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Summary Record of the First Meeting

NEA Headquarters, Issy-les-Moulineaux, France
16th November 1995

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TASK FORCE ON COMPUTING RADIATION DOSE AND MODELLING OF NUCLEAR RADIATION-INDUCED DEGRADATION OF REACTOR COMPONENTS (TFRDD)

Summary Record of the First Meeting held at
NEA Headquarters, Issy-les-Moulineaux, France, 16th November 1995

Participants

H. Ait Abderrahim	SCK/CEN	Belgium	
C. Højerup	Risø	Denmark	
P. Aaltonen	VTT	Finland	
C. Diop	CE Saclay	France	
I. Kodeli	CE Saclay	France	
G. Hehn	University of Stuttgart	Germany	**(Chairman)**
J. Koban	Siemens AG	Germany	
M. Pescarini	ENEA, Bologne	Italy	
H.R. Hwang	KAERI	Korea	
A. Hogenbirk	ECN, Petten	Netherlands	
R. Hakansson	Studsvik, Nykøping	Sweden	
J. Paratte	PSI, Villigen	Switzerland	
T. Lewis	Nuclear Electric, Berkeley	United Kingdom	

NEA Secretariat:

Ph. Savelli, Deputy Director
A. Miller, Division of Nuclear Safety
R.P. Rulko, Data Bank
E. Sartori, Data Bank

General

1. The meeting was opened by the Chairman, G. Hehn, from the University of Stuttgart, who welcomed attending members of the TFRDD group and introduced the scope and objectives of the meeting.

2. The scope and objectives of the meeting were defined as:

- to discuss primarily the status of computational methods for radiation dose prediction and also issues of basic phenomena of radiation-induced degradation of materials;
- to discuss the preparation of the state-of-the-art report to be submitted to the next NSC meeting in May 1996;

- to report on on-going activities in participants' countries;
- to improve the dialogue between material science and dosimetry communities.

3. The participants then introduced themselves and described their experience in reactor dosimetry calculations.

4. A. Miller explained that the TFRDD group was formed in response to the CSNI request to NSC that a review of the methods used to calculate radiation doses to reactor components be carried out in support of the activities conducted by the CSNI in the area of reactor component ageing.

5. The discussion was opened by a request from G. Hehn supported by other group members that the USA and Japanese (not present at the meeting) participate in the project. The question was raised of including experts from the East-European countries (the Czech Republic and the Russian Federation).

6. At this point, the NEA Deputy Director, Ph. Savelli, joined the meeting and addressed the gathering. Ph. Savelli pointed out the importance of the TFRDD group as an example of enhancement of the scientific aspects over the more practical focus of other NEA projects. He also expressed hope that the meeting would identify additional scientific issues of reactor component ageing (apart from preparing the state-of-the-art report) worthy of further international scientific investigation. He ended by wishing everybody "fruitful discussions".

7. G. Hehn asked Ph. Savelli about the possibility of including the East European experts in the group. Ph. Savelli responded that NEA is not immediately concerned with specific issues of the Eastern European nuclear technology but that it is involved in helping the East Europeans to establish proper safety R&D, safety authorities, etc. and that the European Union and G24 deals with immediate Eastern European nuclear industry problems. He further added that during the last NEA Steering Committee meeting, there was concern voiced over NEA helping to extend the life of certain types of Eastern European reactors when the general attitude in the West was to shut them down as soon as possible. Therefore, Ph. Savelli mentioned that, if the intention of the TFRDD was to have good specialists on dosimetry from Eastern Europe, this should be acceptable but, short of some issues, their presence may be a little sensitive. G. Hehn proposed that the TFRDD group would invite two to four experts from the Russian Federation and the Czech Republic. Mr. Savelli responded that this could be done if the experts were very important to the project.

8. R.P. Rulko spoke on the IAEA progress in reactor dosimetry (showing that there was no overlapping between the TFRDD proposed project and any of the IAEA projects). A. Miller said that at the recent IAEA Specialists' Meeting on Irradiation Embrittlement, the meeting chairman had supported further international collaboration in dosimetry aspects of embrittlement.

9. This ended the first (general) part of the meeting.

Technical Discussion

10. The next part of the meeting was initiated by R.P. Rulko who gave a short presentation of his report on "Issues of irradiation-induced ageing of reactor components".

11. After the presentation, G. Hehn initiated a group discussion on the possible topics of interest for the TFRDD group as well as the issues of the state-of-the-art in the field of dosimetry, taking as a point of reference R.P. Rulko's report.

