IAPWS Working Group Power Cycle Chemistry (PCC)

Minutes of IAPWS PCC WG Meetings
Doorwerth, The Netherlands, 7-10 September 2009

Chairman: Robert Svoboda
Members present See PCC Attachment A

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1. Agenda

1.1 Amendments / Adoption of Agenda

Andy Rudge requested the addition to item 4.6 of consideration of ISO standard 5667 Part 7 on sampling.

1.2 Week program: split up of PCC for joint workshops and task groups

Robert Svoboda summarized the schedule.

2. Appointment of Clerk of Minutes

Geoff Bignold agreed to act as Clerk of Minutes.

3. Approval of Minutes of PCC WG in Berlin, Germany, 2008

The minutes were approved without any corrections.

4. Progress Reports on PCC Activities 2008 / 2009

4.1 International Collaboration

Derek Lister reported that the earlier international collaboration on sampling had been successfully extended (on own funds) to include computerized fluid dynamics studies of steam sampling equipment. He indicated that there remains the question of the alterations of the sample in the sampling equipment (lines, valves etc). It was decided to launch a new proposal for IAPWS International Collaboration. DL agreed to lead the drafting of a proposal to cover the next stage (draft to be submitted for approval by end of 8 September 2009).

Action D.Lister

Karol Daucik advised that the work should take full account of the developments on the relevant ISO standard.

Andy Rudge indicated an interest from Imperial College, London (Dr M.Trusler) for involvement on flue gas condensation issues. He agreed to discuss this with Dr Okita (since it falls outside the PCC remit).

Action A.Rudge

4.2 ICRN

ICRN #13 – on surface tension. Frank Gabrielli agreed to submit a closure statement.

Action F.Gabrielli

ICRN #18 - on thermal degradation of ion exchange resins. Karol Daucik reported that there had been little or no research undertaken in response to this ICRN. However, in view of the increasing use of resins in combination with air cooled condensers, the topic was viewed as of increased importance. The ICRN should therefore be extended in 2010 for a further period.

ICRN #19 – on coolant sampling. Derek Lister reported that work currently in progress is demonstrating a further research requirement. The ICRN will therefore be continued for a further period. The ICRN should therefore be extended in 2010 for a further period.

ICRN #20 – on high temperature sensors. Work in progress is yielding useful results but Shunsuke Uchida restated the case for further work particularly for the nuclear plants. He indicated that an update to the ICRN is required and he agreed to undertake this in coordination with Sergei Lvov.

Action S. Uchida

4.3 PCC Task Groups

Barry Dooley reported progress on the development of IAPWS Guidelines. A guideline on chemical instrumentation for fossil fuelled plants had been drafted, circulated to national committees for comment and revised in response to the comments received. A subcommittee meeting (G. Bignold, M.de Whispelaere, S.-E. Therkildsen and BD) on 7 September had agreed the best approach to the final outstanding nomenclature issue. A revision will be issued to national committee chairmen with the aim of achieving endorsement by the IAPWS executive on 11 September.

A guideline document on chemical instrumentation for nuclear plants is being prepared under the leadership of S.Uchida.

Jim Bellows indicated that no progress had been made on the proposed guideline on steam purity requirements for steam turbines.

Action J Bellows / R Svoboda

BD confirmed that the work on development of guidelines should continue at the present level of activity.

Karol Daucik reported progress of the Task Group on damage assessment in power plants. A draft paper on the first stage of the evaluation process has been prepared and is available for discussion.

4.4 European Standard EN 12952:12

Geoff Bignold reported that the CEN committee responsible for organising updating of EN 12952 had voted to retain the current version of Part 12 by a single vote majority (6 in favour of retaining the current version against 5 in favour of revision). However, the extent of comments received from countries in favour of revision was such that the position would be discussed further at their next meeting on 5 March 2010.

Robert Svoboda responded that the next step should be to identify the national representatives on CEN who had voted against revision and to ensure that they are made fully aware of the case.

Action G Bignold

4.5 PCC Public Relations

There was a consensus in favour of on-going efforts to publicise the work of PCC via publications with the appropriate level of acknowledgement, conference papers based on the guidance documents, etc. Jim Bellows suggested that items on the IAPWS website should be supplemented with appropriate key words to maximise the impact. This approach should also be suggested to the other working groups at the executive meeting.

