Minutes

IAPWS Thermophysical Properties of Water and Steam WG

LUCERNE, SWITZERLAND AUGUST 27-30, 2007

NOTE: Items are listed according to their order on the agenda, which is attached as Attachment A. **Bold print** denotes significant actions. These minutes include some items (4, 8-12, 16, 18) that were done jointly with the WG IRS and also the jointly held workshops on humid air (13) and on seawater (14).

1-3. The meeting was opened on Monday, August 27 by the Chair, Hans-Joachim Kretzschmar. The agenda (Attachment A) was adopted after a few revisions. Allan Harvey was appointed Clerk of Minutes. The minutes of the 2006 TPWS WG meeting in Witney were approved. It was decided that, starting with 2007, circulation and approval of WG minutes would be by email as soon as possible after the meeting.

4. No new collaborative projects were proposed by the WGs TPWS or IRS for this year.

5-7. [These items are reported in the IRS minutes.]

8. W. Wagner presented the background of the proposed Revised Release for the melting and sublimation curves, consistent with the IAPWS formulations for fluid water and for ice. **An Evaluation Task Group was appointed consisting of Cooper (Chair), Mares, and Miyagawa. The planned schedule for possible adoption of this document at the 2008 IAPWS meeting will be as follows:**

Dec. 31, 2007 Completion of evaluation by Evaluation Task Group
Jan. 15, 2008 Evaluation report and revised release distributed to Working Group
Feb. 15, 2008 Deadline for input from WG members
Mar. 1, 2008 Finalized draft of Release to Editorial Committee
April 1, 2008 Approval by Editorial Committee
Apr. 15, 2008 Distribution by Executive Secretary to National Delegates

9. A. Harvey and J. Hruby presented a report on their efforts to produce convenient formulations for properties of liquid water at 1 bar pressure. This involves a single self-consistent formulation for the thermodynamic properties, and separate equations for the viscosity, thermal conductivity, and static dielectric constant. It was pointed out that these equations should not extend beyond the range of the underlying full IAPWS formulation; this is particularly an issue for the thermal conductivity. **Harvey and Hruby were authorized to prepare a draft of a Supplementary Release. An Evaluation Task Group was appointed consisting of Sengers, Mares, and Miyagawa. The group will discuss among themselves to select a Chair. The proposers will send supplementary information to the Evaluation Task Group when they send them the draft document. The planned schedule for possible adoption of this document at the 2008 IAPWS meeting will be as follows:**

Jan. 31, 2008 Completion of evaluation by Evaluation Task Group
Feb. 15, 2008 Evaluation report and revised release distributed to Working Group
Mar. 15, 2008 Deadline for input from WG members

Apr. 1, 2008 Finalized draft of Release to Editorial Committee
May 1, 2008 Approval by Editorial Committee
May 15, 2008 Distribution by Executive Secretary to National Delegates

10. R. Feistel presented an update on the project to achieve an improved description of the ideal-gas heat capacity of water, especially at very low and high temperatures. The work is being done in collaboration with the group of Prof. Tennyson at University College London. It is hoped that the technical work will be complete before next year's IAPWS meeting.

11.1 J. Sengers reported on the development of the new viscosity Release, and the work done on the document since last year, with many improvements due to the helpful input of the Evaluation Task Group. R. Mares presented the report of the Evaluation Task Group, which has endorsed the work but had some suggestions about the way some material should be presented, particularly about the simplification obtained by omitting the critical enhancement and what should be said about industrial use. After much discussion, the WG concluded that the simplification should be presented as something for all (not just industrial) users, and that it was very important that our recommendation for industrial use clearly tell people only one way to do things (without extra options that would cause confusion). A temporary Task Group (Harvey, Friend, Sengers, Weber, Mares, Okita) was appointed to draft changes to the document consistent with the discussion. The new draft language was brought back to the WG later in the week.

The item was taken up again on Thursday, and the new language was endorsed with minor revisions. In addition, it was decided to add a footnote to reflect work done by Mr. Miyagawa about the region where the critical enhancement becomes insignificant. **The Working Groups endorsed the document, subject to these revisions and minor editorial changes. We ask the Executive Secretary to distribute it for Postal Ballot following review by the Editorial Committee.**

11.2 J. Sengers described the work toward a new thermal conductivity formulation. The database has been completed and the functional form has been chosen. The data to be used near the critical point have been identified. It is desired to include the Evaluation Task Group at earlier stages compared to the viscosity release, so they can agree on issues such as the database. An Evaluation Task Group will be appointed in 2008.

