes (Attachment 8). The President indicated that he will review the Mission Statements from all WGs and sub-committees with the Editorial Committee prior to them being put on the IAPWS Website.

12. Editorial Committee Report

Editorial Committee Chairman Harvey reported that in the preceding year, the Editorial Committee had reviewed many proposed documents, including the new Guideline on Humid Air, a Revision of Advisory Note # 2, two editorial changes for existing releases, two Technical Guidance Documents, and four ICRNs.

Chairman Harvey proposed to the EC that McDougall (Australia) is added as a third member of the Editorial Committee.

The EC Unanimously approved this Addition to the Editorial Committee.

13. Membership and Associates

13.1 Members Defaulting on Dues.

The President asked the Executive Secretary to report on the members that are deficient in paying their dues. To the beginning of July 2010 the following member countries had not paid their 2010 dues: France, Greece and Japan. The Greece National Committee also had not paid their dues in 2008 and 2009. The French National Committee has not paid dues for 2005 to 2010.

The EC then discussed the IAPWS Statute 3.2.1f which indicates that Members defaulting on the payment of dues for three years will have their status changed to that of Associate Member. In special circumstances the EC can vote to keep such a Member at the status of Full Member and reexamine the position each year. Following the 2009 EC meeting in Doorwerth, the Executive Secretary reported that, as instructed by the EC, he had written to the Head of the French National Committee with copies to the French people who were at the Berlin ICPWS. The letter indicated that France was in danger of having its status changed to Associate Member if there was no positive response by 31st January, 2010. The French Chairman, Dorey, responded in January that he had contacted the various people in France associated with IAPWS activities. They hoped to have a meeting in February/March, but there had been no further response. A reminder was sent by the Executive Secretary to the French NC Chairman at the beginning of July. The President then requested comments from the EC. The Statutes were reviewed and after much discussion the President formulated a motion to change the status of the French to that of Associate Member.

The EC Approved this Motion with a vote of 7 in favor and 1 opposed.

The President then requested comments on the Greece National Committee. The Executuve Secretary reported that he had not been able to make contact with the Head of the Greece committee. After some discussion by the EC, the President formulated a motion to approach the Greece National Committee with a similar letter which was sent to France following the Doorwerth meeting to indicate that Greece is in danger of having its status changed to Associate Member if there was no positive response by 31st January 2011.

The EC Approved this Motion Unanimously.

The President then requested if there was any discussion about the Associate Memberships of Argentina/Brazil and Italy. The concensus was to keep them as Associate Members.

13.2 Switzerland as an Associate Member

The President requested the Head of the National Committee of Switzerland, formed in 2007, to say a few words on the advancement of the Swiss National Committee. Svoboda reported that there are 13 members of the Swiss National

Committee, but they have not been able to get any longterm financial commitment. Svoboda then requested that the EC approves a second three years as an Associate Member of IAPWS.

The EC Approved this Request Unanimously.

13.3 Application of Scandinavian Joint Committee of IAPWS.

The President requested the Head of the Danish NC to provide information on the application submitted to the Executive Secretary on 26th April 2010 for a Scandinavian Joint Committee of IAPWS. Daucik reported that many of the companies supporting the Danish NC have associate companies across Scandinavia (Denmark, Sweden, Norway, and Finland). The application is for a joint Scandinavian IAPWS Committee, which will be abbreviated to SIAPWS. Daucik reported that SIAPWS has conducted an initial meeting and has developed a set of Statutes. There has not been any commitment yet in Iceland, but SIAPWS is hoping that Iceland will also join. Daucik was voted to be the first official Delegate to IAPWS. He then proposed to the EC that the application for full IAPWS membership of SIAPWS be approved.

The EC Approved the Application of SIAPWS Unanimously.

The President then confirmed that the current Danish NC will be disbanded.

13.4 Other Activities in Membership of IAPWS.

The Executive Secretary informed the EC that applications for Associate Membership had also been sent to the United Arab Emirates (UAE) and to Australia.

14. Executive Secretary's Report

14.1 Financial, Auditors and IAPWS Dues

The Executive Secretary reported that IAPWS remained on a sound financial footing with currently over $96,600 in the US account. The status as at 5th July 2010 in the bank accounts had been provided to each National Delegate present at the EC meeting.

The Executive Secretary next reported that the 2009 financial statements had been forwarded to the IAPWS Auditors in January 2010. Both VDI in Germany and Professor Savarik in Czech Republic had reviewed and approved the financial statements. The Auditors' reports had also been provided to 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 remain unchanged for 2011.

The EC Unanimously Agreed to this Proposal.

The Executive Secretary also provided a rough estimate of the income and known planned expenditures for 2010/2011.

14.2 IAPWS Bank Account and Future Dues Payments

The President reminded the EC of the discussions on Monday of the situation with the past IAPWS Swiss Bank account and the IAPWS Dues payments (Minute 2.5). He asked Svoboda to summarize the findings of the two man committee as Tremaine had left the EC meetings.

Svoboda indicated that the use of a Swiss Bank had become combersome as the Executive Secretary had explained at the EC meeting on Monday. For 2011, the Committee proposes that the IAPWS Dues are collected in US dollars equivalent to the Swiss Franc Dues amount for each IAPWS Member at the current rate of exchange on the date that the Dues must be paid. The deposits should be made to the IAPWS US bank account.

The Committee also proposed that the EC will need to prepare and circulate a draft amendment to the IAPWS Statutes at the next ICPWS. This would be to assess dues directly in US dollars for deposit to the IAPWS US bank account.

The EC Unanimously Agreed to these Proposals.

14.3 Time and Place of the 2011, 2012, 2013 and 2014 Meetings

The Executive Secretary indicated that the 2011 meetings would be held in the Czech Republic. Hruby reported that the Czech Republic National Committee will host the 2011 IAPWS Meetings in Pilsen between 4-9 September 2011. He showed a few slides of Pilsen and indicated that the Czech National Committee is looking forward to hosting the 2011 meetings.

The Executive Secretary reported that based on the timing and locations of the previous meetings Russia had been invited to host the 2012 meetings. The Head of the Russian NC responded that 2012 was not possible but that the 2014 meetings could be held in Russia. The next member country in line to hold an annual meeting is the USA. The Head of the US NC was asked if they could consider holding a meeting in 2012. Harvey responded that they would discuss this at their next meeting in September. The Executive Secretary then reminded the EC that he had received a proposal previously to hold a meeting in Abu Dhabi, UAE. Discussion with the IAPWS President lead to following suggested approach: following an Application for Associate Member status for the UAE in

IAPWS, and approval by the National Committees, the EC would consider a proposal to hold the annual meeting in Abu Dhabi in 2012 if this was received before 1st November 2010. The President asked if any member of the EC had any objections to holding an annual meeting in the UAE. None were voiced.

The 16th ICPWS will be held in the UK and will be arranged by BIAPWS. The BIAPWS delegate, Bignold, provided a short presentation on the arrangements to date. BIAPWS have sought the engagement of the Institute of Mechanical Engineers in order to optimise the planning of the event. A venue has not yet been set for the conference. In the current negotiations, consideration of the budget assumes that a donation of $25,000 will be provided by IAPWS. The President assured BIAPWS that this would be available as discussed at previous EC meetings. The Executive Secretary reminded BIAPWS that initial planning details on these aspects will be required at the 2011 EC meetings. At that time, the Local Organizing Committee will be in place, an International Program Committee will be determined by the EC and plans should be in place for a joint meeting in 2012 in the UK of these two committees.

The final item in this section was a request by the President for any comments on the annual meetings. A couple of the attendees wanted to record that the number of retired people in IAPWS was increasing as well as the cost of each annual meeting.

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

The President indicated that the Releases and ICRNs had been discussed within the WG Reports so no further action was required by the EC.

15.1 International Collaborative Projects.

The President requested the Chairman of the 2010 International Collaboration Committee to report on the findings of that committee during the week. Feistel reported that two collaborative projects had been proposed. The details are provided in Attachments 9 and 10:

- An Experimental Study of Thermal Conductivity of the Binary Ammonia + Water System at High Temperatures and Pressures. The IAPWS sponsors are Harvey (USA) and Petrova (Russia). The young scientist is Fanis N. Shamsetdinov or a colleague to be named from the Kazan State Technological University in Kazan, Tatarstan, Russia, and it is proposed that the IAPWS funding of $18,000 will allow the student to spend six months at NIST, Boulder in the USA.

- Development of Thermodynamic Models for Hydrates in Water – Carbon Dioxide Mixtures. The IAPWS sponsors are Hruby (Czech Republic) and Span (Germany). The young scientist Václav Vinš from the Institute of Thermomechanics, Academy of Science, Czech Republic. It is proposed that the scientist will spend six months at Ruhr-Universität in Bochum in a single stay

starting in February 2011. The proposed IAPWS funding is Euros 12,000 ($15,423 US). The travel will be paid by the Institute of Thermomechanics.

Feistel indicated that the Evaluation Committee supported both proposals. He indicated that the Committee had ranked the proposals with the Ammonia/Water proposal first because it was based on an ICRN, and had good international cooperation. This lead to review of the IAPWS Guidelines for Spending of IAPWS Funds (Toronto, September 1999), and to President Friend requesting that any EC delegate associated with either of the two proposals should leave the room. This left six voting members of the EC. The President then asked whether IAPWS should fund one or both proposals. The delegate from Germany motioned to accept both proposals. This was seconded by the delegate from BIAPWS.

The remaining members of the EC Unanimously supported the proposal to fund both projects. (The delegates from Czech Republic and the US were not present)

16. IAPWS Awards

16.1 IAPWS Helmholtz Award

The President reported that the 2010 Helmholtz Award had been presented to Melonie Myszczyszyn from Canadian Natural Resources Limited at the IAPWS Symposium on Wednesday.

Friend then asked the BIAPWS Delegate, Bignold, for the names of the 2011 Helmholtz Award Committee. The 2011 Helmholtz Committee will consist of: Chairman Rudge (BIAPWS), Guzonas (Canada), Hruby (Czech Republic), Therkildsen (Denmark) and Dorey (France). Nominations will be due to the Executive Secretary by 31st January 2011.

16.2 IAPWS Honorary Fellowships

The President reported that Bignold (BIAPWS) had been elected 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 at the IAPWS Dinner on Thursday evening by the IAPWS President. He reminded the EC of the Awards Committee for 2011 with Watanabe as Chairman and Rukes as member with the IAPWS President as ex.-officio member. Nominations are due to the Executive Secretary by 31st January 2011.

17. Election of IAPWS Officers for 2010 and 2011

The President indicated that he would step down at the end of 2010 and that Vice President Daucik will assume the position of IAPWS President on January 1, 2011. 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, noted that it is 26 years since Russia had held the IAPWS Presidency and proposed that the Russian National Committee should be asked to nominate one of their committee members for the position. The President 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 Russian 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 October 2010.

Vice President Daucik thanked the President for his leadership over the last two years, and indicated that he was enthusiastic to continue the developments. The EC applauded Friend.

18. New Business

18.1 Press Release

The President requested that Bellows project the Press Release for review by the EC. Suggestions were provided by the EC and the final version is contained in Attachment 11.

18.2 IAPWS Website and Keywords for IAPWS Internet Access

The President asked Harvey to report on the Committee set up at the Monday EC meetings (Minute 2.6). Harvey provided the following information:

- IAPWS documents and pages are not always easily found (or are not at the top of list) by search engines.
- Use of "FRAMES" makes design easier, but makes "TITLE" and other information that search engines use harder to extract.
- Information as PDF are indexed by search engines but not as easily.
- IAPWS would like Releases, Guidelines and Guidance Documents to be easily found

The Committee suggested that IAPWS uses an HTML page. The page would contain the title of the document, a link to the PDF, a brief description of the document (prepared by the responsible WG), the revision history, and the responsible WG. This will require small redesigns so that the page title is more accessible. This can be implemented gradually as time permits and the details of the pages are provided.

The President proposed to the EC that this new format is adopted.

The EC Unanimously Approved the Proposed New Format.

Harvey then raised a request from PCC Member Maughan about putting the annual IAPWS Symposium papers on the Website. The Canadian delegate, Guzonas, reported that this year's papers will go on the Canadian NC website. A link will be provided from the IAPWS Website. In future it will be necessary to request permission from authors/presenters to post their contributions on the IAPWS Website.

The final item on this topic was that the Russian NC had suggested to produce a Website where Mathcad can be used and to provide a link to this site. IAPWS's previous policy has been not to issue software, so Harvey questioned whether a "link" is included in this policy. The President suggested a small task group of Harvey, Orlov and Nemec to review and report back to the EC at the 2011 meeting.

18.3 Proposal to Establish Links with CIPM

President Friend requested Feistel to inform the EC on this matter. Feistel wondered if a mutual recognition arrangement with the International Committee of Weights and Measures (CIPM) might have some benefit for IAPWS. The International Bureau of Weights and Measures (BIPM) was set up by the Metre Convention and operates under the exclusive supervision of the CIPM. Its mandate is to provide the basis for a single, coherent system of measurements throughout the world, traceable to the International System of Units (SI). Some of Feistel's thoughts/question to the EC include the following:

- Should IAPWS documents be developed consistently with the SI and the metrological principles of BIPM
- BIPM could formally acknowledge that IAPWS documents are consistent with the SI and the metrological principles of BIPM
- A possible IAPWS international role as the BIPM for water properties
- IAPWS could belong to the list of formal BIPM partner organizations.

The President suggested that a small committee of Feistel (Chair), Cooper and Friend investigate the possibilities and benefits of IAPWS developing a cooperation, and report back to the EC at the 2011 meetings.

18.4 Other New Business

President Friend asked the EC if there was any further business. Cooper suggested that each EC meeting includes an item for feedback on the annual Symposium. The Canadian Delegate, Guzonas, reported that the 2010 Symposium had been very helpful in assembling Canadian scientists and engineers and that one new member had joined the Canadian IAPWS Committee.

18.5 Reports from National Committees.

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

Canada	Attachment 12
Czech Republic	Attachment 13
Denmark	Attachment 14
Germany	Attachment 15
Japan	Attachment 16
Russia	Attachment 17
Switzerland	Attachment 18
USA	Attachment 19

18.6 Participants

Attachment 20 provides a list of participants at the IAPWS EC and WG Meetings and at the Symposium in Niagara Falls, Canada in July 2010.

18.7 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 Niagara Falls Meetings. This will be forwarded electronically to the Head of each National Committee.

19. Closing Remarks and Adjournment

The President thanked Guzonas and his Canadian NC colleagues for hosting the IAPWS Niagara Falls Meetings. He also thanked everybody for participating at this EC meeting. Then he formally closed the 2010 EC meeting at 12:24 pm.

AGENDA for the EXECUTIVE COMMITTEE of IAPWS
Niagara Falls, Canada. 18-23 July 2010

Monday, 19th July 2010. Opening Session (8:30 – 9:30am)

Opening Remarks and Welcome by IAPWS President

1. Adoption of Agenda
2. IAPWS Business and Appointment of Committees
   - 2.1 Releases, Advisory Note, ICRN and Guidance Document
   - 2.2 Press Release
   - 2.3 Evaluation Committee on International Collaboration
   - 2.4 IAPWS Awards Committees for 2011 (Honorary Fellow and Helmholtz)
   - 2.5 IAPWS Bank Account and Future IAPWS Dues
   - 2.6 Committee on Keywords for Internet Access
   - 2.7 WG Future Activities and Mission Statements
   - 2.8 New IAPWS WG
   - 2.9 WG 127 and SCOR
   - 2.10 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, 23rd July 2010. 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 the Sub-committee on Seawater
10. Report and Recommendations of PCAS
11. Report and Recommendations of PCC
12. Editorial Committee Report
13. Membership and Associates
    - 13.1 Report on Membership. Including Members Defaulting on Dues.
    - 13.2 Report on Associate Member Switzerland
    - 13.3 Application of Scandinavian Joint Committee of IAPWS
    - 13.4 Other Activities in Membership of IAPWS
14. Executive Secretary's Report
    - 14.1 Financial, Auditors and IAPWS Dues
    - 14.2 IAPWS Bank Account and Future Dues Payments
    - 14.3 Time and Place of 2011/2012/2013/2014 Meetings.
      Includes BIAPWS's Update on the 16th ICPWS

15. Guidelines, Releases, Certified Research Needs, and International Collaborations
    - 15.1 International Collaborations
16. IAPWS Awards
    - 16.1 Helmholtz Award Committee
    - 16.2 Honorary Fellowship
17. Election of Officers for 2011 and 2012
18. New Business
    - 18.1 Press Release
    - 18.2 IAPWS Website and Keywords for IAPWS Internet Access
    - 18.3 Proposal to Establish Links with CIPM
19. Adjournment

Schedule of IAPWS Meetings
Niagara Falls, Canada. 18-23 July 2010

(All meetings will be at the Sheraton Fallsview Hotel)

Sunday 18 July. 6:00pm Informal Get-together, Cocktails and Registration
(Location will be at the Sheraton Fallsview Hotel)

Monday 19 July. 8:30am. Opening Plenary Session - Executive Committee
10:00am TPWS/IRS/SCSW Joint Meeting
(To set agendas for the week and to conduct IAPWS Business, thus allowing remainder of week for technical matters)
10:00am. PCAS and PCC Separate Meetings
(To conduct IAPWS Business, thus allowing remainder of week for technical matters)
1:30pm. TPWS/IRS/SCSW Joint Meeting
1:30pm. PCC and PCAS Separate WG Meetings

Tuesday 20 July. 8:30am. PCAS Workshop (other WG Members will be welcome)
8:30am PCC Workshop
"Update on Power Cycle Chemistry Research and Experience"
8:30am. TPWS/IRS/SCSW Joint Working Group Meeting
10:30am. TPWS/IRS/SCSW Joint Meeting. PCC, PCAS Separate Meetings
1:30pm TPWS/IRS/SCSW Joint Meeting.
1:30pm PCC/PCAS Joint WG Meeting and Workshop
3:30pm PCC and PCAS Separate Meetings

Wednes. 21 July. 9:00 – 5:00 **IAPWS Symposium**
" Chemistry Research, Sampling and Monitoring"
(Location will be at Sheraton Fallsview Hotel)

Thursday 22 July. 8:30am. IRS, SCSW and PCC Separate WG Meetings
8:30am. TPWS/PCAS Joint WG Meeting
"**Scaled Formulation of Self Diffusion Coefficients for Water over a Wide Range of Density and Temperature Including the Supercritical"**
1:30pm. Separate meetings of Working Groups
(If needed to prepare for Executive meeting)
6:30 pm. **IAPWS Dinner/Banquet**.
(Niagara Falls Restaurant)

Friday 23 July . 8:30am. Executive Meeting **(8:30am - 1: 00pm)**
(Will include at least one member from each National Delegation)
2:00pm Visit to Adam Beck Hydro Plant

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

Barry Dooley
24th July 2010

BUILDING ON SYNERGIES:
CHEMISTRY RESEARCH, SAMPLING AND MONITORING IN HIGH-TEMPERATURE WATER AND STEAM-WATER SYSTEMS

IAPWS Symposium 2010 July 21
Sheraton Fallsview at 6755 Fallsview Boulevard, Oaks North Ballroom
Niagara Falls, Canada

Symposium Schedule

09:00	Introductory remarks: Daniel Friend, IAPWS President
09:10	Helmholtz Award Lecture – "To Scale or Not to Scale in 2500 psig Thermal Enhanced Oil Recovery Steam Generators Utilized for Produced Water Applications" Melonie Myszczyszyn (Canadian Natural Resources Limited)
09:55	Welcome to Symposium - Dave Guzonas (Atomic Energy of Canada Ltd)

Session 1: ***Fossil and Nuclear Boiler Operational Experience*** *(Chair: Dave Guzonas)*

10:00	Experiences in Sampling and Chemistry Control in a Lignite-Fired Boiler System in a Water Resource Constrained Region Rod Nashiem (Bruce Power)
10:25	Fossil Boiler Water Chemistry Experiences and Challenges John Jevec (Babcock & Wilcox)
10:50	Break

Session 2: ***Fossil and Nuclear Boiler Operational Experience (continued)*** *(Chair: Ian Hey)*

11:20	Optimization of Sampling for Power Plants John Roberts (Bruce Power - consultant)
11:45	Progress in Monitoring and Chemistry Control in Power Plants Carl Turner (Atomic Energy of Canada Ltd)
12:10	**Lunch**

Session 3: ***Supercritical Water Chemistry*** *(Chair: Willy Cook)*

13:30	Metal Oxide Solubility and Speciation in Supercritical Water Power Stations Peter Tremaine (University of Guelph)
13:55	Studies of Supercritical Water Chemistry Alan Anderson (Saint Francis Xavier University)
14:20	Break

Session 4: ***Linking Boiler Corrosion and Water Chemistry*** *(Chair: Derek Lister)*

14:50	Low Temperature Corrosion by Sulfur Species Roger Newman (University of Toronto)
15:15	Sampling for Chemical Control: Pitfalls and Compromises Geoff Bignold (GJB Chemistry for Power Ltd)
15:40	**Wrap up Discussion:** Paul Spekkens (Ontario Power Generation)
16:00	Close of Symposium

Minutes

IAPWS Thermophysical Properties of Water and Steam WG

Niagara Falls, Canada, July 19-22, 2010

NOTE: These Minutes include some 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, July 19 at 10:10 by the TPWS Chair, Hans-Joachim Kretzschmar. The agenda (Attachment A) was adopted after minor additions (attachment reflects additions). The Chair noted that, in accordance with our new procedure, the 2009 Minutes had been circulated and approved with minor corrections shortly after the 2009 meeting. He also noted the achievement during the year of IAPWS formulations for seawater, ice, and "sea air" being adopted as IAPWS standards. He also recognized longtime WG member Wolfgang Wagner on his recent 70th birthday. Allan Harvey was appointed Clerk of Minutes for TPWS.

3. H.-J. Kretzschmar and M. Kunick demonstrated access to a password-protected website for documents and presentations of the TPWS and IRS Working Groups and the SCSW. The site is accessible from the Working Groups page on www.iapws.org.

4. J. Hruby discussed a proposed international collaboration with the group of Prof. Span on modeling CO_2 gas hydrate systems. A. Harvey discussed a proposed international collaboration with a group in the Russian Federation for measurements and modeling of thermal conductivity of the ammonia/water mixture. The Working Groups endorsed both proposals, making no recommendation on priority between the two.

5. (humid air with seawater & ice) R. Feistel reported on a proposed guideline for thermodynamic properties of humid air for use in oceanographic work. In the absence of K. Miyagawa, J. Hruby presented the Evaluation Report, which was favorable. After some discussion of the restricted scope of the title, it was decided to keep the title as proposed. With one abstention, **the WGs approved the Guideline on an Equation of State for Humid Air in Contact with Seawater and Ice, Consistent with the IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater.**

6. (IAPWS-IF97 editorial changes) (this item is reported in the IRS Minutes).

