INTERIM REPORT

Accession No. _____

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Contract Program or Project Title: Light Water Reactor Pressure Vessel Irradiation Program

Subject of this Document: Summary of Conferences on "Accuracies in Correlation Between Property Change and Exposure Data from Reactor Pressure Vessel Steel Irradiations" at Julich, September 24-27, 1979 and the Third ASTM-EURATOM Symposium on Reactor Dosimetry at Ispra, October 1-5, 1979, and report of visit to CEN/SCK, Mol, Belgium, October 8, 1979.

Type of Document: Foreign Trip Report

Author: F. B. K. Kam

Date of Document: October 18, 1979

Responsible NRC Individual and NRC Office or Division: C. Z. Serpan, Chief, Metallurgy and Materials Research Branch, Division of Reactor Safety Research

This document was prepared primarily for preliminary or internal use. It has not received full review and approval. Since there may be substantive changes, this document should not be considered final.

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Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830
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INTERIM REPORT

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POST OFFICE BOX X
OAK RIDGE, TENNESSEE 37830

ORNL

FOREIGN TRIP REPORT

ORNL/FTR-742

DATE: October 18, 1979

SUBJECT: Report of Foreign Travel of F. B. K. Kam, Project Manager of LWR-PV Irradiation Program, Operations Division

TO: Herman Postma

FROM: F. B. K. Kam

PURPOSE: To participate in an IAEA specialists' meeting on accuracies in correlation between property change and exposure data from reactor pressure vessel steel irradiation at KFA, Jülich, West Germany and in the Third ASTM-EURATOM symposium on reactor dosimetry at Ispra, Italy. To visit CEN-SCK, Belgium for the purpose of assessing their LWR Dosimetry Surveillance Program.

SITES VISITED:				
	9/24-27/1979	KFA	Jülich, West Germany	W. Schneider D. Pachur
	10/1-5/1979	CCR	Ispra, Italy	U. Farinelli J. P. Genthon
	10/8/79	CEN/SCK	Mol, Belgium	J. Debrue

ABSTRACT: The traveler co-authored an invited paper with A. Fabry of CEN/SCK and participated in the discussions relating to the dosimetry-metallurgy interface as applied to the LWR pressure vessel surveillance program. The papers reiterated the difficulties of correlating steel embrittlement and fracture toughness as a function of metallurgical variables, temperature and radiation exposure.

Of particular interest to ORNL's LWR-PV irradiation program was the emphasis placed on temperature and dosimetry. Both parameters have received considerable attention in the design considerations. The papers at the ASTM-EURATOM symposium focused on three major U. S. programs; LWR, FBR, and MFE. The topics covered dosimetry techniques, LWR surveillance spectrum adjustment codes, benchmark field referencing, fuels irradiation, and uncertainty analysis from experiment and calculated data.

Report of Travel to Western Europe

September 21 - October 8, 1979

IAEA SPECIALISTS' MEETING

The meeting was attended by 53 participants from both eastern and western Europe, U.S. and Japan. The purpose was to bring together the metallurgists and the metrologists in order to access the accuracies in the correlation between property change and neutron exposure in LWR-PV irradiations. The metallurgists emphasized the difficulties and uncertainties associated with determining radiation embrittlement as a function of the following parameters:

1. Temperature
2. Chemical composition
3. Microstructure
4. Heat treatment
5 Neutron exposure; and
6. Spectral and dose rate effects.

An invited paper, "Towards an Adequate Evaluation of LWR Pressure Vessel Steel Irradiation Exposures" was presented jointly with A. Fabry of CEN/SCK. T. Marston of EPRI mentioned the fact that perhaps one should talk about fracture toughness instead of embrittlement. However, the trend curves in the present NRC guidelines are in terms of embrittlement and would have to be changed. R. Wullaert of Fracture Control Corporation discussed the re-evaluation of the whole MPC data base from a statistical point of view. The results would present the data in terms of the newly recommended exposure unit, displacements per atom (dpa). It was emphasized that the scatter in the data would be reduced. Several participants emphasized the fact that there is a serious problem of separating good data from bad. Documentation was not adequate in many instances

R. Odette from the University of California Santa Barbara presented a physical model for representing the damage as a function of the various parameters mentioned above. He emphasized that his approach was a phenomenological one but appears to fit the data that he investigated.