12. J. Cooper presented the work on modification of the formulations of the transport properties of heavy water. A. Harvey presented a brief evaluation report on behalf of K. Miyagawa; the recommendation was to endorse the revisions and the new document. **The Working Groups TPWS and IRS approved the draft Revised Release and recommended its approval by the EC (subject to some very minor editorial changes for formatting).**

13.1. M. Wendland presented his results on "Measurements of the Water Vapor Concentration Enhancement in Compressed Air, Nitrogen, and Argon with FTIR Spectroscopy."

13.2. A. Harvey presented his results on "First-Principles Calculation of Interaction Second Virial Coefficients Between Water and Common Gases Including Air." Discussion ensued on discrepancies between the model calculations and various experimental results. It is clear that more research and discussion is needed to resolve these discrepancies.

13.3 N. Okita presented his report, and a proposed ICRN, from the Task Group on the dew point of combustion gas. J. Hruby presented some calculations of the dew point of mixtures of water and sulfuric acid.

The IRS WG chairman pointed out that the problem statement of the draft was not yet clear enough. Some discussion evolved around this topic. It was the common understanding that there are two steps involved in this matter:

1. The first step is the conversion of the sulfur in the fuel to SO_2 / SO_3 in the flue gas including the conversion rate between SO_2 and SO_3.
2. The second step is the determination of the dew point based on a known SO_2 / SO_3 content in the flue gas.

It was the feeling that step 1 is somewhat outside the scope of IAPWS. For step 2 apparently quite a few investigations were published recently. There wouldn't be any progress to be expected through an involvement of IAPWS. N. Okita presented an updated draft of an ICRN, however it was the feeling of the WGs that the draft still needs some clarification. **A task group was formed to establish an ICRN on this topic requiring only formal acceptance at the 2008 IAPWS meeting. Members of the task group are N. Okita (chair), J. Hruby, B. Rukes, R. Span. Timeline for the task group is:**
2008-01-31: Circulate updated draft of ICRN to members of WGs
2008-03-31: Deadline for comments, transfer of the finalized draft to the editorial committee

13.4 R. Span discussed the existing ICRN #14 on properties of humid air and combustion gases, which is expiring in 2008. There was consensus that this was still an area in need of work, with some shift in focus to humid combustion gases. **Prof. Span was authorized to proceed forward to produce a revised ICRN for 2008. The requested timeline is that a revised ICRN should be circulated to the Working Groups by March 31, 2008.**

14. The Workshop on Seawater was done as a joint session on Tuesday afternoon. The presentations were as described on the agenda (Attachment A).

The new standard for the definition of salinity was discussed, and IAPWS had no objection to this proposal.

R. Feistel presented a Draft Release on thermodynamic properties of seawater. It was agreed to proceed forward for possible adoption in 2008, with the Release being from PCAS and TPWS. An Evaluation Task Group was appointed consisting of Hruby (Chair), Kretzschmar, Cooper, Miyagawa, and Tremaine. The evaluators were instructed to think about the relevance of the Release for desalination conditions. The timetable will be as follows:
Jan. 31, 2008 Completion of evaluation by Evaluation Task Group
Feb. 15, 2008 Evaluation report and revised release distributed to Working Group
Mar. 15, 2008 Deadline for input from WG members
Apr. 1, 2008 Finalized draft of Release to Editorial Committee
May 1, 2008 Approval by Editorial Committee
May 15, 2008 Distribution by Executive Secretary to National Delegates

R. Feistel presented a draft ICRN for seawater properties. **The Working Groups endorsed this ICRN and request that it be sent out for approval.**

15. [The joint PCAS/TPWS workshop is reported in the PCAS minutes.]

16. A. Harvey reported that there would be no update this year on the IAPWS Fundamental Constants document, but that an update would be prepared for 2008.

The contents of Advisory Note #2 are affected by some of the documents to be adopted at this meeting. **Cooper and Harvey were authorized to update this Advisory Note by the usual procedure.**

H.-J. Kretzschmar reported on the Steam Tables for pocket calculators now available at a site linked from the IAPWS website. There have been 452 downloads of this software so far.

V. Ochkov reported on the software he has developed for convenient calculation of water and steam properties in many formats and languages. It is available through a site linked from the IAPWS website. He also reported on some useful implementations that allow online checking and calculation of IAPWS formulations.