Action R Svoboda

Jim Bellows also suggested that presenting information on PCC initiatives at meetings of other bodies such as the appropriate ASME subcommittee would also be beneficial. Barry Dooley agreed to progress this.

Action B Dooley

4.6 Other Action List Items

4.6.1 ISO 5667 Part 7

Andy Rudge reported that BIAPWS have been asked to take part in the BSi committee responsible for the updating of ISO 5667 Part 7 on Steam and Water Sampling in Boiler Plant. This is a very much better standard than EN 12952:12 and in a recent ISO ballot only one vote had been cast in favour of revision. BIAPWS had identified two issues that required re-examination (iso-kinetic sampling in plant under flexible operation, and the criteria for flow rate in terms of Reynolds Number).These will be discussed at an ISO meeting in Vienna in the near future.

Robert Svoboda strongly supported BIAPWS approach to involvement with the major standards organisations.

5. Priority List Review

The priority list was discussed on a point by point basis. The outcome is attached (attachment B).

6. Changes in PCC Task Groups

No changes to task group formulation or objectives were raised.

TASK GROUP PROGRESS:

Production of IAPWS Guidelines (B. Dooley in chair)

BD reminded members of the scope and justification of the work on Technical Guidance Documents, which are major IAPWS products of high authority and comparable with the precedence for such products set by the other IAPWS working groups.

The Technical Guidance Documents on **Philosophy of Cycle Chemistry Control** remains in preparation (task group = **M.Rziha,** F.Gabrielli, F-U. Leidich and M. Ball). F-U.L reported that the group had agreed the structure and scope for the document, but were yet to proceed beyond the first iteration. He agreed to contact M.Rziha for a current status update with the intention that the work should continue on the current basis for completion and endorsement by the 2010 IAPWS meeting.

Action F-U Leidich

The Technical Guidance Document on **Instrumentation for Monitoring and Control of Cycle Chemistry for Steam/water Circuits of fossil-fired and combined cycle power plants** was reviewed, giving particular attention to the final edits covering the comments received from the German delegation. PCC approved the circulation of the final version to national representatives and the submission for executive committee endorsement on 11 September.

Action R Svoboda / B Dooley

The scope of a Technical Guidance Document on **Instrumentation for monitoring cycle chemistry in Nuclear Plants** was discussed by S. Uchida. The presentation on this topic had been circulated in advance of the meeting and comments had been made by D.Lister. The issues to be covered are potentially wider than for conventional plants. It was agreed that a nuclear subcommittee – S.Uchida, D.Lister and A.Rudge – should convene to clarify if such support is appropriate for the nuclear community and if so, then to develop a more detailed outline of the content of the document.

Action S.Uchida / D.Lister / A.Rudge

Jim Bellows and Robert Svoboda agreed to develop an outline of content for a Technical Guidance Document on **Steam Purity Requirements for Steam Turbines.**

Action J Bellows / R Svoboda

The topic of a possible Guidance document on **Sampling** techniques and issues was discussed. This item should await the outcome of on-going international collaboration and developments of the ISO standard.

Barry Dooley advocated the development of a Technical Guidance Document on **Cycle Chemistry for Steam/water Circuits of fossil-fired and combined cycle power plants using volatile conditioning** (AVT and OT). The members of the group who had worked on the

instrumentation guideline (de Wispelaere, Therkildsen, Dooley and Bignold) together with K.Daucik agreed to collaborate on this. BD agreed to ask Malcolm Ball if he would be willing to lead the task.

Action B Dooley

Task Group on quantification of risk of asset damage accrued from operation outside of targets.

Karol Daucik presented the progress to date on a document that he had circulated to the task group for their further input. The document sets out an evaluation of the lost relative marginal return. The calculation for a supercritical fossil plant indicated that every hour off load resulted in loss of 10^{-5} times the capital cost. (It was noted that this figure should be adjusted, because the cost of the first two days are much higher due to the price of urgent replacement generation.)

When calculating lost absolute marginal return a calculation of the probability of event was necessary. This was defined as relative extra life time consumption due to chemical excursion. The extra life time consumption was calculated on the basis of a published exponential chemical index.

