IAPWS Working Group Power Cycle Chemistry (PCC)

Minutes of IAPWS PCC WG Meetings
Plzeň, Czech Republic, 4-9 September 2011.

Chairman: Robert Svoboda
Members present See PCC Attachment A

1. Agenda

1.1. Amendments / Adoption of Agenda
There were no amendments to the draft agenda.

1.2. Week program: split up of PCC for joint workshops and task groups.
R. Svoboda summarized the schedule.

2. Appointment of Clerk of Minutes

G. Bignold agreed to act as Clerk of Minutes.

3. Approval of Minutes of PCC WG in Niagara Falls, Canada, 2010

The minutes were approved without any corrections.

4. Progress Reports on PCC Activities 2010 / 2011

4.1. International Collaboration

D. Lister reported that progress with the collaboration on sampling had been unavoidably delayed as a result of the Japanese earthquake disaster. He described the development of equipment for the programme and the results of initial tests showing the need for adaptations to experimental techniques to avoid the influence of the iron content of the titanium sample lines on the results. The student, J. Xiong, had benefitted from substantial help and advice from S. Uchida, K. Daucik and R. Svoboda. The delays would require extension of the programme into 2012.

R.Svoboda commented on the variations between the tests with titanium sample lines and the common industrial practice of using stainless steel. He suggested that experiments in stainless steel using radiotracers would be a valuable alternative.

M. Rziha suggested the use of hot thioglycollic acid for recovering deposited iron (rather than the nitric/hydrofluoric acid mixture that had proved too aggressive).

J. Bellows noted the importance of controlling redox conditions in generating the source iron for the tests.

G. Bignold indicated that practical plant experience was that mixtures of dissolved iron and particulate oxides gave substantially higher total iron concentrations than had been generated in the experiments to date.

T. Petrova asked for clarification of the chemistry used to control pH in the samples. LiOH had been used for pH control.

F-U. Leidich indicated examples in ultra-supercritical plants where carbon steel materials have been used for sample lines; release of materials from these has influenced conductivity and pH.

The progress report is available in PCC 2011 workshop handouts. The continuing importance of the topic of representative sampling was agreed.

The PCC had no new proposals for international collaboration in 2011. D. Lister suggested that a proposal for a further phase of work would be appropriate and agreed to produce a draft for PCC consideration by end of May 2012.

Action D. Lister

4.2. ICRN

ICRN#13 on Surface tension. F. Gabrielli had prepared a closure statement. R.Svoboda proposed its circulation to PCC members for their agreement.
Action R. Svoboda

ICRN#17 on Amines. J.Bellows undertook to provide an update to A. Harvey (for IAPWS website) by the end of the meetings.

Action J. Bellows

ICRN#18 on Thermal decomposition of ion exchange resins. A closure statement has been published (K. Daucik). No further action.

ICRN#19 on Sampling of corrosion products. Subject to minor updating on the basis of the on-going work.

ICRN #20 on High temperature sensors. S Uchida presented the current version of this ICRN at the PCC workshop. It was agreed that the draft should be fully supported. R. Svoboda will seek Executive approval for postal ballot by National Committees.

Action R.Svoboda

ICRN#25 on Corrosion mechanisms that are related to the presence of contaminants in steam/water circuits, particularly in boiler-water. W. Cook had incorporated all comments received on the draft and undertook to have further discussions with J.Bellows and G Bignold before submission to PCC for approval. Deadline - end of September.

Action W. Cook, J Bellows, G. Bignold.

ICRN#26 on Behaviour of Aluminium in the Steam Water Cycle of Power Plants has been circulated to National Committees for postal ballot in October 2010.

4.3. PCC Task Groups

IAPWS Guidance documents

B. Dooley reviewed progress over the last three years. Three guidance documents have been issued, covering carry-over, key instrumentation and AVT chemistry for steam/water circuits and all are now in widespread use worldwide.

The most recent changes to the new guidance document on alkaline treatments for drum boiler plants were presented by B. Dooley and unanimously approved by PCC. It was agreed that this document is now ready for presentation to the IAPWS Executive for final approval on 9 September.

Action R. Svoboda

H. Takaku introduced a number of potential updates to the guideline document on instrumentation for power cycle steam/water cycles. These included introduction of an additional column covering optional choices within the tables and the use of silica monitors for drum boiler water. The suggestions were debated. The case against recommending silica monitoring for boiler water was put forward by M.Rziha. The case for keeping optional alternatives in the main text of the document rather than in the tables was made by B.Dooley and M.Rziha. G.Bignold agreed to lead a task group to consider the upgrades proposed by the Japanese committee and to submit a revision for PCC consideration. Task Group to include M, Ball, B.Dooley, M. Hellman, F.-U. Leidich, M. Rziha, H. Takaku.

