SASR 88-49
DRF A00-02764-1
June 1988

FLUX WIRE DOSIMETER EVALUATION
FOR
RIVER BEND STATION

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APPENDICES

1. INTRODUCTION

In September 1987, River Bend Station completed its first fuel cycle. During the outage that followed, the flux wire dosimeter attached to the surveillance capsule at the vessel 3° azimuth was removed. The dosimeter was shipped to the General Electric Vallecitos Nuclear Center (VNC) in Pleasanton, CA for testing. The test results and the associated determination of peak vessel flux and fluence are presented in this report.

The surveillance program for River Bend consists of three surveillance capsules and one flux wire dosimeter. Each surveillance capsule contains Charpy specimens of the beltline base, weld and HAZ materials, and a set of flux wires used to determine the fluence experienced by the capsule. The surveillance capsules are scheduled to be withdrawn periodically during plant life (the current schedule required by ASTM E185-82 is a capsule at 6, 15, and 32 effective full power years). In addition to the flux wires in the surveillance capsules, a flux wire dosimeter is attached to the capsule at 3°, as shown in Figure 1-1, for removal after the first fuel cycle. Since the vessel fluence is proportional to thermal power produced, the results of the flux wire dosimeter test are used to provide a calibration point of vessel fluence versus accumulated thermal power. A linear extrapolation provides an estimate of the fluence at 32 effective full power years (EFPY). It should be noted that the flux wires that will be removed later as part of the surveillance capsules will have an irradiation history more typical of normal operation, and will be useful for re-calibrating the 32 EFPY fluence estimate.