A simple worked example of the calculation was included. This calculated the marginal return loss and probability of a serious event if a hypothetical unit operates for 30 years very strictly according to EPRI guidelines, using all the flexibility for chemical excursions given in them. The result was the probability of 1 and cost of 1.2 M€. It indicates that there will be a chemical problem at the end of the designed lifetime of a unit, even if it operates strictly after EPRI guidelines.

The project now requires data from utilities that have suffered chemistry related damage in order co calibrate the method and justify the outcome. Members were requested to send available data to KD.

The group agreed to continue with the presented evaluation strategy, but any comments are still welcome. KD agreed to circulate the current draft to all members of PCC.

Action K Daucik

7. ICRN

The following ICRNs were discussed in a joint meeting with the PCAS Working Group:

ICRN# 17 on Amines. Jim Bellows received comments that enable the production of a version suitable for submission to the executive.

Action J Bellows

ICRN# 21 on Ultra-supercritical plant. In the absence of Peter Tremaine, comments received on this were noted by Robert Svoboda for the generation of an updated version to be submitted to the IAPWS executive.

Action R Svoboda

ICRN# 22 on Chemistry of the phase transition zone. This had been substantially reformatted and amplified during the last year. M Stastny received further comments and offers of assistance from A Rudge to enable its presentation to the executive committee for support.

Action M Stastny / A Rudge

ICRN# 25 on Corrosion mechanisms that are related to the presence of contaminants in steam/water circuits – Geoff Bignold introduced this draft ICRN for initial comments. It was agreed that this should be circulated to all members of PCC and PCAS for consideration.

Action G Bignold

8. Proposals for International Collaboration

Derek Lister developed the new proposal (raised under item 4.1) for submission to the IAPWS Executive.

9. Other Business

Karol Daucik raised the requirement for consideration of the kinetics of decomposition of ammonia and its reactions with plant materials at temperatures anticipated in ultra-supercritical units. It was noted that this has not caused practical problems in plants operating up to 620ºC, but, as future temperatures are higher, it was agreed to add the issue into ICRN #21.

Action J Bellows

On the proposal to set up a subgroup on waste water and cooling water issues (Priority list item 13) Robert Svoboda agreed to discuss this with other Working Group Chairmen and to raise it at the executive committee meeting.

Action R Svoboda

A number of members of PCC had received and responded to a request from Eric Maughan at ESKOM to provide information on regulation of aqueous effluent disposal issues. No further PCC action was deemed to be necessary.

10. Changes in Membership, election of Officers

PCC noted with great sadness the recent death of Otakar Jonas. Robert Svoboda stated that his last two communications to PCC covering on going projects and unsolved issues would again be circulated to all PCC members.

The following members have been contacted to establish their willingness to continue as PCC members:

W.Allmon	Barry Dooley confirmed his continuing involvement.
L Guinard	will not continue membership. Robert Svoboda will invite a replacement representative from EDF.
V.Kritski	B Dooley / S Uchida will contact again.

P.Saidl Robert Svoboda confirmed her continuing involvement.
J.Vosta The Czech delegation communicated that he will not be able to continue in the group.
Hideki Takiguchi It was indicated that he may have different assignments.
R.Svoboda to clarify PCC membership.

11. Preparation of Action List 2009 / 2010, Task Distribution, Next Year's Agenda

Proceed with ICRN #17, 21, 22 and 25 (see 4.2)
Proceed with Task Group work (see 6.)

12. Preparation of PCC WG Report for Executive Meeting

- Summary of new ICRN
- Present modifications on draft Guidance Document "Instrumentation for Monitoring and Control of Cycle Chemistry for Steam/water Circuits of fossil-fired and combined cycle power plants"
- Overview of planned other Guidance Documents
- Perspective for diversification of IAPWS workgroups on Waste Water and Cooling Water.
- Propose adding keywords to IAPWS documents on the website so that they can be found with an Internet search engine
- Personnel changes.
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13. Miscellaneous and Adjournment

PCC minutes, Doorwerth September 2009

Those present at the PCC WG meeting were as follows:

