Minutes of meeting of working group
Industrial Requirements & Solutions (IRS)

Lucerne, Switzerland, 27. – 31. August 2007

Remark: Most of the IRS meetings were held as joint meetings with TPWS (marked by *). Of these joint meetings the IRS minutes cover the topics chaired by the IRS chairman.

1. **Opening remarks, Adoption of Agenda**
   Chairman B. Parry welcomed the WG members to Lucerne. The agenda was adopted with slight adjustments.

2. **Appointment of Clerk of Minutes**
   I. Weber was appointed clerk of minutes.

3. **Approval of Witney Meeting Minutes**
   The minutes of the 2006 IRS WG meeting were approved unchanged.

   A different procedure for a more effective approval of the minutes was suggested by members of the WG. The proposal is that the minutes are sent out to all WG members directly after the meeting requesting any comments / corrections within a defined time frame. Any comments will be incorporated and the updated minutes are distributed again. If no comments are received anymore the minutes are approved. The "approval of the minutes" topic of the WG agenda could be eliminated.
   The EC will be informed that WG IRS will proceed accordingly.

4. **Revised Release on IAPWS-IF97 including extension of Region 5***
   a. **Report of the Task Group**
      W. Wagner had presented a full report on the topic last year in Witney, no additional technical information was given this time. The proposed changes to the release were presented last year, the evaluation task group evaluated the equations and the revised release document.
   b. **Report of the Evaluation Committee**
      R. Mares presented the results of the evaluation on behalf of the task group chair K. Miyagawa. The evaluation task group found that the accuracy meets the requirements, that the computing speed is acceptable and that the wording of the draft is acceptable. The evaluation task group recommends to the WGs to adopt the revised release.
   c. **Formal Consideration of the Revised Release by the WGs TPWS and IRS**
      The WGs unanimously voted to recommend to the EC that the revised release is adopted.

5. **Industrial Requirements for Steam Property Calculations***
   Bill Parry presented an overview about the speed requirements for water / steam properties throughout the years - starting from the early times when speed was not a factor all the way to the requirements of Computational Fluid Dynamics (CFD). CFD modeling requires vast numbers of property calls, as an example simplified modeling of a low pressure section of a steam turbine requires property calls in the order of magnitude of 10^{13}. Considering this huge number of calculations using the fastest existing method (TTSE) the calculation still would require roughly a day. However, the goal is a detailed CFD model with all nozzles, leakages, etc. This kind of calculation would again multiply the required property calls by a factor of 10000. I.e. the current speed capabilities are by no means acceptable for this type of calculation. Accuracy is an important factor, however consistency plays an even more important role. With the current quality of consistency CFD calculations will not be successful, additional iterations within the property function routines are required – causing additional time requirements. It was the opinion of the

WGs that table-lookup methods would be the method of choice for this type of application. Another aspect of CFD calculations is the question of modeling metastable states. Here the question arises how the expansion through the saturation line is to be modeled correctly. Some discussion evolved about the "metastable issue", it was mentioned that this topic has been discussed a few times already without any concrete result. Problem is that the behavior depends on many factors which partly are outside the pure thermodynamic field.
As a conclusion of the discussion the following tasks where identified:

- **a.** A task group was founded to establish requirements and current possibilities for high-speed property functions. Members of the task group are: W. Parry (chair), B. Rukes / I. Weber, M. Hiegemann, R. Mares, N. Okita, H.-J. Kretzschmar and K. Miyagawa. It was suggested to utilize the forthcoming 15th ICPWS to present future requirements for water/steam property routines for industrial use.
- **b.** J. Hruby agreed to found a task group for homogeneous nucleation. P. Blangetti agreed to contact Mr. Yamamati, an expert in this field. Additionally R. Feistel offered to contact people during the forthcoming meeting of the Organization on Nucleation Theory and Applications in Dubna / Moscow, Russia. Possibly some kind of workshop within the framework of the 15th ICPWS could be organized.

6. Advisory Note No. 3 on Thermodynamic Derivatives from IAPWS Formulations*

- **a. Report of the Evaluation Committee**
  N. Okita presented the report of the evaluation task group consisting of K. Miyagawa and N. Okita. No major issues were found, only minor corrections were communicated. After amendment the advisory note was checked by the editorial committee. The evaluation task group recommends to the WGs to adopt the advisory note.
- **b. Formal Consideration of the Advisory Note by the WGs TPWS and IRS**
  The WGs unanimously voted to recommend to the EC that the advisory note is adopted.