12. Comments on subsequent paragraphs of the R.P. Rulko's report resulting from the group discussion were as follows:

Paragraphs 1-4:

A. The information about the US NRC LWRPVSD programme conducted at the HEDL and ORNL in the 1980's should be included. The scope of the programme was to define standards for the fluence calculations in the RPV. The developed standards result in up to 15 percent accuracy in fluence calculations. The computational methods developed were benchmarked at experimental facilities: PCA (USA), PSF (USA), VENUS (Belgium), NESDIP (UK), as well as the NPPs: MBR-2 (USA), ANO-I (USA) [confirmation of details of LWRPVSD is expected from H. Ait Abderrahim (Mol)]. Comments on the LEPRICON code utilising ASTM standards should be added.

B. Issues specific to BWR, FBR and $D_2 0$ moderated reactors should be included in the discussion (comments of G. Hehn, H. Ait Abderrahim and T. Lewis).

Paragraphs 5-7:

No comments.

Paragraphs 8-13:

A. Neutron fluence above 1 MeV is used to estimate the leading order of the neutron damage to materials only (a comment by H. Ait Abderrahim, J. Koban and T. Lewis).

B. PKA versus DPA: The PKA spectra give a better correlation to damage models than the DPA concept. The Argonne National Laboratory code SPECTER calculates the PKA spectra. The PKA program of ENEA Bologne consists of calculating the PKA spectra in the ENDF format which could be interfaced with the NJOY code (comments by M. Pescarini).

C. Material scientists have to provide the effects of neutron damage to materials in terms of cross-sections concept so that the fluence information can be readily converted into the material damage information. Even the most accurate fluence calculations are not very useful without reliable neutron damage model expressed in terms of damage cross-sections (comments of H. Ait Abderrahim and T. Lewis, supported by J. Koban).

D. In view of the above, G. Hehn recommended a two-phase scope of the project: fluence computations as Phase I and damage model research as Phase II. H. Ait Abderrahim supported by T. Lewis stated that the current level of accuracy in fluence computations would be sufficient if accompanied by an improved material damage model due to irradiation.

E. Computational problems of precision in calculating thermal neutron flux/fluence are affecting dosimetry but are limited to research reactors specifically designated for high thermal-to-fast-flux ratio. Transfer of information about material damage in such sectors to commercial PWR power reactors is not direct (due to differences in spectrum, flux density, and operating temperature of such reactors versus commercial PWRs) (comments synthesised from group discussion by G. Hehn).

F. The importance of -induced damage was not determined by the group due to limited knowledge of the problem; it was agreed that γ flux material damage may be an important problem when γ flux levels were high but that it was a minor problem in PWR reactors. There is a need for γ flux damage models to determine the importance of this material damage mechanism. On the other hand, in BWR reactors γ flux may be a highly contributing factor from the point of view of γ flux induced corrosion of reactor components (G. Hehn's synthesis for the group discussion).

Paragraphs 14-17:

A. The problem of backscattering effects on measurements (and computations) from concrete present in the reactor cavity should be dealt with (a comment made by H. Ait Abderrahim).

B. Computation for cavity locations can be ambiguous: the so-called ex-vessel dosimetry is less accurate than the in-vessel dosimetry and it is not obvious how to extrapolate the ex-vessel results for in-vessel positions. In general, the uncertainties of the ex-vessel dosimetry are higher than and of a different nature from the in-vessel dosimetry (a synthesis by G. Hehn of comments made by H. Ait Abderrahim, T. Lewis and J. Koban).

C. No least-square adjustment of the calculated multigroup neutron fluxes is needed if good cross-section data are used (a comment by J. Koban).

D. There is a need for standardisation of the photo-fission effect in Np^{237} and U^{238} (comments by I. Kodeli).

E. The importance of the good quality cross-sections data in fluence computations was stressed by A. Hogenbirk who further added that the inelastic Fe scattering cross-section is still causing problems in the 10-100 keV energy range.

Paragraphs 18-19

A. In KAERI, the US NRC guidelines are used regarding fluence computations with S_N codes (quadrature set orders, cross-section expressions, etc.). The computational uncertainties as discussed in paragraph 19 of R.P. Rulko's report are generally confirmed by KAERI's experience (comments by H.R. Hwang).

B. The statement in paragraph 18 regarding U^{235} spectrum should include information about the mixed high burnup fission spectrum currently used in the state-of-the-art fluence computations (comment by M. Pescarini).

C. In paragraph 19, it should be added that the S_8 quadrature sets in S_N computations are sufficient for in-vessel dosimetry but not enough in ex-vessel computations (comments by H. Ait Abderrahim, T. Lewis and G. Hehn):

- the BUGLE energy-group structure is sufficient for computations;
- cavity streaming can be a problem above the core midplane;
- the flux 3-D synthesis using 1-D and 2-D computations can be inaccurate above the core midplane;
- the computations in thick slabs of steel (as in the PV wall) are not accurate enough for the ex-vessel dosimetry due to problems with the inelastic scattering cross-section of Fe - the

minimum requirement is the use of the ENDF/B-VI or EFF-3 data; the ENDF/B-V data are not accurate enough;
- dosimeter cross-section as given by the IRDF-90/Rev. 2 data sets are accurate enough but there is a need for standardisation of the photo-fission effects on Np^{237} and U^{238} dosimeter cross-sections (4-8 per cent or 20-30 per cent errors?);
- fine meshes are needed in calculations;
- contents of the two published benchmarks by Babcox & Wilcox on ex-vessel dosimetry should be discussed.

