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Revision 1

WESTINGHOUSE NON-PROPRIETARY CLASS 3

Consumers Power Company
Reactor Vessel Neutron Fluence Measurement Program
for
Palisades Nuclear Plant - Cycles 1 through 11

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Westinghouse Energy Systems

EXECUTIVE SUMMARY

Beginning with Fuel Cycle 8, a reactor cavity measurement program was instituted at Palisades to provide a continuous monitoring of the reactor pressure vessel and reactor vessel support structure. This report presents the results of the reactor cavity neutron dosimetry measurements during Fuel Cycles 8, 9, and 10/11 along with the previous A240, W290, W290-9, and W110 surveillance capsule measurements. The use of the cavity measurement program coupled with available surveillance capsule measurements provides a plant specific data base that enables the evaluation of the vessel exposure and the uncertainty associated with that exposure over the service life of the unit.

For the Palisades Nuclear Plant, the maximum reactor vessel fast neutron exposure is to the circumferential beltline region which has a peak fluence at angles symmetric with 75°. The exposure to the longitudinal welds at 0° and 30° is also important. Based on comparisons of measurements with calculations, it is concluded that the DORT neutron transport calculations, based on plant specific parameters, over-predict the reactor vessel fast neutron fluence (E > 1.0 MeV) by 17%. Taking into account this bias, the best estimate fluence at the core midplane on the pressure vessel at azimuthal locations at 15° intervals over a core quadrant following Cycle 11 are as follows:

Φ(E > 1.0 MeV) [n/cm^2]

	0°	15°	30°	45°	60°	75°[1]	90°
Cycle 11	9.46e+18	1.32e+19	9.73e+18	6.17e+18	9.82e+18	1.32e+19	9.47e+18

As further data are accumulated from subsequent irradiations, the neutron environment in the vicinity of the reactor vessel will become better characterized and the uncertainties in the vessel exposure projections will be reduced. Thus, the measurement program will permit the assessment of vessel condition to be based on realistic exposure levels with known uncertainties and will eliminate the need for any unnecessary conservatism in the determination of vessel operating parameters.

All of the calculations and dosimetry evaluations presented in this report have been based on the latest available nuclear cross-section data derived from ENDF/B-VI and are intended to be consistent with the requirements of Draft Regulatory Guide DG-1025, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence". As such, the data provided here are intended to supersede prior evaluations documented in References 1 through 7.

[1] Peak azimuthal fluence location.

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SECTION 1

OVERVIEW OF THE PROGRAM

The Reactor Cavity Neutron Measurement Program[1-3] initiated at Palisades at the start of Fuel Cycle 8 was designed to provide a mechanism for the long term continuous monitoring of the neutron exposure of those portions of the reactor vessel and vessel support structure which may experience radiation induced increases in reference nil ductility transition temperature (RT_{NDT}) over the nuclear power plant lifetime. When used in conjunction with dosimetry from internal surveillance capsules[4-7] and with the results of neutron transport calculations, the reactor cavity neutron dosimetry provides an extensive plant specific measurement data base that can be used to determine the best estimate neutron exposure of the reactor vessel and to project embrittlement gradients through the vessel wall with a minimum uncertainty. Minimizing the uncertainty in the neutron exposure projections will, in turn, help to assure that the reactor can be operated in the least restrictive mode possible with respect to:

1 - 10CFR50 Appendix G pressure/temperature limit curves for normal heatup and cooldown of the reactor coolant system,

2 - Emergency Operating Procedure (EOP) pressure/temperature limit curves, and

3 - Pressurized Thermal Shock (PTS) RT_{PTS} screening criteria.

In addition, an accurate measure of the neutron exposure of the reactor vessel and support structure can provide a sound basis for requalification should operation of the plant beyond the current design and/or licensed lifetime prove to be desirable.

In the assessment of the state of embrittlement of light water reactor vessels, an accurate evaluation of the neutron exposure of the materials comprising the beltline region of the vessel is required. This exposure evaluation must, in general, include assessments not only at locations of maximum exposure at the inner diameter of the vessel, but, also, as a function of axial, azimuthal, and radial location throughout the vessel wall.

In order to satisfy the requirements of 10CFR50 Appendix G for the calculation of pressure/temperature limit curves for normal heatup and cooldown of the reactor coolant system, fast neutron exposure levels must be defined at depths within the vessel wall equal to 25 and 75 percent of the wall thickness for each of the materials comprising the beltline region. These locations are commonly referred to as the 1/4T and 3/4T positions in the vessel wall. The 1/4T exposure levels are also used in the determination of upper shelf fracture toughness as specified in 10CFR50 Appendix G.

In the determination of values of RT_{PTS} for comparison with applicable pressurized thermal shock screening criteria for plates and circumferential welds, maximum neutron exposure levels experienced by each of the beltline materials are required. These maximum levels will, of course, occur at the vessel inner radius.

In the event that a probabalistic fracture mechanics evaluation of the reactor vessel is performed, or if an evaluation of thermal annealing and subsequent material re-embrittlement is undertaken, a complete embrittlement profile is required for the entire volume of the reactor vessel beltline. The determination of this embrittlement profile would, in turn, necessitate the evaluation of neutron exposure gradients throughout the entire beltline.

The methodology used to provide these required best estimate neutron exposure evaluations for the Palisades reactor vessel is based on the underlying philosophy that, in order to minimize the uncertainties associated with vessel exposure projections, plant specific neutron transport calculations must be supported by benchmarking of the analytical approach, comparison with industry wide power reactor data bases of surveillance capsule and reactor cavity dosimetry, and, ultimately, by validation with plant specific surveillance capsule and reactor cavity dosimetry data bases.

That is, as a progression is made from the use of a purely analytical approach tied to experimental benchmarks to an approach that makes use of industry and plant specific power reactor measurements to remove potential biases in the analytical method, knowledge regarding the neutron environment applicable to a specific reactor vessel is increased and the uncertainty associated with vessel exposure projections is minimized.

With this overall methodology in mind, the Reactor Cavity Measurement Program was established to meet the following objectives:

1 - Provide a measurement data base sufficient to:
    a) remove biases that may be present in analytical predictions of neutron exposure; and

b) support the methodology for the projection of exposure gradients through the thickness of the reactor vessel wall.

2 - Establish uncertainties in the best estimate fluence projections for the reactor vessel wall.

3 - Provide a long term continuous monitoring capability for the beltline region of the reactor vessel.

The reactor cavity dosimetry program has currently been discontinued. It is anticipated that future dosimetry information will be from the in-vessel surveillance capsules.

This report provides the results of neutron dosimetry evaluations performed subsequent to the completion of Fuel Cycle 11. Fast neutron exposure in terms of fast neutron fluence ($E > 1.0$ MeV) and dpa is established for all measurement locations in the reactor cavity. The analytical formalism describing the relationship among the measurement points and locations within the reactor vessel wall is described and used to project the exposure of the vessel itself.

Results of exposure evaluations from surveillance capsule dosimetry withdrawn at the end of Fuel Cycles 2, 5, 9 and 10 as well as reactor cavity dosimetry results from Cycles 8 and 9 are incorporated to provide the integrated exposure of the reactor vessel from plant startup through the end of Cycle 11. Also, uncertainties associated with the derived exposure parameters at the measurement locations and with the projected exposure of the reactor vessel are provided.

All of the calculations and dosimetry evaluations presented in this report are intended to meet the requirements of Draft Regulatory Guide DG-1025, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence"; and, have been based on the latest available nuclear cross-section data derived from ENDF/B-VI. As such, the data provided here are intended to supersede prior evaluations documented in References 1 through 7.

In addition to the dosimetry evaluations, an analysis of the neutron and gamma ray heat deposition in the biological shield wall for Cycle 11 is presented. A detailed description of the analysis and results are provided in Appendix E of this report.

SECTION 2

DESCRIPTION OF THE MEASUREMENT PROGRAM

2.1 Description of Reactor Cavity Dosimetry

To achieve the goals of the Reactor Cavity Neutron Measurement Program, comprehensive multiple foil sensor sets including radiometric monitors (RM) were installed at several locations in the reactor cavity to characterize the neutron energy spectra within the beltline region of the reactor vessel. In addition, gradient chains were used in conjunction with the encapsulated sensors to complete the azimuthal and axial mapping of the neutron environment over the regions of interest.

Placement of the multiple foil sensor sets was such that spectra evaluations could be made at various azimuthal locations at an axial elevation representative of the midplane of the reactor core. The intent here was to determine changes in spectra caused by varying amounts of water located between the core and the reactor vessel. Due to the irregular shape of the reactor core, water thickness varies significantly as a function of azimuthal angle. Additional sensor sets were positioned opposite the bottom of the active core at an azimuthal angle of a longitudinal reactor vessel weld (270 degrees) and at a particular azimuthal angle (290 degrees) of an in-vessel surveillance capsule, and at a particular azimuthal angle (280 degrees) of the peak azimuthal flux. Here the intent was to measure variations in neutron spectra over the core height. At each of the azimuthal locations selected for core midplane spectra measurements, gradient chains extended over the bottom half of the active fuel. Additional gradient chains were placed at symmetric locations in other quadrants to confirm symmetry of the neutron flux distribution. These additional gradient chains extended over nearly the full height of the active fuel (except for the bottom-most nine inches) and extended up past the reactor vessel support structure.

The sensor set deployment described in the preceding paragraphs is characteristic of the basic long term monitoring program designed to provide fast neutron exposure assessments for materials comprising the beltline region of the reactor vessel. The reactor cavity dosimetry program has currently been discontinued. It is anticipated that future dosimetry information will be from the in-vessel surveillance capsules.

2.1.1 Sensor Placement in the Reactor Cavity

A detailed description of the reactor cavity dosimetry hardware and plant specific installation can be found in References 1 through 3. However, the following information is provided in this report to orient the reader to the plant geometry and the specifics of the sensor sets.

The placement of the individual multiple foil sensor sets and gradient chains within the reactor cavity is illustrated in Figure 2.1-1. In Figure 2.1-1 a plan view of the azimuthal locations of the strings of sensor sets is depicted along with the azimuthal locations of the gradient chains. The strings were located at azimuthal positions of 270, 280, 290, 300, 315 and 330 degrees relative to the core cardinal axes. The sensor strings were hung in the annular gap between the reactor vessel insulation and the primary biological shield at a nominal radius of 108 inches relative to the core centerline and were hung from an aluminum support bar supported from the reactor cavity seal drip pan. Note that it has been determined that the dosimetry support bar was skewed radially (the 270 degree end of the bar was closer to the reactor vessel[6]) thus, the bar shifted radial and azimuthal positions of the dosimetry are shown below.

Reference Azimuth	First Octant Equivalent	Bar Shifted Angle	Dosimeter Radius (in)
270°	0°	6°	100.7
280°	10°	16°	101.6
290°	20°	26°	102.5
300°	30°	36°	103.5
315°	45°	39°	105.3
330°	30°	24°	107.6

The gradient chains, located at azimuthal positions of 30, 90, 150, 210, 260 and 340 degrees, were also located in the annular gap between the reactor vessel insulation and the primary biological shield at a nominal radius of 108 inches relative to the core centerline and were supported from the reactor cavity seal drip pan.

2.1.2 Description of Irradiation Capsules

The sensor sets used to characterize the neutron spectra within the reactor cavity were retained in 3.87 inch × 1.00 inch × 0.50 inch rectangular aluminum 6061 capsules such as that shown in Figure 2.1-2. Each capsule included three compartments to hold the neutron sensors. The top compartment (position 1) contained the bare radiometric monitors, whereas, the two remaining compartments (positions 2 and 3) housed the cadmium shielded packages. The separation between positions 1 and 2 was such that cadmium shields inserted into position 2 did not introduce perturbations in the thermal flux in position 1. Aluminum 6061 was selected for the dosimeter capsules in order to minimize neutron flux perturbations at the sensor set locations as well as to limit the radiation levels associated with post-irradiation shipping and handling of the capsules. A summary of the contents of the multiple foil capsules used during each cycle of irradiation is provided in the appendices to this report.

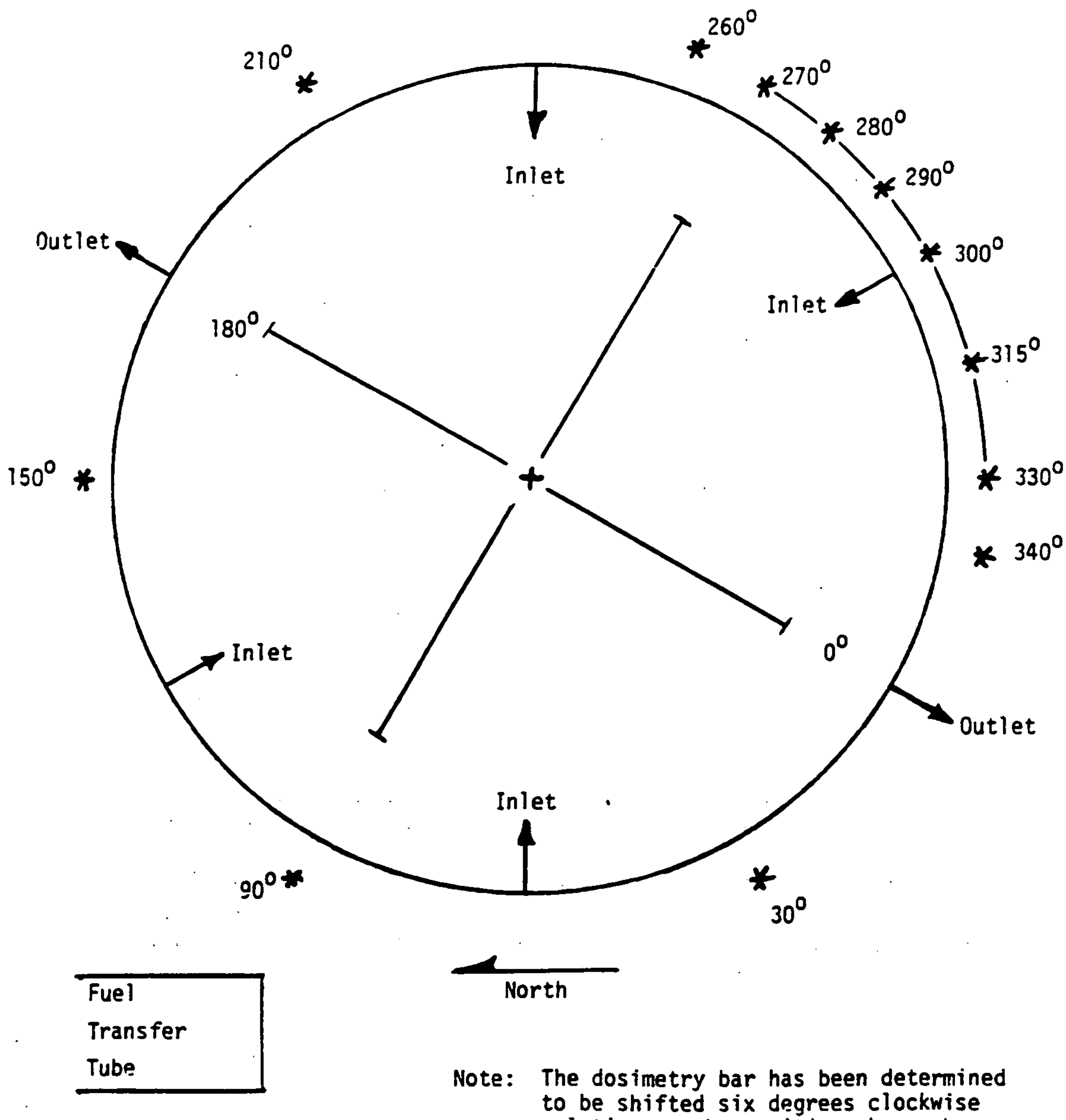
2.1.3 Description of Gradient Chains

Along with the multiple foil sensor sets placed at discrete locations within the reactor cavity, gradient chains were employed to obtain axial variations of fast neutron exposure along each of the twelve traverses. Subsequent to irradiation these gradient chains were removed from the reactor cavity and segmented to provide neutron reaction rate measurements at six-inch to one-foot intervals over the height of the axial traverses. These gradient chains consisted of Type 304 stainless steel bead chain of 0.188 inch diameter.

When coupled with a chemical analysis, the stainless steel gradient chains yielded activation results for the $^{54}Fe(n,p)^{54}Mn$, $^{58}Ni(n,p)^{58}Co$, and $^{59}Co(n,\gamma)^{60}Co$ reactions. The high purity iron, nickel, and cobalt-aluminum foils contained in the multiple foil sensor sets established a direct correlation with the measured reaction rates from the stainless steel chain; and provided a check on the chemical analysis of the Type 304 stainless steel.

FIGURE 2.1-1

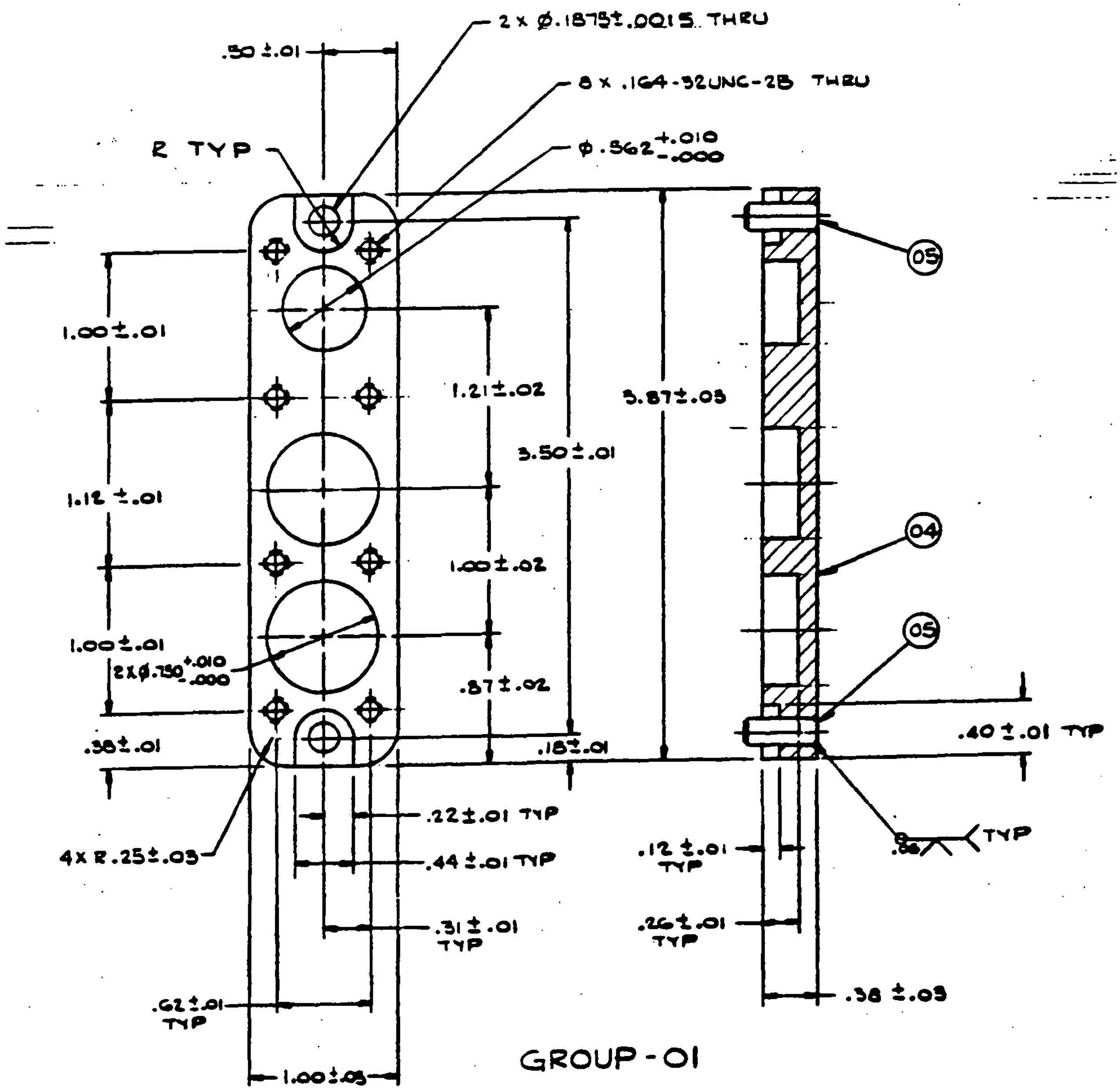
AZIMUTHAL LOCATION OF SENSOR STRINGS



Note: The dosimetry bar has been determined to be shifted six degrees clockwise relative to the position shown above.

FIGURE 2.1-2

IRRADIATION CAPSULE FOR REACTOR CAVITY SENSOR SETS



2.2 Description of Surveillance Capsule Dosimetry

Over the course of the first 10 fuel cycles at Palisades, three materials surveillance capsules were withdrawn from their positions. One from the outer surface of the core support barrel and the other two from the inner surface of the reactor vessel. The neutron dosimetry contained within these capsules provided a measure of the integral exposure received by each of the capsules during its respective irradiation period; and established a measurement continuity between the initial startup of the reactor and the initiation of the Reactor Cavity Measurement Program. The specific withdrawal dates of these three capsules were as shown below.

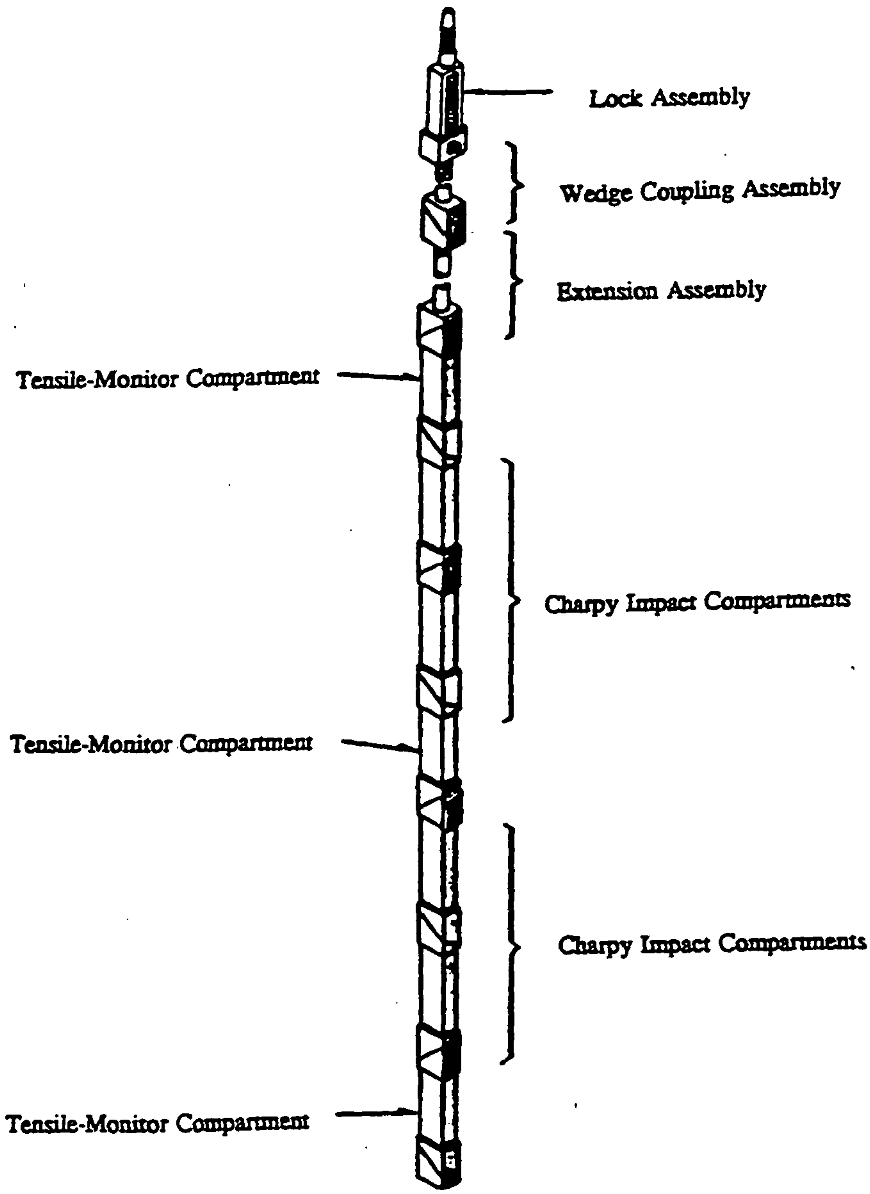
Capsule A240	End of Cycle 2	01/78
Capsule W290	End of Cycle 5	08/83
Capsule W110	End of Cycle 10	06/93

An additional capsule was installed at the W290 location for irradiation in Cycle 9 only. This capsule had the same external configuration as the others with minor design modifications to facilitate remote installation. Figure 2.2-1 shows a typical Palisades in-vessel surveillance capsule assembly geometry.

The type and location of the neutron sensors included in the materials surveillance program are described in some detail in References 4 through 7. Specific information pertinent to the individual sensor sets included in Capsules A240, W290, W110 and W290-9 is provided in the appendices to this report.

FIGURE 2.2-1

TYPICAL SURVEILLANCE CAPSULE



SECTION 3

NEUTRON TRANSPORT AND DOSIMETRY EVALUATION METHODOLOGIES

As noted in Section 1 of this report, the best estimate exposure of the reactor vessel was developed using a combination of absolute plant specific neutron transport calculations and plant specific measurements from the reactor cavity and internal surveillance capsules. In this section, the neutron transport and dosimetry evaluation methodologies are discussed in some detail; and the approach used to combine the calculations and measurements to produce the best estimate vessel exposure is presented.

3.1 Neutron Transport Analysis Methods

Fast neutron exposure calculations for the reactor and reactor cavity geometry were carried out using forward discrete ordinates transport techniques. By using fuel cycle specific core power distributions these calculations provided the energy distribution of neutrons for use as input to neutron dosimetry evaluations as well as for use in relating measurement results to the actual exposure at key locations in the reactor vessel wall. In addition, they established the means to compute absolute exposure rate values, thus, providing a direct comparison with all dosimetry results obtained over the operating history of the reactor.

Incorporating, the cycle specific data to derive neutron energy spectra distributions from the forward calculation provided the means to:

1 - Evaluate neutron dosimetry from reactor cavity and surveillance capsule locations.

2 - Enable a direct comparison of analytical prediction with measurement.

3 - Determine plant specific bias factors to be used in the evaluation of the best estimate exposure of the reactor vessel.

4 - Establish a mechanism for projection of reactor vessel exposure as the design of each new fuel cycle evolves.

A plan view of the reactor geometry at the core midplane elevation is shown in Figures 3.1-1 through 3.1-5. Figure 3.1-1 shows the model used for Cycles 1 and 2 which includes the accelerated 30 degree surveillance capsule location in addition to the 20 degree wall capsule. The Cycles 3-7 and 9 did not have the accelerated capsule position as shown in Figure 3.1-2. Cycles 8, 10 and 11 differed in that the fuel region included stainless steel pins in place of actual fuel pins at various locations as depicted in Figures 3.1-3 through 3.1-5, respectively.

The reactor exhibits ¼ core symmetry, thus, a 0-90 degree sector is depicted to evaluate the maximum flux at the reactor vessel. This 45-90 degree sector does not contain the in-vessel capsules. In addition to the core, reactor internals, reactor vessel, and the primary biological shield, the model also included explicit representations of the surveillance capsules, the reactor vessel cladding, and the mirror insulation located external to the vessel.

The models depicted in Figures 3.1-1 through 3.1-5 were developed using nominal design dimensions for all components. Specified tolerances in the design dimensions are reflected in the overall uncertainty assessments associated with projected neutron exposures. This modeling approach is consistent with the guidelines of DG-1025.

A description of a single surveillance capsule attached to the core support barrel or the reactor vessel cladding is shown in Figure 3.1-6. From a neutronic standpoint, the inclusion of the surveillance capsules and associated support structures in the analytical model is significant. Since the presence of the capsules and structure has a marked impact on the magnitude of the neutron flux as well as on the relative neutron energy spectra at dosimetry locations within the capsules, a meaningful comparison of measurement and calculation can be made only if these perturbation effects are properly accounted for in the analysis.

In contrast to the relatively massive stainless steel and carbon steel structures associated with the internal surveillance capsules, the small aluminum capsules used in the reactor cavity measurement program were designed to minimize perturbations in the neutron flux and, thus, to provide free field data at the measurement locations. Therefore, explicit modeling of these small capsules in the forward transport models was not required.

The forward transport calculations for the reactor model depicted in Figures 3.1-1 through 3.1-5 were carried out in R,θ geometry using the DORT two-dimensional discrete ordinates transport theory code[8] and the BUGLE-93 cross-section library[9]. The BUGLE-93 library is a 47 neutron and 20 gamma ray energy group, ENDF/B-VI based, data set produced specifically for light water reactor applications. In these analyses, anisotropic scattering was treated with a P_3 expansion of the scattering cross-sections and the angular discretization was modeled with an S_{16} order of angular quadrature.

The forward calculations were normalized to a core midplane power density and for operation at a thermal power level of 2530 MWt. The spatial core power distributions utilized in the forward calculations were supplied by Consumers Power[10]. The power distributions were supplied as pin-by-pin power distributions, initial enrichments, and cycle burnups for each fuel assembly in the quadrant. The neutron source was derived for each fuel pin and for each assembly using burnup dependent values of the fission neutron energy spectrum, neutrons per fission, and energy per fission evaluated at the mean assembly burnup value. The source spectrum was calculated by determining the fraction of fissions occurring in each of the important uranium and plutonium isotopes for the mid-cycle burnup and calculating the resultant average fission spectrum using the ENDF/B-VI fission spectrum for each isotope.

The source from each fuel assembly was spatially located to take into account the varying gaps between fuel assemblies and thus represents the location of source from each pin as accurately as possible. The source was converted from the X-Y pin geometry to the R-θ DORT geometry by distributing the source over a square area equal to the pitch for each pin.

Details of the fuel assembly locations, core geometry, and other reactor parameters were taken from Reference 6. The core average, by-pass, and inlet coolant temperatures were taken from Reference 10.

The results of the DORT calculations are given in Section 4 of this report.