7. (IAPWS-95 editorial changes) W. Wagner reported on minor editorial changes for the IAPWS-95 thermodynamic property release document, adding a reference to IAPWS Advisory Note #1 which describes uncertainty in calculated enthalpies. **The WGs approved the editorial changes to the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use.**

8. (melting/sublimation) W. Wagner reported on a revision to the revised release on the melting and sublimation curves, to improve the estimate of the uncertainty which was too large near the triple point. **The WGs approved the revision of the Revised Release on the Pressure along the Melting and Sublimation Curves of Water. Because this revision was not done in time for advance circulation to the EC and the Editorial Committee, we request that the EC send this document to the Members for Postal Ballot in the coming year, following review by the Editorial Committee.**

9. (thermal conductivity) J. Sengers presented the proposed correlation for the thermal conductivity of ordinary water. In addition to the correlation for general and scientific use, there is a recommendation for industrial use that the same correlation be used, but with IAPWS-IF97 for the calculation of thermodynamic properties and the industrial version of the viscosity correlation to calculate that property. It was proposed and agreed that separate evaluations should be performed for the scientific and industrial versions. With that change, and one replacement for a member no longer able to serve, **the Evaluation Task Group will consist of R. Mareš (Chair, responsible for evaluation of scientific formulation), W. Parry (Co-Chair, responsible for evaluation of industrial formulation), J. Hruby, K. Miyagawa and K. Orlov. The initial evaluation should be completed by the end of 2010, with the tentative plan (potentially affected by the speed of evaluation and possible revision in response to evaluation) of being able to have Working Group approval at the 2011 IAPWS meeting, followed by a Postal Ballot.**

10. (industrial calculations) (this item is reported in the IRS Minutes).

11. (nucleation) J. Hruby reported for the Task Group on "Metastable Steam and Nucleation". **The membership of the Task Group will be J. Hruby (Chair), K. Yasuoka, and N. Okita**. This Task Group will modify the existing ICRN-15 on thermodynamic properties of metastable steam to include the possibility of calculation from molecular properties, and will work on a new ICRN on homogeneous nucleation of droplets from supersaturated steam and steam-inert gas mixtures. These should both be prepared for the 2011 IAPWS meeting. In the future, the scope of this Task Group may be expanded to include all metastable states of water.

12. R. Span presented the progress that had been made on items in ICRN-14 (on humid air and combustion gases) since the ICRN was first adopted in 2002. Many of the items have now been addressed. The bigger needs now are in somewhat related areas concerning carbon capture and sequestration (CCS) and possibly influence of dissociation on properties. The WG decided to take the following actions: **ICRN-14 will be allowed to expire in 2011. R. Span and A. Harvey will prepare a closing statement before the 2011 IAPWS meeting. Span and Harvey will draft a new ICRN on properties for CCS to be considered at the 2011 IAPWS meeting.**

13. (seawater) (these items are reported in the SCSW Minutes)

14-16. The 3 presentations as listed on the Agenda were given in a joint session with the Working Group PCAS.

17. (Uncertainties) R. Feistel reported on a method for deriving the uncertainty of quantities computed from thermodynamic potentials under the assumption of random errors in the input data used to fit the model.

18. (CIPM MRA) R. Feistel reported on the Mutual Recognition Arrangement that some agencies, such as the WMO, have signed with the CIPM. It was considered that IAPWS might be a candidate to enter into such an arrangement to strengthen our ties to metrology and the SI. **We request that this topic be added to the EC agenda.**

19.1. A. Harvey reported that there was no need to update the Fundamental Constants Guideline this year, but that there would probably be new recommended values of fundamental physical constants from CODATA to be incorporated next year.

19.2. A. Harvey and J. Cooper presented a revision of Advisory Note 2 to reflect documents approved and/or revised in 2009. **The updated Advisory Note 2 was approved, subject to possible additional editorial work by Harvey and Cooper.**

19.3. K. Orlov presented thoughts on the presentation of IAPWS releases, which are not always in a convenient form for programmers. He demonstrated the "live calculation" capability developed in Moscow which could be useful for verifying calculations on the Internet.

19.4. A. Harvey presented the proposed new structure for presenting documents on the IAPWS website, where Working Groups will be requested to supply brief descriptions and perhaps keywords. The WG was supportive of this redesign. Possibly there could be a link from this new page to the "live" tables, but this raises issues of the appearance of IAPWS connection to software which is an issue for the EC to decide.

19.5. H.-J. Kretzschmar reported on the availability from his institute of free steam tables for Excel and for pocket calculators. There have been 773 downloads of the Excel product since June 2009, and 995 downloads of pocket calculator software since the 2009 IAPWS meeting (and 3037 total for pocket calculators).

19.6. J. Cooper stated that there was nothing new to report regarding liaison with the IEC.

19.7. P. Spitzer reported on the joint WMO/BIPM meeting in Geneva earlier this year. In addition to signing the MRA (see Minute 18 above), there was a workshop on topics of mutual interest, mainly measurements related to atmospheres and oceans, including issues concerning salinity in the oceans where issues of traceability, consistency, and uncertainty were considered important.

19.8. R. Feistel reported on the joint conference TEMPMEKO and ISHM (International Symposium on Humidity & Moisture) held in Slovenia in May. IAPWS work on water and ice saturation pressures (and their uncertainties) is of great interest to the humidity community, and there is overlap with IAPWS interests in humid air properties for calculation of enhancement factors. R. Feistel will keep WG6 (humidity) of the CCT informed about relevant IAPWS work, and vice-versa. S. Rudtsch discussed the temperature scale and

thermometry, including the probable future redefinition of the kelvin in terms of the Boltzmann constant.

20. **The WG approved the addition of K. Orlov (Russia) to membership in TPWS. The following are removed from membership due to their request and/or lack of participation: Prof. Oguchi (Japan), Prof. Dittmann (Germany), and Prof. Schiebener (Germany).** The Chair of TPWS, Prof. Kretzschmar, announced his intention to step down at the conclusion of the 2011 meeting. The Vice-Chair, Dr. Harvey, stated his willingness to become Chair at that time. **It was voted to add an additional Vice-Chair for TPWS, Dr. J. Hruby, effective immediately.**

21. Regarding collaborative projects, M. Anisimov gave a brief report about the current IAPWS collaborative project on supercooled water, where a thermodynamically consistent description has been obtained of experimental data in supercooled water and of the likely liquid-liquid critical point. They are working to improve and extend the description to heavy water and to connect the results to water confined in nanopores.

Regarding the Mission Statement requested by the President, the following was agreed upon as an initial statement to bring to the EC, with the understanding that it would be subjected to further editing and work to harmonize with the mission statement of other Working Groups:

The mission of the Thermophysical Properties of Water and Steam Working Group is to develop recommended formulations for the thermophysical properties of water (in all its phases) and important water-containing mixtures as needed for scientific and industrial applications, and to encourage and facilitate research to improve knowledge of these properties.

22. The Chair and Clerk of Minutes were appointed to prepare the formal motion of the TPWS WG to the EC.

23. The meeting was adjourned at 4:58 PM on Thursday, July 22.

Agenda for the Working Group
Thermophysical Properties of Water and Steam (TPWS)
Niagara Falls, Canada. 18-23 July 2010

1. Opening Remarks; Adoption of Agenda
2. Appointment of Clerk of Minutes
3. Web Space OPAL for Working Material for WGs TPWS, IRS, and SC SW, joint with WG IRS and SC SW
4. Potential International Collaborative Projects
5. Guideline on an Equation of State for Humid Air in Contact with Seawater and Ice, Consistent with the IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater, joint with SC SW and WG IRS
   - Report (R. Feistel)
   - Test Report (K. Miyagawa, J. Hruby, V. Vins, V.F. Ochkov)
   - Formal consideration of the Guideline
6. Editorial Changes on the Revised Release on the Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam (IAPWS-IF97), joint with WG IRS and SC SW
   - Report (W. Wagner)
   - Test Report (K. Miyagawa)
   - Formal consideration of the Editorial Changes
7. Editorial Changes on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (IAPWS-95), joint with SC SW and WG IRS
   - Report (W. Wagner)
   - Test Report (K. Miyagawa)
   - Formal consideration of the Editorial Changes
8. Revision of the Revised Release on the Pressure along the Melting and Sublimation Curves of Water, joint with SC SW and WG IRS
   - Report (W. Wagner, R. Feistel)
   - Test Report (K. Miyagawa, A.H. Harvey)
   - Formal consideration of the Revision
9. Transport Properties of Water and Steam, joint with WG IRS and SC SW
   - Progress Report and Proposed Formulation on the Thermal Conductivity of H2O (J.V. Sengers, E. Vogel, R.A. Perkins, M.L. Huber, D.G. Friend, M.J. Assael, I.N. Metaxa)
10. Industrial Requirements and Solutions for Steam Property Calculations, joint with WG IRS
    - Report of the Task Group (H.-J. Kretzschmar, W.T. Parry)
    - Future of the Industrial Formulation (P. Murphy, GE)

11. Nucleation of Water from Supercooled Steam and Revision of ICRN-15 on Metastable Steam
    - Report of the Task Group (J. Hruby)

12. Properties of Humid Air and Humid Combustion Gases, joint with WGs IRS, PCAS, and SC SW
    - Revision of ICRN-14 on Thermophysical Properties of Humid Air and Combustion-Gas Mixtures (R. Span, A.H. Harvey)

13. Properties of Seawater (R. Feistel), joint with SC SW and WG IRS
    - 13.1 Task Group Report "Oceanographic Standards" (T.J. McDougall, R. Feistel)
    - 13.2 Implementation of the "TEOS-10 SIA Library" (D.G. Wright, R. Feistel)
    - 13.3 Task Group Report "Industrial Requirements" (M. Hiegemann, J. Bellows, H. Glade)
    - 13.4 Task Group Report "Advisory Note on Industrial Formulation" (J. Cooper)
    - 13.5 Task Group Report "Transport Properties"
        - Development of a model for calculating thermal conductivity of seawater (A. Anderko)
        - The accuracy of electrical conductivity models when applied to natural waters (R. Pawlowicz)
    - 13.6 Recent Measurements of Seawater Properties (R. Feistel, J. Safarov, F.J. Millero)
    - 13.7 Renewal of ICRN 16 on Thermophysical Properties of Seawater (R. Feistel)

14. Scaled Formulation of Self-diffusion Coefficients for Water over a Wide Range of Density and Temperature in Including the Supercritical (M. Nakahara), joint with PCAS

15. The Phase Diagram of Water with Various Models (S. Yoo, Pacific Northwest National Laboratory), joint with PCAS

16. Surface Tension of Water with Rigid Models (K. Yasuoka), joint with PCAS

17. Uncertainty of Properties Derived from Thermodynamic Potentials, joint with SC SW
    - Report (R. Feistel)

18. CIPM Mutual Recognition Arrangement – to be recognized by IAPWS?, joint with SC SW
    - Report (R. Feistel, P. Spitzer)

19. Reports on Other TPWS Activities
    - 19.1 Guideline on Fundamental Constants (A.H. Harvey), joint with WG IRS and SC SW
    - 19.2 Update of Advisory Note # 2: Roles of Various IAPWS Documents (J.R. Cooper, A.H. Harvey), joint with WG IRS and SC SW
    - 19.3 A question about IAPWS formulations representation (K.A. Orlov, V.F. Ochkov), joint with WG IRS
    - 19.4 Web presentation of Releases, etc. (A.H. Harvey), joint with WG IRS and SCSW
    - 19.5 Steam Tables for Excel® and Pocket Calculators for Education on the IAPWS Website (H.-J. Kretzschmar), joint with WG IRS
    - 19.6 Liaison with IEC (J.R. Cooper), joint with WG IRS
    - 19.7 Report on the WMO/BIPM meeting in Geneva, April 2010 (P. Spitzer, R. Feistel), joint with SC SW
    - 19.8 Report on the Tempmeko & ISHM Conference in Portorož, June 2010 (S. Rudtsch, J. Fischer, R. Feistel), joint with SC SW
20. Membership
21. Other Business
    - Report on International Collaborative Projects
    - Future Directions and Mission of TPWS
22. Preparation of the Formal Motion to the EC
23. Adjournment

July 22, 2010

H.-J. Kretzschmar (Chair) and A.H. Harvey (Vice-Chair)

Minutes of meeting of working group
Industrial Requirements & Solutions (IRS)

Niagara Falls, Canada, 18-23 July 2010

Remark: Most of the IRS meetings were held as joint meetings with TPWS (marked by *). Of these joint meetings the IRS minutes cover the topics chaired by the IRS chairman.

1. Opening Remarks; Adoption of Agenda

Chairman W. Parry welcomed the WG members to Niagara Falls. The agenda was adopted with slight adjustments.

2. Appointment of Clerk of Minutes

P. Murphy was appointed clerk of minutes.

3. Web Space for Working Material for WGs TPWS, IRS, and SC SW *

See TPWS minutes.

4. Potential International Collaborative Projects. *

See TPWS minutes.

5. Guideline on an Equation of State for Humid Air in Contact with Seawater and Ice, Consistent with the IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater. *

See TPWS minutes.

6. Editorial Changes on the Revised Release on the Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam (IAPWS-IF-97).

Dr. Wagner presented a brief history of the current Industrial Formulation, IF-97, followed by a discussion on the range of validity between 273.15 K and 273.16 K. Dr. Wagner then showed that the current description of this region is not correct and proposed new wording. Dr. Wagner then stated that the current Release does not give guidance on the estimate of uncertainties of specific enthalpy, and proposed adding a new sentence to the end of the subsection. J. Hruby presented K. Miyagawa's test report accepting the proposed changes. The WG unanimously voted to recommend to the EC that the editorial changes be adopted.

7. Editorial Changes on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (IAPWS-95. *

See TPWS minutes.

8. Revision of the Revised Release on the Pressure along the Melting and Sublimation Curves of Water. *

See TPWS minutes.

9. Transport Properties of Water and Steam. *
See TPWS minutes.

10. Industrial Requirements and Solutions for Steam Property Calculations.

H.-J. Kretzschmar presented required industrial formulations for both thermodynamic and transport properties. H.-J. Kretzschmar then gave a quick update on the development of steam table look-up methods. P. Murphy then gave a presentation on the future of the industrial steam properties. P. Murphy showed a brief history of the industrial steam properties and the changing needs of industry. P. Murphy showed the increasing use of CFD in industrial analyses, along with the need for steam tables in current CFD analysis. He also showed the lack of standards (both the steam tables and the interpolation routines) in the use of steam tables in CFD analysis. He then presented that there is a lack of industrial requirements for speed, accuracy, consistency of steam table methods. Once the industrial requirements are known then, assessments can be made of different steam table sizes and interpolation routines.

During these presentations, discussions on the following took place:

1. Need for D_2O industrial properties. W. Parry agreed to talk to the Canadian delegation about the industrial needs for D2O properties.
   W. Parry talked with P. Tremaine concerning the need for an industrial formulation for D2O. P. Tremaine felt that an industrial formulation for D_2O was not necessary, but an improved scientific formulation for D2O to replace the present formulation would be desirable.
2. Prioritization of the industrial requirements.
3. Need for the industrial requirements for speed, accuracy, and consistency new fast calculation of steam properties using steam lookup tables. This new fast method would have application in CFD calculations.
4. Industrial requirements for dependent and independent variables in new fast calculation method using steam lookup tables.

For items 2 through 4, it was decided that an industrial survey is needed to determine these requirements.

11. Nucleation of Water from Supercooled Steam and Revision of ICRN-1 5 on Metastable Steam.*
See TPWS minutes.

12. Properties of Humid Air and Humid Combustion Gases. *
See TPWS minutes.

13. Properties of Seawater. *
See TPWS minutes.

14. Reports on Other IRS Activities. *
See TPWS minutes.

15. Membership -- Appointment of New Chair

I. Weber was elected new chairman of IRS, replacing W. Parry. N. Okita was elected new vice-chairman, replacing I. Weber. These changes take effect at the conclusion of the annual meeting.

P. Murphy, A. Novy, M. Hiegemann were elected as members of the WG

The Japanese National Committee informed IRS that their member, Mr. Oguchi has retired from their committee, and recommended to conclude his membership in Working Group IRS.

16. Other Business

Mission Statement

It was decided that the mission statement for the WG should be:

> **To identify and prioritize industrial requirements for water, steam, aqueous systems and work with other IAPWS working groups to deliver solutions which meet them.**

Industrial Survey Task Group

A task group was set up to determine the list of companies to include in an industrial survey to determine industrial needs and requirements, develop the industrial survey, develop IAPWS material to send with the survey, send the survey to the identified companies and to the national committees. This task group includes: W. Parry (Chair), B. Rukes, M. Hiegamann, A. Novy, N. Okita, J. Cooper, and P. Murphy.

ICRN #23 – Dew Point of Combustion Gases

N. Okita gave an update on ICRN #23. There is a new dew point equation in the ASHRAE handbook, published 2009. This equation gives a different result that the Japanese handbook. A new equation for the dew point of combustion gases was published in the Oil& Gas Journal in September 2009. N. Okita will investigate this new information as soon as possible; if the ICRN needs to be revised, he will prepare a revised document for the next IAPWS meeting.

Industrial Requirements and Solutions for Steam Property Calculations Task Group

P. Murphy and M. Kunick have been added as members of this task group.

Advisory Note Task Group

Investigate whether the current system of advisory notes is sufficient to ensure that IAPWS formulations are used correctly. This task group will include W. Parry (chair), B. Rukes, M. Hiegemann.

17. Preparation of the Report to the EC

Chairman W. Parry and the Clerk of the Minutes, P. Murphy prepared the report to the EC.

18. Adjournment

W. Parry closed the IRS meeting.

Minutes

IAPWS Subcommittee on Seawater (SCSW)

Niagara Falls, Canada, July 19-22, 2010

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

1. The meeting was opened on Monday, July 19 by the SCSW Chair, Rainer Feistel. The agenda (Attachment A) was adopted after minor additions (attachment reflects additions). The Chair gave a brief appreciation of the life and contributions of Dan Wright, a member of the SCSW who had died earlier in July. This was followed by a moment of silence.

2. Allan Harvey was appointed Clerk of Minutes for SCSW.

3. (included as item #3 in TPWS Minutes)

4. (humid air with seawater & ice) (included as item #5 in TPWS Minutes)

5. (IAPWS-IF97 editorial changes) (included as item #6 in TPWS Minutes)

6. (IAPWS-95 editorial changes) (included as item #7 in TPWS Minutes)

7. (melting/sublimation) (included as item #8 in TPWS Minutes)

8. (thermal conductivity) (included as item #9 in TPWS Minutes)

9. (humid gases) (included as item #12 in TPWS Minutes)

10.1. On behalf of T. McDougall, R. Feistel reported on the status of the new oceanographic standards that IAPWS has been involved in. The suite of formulations known as TEOS-10 has been adopted by the International Oceanographic Commission, and the manual has been published along with articles describing the formulations and their implementation. Details are available at www.TEOS-10.org.

Since the time period for the SCOR/IAPSO Working Group WG127 will expire soon, the question arises about long-term coordination and cooperation in these activities. Additional areas for cooperation include metrological traceability to the SI, development of a dynamic salinity model, and uncertainties. **A letter is being drafted from IAPWS to the Presidents of IAPSO and SCOR inviting continuing cooperation in some form of a joint task group.**

10.2. **It was voted to add T. McDougall as an additional Vice-Chair for SCSW, effective immediately.**

10.3. On behalf of D. Wright, R. Feistel summarized the implementation of the TEOS-10 SIA (Seawater, Ice, Air) library. Two papers describing this have been published in *Ocean Science*.

10.4. M. Hiegemann (with contributions from H. Glade who was not present) reported on industrial requirements for seawater properties in desalination (by membrane and two distillation procedures), in power station cooling, and LNG evaporation. To meet the needs of these industries, the current IAPWS seawater formulation has an insufficient range in some cases (particularly in temperature). Temperature requirements may reach 120 °C, and to allow for future developments it would be desirable for temperatures up to 150 °C to be covered. Salinities may go to 70, but it would be desirable to have values covered to 100. Pressures are not so high compared to oceanographic conditions. Some initial thoughts were presented about desired accuracy in properties; uncertainty of 0.1% in the saturation pressure-temperature relationship was singled out as especially desirable. There are probably not major speed requirements. Requirements may also exist for description of osmotic pressure and surface tension. It was decided that more clarity on the requirements from industry are needed before a new formulation can be pursued.

10.5. J. Cooper reported that no progress had been made on the Advisory Note describing the use of IAPWS-IF97 in industrial calculations with seawater within the limits of validity of the current seawater formulation (which will exclude some applications). **This document should now be prepared on a schedule allowing for approval at the 2011 IAPWS meeting. The members of the Task Group for this (from the 2009 Minutes) are Cooper (Chair), Feistel, and Hiegemann, with authorization for one more industrial member to be added later by agreement of the existing members. An Evaluation Task Group consists of Hruby (Chair), Mareš, and Miyagawa.**

10.6. A. Anderko presented his work with P. Wang on modeling the thermal conductivity of seawater. The results are good for well-defined systems; the limited data available for seawater are scattered and sometimes not physically reasonable. **The Task Group on Transport Properties appointed in item 6 of the 2009 SCSW minutes was encouraged to continue toward developing a final formulation (to become an IAPWS Guideline), interacting with the effort to produce a new pure-water thermal conductivity correlation so that the new seawater correlation will meet this pure-water limit.**

R. Pawlowicz presented his modeling of the electrical conductivity of natural waters and seawater. While for seawater the model is not nearly as accurate as good conductivity measurements, it may be possible to use the model to look at composition variations. In combination with existing measurements of seawater conductivity, **a progress report on the work on a future IAPWS formulation on the electrical conductivity of seawater is intended to be prepared for 2011 by the task group**.

10.7. R. Feistel presented a summary of some new experimental data for density of seawater (some of which are outside the range of validity of the seawater release, extending up to 195 °C). A publication with complete description of the work is needed before we can assess the usefulness of this work in extending the Gibbs function of seawater. With regard to

extending the range of available data, it was mentioned that some heat-capacity data are forthcoming, and that speed-of-sound data would be desirable.

10.8. ICRN-16 on thermophysical property needs for seawater was discussed. R. Feistel presented some minor suggested updates. It was suggested that some numbers in the ICRN should change to reflect the report in Minute 10.4 above. J. Cooper and M. Hiegemann were appointed to review the document and make any necessary adjustments. These adjustments were made, and **the revised ICRN-16 was approved by the Subcommittee, with new expiration date of 2013**.

