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Transport Calculations of Radiation Exposure to Vessel Support Structures in the Trojan Reactor

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ABSTRACT

Neutron transport calculations and cavity dosimetry measurements were performed at the Trojan Reactor in order to determine the neutron environment within the ex-vessel region of the plant that contains the vessel support structure. The radiation embrittlement of a steel member that has a relative high degree of stress is a primary concern.

Comparison of transport calculations of the dosimeter activities with the experimental measurements shows that the values obtained with ENDF/B-VI cross-section data overestimate the measured results for high-energy-threshold reactions in the cavity by up to 41%, and thermal reactions by up to a factor of 3.0. The transport calculations performed with the original SAILOR cross-section library (based on ENDF/B-IV data) overestimate measured threshold reactions by only 15% and the thermal reactions by about a factor of 2.50. These results are inconsistent with those obtained in earlier studies that compared transport calculations done with SAILOR vs ENDF/B-VI, which indicate that SAILOR tends to underestimate cavity dosimeter activities for threshold reactions, while the ENDF/B-VI values usually agree better with experimental results. One factor that probably contributes to the rather large discrepancy between the computed and measured activities is the core power distribution used in the transport calculations. Because of unavailability of plant-specific data, a generic power distribution provided by Westinghouse was used. Since the calculated cavity flux levels appear to be over-estimated, the results estimated for the exposure to the support structure should be conservative.

The ENDF/B-VI calculations give a fast fluence rate at the critical stress point equal to $6.90\text{E}+07$ neutrons per cm^2 per second. The thermal-to-fast-flux ratio at this point is computed to be equal to 46. The DPA rate at the critical point is calculated to equal $2.0\text{E}-13$ displacements per atom per second.

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1 INTRODUCTION

The embrittlement of steel in reactor pressure vessels (RPVs) due to exposure to fast neutrons is well known and is constantly monitored during the operating lifetime of power reactors. In the past, the radiation embrittlement of ex-vessel steel components has been of less concern because (1) the fast neutron levels beyond the RPV are much lower compared with levels at vessel welds and (2) most of the critical load-bearing members are far removed from neutron exposure. However, a particular Westinghouse PWR design includes a portion of the vessel support structure embedded within the concrete shield surrounding the reactor cavity, as shown in Fig. 1. Note that the steel structure supporting the vessel consists of two vertical members connected by a short horizontal member near the core midplane elevation. The vertical members are subjected to compressive forces and present no structural concerns due to embrittlement. However, the horizontal beam is under stress from a bending moment and could be susceptible to loss of ductility. The maximum stress occurs at approximately 18 cm from the surface of the concrete shield wall around the cavity. Earlier analyses have indicated that the fast neutron (i.e., those with energies above 1 MeV) flux present at the vessel support structure is well within the acceptable range that will not exceed allowable fluence limits during the reactor lifetime. The fast neutron flux is low at these locations because the concrete surrounding the structure thermalizes the high energy flux, thus lowering the fast neutron intensity while enhancing the thermal spectrum component. However, knowledge of the ratio of the thermal to fast flux at the maximum stress location is of prime interest in this plant to obtain an estimate of the overall radiation embrittlement due to neutrons of all energies, including thermal neutrons.¹

The purpose of this study is to compute the neutron flux spectrum and magnitude in the cavity and within the concrete shield surrounding the cavity of the Trojan PWR, in order to provide an estimate for the neutron environment in the vicinity of the vessel support structure. An experimental program was also performed in conjunction with the calculational study to determine measured dosimetry reaction rates to verify the results from the transport calculations. This report summarizes results from the transport calculations and the experimental measurements and compares the computed dosimeter activities with the experimental values.

Figure 1 Vessel support structure in the Trojan PWR

2 DESCRIPTION OF TROJAN PLANT AND EXPERIMENT CONFIGURATION

The Trojan Reactor is a Westinghouse PWR of the "three loop" design type that produces 3411 MW (thermal) of power. The plant has been operated by Portland General Electric Company since going critical in 1976. Because the same vessel support design as included in Trojan is also present in several other Westinghouse reactors that continue to operate in the United States, and because the experiment was already completed for this plant, this research project is being completed even though the reactor operation is being terminated.

Experimental dosimetry was placed in the reactor cavity of the plant by Oak Ridge National Laboratory (ORNL) during Cycle 13, for the time period July 13, 1990, to March 4, 1991. A combination of radiometric foils, solid-state track recorders (SSTRs), and bead chain gradient dosimeters were utilized (See Section 4). During this cycle the fuel was loaded in a "low-leakage" pattern, which reduced the fluence at the vessel and beyond, compared with some of the earlier cycles. Cycle 7 was the first to use a low-leakage core configuration in the Trojan core. However, the core loading for cycle 13 is somewhat unusual because highly burned assemblies are placed in the peripheral location, while fresh fuel is placed next to the peripheral assemblies. This causes a steep gradient in the pinwise power distribution in the row of assemblies. As part of the routine RPV surveillance program, Westinghouse has analyzed plant dosimetry for some earlier cycles,^{2,3} but unfortunately, no in-vessel surveillance dosimetry was scheduled to be removed from the plant during this particular cycle. Thus only experimental results from beyond the vessel are available to validate the current transport calculations.

Figure 2 shows the ex-vessel geometry of interest in this project. As is typical for this reactor design, there are two large "detector wells" in the cavity at 0 and 45°, respectively, that indent the concrete shield surrounding the cavity, extending nearly the entire core height. These detector wells will impact the thermal to fast flux ratio in this vicinity. Note also that there is an ex-core detector, normally used to monitor the reactor core, located in the cavity region at an azimuthal position of approximately 0°. The cylindrical detector contains a large polyethylene segment (13.66 cm OD) to thermalize neutrons for detection, which significantly perturbs the flux in this region. The detector is movable into the recessed detector well within the concrete, as shown in Figure 2. A vertical instrument tube (5.08 cm OD) is positioned above the recessed compartment for access to the ex-core detector. The instrument tube channel through the concrete provided access for two sets of dosimeters that were placed in the cavity. The various activation foils and SSTRs are inserted in the instrument tube at distances of 20.3 cm below and 121.9 cm above the core midplane, respectively, at a radius of 321.6 cm from the core center. Unfortunately, this radial location in the cavity places the dosimeters behind the polyethylene segment of the ex-core detector with about 20 cm separating the dosimeters and the detector, making the geometry for the transport calculations more difficult to model accurately. Two more similar sets of dosimeters at the same axial positions were also placed in the cavity about 5 cm behind the thermal insulation that surrounds the RPV. These dosimeters are located at an azimuthal angle near 0°, between the pressure vessel insulation and the ex-core detector. In addition to the dosimeter foils and SSTRs hung at 0°, two bead chain flux-gradient dosimeters were placed in the cavity at 0° and 45°, respectively.

Figure 2 Ex-vessel geometry for Trojan

3 DETAILS OF TRANSPORT CALCULATIONS

The methodology previously established at ORNL for RPV fluence analysis was used in this study. A three-dimensional distribution of the multigroup flux in cylindrical geometry (R-Theta-Z) is computed by synthesizing fluxes determined from discrete-ordinates calculations in two-dimensional R-Theta and R-Z and one-dimensional R coordinates, respectively.⁴ The transport calculations were performed with the DOT 4.2 code using an S_8 quadrature and a P3 Legendre expansion of the scattering cross sections. The multigroup structure was that of the 47 group SAILOR library.⁵

Most of the nuclear cross-section data were taken directly from the SAILOR library. This library is collapsed from the original VITAMIN-C library⁶ that was processed from ENDF/B-IV. However, two different data sources were used for the cross sections of hydrogen, oxygen, and iron. One set of transport calculations used the standard set of cross-section data contained in SAILOR for these three materials. A second set of calculations was based on new multigroup data for H-O-Fe that was recently processed from ENDF/B-VI evaluations.⁷ The newer ENDF/B-VI cross sections have been found to improve agreement between transport calculations and measured dosimetry activities for cavity locations in some earlier studies because of an increase in the transmission of fast neutrons through the RPV.⁸

Due to the symmetrical fuel loading pattern in the core, only one-eighth of the core is typically considered for the transport calculation. The one-eighth-core model corresponds to a 45° slice with reflected boundary conditions at 45° and 0° . However, in this reactor design, the ex-core geometry is not exactly symmetrical by octant because the neutron pad is not symmetrically oriented about 45° ; it extends from 25° to 57.5° . Hence, a quarter-core model is more appropriate for these types of reactors. The impact of using a quarter-core vs an eighth-core reactor model was examined, and it was found that the computed dosimeter activities at 0° are not affected; the values at 45° , however, differ by up to 12%. The results of this comparison are summarized in Appendix B. The dosimeter results presented in the text were obtained from the one-eighth core calculation.

Figure 3 represents an octal section of the reactor at the horizontal midplane from the center of the core to beyond the biological concrete shield wall. The cross-sectional representation of the surveillance capsules, ex-core detector, instrument tube, and void indentation in the concrete wall are included in the DOT-IV R-Theta calculation to account for the significant flux perturbation effects from the presence of these components. The ex-core detector was modeled approximately based on information obtained from the manufacturer. Note that the $\Theta = 0^\circ$ coordinate in the DOT model actually corresponds to the 90° azimuth in the actual reactor configuration, but the 45° coordinates are consistent. The R-Z model, Figure 4, used in the R-Z calculation represents the portion of the reactor from the center of the core to beyond the shield wall radially, and from below the bottom of the active fuel up to above top of the active fuel axially. Figure 5 represents the 1-D model used in one-dimensional calculation, extending from the center of the reactor core to beyond the shield wall. Table 1 gives the material compositions used in all the DOT-IV calculations.

The calculation of neutron source for all DOT-IV runs were performed using the DOTSOR code.⁹ This code generates the R-Theta and R-Z source for DOT-IV transport calculations from

Figure 3 DOT R-Theta model of Trojan used in transport calculations

Figure 4 DOT R-Z model of Trojan used in transport calculations

Figure 5 DOT 1-D model of Trojan used in transport calculations

Table 1 Material compositions used in "DOT" calculations

MATERIAL

CORE (WESTINGHOUSE ^a)

U-235 = 2.37E-4	U-238 = 6.73E-3	O (FUEL) = 1.393E-2
O(H ₂ O) = 1.393E-2	H = 2.785E-2	Fe = 1.069E-4
Mn = 1.976E-6	Cs = 6.162E-5	Ni = 1.291E-4
Zr = 4.348E-3		

EXCORE WATER (WESTINGHOUSE ^a)

H = 5.007E-2	O = 2.503E-2
--------------	--------------

INCORE WATER

H = 4.782E-2	O = 2.391E-2
--------------	--------------

SS-304 (WESTINGHOUSE^{*})

Fe = 5.978E-2	Mn = 1.761E-3	Cr = 1.768E-2
Ni = 8.242E-3		

A533B STEEL (WESTINGHOUSE^a)

C = 9.820E-4	Mn = 1.116E-3	Fe = 8.270E-2
Ni = 4.420E-4		

POLYETHYLENE

Density of .963 G/CC

C = 4.134E-2	H = 6.612E-2
--------------	--------------

INSULATION

SS-304 @ 3% DENSITY

CONCRETE TYPE 02-B

H = 6.873E-3	O = 4.329E-2	C = 1.153E-4
Mg = 1.239E-4	Al = 1.741E-3	Si = 1.662E-2
K = 4.606E-4	Ca = 1.503E-3	Fe = 3.451E-4
Na = 9.641E-4		

^a Personal communication from E. P. Lippincott

the given X-Y core power distribution. The X-Y core power distribution was determined from the given assemblywise BOC and EOC burnup data combined with the relative pinwise power distribution. Table 2 represents the assemblywise BOC, and EOC burnup, and the absolute power corresponding to the cycle averaged distribution normalized to the full power (3411 MW). The assembly burnup data were plant-specific values for Cycle 13, provided by Westinghouse.^a However, the pinwise power distribution provided by Westinghouse was "generic," because the plant-specific pinwise power was not readily available. Because of the unusually severe gradient across the peripheral assemblies in this cycle, the generic pinwise power distribution will tend to cause the calculated dosimeter activities to be over estimated. In the R-Z calculation, the cycle-average relative axial power distribution, as shown in Figure 6, was used. The 1-D source is obtained by integrating the R-Z source over Z.

The activation cross sections for computing the dosimeter reactions were obtained from ENDF/B-VI. The fission spectrum for the core source was represented by a weighted combination of the U^{235} and the Pu^{239} spectra based on an ENDF/B-V Watt distribution. The relative contribution of the two isotopes was determined by the fractional contribution of each to the fission source in the peripheral assemblies, at the mid-cycle burnup of these assemblies.

One difficulty with using the SAILOR cross-section library in this study is that the SAILOR group structure includes only two groups below 0.414 eV; furthermore, no upscattering within the thermal energy range is accounted for in the scatter matrix of the SAILOR cross sections. Historically, virtually all RPV fluence studies have reported difficulty in estimating dosimeter reactions such as Co^{59} capture that are sensitive to the thermal energy range, probably a result of the rather crude treatment of the thermal scattering in the commonly used libraries (e.g., SAILOR and ELXSIR¹⁰). Often discrepancies of 2 or more are observed between the measured and computed activities. Unfortunately, no other appropriate library with multiple thermal groups was available at the time of this study. Therefore, there is some uncertainty about the accuracy of the computed thermal flux that must be taken into account when assessing the reported results. The measured activities from the thermal neutron dosimetry can be used to improve the computed thermal flux estimate.

^aPersonal Communications, E. P. Lippincott, Westinghouse Corporation

**Table 2 Assemblywise BOC, EOC burnup (MWD/T), and
absolute power (MWth) for Trojan Cycle 13^a**

17930.0 26223.0 4.575	16084.0 25280.0 10.146	13275.0 22882.0 10.599	24670.0 33528.0 9.773	9187.0 19483.0 11.359	27890.0 36042.0 8.994	0.0 10115.0 11.160	33080.0 36773.0 4.074
16082.0 25255.0 10.120	8149.0 18233.0 22.251	19147.0 28123.0 19.806	9311.0 19582.0 22.664	9187.0 19541.0 22.847	28271.0 36401.0 17.939	0.0 10118.0 22.326	28588.0 32438.0 8.495
13335.0 22728.0 10.363	19483.0 28400.0 19.676	20252.0 28644.0 18.517	19738.0 28782.0 19.956	9065.0 19064.0 22.063	25190.0 33454.0 18.235	0.0 10028.0 22.127	28944.0 332749.0 8.396
24671.0 33634.0 9.889	9306.0 19588.0 22.688	20270.0 29240.0 19.793	8161.0 18058.0 21.838	20428.0 28889.0 18.670	23181.0 31402.0 18.140	0.0 8935.0 19.716	27274.0 29898.0 5.790
9158.0 19473.0 11.380	9179.0 19518.0 22.814	9083.0 19038.0 21.966	20483.0 28834.0 18.427	28916.0 36880.0 17.573	0.0 10309.0 22.747	20280.0 25522.0 11.567	
27869.0 38035.0 11.216	28257.0 36388.0 17.942	26584.0 34680.0 17.864	22174.0 30470.0 18.306	0.0 10320.0 22.772	0.0 8892.0 19.621	34208.0 36872.0 5.878	
0.0 10134.0 11.181	0.0 10141.0 22.377	0.0 10011.0 22.090	0.0 8830.0 19.484	20478.0 25708.0 11.540	34173.0 36834.0 5.872		
33505.0 37184.0 4.059	29163.0 33178.0 8.859	29125.0 32938.0 8.414	27349.0 29986.0 5.819				
<div>BOC BURNUP</div> <div>EOC BURNUP</div> <div>ABS POWER ^b</div>							

^aOnly one-eighth of core is used in R-θ model.

^bAssembly power corresponds to cycle-averaged distribution in MW, normalized to full power (3411 MW).

Fig. 6 Relative axial power distribution for Trojan Cycle 13

4 DESCRIPTION OF EXPERIMENTAL MEASUREMENTS

A dosimetry experiment based on several different threshold reactions was placed in the reactor cavity of the TROJAN plant during Cycle 13. The list of the different dosimeters used in this experiment, along with the type of reaction, half-life, and threshold energy, is given in Table 3. Four sets of these dosimeters were placed at different locations in the reactor cavity. Two sets of experimental measurements were made in the instrument channel located behind one of the ex-vessel detectors near 0° azimuth. Two other sets of experimental measurements were taken behind the RPV insulation.

The coordinates of these four sets are as follows (coordinates are referenced to coordinate system used in DOT transport calculations):

1. CAPSULE A (behind RPV insulation):

$$R = 257 \text{ cm}, \quad \theta = 0^\circ, \quad Z = 121.9 \text{ cm above midplane}$$

2. CAPSULE B (behind RPV insulation):

$$R = 257 \text{ cm}, \quad \theta = 0^\circ, \quad Z = 20.3 \text{ cm below midplane}$$

3. CAPSULE C (instrument tube):

$$R = 321.63 \text{ cm}, \quad \theta = 0^\circ, \quad Z = 121.9 \text{ cm above midplane}$$

4. CAPSULE D (instrument tube):

$$R = 321.63 \text{ cm}, \quad \theta = 0^\circ, \quad Z = 20.3 \text{ cm below midplane}$$

In addition to the above radiometric foils and SSTR dosimeters, two gradient bead dosimeters were placed in the cavity at 0° and 45°, respectively. These results have not been considered in this study. The experimental measurements were performed by Westinghouse¹¹ and reviewed by NIST, who made some corrections in the SSTR fission dosimetry results to account for ²³⁵U impurities. The saturated activities obtained for the various dosimeters at the four cavity locations are summarized in Table 4. More details of the dosimeter measurement results are given in Appendix A.

Table 3 Neutron dosimeters used in the cavity experiment

Reaction	Half-life	Threshold energy (MeV)	Dosimeter type ^a
$^{54}\text{Fe}(n,p) ^{54}\text{Mn}$	312 days	2.20	RM
$^{58}\text{Ni} (n,p) ^{58}\text{Co}$	71 days	1.60	RM
$^{63}\text{Cu}(n,p) ^{60}\text{Co}$	5.27 years	5.00	RM
$^{46}\text{Ti} (n,p) ^{46}\text{Sc}$	84.0 days	3.90	RM
$^{238}\text{U} (n,f) ^{137}\text{Cs}$	30.1 years	1.50	SSTR,RM
$^{237}\text{Np}(n,f)$		0.20	SSTR
$^{59}\text{Co}(n,) ^{60}\text{Co}$	5.27 years	Thermal	RM

^aRM = radiometric foil; SSTR = solid state track recorder.

