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FLUX WIRE DOSIMETER EVALUATION

FOR

LASALLE NUCLEAR POWER STATION, UNIT 1

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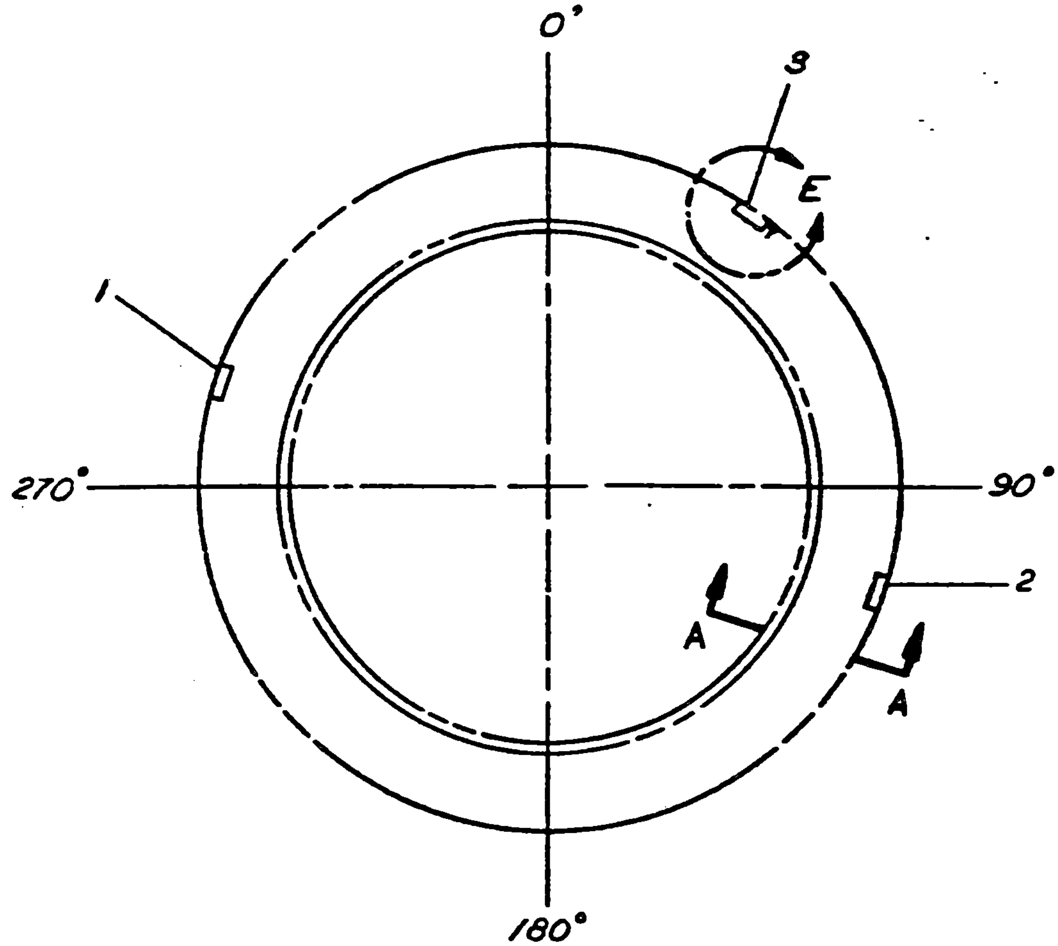
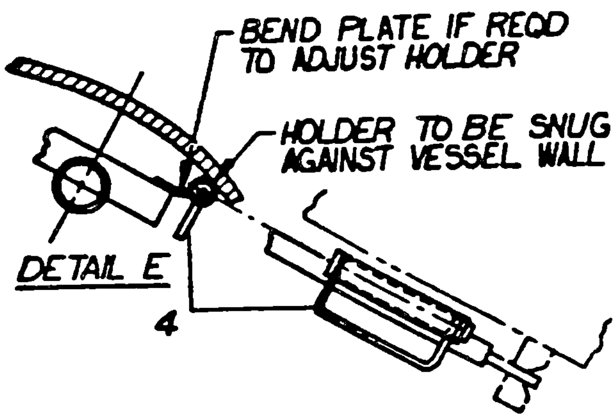
1. INTRODUCTION

