THE INTERNATIONAL ASSOCIATION FOR THE PROPERTIES OF WATER AND STEAM

MEMBERS
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Czech Republic
Denmark
France
Germany
Greece
Japan
Russia
United States of America

ASSOCIATE MEMBERS
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Switzerland

EXECUTIVE SECRETARY
Dr. Barry Dooley. Structural Integrity
2616 Chelsea Drive
Charlotte, North Carolina
28209, USA

Phone: 704-502-5081
Email: bdooley@structint.com

Minutes of the Meetings

of the

Executive Committee

of the

International Association for the Properties of

Water and Steam

Doorwerth, The Netherlands
7-11 September 2009

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
Doorwerth, The Netherlands
7-11 September 2009

Plenary Session. Monday, 7th September 2009. 8:32 am

The new President of IAPWS, Friend, welcomed the Executive Committee (EC) and other IAPWS members to Doorwerth for the EC and Working Group (WG) Meetings of IAPWS. The President officially opened the 2009 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. In total, 57 people were in attendance for the opening IAPWS EC meeting

The President asked the representative of The Netherlands to provide some opening comments. Zeijseink welcomed everybody to Doorwerth and to the 2009 IAPWS meetings. He provided some background to KEMA and introduced the IAPWS Symposium which will be held on Wednesday, and mentioned that he hoped that this meeting would be the initiation of developing a Benelux joint member of IAPWS.

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 Berlin meeting for final review prior to being approved during the current EC Meeting. The Executive Secretary reminded the EC of these documents:

- ICRN 23 on Dewpoint of Flue Gases. Distributed 20th February 2009. There had not been any objections within a four month period so this ICRN became official according to the IAPWS By-Law 4.4.

- Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use.

Distributed 10th July 2009. There had been one comment on English grammar which had subsequently been corrected. According to IAPWS By-Law 3.5, this document is ready for final approval by the TPWS Working Group

- Revised Release on the Equation of State 2006 for H2O Ice Ih. Distributed 16th May 2009. No comments had been received. According to IAPWS By-Law 3.5, this document is ready for final approval by the TPWS Working Group.

- Technical Guidance Document: "Instrumentation for Monitoring and Control of Cycle Chemistry for Steam-Water Circuits of Fossil Fired and Combined Cycle Power Plants". Distributed 16th May 2009. Some minor nomenclature issues had been raised. These have subsequently been addressed and a revised version of the document was provided to the National Committees during the week. Also according to IAPWS By-Law 3.5, this document is ready for final approval by the PCC Working Group.

- Supplementary Release on a Computationally Efficient Thermodynamic Formulation for Liquid Water for Oceanographic Use. Distributed 3rd June 2009. A small editorial correction was identified. According to IAPWS By-Law 3.5, this document is ready for final approval by the TPWS Working Group.

- Advisory Note No. 4: Roles of IAPWS and CIPM Standards for the Density of Water. Distributed 3rd June 2009. A small editorial correction was identified. According to IAPWS By-Law 3.5, this document is ready for final approval by the TPWS Working Group.

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

2.2 Press Release.

The President asked Bellows to serve on this Committee. The Clerk of Minutes from each WG will also provide input. A representative from KEMA will also be assigned to provide local information. The Press Release is discussed in Minute 16.1 and Attachment 10.

2.3 Evaluation Committee on International Collaboration.

The President indicated that one proposal had been received by the Executive Secretary prior to the meeting, and that any suggestions from WGs should be given to the Executive Secretary by the end of day. The President then reminded the EC that the Committee to review 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 14.1.

2.4 IAPWS Awards Committees

2.4.1 Helmholtz Award Committee

The President indicated that there was not a Helmholtz Awardee this year. The Executive Secretary then reminded the EC that the Helmholtz Committee for the 2010 award would consist of a member from USA, Argentina/Brazil, BIAPWS, Canada and Czech Republic. The President indicated that the US National Committee had already nominated Anderko as the representative. The President asked him to organize the committee and to report back to the EC on Friday with the names of the members of this committee (Minute 15.1).

2.4.2 Honorary Fellow Award Committee

The Executive Secretary requested that Watanabe remain on the Committee and become the Chairman for 2010. The President then requested Rukes to be the other member. The IAPWS President would be ex. Officio.

2.5 Editorial Committee

The President reminded the EC that in Berlin Past President Cooper had proposed that another English speaking person should be added to the Editorial Committee. The suggestion had been made that the English speaking National Committees (BIAPWS, Canada and the USA) should consider nominating one of their members at the 2009 EC Meeting. The Chairman of the Editorial Committee, Harvey, suggested that he would deal with this selection in his report to the EC on Friday. (See Minute 11).

2.6 Other business for General Meeting or Requiring Extensive Discusssions

No other business was raised by the EC.

3. <u>EC Mandate to Working Groups and Membership</u>

The President opened this discussion by mentioning the global crisis and that although IAPWS was not a policy making organization it should have lots of work to do with the load being applied to the Working Groups. He specifically asked the WGs to discuss during the week and report back to the EC on Friday how IAPWS can contribute to global sustainability. He indicated that there were four areas he wanted to emphasize:

- Review the IAPWS documents for approval
- Concentrate on new documents
- Set up new directions of WG involvement

- Address the overall organization of IAPWS WGs. Here he requested that each WG Chairman provide a brief report at Friday's EC meeting on how the current structure of WGs will meet the future, and whether new partnerships need to be developed.

3.1 Releases, Guidelines and Certified Research Needs.

The President indicated that the IAPWS documents ready for approval had been dealt with under item 2.1. The Executive Secretary indicated that seven ICRNs had either expired in September 2008 or will expire in September 2009 and thus needed attention by the WGs during the week: #10 on pH, #13 on Surface Tension, #14 on Humid Air, #15 on Metastable Steam, #18 on Ion Exchange Resins, #19 on Sampling, and #20 on Sensors.

3.2 Working Group Directions.

The President emphasized that the WG Chairmen should 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 10 (Attachments 4 to 7).

The President closed the opening session of the EC at 9:50am.

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, 9th September 2009. The overall theme was on The Role of Water in Energy Transition. It consisted of two parts: the first was a visit to The Netherlands Water Museum, followed by a Symposium of eight presentations associated with Eurpean, Japanese and Dutch Energy Transition. The Symposium Program is shown in Attachment 3.

Executive Committee Meeting. Friday, 11 September 2009

President Friend opened the continuation of the EC Meeting at 8:34am. 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 Berlin, German in September 2008. No changes were noted, thus the 2008 Minutes were accepted.

6. President's Report

President Friend opened his report by reminding the EC that IAPWS had learnt in the week that water was critical to The Netherlands. IAPWS has a history back to 1929 and he was very pleased with the attendance and financial situation. IAPWS is doing very well currently and the organization has an obligation to contine. He thought that this was dependent on the National Committees, and he asked them to ensure that there was vibrancy of the local communities. There is a possibility of a new National Committee in Australia, but he was a little disappointed that a Benelux membership had not come to fruition. Friend next talked about global survival, the energy crisis, the supply/demand and sustainability and felt this is where IAPWS can make a difference in the future. The areas of involvement are now very different than in 1929 but in the energy industry climate change and seawater are very important. These put IAPWS in a strong position. There is also the discussion about survival of the power plants with demand increasing, and IAPWS continues to have a large role to play. IAPWS must continue to provide a forum for discussion and sharing information to ensure survival of the power industry and global civilization

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

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 most 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 for the Subcommittee on Seawater, which is reported in Minute 8. Full Minutes and the Agenda can be found in Attachment 4.

7.1 Potential International Collaborative Projects. One Collaborative Project had been suggested by Hruby on the Thermophysical Properties of Supercooled Water. The WGs had endorsed the project. Discussion on the project is contained in Minute 14.1.

7.2 Web Space for Working Materials of WG TPWS and IRS. A password protected website for documents from the WG has been setup with accessibility from the WG page on IAPWS.org.

7.3 Revision of IAPWS-95 Release. The WGs had approved the revised release and now requested approval from the EC.

The EC Approved the Revision Unanimously

7.4 Editorial changes to the Revised IF-97 Release. The WGs approved the editorial changes and authorized the Editorial Committee to consider a cover page issue and to make changes if considered necessary. The WG had also requested that the TPWS Chairman write a note of appreciation to Harvey and Stöcker for their work on the document.

7.5 Editorial Changes to the Supplementary Release IAPWS-IF97-S04 on Backward Equations $p(h,s)$ for Region 3. The WGs approved the Editorial Changes.

7.6 New Supplementary Release on a Computationally Efficient Thermodynamic Formulation for Liquid Water for Oceanographic Use. The WGs requested approval of the Revised Release from the EC.

The EC Approved the Revision Unanimously

7.7 Development of a new Release on Thermal Conductivity. Vogel had presented the work from his group on the calculation at the molecular level of the low density thermal conductivity of water vapor. The WG found some systematic disagreement with the existing experimental data (and the current IAPWS release) at high temperatures. Sengers had given a status report on the development of a new thermal conductivity formulation. The remainder of the work awaits a decision on how to proceed with the low density part. The WG had some discussion on how to proceed with the low density thermal conductivity work and developed the recommendation that the Task Group will proceed to complete the thermal conductivity correlation without waiting for a possible resolution of the apparent discrepancy between theory and experiment. But the data of Vogel will be considered in the development of the new formulation. Vogel had been added to the Task Group on Thermal Conductivity. The WGs appointed an Evaluation Task Group consisting of Prof. Mareš (chair), J. Hruby, K. Miyagawa and V. Ochkov. Harvey had proposed the new ICRN 24 on Thermal Conductivity of H_2O at Low Pressures and High Temperatures. This ICRN encourages theoretical work and new experimental work to help resolve the discrepancy mentioned above. The WGs approved the ICRN and recommend that the EC authorize the normal distribution and approval process after the Editorial Committee makes some minor editorial revision.

The EC Approved the Process Unanimously

7.8 Revision of the Release 2006 on the Equation of State of H_2O Ice Ih. The WGs had approved the Revised Release and recommend the approval by the EC.

The EC Approved the Revision Unanimously

7.9 Advisory Note 4 on the Roles of IAPWS and the International Committee for Weights and Measures (CIPM) Standards for the Density of Water. Harvey had presented the history of the joint recommendations between IAPWS and the CCM

on the roles of the different standards for the density of water. The WGs had approved the Advisory Note and recommend the approval by the EC.

The EC Approved the Advisory Note Unanimously

Japanese Delegate Watanabe thanked Harvey for preparing this Advisory Note.

7.10 Nucleation of water from Supercooled Steam. Hruby had reported on the nucleation of water from supercooled steam, and on efforts (unsuccessful so far) to organize a database (and eventual correlation) for water nucleation data. The WG decided to have a Task Group "Metastable Steam and Nucleation" with Hruby as Chair. Kretzschmar requested to the EC that National Committees forward names of other candidates to the Executive Secretary for this Task Group by December 31, 2009. Japanese Delegate Watanabe requested that clarification was provided to the National Committees. After some discussion, Hruby indicated that this is for pure water and that the chemistry effects were being dealt with by the PCC WG. Hruby was asked to provide a one page clarifying note which could be distributed to National Committees through the Executive Secretary by 31st December 2009.

7.11 ICRN 15 on Thermodynamic Properties of Metastable Steam. This ICRN had expired in September 2008, but the topic area is still clearly important. A mandate had been given to the Task Group on "Metastable Steam and Nucleation" to revise this ICRN by 2011. The WG requested that ICRN # 15 be extended to expire in 2011.

The EC Approved the Extension Unanimously

7.12 ICRN 14 on Thermodynamic Properties of Humid Air and Combustion-Gas Mixtures. This ICRN expired in September 2008, but the topic area is still clearly important. A mandate had been given to the Task Group on "Humid Air and Combustion-Gas Mixtures" to work on revising this ICRN by 2011. The WGs requested that ICRN 14 be extended to expire in 2011.

The EC Approved the Extension Unanimously

7.13 Update of Advisory Note # 2 on Roles of Various IAPWS Documents. Advisory Note # 2 is being updated primarily to incorporate the new and revised documents adopted this year. Cooper and Harvey were authorized to make the appropriate updates in the document, along with any needed editorial changes and the WGs requested that the EC supports this procedure.

The EC Approved the Procedure Unanimously

7.14 Educational Steam Tables. Ochkov had presented "Live Calculations" of IAPWS Releases on his website which is linked to the IAPWS website. Kretzschmar had presented the educational Steam Tables for Excel now also linked to the IAPWS website. Chairman Kretzschmar indicated to the EC that the steam tables for

pocket calculators had been a successful project with over 500 downloads since the last IAPWS meeting and more than 1,700 downloads altogether.

7.15 With regards to membership Kretzschmar requested that the following two new members are approved:

E. Vogel, Ruhr University of Rostock, Germany (TPWS)
M. Kunick, Zittau/Goerlitz University, Germany (TPWS and IRS)

The EC approved these membership changes unanimously.

8 Report and Recommendations on the new IAPWS Subcommittee on Seawater

Subcommittee Chairman Feistel provided a report on the activities of the new Subcommittee. Full minutes are in Attachment 5. He told the EC that the Inaugral Meeting took place on Tuesday 8th September 2009. The first order of business had been to populate the Subcommittee. Feistel recommended to the EC that the following two groups of people become members of the Sucommittee. The first 18 people were already members of other IAPWS WGs and had agreed to join the Subcommittee:

A. Anderko, M. Anisimov, J. Cooper, D. Friend, A. Harvey, M. Hiegemann, J. Hruby, B. King, H.-J. Kretzschmar, T. McDougall, K. Miyagawa, M. Nakahara, B. Rukes, S. Seitz, R. Span, P. Spitzer, P. Tremaine, D. Wright.

The following six people were new to IAPWS:

F. Camoes, University of Lisbon, Portugal
D. Fuentevilla, University of Maryland, USA
H. Glade, University of Bremen, Germany
G. Marion, Desert Research Institute, Reno, USA
F. Millero, University of Miami, USA
B. Rathke, University of Bremen, Germany

The EC approved these membership changes unanimously.

Chairman Feistel next indicated that the new Subcommittee recommended to the EC that M. Hiegemann become the Vice Chairman of the Subcommittee.

The EC approved the Vice Chairman unanimously.

Feistel then informed the EC that together with the Vice Chairman the had decided to keep the name of the Subcommittee as the "Subcommittee on Seawater" with the abbreviation of SCSW.

Feistel then had a number of informational items for the EC.

8.1. The following two new IAPWS documents had been developed jointly with TPWS and approved by the EC as described in Minute 7

- Supplementary Release on a Computationally Efficient Thermodynamic Formulation for Liquid Water for Oceanographic Use, and
- Revised Release on the Equation of State 2006 of H_2O Ice Ih.

8.2 The following new Subcommittee on Seawater Task Groups had been formed:

- Oceanographic Standards (joint with TPWS) with McDougall as Chair and members: Feistel, Fuentevilla, King, Millero and Wright.
- Advisory Note on Industrial Formulation (joint with TPWS and IRS) with Cooper as Chair and members: Feistel, Glade and Hiegemann.
- Traceability of Salinity (joint with TPWS and PCAS) with Seitz as Chair and members: Camoes, Feistel, Friend, King, McDougall, Millero, Spitzer, and Wright, and Henning Wolf as a coopted member.
- pH Values (joint with PCAS) with Marion as Chair and members: Camoes, Millero, Nakahara, and Spitzer.
- Transport Properties (joint with TPWS and IRS) with Anderko as Chair and members: Glade, Harvey, Millero and Nakahara, and Rich Pawlowicz as a coopted member.
- Industrial Requirements (for desalination and other processes) (joint with IRS and PCC) with Hiegemann as Chair and members: Bellows and Glade.
- Guideline on Sea Air (joint with TPWS) with Feistel as Chair and members: Harvey, Kretzschmar, Wright, and Eric Lemmon as a coopted expert.

9. <u>Report and Recommendations of Physical Chemistry of Aqueous Systems Working Group (PCAS)</u>

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

9.1 International Collaboration. Sedlbauer had presented an update on the collaborative project between Canada (Tremaine) and Czech Republic (Sedlbauer). This project has now finished and a report has been sent to the Executive Secretary.

9.2 ICRNs. The Chairman reported on the following ICRNs:

- ICRN 10 (pH). Expires September 2009. Both principal investigators, Palmer and Lvov, were not present in Doorwerth so Nakahara had planned to ask them whether the ICRN should continue. But Feistel suggested that as the SCSW was also involved in pH and had formed a Task Group, it might be better to delay making any decision on the ICRN until 2010.
- ICRN 13 (Surface Tension). Marsik had informed PCAS that the project had been closed. An application paper has been published in the Journal of Solution Chemistry. Marsik prepared a closing statement, which is attached as PCAS Attachment B. Svoboda agreed that the ICRN should be closed and commented that the closing statement needed more information.
- ICRN 17 (Amines). This ICRN was reviewed jointly with PCC (see Minute 10.2).

- ICRN 21 (Ultrasupercritical Plant Chemistry). This ICRN was reviewed jointly with PCC (see Minute 10.2).
- ICRN 22 (Nucleation in Steam Turbines). This ICRN was reviewed jointly with PCC (see Minute 10.2).

9.3 Task groups, future directions, and future ICRNs. Chairman Nakahara presented to the EC the following future possible research directions that may result in new ICRNs and guidelines: cavitation, viscosity and thermal conductivity of seawater, electrolyte thermodynamic modeling of muticomponent solutions, hydration properties, application for power generation, fuel cell electrochemistry, CO_2 emmission reduction.

9.4 PCAS workshop. Chairman Nakahara provided information on the PCAS workshop which included the following two presentations on IAPWS projects:

- Standard Partial Molar Properties of Solutes. Sedlbauer reported that this work is nearing completion. Publication of the results is planned in the near future. The main medium for disseminating the results of this project will be a database. The project is on track and there are no problems with the budget approved by the EC.
- Equilibrium Constants and Speciation of Aqueous Transition Metal Chlorocomplexes over a Wide Range of Temperature and Pressure. Ehlerova (speaker) and Sedlbauer presented a summary of this IAPWS collaborative project. This work was performed between the University of Liberec (Czech Republic) and Guelph University (Canada). The report from this project has been provided to the Executive Secretary.

9.5 Chairman Nakahara reported to the EC that the PCAS WG had discussed how the declining number of participants in PCAS should be addressed in the future. The size of the group has dropped below the "critical mass" for effective work. Anderko had proposed shifting all presentations to joint sessions with TPWS/SCSW or PCC, depending on the topic. Marsik supported the idea. The Chairman had expressed a concern that such an approach was drastic and could make the further existence of the group questionable.

The President requested that further discussion on this topic be delayed until the New Business (Minute 16.4)

10. 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 7.

10.1 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. This document is already getting much use in the industry worldwide. The second document has been prepared over the last year and is entitled Instrumentation for Monitoring and

Control of Cycle Chemistry in Fossil and Combined Cycle/HRSG Plants. The document was prepared by the PCC Task Group, reviewed by the PCC and the Editorial Committee and then sent in May 2009 to National Committees for their Review. A couple of suggestions had been provided by the German National Committee on pH and conductivity. These had been addressed by the Task Group and the document was forwarded to the German National Committee. Another comment was received on terminology used in the power industry with respect to "specific conductivity". This was also addressed by the Task Group. Final copies were provided to all National Committees in attendance in Doorwerth. Chairman Svoboda then requested approval from the EC.

The EC focused on whether this document needed to be recirculated to the National Committees. After some discussion a formal proposal to the EC for approval was developed which included a final review by the Editorial Committee.

The EC approved the Technical Guidance Document Unanimously with the caveat that it was reviewed by the Editorial Committee before Publication.

10.2 ICRNs. Svoboda reported the following information on four ICRNs:

- ICRN 17 on Amines. When the original was circulated in 2008 to National Committees there had been a number of objections. An update will be circulated within the next few weeks to PCC members to restart the approval process.

- ICRN 21 on Ultrasupercritical Cycle Chemistry. The initial version was circulated to National Committees in 2006 and a number of objections were received from the US National Committee. These comments will be addressed by Harvey and a revised ICRN will be circulated within the next year to restart the approval process.

- ICRN 22 on Steam Chemistry in the Phase Transition Zone. Finalization of the first draft was completed during the Doorwerth week. This will be circulated to PCC members to start the approval process in the next few weeks.

- ICRN 25. Corrosion Mechanisms Related to Impurities. The initial draft was discussed during the Doorwerth week. This will be finalized and circulated to PCC members to start the approval and editorial processes prior to approval.

10.3 Svoboda indicated that a new International Collaboration Project had been initiated on Sampling Lines to follow the previous Project on Sampling Nozzles. This was based on ICRN 19 and is discussed in Minute 14.1.

10.4 Water Use outside of the Steam/Water Cycle. Chairman Svoboda indicated to the EC that the PCC WG would like to suggest the following new possible areas of involvement for IAPWS: cooling water, waste water, geothermal water and

steam, external process, and recycling for use as makeup. These areas are not within the technical expertise of current PCC members and thus could be the basis of a new WG or Subcommittee of IAPWS.

