Minutes:

IAPWS Thermophysical Properties of Water and Steam WG

Dresden, Germany, 12–15 September 2016

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.

Obituary: W. Wagner reported that Dr. P. Hill, former member of TPWS, died. Phil Hill was born in Vancouver in 1932. He studied at Queen's University in Kingston (Canada). After completing his PhD at MIT (USA), he taught at Queen's University at Kingston (Canada). He returned to Vancouver in 1975 and became Professor at the Department of Mechanical Engineering of the University of British Columbia. He retired in 1997. Phil Hill is coauthor of the famous Steam Tables authored by Keenan, Keyes, Hill, and Moore, published in 1969. In 1982, he published an article on the equation of state for heavy water of which the release was adopted by IAPWS in 1984. He also developed an equation of state for ordinary water published in the J. Phys. Chem. Ref. Data in 1990. He had been active in TPWS until 1996. Besides this, he co-authored many papers and a textbook on turbomachinery propulsion. In 1995, he co-founded Westport Innovations Inc., a company specialized in alternative fuel for transportation and industrial machinery. There, he worked until very shortly before his death.

1-2. The meeting was opened on Monday, September 12, 2016 by the TPWS Chair, Allan Harvey. The agenda (Attachment A) was adopted after some additions. The Chair noted that the 2015 Minutes had been circulated and approved by email shortly after the 2015 meeting. J. Hrubý was appointed Clerk of Minutes for TPWS. (Olaf Hellmuth was appointed Clerk for SCSW and Adam Nový for IRS.)

3. No new Collaborative Project was suggested at TPWS. Collaborative Project "Towards an IAPWS Guideline for the Thermodynamic Properties of Supercooled Heavy Water" was approved at the 2015 IAPWS meeting as a collaboration between the Czech and US national committees. A young scientist, Dr. M. Duška, started his stay at Maryland University. As a result of a substantial change of the exchange rate with GBP, the IAPWS subsidence in USD significantly dropped so that the fulfillment of the project is threatened. A motion to recommend to the EC an amendment of this project increasing the IAPWS subsidence to balance the exchange rate loss was approved by TPWS (no vote against, one abstained). **The Working Group (jointly with SC SW and IRS) requests that the EC authorize additional funds toward the collaborative project "Toward an IAPWS Guideline on the Thermodynamic Properties of Supercooled Heavy Water" which was approved in 2015 and allocated 17,490 GBP. It is requested that the amount allocated to this project be increased by an amount (to be calculated by the Executive Secretary) to make the total number of US dollars available now equal to the number of US dollars that the original allocation would have bought at the time of the Stockholm meeting.**

NOTE: Items 4 and 5 are reported on in the IRS minutes.

4. Industrial Requirements and Solutions for Steam Property Calculations, joint with WG IRS

4.1 Report of the Task Group "Industrial Advisory Note" (M. Hiegemann, B. Rukes, A. Singh, A. Harvey)

4.2 Large eddy simulation of condensing steam in a turbine cascade (P. Post, F. di Mare)

5. Editorial Changes for IAPWS Industrial Documents (joint with WG IRS and SC SW)

5.1 Report on proposed Editorial Changes on the Revised Supplementary Release on Backward Equations for Specific Volume as a Function of Pressure and Temperature v(p,T) for Region 3 of the IAPWS Industrial Formulation 1997 (M. Kunick, H.-J. Kretzschmar, W. Wagner, A. H. Harvey)

5.2 Formal consideration of the Editorial changes to the Supplementary Release

5.3 Report of proposed editorial changes to Advisory Note 5: Industrial Calculation of the Thermodynamic Properties of Seawater (S. Herrmann, H.-J. Kretzschmar, K. Orlov)