In October 1985, LaSalle Nuclear Power Station Unit 1 (LaSalle 1) completed its first fuel cycle. During the outage that followed, the flux wire dosimeter attached to the surveillance capsule at the vessel 30° azimuth was removed. The dosimeter was shipped to the General Electric Vallecitos Nuclear Center (VNC) in Pleasanton, CA in May 1986 for testing. The test results and the associated determination of peak vessel flux and fluence are presented in this report.

The surveillance program for LaSalle 1 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 The surveillance capsules are scheduled to be withdrawn periodically during plant life (the current schedule required by ASTM E185-82 is a capsule at 6, 15, and 32 effective full power years).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 Capsule 3, as shown in Figure 1-1, for removal after the first fuel cycle. Since the vessel fluence is directly proportional to thermal power produced, the results of the flux wire dosimeter test are intended to provide a calibration point of vessel fluence versus accumulated thermal power. A linear extrapolation provides an estimate of the end-of-life (EOL) fluence. It should be noted that the flux wires that will be removed with the surveillance capsules will have an irradiation history more typical of normal operation, and will be useful for re-calibrating the EOL fluence estimate.



PLAN VIEW–LOCATION OF HOLDERS



ITEM NO.	REF AZIMUTH LOCATIONS OF SPECIMEN HOLDERS			
	VESSEL SIZE	183	218 251	201
1		288°	300°	300°
2		108°	120°	120°
3		36°	30°	30°
4		36°	30°	30°

Figure 1-1. Schematic of Capsule Positions for the Surveillance Program

2. ANALYSIS

The determination of the peak EOL 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 copper and 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-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 251 inch diameter vessel with 764 fuel bundles. This is the configuration of LaSalle 1. The lead factors, which ratio flux from one location to another, 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 a generic 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 EOL 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 element 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 were 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 eighth core symmetry was used with periodic boundary conditions at 0° degree and 45°. Neutron cross sections were determined for 26 energy groups, with angular scattering approximated by a third-order Legendre expansion. A schematic of the two-dimensional vessel model is shown in Figure 2-1. A total of 99 radial elements and 45 azimuthal elements 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, as shown in Figure 2-2, establishing the azimuth of the peak flux and its magnitude relative to the flux at the dosimeter location of 30°. This could be referred to as the azimuthal component of the lead factor.

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 would be considered 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.