President Friend indicated that this item would be dealt with during New Business (Minute 16.5)

10.5 The PCC Chairman reported that there appeared to be a new found deficiency with the IAPWS website in that key words used on the internet did not access the PCC documents, or that key words were not being recognized by the normal search engines. President Friend indicated that this would be discussed further in New Business. (Minute 16.3)

10.6 PCC Membership. The Chairman informed the EC that three PCC members had withdrawn from membership:

O. Jonas, USA (deceased)
L. Guinard, France
J. Vosta, Czech Republic

11. Editorial Committee Report

Editorial Committee Chairman Harvey reported that in the preceding year, the Editorial Committee had reviewed many proposed documents, including two Revised Releases (IAPWS-95, and Ice), one new Supplementary Release (liquid water for oceanographic use), the new Advisory Note 4 (liquid density standards), and one Technical Guidance Document (instrumentation for monitoring). The Committee had also reviewed two documents undergoing editorial changes (IAPWS-IF97 and one of its Supplementary Releases), and provided editorial assistance for ICRN 23 on dew point of flue gases.

In addition, The Editorial Committee updated Advisory Note #2 which describes the relative roles of various IAPWS documents concerning thermodynamic properties of water.

Chairman Harvey indicated that the Committee had realized that IAPWS documents have been inconsistent in the way references are included for journal articles. The Committee has therefore established a standard format to be used for future documents (including future revisions of existing documents). The format is:
Wagner, W., and Pruß, A., The IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use, *J. Phys. Chem. Ref. Data* **31**, 387-535 (2002).

Use of the title is recommended but not required, and the closing page number is optional (but should be consistent within a document).

Chairman Harvey next responded to the item deferred from Monday (Minute 2.5) and indicated that he had conferred with Cooper and proposed to the EC that the third member of the Editorial Committee becomes Dan Wright from Canada.

The EC unanimously approved this Addition to the Editorial Committee.

12. Membership and Associates

12.1 Members Defaulting on Dues.

The President asked the Executive Secretary to report on the members that are deficient in paying their dues. To the end of August 2009 the following countries had not paid their dues: Canada, France, USA, Russia and Greece. The Russian dues had been paid during the Doorwerth Week. The Canadian and USA dues are in process. The Greece National Committee also did not pay their dues in 2008. The French National Committee has not paid dues for 2005 to 2008.

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. After this discussion President Friend suggested a motion for the EC that the Executive Secretary will write to the Head of the French National Committee with copies to the French people who were at the Berlin meeting. The letter will indicate that France is in danger of having its status changed to Associate Member and request a response on the current situation. If there is a positive response then the decision will be left to the 2010 EC meeting. If there is no response by January 31, 2010 then France will become an Associate Member of IAPWS.

The EC Approved this Motion Unanimously.

12.2 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 since the Berlin EC meeting. Svoboda reported that the Swiss National Committee has not received any further commitment from other industries in Switzerland. The Committee plan a symposium in the fossil areas to attract attention.

13. Executive Secretary's Report

13.1 Financial, Auditors and Dues

The Executive Secretary reported that IAPWS remained on a sound financial footing with currently over SFrs 77,550 in the Swiss bank account and about $9,945 in the US account for a total of $82,326 combined. The status as at 31 August 2009 in the bank accounts had been provided to each National Delegate present at the EC meeting.

The Executive Secretary next reported that the 2008 financial statements had been forwarded to the IAPWS Auditors in January 2009. Both VDI in Germany and Mr. Miyagawa in Japan had reviewed and approved the financial statements. The Auditors' reports had also been provided to all the National Delegates present.

The Executive Secretary asked the Head of the Japanese National Committee, Watanabe, to relay a message from Mr. Miyagawa to the EC. Watanabe indicated that Miyagawa had been one of the IAPWS Auditors for a number of years and would like to step down. Watanabe also indicated that Japan had taken this rotation from the Russian National Committee and it was now time to move it to another IAWPS Member. The Head of the Czech National Committee, Hruby, suggested Professor Pavel Safarik of the Czech Technical University in Prague for this position.

The EC approved Professor Safarik unanimously as an Auditor for IAPWS

The Executive Secretary proposed to the EC that the dues structure for member countries remain unchanged for 2010.

The EC unanimously agreed to this proposal.

The Executive Secretary also provided a rough estimate of the income and known planned expenditures for 2009/10.

13.2 Time and Place of the 2010 and 2011 Meetings

The Executive Secretary reported that based on discussions with Tremaine and Hruby at the 2008 Berlin meetings, IAPWS would hold the 2010 meetings in Canada and the 2011 meetings in the Czech Republic. The delegate present from Canada, Lister, indicated that Canada is looking forward to hosting the 2010 meetings in Niagara Falls. The date was originally suggested to be close to a conference on Nuclear Chemistry to be held in the first week of October but the Candian National Committee now thought that this might be a little too late for the academics in IAPWS.

President Friend requested the Canadian National Committee to inform the Executive Secretary of the dates by the end of October 2009.

Hruby reported that the Czech Republic National Committee will host the 2011 IAPWS Meetings in Pilsen. He showed a few slides of Pilsen and indicated that the Czech National Committee will provide more details at the 2010 meetings.

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

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

14.1 International Collaborative Projects.

The President requested the Chairman of the 2009 International Collaboration Committee report on the findings of that committee during the week. Nakahara

reported that two collaborative projects had been proposed. The details are provided in Attachments 8 and 9:

- Thermophysical Properties of Supercooled Water. The IAPWS sponsors are Anisimov (USA) and Mares (Czech Republic). The young scientist is Jana Kalova from the University of West Bohemia in Pilsen, Czech Republic, and it is proposed that the IAPWS funding of $15,000 will allow her to spend six months at the University of Maryland in the USA starting in January 2010.

- Improved Sampling Techniques. The IAPWS sponsors are Svoboda (Switzerland), Lister (Canada), Daucik (Denmark) and Uchida (Japan). The young scientist will be from Japan but has not yet been decided. It is proposed that the scientist will spend a year in Canada at the University of New Brunswick starting in 2010. The proposed IAPWS funding is $12,000.

Nakahara indicated that the Evaluation Committee supported both proposals. One was a nice scientific study and the other was applicable to power plants. But the committee realized that the total of $27,000 needed discussion by the EC. This lead to review of the IAPWS Guidelines for Spending of IAPWS Funds (Toronto, September 1999), and to President Friend requesting that anybody associated with the two proposals should leave the room. This left four voting members of the EC. Friend then requested the EC to rank the two proposals. This resulted in the Proposal on supercooled water being prioritized highest. The President then proposed that IAPWS should fund this proposal.

The EC unanimously supported the proposal to fund the project on supercooled water.

The President then proposed that the second project also be funded contingent on the Executive Secretary receiving details on the proposed student by 1st December 2009. These details will then be circulated to the National Committees for review.

The EC supported this proposal to fund the second project on sampling with three acceptance votes (BIAPWS, Germany, and USA) and one abstention (Japan).

15. IAPWS Awards

15.1 IAPWS Helmholtz Award

The President reported that there had been no nominations for the 2009 Helmholtz Award which was very disappointing. He then asked the US Delegate, Anderko, for the names of the 2010 Helmholtz Award Committee. The 2010 Helmholtz Committee will consist of: Chairman Anderko (USA), Corti (Argentina/Brazil), Rudge (BIAPWS), Marsik (Czech Republic) and Tremaine (Canada). Nominations will be due to the Executive Secretary by January 31, 2010.

15.2 IAPWS Honorary Fellowships

The President reported that there had been no nominations for a 2009 IAPWS Honorary Fellow Award. He reminded the EC of the Awards Committee for 2009 with Watanabe as Chairman and Rukes as member with the IAPWS President as ex.-officio member. Nominations are due to the Executive Secretary by January 31, 2010. The President reminded the EC that the award is recognition of outstanding contributions to the functioning and work of IAPWS over substantial periods of time. The contributions to the organization can take many forms, such as highly effective service as an IAPWS Officer or Working Group Chair, or sustained substantial scientific and engineering contributions to the work areas and output of IAPWS. A nomination by a National Committee can be made only for people outside of that National Committee.

16. New Business

16.1 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 10.

16.2 15th and 16th ICPWS

The President first requested Rukes to provide a brief report on the final consolidation of the 15th ICPWS.

The 15th ICPWS Local Organizing Committee had prepared a financial statement for the 15th ICPWS and presented it to the IAPWS President and Executive Secretary. The Committee would like to express their gratitude to the following companies for their financial support:

- Siemens AG Energy Sector
- Alstom Power
- Areva NP GmbH
- EnBW Kraftwerke AG
- Evonik Energy Services GmbH
- RWE AG
- Swan Analytical Instruments AG
- Dr. Thiedig + Co
- Vattenfall Europe AG

Additionally IAPWS is thanked for their funding of the conference. Due to the generous contributions by the above mentioned companies the initially requested IAPWS funding of US$ 25,000 was finally reduced to roughly US$ 15,000.

The 15th ICPWS Local Organizing Committee welcomes requests by the 16th ICPWS organizing committee. Any useful detail information on the conference organization process will be made available.

The President once again wanted to provide his appreciation on behalf of IAWPS for the 15th ICPWS arrangments conducted by the German National Committee.

The President then asked the BIAPWS Delegate, Rudge, to report on the decision making process for the 16th ICPWS. Rudge indicated that BIAPWS were happy to host the 16th ICPWS in 2013 so as not to clash with the Olympic Games of 2012 in London. They have not selected a location yet but it will be in the UK and not in Ireland. BIAPWS has formed a Sub Group, which will eventually become the local organizing committee. They are actively looking for companies to sponsor the event. Rudge wanted to emphasize that the positive decision to hold the 16th was based on a financial evaluation which concluded that BIAPWS would be able to hold the event but that they would require an IAPWS donation, which for the past two conferences has been $25,000. BIAPWS may need to request an increased amount but this decision will be made at future EC meetings and will depend on the exchange rate and the predicted attendance.

The President thanked BIAPWS for working to make the decision to host the 16th ICPWS and that IAPWS looked forward to future developments.

16.3 Keywords for Internet Access for IAPWS Documents

The President indicated that this item had been raised in the PCC report (Minute 10.5) and requested that a Task Group is set up to review the situation and options available. The committee will consist of Svoboda (Temporary Chair), Harvey, and Nemec.

16.4 Future WG Activities

President Friend reminded the EC that this item had been raised in the PCAS report (Minute 9.5) because of the declining numbers in the PCAS WG. The Japanese Delegate, Watanabe, suggested that the PCAS should continue with its current new leadership for at least another year and that each National Committee should encourage people to join PCAS. The President indicated that he would like to see the Mission Statement of PCAS and the other WGs and Subcommittee on Seawater on the IAPWS website, and requested the respective chairmen to develop these for next year's meeting. Overall this discussion provided a very positive consensus that PCAS should continue as an IAPWS WG and that there should be multiple joint WG sessions with TPWS, PCC and SCSW.

16.5 Possible New IAPWS Working Group

President Friend reminded the EC that this item had been raised in the PCC report (Minute 10.4) where a number of new possible topic areas for IAPWS had been delineated. The PCC Chairman had indicated that these topics were outside of the

PCC expertise. The President asked the EC if there were any other possible new areas that should be considered, and also indicated that molecular simulation appeared to be a possibility. TPWS Chairman, Kretzschmar, noted that TPWS does have a molecular simulation Task Group which was not very active. He intended to ask new member, Vogel, to join the group.

The President asked for comments and suggestions. A US delegate, Bellows, suggested that he will enquire of the interest in one of the ASME Research Groups and report back. The President requested that the US National Committee develop a name for a possible new subcommittee by 30th November 2009 and that all the National Committees look for possible members and forward the names to the Executive Secretary.

16.6 Reports from National Committees.

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

Britain and Ireland	Attachment 11
Canada	Attachment 12
Czech Republic	Attachment 13
Germany	Attachment 14
Japan	Attachment 15
Russia	Attachment 16
USA	Attachment 17

16.7 Participants

Attachment 18 provides a list of participants at the IAPWS EC and WG Meetings in Doorwerth, The Netherlands in September 2009.

16.8 List of Members

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

17. Closing Remarks and Adjournment

The President thanked Andre Zeijseink and KEMA for hosting the IAPWS Doorwerth Meetings. He also thanked everybody for participating at this EC meeting. Then he formally closed the 2009 EC meeting at 12:46 pm.

Attachment 1

AGENDA for the EXECUTIVE COMMITTEE of IAPWS

Doorwerth, The Netherlands. 6-12 September 2009

Monday, 7 September. 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 2010 (Honorary Fellow and Helmholtz)
   - 2.5 Editorial Committee
   - 2.6 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, 11 September 2009. 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 the Sub-committee on Seawater
9. Report and Recommendations of PCAS
10. Report and Recommendations of PCC
11. Editorial Committee Report
12. Membership and Associates
    - 12.1 Report on Membership (Including Members Defaulting on Dues)
13. Executive Secretary's Report
    - 13.1 Financial, Auditors and Dues
    - 13.2 Time and Place of 2010/2011 Meetings
14. Guidelines, Releases, Certified Research Needs, and International Collaborations
    - 14.1 International Collaborations
15. IAPWS Awards
    - 15.1 Helmholtz Award Committee
    - 15.2 Honorary Fellowship
16. New Business
    - 16.1 Press Release
    - 16.2 Final Statement for 15th ICPWS and host/location for 16th ICPWS
    - 16.3 Keywords for Internet Access for IAPWS Documents
    - 16.4 Future WG Activities
    - 16.5 Possible New IAPWS Working Group
17. Adjournment

Attachment 2

Schedule of IAPWS Meetings
Arnhem, The Netherlands. 6-11 September 2009

(All meetings will be at the Golden Tulip Doorwerth Hotel)

Sunday 6 Sept. 7:00pm Informal Get-together, Cocktails and Registration
(Location will be at the Golden Tulip Doorwerth Hotel)

Monday 7 Sept. 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 8 Sept. 8:30am. PCAS Workshop (other WG Members will be welcome)
"Topic to be Decided by WG Chairman"
8:30am. TPWS/IRS/SCSW Joint Working Group Meeting
8:30am PCC Separate Working Group Meeting
10:30am. TPWS/IRS/SCSW Joint Meeting. PCC, PCAS Separate Meetings
1:30pm TPWS/IRS/SCSW Joint Meeting. PCC, PCAS Separate Meetings
2:30pm PCC/PCAS Joint WG Meeting and Workshop
"Topic to be Decided by WG Chairmen"

Wednes. 9 Sept. 9:00 – 5:00 **IAPWS Symposium**
" The Role of Water in Energy Transition"
(Location will be at the Water Museum)

Thursday 10 Sept. 8:30am. IRS and PCC Separate WG Meetings
8:30am. TPWS/SCSW/PCAS Joint WG Meeting
"**Topic to be Decided by WG Chairmen"**
1:30pm. Separate meetings of Working Groups
(If needed to prepare for Executive meeting)
6:30 pm. **IAPWS Dinner/Banquet**.
(Kasteel Doorwerth)

Friday 11 Sept. 8:30am. Executive Meeting **(8:30am - 1: 00pm)**
(Will include at least one member from each National Delegation)
2:00pm Visit to KEMA

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
4th September 2009

THE ROLE OF WATER IN ENERGY TRANSITION

IAWPS 2009, September 9th, Arnhem, The Netherlands

08.30 – 09.15	**TRAVEL TO WATERMUSEUM FROM HOTEL DOORWERTH**	
09.30 – 10.00	**GENERAL INTRODUCTION ON ENERGY TRANSITION** Drs. A. Zeijseink	
10.00 – 11.30	**GUIDED TOUR WATER MUSEUM**	
11.30 – 12.00	**TRAVEL TO ELEKTRUM**	
12.00 – 13.30	**LUNCH** Elektrum	
13.30 – 14.20	**ENERGY TRANSITION IN INTERNATIONAL CONTEXT**	
13.30 – 14.00	Energy Transition in Europe	Prof. Dr Ir. A.H.M. Verkooijen
14.00 – 14.20	Energy Transition in Japan	Prof. Dr. S. Uchida
14.20 – 15.20	**SPECIFIC ROLE OF WATER (GREENER)**	
14.20 – 14.40	Concentrated Solar Power	Dipl.-Ing. K. Hennecke
14.40 – 15.00	Blue Energy	Ir. T. Bosma
15.00 – 15.20	Energy Island	Ir. M. Schrijner
15.20 – 15.35	**BREAK**	
15.35 – 16.35	**SPECIFIC ROLE OF WATER (CLEANER)**	
15.35 – 15.55	TOP-HAT Cycle	Dr.Ir. P. Ploumen
15.55 – 16.15	Water recovery from flue gases	Dr. F. de Vos
16.15 – 16.35	Coal Gasification	N.N.
16.35 – 17.00	**DISCUSSION ON RESEARCH NEEDS AND ROUND UP**	

Minutes
IAPWS Thermophysical Properties of Water and Steam WG
IAPWS Industrial Requirements and Solutions WG
Doorwerth, Netherlands, September 7-10, 2009

NOTE: Because the working groups met jointly, these Minutes combine the activities of Working Groups TPWS and IRS, and also some of the work of the Subcommittee on Seawater. Items are listed according to their order on the TPWS agenda, which is attached as Attachment A. **Bold print** denotes significant actions.

1-2. The meeting was opened on Monday, September 7 at 10:15 by the TPWS Chair, Hans-Joachim Kretzschmar, who was also chairing the IRS portion of the meeting in the absence of the IRS Chair and Vice-Chair. The agenda (Attachment A) was adopted. Allan Harvey was appointed Clerk of Minutes to take combined Minutes for TPWS and IRS. The Chair noted that, in accordance with our new procedure, the 2008 Minutes had been circulated and approved shortly after the 2008 meeting.

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 "Thermophysical Properties of Supercooled Water," which would send Jana Kalova to the University of Maryland for 6 months at the beginning of 2010. The Working Groups endorsed the proposal.

5. (IAPWS-95) W. Wagner reported about the revision to the IAPWS-95 release to better match the triple-point datum states, and to make some minor editorial corrections. In the absence of Mr. Miyagawa, Prof. Kretzschmar reported the favorable evaluation report. There was some discussion about clarifying the language about molar properties, and slightly revised wording was worked out. **The WGs approved the Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use.**

6. (IAPWS-IF97) W. Wagner reported about proposed minor editorial changes to the IAPWS-IF97 release. In the absence of Mr. Miyagawa, Prof. Kretzschmar reported the favorable evaluation report. There was some discussion about how to inform readers on the title page that editorial changes had been made. **The WGs approved the editorial changes to the Revised Release on the Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam, and authorized the Editorial Committee to consider the cover page issue and make a change there if they decided appropriate.** The Chair was requested to write a note of appreciation to Drs. Harvey and Stöcker for their work on this document.

7. (IAPWS-IF97-S04) H.-J. Kretzschmar reported about proposed minor editorial changes to the IAPWS-IF97-S04 Supplementary Release. In the absence of Mr. Miyagawa, Prof. Kretzschmar reported the favorable evaluation report. It was agreed to change "density" to "mass density" in the Nomenclature to be consistent with IAPWS-IF97. **The WGs approved the editorial changes to the Supplementary Release on Backward Equations *p*(*h*,*s*) for**

Region 3, Equations as a Function of *h* and *s* for Region boundaries, and an Equation $T_{sat}(h,s)$ for Region 4 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam (IAPWS-IF97-S04), and authorized the Editorial Committee to deal with the same cover page issue mentioned in item 6.

8. R. Feistel presented the proposed Supplementary Release on a computationally efficient Gibbs energy formulation for liquid water, intended to be used in place of IAPWS-95 with the release on thermodynamic properties of seawater in order to speed up oceanographic calculations. J. Hruby presented the favorable evaluation report. **The WGs approved the Supplementary Release on a Computationally Efficient Thermodynamic Formulation for Liquid Water for Oceanographic Use**.

9. (thermal conductivity) E. Vogel presented work from his group on calculation at the molecular level of the low-density thermal conductivity of water vapor. There is some systematic disagreement with existing experimental data (and the current IAPWS release) at high temperatures.

J. Sengers gave a status report on the development of a new thermal conductivity formulation. The critical enhancement is known well from theory and agrees well with data with only one adjustable parameter; it is also consistent with the new viscosity formulation. The remainder of the work awaits a decision on how to proceed with the low-density part.