The French presented several papers on variability of steels, capsule designs and the use of graphite and tungsten damage detectors which can be correlated to steel damage. The Belgians are also working on damage detectors, but are using silicon.

The present techniques for testing specimens are destructive tests. KFA, Jülich and EPRI indicated that there is work on non-destructive testing (e.g. neutron scattering) and the community will see many more papers in the near future.

From the dosimetry side, it was stated that the present state-of-the-art techniques can give results in the 10-15% (1σ) range which is desirable for LWR-PV surveillance conditions. The techniques are not currently applied to power reactor surveillance programs and one speaker wondered whether such accuracies can be attained in routine surveillance.

There was a suggestion from the European community that equivalent fission flux be reported in all documentation. However there are two approaches presently used to determine the equivalent fission flux; the first is obtained from given values of fission average cross sections, and the second by flux transfer from a ^{252}Cf source or a ^{235}U fission cavity source. Albert Fabry of CEN/SCK stated that benchmark field referencing to obtain the equivalent fission flux results in smaller uncertainties and better accuracies. It was further stated that:

1. Neutronic calculational codes be validated to reference benchmark fields;
2. Corrections for neutron field perturbations within surveillance capsules be considered; and
3. Damage induced by neutrons below 1 MeV be taken into consideration when reporting neutron exposure.

The recommendations and conclusions of this meeting will be published along with the papers in about four months. The topics presented at this meeting impact directly on the objectives of ORNL commitments to NRC under the LWR-PV irradiation program.

In addition to the IAEA session, discussions were held with G. Pott and D. Pachur of KFA on the results of their prototype HSST experiment in FRJ 1. It appears that the temperature distribution throughout the 4T-CT compact specimens will not be within the range 288 ± 10°C even with a lead thermal shield in front of their capsule. They have agreed to send me both the neutron and thermal characteristics based on their measurements after the experiment is done. NRC has sent them the results of our HSST measurements and has established an exchange of information agreement with them.

THIRD ASTM-EURATOM SYMPOSIUM

The symposium covered a wide-range of topics in the LWR, FBR, and MFE programs. The main subjects were:

1. Metallurgy and dosimetry interface;
2. LWR-PV surveillance in practice;
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1. Metallurgy and dosimetry interface;
2. LWR-PV surveillance in practice;
3. Fast reactor and research reactor characterization;

4. Adjustment codes;
5. Benchmark fields;
6. Fuel dosimetry;
7. Fusion; and
8. Dosimetry techniques.

My interest was in items 1, 2, 4, 5, and 8 since these topics were within the scope of ORNL's LWR program. In addition to the sessions, several meetings were held in conjunction. As the incoming U.S. program chairman for the 4th ASTM-EURATOM symposium scheduled in 1981, meetings were held with both the U.S. and EURATOM committees to discuss the probable time, place and program topics. J. P. Genthon of CEN, Saclay is the new EURATOM chairman and informal discussions were held with him to facilitate communications between us.

Discussions with C. Z. Serpan (NRC), W. N. McElroy (HEDL) and J. Grundl (NBS) were held to determine what input to NRC's Task A-11 can come from the LWR-PV surveillance dosimetry programs at the three laboratories. Other discussions were held to discuss the "PCA Blind Test" which is sponsored by NRC. There seems to be interest from many participants who are now faced with analyzing their surveillance capsule data and extrapolating their results in-vessel.

Five papers were presented at the sessions by F. W. Stallmann and myself. These papers summarized the work which was performed in FY-79 and are listed below:

1. "Status of the PSF Metallurgical Irradiation Program" by F. B. K. Kam and A. Fabry
2. "Neutron Spectral Characterization of the NRC-HSST Experiments", F. W. Stallmann and F. B. K. Kam;
3. "Status Report on the Activities of ASTM E10.05.01 Task Group on Uncertainty Analysis", F. B. K. Kam and F. W. Stallmann;
4. "The Core Power of the Pool Critical Assembly Light Water Reactor Benchmark", F. B. K. Kam et al.; and
5. "Neutron Characterization of the PCA-PV Benchmark Facility", F. W. Stallmann and F. B. K. Kam.