5.4 Formal consideration of the Editorial changes to the Advisory Note

6. Heavy Water Properties (joint with WG IRS)

6.1 S. Herring reported on behalf of the Task Group on Heavy Water Thermodynamic Properties (other members R. Span, A. Harvey). The work started in 2013 as a collaborative project between NIST and Ruhr Universität Bochum. A preliminary EoS was developed in 2014. Since then, new data for speed of sound for liquid heavy water has been obtained and the second virial coefficient has been computed quantum mechanically down to 200 K. These new data were included in a new version of the thermodynamic formulation. The equation is valid up to 825 K and 1200 MPa. Behavior in the liquid-vapor critical region has been improved. Not yet available are calculated data for the ideal gas properties and the third virial coefficient and experimental data for supercooled liquid density. In the following discussion, it was stressed that the work needs to be finished soon. It has been decided that new data can only be included in the formulation if provided before the end of 2016. The formulation should be provided to the Evaluation Task Group by the end of May 2017.

6.2 Evaluation Task Group for Heavy Water Formulation, including H.-J. Kretzschmar (Chair), M. Duška, and co-opted expert Thomas Beuthe (AECL, Canada), has been appointed in Moscow at the 2014 IAPWS Meeting. V. Holten and J. Hrubý were nominated as additional members of the Evaluation Task Group. The Evaluation Task Group should provide a report by the end of July, 2017.

6.3 Report of TG for Heavy Water Transport Properties (J. Sengers, M. Assael, M. Huber, R. Perkins). Jan Sengers reported that theoretical calculations had been received for the dilute-gas viscosity and thermal conductivity, although the thermal conductivity numbers will change slightly when new ideal-gas heat capacities are obtained. The rest of the project is on hold until the final EoS is available (c.f. item 6.1).

6.4 Measurements of the Viscosity of Supercooled D_2O (Pierre Ragueneau, Amine Dehaoui, Bruno Issenmann, Frédéric Caupin). Brownian motion diffusion coefficient of polystyrere spheres (400 nm dia.) was studied to obtain the viscosity through the Stokes-Einstein relation (with calibration at 20 °C where the viscosity is well known). Earlier results from others using

smaller diameter capillaries were probably distorted by an unappreciated artefact. D_2O and H_2O and their mixtures were studied.

6.5 J. Hrubý reported on measurements of the density of supercooled D_2O up to 100 MPa (co-authors M. Duška, P. Peukert, V. Hykl, V. Vinš). The experimental technique is based on observation of the change of height of a liquid column in two fused silica capillaries. The important improvements of the technique, the calibration of the capillaries and removing the polyimide protective layer, were reported. The measurements are relative to densities at corresponding pressure at 298.15 K and to density of synthetic fused silica. Moderate deviations (order of 0.1%) with respect to the current IAPWS standard were found. Final data will be provided before the end of 2016.

7. Proposed Improvements of IAPWS-95 Release

7.1 W. Wagner reported on behalf of the Task Group on Uncertainty Estimates of IAPWS-95 in Isobaric Heat Capacity (other members M. Thol, A. Harvey). In the region from 250 to 300 K and 100 to 400 MPa, an improved estimate of IAPWS-95 uncertainty for Cp was developed based on speed of sound data by Lin and Trusler. The region was divided into several subregions with increasing uncertainty towards low temperature and high pressure. A detailed report was provided to TPWS members prior to the meeting.

7.2 W. Wagner (co-authors A. Harvey, V. Holten) reported on a proposed improvement of the description of extrapolation for metastable subcooled liquid. With respect to new data available for the supercooled liquid, it was suggested that the statement about the performance of IAPWS-95 in this region be modified. In a subsequent discussion, it was suggested that also the statement for superheated water is modified by restricting extrapolation area to positive pressures.

W. Wagner announced that he has concluded his work concerning the IAPWS-95. The working groups expressed their gratitude for his devoted service.

