

IAPWS Thermophysical Properties of Water and Steam WG

Boulder, USA, 23 June 2024

NOTE: These Minutes include some items that were held jointly with the IRS and/or PCAS Working Groups. 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, June 23, 2024 at 9:00 by the TPWS Chair, Karsten Meier. A modified Agenda was adopted (Attachment A). The 2023 Minutes had been circulated and approved by email shortly after the 2023 meeting. Jan Hrubý was appointed Clerk of Minutes for TPWS.

3. Tributes for deceased colleagues.

A. Harvey presented a brief tribute to Anneke Levelt Sengers (1929-2024). She joined IAPWS in 1968 at IAPWS Conference in Tokyo. She served as a leader of Working Group, IAPWS President, and U.S. national representative. She was IAPWS Honorary Fellow. She was also active in promoting women in science. The Chair led the Working Groups in a moment of silence.

4. Potential International Collaborative Projects

F. Caupin presented a Proposal for a collaborative project “Guideline on the Thermodynamic Properties of Metastable Water” (F. Caupin, M. Anisimov, J. Hrubý). The goal is developing a thermodynamic property formulation describing supercooled and stretched liquid water. The resulting Guideline should replace the present “Guideline on Thermodynamic Properties of Supercooled Water” (IAPWS G12-15), which does not cover the region of stretched liquid (liquid at negative pressures). The resulting equation would provide a constraint and support for the envisaged new fundamental formulation of thermodynamic properties of ordinary water. A draft of the Proposal was sent to the WG Chair before the TPWS meeting. TPWS endorsed submission of the proposal. The Proposal was formally completed and submitted to the Executive Secretary.

5. State of Development of a New Formulation for the Thermodynamic Properties of Ordinary Water (Replacement of IAPWS-95)

A. Harvey reported on behalf of Task Group (A. Harvey, A. Giuliano Albo, F. Caupin, D. Friend, J. Hrubý, Y. Kayukawa, S. Lago, N. Okita, R. Span). Brief justification of the need of IAPWS-95 replacement: Extrapolation, unphysical oscillations near critical point, oscillations of pressure vs. density isotherm inside the binodal (multiple van der Waals loop), existence of new data. Accuracy can be improved in several regions. So far, no serious activity was developed. In frame of the running International Collaborative Project, researchers from NIST, Ruhr Universität Bochum, and Institute of Thermomechanics, Prague, will work on two main tasks: (i) Organizing a database of experimental data, (ii) Principal development of EOS showing a single van der Waals loop, suitable for modeling mixtures and phase interfaces.

6. V. Vinš reported on behalf of Task group on surface tension of ordinary water (V. Vinš, A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, R. Mareš, F. Caupin). Sufficient data exists in the region of supercooled water. New accurate data is needed above 100 °C. Several correlations suggested. However, in absence of reliable high-temperature data it does not appear practical to

change the equation. The TG will prepare an improved definition of uncertainties as an update of the surface tension release.

7. IAPWS Certified Research Needs (ICRNs)

7.1 ICRN 16: Thermophysical Properties of Seawater (R. Pawlowicz), expired 2019
WG Chair will ask R. Pawlowicz to write a concluding statement.

7.2 ICRN 28: Thermophysical Properties of Metastable Steam and Homogeneous Nucleation (J. Hrubý), expired 2019

J. Hrubý will prepare a concluding statement.

7.3 ICRN 30: Thermophysical Properties of Supercooled Water (O. Hellmuth), expired 2020
WG Chair will ask O. Hellmuth to write a concluding statement.

7.4 ICRN 31: New Thermodynamic Data for Ordinary Water (A. Harvey and J. Hrubý), expires October 2024

A. Harvey and J. Hrubý will prepare an update of the release, in particular a more detailed description of needed molecular simulation data in the regions of supercooled steam and superheated/stretched liquid.