Table 4 Experimental results of Trojan cavity dosimetry measurements

Saturated Activities (Reaction Per Atom Per Second) CAPSULE				
Reaction	A	B	C	D
$^{63}\text{Cu} (n,)$	2.42E-19	3.20E-19	1.62E-19	2.11E-19
$^{46}\text{Ti} (n,p)$	3.44E-18	4.60E-18	2.35E-18	3.04E-18
$^{54}\text{Fe} (n,p)$	1.56E-17	2.07E-17	1.06E-17	1.35E-17
$^{58}\text{Ni} (n,p)$	2.31E-17	3.10E-17	1.55E-17	2.01E-17
$^{238}\text{U} (n,f)$	8.24E-17	1.08E-16	5.94E-17	7.29E-17
$^{237}\text{Np} (n,f)$	1.16E-15	1.51E-15	1.03E-15	1.02E-15
$^{59}\text{Co} (n,), \text{Bare}$	1.95E-14	3.25E-14	2.05E-14	2.86E-14
$^{59}\text{Co} (n,), \text{Cd}$	1.12E-15	1.49E-14	9.66E-15	1.25E-14
$^{235}\text{U} (n,f), \text{Bare}$	1.11E-13	2.12E-13	1.54E-13	2.68E-13
$^{235}\text{U} (n,f), \text{Cd}$	3.29E-14	2.90E-14	2.61E-14	3.56E-14

5 RESULTS

Neutronic transport calculations were performed with both the ORIGINAL SAILOR and the MODIFIED SAILOR library which contains ENDF/B-VI Fe-O-H data. The synthesized absolute fluxes were obtained for both sets of calculations. Based on these calculations, Tables 5 and 6 show the absolute flux spectra at the center of the 31.5 and 34.0° surveillance capsules, respectively, obtained with MODIFIED SAILOR library. Tables 7 and 8 show the same quantity obtained with ORIGINAL SAILOR library. At these locations the ENDF/B-VI Fe-O-H increases the ORIGINAL SAILOR value of the flux above 1.0 MeV by about 10%. Tables 9 through 12 show the calculated saturated activities and the spectrum- averaged cross section at the surveillance locations obtained with both libraries. No surveillance capsule measurements were performed for Cycle 13, and hence no in-vessel measurements to which the transport calculations could be compared for this cycle. However, Table 13 shows the comparison of the calculated dosimeter activities for Cycle 13 with the capsule X experimental results from several cycles back, removed April 1984.² It can be seen that Cycle 13 calculated values obtained by LSU with both libraries underestimate the capsule X experimental results. The difference in the power distributions of the two different dosimeter activation periods could cause the discrepancy.

The flux above 1.0 MeV in the RPV of TROJAN Reactor was found to peak at an azimuthal angle of about 45°. Table 14 illustrates the azimuthal variation of the flux above 1.0 MeV at the RPV 0T, 3/4T positions, and at the radial locations of the wire dosimeters and center of the instrumentation tube, based on the ENDF/B-VI Fe-O-H calculations. A factor of 1.87 maximum variation is present in the azimuthal dependence of the flux above 1.0 MeV at 0T of the RPV. This factor has a value of 1.20 at the radial location of the center of the instrumentation tube. From the R-Z transport calculations, based on the cycle-averaged axial power shape, the flux above 1.0 MeV is found to peak at the core midplane. Table 15 illustrates the axial variation of the flux above 1.0 MeV. As shown, the flux above 1.0 MeV is almost constant within 38.1 cm about the core midplane for the cycle-averaged power shape.

Tables 16 and 17 show the radial variation of integrated flux parameters through the RPV at 0° and 45°, calculated with ENDF/B-VI Fe-O-H, respectively. The same quantities at the same locations calculated with the ORIGINAL SAILOR are shown in Tables 18 and 19. The flux above 1.0 MeV incident on the vessel wetted surface at the peak azimuthal and axial location calculated with ENDF/B-VI Fe-O-H is about $1.868\text{E}+10 \text{ cm}^2\cdot\text{s}^{-1}$. This value is only about 10% higher than the one calculated with ORIGINAL SAILOR library. Tables 20 and 21 show the radial variation of the cumulative fluence (cm^2) and DPA through the RPV at 0° and at the peak azimuthal location, respectively, calculated with ENDF/B-VI Fe-O-H. Based on the calculated peak flux above 1.0 MeV, the fast fluence due to the 211.25 effective full-power days of Cycle 13 at the vessel wetted surface and RPV 0T are $3.410\text{E}+17$ and $3.314\text{E}+17 \text{ cm}^2$,

Table 5 Absolute flux spectrum obtained with ENDF/B-VI Fe-O-H at the center of the 31.5° surveillance capsule at 20.3 cm below the core midplane

Group	Upper energy	Group flux	Cumulative flux	Group DPA	Cumulative DPA	Cumulative DPA fraction
1	1.733E+01	8.523E+06	8.523E+06	2.490E-14	2.490E-14	1.580E-04
2	1.419E+01	3.487E+07	4.339E+07	9.225E-14	1.172E-13	7.433E-04
3	1.221E+01	1.410E+08	1.844E+08	3.398E-13	4.569E-13	2.899E-03
4	1.000E+01	2.933E+08	4.777E+08	6.508E-13	1.108E-12	7.028E-03
5	8.607E+00	5.150E+08	9.927E+08	1.075E-12	2.183E-12	1.385E-12
6	7.408E+00	1.234E+09	2.227E+09	2.398E-12	4.581E-12	2.906E-02
7	6.065E+00	1.882E+09	4.109E+09	3.357E-12	7.937E-12	5.036E-02
8	4.966E+00	3.890E+09	7.999E+09	6.112E-12	1.405E-11	8.913E-02
9	3.679E+00	3.259E+09	1.126E+10	4.465E-12	1.851E-11	1.175E-01
10	3.012E+00	2.588E+09	1.385E+10	3.289E-12	2.180E-11	1.383E-01
11	2.725E+00	3.172E+09	1.702E+10	4.045E-12	2.585E-11	1.640E-01
12	2.466E+00	1.578E+09	1.860E+10	1.849E-12	2.770E-11	1.757E-01
13	2.365E+00	4.605E+08	1.906E+10	5.047E-13	2.820E-11	1.789E-01
14	2.346E+00	2.319E+09	2.137E+10	2.414E-12	3.062E-11	1.942E-01
15	2.231E+00	6.747E+09	2.812E+10	6.977E-12	3.759E-11	2.385E-01
16	1.920E+00	8.744E+09	3.687E+10	7.112E-12	4.470E-11	2.836E-01
17	1.653E+00	1.355E+10	5.041E+10	1.098E-11	5.568E-11	3.532E-01
18	1.353E+00	3.053E+10	8.095E+10	1.711E-11	7.279E-11	4.618E-01
19	1.003E+00	2.314E+10	1.041E+11	8.482E-12	8.127E-11	5.156E-01
20	8.208E-01	1.091E+10	1.150E+11	6.121E-12	8.739E-11	5.544E-01
21	7.427E-01	3.749E+10	1.525E+11	1.355E-11	1.009E-10	6.404E-01
22	6.081E-01	3.308E+10	1.856E+11	9.736E-12	1.107E-10	7.021E-01
23	4.979E-01	3.617E+10	2.217E+11	1.434E-11	1.250E-10	7.931E-01
24	3.688E-01	3.588E+10	2.576E+11	7.420E-12	1.324E-10	8.402E-01
25	2.972E-01	4.847E+10	3.061E+11	9.718E-12	1.421E-10	9.018E-01
26	1.832E-01	4.299E+10	3.491E+11	6.061E-12	1.482E-10	9.403E-01
27	1.111E-01	3.219E+10	3.813E+11	4.162E-12	1.524E-10	9.667E-01
28	6.738E-02	2.706E+10	4.083E+11	1.753E-12	1.541E-10	9.778E-01
29	4.087E-02	9.326E+09	4.177E+11	7.548E-13	1.549E-10	9.826E-01
30	3.183E-02	3.824E+09	4.215E+11	1.087E-12	1.560E-10	9.895E-01
31	2.606E-02	1.078E+10	4.323E+11	2.174E-13	1.562E-10	9.909E-01
32	2.418E-02	6.666E+09	4.389E+11	2.919E-14	1.562E-10	9.911E-01
33	2.188E-02	1.272E+10	4.516E+11	1.041E-13	1.563E-10	9.917E-01
34	1.503E-02	2.481E+10	4.765E+11	4.654E-13	1.568E-10	9.947E-01
35	7.102E-03	3.027E+10	5.067E+11	2.693E-13	1.571E-10	9.964E-01
36	3.355E-03	2.748E+10	5.342E+11	9.674E-14	1.571E-10	9.970E-01
37	1.585E-03	4.514E+10	5.793E+11	7.592E-14	1.572E-10	9.975E-01
38	4.540E-04	2.072E+10	6.001E+11	2.042E-15	1.572E-10	9.975E-01
39	2.144E-04	2.512E+10	6.252E+11	3.602E-15	1.572E-10	9.975E-01
40	1.013E-04	3.374E+10	6.589E+11	7.526E-15	1.572E-10	9.976E-01
41	3.727E-05	4.015E+10	6.991E+11	1.582E-14	1.573E-10	9.977E-01
42	1.068E-05	2.190E+10	7.210E+11	1.408E-14	1.573E-10	9.977E-01
43	5.043E-06	2.547E+10	7.464E+11	2.547E-14	1.573E-10	9.979E-01
44	1.855E-06	1.535E+10	7.618E+11	2.360E-14	1.573E-10	9.981E-01
45	8.764E-07	1.216E+10	7.739E+11	2.728E-14	1.573E-10	9.982E-01
46	4.140E-07	7.363E+09	7.813E+11	2.885E-14	1.574E-10	9.984E-01
47	1.000E-07	2.685E+10	8.082E+11	2.510E-13	1.576E-10	1.000E+00

Table 6 Absolute flux spectrum calculated with ENDF/B-VI Fe-O-H at the center of the 34.0° surveillance capsule at 20.3 cm below the core midplane

Group	Upper energy	Group flux	Cumulative flux	Group DPA	Cumulative DPA	Cumulative DPA fraction
1	1.733E+01	8.758E+06	8.758E+06	2.559E-14	2.559E-14	1.390E-04
2	1.419E+01	3.603E+07	4.479E+07	9.535E-14	1.209E-13	6.569E-04
3	1.221E+01	1.475E+08	1.923E+08	3.553E-13	4.763E-13	2.587E-03
4	1.000E+01	3.087E+08	5.010E+08	6.850E-13	1.161E-12	6.307E-03
5	8.607E+00	5.470E+08	1.048E+09	1.142E-12	2.303E-12	1.251E-02
6	7.408E+00	1.319E+09	2.367E+09	2.563E-12	4.866E-12	2.643E-02
7	6.065E+00	2.040E+09	4.407E+09	3.640E-12	8.506E-12	4.620E-02
8	4.966E+00	4.316E+09	8.724E+09	6.780E-12	1.529E-11	8.303E-02
9	3.679E+00	3.682E+09	1.241E+10	5.044E-12	2.033E-11	1.104E-01
10	3.012E+00	2.927E+09	1.533E+10	3.720E-12	2.405E-11	1.306E-01
11	2.725E+00	3.603E+09	1.894E+10	4.594E-12	2.864E-11	1.556E-01
12	2.466E+00	1.793E+09	2.073E+10	2.102E-12	3.075E-11	1.670E-01
13	2.365E+00	5.233E+08	2.125E+10	5.736E-13	3.132E-11	1.701E-01
14	2.346E+00	2.638E+09	2.389E+10	2.746E-12	3.407E-11	1.850E-01
15	2.231E+00	7.704E+09	3.159E+10	7.966E-12	4.203E-11	2.283E-01
16	1.920E+00	1.006E+10	4.166E+10	8.184E-12	5.022E-11	2.727E-01
17	1.653E+00	1.567E+10	5.733E+10	1.270E-11	6.292E-11	3.417E-01
18	1.353E+00	3.577E+10	9.310E+10	2.004E-11	8.296E-11	4.506E-01
19	1.003E+00	2.735E+10	1.204E+11	1.002E-11	9.298E-11	5.050E-01
20	8.208E-01	1.287E+10	1.333E+11	1.163E-10	1.002E-10	5.442E-01
21	7.427E-01	4.467E+10	1.780E+11	1.280E-10	1.163E-10	6.319E-01
22	6.081E-01	3.956E+10	2.176E+11	1.451E-10	1.280E-10	6.951E-01
23	4.979E-01	4.321E+10	2.608E+11	1.540E-10	1.451E-10	7.882E-01
24	3.688E-01	4.319E+10	3.039E+11	1.657E-10	1.540E-10	8.367E-01
25	2.972E-01	5.794E+10	3.619E+11	1.729E-10	1.657E-10	8.998E-01
26	1.832E-01	5.148E+10	4.134E+11	1.779E-10	1.729E-10	9.392E-01
27	1.111E-01	3.847E+10	4.518E+11	1.800E-10	1.779E-10	9.662E-01
28	6.738E-02	3.231E+10	4.842E+11	1.809E-10	1.800E-10	9.776E-01
29	4.087E-02	1.106E+10	4.952E+11	1.822E-10	1.809E-10	9.824E-01
30	3.183E-02	4.488E+09	4.997E+11	1.824E-10	1.822E-10	9.894E-01
31	2.606E-02	1.288E+10	5.126E+11	1.825E-10	1.824E-10	9.908E-01
32	2.418E-02	8.011E+09	5.206E+11	1.826E-10	1.825E-10	9.910E-01
33	2.188E-02	1.501E+10	5.356E+11	1.831E-10	1.826E-10	9.916E-01
34	1.503E-02	2.914E+10	5.647E+11	1.834E-10	1.831E-10	9.946E-01
35	7.102E-03	3.567E+10	6.004E+11	1.836E-10	1.834E-10	9.963E-01
36	3.355E-03	3.247E+10	6.329E+11	1.836E-10	1.836E-10	9.970E-01
37	1.585E-03	5.350E+10	6.864E+11	1.836E-10	1.836E-10	9.974E-01
38	4.540E-04	2.441E+10	7.108E+11	1.837E-10	1.836E-10	9.975E-01
39	2.144E-04	2.966E+10	7.405E+11	1.837E-10	1.837E-10	9.975E-01
40	1.013E-04	3.995E+10	7.804E+11	1.837E-10	1.837E-10	9.975E-01
41	3.727E-05	4.756E+10	8.280E+11	1.837E-10	1.837E-10	9.976E-01
42	1.068E-05	2.591E+10	8.539E+11	1.837E-10	1.837E-10	9.977E-01
43	5.043E-06	3.003E+10	8.839E+11	1.838E-10	1.837E-10	9.979E-01
44	1.855E-06	1.798E+10	9.019E+11	1.838E-10	1.838E-10	9.980E-01
45	8.764E-07	1.412E+10	9.160E+11	3.168E-14	1.838E-10	9.982E-01
46	4.140E-07	8.518E+09	9.245E+11	3.337E-13	1.838E-10	9.984E-01
47	1.000E-07	3.175E+10	9.563E+11	2.968E-13	1.841E-10	1.000E+00

Table 7 Absolute flux spectrum calculated with ORIGINAL SAILOR at the center of the 31.5° surveillance capsule at 20.3 cm below the core midplane

Group	Upper energy	Group flux	Cumulative flux	Group DPA	Cumulative DPA	Cumulative DPA fraction
1	1.733E+01	7.643E+06	7.643E+06	2.233E-14	2.233E-14	1.550E-04
2	1.419E+01	3.389E+07	4.153E+07	8.967E-14	1.120E-13	7.775E-04
3	1.221E+01	1.378E+08	1.793E+08	3.320E-13	4.440E-13	3.082E-03
4	1.000E+01	2.768E+08	4.562E+08	6.143E-13	1.058E-12	7.347E-03
5	8.607E+00	4.851E+08	9.413E+09	1.012E-12	2.071E-12	1.437E-02
6	7.408E+00	1.129E+09	2.070E+09	2.194E-12	4.265E-12	2.960E-02
7	6.065E+00	1.570E+09	3.640E+09	2.801E-12	7.065E-12	4.905E-02
8	4.966E+00	3.136E+09	6.777E+09	4.927E-12	1.199E-11	8.325E-02
9	3.679E+00	2.844E+09	9.621E+09	3.896E-12	1.589E-11	1.103E-01
10	3.012E+00	2.380E+09	1.200E+10	3.025E-12	1.891E-11	1.313E-01
11	2.725E+00	2.884E+09	1.488E+10	3.677E-12	2.259E-11	1.568E-01
12	2.466E+00	1.440E+09	1.632E+10	1.687E-12	2.428E-11	1.685E-01
13	2.365E+00	4.475E+08	1.677E+10	4.904E-13	2.477E-11	1.719E-01
14	2.346E+00	2.231E+09	1.900E+10	2.323E-12	2.709E-11	1.881E-01
15	2.231E+00	5.940E+09	2.494E+10	6.142E-12	3.323E-11	2.307E-01
16	1.920E+00	8.067E+09	3.301E+10	6.561E-12	3.979E-11	2.762E-01
17	1.653E+00	1.238E+10	4.539E+10	1.003E-11	4.983E-11	3.459E-01
18	1.353E+00	2.769E+10	7.309E+10	1.552E-11	6.534E-11	4.536E-01
19	1.003E+00	2.146E+10	9.455E+10	7.866E-12	7.321E-11	5.082E-01
20	8.208E-01	9.770E+09	1.043E+11	5.480E-12	7.869E-11	5.462E-01
21	7.427E-01	3.585E+10	1.402E+11	1.296E-11	9.165E-11	6.362E-01
22	6.081E-01	2.970E+10	1.699E+11	8.742E-12	1.004E-10	6.969E-01
23	4.979E-01	3.399E+10	2.039E+11	1.348E-11	1.139E-10	7.904E-01
24	3.688E-01	3.476E+10	2.386E+11	7.189E-12	1.211E-10	8.403E-01
25	2.972E-01	4.224E+10	2.809E+11	8.469E-12	1.295E-10	8.991E-01
26	1.832E-01	4.177E+10	3.226E+11	5.890E-12	1.354E-10	9.400E-01
27	1.111E-01	3.174E+10	3.544E+11	4.104E-12	1.395E-10	9.685E-01
28	6.738E-02	2.545E+10	3.798E+11	1.648E-12	1.412E-10	9.799E-01
29	4.087E-02	7.709E+09	3.875E+11	6.239E-13	1.418E-10	9.842E-01
30	3.183E-02	2.761E+09	3.903E+11	7.850E-13	1.426E-10	9.897E-01
31	2.606E-02	1.043E+10	4.007E+11	2.102E-13	1.428E-10	9.912E-01
32	2.418E-02	6.821E+09	4.075E+11	2.987E-14	1.428E-10	9.914E-01
33	2.188E-02	1.257E+10	4.201E+11	1.030E-13	1.429E-10	9.921E-01
34	1.503E-02	2.069E+10	4.408E+11	3.881E-13	1.433E-10	9.948E-01
35	7.102E-03	2.780E+10	4.686E+11	2.473E-13	1.435E-10	9.965E-01
36	3.355E-03	2.540E+10	4.940E+11	8.939E-14	1.436E-10	9.971E-01
37	1.585E-03	3.853E+10	5.325E+11	6.481E-14	1.437E-10	9.976E-01
38	4.540E-04	1.899E+10	5.515E+11	1.872E-15	1.437E-10	9.976E-01
39	2.144E-04	2.291E+10	5.744E+11	3.285E-15	1.437E-10	9.976E-01
40	1.013E-04	3.095E+10	6.054E+11	6.904E-15	1.437E-10	9.976E-01
41	3.727E-05	3.673E+10	6.421E+11	1.447E-14	1.437E-10	9.977E-01
42	1.068E-05	2.013E+10	6.622E+11	1.293E-14	1.437E-10	9.978E-01
43	5.043E-06	2.329E+10	6.855E+11	2.329E-14	1.438E-10	9.980E-01
44	1.855E-06	1.420E+10	6.997E+11	2.183E-14	1.438E-10	9.981E-01
45	8.764E-07	1.107E+10	7.108E+11	2.483E-14	1.438E-10	9.983E-01
46	4.140E-07	1.535E+10	7.261E+11	6.013E-14	1.439E-10	9.987E-01
47	1.000E-07	1.956E+10	7.457E+11	1.828E-13	1.441E-10	1.000E+00

