



REPORT ON THE WP4 "NUCLEAR CORROSION" ACTIVITY

SPRING 2004 - SPRING 2005

BY

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The activity of the WP4 "nuclear corrosion" has been conducted with the main objectives which have been approved during the Budapest WP4 meeting (September 2003) and which are recall hereafter:

- o To provide links between European teams in nuclear corrosion field, with an opening on to the world.
- o To stimulate opportunities of exchanges on technical subjects related to corrosion behaviour and to the today main nuclear research areas (waste systems, water reactors, Generation IV and fusion reactors ...)
- o To attract interest of Euratom and of international nuclear organisations.

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1. EFC WP4 MEETINGS

Two meetings are now organized each year: one spring meeting and the autumn meeting during Eurocorr's.

The first spring meeting took place in Paris on April 16th 2004 and was mainly devoted to the nuclear corrosion research programs inside Euratom funded programs of the 5th PCRD -LIREs and INTERWELD programs- and of the 6th PCRD - PERFECT program (minutes EFC-CEA-040514). 11 members were participating to this first spring meeting.

29 members participated to the autumn meeting during Eurocorr'2004 in Nice (minutes EFC-CEA-041028) while 23 members were in Antwerp (Belgium) for the last spring meeting on 15th April 2005

2. EUROCORR'2004

Two events have been organized in Nice:

- "The 2nd Workshop on prediction of long term corrosion in nuclear waste systems"
- The general session which focus mainly on light water reactors.

Four keynote lectures and 28 oral presentations have been made. It could be recall also that two plenary lectures were initially proposed as keynotes for the nuclear sessions (D.D. Macdonald and Peter Scott lectures). These two events lasted 2.5 days which could be compared to the one day session during in Budapest (Eurocorr'2003).

As decided during the Paris 2004 spring meeting, it is now planned to have two sessions during Eurocorr's: the general session open to the different nuclear corrosion issues, and a specific subject workshop.

It has been decided during the open discussion at the end of the workshop to hold this workshop on prediction of long term corrosion in nuclear waste systems each four years in Europe either during Eurocorr or as a specific event, and if possible, with the support of international nuclear agencies (NEA and/or IAEA).

3. EFC EVENT N°279: SEMINAR ON "HIGH TEMPERATURE ELECTROCHEMISTRY IN LIGHT WATER REACTORS" (MINUTES BASED ON R.W. BOSCH'S REPORT)

The seminar has been organized by R.W. Bosch in connection with the final meeting of the European Community project LIREs (Development of Light Water Reactor reference electrodes). The objective of the seminar was to give an overview of the developments of electrochemical methods and techniques for use in high temperature high pressure aqueous environments in Europe and to focus on their application to Light Water Reactors. The seminar ended by a roundtable to discuss the actual status and future of Nuclear Corrosion research in Europe. More than 40 participants from 14 different countries were present at the seminar which consisted of 9 scientific presentations and a roundtable discussion.

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The first presentation was given by Prof. Digby Macdonald (Penn State University, USA). He gave an overview of different types of reference electrodes, showing the main difference between the electrochemistry of a BWR and a PWR and stressed the importance of the role of electrochemistry in stress corrosion cracking phenomena.

The second lecture (R.W. Bosch, SCK-CEN, Belgium) gave an overview of the LIRES project. The main results were the development of three types of reference electrodes (external Ag/AgCl, YSZ (Ni/NiO) and Rh-electrode) that could be used inside a NPP. All types were shown to work at high temperature and constructed from irradiation resistant materials. The YSZ- and Rh-electrodes have been test in MTR's under BWR and PWR conditions. They could properly measure ECP values for at least one reactor cycle.

The third presentation (A. Molanders, Studsvik Nuclear, Sweden) showed that ECP measurements on out-of-core locations (but in-pipe) have been performed regularly at Swedish NPP for the last 20-years. There main application is to check if the HWC worked properly. For the secondary side OWC (Oxygenated Water Chemistry) has been suggested. For application of OWC ECP measurements were shown to be very useful to control the water chemistry.

The fourth lecture (T. Saario, VTT, Finland) summarizes the main applications of electrochemical techniques to solve problems encountered in NPP's. These problems are: (1) stress corrosion cracking, (2) activity build-up in the primary circuit and (3) fuel cladding corrosion.