8. Industrial Requirements and Solutions for Property Calculations (joint with WG IRS, PCAS and SCSW, N. Okita) [afternoon]

8.1 Report on a white paper for acid gas dew points (N. Okita)

8.2 N. Okita reported on behalf of the Task Group “Categories of Industrial Requirements”. An extensive table of industrial requirements was presented.

8.3 Report of the Task Group “Wet steam properties calculation”: No progress, TG remains.

8.4 Translation of IF-97 Fortran routines into other programming languages: ongoing activity, task continues (A. Nový).

8.5 M. Kunick reported on a proposal for the development of a new industrial formulation for the properties of water and steam. It was suggested that a new industrial formulation is developed in the form of SBTL method (biquadratic spline polynomials). Computations with method are up to 270 times faster than IF-97 backward equations. It is intended to publish the tables of coefficients and interpolation algorithms. It was discussed whether the splines should be based on IAPWS-95 formulation or on IAPWS-97 formulation, the latter option being preferred with respect to the users in the industry. TG will approach the industry in explaining the pros and cons of the two options.

9. Heavy Water Properties (joint with WG IRS, PCAS and SCSW)

9.1 A. Harvey reported on progress on a formulation for the static dielectric constant of heavy water (J. Cox, A. Harvey, and P. Tremaine). The new formulation should improve the behavior in the low-temperature region.

10. A. Harvey reported on the activities concerning enhancement factor of mixtures containing steam. This problem was considered in a project the EU project PROMETH2O. Further activity of IAPWS in this direction will depend on the final reports of this project, which are not yet published.

A. Harvey was appointed as an IAPWS representative for Consultative Committee for Thermometry / Working Group on humidity (CCT-WG-Hu)

11. Reports on seawater-related topics

11.1 Discussion on the future of the Subcommittee on Sea Water: discussion did not take place because of missing SCSW members. It was indicated that sea water session might attract new members.

12. Discussion on Future Activities of TPWS

12.1 Review of current TPWS task groups:

- Task Group on the Development of a New Formulation for the Thermodynamic Properties of Ordinary Water (Replacement of IAPWS-95) (A. Harvey, F. Caupin (supercooled water), D. Friend, A. Giuliano Albo (motivation of experiments), J. Hrubý, Y. Kayukawa, S. Lago (vice-chair), A. Nový, N. Okita, R. Span)
- Task Group on Surface Tension of Ordinary Water (V. Vinš, A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, R. Mareš, F. Caupin)
- Task Group on the Enhancement Factor of Mixtures Containing Steam (K. Meier, R. Hellmann, A. Harvey, V. Fericola)
- Task Group on the Formulation for the Static Dielectric Constant of Heavy Water (A. Harvey, P. Tremaine)
- Task Group on the Diffusivity of Ordinary Water (K. Yoshida, F. Caupin, A. Harvey, R. Hellmann, M. Huber)
- Task Group on Possible Revision of IAPWS Formulations for Melting Curves (V. Holten, A. Harvey, H.-J. Kretzschmar)

12.2 Possible future areas of interest to TPWS, such as the description of the properties of H₂O and D₂O ice Ih, water electrolysis and hydrogen fuel cells were discussed.

13. Report on International Collaborative Projects

Running International Collaborative Project concerns preliminary work for a new fundamental formulation of thermodynamic properties of ordinary water, see Item 5.

14. Membership

J. Sengers left TPWS for the reason of his age. His long-term contributions are highly appreciated. A summary of his contributions to the transport properties of water, as written by him, is published as an annex to these Minutes.

15. Election of a new Chair and Vice-Chair

Jan Hrubý (Institute of Thermomechanics, Prague) was elected as a new TPWS Chair and Andreas Jäger (Technische Universität Dresden) was elected as a new TPWS Vice-Chair, both starting in January 2025. Present TPWS Chair Karsten Meier remains as second TPWS Vice-Chair for 2025.

16.-17. TPWS Chair will prepare a Contribution to Press Release and the Formal Motion to the EC

18. Adjournment

The meeting was adjourned at 16:04 on Sunday, June 23, 2024.