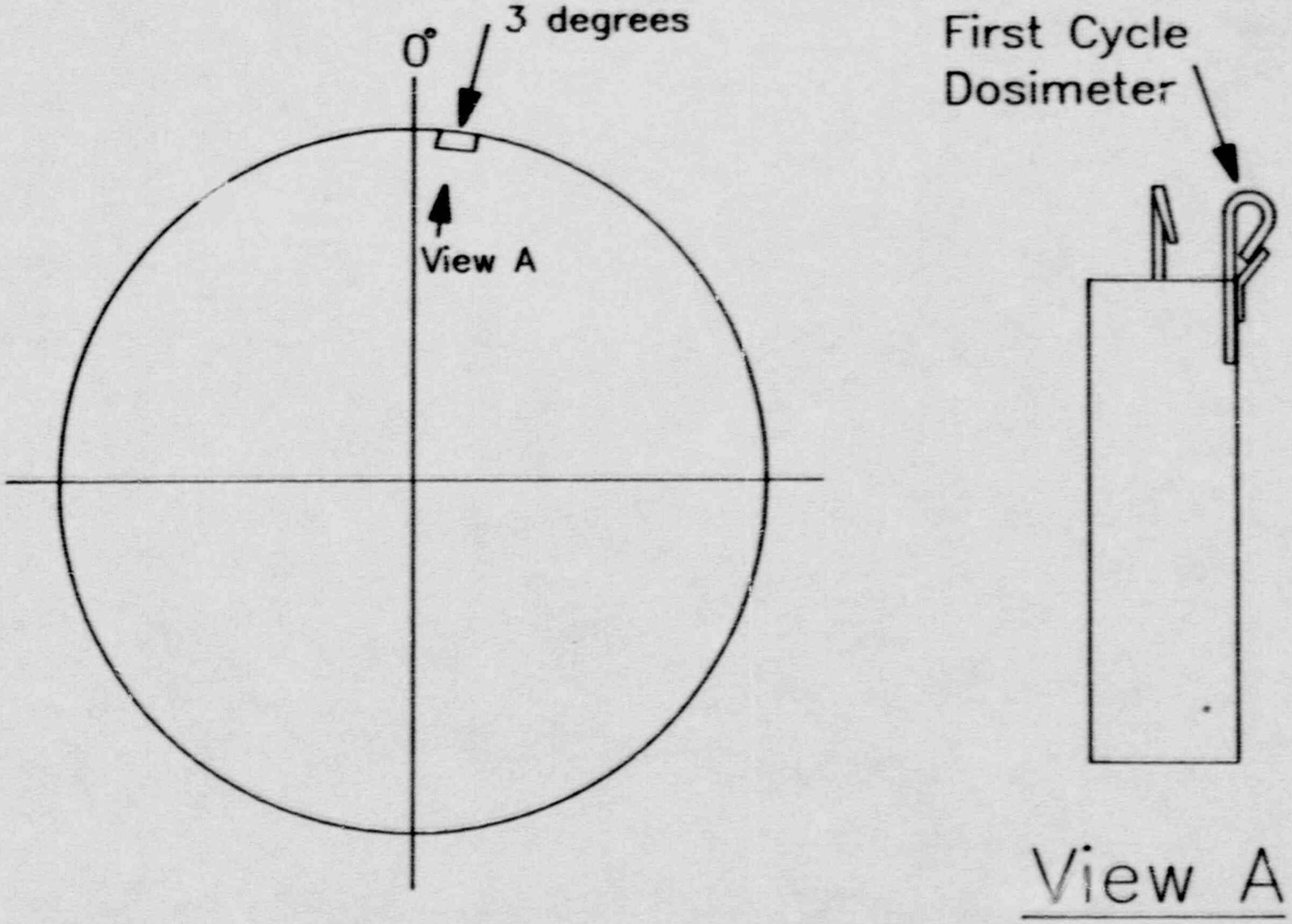

Figure 1-1. Schematic of Dosimeter Position in Vessel

2. ANALYSIS

The determination of the peak 32 EFPY fluence is basically a two-step process. First, the flux wires are analyzed to determine the flux and fluence at the dosimeter location. Then, lead factors are calculated which relate the flux magnitude at the dosimeter location to that at the location of peak flux.

The flux wire dosimeter was disassembled at VNC and the iron flux wires were cleaned and weighed. Gamma spectrometry was used to determine the rate of disintegrations. The daily power history of the first fuel cycle was used, along with cross-section data developed for BWRs to transform the disintegration data into rates of irradiation, or flux ($n/cm^2 \cdot s$). The detailed procedure used in evaluating the flux wires is contained in the test report in Appendix A.

The determination of lead factors was done for a generic 218 inch diameter vessel with 624 fuel bundles. This matches the River Bend configuration. The lead factors are essentially geometry dependent. Plant-specific characteristics of the flux are accounted for in the results of the flux wire test. Furthermore, the generic lead factors were calculated assuming an equilibrium fuel cycle, which is representative of a typical normal operation core power distribution. Therefore, the generic lead factors provide the best available means of predicting peak 32 EFPY fluence from the flux wire data.

Determination of the lead factors for the RPV peak location at the inside wall and 1/4 T depth was done using a combination of one-dimensional and two-dimensional finite difference computer analysis. The two-dimensional analysis established the relative fluence in the azimuthal direction at the vessel surface and 1/4 T depth. A series of one-dimensional analyses was done to determine the core height of the axial flux peak and its relationship to the surveillance capsule height. The combination of azimuthal and axial distribution results provides the lead factor between the dosimeter location and the peak flux location.

The two-dimensional DOT computer program was used to solve the Boltzman transport equation using the discrete ordinate method on an (R,θ) geometry, assuming a fixed source. One quarter core symmetry was used with periodic boundary conditions at 0° and 90°. Neutron cross sections were determined for 26 energy groups, with angular scattering approximated by a third-order Legendre expansion. A total of 99 radial intervals and 90 azimuthal intervals were used. The model consists of an inner and outer core region, the shroud, water regions inside and outside the shroud, the vessel wall, and an air region representing the drywell. Flux as a function of azimuth was calculated, establishing the azimuth of the peak flux and its magnitude relative to the flux at the dosimeter location of 3°. This factor, the azimuthal component of the lead factor, is shown in Figure 2-1.