FIGURE 3.1-1

REACTOR GEOMETRY SHOWING A 90° R,θ SECTOR FOR CYCLES 1 AND 2

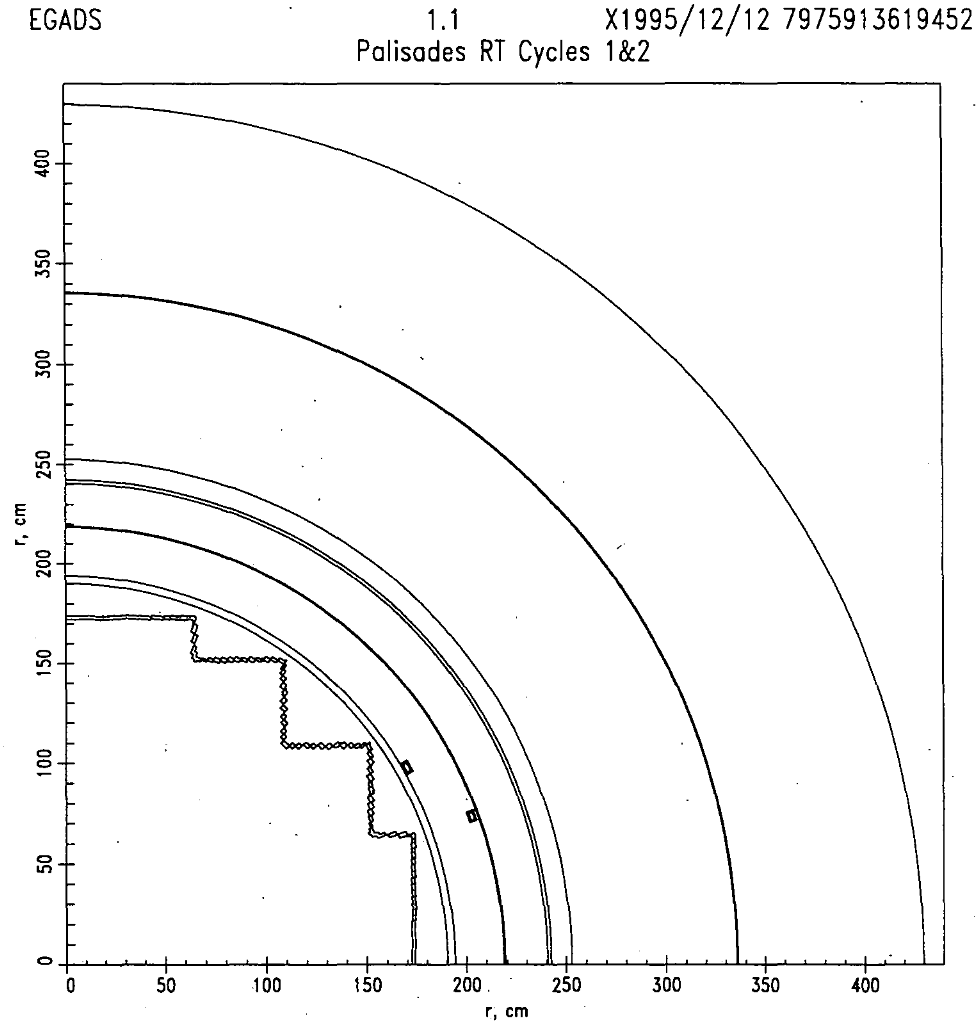


FIGURE 3.1-2

REACTOR GEOMETRY SHOWING A 90° R,θ SECTOR FOR CYCLES 3-7 AND 9

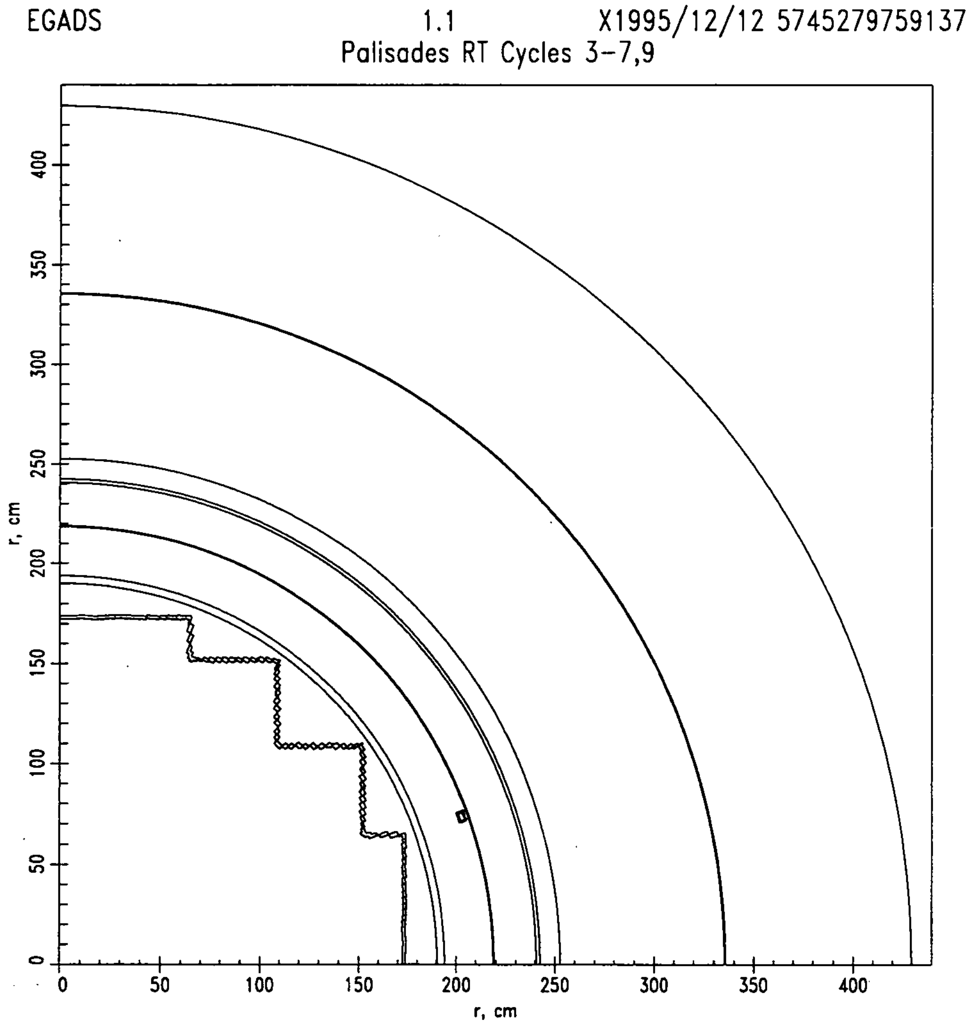


FIGURE 3.1-3

REACTOR GEOMETRY SHOWING A 90° R,θ SECTOR FOR CYCLE 8

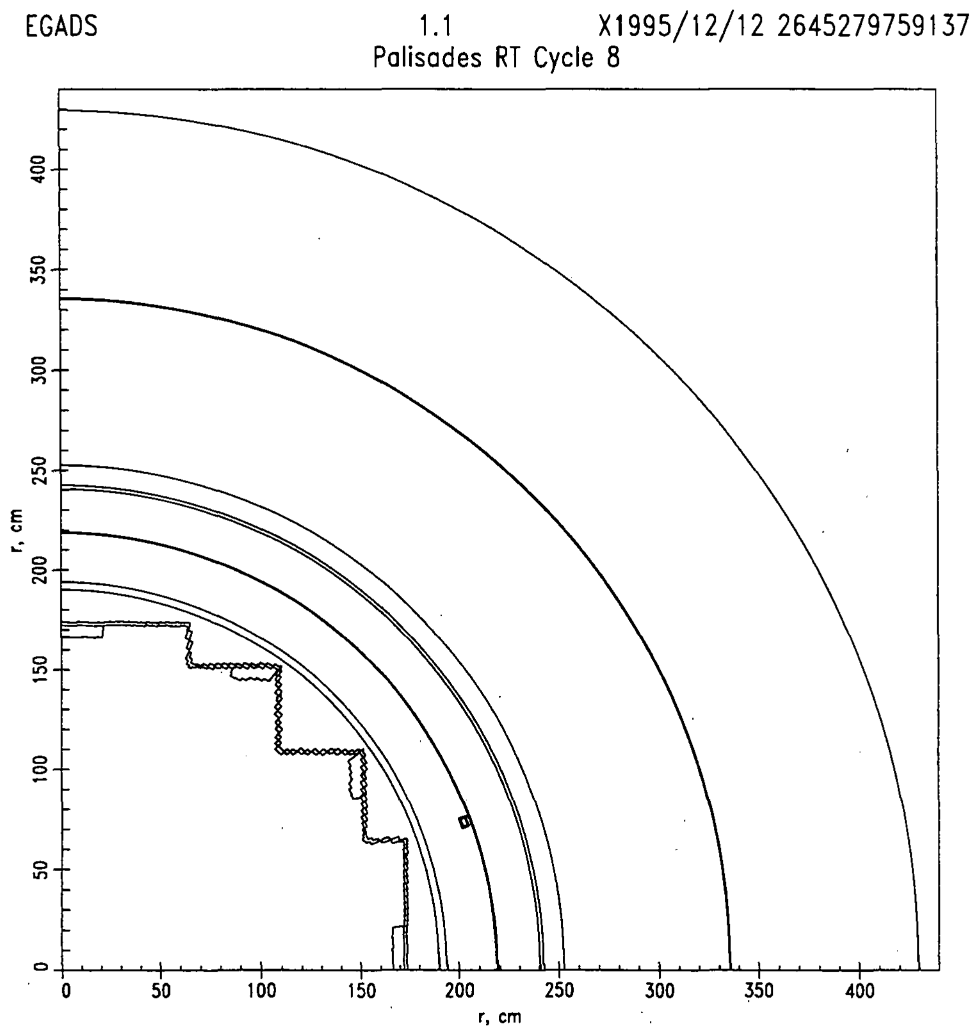


FIGURE 3.1-4

REACTOR GEOMETRY SHOWING A 90° R,θ SECTOR FOR CYCLE 10

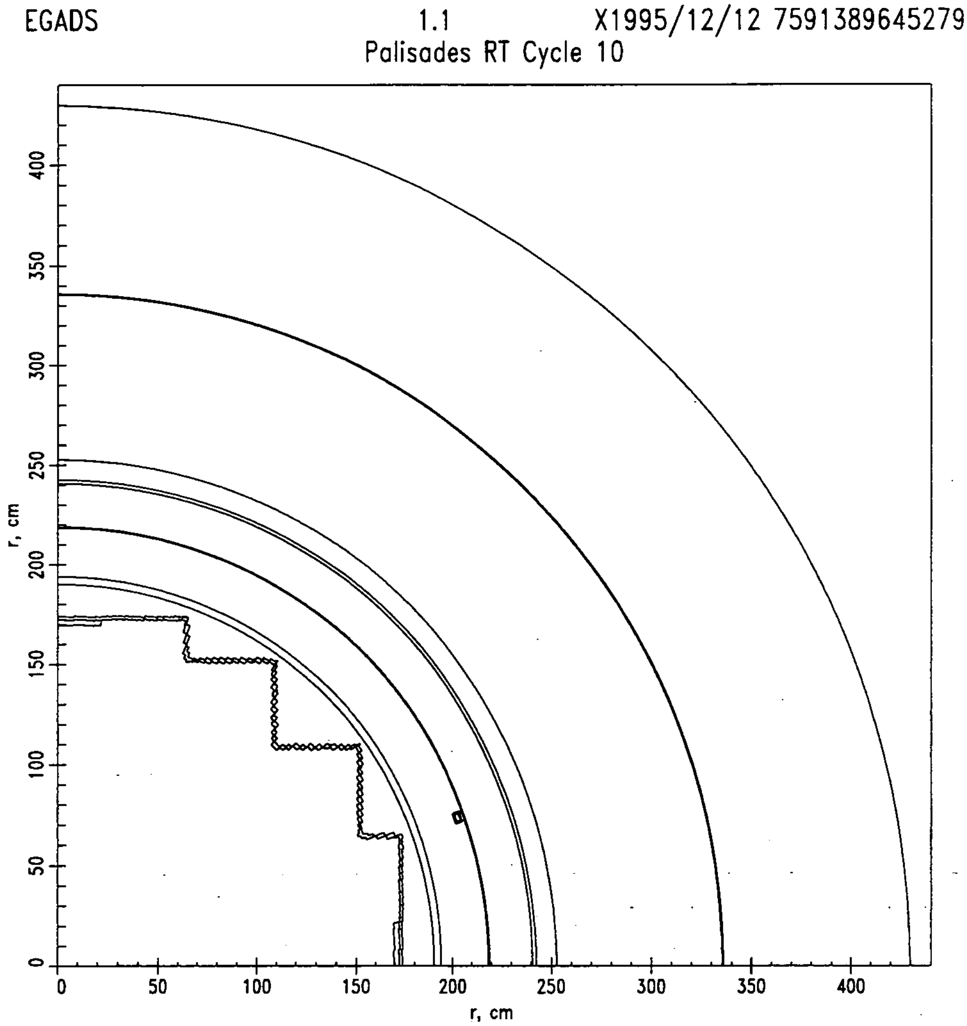


FIGURE 3.1-5

REACTOR GEOMETRY SHOWING A 90° R,θ SECTOR FOR CYCLE 11

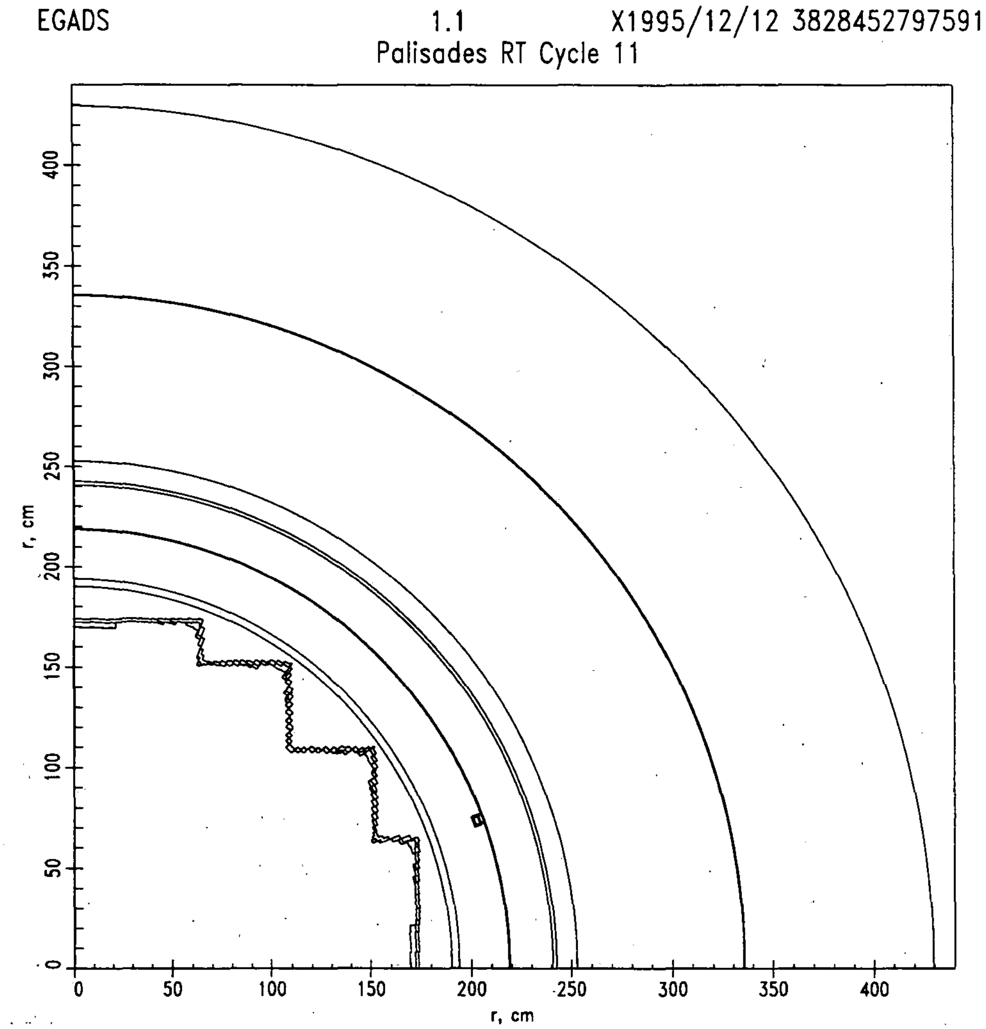
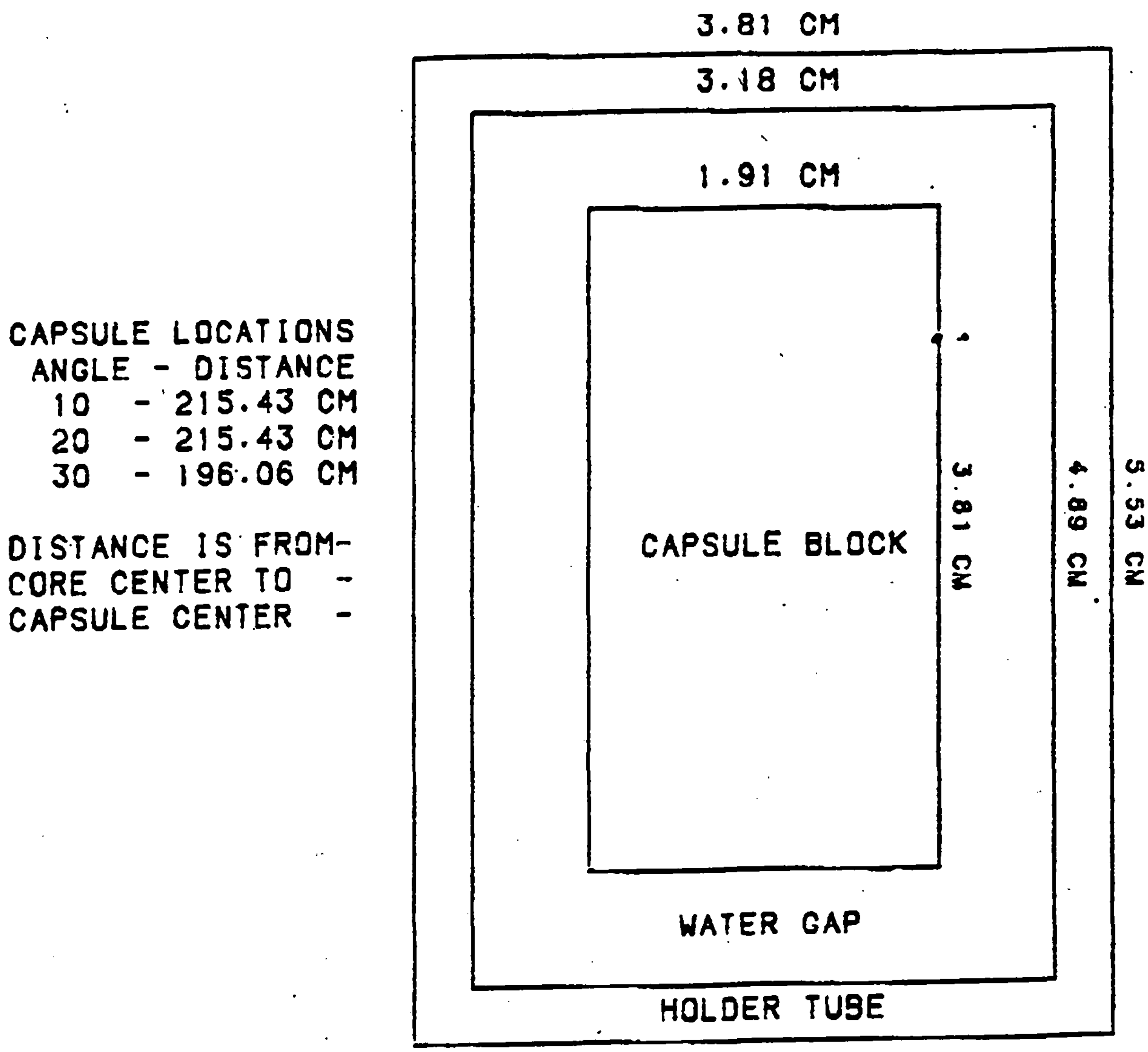


FIGURE 3.1-6

INTERNAL SURVEILLANCE CAPSULE GEOMETRY



3.2 Neutron Dosimetry Evaluation Methodology

The use of passive neutron sensors such as those included in the internal surveillance capsule and reactor cavity dosimetry sets does not yield a direct measure of the energy dependent neutron flux level at the measurement location. Rather, the activation or fission process is a measure of the integrated effect that the time- and energy-dependent neutron flux has on the target material over the course of the irradiation period. An accurate assessment of the average flux level and, hence, time integrated exposure (fluence) experienced by the sensors may be developed from the measurements only if the sensor characteristics and the parameters of the irradiation are well known. In particular, the following variables are of interest:

1 - The measured specific activity of each sensor,
2 - The physical characteristics of each sensor,
3 - The operating history of the reactor,
4 - The energy response of each sensor,
5 - The neutron energy spectrum at the sensor location.

In this section the procedures used by Westinghouse to determine sensor specific activities, to develop reaction rates for individual sensors from the measured specific activities and the operating history of the reactor, and to derive key fast neutron exposure parameters from the measured reaction rates are described.

For the most part, these procedures apply to all of the evaluations provided in this report. However, in the case of internal surveillance capsule A240, the specific activities of the multiple foil sensor set were determined from prior analysis performed by Battelle Columbus Laboratory[4]. In this case, the source of the measured specific activity data was referenced and the remainder of the data evaluation proceeded using the methodology described in this section.

3.2.1 Determination of Sensor Reaction Rates

Following irradiation, the multiple foil sensor sets from surveillance capsule and reactor cavity irradiations along with reactor cavity gradient chains were recovered and transported to Pittsburgh for evaluation. Analysis of all radiometric foils and gradient chains was performed at the Westinghouse Analytical Services Laboratory.

3.2.1.1 Radiometric Sensors

The specific activity of each of the radiometric sensors and gradient chain segments was determined using established ASTM procedures[11 through 21]. Following sample preparation and weighing, the specific activity of each sensor was determined by means of a lithium drifted germanium, Ge(Li), gamma spectrometer. In the case of the surveillance capsule and reactor cavity multiple foil sensor sets, these analyses were performed by direct counting of each of the individual foils or wires; or, as in the case of ^{238}U and ^{237}Np fission monitors from internal surveillance capsules, by direct counting preceded by dissolution and chemical separation of cesium from the sensor. For the stainless steel gradient chains used in the reactor cavity irradiations, individual sensors were obtained by cutting the chains into a series of segments to provide data points at six-inch to one-foot intervals. For the long gradient chains, the data points encompass an axial span from 4.5 feet below the core midplane to 8.0 feet above the core midplane. For the short gradient chains, which are attached to the support bar, the data points encompass an axial span from 5.5 feet below the core midplane to 0.5 feet above the core midplane.

The irradiation history of the reactor over the first ten operating cycles was obtained from NUREG-0020, "Licensed Operating Reactors Status Summary Report" and the irradiation history of Cycle 11 was supplied by Consumers Power[22]. In particular, operating data were extracted from these reports on a monthly basis from reactor startup to the end of the current evaluation period. For the sensor sets utilized in surveillance capsule and reactor cavity irradiations, the half-lives of the product isotopes are long enough that a monthly histogram describing reactor operation has proven to be an adequate representation for use in radioactive decay corrections for the reactions of interest in the exposure evaluations.

Having the measured specific activities, the operating history of the reactor, and the physical characteristics of the sensors, reaction rates referenced to full power operation at 2530 MWt were determined from the following equation:

$$R = \frac{A}{N_0 \, F \, Y \sum_j \frac{P_j}{P_{ref}} C_j \, [1 - e^{-\lambda t_j}] \, e^{-\lambda t_d}}$$

where:

A	=	measured specific activity (dps/gm)
R	=	reaction rate averaged over the irradiation period and referenced to operation at a core power level of P_{ref} (rps/nucleus).
N_0	=	number of target element atoms per gram of sensor.
F	=	weight fraction of the target isotope in the sensor material.
Y	=	number of product atoms produced per reaction.
P_j	=	average core power level during irradiation period j (MW).
P_{ref}	=	maximum or reference core power level of the reactor (MW).
C_j	=	calculated ratio of $\phi(E > 1.0$ MeV) during irradiation period j to the time weighted average $\phi(E > 1.0$ MeV) over the entire irradiation period.
λ	=	decay constant of the product isotope (sec^{-1}).
t_j	=	length of irradiation period j (sec).
t_d	=	decay time following irradiation period j (sec).

and the summation is carried out over the total number of monthly intervals comprising the total irradiation period.

In the above equation, the ratio P_j/P_{ref} accounts for month by month variation of power level within a given fuel cycle. The ratio C_j is calculated for each fuel cycle using the forward transport methodology and accounts for the change in sensor reaction rates caused by variations in flux level due to changes in core power spatial distributions from fuel cycle to fuel cycle. For a single cycle irradiation $C_j = 1.0$. However, for multiple cycle irradiations, particularly those employing low leakage fuel management the additional C_j correction must be utilized.

3.2.1.2 Corrections to Reaction Rate Data

Prior to using the measured reaction rates in the least squares adjustment procedure discussed in Section 3.2.2 of this report, additional corrections were made to the ^{238}U foil measurements to account for the presence of ^{235}U impurities in the sensors as well as to adjust for the build-in of plutonium isotopes over the course of the irradiation. These corrections were location and fluence dependent and were derived from the data obtained from the forward transport calculations.

In addition to the corrections made for the presence of ^{235}U in the ^{238}U fission sensors, corrections were also made to both the ^{238}U and ^{237}Np sensor reaction rates to account for gamma ray induced fission reactions occurring over the course of the irradiation. These photo-fission corrections were, likewise, location dependent and were also based on the forward transport calculations described in Section 3.1.1.

3.2.2 Least Squares Adjustment Procedure

Values of key fast neutron exposure parameters were derived from the measured reaction rates using the FERRET least squares adjustment code[23]. The FERRET approach used the measured reaction rate data, sensor reaction cross-sections, and a calculated trial spectrum as input and proceeded to adjust the group fluxes from the trial spectrum to produce a best fit (in a least squares sense) to the measured reaction rate data. The "measured" exposure parameters along with the associated uncertainties were then obtained from the adjusted spectrum.

In the FERRET evaluations, a log-normal least squares algorithm weights both the trial values and the measured data in accordance with the assigned uncertainties and correlations. In general, the measured values f are linearly related to the flux ϕ by some response matrix A:

$$f_i^{(s,\alpha)} = \sum_g A_{ig}^{(s)} \phi_g^{(\alpha)}$$

where i indexes the measured values belonging to a single data set s, g designates the energy group, and α delineates spectra that may be simultaneously adjusted. For example,

$$R_i = \sum_g \sigma_{ig} \phi_g$$

relates a set of measured reaction rates R_i to a single spectrum ϕ_g by the multigroup reaction cross-section σ_{ig}. The log-normal approach automatically accounts for the physical constraint of positive fluxes, even with large assigned uncertainties.

In the least squares adjustment, the continuous quantities (i.e., neutron spectra and cross-sections) were approximated in a multi-group format consisting of 53 energy groups. The trial input spectrum was converted to the FERRET 53 group structure using the SAND-II code[24]. This procedure was carried out by first expanding the 47 group calculated spectrum into the SAND-II 620 group structure using a SPLINE interpolation procedure in regions where group boundaries do not coincide. The 620 point spectrum was then re-collapsed into the group structure used in FERRET.

The sensor set reaction cross-sections, obtained from the ENDF/B-VI dosimetry file[25], were also collapsed into the 53 energy group structure using the SAND-II code. In this instance, the trial spectrum, as expanded to 620 groups, was employed as a weighting function in the cross-section collapsing procedure. Reaction cross-section uncertainties in the form of a 53 × 53 covariance matrix for each sensor reaction were also constructed from the information contained on the ENDF/B-VI data files. These matrices included energy group to energy group uncertainty correlations for each of the individual reactions. However, correlations between cross-sections for different sensor reactions were not included. The omission of this additional uncertainty information does not significantly impact the results of the adjustment.

Due to the importance of providing a trial spectrum that exhibits a relative energy distribution close to the actual spectrum at the sensor set locations, the neutron spectrum input to the FERRET evaluation was obtained from the plant specific calculation for each dosimetry location. While the 53 × 53 group covariance matrices applicable to the sensor reaction cross-sections were developed from the cross-section data files, the covariance matrix for the input trial spectrum was constructed from the following relation:

$$M_{gg'} = R_n^2 + R_g R_{g'} P_{gg'}$$

where R_n specifies an overall fractional normalization uncertainty (i.e., complete correlation) for the set of values. The fractional uncertainties R_g specify additional random uncertainties for group g that are correlated with a correlation matrix given by:

$$P_{gg'} = [1-\theta]\, \delta_{gg'} + \theta\, e^{-H}$$

where:

$$H = \frac{(g-g')^2}{2\,\gamma^2}$$

The first term in the correlation matrix equation specifies purely random uncertainties, while the second term describes short range correlations over a group range γ (θ specifies the strength of the latter term). The value of δ is 1 when $g = g'$ and 0 otherwise. For the trial spectrum used in the current evaluations, a short range correlation of γ = 6 groups was used. This choice implies that neighboring groups are strongly correlated when θ is close to 1. Strong long range correlations (or anti-correlations) were justified based on information presented by R. E. Maerker[26]. Maerker's results are closely duplicated when $\gamma = 6$. For the integral reaction rate covariances, simple normalization and random uncertainties were combined as deduced from experimental uncertainties.

In performing the least squares adjustment with the FERRET code, the fast neutron flux spectra (E > 1.0 MeV) calculated at the center of the dosimetry location was input to the analyses. The specific assignment of uncertainties in the measured reaction rates and the input (trial) spectra used in the FERRET evaluations was as follows:

REACTION RATE UNCERTAINTY	5%
FLUX NORMALIZATION UNCERTAINTY	30%
FLUX GROUP UNCERTAINTIES	
(E > 0.0055 MeV)	30%
(0.68 eV < E < 0.0055 MeV)	58%
(E < 0.68 eV)	104%
SHORT RANGE CORRELATION	
(E > 0.0055 MeV)	0.9
(0.68 eV < E < 0.0055 MeV)	0.5
(E < 0.68 eV)	0.5
FLUX GROUP CORRELATION RANGE	
(E > 0.0055 MeV)	6
(0.68 eV < E < 0.0055 MeV)	3
(E < 0.68 eV)	2

It should be noted that the uncertainties listed for the upper energy ranges extend down to the lower range. Thus, the 58% group uncertainty in the second range is made up of a 30% uncertainty with a 0.9 short range correlation and a range of 6, and a second part of magnitude 50% with a 0.5 correlation and a range of 3.

These input uncertainty assignments were based on prior experience in using the FERRET least squares adjustment approach in the analysis of neutron dosimetry from surveillance capsule, reactor cavity, and benchmark irradiations. The values are liberal enough to permit adjustment of the input spectrum to fit the measured data for all practical applications.

3.3 Determination of Best Estimate Reactor Vessel Exposure

As noted earlier in this report, the best estimate exposure of the reactor vessel was developed using a combination of absolute plant specific transport calculations based on the methodology discussed in Section 3.1 and plant specific measurement data determined using the measurement evaluation techniques described in Section 3.2. In particular, the best estimate vessel exposure is obtained from the following relationship:

$$\Phi_{Best\ Est.} = K\ \Phi_{Calc.}$$

where:	$\Phi_{Best\ Est.}$	=	The best estimate fast neutron exposure at the location of interest.
	K	=	The plant specific measurement/calculation (M/C) bias factor derived from all available surveillance capsule and reactor cavity dosimetry data.
	$\Phi_{Calc.}$	=	The absolute calculated fast neutron exposure at the location of interest.

The approach defined in the above equation is based on the premise that the measurement data represent the most accurate plant specific information available at the locations of the dosimetry; and, further that the use of the measurement data on a plant specific basis essentially removes biases present in the analytical approach and mitigates the uncertainties that would result from the use of analysis alone. That is, at the measurement points the uncertainty in the best estimate exposure is dominated by the uncertainties in the measurement process. At locations within the reactor vessel wall, additional uncertainty is incurred due to the analytically determined relative ratios among the various measurement points and locations within the reactor vessel wall.

The implementation of this approach acts to remove plant specific biases associated with the definition of the core source, actual vs. assumed reactor dimensions, and operational variations in water density within the reactor. As a result, the overall uncertainty in the best estimate exposure projections within the vessel wall depend on the individual uncertainties in the measurement process, the uncertainty in the dosimetry location, and in the uncertainty in the calculated ratio of the neutron exposure at the point of interest to that at the measurement location. The uncertainties in the measured flux were derived directly from the results of the least squares evaluation of dosimetry data.

SECTION 4

RESULTS OF NEUTRON TRANSPORT CALCULATIONS

4.1 Forward Calculation

As noted in Section 3 of this report, data from the cycle specific forward transport calculations were used in evaluating dosimetry from both reactor cavity and surveillance capsule irradiations as well as in relating the results of these evaluations to the neutron exposure of the reactor vessel wall. In this section, the key data extracted from the forward calculations are presented and their relevance to the dosimetry evaluations and vessel exposure projections is discussed. This fluence methodology is consistent with the approved method specified in Reference 27.

4.1.1 Reactor Cavity Sensor Set Locations

Data from the Cycle 8, Cycle 9, and Cycles 10/11 specific forward calculations pertinent to reactor cavity sensor evaluations are provided in Tables 4.1-1 through 4.1-3. Specifically, the calculated neutron energy spectra are listed for the dosimetry locations at 6, 16, 24, 26, and 39 degrees relative to the core cardinal axes at the axial core midplane and at the radial locations in the reactor cavity corresponding to the dosimetry positions as described in Section 2.

Table 4.1-1 presents the three spectra used for the analysis of the Cycle 8 dosimetry. Table 4.1-2 presents the four spectra used for the analysis of the Cycle 9 dosimetry, and Table 4.1-3 presents the four spectra used for the analysis of the Cycle 10/11 dosimetry. These data represent the trial spectra used as the starting guess in the FERRET least squares adjustment evaluations of the reactor cavity sensor sets. On a relative basis these calculated energy distributions establish a baseline against which adjusted spectra may be compared.

4.1.2 Surveillance Capsule Locations

Data from the cycle specific forward calculation pertinent to surveillance capsule evaluations are provided in Table 4.1-4.

In Table 4.1-4, the calculated neutron energy spectra at the geometric center of surveillance capsules located at 30 degrees (symmetric to the actual location of 240 degrees) and radially at 196.06 cm and 20 degrees (symmetric to the actual location of 290 degrees) and radially at 215.43 cm are listed.

4.1.3 Reactor Vessel Wall

Data from the forward calculations pertinent to the reactor vessel wall are provided in Tables 4.1-5 through 4.1-18.