A. Harvey presented a proposed ICRN (#24) on Thermal Conductivity of H_2O at Low Pressures and High Temperatures. This ICRN encourages theoretical work and new experimental work to help resolve the discrepancy mentioned above. **The WGs approved the ICRN on Thermal Conductivity of H_2O at Low Pressures and High Temperatures and requests that the EC authorize the normal distribution and approval process after the Editorial Committee makes some minor editorial revisions.**

After some discussion of how to proceed on the low-density thermal conductivity, **the following recommendations were adopted**:

1. The Task Group will re-analyze the zero-density extrapolation of thermal conductivity data, using the same methods as for the viscosity.
2. It is thought that the "best" theoretical estimates for the thermal conductivity might be about 1% higher than the current calculations.
3. Uncertainties assigned to experimental data will be expanded if needed to include theoretical values plus 1%, and these larger uncertainties will be used in the weighting of the fitting and in uncertainty evaluation of the final correlation.
4. The low-density thermal conductivity at low temperatures will be reexamined in light of the theoretical calculations.
5. E. Vogel will be added to the Task Group on thermal conductivity.
6. The Task Group will proceed in completing the thermal conductivity correlation on this basis without waiting for possible resolution of the apparent discrepancy between theory and experiment.

The remaining item for the thermal conductivity was to **appoint an Evaluation Task Group. The members will be R. Mareš (Chair), J. Hruby, K. Miyagawa and V. Ochkov.**

10. A. Novy presented some work on spline modeling for backward calculations of the sublimation and melting curves. It was decided to include Mr. Novy as an outside expert on the Task Group appointed in 2008 for fast property calculations.

11. (ice) R. Feistel presented the proposed revision of the 2006 release for thermodynamic properties of ice, to improve consistency with the triple-point datum for energy and entropy. A. Harvey presented the favorable evaluation report on behalf of the Evaluation Committee. One additional minor editorial change was discussed and agreed to in order to make clear the uncertainty of the experimental triple-point pressure. **The WGs approved the Revised Release on the Equation of State 2006 of H_2O Ice Ih**.

12. J. Cooper presented some results of investigation of the possibility of using IAPWS-95 and corresponding-states principles to predict heavy water thermodynamic properties. The method was unable to reproduce densities within the tolerances given in the existing heavy water release.

13.1. T. McDougall reported that the IOC (Intergovernmental Oceanographic Commission) had adopted the IAPWS formulations for seawater and ice as part of their standard known as TEOS-10. This is being adopted widely within marine science communities, and produces many improvements (such as accuracy, additional important properties, and thermodynamic consistency) over the old equations. D. Wright discussed the source code library being developed to put these standards into four computer languages. T. McDougall reported on the work primarily performed by D. Jackett on optimizing the IAPWS-95 Fortran code which produced speed improvements by approximately a factor of 8.

13.2 There was discussion about industrial calculation of seawater properties (for seawater cooling in power applications and for desalination). There was agreement that IAPWS-IF97 should be suitable for the pure-water part for this purpose (even though it was not accurate enough for oceanography). The current seawater release does not extend to high enough temperature for some areas of interest. **It was decided to appoint a Task Group on industrial calculations for seawater with the following mandate: (1) Prepare an Advisory Note describing the use of IAPWS-IF97 in this context, explaining the current limits of the seawater formulation. This Advisory Note should be prepared in time for approval at the 2010 IAPWS meeting. (2) Discern the range of conditions required to satisfy significant industrial needs for seawater thermodynamic properties and recommend where the current formulation might need to be extended (perhaps in an ICRN). The members of the Task Group 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 was appointed consisting of Hruby (Chair), Mareš, and Miyagawa. The Clerk of Minutes was requested to make a schedule for tasks reflecting completion of a draft by the end of 2009 and circulation for approval at the 2010 IAPWS meeting. That schedule will be:**

Dec. 31, 2009	**Advisory Note drafted & sent to Evaluation TG**
Feb. 28, 2010	**Completion of evaluation by Evaluation TG**
March 15, 2010	**Distribution of Advisory Note and evaluation report to WG**
April 15, 2010	**Deadline for input from WG members**
May 15, 2010	**Finalized draft to Editorial Committee**
June 15, 2010	**Approval by Editorial Committee**

July 1, 2010 Distribution by Executive Secretary to National Delegates

13.3. G. Marion presented a summary of different conventions for defining pH and their effects for seawater and other aqueous electrolyte solutions. Further action was deferred until the meeting of the Subcommittee on Seawater.

13.4. R. Feistel presented a summary of two new experimental data sets for density of seawater (some of which are outside the range of validity of the seawater release) and of a set of data for freezing of seawater brines. Agreement with the freezing data was good. Some empirical correction models were described that could achieve better agreement with the density data. T. McDougall discussed the composition anomalies of the world's oceans, where practical salinity does not definitively determine density and the difference can largely be correlated with silicate composition. On behalf of P. Spitzer, R. Feistel presented some information on SI traceability and uncertainty for seawater measurements, where the main current concern is getting an SI-traceable measurement for salinity. One idea is to use the density as a surrogate variable for the salinity. A Task Group for this will be appointed (see item 6 in the Minutes of the Subcommittee on Seawater).

13.5. (joint with PCAS) A. Anderko presented his work with P. Wang on modeling the viscosity and thermal conductivity of seawater. The results look promising so far. The Task Group on Transport Properties appointed in item 6 of the SCSW minutes was encouraged to continue toward developing final formulations.

14. R. Feistel presented the formulation for humid air properties prepared for the TEOS-10 library which has been adopted by UNESCO. The formulation combines IAPWS-95 with a reference-quality EOS for dry air, and best available values for the 2nd and 3rd cross virial coefficients. It was discussed whether IAPWS should work toward recommendations for properties of humid air or more generally humid gases (such as combustion gases). A Task Group for this already exists from our 2008 meeting consisting of Span (Chair), Harvey, Hruby, Kretzschmar, and Wendland. **It was decided to add R. Feistel to this Task Group.** The mandate of this Task Group is to consider updating the current ICRN on humid gases (ICRN-14) and to consider more generally the existing methods for computing thermodynamics of humid air and humid gases (for example, in the context of metrology and in the energy industries) and consider needs and prospects for IAPWS products in these areas.

In further discussion, it was decided that the formulation used in TEOS-10 should be incorporated into an IAPWS Guideline for thermodynamics of air in contact with seawater. **A Task Group was appointed for drafting this Guideline consisting of Feistel (Chair), Harvey, Kretzschmar, and Wright. An Evaluation Task Group was appointed of Miyagawa (Chair), Hruby, and Ochkov. The Clerk of Minutes was requested to make a schedule for tasks reflecting completion of a draft by the end of 2009 and circulation for approval at the 2010 IAPWS meeting. That schedule will be:**

Dec. 31, 2009	**Guideline drafted & sent to Evaluation TG**
Feb. 28, 2010	**Completion of evaluation by Evaluation TG**
March 15, 2010	**Distribution of Guideline and evaluation report to WG**
April 15, 2010	**Deadline for input from WG members**
May 15, 2010	**Finalized draft to Editorial Committee**
June 15, 2010	**Approval by Editorial Committee**

July 1, 2010 Distribution by Executive Secretary to National Delegates

15. (joint with PCAS) D. Fuentevilla presented her work with colleagues at the University of Maryland on the vapor-liquid critical locus of aqueous electrolyte systems (especially aqueous NaCl) at high temperature. The WGs encouraged the plan of looking at additional systems and working toward a Guideline on this behavior in a number of systems, which would replace the existing Guideline for the H_2O/NaCl critical locus adopted in 2000.

M. Nakahara presented his work on the use of formic acid as a hydrogen carrier in energy technology, with the formation reaction in H_2O or in an ionic liquid.

16. (Advisory Note 4) A. Harvey presented the history of the joint recommendations between IAPWS and the CCM on roles of the different standards for the density of water. The Advisory Note states the recommendations adopted by IAPWS in 2008 (see EC Minute 7.4 from 2008). **The WGs approved the Advisory Note on Roles of IAPWS and CIPM Standards for the Density of Water.**

17.1. J. Kalova presented on an investigation of the density of liquid water from the standpoint of data and correlations, first for temperatures between 0 °C and 40 °C, and then for supercooled water below 0 °C.

17.2. J. Hruby reported on the nucleation of water from supercooled steam, and on efforts (unsuccessful so far) to organize a database effort (and eventual correlation) for water nucleation data. There was discussion of how to advance this important project. **It was decided to have a Task Group with Hruby as Chair. We request the EC to ask National Committees to forward names of other candidates to the Executive Secretary for this Task Group by Dec. 31.**

17.3. ICRN-15 on metastable steam has expired, but from the previous item the area is still clearly important. **We request that ICRN-15 be extended to expire in 2011. An additional mandate of the Task Group mentioned in 17.2 is to work on revising this ICRN by 2011.**

17.4. ICRN-14 on humid gases has expired, but from item 14 the area is still clearly important. **We request that ICRN-14 be extended to expire in 2011. An additional mandate of the Task Group mentioned in item 14 above is to work on revising this ICRN by 2011.**

17.5. A. Harvey reported that there was no need to update the Fundamental Constants Guideline this year.

17.6. Advisory Note 2 is being updated primarily to incorporate the new and revised documents adopted this year (such as that mentioned in Minute 8 above). **Cooper and Harvey were authorized to make the appropriate updates in the document, along with any needed editorial changes.**

17.7. V. Ochkov presented his work on interactive online calculations of properties from IAPWS formulations.

17.8. H.-J. Kretzschmar presented the educational Steam Tables for Excel now linked to from the IAPWS website. He also mentioned that the steam tables for pocket calculators had been a successful project with over 500 downloads since the last IAPWS meeting.

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

18. **It was voted to accept E. Vogel (Rostock, Germany) as a new member of TPWS, and M. Kunick (Zittau) as a new member of both IRS and TPWS.**

19. Regarding collaborative projects, see item 4.

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

21. The meeting was adjourned at 12:15 on Thursday, September 10.

Agenda for the Working Groups

Thermophysical Properties of Water and Steam (TPWS) and Industrial Requirements and Solution (IRS) Doorwerth, The Netherlands. 6-10 September 2009

1. Opening Remarks; Adoption of Agenda
2. Appointment of Clerk of Minutes
3. Web Space for Working Material for WGs TPWS, IRS, and SCSW, joint with WG IRS and SCSW
4. Potential International Collaborative Projects
5. Revised Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use (IAPWS-95), joint with SCSW and WG IRS
   - Report (W. Wagner)
   - Test Report (K. Miyagawa)
   - Formal consideration of the Revised Release
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
   - Report (W. Wagner)
   - Test Report (K. Miyagawa)
   - Formal consideration of the Editorial Changes
7. Editorial Changes on the Supplementary Release on Backward Equations $p(h,s)$ for Region 3, Equations as a Function of h and s for the Region Boundaries, and an Equation $T_{sat}(h,s)$ for Region 4 of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam (IAPWS-IF97-S04), joint with WG IRS
   - Report (H.-J. Kretzschmar)
   - Test Report (K. Miyagawa)
   - Formal consideration of the Editorial Changes
8. Supplementary Release on a Computationally Efficient Thermodynamic Formulation for Liquid Water for Oceanographic Use, joint with SCSW
   - Report of the Evaluation Task Group (J. Hruby, K. Miyagawa)
   - Formal consideration of the Revised Release
9. Transport Properties of Water and Steam, joint with WG IRS and SCSW
   - 9.1 Zero-Density Thermal Conductivity of Water Vapor: Comparison of the IAPWS Formulation with Theoretically Calculated Values and Possible Reasons for Their Differences (E. Vogel, E. Bich, R. Hellmann, A.S. Dickinson, V. Vesovic)
   - 9.2 Progress Report on the Thermal Conductivity of H2O (J.V. Sengers, R.A. Perkins, M.L. Huber, D.G. Friend, M.J. Assael, I.N. Metaxa)

9.3 Proposal for ICRN 24 on the Thermal Conductivity of H2O at Low Pressures and High Temperatures (A.H. Harvey, J.V. Sengers, E. Vogel)

10. Industrial Requirements and Solutions for Steam Property Calculations, joint with WG IRS
    - Backward function for sublimation and melting curves based on spline technique (I. Kodl, A. Novy)
    - Fast Steam Property Calculations for CFD (W.T. Parry, H.-J. Kretzschmar)

11. Revised Release on the Equation of State 2006 of H_2O Ice Ih, joint with SCSW and WG IRS
    - Report (R. Feistel)
    - Test Report (J. Hruby)
    - Formal consideration of the Revised Release

12. Properties of Heavy Water D_2O, joint with WG IRS
    - Report (J.R. Cooper)

13. Properties of Seawater (R. Feistel)

    13.1 Oceanographic Seawater Standard TEOS-10
    - Adoption by the international bodies IOC/Unesco (T.J. McDougall)
    - Review of papers published (T.J. McDougall)
    - Review of library code developed (D.G. Wright)
    - Fast ocean-model code versions (T.J. McDougall)

    13.2 Development of an IAPWS Standard on Seawater Properties for Industrial Use
    - Discussion about preparing an IAPWS Standard and appointing a Task Group (M. Hiegemann, H.-J. Kretzschmar, R. Feistel)

    13.3 pH Scales for Aqueous Solutions and Seawater (G.M. Marion)
    - Define and compare scales
    - Experimental measurements vs. modeling
    - Preferences - pros and cons
    - Future directions

    13.4 Seawater Density Measurements
    - New measurements compared to the IAPWS Release 2008 (R. Feistel)
    - Measuring and modeling composition anomalies (T.J. McDougall, F.J. Millero, D.R. Jackett, R. Feistel)
    - SI traceability and uncertainty on climatic time scales (P. Spitzer, S. Seitz)

    13.5 Proposed Models for Calculating Thermal Conductivity and Viscosity of Seawater, joint with WGs PCAS and IRS, and SCSW (A. Anderko)

14. Properties of Humid Air and Humid Combustion Gases, joint with WGs IRS and PCAS, and SCSW
    - Humid-Air Implementation in the TEOS-10 Library (R. Feistel, D.G. Wright)

15. Properties of Aqueous Solutions, joint with WG PCAS and SCSW
    - Vapor-liquid critical locus of aqueous solutions of NaCl revisited (D.A. Fuentevilla, J.V. Sengers, and M.A. Anisimov)
    - A new scheme of hydrogen technology based on hydrothermal chemistry of formic acid (M. Nakahara)
16. Advisory Note No. 4: Roles of IAPWS and CIPM Standards for the Density of Water
    - Report of the Task Group (A.H. Harvey, R. Span)
    - Formal consideration of the Advisory Note
17. Reports on Other TPWS Activities
    - 17.1 Data and Calculations for Density of Liquid Water (J. Kalova)
    - 17.2 Report on Assessment and Correlation of Nucleation of Water Droplets from Supersaturated Steam and Collaboration with Committee for Nucleation and Atmospheric Aerosols (J. Hruby)
    - 17.3 ICRN # 15 Thermodynamic Properties of Metastable Steam (J. Hruby), joint with WG IRS
    - 17.4 ICRN # 14 Thermophysical Properties of Humid Air and Combustion-Gas Mixtures (R. Span, M. Wendland, A.H. Harvey, H.-J. Kretzschmar), joint with WG IRS and SCSW
    - 17.5 Guideline on Fundamental Constants (A.H. Harvey), joint with WG IRS
    - 17.6 Update of Advisory Note # 2: Roles of Various IAPWS Documents (J.R. Cooper, A.H. Harvey), joint with WG IRS
    - 17.7 Modern Notations and "Network Interactive Open IAPWS Formulations" (V.F. Ochkov, J.V. Chudova), joint with WG IRS
    - 17.8 Steam Tables for Excel® for Education on the IAPWS Website (H.-J. Kretzschmar), joint with WG IRS
    - 17.9 Liaison with IEC (J.R. Cooper), joint with WG IRS
18. Membership
19. Other Business
    - Report on International Collaborative Projects
20. Preparation of the Formal Motion to the EC
21. Adjournment

Minutes
IAPWS Subcommittee on Seawater
Doorwerth, Netherlands, September 7-10, 2009

NOTE: A large fraction of the work of the Subcommittee on Seawater is reported in the TPWS/IRS minutes (see particularly item 13 there). **Bold print** denotes significant actions.

1-2. *Welcome, Clerk of Minutes*. The meeting was opened on Tuesday, September 8 at 11:10 by Subcommittee Chair Rainer Feistel. Allan Harvey was appointed Clerk of Minutes.

3. *Membership*. The previous list was reviewed to find names of those who would be official members of the Subcommittee. **The following members of existing IAPWS WGs were proposed for membership: A. Anderko, M. Anisimov, J. Cooper, D. Friend, A. Harvey, M. Hiegemann, J. Hruby, B. King, H.-J. Kretzschmar, T. McDougall, K. Miyagawa, M. Nakahara, B. Rukes, S. Seitz, R. Span, P. Spitzer, P. Tremaine, D. Wright. The following additional people were proposed for membership: F. Camoes (U. Lisbon), D. Fuentevilla (U. of Maryland), H. Glade (U. Bremen), G. Marion (Desert Research Institute, Reno, NV), F. Millero (U. of Miami, FL), B. Rathke (U. Bremen).**

4. *Vice-Chair*. By unanimous agreement, pending his official appointment to the Subcommittee by the EC, **Michael Hiegemann was named as the Vice-Chair**.

5. *Name*. **It was decided to retain the name "Subcommittee on Seawater".** A suitable acronym will be decided by the Chair and Vice-Chair. After the meeting, **the acronym "SCSW" was decided** by the Chair and Vice-Chair.

6. *Task Groups*. **Task Groups were appointed for a variety of projects, as follows:**

Oceanographic Standards (considered to be joint with TPWS): McDougall (Chair), Feistel, Fuentevilla, King, Millero, Wright.

Advisory Note on Industrial Formulation (joint with TPWS and IRS): Cooper (Chair), Feistel, Glade, Hiegemann.

Traceability of Salinity (joint with TPWS and PCAS): Seitz (Chair), Camoes, Feistel, Friend, King, McDougall, Millero, Spitzer, Wolf, Wright.

pH Values (joint with PCAS): Marion (Chair), Camoes, Millero, Nakahara, Spitzer.

Transport Properties (joint with TPWS and IRS): Anderko (Chair), Glade, Harvey, Millero, Nakahara.

Industrial Requirements (for desalination and other processes) (joint with IRS and PCC): Hiegemann (Chair), Bellows, Glade.

The separate meeting of the Subcommittee on Seawater was adjourned shortly after noon on Tuesday September 8.

On September 10, the joint meeting of TPWS and SCSW decided on the appointment of another joint taskgroup

Sea Air (TPWS joint with SCSW): Feistel (Chair), Harvey, Kretzschmar, Wright.

2009 IAPWS Annual Meeting
Doorwerth, the Netherlands

PCAS WG Minutes

Monday, September 7, morning

Present: Masaru Nakahara (chair), Andre Anderko (vice chair, clerk of minutes), Jana Ehlerova, Anneke Levelt-Sengers, Frantisek Marsik, Pavel Safarik, Milan Sedlar, Josef Sedlbauer

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 (PCAS Attachment A). The agenda has been adopted unchanged.

2. **Minutes of the 2008 Meeting** in Berlin were adopted as written.

3. **IAPWS Interntional Collaboration.** Josef Sedlbauer presented an update on the collaborative project between Canada (Peter Tremaine) and Czech Republic (Josef Sedlbauer). This project has been finished and report has been sent to the Executive Committee.

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

   ICRN no. 10 (pH). Masaru Nakahara informed that this project expired. Since both principal investigators, Donald Palmer and Serguei Lvov, are absent, Masaru Nakahara will ask them whether they wish to continue. It has been noted that a guideline on the ionization constant of water has been published and accepted. Anenke Levelt-Sengers noted that pH of seawater is currently being investigated by the Subcommitte on Seawater, which offers an opportunity for cross-linking.

   ICRN no. 13 (surface tension). Frantisek Marsik informed that the project has been closed. An application paper has been published in the Journal of Solution Chemistry. Frantisek Marsik prepared a closing statement, which is attached as PCAS Attachment B.

   ICRN no. 17 (amines). This ICRN is to be reviewed jointly with PCC

   ICRN no. 21 (ultrasupercritical plant chemistry). Masaru Nakahara will inquire about the status of this ICRN with Don Palmer and Barry Dooley.

   ICRN no. 22 (nucleation in steam turbines). Frantisek Marsik has indicated that this ICRN is coordinated by Dr. Stastny and really belongs in PCC.

5. Task groups, future directions, and future ICRNs. Masaru Nakahara opened discussion on future research directions that may result in new ICRNs and guidelines. The following possible thrust areas have been discussed:

Cavitation – Frantisek Marsik indicated his interest in a new ICRN on cavitation. He prepared a statement of interest and project outline on this topic. This document is attached as PCAS Attachment C. The group unanimously approved the idea of proposing the new ICRN on cavitation.

Viscosity and thermal conductivity of seawater – Masaru Nakahara indicated that these topics are being studied within the framework of the Subcommitte on Seawater

Electrolyte thermodynamic modeling of muticomponent solutions – Andre Anderko proposed investigating models for complex electrolyte systems with a particular focus on applications in hydrometallurgy and power generation.