Table 8 Absolute flux spectrum calculated with ORIGINAL SAILOR at the center of the 34.0° surveillance capsule at 20.3 cm below the core midplane

Group	Upper energy	Group flux	Cumulative flux	Group DPA	Cumulative DPA	Cumulative DPA fraction
1	1.733E+01	7.874E+06	7.874E+06	2.301E-14	2.301E-14	1.367E-04
2	1.419E+01	3.503E+07	4.291E+07	9.270E-14	1.157E-13	6.876E-04
3	1.221E+01	1.438E+08	1.868E+08	3.465E-13	4.622E-13	2.747E-03
4	1.000E+01	2.907E+08	4.774E+08	6.450E-13	1.107E-12	6.580E-03
5	8.607E+00	5.139E+08	9.913E+08	1.073E-12	2.180E-12	1.295E-02
6	7.408E+00	1.205E+09	2.196E+09	2.341E-12	4.521E-12	2.687E-02
7	6.065E+00	1.699E+09	3.895E+09	3.031E-12	7.552E-12	4.487E-02
8	4.966E+00	3.470E+09	7.365E+09	5.451E-12	1.300E-11	7.727E-02
9	3.679E+00	3.216E+09	1.058E+10	4.406E-12	1.741E-11	1.034E-01
10	3.012E+00	2.694E+09	1.327E+10	3.424E-12	2.083E-11	1.238E-01
11	2.725E+00	3.277E+09	1.655E+10	4.178E-12	2.501E-11	1.486E-01
12	2.466E+00	1.636E+09	1.819E+10	1.918E-12	2.693E-11	1.600E-01
13	2.365E+00	5.086E+08	1.870E+10	5.575E-13	2.749E-11	1.633E-01
14	2.346E+00	2.539E+09	2.124E+10	2.643E-12	3.013E-11	1.790E-01
15	2.231E+00	6.777E+09	2.801E+10	7.007E-12	3.714E-11	2.207E-01
16	1.920E+00	9.286E+09	3.730E+10	7.552E-12	4.469E-11	2.655E-01
17	1.653E+00	1.431E+10	5.161E+10	1.159E-11	5.628E-11	3.344E-01
18	1.353E+00	3.244E+10	8.405E+10	1.818E-11	7.446E-11	4.424E-01
19	1.003E+00	2.536E+10	1.094E+11	9.295E-12	8.375E-11	4.977E-01
20	8.208E-01	1.152E+10	1.209E+11	6.464E-12	9.022E-11	5.361E-01
21	7.427E-01	4.273E+10	1.637E+11	1.544E-11	1.057E-10	6.278E-01
22	6.081E-01	3.549E+10	1.992E+11	1.045E-11	1.161E-10	6.899E-01
23	4.979E-01	4.067E+10	2.398E+11	1.612E-11	1.322E-10	7.857E-01
24	3.688E-01	4.179E+10	2.816E+11	8.642E-12	1.409E-10	8.371E-01
25	2.972E-01	5.035E+10	3.320E+11	1.009E-11	1.510E-10	8.970E-01
26	1.832E-01	4.997E+10	3.189E+11	7.046E-12	1.580E-10	9.389E-01
27	1.111E-01	3.795E+10	4.199E+11	4.908E-12	1.629E-10	9.681E-01
28	6.738E-02	3.035E+10	4.502E+11	1.966E-12	1.649E-10	9.798E-01
29	4.087E-02	9.107E+09	4.593E+11	7.370E-13	1.656E-10	9.841E-01
30	3.183E-02	3.236E+09	4.626E+11	9.200E-13	1.665E-10	9.896E-01
31	2.606E-02	1.245E+10	4.750E+11	2.511E-13	1.668E-10	9.911E-01
32	2.418E-02	8.204E+09	4.832E+11	3.593E-14	1.668E-10	9.913E-01
33	2.188E-02	1.487E+10	4.981E+11	1.218E-13	1.669E-10	9.920E-01
34	1.503E-02	2.419E+10	5.223E+11	4.538E-13	1.674E-10	9.947E-01
35	7.102E-03	3.272E+10	5.550E+11	2.910E-13	1.677E-10	9.965E-01
36	3.355E-03	3.001E+10	5.850E+11	1.056E-13	1.678E-10	9.971E-01
37	1.585E-03	4.557E+10	6.306E+11	7.666E-14	1.679E-10	9.975E-01
38	4.540E-04	2.234E+10	6.529E+11	2.203E-15	1.679E-10	9.976E-01
39	2.144E-04	2.703E+10	6.800E+11	3.876E-15	1.679E-10	9.976E-01
40	1.013E-04	3.662E+10	7.166E+11	8.170E-15	1.679E-10	9.976E-01
41	3.727E-05	4.347E+10	7.601E+11	1.712E-14	1.679E-10	9.977E-01
42	1.068E-05	2.379E+10	7.839E+11	1.529E-14	1.679E-10	9.978E-01
43	5.043E-06	2.744E+10	8.113E+11	2.744E-14	1.679E-10	9.980E-01
44	1.855E-06	1.663E+10	8.279E+11	2.556E-14	1.680E-10	9.981E-01
45	8.764E-07	1.285E+10	8.408E+11	2.883E-14	1.680E-10	9.983E-01
46	4.140E-07	1.776E+10	8.585E+11	6.959E-14	1.681E-10	9.987E-01
47	1.000E-07	2.314E+10	8.817E+11	2.164E-13	1.683E-10	1.000E+00

Table 9 Calculated saturated activities at the center of Trojan 31.5° surveillance capsule at the core midplane for Cycle 13

Dosimeter	Reaction per atom per second	
	W/ENDF/B-VI Fe-O-H ^a	W/ORIGINAL SAILOR ^a
	R = 207.33 cm	R = 207.33 cm
⁵⁴ Fe(n,p) ⁵⁴ Mn	4.851E-15	4.233E-15
⁵⁸ Ni (n,p) ⁵⁸ Co	6.813E-15	5.985E-15
⁶³ Cu(n,α) ⁶⁰ Co	4.409E-17	4.051E-17
²³⁷ Np(n,f) ¹³⁷ Cs	2.506E-13	2.294E-16
²³⁸ U (n,f) ¹³⁷ Cs	2.623E-14	2.361E-14
⁴⁶ Ti(n,p) ⁴⁶ Sc	7.094E-16	6.281E-16
⁵⁹ Co(n,γ) ⁶⁰ Co	3.443E-12	3.092E-12
Flux	φ (E) cm ⁻² ·s ⁻¹	
φ (E > 1.0 MeV)	8.132E+10	7.343E+10
φ (E > 0.1 MeV)	3.491E+11	3.226E+11
φ (E < 0.4 eV)	3.421E+10	3.491E+10
DPA rate	dpa/s	
Total DPA rate	1.576E-10	1.441E-10

^aENDF/B-VI dosimetry cross sections were used in both calculations.

Table 10 Calculated saturated activities at the center of Trojan 34.0°
surveillance capsule at the core midplane for Cycle 13

Reaction per atom per second		
Dosimeter	W/ENDF/B-VI Fe-O-H ^a	W/ORIGINAL SAILOR ^a
	R = 207.33 cm	R = 207.33 cm
⁵⁴ Fe(n,p) ⁵⁴ Mn	5.358E-15	4.669E-15
⁵⁸ Ni (n,p) ⁵⁸ Co	7.566E-15	6.639E-15
⁶³ Cu(n,α) ⁶⁰ Co	4.693E-17	4.301E-17
⁴⁶ Ti (n,p) ⁴⁶ Sc	2.928E-13	2.681E-13
²³⁸ U (n,f) ¹³⁷ Cs	2.977E-14	2.679E-14
²³⁷ Np(n,f) ¹³⁷ Cs	7.643E-16	6.745E-16
⁵⁹ Co(n,γ) ⁶⁰ Co	4.062E-12	3.643E-12
Flux	φ (E) cm ⁻² · s ⁻¹	
φ (E > 1.0 MeV)	9.354E-10	8.445E+10
φ (E > 0.1 MeV)	4.134E-11	3.819E+11
φ (E < 0.4 eV)	4.027E-10	4.091E+10
DPA rate	dpa/s	
Total DPA rate	1.841E-10	1.683E-10

^a ENDF/B-VI dosimetry cross sections were used in both calculations.

Table 11 Spectrum-averaged cross section at the center of the 31.5°
surveillance capsule at core midplane of Trojan Cycle 13

Reaction	W/ENDF/B-VI Fe-O-H ^a		W/ORIGINAL SAILOR ^a	
	E > 1 $\bar{\sigma}$ (barns) ^b	E > .11 $\bar{\sigma}$ (barns) ^c	E > 1 $\bar{\sigma}$ (barns) ^b	E > .11 $\bar{\sigma}$ (barns) ^c
⁵⁴ Fe(n,p) ⁵⁴ Mn	5.965E-02	1.390E-02	5.764E-02	1.312E-02
⁵⁸ Ni (n,p) ⁵⁸ Co	8.379E-02	1.952E-02	8.150E-02	1.855E-02
⁶³ Cu(n,α) ⁶⁰ Co	5.422E-04	1.263E-04	5.517E-04	1.256E-04
⁴⁶ Ti (n,p) ⁴⁶ Sc	8.724E-03	2.032E-03	8.553E-03	1.947E-03
²³⁸ U (n,f) ¹³⁷ Cs	3.226E-01	7.514E-02	3.215E-01	7.318E-02
²³⁷ Np(n,f) ¹³⁷ Cs	3.082E+00	7.178E-01	3.124E-00	7.111E-01
⁵⁹ Co(n,γ) ⁶⁰ Co	4.234E+01	9.862E-00	4.210E+01	9.583E-00

^a ENDF/B-VI dosimetry cross sections were used in both calculations.

$$^b \bar{\sigma} = \frac{\int_0^{\infty} \sigma(E)\phi(E)dE}{\int_1^{\infty} \phi(E)dE}$$

$$^c \bar{\sigma} = \frac{\int_0^{\infty} \sigma(E)\phi(E)dE}{\int_{0.11}^{\infty} \phi(E)dE}$$

Table 12 Spectrum-averaged cross section at the center of the 34.0 surveillance capsule at core midplane of Trojan Cycle 13

Reaction	W/ENDF/B-VI Fe-O-H ^a		W/ORIGINAL SAILOR ^a	
	E > 1 $\bar{\sigma}$ (barns) ^b	E > .11 $\bar{\sigma}$ (barns) ^c	E > 1 $\bar{\sigma}$ (barns) ^b	E > .11 $\bar{\sigma}$ (barns) ^c
⁵⁴ Fe(n,p) ⁵⁴ Mn	5.728E-02	1.296E-02	5.528E-02	1.222E-02
⁵⁸ Ni (n,p) ⁵⁸ Co	8.089E-02	1.830E-02	7.861E-02	1.738E-02
⁶³ Cu(n,α) ⁶⁰ Co	5.017E-04	1.135E-04	5.093E-04	1.126E-04
⁴⁶ Ti (n,p) ⁴⁶ Sc	8.171E-03	2.849E-03	7.986E-03	1.766E-03
²³⁸ U (n,f) ¹³⁷ Cs	3.183E-01	7.202E-02	3.172E-01	7.014E-02
²³⁷ Np(n,f) ¹³⁷ Cs	3.130E+00	7.082E-01	3.174E-00	7.019E-01
⁵⁹ Co(n,γ) ⁶⁰ Co	4.343E+01	9.826E-00	4.314E+01	9.540E-00

^a ENDF/B-VI dosimetry cross sections were used in both calculations.

$$^b \bar{\sigma} = \frac{\int_0^{\infty} \sigma(E)\phi(E)dE}{\int_1^{\infty} \phi(E)dE}$$

$$^c \bar{\sigma} = \frac{\int_0^{\infty} \sigma(E)\phi(E)dE}{\int_{0.11}^{\infty} \phi(E)dE}$$

Table 13 Comparison of calculated absolute saturated reaction rates
for Trojan Cycle 13 with experimental and Westinghouse
calculated results of Capsule X (removed April 1984)

Reaction	<u>Westinghouse (for Capsule X)</u>		<u>LSU Calculated (for Cycle 13)</u>	
	Experimental	Calculated	w/ENDF6 Fe-O-H	w/ORIGINAL SAILOR
$^{54}\text{Fe}(n,p) ^{54}\text{Mn}$	4.16E6	4.97E6(1.20) ^a	3.35E6(0.81) ^a	2.92E6(0.70) ^a
$^{63}\text{Cu}(n,\alpha) ^{60}\text{Co}$	4.09E5	4.31E5(1.05)	3.08E5(0.75)	2.82E5(0.69)
$^{58}\text{Ni}(n,p) ^{58}\text{Co}$	6.28E7	7.47E7(1.19)	5.31E7(0.85)	4.65E7(0.74)
$^{237}\text{Np}(n,f) ^{137}\text{Cs}$	7.30E7	7.46E7(1.02)	4.67E7(0.64)	4.27E7(0.59)
$^{238}\text{U}(n,f) ^{137}\text{Cs}$	7.68E6	6.47E6(0.84)	4.53E6(0.59)	4.07E6(0.53)

^aRatio of calculated to capsule X experimental values.

Table 14 Calculated relative azimuthal variation of flux > 1 MeV
at four radial locations for Trojan Cycle 13

J	$\bar{\theta}$	0 T	3/4 T	R ^a = 257.0 cm	R ^b = 321.6 cm
1	5.0000E-03	0.5328	0.5809	0.6963	0.8346
2	2.0601E-01	0.5364	0.5796	0.6968	0.8282
3	4.2601E-01	0.5387	0.5783	0.6974	0.8225
4	7.2500E-01	0.5354	0.5800	0.6994	0.8037
5	1.1250E+00	0.5389	0.5809	0.7008	0.7500
6	1.2530E+00	0.5441	0.5802	0.7003	0.7249
7	1.3100E+00	0.5377	0.5798	0.7005	0.7187
8	1.7820E+00	0.5396	0.5822	0.6989	0.6899
9	2.6000E+00	0.5448	0.5871	0.7015	0.6005
10	3.2500E+00	0.5485	0.5916	0.7064	0.5000
11	3.5565E+00	0.5536	0.5952	0.7087	0.4392
12	3.8140E+00	0.5534	0.5985	0.7118	0.3667
13	4.1326E+00	0.5597	0.6001	0.7145	0.3038
14	4.3990E+00	0.5609	0.6028	0.7169	0.2755
15	4.7740E+00	0.5663	0.6094	0.7201	0.2556
16	5.1950E+00	0.5725	0.6130	0.7231	0.2374
17	6.0700E+00	0.5848	0.6274	0.7352	0.2219
18	7.5001E+00	0.6112	0.6533	0.7546	0.2153
19	9.0000E+00	0.6432	0.6858	0.7759	0.2181
20	1.0435E+01	0.6781	0.7211	0.8001	0.2243
21	1.1310E+01	0.7017	0.7418	0.8177	0.2265
22	1.1750E+01	0.7162	0.7558	0.8264	0.2294
23	1.2375E+01	0.7320	0.7714	0.8387	0.2308
24	1.2994E+01	0.7490	0.7890	0.8515	0.2335
25	1.3619E+01	0.7702	0.8052	0.8626	0.2345
26	1.4375E+01	0.7906	0.8255	0.8757	0.2367
27	1.5255E+01	0.8120	0.8494	0.8897	0.2378
28	1.6380E+01	0.8461	0.8740	0.9044	0.2382
29	1.7500E+01	0.8722	0.8975	0.9158	0.2381
30	1.8435E+01	0.8910	0.9103	0.9221	0.2372
31	1.9435E+01	0.9099	0.9158	0.9235	0.2371
32	2.0375E+01	0.9149	0.9127	0.9212	0.2362
33	2.1037E+01	0.9050	0.9043	0.9172	0.2368
34	2.1912E+01	0.8884	0.8834	0.9094	0.2350
35	2.3000E+01	0.8472	0.8537	0.8968	0.2339
36	2.3875E+01	0.8062	0.8262	0.8848	0.2325
37	2.4444E+01	0.7850	0.8063	0.8757	0.2317
38	2.4819E+01	0.7761	0.7946	0.8696	0.2311
39	2.5017E+01	0.7744	0.7873	0.8669	0.2314
40	2.5452E+01	0.7480	0.7711	0.8586	0.2311
41	2.6385E+01	0.7012	0.7333	0.8428	0.2297
42	2.7450E+01	0.6434	0.6869	0.8265	0.2295
43	2.8301E+01	0.5970	0.6523	0.8156	0.2290
44	2.8710E+01	0.5814	0.6372	0.8109	0.2291
45	2.9174E+01	0.5739	0.6242	0.8062	0.2298
46	3.0015E+01	0.5565	0.6102	0.7992	0.2311
47	3.0650E+01	0.5403	0.6030	0.7954	0.2318
48	3.1500E+01	0.5441	0.6046	0.7973	0.2313
49	3.2300E+01	0.5580	0.6083	0.8005	0.2312
50	3.2471E+01	0.5619	0.6102	0.8027	0.2314
51	3.2821E+01	0.5676	0.6195	0.8063	0.2310
52	3.3200E+01	0.5784	0.6294	0.8097	0.2306
53	3.3995E+01	0.6088	0.6611	0.8214	0.2303
54	3.4695E+01	0.6396	0.6912	0.8332	0.2293

Table 14 (continued)

J	$\bar{\theta}$	0 T	3/4 T	R ^a = 257.0 cm	R ^b = 321.6 cm
55	3.4850E+01	0.6570	0.6978	0.8354	0.2299
56	3.5500E+01	0.7066	0.7277	0.8487	0.2309
57	3.6500E+01	0.7743	0.7740	0.8722	0.2321
58	3.7375E+01	0.8241	0.8142	0.8942	0.2349
59	3.8124E+01	0.8664	0.8466	0.9133	0.2392
60	3.8788E+01	0.8913	0.8747	0.9281	0.2464
61	3.9289E+01	0.8990	0.8950	0.9368	0.2536
62	3.9749E+01	0.9132	0.9113	0.9453	0.2668
63	4.0100E+01	0.9287	0.9221	0.9539	0.2801
64	4.0237E+01	0.9370	0.9254	0.9574	0.2827
65	4.0340E+01	0.9349	0.9285	0.9596	0.2859
66	4.0703E+01	0.9421	0.9378	0.9667	0.3320
67	4.1193E+01	0.9544	0.9506	0.9753	0.4697
68	4.1443E+01	0.9585	0.9561	0.9791	0.6625
69	4.1751E+01	0.9642	0.9626	0.9824	0.7939
70	4.2251E+01	0.9726	0.9710	0.9888	0.8947
71	4.2750E+01	0.9792	0.9789	0.9939	0.9571
72	4.3249E+01	0.9891	0.9860	0.9974	0.9692
73	4.3749E+01	0.9944	0.9912	0.9998	0.9852
74	4.4249E+01	0.9992	0.9955	1.0000	0.9941
75	4.4744E+01	1.0000	0.9983	0.9983	0.9975
76	4.4995E+01	0.9931	1.0000	0.9967	1.0000

^aR = 257.0 cm is the radial location of the dosimeters behind RPV insulation.