10.9. P. Spitzer (with input from S. Seitz who was not present) gave a progress report from the Task Group "Traceability of Salinity." There is work in progress to use standard seawater to calibrate conductivity sensors, and to correlate accurate density measurements with the salinity.

10.10. G. Marion presented a summary of different conventions for defining pH and for extracting pH from measurements (including the "total" scale for seawater work that includes other ions), and discussed their effects for seawater and other aqueous electrolyte solutions. It was pointed in discussion out that IUPAC has established a standard definition, and that it might be useful to distinguish between the thermodynamic definition and various conventions for realizing that definition. There is also interest in pH in the PCAS WG, and Dr. Marion was encouraged to discuss the issue with PCAS members.

10.11. Regarding the Mission Statement requested by the President, the following was agreed upon as an initial statement to bring to the EC, with the understanding that it would be subjected to further editing and work to harmonize with the mission statement of other Working Groups:

Intended for application in oceanography, marine technology and industry, it is the aim of the IAPWS Subcommittee on Seawater to develop new and to improve existing formulations on thermophysical properties of seawater, including physical and chemical properties of related ambient substances such as ice, humid air and seawater solutes.

11. (uncertainties) (included as item #17 in the TPWS Minutes)

12. (CIPM MRA) (included as item #18 in the TPWS Minutes)

13.1-13.3 (included under item 19 of the TPWS Minutes)

13.4. R. Pawlowicz gave a presentation about standardization of nomenclature for salinity and salinity anomalies, where the many different definitions and notations in use cause some differences that can be significant in some contexts. A paper describing these issues has been submitted to Ocean Science.

13.5. F. Millero presented on seawater anomalies in the oceans, with effects due to $CaCO_3$ and silica from organisms and possible effects of dissolved organic carbon (DOC). New data will be forthcoming in the coming years.

13.6. R. Feistel presented on seawater anomalies in the Baltic Sea, where he modeled anomalies in terms of the Gibbs function and the electrical conductivity. The anomalies do not significantly affect most thermophysical properties, but they can be significant (compared to measurement uncertainties) for the density and the speed of sound.

13.7. P. Spitzer presented on a European metrology research project getting underway on "Metrology for Oceanic Salinity and Acidification." Topics of the proposed work packages include density, sound speed, and salinity.

13.8, 13.9 (included under item 19 of the TPWS Minutes)

14. **It was voted to accept R. Pawlowicz (University of British Columbia, Canada) to membership in SCSW.**

15. There was no additional business presented.

16. The Chair and Clerk of Minutes were appointed to prepare the formal motion of the TPWS/IRS WGs to the EC.

17. The meeting was adjourned at 4:58 PM on Thursday, July 22.

Preliminary Agenda
IAPWS Subcommittee on Seawater SC SW
Niagara Falls, Canada. 18-23 July 2010

1. Opening Remarks; Adoption of Agenda
2. Appointment of Clerk of Minutes
3. Web Space for Working Material for WGs TPWS, IRS, and SC SW, joint with WG TPWS
4. Guideline on an Equation of State for Humid Air in Contact with Seawater and Ice, Consistent with the IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater, joint with WGs TPWS, IRS
   - Report (R. Feistel)
   - Test Report (K. Miyagawa, J. Hruby, V. Vins, V.F. Ochkov)
   - Formal consideration of the Guideline
5. Editorial Changes on the Revised Release on the Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam (IAPWS-IF97), joint with WGs TPWS and IRS
   - Report (W. Wagner)
   - Test Report (K. Miyagawa)
   - Formal consideration of the Editorial Changes
6. Editorial Changes on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (IAPWS-95), joint with WGs TPWS and IRS
   - Report (W. Wagner)
   - Test Report (K. Miyagawa)
   - Formal consideration of the Editorial Changes
7. Revision of the Revised Release on the Pressure along the Melting and Sublimation Curves of Water, joint with WGs TPWS and IRS
   - Report (W. Wagner, R. Feistel)
   - Test Report (K. Miyagawa, A.H.Harvey)
   - Formal consideration of the Revised Release
8. Transport Properties of Water and Steam, joint with WGs TPWS and IRS
   - Progress Report on the Thermal Conductivity of H_2O (J.V. Sengers, E. Vogel, R.A. Perkins, M.L. Huber, D.G. Friend, M.J. Assael, I.N. Metaxa)
9. Properties of Humid Air and Humid Combustion Gases, joint with WGs TPWS, IRS and PCAS
   - Revision of ICRN-14 on Thermophysical Properties of Humid Air and Combustion-Gas Mixtures (M. Wendland, R. Span, A.H. Harvey)
10. Properties of Seawater, joint with WGs TPWS and IRS

10.1 Task Group Report “Oceanographic Standards” (T.J. McDougall, R. Feistel)

10.2 Change of the Vice Chair of SC SW

10.3 Implementation of the "TEOS-10 SIA Library" (D.G. Wright, R. Feistel)

10.4 Task Group Report "Industrial Requirements" (M. Hiegemann, J. Bellows, H. Glade)

10.5 Task Group Report "Advisory Note on Industrial Formulation" (J. Cooper)

10.6 Task Group Report "Transport Properties", joint with WG PCAS

- Development of a Model for Calculating Thermal Conductivity of Seawater (A. Anderko)
- The Accuracy of Electrical Conductivity Models when Applied to Natural Waters (R. Pawlowicz)

10.7 Recent Measurements of Seawater Properties (R. Feistel, J. Safarov, F.J. Millero)

10.8 Renewal of ICRN-16 on Thermophysical Properties of Seawater (R. Feistel)

10.9 Task Group Report "Traceability of Salinity" (S. Seitz, H. Wolf)

10.10 Task Group Report "pH Values" (G. M. Marion, F. Camoes)

10.11 Mission Statement of SC SW

11. Uncertainty of Properties Derived from Thermodynamic Potentials
    - Report (R. Feistel)

12. CIPM Mutual Recognition Arrangement – to be recognized by IAPWS?
    - Report (R. Feistel, P. Spitzer)

13. Reports on Other SC SW Activities

13.1 Guideline on Fundamental Constants (A.H. Harvey) joint with WGs TPWS, IRS

13.2 Update of Advisory Note # 2: Roles of Various IAPWS Documents (J.R. Cooper, A.H. Harvey), joint with WGs TPWS, IRS

13.3 Web presentation of Releases, etc. (A.H. Harvey), joint with WGs TPWS, IRS

13.4 Standard Nomenclature of Salinities and Anomalies (D.G. Wright, R. Pawlowicz)

13.5 Seawater Anomalies in the Ocean (F.J. Millero, T.J. McDougall)

13.6 Seawater Anomalies in the Baltic Sea (R. Feistel, R. Pawlowicz)

13.7 Metrology for Oceanic Salinity and Acidification - a Selected Research Topic within the European Metrology Research Programme (P. Spitzer)

13.8 Report on the WMO/BIPM Meeting in Geneva, April 2010 (P. Spitzer, R. Feistel) joint with WG TPWS

13.9 Report on the Tempmeko & ISHM Conference in Portorož, June 2010 (R. Feistel, S. Rudtsch) joint with WG TPWS

14. Membership

15. Other Business

16. Preparation of the Formal Motion to the EC

17. Adjournment

21 July 2010, R. Feistel (Chair)

2010 IAPWS Annual Meeting
Niagara Falls, Canada

PCAS WG Minutes

Present: Masaru Nakahara (chair), Andre Anderko (vice chair, clerk of minutes), Mikhail Anisimov, Francis Brosseau, Jana Ehlerova, David Guzonas, Milan Sedlar, Peter Tremaine, Masakatsu Ueno

Monday, July 19, morning

1. **Opening remarks.** Masaru Nakahara made opening remarks. Andre Anderko was appointed clerk of minutes. Masaru Nakahara presented the meeting agenda, which was previously distributed by e-mail (PCAS Appendix A). The agenda has been adopted unchanged.

2. **Minutes of the 2009 Meeting** in Doorwerth were adopted as written.

3. **IAPWS Interntional Collaboration.** Mikhail Anisimov has indicated his intention to propose an international collaboration between his group at the University of Maryland (USA) and the group of Alexei Victorov at the St. Petersburg University (Russia) in the area of self-assembly of small molecules. A formal proposal is planned to be presented next year.

4. **Existing ICRNs.** The group discussed the ICRNs that were associated with previous activities.

   ICRN 17 (Research on Amines in the Power Industry)**.** Peter Tremaine suggested creating group contributions for high-temperature amines. Masaru Nakahara indicated that distributing partial molar properties for amines up to 300 °C would be useful.

   ICRN 21 (Thermophysical Properties Associated with Ultra Supercritical Coal-Fired Steam Generators).

   ICRN 22 (Steam Chemistry in the Turbine Phase Transition Zone). This ICRN is to be reviewed jointly with PCC

   ICRN 26 (Behavior of Aluminum in the Steam Water Cycle of Power Plants). This is a new proposal originating in PCC. The group discussed whether there was practical interest in aluminum in supercritical water. David Guzonas indicated that there was interest in accident containment scenarios. Al is used in pipe insulation and cladding.

ICRN 25 (Corrosion Mechanisms That Are Related to the Presence of Contaminants in Steam/Water Circuits, Particularly in Boiler Water). Peter Tremaine and Andre Anderko expressed support for this line of research.

ICRN 10 (pH Measurements and Potentiometric Studies of Supercritical Aqueous Solutions). This ICRN is up for renewal. Peter Tremaine expressed interest in moving the pH definition to molality to avoid single-ion activities. Peter Tremaine plans to look at this ICRN and rewrite it.

The group decided to analyze the ICRN documents and to conduct a further discussion related to ICRN's on Thursday.

5. **Releases.** No releases are currently worked.

6. **Membership.** David Guzonas became a member of PCAS. Masaru Nakahara raised the issue of membership of persons who have not participated in the activities of PCAS for a long time. Andre Anderko suggested sending out an e-mail with an inquiry whether they wish to participate. Masaru Nakahara expressed his plan to discuss this issue with other working group chairmen and finalize the policy by Thursday.

7. **Guidelines.** Masaru Nakahara opened discussion on creating a guideline on the basis of the IAPWS/IUPAC project "Establishing Recommended Data on Thermodynamic Properties of Hydration for Selected Organic Solutes and Gases" (Josef Sedlbauer, project coordinator). Originally, this project was supposed to result in the publication of a book. However, these plans have been changed and a new method of disseminating the results needs to be established. Jana Ehlerova presented some options regarding the publication of the results. They include an Excel format or a web-based application. Also, a report is scheduled for September. Jana Ehlerova distributed the current version of the report in an electronic form. Further discussion has been deferred until Thursday so that the members have time to familiarize themselves with the report.

Tuesday, July 20, morning

PCAS Workshop

The following presentations were given in the PCAS workshop:

1. Jana Ehlerova: Establishing Recommended Data on Thermodynamic Properties of Hydration for Selected Organic Solutes and Gases

Jana explained the project goals, timetable, rationale, and outlined the approach taken. She discussed the evaluation of the primary data. Over 5000 data points were retrieved from the literature. A database of recommended hydration properties for about 150 compounds was produced at 25 C, 0.1 MPa. The work is still unfinished, with about ½ of the compounds yet to be checked for consistency.

The question was raised as to what the output for IAPWS was to be, e.g., guidelines. A journal paper is almost completed. A brief update on the project budget was given – there have been no expenses claimed yet, and there is 8000 euro left. The expenses for the two young scientists will be claimed at the end of the project. There was a discussion on how the high temperature data will be reported. It was suggested that all the high temperature data be included, including the uncertainties. There was a question raised about the relationship between IAPWS and IUPAC on this work, and it was explained that a fraction of the budget was provided by each group.

2. Mikhail Anisimov: Can small molecules self-assemble in aqueous solutions

The types of molecules being considered were molecules like 3-methylpyridine and t-butanol. The results of dynamic light scattering showed unexpected behaviour, suggesting the formation of mesoscopic structures. It was noted that TBA is that last alcohol that is miscible with water. There have been anomalies reported for about 40 years – these have not yet been explained but there is evidence that impurities or gas bubbles may play a role. So the question arises as to whether the observed effects are real or artefacts, and are they genuine equilibrium structures or long-lived non-equilibrium structures? The question was raised as to whether this phenomenon can be used to create new materials.

3. Masakatsu Ueno: Electric Conductivities of 1:1 Electrolytes in High-Temperature Ethanol Along the Liquid-Vapor Coexistence Curve

There was a brief discussion of the density effect on transport properties; in low density solvents, transport is dominated by binary collisions whereas in high density solvents many-body effects dominate. Alcohols were chosen as the model solvent because water is complicated because of hydrogen. While alcohols are also hydrogen bonded, they are less so than water. The concept of dielectric friction was discussed and models were presented. It was found that non-hydrodynamic effects in EtOH and MeOH are well explained by HO theory at higher density, but at lower density limitations are observed. There was a discussion of other models for conductivity and there application to these data.

4. Milan Sedlar: Homogeneous Nucleation during Cavitation Processes

There was a brief introduction to sources of cavitation nuclei in water during cavitation. He pupose of the project was to create a model of the processes for incorporation into CFD codes. The concept of the critical nucleation work was explained, and the details of developing a model outlined. There was a discussion on the difficulties in incorporating such a model into CFD codes. There was some discussion on how easy it might be to extend the model to higher temperatures; the current focus was on low temperature applications. However, there was no obvious impediment to extending this to higher temperatures.

5. Francis Brosseau: Activity Transport Models for CANDU-6 Pressurized Heavy Water Reactors.

   The title study has been carried out to extend the previous work done by Peter Tremaine and co-workers. The reaction conditions examined are extened up to 550-600°C and 25-30 MPa.

6. Peter Tremaine: Deuterium Isotope Effects on Acid Ionization

   The solvent isotope (D_2O/H_2O) effect on the ionization constants has been discussed in relation to the substances used in the CANDU reactor. The importance of the zero-point energy difference has been pointed out.

Tuesday, July 20, afternoon

Joint PCC/PCAS Workshop

The first part of the workshop was devoted to the presentation of proposed ICRNs. The following two ICRNs were introduced at the workshop:

a. Jeff Bignold: **ICRN 25** (Corrosion Mechanisms That Are Related to the Presence of Contaminants in Steam/Water Circuits, Particularly inoiler Water)

b. Robert Svoboda: **ICRN 26** (Behavior of Aluminum in the Steam Water Cycle of Power Plants).

In the second part of the workshop, the following three presentations have been made:

1. Hiroshi Takaku: Combined Effect of Chloride and Sulfate Ions

2. Andre Anderko: Thermodynamic Modeling of High-Temperature Aqueous Chemistry in Power Plant Environments

3. Masaru Nakahara: Carbon Dioxide Fixation and Hydrogen Storage and Transportation in the Form of Formic Acid

PCAS Workshop - continued

One presentation was made after the end of the joint PCC/PCAS workshop:

1. David Guzonas: Corrosion in Supercritical Water-Cooled Reactor

Guidelines - continued

Discussion resumed on the guideline resulting from the project "Establishing Recommended Data on Thermodynamic Properties of Hydration for Selected Organic Solutes and Gases". Masaru Nakahara reported that he had discussed the format for the guideline with Allan Harvey, who will provide detailed feedback. Peter Tremaine indicated that it would desirable to publish high-temperature data in addition to the publication that is tentatively planned to be submitted to Chemosphere. The group concurred.

Thursday, July 22, morning and afternoon

Joint Workshop of TPWS, SCSW, and PCAS

The following presentations were given at workshop:

1. Soohaeng Yoo: The Phase Diagram of Water with Various Models

2. Kenji Yasuoka: Surface Tension of Water with Rigid Models

3. Masaru Nakahara: Scaled Formulation of self-Diffusion Coefficients for Water Over a Wide Range of Density and Temperature Including the Supercritical"

Following the joint workshop, discussions resumed within the PCAS group.

Press Release. Masaru Nakahara conveyed Jim Bellows' request to provide him with a contribution to the press release. The group decided that the press release should describe the project "Establishing Recommended Data on Thermodynamic Properties of Hydration for Selected Organic Solutes and Gases", which is nearing completion. Subsequently, Jana Ehlerova and Andre Anderko formulated the PCAS contribution to the press release.

ICRNs. Discussion of ICRNs was resumed.

ICRN 26. David Guzonas provided background information on the importance of aluminum chemistry. Accordingly, the results of ICRN would also be of value to the nuclear industry, in particular in clarifying the behavior of aluminum in post-LOCA (Loss of Coolant Accident) containment sump water interactions of aluminum hydroxide or oxyhydroxide on ion-exchange resins. Peter Tremaine moved to approve the ICRN and the rest of the group concurred. David Guzonas a Peter Tremaine proposed adding a friendly amendment to mention additional application areas as described here.

ICRN 20 on sensors. Masaru Nakahara stated that this ICRN expired but there was interest in PCC in renewing it. The group decided to agree with the changes proposed by PCC.

ICRN 10 on pH. David Guzonas raised a question whether this subject is of practical importance and indicated that the topic is too narrow. Peter Tremaine recommended sending it to PCC with a request to identify broader applications or, absent any changes, close it. The group concurred.

ICRN 25. Andre Anderko indicated that this topic is of great importance and is definitely worth investigating. However, Peter Tremaine and Andre Anderko stated that this ICRN does not have a sufficient focus and looks like a project vision for decades of research. The group recommends sending it back to PCC with a recommendation to put more focus so that it is not an open-ended project.

Mission Statement. Peter Tremaine drafted a mission statement in response to a general request that the working groups prepare/update their mission statements. The group introduced minor modifications and approved the draft. Masaru Nakahara will submit it to the Executive Committee.

PCAS Mission Statement 2010

1) To provide critically evaluated thermodynamic and transport property data for solutes and interfaces in high-temperature high-pressure aqueous solutions, of interest to the electric power industry and other industrial applications.
2) To develop new experimental techniques and modeling methods needed to obtain key thermodynamic transport property data for high temperature aqueous solutions and interfaces relevant to the IAPWS mission.

Finalizing the guideline. Masaru Nakahara reiterated the need to develop a schedule for finalizing the project on hydration. Jana Ehlerova indicated that the low-temperature part will be finished in September and the schedule for the high-temperature part has not been decided yet. Further inquiries will be forwarded to Josef Sedlbauer.

Future of PCAS. The future of PCAS was discussed. The low turnout at PCAS meetings remains a concern. Peter Tremaine proposed considering converting PCAS to a subcommittee and/or holding only joint workshops with other working groups. Andre Anderko indicated that the current model of presenting the majority of talks in joint workshops is a step in the right direction but more focus is needed. Masaru Nakahara indicated that it is desirable to preserve a separate PCAS workshop. This is partially due to the fact that PCAS's mission is to solve fundamental problems, which differentiates it from the other groups. For future ICRNs, Milan Sedlar indicated that he is going to prepare, jointly with Frantisek Marsik, an ICRN in the area of nucleation.

Adjournment. The meeting adjourned at 3:20pm.

The International Association for the Properties of Water and Steam
http://www.iapws.org

Physical Chemistry of Aqueous Systems Working Group (PCAS WG)

Schedule

Niagara Falls, Canada, 18 – 23 July, 2010

Sun 18	19:00	Informal Get-together, Cocktails and Registration
Mon 19	08:30	Opening Plenary Session - Executive Committee
	10:00	PCAS WG Meeting a) *Opening.* b)*Clerk.* c)*Approval of Previous Minutes*. d)*International Collaboration*
	13:30	PCAS WG Meeting e)*ICRN*. f)*Release*. g)*Membership*. h) *"Hydration Project" by Sedlbauer, Guideline*.
Tue 20	08:30	PCAS Workshop on "Basic Solution Chemistry and Physics Useful for Power Cycle Applications"
	1)	Jana Ehlerova instead of Josef Sedlbauer. The Joint IUPAC/IAPWS project. Establishing Recommended Data on Thermodynamic Properties of Hydration for Selected Organic Solutes and Gases.
	2)	Mikhail Anisimov. Self-Assemby of Small Molecules in Aqueous Solution.
	3)	Masakatsu Ueno. Electric Conductivities of 1:1 Electrolytes in High-Temperature Ethanol along the Liquid-Vapor Coexistence Curve. NaBr, KBr, and CsBr.
	4)	Milan Sedlar. Nucleation in Water during Cavitation Processes.
	5)	Dave Guzonas and Peter Tremaine. Activity Transport Models for CANDU-6 Pressurized Heavy Water Reactors.
	11:00	PCAS Task Group Meeting i)*Organics in Hot Water*. j)*Inorganics in Hot Water*
	1)	Peter Tremaine. Deuterium Isotope Effects on Acid Ionization Constants under Hydrothermal Conditions.
	2)	Francis Brosseau and Peter Tremaine. Critical Evaluation of Iron and Nickel Thermochemical Data under Hydrothermal Conditions, and Extrapolations to Supercritical Conditions.

13:30 PCC/PCAS Joint WG Meeting
– ICRNs: ICRNs 17, 21, 22, 25, and ICRN on Aluminum, …
– Workshop on "Solution/Interface Chemistry and Engineering"??
- Many Talks Other than Those Listed below
- Andre Anderko. Thermodynamic Modeling of High-Temperature Aqueous Chemistry.
- Masaru Nakahara. Carbon Dioxide Fixation and Hydrogen Storage and Transportation in the Form of Formic Acid.

15:30 PCAS WG Meeting
- ICRNs 17, 21, and 22 (approved)
- ICRN 25: Corrosion mechanisms that are related to the presence of contaminants in steam/water circuits, particularly in boiler-water.

ICRN 26: **Behavior of Aluminum in the Steam Water Cycle of Power Plants**

Wed 21 09:00-17:00 IAPWS Symposium

Thu 22 08:30 TPWS/SCSW/PCAS Joint WG Meeting
– Revision of ICRN-14 on Thermophysical Properties of Humid Air and Combustion-Gas Mixtures (M. Wendland, R. Span, A. H. Harvey)
– Contributed from the Molecular Simulation Task Group

1) Soohaeng Yoo, Pacific Northwest National Laboratory (USA). The Phase Diagram of Water with Various Models
2) Kenji Yasuoka, Keio University (Japan). Surface Tension of Water with Rigid Models
– Properties of Sea Water: Task Group Report "Transport Properties"
- Many Talks Planned Other than Those Listed below
- Andrei Anderko. Development of a Model for Calculating Thermal Conductivity of Seawater.
– Self-Diffusion of Water
- Masaru Nakahara. Scaled Formulation of Self-Diffusion Coefficients for Water over a Wide Range of Density and Temperature Including the Supercritical.

13:30 PCAS WG Meeting Summary
15:30 PCAS Report to Executive Committee

18:30 IAPWS Banquet

IAPWS Working Group Power Cycle Chemistry (PCC)

Minutes of IAPWS PCC WG Meetings
Niagara Falls, Canada, 19-22 July 2010.