7.3 Formal consideration of the Revised Release. A draft Revised IAPWS-95 Release has been prepared, incorporating the changes suggested in items 7.1 and 7.2. **TPWS unanimously approved the revised Release and recommended that it be sent for postal ballot by the EC following Editorial Committee review.**

8. V. Vinš reported on behalf of the Task Group on Surface Tension of Ordinary Water (other members A. Harvey, O Hellmuth, V. Holten, J. Hrubý, J. Kalová, R. Mareš, J. Pátek). The task was to review and analyze new and old literature data for surface tension and to revise the uncertainty estimates. New measurements for supercooled water using an altenative method agree with the published ones within their uncertainty. A new equation for the surface tension of water has been developed (J. Pátek, M. Součková, J. Klomfar, J. Chem. Eng. Data 61 (2016), 928−935). The equation has the form of the IAPWS Release, only the values of the parameters are modified. In the high-temperature region, the correlation relies solely on data by Voljak (1950) and Vargaftik et al. (1973), so it would be helpful if other data at high temperatures could be obtained. F. Caupin remarked that a group at Pau might have such data or be able to take them; the Task Group will investigate this.

R. Mareš reported on his measurements of surface tension for supercooled water using thin capillaries (down to I.D. 0.05 mm). An equation for the settling time has been derived. The settling time for thin capillaries approaches an hour.

B. Planková reported on computations of surface tension using molecular dynamics simulations. Anomalous temperature dependence reported in some earlier works has not been confirmed.

It was suggested, that the equation by Pátek et al. could be considered as a basis for a revised guideline. However, in the discussion it was suggested, that the equation should be adjusted to a proper value of the universal critical exponent. Also, it has been suggested that the measurements in the supercooled region are finished and that groups capable of surface tension measurements at high temperatures would be searched for. The Task Group will continue its work. **TPWS authorizes the TPWS Chair to nominate an Evaluation Task Group before the next meeting if it would help accelerate the process of finalizing a new Release.**

The possibility of a project for updating the IAPWS Release for the surface tension of heavy water was brought up, but this is not a high priority.

9. O. Hellmuth reported on the parameterization of humid air fugacity and enhancement factor. **A Task Group was formed to consider developing an IAPWS document based on recent work on an explicit approximation for the enhancement factor of water in humid air (and humid gases more generally).** The Task Group consists of O. Hellmuth (Chair), J. Hrubý, R. Feistel, A. Harvey, J. Cooper, and H.-J. Kretzschmar. More details are in the SCSW Minutes.

10. Metastable Water (joint with SC SW)

10.1 R. Romeo (co-authors S. Lago, P. A. G. Albo, S. Lorefice) presented measurements of densities of liquid water in stable and metastable (supercooled) states from 140 to 400 MPa. The measurements were performed using a modified isochoric method. Pressure of liquid in a cell with volume of about 30 cm^3 was recorded at varying temperature. The mass was determined based on IAPWS-95 by expanding the liquid at temperature higher than 0 °C into a smaller volume such that the resulting pressure was smaller than 10 MPa. The volumes of the cell and the expansion cell were determined gravimetrically. Coefficients of the linear pressure and temperature corrections of the cell volume were determined based on IAPWS-95 at temperatures higher than 0 °C. Uncertainty is estimated as 0.07 % in density. The data show a good agreement with other experiments and with IAPWS formulation for supercooled water.

10.2 J. Hrubý (co-authors M. Duška, P. Peukert, V. Hykl, V. Vinš) presented measurements of density of cold and supercooled water between 0.1 and 100 MPa using the same technique as for heavy water (c.f. item 6.5). The measurements are relative to densities at corresponding pressure at 298.15 K and to density of synthetic fused silica.

10.3 F. Caupin presented measurements of viscosity of supercooled liquid water under pressure and a two-state model interpreting these results.

10.4 J. Hrubý reported on behalf of the Task Group on Superheated Liquid Water (second member R. Feistel). Experimental data for specific volume and speed of sound of superheated water at positive pressures have been collected. A part of the data was not considered by IAPWS-95 developers. Extrapolated IAPWS-95 represents these data within the experimental uncertainty in agreement with the corresponding statement in the IAPWS-95 release (c.f. items 7.2 and 7.3)

10.5 As reported by O. Hellmuth, the Task Group on an ICRN for Interfacial Properties of Supercooled Water (other members J. Hrubý, J. Sengers), did not have any activity. The TG will continue with the same task.