^bR = 321.6 cm is the center of the instrumentation tube.

Table 15 Calculated relative axial variation of flux > 1 MeV
at four radial locations for Trojan Cycle 13

J	$\bar{Z}^a$	0 T	3/4 T	R ^b = 257.0 cm	R ^c = 321.6 cm
1	2.159E+00	0.0407	0.0458	0.1581	0.1448
2	6.477E+00	0.0636	0.0759	0.1796	0.2017
3	1.079E+01	0.0882	0.1044	0.2058	0.2373
4	1.511E+01	0.1188	0.1361	0.2343	0.2666
5	1.943E+01	0.1544	0.1716	0.2649	0.2952
6	2.381E+01	0.1952	0.2115	0.2981	0.3245
7	2.826E+01	0.2411	0.2550	0.3325	0.3549
8	3.231E+01	0.2862	0.2973	0.3645	0.3818
9	3.780E+01	0.3480	0.3570	0.4104	0.4196
10	4.511E+01	0.4360	0.4399	0.4737	0.4695
11	5.243E+01	0.5276	0.5247	0.5376	0.5197
12	5.974E+01	0.6170	0.6079	0.5997	0.5687
13	6.706E+01	0.6972	0.6848	0.6585	0.6162
14	7.437E+01	0.7651	0.7516	0.7124	0.6636
15	8.169E+01	0.8201	0.8069	0.7603	0.7078
16	8.900E+01	0.8627	0.8511	0.8021	0.7496
17	9.632E+01	0.8954	0.8856	0.8375	0.7878
18	1.036E+02	0.9211	0.9123	0.8675	0.8213
19	1.109E+02	0.9401	0.9329	0.8925	0.8507
20	1.183E+02	0.9541	0.9485	0.9134	0.8765
21	1.256E+02	0.9649	0.9604	0.9308	0.8991
22	1.329E+02	0.9730	0.9696	0.9453	0.9191
23	1.402E+02	0.9793	0.9767	0.9574	0.9362
24	1.475E+02	0.9843	0.9823	0.9673	0.9507
25	1.548E+02	0.9881	0.9867	0.9755	0.9628
26	1.622E+02	0.9913	0.9903	0.9821	0.9728
27	1.695E+02	0.9938	0.9932	0.9876	0.9809
28	1.768E+02	0.9959	0.9955	0.9918	0.9876
29	1.841E+02	0.9976	0.9973	0.9951	0.9925
30	1.914E+02	0.9987	0.9987	0.9975	0.9964
31	1.987E+02	0.9996	0.9996	0.9991	0.9987
32	2.060E+02	1.0000	1.0000	1.0000	0.9999
33	2.134E+02	1.0000	1.0000	1.0000	1.0000
34	2.207E+02	0.9995	0.9994	0.9993	0.9988
35	2.280E+02	0.9986	0.9984	0.9978	0.9967
36	2.353E+02	0.9971	0.9968	0.9955	0.9932
37	2.426E+02	0.9951	0.9947	0.9923	0.9886
38	2.499E+02	0.9927	0.9921	0.9881	0.9824
39	2.573E+02	0.9896	0.9888	0.9829	0.9747
40	2.646E+02	0.9860	0.9848	0.9765	0.9654
41	2.719E+02	0.9815	0.9799	0.9688	0.9543
42	2.792E+02	0.9762	0.9740	0.9595	0.9411
43	2.865E+02	0.9697	0.9669	0.9483	0.9256
44	2.938E+02	0.9615	0.9580	0.9349	0.9074
45	3.011E+02	0.9514	0.9468	0.9191	0.8865
46	3.085E+02	0.9382	0.9327	0.9002	0.8628
47	3.158E+02	0.9216	0.9146	0.8779	0.8360
48	3.231E+02	0.9000	0.8915	0.8515	0.8059
49	3.304E+02	0.8714	0.8622	0.8205	0.7721
50	3.377E+02	0.8359	0.8256	0.7843	0.7339
51	3.450E+02	0.7915	0.7802	0.7426	0.6928

Table 15 (continued)

J	$\bar{z}^a$	0 T	3/4 T	$R^b = 257.0 \text{ cm}$	$R^c = 321.6 \text{ cm}$
52	3.523E+02	0.7363	0.7248	0.6951	0.6484
53	3.597E+02	0.6696	0.6588	0.6423	0.6028
54	3.670E+02	0.5909	0.5837	0.5852	0.5558
55	3.743E+02	0.5043	0.5031	0.5252	0.5075
56	3.816E+02	0.4164	0.4212	0.4645	0.4587
57	3.889E+02	0.3321	0.3420	0.4045	0.4110
58	3.944E+02	0.2732	0.2854	0.3613	0.3752
59	3.995E+02	0.2204	0.2363	0.3227	0.3455
60	4.061E+02	0.1615	0.1800	0.2759	0.3060
61	4.127E+02	0.1138	0.1328	0.2357	0.2669
62	4.194E+02	0.0778	0.0951	0.2001	0.2321
63	4.260E+02	0.0521	0.0664	0.1683	0.1969
64	4.319E+02	0.0355	0.0468	0.1435	0.1678
65	4.371E+02	0.0245	0.0333	0.1244	0.1401
66	4.424E+02	0.0149	0.0197	0.1089	0.0978

^aAxial height in cm (reactor core 30.48 – 396.24 cm, core midplane = 213.36 cm).

^b $R = 257.0 \text{ cm}$ is the radial location of the dosimeters behind the RPV insulation.

^c $R = 321.6 \text{ cm}$ is the center of the instrumentation tube.

Table 16 Radial variation of integrated parameters along RPV, calculated with ENDF/B-VI
Fe-O-H at 0° (20.3 cm below midplane), for Trojan Cycle 13*

Location	Fast flux >1.0 MeV	Flux >0.1 MeV	Thermal flux < 0.4 eV	Thermal/ fast	DPA rate (DPA/S)
RPV liner	1.005E+10	1.985E+10	2.429E+10	2.416	1.553E-11
O-T	9.736E+09	2.020E+10	1.499E+10	1.540	1.506E-11
1/4-T	5.606E+09	1.774E+10	2.535E+08	0.045	9.674E-12
3/4-T	1.302E+09	8.883E+09	2.785E+07	0.021	3.432E-12

*RPV liner starts at 219.71 cm, RPV extends from 220.27 to 242.17 cm.

NOTE: Negligible difference between midplane values and 20.3 cm below midplane.

Table 17 Radial variation of integrated parameters along RPV, calculated with ENDF/B-VI
Fe-O-H at 45° (20.3 cm below midplane), for Trojan Cycle 13*

Location	Fast flux >1.0 MeV	Flux >0.1 MeV	Thermal flux < 0.4 eV	Thermal/ fast	DPA rate (DPA/S)
RPV liner	1.868E+10	4.430E+10	1.331E+11	7.123	2.992E-11
O-T	1.816E+10	4.500E+10	8.163E+10	4.495	2.892E-11
1/4-T	1.027E+10	3.803E+10	1.203E+09	0.117	1.859E-11
3/4-T	2.243E+09	1.750E+10	3.432E+07	0.015	6.420E-12

*RPV liner starts at 219.71 cm, RPV extends from 220.27 to 242.17 cm.

NOTE: Negligible difference between midplane values and 20.3 cm below midplane.

Table 18 Radial variation of integrated parameters along RPV, calculated with ORIGINAL SAILOR
at 0° (20.3 cm below midplane), for Trojan Cycle 13*

Location	Fast flux >1.0 MeV	Flux >0.1 MeV	Thermal flux < 0.4 eV	Thermal/ fast	DPA rate (DPA/S)
RPV liner	9.858E+09	1.925E+10	2.255E+10	2.287	1.521E-11
O-T	9.525E+09	1.961E+10	1.416E+10	1.486	1.472E-11
1/4-T	5.241E+09	1.710E+10	2.823E+08	0.054	9.128E-12
3/4-T	1.116E+09	8.065E+09	3.354E+07	0.030	3.044E-12

*RPV liner starts at 219.71 cm, RPV extends from 220.27 to 242.17 cm.

NOTE: Negligible difference between midplane values and 20.3 cm below midplane.

Table 19 Radial variation of integrated parameters along RPV, calculated with ORIGINAL SAILOR at 45° (20.3 cm below midplane), for Trojan Cycle 13^a

Location	Fast flux >1.0 MeV	Flux >0.1 MeV	Thermal flux < 0.4 eV	Thermal/ fast	DPA rate (DPA/S)
RPV liner	1.709E+10	4.027E+10	1.187E+11	6.942	2.725E-11
O-T	1.658E+10	4.096E+10	7.378E+10	4.450	2.631E-11
1/4-T	9.016E+09	3.439E+10	1.246E+09	0.138	1.647E-11
3/4-T	1.807E+09	1.496E+10	4.083E+07	0.023	5.373E-12

^aRPV liner starts at 219.71 cm, RPV extends from 220.27 to 242.17 cm.

NOTE: Negligible difference between midplane values and 20.3 cm below midplane.

Table 20 Radial variation of cumulative fluence (n.cm⁻²) and DPA along RPV, calculated with ENDF/B-VI Fe-O-H at 0°, at near core midplane for Trojan Cycle 13^a

Location	Cycle-13 ^b		32 EFPY ^c	
	Fluence	DPA	Fluence	DPA
RPV liner	1.834E+17	2.835E-04	1.016E+19	1.570E-02
O-T	1.777E+17	2.749E-04	9.843E+18	1.523E-02
1/4-T	1.023E+17	1.766E-04	5.668E+18	9.780E-03
3/4-T	2.376E+16	6.264E-05	1.316E+18	3.470E-03

^aRPV liner starts at 219.71 cm, RPV extends from 220.27 to 242.17 cm.

^b211.25 full-power days = 1.8252E+07 seconds.

^c32 EFPY amounts to 11,696 full-power days = 1.011E+09 seconds.

Table 21 RPV peak cumulative fluence (n.cm⁻²) and DPA calculated with ENDF/B-VI Fe-O-H for Trojan Cycle 13^a

Location	Cycle-13 ^b		32 EFPY ^c	
	Fluence	DPA	Fluence	DPA
RPV liner	3.410E+17	5.461E-04	1.889E+19	3.025E-02
O-T	3.314E+17	5.278E-04	1.836E+19	2.924E-02
1/4-T	1.874E+17	3.393E-04	1.038E+19	1.879E-02
3/4-T	4.094E+16	1.172E-04	2.268E+18	6.491E-03

^aRPV liner starts at 219.71 cm, RPV extends from 220.27 to 242.17 cm.

^b211.25 full-power days = 1.8252E+07 seconds.

^c32 EFPY amounts to 11,696 full-power days = 1.011E+09 seconds.

respectively. The projected cumulative fluence after 32 EFY for the same locations are about $1.889\text{E}+19$ and $1.836\text{E}+19$ n.cm⁻², respectively.

Tables 22 and 23 show the absolute flux spectra at the 0° cavity dosimeter location (5 cm behind insulation) and at the center of the instrumentation tube, at 20.3 cm below the core midplane, while Tables 24 and 25 show the values calculated with ORIGINAL SAILOR. Tables 26 and 27 show the calculated saturated reaction rates obtained with both libraries at the above locations, and Tables 28 through 33 show the same quantities at the same dosimeters radial location, but at the axial location of 1.219 meters above the core midplane. The spectrum averaged cross sections for several reactions calculated at the radial locations of the two dosimeter capsules, at 20.3 cm below the core midplane are given in Tables 34 and 35, respectively. At the axial location of 121.9 cm above the core midplane, the values of the spectrum averaged cross section for the same reactions differ by less than $\pm 1\%$ compared with the values at 20.3 cm below midplane, indicating little axial variation in the neutron energy spectrum. Table 36 shows the non-saturation factors for each dosimeter calculated from the power time history of Cycle 13. These factors correspond to the fraction of saturation obtained by each dosimeter at the time of removal from the core.

Table 37 gives the ratio of calculated to experimental (C/E) results for the various dosimeters, obtained with the ENDF/B-VI data; Table 38 presents similar results obtained with the ORIGINAL SAILOR library. Note that the ENDF/B-VI results for the threshold dosimeters are about 30 to 40% higher than the measured results at the RPV insulation location (i.e., Capsules A & B), and they are about 50 to 70% higher at the instrument tube location (Capsules C & D). The poorest agreement at the instrument tube location is not surprising, since these dosimeters are located within the detector well behind the ex-core detector. This region cannot be modeled well with two-dimensional geometry. The ORIGINAL SAILOR results are about 20% higher than the experimental values at the RPV and are 20 to 40% high within the instrument tube. In contrast to other studies (e.g., the HBR Cycle 9 analysis)^{12,13} which indicate that the ORIGINAL SAILOR library tends to underestimate the fast neutron reaction rates in the cavity, these Trojan calculations performed with the ORIGINAL SAILOR *overpredict* the reaction rates compared to the measurements. Recall that the surveillance capsule X dosimeter measurements are underpredicted by the Cycle 13 transport calculations. Consistent with the earlier studies, the new ENDF/B-VI calculations are about 20 to 25% higher than the ORIGINAL SAILOR results. However, since the ORIGINAL SAILOR fast-neutron-dosimetry results obtained here are already too high, the ENDF/B-VI values come out very high compared with the experiment. Thus the ENDF/B-VI calculations agreement is substantially poorer with the measurements than the ORIGINAL SAILOR calculations for the Trojan cavity dosimeters. We do not presently understand why these Trojan C/E values for ENDF/B-VI are so different from those obtained earlier in H. B. Robinson¹³ and those projected for the ANO-1 reactor.⁸ However, the generic pinwise power distribution used in the transport calculations is at least partially responsible for the excessively high computed activities. A constant factor of ~ 0.75 applied to all calculated results would bring the C/E values in line with the earlier results. Both the ORIGINAL SAILOR and the ENDF/B-VI overestimate the bare $\text{Co}(n,\gamma)$ reaction by up to a factor

of 2, and the $^{235}\text{U}(n,f)$ is overestimated by a factor of 2 to 3. The latter two dosimeters are sensitive to thermal neutrons and can be impacted by a number of factors with high uncertainties, such as the amount of water and impurity materials present in the concrete shield around the cavity. The C/E's of the thermal dosimeters in Capsule A appear to be inconsistent with the other capsules.

Based on the Trojan cavity dosimeter analysis for Cycle 13, it appears that there is an unexplained inconsistency between the calculated and measured dosimetry results. Comparison with in-vessel dosimeter measurements for this cycle, if available, would help to narrow the possible causes for the observed discrepancies. Also, obtaining and utilizing the plant-specific pinwise power would eliminate this contribution to the discrepancy. Since the ENDF/B-VI calculations produce the higher estimates for the cavity flux, we recommend for now that these results be used in the radiation damage assessments, with the understanding that these fluxes should be conservative by about a factor of 2 for the thermal range and by 50% in the fast-energy range.

Of primary concern in Trojan and other similarly designed reactors is the radiation embrittlement of the pivot joint in the horizontal support structure component embedded in the concrete shield. This steel member carries a large bending moment, and if it fails, the reactor support could be compromised. The location of this critical point is approximately 18 cm into the concrete, near $\theta = 23^\circ$, and about 20.3 cm below the core midplane. Table 39 shows the calculated saturated reaction rates for several dosimeters at this location. Table 40 gives results computed for the flux above 1 MeV, above 0.1 MeV, DPA rate in iron, cumulative fluence, and the thermal flux at this location as well as two other locations of 13 cm and 23 cm into the concrete. The ratio of thermal to fast flux at the 18 cm depth is calculated to be 46.13. Based on the calculated flux above 1.0 MeV, the total fluence at this location due to 211.25 effective full-power days of Cycle 13 is about $1.258\text{E}+15 \text{ n.cm}^{-2}$. Based only on the fluence rate computed for Cycle 13, the projected cumulative fast fluence at the joint after 32 EFY is about $6.971\text{E}+16 \text{ cm}^{-2}$. Table 41 shows the absolute flux spectrum at the critical point.

The results are based on the ENDF/B-VI calculations, since they are higher than the ORIGINAL SAILOR values, and are therefore conservative. These are absolute results, corresponding to full-power conditions with the power distribution of Cycle 13. The actual structural components are not included in the transport model; hence, the values in Table 40 reflect the results calculated within the concrete with no correction for perturbations due to the steel itself. This fact, along with considerable uncertainty in the water content of the concrete, and the lumped thermal group approximation introduces a large uncertainty into the calculated value for the thermal flux exposure at the support structure.