J Bellows	USA	
G Bignold	UK	
A Bursik	Germany	
K Cramer	Switzerland	
K Daucik	Denmark	
F de Vos	Netherlands	
B Dooley	Canada / USA	
F Gabrielli	USA	
P Gotovtsev	Russia	
J B Hughes	UK	
I Jiricek	Czech Republic	
F U Leidich	Germany	
D Lister	Canada	
K Marugame	Japan	
A Minaev	Russia	
A Rudge	UK	
M Stastny	Czech Republic	
R Svoboda	Switzerland	(Chair PCC)
H Takaku	Japan	
S-E Therkildsen	Denmark	
S Uchida	Japan	
S Vidojkovic	Serbia	
M de Wispelaere	Belgium	

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PCC Priority List for Further Research

1. Interfacial situation in advanced ultra supercritical plants

Formation and exfoliation mechanism of scale (oxide films) in steam lines
effects of chemistry (oxygen, ammonia ?)
Corrosion interactions materials / steam, influence / effect of
supercritical parameters, protective layers, radiation
Faster decomposition of chemicals (TOC, ammonia etc)?

Status 2009: Joint PPC/PCAS ICRN #21 to cover some of these topics has been drafted; comments by US natl. comm. to be considered, draft to be supplemented by chemical / thermodynamic considerations, volatility of oxides etc. (Harvey to lead update, with Palmer, Dooley, Tremaine, Harvey, Bellows)

2. Mechanism of Decomposition of Ion-exchange Resin

Operating conditions, quality control of resin; leak rates are slow, but sulphate is one of the products, organic leachables, oxidation.
Additional information has to be researched.

Status 2009: ICRN # 18 has been issued in 2006, no activities known in 2009, should be extended at 2010 meeting

3. Development / Application of Sensors (Ambient and High Temperature Sensors)

ECP (nuclear, fossil application), ORP,
problem: abstract parameters, acceptance by plant operators

Status 2009: ICRN #20 has been issued in 2006, some activities known in 2009 (Balashov, Petkin, Lvov), extension in 2010 together with needs from nuclear industry (Uchida, Lvov)

4. Improved analysis of low concentration of metals (Fe, Cu, Co, etc in the ppb range)

Techniques for analysis are known, but problems with implementation.

PCC to clarify by 2010 meeting if IAPWS/PCC could support on this matter.

5. * Corrosion mechanisms that are related to the presence of contaminants in steam/water circuits, particularly in boiler-water

Define critical species / quantify critical quantities of steam generator water impurities, synergy with other species (e.g. oxygen), consideration of the materials

Status 2009: Geoff Bignold drafted ICRN #25; draft to be circulated within PCC and PCAS for finalizing

6. The relationships between the chemistry of the contaminants and their concentration at point of measurement

Detailed definition of the problem. Additional problems with adequate sampling, especially of Fe, Cu, Co, Oxygen, etc.

ICRN: Lister + Daucik; ICRN #19 on sampling of corrosion products has been issued. International collaboration 2006/7 has been performed: Piti S. (Lister, Daucik, Svoboda). 3 papers on "nozzles" by Piti et al, Status 2009: plan to extend collaboration to "sampling lines" (Lister, Uchida)

7. * The quantification of risk of asset damage

Problems of getting background data, important long-term issue
need: tool for operators, design engineers & commercial persons
PCC: to provide basic background data, e.g. corrosion / deposition rates

PCC task group has been set up (chair: K.Daucik)
Status 2009: task group in progress

8. Improved understanding of condensation mechanisms

- dropwise vs filmwise condensation in condensers (improve heat transfer),
- heterogenous – homogeneous nucleation models for prediction of condensation in steam turbines (chemistry, electrostatic,...),
- chemistry of the phase transition zone in nuclear turbine systems

ICRN draft#22 written, (Stastny, Rudge, et al; Stastny to finalize and send to PCC chair for processing

9. Deposition of contaminants and corrosion products in steam and water circuits

- supersaturation,
- mass transfer,
- adsorption,
- crystal nucleation,
- deposit re-dissolution,
- scouring and exfoliation,
- activation and activity transport in reactor systems
- Mechanism and Influence of Cu Deposition:
  (essentially a solved problem from a scientific viewpoint)
  - mechanism of deposition on a turbine blade is not understood
  - discrepancies in temperature influence on deposition (?)