Chairman: Robert Svoboda
Members present See PCC Attachment A

Agenda

Amendments / Adoption of Agenda

There were no amendments to the draft agenda.

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

R. Svoboda summarized the schedule. The workshops program is listed in Attachment B.

Appointment of Clerk of Minutes

G. Bignold agreed to act as Clerk of Minutes.

Approval of Minutes of PCC WG in Doorwerth, The Netherlands, 2009

The minutes were approved without any corrections.

Progress Reports on PCC Activities 2009 / 2010

International Collaboration

D. Lister reported continuing progress with the international collaboration on sampling. The appointed student from Japan had spent an initial two-week period at University of New Brunswick. The work plan had been established and the framework for CFD modeling of a sampling system had bee constructed. The experimental program is planned to start later in 2010 and the collaboration is planned to last until 2012. The potential for further work is anticipated. Meanwhile the progress is according to plan.

ICRN

New ICRN have been prepared since the last meeting
- #25 on Corrosion mechanisms that are related to the presence of contaminants
- #26 on Behavior of Aluminum in the Steam Water Cycle

ICRN that need to be updated
- #19 on Sampling of corrosion products
- #20 on High temperature sensors

ICRN that need to be closed (ICRN #13, 18)
- #13 on Surface tension.
- #18 on Thermal decomposition of ion exchange resins

These ICRN are discussed in detail in item 7.

PCC Task Groups

The three task groups currently constituted cover:

IAPWS Guidance documents

B. Dooley summarized the current position. The two issued guidance documents (on carry-over and on key instrumentation) are confirmed as being in widespread use worldwide. Final changes to the third document (on volatile treatments for steam/water circuits) were to be discussed in the task group before submission to the executive committee for approval on 23 July. The task group will next plan to develop a guidance document on non-volatile alkali boiler dosing. Future plans include coverage of sampling QA and QC, steam purity for steam turbines, volatile treatments for nuclear plants and there will be scope for updating of the established documents as and when necessary.

Quantification of chemistry related asset damage.

K.Daucik reported that the group activities were the production of an updated draft report and that it is anticipated that the work will be finished in 2010 / 2011.

European Standard EN 12952.

G.Bignold reported that the decisions to revise both of the CEN standards covering boiler water chemistry requirements (EN 12952 part 12 and EN12953 part 10) had been agreed at a meeting of CEN technical committee TC269 in March 2010. The TC269 working groups had been instructed to add these revisions into their programs. To date there had been only one further meeting (working group 2) which acknowledged the addition to its work program.

This position represents a successful outcome of the lobbying by European members of PCC. BIAPWS will maintain contact with the revision (via representation on BSi). No further defined action at this time.

PCC Public Relations

R. Svoboda noted that the PCC initiative on addition of key word to the IAPWS website is being implemented (see the EC minutes 2010).

PowerPlantChemistry is now under new ownership, which is closely allied with the Swiss national committee of IAPWS. A.Bursik continues to be editor..

B. Dooley noted that the widespread dissemination and use of the PCC Guidance Documents has raised the profile of PCC within the power industry worldwide.

Other Action List Items

There were no other items not covered on the agenda.

Priority List Review

The priority list was discussed on a point-by-point basis. The outcome is attached (attachment C).

PCC Task Groups

IAPWS Guidance Documents (B.Dooley, chair)

Guidance Documents Task Groups Work Plan
(assuming that the annual meeting is by begin of September)

- Initial draft/skeleton by Nov/Dec
- Circulated to Sub-Task Group Dec/Jan
- Circulated to PCC WG February
- Editorial Committee: April
- National Committees: May/June

Volatile Treatments

B. Dooley set out the modifications to the draft on Volatile treatments for steam/water circuits that had been requested by Japanese and Russian national committees. Four improvements had been suggested by the Japanese committee. Modifications to the document had been formulated and these were all endorsed by PCC.

The Russian delegation had requested reconsideration of the information covering behavior of aluminum in steam water circuits. PCC consensus was that generic coverage of this topic should be retained with added caveats covering the implications of aluminum components on pH ranges and on consequential risks. Specific mention of Heller cooling systems was agreed to be inappropriate.

The approach to SI units for conductivity were also discussed and a paragraph covering the current use of $\mu S.cm^{-1}$ (rather than $\mu S.m^{-1}$) was agreed.

On the basis of these final changes, the PCC agreed to the submission of the document to the IAPWS Executive for formal adoption.

Action R. Svoboda

Carry-over

An update to the Guidance Document on carry-over has been identified as necessary. This will cover sampling and QA/QC issues. F.Gabrielli agreed to set out a scope of amendment by November/December 2010.

Action F.Gabrielli (with assistance from B.Dooley, G.Bignold and M.Ball subject to confirmation)

Sampling

In view of ongoing international collaboration it was agreed that preparation of guidance on sampling QA/QC should be deferred for one year.

Nuclear Circuit Chemistry

To liaise with IAEA on potential for collaboration on a guidance document for circuit chemistry for nuclear plants and report back to PCC.

Action D. Lister, S. Uchida.

Boiler Chemistry using phosphates and hydroxides

Preparation of a new guideline on solid alkali boiler chemistries is proposed for the coming year. Coverage to include:

- Trisodium Phosphate use, effects of hide-out and of dry-out, influence of in-leakage of alkaline cooling waters, etc.
- Sodium hydroxide use, pressure range for applicability.
- Dosing and dosing control safeguards.

There was no immediate consensus on the coverage of commercial blended phosphate mixtures, on the pressure range for applicability of phosphates.

The use of mixtures containing other components (antifoaming agents, etc) cannot practicably be comprehensively covered.

B. Dooley will initiate the drafting and will produce a structural document by November 2010. Authors for individual components of the guideline will then be identified. The collaborating task group will include M.Rziha, R.Svoboda, S.-E. Therkildsen, G.Bignold, M. Ball (subject to confirmation).

Action B. Dooley

Steam Purity for Steam Turbines

J.Bellows and R.Svoboda have initiated the production of a guideline on steam purity for steam turbines. The work is estimated to be 20% completed. It was agreed that the document should cover:

- Silica behavior,
- Copper behavior,
- Chemically related failure mechanisms, including the relevance of processes during turbine shutdown
- Implications of contamination of spray water (attemperators and hood sprays).

No final decision on coverage of the behavior of aluminum in steam turbines was reached. The task group was set up with R.Svoboda, J. Bellows, and will be expanded by M. Rziha, B. Dooley, plus a representative from Japan (H. Takaku to nominate).It shall develop of a guidance document within the milestones set in the Task Group Work Plan..

Action R.Svoboda, J.Bellows and M.Rziha

Philosophy of Chemistry Control

The scope for this has effectively been incorporated into the other guidance documents. Presently, a separate document is not considered to be necessary.

Quantification of chemistry related asset damage (K.Daucik, chair)

K.Daucik presented the latest draft of the study, which was subsequently discussed within PCC. There was agreement that the work has advanced towards its final stage. B.Dooley suggested to coordinate the study with work that has been done for EPRI, respectively their consultant Lew Rubin. There was agreement that the final study should be a paper published in two or three differently orientated technical magazines.

Action: K.Daucik

European Standard EN 12952 (G.Bignold, chair)

No further defined action at this time. See 4.3.

ICRN

New ICRN

ICRN#25 on Corrosion mechanisms that are related to the presence of contaminants in steam/water circuits, particularly in boiler-water. Written comments had been received from Don Palmer, and Andy Rudge and a statement of support had been received from the Russian delegation. W. Cook agreed to be nominated as a new main contact for this ICRN in collaboration with G. Bignold. E. Maughan advocated that consideration be given to combinations of contaminants and to ionic balance. R.Svoboda agreed to send the ICRN template to W. Cook/ G. Bignold.

Actions: R. Svoboda, W.Cook

ICRN#26 on Behavior of Aluminum in the Steam Water Cycle of Power Plants. PCC aim to finalize this ICRN on the basis of comments that have been received from Don Palmer and Barry Dooley. It was agreed that a final version should be prepared by end of November 2010.

Action R. Svoboda/ M. Rziha

Existing ICRN to be updated

ICRN#19 on Sampling of corrosion products. In view of the intensive activities of this subject it was agreed that this ICRN should be extended for a further period. D. Lister submitted an update to the ICRN, which should be added to the ICRN on the IAPWS website

Action: R.Svoboda

ICRN #20 on High temperature sensors. It was agreed that this should be revised to avoid the impractical implications of application to very severe conditions (excessively high pressures and temperatures).

Action: S.Uchida

ICRN to be closed

ICRN#13 on Surface tension. F. Gabrielli to prepare a closure statement.

Action: F.Gabrielli

ICRN#18 on Thermal decomposition of ion exchange resins. A closure statement had been drafted by Karol Daucik although it was agreed that the problem remains in existence. The closure statement should be added to the IAPWS website

Action: R.Svoboda

Proposals for International Collaboration

The collaborators: R.Svoboda, S.Uchida, K.Daucik, P. Srisukvatanan, S.-E. Therkildsen and D.Lister met to discuss the first phase of the current project. The experimental procedures and objectives of the CFD modeling were discussed and agreed.

Other Business

The PCC Mission statement was reconsidered and minor updates were agreed. The revised version is attachment D.

Changes in Membership, election of Officers

Although these persons were not PCC members, PCC noted with regret the deaths of Mike Fountain, George Gyarmathy and Ulrich Staudt.

Membership withdrawn:

Jun Izumi	communication by the Japanese National Committee, that Mr. Inzumi is not any more active in IAPWS matters
Milan Zmitko	communication by the Czech National Committee, that Mr. Zmitko has changed field of work

PCC wants to thank Mr. Izumi and Mr. Zmitko for their former support and contributions.

Preparation of Action List 2010 / 2011, Task Distribution, Next Year's Agenda

- Proceed with ICRN #19, 20 (updates), 25, 26 (new), see 4.2
- Proceed with Task Group Work, see 6.

Preparation of PCC WG Report for Executive Meeting

- Technical Guidance Documents
- ICRN
- International Collaboration
- Members
- Mission statement (update)

Miscellaneous and Adjournment

PCC Minutes, Niagara Falls July 2010

Those present at the PCC WG meeting were as follows:

O Bartos	Czech Republic	
J Bellows	USA	
G Bignold	UK	
W Cook	Canada	
K Daucik	Denmark	
B Dooley	Canada / USA	
F Gabrielli	USA	
I Hey	Canada	
J Jevec	USA	
I Jiricek	Czech Republic	
D Lister	Canada	
E Maughan	S.Africa	
J McLinney	USA	
M Miyajima	Japan	
M Myszczyszyn	Canada	
M Rziha	Germany	
P Safarik	Czech Republic	
P Srisukvatananan	Canada	
R Svoboda	Switzerland	(Chair PCC)
H Takaku	Japan	
S-E Therkildsen	Denmark	
S Uchida	Japan	

PCC Minutes, Niagara Falls July 2010

PCAS / PCC workshop (Tuesday 13:30 - 15:30)

Thermodynamics, dynamics, and chemical reactions related to power cycle

1. G.Bignold: Draft for ICRN 25 "Corrosion mechanisms that are related to the presence of contaminants in steam/water circuits, particularly in boiler-water."

2. R.Svoboda: Draft for ICRN 26 "Behavior of Aluminum in the Steam Water Cycle of Power Plants"

3. H.Takaku, T. Nakane, Li-Bin Niu: "The combined effect of chloride and sulfate ions in simulated AVT waters on the electrochemical corrosion behavior and oxide film characteristics for LP steam turbine materials"

4. Andre Anderko: Thermodynamic Modeling of High-Temperature Aqueous Chemistry

5. Masaru Nakahara: Carbon Dioxide Fixation and Hydrogen Storage and Transportation in the Form of Formic Acid

PCC workshop (Tuesday 08:30-10:30 and Thursday 08:30-10:30)

Update on Power Cycle Chemistry Research and Experience

1. G.Bignold: "Discussion on "Processes that contribute to corrosion fatigue failures in economizers"

2. S.Uchida: "Evaluation of FAC simulation Code based on Verification and Validation"

3. P. Srisukvatananan: "Improved Sampling Techniques", activities related to IAPWS International Collaboration projects

4. E.Maughan: "Concept for an on-line analyzer network with full automation and chemical intelligence"

5. E.Maughan: "Concept for an Interactive Knowledge Management for long-term conservation of technical know-how and experience"

6. O.Bartoš: "Measurement of heterogeneous particles in superheated steam in turbines of coal-fired power plants"

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PCC Priority List for Further Research

1. Interfacial situation in advanced ultra supercritical plants

Formation and exfoliation mechanism of scale (oxide films) in steam lines
effects of chemistry (oxygen, ammonia ?)
Corrosion interactions materials / steam, influence / effect of supercritical parameters, protective layers, radiation
Faster decomposition of chemicals (TOC, ammonia etc)?

Status 2010: Joint PPC/PCAS ICRN #21 is on the IAPWS website

2. Mechanism of Decomposition of Ion-exchange Resin

Operating conditions, quality control of resin; leak rates are slow, but sulphate is one of the products, organic leachables, oxidation
Additional information has to be researched
Status 2010: ICRN # 18 (use in condensate polishing) has been issued in 2006, no activities known in 2010, will be closed at the 2010 meeting

3. Development / Application of Sensors (Ambient and High Temperature Sensors)

ECP (nuclear, fossil application), ORP,
problem: abstract parameters, acceptance by plant operators

Status 2010: ICRN #20 has been issued in 2006, some activities known in 2009 (Balashov, Petkin, Lvov), re-formulation in 2010 related to the needs from nuclear industry (Uchida)

4. Improved analysis of low concentration of metals (Fe, Cu, Co, etc in the ppb range)
(merged into Priority List item #6)

5. * Corrosion mechanisms that are related to the presence of contaminants in steam/water circuits, particularly in boiler-water

Define critical species / quantify critical quantities of steam generator water impurities, synergy with other species (e.g. oxygen), consideration of the materials

Status 2010: Geoff Bignold drafted ICRN #25 which should be finalized in 2010 (Bignold, Cook)

6. * The relationships between the chemistry of the contaminants and their concentration at point of measurement

Main scope will be the minimum requirements for sampling specifically for Fe, Cu, Co, Oxygen, etc.

Status 2010: ICRN #19 on sampling of corrosion products will be extended in 2010. International collaboration 2006/7 2010/2012. (Lister, Daucik, Svoboda, Uchida). 4 papers by Piti et al. IAPWS Guidance Document on sampling under consideration

7. * The quantification of risk of asset damage

problems of getting background data, important long-term issue
need: tool for operators, design engineers & commercial persons
PCC: to provide basic background data, e.g. corrosion / deposition rates

PCC task group has been set up (chair: K.Daucik)
Status 2010: task group in progress

8. Improved understanding of condensation mechanisms

- drop-wise vs film-wise condensation in condensers (improve heat transfer)
- heterogeneous – homogeneous nucleation models for prediction of condensation in steam turbines (chemistry, electrostatic,...)
- chemistry of the phase transition zone in nuclear turbine systems

ICRN #22 is on the IAPWS website

9. Deposition of contaminants and corrosion products in steam and water circuits

- supersaturation,
- mass transfer,
- adsorption,
- crystal nucleation,
- deposit re-dissolution,
- scouring and exfoliation,
- activation and activity transport in reactor systems
- Mechanism and Influence of Cu Deposition :

(essentially a solved problem from a scientific viewpoint)
- mechanism of deposition on a turbine blade is not understood
- discrepancies in temperature influence on deposition (?)

Status 2010: wide range of information available and research ongoing, opportunity for several ICRN

10. Radiation chemistry of water

Radiolysis, main importance for nuclear generation

2007 PCAS/PCC presentations have been made
Status 2010: activities related to supercritical water reactors ongoing (to be determined, Katsumura), 2010 International nuclear conference Quebec: Workshop on Radiolysis (Lister)

11. * Behavior of Aluminum in the steam / water cycle
    - **Al release under various water treatment regimes**
    - volatile carry-over and deposition in the turbine
    - deposition on boiler tubes,
    - solubility in water and steam
    - behavior in condensate purification
    - interaction of Al with boiler chemistry
    - specification values for Al in feedwater, boilerwater, steam
    - impact of the use of Al on materials and cycle chemistry of the rest of the cycle

Status 2010: topic still pending, practical data to define scope of problem incoming, ICRN #26 in processing (Rziha, Svoboda)

12. Water cooling of copper in electrical machines
- generator stators
- accelerators

Status 2010: paper at ICPWS 2008;EPRI guideline 2008, CIGRE guidance document to be published in 2010, new investigations Palmer/Svoboda considered

13. Water use outside the steam / water cycle
- cooling water
- waste water
- external process
- recycling for use as make-up
- etc.

For further consideration for 2011, possibly new IAPWS sub-committee.
PCC does not have the resources to take leadership on these items.

14. Chemistry in geothermal and oil / sand cycles

Behavior of water constituents, effects on system materials, geochemical and wastewater issues.

Status 2010: ICRN to be considered for 2011 (Leidich, Rziha, Myszczyszyn)

**** urgent priority***

The numbering in the list is made for reference only and does not contain any information on actual priority

In addition, PCC should maintain awareness of the following items

- Chemistry and corrosion related items to future nuclear generation systems (6-best-design-reactor concepts, Generation IV reactor plants, ITER)

- High pressure / high temperature steam and humid air (24 MPa and up, 2000°C), thermophysical properties and chemistry formulation.
  (Long term interest in power industry, Treated in TPWS)

PCC Minutes, Niagara Falls July 2010

Mission and Working Process of PCC
07 Sep 2008, rev. 21 Jul 2010

MISSION

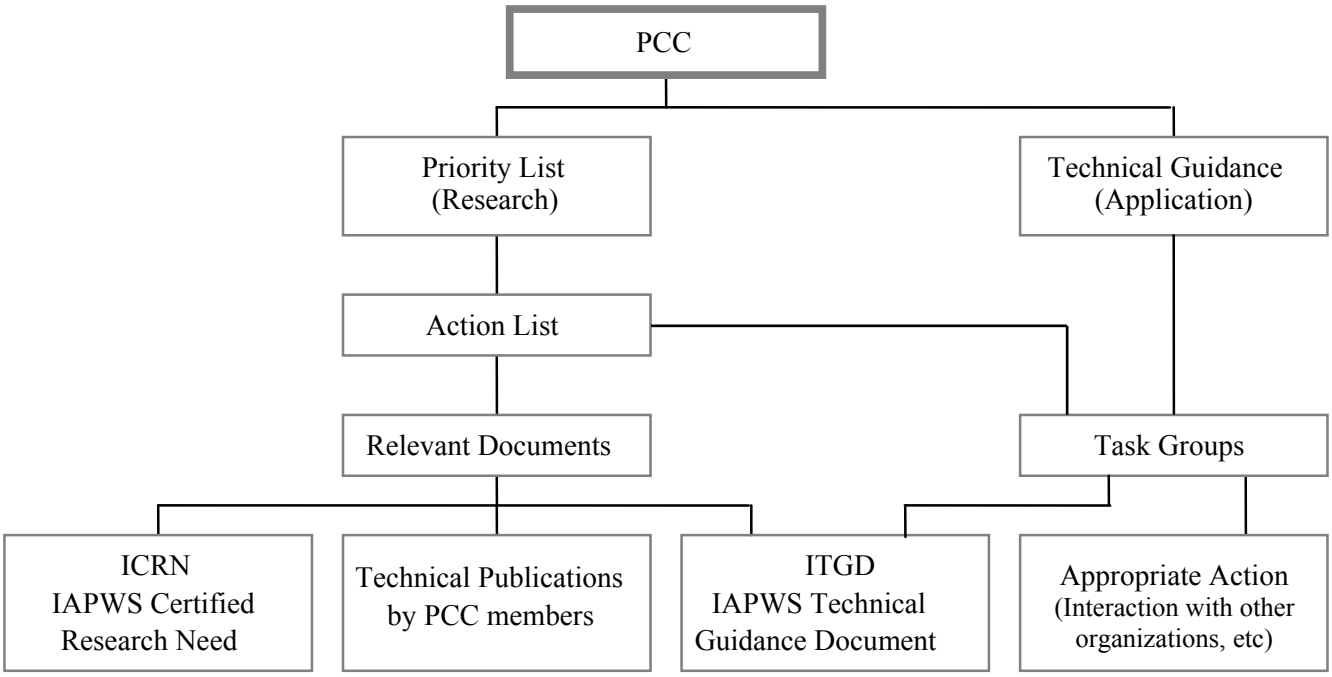
The Power Cycle Chemistry Working Group (PCC) brings together scientists and engineers from academia and research organizations, power plant operators, equipment manufacturers and other relevant interested parties from around the world with an interest in power cycle chemistry to

- Collaborate and share results of scientific and engineering research and experience
- Identify gaps in technical information relating to power cycle chemistry
- Seek resolution of these gaps through international cooperative projects and the release of appropriate documents

for the benefit of industry. Within IAPWS, it serves as a liaison between industrial needs and related research represented by PCAS Working Group.

PCC WORKING PROCESS

Workflow



Working Tools

- Discussions at annual IAPWS meeting (mainly for steering)
- Individual or group work on PCC assigned tasks throughout the year
- IAPWS International Collaboration

IAPWS Collaborative Grant Proposal

An experimental study of thermal conductivity of the binary ammonia + water system at high temperatures and pressures

IAPWS Sponsors

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Visiting Young Scientist
(Fanis N. Shamsetdinov or colleague to be named)
Kazan State Technological University,
K. Marx St., 68, Kazan 420015, Tatarstan, Russia Federation

This proposal will have four principal outcomes: it will strengthen collaborations between the Department of Theoretical Bases of Thermal Engineering of the Kazan State Technological University (KSTU) and the National Institute of Standards and Technology (NIST) in the US; it will enable a young scientist to travel from the KSTU to NIST for training in best practices for calibrations, measurements and data evaluation; it will provide the IAPWS community with new measurements of thermal conductivity measurements for the aqueous system ammonia + water in wide ranges of temperature and pressure; and, it will initiate a broad program of measurements and models for the ammonia + water system.

An IAPWS Certified Research Need [1] indicated a need for properties for ammonia + water mixtures at temperatures to 866 K (593 °C) at pressures up to 35 MPa, covering the complete range of composition. In spite of research activity from 1997 to 2002 that was reported in the Closure Statement for this ICRN, thermal conductivity data are still very limited for ammonia + water mixtures.

The primary reasons for the scarcity of data are experimental difficulties related to the fact that this system is corrosive, toxic, potentially flammable, and has a high relative volatility. Special materials, safety procedures, special equipment and knowledge of their proper use are all required. Only a handful of labs, including NIST, have been able to make sufficient investment in training and materials to make such measurements.