The one-dimensional computer code (SN1D) was used to calculate radial flux distribution for several core elevations at the peak azimuth angle. The elevation of the peak flux was determined, as well as its magnitude relative to the flux at the dosimeter elevation. This factor is the axial component of the lead factor. The lead factor between the peak and dosimeter locations was calculated as the azimuthal component times the axial component.

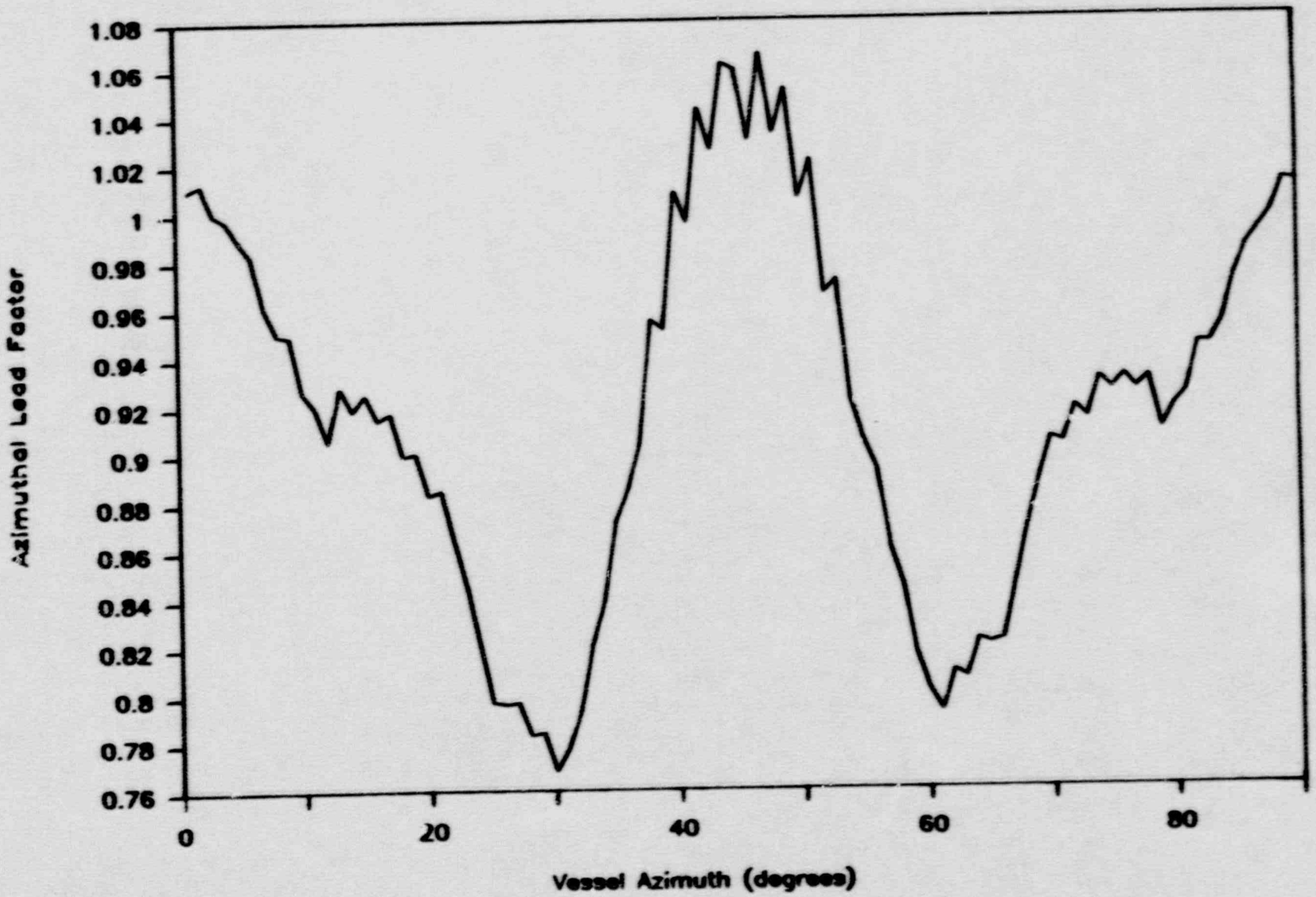

Figure 2-1. Azimuthal Lead Factor for a 218 Inch BWR with 624 Fuel Bundles

3. RESULTS

The flux wire dosimeter test results are presented in detail in Appendix A. A summary of the >1 MeV flux and fluence values for the dosimeter are presented in Table 3-1. As discussed in the test report, there is an uncertainty of +25%, -50% on the >1 MeV flux and fluence. Table 3-1 shows the upper bound values with the nominal values.

