POOR ORIGINAL

Send copy

ROUTING AND TRANSMITTAL SLIP Date 7/5/79

TO: (Name, office symbol, room number, building, Agency/Post)	Initials	Date
1. Dick Johnson		
2. Peter Kapo		
3. SHH - All file		
4.		
5.		

	Action		File		Note and Return
	Approval		For Clearance		Per Conversation
	As Requested		For Correction		Prepare Reply
	Circulate	✓	For Your Information		See Me
	Comment		Investigate		Signature
	Coordination		Justify		

REMARKS

1739 354

DO NOT use this form as a RECORD of approvals, concurrences, disposals, clearances, and similar actions

FROM: (Name, org. symbol, Agency/Post)	Room No.—Bldg.
Sherett	Phone No.

5041-102 OPTIONAL FORM 41 (Rev. 7-76)

Prescribed by GSA
FPMR (41 CFR) 101-11.206

☆U. S. GPO: 1978-0-261-647 3354

8001070239

Report Summary

Measurement and Analysis of Gamma Ray Induced Contamination of Neutron Dosimetry Procedures Used for Reactor Pressure Vessel Applications

NP-1056
Research Project 827-1

Final Report, April 1979

Prepared by

SCIENCE APPLICATIONS, INCORPORATED
1200 Prospect Street
La Jolla, California 92038

Principal Investigator
G. L. Simmons

Contributors
V. V. Verbinski
W. K. Hagan
C. G. Cassapakis

1739 355

Prepared for

Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, California 94304

EPRI Project Manager
H. Till
Nuclear Power Division

ORDERING INFORMATION

Requests for copies of this report should be directed to Research Reports Center (RRC), Box 10090, Palo Alto, CA 94303, (415) 961-9043. There is no charge for reports requested by EPRI member utilities and affiliates, contributing nonmembers, U.S. utility associations, U.S. government agencies (federal, state, and local), media, and foreign organizations with which EPRI has an information exchange agreement. On request, RRC will send a catalog of EPRI reports.

1739 356

NOTICE

This report was prepared by the organization(s) named below as an account of work sponsored by the Electric Power Research Institute, Inc. (EPRI). Neither EPRI, members of EPRI, the organization(s) named below, nor any person acting on their behalf: (a) makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or (b) assumes any liabilities with respect to the use of, or for damages resulting from the use of, any information, apparatus, method, or process disclosed in this report.

Prepared by
Science Applications, Incorporated
La Jolla, California

EPRI PERSPECTIVE

PROJECT DESCRIPTION

For the purpose of assessing radiation-induced degradation of nuclear plant pressure vessels, it is necessary to characterize the neutron and gamma flux, fluence, and spectrum. Primary reliance is placed on the combination of analytical calculations, and a series of metallurgical surveillance specimens placed inside the reactor vessel in accelerated flux positions to monitor changes in material properties with exposure. The success of this approach relies on the ability to validate the calculations through dosimetric measurements and to correlate changes in the material properties with the radiation flux and spectrum.

To obtain neutron flux and spectrum information below 1 MeV, fission foils are often employed. When such foils are applied without any adjustment for the photofission effect, an overprediction of the neutron flux can result at locations where the relative gamma flux is high. Photofission can also cause problems in unfolding the spectrum by increasing the unfolded spectrum in energy groups above the actual threshold energy of the detector. This spurious increase in foil activations can either lead to large and erroneous fluctuations in the spectrum when unfolded, or in the nonconvergence of the iterative unfolding process. In seeking to determine the extent of this effect, work has been performed at the University of Virginia reactor facility. The fission foils used were ^{232}Th, ^{235}U, ^{238}U, and ^{239}Np.

PROJECT OBJECTIVES

The objectives of the program for the assessment of radiation effects in pressure vessels are to provide dosimetric data for pressure vessel embrittlement in the form of experimental measurements and validated calculational techniques that can be used (1) to estimate the changes in material properties through service life, (2) to assess the status of those pressure vessels which are thought to be in regulatory jeopardy due to various trace elements such as copper and phosphorus in the weldments, and (3) to provide flux and spectrum estimates for the development of new damage correlation models.