In Tables 4.1-5 through 4.1-15, the calculated azimuthal distribution of exposure rates in terms of $\phi(E > 1.0\ \text{MeV})$, $\phi(E > 0.1\ \text{MeV})$, and dpa/sec are listed at approximately five degree intervals over the reactor geometry for Cycles 1 to 11, respectively. These data in these tables are applicable to the reactor vessel clad/base metal interface. Also given in these tables are the exposure rate ratios $[\phi(E > 0.1\ \text{MeV})]/[\phi(E > 1.0\ \text{MeV})]$ and $[\text{dpa/sec}]/[\phi(E > 1.0\ \text{MeV})]$ that provide an indication of the variation in neutron spectrum as a function of azimuthal angle at the reactor vessel inner radius.

Radial gradient information for $\phi(E > 1.0\ \text{MeV})$, $\phi(E > 0.1\ \text{MeV})$, and dpa/sec is given in Tables 4.1-16, 4.1-17, and 4.1-18 for Cycle 11, respectively. These data are presented on a relative basis for each exposure parameter at 15 degree azimuthal intervals of a core quadrant. The cycle to cycle variation is small such that the relative radial distributions for Cycle 11 is similar to the previous cycles and can be used to calculate the exposure rate distributions through the reactor vessel wall. Exposure rate distributions within the vessel wall are obtained by normalizing the calculated or best estimate exposure at the vessel inner radius to the gradient data given in Tables 4.1-16 through 4.1-18.

TABLE 4.1-1

CALCULATED NEUTRON ENERGY SPECTRA
AT REACTOR CAVITY SENSOR SET LOCATIONS FOR CYCLE 8

	Neutron Flux (n/cm^2-sec) Azimuthal Angle		
Lower Energy (MeV)	F_a = 1.084 16°	F_a = 1.084 26°	F_a = 1.084 39°
1.42e+01	3.758e+05	3.143e+05	2.391e+05
1.22e+01	1.064e+06	8.741e+05	6.504e+05
1.00e+01	4.121e+06	3.311e+06	2.388e+06
8.61e+00	7.562e+06	6.014e+06	4.287e+06
7.41e+00	1.147e+07	8.981e+06	6.299e+06
6.07e+00	2.454e+07	1.899e+07	1.321e+07
4.97e+00	3.334e+07	2.571e+07	1.793e+07
3.68e+00	5.875e+07	4.540e+07	3.198e+07
3.01e+00	4.602e+07	3.582e+07	2.557e+07
2.73e+00	3.634e+07	2.823e+07	2.008e+07
2.47e+00	4.472e+07	3.512e+07	2.546e+07
2.37e+00	2.294e+07	1.795e+07	1.294e+07
2.35e+00	7.037e+06	5.393e+06	3.724e+06
2.23e+00	3.552e+07	2.743e+07	1.923e+07
1.92e+00	9.856e+07	7.664e+07	5.432e+07
1.65e+00	1.377e+08	1.072e+08	7.573e+07
1.35e+00	2.331e+08	1.843e+08	1.334e+08
1.00e+00	5.621e+08	4.476e+08	3.251e+08
8.21e-01	5.530e+08	4.440e+08	3.233e+08
7.43e-01	2.548e+08	2.153e+08	1.730e+08
6.08e-01	1.193e+09	9.708e+08	7.199e+08
4.98e-01	1.147e+09	9.547e+08	7.380e+08
3.69e-01	1.183e+09	1.007e+09	8.119e+08

NOTE: The upper energy of group 1 is 17.33 MeV.

TABLE 4.1-1 (continued)

CALCULATED NEUTRON ENERGY SPECTRA
AT REACTOR CAVITY SENSOR SET LOCATIONS FOR CYCLE 8

	Neutron Flux (n/cm^2-sec) Azimuthal Angle		
Lower Energy (MeV)	F_a = 1.084 16°	F_a = 1.084 26°	F_a = 1.084 39°
2.97e-01	1.773e+09	1.486e+09	1.152e+09
1.83e-01	2.188e+09	1.934e+09	1.644e+09
1.11e-01	2.388e+09	2.109e+09	1.786e+09
6.74e-02	1.575e+09	1.420e+09	1.241e+09
4.09e-02	1.172e+09	1.074e+09	9.615e+08
3.18e-02	3.681e+08	3.477e+08	3.244e+08
2.61e-02	1.869e+08	1.800e+08	1.718e+08
2.42e-02	6.482e+08	5.571e+08	4.406e+08
2.19e-02	4.114e+08	3.595e+08	2.937e+08
1.50e-02	7.520e+08	6.997e+08	6.369e+08
7.10e-03	9.690e+08	9.279e+08	8.804e+08
3.36e-03	1.037e+09	9.898e+08	9.353e+08
1.59e-03	8.718e+08	8.399e+08	8.032e+08
4.54e-04	1.329e+09	1.285e+09	1.236e+09
2.14e-04	6.751e+08	6.581e+08	6.389e+08
1.01e-04	6.994e+08	6.802e+08	6.585e+08
3.73e-05	8.809e+08	8.573e+08	8.306e+08
1.07e-05	1.011e+09	9.854e+08	9.567e+08
5.04e-06	5.469e+08	5.343e+08	5.202e+08
1.86e-06	6.783e+08	6.643e+08	6.490e+08
8.76e-07	4.816e+08	4.729e+08	4.636e+08
4.14e-07	3.865e+08	3.817e+08	3.768e+08
1.00e-07	7.955e+08	7.882e+08	7.810e+08
0.00	1.928e+09	1.912e+09	1.896e+09

TABLE 4.1-2

CALCULATED NEUTRON ENERGY SPECTRA
AT REACTOR CAVITY SENSOR SET LOCATIONS FOR CYCLE 9

Lower Energy (MeV)	Neutron Flux (n/cm^2-sec) Azimuthal Angle F_a = 1.084 6°	F_a = 1.106 16°	F_a = 1.106 26°	F_a = 1.106 39°
1.42e+01	3.272e+05	2.958e+05	2.570e+05	1.879e+05
1.22e+01	9.067e+05	8.148e+05	7.024e+05	5.038e+05
1.00e+01	3.420e+06	3.063e+06	2.611e+06	1.828e+06
8.61e+00	6.198e+06	5.576e+06	4.724e+06	3.285e+06
7.41e+00	9.216e+06	8.312e+06	6.990e+06	4.826e+06
6.07e+00	1.943e+07	1.757e+07	1.470e+07	1.014e+07
4.97e+00	2.616e+07	2.355e+07	1.969e+07	1.378e+07
3.68e+00	4.599e+07	4.090e+07	3.431e+07	2.458e+07
3.01e+00	3.629e+07	3.198e+07	2.695e+07	1.965e+07
2.73e+00	2.858e+07	2.512e+07	2.114e+07	1.542e+07
2.47e+00	3.561e+07	3.097e+07	2.625e+07	1.951e+07
2.37e+00	1.816e+07	1.583e+07	1.339e+07	9.917e+06
2.35e+00	5.421e+06	4.802e+06	4.008e+06	2.864e+06
2.23e+00	2.768e+07	2.432e+07	2.039e+07	1.475e+07
1.92e+00	7.765e+07	6.775e+07	5.699e+07	4.158e+07
1.65e+00	1.087e+08	9.454e+07	7.955e+07	5.794e+07
1.35e+00	1.872e+08	1.607e+08	1.365e+08	1.018e+08
1.00e+00	4.564e+08	3.881e+08	3.308e+08	2.476e+08
8.21e-01	4.541e+08	3.826e+08	3.273e+08	2.460e+08
7.43e-01	2.207e+08	1.793e+08	1.591e+08	1.306e+08
6.08e-01	9.978e+08	8.284e+08	7.143e+08	5.463e+08
4.98e-01	9.797e+08	8.015e+08	7.024e+08	5.578e+08
3.69e-01	1.036e+09	8.328e+08	7.416e+08	6.111e+08

NOTE: The upper energy of group 1 is 17.33 MeV.

TABLE 4.1-2 (continued)

CALCULATED NEUTRON ENERGY SPECTRA
AT REACTOR CAVITY SENSOR SET LOCATIONS FOR CYCLE 9

	Neutron Flux (n/cm^2-sec) Azimuthal Angle			
Lower Energy (MeV)	F_a = 1.084 6°	F_a = 1.106 16°	F_a = 1.106 26°	F_a = 1.106 39°
2.97e-01	1.536e+09	1.242e+09	1.092e+09	8.699e+08
1.83e-01	1.993e+09	1.558e+09	1.424e+09	1.231e+09
1.11e-01	2.178e+09	1.700e+09	1.551e+09	1.337e+09
6.74e-02	1.465e+09	1.129e+09	1.045e+09	9.267e+08
4.09e-02	1.106e+09	8.441e+08	7.907e+08	7.164e+08
3.18e-02	3.573e+08	2.678e+08	2.562e+08	2.410e+08
2.61e-02	1.858e+08	1.370e+08	1.328e+08	1.274e+08
2.42e-02	5.830e+08	4.577e+08	4.076e+08	3.313e+08
2.19e-02	3.741e+08	2.916e+08	2.631e+08	2.202e+08
1.50e-02	7.196e+08	5.432e+08	5.141e+08	4.736e+08
7.10e-03	9.547e+08	7.078e+08	6.835e+08	6.526e+08
3.36e-03	1.020e+09	7.567e+08	7.291e+08	6.933e+08
1.59e-03	8.629e+08	6.380e+08	6.189e+08	5.948e+08
4.54e-04	1.318e+09	9.735e+08	9.474e+08	9.149e+08
2.14e-04	6.740e+08	4.958e+08	4.852e+08	4.726e+08
1.01e-04	6.964e+08	5.132e+08	5.015e+08	4.872e+08
3.73e-05	8.772e+08	6.464e+08	6.320e+08	6.145e+08
1.07e-05	1.008e+09	7.421e+08	7.266e+08	7.077e+08
5.04e-06	5.454e+08	4.017e+08	3.939e+08	3.848e+08
1.86e-06	6.774e+08	4.984e+08	4.899e+08	4.799e+08
8.76e-07	4.816e+08	3.542e+08	3.488e+08	3.427e+08
4.14e-07	3.878e+08	2.848e+08	2.816e+08	2.785e+08
1.00e-07	7.993e+08	5.866e+08	5.816e+08	5.773e+08
0.00	1.939e+09	1.422e+09	1.411e+09	1.402e+09

TABLE 4.1-3

CALCULATED NEUTRON ENERGY SPECTRA
AT REACTOR CAVITY SENSOR SET LOCATIONS FOR CYCLES 10-11

Lower Energy (MeV)	Neutron Flux (n/cm^2-sec) Azimuthal Angle F_a = 1.108 6°	F_a = 1.108 16°	F_a = 1.108 24°	F_a = 1.108 26°	F_a = 1.108 36°	F_a = 1.108 39°
1.42e+01	2.248e+05	2.418e+05	2.228e+05	2.360e+05	2.075e+05	1.981e+05
1.22e+01	6.105e+05	6.608e+05	6.056e+05	6.405e+05	5.576e+05	5.303e+05
1.00e+01	2.249e+06	2.460e+06	2.236e+06	2.362e+06	2.030e+06	1.920e+06
8.61e+00	4.049e+06	4.458e+06	4.035e+06	4.257e+06	3.645e+06	3.437e+06
7.41e+00	5.943e+06	6.605e+06	5.951e+06	6.262e+06	5.341e+06	5.020e+06
6.07e+00	1.245e+07	1.392e+07	1.250e+07	1.313e+07	1.119e+07	1.050e+07
4.97e+00	1.651e+07	1.857e+07	1.672e+07	1.744e+07	1.494e+07	1.404e+07
3.68e+00	2.846e+07	3.213e+07	2.905e+07	3.009e+07	2.603e+07	2.452e+07
3.01e+00	2.232e+07	2.514e+07	2.279e+07	2.354e+07	2.052e+07	1.939e+07
2.73e+00	1.746e+07	1.972e+07	1.786e+07	1.843e+07	1.606e+07	1.517e+07
2.47e+00	2.170e+07	2.436e+07	2.219e+07	2.283e+07	2.006e+07	1.902e+07
2.37e+00	1.104e+07	1.244e+07	1.132e+07	1.164e+07	1.021e+07	9.666e+06
2.35e+00	3.275e+06	3.748e+06	3.384e+06	3.484e+06	3.007e+06	2.830e+06
2.23e+00	1.673e+07	1.902e+07	1.715e+07	1.771e+07	1.538e+07	1.448e+07
1.92e+00	4.694e+07	5.308e+07	4.783e+07	4.950e+07	4.314e+07	4.069e+07
1.65e+00	6.544e+07	7.402e+07	6.663e+07	6.901e+07	6.007e+07	5.666e+07
1.35e+00	1.125e+08	1.262e+08	1.145e+08	1.182e+08	1.038e+08	9.843e+07
1.00e+00	2.732e+08	3.052e+08	2.763e+08	2.860e+08	2.515e+08	2.387e+08
8.21e-01	2.707e+08	3.011e+08	2.729e+08	2.826e+08	2.489e+08	2.365e+08
7.43e-01	1.326e+08	1.433e+08	1.349e+08	1.368e+08	1.251e+08	1.212e+08
6.08e-01	5.932e+08	6.540e+08	5.930e+08	6.155e+08	5.458e+08	5.200e+08
4.98e-01	5.840e+08	6.367e+08	5.870e+08	6.036e+08	5.436e+08	5.224e+08
3.69e-01	6.201e+08	6.664e+08	6.216e+08	6.360e+08	5.824e+08	5.634e+08

NOTE: The upper energy of group 1 is 17.33 MeV.

TABLE 4.1-3 (continued)

CALCULATED NEUTRON ENERGY SPECTRA
AT REACTOR CAVITY SENSOR SET LOCATIONS FOR CYCLES 10-11

Lower Energy (MeV)	Neutron Flux (n/cm^2-sec) Azimuthal Angle F_a = 1.108 6°	F_a = 1.108 16°	F_a = 1.108 24°	F_a = 1.108 26°	F_a = 1.108 36°	F_a = 1.108 39°
2.97e-01	9.126e+08	9.883e+08	9.065e+08	9.375e+08	8.461e+08	8.123e+08
1.83e-01	1.196e+09	1.260e+09	1.202e+09	1.217e+09	1.138e+09	1.113e+09
1.11e-01	1.305e+09	1.374e+09	1.302e+09	1.325e+09	1.238e+09	1.208e+09
6.74e-02	8.807e+08	9.178e+08	8.809e+08	8.907e+08	8.430e+08	8.274e+08
4.09e-02	6.672e+08	6.898e+08	6.684e+08	6.728e+08	6.432e+08	6.340e+08
3.18e-02	2.166e+08	2.208e+08	2.183e+08	2.175e+08	2.116e+08	2.104e+08
2.61e-02	1.130e+08	1.137e+08	1.125e+08	1.126e+08	1.106e+08	1.102e+08
2.42e-02	3.449e+08	3.666e+08	3.316e+08	3.485e+08	3.177e+08	3.044e+08
2.19e-02	2.216e+08	2.344e+08	2.172e+08	2.246e+08	2.070e+08	2.005e+08
1.50e-02	4.330e+08	4.451e+08	4.376e+08	4.367e+08	4.203e+08	4.167e+08
7.10e-03	5.794e+08	5.860e+08	5.816e+08	5.793e+08	5.676e+08	5.655e+08
3.36e-03	6.189e+08	6.262e+08	6.171e+08	6.178e+08	6.044e+08	6.006e+08
1.59e-03	5.252e+08	5.295e+08	5.246e+08	5.240e+08	5.151e+08	5.130e+08
4.54e-04	8.036e+08	8.090e+08	8.039e+08	8.017e+08	7.898e+08	7.874e+08
2.14e-04	4.118e+08	4.132e+08	4.118e+08	4.104e+08	4.059e+08	4.053e+08
1.01e-04	4.254e+08	4.274e+08	4.253e+08	4.241e+08	4.190e+08	4.181e+08
3.73e-05	5.360e+08	5.384e+08	5.357e+08	5.344e+08	5.282e+08	5.269e+08
1.07e-05	6.159e+08	6.184e+08	6.160e+08	6.142e+08	6.075e+08	6.062e+08
5.04e-06	3.338e+08	3.350e+08	3.343e+08	3.330e+08	3.297e+08	3.293e+08
1.86e-06	4.148e+08	4.160e+08	4.162e+08	4.140e+08	4.105e+08	4.103e+08
8.76e-07	2.952e+08	2.958e+08	2.967e+08	2.947e+08	2.926e+08	2.927e+08
4.14e-07	2.380e+08	2.382e+08	2.406e+08	2.379e+08	2.368e+08	2.376e+08
1.00e-07	4.908e+08	4.910e+08	4.981e+08	4.912e+08	4.897e+08	4.920e+08
0.00	1.189e+09	1.190e+09	1.214e+09	1.192e+09	1.189e+09	1.197e+09

TABLE 4.1-4

CALCULATED NEUTRON ENERGY SPECTRA
AT SURVEILLANCE CAPSULE CENTER

Lower Energy (MeV)	F_a = 1.149 30°	F_a = 1.149 20°	F_a = 1.106 20°- Cyc 9
	Neutron Flux (n/cm^2-sec) Azimuthal Angle		
1.42e+01	7.647e+07	1.898e+07	1.394e+07
1.22e+01	2.658e+08	6.050e+07	4.320e+07
1.00e+01	1.267e+09	2.538e+08	1.764e+08
8.61e+00	2.648e+09	4.936e+08	3.417e+08
7.41e+00	5.135e+09	8.653e+08	5.906e+08
6.07e+00	1.420e+10	2.296e+09	1.551e+09
4.97e+00	2.362e+10	3.404e+09	2.267e+09
3.68e+00	5.048e+10	6.125e+09	4.010e+09
3.01e+00	4.071e+10	4.209e+09	2.734e+09
2.73e+00	3.006e+10	2.984e+09	1.927e+09
2.47e+00	3.462e+10	3.324e+09	2.139e+09
2.37e+00	1.678e+10	1.620e+09	1.040e+09
2.35e+00	4.314e+09	4.118e+08	2.646e+08
2.23e+00	2.155e+10	2.008e+09	1.288e+09
1.92e+00	5.570e+10	4.955e+09	3.172e+09
1.65e+00	5.973e+10	4.948e+09	3.160e+09
1.35e+00	8.446e+10	6.591e+09	4.199e+09
1.00e+00	1.273e+11	8.898e+09	5.638e+09
8.21e-01	8.116e+10	5.431e+09	3.433e+09
7.43e-01	4.295e+10	2.896e+09	1.833e+09
6.08e-01	9.852e+10	6.342e+09	3.962e+09
4.98e-01	7.978e+10	5.218e+09	3.260e+09
3.69e-01	8.565e+10	5.687e+09	3.552e+09

NOTE: The upper energy of group 1 is 17.33 MeV.

TABLE 4.1-4 (continued)

CALCULATED NEUTRON ENERGY SPECTRA
AT SURVEILLANCE CAPSULE CENTER

Lower Energy (MeV)	Neutron Flux (n/cm^2-sec) Azimuthal Angle F_a = 1.149 30°	F_a = 1.149 20°	F_a = 1.106 20°- Cyc 9
2.97e-01	7.273e+10	4.825e+09	2.982e+09
1.83e-01	1.117e+11	7.697e+09	4.806e+09
1.11e-01	9.796e+10	6.662e+09	4.145e+09
6.74e-02	7.655e+10	5.269e+09	3.288e+09
4.09e-02	6.510e+10	4.531e+09	2.833e+09
3.18e-02	2.594e+10	1.848e+09	1.159e+09
2.61e-02	1.445e+10	9.726e+08	6.112e+08
2.42e-02	1.965e+10	1.359e+09	8.440e+08
2.19e-02	1.226e+10	8.228e+08	5.112e+08
1.50e-02	3.722e+10	2.737e+09	1.713e+09
7.10e-03	6.939e+10	5.175e+09	3.250e+09
3.36e-03	7.430e+10	5.459e+09	3.428e+09
1.59e-03	7.129e+10	5.133e+09	3.229e+09
4.54e-04	1.182e+11	8.518e+09	5.371e+09
2.14e-04	6.763e+10	4.904e+09	3.097e+09
1.01e-04	7.188e+10	5.224e+09	3.302e+09
3.73e-05	9.534e+10	6.876e+09	4.351e+09
1.07e-05	1.185e+11	8.543e+09	5.414e+09
5.04e-06	6.964e+10	5.034e+09	3.193e+09
1.86e-06	9.435e+10	6.940e+09	4.410e+09
8.76e-07	7.198e+10	5.410e+09	3.443e+09
4.14e-07	6.748e+10	5.198e+09	3.318e+09
1.00e-07	1.519e+11	1.269e+10	8.143e+09
0.00	4.526e+11	6.802e+10	4.270e+10

TABLE 4.1-5

AZIMUTHAL VARIATION OF NEUTRON FLUX AND DPA/SEC
AT REACTOR VESSEL CLAD-BASE METAL INTERFACE
CYCLE 1

Theta	Flux (n/cm^2-sec)			Ratio	
(deg.)	E > 1.0	E > 0.1	dpa/sec	E > 0.1 / E > 1.0	dpa/sec / E > 1.0
0	3.694e+10	7.267e+10	5.659e-11	1.97	1.53e-21
5	3.896e+10	7.688e+10	5.957e-11	1.97	1.53e-21
10	4.429e+10	8.749e+10	6.745e-11	1.98	1.52e-21
15	4.868e+10	9.633e+10	7.386e-11	1.98	1.52e-21
20	4.221e+10	8.952e+10	6.431e-11	2.12	1.52e-21
25	3.732e+10	7.449e+10	5.705e-11	2.00	1.53e-21
30	3.579e+10	7.147e+10	5.460e-11	2.00	1.53e-21
35	3.523e+10	6.999e+10	5.347e-11	1.99	1.52e-21
40	2.696e+10	5.376e+10	4.130e-11	1.99	1.53e-21
45	2.277e+10	4.531e+10	3.515e-11	1.99	1.54e-21
50	2.697e+10	5.379e+10	4.132e-11	1.99	1.53e-21
55	3.543e+10	7.034e+10	5.379e-11	1.99	1.52e-21
60	3.700e+10	7.336e+10	5.638e-11	1.98	1.52e-21
65	3.774e+10	7.520e+10	5.768e-11	1.99	1.53e-21
70	4.451e+10	8.873e+10	6.768e-11	1.99	1.52e-21
75	4.899e+10	9.674e+10	7.431e-11	1.97	1.52e-21
80	4.428e+10	8.749e+10	6.745e-11	1.98	1.52e-21
85	3.895e+10	7.685e+10	5.955e-11	1.97	1.53e-21
90	3.693e+10	7.258e+10	5.655e-11	1.97	1.53e-21

TABLE 4.1-6

AZIMUTHAL VARIATION OF NEUTRON FLUX AND DPA/SEC
AT REACTOR VESSEL CLAD-BASE METAL INTERFACE
CYCLE 2

Theta	Flux (n/cm^2-sec)			Ratio	
				E > 0.1 / E > 1.0	dpa/sec / E > 1.0
(deg.)	E > 1.0	E > 0.1	dpa/sec		
0	3.358e+10	6.603e+10	5.142e-11	1.97	1.53e-21
5	3.513e+10	6.931e+10	5.372e-11	1.97	1.53e-21
10	3.932e+10	7.770e+10	5.991e-11	1.98	1.52e-21
15	4.298e+10	8.512e+10	6.525e-11	1.98	1.52e-21
20	3.769e+10	7.998e+10	5.745e-11	2.12	1.52e-21
25	3.411e+10	6.803e+10	5.214e-11	1.99	1.53e-21
30	3.299e+10	6.588e+10	5.032e-11	2.00	1.53e-21
35	3.258e+10	6.474e+10	4.946e-11	1.99	1.52e-21
40	2.519e+10	5.019e+10	3.858e-11	1.99	1.53e-21
45	2.144e+10	4.261e+10	3.307e-11	1.99	1.54e-21
50	2.519e+10	5.021e+10	3.859e-11	1.99	1.53e-21
55	3.277e+10	6.506e+10	4.975e-11	1.99	1.52e-21
60	3.413e+10	6.766e+10	5.200e-11	1.98	1.52e-21
65	3.450e+10	6.869e+10	5.272e-11	1.99	1.53e-21
70	3.977e+10	7.930e+10	6.049e-11	1.99	1.52e-21
75	4.324e+10	8.544e+10	6.561e-11	1.98	1.52e-21
80	3.932e+10	7.770e+10	5.990e-11	1.98	1.52e-21
85	3.512e+10	6.928e+10	5.370e-11	1.97	1.53e-21
90	3.357e+10	6.595e+10	5.139e-11	1.96	1.53e-21

TABLE 4.1-7

AZIMUTHAL VARIATION OF NEUTRON FLUX AND DPA/SEC
AT REACTOR VESSEL CLAD-BASE METAL INTERFACE
CYCLE 3

Theta	Flux (n/cm^2-sec)			Ratio	
				E > 0.1	dpa/sec
(deg.)	E > 1.0	E > 0.1	dpa/sec	E > 1.0	E > 1.0
0	4.461e+10	8.803e+10	6.828e-11	1.97	1.53e-21
5	4.702e+10	9.309e+10	7.184e-11	1.98	1.53e-21
10	5.340e+10	1.059e+11	8.128e-11	1.98	1.52e-21
15	5.866e+10	1.165e+11	8.895e-11	1.99	1.52e-21
20	5.067e+10	1.080e+11	7.719e-11	2.13	1.52e-21
25	4.498e+10	9.000e+10	6.870e-11	2.00	1.53e-21
30	4.351e+10	8.660e+10	6.626e-11	1.99	1.52e-21
35	4.135e+10	8.242e+10	6.275e-11	1.99	1.52e-21
40	3.147e+10	6.300e+10	4.819e-11	2.00	1.53e-21
45	2.662e+10	5.316e+10	4.106e-11	2.00	1.54e-21
50	3.146e+10	6.298e+10	4.817e-11	2.00	1.53e-21
55	4.133e+10	8.237e+10	6.272e-11	1.99	1.52e-21
60	4.348e+10	8.652e+10	6.621e-11	1.99	1.52e-21
65	4.489e+10	8.977e+10	6.856e-11	2.00	1.53e-21
70	5.339e+10	1.068e+11	8.114e-11	2.00	1.52e-21
75	5.855e+10	1.162e+11	8.879e-11	1.99	1.52e-21
80	5.340e+10	1.059e+11	8.128e-11	1.98	1.52e-21
85	4.706e+10	9.315e+10	7.190e-11	1.98	1.53e-21
90	4.466e+10	8.805e+10	6.833e-11	1.97	1.53e-21

TABLE 4.1-8

AZIMUTHAL VARIATION OF NEUTRON FLUX AND DPA/SEC
AT REACTOR VESSEL CLAD-BASE METAL INTERFACE
CYCLE 4

Theta	Flux (n/cm^2-sec)			Ratio	
				E > 0.1	dpa/sec
(deg.)	E > 1.0	E > 0.1	dpa/sec	E > 1.0	E > 1.0
0	4.511e+10	8.910e+10	6.903e-11	1.98	1.53e-21
5	4.751e+10	9.415e+10	7.258e-11	1.98	1.53e-21
10	5.394e+10	1.070e+11	8.209e-11	1.98	1.52e-21
15	5.946e+10	1.182e+11	9.018e-11	1.99	1.52e-21
20	5.193e+10	1.108e+11	7.912e-11	2.13	1.52e-21
25	4.717e+10	9.448e+10	7.204e-11	2.00	1.53e-21
30	4.704e+10	9.370e+10	7.159e-11	1.99	1.52e-21
35	4.565e+10	9.102e+10	6.923e-11	1.99	1.52e-21
40	3.491e+10	6.990e+10	5.341e-11	2.00	1.53e-21
45	2.949e+10	5.893e+10	4.546e-11	2.00	1.54e-21
50	3.491e+10	6.990e+10	5.341e-11	2.00	1.53e-21
55	4.566e+10	9.102e+10	6.924e-11	1.99	1.52e-21
60	4.704e+10	9.370e+10	7.160e-11	1.99	1.52e-21
65	4.713e+10	9.434e+10	7.197e-11	2.00	1.53e-21
70	5.480e+10	1.098e+11	8.328e-11	2.00	1.52e-21
75	5.942e+10	1.181e+11	9.010e-11	1.99	1.52e-21
80	5.394e+10	1.070e+11	8.209e-11	1.98	1.52e-21
85	4.750e+10	9.412e+10	7.257e-11	1.98	1.53e-21
90	4.510e+10	8.900e+10	6.898e-11	1.97	1.53e-21

TABLE 4.1-9

AZIMUTHAL VARIATION OF NEUTRON FLUX AND DPA/SEC
AT REACTOR VESSEL CLAD-BASE METAL INTERFACE
CYCLE 5

Theta (deg.)	Flux (n/cm^2-sec) E > 1.0	E > 0.1	dpa/sec	Ratio E > 0.1 / E > 1.0	dpa/sec / E > 1.0
0	4.211e+10	8.317e+10	6.447e-11	1.97	1.53e-21
5	4.464e+10	8.846e+10	6.823e-11	1.98	1.53e-21
10	5.144e+10	1.020e+11	7.829e-11	1.98	1.52e-21
15	5.736e+10	1.140e+11	8.699e-11	1.99	1.52e-21
20	5.037e+10	1.074e+11	7.674e-11	2.13	1.52e-21
25	4.570e+10	9.144e+10	6.980e-11	2.00	1.53e-21
30	4.516e+10	8.988e+10	6.875e-11	1.99	1.52e-21
35	4.349e+10	8.665e+10	6.596e-11	1.99	1.52e-21
40	3.320e+10	6.644e+10	5.081e-11	2.00	1.53e-21
45	2.807e+10	5.605e+10	4.327e-11	2.00	1.54e-21
50	3.320e+10	6.644e+10	5.081e-11	2.00	1.53e-21
55	4.349e+10	8.665e+10	6.596e-11	1.99	1.52e-21
60	4.516e+10	8.987e+10	6.874e-11	1.99	1.52e-21
65	4.566e+10	9.130e+10	6.972e-11	2.00	1.53e-21
70	5.315e+10	1.064e+11	8.076e-11	2.00	1.52e-21
75	5.731e+10	1.138e+11	8.689e-11	1.99	1.52e-21
80	5.142e+10	1.020e+11	7.828e-11	1.98	1.52e-21
85	4.462e+10	8.842e+10	6.820e-11	1.98	1.53e-21
90	4.209e+10	8.306e+10	6.442e-11	1.97	1.53e-21

TABLE 4.1-10

AZIMUTHAL VARIATION OF NEUTRON FLUX AND DPA/SEC
AT REACTOR VESSEL CLAD-BASE METAL INTERFACE
CYCLE 6

Theta	Flux (n/cm^2-sec)			Ratio	
				E > 0.1 / E > 1.0	dpa/sec / E > 1.0
(deg.)	E > 1.0	E > 0.1	dpa/sec		
0	4.560e+10	8.999e+10	6.978e-11	1.97	1.53e-21
5	4.786e+10	9.478e+10	7.313e-11	1.98	1.53e-21
10	5.392e+10	1.069e+11	8.207e-11	1.98	1.52e-21
15	5.904e+10	1.173e+11	8.954e-11	1.99	1.52e-21
20	5.128e+10	1.093e+11	7.813e-11	2.13	1.52e-21
25	4.619e+10	9.245e+10	7.055e-11	2.00	1.53e-21
30	4.544e+10	9.045e+10	6.917e-11	1.99	1.52e-21
35	4.360e+10	8.690e+10	6.613e-11	1.99	1.52e-21
40	3.318e+10	6.644e+10	5.079e-11	2.00	1.53e-21
45	2.802e+10	5.598e+10	4.320e-11	2.00	1.54e-21
50	3.318e+10	6.645e+10	5.079e-11	2.00	1.53e-21
55	4.360e+10	8.690e+10	6.614e-11	1.99	1.52e-21
60	4.544e+10	9.045e+10	6.917e-11	1.99	1.52e-21
65	4.615e+10	9.232e+10	7.047e-11	2.00	1.53e-21
70	5.411e+10	1.083e+11	8.224e-11	2.00	1.52e-21
75	5.899e+10	1.172e+11	8.946e-11	1.99	1.52e-21
80	5.392e+10	1.069e+11	8.208e-11	1.98	1.52e-21
85	4.786e+10	9.476e+10	7.312e-11	1.98	1.53e-21
90	4.560e+10	8.991e+10	6.974e-11	1.97	1.53e-21