VISIT TO CEN/SCK, BELGIUM

One day was spent at CEN/SCK looking at their detector equipment and discussing with J. Debrue the different programs that were in progress relating to LWR's and dosimetry. It is my impression that they are more oriented to passive dosimetry techniques than at ORNL. Their active dosimetry techniques are limited to proton-recoil and $^{6}Li(n,\alpha)t$ detectors. The facilities for calibration of instruments are excellent. I was surprised to learn that they work very closely with industry in the LWR surveillance program. Because of this cooperation, the R&D techniques are not confined to the laboratory and are put into practice.

CONCLUSIONS

My impressions gained from the trip indicated that current state-of-the-art dosimetry techniques are able to obtain accuracies to within 10-15% (1σ) for neutron exposure in test reactor facilities. However whether such accuracies are attainable in power reactor environments has not been demonstrated. On the metallurgical side, there appears to be more uncertainties and larger scatter of data. The correlation between damage and metallurgical variables needs more study. Temperature is another parameter which received considerable discussion but has not received enough attention during the design of experiments. The current work for NRC at ORNL will have a positive impact on these problems. The contacts and exchange of information with our European counterparts will be valuable in understanding and solving mutual problems.

APPENDIX

FULL ITINERARY:

9/23-24/1979	Weekend and travel from Oak Ridge, Tennessee to Julich, West Germany
9/24-27/1979	Jülich, West Germany
9/27-30/1979	Travel to Varese, Italy
10/1-5/1979	Ispra, Italy
10/6-7/1979	Travel to Brussels, Belgium and weekend
10/8/1979	CEN/SCK, Mol, Belgium
10/9/1979	Travel to Oak Ridge, Tennessee

PERSONS CONTACTED:

W. Schneider, D. Pachur and G. Pott, KFA Jülich, West Germany
A. Alberman and J. P. Genthon, CEN, Saclay, France
M. Austin and R. Squire, Rolls Royce Ltd., Derby, U.K.
A. Fudge, Harwell, U.K.
G. Hehn and G. Prillinger, IKE, FRG
C. Ertek, IAEA, Seibersdorf, Austria
J. Debrue, G. & S. DeLeeuw, CEN/SCK, Mol, Belgium
R. Dierckx, CCR, Ispra, Italy

BIBLIOGRAPHY

Many of the papers presented at the meetings and a few which were obtained from persons contacted, are in my file. Anyone interested in the list of the papers or the papers themselves are welcome to look at the file.

DISTRIBUTION

1-2. Assistant Secretary for International Affairs, DOE, Wash.
3. R. G. Staker, Division of Reactor Research and Technology, DOE, Wash.
4. Director, Division of Safeguards and Security, DOE, Wash.
5-6. Director, Division of International Security Affairs, DOE, Wash.
7. T. E. Murley, Director, Division of Reactor Safety Research, NRC, Wash.
8. L. S. Tong, Assistant Director, Division of Reactor Safety Research, NRC, Wash.
9-10. Director of International Programs, NRC, WASH.
11-12. Division of Technical Information and Document Control, NRC, Wash.
13. C. Z. Serpan, Chief, Metallurgy and Materials Research Branch, Division of Reactor Safety Research
14. J. A. Lenhard, DOE/ORO
15. J. S. Denton, DOE/ORO
16. F. B. K. Kam
17. J. A. Cox
18. F. R. Mynatt
19. H. Postma
20. J. H. Swanks
21-22. Laboratory Records Department
23. Laboratory Records Department - RC
24. Laboratory Protection Division
25. ORNL Patent Section
26. ORNL Public Relations Office
27-28. Technical Information Center, P. O. Box 62, Oak Ridge, TN 37830