The H2O + NH3 mixture is receiving increased attention due to the potential use of the system as a working fluid in refrigeration and power plant cycles. The binary H2O + NH3 mixture has a large technical significance in the fields of absorption refrigeration machines, absorption heat pumps, and heat transformers. To decrease environmental impact, natural working fluids such as ammonia and water have been considered as alternative refrigerants to replace chlorofluorocarbons (CFC) in some refrigeration applications. The ammonia-water mixture does not affect the atmospheric ozone layer nor does it contribute to the greenhouse effect. Therefore, the significance of this mixture in refrigeration technology is strongly increasing. Refrigeration cycles with H2O + NH3 mixtures as working fluids have been shown to reach higher coefficients of performance than traditional working fluids. Thermophysical modeling of technological processes requires information on the transport properties (viscosity and thermal conductivity) of H2O + NH3 mixtures. The important properties of viscosity and thermal conductivity are required for absorption cycle analysis and in the design of heat exchangers. Power cycles with H2O + NH3 mixtures as working fluids also have been shown to reach higher thermal efficiencies than the traditional steam turbine (Rankine) cycle with water as the working fluid. The best H2O + NH3 cycle produced approximately 40-70 % more power than a single-pressure steam cycle and 20-25 % more power than a dual-pressure steam cycle. In calculating the performance of the power cycles, accurate transport properties data of the H2O + NH3 mixture play an important role. The demand to decrease the consumption of primary energy leads to optimization of technological processes. To improve the H2O + NH3 cycle efficiency and to operate apparatus at high temperatures and pressures, the need for pertinent data in regions beyond those covered by the available data becomes more urgent. For this aim, engineering design of absorption air-conditioning equipment utilizing the H2O + NH3 cycle requires accurate transport property data of H2O + NH3 mixtures over a wide range of T, P, x. However, the

existing reported transport property data cover a limited range of T, P, x, and contain large uncertainties and inconsistencies. A number of speeches about geothermal power cycle applications have been presented at the latest geothermal conference in Germany, 2010. At NIST, two groups from the Thermophysical Properties Division, TRC (M. Frenkel) and Theory and Modeling of Fluids Group (E. Lemmon), have received repeated requests from various industrial companies for transport properties of the ammonia + water mixture.

Accurate thermal conductivity data are also essential to the development of a reference correlation equation. The currently available thermal conductivity data [2-4] cover only very limited temperature, pressure, and concentration ranges. Most reported data are at atmospheric pressure and at temperatures up to 375 K. Moreover, the data reported by Baranov et al. [4] are presented graphically (the data were never published). The other two publications [2,3] are very old (1898 and 1937). A detailed analysis of the reported data is presented in Ref. [5]. Both the Thermophysical Properties Division of NIST (Dr. R. Perkins) and KSTU (Prof. Tarzimanov's team, Vargaftik's student) have extensive experience and capabilities in accurate thermal conductivity measurements covering wide ranges of temperature, pressure, and concentration and their modeling (Dr. M. Huber). In a previous IAPWS project we have reported [6-8] PVTx and CvVTx data for the aqueous system (H2O + ammonia) in the near-critical and supercritical regions. For the reasons mentioned earlier, the labs of TSTU and NIST are among the few research facilities in the world with capabilities for H2O + ammonia thermal conductivity measurements at high temperatures and high pressures.

Using other funding, Prof. Tarzimanov's team in the KSTU Labs will investigate thermal conductivity in a temperature range from 298 to 363 K and at pressures up to 20 MPa for the concentrations 25, 50, and 75 mass % of ammonia, with an uncertainty in thermal conductivity of less than 2 %. This investigation will provide reliable thermal conductivity data by using a hot wire technique [9-11].

Following the experiments, we plan to bring a younger KSTU Labs scientist to the Boulder Labs of NIST for 6 months. Ph.D. Student Fanis Shamsetdinov will be our top choice, since his PhD dissertation is on thermophysical properties of aqueous systems. Mr. F. Shamsetdinov will assist Dr. Huber and her team in the Boulder Labs with the following tasks: (1) analysis of the thermal conductivity data for water+ammonia mixture; and, (2) comparison with published measurements and models; (3) develop new thermal conductivity model for the mixture; (4) prepare MS of the paper for publication. As an additional educational component of his visit, we will conduct detailed discussions and comparisons of the experimental thermal conductivity techniques used in the KSTU Labs with those used in the Boulder Labs, methods for precise gravimetric mixture preparation, a propagation of uncertainties analysis, round-robin measurement comparisons, and establishing a chain of traceability to national and international standards.

Budget

We propose a total budget of $18,000 for this. This would pay for the travel expenses and 6-month visit for Mr. Fanis Shamsetdinov or other young KSTU scientist for his work in Boulder with the US-based research team. A project report will be prepared and submitted to IAPWS by the next annual meeting.

Leveraging of the IAPWS Support

The research team has planned a comprehensive research project on the ammonia + water system, involving partnerships with university-based researchers. To leverage the support from IAPWS, we will seek additional support from other agencies. Toward the end of the proposed IAPWS project, one or more proposals will be prepared to support the following tasks: (1) additional measurements of transport properties (viscosity data for the ammonia + water system and thermal diffusivity measurements at high temperatures and high pressures); (2) development of new models for thermal conductivity and viscosity.

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Attachment 10

Proposal of the Young Scientist IAPWS Project for 2011

Development of Thermodynamic Models for Hydrates in Water–Carbon Dioxide Mixture

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Inviter:

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Young Scientist – Applicant:

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June, 2010

Introduction and Background

Water-carbon dioxide mixtures play an important role both in nature (environmental and geological processes) and in many industrial applications (natural gas industry, energy production, etc.). The H_2O–CO_2 system is a binary mixture with rather complex phase equilibria including a total of six phases. The phase diagrams of the mixture water-carbon dioxide were discussed for example by Wendland [1], Diamond [2], and Longhi [3]. Phase equilibria of the H_2O–CO_2 system show liquid-liquid immiscibility over a large range of *p*-*T* conditions, interrupted critical curves, and formation of crystalline water-based solids – hydrates [4]. The proposed project will focus especially on the last mentioned phenomenon occurring in the H_2O–CO_2 system.

The CO_2-hydrate, clathrate, is the only intermediate solid compound in the water-carbon dioxide system, since the end-member solid phases, water ice and solid CO_2, do not admit mutual solution. Clathrate has a nominal composition of $CO_2 \cdot 7.5H_2O$, although this composition can slightly vary with temperature and pressure in reality. CO_2-clatharte-hydrate occurs already at relatively high temperatures. For instance, the first quadruple point, when four phases (vapor + aqueous liquid + water ice + clathrate) are in equilibrium, has *p*-*T* coordinates of 1.0 MPa and – 1.5°C. As a consequence, the CO_2-hydrates can result for example in pipeline blockage during natural gas transportation. Accurate knowledge of clathrate in the water-carbon dioxide mixture is therefore of great interest particularly for the petroleum industry.

As already noted, the mixture water-carbon dioxide is a rather complex non-ideal system that should be further investigated. The inviting working group (Lehrstuhl für Thermodynamik in Bochum) has recently made some progress in describing the role of carbon dioxide in aqueous solutions. Jäger and Span [5, 6] developed a fundamental equation for solid CO_2 – dry ice. The fluid phase equilibrium of the H_2O–CO_2 system is being modeled by a modified GERG [7] equation of state now. Span and Gernert [8] have verified that the GERG-2004 equation of state accurately describes the H_2O–CO_2 system after some refitting to relevant experimental data.

At the current stage, the intermediate solid phase of the H_2O–CO_2 system, i.e. clathrate, needs to be treated. Clathrate plays an important role in the behavior of the water-carbon dioxide mixture. However, it has been described only partially. It is therefore planned to develop a fundamental equation for CO_2-hydrates under the cooperation of Lehrstuhl für Thermodynamik in Bochum and the Institute of Thermomechanics in Prague.

Scope of the project

In the proposed project, possibilities of an accurate modeling of thermophysical properties of clathrate in H_2O–CO_2 system will be studied. The project can be split into two parts.

- An overview regarding the available data for CO_2-hydrates is already prepared. In the preliminary part of the project, a detailed literature review will be done to complete the data set.
- The main aim of the project is to develop a fundamental equation describing the clathrate phase in H_2O–CO_2 systems. Similarly as the equation of state for dry ice [5, 6], the equation for CO_2-hydrates will be explicit in Gibbs energy $g = g(T, p)$. The Gibbs energy will in principle be determined by fitting the data for isobaric heat capacity and molar volume $v(T, p)$. The new equation of state for clathrate should also fulfill equilibrium conditions with other phases, especially with water ice described by the

IAPWS equation of state [9] and with dry ice modeled with the equation by Jäger and Span [5, 6].

Purpose of the Project and Justification for IAPWS Support

The purpose of the collaborative project with IAPWS is to analyze available experimental data for the clathrate phase of the H_2O–CO_2 system and to develop a fundamental equation of state for CO_2-hydrate. The IAPWS funding will make it possible to spend six months at Ruhr-Universität in Bochum in a single stay starting in February 2011.

The proposed project is closely connected with the research activities of both concerned departments; namely with investigation of water mixtures, metastable water, CO_2 separation, and nucleation in natural gas. Results from the project would therefore be further used at both departments and will contribute to different IAPWS activities in a broader sense.

Budget estimate (in EURO)

Subsistence for 6 months: IAPWS Young Scientist Grant … **12.000 €**

Travel (round trip) and insurance will be covered by the Institute of Thermomechanics.

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Curriculum Vitae

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Education Ph.D. (2005 – 2009): Czech Technical University (CTU) in Prague, Faculty of Mechanical Engineering, Study program – Mathematical and Physical Engineering

Ing. (1999 – 2005): CTU in Prague, Faculty of Mechanical Engineering

Study stays August 2002 – January 2003: study at Lund Institute of Technology at Lund University (Sweden) organized by Erasmus/Socrates program

Working activities 2001 – 2005: assistant in the research at Department of Physics at CTU

July and August 2003: *Summer Student Program* at CERN

February – November 2005: *Technical Student Program* at CERN

2006 – 2009: cooperation with PH department at CERN

2006 – 2008: part time job at Institute of Thermomechanics AS CR

2009 – now: postdoc researcher at the Institute of Thermomechanics AS CR

Main publishing activities

- G. Hallewell, V. Vacek, V. Vinš: Properties of saturated fluorocarbons: Experimental data and modeling using perturbed-chain-SAFT, *Fluid Phase Equilibria* 292 (1-2), 2010, pp. 64-70
- V. Vinš, V. Vacek: Experimental investigation of throttling process affected by gas impurities, *Experimental Fluid Mechanics, Proceedings of the international conference*, November 25-27 2009, Liberec, Czech Rep., ISBN 978-80-7372-538-9, pp. 411-417
- V. Vinš, V. Vacek: Effect of gas impurities on the throttling process of fluorocarbon refrigerants: Estimation of the Henry's law constant, *Journal of Chemical and Engineering Data* 54(9), 2009, pp. 2395-2403
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- V. Vinš, V. Vacek: Mass flow rate correlation for two-phase flow of R218 through a capillary tube, *Applied Thermal Engineering* 29 (14-15), 2009, pp. 2816-2823

- M. Deile, E. Radermacher, M. Oriunno, G. Ruggiero, V. Vacek, V. Vins: The TOTEM experiment and the CERN Large Hadron Collider, *Journal of Instrumentation* 3, 2008, S08007
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Press Release
International Association for the Properties of Water and Steam
2010 Meeting

Continuing a series of conferences started in 1929, 56 scientists and engineers from 10 countries attended the annual meetings of the International Association for the Properties of Water and Steam (IAPWS), July 18-24 in Niagara Falls, Ontario, Canada. The meeting hosted by the IAPWS Canadian National Committee with support from the CANDU Owners Group and Atomic Energy of Canada Limited. The meeting connects academic researchers with engineers who use their information. It provides the researcher with guidance on useful problems and provides the engineers with the latest research. IAPWS has traditionally concentrated on the science underlying the thermodynamics and chemistry in steam power plants, but is broadening into other aspects of power generation and high-temperature aqueous systems as well as seawater and ice. Discussions range from puzzling power plant chemistry results to reports on solutions to such problems to practical implications of fundamental theory and molecular modeling of thermodynamic and transport properties.

The IAPWS delegates were joined by additional people from Canada for a symposium **Building on Synergies: Chemistry Research, Sampling and Monitoring in High-Temperature Water and Steam-Water Systems**. The symposium opened with the IAPWS Helmholtz award lecture "To Scale or Not to Scale in 2500 psig Once-Through Steam Generators." This presentation introduced IAPWS to steam used in producing oil in Alberta. The symposium continued with presentations on chemistry and water sampling in more conventional power plants, then moved to the research needed for supercritical systems.

Melonie Myszczyszyn presents the IAPWS Helmholtz Award Lecture, introducing the audience to steam and produced water issues.

IAPWS produces releases, guidelines, certified research needs, and has started to issue technical guidance documents. Information may be found at the IAPWS website: www.iapws.org. The ICRN is guidance for funding agencies and an aid to people doing research in defining important research. An ICRN expressing the need for improved theory and/or experimental data for the thermal conductivity of high-temperature steam was approved this year.

With the adoption of the IAPWS Guideline on Humid Air in Contact with Seawater and Ice, the fifth and final IAPWS document was released on which the new thermodynamic description of seawater including its phase transitions to ice or water vapor, TEOS-10, is based. The Intergovernmental Oceanographic Commission (IOC) of UNESCO has recently endorsed the use of TEOS-10 to replace the previous description of seawater which has been used for the past 30 years. IAPWS' extensive and continued work on TEOS-10 began with the presentation of a new equation of state of ice on the XIV. ICPWS in Kyoto 2004 and culminated in the IAPWS Release on seawater properties on the XV. ICPWS in Berlin 2008.

A joint IAPWS/IUPAC project titled "Establishing Recommended data on Thermodynamic Properties of Hydration for Selected Organic Solutes and Gases" is near completion. The collected properties will be available for testing and development of new physico-chemical models and methods of molecular simulation.

IAPWS is working toward a revision of its formulation for thermal conductivity of water and steam which dates back over 30 years. Both experiment and molecular theory are contributing to this effort. Work continues on properties of metastable steam.

IAPWS will be sending a questionnaire to industrial organizations eliciting needs for steam properties and new priorities. People interested in receiving the questionnaire are encouraged to contact the Executive Secretary of IAPWS.

The Power Cycle Chemistry Working Group completed a new technical guidance document, "Volatile Treatments for The Steam-Water Circuits of Fossil and Combined Cycle/HRSG Power Plants". The working group keeps a priority list for research related to power plant chemistry. It is currently headed by the behavior of aluminum in the steam / water cycle, the quantification of risk of asset damage relating out of specification chemistry to damage to equipment, and the metal-water/steam interface in advanced ultra supercritical plants, and the accuracy of water and steam sampling in power plants. This working group includes in its scope the concentrated solutions found in the cooling water that goes through power plant condensers, makeup water and waste streams.

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 is will be in Pilsen, Czech Republic, September 4-9, 2011. Further information on meetings can be found at the IAPWS website, www.iapws.org, as it becomes available. IAPWS documents may also be found on the website.

People interested in IAPWS documents and activities should contact the chairman of their IAPWS National Committee (see website) or the IAPWS Executive Secretary, Dr. Barry Dooley, Structural Integrity Associates, Inc., 2616 Chelsea Drive, Charlotte, North Carolina 28209, USA, e-mail: bdooley@structint.com. People do not need to be citizens or residents of member countries to participate.

IAPWS Canadian National Committee

Annual Report 2010

Executive: *David Guzonas (Chair), Peter Tremaine (Past Chair), Derek Lister (Secretary Treasurer), Willy Cook (Member at Large), Ian Hey (CANDU Owners Group Representative)*

1: Canadian National Committee

Dues for the Canadian National Committee of IAPWS are supported by the National Research Council of Canada. This arrangement requires support and participation by a national association representing industry. In 2004, this role was taken on by the CANDU Owners Group (COG) on a trial basis. In 2007, COG agreed to accept this responsibility for a five-year term, to provide travel support for the CNC, and to organize an annual meeting aimed at providing liaison with the electric power industry. COG has been proactive in supporting the CNC since this arrangement was put in place.

2: IAPWS Annual Meeting

Canada hosted the 2010 Annual Meeting in Niagara Falls, 2010 July 18-23. The full details can be found in the minutes of the annual meeting.

3: IAPWS Collaborations

1) ICRN 19: Improved Coolant Sampling and Analysis of Low Concentration Metals (Fe, Cu, Co, etc.)

ICRN 19 was issued in September 2006 as an effort to address inadequate sampling techniques that all too often give rise to uncertainties in the constituents and composition of water and steam cycles. Sampling was the overarching theme of 2010 IAPWS Annual Symposium, Niagara Falls, Canada. ICRN 19 expired in September 2009, but at the 2010 meeting it was recommended that this ICRN be extended to 2012.

The ICRN was the subject of an IAPWS International Collaboration among: UNB, Canada; University of Tokyo, Japan; Alstom, Switzerland and Dong Energy, Denmark (2009); a student from Japan will visit UNB twice in 2010/2011 to investigate the interaction between hot sample streams and typical sample system materials.

Publications:

A CFD Study of Corrosion Product Collection Efficiency of Sampling Nozzles under Power Plant Conditions (2009). P. Srisukvatananan, D.H. Lister, R. Svoboda and K. Daucik. The 9thIntl. Conf. on Cycle Chemistry in Fossil and Combined Cycle Plants with HRSGs, Boston, USA.

A CFD Study of Corrosion Product Collection Efficiency of Sampling Nozzles under Power Plant Conditions, P. Srisukvatananan, D.H. Lister, R. Svoboda and K. Daucik, Power Plant Chemistry, 11(10) (2009).

2) Canada-Czech Collaboration

The CNC has completed an international collaboration with the Czech National Committee (Tremaine and Sedlbauer). A Czech PhD. student, Jana Ehlerova, worked at the University of Guelph from 2008 July to 2009 June. The results of this and her previous IAPWS project were published as:

Spectrophotometric Determination of the Ionization Constants of Aqueous Nitrophenols at Temperatures up to 225°C, J. Ehlerova, L.N. Trevani, J. Sedlbauer and P. Tremaine, J. Solution Chem. **37**, 854-857 (2008).

Complexation in the Cu(II)-LiCl-H2O System at Temperatures to 423 K by UV-Visible Spectroscopy, L.N. Trevani, J. Ehlerova, J. Sedlbauer and P. Tremaine, Int. J. Hydrogen Energy, **96**, 117-124 (2009).

4: Research into the Properties of Water and Steam at Canadian Universities

a) University Network of Excellence in Nuclear Engineering (UNENE)

In 2004, the Canadian government and nuclear industry cofounded an initiative to create a number of NSERC University Research Chairs to form a research network, and a common post-graduate MSc program in nuclear engineering. The industrial participants are Atomic Energy of Canada Limited (AECL), Ontario Power Generation (OPG), Bruce Power, and COG. The chairs relevant to the mission of IAPWS are listed below, along with related NSERC Industrial Chairs that form part of the network, with one-on-one funding by industry:

- **Roger Newman (University of Toronto):** Corrosion, materials performance, electrochemistry in the primary and secondary coolants.
- **Dave Shoesmith (University of Western Ontario):** Electrochemistry, materials performance and corrosion for high-level nuclear waste repositories.
- **Clara Wren (University of Western Ontario):** Radiolysis and radiation chemistry in irradiated reactor systems (primary coolant, moderator) and reactor accident scenarios.
- **Derek Lister (University of New Brunswick, Associate Member of UNENE):** Primary and secondary coolant chemistry, activity transport, corrosion.

Canadian researchers are also involved with UNENE as members of universities that are associate members in UNENE:

Peter Tremaine (University of Guelph, Associate Member): Solution thermodynamics, phase relations, and solubility in sub-critical and supercritical water, D_2O isotope effects and CANDU primary water conditions.

b) Other University Research in Areas of Interest to IAPWS

Generation IV Supercritical Water-cooled Reactors:

Canada has established a National Program to perform research and development in support of the concept of a CANDU Supercritical Water-cooled Reactor (SCWR). The research being carried out focuses primarily on key technology areas such as materials, chemistry, thermal-

hydraulics, safety, physics, and hydrogen production. Natural Resources Canada (NRCan), along with the Natural Sciences and Engineering Research Council of Canada (NSERC) and AECL established the NSERC/NRCan/AECL Generation IV Energy Technologies Grant Program, focusing on these four key areas of research for the Supercritical Water-cooled Reactor (SCWR) system. This grant program is co-funded by NSERC and NRCan's Office of Energy Research and Development, with in-kind contribution from AECL to guide and supervise research activities. Canadian academic researchers, in collaboration with AECL and NRCan scientists, receive grant funds to undertake specific research in support of Generation IV Energy Technologies. The following researchers are involved in chemistry-related projects of potential interest to IAPWS in this program:

- **Igor Svischev (Trent University):** Molecular simulations of high temperature aqueous systems.
- **Paul Percival (Simon Fraser University):** Muonium ion chemistry and radiolysis in sub-critical and supercritical water using the TRIUMF cyclotron national facility.
- **Alan Anderson (St. Francis Xavier University):** Solubility and phase relations in supercritical water using diamond anvil cell methods.
- **Cory Pye (St. Mary's University):** Ab initio calculations on ionic hydration and complexation.
- **Willy Cook (University of New Brunswick):** Corrosion, water chemistry and corrosion product transport in nuclear reactor systems, including supercritical water.
- **Jean-Paul Jay-Gerin (University of Sherbrooke):** Computational studies of radiolysis in high temperature water.

D. Guzonas (AECL) provides guidance on program direction as well as advice related to the reactor design concept.

Other Canadian researchers with active programs in high-temperature water chemistry include:

- **Vladimiros Papangelakis (University of Toronto):** Hydrometallurgy of pressure-leach processes involving nickel, cobalt, copper, and zinc ores.

5. Other Publications of Interest to IAPWS

Chemistry Control Challenges in a Supercritical Water-cooled Reactor, D. Guzonas, P. Tremaine, J.-P. Jay-Gerin, Power Plant Chemistry, **11,** 284-291 (2009).

Research and Development Initiatives in Support of the Conceptual Design for the CANDU Supercritical Water-Cooled Reactor, D. Brady, D. Guzonas, W. Zheng, L. Leung, 31st CNS Annual Conference, Montreal, Canada, May 2010.

Enhancing University R&D Capabilities in Support of Generation-IV Nuclear Reactor Development, D. Brady, D. Guzonas, L. Leung, W. Zheng, J. Poupore, T. Anderson, CNS Conference on Nuclear Education and Outreach (NEO-2010), June 20-22, 2010, University of Calgary, Calgary.