Table 22 Absolute flux spectrum obtained with ENDF/B-VI Fe-O-H, behind RPV insulation at 0°, R = 257.0 cm, and 20.3 cm below the core midplane

Group	Upper energy	Group flux	Cumulative flux	Group DPA	Cumulative DPA	Cumulative DPA fraction
1	1.733E+01	1.745E+05	1.745E+05	5.099E-16	5.099E-16	3.450E-04
2	1.419E+01	6.210E+05	7.955E+05	1.643E-15	2.153E-15	1.457E-03
3	1.221E+01	1.883E+06	2.679E+06	4.537E-15	6.690E-15	4.527E-03
4	1.000E+01	3.385E+06	6.064E+06	7.511E-15	1.420E-14	9.609E-03
5	8.607E+00	4.788E+06	1.085E+07	9.992E-15	2.419E-14	1.637E-02
6	7.408E+00	9.574E+06	2.043E+07	1.860E-14	4.279E-14	2.896E-02
7	6.065E+00	1.200E+07	3.242E+07	2.140E-14	6.420E-14	4.344E-02
8	4.966E+00	1.939E+07	5.181E+07	3.046E-14	9.466E-14	6.405E-02
9	3.679E+00	1.492E+07	6.674E+07	2.044E-14	1.151E-13	7.789E-02
10	3.012E+00	1.159E+07	7.833E+07	1.473E-14	1.298E-13	8.786E-02
11	2.725E+00	1.414E+07	9.247E+07	1.803E-14	1.479E-13	1.001E-01
12	2.466E+00	7.140E+06	9.961E+07	8.368E-15	1.562E-13	1.057E-01
13	2.365E+00	2.230E+06	1.018E+08	2.444E-15	1.587E-13	1.074E-01
14	2.346E+00	1.122E+07	1.131E+08	1.168E-14	1.704E-13	1.153E-01
15	2.231E+00	3.136E+07	1.444E+08	3.242E-14	2.028E-13	1.372E-01
16	1.920E+00	4.577E+07	1.902E+08	3.723E-14	2.400E-13	1.624E-01
17	1.653E+00	7.436E+07	2.646E+08	6.026E-14	3.003E-13	2.032E-01
18	1.353E+00	1.894E+08	4.540E+08	1.061E-13	4.064E-13	2.750E-01
19	1.003E+00	1.843E+08	6.383E+08	6.755E-14	5.740E-13	3.207E-01
20	8.208E-01	8.402E+07	7.223E+08	4.713E-14	5.211E-13	3.526E-01
21	7.427E-01	4.279E+08	1.150E+09	1.547E-13	6.757E-13	4.572E-01
22	6.081E-01	3.782E+08	1.528E+09	1.113E-13	7.871E-13	5.326E-01
23	4.979E-01	4.365E+08	1.965E+09	1.730E-13	9.601E-13	6.496E-01
24	3.688E-01	6.108E+08	2.576E+09	1.263E-13	1.086E-12	7.351E-01
25	2.972E-01	7.795E+08	3.355E+09	1.563E-13	1.243E-12	8.409E-01
26	1.832E-01	7.054E+08	4.061E+09	9.946E-14	1.342E-12	9.082E-01
27	1.111E-01	4.606E+08	4.521E+09	5.956E-14	1.402E-12	9.485E-01
28	6.738E-02	3.299E+08	4.851E+09	2.137E-14	1.423E-12	9.629E-01
29	4.087E-02	1.137E+08	4.965E+09	9.199E-15	1.437E-12	9.692E-01
30	3.183E-02	6.025E+07	5.025E+09	1.713E-14	1.449E-12	9.807E-01
31	2.606E-02	2.018E+08	5.227E+09	4.068E-15	1.453E-12	9.835E-01
32	2.418E-02	1.198E+08	5.347E+09	5.246E-16	1.454E-12	9.838E-01
33	2.188E-02	2.295E+08	5.576E+09	1.879E-15	1.456E-12	9.851E-01
34	1.503E-02	3.120E+08	5.888E+09	5.853E-15	1.462E-12	9.891E-01
35	7.102E-03	3.152E+08	6.203E+09	2.804E-15	1.465E-12	9.910E-01
36	3.355E-03	2.731E+08	6.476E+09	9.612E-16	1.465E-12	9.916E-01
37	1.585E-03	4.193E+08	6.896E+09	7.052E-16	1.466E-12	9.921E-01
38	4.540E-04	2.083E+08	7.104E+09	2.054E-17	1.466E-12	9.921E-01
39	2.144E-04	2.153E+08	7.319E+09	3.088E-17	1.466E-12	9.921E-01
40	1.013E-04	2.710E+08	7.590E+09	6.047E-17	1.466E-12	9.922E-01
41	3.727E-05	3.119E+08	7.902E+09	1.229E-16	1.466E-12	9.923E-01
42	1.068E-05	1.716E+08	8.074E+09	1.103E-16	1.467E-12	9.923E-01
43	5.043E-06	2.048E+08	8.279E+09	2.048E-16	1.467E-12	9.925E-01
44	1.855E-06	1.343E+08	8.413E+09	2.064E-16	1.467E-12	9.926E-01
45	8.764E-07	1.200E+08	8.533E+09	2.694E-16	1.467E-12	9.928E-01
46	4.140E-07	1.486E+08	8.682E+09	5.824E-16	1.468E-12	9.932E-01
47	1.000E-07	1.077E+09	9.759E+09	1.007E-14	1.478E-12	1.000E+00

Table 23 Absolute flux spectrum obtained with ENDF/B-VI Fe-O-H at the center of the instrumentation tube, R = 321.63 cm, 0° and 20.3 cm below the core midplane

Group	Upper energy	Group flux	Cumulative flux	Group DPA	Cumulative DPA	Cumulative DPA fraction
1	1.733E+01	1.367E+01	1.367E+05	3.995E-16	3.995E-16	3.102E-04
2	1.419E+01	4.884E+05	6.251E+05	1.292E-15	1.692E-15	1.313E-03
3	1.221E+01	1.488E+06	2.113E+06	3.585E-15	5.277E-03	4.097E-03
4	1.000E+01	2.682E+06	4.795E+06	5.951E-15	1.123E-14	8.717E-03
5	8.607E+00	3.807E+06	8.603E+06	7.946E-15	1.917E-14	1.489E-02
6	7.408E+00	7.657E+06	1.626E+07	1.488E-14	3.405E-14	2.644E-02
7	6.065E+00	9.736E+06	2.600E+07	1.737E-14	5.142E-14	3.993E-02
8	4.966E+00	1.604E+07	4.203E+07	2.520E-14	7.662E-14	5.949E-02
9	3.679E+00	1.247E+07	5.450E+07	1.708E-14	9.370E-14	7.275E-02
10	3.012E+00	9.700E+06	6.420E+07	1.233E-14	1.060E-13	8.232E-02
11	2.725E+00	1.196E+07	7.616E+07	1.525E-14	1.213E-13	9.416E-02
12	2.466E+00	6.106E+06	8.226E+07	7.156E-15	1.284E-13	9.971E-02
13	2.365E+00	1.889E+06	8.415E+07	2.071E-15	1.305E-13	1.013E-01
14	2.346E+00	9.544E+06	9.370E+07	9.935E-15	1.404E-13	1.090E-01
15	2.231E+00	2.608E+07	1.198E+08	2.697E-14	1.674E-13	1.300E-01
16	1.920E+00	3.796E+07	1.577E+08	3.087E-14	1.983E-13	1.539E-01
17	1.653E+00	6.272E+07	2.205E+08	5.082E-14	2.491E-13	1.934E-01
18	1.353E+00	1.563E+08	3.767E+08	8.756E-14	3.366E-13	2.614E-01
19	1.003E+00	1.511E+08	5.278E+08	5.537E-14	3.920E-13	3.044E-01
20	8.208E-01	7.829E+07	6.061E+08	4.391E-14	4.359E-13	3.385E-01
21	7.427E-01	3.548E+08	9.609E+08	1.282E-13	5.642E-13	4.380E-01
22	6.081E-01	3.269E+08	1.288E+09	9.622E-14	6.604E-13	5.127E-01
23	4.979E-01	3.668E+08	1.655E+09	1.454E-13	8.058E-13	6.256E-01
24	3.688E-01	5.073E+08	2.162E+09	1.049E-13	9.107E-13	7.071E-01
25	2.972E-01	7.384E+08	2.900E+09	1.481E-13	1.059E-12	8.220E-01
26	1.832E-01	6.788E+08	3.579E+09	9.571E-14	1.154E-12	8.963E-01
27	1.111E-01	4.484E+08	4.027E+09	5.798E-14	1.212E-12	9.414E-01
28	6.738E-02	3.337E+08	4.361E+09	2.162E-14	1.234E-12	9.581E-01
29	4.087E-02	1.197E+08	4.481E+09	9.685E-15	1.244E-12	9.657E-01
30	3.183E-02	6.537E+07	4.546E+09	1.858E-14	1.262E-12	9.801E-01
31	2.606E-02	1.657E+08	4.712E+09	3.341E-15	1.266E-12	9.827E-01
32	2.418E-02	1.043E+08	4.816E+09	4.569E-16	1.266E-12	9.830E-01
33	2.188E-02	2.203E+08	5.037E+09	1.804E-15	1.268E-12	9.844E-01
34	1.503E-02	3.336E+08	5.370E+09	6.257E-15	1.274E-12	9.893E-01
35	7.102E-03	3.355E+08	5.706E+09	2.984E-15	1.277E-12	9.916E-01
36	3.355E-03	3.063E+08	6.012E+09	1.078E-15	1.278E-12	9.924E-01
37	1.585E-03	4.660E+08	6.478E+09	7.838E-16	1.279E-12	9.931E-01
38	4.540E-04	2.390E+08	6.717E+09	2.356E-17	1.279E-12	9.931E-01
39	2.144E-04	2.461E+08	6.963E+09	3.530E-17	1.279E-12	9.931E-01
40	1.013E-04	3.112E+08	7.274E+09	6.943E-17	1.279E-12	9.931E-01
41	3.727E-05	3.600E+08	7.634E+09	1.418E-16	1.279E-12	9.933E-01
42	1.068E-05	1.983E+08	7.833E+08	1.274E-16	1.279E-12	9.934E-01
43	5.043E-06	2.370E+08	8.070E+09	2.370E-16	1.280E-12	9.935E-01
44	1.855E-06	1.543E+08	8.224E+09	2.371E-16	1.280E-12	9.937E-01
45	8.764E-07	1.347E+08	8.358E+09	3.023E-16	1.280E-12	9.940E-01
46	4.140E-07	1.258E+08	8.484E+09	4.928E-16	1.281E-12	9.943E-01
47	1.000E-07	7.796E+08	9.264E+09	7.288E-15	1.288E-12	1.000E+00

Table 24 Absolute flux spectrum calculated with ORIGINAL SAILOR behind the RPV insulation at 0° dosimeters, R = 257.0 cm, and 20.3 cm below the core midplane

Group	Upper energy	Group flux	Cumulative flux	Group DPA	Cumulative DPA	Cumulative DPA fraction
1	1.733E+01	1.434E+05	1.434E+05	4.189E-16	4.189E-16	3.478E-04
2	1.419E+01	5.957E+05	7.391E+05	1.576E-15	1.995E-15	1.657E-03
3	1.211E+01	1.782E+06	2.522E+06	4.294E-15	6.289E-15	5.221E-03
4	1.000E+01	3.025E+06	5.546E+06	6.712E-15	1.300E-14	1.079E-02
5	8.607E+00	4.236E+06	9.783E+06	8.841E-15	2.184E-14	1.813E-02
6	7.408E+00	8.116E+06	1.790E+07	1.577E-14	3.761E-14	3.123E-02
7	6.065E+00	8.940E+06	2.684E+07	1.595E-14	5.356E-14	4.447E-02
8	4.966E+00	1.380E+07	4.064E+07	2.168E-14	7.524E-14	6.247E-02
9	3.679E+00	1.177E+07	5.241E+07	1.612E-14	9.137E-14	7.586E-02
10	3.012E+00	9.565E+06	6.197E+07	1.216E-14	1.035E-13	8.595E-02
11	2.725E+00	1.167E+07	7.364E+07	1.488E-14	1.184E-13	9.830E-02
12	2.466E+00	5.832E+06	7.947E+07	6.836E-15	1.252E-13	1.040E-01
13	2.365E+00	1.993E+06	8.147E+07	2.185E-15	1.274E-13	1.058E-01
14	2.346E+00	9.826E+06	9.129E+07	1.023E-14	1.376E-13	1.143E-01
15	2.231E+00	2.427E+07	1.156E+08	2.509E-14	1.627E-13	1.351E-01
16	1.920E+00	3.851E+07	1.541E+08	3.132E-14	1.941E-13	1.611E-01
17	1.653E+00	5.812E+07	2.122E+08	4.709E-14	2.412E-13	2.002E-01
18	1.353E+00	1.524E+08	3.646E+08	8.539E-14	3.265E-13	2.711E-01
19	1.003E+00	1.605E+08	5.251E+08	5.883E-14	3.854E-13	3.200E-01
20	8.208E-01	6.501E+07	5.901E+08	3.647E-14	4.218E-13	3.502E-01
21	7.427E-01	3.347E+08	9.248E+08	1.210E-13	5.428E-13	4.507E-01
22	6.081E-01	3.202E+08	1.245E+09	9.424E-14	6.370E-13	5.289E-01
23	4.979E-01	3.338E+08	1.579E+09	1.323E-13	7.694E-13	6.388E-01
24	3.688E-01	4.940E+08	2.073E+09	1.022E-13	8.715E-13	7.236E-01
25	2.972E-01	5.909E+08	2.664E+09	1.185E-13	9.900E-13	8.219E-01
26	1.832E-01	6.458E+08	3.309E+09	9.106E-14	1.081E-12	8.975E-01
27	1.111E-01	4.186E+08	3.728E+09	5.412E-14	1.135E-12	9.425E-01
28	6.738E-02	3.249E+08	4.053E+09	2.104E-14	1.156E-12	9.599E-01
29	4.087E-02	1.012E+08	4.154E+09	8.186E-15	1.164E-12	9.667E-01
30	3.183E-02	4.846E+07	4.203E+09	1.378E-14	1.178E-12	9.782E-01
31	2.606E-02	2.131E+08	4.416E+09	4.296E-15	1.182E-12	9.817E-01
32	2.418E-02	1.561E+08	4.572E+09	6.837E-16	1.183E-12	9.823E-01
33	2.188E-02	2.693E+08	4.841E+09	2.206E-15	1.185E-12	9.841E-01
34	1.503E-02	2.869E+08	5.128E+09	5.381E-15	1.191E-12	9.886E-01
35	7.102E-03	2.805E+08	5.408E+09	2.495E-15	1.193E-12	9.907E-01
36	3.355E-03	2.332E+08	5.642E+09	8.210E-16	1.194E-12	9.913E-01
37	1.585E-03	3.537E+08	5.995E+09	5.949E-16	1.195E-12	9.918E-01
38	4.540E-04	1.807E+08	6.176E+09	1.782E-17	1.195E-12	9.919E-01
39	2.144E-04	1.860E+08	6.362E+09	2.667E-17	1.195E-12	9.919E-01
40	1.013E-04	2.351E+08	6.597E+09	5.244E-17	1.195E-12	9.919E-01
41	3.727E-05	2.714E+08	6.868E+09	1.069E-16	1.195E-12	9.920E-01
42	1.068E-05	1.494E+08	7.018E+09	9.603E-17	1.195E-12	9.921E-01
43	5.043E-06	1.795E+08	7.197E+09	1.795E-16	1.195E-12	9.922E-01
44	1.855E-06	1.188E+08	7.316E+09	1.826E-16	1.195E-12	9.924E-01
45	8.764E-07	1.052E+08	7.421E+09	2.361E-16	1.196E-12	9.926E-01
46	4.140E-07	2.367E+08	7.658E+09	9.276E-16	1.196E-12	9.934E-01
47	1.000E-07	8.564E+08	8.514E+09	8.006E-15	1.204E-12	1.000E+00

Table 25 Absolute flux spectrum calculated with ORIGINAL SAILOR, at the center of the instrumentation tube, R = 321.63 cm, 0° below the core midplane

Group	Upper energy	Group flux	Cumulative flux	Group DPA	Cumulative DPA	Cumulative DPA fraction
1	1.733E+01	1.130E+05	1.130E+05	3.302E-16	3.302E-16	3.152E-04
2	1.419E+01	4.686E+05	5.816E+05	1.240E-15	1.570E-15	1.499E-03
3	1.211E+01	1.413E+06	1.995E+06	3.404E-15	4.974E-15	4.747E-03
4	1.000E+01	2.401E+06	4.396E+06	5.329E-15	1.030E-14	9.833E-03
5	8.607E+00	3.382E+06	7.778E+06	7.059E-15	1.736E-14	1.657E-02
6	7.408E+00	6.519E+06	1.430E+07	1.267E-14	3.003E-14	2.866E-02
7	6.065E+00	7.276E+06	2.157E+07	1.298E-14	4.301E-14	4.105E-02
8	4.966E+00	1.143E+07	3.300E+07	1.795E-14	6.096E-14	5.818E-02
9	3.679E+00	9.789E+06	4.279E+07	1.341E-14	7.437E-14	7.098E-02
10	3.012E+00	7.989E+06	5.078E+07	1.015E-14	8.453E-14	8.067E-02
11	2.725E+00	9.836E+06	6.061E+07	1.254E-14	9.707E-14	9.264E-02
12	2.466E+00	4.996E+06	6.561E+07	5.856E-15	1.029E-13	9.823E-02
13	2.365E+00	1.681E+06	6.729E+07	1.842E-15	1.048E-13	9.999E-02
14	2.346E+00	8.335E+06	7.563E+07	8.676E-15	1.134E-13	1.083E-01
15	2.231E+00	2.012E+07	9.575E+07	2.080E-14	1.342E-13	1.281E-01
16	1.920E+00	3.172E+07	1.275E+08	2.580E-14	1.600E-13	1.527E-01
17	1.653E+00	4.884E+07	1.763E+08	3.957E-14	1.996E-13	1.905E-01
18	1.353E+00	1.258E+08	3.021E+08	7.050E-14	2.701E-13	2.578E-01
19	1.003E+00	1.302E+08	4.323E+08	4.771E-14	3.178E-13	3.033E-01
20	8.208E-01	6.069E+07	4.930E+08	3.404E-14	3.519E-13	3.358E-01
21	7.427E-01	2.764E+08	7.694E+08	9.990E-14	4.518E-13	4.312E-01
22	6.081E-01	2.735E+08	1.043E+09	8.048E-14	5.322E-13	5.080E-01
23	4.979E-01	2.872E+08	1.330E+09	1.138E-13	6.461E-13	6.166E-01
24	3.688E-01	4.069E+08	1.737E+09	8.414E-14	7.302E-13	6.969E-01
25	2.972E-01	5.598E+08	2.297E+09	1.122E-13	8.425E-13	8.041E-01
26	1.832E-01	6.074E+08	2.904E+09	8.565E-14	9.281E-13	8.858E-01
27	1.111E-01	4.041E+08	3.308E+09	5.226E-14	9.804E-13	9.357E-01
28	6.738E-02	3.168E+08	3.625E+09	2.052E-14	1.001E-12	9.553E-01
29	4.087E-02	1.039E+08	3.729E+09	8.409E-15	1.009E-12	9.633E-01
30	3.183E-02	5.343E+07	3.782E+09	1.519E-14	1.024E-12	9.778E-01
31	2.606E-02	1.690E+08	3.951E+09	3.407E-15	1.028E-12	9.810E-01
32	2.418E-02	1.260E+08	4.077E+09	5.516E-16	1.028E-12	9.816E-01
33	2.188E-02	2.456E+08	4.323E+09	2.011E-15	1.030E-12	9.835E-01
34	1.503E-02	3.000E+08	4.623E+09	5.627E-15	1.036E-12	9.888E-01
35	7.102E-03	3.004E+08	4.923E+09	2.672E-15	1.039E-12	9.914E-01
36	3.355E-03	2.608E+08	5.184E+09	9.181E-16	1.040E-12	9.923E-01
37	1.585E-03	3.920E+08	5.576E+09	6.593E-16	1.040E-12	9.929E-01
38	4.540E-04	2.072E+08	5.783E+09	2.043E-17	1.040E-12	9.929E-01
39	2.144E-04	2.121E+08	5.995E+09	3.041E-17	1.040E-12	9.930E-01
40	1.013E-04	2.693E+08	6.265E+09	6.008E-17	1.040E-12	9.930E-01
41	3.727E-05	3.120E+08	6.577E+09	1.229E-16	1.041E-12	9.931E-01
42	1.068E-05	1.719E+08	6.749E+09	1.105E-16	1.041E-12	9.932E-01
43	5.043E-06	2.062E+08	6.955E+09	2.062E-16	1.041E-12	9.934E-01
44	1.855E-06	1.353E+08	7.090E+09	2.080E-16	1.041E-12	9.936E-01
45	8.764E-07	1.177E+08	7.208E+09	2.640E-16	1.041E-12	9.939E-01
46	4.140E-07	2.251E+08	7.433E+09	8.818E-16	1.042E-12	9.947E-01
47	1.000E-07	5.923E+08	8.025E+09	5.537E-15	1.048E-12	1.000E+00