Hydration properties – Josef Sedlbauer indicated that guidelines on hydration properties will be closed next year; he also expressed interest in electrolyte modeling

Application for power generation – Masaru Nakahara indicated that he is conducting discussions with Japanese power generation companies on their needs.

Fuell cell electrochemistry – Frantisek Marsik indicated that this may be an appropriate area of research for PCAS.

CO_2 emmission reduction – Masaru Nakahara indicated that this may be another area of interest for PCAS.

Monday, September 7, afternoon

Present: Masaru Nakahara (chair), Andre Anderko (vice chair, clerk of minutes), Jana Ehlerova, Anneke Levelt-Sengers, Frantisek Marsik, Pavel Safarik, Milan Sedlar, Josef Sedlbauer

5. Task groups, future directions, and future ICRNs – continued

Cavitation – Frantisek Marsik gave a presentation on cavitation in pure water and water solution. This topic is intended to be the subject of a new ICRN (see Attachment C). A discussion followed. Andre Anderko asked about the anticipated final product of this research. Frantisek Marsik indicated that focus will be put on publishing algorithms and integrating them with CFD codes. Milan Sedlar will take the lead on the implementation tasks. Masaru Nakahara asked about the theoretical fundamantals. Frantisek Marsik answered that the model will be based on nonequilibrium thermodynamics. Josef Sedlbauer inquired about the main anticipated novelty of the method. Frantisek Marsik responded that the main novelty will lie in taking into account the concentration dependence. A further question related to the effects of gravity. This effect is unimportant.

Electrolyte thermodynamic modeling of muticomponent solutions – Andre Anderko gave an impromptu presentation on the recent work at OLI System on modeling systems of hydrometallurgical importance. Masaru Nakahara inquired about the fundamental nature of the thermodynamic model. Andre Anderko responded that the model is a combination of a formulation for standard-state properties and the excess Gibbs energy. The fundamentals of the model have been already published (P. Wang, A. Anderko and R.D. Young, *Fluid Phase Equilibria*, 203 (2002) 141-176, P. Wang, A. Anderko, R. D. Springer, and R. D. Young, *J. Molec. Liquids*, 125 (2006) 37-44). The work on developing model parameters is carried out in collaboration with Professor Papangelakis of the University of Toronto.

Tuesday, September 8, morning

Present: Masaru Nakahara (chair), Andre Anderko (vice chair, clerk of minutes), Jana Ehlerova, Frantisek Marsik, Milan Sedlar, Josef Sedlbauer

PCAS Workshop

Three presentations were given in the PCAS workshop:

"Standard Partial Molar Properties of Solutes" by Josef Sedlbauer. This work is nearing completion. Publication of the results is planned in the near future. The main medium for disseminating the results of this project will be a database.

"Formic Acid as a Chemical Tank for Hydrogen" by Masaru Nakahara. Recent research in this area has been reviewed. A discussion followed on the fate of carbon dioxide that is associated with this process.

"Equilibrium Constants and Speciation of Aqueous Transition Metal Chlorocomplexes Over a Wide Range of Temperature and Pressure" by Jana Ehlerova (speaker) and Josef Sedlbauer. A summary of this project was given. This work was performed on a collaborative basis between the University of Liberec (Czech Republic) and Guelph University (Canada).

Tuesday, September 8, afternoon

Joint Meeting of PCAS and PCC

The following presentations were given at workshop:

"The Efficiency of the Coupled Electrode Membrane Processes" by Frantisek Marsik

"Electrophoretic Mobility and Zeta Potential of Magnetite at Temperatures Corresponding to Power Plant Operating Conditions" by Sonja Vidojkovic

"Generator Water Chemistry – Behavior of Copper Oxide" by Robert Svoboda

"Equilibrium Constants and Speciation of Copper Chloride" by Jana Ehlerova

The second part of the joint meeting was devoted to the discussion of ICRNs:

ICRN 17: "Research on Amines in the Power Industry" by Jim Bellows. This topic encompasses (1) degradation of amines, mechanisms and products; (2) what does it do in terms of corrosion and (3) implication of the degradation in plants.

ICRN 20: "Steam Chemistry in Turbine Phase Transition Zone" by Miroslav Stastny. This topic includes (1) formation of substances that act as precursors to nucleation; (2) chemistry of first condensate; (3) additives that influence nucleation; (4) theory for mathematical simulation of heterogeneous condensation processes; (5) chemical and mechanical structure of deposits on turbine blades.

ICRN 21: "Interfacial Situation in Advanced Ultra-Supercritical Plants". This ICRN had been proposed by Peter Tremaine and was discussed in his absence by Robert Svoboda.

ICRN 25: "Corrosion Mechanisms in the Presence of Contaminants in Steam/Water Circuits, Particularly in Boiler Water". This ICRN encompasses the study of local corrosive envronments that are formed by various cation and anions as a result of condensation and it seeks to relate the local environments to the observed corrosion rates.

Thursday, September 10, morning

Joint Meeting of TPWS, PCAS, SCSW, and IRC (8:30am – 10:30am)

The following presentations were given at the joint meeting:

"Towards Models for Viscosity and Thermal Conductivity of Seawater: Model Fundamentals" by Andre Anderko

"Critical Locus of Salt Water" by Daphne Fuentevilla
"A New Scheme of Hydrogen Technology Based on Hydrothermal Chemistry of Formic Acid" by Masaru Nakahara

Thursday, September 10, morning (10:45am – 12:15am)

Present: Masaru Nakahara (chair), Andre Anderko (vice chair, clerk of minutes), Jana Ehlerova, Frantisek Marsik, Milan Sedlar

Milan Sedlar gave a presentation "Numerical and Experimental Investigation of Cavitation in Water". This presentation was related to the proposed new ICRN.

The group discussed how the declining number of participants should be addressed in the future. It has been agreed that the size of the group dropped below the "critical mass" for effective work. Andre Anderko proposed shifting all presentations to joint sessions with TPWS/SCSW or PCC, depending on the topic. Frantisek Marsik supported the idea. Masaru Nakahara expressed a concern that such an approach is drastic and could make the further existence of the group questionable. Frantisek Marsik and Andre Anderko expressed the opinion that PCAS meetings would be still desirable and would be focused on discussions of present and future activities.

Physical Chemistry of Aqueous Systems Working Group (PCAS WG)

Agenda

Arnhem, The Netherlands, 6 – 11 September 2009
(Hotel Golden Tulip, Doorwerth)

1. Agenda

1.1 Amendments / Adoption of Agenda
1.2 Week program: split up of PCAS for joint workshops and task groups

2. Appointment of Clerk of Minutes

3. Approval of Minutes of PCAS WG in Berlin, Germany, 2008

4. Progress Reports on PCAS Activities 2008 / 2009

◊ Activities 2008: from minutes of EC, 2008; 8. PCAS, full minutes can be found in Attachment 4.

◊ 8.1 International Collaboration on "The aqueous copper (II) complexation as a function of T" By Peter Tremaine (Canada) and Josef Sedlbauer (Czech Republic); Ms. Jana Ehlerova (Cz. Pep.)

◊ 8.2 The joint symposium with the Electrochemical Society in Washington, DC in 2007.

◊ 8.3 New PCAS WG members: D. Guzonas, AECL, Canada; Professor Nobuyuki Matubayasi

◊ 8.4 New Chairman and Vice Chairman: Masaru Nakahara and Andre Anderko, respectively. (gradual transition from Serguei Lvov between September, 2008 and 1st January, 2009)

◊ 8.5 Reported on the discussions (joint with PCC) about icrns 17, 21, and 22
(minutes 9.2)
ICRN 17 (amines); reviewed jointly
ICRN 21 (ultrasupercritical plant chemistry); reviewed jointly
ICRN 22 (nucleation in steam turbines); still under review by PCC, Comments by Hruby, Cz.Rep.

4.1 The Joint IUPAC/IAPWS Project *"Standard Partial Molal Proporeties of Solutes"to be reported by Professor Josef Sedlbauer*: **Berlin EC Minute 8.7.**

4.2 International Collaboration
08EC8.1 International Collaboration on "The aqueous copper (II) complexation as a function of T" **By Josef Sedlbauer (Czech Republic) and Jana Ehlerova (Cz. Pep.)**

4.3 ICRN
Reported on the discussions (joint with PCC) about icrns 17, 21, and 22 (minutes 9.2)
ICRN 17 (amines, Maughgan); reviewed jointly
ICRN 21 (ultrasupercritical plant chemistry, Don Palmer and Serguei Luvov); reviewed jointly
ICRN 22 (nucleation in steam turbines); still under review by PCC, Comments by Hruby, Cz.Rep.

4.4 PCAS Task Groups

- Hydrometallugy: Complex Ions, Complex formation, Solubility
- Hydrogen Energy
- EOS of aq nacl; Peter Tremaine, Allan Harvey (Anneke Sengers)
- Self-diffusion coefficients for H2O
- Viscosity coefficients for aq solutions
- What outputs can be made by PCAS?
- Changes in PCAS Task Groups, Priority List

5 New icrns?

5.1 ICRN #30 “Cavitation…”

6. Proposals for International Collaboration?

7. Other Business

8. Changes in Membership, Election of Officers

9. Preparation of Action List 2009 / 2010, Task Distribution, Next Year's Agenda

10. Preparation of PCAS WG Report for Executive Meeting

11. Miscellaneous and Adjournment

IAPWS Certified Research Need 13

Surface Tension of Aqueous Solutions. Issued September 1998. Expires July 2005. IAPWS Contacts: F. Sigon and F. Gabrielli

Closure Document

In consideration that the sponsor is not longer active in IAPWS, and the subject is covered in an IAPWS book, the Working Group on Physical Chemistry of Water and Steam recommended a closing statement.

Background

This ICRN was first issued in 1998 by researchers from ENEL (Italy) in cooperation with Alstom Power. Studies were continued under grants from the Czech Republic and the Czech Academy of Sciences.

Results Achieved

This subject has been covered by the paper written by: František Maršík, Tomáš Němec, Jan Hrubý, Pavel Demo, Zdeněk Kožíšek, Václav Petr, Michal Kolovratník:
Binary Homogeneous Nucleation in Selected Aqueous Vapor Mixtures, J Solution Chem (2008) 37: 1671–1708, DOI 10.1007/s10953-008-9337-4

Proposed IAPWS Certified Research Need – ICRN

Cavitation in Pure Water and Water Solutions

Tomas Nemec, Milan Sedlar, Frantisek Marsik, C. F. Delale (external collaborater)

The reliability, efficiency and life time of hydro-machine performance is strongly affected by cavitation. Classical theory of cavitation, which is based on the surface tension of pure water fails by 5 orders in cavitation rates prediction. It causes the application of empirical formulas for prediction of primary bubbles population in the real fluid (water). These formulas depend not only on a chemical composition of admixtures but on an amount of diluted gases. This is a main reason why applied empirical formulas have to be fitted for each actual working conditions.

The goal of this project is to elaborate better physico-chemical description of the cavitation theory, which would be applicable for the design or optimization of hydro-machines, especially for utilization in current computer codes.

IAPWS Working Group Power Cycle Chemistry (PCC)

Minutes of IAPWS PCC WG Meetings
Doorwerth, The Netherlands, 7-10 September 2009

Chairman: Robert Svoboda
Members present See PCC Attachment A

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1. Agenda

1.1 Amendments / Adoption of Agenda

Andy Rudge requested the addition to item 4.6 of consideration of ISO standard 5667 Part 7 on sampling.

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

Robert Svoboda summarized the schedule.

2. Appointment of Clerk of Minutes

Geoff Bignold agreed to act as Clerk of Minutes.

3. Approval of Minutes of PCC WG in Berlin, Germany, 2008

The minutes were approved without any corrections.

4. Progress Reports on PCC Activities 2008 / 2009

4.1 International Collaboration

Derek Lister reported that the earlier international collaboration on sampling had been successfully extended (on own funds) to include computerized fluid dynamics studies of steam sampling equipment. He indicated that there remains the question of the alterations of the sample in the sampling equipment (lines, valves etc). It was decided to launch a new proposal for IAPWS International Collaboration. DL agreed to lead the drafting of a proposal to cover the next stage (draft to be submitted for approval by end of 8 September 2009).

Action D.Lister

Karol Daucik advised that the work should take full account of the developments on the relevant ISO standard.

Andy Rudge indicated an interest from Imperial College, London (Dr M.Trusler) for involvement on flue gas condensation issues. He agreed to discuss this with Dr Okita (since it falls outside the PCC remit).

Action A.Rudge

4.2 ICRN

ICRN #13 – on surface tension. Frank Gabrielli agreed to submit a closure statement.

Action F.Gabrielli

ICRN #18 - on thermal degradation of ion exchange resins. Karol Daucik reported that there had been little or no research undertaken in response to this ICRN. However, in view of the increasing use of resins in combination with air cooled condensers, the topic was viewed as of increased importance. The ICRN should therefore be extended in 2010 for a further period.

ICRN #19 – on coolant sampling. Derek Lister reported that work currently in progress is demonstrating a further research requirement. The ICRN will therefore be continued for a further period. The ICRN should therefore be extended in 2010 for a further period.

ICRN #20 – on high temperature sensors. Work in progress is yielding useful results but Shunsuke Uchida restated the case for further work particularly for the nuclear plants. He indicated that an update to the ICRN is required and he agreed to undertake this in coordination with Sergei Lvov.

Action S. Uchida

4.3 PCC Task Groups

Barry Dooley reported progress on the development of IAPWS Guidelines. A guideline on chemical instrumentation for fossil fuelled plants had been drafted, circulated to national committees for comment and revised in response to the comments received. A subcommittee meeting (G. Bignold, M.de Whispelaere, S.-E. Therkildsen and BD) on 7 September had agreed the best approach to the final outstanding nomenclature issue. A revision will be issued to national committee chairmen with the aim of achieving endorsement by the IAPWS executive on 11 September.

A guideline document on chemical instrumentation for nuclear plants is being prepared under the leadership of S.Uchida.

Jim Bellows indicated that no progress had been made on the proposed guideline on steam purity requirements for steam turbines.

Action J Bellows / R Svoboda

BD confirmed that the work on development of guidelines should continue at the present level of activity.

Karol Daucik reported progress of the Task Group on damage assessment in power plants. A draft paper on the first stage of the evaluation process has been prepared and is available for discussion.

4.4 European Standard EN 12952:12

Geoff Bignold reported that the CEN committee responsible for organising updating of EN 12952 had voted to retain the current version of Part 12 by a single vote majority (6 in favour of retaining the current version against 5 in favour of revision). However, the extent of comments received from countries in favour of revision was such that the position would be discussed further at their next meeting on 5 March 2010.

Robert Svoboda responded that the next step should be to identify the national representatives on CEN who had voted against revision and to ensure that they are made fully aware of the case.

Action G Bignold

4.5 PCC Public Relations

There was a consensus in favour of on-going efforts to publicise the work of PCC via publications with the appropriate level of acknowledgement, conference papers based on the guidance documents, etc. Jim Bellows suggested that items on the IAPWS website should be supplemented with appropriate key words to maximise the impact. This approach should also be suggested to the other working groups at the executive meeting.

Action R Svoboda

Jim Bellows also suggested that presenting information on PCC initiatives at meetings of other bodies such as the appropriate ASME subcommittee would also be beneficial. Barry Dooley agreed to progress this.

Action B Dooley

4.6 Other Action List Items

4.6.1 ISO 5667 Part 7

Andy Rudge reported that BIAPWS have been asked to take part in the BSi committee responsible for the updating of ISO 5667 Part 7 on Steam and Water Sampling in Boiler Plant. This is a very much better standard than EN 12952:12 and in a recent ISO ballot only one vote had been cast in favour of revision. BIAPWS had identified two issues that required re-examination (iso-kinetic sampling in plant under flexible operation, and the criteria for flow rate in terms of Reynolds Number).These will be discussed at an ISO meeting in Vienna in the near future.

Robert Svoboda strongly supported BIAPWS approach to involvement with the major standards organisations.

5. Priority List Review

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

6. Changes in PCC Task Groups

No changes to task group formulation or objectives were raised.

TASK GROUP PROGRESS:

Production of IAPWS Guidelines (B. Dooley in chair)

BD reminded members of the scope and justification of the work on Technical Guidance Documents, which are major IAPWS products of high authority and comparable with the precedence for such products set by the other IAPWS working groups.

The Technical Guidance Documents on **Philosophy of Cycle Chemistry Control** remains in preparation (task group = **M.Rziha,** F.Gabrielli, F-U. Leidich and M. Ball). F-U.L reported that the group had agreed the structure and scope for the document, but were yet to proceed beyond the first iteration. He agreed to contact M.Rziha for a current status update with the intention that the work should continue on the current basis for completion and endorsement by the 2010 IAPWS meeting.

Action F-U Leidich

The Technical Guidance Document on **Instrumentation for Monitoring and Control of Cycle Chemistry for Steam/water Circuits of fossil-fired and combined cycle power plants** was reviewed, giving particular attention to the final edits covering the comments received from the German delegation. PCC approved the circulation of the final version to national representatives and the submission for executive committee endorsement on 11 September.

Action R Svoboda / B Dooley

The scope of a Technical Guidance Document on **Instrumentation for monitoring cycle chemistry in Nuclear Plants** was discussed by S. Uchida. The presentation on this topic had been circulated in advance of the meeting and comments had been made by D.Lister. The issues to be covered are potentially wider than for conventional plants. It was agreed that a nuclear subcommittee – S.Uchida, D.Lister and A.Rudge – should convene to clarify if such support is appropriate for the nuclear community and if so, then to develop a more detailed outline of the content of the document.

Action S.Uchida / D.Lister / A.Rudge

Jim Bellows and Robert Svoboda agreed to develop an outline of content for a Technical Guidance Document on **Steam Purity Requirements for Steam Turbines.**

Action J Bellows / R Svoboda

The topic of a possible Guidance document on **Sampling** techniques and issues was discussed. This item should await the outcome of on-going international collaboration and developments of the ISO standard.

Barry Dooley advocated the development of a Technical Guidance Document on **Cycle Chemistry for Steam/water Circuits of fossil-fired and combined cycle power plants using volatile conditioning** (AVT and OT). The members of the group who had worked on the

instrumentation guideline (de Wispelaere, Therkildsen, Dooley and Bignold) together with K.Daucik agreed to collaborate on this. BD agreed to ask Malcolm Ball if he would be willing to lead the task.

Action B Dooley

Task Group on quantification of risk of asset damage accrued from operation outside of targets.

Karol Daucik presented the progress to date on a document that he had circulated to the task group for their further input. The document sets out an evaluation of the lost relative marginal return. The calculation for a supercritical fossil plant indicated that every hour off load resulted in loss of 10^{-5} times the capital cost. (It was noted that this figure should be adjusted, because the cost of the first two days are much higher due to the price of urgent replacement generation.)

When calculating lost absolute marginal return a calculation of the probability of event was necessary. This was defined as relative extra life time consumption due to chemical excursion. The extra life time consumption was calculated on the basis of a published exponential chemical index.

A simple worked example of the calculation was included. This calculated the marginal return loss and probability of a serious event if a hypothetical unit operates for 30 years very strictly according to EPRI guidelines, using all the flexibility for chemical excursions given in them. The result was the probability of 1 and cost of 1.2 M€. It indicates that there will be a chemical problem at the end of the designed lifetime of a unit, even if it operates strictly after EPRI guidelines.

The project now requires data from utilities that have suffered chemistry related damage in order co calibrate the method and justify the outcome. Members were requested to send available data to KD.

The group agreed to continue with the presented evaluation strategy, but any comments are still welcome. KD agreed to circulate the current draft to all members of PCC.

Action K Daucik

7. ICRN

The following ICRNs were discussed in a joint meeting with the PCAS Working Group:

ICRN# 17 on Amines. Jim Bellows received comments that enable the production of a version suitable for submission to the executive.

Action J Bellows

ICRN# 21 on Ultra-supercritical plant. In the absence of Peter Tremaine, comments received on this were noted by Robert Svoboda for the generation of an updated version to be submitted to the IAPWS executive.

Action R Svoboda

ICRN# 22 on Chemistry of the phase transition zone. This had been substantially reformatted and amplified during the last year. M Stastny received further comments and offers of assistance from A Rudge to enable its presentation to the executive committee for support.

Action M Stastny / A Rudge

ICRN# 25 on Corrosion mechanisms that are related to the presence of contaminants in steam/water circuits – Geoff Bignold introduced this draft ICRN for initial comments. It was agreed that this should be circulated to all members of PCC and PCAS for consideration.

Action G Bignold

8. Proposals for International Collaboration

Derek Lister developed the new proposal (raised under item 4.1) for submission to the IAPWS Executive.

9. Other Business

Karol Daucik raised the requirement for consideration of the kinetics of decomposition of ammonia and its reactions with plant materials at temperatures anticipated in ultra-supercritical units. It was noted that this has not caused practical problems in plants operating up to 620ºC, but, as future temperatures are higher, it was agreed to add the issue into ICRN #21.