The lead factors for the peak location inside surface and 1/4 T depth are presented in Table 3-1 with the dosimeter test results. The lead factors are used to predict the peak fluence according to the following equation:

Peak Fluence = (Dosimeter Flux)*(Full Power Seconds)/Lead Factor

The first fuel cycle for River Bend consisted of 619 days of operation with an average capacity factor of 0.588. This is equivalent to 364.0 days at full power, or 1.0 EFPY. These values are used to calculate the fluence values at the end of cycle one (EOC1) and at 32 EFPY, as shown in Table 3-1.

The fluences at the peak location I.D. and 1/4 T are plotted as a function of EFPY in Figure 3-1.

The error range of +25%, -50% is not symmetrical because of judgement based on previous dosimeter test results. As some of the 10 year surveillance capsules are being tested, the 10 year dosimetry in these capsules are consistently testing at lower flux values than the first cycle dosimetry tests. This is expected to be caused by the atypical operation of the first fuel cycle compared to the subsequent 10 years of operation. Therefore, it is expected that the flux values determined for River Bend in this test are higher than will typically be experienced in future operation.

Table 3-1

FLUENCE DETERMINATION FOR THE PEAK LOCATION IN THE RIVER BEND VESSEL

Time at Power:

EOC1	1.0 EFPY = 3.14×10^{7} seconds
32 EFPY	32 EFPY = 1.01×10^{9} seconds

Lead Factors:

I.D.	0.50
1/4 T	0.66

Dosimeter Flux ($n/cm^2 \cdot s$) 4.4×10^{9} (nominal) 5.5×10^{9} (upper bound)

FLUENCE (n/cm^2):

	NOMINAL	UPPER BOUND
EOC1 Peak I.D.	2.8×10^{17}	3.5×10^{17}
EOC1 Peak 1/4 T	2.1×10^{17}	2.6×10^{17}
32 EFPY Peak I.D.	8.9×10^{18}	1.1×10^{19}
32 EFPY Peak 1/4 T	6.7×10^{18}	8.4×10^{18}