J. Cooper reported that there was nothing to report regarding liaison with the IEC.

A. Harvey reported on the efforts toward making a joint document with the CCM to guide people about when to use their standard for water density for metrology, and when use of IAPWS-95 is appropriate. Progress along the original plans (where a comprehensive paper would be produced) has been stopped due to concerns on the CCM side. The WG was not in favor of a joint publication which only had a few comparisons but was not comprehensive. The consensus was in favor of an alternative where only a brief paper would be written as a joint statement, without any technical information. **Harvey was instructed to proceed forward on these lines.**

17. We were informed by the Czech delegation that **Prof. Kadrnozka is withdrawn from TPWS membership. It was voted to accept V. Ochkov, P. Spitzer, and M. Wendland for membership in TPWS.**

18.1 Prof. Wagner informed the Working Groups about the fact that calculations of the IAPWS dielectric constant and refractive index are still good if IAPWS-IF97 is used to calculate density. He pointed out that the current releases specify calculation with IAPWS-95, which could be a problem for any people using the Industrial Formulation who wish to calculate these properties. Some discussion ensued about whether there was a need to amend the releases or otherwise provide guidance. It was decided that this question should be on the TPWS/IRS agenda in 2008. In addition, **we request the EC to ask National Committees if they have any input on the following question: "Is there a need for instruction from IAPWS about using IAPWS-IF97 in conjunction with formulations for more scientific quantities that have been based on IAPWS-95 (dielectric constant, refractive index, ionization constant, etc.)."**

18.2 There was nothing further on this item.

18.3 There were no collaborative projects proposed from TPWS or IRS.

18.4 The issue of Acknowledgments in IAPWS documents was discussed. **The combined WGs TPWS and IRS considered a motion that such Acknowledgments should not be allowed in IAPWS documents. The motion passed with 13 in favor, 4 opposed, and 4 abstaining.**

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

20. The meeting was adjourned at 5:20 PM on Thursday, August 30.

Agenda

IAPWS Thermophysical Properties of Water and Steam WG
LUCERNE, SWITZERLAND, 26 – 31 AUGUST 2007

1. Opening Remarks; Adoption of Agenda
2. Appointment of Clerk of Minutes
3. Approval of Minutes of TPWS WG in Witney, UK (September 2006)
4. Potential International Collaborative Projects
5. Revised Release on IAPWS-IF97 Including the Extension of Region 5, joint with WG IRS
   - Report of the Task Group (W. Wagner)
   - Report of the Evaluation Committee (R. Mareš, K. Miyagawa)
   - Formal Consideration of the Revised Release by the WGs TPWS and IRS
6. Industrial Requirements for Steam Property Calculations (W.T. Parry), joint with IRS
   - 6.1 CFD – The Need for Speed
   - 6.2 Tradeoffs between Speed, Consistency, and Accuracy
   - 6.3 Metastable Considerations
7. Advisory Note No. 3 on Thermodynamic Derivatives from IAPWS Formulations, joint with WG IRS
   - Report of the Evaluation Committee (N. Okita in place of K. Miyagawa)
   - Formal Consideration of the Advisory Note by the WGs TPWS and IRS
8. Revised Release on the Pressure along the Melting and Sublimation Curves of Water, joint with WG IRS
   - Report of the Task Group (W. Wagner)
   - Appointment of an Evaluation Task Group
9. Properties of Liquid Water at Atmospheric Pressure, joint with WG IRS
   - Report of the Task Group (A.H. Harvey, J. Hruby)
10. Ideal-Gas Properties, joint with WG IRS
    - Report of the Task Group (R. Feistel)

11. Transport Properties of Water and Steam, joint with WG IRS

11.1 Release on the IAPWS Formulation 2007 for the Viscosity of Water

- Report of the Task Group (J.V. Sengers)
- Report of the Evaluation Task Group (R. Mares, K. Miyagawa)
- Formal Consideration of the Release by the WGs TPWS and IRS

11.2 Thermal Conductivity

- Report of the Task Group (J.V. Sengers)
- Appointment of an Evaluation Task Group

12. Transport Properties of Heavy Water, joint with WG IRS

- Report of the Task Group (J.R. Cooper)
- Report about the Evaluation Work (A. Harvey, K. Miyagawa)
- Formal Consideration of the Revised Release by the WGs TPWS and IRS

