Minutes

IAPWS Thermophysical Properties of Water and Steam WG
London, England, 01 September 2013

NOTE: These Minutes include many 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 Sunday morning, September 1 by the TPWS Chair, Allan Harvey. The agenda (Attachment A) was adopted. The Chair noted that, in accordance with our procedure, the 2012 Minutes had been circulated and approved with minor corrections shortly after the 2012 meeting. Jan Hrubý was appointed Clerk of Minutes for TPWS. (Michael Hiegemann was appointed Clerk for SCSW and IRS)

Jan Sengers commemorated William Leitch "Bill" Marshall, Jr., who passed away on August 25, 2013. He was a life-long researcher at Oak Ridge National Laboratory and contributed to IAPWS-related activities in the fields of aqueous chemistry, hydrothermal chemistry and geochemistry. IAPWS has issued three Guidelines on aqueous systems that are primarily based on his work. The members of WGs commemorated Bill Marshall with a moment of silence.

3. S. Herrmann (speaker) and H.-J. Kretzschmar informed about the 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. No collaborative projects were suggested in TPWS.

5. M. Hiegemann presented a Report of the Evaluation Task Group for the Advisory Note on the Properties of Seawater for Industrial Use (joint with WGs IRS and SC SW). The Advisory Note was prepared by H.-J. Kretzschmar and collaborators. According to this Advisory Note, IAPWS-IF97 may be used for the pure-fluid reference equation instead of IAPWS-95 for computation of the properties of seawater. The deviations in computed properties were found to be almost negligible. Using IF97 speeds up the computations by a factor of 200. H.-J. Kretzschmar informed that a publication is being prepared (journal *Desalination*). **The Working groups approved the Advisory Note unanimously.**

6. Supercooled Water

6.1 J. Hrubý presented the Report of the Task Group on Supercooled Water as a Reference for Seawater, joint with SCSW. Validity of IAPWS-95 was investigated in the "seawater range" defined by a pressure range from 0.1 to 140 MPa and by a temperature range from 273.15 K down to 4 K below the equilibrium melting temperature for a given pressure. Several data sets not considered in the development of IAPWS-95 were considered. The uncertainty of density given by IAPWS-95 was estimated to be less than 0.1%, and for the speed of sound the uncertainty is estimated to be less than 0.5%. **Based on these estimates, IAPWS-95 can be recommended as a pure-fluid reference model for the formulation of thermodynamic properties of seawater.**

In addition, an "extended range" extending up to 400 MPa and from 250 K to 300 K was considered. Estimation of uncertainties of IAPWS-95 in this range is more complex. As a side-result, the possibility of reconsidering the uncertainties stated by IAPWS-95 emerged and is reported under item 7 of these minutes.

When talking about the behavior of IAPWS-95 beyond the stable liquid region, it was recommended to use the term **"extrapolated IAPWS-95 formulation"**.

6.2 Possible future IAPWS recommendations for thermodynamics of supercooled water. It was found that volumetric data spanning over the extended range with an uncertainty of 0.01-0.02% would be of high importance. Also, it was found that accurate sound speed data in the supercooled liquid region are needed.
It would be valuable for IAPWS to develop a Guideline with a separate formulation for the supercooled region. **A task group consisting of J. Hrubý (chair), M. Anisimov, R. Feistel, O. Hellmuth, V. Holten, and K. Orlov was established.**
Besides the "seawater region" considered in this report, also the metastable state of superheated liquid ordinary water is relevant for the seawater formulation. **A task group was established, consisting of H.-J. Kretzschmar (chair), R. Feistel, J. Hrubý, K. Orlov, and B. Rukes to examine the behavior of IAPWS-95 in this region.**

7. W. Wagner reported on the possible improvement of the uncertainty estimates of IAPWS-95 in the region of liquid water in the pressure range from 100 to 400 MPa. Based on the recent sound speed data (Lin and Trusler), it appears possible to significantly reduce the uncertainty estimates for the sound speed and to provide uncertainty estimates in regions where no uncertainty estimates are given in the present Release. On the other hand, isobaric heat capacity in the pressure range from 200 to 400 MPa in a band of about 10 to 15 K above to the melting line requires an uncertainty estimate bigger than 6%. **A task group was formed, consisting of A. Harvey (chair), W. Wagner, M. Trusler, to reconsider the IAPWS-95 uncertainty estimates in this region.**

8. Proposal for an IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using Spline Interpolation, joint with WG IRS
   This item is included in the IRS Minutes

9. Industrial Requirements and Solutions for Steam Property Calculations, joint with WG IRS
   - 9.1 Report of the New Industrial Requirements Task Group
     This item is included in the IRS Minutes
   - 9.2 Report of the Industrial Survey Task Group
     This item is included in the IRS Minutes
   - 9.3 Report of the Task Group "Advisory Notes"
     This item is included in the IRS Minutes

10. Report of Task Group on Extension of Range of Formulation for Thermodynamic Properties of Sea Water, joint with WGs IRS and SC SW
    This item is included in the SCSW Minutes

11. Report of Task Group on Transport Properties of Seawater, joint with SC SW and WGs IRS and PCAS
    This item is included in the SCSW Minutes