Action J Bellows

On the proposal to set up a subgroup on waste water and cooling water issues (Priority list item 13) Robert Svoboda agreed to discuss this with other Working Group Chairmen and to raise it at the executive committee meeting.

Action R Svoboda

A number of members of PCC had received and responded to a request from Eric Maughan at ESKOM to provide information on regulation of aqueous effluent disposal issues. No further PCC action was deemed to be necessary.

10. Changes in Membership, election of Officers

PCC noted with great sadness the recent death of Otakar Jonas. Robert Svoboda stated that his last two communications to PCC covering on going projects and unsolved issues would again be circulated to all PCC members.

The following members have been contacted to establish their willingness to continue as PCC members:

W.Allmon	Barry Dooley confirmed his continuing involvement.
L Guinard	will not continue membership. Robert Svoboda will invite a replacement representative from EDF.
V.Kritski	B Dooley / S Uchida will contact again.

P.Saidl Robert Svoboda confirmed her continuing involvement.
J.Vosta The Czech delegation communicated that he will not be able to continue in the group.
Hideki Takiguchi It was indicated that he may have different assignments.
R.Svoboda to clarify PCC membership.

11. Preparation of Action List 2009 / 2010, Task Distribution, Next Year's Agenda

Proceed with ICRN #17, 21, 22 and 25 (see 4.2)
Proceed with Task Group work (see 6.)

12. Preparation of PCC WG Report for Executive Meeting

- Summary of new ICRN
- Present modifications on draft Guidance Document "Instrumentation for Monitoring and Control of Cycle Chemistry for Steam/water Circuits of fossil-fired and combined cycle power plants"
- Overview of planned other Guidance Documents
- Perspective for diversification of IAPWS workgroups on Waste Water and Cooling Water.
- Propose adding keywords to IAPWS documents on the website so that they can be found with an Internet search engine
- Personnel changes.
-

13. Miscellaneous and Adjournment

PCC minutes, Doorwerth September 2009

Those present at the PCC WG meeting were as follows:

J Bellows	USA	
G Bignold	UK	
A Bursik	Germany	
K Cramer	Switzerland	
K Daucik	Denmark	
F de Vos	Netherlands	
B Dooley	Canada / USA	
F Gabrielli	USA	
P Gotovtsev	Russia	
J B Hughes	UK	
I Jiricek	Czech Republic	
F U Leidich	Germany	
D Lister	Canada	
K Marugame	Japan	
A Minaev	Russia	
A Rudge	UK	
M Stastny	Czech Republic	
R Svoboda	Switzerland	(Chair PCC)
H Takaku	Japan	
S-E Therkildsen	Denmark	
S Uchida	Japan	
S Vidojkovic	Serbia	
M de Wispelaere	Belgium	

PCC Minutes, Doorwerth September 2009

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 2009: Joint PPC/PCAS ICRN #21 to cover some of these topics has been drafted; comments by US natl. comm. to be considered, draft to be supplemented by chemical / thermodynamic considerations, volatility of oxides etc. (Harvey to lead update, with Palmer, Dooley, Tremaine, Harvey, Bellows)

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 2009: ICRN # 18 has been issued in 2006, no activities known in 2009, should be extended at 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 2009: ICRN #20 has been issued in 2006, some activities known in 2009 (Balashov, Petkin, Lvov), extension in 2010 together with needs from nuclear industry (Uchida, Lvov)

4. Improved analysis of low concentration of metals (Fe, Cu, Co, etc in the ppb range)

Techniques for analysis are known, but problems with implementation.

PCC to clarify by 2010 meeting if IAPWS/PCC could support on this matter.

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 2009: Geoff Bignold drafted ICRN #25; draft to be circulated within PCC and PCAS for finalizing

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

Detailed definition of the problem. Additional problems with adequate sampling, especially of Fe, Cu, Co, Oxygen, etc.

ICRN: Lister + Daucik; ICRN #19 on sampling of corrosion products has been issued. International collaboration 2006/7 has been performed: Piti S. (Lister, Daucik, Svoboda). 3 papers on "nozzles" by Piti et al, Status 2009: plan to extend collaboration to "sampling lines" (Lister, Uchida)

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 2009: task group in progress

8. Improved understanding of condensation mechanisms

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

ICRN draft#22 written, (Stastny, Rudge, et al; Stastny to finalize and send to PCC chair for processing

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 2009: opportunity for several ICRN, to be re-considered in 2010

10. Radiation chemistry of water

Radiolysis, main importance for nuclear generation

2007 PCAS/PCC presentations have been made
Status 2009: no activities

11. * Behaviour of Aluminium 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
- behaviour in condensate purification
- interaction of Al with boiler chemistry
- specification values for Al in feedwater, boiler water, steam

Status 2009: topic still pending, practical data to define scope of problem incoming, ICRN and / or publication for 2010 (Rziha, Svoboda)

12. Water cooling of copper in electrical machines

- generator stators
- accelerators

Status 2009: paper at ICPWS 2008; EPRI guideline 2008, CIGRE guidance, new investigations Palmer Svoboda considered

Water use outside the steam / water cycle

- cooling water
- waste water
- external process
- recycling for use as make-up
- etc.

For further consideration for 2010, possibly new IAPWS sub-committee

*** *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 4 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)

- Water and steam chemistry in geothermal power plants (large amount of information available, but still insufficient for guidance; further consideration for 2010)

PCC Minutes, Doorwerth September 2009

PCAS / PCC workshop (08/09/2009 13:30 - 15:30)

Physical chemistry research needs for the power industry

1. Thermodynamic Analysis of the Efficiency of Membrane Electrolyte Assembly of Hydrogen Fuel Cells (F. Maršík, T. Němec, S. Lvov)

2. Electrophoretic Mobility and Zeta Potential of Magnetite at Temperatures Corresponding to the Power Plant Operation Conditions (S.Vidojkovic, V. Rodrigez, M. Fedkin, S. Lvov)

3. Behavior of Copper-Oxides in ultra pure water systems as for generator cooling (R.Svoboda)

4. International Collaboration on: " Aqueous transition metal Chloro-complexes over a wide range of temperatures and pressures" (Jana Ehlerova, J.Sedlbauer, P.Tremaine)

5. Discussion of draft ICRN #17: “Research on Amines for the Power Industry” (J.Bellows)

6. Discussion of draft ICRN #21: “Thermophysical properties associated with ultra-super critical coal fired steam generators”. (R.Svoboda)

7. Discussion of draft ICRN #22: “Steam Chemistry in the Turbine Phase-transition Zone”. (M.Stastny)

8. Introduction of new draft ICRN #25: "Corrosion mechanisms that are related to the presence of contaminants in steam / water cycles" (G.Bignold)

PCC workshop (08/09/2009 08:30-10:30 and 10/09/2009 08:30-10:30)

Update on Power Cycle Chemistry Research and Experience

1. Prospective Using of Sea Water for Power Plants Equipment (A.Minaev)

2. Instrumentation for Monitoring and Control of Water Chemistry for Nuclear Power Plants (S. Uchida)

3. CFD Modelling of High-Temperature Sampling Systems (D.Lister, Piti S., K.Daucik, R.Svoboda)

4. Design of a steam sampling device (K.Daucik)

5. What is the best advice on sample system flow rate? (G.Bignold)

6. Condensation of water steam with NaCl impurity flowing in a nozzle and in a turbine cascade (M.Stastny)

7. The Effect of Pre-filming on the Growth Behavior of Oxide Scales in High-temperature Steam (M.Yoshida, K.Marugame, M.Miyajima and H.Takaku)

8. Evaluation of Corrosion Damage of Structural Materials in NPP cooling systems by Coupling Analysis of Corrosion and Flow Dynamics - Flow acceleration and Liquid Droplet Impingement (S.Uchida)

9. Artificial neural networks for water chemistry analysis (D.Smetanin, P.Gotovtsev)

Young Scientist IAPWS Fellowship Project

Thermophysical Properties of Supercooled Water

IAPWS Sponsors

Mikhail A. Anisimov
Professor
Institute for Physical Sciences and Technology
Department of Chemical Engineering
University of Maryland
College Park, MD 20742, USA

Radim Mares
Professor
Faculty of Mechanical Engineering
Department of Power System Engineering
University of West Bohemia, Pilsen
Czech Republic

Young Scientist

Jana Kalova
PhD Student
Institute of Technology and Business
Ceske Budejovice
and
University of West Bohemia in Pilsen
Czech Republic

April, 2009

1. BACKGROUND

The anomalous enhancements of isothermal compressibility, isobaric heat capacity, and in the magnitude of the thermal expansion coefficient of liquid water upon supercooling have been interpreted in terms of a retracing spinodal curve [1, 2], in terms of singularity free interpretation of the thermodynamics of supercooled water [3], and in terms of the metastable, low-temperature critical point. The second-critical-point scenario [4] is leading theory now. Recent experiments have given an indirect support for this liquid-liquid critical point [5].
Liquid water can be supercooled to -41 °C at atmospheric pressure and -92 °C at 2.10^8 Pa. These limits are the boundary where experimental data exist. The temperature T_H is called homogenous nucleation temperature. If water is rapidly cooled below T_H, water freezes into glassy, amorphous solid, forming at low pressure a low-density amorphous state (LDA) and at high pressure a high-density amorphous state (HDA). For LDA and HDA states there are estimations of thermophysical properties of water [6]. Experimental data for bulk water are missing for temperatures between150 K and 232 K.
Recently, Fuentevilla and Anisimov [7] have published a scaled parametric equation of state that is universal in terms of theoretical variables and belongs to the three-dimensional Ising-model class of universality. The equation can be used to describe and predict properties of supercooled water. The main advantage of the scaled equation mentioned above is the possibility to predict some properties of supercooled water below the limit of homogenous nucleation, for which it is very difficult to obtain experimental data.
Kalova and Mares [8] used the theory to predict vapour pressure of supercooled water for calculation of correction terms to Wagner and Pruß [9] equation. The extrapolation based on the theory extends temperature interval of validity below 0 °C to - 150 °C.
Fuentevilla and Anisimov equation [7] uses several parameters, e.g. location of the second critical point and coefficients of the equation. The coefficients are calculated from the liquid – liquid coexistence curve and from Widom line. The experimental heat-capacity data [10] are used for estimation of the second critical point parameters. The scaled equation is valid only in the immediate vicinity of the critical point, but available experimental data are far away from it. Analytical background functions are needed to describe thermophysical properties in a larger distance from the critical point.

2. SCOPE

The calculation of properties using existing experimental data or data calculated from IAPWS 95 brings quite complex analytical background function in some cases (Kalova, Mares [11]). It is the reason to calculate all coefficients of the scaled equation including parameters of the second critical point again. It is possible to use not only experimental data and estimations from the range of amorphous ice but also data from IAPWS 95 for the calculation. The extrapolation of properties gained from IAPWS 95 can be tested on a model.
Planned steps:
- Overview and critical evaluation of existing experimental data for supercooled water, not only at ambient pressure, and critical evaluation.
- Analysis of Widom line (experimental limits of stability, computer simulations).

- Experimental data on amorphous ice can be used to constrain the thermodynamics functions of water at temperatures below 155 K.
- Extrapolation of IAPWS 95 and other formulations of properties in the supercooled temperature range.
- Recalculation of coefficients in the scaled equation including the second critical point parameters.
- Finding the background functions for specific thermophysical properties of water.
- Evaluation of the scaled equation and comparison with IAPWS 95 and with experimental data.

3. PROPOSED RESEARCH AND JUSTIFICATION FOR IAPWS SUPPORT

The purpose of the collaborative project with IAPWS is to recalculate coefficients in the scaled equation and to compare gained thermophysical properties with extrapolated values from IAPWS 95. The IAPWS funding will make it possible to spend at the University of Maryland for six months in a single stay starting in January 2010.

4. BUDGET (in $US)

Total Cost.....$18000
Subsistence for 6 months: IAPWS Young Scientist Grant.....$15000
Travel (round trip): to be paid by Institute of Technology and Business in Ceske Budejovice.....$3000

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6. CURRICULUM VITAE

Jana Kalova

Born

1965

Education

2007- University of West Bohemia, Faculty of Mechanical Engineering, Pilsen, Czech Republic, PhD. stud., programme Thermomechanics and Fluid Mechanics
2007 University of West Bohemia, Faculty of Applied Science, Pilsen, Czech Republic, RNDr.
2003-2006 University of West Bohemia, Faculty of Applied Science, programme Mathematical engineering – Mathematical modelling, Pilsen, Czech Republic, Ing.
1985-1989 University of South Bohemia, Pedagogical Faculty, programme Mathematics and Physics, Ceske Budejovice, Czech Republic, Mgr.

Employment

2007- Assistant Profesor, Institute of Technology and Business in Ceske Budejovice
1994 - 2007 High-school teacher of mathematics, in Ceske Budejovice

IAPWS WG PCC

07 September 2009

Proposal for IAPWS to support International Collaboration Project

IMPROVED SAMPLING TECHNIQUES

Participants

Robert Svoboda
Alstom Power Service
CH-5401 Baden
Switzerland

Derek Lister
University of New Brunswick
P.O. Box 4400
Fredericton, N.B.
Canada

Karol Daucik
Elsam Engineering
Kraftvaerksvej 53
DK-7000 Fredericia
Denmark

Shunsuke Uchida
JAERI
Sendai
Japan

Young Scientist/Student

TBD – from Japan.

Background

The formation and transport of corrosion products in water/steam cycles has been a major problem since the inception of thermal energy circuits. The determination of corrosion product concentrations has subsequently become a very important method of monitoring the chemical state of an operating unit. Since the solubility of the corrosion products is rather low at the conditions of the water/steam cycle, they appear mainly as particulates. This complicates the sampling, as the heterogeneous character of the system can easily lead to partial separation of phases resulting in non-representative sampling. This problem becomes particularly pronounced at low concentrations of corrosion products.

A previous IAPWS-sponsored International Collaboration considered sampling effectiveness in high-temperature systems from the point of view of the design of sampling nozzles and the importance of imposing isokinetic conditions. A commercial computational fluid dynamics code was used to model the sampling efficiency for micrometre-sized particles of corrosion products in steam and water. It was concluded that imposing isokinetic conditions is inconsequential in water systems, since the apparent concentration of particles taken into a nozzle is virtually unaffected by the sampling velocity. In steam systems, however, practical nozzles always perturb the fluid flow field and lead to apparent concentrations of particles that deviate from the true concentrations. The deviations depend on sampling velocity as well as particle size [1,2,3].

While the collaboration successfully identified issues with sampling nozzles, it was clear that interactions between the sample drawn into the nozzle and the walls of the sample line (including the cooler) may well dominate and be the major cause of unrepresentative results. It was concluded that there is a need to study the interactions with a view to minimising them and proposing methods of correcting for them.

Objective

The objective of this project is to assemble relevant information from the literature and identify the best practices for current sample systems to minimise sample-wall interactions. This will lead to the design of a program of laboratory research in a high-temperature water system that would lead to an understanding of the mechanisms involved so that optimal sample systems can be designed in the future and a capability for predicting and correcting for interactions can be obtained.

Completion

The student will spend a year in Derek Lister's laboratory at the University of New Brunswick in Canada. There, she/he will interact with staff who have already been involved with the previous IAPWS International Collaboration on sampling. He/she will become familiar with the operation of high-temperature water systems and how they are sampled. Preliminary experiments on evaluating the sample systems will be performed and the results will help in the formulation of a detailed research program for the future.

Deliverables

Report on "Effect on Quality of Samples from High-Temperature Systems of Interaction with Sample System Materials".

Schedule

The work will be done in 2010 and the report delivered at the IAPWS meeting in 2011.

Budget

Item	**Cost ($US)**	
Student travel cost	3 000	
Student cost of living	16 000	
Materials and supplies	2,500	
Local costs	1 500	
Time of participants	20 000	
Total	**43 000**	
Cost to IAPWS	**12 000**	

Requested contribution from IAPWS is $ 12 000.

References

1 P. Srisukvatananan, D.H. Lister, R. Svoboda, K. Daucik. "Assessment of the state of the art of sampling of corrosion products from water / steam cycles". Power Plant Chemistry 10 (2007) 10, pg 613-626

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3 P. Srisukvatananan, D.H. Lister, R. Svoboda, K. Daucik. " A CFD Study of Corrosion Product Collection Efficiency of Sampling Nozzles under Power Plant Conditions". 9th International EPRI Conference on Cycle Chemistry in Fossil and Combined Cycle Plants with Heat Recovery Steam Generators, June, Boston / USA

Press Release
International Association for the Properties of Water and Steam
2009 Meeting

Continuing a series of conferences started in 1929, 60 scientists and engineers from 13 countries attended the annual meetings of the International Association for the Properties of Water and Steam (IAPWS), September 6-12, 2009 in Doorwerth, The Netherlands. The meeting was hosted and supported by KEMA, an international consulting company, headquartered in The Netherlands. A highlight of the meeting was the organization of a subcommittee on seawater. 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 KEMA, Germany and The Netherlands for a symposium on **The Role of Water in Energy Transition**. The symposium discussed new methods of power generation and current issues in water supply, such as the recovery of water from flue gas. In a separate session, issues in nuclear power plant chemistry, particularly those related to flow-accelerated corrosion, were featured.

The new IAPWS Subcommittee on Seawater met for the first time, filling out its membership with approximately 25 scientists and engineers from nine different countries. Task Groups were formed to address important areas related to seawater including SI traceability, pH, transport properties, and industrial applications such as desalination.

In June 2009 the Intergovernmental Oceanographic Commission (IOC) of UNESCO, representing all 140 maritime nation states of the world, adopted the three IAPWS thermodynamic formulations of fluid water, ice and of seawater as the official thermodynamic representation of seawater for use in marine science internationally. For the first time oceanographers now have consistent and accurate formulations to quantify the transport of heat in the ocean and the exchange of heat between the ocean and atmosphere. The new thermodynamic definition of seawater involves a new salinity variable which incorporates the small spatial variations in the composition of seawater. This new salinity variable is needed to more accurately calculate the density of seawater and thereby to quantify the ocean circulation.

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.

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.

The Power Cycle Chemistry Working Group completed a new technical guidance document, “Instrumentation for Monitoring and Control of Cycle Chemistry for Steam/water Circuits of Fossil-fired and Combined Cycle 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. This working group expanded its scope to 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 will be in eastern Canada, probably in September 2010. 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. People do not need to be citizens or residents of member countries to participate.

BIAPWS Report to the IAPWS Meeting, Doorwerth, Netherlands, September 2009

1. BIAPWS Committee

BIAPWS committee meetings are held three times a year, and the attendance at these has been very good, typically around 15, helped by the introduction of technical presentations and discussions into the meeting agenda. The discussions provide a useful forum for updating information and exchanging views on a number of topics. Sponsor's representatives are able to bring a colleague to the meeting to benefit from and contribute to the discussions.

In October 2008, the BIAPWS committee meeting was held in Dublin, a change from the usual venue of Birmingham. This temporary change of venue was made in acknowledgement of the support received from BIAPWS members in Ireland, and the meeting was followed by a morning of technical presentations to BIAPWS members and representatives from the power plant chemistry community in Ireland. The meeting was very successful and BIAPWS were grateful to ESB for hosting the meeting. BIAPWS aims to continue to hold meetings in Birmingham as the default, but to consider meetings at alternative venues, such as Dublin, on occasions.

In 2008, BIAPWS considered how to be most effective in its dual roles of UK & Irish national committee of IAPWS and representative body for power plant chemistry in the UK & Ireland. As a result, the BIAPWS statutes have been revised, principally to better reflect the role of BIAPWS as the representative body for power plant chemistry in the UK & Ireland. At the same time the committee is approaching academic specialists about becoming corresponding members of BIAPWS, in the hope that this will enable BIAPWS to better represent the UK & Ireland in areas of interest to the IAPWS working groups Thermophysical Properties of Water & Steam (TPWS), Industrial Relations and Solutions (IRS) and Physical Chemistry of Aqueous Systems (PCAS).

Finally, there was an election of officers in 2008, and BIAPWS would like to express its gratitude to Dr. Richard Harries and Mr. Malcolm Ball, who have stepped down from their roles as Chairman and Secretary respectively, for their time and dedication to the organisation of BIAPWS.

2. BIAPWS Award

The BIAPWS Award is given annually by BIAPWS to qualifying students as a means of promoting awareness of the topics of interest to BIAPWS. In 2008 the BIAPWS award was co-sponsored by E.ON Engineering. The award recipient was Joe Hook, who is studying for a Masters Degree in Physics at the University of York. The Award is given in the form of contributory funding by BIAPWS for a work experience placement for the student. Joe spent three months working on a project to assess technologies for post combustion carbon capture at E.ON's Technology Centre at Ratcliffe-on-Soar near Nottingham. Joe gave an excellent presentation on his work at the BIAPWS Symposium in April 2009.

