

Minutes
IAPWS Thermophysical Properties of Water and Steam WG

SANTORINI, GREECE

JULY 4-8, 2005

NOTE: Items are listed according to their order on the agenda, which is attached as Attachment A. **Bold print** denotes significant actions. These minutes include some items (4-10) that were done jointly with the WG IRS and some (11f-h,12-14) with PCAS.

1-3. The meeting was opened on Monday, July 4 by the Chair, Dan Friend. The agenda (Attachment A) was adopted after numerous revisions. **New officers were elected; these will be H.-J. Kretzschmar as Chair and A.H. Harvey as Vice-Chair. If approved by the EC, these will take effect July 11.** Allan Harvey was appointed Clerk of Minutes. The minutes of the 2004 IAPWS TPWS WG meeting in Kyoto were approved.

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

5-7. [These items are reported in the IRS minutes.]

8. Prof. Kretzschmar presented a proposed document on the calculation of thermodynamic derivatives from IAPWS-95 and IAPWS-IF97. There was extensive discussion about whether this information should be an Advisory Note or have some less formal dissemination such as an FAQ on the Website. **A vote was taken with 9 in favor of the Advisory Note and 6 in favor of some alternative. Prof. Kretzschmar was authorized to make a draft of what would be Advisory Note #3, with the intention of having it adopted in 2006.**

9. Dr. Bellows from PCC raised the issue of future power cycles possibly requiring steam thermodynamic properties at temperatures above the upper limit of IAPWS-95 and pressures above the upper limit of IAPWS-IF97 Region 5. It was decided that, for the near term, extrapolated properties from IAPWS-95 were sufficient for exploratory calculations. If these cycles get closer to reality, we can look more closely at extending IAPWS-IF97 Region 5 to a higher pressure such as 30 MPa. Prof. Kretzschmar has already done some preliminary work in this area, and he was encouraged to continue.

10. Mr. Hiegemann presented his perspective on industrial requirements for working fluids. He first presented some small comments on water and steam properties. He then described the need for property standards for seawater to be used in condensers and possibly desalination. He will get input from industry before next year to assess the needs. He also described the need for properties of fuel gas to higher temperatures than those covered by current AGA and GERG formulations. Later Dr. Feistel described that seawater properties would also be needed for oceanography and he was working with the IAPSO (International Association for the Physical Science of the Oceans) on a proposal to work toward a new standard. **Dr. Feistel was appointed as our liaison to this organization. A Task Group on Seawater was appointed consisting of Feistel, Wagner, Harvey, and Hiegemann. A letter will be sent to IAPSO from the TPWS and IRS Chairs expressing our interest in working jointly on this problem.**

11a. Dr. Harvey reported that minor changes were needed to the Fundamental Constants Guideline to update references. **The WG endorsed the revisions.**

11b. Dr. Harvey reported that a document describing obsolete IAPWS documents, which had been requested 2 or 3 years ago, had been completed and placed on the Releases and Guidelines section on the IAPWS website. **Jan Sengers will write a FAQ on thermal conductivity near the critical point for industrial use. The new Seawater Task Group was assigned to write a FAQ on that subject, contingent on the approval of the joint project by the IAPSO.**

11c. There was nothing to report regarding the liaison with the IEC.

11d. Dr. Harvey reported on discussions as authorized by TPWS last year with the Chair of the Density WG of the CCM. The CCM is willing in principle to go forward with a joint clarification on the relative roles of their standard for metrology and the wider-ranging IAPWS standard. **The Task Group appointed last year (Harvey and Span) was authorized to go forward working on a joint paper in Metrologia and preparing an Advisory Note (recommending use of the CCM standard for metrology in its range of applicability and use of IAPWS-95 if it is needed to cover a wider range) to be adopted by IAPWS in 2006 or 2007.**

11e. Mr. Cooper presented a thorough analysis of converting the D₂O thermodynamic property release for the ITS-90 temperature scale, and presented a draft for a revised release. Changing the temperature scale within the current formulation does not adversely affect the accuracy within the uncertainty of the formulation. **The WG endorsed the draft revised release and requested approval by the EC subject to editorial revisions.**

11f. Mr. Okita presented some recommendations from the environmental Task Group regarding new trends in power generation for environmental reasons. This was refined later in the week and made into a priority list. In order, the top 5 priorities are (1) solutions for CO₂ capture (time scale, 2008); (2) properties of high-temperature steam (reliable transport properties needed by 2007, extension to higher temperatures for thermodynamic properties (extension of Region 5 to higher pressures) by 2010); (3) properties of humid air (needed quickly); (4) high-temperature oxidation (time scale 2008); (5) dew point of exhaust gases (needed quickly). The Task Group will continue its work with the goal of drafting some ICRNs addressing these priorities for possible adoption in 2006. Mr. Parry presented some related thoughts on future property needs in power generation; these are described in the IRS minutes.

11g-h. Prof. Yasuoka and Prof. Svishchev reported on the activities of the simulation Task Group over the past year. A definitive description of SPC/E water is being worked on, and future plans were described. Prof. Yasuoka also described his progress in simulating bubble nucleation.

