Minutes
IAPWS Thermophysical Properties of Water and Steam WG
IAPWS Industrial Requirements and Solutions WG
Berlin, Germany, September 7, 2008

NOTE: Because the working groups met jointly, these Minutes combine the activities of Working Groups TPWS and IRS. 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 Sunday, September 7 at 10:55 by the IRS Chair, Bill Parry. TPWS Chair Hans-Joachim Kretzschmar added his welcome, thanking the Working Groups for extensive work during the year with particular appreciation to K. Miyagawa and A. Harvey. 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 2007 Minutes had been circulated and approved shortly after the 2007 meeting.

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

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

5. (Seawater) J. Hruby presented the favorable report of the Evaluation Task Group for the draft release on thermodynamic properties of seawater, describing the extensive process of testing and adjustment of the release to improve consistency with other IAPWS products and to improve the description of uncertainty. Acceptance was recommended. **The WG approved the Release on the IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater, with the provision that some minor editorial items be corrected before posting of the final document.**

6. (Melting/Sublimation) J. Cooper presented the favorable report of the Evaluation Task Group for the draft revised release on the melting and sublimation curves of water. **The WG approved the Revised Release on the Pressure along the Melting and Sublimation Curves of Ordinary Water Substance.** Because it became known during the work on this document and the Seawater release that the 2006 release on thermodynamic properties of ice Ih was very slightly inconsistent with other IAPWS releases, a Task Group (the same as the Seawater Task Group) was appointed to consider the preparation of a minor editorial revision to the ice release. The evaluation Task Group for this effort will consist of Hruby, Miyagawa, and Harvey.

7. W. Wagner reported on suggested editorial changes to the IAPWS-95 release document, in order to clarify the conditions at the critical point and to correct some entries in tables of check values that had been generated with slightly wrong (truncated) coefficients. K. Miyagawa presented an informal evaluation report on the changes. There was much discussion about whether the change intended to clarify the adjustment of two constants in

order to meet the convention for values of entropy and internal energy at the triple point was helpful or might create confusion. It was finally agreed to change the proposed footnote on Table 1 so that it did not report different (adjusted) constants, but rather pointed users to the existing instructions on page 4 concerning this adjustment. **After this amendment, the WG voted to adopt these editorial changes to the Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use.** It was decided to prepare a minor revision of the IAPWS-95 release for 2009 that would give correctly adjusted numbers in Table 1 and otherwise clarify the current confusion (without changing the thermodynamic calculations). A Task Group of Wagner and Harvey was appointed to make this revision, with Miyagawa to test and evaluate it.

8. (0.1 MPa properties) A. Harvey and J. Hruby presented the proposed supplementary release to produce convenient formulations for properties of liquid water as a function of temperature at 0.1 MPa pressure. J. Sengers presented the favorable evaluation report. **The WG voted to approve the Supplementary Release on Properties of Liquid Water at 0.1 MPa.** The issue came up about possible properties to add to this document in the future. It was pointed out that any property correlated as a function of temperature and density could be computed fairly simply by using the supplementary release to calculate density as a function of temperature, and then using that density in the correlation. An opportune time to consider adding other properties will be when the new IAPWS thermal conductivity correlation is completed, since that will require revision of the supplementary release.

9.1 A. Harvey explained the need for a minor editorial change in the viscosity release (in the references) to be consistent with the just-adopted release on the melting and sublimation curves. There are also some minor issues with consistency of notation pointed out by Jan Sengers. **The WG authorized these minor editorial changes to be made before publication of the viscosity release.**

9.2 A. Harvey presented the proposal for a minor revision of the thermal conductivity release to make it consistent with the new viscosity release. K. Miyagawa presented the favorable report of the Evaluation Task Group. **The WG voted to approve the Revised Release on the IAPS Formulation 1985 for the Thermal Conductivity of Ordinary Water Substance.**

9.3 J. Sengers reported that the journal article on the new viscosity formulation would be submitted soon, and he commended the international cooperative effort on this project. He reported that there is now a firm theoretical basis, confirmed by experiment, for the critical enhancement of the thermal conductivity. Work on the new thermal conductivity formulation is proceeding well, and it is hoped to have a draft of the new formulation ready for our 2009 meeting.

10. R. Feistel reported on the need for a computationally simpler formulation (compared to IAPWS-95) formulation for pure water that was a function of temperature and pressure designed for the oceanographic range of conditions (temperatures from approximately 0 °C to 40 °C and pressures to 100 MPa). SCOR/IAPSO is recommending a previously developed function known as F03. T. McDougal presented information showing that F03 was much more accurate than IAPWS-IF97 in this range, and stated that the improvement was

significant for oceanography. K.. Miyagawa presented further comparisons. It was proposed that IAPWS should issue a supplementary release with this formulation for oceanographic use. There was discussion that, in order to avoid confusion and inappropriate use, the range and use of such a formulation must be delineated very clearly. An Evaluation Task Group was set up consisting of Miyagawa (chair), Mares, and Hruby. A schedule should be set leading to possible adoption of the Supplementary Release by IAPWS in 2009.