Both Joe and the 2007 BIAPWS Award winner, Rochelle Green, have since gone on to full time employment in the power plant industry, both with BIAPWS sponsors, demonstrating a significant success for the Award in attracting high calibre individuals into the power generation industry.

BIAPWS has also supported a further educational initiative in 2008, sponsoring and judging prizes for energy related projects at a schools science fair in Hinckley, Leicestershire.

3. BIAPWS Symposium

The 11th BIAPWS Symposium, 'Progress in Environmental and Cycle Chemistry', took place at the Village Hotel, Nottingham, on 22 April 2009. This was preceded by a half day workshop on 21 April. Two sessions were held in the Symposium: 'Environmental Issues in Power Plants' and 'Flexibility in Cycle Chemistry', whilst two sessions were also held in the workshop, both on chemical aspects of flexible operation. This proved to be another successful meeting, with around seventy delegates attending the Symposium and thirty delegates attending the workshop. A summary report of the meeting was published in Power Plant Chemistry earlier this year.

4. BSI Representation

BIAPWS continues to represent the power industry on the BSI committee dealing with standards for power cycle chemistry, i.e. BS-EN 12952:12 and BS-EN12953:10. BIAPWS has taken a lead on behalf of European members of IAPWS to coordinate representations to CEN to get these standards reviewed.

In 2008, BIAPWS also joined the BSI committee with responsibility for the administration of ISO 5667 – Water Quality, Sampling. BSI has joined this committee with the aim of supporting a revision to Part 7 of this standard: 'Guidance on sampling water and steam in boiler plants'. BIAPWS is liaising with IAPWS PCC working group in this activity.

5. IAPWS Activities

BIAPWS has continued to support IAPWS through its formal membership and participation in IAPWS activities. A number of BIAPWS committee members are represented on IAPWS working groups, in particular Power Cycle Chemistry (PCC), and BIAPWS was especially proud that one of its members, Jeff Cooper, completed his second year as IAPWS President in 2008. BIAPWS members of the PCC working group have also supported the production of a new suite of IAPWS Technical Guidance Documents that are expected to provide a valuable resource to those involved power cycle chemistry.

The 15th International Conference on the Properties of Water and Steam (ICPWS) was held in Berlin in September 2008, and a number of BIAPWS members participated. At the meeting BIAPWS was invited to host the next ICPWS. Following an internal review, BIAPWS has agreed to host the 16th ICPWS, expected to be held in 2013. A BIAPWS sub-group has been formed to take the organisation of this conference forward.

6. Overview

This has been another successful year for BIAPWS. Membership remained strong and the BIAPWS symposium and BIAPWS Award have both been successful. The introduction of technical discussions into committee meetings is resulting in increased interest and participation in BIAPWS activities. The agreement by BIAPWS to host the 16th ICPWS presents a long term challenge for BIAPWS, but also provides an opportunity to show the UK & Ireland in a positive light.

Dr. Andy Rudge
Chair, British & Irish Association for the Properties of Water and Steam
September 2009

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

IAPWS-Related Research in Canada
2009

SUMMARY OF ACTIVITIES

1.0 National Workshop

On 2009 May 11th and 12th, the Canadian National Committee of IAPWS organized a workshop in Toronto for researchers, applied scientists and practising engineers in water-related areas to describe their work and discuss priorities for the future. The CANDU Owners Group was the sponsor and its staff were key in ensuring an efficient organization. About 50 people attended and participated in lively discussions after the presentations. In the final session, breakout groups focused on important issues arising from the areas of: process chemistry; deposition/precipitation; corrosion in confined regions and concentrated solutions; and, radiation chemistry. The findings of the groups are presented in Appendix 1.

Favourable comments were received after the event. This workshop will be held every two years and is seen as an important vehicle for bringing together Canadian researchers and practitioners and for promoting collaborations and funding support.

2.0 International Certified Research Needs

The Canadian National Committee has considered ICRNs and suggests the following for discussion:

- Sampling from high-temperature water and steam systems (specifically, the interaction of the sample with the sampling system walls).
- Chemical thermodynamics and kinetics of electrolytes and organics in subcritical and supercritical water (300 to 450 °C)
- Materials performance under supercritical steam-generator conditions (nuclear and thermal)
- Radiolysis models for high-temperature water at in-core reactor conditions.

3.0 International Collaborations

3.1 Czech Republic and Canada:

PhD student Jana Ehlerova (Supervisor Dr. Josef Sedlbauer, University of Liberec) completed a 1-year IAPWS collaborative project with Dr. Tremaine (University of Guelph) entitled *"Euilibrium Constants and Speciation of Aqueous Transition Metal Chloro-complexes over a Wide Range of Temperatures and Pressures"*. During this period Dr. Sedlbauer also spent 3 weeks at Guelph working with Dr. Tremaine and Dr. Trevani on data interpretation. A full report will be presented at the IAPWS 2009 Meeting in the Netherlands.

3.2 Denmark, Switzerland and Canada

The PhD student Piti Srisukvatananan, supervised by Derek Lister at the University of New Brunswick (UNB) in Canada, presented the results of the IAPWS-sponsored collaboration on the CFD modeling of systems for sampling high-temperature water and steam at the Berlin meeting of IAPWS in 2008. Subsequently, the collaboration involving UNB, Dong Energy in Denmark (Karol Daucik) and Alstom in

Switzerland (Bobby Svoboda) was extended and with support from Dong Energy undertook a further CFD study of sampling. The results are summarized in a presentation at the IAPWS 2009 meeting in the Netherlands.

4.0 Proposed IAPWS Meeting in 2010

The Canadian National Committee is prepared to host the 2010 IAPWS Meeting and Niagara Falls, Ontario, is proposed as a convenient venue.

It has been suggested holding it either the week before or the week after the International Conference on the Water Chemistry of Nuclear Reactor Systems (NPC2010), which is being held in Quebec City on October 3rd – 7th. However, it is recognized that this is rather late and may inconvenience several members; earlier in the summer may be better. IAPWS will be informed very soon about the decision.

Appendix 1. Findings of Workshop Discussion Groups

A1.1 Process Chemistry

- Diagnostics/Sensor Development for the study of chemistry processes in high temperature water at sub- and super-critical conditions.
    - In the study of water chemistry at high temperatures, on line diagnostic tools are required in the short term both for understanding the chemistry prevailing at these conditions and in the longer term to control processes that will take advantage of these high temperatures e.g. SCWR and SCWO.
    - Progress in these studies is hampered by the unavailability of high integrity diagnostic tools such as pH and redox potential measuring probes able to cover a wide temperature range from 200°C up to supercritical water conditions (350-400°C)
- Modelling High Temperature and Supercritical Water Chemistry
    - HKF models predicting the species in solution only utilize data below 300°C.
    - There is a need to generate more data at higher temperatures up to and beyond the supercritical point and then refine models to fit the data.
    - Paul's comment – are there models utilized in the hydrometallurgy industry that can be utilized in the nuclear industry to model hideout return that are better than the current industry standard – MulteQ?

A1.2 Deposition / Precipitation Processes

Significant Issues

1. Morphology of deposits and how the thermal conductivity is affected.
2. Mechanics of the deposition process
3. Deposition rate and temperature dependence
4. Solubility data in SCW and other thermodynamic properties
5. Mechanical properties of the deposits and heat flux
6. Nucleation issues
7. What is the actual structure of SCW?

Actions

1. Examine different NRCan coupons in SCW and study the subsequent corrosion. Perhaps set up a round-robin of tests?
2. Solubility of corrosion products in SCW, e.g., magnetite
3. Transport of deposits
4. The cladding materials should also be examined, e.g., ZrO_2 ceramics

N.B. Some of the work should also be done under subcritical as well as SCW conditions.

Non-Power-Plant Issue

1. Heat-exchanger fouling
2. Synthesis of new alloys, nonmetal materials and coatings

A1.3 Corrosion in Confined Regions / Concentrated Solutions

- Broad issue of significance:

  Properties of water in confined space and how it affects to corrosion

- Specific research action needed:

  Although a significant amount of work has been completed on the effect of water properties on corrosion of materials in general, additional work on the effect of water properties on corrosion in confined spaces would seem to be warranted. In particular there are still essentially no results for the key transport properties (viscosity, thermal conductivity, cell concentration and diffusion) for confined space.

- Non-power-plant aspects of the issue:

  Many other industries experience and deal with corrosion in confined spaces. These industries include the hydrometallurgical, chemical, and petrochemical industries. Any advances made in relation to power plants would benefit these industries and vice-versa.

- Knowledge management:

  It was emphasized that it is important to involve technical experts from industry to provide input and feedback to ensure direct relevance of the theoretical work to practice.

A1.4 Radiation Chemistry

Needs:

1. A better water radiolysis model for application to reactor systems. In the shorter term this would involve better inputs and model benchmarking so that we fully understand in-reactor-core processes. In the longer term we need to have models available that can be applied by non-experts.

2. A wider database for impurity degradation in radiation fields. In addition to prediction of hydrogen generation etc, we need to be able to understand the degradation pathways to look for undesirable products (e.g. oxalate, and organic goo).

3. Supercritical water. Understanding in-core radiolysis in SCW will be key to defining the correct chemistry regime for a SCW cooled reactor. Measurement of reliable radiolysis parameters in SCW should lead to some of the improvements in high temperature data described in point 1. Better knowledge of SCW radiolysis will also be of benefit in the application of SCW to waste treatment processes.

Appendix 2. Canadian Researchers

A2.1. University Research

Alan Anderson, St. Francis Xavier University
Synchrotron Measurements on Supercritical Fluids

Willy Cook, University of New Brunswick
Materials and Corrosion Product Behavior under CANDU-SCWR Conditions

Janusz Kozinski, University of Saskatchewan
Supercritical Water Chemistry in Materials and Energy Research

Derek Lister, University of New Brunswick
Power System Coolant Chemistry and Corrosion

Vladimiros Papengelakis, University of Toronto
Measurements and Modelling of Metal Solubility in Hydrometallurgical Processes

Paul Percival, Simon Fraser University
Muons as a Tool for Probing Supercritical Water Chemistry

Steve Rogak, University of British Columbia
Supercritical Water Material Testing and Electrochemical Measurements

Igor Svischev, Trent University
Computer Simulations of Supercritical Aqueous Fluids and Particle Formation Processes

Peter Tremaine, University of Guelph
Deuterium Isotope Effects on Chemical Reactions under CANDU Operating Conditions and Gen IV Supercritical Water Reactor Chemistry

Clara Wren, University of Western Ontario
Radiolysis in CANDU Coolant and its Effect on Chemistry and Materials

A2.2 Industrial/Government Research

Dave Guzonas, Atomic Energy of Canada Ltd
Chemistry and Materials Challenges in Generation IV Supercritical Water Reactors

Gabriel Nicolaides, Ontario Power Generation
OPG WTP Performance / Trends in High Purity Water Treatment

Otto Herrmann and Teresa Switzer, Kinectrics
Determination of Metals by ICP-MS

Ken Sedman, Bruce Power
Stress Corrosion Cracking and Intergranular Attack of Steam Generator Tubing

Craig Stuart, Atomic Energy of Canada Ltd
Radiolysis in Reactor Coolant Systems

Dan Wright, Bedford Institute of Oceanography
Scientific and Industrial Formulations for the Properties of Seawater

Peter King, B&W Canada
Steam Generator Chemistry and Materials Degradation

The Czech National Committee

International Association for the Properties of Water and Steam

REPORT on IAPWS related activities – August 2008 / August 2009

Submitted to the EC Meeting of IAPWS, Arenhem, NL – September 2009.

National Committee Contacts:

CZ NC PWS, Institute of Thermomechanics AS CR, v.v.i., Dolejškova 5, 182 00 Prague 8, Czech Republic, Fax: + 420 2858 4695, E-mail: secr.czncpws@it.cas.cz
Head: Dr. Jan Hruby, E-mail: hruby@it.cas.cz

Following Institutions participated in the research into the thermophysical properties and 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 6.

Technical University Brno (TU), Faculty of Mechanical Engineering, Energy Institute, Department of Power Engineering and Department of Thermodynamics and Environmental Engineering, Technicka 2, CZ-616 69 Brno.

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.

Nuclear Research Institute, plc. (NRI), Rez, CZ-250 68 Rez.

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.

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

- In the 15th ICPWS in Berlin participated 13 workers from CR with 12 papers, Refs. [1 to 12]. The Workshop on Homogeneous Vapor-Liquid Nucleation in Water, organized the head of CZ NC PWS, Dr. J. Hruby, was a part of the 15th ICPWS and 11 contributions were presented and discussed.
- The 12 CD containing Proceedings of 15th ICPWS has been hand over to technical libraries in Czech Republic.
- A brief commentary has been published on web sites of CZ NC PWS to the new documents adopted and authorized by IAPWS.
- A new joint project IT AV ČR and WBU Plzen has been elaborated and accepted in the Research and Development Contest of the Ministry of Education, Youth and Sports of the ČR, which enabled cooperation with IAPWS for the next four years.

- Workers of the Institute of Chemical Technology, Prague, Faculty of Environmental Technology and Institute of Energetics (ICT-IE) organized in September 2008 the 7th International Power Cycle Chemistry Conference - CHEO-7 – dealing with water treatment for power and environment, corrosion in energetics and renewable energy sources. Selection of published articles, Refs. [13 to 22].
- Dr. Hruby (IT) participated in the evaluation of the formulations of the properties of seawater and ice, resulting in publication Ref. [23].
- Dr. Hruby (IT) with his collaborators, in collaboration with A. Harvey of NIST (USA), developed a formulation of thermophysical properties of liquid water at atmospheric pressure. The formulation was described in a draft of a Supplementary Release and was adopted in Berlin 2008, Ref. [24]. A background-paper for Supplementary Release on Properties of Liquid Water at 0.1 MPa was published, Ref. [25].
- Prof. Mares (UWB) with his collaborators took part at development a new international formulation for the viscosity of water and steam, Refs.[26 and 27] and took part in publication of supplementary backward equations, Ref.[28], contributed on behaviour of super-cooled water, Refs.[5 and 6, 29 and 30], on density of water substance at ambient pressure, Refs.[31 and 32], and on thermodynamic properties of water and steam. Ref. [7].
- Prof. Marsik (IT) coordinated research in the electrolyte membrane and efficiency of fuel cells, Ref. [33], and the metastable states, nucleation and development of a new model of cavitation erosion potential. Refs. [4, 34 to 40].
- Doc. Sedlbauer (TUL) and his team did research works on subject of chemistry of aqueous systems. Refs. [1, 11, 41 and 42]
- Doc.Sedlbauer (TUL) collaborated with team of Prof. Tremaine (Canada) and investigated the ionization constants of aqueous nitrophenols and the speciation of aqueous transition metal chloro-complexes. Refs. [10 and 43].
- 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, Ref. [44], heterogeneous condensation seeds in expanding steam, Ref. [4 and 45], electrostatic charge of droplets in expanding wet steam, Ref. [46], hydrogen technologies, Ref. [47].
- The SIGMA Research and Development Institute (SIGMA) solved problems of erosion effects of cavitation bubbles on the blades of water pumps and the problems of the effect of water properties on cavitation phenomena. Refs. [4, 36 to 38, 48].
- Dr. Jiricek (ICT-IE) with collaborators investigated corrosion processes, renewable power sources and chemical effects in water and steam systems of power plants. Refs. [12, 13 to 22].
- Dr. Hnedkovsky (ICT-IPC) with collaborators investigated properties of organic solutes in water. Published articles and conference contributions are under Refs. [49 and 50].
- 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, and collaborated in frame of the IAPWS ICRN 22. Refs. [2, 51 to 53].

Young Scientists IAPWS Fellowships

Information on the Young Scientists IAPWS Fellowship Projects.

- Ing. Ehlerova handed over the Final Report finished in the frame of the Young Scientists IAPWS Fellowship Project 2008 „Equilibrium Constants and Speciation of Aqueous Transition Metal Chlorocomplexes over a Wide Range of Temperatures and Pressures”. The report was assigned to the Executive Secretary of IAPWS. A brief summary will be presented on negotiations of WG PCAS at IAPWS Meeting 2009. The results will be published in journals and her dissertation thesis.

- Prof. R. Mares (CZ) and Prof. M. A. Anisimov (USA) (WG TPWS) prepared a Proposal for Young Scientist IAPWS Project 2010 for J. Kalova "*Thermophysical Properties of Supercooled Water* ". Proposed project has following research steps:
  - Overview and critical evaluation of existing experimental data for supercooled water, not only at ambient pressure, and critical evaluation.
  - Analysis of Widom line (experimental limits of stability, computer simulations).
  - Experimental data on amorphous ice can be used to constrain the thermodynamics functions of water at temperatures below 155 K.
  - Extrapolation of IAPWS 95 and other formulations of properties in the supercooled temperature range.
  - Recalculation of coefficients in the scaled equation including the second critical point parameters.
  - Finding the background functions for specific thermophysical properties of water.
  - Evaluation of the scaled equation and comparison with IAPWS 95 and with experimental data.

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German National Committee to IAPWS

Research Activities on the Thermodynamic Properties of Water and Steam

Report "Research in Progress 2009"

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

1. Preparation of the Revised Release on the Equation of State 2006 for H_2O Ice Ih

2. Preparation of the): Supplementary Release on a Computationally Efficient Thermodynamic Formulation for Liquid Water for Oceanographic Use

3. other Publications:

   Feistel, R., Wright, D.G., Jackett, D.R., Miyagawa, K., Reissmann, J.H., Wagner, W., Overhoff, U., Guder, C., Tchijov, V., 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., 2009, in preparation.

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   McDougall, T.J., Feistel, R., Millero, F.J. , Jackett, D.R., Wright, D.G., King, B.A., Marion, G.M., Chen, C.-T.A., Spitzer, P., Seitz, S.: IOC Manuals and Guides No. xx, 2010: The International Thermodynamic Equation Of Seawater 2010 (TEOS-10): Calculation and Use of Thermodynamic Properties, UNESCO (English) 2009, 150pp. Internet: www.teos-10.org

   Marion, G.M., Millero, F.J., Feistel, R.: Precipitation of solid phase calcium carbonates and their effect on application of seawater S_A–T–P models. Ocean Science 5, 285-291, 2009. Internet: www.ocean-sci.net/5/285/2009/

   Feistel, R., Wright, D.G., Miyagawa, K., Harvey, A.H., Hruby, J., Jackett, D.R., McDougall, T. J., Wagner, W.: Mutually consistent thermodynamic potentials for fluid water, ice and seawater: a new standard for oceanography. Ocean Science 4, 275-291, 2008. Internet: www.ocean-sci.net/4/275/2008/

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

1. Supplementary Backward Equations $v(p,T)$ for Region 3 of IAPWS-IF97 (IAPWS-IF97-S05)
   - The comprehensive article on the backward equations $v(p,T)$ was published in the "Journal of Engineering for Gas Turbines and Power"
2. 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.
3. Thermodynamic Properties of Humid Air
   - The research project RP-1485 "Thermodynamic Properties of Real Moist Air, Dry Air, Steam, Water, and Ice" of the American Society of Heating, Refrigerating, Air-Conditioning Engineers (ASHRAE) was completed.
   - Two comprehensive articles on the properties of moist air were prepared for the Journal "HVAC&R Research" and the "Journal of Engineering for Gas Turbines and Power".
   - The property library LibHuAirProp for calculating thermodynamic and transport properties of real moist Air was prepared.
4. Thermodynamic Properties of Seawater
   - 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

- Kretzschmar, H.-J., Harvey, A.H., Knobloch, K., Mareš, R., Miyagawa, K., Okita, N., Span, R., Stöcker, I., Wagner, W., and Weber, I.: Supplementary Backward Equations $v(p,T)$ for the Critical and Supercritical Regions (Region 3) of the IAPWS Industrial Formulation 1997 for the Thermodynamic Properties of Water and Steam. Journal of Engineering for Gas Turbines and Power, Vol. 131 (2009) pp. 043101-1
- Herrmann, S., Kretzschmar, H.-J., Teske, V., Vogel, E., Ulbig, P., Span, R., Gatley, D.P.: Determination of Thermodynamic and Transport Properties of Humid Air for Power-Cycle Calculations. Report PTB-CP-3 (2009), ISBN 1614-953X
- Herrmann, S., Kretzschmar, Gatley, D.P.: Thermodynamic Properties of Real Moist Air, Dry Air, Steam, Water, and Ice. Final Report ASHRAE RP-1485 (2008). Available from http://www.ashrae.org
- Kretzschmar, H.-J., Stöcker, I.: Mollier *h*-*s* Diagram for Water and Steam (Pressure in MPa). Springer, Berlin (2009), ISBN 978-3-642-03321-6
- Kretzschmar, H.-J., Stöcker, I.: Mollier *h*-*s* Diagram for Water and Steam. Siemens Energy Sector, Erlangen (2009)
- Kretzschmar, H.-J., Kraft, I.; Kleine Formelsammlung Technische Thermodynamik (Small Formula Collection of Technical Thermodynamics), third edition. Carl Hanser, Munich (2009)

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

1. Formulating a Revised Release on the IAPWS-95 formulation

   This revised release is identical to the original release issued by IAPWS in 1996, except for inclusion of the calculated triple-point pressure, improved values for coefficients n_1^0 and n_2^0 in Table 1 to more accurately match the arbitrary conventions for the zeros of energy and entropy, and corrections in the last digits of a few calculated values in Tables 6-8. Calculations for physically measurable quantities are unchanged. Some minor editorial corrections and updates to references have also been made.