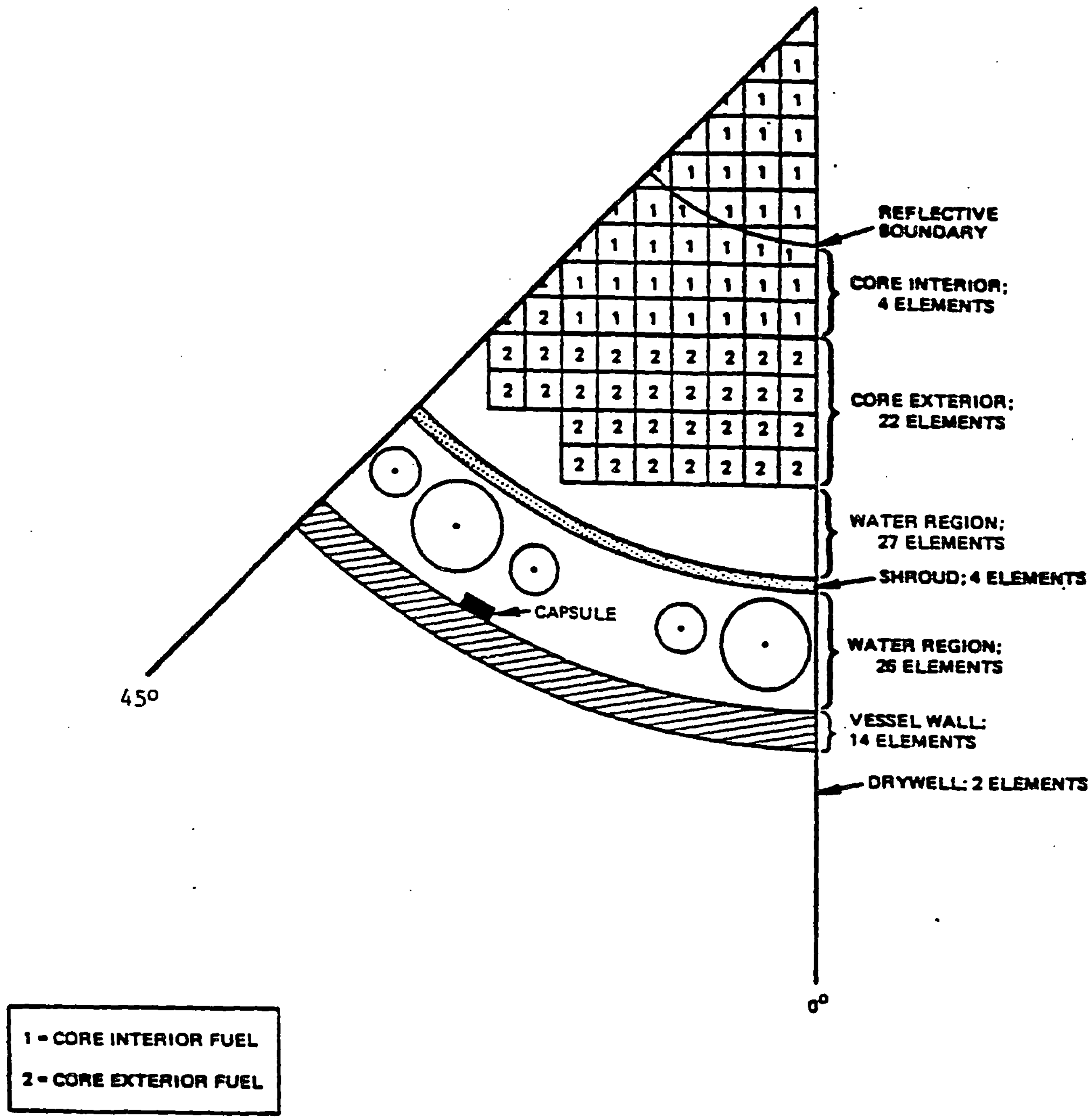


Figure 2-1. Schematic of Model for Two-Dimensional Flux Distribution Analysis

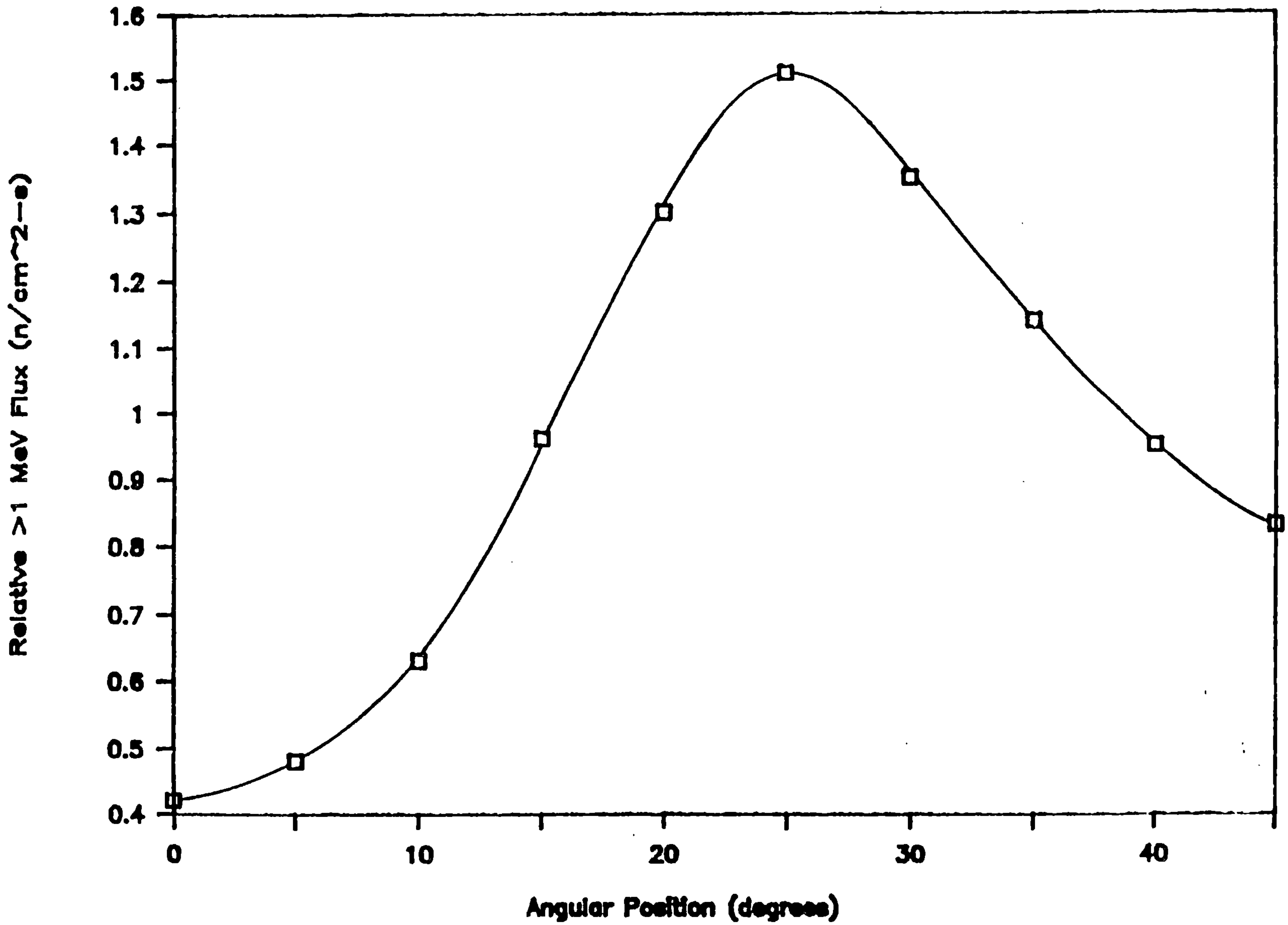


Figure 2-2. Azimuthal Flux Distribution for the Generic 251 Inch Vessel

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% 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 (3-1)

The first fuel cycle for LaSalle 1 consisted of 895 days of operation with an average capacity factor of 0.563. This is equivalent to 503.9 days at full power, or 1.38 effective full power years (EFPY). The standard assumption for EOL is 32 EFPY. These values are used to calculate the fluence values at the end of cycle one (EOC1) and at EOL, 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.

Table 3-1

FLUENCE DETERMINATION FOR THE PEAK LOCATION IN THE LASALLE 1 VESSEL

Time at Power:

EOC1	1.38 EFPY = 4.35×10^{7} seconds
EOL	32 EFPY = 1.01×10^{9} seconds

Lead Factors:

I.D.	0.98
1/4 T	1.51

Dosimeter Flux (n/cm^2-s)	4.7×10^{8} (nominal)	5.88×10^{8} (upper bound)

FLUENCE (n/cm^2)	NOMINAL	UPPER BOUND
EOC1 Peak I.D.	2.1×10^{16}	2.6×10^{16}
EOC1 Peak 1/4 T	1.4×10^{16}	1.7×10^{16}
EOL Peak I.D.	4.8×10^{17}	6.1×10^{17}
EOL Peak 1/4 T	3.1×10^{17}	3.9×10^{17}