TABLE 4.1-11

AZIMUTHAL VARIATION OF NEUTRON FLUX AND DPA/SEC
AT REACTOR VESSEL CLAD-BASE METAL INTERFACE
CYCLE 7

Theta	Flux (n/cm^2-sec)			Ratio	
				E > 0.1 / E > 1.0	dpa/sec / E > 1.0
(deg.)	E > 1.0	E > 0.1	dpa/sec		
0	4.355e+10	8.594e+10	6.665e-11	1.97	1.53e-21
5	4.570e+10	9.047e+10	6.983e-11	1.98	1.53e-21
10	5.144e+10	1.020e+11	7.831e-11	1.98	1.52e-21
15	5.628e+10	1.118e+11	8.537e-11	1.99	1.52e-21
20	4.892e+10	1.043e+11	7.454e-11	2.13	1.52e-21
25	4.417e+10	8.839e+10	6.748e-11	2.00	1.53e-21
30	4.352e+10	8.663e+10	6.627e-11	1.99	1.52e-21
35	4.185e+10	8.339e+10	6.349e-11	1.99	1.52e-21
40	3.201e+10	6.405e+10	4.899e-11	2.00	1.53e-21
45	2.711e+10	5.411e+10	4.179e-11	2.00	1.54e-21
50	3.201e+10	6.405e+10	4.899e-11	2.00	1.53e-21
55	4.185e+10	8.339e+10	6.349e-11	1.99	1.52e-21
60	4.352e+10	8.662e+10	6.626e-11	1.99	1.52e-21
65	4.414e+10	8.826e+10	6.740e-11	2.00	1.53e-21
70	5.162e+10	1.033e+11	7.846e-11	2.00	1.52e-21
75	5.624e+10	1.117e+11	8.529e-11	1.99	1.52e-21
80	5.144e+10	1.020e+11	7.831e-11	1.98	1.52e-21
85	4.569e+10	9.045e+10	6.981e-11	1.98	1.53e-21
90	4.354e+10	8.585e+10	6.661e-11	1.97	1.53e-21

TABLE 4.1-12

AZIMUTHAL VARIATION OF NEUTRON FLUX AND DPA/SEC
AT REACTOR VESSEL CLAD-BASE METAL INTERFACE
CYCLE 8

Theta	Flux (n/cm^2-sec)			Ratio	
				E > 0.1	dpa/sec
(deg.)	E > 1.0	E > 0.1	dpa/sec	E > 1.0	E > 1.0
0	1.940e+10	3.853e+10	3.006e-11	1.99	1.55e-21
5	2.404e+10	4.794e+10	3.700e-11	1.99	1.54e-21
10	3.642e+10	7.215e+10	5.540e-11	1.98	1.52e-21
15	4.641e+10	9.178e+10	7.019e-11	1.98	1.51e-21
20	4.026e+10	8.560e+10	6.117e-11	2.13	1.52e-21
25	3.103e+10	6.172e+10	4.739e-11	1.99	1.53e-21
30	2.222e+10	4.406e+10	3.413e-11	1.98	1.54e-21
35	1.760e+10	3.516e+10	2.710e-11	2.00	1.54e-21
40	1.694e+10	3.323e+10	2.607e-11	1.96	1.54e-21
45	1.660e+10	3.235e+10	2.560e-11	1.95	1.54e-21
50	1.700e+10	3.334e+10	2.616e-11	1.96	1.54e-21
55	1.764e+10	3.524e+10	2.716e-11	2.00	1.54e-21
60	2.220e+10	4.403e+10	3.411e-11	1.98	1.54e-21
65	3.097e+10	6.157e+10	4.730e-11	1.99	1.53e-21
70	4.254e+10	8.484e+10	6.447e-11	1.99	1.52e-21
75	4.636e+10	9.163e+10	7.010e-11	1.98	1.51e-21
80	3.642e+10	7.215e+10	5.540e-11	1.98	1.52e-21
85	2.404e+10	4.792e+10	3.699e-11	1.99	1.54e-21
90	1.940e+10	3.849e+10	3.004e-11	1.98	1.55e-21

TABLE 4.1-13

AZIMUTHAL VARIATION OF NEUTRON FLUX AND DPA/SEC
AT REACTOR VESSEL CLAD-BASE METAL INTERFACE
CYCLE 9

Theta	Flux (n/cm^2-sec)			Ratio	
				E > 0.1 / E > 1.0	dpa/sec / E > 1.0
(deg.)	E > 1.0	E > 0.1	dpa/sec		
0	2.014e+10	3.945e+10	3.100e-11	1.96	1.54e-21
5	2.185e+10	4.295e+10	3.354e-11	1.97	1.54e-21
10	2.637e+10	5.183e+10	4.025e-11	1.97	1.53e-21
15	3.018e+10	5.941e+10	4.587e-11	1.97	1.52e-21
20	2.656e+10	5.606e+10	4.052e-11	2.11	1.53e-21
25	2.313e+10	4.566e+10	3.540e-11	1.97	1.53e-21
30	1.961e+10	3.859e+10	3.002e-11	1.97	1.53e-21
35	1.640e+10	3.244e+10	2.508e-11	1.98	1.53e-21
40	1.253e+10	2.479e+10	1.931e-11	1.98	1.54e-21
45	1.098e+10	2.162e+10	1.702e-11	1.97	1.55e-21
50	1.253e+10	2.480e+10	1.931e-11	1.98	1.54e-21
55	1.640e+10	3.245e+10	2.508e-11	1.98	1.53e-21
60	1.961e+10	3.859e+10	3.002e-11	1.97	1.53e-21
65	2.311e+10	4.558e+10	3.535e-11	1.97	1.53e-21
70	2.809e+10	5.565e+10	4.275e-11	1.98	1.52e-21
75	3.016e+10	5.934e+10	4.584e-11	1.97	1.52e-21
80	2.638e+10	5.186e+10	4.027e-11	1.97	1.53e-21
85	2.186e+10	4.297e+10	3.356e-11	1.97	1.54e-21
90	2.015e+10	3.943e+10	3.100e-11	1.96	1.54e-21

TABLE 4.1-14

AZIMUTHAL VARIATION OF NEUTRON FLUX AND DPA/SEC
AT REACTOR VESSEL CLAD-BASE METAL INTERFACE
CYCLE 10

Theta	Flux (n/cm^2-sec)			Ratio	
				E > 0.1	dpa/sec
(deg.)	E > 1.0	E > 0.1	dpa/sec	E > 1.0	E > 1.0
0	1.471e+10	2.883e+10	2.267e-11	1.96	1.54e-21
5	1.619e+10	3.184e+10	2.489e-11	1.97	1.54e-21
10	1.988e+10	3.903e+10	3.038e-11	1.96	1.53e-21
15	2.260e+10	4.443e+10	3.443e-11	1.97	1.52e-21
20	2.060e+10	4.334e+10	3.150e-11	2.10	1.53e-21
25	2.003e+10	3.936e+10	3.068e-11	1.96	1.53e-21
30	1.886e+10	3.702e+10	2.885e-11	1.96	1.53e-21
35	1.700e+10	3.354e+10	2.598e-11	1.97	1.53e-21
40	1.385e+10	2.727e+10	2.132e-11	1.97	1.54e-21
45	1.252e+10	2.449e+10	1.937e-11	1.96	1.55e-21
50	1.387e+10	2.729e+10	2.134e-11	1.97	1.54e-21
55	1.703e+10	3.359e+10	2.602e-11	1.97	1.53e-21
60	1.890e+10	3.709e+10	2.891e-11	1.96	1.53e-21
65	2.006e+10	3.940e+10	3.072e-11	1.96	1.53e-21
70	2.183e+10	4.313e+10	3.331e-11	1.98	1.53e-21
75	2.261e+10	4.443e+10	3.444e-11	1.96	1.52e-21
80	1.990e+10	3.906e+10	3.040e-11	1.96	1.53e-21
85	1.620e+10	3.184e+10	2.489e-11	1.97	1.54e-21
90	1.470e+10	2.880e+10	2.266e-11	1.96	1.54e-21

TABLE 4.1-15

AZIMUTHAL VARIATION OF NEUTRON FLUX AND DPA/SEC
AT REACTOR VESSEL CLAD-BASE METAL INTERFACE
CYCLE 11

Theta	Flux (n/cm^2-sec)			Ratio	
(deg.)	E > 1.0	E > 0.1	dpa/sec	E > 0.1 / E > 1.0	dpa/sec / E > 1.0
0	1.348e+10	2.636e+10	2.077e-11	1.95	1.54e-21
5	1.460e+10	2.862e+10	2.243e-11	1.96	1.54e-21
10	1.726e+10	3.382e+10	2.638e-11	1.96	1.53e-21
15	1.891e+10	3.714e+10	2.882e-11	1.96	1.52e-21
20	1.655e+10	3.481e+10	2.533e-11	2.10	1.53e-21
25	1.584e+10	3.113e+10	2.429e-11	1.97	1.53e-21
30	1.506e+10	2.952e+10	2.304e-11	1.96	1.53e-21
35	1.340e+10	2.645e+10	2.049e-11	1.97	1.53e-21
40	1.094e+10	2.153e+10	1.685e-11	1.97	1.54e-21
45	9.946e+09	1.944e+10	1.540e-11	1.95	1.55e-21
50	1.103e+10	2.171e+10	1.699e-11	1.97	1.54e-21
55	1.363e+10	2.692e+10	2.086e-11	1.97	1.53e-21
60	1.556e+10	3.050e+10	2.381e-11	1.96	1.53e-21
65	1.677e+10	3.297e+10	2.571e-11	1.97	1.53e-21
70	1.914e+10	3.780e+10	2.922e-11	1.98	1.53e-21
75	2.089e+10	4.099e+10	3.181e-11	1.96	1.52e-21
80	1.875e+10	3.675e+10	2.864e-11	1.96	1.53e-21
85	1.531e+10	3.005e+10	2.353e-11	1.96	1.54e-21
90	1.388e+10	2.715e+10	2.140e-11	1.96	1.54e-21

TABLE 4.1-16

RELATIVE RADIAL DISTRIBUTION OF NEUTRON FLUX (E > 1.0 MeV)
THROUGH THE REACTOR VESSEL WALL
CYCLE 11

Radius (cm)	Vessel Fraction	Azimuthal Angle 0°	15°	30°	45°
219.060	(a)	1.0198	1.0204	1.0201	1.0193
219.380	0.000	1.0000	1.0000	1.0000	1.0000
219.910	0.024	0.9673	0.9663	0.9667	0.9681
220.975	0.071	0.8770	0.8744	0.8759	0.8796
221.613	0.100	0.8193	0.8144	0.8167	0.8214
222.730	0.150	0.7214	0.7148	0.7176	0.7239
223.846	0.200	0.6330	0.6239	0.6278	0.6348
224.963	0.250	0.5515	0.5420	0.5458	0.5541
226.079	0.300	0.4791	0.4703	0.4736	0.4828
227.196	0.350	0.4165	0.4039	0.4094	0.4170
228.312	0.400	0.3587	0.3477	0.3517	0.3605
229.429	0.450	0.3088	0.2983	0.3024	0.3109
230.546	0.500	0.2658	0.2558	0.2596	0.2679
231.662	0.550	0.2285	0.2189	0.2226	0.2305
232.779	0.600	0.1959	0.1869	0.1903	0.1979
233.895	0.650	0.1678	0.1593	0.1626	0.1698
235.012	0.700	0.1434	0.1357	0.1386	0.1455
236.128	0.750	0.1222	0.1151	0.1179	0.1245
237.245	0.800	0.1047	0.0970	0.1003	0.1060
238.361	0.850	0.0883	0.0817	0.0843	0.0904
239.478	0.900	0.0743	0.0681	0.0706	0.0767
240.594	0.950	0.0617	0.0558	0.0583	0.0646
241.180	0.976	0.0554	0.0495	0.0521	0.0587
241.711	1.000	0.0522	0.0461	0.0489	0.0557

Note: Base metal inner radius = 219.380 cm; outer radius = 241.711 cm
(a) Center of vessel clad

TABLE 4.1-16 (continued)

RELATIVE RADIAL DISTRIBUTION OF NEUTRON FLUX (E > 1.0 MeV)
THROUGH THE REACTOR VESSEL WALL
CYCLE 11

Radius (cm)	Vessel Fraction	Azimuthal Angle 60°	75°	90°
219.060	(a)	1.0201	1.0202	1.0197
219.380	0.000	1.0000	1.0000	1.0000
219.910	0.024	0.9667	0.9665	0.9673
220.975	0.071	0.8760	0.8750	0.8772
221.613	0.100	0.8168	0.8148	0.8196
222.730	0.150	0.7177	0.7148	0.7218
223.846	0.200	0.6280	0.6240	0.6335
224.963	0.250	0.5461	0.5421	0.5521
226.079	0.300	0.4739	0.4706	0.4797
227.196	0.350	0.4097	0.4042	0.4171
228.312	0.400	0.3520	0.3477	0.3593
229.429	0.450	0.3026	0.2985	0.3094
230.546	0.500	0.2599	0.2559	0.2664
231.662	0.550	0.2229	0.2191	0.2291
232.779	0.600	0.1906	0.1870	0.1965
233.895	0.650	0.1629	0.1595	0.1684
235.012	0.700	0.1389	0.1358	0.1439
236.128	0.750	0.1181	0.1152	0.1227
237.245	0.800	0.1005	0.0969	0.1052
238.361	0.850	0.0845	0.0817	0.0887
239.478	0.900	0.0708	0.0680	0.0747
240.594	0.950	0.0584	0.0556	0.0622
241.180	0.976	0.0522	0.0492	0.0559
241.711	1.000	0.0490	0.0458	0.0527

Note: Base metal inner radius = 219.380 cm; outer radius = 241.711 cm
(a) Center of vessel clad

TABLE 4.1-17

RELATIVE RADIAL DISTRIBUTION OF NEUTRON FLUX (E > 0.1 MeV)
THROUGH THE REACTOR VESSEL WALL
CYCLE 11

Radius	Vessel	Azimuthal Angle			
(cm)	Fraction	0°	15°	30°	45°
219.060	(a)	0.9917	0.9941	0.9933	0.9909
219.380	0.000	1.0000	1.0000	1.0000	1.0000
219.910	0.024	1.0137	1.0097	1.0111	1.0151
220.975	0.071	1.0030	0.9935	0.9972	1.0084
221.613	0.100	0.9907	0.9763	0.9819	0.9966
222.730	0.150	0.9552	0.9350	0.9425	0.9631
223.846	0.200	0.9154	0.8888	0.8990	0.9241
224.963	0.250	0.8705	0.8411	0.8518	0.8822
226.079	0.300	0.8255	0.7921	0.8044	0.8380
227.196	0.350	0.7817	0.7435	0.7581	0.7940
228.312	0.400	0.7348	0.6953	0.7100	0.7490
229.429	0.450	0.6886	0.6475	0.6630	0.7040
230.546	0.500	0.6434	0.6011	0.6172	0.6599
231.662	0.550	0.5989	0.5558	0.5724	0.6163
232.779	0.600	0.5549	0.5115	0.5284	0.5734
233.895	0.650	0.5119	0.4686	0.4857	0.5314
235.012	0.700	0.4694	0.4269	0.4438	0.4903
236.128	0.750	0.4286	0.3860	0.4035	0.4502
237.245	0.800	0.3898	0.3464	0.3649	0.4111
238.361	0.850	0.3482	0.3071	0.3246	0.3722
239.478	0.900	0.3085	0.2682	0.2860	0.3341
240.594	0.950	0.2677	0.2281	0.2464	0.2957
241.180	0.976	0.2456	0.2061	0.2250	0.2752
241.711	1.000	0.2335	0.1938	0.2131	0.2644

Note: Base metal inner radius = 219.380 cm; outer radius = 241.711 cm

(a) Center of vessel clad

TABLE 4.1-17 (continued)

RELATIVE RADIAL DISTRIBUTION OF NEUTRON FLUX (E > 0.1 MeV)
THROUGH THE REACTOR VESSEL WALL
CYCLE 11

Radius (cm)	Vessel Fraction	Azimuthal Angle 60°	75°	90°
219.060	(a)	0.9932	0.9942	0.9916
219.380	0.000	1.0000	1.0000	1.0000
219.910	0.024	1.0112	1.0095	1.0140
220.975	0.071	0.9976	0.9932	1.0036
221.613	0.100	0.9823	0.9758	0.9915
222.730	0.150	0.9431	0.9336	0.9563
223.846	0.200	0.8998	0.8873	0.9168
224.963	0.250	0.8527	0.8393	0.8722
226.079	0.300	0.8054	0.7901	0.8273
227.196	0.350	0.7592	0.7414	0.7836
228.312	0.400	0.7110	0.6928	0.7369
229.429	0.450	0.6641	0.6450	0.6908
230.546	0.500	0.6183	0.5985	0.6456
231.662	0.550	0.5734	0.5532	0.6012
232.779	0.600	0.5294	0.5088	0.5572
233.895	0.650	0.4866	0.4659	0.5142
235.012	0.700	0.4447	0.4240	0.4716
236.128	0.750	0.4042	0.3831	0.4309
237.245	0.800	0.3655	0.3433	0.3920
238.361	0.850	0.3251	0.3039	0.3505
239.478	0.900	0.2863	0.2649	0.3108
240.594	0.950	0.2465	0.2245	0.2699
241.180	0.976	0.2249	0.2023	0.2477
241.711	1.000	0.2129	0.1898	0.2356

Note: Base metal inner radius = 219.380 cm; outer radius = 241.711 cm

(a) Center of vessel clad

TABLE 4.1-18

RELATIVE RADIAL DISTRIBUTION OF IRON ATOM DISPLACEMENT RATE (dpa/sec) THROUGH THE REACTOR VESSEL WALL CYCLE 11

Radius (cm)	Vessel Fraction	Azimuthal Angle 0°	15°	30°	45°
219.060	(a)	1.0164	1.0174	1.0170	1.0159
219.380	0.000	1.0000	1.0000	1.0000	1.0000
219.910	0.024	0.9728	0.9713	0.9718	0.9737
220.975	0.071	0.8992	0.8951	0.8969	0.9019
221.613	0.100	0.8526	0.8459	0.8487	0.8552
222.730	0.150	0.7733	0.7640	0.7675	0.7767
223.846	0.200	0.7009	0.6885	0.6934	0.7042
224.963	0.250	0.6331	0.6195	0.6245	0.6377
226.079	0.300	0.5720	0.5576	0.5629	0.5777
227.196	0.350	0.5179	0.4995	0.5069	0.5216
228.312	0.400	0.4665	0.4486	0.4552	0.4718
229.429	0.450	0.4206	0.4023	0.4093	0.4266
230.546	0.500	0.3795	0.3610	0.3680	0.3859
231.662	0.550	0.3423	0.3235	0.3307	0.3490
232.779	0.600	0.3081	0.2894	0.2967	0.3153
233.895	0.650	0.2770	0.2584	0.2658	0.2847
235.012	0.700	0.2482	0.2302	0.2374	0.2566
236.128	0.750	0.2220	0.2041	0.2114	0.2308
237.245	0.800	0.1985	0.1797	0.1879	0.2068
238.361	0.850	0.1748	0.1572	0.1647	0.1845
239.478	0.900	0.1531	0.1358	0.1435	0.1637
240.594	0.950	0.1320	0.1148	0.1229	0.1440
241.180	0.976	0.1209	0.1036	0.1120	0.1339
241.711	1.000	0.1151	0.0976	0.1062	0.1287

Note: Base metal inner radius = 219.380 cm; outer radius = 241.711 cm

(a) Center of vessel clad

TABLE 4.1-18 (continued)

RELATIVE RADIAL DISTRIBUTION OF IRON ATOM DISPLACEMENT RATE (dpa/sec) THROUGH THE REACTOR VESSEL WALL
CYCLE 11

Radius	Vessel	Azimuthal Angle		
(cm)	Fraction	60°	75°	90°
219.060	(a)	1.0170	1.0173	1.0163
219.380	0.000	1.0000	1.0000	1.0000
219.910	0.024	0.9719	0.9713	0.9730
220.975	0.071	0.8971	0.8953	0.8995
221.613	0.100	0.8489	0.8458	0.8530
222.730	0.150	0.7679	0.7634	0.7738
223.846	0.200	0.6937	0.6878	0.7017
224.963	0.250	0.6250	0.6187	0.6340
226.079	0.300	0.5633	0.5569	0.5729
227.196	0.350	0.5074	0.4987	0.5189
228.312	0.400	0.4557	0.4475	0.4676
229.429	0.450	0.4098	0.4014	0.4217
230.546	0.500	0.3686	0.3599	0.3806
231.662	0.550	0.3313	0.3224	0.3434
232.779	0.600	0.2972	0.2882	0.3092
233.895	0.650	0.2663	0.2573	0.2781
235.012	0.700	0.2378	0.2290	0.2493
236.128	0.750	0.2118	0.2028	0.2231
237.245	0.800	0.1882	0.1784	0.1996
238.361	0.850	0.1650	0.1559	0.1759
239.478	0.900	0.1437	0.1344	0.1542
240.594	0.950	0.1229	0.1132	0.1331
241.180	0.976	0.1120	0.1019	0.1220
241.711	1.000	0.1061	0.0957	0.1161

Note: Base metal inner radius = 219.380 cm; outer radius = 241.711 cm
(a) Center of vessel clad

SECTION 5

EVALUATIONS OF SURVEILLANCE CAPSULE DOSIMETRY

In this section, the results of the evaluations of the four neutron sensor sets withdrawn from the Palisades reactor vessel are presented. The capsule designation, location within the reactor, and time of withdrawal of each of these dosimetry sets were as listed below.

Capsule ID	Azimuthal Location	Withdrawal Time	Irradiation Time (EFPS)
A240	30°	EOC 2	7.166e+07
W290	20°	EOC 5	1.642e+08
W290-9[1]	20°	EOC 9	2.579e+07
W110	20°	EOC 10	3.139e+08

EOC - End of Cycle

5.1 Measured Reaction Rates

With the exception of Capsule A240, radiometric counting of each of these capsule dosimetry data sets was accomplished by Westinghouse using the procedures discussed in Section 3 of this report. The measured specific activities are included in Appendix A to this report. Radiometric counting of the sensors from Capsule A240, on the other hand, was carried out by the Battelle Memorial Institute[4]. However, in this case, the measured specific activities were not reported.

The irradiation history of the Palisades reactor during the first 10 fuel cycles is also listed in Appendix A. The irradiation history was obtained from NUREG-0020, "Licensed Operating Reactors Status Summary Report" for the applicable operating periods. In addition to the reactor power history, for the multiple cycle irradiations Capsules A240, W290, and W110, the flux level adjustment factors for each cycle are also tabulated in Appendix A. These adjustment factors were determined from the fuel cycle specific forward calculations described in Section 4.1 of this report.

[1] Irradiated during Cycle 9 only.

Based on the irradiation history, the individual sensor characteristics, capsule gradient corrections, and the measured specific activities, reaction rates averaged over the appropriate irradiation periods and referenced to a core power level of 2530 MWt were computed for the sensor sets removed from Capsules W290, W290-9, and W110. In the case of Capsule A240, reaction rates were developed directly from the derived neutron flux and spectrum averaged reaction cross-sections reported in Reference 4. The computed reaction rates for the multiple foil sensor sets from each of the four internal surveillance capsules are provided in Table 5.1-1.

In regard to the data listed in Table 5.1-1, the fission rate measurements for the ^{238}U sensors include corrections for ^{235}U impurities, the build-in of plutonium isotopes during the long irradiations, and for the effects of photofission reactions. Likewise, the fission rate measurements for the ^{237}Np sensors include adjustments for photofission reactions occurring over the course of the respective irradiation periods.

It should be noted that the changes in the measured data, as compared to the previous analysis in Reference 6, are due to the elimination of conservatism and the explicit source modelling of each cycle which is specific to this Palisades analysis. This included photofission reaction corrections, as noted above, and use of the long half-life ^{238}U (n,f) ^{137}Cs and ^{237}Np (n,f) ^{137}Cs reactions.

5.2 Results of the Least Squares Adjustment Procedure

The results of the application of the least squares adjustment procedure to the four sets of surveillance capsule dosimetry are provided in Table 5.2-1 through 5.2-4. In these tables, the derived exposure experienced by the capsule along with data illustrating the fit of both the trial and adjusted spectra to the measurements are given. Also included in the tabulations are the 1 σ uncertainties associated with each of the derived exposure rates.

In regard to the comparisons listed in Tables 5.2-1 through 5.2-4, it should be noted that the columns labeled "trial calc" represent the absolute calculated neutron flux ($E > 1.0$ MeV) from Table 4.1-4 averaged over the applicable irradiation periods (Cycles 1 and 2 for Capsule A240, Cycles 1 through 5 for Capsule W290, Cycle 9 for Capsule W290-9, and Cycles 1 through 10 for Capsule W110) as discussed in Section 3. Thus, the comparisons illustrated in Tables 5.2-1 through 5.2-4 indicate the degree to which the calculated neutron energy spectra matched the measured sensor data before and after adjustment. Absolute comparisons are discussed further in Section 7 of this report.

TABLE 5.1-1

SUMMARY OF REACTION RATES DERIVED FROM MULTIPLE FOIL SENSOR SETS WITHDRAWN FROM INTERNAL SURVEILLANCE CAPSULES

	Reaction Rate (rps/nucleus)			
Reaction	A240	W290	W290-9	W110
^{63}Cu (n,α) ^{60}Co Cd	4.97e-16	9.50e-17	5.72e-17	8.85e-17
^{54}Fe (n,p) ^{54}Mn	5.58e-14	7.70e-15	4.28e-15	7.01e-15
^{58}Ni (n,p) ^{58}Co Cd	6.99e-14	1.01e-14	5.76e-15	9.08e-15
^{46}Ti (n,p) ^{46}Sc	9.65e-15	1.51e-15	9.44e-16	1.43e-15
^{238}U (n,f) ^{137}Cs Cd		2.53e-14	1.48e-14	
^{237}Np (n,f) ^{137}Cs Cd			6.26e-14	
^{59}Co (n,γ) ^{60}Co			1.70e-12	
^{59}Co (n,γ) ^{60}Co Cd			2.38e-13	

Note: Cd indicates that the sensor was cadmium covered

TABLE 5.2-1

DERIVED EXPOSURE RATES FROM SURVEILLANCE CAPSULE A240 DOSIMETRY WITHDRAWN AT THE END OF FUEL CYCLE 2

	Trial Value	Adjusted Value	1 σ Uncertainty
$\phi(E > 1.0$ MeV)	6.29e+11	5.36e+11	11%
$\phi(E > 0.1$ MeV)	1.38e+12	1.18e+12	19%
$\phi(E < 0.414$ eV)	6.62e+11	6.33e+11	86%
dpa/sec	9.06e-10	7.83e-10	12%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES SURVEILLANCE CAPSULE A240

Reaction Rate (rps/nucleus)

	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	4.97e-16	5.06e-16	4.99e-16	0.98	1.00
^{54}Fe (n,p)	5.58e-14	6.20e-14	5.63e-14	0.90	0.99
^{58}Ni (n,p) Cd	6.99e-14	8.10e-14	7.13e-14	0.86	0.98
^{46}Ti (n,p)	9.65e-15	9.03e-15	9.35e-15	1.07	1.03

TABLE 5.2-2

DERIVED EXPOSURE RATES FROM SURVEILLANCE CAPSULE W290 DOSIMETRY WITHDRAWN AT THE END OF FUEL CYCLE 5

	Trial Value	Adjusted Value	1σ Uncertainty
$\phi(E > 1.0\ MeV)$	6.69e+10	5.63e+10	9%
$\phi(E > 0.1\ MeV)$	1.24e+11	1.06e+11	16%
$\phi(E < 0.414\ eV)$	1.01e+11	9.56e+10	87%
dpa/sec	9.63e-11	8.25e-11	9%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES SURVEILLANCE CAPSULE W290

	Reaction Rate (rps/nucleus)				
	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
$^{63}Cu\ (n,\alpha)$ Cd	9.50e-17	9.70e-17	9.41e-17	0.98	1.01
^{54}Fe (n,p)	7.70e-15	9.00e-15	7.87e-15	0.86	0.98
^{58}Ni (n,p) Cd	1.01e-14	1.15e-14	1.01e-14	0.88	1.00
^{46}Ti (n,p)	1.51e-15	1.57e-15	1.49e-15	0.96	1.01
^{238}U (n,f) Cd	2.53e-14	2.95e-14	2.52e-14	0.86	1.00

TABLE 5.2-3

DERIVED EXPOSURE RATES FROM SURVEILLANCE CAPSULE W290-9 DOSIMETRY WITHDRAWN AT THE END OF FUEL CYCLE 9

	Trial Value	Adjusted Value	1 σ Uncertainty
ϕ(E > 1.0 MeV)	3.82e+10	3.12e+10	7%
ϕ(E > 0.1 MeV)	6.99e+10	5.76e+10	13%
ϕ(E < 0.414 eV)	5.61e+10	5.96e+10	14%
dpa/sec	5.50e-11	4.59e-11	7%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES SURVEILLANCE CAPSULE W290-9

	Reaction Rate (rps/nucleus)				
	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	5.72e-17	5.85e-17	5.67e-17	0.98	1.01
^{54}Fe (n,p)	4.28e-15	5.26e-15	4.48e-15	0.81	0.96
^{58}Ni (n,p) Cd	5.76e-15	6.70e-15	5.78e-15	0.86	1.00
^{46}Ti (n,p)	9.44e-16	9.36e-16	9.16e-16	1.01	1.03
^{238}U (n,f) Cd	1.48e-14	1.70e-14	1.42e-14	0.87	1.04
^{237}Np (n,f) Cd	6.26e-14	7.66e-14	6.26e-14	0.82	1.00
^{59}Co (n,γ)	1.70e-12	1.71e-12	1.70e-12	0.99	1.00
^{59}Co (n,γ) Cd	2.38e-13	3.51e-13	2.39e-13	0.68	1.00

TABLE 5.2-4

DERIVED EXPOSURE RATES FROM SURVEILLANCE CAPSULE W110 DOSIMETRY WITHDRAWN AT THE END OF FUEL CYCLE 10

	Trial Value	Adjusted Value	1σ Uncertainty
$\phi(E > 1.0\ MeV)$	6.12e+10	5.06e+10	11%
$\phi(E > 0.1\ MeV)$	1.14e+11	9.51e+10	18%
$\phi(E < 0.414\ eV)$	9.22e+10	8.75e+10	87%
dpa/sec	8.81e-11	7.44e-11	11%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES SURVEILLANCE CAPSULE W110

	Reaction Rate (rps/nucleus)				
	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	8.85e-17	8.88e-17	8.77e-17	1.00	1.01
^{54}Fe (n,p)	7.01e-15	8.23e-15	7.19e-15	0.85	0.97
^{58}Ni (n,p) Cd	9.08e-15	1.05e-14	9.14e-15	0.86	0.99
^{46}Ti (n,p)	1.43e-15	1.44e-15	1.40e-15	0.99	1.02

SECTION 6

EVALUATIONS OF REACTOR CAVITY DOSIMETRY

In this section, the results of the evaluations of all neutron sensor sets irradiated since the inception of the Reactor Cavity Measurement Program are presented. At Palisades the program was initiated prior to the startup of Cycle 8; and, to date, has included measurement evaluations at the conclusion of Cycles 8, 9, and 11. The evaluation of each of these sets of measured data was accomplished using a consistent approach based on the methodology discussed in Section 3, resulting in an accurate data base to be used in defining the best estimate neutron exposure of the reactor vessel wall.

6.1 Cycle 8 Results

6.1.1 Measured Reaction Rates

During the Cycle 8 irradiation, four multiple foil sensor sets, and ten stainless steel gradient chains were deployed in the reactor cavity. The capsule identifications associated with each of the multiple foil sensor sets mounted from the dosimetry support bar are listed below.

Reference		Bar	Capsule Identification	
Azimuth	FOE	Shifted Angle	Core Midplane	Core Bottom
270°	0°	6°	Not Recovered	Not Recovered
280°	10°	16°	B	
290°	20°	26°	D	E
300°	30°	36°	Not Recovered	
315°	45°	39°	G	
330°	30°	24°	No Capsule	

The contents of each of these irradiation capsules is specified in Appendix B to this report.

The irradiation history of the Palisades reactor during Cycle 8 is also listed in Appendix B. The irradiation history was obtained from NUREG-0020, "Licensed Operating Reactors Status Summary Report" for the applicable operating period. Based on this reactor operating history, the individual sensor characteristics, and the measured specific activities given in Appendix B, cycle average reaction rates referenced to a core power level of 2530 MWt were computed for each multiple foil sensor and gradient chain segment.