Action G. Bignold

S.Uchida reported that, as a result of discussions between interested parties, the proposal to develop a guidance document for circuit chemistry for nuclear plants, potentially in collaboration with IAEA, has been put in abeyance at this time.

R.Svoboda reported that progress has been made on the development of a guidance document on steam purity requirements for steam turbines. It is aimed to circulate an early draft for comment by the end of November. Task Group comprises B. Dooley, J. Bellows, M. Rziha, R. Svoboda, H. Takaku.

Action R. Svoboda

The potential for a guidance document on sampling and QA/QC for steam/water circuit monitoring was discussed. M. Rziha stated the strong case for the production of such a

document. F-U. Leidich reported that VGB are actively producing a document covering sampling; G. Bignold also stated that an ISO standard exists and is currently under revision. PCC agreed that an IAPWS guidance document should be aimed at underwriting the strategy of the more specific recommendations in ISO, VGB and other more detailed guidelines. A Task Group will be led by D. Lister and will comprise P. Colman, W. Cook, k. Daucik, F.-U. Leidich, H. Takaku, K. Thomsen, R. Svoboda and S.Uchida.

Action D.Lister

PCC policy with regard to review of guidance documents was debated. It was agreed that the documents can be updated whenever there is new information to be included, and would be subject to review every five years.

Quantification of chemistry related asset damage,

K. Daucik reported that, despite the importance, no new information had been made available since the last meeting. Accordingly, he agreed to prepare a paper for publication, based on the material that he had presented in 2009.

Action K.Daucik

4.4. European Standard EN 12952

G.Bignold reported that the task of revision of both of the CEN standards covering boiler water chemistry requirements (EN 12952 part 12 and EN 12953 part 10) had been added to the work lists of the Working Groups of CEN technical committee TC269. The working groups had yet to implement this work.

BIAPWS will continue to maintain contact with the revision (via representation by M. Robson on BSi and via representation by P. Colman on the Irish Standards committee).

4.5. PCC Public Relations

R. Svoboda expressed the PCC's gratitude to A. Bursik for publication of information about PCC meetings in PowerPlant Chemistry.

The suggestion made by J. Cooper that the subject of the Guidance Documents should be the basis for a Symposium at the ICPWS in 2013 was endorsed.

B. Dooley recommended that there should be a change to IAPWS Statutes to elevate the Technical Guidance Documents to the same level of authority as IAPWS Releases. This would make Guidance Documents major activities of IAPWS. R. Svoboda agreed to take this proposal to the executive.

Action R. Svoboda

PCC supported the proposal that they should be actively associated with the forthcoming relevant conferences on water chemistry of nuclear reactor systems (France 2012) and on flow accelerated corrosion (USA an France 2013).

A proposal for a letter to every manufacturer of fossil and combined cycle plants promoting the use of the IAPWS Guidance Documents was discussed. No actions were agreed.

4.6. Other Action List Items

There were no other items not covered on the agenda.

5. Priority List Review

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

6. Other Business

PCC re-examined the current mission statement and M. Rziha proposed that it remains fully fit for purpose and requires no updating in 2011. This view was unanimously agreed. R. Svoboda will report this position to the executive.

Action R.Svoboda

M.Rziha chaired a discussion PPC views on the topics for the ICPWS in U.K. in 2013. The PCC's proposals to the ICPWS programme committee and IAPWS executive are set out in Attachment D.

7. Changes in Membership, election of Officers

News of the recent death of Eric Maughan was greeted with great sadness. Eric's lively temperament and capacity for open debate will be sadly missed. J.Bellows will convey PCCs condolences to Mrs Maughan.

R. Svoboda has completed five years as PCC Chairman and is now stepping down. The appointment of M. Rziha as Chairman was unanimously agreed.

M. Rziha proposed that A. Rudge be approached to stand as new vice-chairman. PCC agreed to this suggestion. R. Svoboda will contact A. Rudge to request that he should take on the role. Action R.Svoboda

D. Smetanin has withdrawn from membership of PCC (information supplied by T. Petrova).

B. Hughes has recently left the industry. His status with respect to PCC will be clarified by BIAPWS (G. Bignold).

Apologies for absence from the current meeting had been received from Andre Bartos, Frank Gabrielli, Richard Harries, Sven-Erik Therkildsen and Andy Rudge.

The following new members of PCC were proposed and unanimously accepted.

New Member	Proposed by:	Seconded by:
Karsten Thomsen	K. Daucik	M. Rziha
Pavel Gotovsev	R. Svoboda	B. Dooley
Willy Cook	D. Lister	R. Svoboda
Frank de Vos	M. Rziha	G. Bignold
Gary Joy	B.Dooley	R. Svoboda
Melonie Myszczyszyn	J. Bellows	K. Daucik

R.Svoboda will propose acceptance of these additional PCC members by the executive committee.