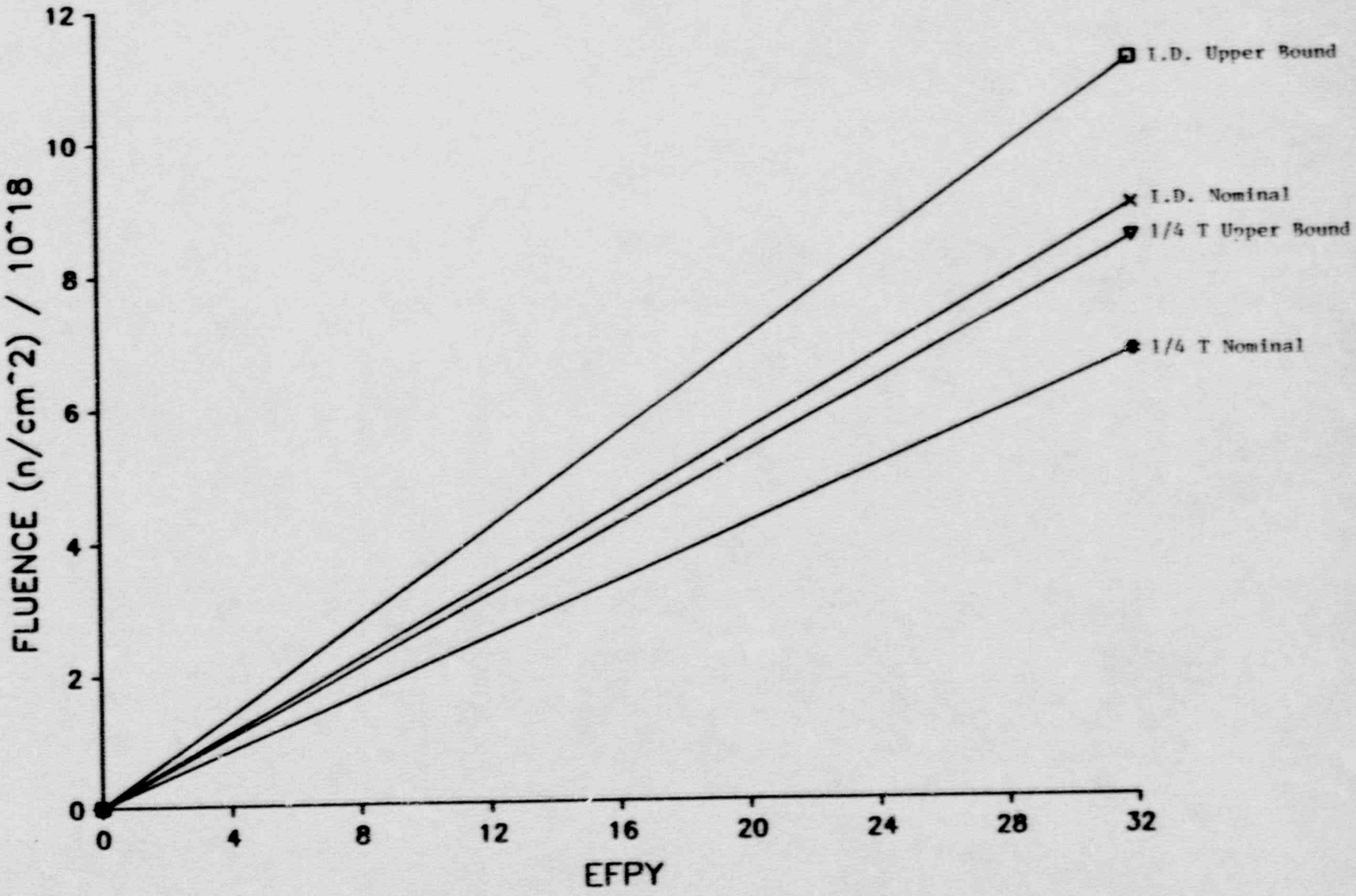

Figure 3-1. Vessel Peak Fluence Based on Dosimetry Results

4. CONCLUSIONS

The flux wire test results summarized in Table 3-1 show a nominal peak fluence on the vessel ID at 32 EFPY of 8.9×10^{18} n/cm^2. The fluence determined by dosimetry is slightly higher than the design fluence value of 8.7×10^{18} n/cm^2 shown in Table 4.3-5 of the updated SAR.

The results from the flux wire testing are generally used to modify the pressure-temperature curves in the Technical Specification. In this case, the flux nearly matches the original design value, if the nominal value from Table 3-1 is used. Furthermore, the NRC is finalizing Revision 2 to Regulatory Guide 1.99, which will prompt a revision of the pressure-temperature curves when it is issued. The curves in the Technical Specification, while based on a slightly non-conservative fluence, are intended for 32 EFPY of operation, so even considering that actual flux may be higher, the curves are conservative for current operation. Therefore, it is recommended that the River Bend curves be revised once Regulatory Guide 1.99, Revision 2 becomes official.

Changes to the Technical Specifications at this time need only include an acknowledgement that the flux wires were tested and possibly a summary of the test results. GSU may want to include a commitment to revise the pressure-temperature curves according to Regulatory Guide 1.99, Revision 2 when it becomes official.

APPENDIX A

TEST REPORT
FOR
FLUX WIRE DOSIMETER
REMOVED FROM
RIVER BEND
AT
END OF CYCLE 1