The fifth lecture (Thomas Dorsch, Framatone ANP, Germany) described the application of the electrochemical noise technique to detect stress corrosion. Although problems are still encountered in proper measurement and analysis of this electrochemical noise, the ECN technique is in principle able to detect in-situ and non-destructive stress corrosion cracking.

The sixth presentation (M. Navas, Ciemat, Spain) shows results of the LIRES Round Robin test were different high temperature reference electrodes were compared based on a previously defined testing standard.

The seventh presentation (Marek Postler, NRI Rez, Tscheck Republic) showed an investigation to the link between SCC and ECP under various environmental conditions (reducing versus oxidizing).

The last two presentations (Gabor Nagy, AEKI, Hungary and M. Tupin, CEA, France) showed results on the investigation of zircalloy cladding materials using electrochemical techniques. It was shown that with Electrochemical Impedance Spectroscopy (EIS) the processes that happens at the material solution interface could be unravelled, but also that an oxide layer thickness could be determined in-situ.

The seminar was concluded with a roundtable to discuss the actual status and future of Nuclear Corrosion research in Europe. First Takis Manolatis (EU Scientific Officer) gave a small overview of the actual status of the 6th Frame Work program. He emphasized on the added value of community funded research being: bring people together, promote co-operation, improve utilisation of infrastructures, provide multidisciplinary to improve understanding on scientific/technological basis. A strong focus is on education and training of people. For Euratom programs, there will be probably only one future call for proposals before the end of the 6th Framework program. Damien Feron gave a presentation about the European Federation of Corrosion and more particularly the WP 4 Nuclear Corrosion. He also presented a proposal of a coordination action (CA) related to Nuclear Corrosion for Euratom programs. Major goal of this proposal is to structure the long term European R&D capabilities related to nuclear corrosion. A large and open discussion focused on specific items like the possibility for US to participate to a European program (Prof. Macdonald question), the added value for EC to

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finance something already existing (EFC WP4), the integration of our colleagues from Eastern Europe to the works done by the EFC WP4.

Due to the limited amount of time, the discussion was continued during the reception, which ended friendly this day seminar. It has been a very fruitful meeting for the participants with a high technical and scientific level of the presentations. It has to be emphasized that the historical location (Leuven University Library) is the appropriate location for this type of event and could be used again for some other EFC WP4 seminars... Many thanks to R.W. Bosch for the perfect organisation, the friendly atmosphere and this very fruitful seminar.

EFC Event n°279: Seminar on "High Temperature Electrochemistry in Light Water Reactors", in Leuven, Belgium (thanks to Kerner Zolt for the photographs)

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4. STATUS OF EFC WP4 REPORTS

3.1. "Corrosion of metallic heritage artefacts"

This report is based on papers presented during the common sessions "Heritage Artefacts" and "Nuclear Corrosion" at EUROCORR'2004, as heritage artefacts can be used as archaeological artefacts for nuclear waste management studies (long term prediction). It aims to "filling the gap" between the Nuclear Corrosion world, carrying out studies on long term corrosion prediction, and the "conservation of heritage artefacts" world. Ph. Dillmann (CNRS, France) organises this report in 4 chapters: general overview, mechanisms and prediction, investigation and archaeology, monitoring and conservation. The 20 reviewed papers are about to be returned to the authors for modification.

3.2. Other reports

Two other WP4 reports are planned to be published in the EFC series:

High Temperature Electrochemistry in Light Water Reactors based on the papers presented at the EFC event 279.

"Corrosion issues in Light Water Reactors", based on the 27 papers presented during WP4/WP5/WP18 sessions at Eurocorr. It is planned to divide it into 6 chapters: overviews, SCC susceptibility, SCC propagation, Zirconium behaviour, tribocorrosion, practical experience. This publication is done in connection with the WP5 and the WP18.

The proceedings of the 2nd International Workshop on "Prediction of Long Term Corrosion Behaviour in Nuclear Waste Systems" are about to be published (planned in June 2005): publication without reviewing, available free of charge on demand (made by ANDRA, French national agency for nuclear waste management). The objective is to disseminate widely the scientific and technical exchanges which occurred during the workshop.