13. Workshop on Properties of Humid Air and Humid Combustion Gases, joint with WGs IRS, PCC, and PCAS (Tuesday morning, 8:30)

13.1 Measurements of the Water Vapor Concentration Enhancement in Compressed Air, Nitrogen, and Argon with FTIR Spectroscopy (M. Wendland, Univ. of Agriculture Wien)

13.2 First-Principles Calculation of Interaction Second Virial Coefficients Between Water and Common Gases, Including Air (A.H. Harvey)

13.3 Dew Point of Combustion Gas

- Report of the Task Group (N. Okita, R. Span, J. Hruby)

13.4 Update for ICRN-14: Thermophysical Properties of Humid Air and Combustion-Gas Mixtures (R. Span)

14. Workshop on Properties of Seawater (P. Tremaine), joint with WGs IRS, PCAS, PCC (Tuesday afternoon, 1:30)

14.1 Activities of the Task Group on Seawater, Liaison with IAPSO, Letters Between the IAPWS President and the President of IAPSO
- Report of the Task Group (R. Feistel, A.H. Harvey, M. Hiegemann, P. Tremaine)

14.2 Investigation of IAPWS-95 Properties Between the Freezing Points of Pure Water and Seawater
- Report of the Task Group (R. Feistel, M: Anisimov, J. Hruby, W. Wagner)

14.3 Composition of Standard Seawater, Reference Salinity Scale (R. Feistel, F.J. Millero, RSMAS, Miami, FL)

14.4 Uncertainty of Conductivity Measurements (P. Spitzer, PTB Braunschweig, Germany)

14.5 Release on the IAPWS Formulation for the Thermodynamic Properties of Seawater
- Report of the Task Group (R. Feistel)
- Appointment of an Evaluation Task Group

14.6 New Measurements for Density of Seawater (R. Feistel in place of F.J. Millero)

14.7 Formulation of an ICRN on the Properties of Seawater (R. Feistel)

14.8 Formula Symbols, e. g. for the Salinity of Seawater (R. Feistel)

15. Joint Meeting with PCAS (Thursday Morning, 8:30)

15.1 Release on the Ionization Constant of Water
- Report of the Evaluation Committee (A.H. Harvey, M. Nakahara, P. Tremaine)
- Formal Consideration of the Release by the WGs TPWS and PCAS

15.2 Workshop on Molecular Simulation (K. Yasuoka)
- Molecular Dynamics Study of Water and Amphiphile/Water: Sub- and Supercritical Water and Micellar Solution (N. Yoshii, Himeji Dokkyo University)
- Report of the Molecular Simulation Task Group (K. Yasuoka)

15.3 The Nucleation, Bubble Dynamics and Effects of the Physical Properties of Water on the Cavitation Erosion (M. Sedlar)

15.4 The Mechanism of Nucleation in Pure Water and the Surface Tension of Ice (T. Nemec).

15.5 Thermochemical Split of Water for Hydrogen Production (S.N. Lvov, P. Tremaine)

16. Reports on Other TPWS & IRS Activities

16.1 Fundamental Constants (A.H. Harvey), joint with WG IRS

16.2 Update of Advisory Note No. 2: Roles of Various IAPWS Documents. (A.H. Harvey, J.R. Cooper), joint with WG IRS

16.3 Download of Steam Tables for Pocket Calculators from the IAPWS Website

16.4 Steam Tables and Diagrams on Mathcad Calculation Server for Personal Computers, Pocket Computers, and SmartPhones (V.F. Ochkov, Moscow Power Institute), joint with WG IRS

16.5 New Internet Technology of IAPWS Formulations Checking, Publication, and On-line Calculation (V.F. Ochkov, Moscow Power Institute), joint with WG IRS

16.6 Liaison with IEC (J.R. Cooper), joint with WG IRS

16.7 Liaison with CCM (A.H. Harvey, R. Span), joint with WG IRS

17. Membership
18. Other Business
    - 18.1 Use of IAPWS-IF97 for the Calculation of the Density for Determining the Dielectric Constant and Refractive Index (W. Wagner), joint with WG IRS
    - 18.2 Topics for the 15th ICPWS 2008 in Berlin (B. Rukes, I. Weber), joint with WG IRS
    - 18.3 Report on International Collaborative Projects
    - 18.4 Acknowledgements in IAPWS Documents
19. Preparation of the Formal Motion to the EC
20. Adjournment

August 30, 2007

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