11. H.-J. Kretzschmar presented the proposed revision of Advisory Note 3 to include seawater and heavy water. **The Revised Advisory Note No. 3: Thermodynamic Derivatives from IAPWS Formulations was approved by the WG with two abstentions**.

12. N. Okita presented a report on the need for better dew-point prediction for flue gases, and a proposed ICRN prepared by the Task Group. R. Span pointed out the need to update one table to include oxyfuel additions. **The WG voted to recommend to the EC that the proposed ICRN be sent out for approval, with the caveat that before being sent out the edits suggested by Prof. Span should be made and one more round of editorial corrections for English should be made.**

13. R. Span presented the background of the current ICRN on properties of humid air and combustion gases. He pointed out how much research had been done along the lines called for in the ICRN, but that new realities, particularly involving carbon capture and sequestration, were creating some different (but related) property needs, particularly in the areas of experimental data, liquid-liquid equilibrium and solids, and CO_2 in brines and geological systems. **The WG decided to allow the current ICRN 14 to expire (a closing statement should be provided in the coming year). A Task Group consisting of Span (chair), Harvey, Hruby, Kretzschmar, and Wendland was appointed to consider the future related needs and produce a draft ICRN for 2009.**

14. H.-J. Kretzschmar presented some preliminary results on using spline interpolation for fast calculation of steam properties with consistency between backward and forward calculations, which is a promising approach for the future.

15.1 The possibility of using IAPWS-IF97 instead of IAPWS-95 with the seawater formulation was mentioned (see also item 10). This is not accurate enough for oceanographers, but may be appropriate for desalination plants. B. Parry expressed the concern that people working in desalination needed some clear guidance about what to do for property calculations. **A Task Group was appointed consisting of Parry (chair), Feistel, Hiegemann, and Miyagawa to think about recommendations for desalination users. The Task Group was authorized to solicit advice from a desalination expert; R. Feistel will attempt to recruit such a person.**

15.2 A. Harvey presented a proposed minor update to the Fundamental Constants Guideline to reflect the latest CODATA adjustment. **The WG approved this update.**

15.3 A. Harvey presented the updates he and J. Cooper had made for Advisory Note 2, which explains the roles of various IAPWS documents for the thermodynamic properties of

water, to reflect new and revised formulations adopted in the past 2 years. **The WG approved this update**.

15.4 H.-J. Kretzschmar reported on the success of the site for steam tables for pocket calculators linked to the IAPWS website. It was proposed to have a similar link for an Excel add-in that has been developed. This was agreeable to the WG; by existing IAPWS policy the German National Committee must give its approval for this product (communicated to the Executive Secretary and the Webmaster) and then the link can be put on the website. It was suggested that the website should be more clear that these Steam Tables were the formulation for industrial use.

15.5. There was nothing to report on liaison with the IEC.

15.6. A. Harvey reported on the liaison with the CCM concerning recommendations for computing the density of water for metrology and other purposes. Consensus has finally been reached on the content of a joint paper and on some joint recommendations (subject perhaps to minor wording adjustments). The WG authorized the Task Group (Harvey and Span) to go forward with the publication to be submitted to *Metrologia*, and to prepare an Advisory Note for adoption in 2009 (with no Evaluation Task Group needed in this case). **In the meantime, the WG endorses, and asks the EC to endorse, the agreed-upon joint recommendations:**

1. **for use in metrology over its recommended range, which is liquid water from 0 °C to 40 °C at pressures near atmospheric. It should not be extrapolated outside this range.**
2. **Densities computed from the IAPWS-95 formulation are consistent with the CIPM standard within the region of validity of the CIPM formulation. For uses outside the CIPM range of validity, the IAPWS-95 formulation is the preferred method for obtaining accurate densities for water.**
3. **For uses covering a range of conditions, some of which are inside the range of validity of the CIPM standard and some of which are not, it is generally preferable to use the IAPWS formulation for the entire calculation in order to avoid discontinuities.**

16. We were informed by the Japan delegation that **H. Sato is withdrawn from TPWS and IRS membership and M. Uematsu is withdrawn from TPWS membership.** We were informed by the U.S. delegation that **G.J. Feller is withdrawn from IRS membership. It was voted to accept J. Gernert (Ruhr Univ. Bochum, Germany), T. McDougal (CSIRO, Australia), D. Wright (Bedford Inst. of Oceanography, Canada), R. Tailleux (U. of Reading, UK), and S. Seitz (PTB, Germany) as members of TPWS, and R. Harwood (Siemens, US) as a member of IRS.**