The Czech National Committee

International Association for the Properties of Water and Steam

REPORT on IAPWS related activities – August 2009 / July 2010

Submitted to the EC Meeting of IAPWS, Niagara Falls, Canada – July 2010.

National Committee Contacts:

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Head: Dr. Jan Hruby, E-mail: hruby@it.cas.cz

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

Institute of Thermomechanics (IT) AS CR, v.v.i., Department of Thermodynamics, Dolejskova 5, CZ-182 00 Prague 8.

Czech Technical University in Prague (CTU), Faculty of Mechanical Engineering, Department of Fluid Mechanics and Power Engineering, Technicka 4, CZ-166 07 Prague.

Institute of Chemical Technology Prague (ICT), Power Engineering Department (ICT-IE) and Department of Physical Chemistry (ICT-IPC), Technicka 5, CZ-166 28 Prague 6.

University of West Bohemia (UWB), Faculty of Mechanical Engineering, Department of Power System Engineering, Univerzitni 8, CZ-306 14 Plzen.

SKODA POWER, Plzen, Inc., Tylova 57, CZ-316 00 Plzen.

Technical University of Liberec (TUL), Department of Chemistry, CZ-461 19 Liberec.

SIGMA Research and Development Institute (SIGMA), Jana Sigmunda 79, CZ-783 50 Lutin.

Activities were sponsored by the Grant Agency of the Academy of Sciences and Grant Agency of the Czech Republic, SKODA POWER Plzen, Ministry of Education, Youth and Sport of the Czech Republic, and Ministry of Industry and Trade of the Czech Republic.

The board of the CZ NC PWS for the period 2010-2013:
Dr. J. Hruby, Prof. R. Mares, Dr. T. Nemec, Prof. P. Safarik, and Doc. J. Sedlbauer.

- In the 2009 IAPWS Meeting in Doorwerth, Nederlands participated 13 workers from CR and some of their papers are in Refs. [1 to 4].
- Brief information has been published on web sites of CZ NC PWS to the new documents adopted and authorized by IAPWS.
- A joint project IT AV ČR and WBU Plzen sponsored by the Ministry of Education, Youth and Sports (MEYS, MŠMT in Czech) enables cooperation with IAPWS for the next four years, till 2012 inclusive.
- Dr. Hruby (IT) investigated properties at homogeneous and heterogeneous nucleation and at heat transfer, Refs. [5 and 6].
- Prof. Mares (UWB) with his collaborator investigated a new international formulation for the viscosity of water and steam, Ref. [7], contributed on behavior of super-cooled water, Ref. [8], and on thermodynamic properties of steam, Ref. [9].

- Prof. Marsik (IT) coordinated research in nucleation and cavitation processes, Refs. [33], and the metastable states, nucleation and development of a new model of cavitation erosion potential. Refs. [10 to 17].
- Doc. Sedlbauer (TUL) and his team continued in the research on chemistry of aqueous systems. Refs. [18 and 19]
- Doc. Sedlbauer (TUL) collaborated with the team of Prof. Tremaine (Canada) and investigated the Cu(II)–LiCl–H_2O system by UV-Visible spectroscopy. Ref. [20].
- Doc. Sedlbauer (TUL) coordinated IAPWS-IUPAC Joint Project: Establishing recommended data on thermodynamic properties of hydration for selected organic solutes and gases.
- Research activities at the (CTU) continued in further improvement of the current knowledge on the following subjects: determination of the heterogeneous particles in the superheated steam in turbines, heterogeneous condensation seeds in expanding steam and hydrogen technologies.
- The SIGMA Research and Development Institute (SIGMA) was engaged in the problems of hydrodynamic cavitation in water, erosion effects of cavitation bubbles on solid surfaces and nucleation processes during cavitation. Refs. [2, 14 to 17].
- Dr. Jiricek (ICT-IE) with collaborators investigated renewable power sources and chemical effects in water and steam systems of power plants. Refs. [21 to 24].
- Dr. Hnedkovsky (ICT-IPC) with collaborators investigated properties of organic solutes in water. Published articles are under Refs. [25 and 28].
- Prof. Stastny (SKODA POWER) with co-workers studied surface structure of the roughness on turbine blades, developed and applied numerical model of the water steam flow in nozzles and turbine blade cascades with NaCl binary nucleation and condensation, Refs. [2, 29 and 30], and collaborated on the IAPWS ICRN 22. Ref. [4].

Young Scientists IAPWS Fellowships

Information on the Young Scientists IAPWS Fellowship Project.

- J. Kalova performs her Young Scientist IAPWS Fellowship Project (CZ-USA) Project "Thermophysical Properties of Supercooled Water" under supervising of Prof. R. Mares, and Prof. M.A. Anisimov. The purpose of the collaborative project is to analyze a critical behavior of water near the liquid – liquid critical point, to calculate second critical point parameters, and to describe properties of supercooled water by means of existing experimental data and data form IAPWS formulations.

  Preliminary results will be presented and discussed at the 2010 IAPWS Meeting in Niagara Falls, Canada. The Final Report of the Project will be finished by the end of the year 2010.

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3. Stastny M., Sejna M.: Condensation of Water-Steam with NaCl Impurity Flowing in a Nozzle and in a Turbine Cascade, Presentation IAPWS Annual Meeting, Doorwerth, 2009.
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Danish National IAPWS Committee - DIAPWS

c/o IDA, Kalvebod Brygge 31 - 33, 1780 Copenhagen V

03 March 2010

IAPWS report 2008 and 2009

The Danish research activities in 2008 and 2009 in the field of properties of water and steam were mainly concentrated at the Technical University of Denmark, Copenhagen. The main task was the modelling of multicomponent aqueous electrolyte systems and application of models to the carbon capture and storage (CCS) processes for treatment of flue gas.

The research at the utilities has concentrated on development of guidelines for sampling of particulate contaminants (corrosion products) in water/steam cycle. An international collaboration project (Canada, Switzerland and Denmark) supported by IAPWS was successfully elaborated in two stages (one each year). Furthermore, the effect of decomposition products from ion exchangers on the water/steam cycle, as well as the condensate polishing plant design, was subject for investigation.

Publications:

Victor Darde; Kaj Thomsen; Willy J.M. van Well; Erling H. Stenby, Chilled ammonia process for CO2 capture, Energy Procedia, 1(2009)1035-1042(issue 1)

Leila Faramarzi; Georgios M. Kontogorgis; Kaj Thomsen; Erling H. Stenby, Thermodynamic modeling of the solubility of CO2 in aqueous alkanolamine solutions using the extended UNIQUAC model application to monoethanolamine and methyldiethanolamine, Energy Procedia, 1(2009)861-867(issue 1)

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Philip Loldrup Fosbøl, Erling Halfdan Stenby, Kaj Thomsen, "The chilled ammonia process - Evaluation of the energy requirements", Internal report (2008)

Victor Camille Alfred Darde, Kaj Thomsen, Erling Halfdan Stenby, "Chilled ammonia process for CO2 capture", Internal report (2008)

German National Committee to IAPWS

Research Activities on the Thermodynamic Properties of Water and Steam

Report "Research in Progress 2010"

Baltic Sea Research Institute, Warnemünde, Germany, Dr. rer. nat. habil. R. Feistel

1. Preparation of the Guideline on an Equation of State for Humid Air in Contact with Seawater and Ice, Consistent with the IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater (with H.J. Kretzschmar, A.H. Harvey, M. Miyagawa)

2. Preparation of the Revision of the Revised Release on the Pressure along the Melting and Sublimation Curves of Water (with W. Wagner, A.H.Harvey)

3. Proposal for Renewal of ICRN 16 on Thermophysical Properties of Seawater

4. other Publications:

   Wright, D.G., Pawlowicz, R., McDougall, T.J., Feistel, R., Marion, G.M.: Absolute Salinity, "Density Salinity" and the Reference-Composition Salinity Scale: Present and Future Use in the Seawater Standard TEOS-10. Submitted to Ocean Science on 30 May 2010

   Seitz, S., Feistel, R., Wright, D.G., Weinreben, S., Spitzer, P., de Bievre, P.: Metrological Traceability of Oceanographic Salinity Measurement Results. Submitted to Ocean Science on 28 May 2010

   Feistel, R., Marion, G.M.M., Pawlowicz, R., Wright, D.G.: Thermophysical Property Anomalies of Baltic Seawater. Ocean Science, submitted 26 May 2010

   Feistel, R.: Stochastic Ensembles of Thermodynamic Potentials. Accreditation and Quality Assurance, submitted 20 May 2010

   Feistel, R., Labrenz, R.: Neuer Internationaler Meerwasserstandard. Schiff & Hafen, April 2010, Nr.4, 66-67

   Wright, D., Pawlowicz, R., McDougall, T., Feistel, R.: Progress Report for the SCOR/IAPSO Working Group 127 on "Thermodynamics and Equation of State of Seawater" CNC/SCOR Newsletter, 49, March 30, 2010, p.1-4 http://www.cmos.ca/scor/NL49Mar2010.pdf

   Wright, D., Pawlowicz, R., McDougall, T., Feistel, R.: Progress Report for the SCOR/IAPSO Working Group 127 on "Thermodynamics and Equation of State of Seawater". CMOS Bulletin, submitted 26 March 2010

   Marion, G.M., Millero, F.J., Camoes, F., Spitzer, P., Feistel, R. Chen, C.-T.A.: pH and Acidity of Natural Waters. Marine Chemistry, submitted 19 Feb 2010

Wright, D.G., Feistel, R., Reissmann, J.H., Miyagawa, K., Jackett, D.R., Wagner, W., Overhoff, U., Guder, C., Feistel, A. and Marion, G.M.: Numerical Implementation and Oceanographic Application of the Thermodynamic Potentials of Water, Vapour, Ice, Seawater and Air. Part II: The Library Routines. Ocean Sci. Discuss., 7, 649-708, 2010. www.ocean-sci-discuss.net/7/649/2010/

Feistel, R., Wright, D.G., Jackett, D.R., Miyagawa, K., Reissmann, J.H., Wagner, W., Overhoff, U., Guder, C., Feistel, A. and Marion, G.M.: Numerical Implementation and Oceanographic Application of the Thermodynamic Potentials of Water, Vapour, Ice, Seawater and Air. Part I: Background and Equations. Ocean Sci. Discuss., 7, 521-647, 2010. www.ocean-sci-discuss.net/7/521/2010/

Feistel, R., Wright, D.G., Kretzschmar, H.-J., Hagen, E., Herrmann, S., Span, R.: Thermodynamic Properties of Sea Air. Ocean Science, 6, 91-141, 2010. http://www.ocean-sci.net/6/91/2010/

Feistel, R., Weinreben, S., Wolf, H., Seitz, S., Spitzer, P., Adel, B., Nausch, G., Schneider, B., Wright, D.G.: Density and Absolute Salinity of the Baltic Sea 2006-2009. Ocean Science, 6, 3-24, 2010. www.ocean-sci.net/6/3/2010/

Safarov, J., Millero, F., Feistel, R., Heintz, A., Hassel, E.: Thermodynamic properties of standard seawater: extensions to high temperatures and pressures. Ocean Science, 5, 235-246, 2009, Internet: www.ocean-sci.net/5/235/2009/

Feistel, R.: Extended equation of state for seawater at elevated temperature and salinity. Desalination 250, 14–18, 2010.

McDougall, T.J., Feistel, R., Wright, D.G., Pawlowicz, R., Millero, F.J. , Jackett, D.R., King, B.A., Marion, G.M., Seitz, S., Spitzer, P., Chen, C.-T.A. (proposers):
IOC, SCOR and IAPSO: The international thermodynamic equation of seawater - TEOS-10: Calculation and use of thermodynamic properties. Intergovernmental Oceanographic Commission, Manuals and Guides No. 56, UNESCO (English), 182 pp., Paris, 2010. www.teos-10.org

University of Applied Sciences Zittau/Görlitz, Faculty of Mechanical Engineering, Department of Technical Thermodynamics, Prof. Dr.-Ing. habil. H.-J. Kretzschmar

1. Development of Fast Property Algorithms Based on Spline Interpolation
   - The algorithms for fast spline-interpolation methods were developed and applied to the calculation of thermodynamic properties of steam and carbon dioxide.
   - An algorithm for the generation of data grids with optimized data density for the user requirements range of state and accuracy is being developed.

3. Thermodynamic Properties of Humid Air
   - The results of the research project RP-1485 "Thermodynamic Properties of Real Moist Air, Dry Air, Steam, Water, and Ice" for the American Society of Heating, Refrigerating, Air-Conditioning Engineers (ASHRAE) were published in the journal "HVAC&R Research".
   - A comprehensive article on the properties of moist air was prepared for the "Journal of Engineering for Gas Turbines and Power".
   - The property library LibHuAirProp for calculating thermodynamic and transport properties for real moist Air, steam, water and ice was completed.
4. Thermodynamic Properties of Seawater and Sea Air
   - The property library LibSeaWa for calculating thermodynamic and transport properties of seawater was completed.
   - A comprehensive article on the properties of sea air was prepared for the Journal "Ocean Science".

Recent Publications

- Herrmann, S.; Kretzschmar, H.-J.; Gatley, D.P.: Thermodynamic Properties of Real Moist Air, Dry Air, Steam, Water, and Ice. HVAC&R Research, 15 (2009), pp. 961-986
- Feistel, R.; Kretzschmar, H.-J.; Span, R.; Hagen, E.; Wright, D. G.; and Herrmann, S.: Thermodynamic Properties of Sea Air. Ocean Sci. (2010) 6, pp. 91-141
- Herrmann, S.; Kretzschmar, H.-J.; Gatley, D.P.:
  Table 2 Thermodynamic Properties of Moist Air at Standard Atmospheric Pressure
  Table 3 Thermodynamic Properties of Water at Saturation
  In: 2009 ASHRAE HANDBOOK FUNDAMENTALS, Chapter PRINCIPLES, SI and I-P Editions, ASHRAE (2009), ISBN 978-1-933742-55-7

Ruhr University Bochum, Germany, Faculty of Mechanical Engineering,
Department of Thermodynamics, Prof. Dr.-Ing. W. Wagner

1. Editorial changes for the Revised Release on the Industrial Formulation IAPWS-IF97

   Editorial changes were made for the correction of the “Notes” in the subsections “Range of validity” for Eq. (7) [region 1 of IAPWS-IF97], page 9, and for Eq. (15) [region 2 of IAPWS-IF97], page 17. In the current Notes, the range of validity of IAPWS-IF97 in the temperature range between 273.15 K and 273.16 K is not correctly described and was correspondingly corrected. In addition, in Section 12 “Estimates of uncertainties” a hint is given where to find estimates of the uncertainty in enthalpy, namely in the IAPWS Advisory Note No. 1 given as Ref. [15].

2. Editorial changes for the Revised Release on the IAPWS-95 Formulation

   In Section 6 “Estimates of uncertainties” a hint is given where to find estimates of the uncertainty in enthalpy, namely in the IAPWS Advisory Note No. 1 given as Ref. [9].

3. Revision of the Revised Release on the Pressure along the Melting and Sublimation Curves of Ordinary Water Substance

   The revision refers to a new estimation of the uncertainty in sublimation pressure. This new estimation is based on a comprehensive physically founded consideration performed by Rainer Feistel with input from Allan Harvey and Wolfgang Wagner.

4. Steam Tables for the VDI-Heat Atlas 2010

   The work on Section D2.1 “Properties of Water and Steam” of the VDI-Heat Atlas 2010 was finished and corresponding steam tables were calculated based on the Industrial Formulation IAPWS-IF97. These steam tables are the main part of this section. Prof. H.-J. Kretzschmar is co-author of this contribution.

Current Status of Research Activities in Japan

Submitted to the Executive Committee Meeting, IAPWS, Ontario, Canada, July 2010

by

Japanese National Committee
International Association for the Properties of Water and Steam
c/o The 139th Committee on Steam Properties
Japan Society for the Promotion of Science (JSPS)
6, Ichiban-cho, Chiyoda-ku
Tokyo 102-8471, Japan

The Japanese National Committee to the IAPWS is countinuing to play an active function as the 139th Committee on Steam Properties chaired by Professor Masaru Nakahara, Kyoto University, at the Japan Society for the Promotion of Science (JSPS), Tokyo.

The following research projects on the thermophysical and physical-chemical properties of water substances including various aqueous systems of technological importance are currently in progress at several universities and institutions in Japan.

At Japan Atomic Energy Agency, Dr. S. UCHIDA made his effort to promote development of evaluation method on flow-accelerated-corrosion (FAC) of components in nuclear power plants and mitigation of stress corrosion cracking of core internals of BWRs. He also promotes the national project on FAC of PWR supported by Nuclear and Industrial Safety Agency as a visiting researcher of the University of Tokyo. A FAC wall thinning rate evaluation model based on combined analyses of a static electrochemical analysis and a dynamic oxide layer growth analysis has been developed to predict wall thinning rates in PWR secondary piping [1],[2], [5] -[12]. 2) Other efforts on water chemistry have been put on evaluating and mitigating corrosive conditions against IGSCC. [3], [4].
[Latest publication: [1] M. Naitoh, S. Uchida, Y. Uehara, H. Okada and S. Koshizuka, “Evaluation of wall thinning rate due to flow accelerated corrosion with the coupled models of electrochemical analysis and double oxide later analysis”, Proc. PVP2009, 2009 ASME Pressure Vessel and Piping Division Conference, July 26-30, 2009, Prague, Czech Republic, PVP2009-77583 (2009), [2] S. Uchida, M. Naitoh, Y. Uehara, H. Okada, S. Koshizuka and D. H. Lister, “Evaluation of Wall Thinning Rate due to Flow Accelerated Corrosion with the Coupled Models of Electrochemical Analysis and Double Oxide Layer Analysis”, Proc. 14th Int. Conf. Environmental Degradation of Materials in Nuclear Power Systems – Water Reactors, Virginia Beach, VA, Aug. 22-27, 2009, ANS, 2009 (in CD), [3] S. Uchida, T. Satoh, T. Tsukada, T. Miyazawa, Y. Satoh and K. Ishii, “Evaluation of the Effects of Oxide Film on Electrochemical Corrosion Potential of Stainless Steel in High Temperature Water”, ibid., [4] T. Satoh, Y. Miwa, T. Tsukada and S. Uchida, “A new concept sensor for determination of oxygen and hydrogen peroxide concentrations in nuclear reactor coolant”, ibid., [5] Tomonori Satoh, H. Ugachi, T. Tsukada and S. Uchida, “Effects of alloy composition of carbon steel on the flow accelerated corrosion and oxide film properties in neutral water condition”, ibid., [6] H. Okada, S. Uchida, Y. Uehara, M. Naitoh and S.

Koshizuka, "Evaluation of Local Wall Thinning of Piping due to Liquid Droplet Impingement by Coupled Analysis of Corrosion and Flow Dynamics", Proc. the 13th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH-13), 2009 (Kanazawa City, Japan), N13P1177 (in CD), [7] M. Naitoh, S. Uchida, H. Okada, Y. Uehara and S. Koshizuka, "Evaluation of Flow Accelerated Corrosion by Coupled Analysis of Corrosion and Flow Dynamics (I) Major Features of Coupled Analysis and Application for Evaluation of Wall Thinning Rates", ibid., [8] Y. Uehara, S. Uchida, H. Okada, M. Naitoh and S. Koshizuka, "Evaluation of Flow Accelerated Corrosion by Coupled Analysis of Corrosion and Flow Dynamics (II) Comparison of LES and k-e Models for Evaluating Mass Transfer Coefficients", ibid., [9] S. Uchida, H. Okada, Y. Uehara, M. Naitoh and S. Koshizuka, "Evaluation of Flow Accelerated Corrosion by Coupled Analysis of Corrosion and Flow Dynamics (III)Relationship of Oxide Film Thickness, Hematite/Magnetite Ratio, ECP and Wall Thinning Rate", ibid., [10] S. Uchida, H. Okada, Y. Uehara, M. Naitoh, S. Koshizuka and D. H. Lister, "Effects of Water Chemistry on Flow Accelerated Corrosion and Liquid Droplet Impingement", Proc. Symposium on Water Chemistry and Corrosion in Nuclear Power Plant in Asia 2009, Nagoya, Japan, Oct. 28-29, 2009, Atomic Energy Society of Japan (2009) (in CD), [11] S. Uchida, M. Naitoh, H. Okada, Y. Uehara, S. Koshizuka, R. Svoboda and D. H. Lister, "Effects of Water Chemistry on Flow Accelerated Corrosion and Liquid Droplet Impingement Accelerated Corrosion", Power Plant Chemistry, 11, 12, (2008) 704-716, [12] S. Uchida, M. Naitoh, Y. Uehara, H. Okada, T. Ohira, H. Takiguchi, W. Sugino and S. Koshizuka, " Evaluation of Flow Accelerated Corrosion of PWR Secondary Components by Corrosion Analysis Coupled Flow Dynamics Analysis (IV), Comparison of Wall Thinning Rates Calculated with the Coupled Model of Static Electrochemical Analysis and Dynamic Double Oxide Layer Analysis and Their Values Measured at a PWR plant", Journal of Nuclear Science and Technology, 47 [2], (2010) 184-196.] [contact: Dr. S. Uchida; E-mail: uchida.shunsuke@jaea.go.jp].