Table 26 Calculated saturated reaction rates at the 0° dosimeters location,
5.08 cm behind insulation (R = 257.0 cm), at a height 20.3 cm
below the core midplane for Cycle 13

Dosimeter	Reaction per atom per second	
	W/ENDF/B-VI Fe-O-H ^a	W/ORIGINAL SAILOR ^a
	R = 257.00 cm	R = 257.00 cm
⁵⁴ Fe(n,p) ⁵⁴ Mn	2.911E-17	2.330E-17
⁵⁸ Ni (n,p) ⁵⁸ Co	4.059E-17	3.260E-17
⁶³ Cu(n,α) ⁶⁰ Co	4.190E-19	3.668E-19
²³⁷ Np(n,f) ¹³⁷ Cs	2.008E-15	1.632E-15
²³⁸ U (n,f) ¹³⁷ Cs	1.439E-16	1.164E-16
⁴⁶ Ti (n,p) ⁴⁶ Sc	5.571E-18	4.654E-18
⁵⁹ Co(n,γ) ⁶⁰ Co	6.029E-14	5.108E-14
Flux	φ (E) cm ⁻² ·s ⁻¹	
φ (E > 1.0 MeV)	4.569E+08	3.672E+08
φ (E > 0.1 MeV)	4.061E+09	3.309E+09
φ (E < 0.4 eV)	1.226E+09	1.093E+09
DPA rate	dpa/s	
Total DPA rate	1.478E-12	1.204E-12

^a ENDF/B-VI dosimetry cross sections were used in both calculations.

Table 27 Calculated saturated reaction rates at the dosimeters location,
center of the instrument tube, at a height 20.3 cm
below the core midplane for Cycle 13

Dosimeter	Reaction per atom per second	
	W/ENDF/B-VI Fe-O-H ^a	W/ORIGINAL SAILOR ^a
	R = 321.63 cm	R = 321.63 cm
⁵⁴ Fe(n,p) ⁵⁴ Mn	2.379E-17	1.904E-17
⁵⁸ Ni (n,p) ⁵⁸ Co	3.325E-17	2.670E-17
⁶³ Cu(n,α) ⁶⁰ Co	3.337E-19	2.928E-19
²³⁷ Np(n,f) ¹³⁷ Cs	1.706E-15	1.383E-15
²³⁸ U (n,f) ¹³⁷ Cs	1.195E-16	9.652E-17
⁴⁶ Ti (n,p) ⁴⁶ Sc	4.472E-18	3.742E-18
⁵⁹ Co(n,γ) ⁶⁰ Co	5.251E-14	4.417E-14
Flux	ϕ (E) n · cm ⁻² · s ⁻¹	
ϕ (E > 1.0 MeV)	3.791E+08	3.042E+08
ϕ (E > 0.1 MeV)	3.579E+09	2.904E+09
ϕ (E < 0.4 eV)	9.054E+08	8.174E+08
DPA	dpa/s	
Total DPA	1.288E-12	1.048E-12

^a ENDF/B-VI dosimetry cross sections were used in both calculations.

Table 28 Absolute flux spectrum calculated with ENDF/B-VI Fe-O-H, behind RPV insulation at 0°, R = 257.0 cm, and 121.19 cm above the core midplane

Group	Upper energy	Group flux	Cumulative flux	Group DPA	Cumulative DPA	Cumulative DPA fraction
1	1.733E+01	1.389E+05	1.389E+05	4.058E-16	4.058E-16	3.471E-04
2	1.419E+01	4.950E+05	6.339E+05	1.310E-15	1.716E-15	1.467E-03
3	1.221E+01	1.509E+06	2.143E+06	3.634E-15	5.350E-15	4.576E-03
4	1.000E+01	2.715E+06	4.858E+06	6.025E-15	1.137E-14	9.728E-03
5	8.607E+00	3.848E+06	8.705E+06	8.030E-15	1.940E-14	1.660E-02
6	7.408E+00	7.709E+06	1.641E+07	1.498E-14	3.438E-14	2.941E-02
7	6.065E+00	9.656E+06	2.607E+07	1.723E-14	5.161E-14	4.414E-02
8	4.966E+00	1.557E+07	4.164E+07	2.446E-14	7.607E-14	6.506E-02
9	3.679E+00	1.196E+07	5.360E+07	1.638E-14	9.245E-14	7.907E-02
10	3.012E+00	9.288E+06	6.289E+07	1.180E-14	1.043E-13	8.917E-02
11	2.725E+00	1.131E+07	7.419E+07	1.442E-14	1.187E-13	1.015E-01
12	2.466E+00	5.721E+06	7.991E+07	6.705E-15	1.254E-13	1.072E-01
13	2.365E+00	1.795E+06	8.171E+07	1.967E-15	1.273E-13	1.089E-01
14	2.346E+00	9.004E+06	9.071E+07	9.373E-15	1.367E-13	1.1690-01
15	2.231E+00	2.510E+07	1.158E+08	2.595E-14	1.627E-13	1.391E-01
16	1.920E+00	3.660E+07	1.524E+08	2.976E-14	1.924E-13	1.646E-01
17	1.653E+00	5.928E+07	2.117E+08	4.803E-14	2.405E-13	2.057E-01
18	1.353E+00	1.506E+08	3.623E+08	8.440E-14	3.249E-13	2.779E-01
19	1.003E+00	1.459E+08	5.082E+08	5.348E-14	3.783E-13	3.236E-01
20	8.208E-01	6.634E+07	5.746E+08	3.721E-14	4.156E-13	3.554E-01
21	7.427E-01	3.375E+08	9.121E+09	1.220E-13	5.375E-13	4.598E-01
22	6.081E-01	2.989E+08	1.211E+09	8.797E-14	6.255E-13	5.350E-01
23	4.979E-01	3.451E+08	1.556E+09	1.368E-13	7.623E-13	6.520E-01
24	3.688E-01	4.785E+08	2.035E+09	9.895E-14	8.613E-13	7.366E-01
25	2.972E-01	6.126E+08	2.647E+09	1.228E-13	9.841E-13	8.417E-01
26	1.832E-01	5.552E+08	3.203E+09	7.829E-14	1.062E-12	9.086E-01
27	1.111E-01	3.633E+08	3.566E+09	4.697E-14	1.109E-12	9.488E-01
28	6.738E-02	2.604E+08	3.826E+09	1.687E-14	1.126E-12	9.632E-01
29	4.087E-02	8.959E+07	3.916E+09	7.251E-15	1.133E-12	9.694E-01
30	3.183E-02	4.714E+07	3.963E+09	1.340E-14	1.147E-12	9.809E-01
31	2.606E-02	1.571E+08	4.120E+09	3.166E-15	1.150E-12	9.836E-01
32	2.418E-02	9.389E+07	4.214E+09	4.112E-16	1.150E-12	9.840E-01
33	2.188E-02	1.806E+08	4.394E+09	1.479E-15	1.152E-12	9.852E-01
34	1.503E-02	2.460E+08	4.641E+09	4.615E-15	1.157E-12	9.892E-01
35	7.102E-03	2.491E+08	4.890E+09	2.216E-15	1.159E-12	9.911E-01
36	3.355E-03	2.158E+08	5.105E+09	7.597E-16	1.160E-12	9.917E-01
37	1.585E-03	3.316E+08	5.437E+09	5.578E-16	1.160E-12	9.922E-01
38	4.540E-04	1.648E+08	5.602E+09	1.625E-17	1.160E-12	9.922E-01
39	2.144E-04	1.705E+08	5.772E+09	2.446E-17	1.160E-12	9.922E-01
40	1.013E-04	2.148E+08	5.987E+09	4.793E-17	1.160E-12	9.923E-01
41	3.727E-05	2.474E+08	6.235E+09	9.747E-17	1.160E-12	9.924E-01
42	1.068E-05	1.362E+08	6.371E+09	8.753E-17	1.160E-12	9.924E-01
43	5.043E-06	1.625E+08	6.533E+09	1.625E-16	1.161E-12	9.926E-01
44	1.855E-06	1.064E+08	6.640E+09	1.636E-16	1.161E-12	9.927E-01
45	8.764E-07	9.503E+07	6.735E+09	2.132E-16	1.161E-12	9.929E-01
46	4.140E-07	1.166E+08	6.851E+09	4.567E-16	1.161E-12	9.933E-01
47	1.000E-07	8.400E+08	7.691E+09	7.853E-15	1.169E-12	1.000E+00

Table 29 Absolute flux spectrum calculated with ENDF/B-VI Fe-O-H, at the center of the instrumentation tube, R = 321.63 cm, 0° and 121.9 cm above the core midplane

Group	Upper energy	Group flux	Cumulative flux	Group DPA	Cumulative DPA	Cumulative DPA fraction
1	1.733E+01	1.017E+05	1.017E+05	2.970E-16	2.970E-16	3.077E-04
2	1.419E+01	3.632E+05	4.649E+05	9.611E-15	1.258E-15	1.303E-03
3	1.211E+01	1.110E+06	1.575E+06	2.675E-15	3.933E-15	4.075E-03
4	1.000E+01	2.002E+06	3.577E+06	4.441E-15	8.375E-14	8.676E-03
5	8.607E+00	2.846E+06	6.423E+06	5.939E-15	1.431E-14	1.483E-02
6	7.408E+00	5.719E+06	1.214E+07	1.111E-14	2.542E-14	2.634E-02
7	6.065E+00	7.280E+06	1.942E+07	1.299E-14	3.841E-14	3.980E-02
8	4.966E+00	1.202E+07	3.144E+07	1.888E-14	5.729E-14	5.935E-02
9	3.679E+00	9.354E+06	4.079E+07	1.282E-14	7.010E-14	7.263E-02
10	3.012E+00	7.257E+06	4.805E+07	9.224E-15	7.933E-14	8.219E-02
11	2.725E+00	8.946E+06	5.699E+07	1.141E-14	9.073E-14	9.400E-02
12	2.466E+00	4.556E+06	6.155E+07	5.339E-15	9.607E-14	9.953E-02
13	2.365E+00	1.407E+06	6.296E+07	1.542E-15	9.762E-14	1.011E-01
14	2.346E+00	7.118E+06	7.008E+07	7.409E-15	1.050E-13	1.088E-01
15	2.231E+00	1.953E+07	8.960E+07	2.019E-14	1.252E-13	1.297E-01
16	1.920E+00	2.846E+07	1.181E+08	2.315E-14	1.484E-13	1.537E-01
17	1.653E+00	4.702E+07	1.651E+08	3.810E-14	1.865E-13	1.932E-01
18	1.353E+00	1.172E+08	2.823E+08	6.567E-14	2.521E-13	2.612E-01
19	1.003E+00	1.132E+08	3.955E+08	4.148E-14	2.939E-13	3.042E-01
20	8.208E-01	5.865E+07	4.541E+08	3.290E-14	3.265E-13	3.383E-01
21	7.427E-01	2.665E+08	7.207E+08	9.632E-14	4.228E-13	4.381E-01
22	6.081E-01	2.446E+08	9.653E+08	7.200E-14	4.948E-13	5.127E-01
23	4.979E-01	2.734E+08	1.239E+09	1.084E-13	6.032E-13	6.250E-01
24	3.688E-01	3.795E+08	1.618E+09	7.849E-14	6.817E-13	7.063E-01
25	2.972E-01	5.545E+08	2.173E+09	1.112E-13	7.929E-13	8.215E-01
26	1.832E-01	5.098E+08	2.683E+09	7.188E-14	8.648E-13	8.959E-01
27	1.111E-01	3.370E+08	3.020E+09	4.357E-14	9.084E-13	9.411E-01
28	6.738E-02	2.509E+08	3.270E+09	1.625E-14	9.246E-13	9.579E-01
29	4.087E-02	9.000E+07	3.360E+09	7.283E-15	9.319E-13	9.655E-01
30	3.183E-02	4.913E+07	3.410E+09	1.397E-14	9.459E-13	9.799E-01
31	2.606E-02	1.245E+08	3.534E+09	2.510E-15	9.484E-13	9.825E-01
32	2.418E-02	7.859E+07	3.613E+09	3.441E-16	9.487E-13	9.829E-01
33	2.188E-02	1.659E+08	3.779E+09	1.359E-15	9.501E-13	9.843E-01
34	1.503E-02	2.513E+08	4.030E+09	4.715E-15	9.548E-13	9.892E-01
35	7.102E-03	2.530E+08	4.283E+09	2.250E-15	9.570E-13	9.915E-01
36	3.355E-03	2.311E+08	4.514E+09	8.133E-16	9.578E-13	9.923E-01
37	1.585E-03	3.520E+08	4.866E+09	5.921E-16	9.584E-13	9.930E-01
38	4.540E-04	1.806E+08	5.047E+09	1.781E-17	9.584E-13	9.930E-01
39	2.144E-04	1.862E+08	5.233E+09	2.671E-17	9.585E-13	9.930E-01
40	1.013E-04	2.357E+08	5.469E+09	5.258E-17	9.585E-13	9.931E-01
41	3.727E-05	2.729E+08	5.742E+09	1.075E-16	9.586E-13	9.932E-01
42	1.068E-05	1.504E+08	5.892E+09	9.669E-17	9.587E-13	9.933E-01
43	5.043E-06	1.800E+08	6.072E+09	1.800E-16	9.589E-13	9.934E-01
44	1.855E-06	1.172E+08	6.189E+09	1.801E-16	9.591E-13	9.936E-01
45	8.764E-07	1.024E+08	6.291E+09	2.298E-16	9.593E-13	9.939E+01
46	4.140E-07	9.565E+07	6.387E+09	3.748E-16	9.597E-13	9.943E-01
47	1.000E-07	5.928E+08	6.980E+09	5.541E-15	9.652E-13	1.000E+00

Table 30 Absolute flux spectrum calculated with ORIGINAL SAILOR, behind RPV insulation at 0, R = 257.0 cm, and 121.9 cm above the core midplane

Group	Upper energy	Group flux	Cumulative flux	Group DPA	Cumulative DPA	Cumulative DPA fraction
1	1.733E+01	1.144E+05	1.144E+05	3.342E-16	3.342E-16	3.500E-04
2	1.419E+01	4.751E+05	5.895E+05	1.257E-15	1.591E-15	1.667E-03
3	1.211E+01	1.430E+06	2.019E+06	3.444E-15	5.035E-15	5.273E-03
4	1.000E+01	2.429E+06	4.448E+06	5.390E-15	1.042E-14	1.092E-02
5	8.607E+00	3.408E+06	7.856E+06	7.113E-15	1.754E-14	1.837E-02
6	7.408E+00	6.540E+06	1.440E+07	1.271E-14	3.024E-14	3.167E-02
7	6.065E+00	7.200E+06	2.160E+07	1.285E-14	4.309E-14	4.513E-02
8	4.966E+00	1.109E+07	3.269E+07	1.743E-14	6.052E-14	6.338E-02
9	3.679E+00	9.442E+06	4.213E+07	1.294E-14	7.345E-14	7.693E-02
10	3.012E+00	7.676E+06	4.981E+07	9.756E-15	8.321E-14	8.714E-02
11	2.725E+00	9.341E+06	5.915E+07	1.191E-14	9.512E-14	9.962E-02
12	2.466E+00	4.676E+06	6.383E+07	5.481E-15	1.006E-13	1.054E-01
13	2.365E+00	1.607E+06	6.543E+07	1.761E-15	1.024E-13	1.072E-01
14	2.346E+00	7.891E+06	7.332E+07	8.215E-15	1.106E-13	1.158E-01
15	2.231E+00	1.943E+07	9.275E+07	2.009E-14	1.307E-13	1.368E-01
16	1.920E+00	3.082E+07	1.236E+08	2.506E-14	1.557E-13	1.631E-01
17	1.653E+00	4.633E+07	1.699E+08	3.754E-14	1.933E-13	2.024E-01
18	1.353E+00	1.214E+08	2.912E+08	6.799E-14	2.613E-13	2.736E-01
19	1.003E+00	1.272E+08	4.185E+08	4.664E-14	3.079E-13	3.225E-01
20	8.208E-01	5.142E+07	4.699E+08	2.884E-14	3.367E-13	3.527E-01
21	7.427E-01	2.648E+08	7.347E+08	9.569E-13	4.324E-13	4.529E-01
22	6.081E-01	2.535E+08	9.882E+08	7.461E-14	5.070E-13	5.310E-01
23	4.979E-01	2.645E+08	1.253E+09	1.049E-13	6.119E-13	6.408E-01
24	3.688E-01	3.896E+08	1.642E+09	8.057E-14	6.925E-13	7.252E-01
25	2.972E-01	4.656E+08	2.108E+09	9.335E-13	7.858E-13	8.230E-01
26	1.832E-01	5.096E+08	2.618E+09	7.186E-14	8.577E-13	8.982E-01
27	1.111E-01	3.306E+08	2.948E+09	4.275E-14	9.004E-13	9.430E-01
28	6.738E-02	2.567E+08	3.205E+09	1.663E-14	9.170E-13	9.604E-01
29	4.087E-02	7.973E+07	3.285E+09	6.453E-15	9.235E-13	9.672E-01
30	3.183E-02	3.776E+07	3.322E+09	1.074E-14	9.342E-13	9.784E-01
31	2.606E-02	1.664E+08	3.489E+09	3.355E-15	9.376E-13	9.819E-01
32	2.418E-02	1.218E+08	3.611E+09	5.334E-16	9.381E-13	9.825E-01
33	2.188E-02	2.116E+08	3.822E+09	1.733E-15	9.399E-13	9.843E-01
34	1.503E-02	2.260E+08	4.048E+09	4.240E-15	9.441E-13	9.887E-01
35	7.102E-03	2.215E+08	4.270E+09	1.970E-15	9.461E-13	9.908E-01
36	3.355E-03	1.841E+08	4.454E+09	6.482E-16	9.467E-13	9.915E-01
37	1.585E-03	2.793E+08	4.733E+09	4.697E-16	9.472E-13	9.920E-01
38	4.540E-04	1.428E+08	4.876E+09	1.408E-17	9.472E-13	9.920E-01
39	2.144E-04	1.472E+08	5.023E+09	2.110E-17	9.472E-13	9.920E-01
40	1.013E-04	1.862E+08	5.209E+09	4.153E-17	9.473E-13	9.920E-01
41	3.727E-05	2.151E+08	5.424E+09	8.473E-17	9.473E-13	9.921E-01
42	1.068E-05	1.185E+08	5.543E+09	7.615E-17	9.474E-13	9.922E-01
43	5.043E-06	1.423E+08	5.685E+09	1.423E-16	9.476E-13	9.924E-01
44	1.855E-06	9.413E+07	5.779E+09	1.447E-16	9.477E-13	9.925E-01
45	8.764E-07	8.323E+07	5.862E+09	1.868E-16	9.479E-13	9.927E-01
46	4.140E-07	1.863E+08	6.049E+09	7.298E-16	9.486E-13	9.935E-01
47	1.000E-07	6.671E+08	6.716E+09	6.236E-15	9.548E-13	1.000E+00