The computed reaction rates for the radiometric foil sensor sets irradiated during Cycle 8 are provided in Table 6.1-1. Corresponding reaction rate data from the ten stainless steel gradient chains are recorded in Tables 6.1-2 through 6.1-7 for the $^{54}Fe(n,p)$, $^{58}Ni(n,p)$, and $^{59}Co(n,\gamma)$ reactions, respectively.

In regard to the data listed in Table 6.1-1, the $^{54}Fe(n,p)$ reaction rates represent an average of the bare and cadmium covered measurements for each capsule. In addition, the fission rate measurements include corrections for ^{235}U impurities in the ^{238}U sensors as well as corrections for photofission reactions in both the ^{238}U and ^{237}Np sensors. It should be noted that the changes in the measured data, as compared to the previous analysis in Reference 6, are due to the elimination of conservatism which is specific to this Palisades analysis. This included photofission reaction corrections, as noted above, and use of the long half-life ^{238}U (n,f) ^{137}Cs and ^{237}Np (n,f) ^{137}Cs reactions.

6.1.2 Results of the Least Squares Adjustment Procedure

The results of the application of the least squares adjustment procedure to the four sets of multiple foil measurements obtained from the Cycle 8 irradiation are provided in Tables 6.1-8 through 6.1-11. In these tables, the derived exposure experienced at each sensor set location along with data illustrating the fit of both the trial and adjusted spectra to the measurements are given. Also included in the tabulations are the 1σ uncertainties associated with each of the derived exposure rates.

In regard to the comparisons listed in Tables 6.1-8 through 6.1-11, it should be noted that the columns labeled "trial calc" represent the absolute calculated neutron flux ($E > 1.0$ MeV) from Table 4.1-1 averaged over the Cycle 8 irradiation period as discussed in Section 3. Thus, the comparisons illustrated in Tables 6.1-8 through 6.1-11 indicate the degree to which the calculated neutron energy spectra matched the measured data before and after adjustment. Absolute comparisons of calculation and measurement are discussed further in Section 7 of this report.

Complete traverses of fast neutron exposure rates in the reactor cavity were developed by combining the results of the least squares adjustment of the multiple foil data with the $^{54}Fe(n,p)$ reaction rate measurements from the gradient chains. The gradient data were employed to establish relative axial distributions over the measurement range and these relative distributions were then normalized to the FERRET results from the midplane sensor sets to produce axial distributions of exposure rates in terms of $\phi(E > 1.0\ MeV)$, $\phi(E > 0.1\ MeV)$, and dpa/sec in the reactor cavity.

The resultant axial distributions of $\phi(E > 1.0\ MeV)$, $\phi(E > 0.1\ MeV)$, and dpa/sec from the gradient chain measurements are given in Tables 6.1-12 through 6.1-14 for the short chains and Tables 6.1-15 through 6.1-17 for the long chains, respectively. The axial distributions of fast neutron flux $\phi(E > 1.0\ MeV)$ are depicted graphically in Figures 6.1-1 through 6.1-7. In these graphical presentations, results for axial locations of 0.0 feet relative to the core midplane represent the explicit results of the FERRET evaluations summarized in Tables 6.1-8 through 6.1-11, while results at the remaining axial locations depict the normalized data from the gradient chains.

TABLE 6.1-1

SUMMARY OF REACTION RATES DERIVED FROM MULTIPLE FOIL SENSOR SETS
CYCLE 8 IRRADIATION

Reaction	Reaction Rate (rps/nucleus)			
	Capsule B	Capsule D	Capsule E	Capsule G
^{63}Cu (n,α) Cd	9.76e-19	7.51e-19	1.99e-19	5.53e-19
^{46}Ti (n,p) Cd	1.45e-17	1.11e-17	3.34e-18	7.89e-18
^{54}Fe (n,p) Cd	7.42e-17	5.60e-17	1.75e-17	4.00e-17
^{58}Ni (n,p) Cd	1.04e-16	7.81e-17	2.57e-17	5.51e-17
^{238}U (n,f) Cd	3.42e-16	2.52e-16		1.92e-16
^{235}U (n,f) Cd	9.70e-14	9.15e-14		8.97e-14
^{238}U (n,f) Cd[1]	4.01e-16	3.04e-16	8.93e-17	1.92e-16
^{235}U (n,f) Cd[1]	8.36e-14	8.22e-14	4.77e-14	9.46e-14
^{237}Np (n,f) Cd	6.67e-15	4.99e-15	1.65e-15	3.55e-15
^{59}Co (n,γ)	4.63e-14	4.34e-14	2.59e-14	4.82e-14
^{59}Co (n,γ) Cd	3.08e-14	2.99e-14	1.75e-14	2.90e-14

Note: Cd indicates that the sensor was cadmium covered.

[1] Paired Uranium Dosimeter (PUD) measurement

TABLE 6.1-2

^{54}Fe (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL SHORT GRADIENT CHAINS - CYCLE 8 IRRADIATION

Feet from	Reaction Rate (rps/nucleus)			
Midplane	16°	24°	26°	39°
+0.5	4.08e-18	3.19e-18	3.09e-18	2.32e-18
0.0		3.56e-18	3.15e-18	
-0.5	4.15e-18	3.38e-18	3.21e-18	2.28e-18
-1.0	4.15e-18	3.42e-18	3.15e-18	2.28e-18
-1.5	4.04e-18	3.03e-18	3.07e-18	2.03e-18
-2.0	3.90e-18	2.88e-18	2.90e-18	2.14e-18
-2.5	3.29e-18	2.70e-18	2.76e-18	1.89e-18
-3.0	3.16e-18	2.46e-18	2.68e-18	1.85e-18
-3.5	3.02e-18	2.03e-18	2.27e-18	1.65e-18
-4.0	2.21e-18	1.74e-18	1.91e-18	1.44e-18
-4.5	1.82e-18	1.24e-18	1.27e-18	1.32e-18
-5.0	1.23e-18	8.97e-19		9.38e-19
-5.5	8.12e-19	5.36e-19		6.94e-19

TABLE 6.1-3

^{58}Ni (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL SHORT GRADIENT CHAINS - CYCLE 8 IRRADIATION

Feet from	Reaction Rate (rps/nucleus)			
Midplane	16°	24°	26°	39°
+0.5	7.69e-17	5.70e-17	5.56e-17	4.31e-17
0.0		5.43e-17		
-0.5	7.97e-17	5.88e-17	5.37e-17	3.83e-17
-1.0	7.53e-17	5.58e-17	5.41e-17	3.71e-17
-1.5	7.17e-17	5.24e-17	5.60e-17	3.91e-17
-2.0	6.93e-17	5.40e-17	5.56e-17	3.83e-17
-2.5	6.89e-17	4.90e-17	5.33e-17	3.34e-17
-3.0	5.97e-17	4.38e-17	4.91e-17	3.34e-17
-3.5	5.73e-17	3.65e-17	4.68e-17	3.04e-17
-4.0	4.76e-17	3.05e-17	4.41e-17	2.90e-17
-4.5	3.56e-17	2.04e-17	3.42e-17	2.41e-17
-5.0	2.37e-17	1.62e-17	2.30e-17	1.80e-17
-5.5	1.70e-17	1.18e-17		1.48e-17

TABLE 6.1-4

^{59}Co (n,γ) REACTION RATES DERIVED FROM THE STAINLESS STEEL SHORT GRADIENT CHAINS - CYCLE 8 IRRADIATION

Feet from	Reaction Rate (rps/nucleus)			
Midplane	16°	24°	26°	39°
+0.5	4.82e-14	5.84e-14	4.39e-14	5.23e-14
0.0		5.84e-14		
-0.5	4.82e-14	5.84e-14	4.38e-14	5.28e-14
-1.0	4.82e-14	5.69e-14	4.39e-14	5.18e-14
-1.5	4.73e-14	5.59e-14	4.33e-14	5.18e-14
-2.0	4.59e-14	5.38e-14	4.30e-14	5.03e-14
-2.5	4.46e-14	5.11e-14	4.14e-14	4.89e-14
-3.0	4.27e-14	4.81e-14	4.10e-14	4.57e-14
-3.5	4.12e-14	4.48e-14	3.94e-14	4.44e-14
-4.0	3.85e-14	4.12e-14	3.73e-14	4.06e-14
-4.5	3.28e-14	3.31e-14	3.49e-14	3.78e-14
-5.0	2.80e-14	2.83e-14	2.80e-14	3.03e-14
-5.5	2.57e-14	2.60e-14		2.57e-14

TABLE 6.1-5

^{54}Fe (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL LONG GRADIENT CHAINS - CYCLE 8 IRRADIATION

	Reaction Rate (rps/nucleus)						
Feet from Midplane	Ref. 90° FOE 0°	Ref. 260° FOE 10°	Ref. 340° FOE 20°	Ref. 30° FOE 30°	Ref. 150° FOE 30°	Ref. 210° FOE 30°	Average FOE 30°
+8.0	2.39e-19	2.47e-19	2.89e-19	1.69e-19	2.32e-19	1.96e-19	1.99e-19
+7.5	3.11e-19	3.22e-19	3.02e-19	2.25e-19	3.52e-19	2.90e-19	2.89e-19
+7.0	5.18e-19	5.00e-19	5.02e-19	4.35e-19	6.70e-19	3.95e-19	5.00e-19
+6.5	7.83e-19	6.65e-19	7.57e-19	5.41e-19	6.43e-19	5.58e-19	5.81e-19
+6.0	1.16e-18		9.89e-19	9.13e-19	9.46e-19	9.41e-19	9.34e-19
+5.5	1.45e-18		1.47e-18	1.15e-18	1.44e-18	1.29e-18	1.29e-18
+5.0	1.77e-18		1.82e-18	1.49e-18	1.71e-18	1.64e-18	1.61e-18
+4.5	2.14e-18		2.09e-18	1.85e-18	1.89e-18	1.98e-18	1.91e-18
+4.0	2.36e-18		2.44e-18	1.98e-18	2.18e-18	2.17e-18	2.11e-18
+3.5	2.60e-18		2.66e-18	2.34e-18	2.61e-18	2.41e-18	2.45e-18
+3.0	2.70e-18		2.91e-18	2.46e-18	2.55e-18	2.47e-18	2.49e-18
+2.5	2.80e-18		2.98e-18	2.60e-18	2.66e-18	2.76e-18	2.67e-18
+2.0	2.85e-18		3.03e-18	2.58e-18	2.77e-18	2.57e-18	2.64e-18
+1.5	2.77e-18		3.02e-18	2.53e-18	2.74e-18	2.64e-18	2.64e-18
+1.0	2.67e-18		2.82e-18	2.58e-18	2.88e-18	2.60e-18	2.69e-18
+0.5	2.82e-18		2.91e-18	2.65e-18	2.78e-18	2.65e-18	2.70e-18
0.0	3.14e-18		3.06e-18	2.70e-18	2.90e-18	2.51e-18	2.71e-18
-0.5	2.97e-18		2.95e-18	2.68e-18	2.75e-18	2.77e-18	2.73e-18
-1.0	2.70e-18		2.94e-18	2.70e-18	2.79e-18	2.62e-18	2.70e-18
-1.5	2.73e-18		2.94e-18	2.55e-18	2.73e-18	2.63e-18	2.63e-18
-2.0	2.62e-18		3.03e-18	2.72e-18	2.66e-18	2.72e-18	2.70e-18
-2.5	2.62e-18		2.99e-18	2.60e-18	2.63e-18	2.47e-18	2.57e-18
-3.0	2.24e-18		2.70e-18	2.48e-18	2.35e-18	2.35e-18	2.39e-18
-3.5	2.48e-18		2.56e-18	2.38e-18	2.33e-18	2.38e-18	2.36e-18
-4.0	2.08e-18		2.27e-18	2.14e-18	2.15e-18	1.95e-18	2.08e-18
-4.5	1.70e-18			1.72e-18	1.81e-18	1.60e-18	1.71e-18

TABLE 6.1-6

^{58}Ni (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL LONG GRADIENT CHAINS - CYCLE 8 IRRADIATION

	Reaction Rate (rps/nucleus)						
Feet from Midplane	Ref. 90° FOE 0°	Ref. 260° FOE 10°	Ref. 340° FOE 20°	Ref. 30° FOE 30°	Ref. 150° FOE 30°	Ref. 210° FOE 30°	Average FOE 30°
+8.0	4.65e-18	5.33e-18	4.76e-18	3.89e-18	3.76e-18	3.78e-18	3.81e-18
+7.5	6.40e-18	6.19e-18	8.70e-18	4.40e-18	6.81e-18	5.51e-18	5.57e-18
+7.0	1.15e-17	9.17e-18	9.56e-18	7.83e-18	1.25e-17	7.87e-18	9.41e-18
+6.5	1.49e-17	1.04e-17	1.32e-17	9.69e-18	1.27e-17	1.22e-17	1.15e-17
+6.0	2.01e-17		2.08e-17	1.58e-17	1.76e-17	1.91e-17	1.75e-17
+5.5	2.66e-17		2.72e-17	2.24e-17	2.47e-17	2.41e-17	2.38e-17
+5.0	3.24e-17		3.16e-17	2.67e-17	3.09e-17	3.17e-17	2.97e-17
+4.5	3.76e-17		3.82e-17	3.38e-17	3.97e-17	3.83e-17	3.73e-17
+4.0	4.15e-17		4.01e-17	3.57e-17	4.21e-17	3.96e-17	3.91e-17
+3.5	4.88e-17		4.31e-17	4.12e-17	4.40e-17	4.12e-17	4.21e-17
+3.0	5.04e-17		4.65e-17	4.24e-17	4.71e-17	4.61e-17	4.52e-17
+2.5	5.08e-17		4.95e-17	4.28e-17	4.63e-17	4.36e-17	4.42e-17
+2.0	5.50e-17		5.02e-17	4.20e-17	5.02e-17	4.85e-17	4.69e-17
+1.5	4.88e-17		5.02e-17	4.32e-17	4.71e-17	4.77e-17	4.60e-17
+1.0	5.27e-17		5.06e-17	4.52e-17	4.59e-17	4.57e-17	4.56e-17
+0.5	5.08e-17		5.10e-17	4.40e-17	4.71e-17	4.98e-17	4.70e-17
0.0	4.84e-17		4.83e-17	4.52e-17	5.14e-17	4.77e-17	4.81e-17
-0.5	5.04e-17		5.21e-17	4.60e-17	4.94e-17	4.85e-17	4.80e-17
-1.0	4.92e-17		5.25e-17	4.60e-17	4.44e-17	4.81e-17	4.62e-17
-1.5	4.57e-17		5.43e-17	5.00e-17	4.59e-17	5.18e-17	4.93e-17
-2.0	4.65e-17		5.32e-17	4.72e-17	4.75e-17	4.85e-17	4.77e-17
-2.5	4.88e-17		5.10e-17	4.76e-17	4.48e-17	4.44e-17	4.56e-17
-3.0	4.38e-17		4.68e-17	4.44e-17	4.63e-17	4.24e-17	4.44e-17
-3.5	4.15e-17		4.09e-17	4.02e-17	4.21e-17	4.07e-17	4.10e-17
-4.0	3.45e-17		3.94e-17	3.74e-17	3.73e-17	3.85e-17	3.77e-17
-4.5	2.83e-17		1.21e-17	3.32e-17	3.29e-17	3.29e-17	3.30e-17

TABLE 6.1-7

^{59}Co (n,γ) REACTION RATES DERIVED FROM THE STAINLESS STEEL LONG GRADIENT CHAINS - CYCLE 8 IRRADIATION

	Reaction Rate (rps/nucleus)						
Feet from Midplane	Ref. 90° FOE 0°	Ref. 260° FOE 10°	Ref. 340° FOE 20°	Ref. 30° FOE 30°	Ref. 150° FOE 30°	Ref. 210° FOE 30°	Average FOE 30°
+8.0	2.05e-14	1.75e-14	1.92e-14	2.03e-14	2.10e-14	1.97e-14	2.04e-14
+7.5	2.24e-14	2.01e-14	2.10e-14	2.21e-14	2.43e-14	2.27e-14	2.30e-14
+7.0	2.67e-14	2.18e-14	2.43e-14	2.62e-14	3.09e-14	2.62e-14	2.77e-14
+6.5	2.87e-14	2.29e-14	2.54e-14	2.71e-14	3.09e-14	2.92e-14	2.91e-14
+6.0	3.20e-14		2.95e-14	3.10e-14	3.36e-14	3.15e-14	3.20e-14
+5.5	3.42e-14		3.08e-14	3.18e-14	3.57e-14	3.39e-14	3.38e-14
+5.0	3.89e-14		3.42e-14	3.67e-14	3.92e-14	3.67e-14	3.75e-14
+4.5	4.13e-14		3.70e-14	3.94e-14	4.20e-14	4.02e-14	4.05e-14
+4.0	4.33e-14		3.97e-14	3.90e-14	4.45e-14	4.25e-14	4.20e-14
+3.5	4.72e-14		4.07e-14	4.36e-14	4.74e-14	4.55e-14	4.55e-14
+3.0	4.85e-14		4.40e-14	4.54e-14	5.00e-14	4.68e-14	4.74e-14
+2.5	5.26e-14		4.51e-14	4.65e-14	5.18e-14	4.88e-14	4.90e-14
+2.0	5.66e-14		4.84e-14	4.91e-14	5.37e-14	5.03e-14	5.10e-14
+1.5	5.30e-14		5.02e-14	5.06e-14	5.56e-14	5.26e-14	5.29e-14
+1.0	5.84e-14		5.06e-14	5.08e-14	5.70e-14	5.35e-14	5.38e-14
+0.5	5.75e-14		5.33e-14	5.29e-14	5.81e-14	5.45e-14	5.52e-14
0.0	5.93e-14		5.42e-14	5.35e-14	5.88e-14	5.68e-14	5.64e-14
-0.5	6.02e-14		5.38e-14	5.30e-14	5.90e-14	5.64e-14	5.61e-14
-1.0	5.93e-14		5.51e-14	5.46e-14	5.86e-14	5.64e-14	5.65e-14
-1.5	5.89e-14		5.33e-14	5.29e-14	5.76e-14	5.54e-14	5.53e-14
-2.0	5.71e-14		5.38e-14	5.32e-14	5.70e-14	5.45e-14	5.49e-14
-2.5	5.48e-14		5.24e-14	5.22e-14	5.51e-14	5.21e-14	5.32e-14
-3.0	5.08e-14		4.93e-14	4.94e-14	5.41e-14	4.93e-14	5.09e-14
-3.5	4.90e-14		4.84e-14	4.78e-14	5.06e-14	4.70e-14	4.85e-14
-4.0	4.45e-14		4.44e-14	4.47e-14	4.81e-14	4.36e-14	4.54e-14
-4.5	4.11e-14		1.46e-14	3.99e-14	4.36e-14	3.95e-14	4.10e-14

TABLE 6.1-8

DERIVED EXPOSURE RATES FROM CAPSULE B DOSIMETRY EVALUATION
16° AZIMUTH - 280° REFERENCE - CORE MIDPLANE

	Trial Value	Adjusted Value	1σ Uncertainty
$\phi(E > 1.0\ MeV)$	1.52e+09	1.34e+09	7%
$\phi(E > 0.1\ MeV)$	1.34e+10	1.18e+10	16%
$\phi(E < 0.414\ eV)$	2.92e+09	6.26e+08	27%
dpa/sec	4.70e-12	4.09e-12	12%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
16° AZIMUTH - 280° REFERENCE - CORE MIDPLANE

	Reaction Rate (rps/nucleus)				
	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	9.76e-19	1.08e-18	9.71e-19	0.90	1.01
^{46}Ti (n,p) Cd	1.45e-17	1.53e-17	1.42e-17	0.95	1.02
^{54}Fe (n,p) Cd	7.42e-17	8.69e-17	7.51e-17	0.85	0.99
^{58}Ni (n,p) Cd	1.04e-16	1.22e-16	1.05e-16	0.85	0.99
^{238}U (n,f) Cd	3.42e-16	4.46e-16	3.84e-16	0.77	0.89
^{235}U (n,f) Cd	9.70e-14	2.44e-13	9.58e-14	0.40	1.01
^{238}U (n,f) Cd[1]	4.01e-16	4.46e-16	3.84e-16	0.90	1.04
^{235}U (n,f) Cd[1]	8.36e-14	2.44e-13	9.58e-14	0.34	0.87
^{237}Np (n,f) Cd	6.67e-15	6.16e-15	6.02e-15	1.08	1.11
^{59}Co (n,γ)	4.63e-14	1.47e-13	4.68e-14	0.31	0.99
^{59}Co (n,γ) Cd	3.08e-14	6.84e-14	3.04e-14	0.45	1.01

1 Paired Uranium Dosimeter (PUD) measurement

TABLE 6.1-9

DERIVED EXPOSURE RATES FROM CAPSULE D DOSIMETRY EVALUATION
26° AZIMUTH - 290° REFERENCE - CORE MIDPLANE

	Trial Value	Adjusted Value	1σ Uncertainty
ϕ(E > 1.0 MeV)	1.19e+09	9.97e+08	7%
ϕ(E > 0.1 MeV)	1.14e+10	9.48e+09	16%
ϕ(E < 0.414 eV)	2.90e+09	5.55e+08	28%
dpa/sec	3.93e-12	3.25e-12	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
26° AZIMUTH - 290° REFERENCE - CORE MIDPLANE

Reaction Rate (rps/nucleus)

	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	7.51e-19	8.47e-19	7.48e-19	0.89	1.00
^{46}Ti (n,p) Cd	1.11e-17	1.19e-17	1.08e-17	0.93	1.03
^{54}Fe (n,p) Cd	5.60e-17	6.75e-17	5.66e-17	0.83	0.99
^{58}Ni (n,p) Cd	7.81e-17	9.47e-17	7.88e-17	0.82	0.99
^{238}U (n,f) Cd	2.52e-16	3.49e-16	2.87e-16	0.72	0.88
^{235}U (n,f) Cd	9.15e-14	2.36e-13	9.16e-14	0.39	1.00
^{238}U (n,f) Cd[1]	3.04e-16	3.49e-16	2.87e-16	0.87	1.06
^{235}U (n,f) Cd[1]	8.22e-14	2.36e-13	9.16e-14	0.35	0.90
^{237}Np (n,f) Cd	4.99e-15	5.03e-15	4.56e-15	0.99	1.09
^{59}Co (n,γ)	4.34e-14	1.44e-13	4.40e-14	0.30	0.99
^{59}Co (n,γ) Cd	2.99e-14	6.66e-14	2.95e-14	0.45	1.01

1 Paired Uranium Dosimeter (PUD) measurement

TABLE 6.1-10

DERIVED EXPOSURE RATES FROM CAPSULE E DOSIMETRY EVALUATION
26° AZIMUTH - 290° REFERENCE - CORE BOTTOM

	Trial Value	Adjusted Value	1σ Uncertainty
$\phi(E > 1.0\ MeV)$	1.19e+09	3.45e+08	8%
$\phi(E > 0.1\ MeV)$	1.14e+10	3.76e+09	17%
$\phi(E < 0.414\ eV)$	2.90e+09	3.40e+08	28%
dpa/sec	3.93e-12	1.25e-12	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
26° AZIMUTH - 290° REFERENCE - CORE BOTTOM

Reaction Rate (rps/nucleus)

	Measured	Trial[1] Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
$^{63}Cu\ (n,\alpha)$ Cd	1.99e-19	8.47e-19	2.05e-19	0.23	0.97
$^{46}Ti\ (n,p)$ Cd	3.34e-18	1.19e-17	3.25e-18	0.28	1.03
$^{54}Fe\ (n,p)$ Cd	1.75e-17	6.75e-17	1.76e-17	0.26	0.99
$^{58}Ni\ (n,p)$ Cd	2.57e-17	9.47e-17	2.55e-17	0.27	1.01
$^{238}U\ (n,f)$ Cd	8.93e-17	3.49e-16	9.56e-17	0.26	0.93
$^{235}U\ (n,f)$ Cd	4.77e-14	2.36e-13	5.16e-14	0.20	0.92
$^{237}Np\ (n,f)$ Cd	1.65e-15	5.03e-15	1.60e-15	0.33	1.03
$^{59}Co\ (n,\gamma)$	2.59e-14	1.44e-13	2.62e-14	0.18	0.99
$^{59}Co\ (n,\gamma)$ Cd	1.75e-14	6.66e-14	1.73e-14	0.26	1.01

1 Calculated using midplane reference spectrum without axial adjustment

TABLE 6.1-11

DERIVED EXPOSURE RATES FROM CAPSULE G DOSIMETRY EVALUATION
39° AZIMUTH - 315° REFERENCE - CORE MIDPLANE

	Trial Value	Adjusted Value	1 σ Uncertainty
ϕ(E > 1.0 MeV)	8.60e+08	6.94e+08	7%
ϕ(E > 0.1 MeV)	9.08e+09	7.52e+09	17%
ϕ(E < 0.414 eV)	2.88e+09	7.60e+08	25%
dpa/sec	3.09e-12	2.52e-12	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
39° AZIMUTH - 315° REFERENCE - CORE MIDPLANE

	Reaction Rate (rps/nucleus)				
	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	5.53e-19	6.00e-19	5.50e-19	0.92	1.01
^{46}Ti (n,p) Cd	7.89e-18	8.39e-18	7.74e-18	0.94	1.02
^{54}Fe (n,p) Cd	4.00e-17	4.76e-17	4.02e-17	0.84	1.00
^{58}Ni (n,p) Cd	5.51e-17	6.70e-17	5.56e-17	0.82	0.99
^{238}U (n,f) Cd	1.92e-16	2.49e-16	2.00e-16	0.77	0.96
^{235}U (n,f) Cd	8.97e-14	2.26e-13	9.60e-14	0.40	0.93
^{238}U (n,f) Cd[1]	1.92e-16	2.49e-16	2.00e-16	0.77	0.96
^{235}U (n,f) Cd[1]	9.46e-14	2.26e-13	9.60e-14	0.42	0.99
^{237}Np (n,f) Cd	3.55e-15	3.80e-15	3.29e-15	0.93	1.08
^{59}Co (n,γ)	4.82e-14	1.42e-13	4.86e-14	0.34	0.99
^{59}Co (n,γ) Cd	2.90e-14	6.45e-14	2.88e-14	0.45	1.01

[1] Paired Uranium Dosimeter (PUD) measurement

TABLE 6.1-12

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION WITHIN THE REACTOR CAVITY SHORT GRADIENT CHAINS - CYCLE 8 IRRADIATION

Feet from	Neutron Flux (n/cm^2-sec)			
Midplane	16°	24°	26°	39°
+0.5	1.33e+09	8.94e+08	9.87e+08	7.01e+08
0.0		9.97e+08		
-0.5	1.35e+09	9.45e+08	1.01e+09	6.87e+08
-1.0	1.35e+09	9.59e+08	1.03e+09	6.87e+08
-1.5	1.31e+09	8.48e+08	1.01e+09	6.13e+08
-2.0	1.27e+09	8.07e+08	9.83e+08	6.46e+08
-2.5	1.07e+09	7.55e+08	9.26e+08	5.69e+08
-3.0	1.03e+09	6.87e+08	8.81e+08	5.58e+08
-3.5	9.81e+08	5.68e+08	8.57e+08	4.98e+08
-4.0	7.17e+08	4.88e+08	7.26e+08	4.34e+08
-4.5	5.93e+08	3.47e+08	6.11e+08	3.99e+08
-5.0	3.99e+08	2.51e+08	4.07e+08	2.83e+08
-5.5	2.64e+08	1.50e+08		2.09e+08

TABLE 6.1-13

FAST NEUTRON FLUX (E > 0.1 MeV) AS A FUNCTION OF AXIAL POSITION WITHIN THE REACTOR CAVITY SHORT GRADIENT CHAINS - CYCLE 8 IRRADIATION

Feet from	Neutron Flux (n/cm^2-sec)			
Midplane	16°	24°	26°	39°
+0.5	1.17e+10	8.50e+09	9.40e+09	7.50e+09
0.0		9.48e+09		
-0.5	1.19e+10	8.99e+09	9.57e+09	7.36e+09
-1.0	1.19e+10	9.12e+09	9.75e+09	7.36e+09
-1.5	1.16e+10	8.07e+09	9.57e+09	6.57e+09
-2.0	1.12e+10	7.68e+09	9.35e+09	6.92e+09
-2.5	9.41e+09	7.18e+09	8.81e+09	6.10e+09
-3.0	9.06e+09	6.54e+09	8.38e+09	5.97e+09
-3.5	8.65e+09	5.40e+09	8.16e+09	5.33e+09
-4.0	6.32e+09	4.64e+09	6.91e+09	4.65e+09
-4.5	5.23e+09	3.30e+09	5.81e+09	4.28e+09
-5.0	3.51e+09	2.39e+09	3.88e+09	3.03e+09
-5.5	2.33e+09	1.43e+09		2.24e+09

TABLE 6.1-14

IRON ATOM DISPLACEMENT RATE AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 8 IRRADIATION

Feet from	Displacement Rate (dpa/sec)			
Midplane	16°	24°	26°	39°
+0.5	4.06e-12	2.92e-12	3.22e-12	2.55e-12
0.0		3.25e-12		
-0.5	4.13e-12	3.08e-12	3.28e-12	2.50e-12
-1.0	4.13e-12	3.13e-12	3.35e-12	2.50e-12
-1.5	4.02e-12	2.77e-12	3.28e-12	2.23e-12
-2.0	3.88e-12	2.63e-12	3.21e-12	2.35e-12
-2.5	3.27e-12	2.46e-12	3.02e-12	2.07e-12
-3.0	3.15e-12	2.24e-12	2.87e-12	2.03e-12
-3.5	3.01e-12	1.85e-12	2.80e-12	1.81e-12
-4.0	2.20e-12	1.59e-12	2.37e-12	1.58e-12
-4.5	1.82e-12	1.13e-12	1.99e-12	1.45e-12
-5.0	1.22e-12	8.19e-13	1.33e-12	1.03e-12
-5.5	8.08e-13	4.90e-13		7.62e-13

TABLE 6.1-15

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION WITHIN THE REACTOR CAVITY LONG GRADIENT CHAINS - CYCLE 8 IRRADIATION

Feet from Midplane	Neutron Flux (n/cm^2-sec) 0°	10°	20°	30°
+8.0	1.02e+08		1.26e+08	7.33e+07
+7.5	1.32e+08		1.32e+08	1.07e+08
+7.0	2.20e+08		2.19e+08	1.84e+08
+6.5	3.33e+08		3.31e+08	2.14e+08
+6.0	4.95e+08		4.32e+08	3.44e+08
+5.5	6.19e+08		6.42e+08	4.76e+08
+5.0	7.52e+08		7.93e+08	5.95e+08
+4.5	9.10e+08		9.11e+08	7.03e+08
+4.0	1.00e+09		1.07e+09	7.78e+08
+3.5	1.11e+09		1.16e+09	9.04e+08
+3.0	1.15e+09		1.27e+09	9.19e+08
+2.5	1.19e+09		1.30e+09	9.85e+08
+2.0	1.21e+09		1.32e+09	9.72e+08
+1.5	1.18e+09		1.32e+09	9.71e+08
+1.0	1.13e+09		1.23e+09	9.91e+08
+0.5	1.20e+09		1.27e+09	9.93e+08
0.0	1.34e+09		1.34e+09	9.97e+08
-0.5	1.26e+09		1.29e+09	1.01e+09
-1.0	1.15e+09		1.28e+09	9.97e+08
-1.5	1.16e+09		1.28e+09	9.70e+08
-2.0	1.11e+09		1.33e+09	9.94e+08
-2.5	1.12e+09		1.30e+09	9.46e+08
-3.0	9.53e+08		1.18e+09	8.82e+08
-3.5	1.05e+09		1.12e+09	8.69e+08
-4.0	8.85e+08		9.90e+08	7.66e+08
-4.5	7.25e+08			6.29e+08

TABLE 6.1-16

FAST NEUTRON FLUX (E > 0.1 MeV) AS A FUNCTION OF AXIAL POSITION WITHIN THE REACTOR CAVITY LONG GRADIENT CHAINS - CYCLE 8 IRRADIATION