4. EUROCORR'2005

As decided during the WP4 Autumn 2004 meeting in Nice, two sessions are organised for Eurocorr'2005 by the WP4:

- * a 2 days workshop (Workshop 8) entitled "Corrosion Issues in Future Nuclear Systems" that includes a keynote by D. Quadakker (Germany), 22 orals, 3 posters which proceedings are planned to be published in EFC series.
- * a 1 day session (Session D) that includes a keynote by J. Hickling (EPRI, USA), 12 orals and 9 posters; it is planned to select some papers for publishing in the Journal of Nuclear Materials in order to inform the nuclear material community of the scientific and technical exchanges which take place during the Eurocorrs.

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5. EUROCORR'2006

It was decided during the last WP4 spring meeting in Antwerp that two sessions will be proposed to the Eurocorr'2006 organisers:

The Nuclear Corrosion session

The specific workshop: The proposal of workshop presented in Nice about "Corrosion Issues related to LWR Ageing and Life Extension" has been cancelled, after a large discussion and debate between participants, because the congress "Fontevraud 6" that is about this particular topic will take place just a week before EUROCORR'2006. A new proposal for a workshop on "Corrosion issues in reprocessing plants", justified by the fact that Europe has two of the three existing reprocessing plants, needs the agreement of the involved industries; the oral agreements of BNFL (UK) and AREVA (France) have been received already, while the agreement of JNFL (Japan) and maybe others industries are under discussion.

6. EVENT N°284: WORKSHOP "NUCPEPF 2006" ON CORROSION AND LONG TERM PERFORMANCE OF CONCRETE IN NUCLEAR POWER PLANTS AND WASTE FACILITIES

This Workshop is organized by EDF and CEA (France) with the sponsorship of EFC WP4 and of OECD/NEA. It will take place in Cadarache (France) on March 27-30th, 2006. It has to face the importance of long term performance of concrete in nuclear industry with specific requirements in terms of tightness and of durability. Not only corrosion of concrete will be discussed during this event, but also corrosion in concrete reinforcement, problems of radiolysis in concrete and radiolysis linked to corrosion, etc. The importance of the NEA co-sponsoring has to be underlined as it is the first time and it gives an international dimension to the event. More information is given on the NUCPEPF web site: www.NUCPEPF2006.fr or by Email at the following address: nucperf@cea.fr

7. EFC WP4 GROUPS

After a large discussion with EFC secretariat (P. McIntyre) and with WP4 members, about the possibility of closed groups inside the EFC or WPs, it has been decided at the Nice meeting to create two "mirror-groups" inside the WP4 to keep the WP informed about non-confidential matters and future collaborations (like open workshops).

1. "European Cooperative Group on Corrosion Monitoring of Nuclear Materials" (ECG-COMON, chairman: A. Molander, Studsvick, Sweden, WP4 correspondent: S. Ritter, PSI, Switzerland). The 1st annual meeting will take place on June 6-7th, 2005 in Ljubljana (Slovenia) at ZAG and that will be about:
 - o presenting past, current and future researches/results concerning the topic of the ECG-COMON and discussions
 - o planning a 1st Round Robin test about measurement equipments of electrochemical noise
2. European Expert Group on Corrosion of Internals in LWRs (EEG-CILWR) which is the mirror-group of the AMALIA group. The link is made by F. Sevini (Euratom, EU)

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Another group (open group) is not yet operational but is planned on "revised stability diagrams", with A. Pourbaix as the coordinator. As the original thermodynamic stability diagrams dates back to 1963 and new thermodynamic data are now available; there is a need of revised, validated, more complete E-pH stability diagrams specially regarding more complex materials/higher temperatures, this huge work is needed to produce a tool of reference for every researcher interested in this field. A. Pourbaix made a proposal based on a funding from the EU. It will be one of the major objectives of 2005-2006 for the WP4 to start this work on one of the fundamental knowledge needed for long term prediction.

In June 2004, an Expression of Interest was send to EU on Nuclear Corrosion and discussed during the K.U. Leuven Seminar in November, 2004 with Takis Manolatis (EU Officer) who was very impressed by the nuclear corrosion community and actions. Unfortunately, the last Euratom call for proposal (April 2005) did not include nuclear corrosion.

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