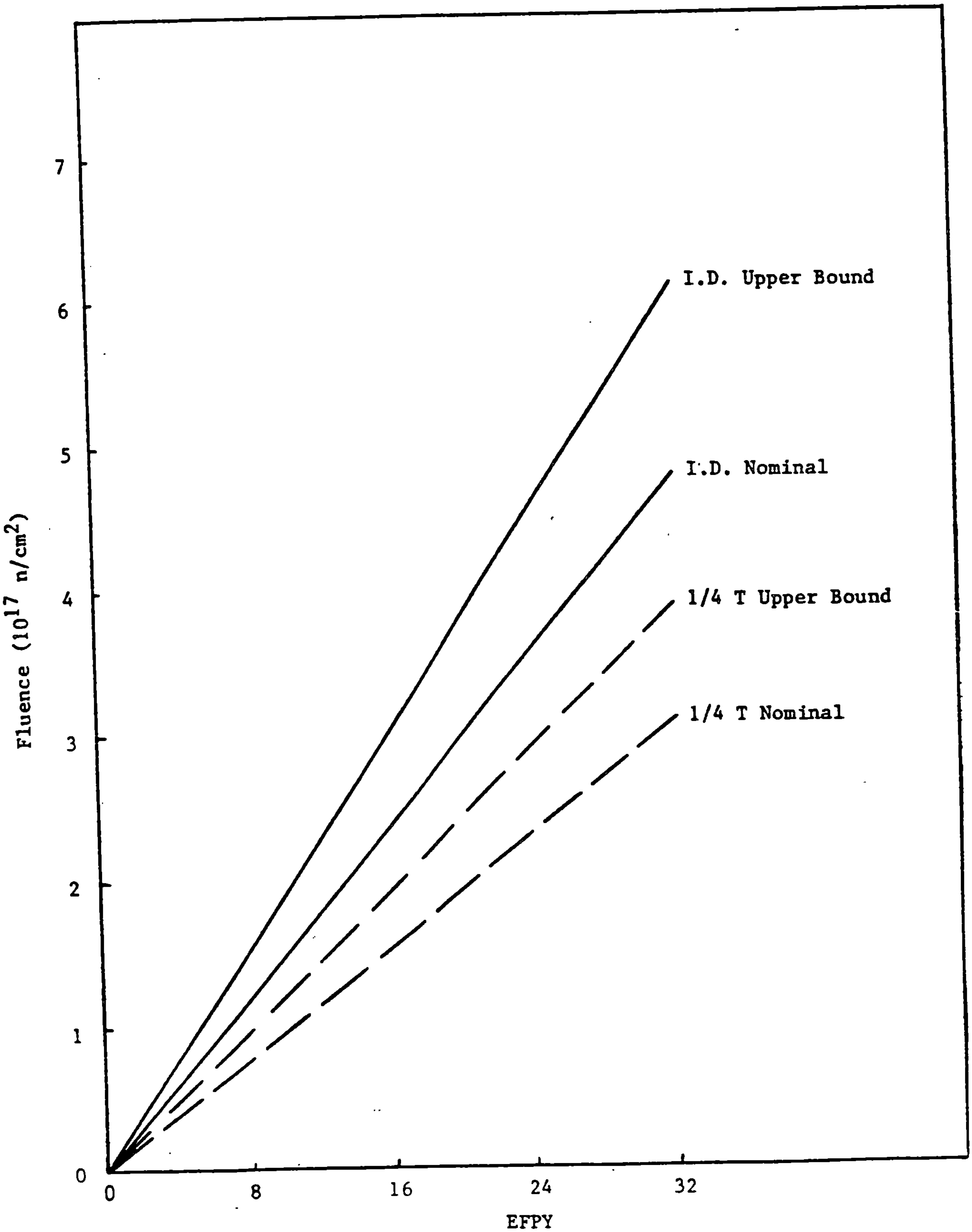


Figure 3-1. Peak Vessel Beltline EOL Fluence versus EFPY