Feet from Midplane	Neutron Flux (n/cm^2-sec) 0°	10°	20°	30°
+8.0	8.97e+08		1.11e+09	6.98e+08
+7.5	1.17e+09		1.16e+09	1.01e+09
+7.0	1.94e+09		1.93e+09	1.75e+09
+6.5	2.93e+09		2.91e+09	2.04e+09
+6.0	4.36e+09		3.81e+09	3.27e+09
+5.5	5.45e+09		5.66e+09	4.53e+09
+5.0	6.62e+09		6.99e+09	5.66e+09
+4.5	8.02e+09		8.03e+09	6.69e+09
+4.0	8.83e+09		9.39e+09	7.40e+09
+3.5	9.74e+09		1.02e+10	8.60e+09
+3.0	1.01e+10		1.12e+10	8.75e+09
+2.5	1.05e+10		1.15e+10	9.38e+09
+2.0	1.07e+10		1.17e+10	9.24e+09
+1.5	1.04e+10		1.16e+10	9.24e+09
+1.0	9.99e+09		1.09e+10	9.43e+09
+0.5	1.06e+10		1.12e+10	9.45e+09
0.0	1.18e+10		1.18e+10	9.48e+09
-0.5	1.11e+10		1.14e+10	9.58e+09
-1.0	1.01e+10		1.13e+10	9.48e+09
-1.5	1.02e+10		1.13e+10	9.23e+09
-2.0	9.81e+09		1.17e+10	9.45e+09
-2.5	9.84e+09		1.15e+10	9.00e+09
-3.0	8.40e+09		1.04e+10	8.40e+09
-3.5	9.28e+09		9.86e+09	8.27e+09
-4.0	7.80e+09		8.72e+09	7.29e+09
-4.5	6.39e+09			5.99e+09

TABLE 6.1-17

IRON ATOM DISPLACEMENT RATE AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
LONG GRADIENT CHAINS - CYCLE 8 IRRADIATION

Feet from		Displacement Rate (dpa/sec)		
Midplane	0°	10°	20°	30°
+8.0	3.12e-13		3.86e-13	2.39e-13
+7.5	4.05e-13		4.04e-13	3.48e-13
+7.0	6.75e-13		6.72e-13	6.01e-13
+6.5	1.02e-12		1.01e-12	6.98e-13
+6.0	1.52e-12		1.32e-12	1.12e-12
+5.5	1.89e-12		1.97e-12	1.55e-12
+5.0	2.30e-12		2.43e-12	1.94e-12
+4.5	2.79e-12		2.79e-12	2.29e-12
+4.0	3.07e-12		3.27e-12	2.54e-12
+3.5	3.39e-12		3.56e-12	2.95e-12
+3.0	3.52e-12		3.89e-12	3.00e-12
+2.5	3.65e-12		3.99e-12	3.22e-12
+2.0	3.72e-12		4.05e-12	3.17e-12
+1.5	3.61e-12		4.04e-12	3.17e-12
+1.0	3.47e-12		3.78e-12	3.23e-12
+0.5	3.67e-12		3.90e-12	3.24e-12
0.0	4.09e-12		4.09e-12	3.25e-12
-0.5	3.87e-12		3.95e-12	3.28e-12
-1.0	3.52e-12		3.93e-12	3.25e-12
-1.5	3.56e-12		3.93e-12	3.17e-12
-2.0	3.41e-12		4.06e-12	3.24e-12
-2.5	3.42e-12		4.00e-12	3.09e-12
-3.0	2.92e-12		3.61e-12	2.88e-12
-3.5	3.23e-12		3.43e-12	2.84e-12
-4.0	2.71e-12		3.03e-12	2.50e-12
-4.5	2.22e-12			2.05e-12

FIGURE 6.1-1

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION ALONG THE 16.0 DEGREE TRAVERSE IN THE REACTOR CAVITY SHORT GRADIENT CHAINS - CYCLE 8 IRRADIATION

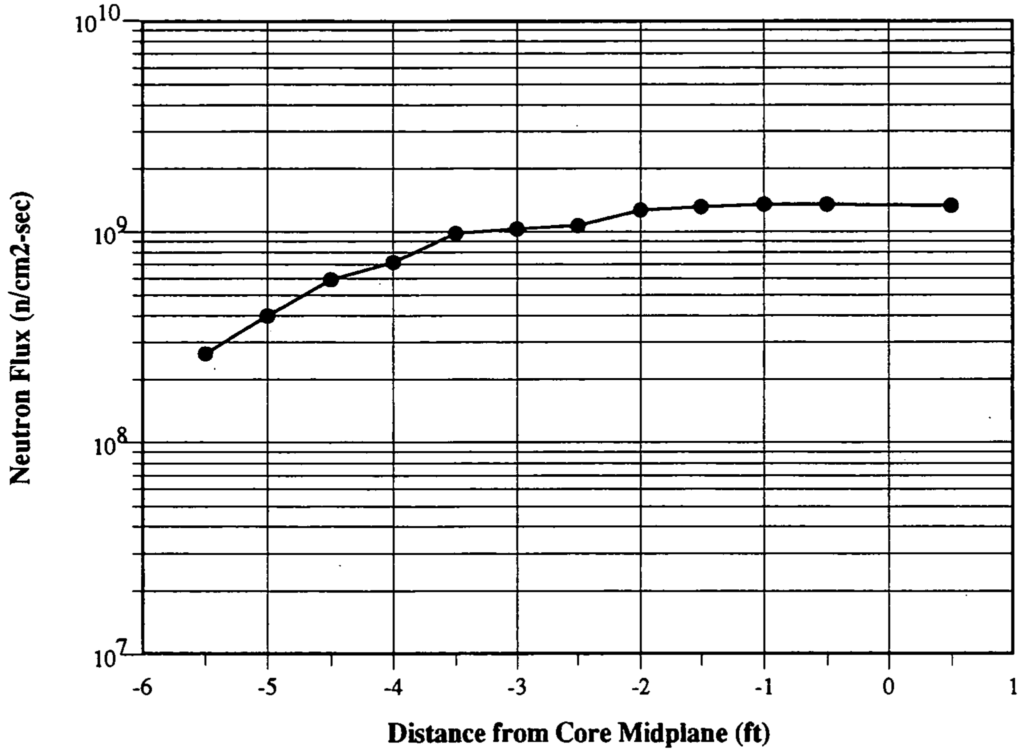


FIGURE 6.1-2

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 24.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 8 IRRADIATION

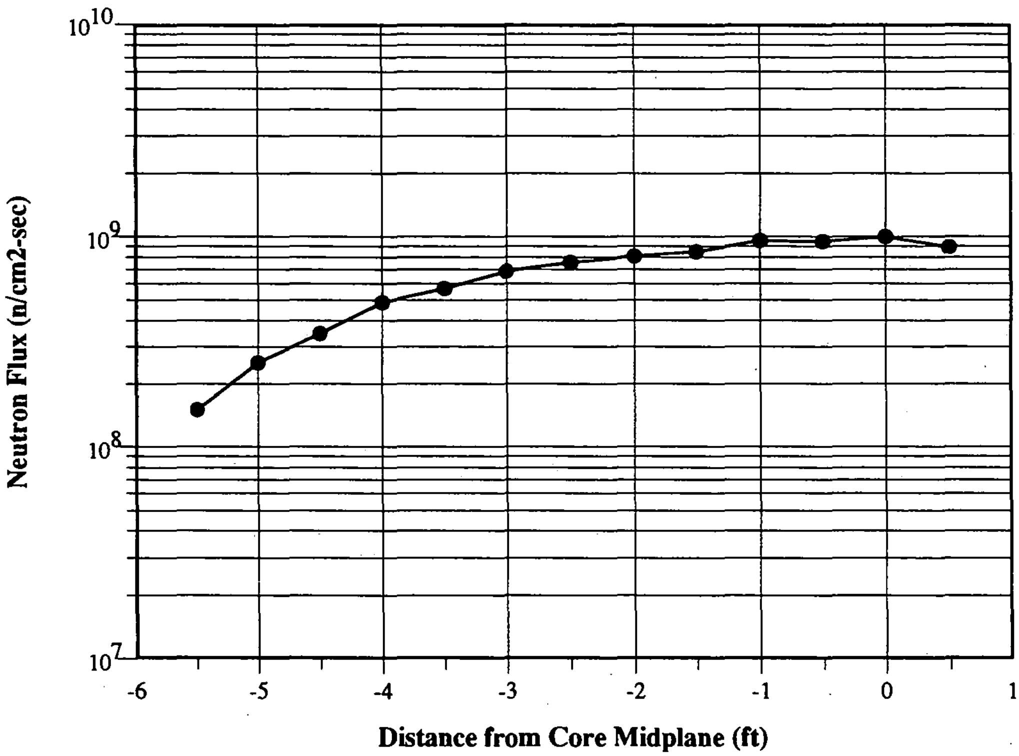


FIGURE 6.1-3

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 26.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 8 IRRADIATION

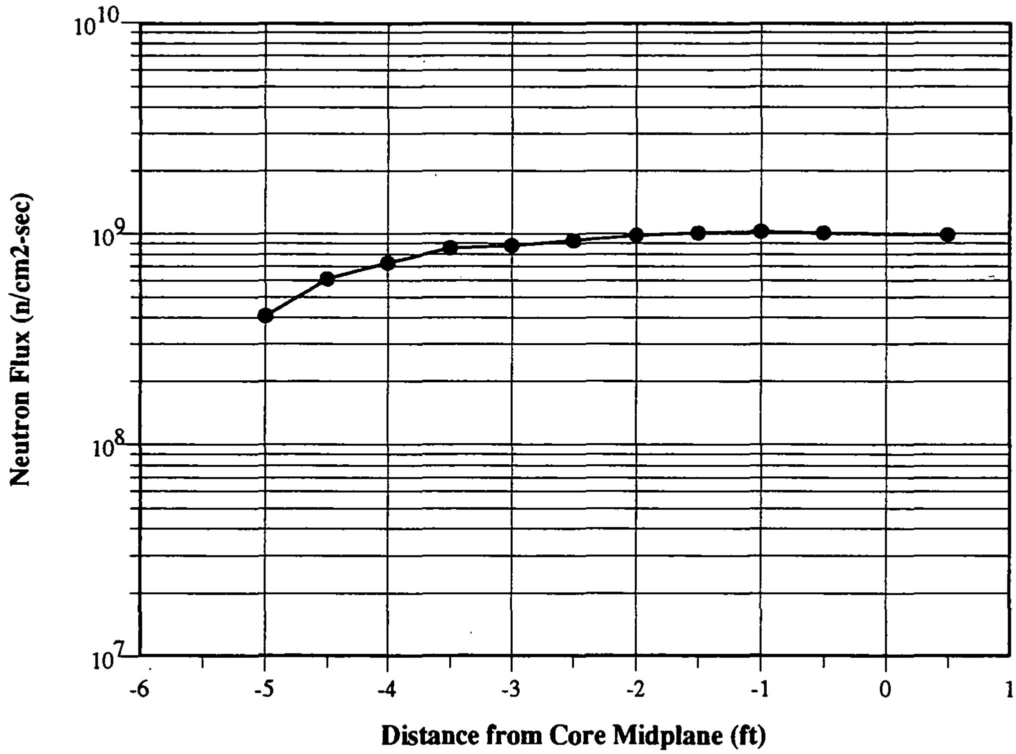


FIGURE 6.1-4

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 39.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 8 IRRADIATION

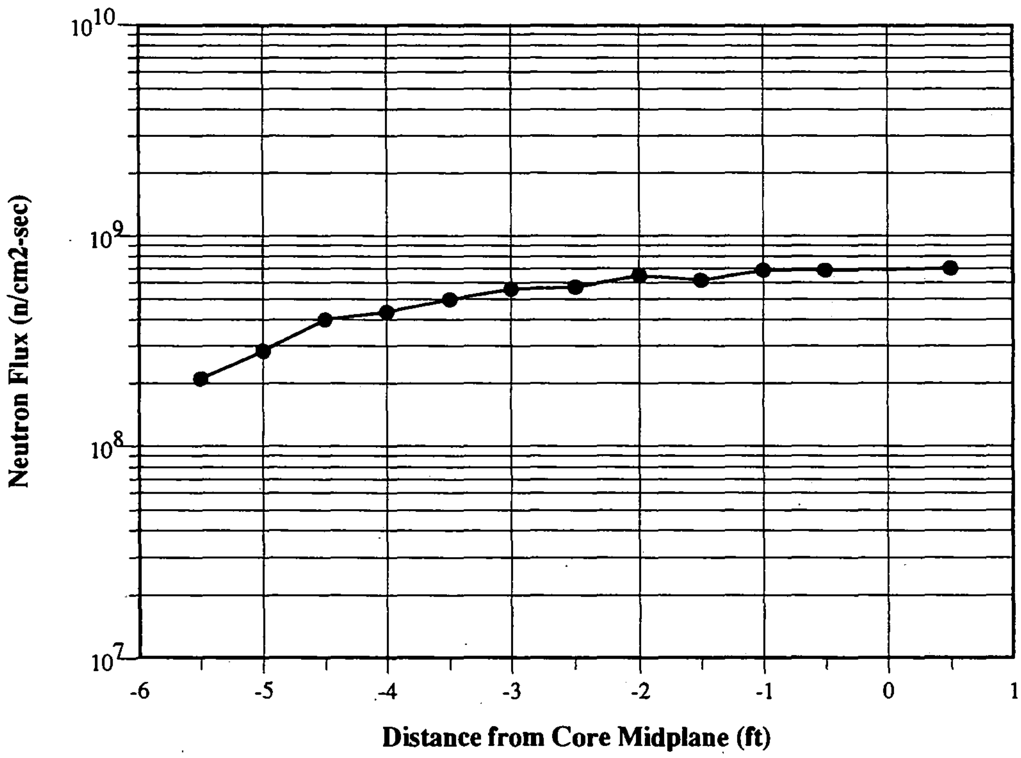


FIGURE 6.1-5

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 0.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
LONG GRADIENT CHAINS - CYCLE 8 IRRADIATION

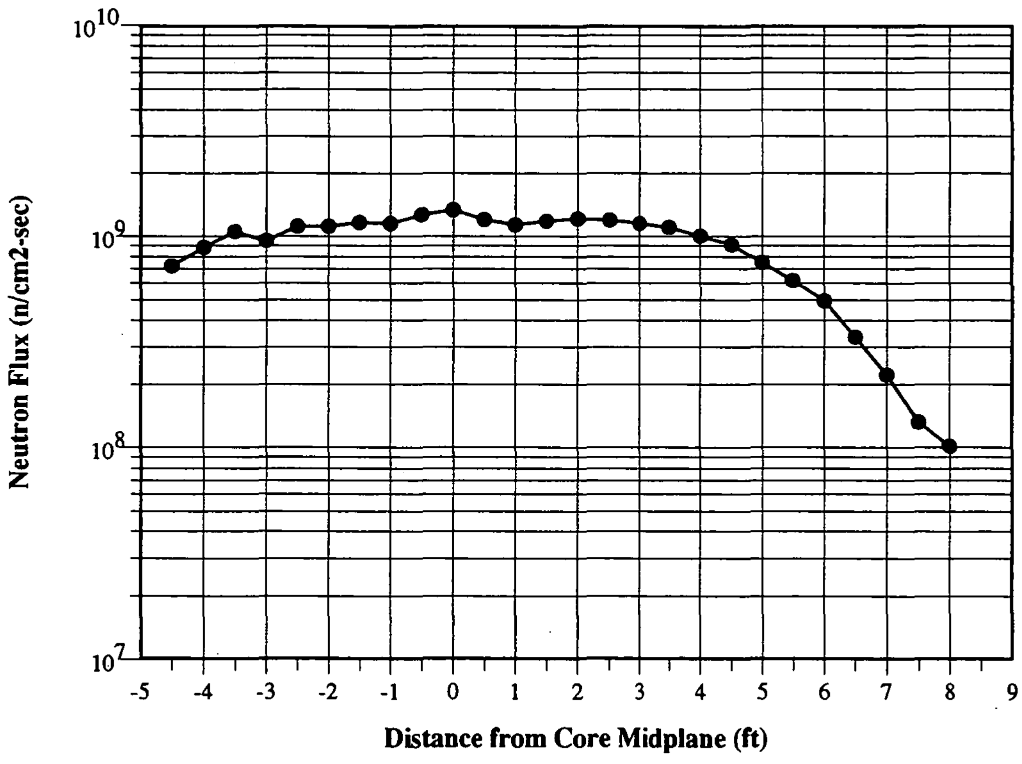


FIGURE 6.1-6

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 20.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
LONG GRADIENT CHAINS - CYCLE 8 IRRADIATION

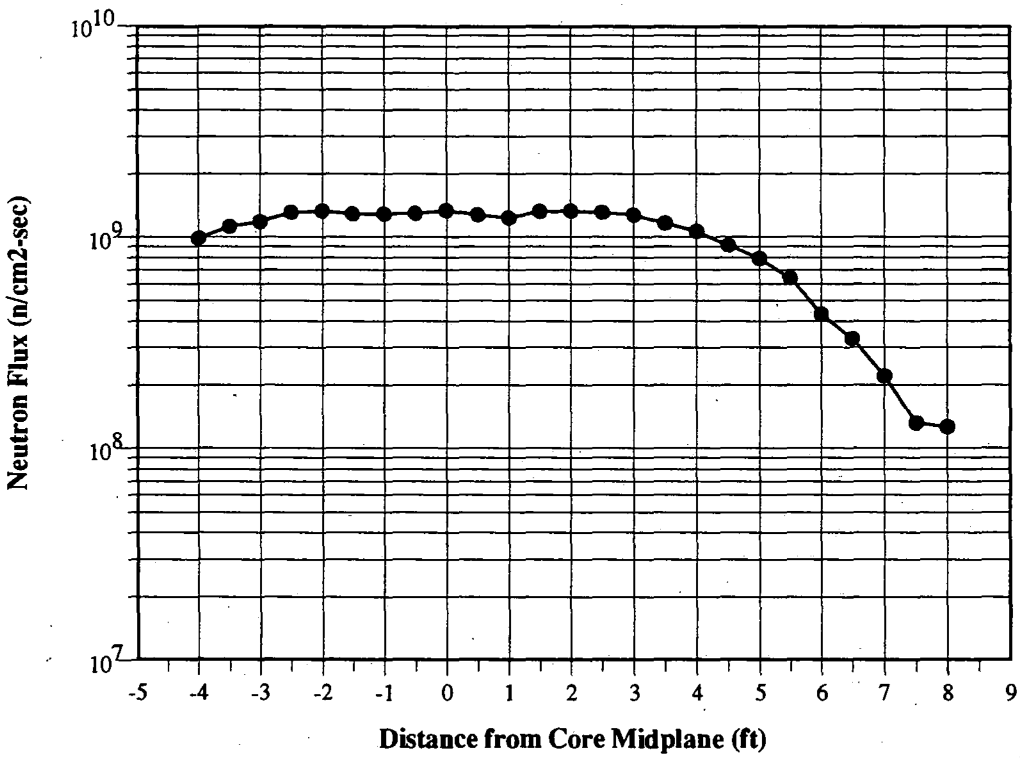
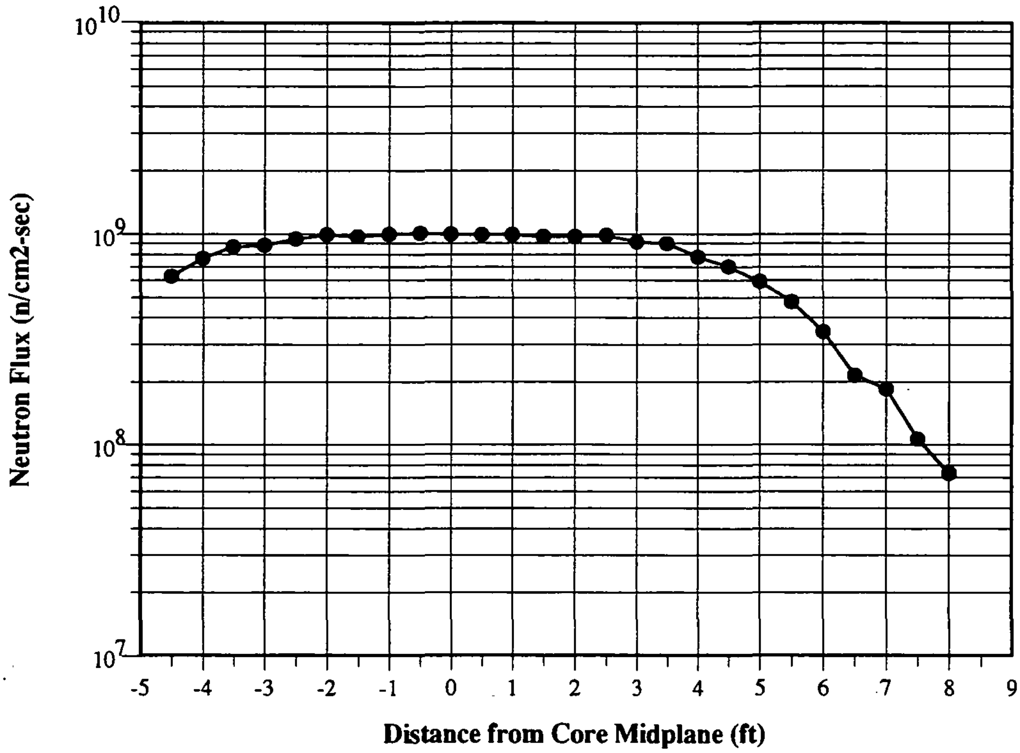


FIGURE 6.1-7

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION ALONG THE 30.0 DEGREE TRAVERSE IN THE REACTOR CAVITY LONG GRADIENT CHAINS - CYCLE 8 IRRADIATION



6.2 Cycle 9 Results

6.2.1 Measured Reaction Rates

During the Cycle 9 irradiation, six multiple foil sensor sets, and ten stainless steel gradient chains were deployed in the reactor cavity. The capsule identifications associated with each of the multiple foil sensor sets mounted from the dosimetry support bar are listed below.

Reference Azimuth	FOE	Bar Shifted Angle	Capsule Identification Core Midplane	Core Bottom
270°	0°	6°	A[1]	C[1]
280°	10°	16°	J	
290°	20°	26°	K	L
300°	30°	36°	Mispositioned[2]	
315°	45°	39°	N	
330°	30°	24°	No Capsule	

The contents of each of these irradiation capsules is specified in Appendix C to this report.

The irradiation history of the Palisades reactor during Cycle 9 is also listed in Appendix C. The irradiation history was obtained from NUREG-0020, "Licensed Operating Reactors Status Summary Report" for the applicable operating period. Based on this reactor operating history, the individual sensor characteristics, and the measured specific activities given in Appendix C, cycle average reaction rates referenced to a core power level of 2530 MWt were computed for each multiple foil sensor and gradient chain segment.

The computed reaction rates for the radiometric foil sensor sets irradiated during Cycle 9 are provided in Table 6.2-1. Corresponding reaction rate data from the ten stainless steel gradient chains are recorded in Tables 6.2-2 through 6.2-7 for the ^{54}Fe(n,p), ^{58}Ni(n,p), and ^{59}Co(n,γ) reactions, respectively.

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1 Dosimetry capsules A and C irradiated during Cycles 8 and 9, Reference 6

2 Mispositioned prior to Cycle 9 irradiation, Reference 6.

In regard to the data listed in Table 6.2-1, the $^{54}Fe(n,p)$ reaction rates represent an average of the bare and cadmium covered measurements for each capsule. In addition, the fission rate measurements include corrections for ^{235}U impurities in the ^{238}U sensors as well as corrections for photofission reactions in both the ^{238}U and ^{237}Np sensors. It should be noted that the changes in the measured data, as compared to the previous analysis in Reference 6, are due to the elimination of conservatism which is specific to this Palisades analysis. This included photofission reaction corrections, as noted above, and use of the long half-life ^{238}U (n,f) ^{137}Cs and ^{237}Np (n,f) ^{137}Cs reactions.

6.1.2 - Results of the Least Squares Adjustment Procedure

The results of the application of the least squares adjustment procedure to the six sets of multiple foil measurements obtained from the Cycle 9 irradiation are provided in Tables 6.2-8 through 6.2-13. In these tables, the derived exposure experienced at each sensor set location along with data illustrating the fit of both the trial and adjusted spectra to the measurements are given. Also included in the tabulations are the 1σ uncertainties associated with each of the derived exposure rates.

In regard to the comparisons listed in Tables 6.2-8 through 6.2-13, it should be noted that the columns labeled "trial calc" represent the absolute calculated neutron flux (E > 1.0 MeV) from Table 4.1-2 averaged over the Cycle 9 irradiation period as discussed in Section 3. Thus, the comparisons illustrated in Tables 6.2-8 through 6.2-13 indicate the degree to which the calculated neutron energy spectra matched the measured data before and after adjustment. Absolute comparisons of calculation and measurement are discussed further in Section 7 of this report.

Complete traverses of fast neutron exposure rates in the reactor cavity were developed by combining the results of the least squares adjustment of the multiple foil data with the $^{54}Fe(n,p)$ reaction rate measurements from the gradient chains. The gradient data were employed to establish relative axial distributions over the measurement range and these relative distributions were then normalized to the FERRET results from the midplane sensor sets to produce axial distributions of exposure rates in terms of $\phi(E > 1.0$ MeV), $\phi(E > 0.1$ MeV), and dpa/sec in the reactor cavity.

The resultant axial distributions of $\phi(E > 1.0$ MeV), $\phi(E > 0.1$ MeV), and dpa/sec from the gradient chain measurements are given in Tables 6.2-14 through 6.2-16 for the short chains and Tables 6.2-17 through 6.2-19 for the long chains, respectively. The distributions of $\phi(E > 1.0$

TABLE 6.2-1

SUMMARY OF REACTION RATES DERIVED FROM MULTIPLE FOIL SENSOR SETS
CYCLE 9 IRRADIATION

	Reaction Rate (rps/nucleus)					
Reaction	Capsule A[1]	Capsule C[1]	Capsule J	Capsule K	Capsule L	Capsule N
^{63}Cu (n,α) Cd	7.45e-19	1.13e-19	7.06e-19	6.05e-19	1.69e-19	4.19e-19
^{46}Ti (n,p) Cd	1.07e-17	1.81e-18	1.02e-17	8.65e-18	2.58e-18	5.89e-18
^{54}Fe (n,p) Cd	5.44e-17	9.88e-18	5.13e-17	4.28e-17	1.35e-17	2.96e-17
^{58}Ni (n,p) Cd	7.43e-17	1.42e-17	7.25e-17	6.12e-17	1.99e-17	4.19e-17
^{238}U (n,f) Cd	2.44e-16	5.62e-17	2.38e-16	2.33e-16	6.46e-17	1.38e-16
^{235}U (n,f) Cd	8.47e-14	4.33e-14	6.13e-14	5.00e-14	3.07e-14	6.42e-14
^{238}U (n,f) Cd[2]	3.23e-16	5.55e-17				
^{235}U (n,f) Cd[2]	7.24e-14	4.05e-14				
^{237}Np (n,f) Cd	4.38e-15	1.10e-15	3.94e-15	3.73e-15	1.16e-15	2.21e-15
^{59}Co (n,γ)	4.32e-14	2.17e-14	3.57e-14	3.19e-14	1.91e-14	3.55e-14
^{59}Co (n,γ) Cd	2.72e-14	1.51e-14	2.36e-14	2.28e-14	1.30e-14	2.23e-14

Note: Cd indicates that the sensor was cadmium covered.

1 Dosimetry capsules A and C irradiated during Cycles 8 and 9, Reference 6

2 Paired Uranium Dosimeter (PUD) measurement

TABLE 6.2-2

^{54}Fe (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL SHORT GRADIENT CHAINS - CYCLE 9 IRRADIATION

Feet from	Reaction Rate (rps/nucleus)				
Midplane	6°[1]	16°	24°	26°	39°
+0.5	2.85e-18	2.69e-18	2.26e-18	2.39e-18	1.62e-18
0.0			2.30e-18		
-0.38		2.81e-18			
-0.5	2.78e-18	2.72e-18	2.21e-18	2.44e-18	1.64e-18
-1.0	2.73e-18	2.71e-18	2.26e-18	2.30e-18	1.60e-18
-1.5	2.66e-18	2.59e-18	2.19e-18	2.40e-18	1.42e-18
-2.0	2.27e-18	2.39e-18	2.14e-18	2.22e-18	1.38e-18
-2.5	2.12e-18	2.26e-18	1.98e-18	2.10e-18	1.30e-18
-3.0	1.71e-18	2.02e-18	1.85e-18	1.93e-18	1.29e-18
-3.5	1.62e-18	1.88e-18	1.66e-18	1.81e-18	1.15e-18
-4.0	1.55e-18	1.55e-18	1.43e-18	1.69e-18	9.70e-19
-4.5	9.50e-19	1.13e-18	1.14e-18	1.38e-18	8.29e-19
-5.0	6.67e-19	8.10e-19	7.64e-19	9.63e-19	6.35e-19
-5.5		6.20e-19	6.02e-19		4.88e-19

1 Dosimetry capsules A and C irradiated during Cycles 8 and 9, Reference 6

TABLE 6.2-3

^{58}Ni (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL SHORT GRADIENT CHAINS - CYCLE 9 IRRADIATION

Feet from Midplane	Reaction Rate (rps/nucleus)				
	6°[1]	16°	24°	26°	39°
+0.5	4.78e-17	4.68e-17	3.67e-17	3.73e-17	2.59e-17
0.0			3.67e-17		
-0.38		4.69e-17			
-0.5	4.67e-17	4.61e-17	3.61e-17	3.79e-17	2.58e-17
-1.0	4.54e-17	4.48e-17	3.58e-17	3.77e-17	2.53e-17
-1.5	4.16e-17	4.36e-17	3.57e-17	3.69e-17	2.41e-17
-2.0	4.11e-17	4.13e-17	3.47e-17	3.56e-17	2.34e-17
-2.5	3.62e-17	3.87e-17	3.28e-17	3.44e-17	2.15e-17
-3.0	2.99e-17	3.58e-17	3.07e-17	3.24e-17	2.04e-17
-3.5	2.66e-17	3.30e-17	2.81e-17	3.06e-17	1.89e-17
-4.0	2.43e-17	2.74e-17	2.44e-17	2.70e-17	1.63e-17
-4.5	1.68e-17	2.13e-17	2.01e-17	2.31e-17	1.42e-17
-5.0	1.20e-17	1.48e-17	1.33e-17	1.56e-17	1.03e-17
-5.5		1.09e-17	9.73e-18		7.98e-18

[1] Dosimetry capsules A and C irradiated during Cycles 8 and 9, Reference 6

TABLE 6.2-4

^{59}Co (n,γ) REACTION RATES DERIVED FROM THE STAINLESS STEEL SHORT GRADIENT CHAINS - CYCLE 9 IRRADIATION

Feet from	Reaction Rate (rps/nucleus)				
Midplane	6°[1]	16°	24°	26°	39°
+0.5	4.38e-14	3.29e-14	3.73e-14	3.08e-14	3.36e-14
0.0			3.68e-14		
-0.38		3.31e-14			
-0.5	4.38e-14	3.30e-14	3.70e-14	3.11e-14	3.39e-14
-1.0	4.30e-14	3.26e-14	3.67e-14	3.12e-14	3.35e-14
-1.5	4.18e-14	3.21e-14	3.61e-14	3.07e-14	3.31e-14
-2.0	4.13e-14	3.13e-14	3.53e-14	3.03e-14	3.23e-14
-2.5	3.79e-14	3.06e-14	3.41e-14	2.94e-14	3.13e-14
-3.0	3.84e-14	2.94e-14	3.26e-14	2.89e-14	3.00e-14
-3.5	3.59e-14	2.79e-14	3.09e-14	2.77e-14	2.86e-14
-4.0	3.27e-14	2.64e-14	2.87e-14	2.64e-14	2.67e-14
-4.5	2.67e-14	2.29e-14	2.64e-14	2.47e-14	2.46e-14
-5.0	2.37e-14	1.93e-14	2.03e-14	2.00e-14	1.89e-14
-5.5		1.83e-14	1.81e-14		1.65e-14

1 Dosimetry capsules A and C irradiated during Cycles 8 and 9, Reference 6

TABLE 6.2-5

^{54}Fe (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL LONG GRADIENT CHAINS - CYCLE 9 IRRADIATION