Status 2009: opportunity for several ICRN, to be re-considered in 2010

10. Radiation chemistry of water

Radiolysis, main importance for nuclear generation

2007 PCAS/PCC presentations have been made
Status 2009: no activities

11. * Behaviour of Aluminium in the steam / water cycle

- Al release under various water treatment regimes
- volatile carry-over and deposition in the turbine
- deposition on boiler tubes,
- solubility in water and steam
- behaviour in condensate purification
- interaction of Al with boiler chemistry
- specification values for Al in feedwater, boiler water, steam

Status 2009: topic still pending, practical data to define scope of problem incoming, ICRN and / or publication for 2010 (Rziha, Svoboda)

12. Water cooling of copper in electrical machines

- generator stators
- accelerators

Status 2009: paper at ICPWS 2008; EPRI guideline 2008, CIGRE guidance, new investigations Palmer Svoboda considered

Water use outside the steam / water cycle

- cooling water
- waste water
- external process
- recycling for use as make-up
- etc.

For further consideration for 2010, possibly new IAPWS sub-committee

*** *urgent priority***

The numbering in the list is made for reference only and does not contain any information on actual priority

In addition, PCC should maintain awareness of the following items

- Chemistry and corrosion related items to future nuclear generation systems (6-best-design-reactor concepts, Generation 4 reactor plants, ITER)

- High pressure / high temperature steam and humid air (24 MPa and up, 2000°C), thermophysical properties and chemistry formulation.
  (Long term interest in power industry, Treated in TPWS)

- Water and steam chemistry in geothermal power plants (large amount of information available, but still insufficient for guidance; further consideration for 2010)

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PCAS / PCC workshop (08/09/2009 13:30 - 15:30)

Physical chemistry research needs for the power industry

1. Thermodynamic Analysis of the Efficiency of Membrane Electrolyte Assembly of Hydrogen Fuel Cells (F. Maršík, T. Němec, S. Lvov)

2. Electrophoretic Mobility and Zeta Potential of Magnetite at Temperatures Corresponding to the Power Plant Operation Conditions (S.Vidojkovic, V. Rodrigez, M. Fedkin, S. Lvov)

3. Behavior of Copper-Oxides in ultra pure water systems as for generator cooling (R.Svoboda)

4. International Collaboration on: " Aqueous transition metal Chloro-complexes over a wide range of temperatures and pressures" (Jana Ehlerova, J.Sedlbauer, P.Tremaine)

5. Discussion of draft ICRN #17: “Research on Amines for the Power Industry” (J.Bellows)

6. Discussion of draft ICRN #21: “Thermophysical properties associated with ultra-super critical coal fired steam generators”. (R.Svoboda)

7. Discussion of draft ICRN #22: “Steam Chemistry in the Turbine Phase-transition Zone”. (M.Stastny)

8. Introduction of new draft ICRN #25: "Corrosion mechanisms that are related to the presence of contaminants in steam / water cycles" (G.Bignold)

PCC workshop (08/09/2009 08:30-10:30 and 10/09/2009 08:30-10:30)

Update on Power Cycle Chemistry Research and Experience

1. Prospective Using of Sea Water for Power Plants Equipment (A.Minaev)

2. Instrumentation for Monitoring and Control of Water Chemistry for Nuclear Power Plants (S. Uchida)

3. CFD Modelling of High-Temperature Sampling Systems (D.Lister, Piti S., K.Daucik, R.Svoboda)

4. Design of a steam sampling device (K.Daucik)

5. What is the best advice on sample system flow rate? (G.Bignold)

6. Condensation of water steam with NaCl impurity flowing in a nozzle and in a turbine cascade (M.Stastny)

7. The Effect of Pre-filming on the Growth Behavior of Oxide Scales in High-temperature Steam (M.Yoshida, K.Marugame, M.Miyajima and H.Takaku)

8. Evaluation of Corrosion Damage of Structural Materials in NPP cooling systems by Coupling Analysis of Corrosion and Flow Dynamics - Flow acceleration and Liquid Droplet Impingement (S.Uchida)

9. Artificial neural networks for water chemistry analysis (D.Smetanin, P.Gotovtsev)