Table 31 Absolute flux spectrum calculated with ORIGINAL SAILOR at the center of the instrumentation tube, R = 321.63 cm, 0° and 121.9 cm above the core midplane

Group	Upper energy	Group flux	Cumulative flux	Group DPA	Cumulative DPA	Cumulative DPA fraction
1	1.733E+01	8.415E+04	8.415E+04	2.459E-16	2.459E-16	3.125E-04
2	1.419E+01	3.486E+05	4.328E+05	9.225E-16	1.168E-15	1.485E-03
3	1.211E+01	1.054E+06	1.487E+06	2.540E-15	3.708E-15	4.712E-03
4	1.000E+01	1.793E+06	3.280E+06	3.978E-15	7.686E-15	9.767E-03
5	8.607E+00	2.528E+06	5.808E+06	5.276E-15	1.296E-14	1.647E-02
6	7.408E+00	4.872E+06	1.068E+07	9.466E-14	2.243E-14	2.850E-02
7	6.065E+00	5.443E+06	1.612E+07	9.711E-15	3.214E-14	4.084E-02
8	4.966E+00	8.565E+06	2.469E+07	1.346E-14	4.559E-14	5.793E-02
9	3.679E+00	7.352E+06	3.204E+07	1.007E-14	5.567E-14	7.073E-02
10	3.012E+00	5.983E+06	3.802E+07	7.604E-15	6.327E-14	8.040E-02
11	2.725E+00	7.364E+06	4.539E+07	9.389E-15	7.266E-14	9.233E-02
12	2.466E+00	3.729E+06	4.911E+07	4.370E-15	7.703E-14	9.788E-02
13	2.365E+00	1.253E+06	5.037E+07	1.373E-15	7.840E-14	9.962E-02
14	2.346E+00	6.219E+06	5.659E+07	6.474E-15	8.488E-14	1.079E-01
15	2.231E+00	1.507E+07	7.166E+07	1.558E-14	1.005E-13	1.276E-01
16	1.920E+00	2.381E+07	9.546E+07	1.936E-14	1.198E-13	1.523E-01
17	1.653E+00	3.666E+07	1.321E+08	2.971E-14	1.495E-13	1.900E-01
18	1.353E+00	9.453E+07	2.267E+08	5.296E-14	2.025E-13	2.573E-01
19	1.003E+00	9.785E+07	3.245E+08	3.586E-14	2.384E-13	3.029E-01
20	8.208E-01	4.554E+07	3.700E+08	2.554E-14	2.639E-13	3.353E-01
21	7.427E-01	2.082E+08	5.782E+08	7.524E-14	3.391E-13	4.309E-01
22	6.081E-01	2.052E+08	7.834E+08	6.040E-14	3.995E-13	5.077E-01
23	4.979E-01	2.150E+08	9.984E+08	8.521E-14	4.847E-13	6.160E-01
24	3.688E-01	3.046E+08	1.303E+09	6.299E-14	5.477E-13	6.960E-01
25	2.972E-01	4.213E+08	1.724E+09	8.447E-14	6.322E-13	8.033E-01
26	1.832E-01	4.576E+08	2.182E+09	6.453E-14	6.967E-13	8.853E-01
27	1.111E-01	3.045E+08	2.486E+09	3.937E-14	7.361E-13	9.353E-01
28	6.738E-02	2.388E+08	2.725E+09	1.547E-14	7.516E-13	9.550E-01
29	4.087E-02	7.833E+07	2.804E+09	6.339E-15	7.579E-13	9.631E-01
30	3.183E-02	4.028E+07	2.844E+09	1.145E-14	7.694E-13	9.776E-01
31	2.606E-02	1.274E+08	2.971E+09	2.568E-15	7.719E-13	9.809E-01
32	2.418E-02	9.512E+07	3.066E+09	4.165E-16	7.723E-13	9.814E-01
33	2.188E-02	1.854E+08	3.252E+09	1.519E-15	7.739E-13	9.833E-01
34	1.503E-02	2.264E+08	3.478E+09	4.248E-15	7.781E-13	9.887E-01
35	7.102E-03	2.269E+08	3.705E+09	2.018E-15	7.801E-13	9.913E-01
36	3.355E-03	1.970E+08	3.902E+09	6.934E-16	7.808E-13	9.922E-01
37	1.585E-03	2.964E+08	4.198E+09	4.985E-16	7.813E-13	9.928E-01
38	4.540E-04	1.568E+08	4.355E+09	1.545E-17	7.813E-13	9.928E-01
39	2.144E-04	1.606E+08	4.516E+09	2.303E-17	7.814E-13	9.929E-01
40	1.013E-04	2.041E+08	4.720E+09	4.554E-17	7.814E-13	9.929E-01
41	3.727E-05	2.367E+08	4.957E+09	9.324E-17	7.815E-13	9.930E-01
42	1.068E-05	1.305E+08	5.087E+09	8.387E-17	7.816E-13	9.931E-01
43	5.043E-06	1.567E+08	5.244E+09	1.567E-16	7.817E-13	9.933E-01
44	1.855E-06	1.029E+08	5.347E+09	1.582E-16	7.819E-13	9.935E-01
45	8.764E-07	8.949E+07	5.436E+09	2.008E-16	7.821E-13	9.938E-01
46	4.140E-07	1.713E+08	5.608E+09	6.712E-16	7.828E-13	9.946E-01
47	1.000E-07	4.506E+08	6.058E+09	4.212E-15	7.870E-13	1.000E+00

Table 32 Calculated saturated reaction rates at the 0° cavity dosimeters location, 5 cm behind insulation (R = 257.0 cm), at a height 121.90 cm above the core midplane for Cycle 13

Dosimeter	Reaction per atom per second	
	W/ENDF/B-VI Fe-O-H ^a	ORIGINAL SAILOR ^a
	R = 257.00 cm	R = 257.00 cm
⁵⁴ Fe(n,p) ⁵⁴ Mn	2.337E-17	1.872E-17
⁵⁸ Ni (n,p) ⁵⁸ Co	3.256E-17	2.618E-17
⁶³ Cu(n,α) ⁶⁰ Co	3.364E-14	2.947E-19
²³⁷ Np(n,f) ¹³⁷ Cs	1.592E-15	1.296E-15
²³⁸ U (n,f) ¹³⁷ Cs	1.151E-16	9.324E-17
⁴⁶ Ti (n,p) ⁴⁶ Sc	4.476E-18	3.742E-18
⁵⁹ Co(n,γ) ⁶⁰ Co	4.728E-14	4.003E-14
Flux	φ (E) n · cm ⁻² · s ⁻¹	
φ (E > 1.0 MeV)	3.647E+08	2.933E+08
φ (E > 0.1 MeV)	3.203E+09	2.618E+09
φ (E < 0.4 eV)	9.566E+08	8.534E+08
DPA	dpa/s	
Total DPA	1.169E-12	9.548E-13

^a ENDF/B-VI dosimetry cross sections were used in both calculations.

Table 33 Calculated saturated reaction rates at the dosimeters location,
center of the instrumentation tube, at a height 121.90 cm
above the core midplane for Cycle 13

Dosimeter	Reaction per atom per second	
	W/ENDF/B-VI Fe-O-H ^a	ORIGINAL SAILOR ^a
	R = 321.63 cm	R = 321.63
⁵⁴ Fe(n,p) ⁵⁴ Mn	1.779E-17	1.425E-17
⁵⁸ Ni (n,p) ⁵⁸ Co	2.488E-17	1.998E-17
⁶³ Cu(n,α) ⁶⁰ Co	2.491E-19	2.187E-19
²³⁷ Np(n,f) ¹³⁷ Cs	1.279E-15	1.039E-15
²³⁸ U (n,f) ¹³⁷ Cs	8.951E-17	7.232E-17
⁴⁶ Ti (n,p) ⁴⁶ Sc	3.341E-18	2.797E-18
⁵⁹ Co(n,γ) ⁶⁰ Co	3.985E-14	3.354E-14
Flux	ϕ (E) n · cm ⁻² · s ⁻¹	
ϕ (E > 1.0 MeV)	2.841E+08	2.282E+08
ϕ (E > 0.1 MeV)	2.683E+09	2.182E+09
ϕ (E < 0.4 eV)	6.884E+08	6.219E+08
DPA	dpa/s	
Total DPA	9.652E-13	7.870E-13

^a ENDF/B-VI dosimetry cross sections were used in both calculations.

Table 34 Spectrum averaged cross section at the cavity dosimeter location, 5 cm behind the RPV insulation, at 0° of Trojan Cycle 13

Reaction	W/ENDF/B-VI Fe-O-H ^a		W/ORIGINAL SAILOR ^a	
	E > 1 $\bar{\sigma}$ (barns) ^b	E > 0.11 $\bar{\sigma}$ (barns) ^c	E > 1 $\bar{\sigma}$ (barns) ^b	E > 0.11 $\bar{\sigma}$ (barns) ^c
⁵⁴ Fe(n,p) ⁵⁴ Mn	6.370E-02	7.168E-03	6.346E-02	7.041E-03
⁵⁸ Ni (n,p) ⁵⁸ Co	8.882E-02	9.994E-03	8.878E-02	9.851E-03
⁶³ Cu(n,α) ⁶⁰ Co	9.169E-04	1.032E-04	9.990E-04	1.108E-04
⁴⁶ Ti (n,p) ⁴⁶ Sc	1.219E-02	1.372E-03	1.267E-02	1.406E-03
²³⁸ U (n,f) ¹³⁷ Cs	3.149E-01	3.543E-02	3.171E-01	3.519E-03
²³⁷ Np(n,f) ¹³⁷ Cs	4.394E+00	4.944E-01	4.446E-00	4.933E-01
⁵⁹ Co(n,γ) ⁶⁰ Co	1.319E+02	1.485E-01	1.391E+02	1.544E-01

^a ENDF/B-VI dosimetry cross sections were used in both calculations.

$$^b \bar{\sigma} = \frac{\int_0^{\infty} \sigma(E) \phi(E) dE}{\int_0^{\infty} \phi(E) dE}$$

$$^c \bar{\sigma} = \frac{\int_0^{\infty} \sigma(E) \phi(E) dE}{\int_{0.11}^{\infty} \phi(E) dE}$$

Table 35 Spectrum averaged cross section at the center of the instrumentation tube at 0° and 20.3 cm below midplane of Trojan Cycle 13

Reaction	W/ENDF/B-VI Fe-O-H ^a		W/ORIGINAL SAILOR ^a	
	E > 1 $\bar{\sigma}$ (barns) ^b	E > 0.11 $\bar{\sigma}$ (barns) ^c	E > 1 $\bar{\sigma}$ (barns) ^b	E > 0.11 $\bar{\sigma}$ (barns) ^(c)
⁵⁴ Fe(n,p) ⁵⁴ Mn	6.274E-02	6.646E-03	6.259E-02	6.557E-03
⁵⁸ Ni (n,p) ⁵⁸ Co	8.771E-02	9.291E-03	8.776E-02	9.194E-03
⁶³ Cu(n,α) ⁶⁰ Co	8.801E-04	9.323E-05	9.626E-04	1.008E-04
⁴⁶ Ti (n,p) ⁴⁶ Sc	1.179E-02	1.249E-03	1.230E-02	1.288E-03
²³⁸ U (n,f) ¹³⁷ Cs	3.153E-01	3.340E-02	3.173E-01	3.324E-03
²³⁷ Np(n,f) ¹³⁷ Cs	4.501E+00	4.768E-01	4.546E-00	4.762E-01
⁵⁹ Co(n,γ) ⁶⁰ Co	1.385E+02	1.467E-01	1.452E+02	1.521E-01

^a ENDF/B-VI dosimetry cross sections were used in both calculations.

$$^b \bar{\sigma} = \frac{\int_0^{\infty} \sigma(E) \phi(E) dE}{\int_0^{\infty} \phi(E) dE}$$

$$^c \bar{\sigma} = \frac{\int_0^{\infty} \sigma(E) \phi(E) dE}{\int_{0.11}^{\infty} \phi(E) dE}$$

Table 36 Non-saturation factors (h) for Trojan Cycle 13

Dosimeter	h ^a
⁵⁴ Fe(n,p) ⁵⁴ Mn	3.780E-01
⁵⁸ Ni (n,p) ⁵⁸ Co	6.501E-01
⁶³ Cu(n,α) ⁶⁰ Co	7.236E-02
⁵⁹ Co(n,γ) ⁶⁰ Co	7.236E-02
²³⁸ U (n,f) ¹³⁷ Cs	1.317E-02
²³⁷ Np(n,f) ¹³⁷ Cs	1.317E-02
⁴⁶ Ti (n,p) ⁴⁶ Sc	6.411E-01

$$^a h = \sum_j P_j (1 - e^{-\lambda T_j}) e^{-\lambda(T-t_j)}$$

TABLE 37 C/E values for Trojan dosimetry, based on ENDF/B-VI calculations

Reaction	A	Dosimetry set		
		B	C	D
$^{63}\text{Cu} (n,\alpha)$	1.39	1.31	1.53	1.58
$^{46}\text{Ti} (n,p)$	1.30	1.21	1.42	1.47
$^{54}\text{Fe} (n,p)$	1.50	1.41	1.68	1.76
$^{58}\text{Ni} (n,p)$	1.41	1.31	1.61	1.66
$^{238}\text{U} (n,f)$	1.40	1.33	1.51	1.64
$^{237}\text{Np} (n,f)$	1.37	1.33	1.24	1.67
$^{59}\text{Co} (n,\gamma)$, Bare	2.42	1.85	1.94	1.84
$^{235}\text{U} (n,f)$, Bare	4.435	2.96	2.41	1.82

TABLE 38 C/E values for Trojan dosimetry, based on original SAILOR calculations

Reaction	A	Dosimetry set		
		B	C	D
$^{63}\text{Cu} (n,\alpha)$	1.22	1.15	1.35	1.39
$^{46}\text{Ti} (n,p)$	1.09	1.01	1.19	1.23
$^{54}\text{Fe} (n,p)$	1.20	1.13	1.34	1.41
$^{58}\text{Ni} (n,p)$	1.13	1.05	1.29	1.33
$^{238}\text{U} (n,f)$	1.13	1.07	1.22	1.32
$^{237}\text{Np} (n,f)$	1.12	1.08	1.01	1.35
$^{59}\text{Co} (n,\gamma)$, Bare	2.05	1.57	1.63	1.54
$^{235}\text{U} (n,f)$, Bare	3.71	2.49	1.99	1.51

Table 39 Absolute flux spectrum calculated with ENDF/B VI Fe-O-H at location of support structure (i.e., $\theta = 23^\circ$, 20.3 cm below core midplane, 17.8 cm into the concrete)

Group	Upper energy	Group flux	Cumulative flux	Group DPA	Cumulative DPA	Cumulative DPA fraction
1	1.733E+01	2.341E+04	2.341E+04	6.841E-17	6.841E-17	3.370E-04
2	1.419E+01	8.750E+04	1.109E+05	2.315E-16	2.999E-16	1.477E-03
3	1.221E+01	2.568E+05	3.677E+05	6.186E-16	9.186E-16	4.524E-03
4	1.000E+01	4.908E+05	8.586E+05	1.089E-15	2.008E-15	9.889E-03
5	8.607E+00	7.144E+05	1.573E+06	1.491E-15	3.499E-15	1.723E-02
6	7.408E+00	1.761E+06	3.334E+06	3.422E-15	6.920E-15	3.408E-02
7	6.065E+00	2.474E+06	5.808E+06	4.413E-15	1.133E-14	5.582E-02
8	4.966E+00	4.328E+06	1.014E+07	6.799E-15	1.813E-14	8.931E-02
9	3.679E+00	3.243E+06	1.338E+07	4.443E-15	2.258E-14	1.112E-01
10	3.012E+00	2.870E+06	1.625E+07	3.648E-15	2.622E-14	1.292E-01
11	2.725E+00	3.624E+06	1.987E+07	4.621E-15	3.084E-14	1.519E-01
12	2.466E+00	2.344E+06	2.222E+07	2.748E-15	3.359E-14	1.654E-01
13	2.365E+00	7.911E+05	2.301E+07	8.671E-16	3.446E-14	1.697E-01
14	2.346E+00	3.414E+06	2.642E+07	3.554E-15	3.801E-14	1.872E-01
15	2.231E+00	6.556E+06	3.298E+07	6.779E-15	4.479E-14	2.206E-01
16	1.920E+00	7.466E+06	4.044E+07	6.072E-15	5.086E-14	2.505E-01
17	1.653E+00	1.213E+07	5.257E+07	9.828E-15	6.069E-14	2.989E-01
18	1.353E+00	1.620E+07	6.877E+07	9.077E-15	6.977E-14	3.436E-01
19	1.003E+00	1.098E+07	7.975E+07	4.023E-15	7.379E-14	3.634E-01
20	8.208E-01	1.020E+07	8.995E+07	5.723E-15	7.952E-14	3.916E-01
21	7.427E-01	3.089E+07	1.208E+08	1.116E-14	9.068E-14	4.466E-01
22	6.081E-01	3.483E+07	1.557E+08	1.025E-14	1.009E-13	4.971E-01
23	4.979E-01	2.775E+07	1.834E+08	1.100E-14	1.119E-13	5.513E-01
24	3.688E-01	2.920E+07	2.126E+08	6.039E-15	1.180E-13	5.810E-01
25	2.972E-01	6.129E+07	2.739E+08	1.229E-14	1.303E-13	6.415E-01
26	1.832E-01	8.804E+07	3.620E+08	1.241E-14	1.427E-13	7.027E-01
27	1.111E-01	7.829E+07	4.402E+08	1.012E-14	1.528E-13	7.525E-01
28	6.738E-02	7.639E+07	5.166E+08	4.948E-15	1.577E-13	7.769E-01
29	4.087E-02	3.487E+07	5.515E+08	2.822E-15	1.606E-13	7.908E-01
30	3.183E-02	2.896E+07	5.805E+08	8.234E-15	1.688E-13	8.314E-01
31	2.606E-02	1.173E+07	5.922E+08	2.366E-16	1.690E-13	8.325E-01
32	2.418E-02	1.520E+07	6.074E+08	6.655E-17	1.691E-13	8.329E-01
33	2.188E-02	5.580E+07	6.632E+08	4.570E-16	1.696E-13	8.351E-01
34	1.503E-02	1.126E+08	7.758E+08	2.113E-15	1.717E-13	8.455E-01
35	7.102E-03	1.105E+08	8.864E+08	9.832E-16	1.727E-13	8.504E-01
36	3.355E-03	1.189E+08	1.005E+09	4.185E-16	1.731E-13	8.524E-01
37	1.585E-03	2.096E+08	1.215E+09	3.525E-16	1.734E-13	8.542E-01
38	4.540E-04	1.296E+08	1.344E+09	1.277E-17	1.734E-13	8.542E-01
39	2.144E-04	1.335E+08	1.478E+09	1.915E-17	1.735E-13	8.543E-01
40	1.013E-04	1.817E+08	1.660E+09	4.054E-17	1.735E-13	8.545E-01
41	3.727E-05	2.308E+08	1.891E+09	9.091E-17	1.736E-13	8.550E-01
42	1.068E-05	1.392E+08	2.030E+09	8.947E-17	1.737E-13	8.554E-01
43	5.043E-06	1.848E+08	2.214E+09	1.848E-16	1.739E-13	8.563E-01
44	1.855E-06	1.364E+08	2.351E+09	2.097E-16	1.741E-13	8.573E-01
45	8.764E-07	1.352E+08	2.486E+09	3.034E-16	1.744E-13	8.588E-01
46	4.140E-07	1.973E+08	2.683E+09	7.731E-16	1.751E-13	8.626E-01
47	1.000E-07	2.983E+09	5.667E+09	2.789E-14	2.030E-13	1.000E+00