The research center of Supercritical Fluid Technology, Graduate School of Engineering, Tohoku University has performed decomposition of heavy oil in supercritical water. It was revealed that the effect of water on bitumen reaction was mainly extraction solvent for lighter fraction in the bitumen and the yield of coke was promoted because the condensed heavy hydrocarbons combined together to form coke [WCCE8 (August 2009, Montréal, Quebec, Canada) M. Watanabe, S. Kato, S. Nozoe, R. L. Smith; Masaru Watanabe, Shin-nosuke Kato, Satoshi Ishizeki, Hiroshi Inomata, Richard Lee Smith Jr. "Heavy oil upgrading in the presence of high density water: Basic study" The Journal of Supercritical Fluids, Volume 53, Issues 1-3, June 2010, Pages 48-52]. They continued to study on polycarbonate decomposition in high pressure steam [Masaru Watanabe, Yasuaki Matsuo, Takashi Matsushita, Hiroshi Inomata, Toshiyuki Miyake, Katsuhiko Hironaka "Chemical recycling of polycarbonate in high pressure high temperature steam at 573 K" Polymer Degradation and Stability, Volume 94, Issue 12, December 2009, Pages 2157-2162]. The center has tried to clarify the effect of temperature and pressure (sometimes with an additive) on sugar and sugar-related compound conversion in high pressure high temperature water [Naota Torii, Atushi Okai, Kazuaki Shibuki, Taku M. Aida, Masaru Watanabe, Masayuki Ishihara, Hiroichi Tanaka, Yoshiyuki Sato, R.L. Smith Jr. "Production of d-glucose from pseudo paper sludge with hydrothermal treatment" Biomass and Bioenergy, Volume 34, Issue 6, June 2010, Pages 844-850]. They also studied the effect of additive on sugar into a furan compound with microwave heating [Xinhua Qi, Masaru Watanabe, Taku M. Aida, Richard L. Smith Jr. "Sulfated zirconia as a solid acid catalyst for the

dehydration of fructose to 5-hydroxymethylfurfural" Catalysis Communications, Volume 10, Issue 13, 25 July 2009, Pages 1771-1775]. The center has recently started to study on biomass combustion in high pressure water media to recover the energy in the biomass as a heat [Kunio Arai, Richard L. Smith Jr., Taku M. Aida "Decentralized chemical processes with supercritical fluid technology for sustainable society" The Journal of Supercritical Fluids, Volume 47, Issue 3, January 2009, Pages 628-636]. The center also performed to synthesize the fluorescent material (ZnSiO4:Mn) in supercritical water [Masafumi Takesue, Atsuko Suino, Yukiya Hakuta, Hiromichi Hayashi, Richard L. Smith Jr." Crystallization trigger of Mn-doped zinc silicate in supercritical water via Zn, Mn, Si sources and complexing agent ethylenediamine tetraacetic acid" Materials Chemistry and Physics, Volume 121, Issues 1-2, 15 May 2010, Pages 330-334; Kazuaki Shibuki, Masafumi Takesue, Taku M. Aida, Masaru Watanabe, Hiromichi Hayashi, Richard L. Smith Jr. "Continuous synthesis of Zn2SiO4:Mn2+ fine particles in supercritical water at temperatures of 400–500 °C and pressures of 30–35 MPa" The Journal of Supercritical Fluids, In Press, Corrected Proof, Available online 21 May 2010] and they have tried to reveal the formation mechanism of the material during the heating process with the assist of Spring-8 [Masafumi Takesue, Kenji Shimoyama, Kazuaki Shibuki, Atsuko Suino, Yukiya Hakuta, Hiromichi Hayashi, Yasuo Ohishi, Richard Lee Smith Jr. "Formation of zinc silicate in supercritical water followed with in situ synchrotron radiation X-ray diffraction" The Journal of Supercritical Fluids, Volume 49, Issue 3, July 2009, Pages 351-355].

At the Institute of Multidisciplinary Research for Advanced Materials at Tohoku University, Prof. M. KAKIHANA and his group developed a panel of stable, non-toxic and water-soluble compounds of Si, V, Ti and Ta. These compounds can be utilized for the synthesis of oxide materials by solution based processes, which are based on the hydrothermal processing or which include a hydrothermal treatment as one of the key synthesis steps. The unique chemical properties of these complexes were used to synthesize new photocatalytic materials for water splitting that involve both Ti and Ta. The combination of hydrothermal process with post-synthetic treatment allowed for the first time to obtain highly crystalline TiO_2(B) materials. The new water-soluble compound of Si was applied for preparation of the series of rare-earth and manganese activated phosphors containing silicon such as $(Y,Ce,Gd)_2SiO_5$, $Ca_3Sc_2Si_2O_{12}:Ce^3$ and $Zn_2SiO_4:Mn^{2+}$, which exhibited remarkably improved fluorescence brightness and color purity compared to the materials synthesized by the conventional approaches. Finally, water soluble complex of V was used in the synthesis of nano-crystalline $YVO_4:Eu^{3+}$ phosphors by the solvothermal process in the mixed alcohol-water solvents under sub-critical conditions, and it yielded YVO_4 nanoparticles with the unique raspberry-like morphology. The peculiar shape of the phosphor particles resulted in the remarkable enhancement of fluorescent intensity due to the favorable particles shape for the more efficient absorption of excitation radiation. [Y. Suzuki, and M. Kakihana, J. Cer. Soc. Japan, **117**, 330 (2009); K. Yamamoto, K. Tomita, K. Fujita, M. Kobayashi, V.Petrykin, and M. Kakihana, J. Crystal Growth, **311(3)**, 619 (2009); K. Yamamoto, H. Shimoita, K. Tomita, K. Fujita, M. Kobayashi, V. Petrykin, and M. Kakihana, J. Cer. Soc. Japan, **117**, 347 (2009); S. Kaowphong, V. Petrykin, S. Thongtem, and M. Kakihana, J. Cer. Soc. of Japan, **117**, 273 (2009); S. Kaowphong, K. Nakashima, V. Petrykin, S. Thongtem, M. Kakihana, J. Am. Cer. Soc., **92**, S16 (2009).] Profs. T. SATO and S. YIN with co-workers studied on the panoscopic assembling of ceramic materials applicable for environmental clean-up, energy saving, UV/NIR shielding, preventing the healthy damage, etc. by solvothermal reactions. They

successfully prepared visible light responsive photocatalysts with controllable phase compositions, morphologies, together with excellent visible light induced deNO_x activity. They also researched on the synthesis of multifunction thin films with UV/NIR shielding property, photocatalytic activity and superhydrophobicity or superhydrophilicity. The relationship between morphologies and photo-chemical properties of inorganic materials was investigated in detail. In addition, environmental friendly synthesis of lead-free dielectric ceramic materials, ceria-based inorganic UV-shielding materials with excellent safety, comfort and transparency in the visible light region; rare earth oxide nanoparticles with controlled morphology and excellent fluoresence properties, Ag/γ-Al_2O_3 nanocomposites with excellent deNO_x catalytic activity, were carried out. [Solid State Sci., 11, 182-188 (2009);Solid State Phenomena, 147-149, 851-855(2009); Nanoscale Res. Lett.,4, 247-253(2009); J. Cryst. Growth, 311, 576-579 (2009); J. Cryst. Growth, 311, 580-584 (2009).; J. Ceram. Soc. Jpn. 117, 320-325 (2009); Appl. Catal. B, 89,118-122 (2009); Mater. Chem. Physics.116, 269-272 (2009); Solid State Sci., 11, 988-993 (2009); Mater. Lett., 63, 1583-1585 (2009); J. Colloid Interface Sci., 336, 150-254 (2009); Crystal Growth Des., 9, 2944-2949 (2009); Nanotechnol. 20, 305302 (2009); J. Molecular Catal. A: Chem., 309, 50-56 (2009); J.Mater.Sci., 44, 4834-4839 (2009); Mater.Chem.Phys., 116, 421-425 (2009); Mate. Sci.Eng.: C, 29, 1849-1854 (2009); Solid State Sci. 11, 1703-1708 (2009); Nanotechnol. 20, 405606 (2009); Appl. Mater. Interfaces,1, 2649-2698 (2009); Eur. J. Inorg. Chem., 29-30, 4441-4445 (2009) J.Am.Ceram.Soc., 92, 3125-3128 (2009); Appl. Clay Sci., 46, 363-368 (2009); Func. Mater.Lett., 2, 157-161 (2009); Dyes & Pigments, 84, 237-241 (2010); Appl.Catal.B., 93, 299-303 (2010).; J.Euro. Ceram. Soc., 30, 699-704 (2010); J.Mater.Sc., 45, 725-732 (2010); Mater. Res. Bull., 45, 275–278 (2010); J.Nanosci.Nanotechnol. 10, 731-738 (2010); J.Cryst. Phys.Chem., 1(1), 11-30 (2010); Res. Chem. Intermed., 36, 61-67 (2010); Res. Chem. Intermed., 36, 69-75 (2010); J.Nanosci.Nanotechnol., 10, 4619–4623 (2010); J.Ceram.Soc.Jpn., 118, 555-557 (2010); Surf. Rev. Lett., 17, 147-152 (2010)].The relationship between morphologies and photo-chemical properties of inorganic materials was mainly investigated in detail. Profs. A. MURAMATSU and K. KANIE with co-workers have been studied the synthesis of monodispersed particles and their formation mechanism in liquid and/or solution phase. The Gel-sol method is originated and novel procedure to prepare the particles precisely controlled in size, shape, structure, and composition with rather higher productivity, based on the well controlled nucleation and growth via selective chemical reaction such as a forced hydrolysis, selective reduction, and selective sulfurization. Now, it has been applied to the formation of ITO particles as a transparent conductive film component, $BaTiO_3$ as dielectrics and/or piezoelectric material, ferric oxides as a magnetic material and so on. Also, they have been making their maximum efforts on the hybridization of monodispersed particles with organic material such as liquid crystals, in order to obtain multi-functional materials. In addition to these original methods, the Liquid-Phase Selective Deposition has also been developed as a novel preparation method of heterogeneous catalysts for industrial use in dilute solution of metal precursory complexes. [Journal of Materials Science, 43(7), 2367-2371 (2008); Catalysis Today 132, 81-87 (2008); Chemistry Letters, 37(12), 1278-1279 (2008); Chemical Communications, 33, 3382-3384 (2008); Chemistry Letters, 38(6), 562-563 (2009); Chemosphere, 76(5) 638-643 (2009); Applied Catalysis B 87(3) 239-244 (2009)]. Adschiri laboratory, recently, proposed a new method to synthesize organic–inorganic hybrid nanocrystals by using supercritical hydrothermal method. In the supercritical state, organic molecules and metal salt aqueous solution forms a homogeneous phase, and water molecule works as a catalyst for promoting organic –inorganic reactions. Thus, just by introducing organic molecules during the hydrothermal synthesis, hybrid nanoparticles are synthesized. Adschiri laboratory has

challenged to synthesize variety of hybrid nanomaterials, including CO_3O_4 and CeO_2 nano crystals.[PHYS. REV. B, **79**,144411(2009), CRYS. GROWTH & DES., 9 ,5297(2009).]

At the Energy Technology Research Institute, National Institute of Advanced Industrial Science and Technology, Drs. T. Takanohashi, M. Morimoto and S. Sato have succeeded in determining the conditions of supercritical water which have good miscibility with heavy oils, through comparisons of dielectric constant (ε) and Hansen solubility parameter (HSP) of supercritical water with those of typical solvent. They found that the required conditions of supercritical water was $2.2 <= \varepsilon <= 10.4$ and HSP for hydrogen bonding, δ_h, < 10.0 $MPa^{0.5}$. Validity of the optimum conditions estimated was confirmed by some experimental results [Morimoto, M., Sato, S. and Takanohashi, T., *Journal of the Japan Petroleum Institute*, 53, 61-62 (2010)]. [contact: Dr. T. Takanohashi; E-mail: toshi-takanohashi@aist.go.jp, Dr. M. Morimoto; E-mail: m.morimoto@aist.go.jp]

At the department of material and environmental chemistry, Utsunomiya University, Dr. T. SATO and co-workers studied heavy oil upgrading with formic acid in supercritical water at 723 K. In supercritical water, water gas shift reaction between CO and supercritical water gives active hydrogen that proceeds hydrogenation of heavy oils. Formic acid is one of the intermediate of water gas shift reaction. The reaction under pyrolysis condition and supercritical water was also conducted. The supercritical water and formic acid system gave highest conversion of asphaltene and lowest amount of coke among these systems, which indicated that both the solvent power of supercritical water and active species derived from decomposition of formic acid promoted the conversion of hyavy oil (bitumen) to lower molecular weight side. The supercritical water and formic acid mixture can be the effective system for upgrading of heavy oil. [T. Sato et al., Proc. 8th World Congress of Chemical Engineering, Montréal, 2009, 01335].

At the Material Properties and Metrological Statistics Division, National Metrology Institute of Japan (NMIJ, formerly NRLM), National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, a section lead by Dr. K. FUJII is working on the density, viscosity, and refractive index standards. A determination of the Avogadro constant is being conducted in this section as an international project organized by the Comité International des Poids et Mesures (CIPM). This project continues through 2004 to 2011 with participants of eight National Metrology Institutes (BIPM, NMI-Australia, IMGC, IRMM, NIST, NMIJ, NPL, and PTB). The target of this project is to replace the present definition of the kilogram with a new definition based on fundamental physical constants. For the fundamental reduction of uncertainty, a 5 kg of ^{28}Si crystal was grown in 2007, and two 1 kg spheres were polished from the crystal in 2008 for density measurement [P. Becker, H. Friedrich, K. Fujii, W. Giardini, G. Mana, A. Picard, H.-J. Pohl, H. Riemann and S. Valkiers, "The Avogadro constant determination via enriched silicon-28," Meas. Sci. Technol., 2009, Vol. 20, 092002]. The density of the crystal has been determined with a relative standard uncertainty of 3×10^{-8} [N. Kuramoto and K. Fujii, "Improvement in the volume determination for the Si spehers with an optical interferometer," IEEE Trans. Instrum. Meas., 2009, Vol. 58, No. 4, pp. 915-918]. Using the silicon crystals as a solid density standard, density standard liquids and PVT properties of fluids are calibrated by the magnetic suspension densimeter developed at

the NMIJ [Y. Kano, Y. Kayukawa, K. Fujii, and H. Sato, "A new method for correcting a force transmission error due to magnetic effects in a magnetic levitation densimeter," Meas. Sci. TEchnol., 2007, Vol. 18, pp. 659-666]. In his group a new absolute viscosity measurement by the falling ball method is in progress. Nanotechnologies for measuring the falling distance and diameters of small silicon spheres have been developed for providing reference data for liquid water with a relative standard uncertainty of 0.01 % [Y. Fujita , N. Kuramoto, Y. Kurano, and K. Fujii, "A new project at NMIJ for an absolute measurement of the viscosity by the falling ball method," Proc. 14th ICPWS, Kyoto, 2004, 112-115]. Based on the viscosity of water, calibration of the viscosity standard liquids is being conducted in a range 1 mPa s to 500 Pa s [Y. Fujita, Y. Kurano and K. Fujii, "Evaluation of uncertainty in viscosity measurements by capillary master viscometers," Metrologia, 2009, Vol. 46, pp. 237–248]. Calibration service for non-Newtonian liquid has also started in 2009 using a new falling cylinder method. Dr. K. FUJII is working as a chairman of the WG-Density, CCM (Consultative Committee for Mass and Related Quantities) to organize the research activities on the density standards at the National Metrology Institutes. In April 2008, the CCM WG-Density meeting was held at the BIPM, and an idea for clarifying the roles of CIPM and IAPWS standards for the density of water has been discussed in the meeting, and approved both by the CCM and the IAPWS [A. H. Harvey, R. Span, K. Fujii, M. Tanaka and R. S .Davis, "Density of water: roles of the CIPM and IAPWS standards," Metrologia, 2009, Vol. 46, pp. 196-198]. For details, contact Dr. K. Fujii, Chief, Fluid Properties Section, NMIJ (E-mail: fujii.kenichi@aist.go.jp).

At the Department of Mechanical Engineering, Keio University, Yokohama, Prof. K. YASUOKA and his group are studying the molecular dynamics (MD) simulation to clarify the nucleation phenomena. They reported urea-water binary droplets on the flat and pillared hydrophobic surfaces. [T. Koishi, K. Yasuoka, X. C. Zeng and S. Fujikawa, Faraday Disc., in press (2010), DOI: 10.1039/b926919c] They also reported how mercury inhibits water permeation through aquaporin-1. [Y. Hirano, N. Okimoto, I. Kadohira, M. Suematsu, K. Yasuoka, and M. Yasui, Biophys. J., 98, 1512 (2010).] They reported phase diagram of Lennard-Jones fluid confined in the slit pores [T. Kaneko, T. Mima, K. Yasuoka, Chem. Phys. Lett., 490, 165 (2010).] [contact: Prof. K. Yasuoka; E-mail: yasuoka@mech.keio.ac.jp].

At the Department of Mechanical Systems Engineering, National Defense Academy, Yokosuka, Prof. N. KAGAWA and his group developed a twin-cell type adiabatic calorimeter for water + alcohol and water + ammonia mixtures. The thermometers of the apparatus are being replaced to improve the measurement uncertainty. By the modified apparatus, isochoric heat capacities of water will be measured for temperatures from 220 to 520 K and pressures to 30 MPa. [contact: Prof. N. Kagawa; E-mail kagawa@nda.ac.jp]

Prof. H. TAKAKU was retired from Faculty of Engineering of Shinshu University in Nagano City at the end of March of 2006. However, at present he is entrusted by Shinshu University as a professor in charge of education, and also has a lecture for graduate students in Energy Engineering School of Tokai University. He has been working as a temporary technical adviser at Naigai Chemical Products Co., LTD. in Tokyo since May of 2006. He and his coworkers engaged in Shinshu University, Naigai Chemical Products Co., the electric power companies and turbine manufacturer are conducting researches on the

corrosion of materials for steam turbines in geothermal power plants, for boiler tubes and low pressure steam turbines in the conventional thermal and combined cycle power plants, and other subjects on corrosion and water chemistry for power plants. The latest papers; (1) T. Nakane, L.-B. Niu, Shuji Oishi and H. Takaku, "Influence of Organic Acids on Corrosion Behavior of Boiler Tube Materials in Simulated AVT Waters Coexisted with Chloride Ions ", *J. Japan Inst. Metals*, Vol. 74, No.9 (2010), (Accepted for printing). (2) L.-B. Niu, T. Goto, T. Nakane, H. Takaku and Yoshihiro Sakai, "Effect of Cl^- and SO_4^{2-} on Pitting Corrosion Susceptibility for Materials of Low-Pressure Steam Turbines in Power Plants", *J. Japan Inst. Metals*, Vol. 74 (2010 or 2011), (Accepted for printing). (3) T. Nakane, L.-B. Niu, S. Oishi and H. Takaku, "Electro-chemical Corrosion Behaviors and Formed Film Characteristics of Boiler Tube Steel Weldments in Simulated AVT Waters", *Journal of The Japanese Society for heat Treatment (NETSU SHORI)* (contributed and in review). (4) T. Nakane, L.-B. Niu and H. Takaku, "Effect of Chloride and Sulfate in Simulated AVT Waters on Electrochemical Corrosion Behaviors and Film Characteristics of Low Pressure Steam Turbine Materials", *PowerPlant Chemistry*, (contributed and in review). [Contact: Prof. H. Takaku; E-mail: takaku06@ybb.ne.jp]

At the Department of Mechanical Systems Engineering, Toyama Prefectural University, Toyama, Dr. H. MIYAMOTO and their group have been studying the various thermodynamic properties including the PVTx, critical locus, and saturation properties at temperatures up to 600 K and at pressures up to 200 MPa. [S. Muromachi, H. Miyamoto, and M. Uematsu, "(p, ρ, T, x) Properties for $\{x\ NH_3 + (1\text{-}x)\ H_2O\}$ mixtures at T = (450, and 500) K over the pressure range from (10 to 200) MPa", J. Chem. Thermodyn., 2008, 40, pp. 1594-1599] [A. Sakabe, D. Arai, H. Miyamoto, and M. Uematsu, "Measurements of the critical parameters for $\{xNH_3 + (1 - x)H_2O\}$ with x = (0.9098, 0.7757,0.6808)", J. Chem. Thermodyn., 2008, 40, pp. 1527-1530] Most of our apparatuses for higher pressure ranges had been developed by the Uematsu Laboratory in Keio University. After Uematsu retired from working at Keio Univ., he provided us most of his measurement apparatuses in 2008. Therefore, we aim to clarify the mixing effects of various mixtures in wider ranges of temperatures and pressures. We are also trying to measure the vapor-liquid equilibrium properties for natural substance mixtures using the new apparatus. [Contact: Dr. H. Miyamoto; E-mail: miyamoto@pu-toyama.ac.jp]

At the Institute for Chemical Research, Kyoto University, Uji, Kyoto, Prof. M. NAKAHARA, Prof. N. MATUBAYASI, Dr. C. WAKAI, and their coworkers study the structure, dynamics, and reactions in super- and subcritical water and related systems such as ionic liquids by means of multinuclear NMR (nuclear magnetic resonance) spectroscopy and computer simulation. Their current focus are (1) the translation dynamics of water and organic solvents in supercritical states and the elucidation of the effect of hydrogen bonding ["Self-diffusion coefficients for water and organic solvents in extremely low-density supercritical states", K. Yoshida, N. Matubayasi, and M. Nakahara, *J. Mol. Liq.* **147**, 96-101 (2009)] and (2) the environmental effect on the chemical shift of the diluted water and its usage in purification of ionic liquids ["Water as an In-situ NMR Indicator for Impurity Acids in Ionic Liquids", Y. Yasaka, C. Wakai, N. Matubayasi, and M. Nakahara, *Anal. Chem.* **81**, 400-407 (2009)]. [contact: Prof. M. Nakahara; E-mail: nakahara@scl.kyoto-u.ac.jp & Prof. N. Matubayasi; E-mail nobuyuki@scl.kyoto-u.ac.jp]

At the Department of Molecular Chemistry and Biochemistry, Doshisha University, Kyo-Tanabe, Kyoto, Prof. M. UENO, Prof. IBUKI and their group have been studying the electric conductivities of 1:1 electrolytes in high-temperature alcohols (methanol and ethanol) ["Electric conductivities of 1:1 electrolytes in high-temperature ethanol along the liquid-vapor coexistence curve. I. NaBr, KBr, and CsBr", *J. Chem. Phys.*, **132** (11), 114501 1-10 (2010)]. In our laboratory, the molecular dynamics simulations have been also studied ["Molecular dynamics simulations of partially diffusion-controlled reaction between mono- and diatomic molecules", *J. Mol. Liq.*, **147** (1-2), 30-36 (2009); "Molecular dynamics simulations of aqueous LiCl solutions at room temperature through the entire concentration range", *J. Mol. Liq.*, **147** (1-2), 56-63 (2009)]. [Contact: Prof. M. Ueno; E-mail: mueno@mail.doshisha.ac.jp]

At Department of Applied Chemistry & Bioengineering, Osaka City University, Dr. N. KOMETANI and his co-workers have studied the TiO2 photocatalysis in high-temperature high-pressure water. They revealed that TiO2 exhibits high photocatalytic activity even under sub- and supercritical conditions [N. Kometani, K. Sugimoto, A. Fujita, Y. Yonezawa, "Photocatalytic Activity of TiO2 Nanoparticles in Hydrothermal and Supercritical Water", J. Chem. Eng. Jpn., Vol.40, pp.463-467 (2007)]. Based on this finding, the hybrid process in which hydrothermal and photocatalytic techniques are combined has been developed. It was demonstrated that such hybrid process could be applied to the treatment of waste water containing organochloride compounds such as chlorobenzene [A. Shimokawa, N. Kometani, Y. Yonezawa, "Degradation of chlorobenzene by the hybrid process of supercritical water oxidation and TiO2 photocatalysis", Sep. Sci. Tech., in press (2010)] as well as the effective gasification of glucose [A. Nakatani, N. Kometani, "Photocatalytic Effect of TiO2 on the Hydrothermal Gasification of Glucose", J. Phys.: Conf. Seri., Vol.215, 012091 (2010)]. The same group also examined the hydrothermal synthesis of size-controlled silver nanoparticles [N. Kometani, T. Teranishi, Y. Yonezawa, "Development of the Metal Nanoparticle Synthesis Method by means of the Hydrothermal Technique", J. Soc. Mater. Sci. Jpn., Vol.58, pp. 481-485 (2009)]. [contact: Dr. N. Kometani; kometani@a-chem.eng.osaka-cu.ac.jp]