12. Cooperation with other international bodies, joint with SC SW
    12.1 IAPWS/IAPSO/SCOR Joint Committee on Seawater
    This item is included in the SCSW Minutes
    12.2 Cooperation with BIPM/CIPM (CCQM and CCT)
    This item is included in the SCSW Minutes
    12.3 ICPWS workshops for IAPWS-BIPM cooperation
    This item is included in the SCSW Minutes

13. Proposal for a Guideline on a Virial Equation for the Fugacity of Water in Humid Air, joint with SC SW
    This item is included in the SCSW Minutes

14. R. Span (speaker) and A. Harvey presented the Report of Task Group on Heavy Water Properties (joint with WG IRS). The present IAPWS Release, adopted in 1984, is based on a fundamental equation of state by Hill et al. In 2005, it was updated for the temperature scale ITS 90. The data situation has not improved very much since 1984, but much better correlation techniques are available now, allowing a better fit and better extrapolation properties. Tentatively the Release will be prepared for submission to an Evaluation Task Group at the 2014 meeting.

15. Reports on other TPWS activities
    15.1 A. Harvey informed that no update was necessary to the Guideline on Fundamental Constants.
    15.2 J. Cooper and A. Harvey (speaker) have updated Advisory Note 2 on the Role of Various IAPWS Documents.

16. Other Business
    16.1 Report on International Collaborative Projects – no reports were presented.
    16.2 Report on ICRNs
    The status of existing ICRNs was reviewed. ICRN 24 (Thermal conductivity of H_2O at low pressures and high temperatures) was extended in term for 3 years at the 2012 meeting, but some minor revisions are needed in the text. A. Harvey is assigned to this task.

17. Membership. **The following memberships were unanimously recommended to EC**:
Dr. Jeremy Lovell-Smith (NMI, NZ) as TPWS (and SCSW) member,
Dr. Stephanie Bell (NPL, GB) as TPWS (and SCSW) member,
Sebastian Hermann (TU Zittau/Görlitz) as TPWS (and IRS) member.

18. Contribution to Press Release
The chair and the clerk of minutes were assigned to prepare the contribution to the Press Release.

19. Preparation of the Formal Motion to the EC
The chair and the clerk of minutes were assigned to prepare the Formal Motion to the EC.

20. Adjournment
The meeting was adjourned at 6:00 p.m.

Agenda for the IAPWS Working Group

Thermophysical Properties of Water and Steam (TPWS)
London, England, 01 September 2013

1. Opening Remarks; Adoption of Agenda
2. Appointment of Clerk of Minutes
3. OPAL Web Space for Working Material for WGs TPWS, IRS, and SC SW, joint with WG IRS and SC SW (H.-J. Kretzschmar)
4. Potential International Collaborative Projects
5. Advisory Note on the Properties of Sea Water for Industrial Use, joint with WGs IRS and SC SW
   - Report of the Evaluation Task Group
   - Formal consideration of the Advisory Note by the Working Groups
6. Supercooled Water
   - 6.1 Report of Task Group on Supercooled Water as a Reference for Seawater, joint with SCSW (J. Hrubý)
   - 6.2 Possible future IAPWS recommendations for thermodynamics of supercooled water
7. Possible Improvement of the Uncertainty Estimates of IAPWS-95 (W. Wagner)
8. Proposal for an IAPWS Guideline on the Fast Calculation of Steam and Water Properties in Computational Fluid Dynamics Using Spline Interpolation, joint with WG IRS (H.-J. Kretzschmar, M. Kunick, J. Hruby, M. Duška, V. Vinš, F. di Mare, and A. Singh)
9. Industrial Requirements and Solutions for Steam Property Calculations, joint with WG IRS
   - 9.1 Report of the New Industrial Requirements Task Group (I. Weber)
   - 9.2 Report of the Industrial Survey Task Group (A. Singh)
   - 9.3 Report of the Task Group “Advisory Notes” (M. Hiegemann, B. Rukes, P. Murphy, A. Harvey)
10. Report of Task Group on Extension of Range of Formulation for Thermodynamic Properties of Sea Water, joint with WGs IRS and SC SW (R. Feistel)
11. Report of Task Group on Transport Properties of Seawater, joint with SC SW and WG IRS and PCAS (A. Anderko, A. Harvey)
12. Cooperation with other international bodies, joint with SC SW
    - 12.1 IAPWS/IAPSO/SCOR Joint Committee on Seawater (R. Pawlowicz)
    - 12.2 Cooperation with BIPM (CCQM and CCT) (R. Feistel, D. Friend, P. Spitzer)
    - 12.3 ICPWS workshops for IAPWS-BIPM cooperation (R. Pawlowicz)
13. Proposal for a Guideline on a Virial Equation for the Fugacity of Water in Humid Air, joint with SC SW (R. Feistel, J. Lovell-Smith)
14. Report of Task Group on Heavy Water Properties, joint with WG IRS (R. Span, A. Harvey)

15. Reports on other TPWS activities
    15.1 Guideline on Fundamental Constants (A. Harvey)
    15.2 Advisory Note 2 (J. Cooper, A. Harvey)
16. Other Business
    16.1 Report on International Collaborative Projects
    16.2 Report on ICRNs
17. Membership
18. Contribution to Press Release
19. Preparation of the Formal Motion to the EC
20. Adjournment

August 26, 2013

A.H. Harvey (Chair), J. Hrubý (Vice-Chair)