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

   Editorial changes were made for the correction of printing errors, a more exact value for the lowest pressure for the validity of Eq. (22) was given, and References [2a] and [10] were updated.

3. Steam Tables for the VDI-Heat Atlas 2010

   The Section D2.1 “Properties of Water and Steam” of the VDI-Heat Atlas 2010 was written 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, Doorwerth, The Netherlands, September 2009

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 Koichi Watanabe, Keio 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 the Nuclear Science and Engineering Directorate, Japan Atomic Energy Agency, Tokai-mura, Dr. S. UCHIDA made his effort to promote development of evaluation method on flow-induced vibration and corrosion of components in two-phase flow by combined analyses of flow dynamics and corrosion [Innovative and Viable Nuclear Energy Technology Development Project of the Ministry of Economy, Trade and Industry]. 1) A FAC (flow accelerated corrosion) wall thinning rate evaluation model based on combined analyses of a static electrochemistry model and a dynamic oxide layer growth corrosion model has been developed to predict wall thinning rates in PWR secondary piping [1]-[3], [5], [7], [9]-[11]. 2) Other efforts on water chemistry have been put on planning Road Maps on Research and Development Plans for Water Chemistry of Nuclear Power Systems in Japan and arranging Japan Industrial Standards for analytical procedures of water chemistry in PWR plants [4], [6], [8]. [Latest publication: [1] M. Naitoh, S. Uchida, S. Koshizuka, H. Ninokata, N. Hiranuma, K. Dosaki, K. Nishida, M. Akiyama and H. Saitoh, "Evaluation Methods for Corrosion Damage of Components in Cooling Systems of Nuclear Power Plants by Coupling Analysis of Corrosion and Flow Dynamics Analysis (I), Major targets and development strategies of the evaluation methods", *J. Nucl. Sci. Technol.*, 45, 1116-1128 (2008). [2] S. Uchida, M. Naitoh, Y. Uehara, H. Okada, N. Hiranuma, W. Sugino and S. Koshizuka, "Evaluation Methods for Corrosion Damage of Components in Cooling Systems of Nuclear Power Plants by Coupling Analysis of Corrosion and Flow Dynamics Analysis (II), Evaluation of corrosive conditions in PWR secondary cooling system", *J. Nucl. Sci. Technol.*, 45, 1275-1286 (2008). [3] S. Uchida, M.Naitoh, Y. Uehara, H. Okada, N. Hiranuma, W. Sugino, S. Koshizuka and Derek H. Lister, "Evaluation Methods for Corrosion Damage of Components in Cooling Systems of Nuclear Power Plants by Coupling Analysis of Corrosion and Flow Dynamics Analysis (III), Evaluation of Pipe Wall Thinning Rate with the Coupled Model of Static Electrochemical Analysis and Dynamic Double Oxide Layer Analysis", *J. Nucl. Sci. Technol.*, 46, 31-40 (2009). [4] S. Uchida, "Corrosion of Structural Materials and Electrochemistry in High Temperature Water of Nuclear Power Systems", *Power Plant Chemistry*, 10, 630-649 (2008). [5] D. H. Lister, L. Liu, A. D. Feicht, M. Khatib, W. G. Cook, K. Fujiwara, E. Kadoi, T. Ohira, H. Takiguchi and S. Uchida, "A Fundamental Study of Flow-Accelerated Corrosion in Feedwater Systems", *Power Plant Chemistry*, 10, 659-667 (2008). [6] S. Uchida, T. Satoh, Y. Satoh and Y. Wada, "Electrochemical sensor array for in situ measurements of hydrogen peroxide concentration in high temperature water", *Energy Materials*, 3, 104-112 (2008). [7] S. Uchida, M. Naitoh, Y. Uehara, H. Okada, S. Koshizuka and D. H. Lister, "Evaluation of Flow Accelerated Corrosion of PWR Secondary Components by Corrosion Analysis Coupled with Flow Dynamics Analysis", Proc. International

Conference on Water Chemistry of Nuclear Reactor Systems, NPC'08, Sep. 15 – 18, 2008, Berlin, Germany, VGB Power Tech (2008) (in CD). [8] S. Uchida, Y. Katsumura, H. Ikoma, K. Takamori , E. Kadoi and K. Ishigure, "Road Maps on Research and Development Plans for Water Chemistry of Nuclear Power Systems in Japan", Proc. International Conference on Water Chemistry of Nuclear Reactor Systems, NPC'08, Sep. 15 – 18, 2008, Berlin, Germany, VGB Power Tech (2008) (in CD). [9] S, Uchida, M. Naitoh, Y. Uehara, H. Okada, S. Koshizuka and D. H. Lister, "Evaluation of Flow Accelerated Corrosion of PWR Secondary Component by Corrosion Analysis Coupled with Flow Dynamics Analysis", Proc. 16th Pacific Basin Nuclear Conference, PBNC-16, Oct. 14-17, 2008, Aomori, Japan, Atomic Energy Society of Japan (2008) (in CD). [10] D. H. Lister, W. G. Cook, A. D. Feicht, K. Fujiwara, E. Kadoi, M. Khatibi, . Liu, T. Ohira, H. Takiguchi and S. Uchida, "A laboratory Study of Flow Accelerated Corrosion in Feedwater Systems", Proc. 16th Pacific Basin Nuclear Conference, PBNC-16, Oct. 14-17, 2008, Aomori, Japan, Atomic Energy Society of Japan (2008) (in CD). [11] S. Uchida, M. Naitoh, Y. Uehara, H. Okada, S. Koshizuka and D. H. Lister, "Evaluation of Flow Accelerated Corrosion of PWR Secondary Piping by Coupling Analysis of Corrosion and Flow Dynamics", Corrosion 2009, Paper No.09468, Mar. 23-26, Atlanta, GA, National association of Corrosion Engineers, 1-15 (2009)] [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 polymers such as PC and PET in high temperature-high pressure water. They have also found the chemical recycling of polycarbonate in high pressure vapor. Even in the vapor phase, hydrolysis of polycarbonate successfully proceeded and high monomer yield was achieved. The results suggest that a high density of liquid water was not suitable for polycarbonate hydrolysis in high pressure water system due to the monomer instability at that conditions [ISHA2008 (September 2008, Nottingham, England) M. Watanabe, T. Matsuhita, Y. Matsuo, H. Inomata]. Decomposition rate and product selectivity were evaluated and utilized to estimate the reaction mechanism/kinetics. Sugar conversion could be controlled by temperature and pressure in high pressure high temperature water. They also revealed that microwave heating was effective for catalytic conversion of sugar into a furan compound. In the case of fructose reaction, 5-hydroxylmethylfurfural was obtained with 90% of yield and 90% of selectivity by an ionic resin as catalyst by microwave heating in some organic mixture solvent. The effect of microwave on the formation of furan from sugar was observed in a water and water-organic mixture solvent [Green solvent 2008 (September 2008, Friedrichshafen, Germany) X. Qi, M. Watanabe, T. M. Aida, R. L. Smith, Jr.]. For the presentation, they won one of the poster presentation awards. They have also studied that sugar conversion could be controlled by temperature and pressure in high pressure high temperature water. The center has tried to clarify the effect of pressure on the sugar conversion in supercritical water by focusing on role of water on the reaction. Dehydration of intermediate was also conducted and found that high pressure (namely water density) promote dehydration of the intermediate [J. Supercrit. Fluids, 50 (2009) 257-264].

At the Institute of Multidisciplinary Research for Advanced Materials at Tohoku University, Prof. M. KAKIHANA and his group developed an original water-soluble and stable compound of silicon. The peculiar chemical properties of the new compound made it possible to elaborate a hydrothermal gelation method for synthesis of multicomponent silicon containing functional materials. 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 were prepared by use of the new water-soluble silicon compound, exhibited remarkably improved fluorescence brightness and color purity compared to the materials synthesized by the conventional approaches. The same group has continued to design and search for the stable water soluble titanium complexes. By utilizing the new peroxo-EDTA complex of Ti and directional application of the additives acting as surface modifies the synthesis of pure nanocrystalline brookite with the highly controlled particles morphology was demonstrated for the first time. The partial nitridation of brookite TiO_2 during the hydrothermal synthesis resulted in the improved light absorption in the visible range, which, in the combination with the improved morphology, led to increased photocatalytic activity of such materials in terms of NO decomposition. [Y.Suzuki, M. Kakihana, J. Physics: Conf. Series: Mater. Sci. Eng., 1, 012012 (2009); Y.Suzuki, M. Kakihana, J. Cer. Soc. Japan, 117, 330 (2009); Y. Morishima, M. Kobayashi, V.

Petrykin, S. Yin, T. Sato, M. Kakihana, K. Tomita, J. Cer. Soc. Japan 117, 320 (2009); M. Kobayashi, V. Petrykin, M. Kakihana, K. Tomita, J. Am. Cer. Soc. 92, S21 (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, preventing the healthy damage, etc. by solvothermal reactions. They successfully prepared visible light responsive photocatalysts such as $TiO_{2-x}N_y$ and $SrTiO_{3-x}N_y$ with controllable phase compositions and morphologies [S. Yin, M. Komatsu, B. Liu, R. Li, Y. Wang, T. Sato, J. Mater. Sci., **43**, 2240 (2008); K. Tomita, M. Kobayashi, V. Petrykin, S. Yin, T. Sato, M. Yoshimura, M. Kakihana, J. Mater. Sci., **43**, 2217 (2008); I. Kangl, Q. Zhang, Y. Shu, T. Sato, F. Saito, Smart Processing Technology, **2**, 137-140 (2008); I. Kangl, Q. Zhang, Y. Shu, T. Sato, F. Saito, Environ. Sci. Technol., **42**, 3622 (2008); S. Yin, B. Liu, T. Sato, Functional Materials Letters, **1**, 173 (2008); S. Yin, B. Liu, P. Zhang, T. Morikawa, K. Yamanaka, T. Sato, J. Phys. Chem., **112**, 12425-12431 (2008); J. Wang, H. Li, H. Li, S. Yin, T. Sato, Solid State Phenomena, **147-149**, 851 (2009); J. Wang, H. Li, S. Yin, T. Sato, Solid State Sciences, **11**, 182 (2009), U. Sulaeman, S. Yin, T. Suehiro, T. Sato, Mater. Sci. Eng., (2009), **1**, 012017, 1 (2009); Y. Morishima, M. Kobayashi, V. Petrykin, S. Yin, T. Sato, M. Kakihana, K. Tomita, J. Cer. Soc. Japan 117, 320 (2009)], and ceria-based new inorganic UV-shielding materials with excellent safety, comfort and transparency in the visible light region [A. M. El-Toni, S. Yin, T. Sato, J. Mater. Sci., **43**, 2411-2417 (2008); T. Sato, A. M. El-Toni, S. Yin, T. Kumei, Synthesis and Reactivity in Inorganic, Metal-Organic, and Nano-Metal Chemistry, **38**, 335 (2008); Phosphors Res.Bulletin., **22**,17(2008); Y. Minamidate, S. Yin, T. Sato, Mater. Sci. Eng., **1**, 012003, 1 (2009); X. Liu, S. Yin, T. Sato, Mater. Sci. Eng., **1**, 012013, 1 (2009)]. They also synthesized ZnO thin films with different superstructures such as nanorods, nanoscrews, nanodisks etc. [S. Yin, K. Ihara, R. Li, T. Sato, Res. Chem. Intermed., **34**, 393 (2008); T. Long, S. Yin, K. Takabatake, P. Zhang, T. Sato, Nanoscale Res. Lett., **4**, 247 (2009); T. Long, K. Takabatake, S. Yin, T. Sato, J. Crstal Growth, 311, 576 (2009)], rare earth oxide nanoparticles with controlled morphology and excellent fluoresence properties [S. Yin, S. Akita, M. Shinozaki, R. Li, T. Sato, J. Mater. Sci., **43**, 2234 (2008); M. K. Devaraju, S. Yin, T. Sato, Mater. Sci. Eng., **1**, 012011, 1 (2009); M.K. Devaraju, S. Yin, T. Sato, J. Crstal Growth, **311**, 580 (2009)], $Ag/\gamma\text{-}Al_2O_3$ nanocomposites possessing excellent $DeNO_x$ catalytic activity [T. Sato, S.o Goto, Q.Tang, S. Yin, J. Mater. Sci., **43**, 2247-2253 (2008)], a new compound, pyrochlore-type $Sn_{1.24}Ti_{1.94}O_{3.66}(OH)_{1.50}F_{1.42}$ [Y. Xie, S.Yin, H. Yamane, T. Hashimoto, H. Machida, T. Sato, Chem. Mater., **20**, 4931 (2008)] and porous SiC granules [H. Morino, H. Yamane, T. Yamada, S. Yin, T. Sato, Mater. Trans., **49**, 1929 (2008)]. 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, they regard supercritical water as a green solvent for biomass conversion and materials synthesis. So far, it has been demonstrated that cellulose could be dissolved and hydrolyzed in sub and supercritical water. Recently, it was found that a mixed solvent of supercritical water and phenolic compounds could convert lignin into varuable chemicals. [Bioresource Tec., **99**,1846(2008)] Adschiri laboratory used a supercritical hydrothermal method to synthesize synthesize variety of nanocrystals by using supercritical hydrothermal synthesis. [Phys. Rev. B, **79**, 144411 (2009), Cryst.Growth & Design,**8**, 2814(2008)] Recently, they proposed a new method to synthesize organic –inorganic hybrid nanocrystals by using supercritical 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 tosynthesize variety of hybrid nanomaterials.[Dalton Transactions,**48**, 7038 (2008), J.Supercrit. Fluids,**44**,441(2008), J.Mater.Sci.,**43**, 2393(2008)] Previous research results for the supercritical hydrothermal synthesis method was summarized as review papers. [J. Mater.Sci.,**43**,2083(2008).Adv. Drug Deliv. Rev.,**60**,299(2008)] [contact: Prof. T. Adschiri; ajiri@tagen.tohoku.ac.jp]

At the Research Center for Compact Chemical Process, National Institute of Advanced Industrial Science and Technology (AIST), Dr. S. –I. KAWASAKI, Dr. K. HATAKEDA, Dr. A. SUZUKI, and co-workers are studying the supercritical water reaction system using a high performance microreactor. The microreactor made by the metal (Inconel 625 or SUS316), it can be used for high temperature and high pressure conditions. In addition, the specific microreactors and tubes lined the corrosion resistant materials (titanium or tantalum) were developed for the acid environment reaction. The corrosion resistant microreactor can be used many applications for safety process establishment. In the organic reactions, the nitration reaction of aromatic hydrocarbon such as benzene or naphthalene under subcritical water and diluted nitric acid conditions were achieved under non-catalytic environment. The systems were consisted by the titanium lined microreactor and tubes. In the nanoparticle production by the hydrothermal synthesis, the nanoparticle characteristics were affected by the mixing performance the starting solution and sc-H_2O. T-shape microreactor, swirl microreactor, central collision microreactor were developed for the hydrothermal synthesis. The CFD simulation was applied to improve the microreactor configuration. The homogeneous nanoparticles were synthesized by the microreactor systems. [K. Hatakeda, Y. Wakashima, A. Suzuki, T. Yokoyama, S. –I. Kawasaki, C. Wako, K. Arai, Proceeding of 5th International Workshop on Micro Chemical Plants, Kyoto, (2006); S. –I. Kawasaki, Y. Xiuyi, K. SUE, Y. Hakuta, A. Suzuki and K Arai, J. Supercrit. Fluids, 50 (2009) 276-282; Y. Wakashima, A. Suzuki, S. Kawasaki, K. Matsui, Y. Hakuta, J. Chem. Eng. JPN, 40 (2007) 622-629; S. –I. Kawasaki, Y. Wakashima, A. Suzuki, K. Sue, Y. Hakuta, K. Arai, Proceeding of 11th European Meeting on Supercritical Fluids, Barcelona , 2008, May, P_PR_36]. In the same research center, Dr. H. KAWANAMI and co-workers are studying organic synthesis and organic reaction using in high-pressure and high-temperature water with microreactors. Theirs reaction system can be applied many organic reactions, for example, C-C coupling, acylation, nitration, halogenations, etc. All these reactions were accelerated efficiently and were finished within few min at least leading very high yields and high selectivities. They further investigate the conversion of variety of saccharides using their water-based reaction method which is environmentally benign and develop the selective decomposition of polysaccharides to the valuable compounds selectively. [H. Kawanami, M. Sato, N. Otabe, T. Tuji, K. Matsushima, M. Chatterjee, T. Yokoyama, Y. Ikushima and T. M. Suzuki, *Green Chem.*, **11**, (2009), 763; H. Kawanami, K. Matsushima, M. Sato, Y. Ikushima, *Angew. Chem., Int. Ed.*, **46**, (2007), 6284; H. Kawanami, M. Sato, K. Matsushima, Y. Ikushima, *Angew. Chem., Int. Ed.*, **46**, (2007), 5129; K. Matsushima, H. Minoshima, H. Kawanami, Y. Ikushima, M. Nishizawa, A. Kawamukai, K. Hara, Ind. & Eng. Chem. Res., 44, (2005) 9626.]

At the department of material and environmental chemistry, Utsunomiya University, Dr. T. SATO and co-workers developed a new flow-type system combined the supercritical water gasification system and steam reforming system with membrane reactor to recover fuel gases especially hydrogen from biomass. In their study, the hydrogen permeable palladium-silver membrane was used for the improvement of the hydrogen recovery by selective removal of hydrogen from reaction field to shift the equilibrium of steam reforming into the favorable direction for hydrogen formation. The gas formation from glucose was carried out at 673 K and at 10 MPa for supercritical gasification and from 0.1 to 0.5 MPa of reaction pressure. The experiments changing the order of catalytic bed and Pd-Ag membrane in the membrane reactor for steam reforming revealed that the elevated high pressures and hydrogen removal before catalytic steam reforming are advantageous for high hydrogen recovery [Chem. Eng. Sci., in press].

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 2010 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 under the cooperation with Russian and German institutes, and two 1 kg spheres were polished from the crystal in 2008 for density measurement. 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. 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 are developed for providing reference data of transport properties of 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]. 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 Materials Science Research Laboratory, Central Research Institute of Electric Power Industry (CRIEPI), Yokosuka, Kanagawa, Dr. M. DOMAE and his co-workers study development of alternative reductant for hydrogen in the primary coolant of pressurized water reactors. Screening of candidates of hydrogen alternative resulted in the conclusion that methanol was the most promising. Type 304 stainless steel specimens were immersed at 593 K in the presence of dissolved hydrogen (DH) or methanol. Electrochemical corrosion potential of the specimens was measured during the immersion tests. After the immersion tests, oxide film formed on the specimens was analyzed. It is concluded that corrosion environment in the presence of DH is identical with that in the presence of methanol. [17th International Conference on Nuclear Engineering, No. 75551, Brussels, Belgium, (2009)].
[contact: Dr. M. Domae; E-mail: domae@criepi.denken.or.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. For heterogeneous vapor-liquid nucleation, which is the cluster nucleation, the molecular dynamics simulation for sulfuric acid-water vapor mixture is performed. [H. Matsubara, T. Ebisuzaki, K. Yasuoka, *J. Chem. Phys.*, **130**, 104705(2009).] They also reported the coexistence and transition between Cassie and Wenzel state on pillared hydrophobic surface.[T. Koishi, K. Yasuoka, S. Fujikawa, T. Ebisuzaki, and X. C. Zeng, PNAS, 106, 8435(2009).] To accelerate the calculation of the molecular dynamics simulation they try to use GPU (Graphic Processing Unit).[Yokota, R., Narumi, T., Sakamaki, R., Kameoka, S., Obi, S., Yasuoka, K., Comput. Phys. Commun., in press.; Narumi, T., Yasuoka, K., Taiji, M., Höfinger, S., J. Comput Chem., in press.; Narumi, T., Kameoka, S., Taiji, M., and Yasuoka, K., SIAM Journal on Scientific Computing, 30, 3108-3125(2008).]
[contact: Prof. K. Yasuoka; E-mail: yasuoka@mech.keio.ac.jp].