	Reaction Rate (rps/nucleus)						
Feet from Midplane	Ref. 90° FOE 0°	Ref. 260° FOE 10°	Ref. 340° FOE 20°	Ref. 30° FOE 30°	Ref. 150° FOE 30°	Ref. 210° FOE 30°	Average FOE 30°
+8.0	1.61e-19	1.46e-19	1.62e-19	1.32e-19	1.35e-19		1.33e-19
+7.5	2.50e-19	2.17e-19	2.31e-19	1.84e-19	2.07e-19		1.95e-19
+7.0	4.17e-19	3.57e-19	3.15e-19	2.96e-19	3.35e-19		3.15e-19
+6.5	6.30e-19	5.61e-19	5.55e-19	4.53e-19	5.05e-19		4.79e-19
+6.0	9.06e-19	7.75e-19	8.08e-19	6.65e-19	6.61e-19		6.63e-19
+5.5	1.18e-18	1.08e-18	1.09e-18	8.65e-19	8.98e-19		8.81e-19
+5.0	1.44e-18	1.35e-18	1.44e-18	1.11e-18	1.12e-18		1.12e-18
+4.5	1.72e-18	1.60e-18	1.70e-18	1.27e-18	1.40e-18		1.33e-18
+4.0	1.84e-18	1.81e-18	1.93e-18	1.48e-18	1.50e-18		1.49e-18
+3.5	2.07e-18	1.97e-18	2.06e-18	1.59e-18	1.63e-18		1.61e-18
+3.0	2.17e-18	2.15e-18	2.15e-18	1.67e-18	1.72e-18		1.70e-18
+2.5	2.24e-18	2.23e-18	2.17e-18	1.74e-18	1.88e-18		1.81e-18
+2.0	2.24e-18	2.18e-18	2.27e-18	1.71e-18	1.90e-18		1.80e-18
+1.5	2.27e-18	2.20e-18	2.27e-18	1.77e-18	2.00e-18		1.89e-18
+1.0	2.34e-18	2.31e-18	2.31e-18	1.78e-18	1.87e-18		1.83e-18
+0.5	2.32e-18	2.36e-18	2.28e-18	1.82e-18	1.92e-18		1.87e-18
0.0	2.35e-18	2.35e-18	2.39e-18	1.84e-18	1.95e-18		1.89e-18
-0.5	2.33e-18	2.35e-18	2.42e-18	1.85e-18	2.02e-18		1.93e-18
-1.0	2.34e-18	2.36e-18	2.45e-18	1.77e-18	2.02e-18		1.89e-18
-1.5	2.08e-18	2.40e-18	2.43e-18	1.83e-18	1.88e-18		1.85e-18
-2.0	2.03e-18	2.33e-18	2.36e-18	1.79e-18	1.91e-18		1.85e-18
-2.5	1.87e-18	2.18e-18	2.23e-18	1.76e-18	1.82e-18		1.79e-18
-3.0	1.87e-18	2.06e-18	2.10e-18	1.74e-18	1.75e-18		1.74e-18
-3.5	1.75e-18	1.95e-18	1.96e-18	1.51e-18	1.68e-18		1.60e-18
-4.0	1.55e-18	1.67e-18	1.68e-18	1.34e-18	1.45e-18		1.39e-18
-4.5	1.33e-18	1.41e-18	1.52e-18	1.18e-18	1.32e-18		1.25e-18

TABLE 6.2-6

^{58}Ni (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL LONG GRADIENT CHAINS - CYCLE 9 IRRADIATION

	Reaction Rate (rps/nucleus)						
Feet from Midplane	Ref. 90° FOE 0°	Ref. 260° FOE 10°	Ref. 340° FOE 20°	Ref. 30° FOE 30°	Ref. 150° FOE 30°	Ref. 210° FOE 30°	Average FOE 30°
+8.0	3.16e-18	2.81e-18	2.97e-18	2.52e-18	2.52e-18		2.52e-18
+7.5	5.18e-18	4.29e-18	4.43e-18	3.66e-18	3.57e-18		3.62e-18
+7.0	7.41e-18	6.54e-18	6.60e-18	5.59e-18	6.01e-18		5.80e-18
+6.5	1.07e-17	9.85e-18	9.84e-18	8.24e-18	8.62e-18		8.43e-18
+6.0	1.51e-17	1.40e-17	1.41e-17	1.12e-17	1.20e-17		1.16e-17
+5.5	2.01e-17	1.87e-17	1.85e-17	1.59e-17	1.66e-17		1.63e-17
+5.0	2.52e-17	2.47e-17	2.39e-17	1.92e-17	2.05e-17		1.98e-17
+4.5	2.98e-17	2.88e-17	2.84e-17	2.28e-17	2.44e-17		2.36e-17
+4.0	3.30e-17	3.22e-17	3.15e-17	2.52e-17	2.61e-17		2.56e-17
+3.5	3.56e-17	3.52e-17	3.42e-17	2.75e-17	3.00e-17		2.87e-17
+3.0	3.74e-17	3.70e-17	3.59e-17	2.82e-17	3.16e-17		2.99e-17
+2.5	3.77e-17	3.80e-17	3.68e-17	2.97e-17	3.27e-17		3.12e-17
+2.0	3.77e-17	3.83e-17	3.76e-17	3.04e-17	3.29e-17		3.17e-17
+1.5	3.86e-17	3.89e-17	3.82e-17	3.04e-17	3.32e-17		3.18e-17
+1.0	3.91e-17	3.92e-17	3.81e-17	3.09e-17	3.32e-17		3.20e-17
+0.5	3.90e-17	3.95e-17	3.82e-17	3.12e-17	3.40e-17		3.26e-17
0.0	3.84e-17	3.98e-17	3.89e-17	3.04e-17	3.42e-17		3.23e-17
-0.5	3.83e-17	4.01e-17	3.83e-17	3.10e-17	3.43e-17		3.27e-17
-1.0	3.80e-17	4.06e-17	3.89e-17	3.13e-17	3.37e-17		3.25e-17
-1.5	3.61e-17	4.06e-17	3.85e-17	3.13e-17	3.29e-17		3.21e-17
-2.0	3.49e-17	3.91e-17	3.85e-17	3.13e-17	3.24e-17		3.19e-17
-2.5	3.35e-17	3.73e-17	3.72e-17	3.07e-17	3.20e-17		3.14e-17
-3.0	3.14e-17	3.59e-17	3.51e-17	2.90e-17	3.07e-17		2.98e-17
-3.5	2.94e-17	3.33e-17	3.25e-17	2.65e-17	2.93e-17		2.79e-17
-4.0	2.66e-17	3.02e-17	2.87e-17	2.43e-17	2.62e-17		2.53e-17
-4.5	2.27e-17	2.56e-17	2.44e-17	2.05e-17	2.21e-17		2.13e-17

TABLE 6.2-7

$^{59}Co\ (n,\gamma)$ REACTION RATES DERIVED FROM THE STAINLESS STEEL LONG GRADIENT CHAINS - CYCLE 9 IRRADIATION

	Reaction Rate (rps/nucleus)						
Feet from Midplane	Ref. 90° FOE 0°	Ref. 260° FOE 10°	Ref. 340° FOE 20°	Ref. 30° FOE 30°	Ref. 150° FOE 30°	Ref. 210° FOE 30°	Average FOE 30°
+8.0	1.50e-14	1.52e-14	1.46e-14	1.42e-14	1.35e-14		1.39e-14
+7.5	1.75e-14	1.70e-14	1.64e-14	1.62e-14	1.58e-14		1.60e-14
+7.0	1.94e-14	1.88e-14	1.81e-14	1.79e-14	1.83e-14		1.81e-14
+6.5	2.14e-14	2.07e-14	2.01e-14	1.94e-14	2.01e-14		1.97e-14
+6.0	2.32e-14	2.24e-14	2.21e-14	2.09e-14	2.17e-14		2.13e-14
+5.5	2.55e-14	2.42e-14	2.43e-14	2.28e-14	2.35e-14		2.31e-14
+5.0	2.76e-14	2.59e-14	2.60e-14	2.47e-14	2.52e-14		2.49e-14
+4.5	2.98e-14	2.77e-14	2.79e-14	2.63e-14	2.74e-14		2.69e-14
+4.0	3.19e-14	2.90e-14	2.96e-14	2.78e-14	2.93e-14		2.85e-14
+3.5	3.37e-14	3.03e-14	3.13e-14	2.91e-14	3.10e-14		3.01e-14
+3.0	3.58e-14	3.17e-14	3.27e-14	3.04e-14	3.26e-14		3.15e-14
+2.5	3.72e-14	3.28e-14	3.44e-14	3.14e-14	3.37e-14		3.26e-14
+2.0	3.73e-14	3.39e-14	3.58e-14	3.24e-14	3.50e-14		3.37e-14
+1.5	4.04e-14	3.47e-14	3.69e-14	3.36e-14	3.62e-14		3.49e-14
+1.0	4.18e-14	3.57e-14	3.79e-14	3.43e-14	3.72e-14		3.57e-14
+0.5	4.24e-14	3.63e-14	3.89e-14	3.53e-14	3.77e-14		3.65e-14
0.0	4.30e-14	3.64e-14	3.92e-14	3.55e-14	3.83e-14		3.69e-14
-0.5	4.30e-14	3.69e-14	3.97e-14	3.60e-14	3.87e-14		3.73e-14
-1.0	4.32e-14	3.67e-14	3.95e-14	3.58e-14	3.81e-14		3.70e-14
-1.5	4.27e-14	3.62e-14	3.93e-14	3.58e-14	3.75e-14		3.66e-14
-2.0	4.18e-14	3.55e-14	3.82e-14	3.55e-14	3.80e-14		3.68e-14
-2.5	3.99e-14	3.47e-14	3.72e-14	3.47e-14	3.65e-14		3.56e-14
-3.0	3.83e-14	3.33e-14	3.59e-14	3.35e-14	3.57e-14		3.46e-14
-3.5	3.61e-14	3.19e-14	3.41e-14	3.18e-14	3.38e-14		3.28e-14
-4.0	3.40e-14	3.00e-14	3.21e-14	2.99e-14	3.18e-14		3.09e-14
-4.5	3.03e-14	2.74e-14	2.92e-14	2.74e-14	2.93e-14		2.84e-14

TABLE 6.2-8

DERIVED EXPOSURE RATES FROM CAPSULE A[1] DOSIMETRY EVALUATION
6° AZIMUTH - 270° REFERENCE - CORE MIDPLANE

	Trial Value	Adjusted Value	1σ Uncertainty
$\phi(E > 1.0$ MeV)	1.11e+09	9.57e+08	7%
$\phi(E > 0.1$ MeV)	1.07e+10	8.58e+09	16%
$\phi(E < 0.414$ eV)	2.68e+09	6.34e+08	26%
dpa/sec	3.68e-12	2.99e-12	12%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
6° AZIMUTH - 270° REFERENCE - CORE MIDPLANE

	Reaction Rate (rps/nucleus)				
	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	7.45e-19	7.94e-19	7.38e-19	0.94	1.01
^{46}Ti (n,p) Cd	1.07e-17	1.11e-17	1.05e-17	0.96	1.02
^{54}Fe (n,p) Cd	5.44e-17	6.27e-17	5.51e-17	0.87	0.99
^{58}Ni (n,p) Cd	7.43e-17	8.80e-17	7.57e-17	0.84	0.98
^{238}U (n,f) Cd	2.44e-16	3.24e-16	2.81e-16	0.75	0.87
^{235}U (n,f) Cd	8.47e-14	2.20e-13	8.31e-14	0.39	1.02
^{238}U (n,f) Cd[2]	3.23e-16	3.24e-16	2.81e-16	1.00	1.15
^{235}U (n,f) Cd[2]	7.24e-14	2.20e-13	8.31e-14	0.33	0.87
^{237}Np (n,f) Cd	4.38e-15	4.70e-15	4.13e-15	0.93	1.06
^{59}Co (n,γ)	4.32e-14	1.34e-13	4.36e-14	0.32	0.99
^{59}Co (n,γ) Cd	2.72e-14	6.22e-14	2.69e-14	0.44	1.01

[1] Dosimetry capsule A irradiated during Cycles 8 and 9, Reference 6

[2] Paired Uranium Dosimeter (PUD) measurement

TABLE 6.2-9

DERIVED EXPOSURE RATES FROM CAPSULE C[1] DOSIMETRY EVALUATION
6° AZIMUTH - 270° REFERENCE - CORE BOTTOM

	Trial Value	Adjusted Value	1σ Uncertainty
$\phi(E > 1.0$ MeV)	1.11e+09	2.13e+08	8%
$\phi(E > 0.1$ MeV)	1.07e+10	2.70e+09	17%
$\phi(E < 0.414$ eV)	2.68e+09	2.72e+08	29%
dpa/sec	3.68e-12	8.73e-13	14%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
6° AZIMUTH - 270° REFERENCE - CORE BOTTOM

Reaction Rate (rps/nucleus)

	Measured	Trial[2] Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	1.13e-19	7.94e-19	1.16e-19	0.14	0.97
^{46}Ti (n,p) Cd	1.81e-18	1.11e-17	1.78e-18	0.16	1.02
^{54}Fe (n,p) Cd	9.88e-18	6.27e-17	9.93e-18	0.16	0.99
^{58}Ni (n,p) Cd	1.42e-17	8.80e-17	1.42e-17	0.16	1.00
^{238}U (n,f) Cd	5.62e-17	3.24e-16	5.70e-17	0.17	0.99
^{235}U (n,f) Cd	4.33e-14	2.20e-13	4.32e-14	0.20	1.00
^{238}U (n,f) Cd[3]	5.55e-17	3.24e-16	5.70e-17	0.17	0.97
^{235}U (n,f) Cd[3]	4.05e-14	2.20e-13	4.32e-14	0.18	0.94
^{237}Np (n,f) Cd	1.10e-15	4.70e-15	1.07e-15	0.23	1.03
^{59}Co (n,γ)	2.18e-14	1.34e-13	2.21e-14	0.16	0.99
^{59}Co (n,γ) Cd	1.51e-14	6.22e-14	1.49e-14	0.24	1.01

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1 Dosimetry capsule C irradiated during Cycles 8 and 9, Reference 6

2 Calculated using midplane reference spectrum without axial adjustment

3 Paired Uranium Dosimeter (PUD) measurement

TABLE 6.2-10

DERIVED EXPOSURE RATES FROM CAPSULE J DOSIMETRY EVALUATION
16° AZIMUTH - 280° REFERENCE - CORE MIDPLANE

	Trial Value	Adjusted Value	1σ Uncertainty
φ(E > 1.0 MeV)	1.07e+09	8.56e+08	8%
φ(E > 0.1 MeV)	9.63e+09	7.36e+09	16%
φ(E < 0.414 eV)	2.20e+09	4.84e+08	27%
dpa/sec	3.37e-12	2.59e-12	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
16° AZIMUTH - 280° REFERENCE - CORE MIDPLANE

	Reaction Rate (rps/nucleus)				
	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	7.06e-19	8.00e-19	7.03e-19	0.88	1.00
^{46}Ti (n,p) Cd	1.02e-17	1.12e-17	1.00e-17	0.91	1.02
^{54}Fe (n,p) Cd	5.13e-17	6.25e-17	5.19e-17	0.82	0.99
^{58}Ni (n,p) Cd	7.25e-17	8.73e-17	7.25e-17	0.83	1.00
^{238}U (n,f) Cd	2.38e-16	3.16e-16	2.53e-16	0.75	0.94
^{235}U (n,f) Cd	6.13e-14	1.82e-13	6.89e-14	0.34	0.89
^{237}Np (n,f) Cd	3.94e-15	4.38e-15	3.66e-15	0.90	1.08
^{59}Co (n,γ)	3.57e-14	1.10e-13	3.61e-14	0.32	0.99
^{59}Co (n,γ) Cd	2.36e-14	5.12e-14	2.33e-14	0.46	1.01

TABLE 6.2-11

DERIVED EXPOSURE RATES FROM CAPSULE K DOSIMETRY EVALUATION
26° AZIMUTH - 290° REFERENCE - CORE MIDPLANE

	Trial Value	Adjusted Value	1 σ Uncertainty
ϕ(E > 1.0 MeV)	9.06e+08	7.83e+08	8%
ϕ(E > 0.1 MeV)	8.55e+09	6.86e+09	16%
ϕ(E < 0.414 eV)	2.18e+09	3.76e+08	29%
dpa/sec	2.97e-12	2.40e-12	12%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
26° AZIMUTH - 290° REFERENCE - CORE MIDPLANE

	Reaction Rate (rps/nucleus)				
	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	6.05e-19	6.75e-19	5.98e-19	0.90	1.01
^{46}Ti (n,p) Cd	8.65e-18	9.41e-18	8.47e-18	0.92	1.02
^{54}Fe (n,p) Cd	4.28e-17	5.25e-17	4.41e-17	0.82	0.97
^{58}Ni (n,p) Cd	6.12e-17	7.34e-17	6.18e-17	0.83	0.99
^{238}U (n,f) Cd	2.33e-16	2.67e-16	2.29e-16	0.87	1.02
^{235}U (n,f) Cd	5.00e-14	1.77e-13	5.85e-14	0.28	0.85
^{237}Np (n,f) Cd	3.73e-15	3.80e-15	3.44e-15	0.98	1.08
^{59}Co (n,γ)	3.20e-14	1.09e-13	3.25e-14	0.29	0.98
^{59}Co (n,γ) Cd	2.28e-14	5.01e-14	2.24e-14	0.46	1.02

TABLE 6.2-12

DERIVED EXPOSURE RATES FROM CAPSULE L DOSIMETRY EVALUATION
26° AZIMUTH - 290° REFERENCE - CORE BOTTOM

	Trial Value	Adjusted Value	1σ Uncertainty
$\phi(E > 1.0$ MeV)	9.06e+08	2.48e+08	8%
$\phi(E > 0.1$ MeV)	8.55e+09	2.60e+09	17%
$\phi(E < 0.414$ eV)	2.18e+09	2.48e+08	27%
dpa/sec	2.97e-12	8.76e-13	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
26° AZIMUTH - 290° REFERENCE - CORE BOTTOM

Reaction Rate (rps/nucleus)

	Measured	Trial[1] Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	1.69e-19	6.75e-19	1.72e-19	0.25	0.98
^{46}Ti (n,p) Cd	2.58e-18	9.41e-18	2.54e-18	0.27	1.02
^{54}Fe (n,p) Cd	1.35e-17	5.25e-17	1.36e-17	0.26	0.99
^{58}Ni (n,p) Cd	1.99e-17	7.34e-17	1.96e-17	0.27	1.02
^{238}U (n,f) Cd	6.46e-17	2.67e-16	7.02e-17	0.24	0.92
^{235}U (n,f) Cd	3.07e-14	1.77e-13	3.41e-14	0.17	0.90
^{237}Np (n,f) Cd	1.16e-15	3.80e-15	1.12e-15	0.31	1.04
^{59}Co (n,γ)	1.92e-14	1.09e-13	1.94e-14	0.18	0.99
^{59}Co (n,γ) Cd	1.30e-14	5.01e-14	1.28e-14	0.26	1.02

1 Calculated using midplane reference spectrum without axial adjustment

TABLE 6.2-13

DERIVED EXPOSURE RATES FROM CAPSULE N DOSIMETRY EVALUATION
39° AZIMUTH - 315° REFERENCE - CORE MIDPLANE

	Trial Value	Adjusted Value	1σ Uncertainty
ϕ(E > 1.0 MeV)	6.70e+08	4.87e+08	8%
ϕ(E > 0.1 MeV)	6.98e+09	4.88e+09	17%
ϕ(E < 0.414 eV)	2.17e+09	5.26e+08	26%
dpa/sec	2.38e-12	1.67e-12	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
39° AZIMUTH - 315° REFERENCE - CORE MIDPLANE

	Reaction Rate (rps/nucleus)				
	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	4.19e-19	4.70e-19	4.16e-19	0.89	1.01
^{46}Ti (n,p) Cd	5.89e-18	6.57e-18	5.80e-18	0.90	1.02
^{54}Fe (n,p) Cd	2.96e-17	3.73e-17	3.00e-17	0.79	0.99
^{58}Ni (n,p) Cd	4.19e-17	5.25e-17	4.19e-17	0.80	1.00
^{238}U (n,f) Cd	1.38e-16	1.95e-16	1.45e-16	0.71	0.95
^{235}U (n,f) Cd	6.42e-14	1.71e-13	6.95e-14	0.38	0.92
^{237}Np (n,f) Cd	2.21e-15	2.94e-15	2.13e-15	0.75	1.04
^{59}Co (n,γ)	3.55e-14	1.07e-13	3.58e-14	0.33	0.99
^{59}Co (n,γ) Cd	2.23e-14	4.87e-14	2.21e-14	0.46	1.01

TABLE 6.2-14

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 9 IRRADIATION

Feet from Midplane	Neutron Flux (n/cm^2-sec) 6°[1]	16°	24°	26°	39°
+0.5	9.69e+08	8.51e+08	7.69e+08	7.74e+08	4.84e+08
0.0			7.83e+08		
-0.38		8.90e+08			
-0.5	9.44e+08	8.61e+08	7.53e+08	7.92e+08	4.90e+08
-1.0	9.28e+08	8.59e+08	7.69e+08	7.45e+08	4.79e+08
-1.5	9.03e+08	8.18e+08	7.46e+08	7.79e+08	4.23e+08
-2.0	7.71e+08	7.56e+08	7.29e+08	7.21e+08	4.11e+08
-2.5	7.22e+08	7.16e+08	6.72e+08	6.82e+08	3.88e+08
-3.0	5.82e+08	6.39e+08	6.30e+08	6.26e+08	3.84e+08
-3.5	5.50e+08	5.96e+08	5.65e+08	5.86e+08	3.42e+08
-4.0	5.27e+08	4.91e+08	4.86e+08	5.47e+08	2.90e+08
-4.5	3.23e+08	3.59e+08	3.89e+08	4.47e+08	2.47e+08
-5.0	2.27e+08	2.56e+08	2.60e+08	3.12e+08	1.90e+08
-5.5		1.96e+08	2.05e+08		1.46e+08

[1] Dosimetry capsules A and C irradiated during Cycles 8 and 9, Reference 6

TABLE 6.2-15

FAST NEUTRON FLUX (E > 0.1 MeV) AS A FUNCTION OF AXIAL POSITION WITHIN THE REACTOR CAVITY SHORT GRADIENT CHAINS - CYCLE 9 IRRADIATION

Feet from	Neutron Flux (n/cm^2-sec)				
Midplane	6°[1]	16°	24°	26°	39°
+0.5	8.70e+09	7.32e+09	6.74e+09	6.78e+09	4.85e+09
0.0			6.86e+09		
-0.38		7.65e+09			
-0.5	8.47e+09	7.40e+09	6.60e+09	6.94e+09	4.90e+09
-1.0	8.33e+09	7.38e+09	6.74e+09	6.53e+09	4.79e+09
-1.5	8.11e+09	7.04e+09	6.54e+09	6.82e+09	4.23e+09
-2.0	6.92e+09	6.50e+09	6.39e+09	6.32e+09	4.11e+09
-2.5	6.48e+09	6.15e+09	5.89e+09	5.98e+09	3.88e+09
-3.0	5.22e+09	5.49e+09	5.52e+09	5.49e+09	3.84e+09
-3.5	4.94e+09	5.12e+09	4.95e+09	5.14e+09	3.43e+09
-4.0	4.73e+09	4.22e+09	4.26e+09	4.80e+09	2.90e+09
-4.5	2.90e+09	3.08e+09	3.41e+09	3.92e+09	2.48e+09
-5.0	2.03e+09	2.20e+09	2.28e+09	2.74e+09	1.90e+09
-5.5		1.69e+09	1.79e+09		1.46e+09

[1] Dosimetry capsules A and C irradiated during Cycles 8 and 9, Reference 6

TABLE 6.2-16

IRON ATOM DISPLACEMENT RATE AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 9 IRRADIATION

Feet from	Displacement Rate (dpa/sec)				
Midplane	6°[1]	16°	24°	26°	39°
+0.5	3.03e-12	2.58e-12	2.35e-12	2.37e-12	1.66e-12
0.0			2.40e-12		
-0.38		2.69e-12			
-0.5	2.95e-12	2.60e-12	2.31e-12	2.43e-12	1.68e-12
-1.0	2.90e-12	2.60e-12	2.36e-12	2.28e-12	1.64e-12
-1.5	2.82e-12	2.48e-12	2.29e-12	2.38e-12	1.45e-12
-2.0	2.41e-12	2.29e-12	2.23e-12	2.21e-12	1.41e-12
-2.5	2.26e-12	2.16e-12	2.06e-12	2.09e-12	1.33e-12
-3.0	1.82e-12	1.93e-12	1.93e-12	1.92e-12	1.32e-12
-3.5	1.72e-12	1.80e-12	1.73e-12	1.80e-12	1.18e-12
-4.0	1.65e-12	1.48e-12	1.49e-12	1.68e-12	9.94e-13
-4.5	1.01e-12	1.08e-12	1.19e-12	1.37e-12	8.50e-13
-5.0	7.08e-13	7.76e-13	7.97e-13	9.56e-13	6.51e-13
-5.5		5.93e-13	6.27e-13		5.00e-13

[1] Dosimetry capsules A and C irradiated during Cycles 8 and 9, Reference 6

TABLE 6.2-17

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION WITHIN THE REACTOR CAVITY LONG GRADIENT CHAINS - CYCLE 9 IRRADIATION

Feet from	Neutron Flux (n/cm^2-sec)			
Midplane	0°	10°	20°	30°
+8.0	6.56e+07	5.96e+07	5.79e+07	5.51e+07
+7.5	1.02e+08	8.84e+07	8.26e+07	8.07e+07
+7.0	1.70e+08	1.45e+08	1.13e+08	1.30e+08
+6.5	2.57e+08	2.28e+08	1.99e+08	1.98e+08
+6.0	3.70e+08	3.15e+08	2.89e+08	2.74e+08
+5.5	4.82e+08	4.40e+08	3.90e+08	3.64e+08
+5.0	5.86e+08	5.50e+08	5.14e+08	4.62e+08
+4.5	7.02e+08	6.51e+08	6.09e+08	5.51e+08
+4.0	7.52e+08	7.38e+08	6.91e+08	6.16e+08
+3.5	8.45e+08	8.01e+08	7.38e+08	6.66e+08
+3.0	8.83e+08	8.73e+08	7.71e+08	7.01e+08
+2.5	9.13e+08	9.07e+08	7.77e+08	7.48e+08
+2.0	9.15e+08	8.87e+08	8.12e+08	7.45e+08
+1.5	9.26e+08	8.96e+08	8.13e+08	7.80e+08
+1.0	9.55e+08	9.40e+08	8.28e+08	7.55e+08
+0.5	9.46e+08	9.62e+08	8.17e+08	7.74e+08
0.0	9.57e+08	9.57e+08	8.56e+08	7.83e+08
-0.5	9.52e+08	9.57e+08	8.66e+08	7.99e+08
-1.0	9.53e+08	9.60e+08	8.79e+08	7.83e+08
-1.5	8.47e+08	9.76e+08	8.70e+08	7.67e+08
-2.0	8.27e+08	9.47e+08	8.43e+08	7.65e+08
-2.5	7.61e+08	8.89e+08	8.00e+08	7.40e+08
-3.0	7.63e+08	8.39e+08	7.51e+08	7.21e+08
-3.5	7.14e+08	7.95e+08	7.01e+08	6.60e+08
-4.0	6.33e+08	6.81e+08	6.02e+08	5.77e+08
-4.5	5.43e+08	5.76e+08	5.46e+08	5.17e+08

TABLE 6.2-18

FAST NEUTRON FLUX (E > 0.1 MeV) AS A FUNCTION OF AXIAL POSITION WITHIN THE REACTOR CAVITY LONG GRADIENT CHAINS - CYCLE 9 IRRADIATION

Feet from Midplane	Neutron Flux (n/cm^2-sec) 0°	10°	20°	30°
+8.0	5.89e+08	5.35e+08	4.97e+08	4.83e+08
+7.5	9.13e+08	7.93e+08	7.10e+08	7.07e+08
+7.0	1.53e+09	1.30e+09	9.69e+08	1.14e+09
+6.5	2.30e+09	2.05e+09	1.71e+09	1.73e+09
+6.0	3.32e+09	2.83e+09	2.49e+09	2.40e+09
+5.5	4.33e+09	3.95e+09	3.35e+09	3.19e+09
+5.0	5.26e+09	4.93e+09	4.42e+09	4.05e+09
+4.5	6.30e+09	5.84e+09	5.24e+09	4.83e+09
+4.0	6.75e+09	6.62e+09	5.94e+09	5.40e+09
+3.5	7.58e+09	7.19e+09	6.35e+09	5.84e+09
+3.0	7.92e+09	7.84e+09	6.63e+09	6.14e+09
+2.5	8.19e+09	8.14e+09	6.67e+09	6.55e+09
+2.0	8.21e+09	7.96e+09	6.98e+09	6.53e+09
+1.5	8.31e+09	8.04e+09	6.99e+09	6.83e+09
+1.0	8.57e+09	8.44e+09	7.12e+09	6.61e+09
+0.5	8.49e+09	8.63e+09	7.02e+09	6.78e+09
0.0	8.59e+09	8.59e+09	7.36e+09	6.86e+09
-0.5	8.54e+09	8.59e+09	7.44e+09	7.00e+09
-1.0	8.55e+09	8.62e+09	7.55e+09	6.86e+09
-1.5	7.60e+09	8.76e+09	7.48e+09	6.72e+09
-2.0	7.42e+09	8.50e+09	7.25e+09	6.70e+09
-2.5	6.82e+09	7.97e+09	6.87e+09	6.48e+09
-3.0	6.85e+09	7.53e+09	6.45e+09	6.32e+09
-3.5	6.41e+09	7.13e+09	6.03e+09	5.79e+09
-4.0	5.68e+09	6.11e+09	5.17e+09	5.05e+09
-4.5	4.87e+09	5.17e+09	4.69e+09	4.53e+09

TABLE 6.2-19

IRON ATOM DISPLACEMENT RATE AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
LONG GRADIENT CHAINS - CYCLE 9 IRRADIATION

Feet from	Displacement Rate (dpa/sec)			
Midplane	0°	10°	20°	30°
+8.0	2.05e-13	1.86e-13	1.75e-13	1.69e-13
+7.5	3.18e-13	2.76e-13	2.50e-13	2.47e-13
+7.0	5.31e-13	4.54e-13	3.41e-13	3.99e-13
+6.5	8.02e-13	7.14e-13	6.02e-13	6.06e-13
+6.0	1.15e-12	9.85e-13	8.75e-13	8.39e-13
+5.5	1.51e-12	1.37e-12	1.18e-12	1.12e-12
+5.0	1.83e-12	1.72e-12	1.55e-12	1.42e-12
+4.5	2.19e-12	2.03e-12	1.84e-12	1.69e-12
+4.0	2.35e-12	2.30e-12	2.09e-12	1.89e-12
+3.5	2.64e-12	2.50e-12	2.23e-12	2.04e-12
+3.0	2.76e-12	2.73e-12	2.33e-12	2.15e-12
+2.5	2.85e-12	2.83e-12	2.35e-12	2.29e-12
+2.0	2.86e-12	2.77e-12	2.45e-12	2.28e-12
+1.5	2.89e-12	2.80e-12	2.46e-12	2.39e-12
+1.0	2.99e-12	2.94e-12	2.51e-12	2.31e-12
+0.5	2.96e-12	3.00e-12	2.47e-12	2.37e-12
0.0	2.99e-12	2.99e-12	2.59e-12	2.40e-12
-0.5	2.97e-12	2.99e-12	2.62e-12	2.45e-12
-1.0	2.98e-12	3.00e-12	2.66e-12	2.40e-12
-1.5	2.65e-12	3.05e-12	2.63e-12	2.35e-12
-2.0	2.58e-12	2.96e-12	2.55e-12	2.34e-12
-2.5	2.38e-12	2.78e-12	2.42e-12	2.27e-12
-3.0	2.38e-12	2.62e-12	2.27e-12	2.21e-12
-3.5	2.23e-12	2.48e-12	2.12e-12	2.02e-12
-4.0	1.98e-12	2.13e-12	1.82e-12	1.77e-12
-4.5	1.70e-12	1.80e-12	1.65e-12	1.58e-12

FIGURE 6.2-1

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION ALONG THE 6.0 DEGREE TRAVERSE IN THE REACTOR CAVITY SHORT GRADIENT CHAINS - CYCLES 8 AND 9 IRRADIATION