7. Development of New Equations for Melting Pressure and Sublimation Pressure*
See TPWS minutes.

8. Properties of Liquid Water at Atmospheric Pressure*
See TPWS minutes.

9. Ideal-Gas Properties*
See TPWS minutes.

10. Transport Properties of Water and Steam*
See TPWS minutes.

11. Transport Properties of Heavy Water*
See TPWS minutes.

12. Properties of Humid Air and Humid Combustion Gases*
See TPWS minutes.

13. Workshop on Properties of Seawater*
See TPWS minutes.

14. Reports on Other TPWS & IRS Activities*
See TPWS minutes.

15. Membership
There were no membership items to be discussed this year.

16. Other Business*

See TPWS minutes.

17. Preparation of Report to Executive Committee
The Chairman and Clerk of Minutes will prepare the report to the EC.

18. Adjournment
The Chairman adjourned the IRS working group meeting at 30. August 2007, 5:30pm.

Agenda
of
Industrial Requirement and Solutions Working Group

LUCERNE, SWITZERLAND, 26 TO 31 AUGUST 2007

1. Opening Remarks, Adoption of Agenda
2. Appointment of Clerk of Minutes
3. Approval of Minutes IRS WG in Whitney, UK (September 2006)
4. Revised Release on IAPWS-IF97 including extension of Region 5, joint with WG TPWS
   - Report of the Task Group (W. Wagner)
   - Report of the Evaluation Committee (R. Mares)
   - Formal Consideration of the Revised Release by the WGs TPWS and IRS
5. Industrial Requirements for Steam Property Calculations (W. Parry)
   - 5.1 CFD – The Need for Speed
   - 5.2 Tradeoffs between Speed, Consistency, and Accuracy
   - 5.3 Metastable Considerations
6. Advisory Note No. 3 on Thermodynamic Derivatives from IAPWS Formulations, joint with WG TPWS
   - Report of the Evaluation Committee (N. Okita)
   - Formal Consideration of the Advisory Note by the WGs TPWS and IRS
7. Development of New Equations for Melting Pressure and Sublimation Pressure, joint with WG TPWS
   - Report of the Task Group (W. Wagner)
8. Properties of Liquid Water at Atmospheric Pressure, joint with WG TPWS
   - Report of the Task Group (A.H. Harvey, J. Hruby)
9. Ideal-Gas Properties, joint with WG TPWS
   - Report of the Task Group (R. Feistel)
10. Transport Properties of Water and Steam, joint with WG TPWS
    - 10.1 Viscosity
      - Report of the Task Group (J.V. Sengers)
      - Report of the Evaluation Task Group (R. Mares)
      - Formal Consideration of the Release by the WGs TPWS and IRS
    - 10.2 Thermal Conductivity
      - Report of the Task Group (J.V. Sengers)
      - Appointment of an Evaluation Task Group
11. Transport Properties of Heavy Water, joint with WG TPWS
    - Report of the Task Group (J.R. Cooper)
    - Formal Consideration of the Revised Release by the WGs TPWS and IRS
12. Properties of Humid Air and Humid Combustion Gases (A.H. Harvey), joint with WGs IRS and PCC (Tuesday morning)
    - 12.1 Measurements of the Water Vapor Concentration Enhancement in Compressed Air, Nitrogen, and Argon with FTIR Spectroscopy (M. Wendland)
    - 12.2 First-Principles Calculation of Interaction Second Virial Coefficients Between Water and Common Gases, Including Air (A.H. Harvey)
    - Dew Point of Combustion Gas
      - Report of the Task Group (N. Okita, R. Span, J. Hruby)

Update for ICRN-14: Thermophysical Properties of Humid Air and Combustion-Gas Mixtures (R. Span)

13. Workshop on Properties of Seawater (P. Tremaine), joint with WGs IRS, PCAS, PCC (Tuesday afternoon)

14. Reports on Other TPWS & IRS Activities
    - 14.1 Fundamental Constants (A.H. Harvey)
    - 14.2 Update of Advisory Note No. 2: Roles of Various IAPWS Documents. (A.H. Harvey, J.R. Cooper)
    - 14.3 Download of Steam Tables for Pocket Calculators from the IAPWS Website
    - 14.4 Liaison with IEC (J.R. Cooper), joint with WG IRS
    - 14.5 Liaison with CCM (A.H. Harvey, R. Span)
15. Membership
16. Other Business (Joint with TPWS)
    - 16.1 Use of IAPWS-IF97 for the Calculation of the Density for Determining the Dielectric Constant and Refractive Index (W. Wagner)
    - 16.2 Topics for the 15th ICPWS 2008 in Berlin (B. Rukes, I. Weber)
    - 16.3 Report on International Collaborative Projects
    - 16.4 Gibbs Award Committee
    - 16.5 Acknowledgements on IAPWS Documents
17. Preparation of the Formal Motion to the EC
18. Adjournment