Table 40 Calculated saturated reaction rates at the location of support structure
(i.e., $\theta = 23^\circ$, 20.3 cm below midplane, 18.0 cm into the concrete)

Dosimeter	Reaction per atom per second	
	W/ENDF/B-VI Fe-O-H	ORIGINAL SAILOR
	R = 325.76 cm	R = 325.76
$^{54}\text{Fe}(n,p) ^{54}\text{Mn}$	5.908E-18	4.928E-18
$^{58}\text{Ni}(n,p) ^{58}\text{Co}$	8.059E-18	6.683E-18
$^{63}\text{Cu}(n,\alpha) ^{60}\text{Co}$	6.715E-20	6.280E-20
$^{237}\text{Np}(n,f) ^{137}\text{Cs}$	2.919E-16	2.283E-16
$^{238}\text{U}(n,f) ^{137}\text{Cs}$	2.777E-17	2.205E-17
$^{46}\text{Ti}(n,p) ^{46}\text{Sc}$	9.831E-19	8.775E-19
$^{59}\text{Co}(n,\gamma) ^{60}\text{Co}$	1.208E-13	9.873E-14
Flux	$\phi(E) \text{ cm}^{-2} \cdot \text{s}^{-1}$	
$\phi(E > 1.0 \text{ MeV})$	6.895E+07	5.383E+07
$\phi(E > 0.1 \text{ MeV})$	3.620E+08	2.723E+08
$\phi(E < 0.4 \text{ eV})$	3.181E+09	2.686E+09
DPA	dpa/s	
Total DPA	2.030E-13	1.581E-13

Table 41 Calculated results of neutron exposure at Trojan support structure location
(i.e., $\theta = 23^\circ$, AND 20.3)

PARAMETERS	12.7 cm into Concrete	17.78 cm into Concrete	22.86 cm into Concrete
θ ($E > 1.0$ MeV), $\text{cm}^{-2} \cdot \text{s}^{-1}$	1.160E+8	6.895E+7	4.242E+7
θ ($E > 0.1$ MeV), $\text{cm}^{-2} \cdot \text{s}^{-1}$	7.759E+8	3.620E+8	1.828E+8
θ ($E < 0.4$ eV), $\text{cm}^{-2} \cdot \text{s}^{-1}$	3.486E+9	3.181E+9	2.590E+9
DPA rate (displacements per atom per s.)	3.710E-13	2.030E-13	1.187E-13
Fluence ^a (Cycle-13), $\text{cm}^{-2} \cdot \text{s}^{-1}$	2.117E+15	1.258E+15	7.742E+14
Fluence ^b (32 EFPY), $\text{cm}^{-2} \cdot \text{s}^{-1}$	1.173E+17	6.971E+16	4.289E+19

^aBased on flux above 1.0 MeV and 211.25 full-power days.

^bBased on flux above 1.0 MeV and 32 EFPY = 11,696 full-power days.

6 CONCLUSIONS

Results from neutron transport calculations based on two different sets of Fe-H-O cross-section data were found to differ by about the same amount in the Trojan analysis as observed in earlier studies comparing the newer ENDF/B-VI cross sections with the earlier multigroup data in the SAILOR library (based on ENDF/B-IV). The cavity dosimetry results for high-threshold reactions were calculated to be about 30% higher with the ENDF/B-VI cross sections, which is consistent with the change recently found in the analysis of the H. B. Robinson PWR,¹³ and projected (based on one-dimensional calculations) for the Arkansas Nuclear One, Unit 1 PWR.⁸ A recent re-analysis of the PCA experiment performed earlier at ORNL also indicated that ENDF/B-VI would increase the neutron transmission through the simulated RPV in that system.^a However, unlike all of the earlier studies, the higher absolute reaction rates in the Trojan cavity results do not improve agreement with the experimental measurements, but rather give worse C/E values than obtained with the ORIGINAL SAILOR library data. The midplane C/E values for the threshold dosimeters located behind the insulation were found to be from 1.01 to 1.15 with the ORIGINAL SAILOR, and from 1.21 to 1.41 with the ENDF/B-VI cross sections. At the instrument tube location the ORIGINAL SAILOR library gives C/E values at the midplane of 1.23 to 1.41 for threshold reactions and ENDF/B-VI gives 1.47 to 1.76. The dosimeters in the instrument tube are more difficult to calculate accurately because they are located behind an ex-core detector. The C/E values for the fast-flux dosimeters are typically 5 to 10% higher at the axial position 121.9 cm above the midplane, compared with values at 20.3 cm below the midplane. Both cross-section libraries substantially overestimate the thermal reaction dosimeters at all locations, by up to a factor of 3 near the midplane.

It is not known at this time why the present Trojan plant should behave in a qualitatively different manner than the other systems that have been analyzed with the ENDF/B-VI data. The experimental values were analyzed by two independent organizations, and the model used in the transport calculations has been extensively checked by LSU as well as Westinghouse personnel. Use of a generic rather than a plant-specific pinwise power distribution in the calculations would tend to cause the computed results be too high due to an over-estimate of the core leakage. The magnitude of this effect is not known, since the plant-specific distribution is unavailable. The approximation of assuming 45 symmetry in the transport calculations was tested by comparing these with results from a more rigorous 90 symmetrical model, and no substantial discrepancies were observed. An inconsistency in the dosimeter location could also cause a discrepancy of this magnitude, but no errors have been identified at this time. Because of the presence of the ex-core detector and detector wells, the flux synthesis approximation could be introducing some errors into the transport calculations for the dosimeters located in the instrument tube. A three-dimensional transport calculation of the cavity region could help to resolve this question. Comparison with recent in-vessel dosimeter measurements would also be very

^a Personal Communications, L. F. Miller and F. B. Kam, ORNL.

useful in identifying the causes for the discrepancies between the computed and measured absolute reaction rates in Cycle 13. Surveillance dosimeters, still contained within the Trojan plant, could be analyzed for this purpose after the reactor is shut down. Note that if these ENDF/B-VI transport calculations are compared with the earlier surveillance capsule dosimeter measurements for Capsule X (removed from reactor in 1984), then C/E values *less than unity* are obtained, whereas the cavity measurements in this study give C/E considerably *more than unity*. Perhaps this inconsistency is merely the consequence of having a significantly different power distribution for Cycle 13 compared with the power distributions appropriate for Capsule X exposure. On the other hand, it could also indicate an inconsistency between the two sets of dosimeter measurements performed at different times. If the causes for the discrepancy between the calculated and measured results cannot be identified and eliminated, then a least-squares adjustment code could be utilized to unfold an absolute spectrum by combining the dosimeter measurements and transport calculations. However, this step was not performed in the present study. It is important to note that both the ORIGINAL SAILOR and the ENDF/B VI SAILOR library produce very similar values for the spectrum-averaged cross-sections of all the dosimeters. Thus, the discrepancies observed in the absolute reaction rates are mainly due to a difference in the overall flux magnitude (i.e., both libraries predict a similar neutron energy distribution). The C/E values for the various fast-neutron dosimeters are also fairly consistent, again indicating a possible discrepancy in the magnitude of the leakage from the core.

Without additional information to resolve the apparent discrepancy between the calculated and measured dosimeters, the higher of the two transport calculations (i.e., ENDF/B VI) has been used to estimate the fast-neutron exposure to the support structure. The fast flux ($E > 1$ Mev) at the critical point of maximum stress in the support structure (~18 cm into concrete shield) is computed to be $6.90\text{E}+07$ neutrons/cm²-s based on the unadjusted ENDF/B-VI calculations. This value is about 30% higher than obtained with the ORIGINAL SAILOR library. The thermal-to-fast-flux ratio at this point is calculated with both sets of cross-section data to be about 46. The thermal neutron dosimeter measurements indicate that the transport calculations tend to significantly overestimate the magnitude of thermal reaction rates in the cavity; thus, this value is probably an overestimate. The DPA rate is calculated to be about $2.0\text{E}-13$ displacements per atom per second. Based on these flux and DPA rates the cumulative fast fluence after 32 EFY is found to be $7.0\text{E}+16$ neutrons/cm², and the cumulative displacements per atom is $2.0\text{E}-04$.

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APPENDIX A EXPERIMENTAL MEASUREMENTS OF DOSIMETER ACTIVITIES FOR TROJAN CYCLE 13

BENCHMARK REFERENCING AND PRELIMINARY ANALYSES OF THE NEUTRON FLUENCE DOSIMETRY MEASUREMENTS

The NRC has sponsored measurements to validate the transport calculations of fast-neutron-fluence exposure of certain critical support structures for the pressure vessel of the TROJAN nuclear power plant. The National Institute of Standards and Technology (NIST) was given the responsibility of seeing that benchmarked neutron fluence measurements were made using technology that was consistent with that in actual use by the nuclear power industry. This was carried out

- (1) by contracting with divisions of Westinghouse to supply dosimeters and make the measurements in the ex-vessel cavity of the TROJAN Reactor, and
- (2) by separately evaluating known-fluence irradiations of representative sets of their dosimeters in the standard neutron fission spectrum at NIST.

Table A.1 summarizes the NIST analysis of the Westinghouse measurements.

The radiometric measurements employed selected isotopic reactions in which radioactivity is induced in disks and wires by primarily fast neutrons ($E > 1$ MeV), and the activity is analyzed by gamma counting. The measurements also employed solid-state track recorders (SSTR), where the exposure fluence is measured by optical counting tracks formed in mica deposits in contact with fissionable deposits of Np^{237} and highly depleted U^{238} .

Because the SSTR technique is considerably newer, mass assay and optical efficiency measurements have been undergoing benchmark measurements in a cooperative program involving Westinghouse and NIST for a number of years and results pertinent to this series of measurements.¹⁴ The significant conclusion is that benchmark irradiation results are within a few percent of certified values depending on the treatment of a 3% to 5% bias, apparently associated with the masses of the ultralight deposits.

The results from the benchmark-irradiated activation monitors are summarized by noting that the specific activities reported by the Waltz Mill Laboratory of Westinghouse were within $\pm 5\%$ of those certified for the NIST irradiations, which were certified to $\pm 2.5\%$.

Examination of spectral differences among the locations.

Four sets of saturated specific activity radiometric results for different isotopic reactions are given in Part 1-A of Table A.1. All values are from Ref. 11 and are in units of 10^{-17} reactions, or fissions, per second per target atom. Part 1-B of the table provides an

examination of the lack of spectral differences among the four locations. In particular, therein all reaction rates have been divided by those of $\text{Ni}^{58}(\text{n,p}) \text{Co}^{58}$. The last two columns show averages and standard deviations, in percent, which suggest that within 5% each ratio species is the same for all locations. The 11.2% value associated with the $\text{U}^{238}(\text{n,f}) \text{Ru}$ data results from an obviously incorrect value in Location C. Since the reaction-rate ratios for five isotopes, each of which responds in a different energy range above 1 MeV, are the same within 5% for all four locations, the fast-neutron spectrum has to be essentially the same for all the locations.

Determination of flux-magnitude differences among the locations.

By dividing each reaction rate ratio to $\text{Ni}^{58}(\text{n,p})$ by its average in all four locations from Part 1-B, we obtain relative results that can be averaged for each location to obtain a measure of how well their relative magnitudes are known. Part 1-C of the table gives such results, where Location B is $(1.37/0.70) = 1.97 \pm 1.8\%$ greater than Location C. As indicated previously, the problem with the $\text{U}^{238}(\text{n,f}) \text{Ru}$ data has been circumvented by eliminating it from these latter analyses.

**Table A.1 NIST analyses of radiometric and SSTR dosimetry data
measured by Westinghouse during Trojan Cycle 13**

Reaction	A	B	C	D	Avg.	Std(%)
1-A^a						
Cu ⁶³ (n,a)	0.0242	0.032	0.0162	0.0211	0.0234	
Ti ⁴⁶ (n,p)	0.344	0.460	0.235	0.304	0.3358	
Fe ⁵⁴ (n,p)	1.560	2.070	1.060	1.350	1.5100	
Ni ⁵⁸ (n,p)	2.310	3.100	1.550	2.010	2.2425	
U ²³⁸ (n,f)Ru	8.830	11.200	7.060	6.860	8.4875	
U ²³⁸ (n,f)Zr	8.020	11.100	5.580	7.020	7.9300	
U ²³⁸ (n,f)Cs	7.760	10.600	5.600	7.090	7.7625	
U ²³⁸ SSTR	8.680	10.800	5.720	6.770	7.9925	
Np ²³⁷ SSTR	124.00	162.00	81.20	110.00	119.30	
1-B^b						
Cu ⁶³ (n,a)	0.01048	0.01032	0.01045	0.01050	0.0104	0.65
Ti ⁴⁶ (n,p)	0.14892	0.14839	0.15161	0.15124	0.1500	0.94
Fe ⁵⁴ (n,p)	0.67532	0.66774	0.68387	0.67164	0.6746	0.88
Ni ⁵⁸ (n,p)	1.0	1.0	1.0	1.0		
U ²³⁸ (n,f)Ru	3.82251	3.61290	4.55484	3.41294	3.8508	11.21
U ²³⁸ (n,f)Zr	3.47186	3.58065	3.60000	3.49254	3.5363	1.55
U ²³⁸ (n,f)Cs	3.35931	3.41935	3.61290	3.52736	3.4797	2.81
U ²³⁸ SSTR	3.75758	3.48387	3.69032	3.36816	3.5750	4.37
Np ²³⁷ SSTR	53.6797	52.2581	52.3871	54.7264	53.263	1.90
1-C^c						
Cu ⁶³ (n,a)	1.03529	1.36898	0.69305	0.90267		
Ti ⁴⁶ (n,p)	1.02457	1.37007	0.69993	0.90544		
Fe ⁵⁴ (n,p)	1.03311	1.37086	0.70199	0.89404		
Ni ⁵⁸ (n,p)	1.03010	1.38239	0.69119	0.89632		
U ²³⁸ (n,f)Ru						
U ²³⁸ (n,f)Zr	1.01135	1.39975	0.70366	0.88525		
U ²³⁸ (n,f)Cs	0.99968	1.36554	0.72142	0.91337		
U ²³⁸ SSTR	1.08602	1.35127	0.71567	0.84704		
Np ²³⁷ SSTR	1.03940	1.35792	0.68064	0.92205		
Avg.	1.0324	1.3708	0.7009	0.8958		
Std (%)	2.44	1.02	1.47	2.25		

^aRadiometric reaction and fission rates per nucleus => (where all values have an exponent of 10⁻¹⁷) <=.

^bRatios of above rates relative to Ni⁵⁸(n,p) reactions.

^cRatios of rates relative to their averages in part-B.

APPENDIX B

IMPACT OF ONE-FOURTH vs ONE-EIGHTH CORE MODEL USED IN TRANSPORT CALCULATIONS

The neutron pad component in Trojan extends from 25° to 57.5° (in the coordinate system of the calculation models); therefore, unlike most reactor systems that contain a full thermal shield that completely surrounds the core, the ex-core geometry of Trojan is not symmetrical over 45° segments. Rather, the neutron pad layout exhibits 90° symmetry.

In a one-eighth core R θ model the neutron pad is represented as extending from 25° to 45° , with a reflected boundary at 45° . This representation effectively reflects the pad into the interval 45° to 65° in the reflected octant. Thus, the azimuthal interval 57.5° to 65° is incorrectly occupied by the stainless steel pad, rather than water down, as in the true reactor geometry.

In order to investigate the impact of the one-eighth core symmetry approximation on cavity dosimeter calculations, a one-fourth core model with the correct asymmetrical neutron pad layout was used in a DOT R θ transport calculation, and results were compared with those obtained from the reflected octant case.

Table B.1 shows the ratios of various cavity reaction rates obtained in the one-eighth core model to those obtained in the one-fourth core model. It can be seen that at 0° there is very little difference in values computed with the two models. At 45° where the greatest impact is expected, the one-fourth core model gives about 12% higher reaction rates for the higher threshold dosimeters with less difference observed for lower threshold reactions.

Table B.1 Ratio of reflected one-eighth core results to nonsymmetrical one-fourth core model

Dosimeter	257 cm Radius		361.23 cm Radius	
	0°	45°	0°	45°
Fe ⁵⁴	1.002	1.04	1.004	1.115
Ni ⁵⁸	1.003	1.04	1.0045	1.1099
Cu ⁶³	1.0008	1.029	1.0017	1.11
Np ²³⁷	1.005	1.024	1.0048	1.045
U ²³⁸	1.0039	1.038	1.005	1.092
Ti ⁴⁶	1.018	1.036	1.0033	1.118
Co ⁵⁹	1.009	1.008	1.0059	1.0064

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