8. Preparation of Action List 2010 / 2011, Task Distribution, Next Year's Agenda

9. Preparation of PCC WG Report for Executive Meeting

10. Miscellaneous and Adjournment

Plzeň, Czech Republic, 4-9 September 2011

Those present at the PCC WG meeting were as follows:

J Bellows	USA
G Bignold	UK
A. Bursik	Germany
P.Colman	Ireland
W Cook	Canada
K Daucik	Denmark
F de Vos	Netherlands
B Dooley	Canada / USA
A. Drexler	Germany
A. Fredrikson	Sweden
P Gotovtsev	Russia
S Hanawa	Japan
V. Hanus	Czech Republic
M. Hellman	Sweden
I Hey	Canada
T Ichihara	Japan
G.Joy	Auatralia
B. Larin	Russia
F.-U. Leidich	Germany
D Lister	Canada
H. Kido	Japan
M Miyajima	Japan
M Myszczyszyn	Canada
T. Petrova	Russia
P. Rudasová	Czech Republic
M Rziha	Germany
P Safařik	Czech Republic
M.Štăstny	Czech Republic
R Svoboda	Switzerland (Chair PCC)
H Takaku	Japan
K. Thomsen	Denmark
S. Vidokovic	Serbia
S Uchida	Japan
H. Zychová	Czech Republic

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PCAS / PCC workshop (Tuesday 13:30 - 15:30)

1. Andre Anderko: "Thermodynamic Modelling of Processes Related to Carbon Dioxide Capture and Sequestration" (*)

2. Vaclav Vins, Andreas Jäger, Johannes Gernert: "Development of Thermodynamic Models for Hydrates in Water–Carbon Dioxide Mixture" (*)

3. Joint PCSAS / PCC discussion on draft ICRN 20: Sensors for use at Elevated Temperature in the Plant Cycle of the Power Industry" (Uchida)

4. Satoshi Hanawa (JAEA): "High Temperature ECP Sensors to Be Applied in An In-pile Loop of An Experimental Reactor"

5. Hiroshi Takaku, (Prof., Shinshu University, retired), Li-Bin Niu (Associate Prof., Shinshu University) and Hodaka Katou (Graduate Student of Shinshu University):
"Crevice corrosion of LP steam turbine materials evaluated by electrochemical re-passivation potential measurement in simulated AVT water with mixed chloride and sulphate ions"

6. Robert Svoboda, Brett A.Reinboth, Matthias Svoboda: "Monitoring generator cooling water system chemistry by the electrochemical potential"

7. Miroslav Stastny, Miroslav Sejna: Effects of Expansion Rate on Binary Condensation of NaCl and Steam Flowing in a Turbine Cascade"

PCC workshop (Tuesday 08:30-12:00 and Thursday 08:30-10:00)
Update on Power Cycle Chemistry Research and Experience

1. Tarou Ichihara , Haruka Kido (Mitsubishi Heavy Industries, LTD.): "Achievement on OT (Oxygenated Feed-Water Treatment) Application in Japan"

2. Shunsuke Uchida: (JAEA) "The Effects of Ferrous Ion Transport in Bulk Water on FAC Rate"

3. M. Yoshida and K. Marugame (Naigai Chemical Products Co.), M. Matsumura (Hiroshima University) H. Takaku: "The Evaluation of FAC by Jet-In-Slit Equipment and the Effect of Pre-filming on the FAC"

4. I.Burakov, T.Petrova (MPEI): "Influence of amines on corrosion rate of carbon steel in boiling water"

5. P.Gototvtsev, V.Voronov. "Mathematical Modelling at Cycle Chemistry Monitoring Systems"

6. Andreas Drexler, Ute Ramminger, Jörg Fandrich (Areva): "Conditioning and Lay-up of secondary side systems in nuclear power plant with film forming amine"

7. Shunsuke Uchida (JAEA): "Water Chemistry Guidance in Nuclear Power Plants in Japan"

8. Michael Rziha (Siemens): "Overview on VGB-working groups activities regarding the guidelines R450 (Chemistry Steam Water Cycle - update), and R451 (Sampling - new guideline)"

9. Karsten Thomsen (Vattenfall, DK): "Action limits and supervision in the revised VGB 450L guideline"

10. Frank-Udo Leidich (Alstom): "Cold end corrosion in steam turbines: diagnosis and remedies"

11. Jinbiao Xiong (University of Tokyo), Derek Lister (University of New Brunswick): "Results of the International Collaboration Project on improved sampling techniques for corrosion products in water"

12. B.M.Larin, E.N.Bushuev, Yu.Yu. Tikhomirova, S.V.Kiet (Ivanovo State Energy University); "Determination of Phosphate Concentration in Boiler Water using Conductivity Measurements"

Plzeň, Czech Republic, 4-9 September 2011

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 2011: Joint PPC/PCAS ICRN #21 is on the IAPWS website

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

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

Status 2010: ICRN #20 has been issued in 2006, some activities known in 2009 (Balashov, Petkin, Lvov), re-formulation in 2010 related to the needs from nuclear industry (Uchida), 2011: still on-going

3. * 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 2011: Geoff Bignold drafted ICRN #25 and passed the responsibility to Willy Cook. To be finalized in 2011 (Cook, Bignold, Bellows)

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

Main scope will be the minimum requirements for sampling specifically for Fe, Cu, Co, Oxygen, etc.