10.6. V. Holten reported on behalf of Task Group on possible revision of IAPWS formulations for melting curves (other members A. Harvey, H.-J. Kretzschmar). The present equations are mostly based on old Bridgman data. Holten developed models of Gibbs energy of ices II, III, V, VI, enabling, in connection with an equation for the liquid phase, calculation of the phase diagram. Ice Ih was represented with the IAPWS formulation. Liquid water was represented by the supercooled water IAPWS formulation below 890 MPa and by IAPWS-95 at higher pressures. Linear temperature and pressure dependence of volume turned out to be insufficient. Final model is based on Birch/Murnaghan equation of state with 6 adjustable parameters for each ice phase. The task group will continue its work towards an improved model to replace the current IAPWS formulation for melting curves. It is hoped that the revision will be ready for IAPWS adoption in 2017.

NOTE: Items 11–14 are reported on in the SCSW Minutes.

11. 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)

12. Cooperation with other international bodies (joint with SC SW)

12.1 IAPWS/IAPSO/SCOR Joint Committee on Seawater, including updates to TEOS-10 (R. Pawlowicz)

12.2 Metrologia articles on BIPM/IAPWS interaction (R. Feistel)

12.3 Possible ISO work on (possibly impure) water for calibration and produced water properties for the oil industry.

13. Reports on seawater-related topics (joint with SCSW)

13.1 A standard for seawater sample handling (G. Budeus)

13.2 Thermophysical Properties of Natural Seawater samples (J. Safarov, A. Mirzalyiev, E. Hassel)

13.3 CO_2 Solubility in Seawater at wide range of salinities. (J. Safarov, S. Berndt, F.J. Millero, R. Feistel, A. Heintz, E. Hassel)

13.4 Update of the EMPIR project (S. Seitz and D. Stoica)

13.5 Absolute salinity and density using a hydrostatic weighting apparatus and using in-situ sound velocity sensors (H. Uchida)

13.6 Chinese Standard Seawater (Y. Li)

13.7 Salinity anomalies – Arctic Rivers and hydrothermal vents (R. Pawlowicz, H. Uchida, R. Woosley, F. Millero)

13.8 Salinity anomalies – a decade in the Baltic (S. Weinreben)

14. Proposed new IAPWS seawater-related documents (joint with SCSW)

14.1 Report on Guideline for Electrical Conductivity of Seawater (R. Pawlowicz)

14.2 Report of Task Group on Supplementary Release for a simplified density equation for oceanographic use (R. Pawlowicz, T. McDougall, P. Barker)

14.3 Report of Task Group on Advisory Note on IAPWS documents contributing to TEOS-10 (R. Feistel, A. Harvey, R. Pawlowicz)

14.4 Formal consideration of Advisory Note on TEOS-10.

15. Reports on miscellaneous TPWS scientific topics (joint with WG IRS and SC SW)

15.1 R. Feistel contributed to the discussion of the Task Group on Covariance in IAPWS work (other members J. Hruby, S. Seitz, J. Lovell-Smith, D. Friend). An article on the Uncertainty of Empirical Correlation Equations has been published (Metrologia 2016). When the covariance matrix of regression parameters is available, it is possible to estimate uncertainty of any property derived from the model. The method has been applied to the IAPWS-95 formulation. Uncertainty of second and third virial coefficients were estimated and these estimates were an order of magnitude smaller than an expert's estimates. In following discussion, it has been stressed that this failure is primarily due to neglecting non-diagonal terms in the covariance matrix of experimental data. However, no methodology is available for estimating them. Other contributors expressed skeptical opinions to the covariance method. However, it was generally accepted that it is desirable to improve the methods for uncertainty estimates. **A motion has been made that TPWS members developing a correlation are recommended to provide also the covariance matrix for the regression coefficients. This motion was approved.**

16. Joint session between TPWS and PCAS

16.1 J. Hrubý reported on the progress toward improved ideal-gas properties of ordinary and heavy water. The groups of A. Csaszar and J. Tennyson have completed a database of rotational-vibrational energy levels for important water isotopologues. The partition function and ideal gas thermodynamic properties are obtained from the energy levels in a straightforward manner. Data for the most abundant isotopologue $H_2{}^{16}O$ are being published. Data for $D_2{}^{16}O$ will be available soon. Less accurate data for the minor isotopologues will be also provided.