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

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

19. The meeting was adjourned at 18:00.

Agenda
IAPWS Thermophysical Properties of Water and Steam WG
Berlin, Germany, 7 September 2008

1. Opening Remarks; Adoption of Agenda
2. Appointment of Clerk of Minutes
3. Web Space for Working Material for WGs TPWS and IRS
4. Potential International Collaborative Projects
5. Release on the IAPWS Formulation 2008 for the Thermodynamic Properties of Seawater, joint with WG IRS
   - Report of the Evaluation Task Group (J. Hruby, K. Miyagawa)
   - Formal consideration of the Release by the WGs TPWS and IRS
6. Revised Release on the Pressure along the Melting and Sublimation Curves of Water, joint with WG IRS
   - Report of the Evaluation Committee (J.R. Cooper, K. Miyagawa, R. Mares)
   - Formal consideration of the Revised Release by the WGs TPWS and IRS
7. Editorial Changes on the Release on the IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use
   - Report (W. Wagner)
   - Test Report (K. Miyagawa)
   - Formal consideration of the Editorial Changes by the WG TPWS
8. Supplementary Release on Properties of Liquid Water at 0.1 MPa, joint with WG IRS
   - Report of the Task Group (A.H. Harvey, J. Hruby)
   - Report of the Evaluation Task Group (J. Sengers, R. Mares, K. Miyagawa)
   - Formal consideration of the Supplementary Release by the WGs TPWS and IRS
   - Future extensions of the Supplementary Release (G. Bignold, J.R. Cooper, A.H. Harvey, J. Hruby)
9. Transport Properties of Water and Steam
   - 9.1 Editorial Adjustment to the Release on the IAPWS Formulation 2008 for the Viscosity of Ordinary Water Substance, joint with WG IRS
     - Report of the Task Group (A.H. Harvey)
   - 9.2 Revised Release on the IAPWS Formulation for the Thermal Conductivity, joint with WG IRS
     - Report of the Task Group (A.H. Harvey)
     - Report of the Evaluation Task Group (K. Miyagawa, R. Mares)
     - Formal Consideration of the Revised Release by the WGs TPWS and IRS
   - 9.3 Development of a New Thermal Conductivity Formulation
     - Report of the Task Group (J.V. Sengers, D.G. Friend)

10. New Equation of State for Liquid Water for Oceanographic Use, joint with WG IRS
    - Report of the Task Group (R. Feistel, K. Miyagawa, T. McDougal)
    - Discussion about Preparing a Supplementary Release for Oceanographic Use and Establishing an Evaluation Task Group
11. Revised Advisory Note No. 3 on Thermodynamic Derivatives from IAPWS Formulations, joint with WG IRS
    - Report of the Task Group (H.-J. Kretzschmar, R. Feistel, J.R. Cooper)
12. ICRN # 23: Dew Point for Flue Gas of Power Plant Exhaust, joint with WG IRS
    - Report of the Task Group (N. Okita)
13. Update for ICRN # 14: Thermophysical Properties of Humid Air and Combustion-Gas Mixtures, joint with WG IRS
    - Report of the Task Group (R. Span)
14. Industrial Requirements for Steam Property Calculations, joint with IRS
    - Report of the Task Group (H.-J. Kretzschmar, W.T. Parry)
15. Reports on Other TPWS & IRS Activities
    - 15.1 Calculation of Seawater Properties Using IAPWS-IF97 (R. Feistel, M. Hiegemann, K. Miyagawa), joint with WG IRS
    - 15.2 Guideline on Fundamental Constants (A.H. Harvey), joint with WG IRS
    - 15.3 Update of Advisory Note # 2: Roles of Various IAPWS Documents (J.R. Cooper, A.H. Harvey), joint with WG IRS
    - 15.4 Steam Tables for Excel®, Mathcad®, and Pocket Calculators for Education on the IAPWS Website (H.-J. Kretzschmar)
    - 15.5 Liaison with IEC (J.R. Cooper), joint with WG IRS
    - 15.6 Liaison with CCM (A.H. Harvey, R. Span)
16. Membership
17. Other Business
    - Report on International Collaborative Projects
18. Preparation of the Formal Motion to the EC
19. Adjournment

Note, the time for the Working Group Meeting is short due to the ICPWS, so we must limit the agenda to essential business and can cannot have any extra presentations.

In case the discussions can not be finished on Sunday they will be continued on Monday evening after the conference sessions.

September 07, 2008

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