Paragraphs 20-21

A. Unadjusted calculations are compared with measurements to determine the order of computational uncertainties (comment by J. Koban).

B. The BR3 reactor in Belgium was shut down because the RPV embrittlement prediction methods used then had not demonstrated the RPV integrity. Hence, there is a strong need for improved radiation-induced material damage models (comment by H. Ait Abderrahim).

Paragraphs 22-24

The details of the proposal as outlined in paragraphs 22 to 24 of the paper were not discussed. Instead the participants agreed on the following:

The project should have three phases:

A. Phase I:
   - The report by R.P. Rulko will be expanded to include:
     - comments as reported in the summary report of the meeting, to be carried out by R.P. Rulko
     - the activities in reactor dosimetry in Japan and USA (NEA will search for this information in Japan and USA);
     - the information on the state-of-the-art of the dosimetry field in different countries, with emphasis on the precision achieved today in fluence calculations; this presentation is to be made by comparing computations with measurements on specific power reactors and reporting on calculational uncertainties, nuclear data and codes used (to be supplied by the TFRDD group members);
   - The second draft will be circulated to the TFRDD group members for comments;
   - A final draft will be distributed to members by the end of March 1996 (the final version of the report is to be completed by April 1996);
   - The report will be submitted to the NSC meeting in 1996 for approval and subsequently distributed to the CSNI Committee and PWG3 group.

B. In phase II, two computational benchmarks will be carried out and compared with two experiments on the VENUS critical facility at SCK/CEN Mol in Belgium; the first VENUS-1 experiment provides 2-D flux measurements for a UOX PWR fresh core and the second VENUS-3 experiment (3-D Benchmark Simulating Partial Length Shielded Assembly Concept) provides the 3-D flux measurement data. The experimental data will be made available to the OECD/NEA for distribution to participants. The purpose of this benchmark is to prove that there is consensus at the international level with respect to computing neutron fluence with the 20 percent accuracy and to verify the computational techniques reported upon in the state-of-the-art report in Phase I of the project. The results of the benchmark study will be discussed at a meeting tentatively scheduled for November 1996 at Mol in Belgium. Phase II will be concluded with the report analysing benchmark results from different participants. This will complete the task proposed by the CSNI to NSC.

C. Phase III of the project, subject to NSC approval, will be devoted to material degradation/damage phenomena. At this stage, the project will include material scientists to improve/standardise the units of material damage and their relation to radiation-induced embrittlement of reactor materials (i.e. basic physics models of radiation damage to materials). The resulting improved models and data will be incorporated into the computational schemes.

Final conclusions of the meeting:

- A paper on the state-of-the-art of the reactor dosimetry issues as well as the research programme of the TFRDD group should be presented to the 9th Symposium on Nuclear Dosimetry to be held in Prague, the Czech Republic, in September 1996.
- A compilation on the VENUS-1 and VENUS-3 experimental data used for computational benchmark studies will be included into the SINBAD system developed at the NEA Data Bank.
- Close contacts will be established with the EWGRD (the European Working Group on Reactor Dosimetry, chaired by P. D'Hondt, SCK/CEN). Mr. Ait Abderrahim was appointed to undertake the liaison between the EWGRD and the TFRDD groups.
- A. Miller will inform the material scientists active in the field of material radiation damage within various groups such as the IAEA-NENP-IWG-LMNPP and CEC-JRC-AMES IGRDM of the task force activities.

ANNEX

LIST OF DOCUMENTS

1. Notification of first meeting/proposed agenda/scope and objectives.
2. Issues of Irradiation-Induced Ageing of Reaction Components, by Robert P. Rulko
3. NEACRP Recommendation for Standard Damage Dose Unit, by Y. Orechwa, M. Salvatores
4. FAX from Harrison on US needs
5. FAX from Japan on Japanese needs
6. Ageing research at JAERI
7. Updated list of TFRDD participants
8. R&D progress on NPI Ageing Coordinated by the IAEA in Vienna, by Robert P. Rulko.
9. NEA meeting on radiation dose of modelling of nuclear radiation-induced degradation of reactor components, by Alex Miller.
10. Measurement of neutron flux. Part 1. Determination of fast neutron fluence with actinides and fission detection.
11. Measurement of neutron flux. Part 2. Determination of fast neutron fluence with Fe actinide detection.