16.2 A. Harvey reported on behalf of the Task Group on Isotopic Fractionation (further members R. Feistel, D. Friend, J. Hrubý, K. Meier). Isotopic fractionation, i.e., unequal fractions of different isotopes (hydrogen or oxygen) between two phases in contact, is important, e.g., for tracing flows of matter in geophysical research. Isotopic fractionation can be of thermodynamic origin (isotopic effect on chemical potentials) or kinetic origin (effect on diffusion coefficients). Liquid-vapor, vapor-solid, liquid-solid fractionation were considered. Reliable correlations are partly available. At present, it appears that IAPWS cannot efficiently contribute to this field. The Task Group will continue, but is not assigned any tasks in the coming year.

16.3 S. Hielscher (co-authors A. Jäger, V. Vinš, R. Span, J. Hrubý, C. Breitkopf) reported on the progress in modeling gas hydrates relevant for carbon capture and storage. The model is based on the molecular model originally due to van der Waals and Platteuw for the hydrate and reference equations of state for the fluid phases and pure crystalline phases (ice Ih and dry ice). The model provides a better description of the phase equilibria with other fluid and solid phases. First results have been produced for a mixed hydrate system with variable fraction of methane and carbon dioxide guests in the clathrate matrix of water molecules.

16.4 M. Nakahara talked about the transformation from carbon-based chemical energy to hydrogen-based chemical energy. He discussed formic acid as a possible liquid carrier of hydrogen for such uses.

17. IAPWS Certified Research Needs (ICRNs)

ICRN 27 (on humid gases and CO_2-rich mixtures) was allowed to expire at the 2014 meeting, but a closing statement is still needed. R. Span and A. Harvey will provide this statement.

18. Reports on other TPWS activities

18.1 A. Harvey proposed an update of the Guideline on Fundamental Constants. The revision reflects an update of the values of fundamental physical constants (CODATA 2014) and recent evaluation of atomic weights. Further, a reference to the new Standard Mean Ocean Water (VSMOW2) was added. The changes do not have significant effect on IAPWS documents. **The update was approved unanimously.**

18.2 A. Harvey (co-author J. Cooper) reported on Advisory Note 2 "Roles of various IAPWS documents." **Minor updates in the document were approved unanimously, to be implemented by Harvey and Cooper in the coming months.**

18.3 M. Kunick informed about the completion and adoption of the IAPWS Guideline on the Fast Calculation of Steam and Water Properties with the Spline-Based Table Look-Up Method SBTL (M. Kunick, H.-J. Kretzschmar, F. di Mare, J. Hrubý, V. Vinš, I. Weber, R. Pawellek, A. Nový, A., D.G. Friend, and A.H. Harvey). The Guideline was adopted by IRS and TPWS at the 2015 Meeting, become official by March 31, 2016. The SBTL method has been implemented in software TRACE (CFD software DLR, Germany), Krawal and Dynaplant, Power Plant Siemens, Ebsilon. Other applications are being developed.

19. Other Business

19.1 Report on International Collaborative Projects: Project approved at the previous meeting (Czech-US) just started, it will be reported on in 2017.

19.2 **D. Friend was appointed to represent TPWS on the Gibbs Award committee**.

20. Membership: Phil Hill (deceased) is removed from membership. **Three new members of TPWS were proposed: Dr. Simona Lago (Istituto Nazionale di Ricerca Metrologica Italy), Dr. Frédéric Caupin (University of Lyon, France), Dr. Andreas Jäger, (Technische Universität Dresden, Germany). They were unanimously approved to be recommended to the EC for appointment to the Working Group.**

21. Contribution to Press Release

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

22. 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.