12. Dr. G. Ghosh described his physically based model for the refractive index of water.

13. Dr. Harvey described some issues (both new data and theoretical considerations) suggesting a possible need for revision of the current IAPWS standard for the dielectric constant of water. No immediate action was planned at this time.

14. Prof. Lvov described his work on a new formulation for water's self-ionization constant. **He was authorized to proceed forward toward making this work an IAPWS Release for possible adoption in 2006.** Prof. Nakahara reported new experimental data on the self-diffusion coefficient of water to high temperatures and pressures. He was encouraged to continue this

pioneering work and it was the opinion of the working groups that this would be a good subject for an IAPWS Guideline.

15. Prof. Kretzschmar reported on the work of the EU project on properties of humid air for compressed air energy storage. Work is proceeding forward but is hampered by lack of data.

The WG recommends that the ICRN on the topic of properties of humid air and combustion gases be renewed for an additional 3 years.

16. Prof. Sengers explained the history of IAPWS viscosity standards. Dr. Friend presented the new formulation and a draft Release and expressed appreciation to Dr. Huber of NIST who had done much of the work. The WG decided that there was a need for the Release to say something about extrapolation to higher temperature. With that caveat, the WG **adopted the following schedule with an aim of adoption of the Release at the Annual Meeting in 2006:**

Sept. 30, 2005 Deadline for comments by WG members on draft document

Dec. 31, 2005 Completion of evaluation by evaluation Task Group

Jan. 15, 2006 Evaluation report distributed to Working Group

Feb. 15, 2006 Deadline for input from WG members

March 1, 2006 Finalized draft of Release to Editorial Committee

April 1, 2006 Approval by Editorial Committee

April 15, 2006 Final Release distributed to National Delegates

The Evaluation Task Group for viscosity consists of Mares (chair), Konas, Alexandrov, Cooper, and Ueno.

P. Konas presented work on analysis of the thermal conductivity database and examined extension of the correlation to high pressures and possible reduction in the number of parameters.

Prof. Mares was added to the Transport Property Task Group for its ongoing work on thermal conductivity.

17. Dr. Feistel presented a Gibbs potential that had been derived for ice, along with a draft Release. There was discussion about the content of the Release; it was decided that some of the background material needed to be removed (and just reported in the published paper), that some text about uncertainties needed to be added, and other suggestions were given. **The WG decided to proceed ahead with a release with the following schedule:**

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An evaluation committee for the ice release was appointed consisting of Hruby (chair) and Harvey.

18. The WG recommends to add to TPWS membership Dr. Rainer Feistel (Germany) and Dr. Jan Hruby (Czech Republic).

19. Dr. Harvey distributed an interim report on the work done on the IAPWS Collaborative Grant between the U.S. and Russia. With regard to potential contributions to life sciences, at this point we consider our work on seawater as a first step in that direction. Dr. Friend was thanked for his years of service as TPWS Chair.

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

21. The meeting was adjourned at 4:15 PM on Thursday, July 7.

Agenda

IAPWS Thermophysical Properties of Water and Steam WG

SANTORINI, GREECE

JULY 3-8, 2005

Monday:

1. Opening Remarks; Adoption of Agenda
2. Officers; Appointment of Clerk of Minutes
3. Approval of Minutes of TPWS WG in Kyoto, Japan (August/September 2004)
4. *Potential International Collaborative Projects
5. *Supplementary release on $v(p,T)$ backward equations in region 3
 - Report of the Evaluation Task group (Kiyoshi Miyagawa)
 - Formal Consideration of Supplementary Release by WGs TPWS and IRS
6. *Computing time investigations of the IAPWS-IF97 backward equations
7. *Revision of Advisory Note #2

Tuesday AM:

8. *Differential quotients of IAPWS-IF97 and IAPWS-95, preparation of a guideline
9. *Extension of IAPWS-95 Formulation
10. *Requirements for Working Fluids: An Industrial Point of View
11. Reports on Other TPWS Activities
 - (a) Fundamental Constants
 - (b) Website Issues/Obsolete Items
 - (c) Liaison with IEC
 - (d) Liaison with CCM
 - (e) D₂O Properties

Tuesday PM:

- (f) +Report of the Environmental Task Group
- (g) +Simulation Task Group
- (h) +Simulation of Bubble Nucleation in Water
12. +Physically based model for the refractive index of water
13. +Dielectric constant
14. +The ionization constant of water-new formulation, also new data for diffusivity.

Thursday:

15. Properties of humid air; status report of the EU project AA-CAES
16. A new equation of state for ice; proposal for a release
17. Transport properties of water and steam
18. Membership
19. Other Business
 - Report on International Collaborative Projects
 - Renewal of ICRN
 - Potential contribution to life sciences
 - Educational Initiatives
20. Preparation of the Formal Motion to the EC
21. Adjournment

* Joint with WG IRS

+ Joint with WG PCAS

June 30, 2005