Status 2011: ICRN #19 on sampling has been extended to 2012. International collaboration 2006/7 2010/2012. (Uchida, Lister, Daucik, Svoboda). 4 papers by Piti et al. IAPWS Guidance Document on sampling under consideration

5. * 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 2011: available information has been compiled, although insufficient for being basis of an IAPWS document, a publication on the existing results will be made (Daucik, 2012)

6. Improved understanding of condensation mechanisms

- dropwise vs filmwise condensation in condensers (improve heat transfer)
- heterogeneous – homogeneous nucleation models for prediction of condensation in steam turbines (chemistry, electrostatic,...)

- chemistry of the phase transition zone in nuclear turbine systems
- development of liquid films on surfaces in saturated steam environments
  (especially with regard to Flow Accelerated Corrosion)

ICRN #22 is on the IAPWS website; additional ICRN on FAC related issue may be considered for 2012

7. 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 2011: wide range of information available and research ongoing, opportunity for several ICRN

8. Radiation chemistry of water

Radiolysis, main importance for nuclear generation

2007 PCAS/PCC presentations have been made

Status 2011: major issue for supercritical water reactors. Workshops held regularly in connection to the bi-annual International Conference on Water Chemistry in Nuclear Reactor Systems

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

- **Al release under various water treatment regimes**
- volatile carry-over and deposition in the turbine
- depsoition on boiler tubes,
- solubility in water and steam
- behaviour in condensate purification
- interaction of Al with boiler chemistry
- specfication values for Al in feedwater, boilerwater, steam
- impact of the use of Al on materials and cycle chemistry of the rest of the cycle

Status 2011: ICRN #26 in processing, final draft is available (Rziha, Svoboda)

10. Water cooling of copper in electrical machines

- generator stators
- accelerators

Status 2011: paper at ICPWS 2008;EPRI guideline 2008, CIGRE guidance document to be published (draft document approved), new investigations Palmer/Svoboda considered

11. Water use outside the steam / water cycle

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

For further consideration for 2012, possibly new IAPWS sub-committee.
PCC does not have the resources to take leadership on these items.

12. Chemistry in geothermal and oil / sand cycles

Behaviour of water constituents, effects on system materials, geochemical and waste water issues, including behaviour of radionuclides in these waters.

Status 2011: ICRN to be considered for 2012 (Leidich, Rziha, Myszczyszyn)

**** 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 IV 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)

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Symposia for 16th ICPWS

Number	Title
1	Calculation of Props for Industry *Including Water Injection into Gas Turbine Compressors*
2	Thermodynamic & Transport Props of Aqueous Systems
3	Molecular Simulation & Spectroscopy in Aqueous Systems
4	Non Equilibrium, Metastable & Critical State
5	Thermodynamics & Kinetics in Hydrothermal Systems
6	Electrochemistry & Corrosion in High Temperature Water
7	Apparatus, Materials & Monitoring Instrumentation for Application at High Temperatures & Pressures
8	Power Cycle Chemistry in Plants with Fossil and Renewable Energy Sources

- Combined Cycles
- Fossil Fired Plants
- Solar Plants
- Geothermal Plants

- **Separate Half Day Workshop** on *IAPWS Technical Guidance Documents*
  # Introduction of Guidance Documents
  # Discussion on Philosophy of Guidance Documents
  # Discussion with Expert Panel (Members from PCC)
  # Discussion for the Needs on New Guidance Documents

9	Power Cycle Chemistry in Plants with Nuclear Energy Sources Fusion Reactors (ITER) Supercritical Reactors, Generation 4 Reactors, etc. *Safety and New Build*
10	Water Purification & Chemistry of Auxiliary Systems

- Auxiliary Systems
- Cooling Water
- Air Cooled Condenser
- Membrane Techniques
- Re-use of Water / Zero Discharge Concepts
- Hybrid Cooling Systems

11	CO_2 in Power Generation Capture, Transportation& Storage
12	Hydrothermal Geochemistry
13	*Supercritical Water for Advanved Materials Synthesis Waste Treatment etc.*
14	Themophysical Props. of Sea Water. Application to Global Climatic and Oceanographic Modeling & Desalination