Minutes

IAPWS Thermophysical Properties of Water and Steam WG

Niagara Falls, Canada, July 19-22, 2010

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

1-2. The meeting was opened on Monday, July 19 at 10:10 by the TPWS Chair, Hans-Joachim Kretzschmar. The agenda (Attachment A) was adopted after minor additions (attachment reflects additions). The Chair noted that, in accordance with our new procedure, the 2009 Minutes had been circulated and approved with minor corrections shortly after the 2009 meeting. He also noted the achievement during the year of IAPWS formulations for seawater, ice, and "sea air" being adopted as IAPWS standards. He also recognized longtime WG member Wolfgang Wagner on his recent 70th birthday. Allan Harvey was appointed Clerk of Minutes for TPWS.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

11. Nucleation of Water from Supercooled Steam and Revision of ICRN-15 on Metastable Steam
    - Report of the Task Group (J. Hruby)
12. Properties of Humid Air and Humid Combustion Gases, joint with WGs IRS, PCAS, and SC SW
    - Revision of ICRN-14 on Thermophysical Properties of Humid Air and Combustion-Gas Mixtures (R. Span, A.H. Harvey)
13. Properties of Seawater (R. Feistel), joint with SC SW and WG IRS
    - 13.1 Task Group Report "Oceanographic Standards" (T.J. McDougall, R. Feistel)
    - 13.2 Implementation of the "TEOS-10 SIA Library" (D.G. Wright, R. Feistel)
    - 13.3 Task Group Report "Industrial Requirements" (M. Hiegemann, J. Bellows, H. Glade)
    - 13.4 Task Group Report "Advisory Note on Industrial Formulation" (J. Cooper)
    - 13.5 Task Group Report "Transport Properties"
        - Development of a model for calculating thermal conductivity of seawater (A. Anderko)
        - The accuracy of electrical conductivity models when applied to natural waters (R. Pawlowicz)
    - 13.6 Recent Measurements of Seawater Properties (R. Feistel, J. Safarov, F.J. Millero)
    - 13.7 Renewal of ICRN 16 on Thermophysical Properties of Seawater (R. Feistel)
14. Scaled Formulation of Self-diffusion Coefficients for Water over a Wide Range of Density and Temperature in Including the Supercritical (M. Nakahara), joint with PCAS
15. The Phase Diagram of Water with Various Models (S. Yoo, Pacific Northwest National Laboratory), joint with PCAS
16. Surface Tension of Water with Rigid Models (K. Yasuoka), joint with PCAS
17. Uncertainty of Properties Derived from Thermodynamic Potentials, joint with SC SW
    - Report (R. Feistel)
18. CIPM Mutual Recognition Arrangement – to be recognized by IAPWS?, joint with SC SW
    - Report (R. Feistel, P. Spitzer)

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

July 22, 2010

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