At the Department of Mechanical Engineering, Kyushu University, Prof. Y. TAKATA and their group are continuously developing a program package for thermophysical properties of fluids: PROPATH. The current version is 13.1 and the package contains 78 pure substances, moist air, binary mixtures and ideal gases. Information on this package is available through the website: http://www2.mech.nagasaki-u.ac.jp/PROPATH/. In addition, his research group is studying thermophysical properties of hydrogen at ultra-high pressures. They are measuring PVT relation ["Review of the Thermodynamic Properties of Hydrogen Based on Existing Equations of State", N. Sakoda, et al., *Int. J. Thermophysics*, **31**-2, 76-296(2010)], viscosity and thermal conductivity of hydrogen up to 100MPa. ["A Procedure for Application of the Three-Omega Method to Measurement of Gas Thermal Conductivity", E. Yusibani, et al., *J. Thermal Sci. and Tech.*, **4**-1,146-158(2009); "An Accelerated Two-Dimensional Unsteady Heat Conduction Calculation Procedure for Thermal-Conductivity Measurement by the Transient Short-Hot-Wire Method", P. L. Woodfield, et. al., *Int. J. Thermophysics*, **30**-3, 796-809(2009); "End Effects in the Three-Omega Method to Measure Gas Thermal Conductivity", E. Yusibani, et al., *Int. J. Thermophysics*, **30**-3, 833-850(2009); "Techniques for Accurate Resistance Measurement in the Transient -Short-Hot-Wire Method Applied to High Thermal-Diffusivity Gas", P. L. Woodfield, et. al., *Int. J. Thermophysics*, **30**-6, 1748-1772(2009)] [contact: Prof. Y. Takata; E-mail: takata@mech.kyushu-u.ac.jp]

The following research projects on the thermophysical and physical-chemical properties of water substances including various aqueous systems of technological importance are currently in progress at several universities and institutions in Japan. At the Department of Applied Chemistry and Biochemistry, Kumamoto University, Kumamoto, Prof. M. GOTO, Assoc. Prof. M. SASAKI, and their group are studying kinetics and mechanism for reactions of biomass related materials in sub- and supercritical water. Biomass and its model compounds such as phenolic compounds and carbohydrates were recovered from lignocellulosic biomass with a batch reactor [Wahyudiono, M. Sasaki and M. Goto, *Fuel*, **88**, 1656-1664 (2009); Wahyudiono, Mitsuru Sasaki and Motonobu Goto, accepted for publication in *Journal of Material Cycles and Waste Management* (2010); Mitsuru Sasaki, Wahyudiono, Hiroaki Kawanabe, Takashi Saito and Motonobu Goto, *Proceeding of 9th International Symposium on Supercritical Fluids 2009*, (CD-ROM), Arcachon, France (2009)]. The liquefaction of bitumen and the decomposition of its model compounds were carried out at 673 K and 723-773 K. These results suggest that supercritical water can be an effective solvent for the extraction and decomposition of them [Wahyudiono, T. Shiraishi, K. Iwata, M. Sasaki and M. Goto, *Proceeding of 9th International Symposium on Supercritical Fluids 2009,* Arcachon, France (2009); Pradip C. Mandal, Tatsuya Shiraishi, Wahyudiono, Mitsuru Sasaki and Motonobu Goto, *Proceeding of AIChE Annual Meeting 2009*, Paper 81e, Nashville, TN, USA (2009)]. Pugment and nutraceutical compounds were extracted from *Chlorella vulgaris* using $scCO_2$ and water in hydrothermal condition. Biological active compounds from other waste biomass were also extracted using $scCO_2$ and hot water. Furthermore, the antioxidant and antibacterial of extracts were analyzed [Kiwa Kitada, Siti Machmudah, Mitsuru Sasaki, Motonobu Goto, Y. Nakashima, S. Kumamoto and T. Hasegawa, *J. Chemical Technology and Biotechnology*, **84**(5), 657-661 (2009); Kiwa Kitada, Siti Machmudah, Mitsuru Sasaki, Motonobu Goto, Y. Nakashima, S. Kumamoto, T. Hasegawa, *Separation Science and Technology*, **44(**5), 1228-1239 (2009); E. M. Suleimenov, Siti Machmudah, Mitsuru Sasaki, Motonobu Goto, *Chemistry of Natural Compounds*, **46(**1), 140-141 (2010)] Yuzu oil was fractionated by semi-continuous supercritical CO_2 extraction column to recover sesquiterpenes [A. Terada, N. Kitajima, Siti Machmudah, Masahiro Tanaka, Mitsuru Sasaki, Motonobu Goto, *Separation and Purification Technology*, **71**(1), 107-113 (2010)] and simultaneous extraction of coffee beans using supercritical CO_2 and water was studied for recovering chlorogenic acid as a water soluble fraction and caffeine as a supercritical CO_2 soluble one [Siti Machmudah, Kiwa Kitada, Mitsuru Sasaki, and Motonobu Goto, accepted for publication in *Ind. Eng. Chem. Res.* (2010)]. They are also studying various natural materials in collaboration with universities [Siti Machmudah, Kiwa Kitada, Mitsuru Sasaki, Motonobu Goto, J. Munemasa, M. Yamagata, submitted for publication in *Ind. Eng. Chem. Res.* (2010); Siti Machmudah, T. Kamogawa, Mitsuru Sasaki and Motonobu Goto, *Proceeding of 9th International Symposium on Supercritical Fluids*, Arcachon, France (2009)] and companies [Ruhan Askin, Mitsuru Sasaki, Motonobu Goto, accepted for publication in *Ind. Eng. Chem. Res.* (2009); Ruhan Askin, Mitsuru Sasaki, and Motonobu Goto, accepted for publication in *Journal of Food and Boproducts Pocessing* (2009); Ruhan Askin, Mitsuru Sasaki, and Motonobu Goto, accepted for publication in *Journal of Separation and Purification Technology* (2009)] As a part of Kumamoto University Global COE program "Global Initiative Center for Pulsed Power Engineering", developments of an evolutional reaction / material processing methods were conducted. Electrospinning is one of the simple techniques to produce nanofibers and we challenged electrospinning of combined polymers in supercritical CO_2 [Motonobu Goto, Kanako Murakami, Wahyudiono, Mitsuru Sasaki, Proceeding of 9th Conference on Supercritical Fluids and Their Applications, Sorrento, Napoli, Italy

(2010); Mitsuru Sasaki, Wahyudiono, Kanako Murakami, Motonobu Goto, Proceeding of International Seminar on Fundamental and Application of Chemical Engineering, Bali, Indonesia (2010)]. Pulsed laser ablation of various metals in supercritical CO_2 has been developed and morphology of ablated plates and generated nanoparticle were examined. Gold nanoparticles have been successfully generated by laser ablation in supercritical CO_2 [Yutaka Kuwahara, Takashi Saito, M. Haba, T. Iwanaga, Mitsuru Sasaki, and Motonobu Goto, J. Applied Physics, 48, 040207 (2009); Siti Machmudah, Yutaka Kuwahara, Mitsuru Sasaki, and Motonobu Goto, Proceeding of Supergreen 2009, Sendai, Japan (2009)]. [contact: Prof. M. Goto; E-mail: mgoto@kumamoto-u.ac.jp, Assoc. Prof. M. Sasaki; E-mail: msasaki@ kumamoto-u.ac.jp]

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Russian National Committee (RNC)
Report 2009-2010

1. RNC active participation in organization of All-Russian theoretical and practical conference “Increasing reliability and efficiency of thermal power plants and energetic systems exploitation» 1-3 of June 2010, Moscow, MPEI (TU).
2. RNC active participation in organization of 3-rd Water-Chemistry Forum, April 2010, Moscow, MPEI (TU).
3. Two meetings of RNC have been held. Current problems are investigated. K. Orlov is elected as secretary of RNC.

Publications list

1. Thermophysical properties of working substances of heat power engineering: reference book. A. Alexandrov, K. Orlov, V. Ochkov, Moscow, 2009. P. 224 [8]. ISBN 978-5-383-00405-0.
2. Improvement of water chemistry and chemistry contol at thermal power V. Voronov, T. Petrova. Thermal Engineering, #07, 2010, p. 2-6.
3. Selected questions on water chemistry monitoring systems developments V. Voronov, P. Gotovcev, O. Egoshina, D. Smetanin. Thermal Engineering, #07, 2010, p. 24-27.
4. Water chemistry and chemical control organization problems on thermal power plants T. Petrova, V. Voronov. All-Russian theoretical and practical conference “Increasing reliability and efficiency of thermal power plants and energetic systems exploitation» 1-3 of June 2010, Moscow.
5. Turbine condenser cooling systems water chemistry optimization D. Repin, T. Petrova. All-Russian theoretical and practical conference “Increasing reliability and efficiency of thermal power plants and energetic systems exploitation» 1-3 of June 2010, Moscow.
6. Water treatment new technologies investigation on thermal power plants B. Larin, A. Korotkov, M. Oparin, A. Larin. All-Russian theoretical and practical conference “Increasing reliability and efficiency of thermal power plants and energetic systems exploitation» 1-3 of June 2010, Moscow.
7. Using causes of infringement searching algorithms and mathematical models in water chemistry monitoring systems P. Gotovcev, D. Smetanin. All-Russian theoretical and practical conference “Increasing reliability and efficiency of thermal power plants and energetic systems exploitation» 1-3 of June 2010, Moscow.
8. T. Petrova, L. Seleznev, A. Isyanova. Assessing the impact of various parameters on the formation of deposits in boilers. New in the Russian electric-power industry, #3, 2010.
9. D. Smetanin, O. Egoshina, P. Gotovcev Prospects of water chemistry monitoring systems. New in the Russian electric-power industry, #8, 2009.
10. The problems of equipment corrosion at thermal power plants T. Petrova. 3-rd Water-Chemistry Forum, April 2010, Moscow.
11. V. Ochkov A New Reference Book for Power Engineers (9th conference on Power System Engineering, Thermodynamics & Fluid Flow - ES 2010, June 17 - 18, 2010, Pilsen, Czech Republic)
12. V. Voloschuk, V. Ochkov, K. Orlov Thermodynamic optimization of a simple binary cycle CCGT with heat recovery boiler with the help of modern information technology // Bulletin of the National Technical University "Kharkov Polytechnic University, #2, 2010, p. 102-106.
13. K. Orlov, V. Voloschuk, V. Ochkov An interactive open calculation of gas turbine power plant // Automation and IT in the energetic, #2, 2010. p. 10-19.

The Swiss National Committee

International Association for the Properties of Water and Steam

Report on IAPWS related activities – August 2009 / July 2010

Submitted to the EC Meeting of IAPWS, Niagara Falls, CA - July 2010.

National Committee Contacts:

SCPWS Swiss Committee for the Properties of Water and Steam
Head: Dr. Robert Svoboda, E-mail: robert.svoboda@power.alstom.com

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

Prof.Dr. Kurt Heininger; University of Applied Sciences, Northwestern Switzerland; Windisch, E-mail: kurt.heiniger@fhnw.ch; web: www.fhnw.ch/technik/itfe

Prof.Dr. Horst-Michael Prasser; Institut für Energietechnik, Swiss Federal Institute of technology, Zürich, E-mail: hprasser@ethz.ch

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

Markus Bernasconi; Swan Analytical Instruments, Hinwil, E-mail: markus.bernasconi@swan.ch

Research activities in the reporting period:

At the University of Applied Sciences, Northwestern Switzerland, a water test rig for 1000 MPa (10 kbar) pressure was set up. At this pressure, water is near the proximity of the liquid-solid phase border at ambient temperatures. This device is useful to study the properties of water for high-pressure cutting and for cleaning. Currently, there is no research project ongoing.

Another project by the University of Applied Sciences, Northwestern Switzerland, in cooperation with the Swiss Institute for Snow and Avalanches, Davos and supported by the Swiss government, was on the energy optimization at the production of artificial snow. Field tests performed during the past winters showed, that with an improved method for nuclei seeding, the energy requirements were reduced to 20% relative to the original design. Further improvements are ongoing.

Contributions to current IAPWS activities:

Chairman Power Cycle Chemistry Working Group (PCC): R.Svoboda
Vice-chairman of Subcommittee on Sea-Water: M.Hiegeman

Initiation of ICRN 26 (Behavior of Aluminum in the Steam Water Cycle of Power Plants)

Participation in the IAPWS International Collaboration on "Improved Sampling Techniques" for corrosion products in water / steam cycles. (Canada, Denmark, Japan, Switzerland)

Informal international collaboration within PCC on technical publications (see "Recent Publications")

Status of Associate Membership to IAPWS:

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

Recent Publications:

B. Elezi: "Inbetriebnahme einer 10kbar-Drucksübersetzer-Pumpe", dissertation at University of Applied Sciences, Northwestern Switzerland,

F. Kreitmeier, "Prof.George Gyrmathy and the wet steam turbine", memorial lecture for G. Gyarmathy (†24 Oct 2009), ASME Turbo Expo, Glasgow, June 2010

B. Dooley, R. Svoboda, " Improving thermal cycle efficiency in advanced power plants: water and steam chemistry and materials performance" (Chapter 4 of "Advanced power plant materials, design and technology"). Woodhead 2010, (to be published).

S. Uchida, M. Naitoh, H. Okada, Y. Uehara, S. Koshizuka, R. Svoboda, D.H. Lister, "Effects of Water Chemistry on Flow Accelerated Corrosion and Liquid Droplet Impingement Accelerated Corrosion", Power Plant Chemistry, 11 (2009) 12, pg 704-717

R.Svoboda, July 14, 2010

U.S. National Committee to IAPWS
2010 Report on Activities of Potential Interest to IAPWS

Communicated from the National Institute of Standards and Technology, Boulder, CO:
A collaboration is continuing with Prof. Richard Wheatley at the University of Nottingham, developing intermolecular pair potentials for aqueous systems for the quantitative calculation of second virial coefficients. Results for the water-carbon-monoxide binary have been obtained and published. Similar results are almost complete for the water-CO_2 binary, and the results have been incorporated into a software model for thermodynamics of moist gases.
References: Wheatley, R.J., and Harvey, A.H., Intermolecular potential energy surface and second virial coefficients for the nonrigid water-CO dimer, *J. Chem. Phys.* **131**, 154305 (2009); Wheatley, R.J., and Harvey, A.H., Intermolecular potential energy surface and second virial coefficients for the water-CO_2 dimer, *J. Chem. Phys.*, in preparation.

In collaboration with researchers in Greece and Germany and at the University of Maryland, work is continuing on the joint IAPWS and IUPAC efforts to update the formulation for the thermal conductivity of water and steam. The form of the critical enhancement has been worked out, and the low-density function and background function have been fitted to data and comparisons with data have been generated. The complete correlation is now ready for evaluation by IAPWS.

In NIST's Process Measurements Division (Gaithersburg, MD), a new gravimetric hygrometer has been developed for direct measurement of humidity in gases. Initially it is being used to validate the performance of humidity generators, but with further refinements it could also be used to measure enhancement factors for the equilibrium solubility of liquid water or ice in air or other gases in order to obtain thermodynamic data for these mixtures. Also in the Process Measurements Division, the vapor pressure of ice has been measured over the temperature range 173 K to 273 K. These measurements were made using cavity ring-down spectroscopy to probe the output of a standard humidity generator which contains isothermal samples of ice. A preliminary analysis indicates better than 1% agreement over this temperature range between the measured ice vapor pressure and the correlation of A. Wexler, *J. Res. NBS* **81A**, 5 (1977).
References: Meyer, C.W, Hodges, J.T., Hyland, R.W., Scace, G.E., Valencia-Rodriguez, J., and Whetstone, J.R., The second-generation NIST standard hygrometer, *Metrologia* **47**, 192 (2010); Bielska, K., Havey, D.K., Scace, G.E., Lisak, D., and Hodges, J.T., Spectroscopic Measurement of the Vapor Pressure of Ice, *Int. J. Thermophys.*, submitted.

NIST's Experimental Properties of Fluids group has built apparatus for two projects to measure thermophysical properties of aqueous gas mixtures at high temperatures. One apparatus is a high-temperature magnetic-suspension densimeter, which has been used to measure H_2O-N_2 and H_2O-CO_2 mixtures up to 620 K. A high-temperature thermal conductivity apparatus (using the transient hot-wire technique) has been converted to alternating-current operation (needed for polar fluids like water) and used to measure the thermal conductivity of H_2O-N_2 and H_2O-CO_2 mixtures up to 740 K.

Communicated from OLI Systems, Morris Plains, NJ:
At OLI Systems, work was continued on various projects related to modeling thermophysical properties of aqueous electrolyte systems. In particular, our work in 2009-2010 was focused on:

(1) Finalizing a comprehensive speciation-based thermodynamic model for aqueous systems containing Fe, Ni, Zn, Li, B, and H_2 at temperatures up to 350 °C
(2) Revising a previously developed model for thermal conductivity of electrolyte solutions (P. Wang and A. Anderko, *Ind. Eng. Chem. Res.*, 47 (2008) 5698-5709) to introduce pressure dependence and to apply it to seawater

(3) Developing a comprehensive model for surface tension of electrolyte solutions, including concentrated and mixed-solvent systems
(4) Developing a phase equilibrium/reaction model for the sulfur-iodine thermochemical cycle for hydrogen production.
(5) Initiating work on a thermodynamic model for interactions between carbon dioxide, natural brines, and minerals

Also, work is underway on developing an electrochemical model for predicting general and localized corrosion of copper in aqueous environments as a function of solution chemistry, temperature and flow conditions.

The following article has been published: P. Wang , A. Anderko, R. D. Springer, J. J. Kosinski, and M.M. Lencka, "Modeling Chemical and Phase Equilibria in Geochemical Systems Using a Speciation-Based Model", *J. Geochemical Exploration*, 106 (2010) 219-225.

International Association for the Properties of Water and Steam Symposium
July 21, 2010, Niagara Falls ON
List of Participants

Andre Anderko	OLI Systems Inc.
Alan Anderson	St. Francis Xavier University
Mikhail Anisimov	University of Maryland, College Park
Lucas Applegarth	University of Guelph
Hugues Arcis	University of Guelph
Ondřej Bartoš	Institute of Thermomechanics AS CR
James Bellows	Siemens Energy, Inc.
Geoffrey Bignold	BIAPWS
Katherine Bissonette	University of Guelph
Francis Brosseau	University of Guelph
Lisheng Chi	Atomic Energy of Canada Ltd.
William Cook	University of New Brunswick
Jeff Cooper	University of London
Kevin Daub	University of Western Ontario
Karol Daucik	DONG Energy Power
Barry Dooley	Structural Integrity Associates, Inc.
Jana Ehlerova	Technical University of Liberec
Rainer Feistel	Baltic Sea Research Institute
Tiffany Fransberger	University of Guelph
Daniel Friend	National Institute of Standards & Technology
Frank Gabrielli	Alstom Power
Daniel Gammage	Babcock & Wilcox Canada
David Guzonas	Atomic Energy of Canada Ltd.
Allan Harvey	National Institute of Standards & Technology
Ian Hey	CANDU Owner's Group
Michael Hiegemann	Alstom (Switzerland) Ltd.
Robert Holloway	Holloway Associates
Jan Hrubý	Institute of Thermomechanics AS CR
John Jevec	The Babcock & Wilcox Company
Peter King	Babcock & Wilcox Canada
Quintin Knapp	University of Western Ontario
Hans-Joachim Kretzschmar	Zittan / Goerlitz University of Applied Sciences
Matthias Kunick	Zittan / Goerlitz University of Applied Sciences
Derek Lister	University of New Brunswick
Kexing Liu	ECOVU
Giles Marion	Desert Research Institute
Eric Maughan	College of Knowledge
Sandy McKay	Ontario Power Generation
Jeff McKinney	Sentry Equipment Corp.
Frank Millero	University of Miami, RSMAS, MAC
Masamichi Miyajima	Chubu Electric Power Co., Inc.
Peter Murphy	General Electric Company
Melonie Myszczyszyn	Canadian Natural Resources Ltd.

International Association for the Properties of Water and Steam Symposium
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List of Participants

Masaru Nakahara	Institute for Chemical Research, Kyoto University
Rod Nashiem	Bruce Power
Roger Newman	University of Toronto
James Noel	University of Western Ontario
Adam Nový	Škoda Power A.S.
Nobuo Okita	Toshiba Corporation Power Systems Company
Konstantin Orlov	Moscow Power Engineering Institute
William Parry	General Electric Company
Rich Pawlowicz	University of British Columbia, Department of Earth & Ocean Sciences
Liyan Qiu	Atomic Energy of Canada Ltd.
John Roberts	Bruce Power (consultant)
Steffen Rudtsch	Physikalisch-Technische Bundesanstalt (PTB)
Bert Rukes	Siemens AG I E F NP
Michael Rziha	Siemens AG, Energy Sector
Pavel Šafařík	Institute of Thermomechanics AS CR
Bill Schneider	Babcock & Wilcox Canada
Milan Sedlar	SIGMA Research and Development Institute
Jaleh Semmler	Atomic Energy of Canada Ltd.
Jan Sengers	University of Maryland, IPST
William Smith	University of Ontario Institute of Technology
Roland Span	RUHR - University Bochum
Paul Spekkens	Ontario Power Generation
Petra Spitzer	Physikalisch-Technische Bundesanstalt (PTB)
Piti Srisukvatananan	University of New Brunswick
Robert Svoboda	Svoboda Consulting
Teresa Switzer	Kinectrics Inc.
Hiroshi Takaku	Shinshu University
Svend-Erik Therkildsen	DONG Energy, Kyndby Power Station
Peter Tremaine	University of Guelph
Liliana Trevani	University of Ontario Institute of Technology (UOIT)
Carl Turner	Atomic Energy of Canada Ltd.
Shunsuke Uchida	Japan Atomic Energy Agency
Masakatsu Ueno	Doshisha University
Václav Vinš	Institute of Thermomechanics AS CR
Wolfgang Wagner	Ruhr-Universitaet Bochum, Lehrstuhl fuer Themodynamik
Koichi Watanabe	Keio University
Kenji Yasuoka	Keio University, Department of Mechancial Engineering
Soohaeng Yoo	Pacific Northwest National Laboratory
Jianguo Yu	Babcock & Wilcox Canada
Xue Yuan (John) Zhang	The University of Western Ontario