1739 357

The objective of this study was to qualitatively establish that photofissions do contribute to the activity produced in the foils, which if not corrected could erroneously overpredict the neutron flux incident upon the pressure vessel. This effect is predictable on theoretical grounds, but was not previously verified in a reactor environment. Since neutrons produce greater damage to metals relative to gamma radiation, this effect can cause the service life of the pressure vessel to be significantly underestimated.

PROJECT RESULTS

The results indicate that the photofission effect can be significant. Overestimates of the neutron flux from this can cause an overprediction by approximately 20% in the radiation damage to the pressure vessel. The importance of the results is that in measurements in the vicinity of the pressure vessel, or in reactor pressure vessel surveillance positions, fission foils used to determine the neutron flux may overpredict the neutron field. This overprediction may lead to underestimates of safety margins of pressure vessels, or discrepancies between experimental and calculational benchmarks.

Henry Till, Project Manager
Nuclear Power Division

SUMMARY

The prediction of the useful lifetime of a light water reactor pressure vessel (RPV) involves the determination of the temperature shift in the Charpy V-notch curve for materials irradiated with neutrons relative to non-irradiated materials. Procedures, such as those embodied in U.S. Nuclear Regulatory Commission Guide 1.99, can be used to predict the allowable change of the reference temperature to correlate this value with the neutron fluence that irradiated the pressure vessel. The neutron fluence, defined as the total flux (neutron/cm^2-sec) greater than 1 MeV multiplied by the irradiation time (seconds), can be used to determine the effective lifetime of the pressure vessel. The critical parameter involved in this determination is the neutron spectrum which is used to determine the greater than 1 MeV fluence. Uncertainties in the neutron spectrum, therefore, have a direct linear correlation with uncertainties in the predicted reactor pressure vessel lifetime. The reactor pressure vessel dosimetry program sponsored by the Electric Power Research Institute (EPRI) has as one of its goals the reduction of the uncertainty in the predicted neutron spectra incident upon and throughout the pressure vessel. Threshold foil, fission track recorder, and fission chamber dosimetry procedures have been and continue to be among the most useful techniques for determining the neutron spectra. The threshold foil procedure uses the neutron activation of threshold foils in combination with spectral unfolding techniques to determine the neutron spectrum at the foil locations. For certain foils used in threshold foil dosimetry, there exists the possibility that gamma rays (which do not significantly damage the RPV) at the dosimeter locations can increase the activation of the foils due to photofission, photoexcitation, and other photon induced reactions. This additional photon induced activity, if not corrected for, will result in an overestimate of the neutron spectrum, a higher predicted value of the greater than 1 MeV fluence, and an underestimate of the effective pressure vessel lifetime.

In order to gain an understanding of the degree to which these photon-induced reactions can "contaminate" activation type dosimetry, EPRI sponsored a research program at Science Applications, Incorporated (SAI) to demonstrate the specificity of

1739 359

this contamination and to establish an experimental/analytical procedure which has the potential for correcting for this contamination. To this end, an experiment was carried out at the University of Virginia pool-type research reactor to measure the photon-induced contamination in certain photo-sensitive foils. This experiment resulted in the development of a technique, requiring both measurements and calculations, that offers the potential for quantifying the photon-induced contamination. Although this experiment was scoping in nature, it has been demonstrated that for certain reactors photon contamination of activation dosimeters can necessitate a significant correction to provide only the neutron-induced reactions. As an example, analytical investigations for a three loop pressurized water reactor (PWR) indicate that without correcting for photon-induced reactions, the dosimetry data would result in an overestimate of the neutron fluence and an underestimate, perhaps by 20%, of the predicted vessel lifetime. These analyses also indicate that each reactor must be considered on an individual basis and that broad generalities concerning the magnitude of the effects for a wide variety of reactors must not be made.

1739 360