23. Adjournment

The meeting was adjourned at 3:15 p.m. on Thursday, September 15.

Preliminary Agenda for the IAPWS Working Group
Thermophysical Properties of Water and Steam (TPWS)

Dresden, Germany, September 12-15, 2016

1. Opening Remarks; Adoption of Agenda
2. Appointment of Clerk of Minutes
3. Potential International Collaborative Projects [Monday]
4. Industrial Requirements and Solutions for Steam Property Calculations, joint with WG IRS (Monday)
   - 4.1 Report of the Task Group "Industrial Advisory Note" (M. Hiegemann, B. Rukes, A. Singh, A. Harvey)
   - 4.2 Large eddy simulation of condensing steam in a turbine cascade (F. di Mare)
5. Editorial Changes for IAPWS Industrial Documents (joint with WG IRS and SC SW) (Monday)
   - 5.1 Report on proposed Editorial Changes on the Revised Supplementary Release on Backward Equations for Specific Volume as a Function of Pressure and Temperature v(p,T) for Region 3 of the IAPWS Industrial Formulation 1997 (M. Kunick, H.-J. Kretzschmar, W. Wagner, A. H. Harvey)
   - 5.2 Formal consideration of the Editorial changes to the Supplementary Release
   - 5.3 Report of proposed editorial changes to Advisory Note 5: Industrial Calculation of the Thermodynamic Properties of Seawater (S. Herrmann, H.-J. Kretzschmar, K. Orlov)
   - 5.4 Formal consideration of the Editorial changes to the Advisory Note
6. Heavy Water Properties (joint with WG IRS)
   - 6.1 Report of Task Group on Heavy Water Thermodynamic Properties (R. Span, A. Harvey, S. Herrig)
   - 6.2 Appointment of Evaluation Task Group for Heavy Water Formulation
   - 6.3 Report of TG for Heavy Water Transport Properties (J. Sengers, M. Assael, M. Huber, R. Perkins)
   - 6.4 Measurements of the Viscosity of Supercooled D_2O (Pierre Ragueneau, Amine Dehaoui, Bruno Issenmann, Frédéric Caupin)
   - 6.5 Measurement of the Density of Supercooled D_2O up to 100 MPa (M. Duška, J. Hrubý)
7. Proposed Improvements of IAPWS-95 Release
   - 7.1 Report of Task Group on Uncertainty Estimates of IAPWS-95 in Isobaric Heat Capacity (W. Wagner, M. Thol, A. Harvey)
   - 7.2 Report on improvement of description of extrapolation for metastable subcooled liquid (A. Harvey, V. Holten, W. Wagner)
   - 7.3 Formal consideration of the Revised Release
8. Report of Task Group on Surface Tension of Ordinary Water (joint with WG IRS and SC SW) (V. Vinš, A. Harvey, O. Hellmuth, V. Holten, J. Hrubý, J. Kalova, R. Mareš, J. Patek)

9. Humid Air Fugacity and Enhancement Factor, joint with SC SW (O. Hellmuth)

10. Metastable Water (joint with SC SW) [Tuesday]
    - 10.1 Experimental densities of water in stable and metastable states up to 400 MPa and comparison with dedicated equations of state (Raffaella Romeo, Simona Lago, P. Alberto Giuliano Albo, Salvatore Lorefice)
    - 10.2 Measurement of the density of supercooled ordinary water up to 100 MPa (M. Duška, J. Hrubý)
    - 10.3 Measurement of viscosity in supercooled water and representation with a two-state model (F. Caupin)
    - 10.4 Report of Task Group on Superheated liquid water, joint with WG IRS and SCSW (J. Hrubý, R. Feistel)
    - 10.5 Report on Task Group on ICRN for Interfacial Properties of Supercooled Water (O. Hellmuth, J. Hrubý, J. Sengers)
    - 10.6 Report of Task Group on possible revision of IAPWS formulations for melting curves (V. Holten, A. Harvey, H.-J. Kretzschmar)