At the Kanagawa Institute of Technology, Atsugi, Dr. K. OGUCHI has completely finished his experimental works concerning *pVT* Properties of fluids, and is now continuing the analytical and theoretical works such as correlating the equation of state for ammonia + water mixtures, especially focusing on the maximum density phenomena. [contact: Dr. K. Oguchi; E-mail: oguchi@kait.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. By the apparatus, isochoric heat capacities of water are currently being 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 of Energy Engineering Field in Tokai University. He has been working as a part-time technical adviser at Naigai Chemical Products Co., LTD. in Tokyo since May of 2006. He and his coworkers who are engaged in Shinshu University, electric power companies and water treatment makers are conducting R&D on the corrosion of steam turbine materials for geothermal power plants, the oxidation behavior of steam line materials in the high temperature-pressure steam for conventional thermal and combined cycle power plants, and other subjects on corrosion and water chemistry for power plants. The main publications; (1) H.-F. Zhan, H. Takaku, Y. Sakai, et al. "Electrochemical Corrosion Behavior of Steam Turbine Materials for Geothermal Power Plants", *Power Plant Chemistry*, **9**, 490-498 (2007), (2) H. Takaku "Essentials of the Revised Guideline-Water Conditioning for Boiler Feed Water and Boiler Water in Japan-(JIS B 8223:2006)", *Power Plant Chemistry*, **9**, 663-667 (2007). [Contact: Prof. H. Takaku; E-mail: takaku06@ybb.ne.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 by means of multinuclear NMR (nuclear magnetic resonance) spectroscopy and computer simulation. Their current focus are (1) the structure of low-density supercritical water studied by neutron scattering and the determination of all the O-O, O-H, and H-H radial distribution functions ["Partial Pair Correlation Functions of Low-Density Supercritical Water Determined by Neutron Diffraction with the H/D Isotopic Substitution Method", T. Otomo, H. Iwase, Y. Kameda, N. Matubayasi, K. Itoh, S. Ikeda, and M. Nakahara, *J. Phys. Chem. B* **112**, 4687-4693 (2008)] and (2) the kinetics and equilibrium of C1 and C2 chemical reactions in hot water toward the tuned control of C-C bond formation and disproportionation ["Hydrothermal C-C Bond Formation and Disproportionation of Acetaldehyde with Formic Acid", S. Morooka, N. Matubayasi, and M. Nakahara, *J. Phys. Chem. A* **112**, 6950–6959 (2008)]. [contact: Prof. M. Nakahara; E-mail: nakahara@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 liquid alcohol (methanol and ethanol) at temperatures up to about 240 °C under high pressure ["Density effect on the electric Conductivities of monovalent ions in methanol along the liquid-vapor coexistence curve", M. Ueno, T. Hoshina, N. Tsuchihashi, and K. Ibuki, *Rev. High Press. Sci. Tech.* **18**, 147-153 (2008)]. In collaboration with Dr. M. Kanakubo (AIST, Sendai) and Dr. Harris (University of New South Wales, Australia), the effect of pressure on the transport properties of the ionic liquid has been studied ["Effect of pressure on the transport properties of the ionic liquid: 1-alkyl-3-methylimidazolium salts", K. R. Harris, M. Kanakubo, N. Tsuchihashi, K. Ibuki, and M. Ueno, *J. Phys. Chem.* B, **112**, 9830-9840 (2008)]. [Contact: Prof. M. Ueno; E-mail: mueno@mail.doshisha.ac.jp]

At the Department of Mechanical Engineering, Kyushu University, Prof. Y. Takata and their group have released the new version of a program package for thermophysical properties of fluids: PROPATH Version 13.1. 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/.
[contact: Prof. Y. Takata; E-mail: takata@mech.kyushu-u.ac.jp]

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. Chemical compounds such as phenolic compounds were recovered from lignocellulosics by using a batch reactor [Wahyudiono, M. Sasaki and M. Goto, *Fuel*, **88**, 1656-1664 (2009); Wahyudiono, Mitsuru Sasaki and Motonobu Goto, *Chemical Engineering Processing*, **47**, 1609-1619 (2008); M. Sasaki, Wahyudiono, H. Kawanabe, T. Saito and M. Goto, Proceeding of 9th International Symposium on Supercritical Fluids 2009, Arcachon, France (2009); Wahyudiono, M. Sasaki and M. Goto, Proceeding of 15th Regional Symposium on Chemical Engineering 2008, Kuala Lumpur, Malaysia (2008)]. 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); Wahyudiono, M. Sasaki and M. Goto, Proceeding of AIChE Annual Meeting 2008, Philadelphia, PA (2008)]. Pigment 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 [K. Kitada, S. Machmudah, M. Sasaki, M. Goto, Y. Nakashima, S. Kumamoto and T. Hasegawa, *J. Chemical Technology and Biotechnology*, **84**, 657-661 (2008); Y. Kawahito, M. Kondo, S. Machmudah, K. Sibano, M. Sasaki and M. Goto, *Separation and Purification Technology*, **61**, 130-135 (2008); K. Kitada, S. Machmudah, M. Sasaki, M. Goto, Y. Nakashima, S. Kumamoto and T. Hasegawa, *Separation Science and Technology*, **44**, 1228-1239 (2009)]. We are also studying various natural materials in collaboration with The University of Basque Country (Spain) [T. Kamogawa, S. Machmudah, M. Sasaki and M. Goto, Proceeding of 15th Regional Symposium on Chemical Engineering in Conjunction with 22nd Symposium of Malaysian Chemical Engineers (2008); S. Machmudah, T. Kamogawa, M. Sasaki and M. Goto, Proceeding of 9th International Symposium on Supercritical Fluids, Arcachon, France (2009)] and companies [R. Askin, M. Goto and M. Sasaki, *J. Food BioProd. Process*, (2009) (in press); R. Askin, M. Sasaki and M. Goto, Proceeding of the 11th European Meeting on Supercritical Fluids, Barcelona (2008)]. We overviewed the current state of the science and technology of supercritical fluids. The principal objective is to acquaint the reader with the unusual properties of supercritical fluids, and with the ways some basic principles are essential in understanding the supercritical fluid extraction (SFE) technique and the independence of relevant process parameters that are exploited for a variety of applications in cases of both SFE and supercritical fluid chromatography (SFC) in the food industry [R. Askin, M. Goto and M. Sasaki, Supercritical Fluid Extraction in Food Analysis, in S. Otles. (Ed), *Handbook of Food Analysis Instruments*, CRC Press, Chapter 3, p. 25 (2008)]. Hydrothermal electrolysis of many organic compounds especially glycerol was done by using batch reactor and the possible reaction mechanism and the effects of current on the decomposition of organic materials were examined [A. Yuksel, H. Koga, M. Sasaki and M. Goto, *Journal of Renewable and Sustainable Energy*, **1**(3), (2009) (in press); A. Yuksel, H. Koga, M. Sasaki and M. Goto, Proceedings of 9th International Symposium on Supercritical Fluids, Arcachon, France (2009)]. Particular phenomena (such as polymerization, exchange reaction, etc.) with discharged arc like plasma was investigated using aromatic compounds as initial materials in sub- and supercritical fluids (such as water, carbon dioxide, etc.) without catalyst [M. Mitsugi, A. Yoshida, T. Kiyan, M. Takade, K. Miyaji, T. Namihira, Y. Kuwahara, H. Akiyama, M. Hara, M. Sasaki, M. Goto, Proceeding of the 15th Regional Symposium on Chemical Engineering in Conjunction with 22nd Symposium of MALAYSIAN Chemical Engineers (2008); M. Goto, M. Sasaki, T. Kiyan, T. Fang, B. C. Roy, T. Namihira, H. Akiyama, M. Hara, Proceeding of Joint 21st AIRAPT and 45th EHPRG int. Conf. on High Pressure Science and Technology (2008)]. [contact: Prof. M. Goto; E-mail: mgoto@kumamoto-u.ac.jp, Assoc. Prof. M. Sasaki; E-mail: msasaki@ kumamoto-u.ac.jp]

Russian National Committee
2009 Report

RNC meeting (18 June 2009) - changes in RNC:

new chairperson Tamara Petrova petrova@twt.mpei.ac.ru
new secretary Denis Smetanin SmetaninDS@mpei.ru

Publications:

Petrova T.I., Voronov V.N. Water chemistry at fossil and nuclear power plants: textbook for students. MPEI, 2009, P. 290. (Rus)

Petrova T.I., Repin D.A. Factors affecting cooling systems operation at fossil power plants // Vestnik MEI, # 1, 2009, pp 106-111 (Rus)

Bushuev E. N. Mathematical simulation of ionic equilibriums of water coolant using electrical conductivity and pH measurements // Thermal engineering, Vol. 56, # 7, 2009, pp 546-552

Ochkov V.F., Chudova Yu.V., Minaeva E. A. "Cloud computations" for chemical departments of power stations // Thermal engineering, Vol. 56, # 7, 2009, pp 553-559

Valyashko V.M. (editor) Hydrothermal properties of materials: Experimental data on aqueous phase equlibria and solution properties at elevated temperatures and pressures. 2008, John Wiley & Sons, Ltd.

Larin B.M., Larin A.B., Oparin M.Yu., Vinogradov V.N. Field experience with a new installation for countercurrent ion-exchange treatment of low-mineralized natural water with high content of organic impurities // Thermal engineering, Vol. 56, # 6, 2009, pp 506 - 509

Mulev Yu.V., Mulev A.Yu. Ultra-high-frequency method of diagnostics of two-phase state of a water coolant // Thermal engineering, Vol. 56, # 4, 2009, pp 316 - 319

The 2-nd International water chemistry forum (Moscow, April 2009) – problems discussed:

- water chemistry
- water chemistry automation
- water make-up systems
- waste water treatment

U.S. National Committee to IAPWS
2009 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 a publication is in press. Similar results are almost complete for the water-CO_2 binary, which is the last item needed to complete a theory-based model for the thermodynamics of humid gases.
Reference: Wheatley, R.J., and Harvey, A.H., Intermolecular potential energy surface and second virial coefficients for the nonrigid water-CO dimer, *J. Chem. Phys.*, in press.

In collaboration with workers in Greece and Germany and at the University of Maryland, work is continuing on the joint IAPWS and IUPAC efforts to update the formulations for the transport properties of water and steam. The correlating surface for viscosity has been completed and a paper has been published in *J. Phys. Chem. Ref. Data*. For the thermal conductivity, the form of the critical enhancement has been worked out, and a preliminary low-density function and preliminary background function have been generated.
Reference: Huber, M.L., Perkins, R.A., Laesecke, A., Friend, D.G, Sengers, J.V., Assael, M.J., Metaxa, I.N., Vogel, E., Mareš, R., and Miyagawa, K., New International Formulation for the Viscosity of H_2O, *J. Phys. Chem. Ref. Data* **38**, 101 (2009).

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.
Reference: Meyer, C.W, Hodges, J.T., Hyland, R.W., Scace, G.E., Valencia-Rodriguez, J., and Whetstone, J.R., A Second-Generation NIST Gravimetric Hygrometer, *Metrologia*, to be 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 (up to 770 K) magnetic-suspension densimeter, which will be used to measure H_2O-N_2 and H_2O-CO_2 mixtures of interest for understanding the thermodynamics of combustion gases. 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) in order to measure the thermal conductivity of H_2O-N_2 and H_2O-CO_2 mixtures at similar conditions. The thermal conductivity apparatus has completed measurements for the H_2O-N_2 binary and its two pure components from 500 K up to 740 K.

Communicated from the University of Maryland, College Park, MD:
An article "Thermal diffusivity of H_2O near the critical point" by J.V. Sengers, R.A. Perkins, M.L. Huber, and B. Le Neindre was completed and will appear in the *International Journal of Thermophysics*.
The group at the University of Maryland is in the process of formulating a theoretically based equation for the critical locus of NaCl+water solutions. Progress of this research will be reported at the 2009 IAWPS meeting under item 15 of the agenda of the Working Group on Thermophysical Properties of Water and Steam.

Communicated from OLI Systems, Morris Plains, NJ:
Work is continuing on developing thermodynamic and transport property models for multicomponent, multiphase electrolyte systems. In 2008-2009, work was focused on (1) a new comprehensive model for thermal conductivity of aqueous and mixed-solvent electrolyte systems; (2) developing thermodynamic model parameters for systems containing Fe, Ni, Zn, Li, B, and H_2 within the framework of a speciation-based thermodynamic model at temperatures up to 350 °C; (3) developing, in collaboration with Professor Vladimiros Papangelakis of the University of Toronto, thermodynamic model parameters for

systems of interest in hydrometallurgy and (4) extension of speciation-based thermodynamic models to systems related to CO_2 sequestration.
References: Wang, P., Anderko, A., Modeling Thermal Conductivity of Concentrated and Mixed-Solvent Electrolyte Systems, *Ind. Eng. Chem. Res*. **47** 5698-5709 (2008); Wang, P., Anderko, A., Springer, R.D., Kosinski, J.J., and Lencka, M.M., Modeling Chemical and Phase Equilibria in Geochemical Systems Using a Speciation-Based Model, *J. Geochemical Exploration*, in press.

Communicated from the Energy Institute Electrochemical Laboratory, Penn State Univ.:
The Energy Institute Electrochemical Laboratory (S.N. Lvov) continues working on a number of electrochemistry related projects. In the past year of 2008-09, the research was focused on topics associated to high-temperature aqueous system such as electrophoresis of metal oxide particles, mineral-water electrical double layer, pH measurements, electrochemical corrosion of metals, zirconia coatings, proton exchange membrane fuel cells, and CuCl/HCl electrolysis for CuCl thermochemical cycle. The main outcomes can be found in the following publications:

1. Balashov V.N., Fedkin M.V., Lvov S. N., Experimental System for Electrochemical Studies of Aqueous Corrosion at Temperatures above 300 °C, *J. Electrochem. Soc.*, 2009, 156, C209-C213.

2. Rodriguez-Santiago V., Fedkin M.V., Wesolowski D.J., Rosenqvist J., and Lvov S. N., Electrophoretic Study of the SnO_2/Aqueous Solution Interface up to 260 °C, *Langmuir*, 2009, 25, 8101–8110.

3. Jankovic Z, Papangelakis V.G., Lvov S.N., Effect of nickel sulphate and magnesium sulphate on pH of sulphuric acid solutions at elevated temperatures, *J. Appl. Electrochem.*, 2009, 6, 751-759.

4. Rodriguez-Santiago V., Fedkin M.V., Vidojkovic S., Wesolowski D.J. and Lvov S. N. Nanoelectrophoresis studies of magnetite and silica in hydrothermal environments *Geochim. et Cosmochim. Acta*, 73, A1111-A1111.

5. Wesolowski D.J., Bandura A.V., Cummings P.T., Fenter P.A., Kubicki J.D., Lvov S. N., Machesky M.L., Mamontov E., Predota M., Ridley M.K., Rosenqvist J., Sofo J.O., Vlcek L., and Zhang Z., Atomistic origins of mineral-water interfacial phenomena and their relation to surface complexation models, *Geochim. et Cosmochim. Acta*, 73, A1429-A1429.

6. Zhang Z. C., Chalkova E., Fedkin M., Wang C., Lvov S. N., Komarneni S., and Chung T.-C. M., Synthesis and Characterization of Poly(vinylidene fluoride)-g-sulfonated Polystyrene Graft Copolymers for Proton Exchange Membrane, *Macromolecules*, 2008, 41, 9130-9139.

7. Zhou Z. F., Chalkova E., Lvov S. N., and Chou P. H., Hydrothermal deposition of zirconia coatings on pre-oxidized BWR structural materials, *J. Nuclear Materials*, 2008, 378, 229-237.

8. Rodriguez-Santiago V., Fedkin M. V., and Lvov S. N., Electrophoresis system for high temperature mobility measurements of nanosize particles. *Rev. Scientific Instr.*, 2008, 79, 093302.

9. Rodriguez-Santiago V., Fedkin M. V., Rosenqvist J., Machesky M. L., Wesolowski D. J., and Lvov S. N., Surface properties of nanosize oxides by high temperature electrophoresis, *Geoch. Cosmoch. Acta*, 2008, 72, A802.

10. Balashov V. N., Fedkin M. V., Lvov S. N., and Dooley R. B., Experimental System for Studying Interfacial Electrochemistry at Temperatures Above 300 °C, *ECS Trans*., 2008, 11, 27-38.

11. Rodriguez-Santiago V., Fedkin M. V., and Lvov S. N. Study of the Electrochemical Step of Novel Active Metal Alloy Thermochemical Cycles for Hydrogen Production, *ECS Trans.*, 2008, 11, 133-142.

12. Fedkin M. V., Chalkova E., Wesolowski D. J., and Lvov S. N., Understanding the Water Retention of Composite Proton Exchange Membranes Based on Surface Chemistry of Inorganic Fillers, *ECS Trans*., 2008, 11, 189-198.

13. Wang C., Chalkova E., Lute C., Fedkin M. V., Komarneni S., Chung T. C. M., and Lvov S. N., Proton Conductive Inorganics for Composite Membranes in PEM Fuel Cells, *ECS Trans*., 2008, 16, 1451-1459.

14. Zhou Z. F., Chalkova E., Balashov V.N., Chou P. H., and Lvov S. N., Interfacial Chemistry of Hydrothermal Deposition of Zirconia on Metal Substrates, *ECS Trans*., 2008, 11, 181-188.

15. Machesky M. L., Wesolowski D. J., Ridley M.K., Palmer D. A., Rosenqvist J., Lvov S. L., Fedkin M. V., Predota M., and Vlcek L., The Protonation Behavior of Metal Oxide Surfaces to Hydrothermal Conditions, *ECS Trans.*, 2008, 11, 151-166.

Attendees at 2009 Doorwerth IAPWS Meeting

	Name IAPWS-member 2009	Affiliation
Dr	A. Anderko	OLI Systems Inc.
Dr	Bellows	Siemens Energy, Inc.
Dr	G. Bignold	GJB Chemistry for Power Ltd
Dr	Bursik	ppchem
Mr	Cooper	University of London
Ms	K. Cramer	
Mr	K. Daucik	DONG Energy
Dr	B. Dooley	Structural Integrity Associates Inc.
Mrs	J. Ehlerova	
Dr	Feistel	Baltic Sea Research Institute
Dr	D. Friend	NIST
Ms	Paul	
Ms	D. Fuentevilla	University of Maryland
Mr	F. Gabrielli	Alstom Power
Mr	J. Gallagher	NIST
Dr	A. Harvey	NIST
Dr	M. Hiegemann	ALSTOM Ltd
Dr	J. Hruby	Institute of Thermomechanics
Mr	B. Hughes	GDF SUEZ UK (Teesside Power Station)
Mrs	J. Kalova	University of West Bohemia
Prof	H-J. Kretzschmar	Zittau/Goerlitz University of Applied Sciences
Mr	M. Kunick	University Zittau/Goerlitz
Dr	D. Lister	Nuclear Engineering, University of New Brunswick
Prof	R. Mares	University of West Bohemia
Dr	G.M. Marion	Desert Research Institute
Prof	F. Marsik	Institute of Thermomechanics, Academy of Sciences of Czech Republic
Dr	K. Marugame	Naigai Chemical Products
Dr	T.J. McDougall	CSIRO Marine and Atmospheric Research
Mr	M. Miyajima	Chubu Electric Power
Prof	M. Nakahara	Institute for Chemical Research, Kyoto University
Mr	A. Novy	Skoda Power a.s.
Prof	Ochkov	MPEI (TU) Russia, Kafedra Technology of Water and Fuel
Dr	A. Rudge	British Energy
Dr	B. Rukes	Siemens AG Power Generation
Prof	P. Safarik	Czech Technical University, Prague
Mr	M. Sedlar	Sigma Research and Development Institute
Prof	J. Sedlbauer	Technical University Liberec
Mr	J.V. Sengers	Institute for Physical Science and Technology, University of Maryland
Mrs	J.M.H. Sengers-Levelt	NIST
Dr	O. Sifner	Institute of Thermomechanics
Mrs	P. Spitzer	PTB Germany, Division Metrology in Chemistry, WG Electrochemistry
Prof	M. Stastny	Volny
Dr	R. Svoboda	Alstom Power Service
Prof	H. Takaku	
Mr	S. Therkildson	DONG Energy

	Name IAPWS-member 2009	**Affiliation**
Dr	S. Uchida	Japan Atomic Energy Agency
Mr	V. Vaclav	
Dr	S. Vidojkovic	Electric Power Industry of Serbia
Prof	E. Vogel	University of Rostock
Prof	W. Wagner	Ruhr-Universität Bochum
Prof	Watanabe	Keio University
Prof	M. Wendland	University of Natural Resources and Applied Life Sciences Vienna (BOKU), Institute for Chemical and Energy Engineering
Mr	M. DeWispelaere	Laborelec
Dr	D. Wright	Ocean Circulation Section, Bedford Institute of Oceanography
Mr	M. Yoshida	Naigai Chemical Products
Dr	A.N. Minaev	Far-Eastern National Technical University
Mr	Millero	
Mr	A.G.L. Zeijseink	KEMA Power Generation