11. 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) (Tuesday)

12. Cooperation with other international bodies (joint with SC SW) (Tuesday)
    - 12.1 IAPWS/IAPSO/SCOR Joint Committee on Seawater, including updates to TEOS-10 (R. Pawlowicz)
    - 12.2 Metrologia articles on BIPM/IAPWS interaction (R. Feistel)
    - 12.3 (ADDED) Possible ISO work on (possibly impure) water for calibration and produced water properties for the oil industry.

13. Reports on seawater-related topics (joint with SCSW) (Tuesday)
    - 13.1 A standard for seawater sample handling (G. Budeus)
    - 13.2 Thermophysical Properties of Natural Seawater samples (J. Safarov, A. Mirzalyiev, E. Hassel)
    - 13.3 CO_2 Solubility in Seawater at wide range of salinities. (J. Safarov, S. Berndt, F.J. Millero, R. Feistel, A. Heintz, E. Hassel)
    - 13.4 Update of the EMPIR project (S. Seitz and D. Stoica)
    - 13.5 Absolute salinity and density using a hydrostatic weighting apparatus and using in-situ sound velocity sensors (H. Uchida)
    - 13.6 Chinese Standard Seawater (Y. Li)
    - 13.7 Salinity anomalies – Arctic Rivers and hydrothermal vents (R. Pawlowicz, H. Uchida, R. Woosley, F. Millero)
    - 13.8 Salinity anomalies – a decade in the Baltic (S. Weinreben)

14. Proposed new IAPWS seawater-related documents (joint with SCSW)
    - 14.1 Report on Guideline for Electrical Conductivity of Seawater (R. Pawlowicz)
    - 14.2 Report of Task Group on Supplementary Release for a simplified density equation for oceanographic use (R. Pawlowicz, T. McDougall, P. Barker)

14.3 Report of Task Group on Advisory Note on IAPWS documents contributing to TEOS-10 (R. Feistel, A. Harvey, R. Pawlowicz)

14.4 Formal consideration of Advisory Note on TEOS-10.

15. Reports on miscellaneous TPWS scientific topics (joint with WG IRS and SC SW)

15.1 Report of Task Group on Covariance in IAPWS work (R. Feistel, J. Hruby, S. Seitz, J. Lovell-Smith, D. Friend)

16. Joint session with WG PCAS [Thursday morning]

16.1 Progress toward improved ideal-gas properties of ordinary and heavy water (J. Hrubý)

16.2 Report of Task Group on Isotopic Fractionation (R. Feistel, D. Friend, A. Harvey, J. Hrubý, K. Meier)

16.3 Progress in modeling gas hydrates relevant for CCS using reference equations of state and extension of the model for mixed hydrates (S. Hielscher, A. Jäger, V. Vinš, R. Span, J. Hrubý, C. Breitkopf)

16.4 Carbon today and hydrogen in the future for chemical energy (M. Nakahara)

17. IAPWS Certified Research Needs (ICRNs)

17.1 ICRN 27: Thermophysical Properties of Humid Gases and CO_2-Rich Mixtures (closing statement needed) (R. Span, A. Harvey)

18. Reports on other TPWS activities

18.1 Guideline on Fundamental Constants (A. Harvey)

18.2 Advisory Note 2 (J. Cooper, A. Harvey)

18.3 Completion and adoption of the IAPWS Guideline on the Fast Calculation of Steam and Water Properties with the Spline-Based Table Look-Up Method SBTL (M. Kunick, H.-J. Kretzschmar, F. di Mare, J. Hrubý, V. Vinš, I. Weber, R. Pawellek, A. Novi, A., D.G. Friend, and A.H. Harvey)

19. Other Business

19.1 Report on International Collaborative Projects

20. Membership

21. Contribution to Press Release

22. Preparation of the Formal Motion to the EC

23. Adjournment

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