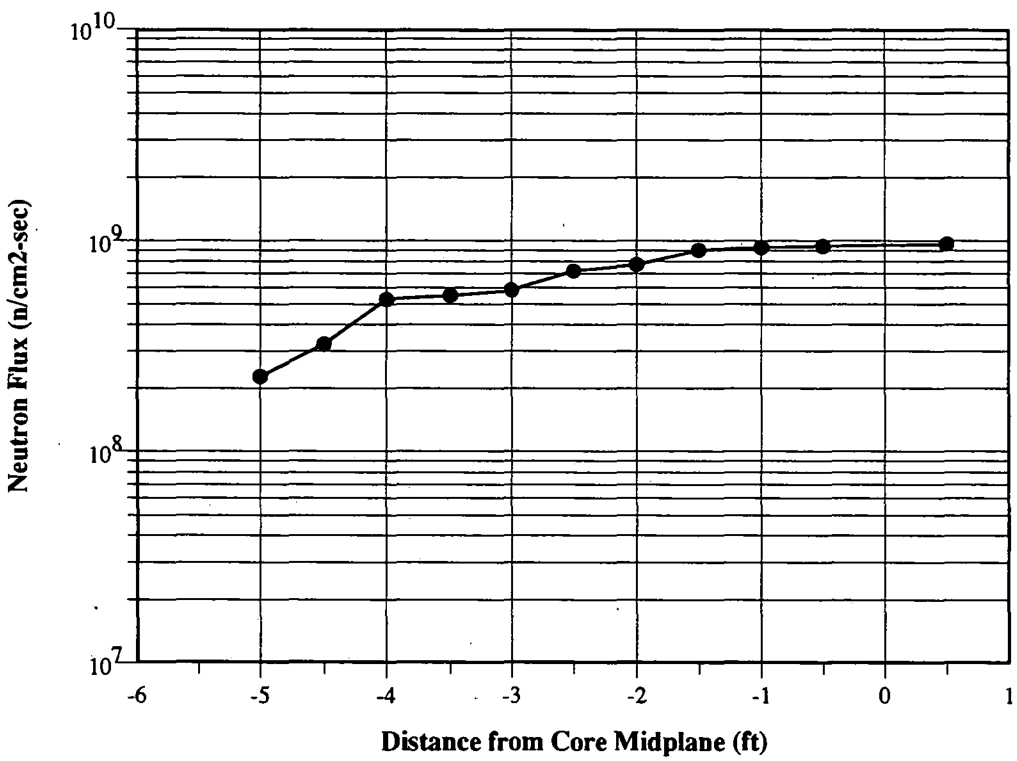


FIGURE 6.2-2

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION ALONG THE 16.0 DEGREE TRAVERSE IN THE REACTOR CAVITY SHORT GRADIENT CHAINS - CYCLE 9 IRRADIATION

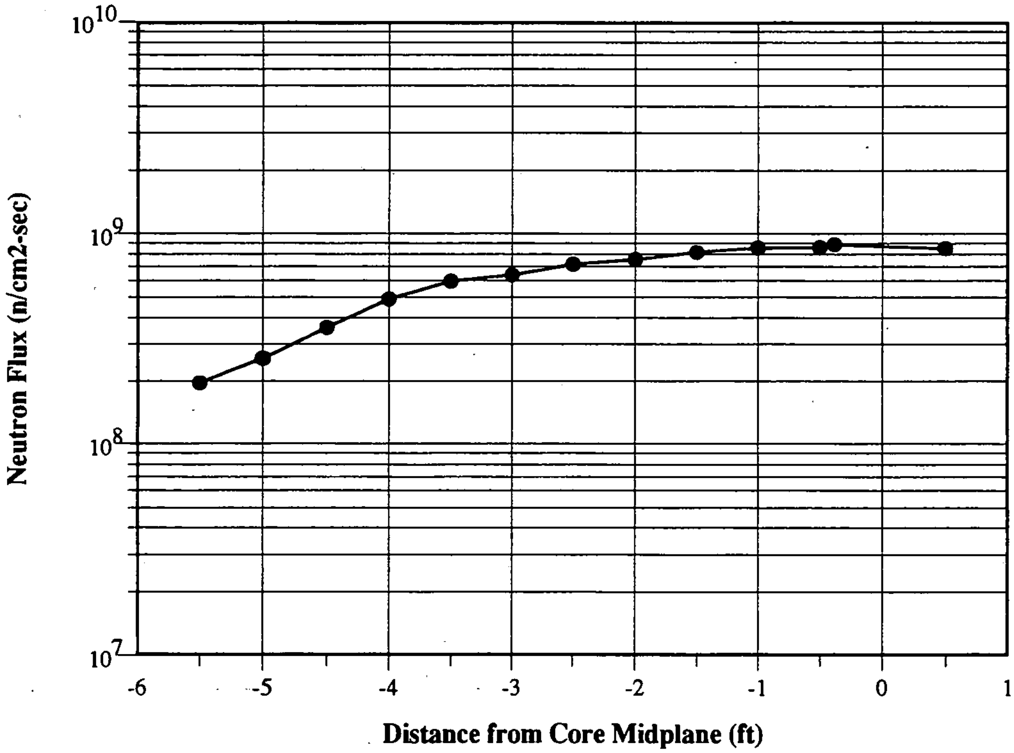


FIGURE 6.2-3

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 24.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 9 IRRADIATION

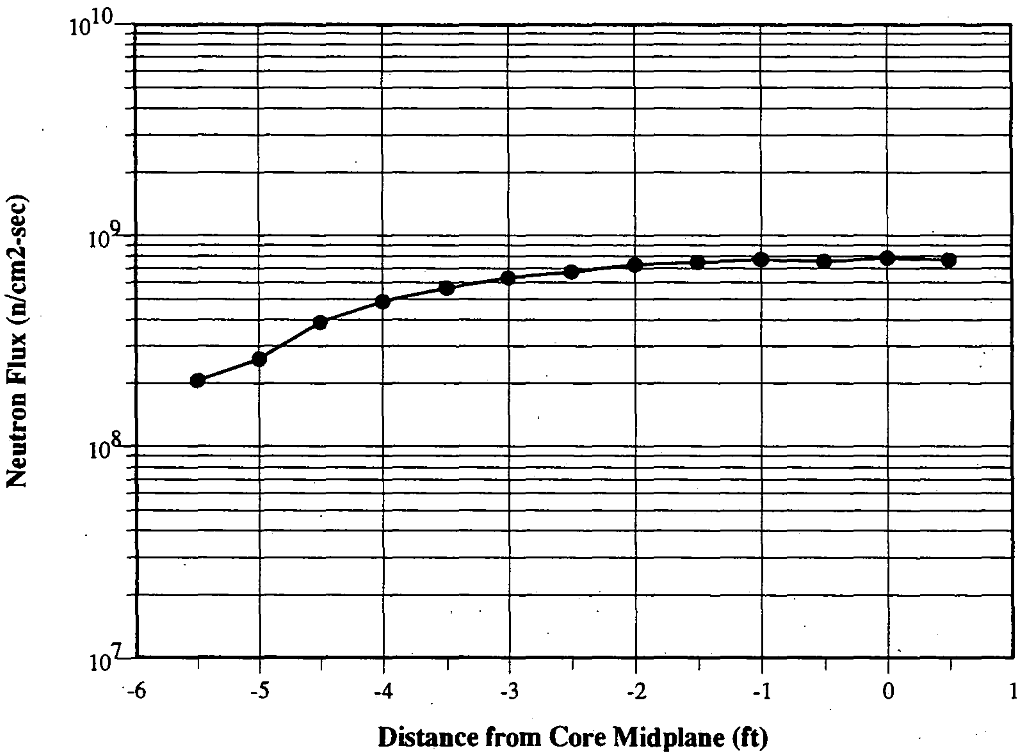


FIGURE 6.2-4

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 26.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 9 IRRADIATION

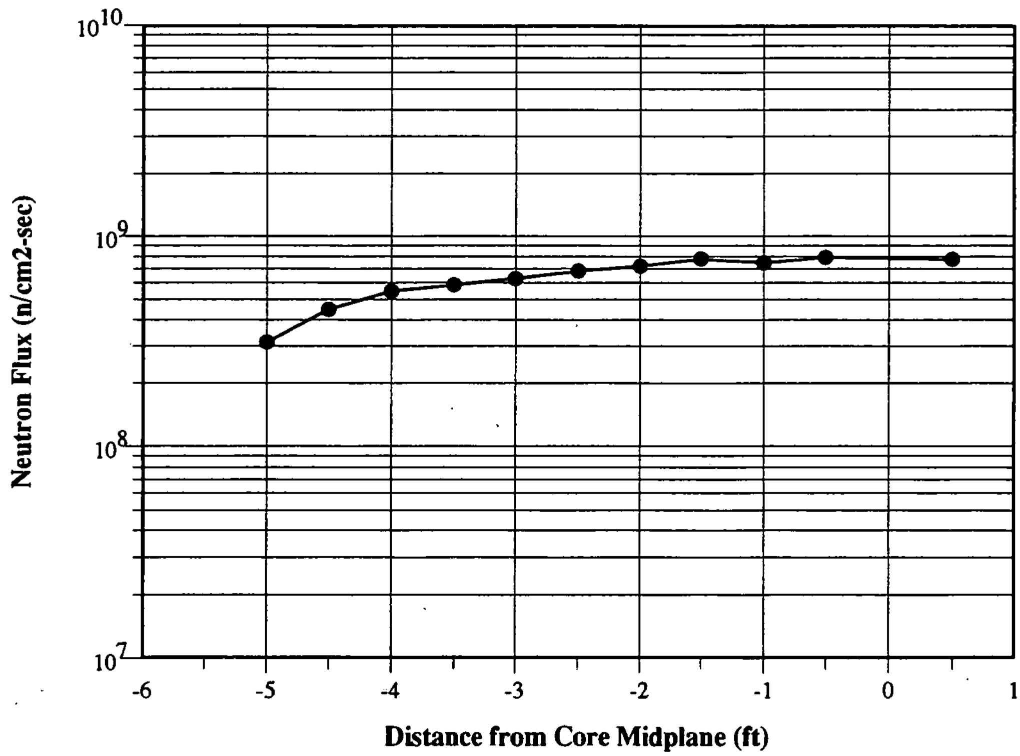


FIGURE 6.2-5

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 39.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 9 IRRADIATION

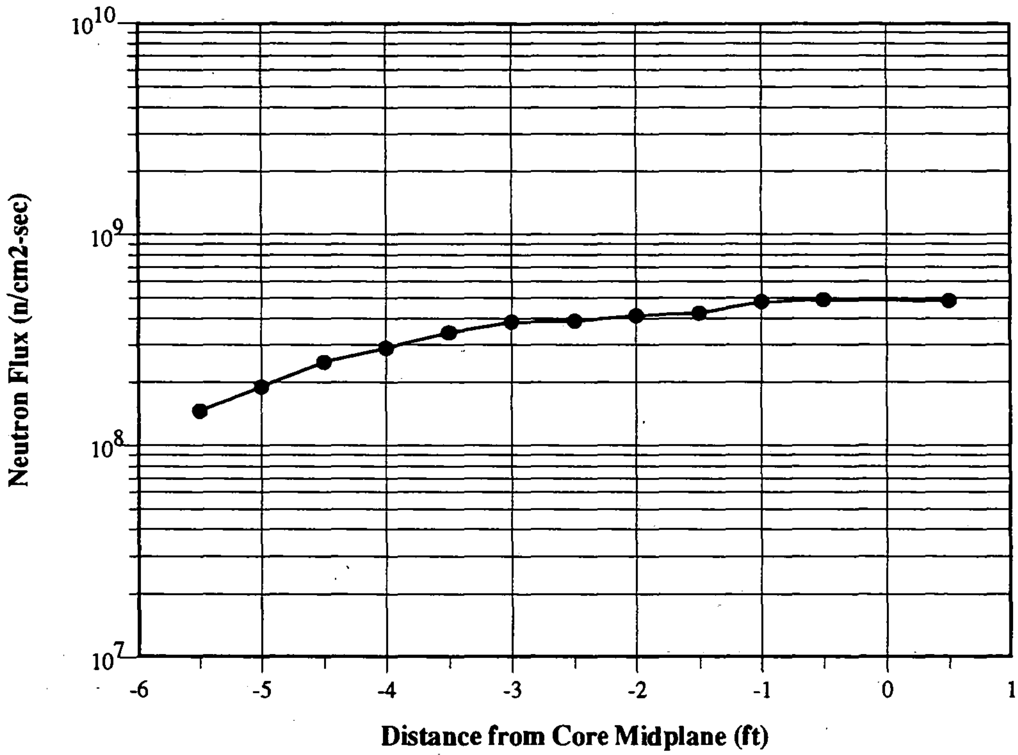


FIGURE 6.2-6

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 0.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
LONG GRADIENT CHAINS - CYCLE 9 IRRADIATION

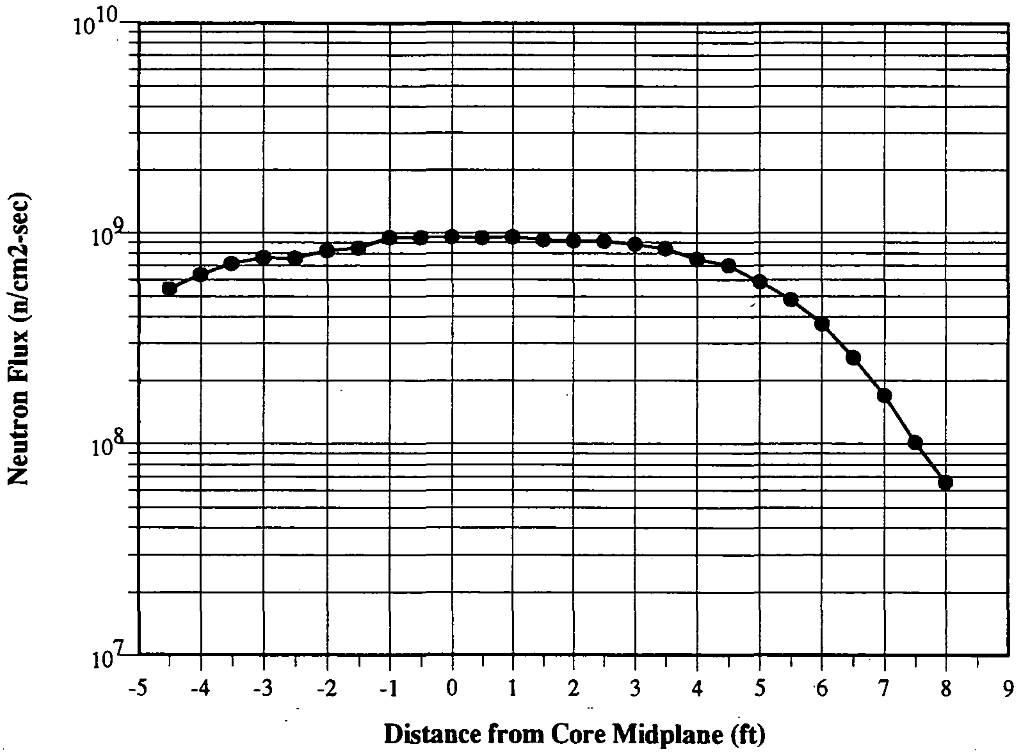


FIGURE 6.2-7

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 10.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
LONG GRADIENT CHAINS - CYCLE 9 IRRADIATION

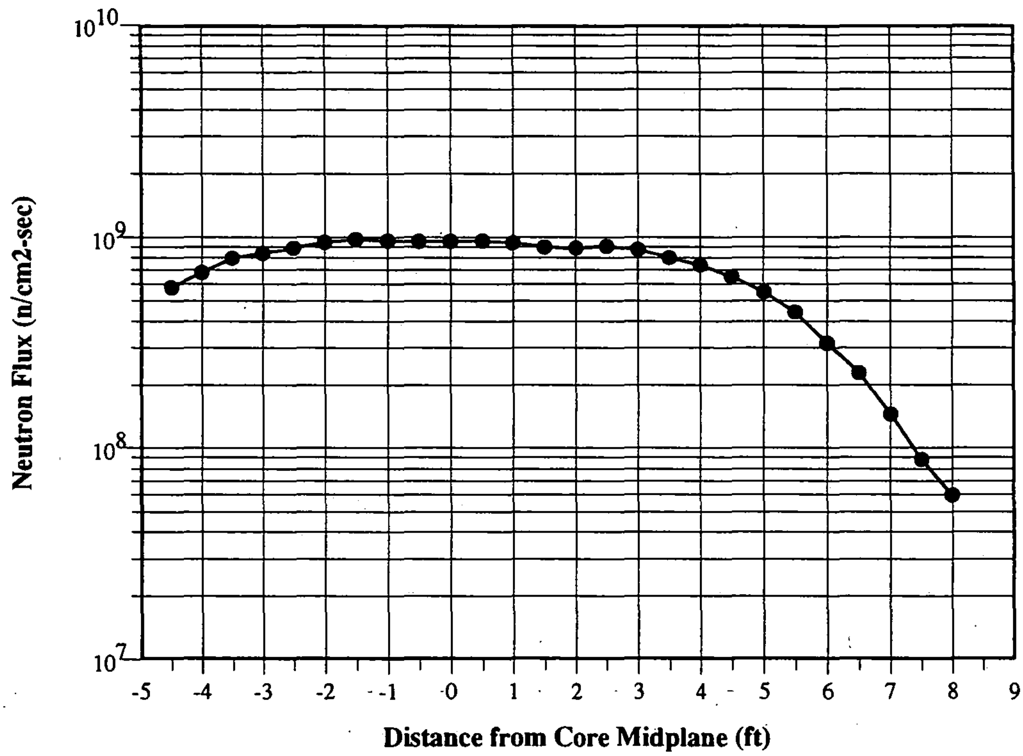


FIGURE 6.2-8

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION ALONG THE 20.0 DEGREE TRAVERSE IN THE REACTOR CAVITY LONG GRADIENT CHAINS - CYCLE 9 IRRADIATION

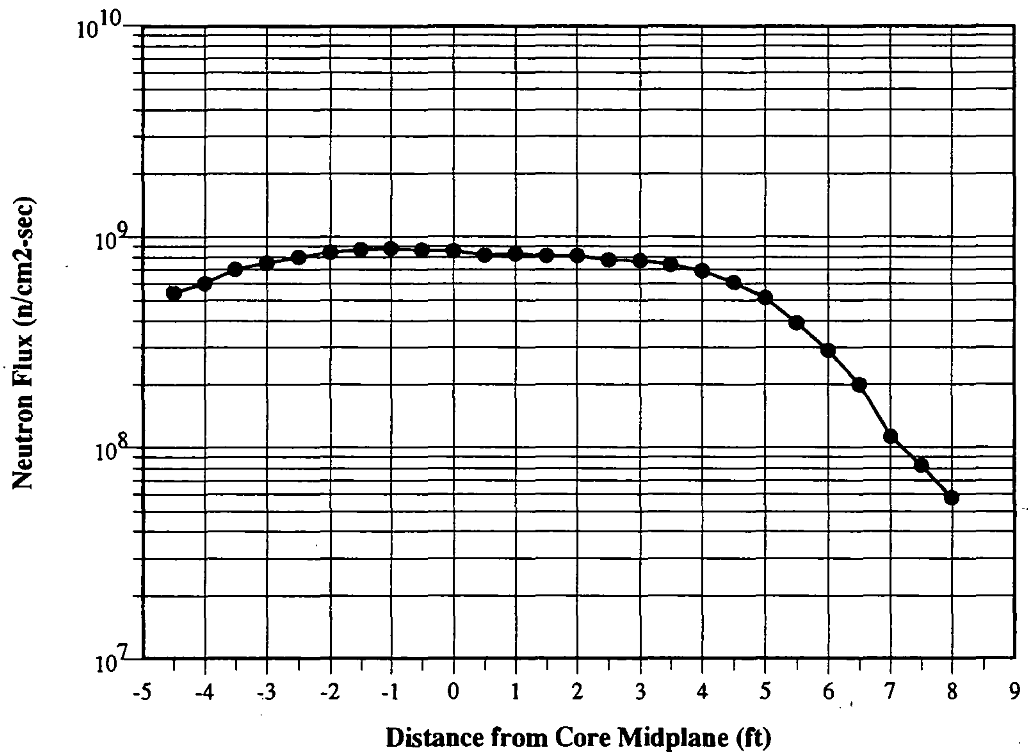
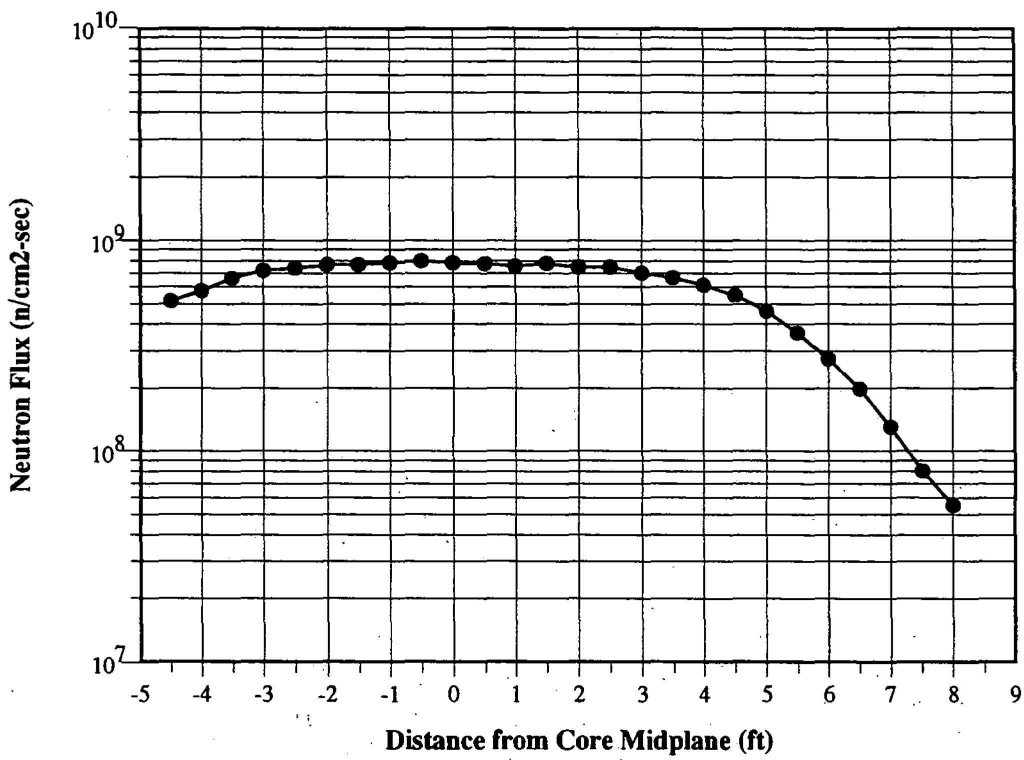


FIGURE 6.2-9

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 30.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
LONG GRADIENT CHAINS - CYCLE 9 IRRADIATION



6.3 Cycle 10/11 Results

6.3.1 Measured Reaction rates

During the Cycle 10/11 irradiation, seven multiple foil sensor sets, and twelve stainless steel gradient chains were deployed in the reactor cavity. The capsule identifications associated with each of the multiple foil sensor sets mounted from the dosimetry support bar were as follows:

Reference		Bar	Capsule Identification	
Azimuth	FOE	Shifted Angle	Core Midplane	Core Bottom
270°	0°	6°	O	
280°	10°	16°	P	Q
290°	20°	26°	R	
300°	30°	36°	S	
315°	45°	39°	T	
330°	30°	24°	U	

The contents of each of these irradiation capsules is specified in Appendix D to this report.

The shipment of irradiation capsules and gradient chains was examined upon receipt at our counting facilities at Waltz Mill. All dosimetry was found to be in good order. As the individual capsules were opened to remove the sensors, the sensor IDs were cross checked against the as-built documentation[3]. A capsule by capsule description of the contents of the irradiation capsules follows.

Capsule O (270 degrees - Core Midplane): All of the dosimetry IDs matched the data in Table 2-3 in WCAP-13552. All of the metal foils were bright and shiny with the exception of the copper foil which exhibited some discoloration.

Capsule P (280 degrees - Core Midplane): All of the dosimetry IDs matched the data in Table 2-3 in WCAP-13552. All of the metal foils were bright and shiny with the exception of the copper foil which exhibited some discoloration.

Capsule Q (280 degrees - Bottom of Core): All of the dosimetry IDs matched the data in Table 2-3 in WCAP-13552. The foils in this set had discolorations that were indicative of high temperatures. In particular, the iron foils had a "blue-black" tempered look.

Capsule R (290 degrees - Core Midplane): All of the dosimetry IDs matched the data in Table 2-3 in WCAP-13552. All of the metal foils were bright and shiny with the exception of the copper foil which exhibited some discoloration.

Capsule S (300 degrees - Core Midplane): All of the dosimetry IDs matched the data in Table 2-3 in WCAP-13552 All of the metal foils were bright and shiny with a couple of exceptions. The copper foil exhibited a blackened discoloration on the edge which covered approximately 15% of the foil surface.

Capsule T (315 degrees - Core Midplane): All of the dosimetry IDs matched the data in Table 2-3 in WCAP-13552. All of the metal foils were bright and shiny with the exception of the copper foil which exhibited some discoloration.

Capsule U (330 degrees - Core Midplane): All of the dosimetry IDs matched the data in Table 2-3 in WCAP-13552. All of the metal foils were bright and shiny.

In general, the copper foils tended to exhibited discoloration, whereas, the other foils were bright and shiny.

The irradiation history of the Palisades reactor during Cycle 10/11 is also listed in Appendix D. The irradiation history was obtained from NUREG-0020, "Licensed Operating Reactors Status Summary Report" for the applicable operating period. Based on this reactor operating history, the individual sensor characteristics, and the measured specific activities given in Appendix D, cycle average reaction rates referenced to a core power level of 2530 MWt were computed for each multiple foil sensor and gradient chain segment.

The computed reaction rates for the radiometric foil sensor sets irradiated during Cycle 10/11 are provided in Table 6.3-1. Corresponding reaction rate data from the twelve stainless steel gradient chains are recorded in Tables 6.3-2 through 6.3-7 for the ^{54}Fe(n,p), ^{58}Ni(n,p), and ^{59}Co(n,γ) reactions, respectively.

In regard to the data listed in Table 6.3-1, the ^{54}Fe(n,p) reaction rates represent an average of the bare and cadmium covered measurements for each capsule. In addition, the fission rate measurements include corrections for ^{235}U impurities in the ^{238}U sensors as well as corrections for photofission reactions in both the ^{238}U and ^{237}Np sensors. It should be noted that the changes in the measured data, as compared to the previous analysis in Reference 6, are due to the elimination of conservatism which is specific to this Palisades analysis. This included photofission reaction corrections, as noted above, and use of the long half-life ^{238}U (n,f) ^{137}Cs and ^{237}Np (n,f) ^{137}Cs reactions.

6.3.2 Results of the Least Squares Adjustment Procedure

The results of the application of the least squares adjustment procedure to the seven sets of multiple foil measurements obtained from the Cycle 10/11 irradiation are provided in Tables 6.3-8 through 6.3-14. In these tables, the derived exposure experienced at each sensor set location along with data illustrating the fit of both the trial and adjusted spectra to the measurements are given. Also included in the tabulations are the 1σ uncertainties associated with each of the derived exposure rates.

In regard to the comparisons listed in Tables 6.3-8 through 6.3-14, it should be noted that the columns labeled "trial calc" represent the absolute calculated neutron flux (E > 1.0 MeV) from Table 4.1-3 averaged over the Cycle 10/11 irradiation period as discussed in Section 3. Thus, the comparisons illustrated in Tables 6.3-8 through 6.3-14 indicate the degree to which the calculated neutron energy spectra matched the measured data before and after adjustment. Absolute comparisons of calculation and measurement are discussed further in Section 7 of this report.

Complete traverses of fast neutron exposure rates in the reactor cavity were developed by combining the results of the least squares adjustment of the multiple foil data with the ^{54}Fe(n,p) reaction rate measurements from the gradient chains. The gradient data were employed to establish relative axial distributions over the measurement range and these relative distributions were then normalized to the FERRET results from the midplane sensor sets to produce axial distributions of exposure rates in terms of $\phi(E > 1.0$ MeV), $\phi(E > 0.1$ MeV), and dpa/sec in the reactor cavity.

The resultant axial distributions of $\phi(E > 1.0$ MeV), $\phi(E > 0.1$ MeV), and dpa/sec from the gradient chain measurements are given in Tables 6.3-15 through 6.3-17 for the short chains and Tables 6.3-18 through 6.3-20 for the long chains, respectively. The distributions of $\phi(E > 1.0$ MeV) are depicted graphically in Figures 6.3-1 through 6.3-10. In these graphical presentations,

TABLE 6.3-1

SUMMARY OF REACTION RATES DERIVED FROM MULTIPLE FOIL SENSOR SETS
CYCLE 10/11 IRRADIATION

	Reaction Rate (rps/nucleus)						
Reaction	Capsule O	Capsule P	Capsule Q	Capsule R	Capsule S	Capsule T	Capsule U
^{63}Cu (n,α) Cd	5.20e-19	5.42e-19	1.31e-19	4.95e-19	4.15e-19	3.70e-19	4.48e-19
^{46}Ti (n,p) Cd	7.02e-18	7.52e-18	1.94e-18	7.11e-18	5.54e-18	5.51e-18	6.40e-18
^{54}Fe (n,p) Cd	3.62e-17	3.83e-17	9.91e-18	3.53e-17	2.80e-17	2.73e-17	3.20e-17
^{58}Ni (n,p) Cd	5.03e-17	5.48e-17	1.47e-17	4.86e-17	7.70e-17	3.83e-17	4.54e-17
^{238}U (n,f) Cd	2.16e-16	1.97e-16	4.73e-17	1.85e-16	1.52e-16	1.40e-16	1.86e-16
^{237}Np (n,f) Cd	2.57e-15	2.73e-15		2.61e-15	2.09e-15	1.99e-15	2.04e-15
^{59}Co (n,γ)	2.84e-14	2.74e-14	1.54e-14	2.58e-14	2.54e-14	2.94e-14	3.08e-14
^{59}Co (n,γ) Cd	1.84e-14	1.82e-14	1.03e-14	1.78e-14	1.81e-14	1.86e-14	1.92e-14

Note: Cd indicates that the sensor was cadmium covered.

TABLE 6.3-2

^{54}Fe (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL SHORT GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

Feet from	Reaction Rate (rps/nucleus)					
Midplane	6°	16°	24°	26°	36°	39°
+0.5	2.03e-18	2.16e-18	1.64e-18	1.83e-18	1.59e-18	1.50e-18
-0.5	2.00e-18	2.06e-18	1.75e-18	1.89e-18	1.56e-18	1.53e-18
-1.0						
-1.5	1.73e-18	2.09e-18	1.63e-18	1.91e-18	1.51e-18	1.38e-18
-2.0						
-2.5	1.49e-18	1.79e-18	1.65e-18	1.72e-18	1.54e-18	1.16e-18
-3.0						
-3.5	1.13e-18	1.58e-18	1.40e-18	1.50e-18	1.26e-18	1.03e-18
-4.0						
-4.5	7.14e-19	1.02e-18	1.03e-18	1.15e-18	1.00e-18	8.84e-19
-5.0						
-5.5	3.52e-19	4.07e-19	4.94e-19	6.23e-19	5.83e-19	4.33e-19

TABLE 6.3-3

^{58}Ni (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL SHORT GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

Feet from	Reaction Rate (rps/nucleus)					
Midplane	6°	16°	24°	26°	36°	39°
+0.5	3.32e-17	3.65e-17	2.78e-17	3.10e-17	2.70e-17	2.50e-17
-0.5	3.23e-17	3.62e-17	2.87e-17	3.13e-17	2.68e-17	2.37e-17
-1.0						
-1.5	2.88e-17	3.43e-17	2.83e-17	3.15e-17	2.60e-17	2.35e-17
-2.0						
-2.5	2.69e-17	2.99e-17	2.87e-17	2.87e-17	2.38e-17	2.18e-17
-3.0						
-3.5	2.02e-17	2.74e-17	2.54e-17	2.61e-17	2.21e-17	1.91e-17
-4.0						
-4.5	1.24e-17	1.88e-17	1.88e-17	2.07e-17	1.84e-17	1.56e-17
-5.0						
-5.5	6.52e-18	7.44e-18	9.40e-18	1.14e-17	1.00e-17	8.69e-18

TABLE 6.3-4

^{59}Co (n,γ) REACTION RATES DERIVED FROM THE STAINLESS STEEL SHORT GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

Feet from Midplane	Reaction Rate (rps/nucleus)					
	6°	16°	24°	26°	36°	39°
+0.5	2.66e-14	2.62e-14	2.74e-14	2.30e-14	2.31e-14	2.59e-14
-0.5	2.58e-14	2.59e-14	2.76e-14	2.32e-14	2.32e-14	2.59e-14
-1.0						
-1.5	2.54e-14	2.56e-14	2.71e-14	2.28e-14	2.25e-14	2.50e-14
-2.0						
-2.5	2.36e-14	2.41e-14	2.59e-14	2.21e-14	2.16e-14	2.38e-14
-3.0						
-3.5	2.12e-14	2.24e-14	2.32e-14	2.07e-14	2.01e-14	2.16e-14
-4.0						
-4.5	1.60e-14	1.86e-14	1.97e-14	1.85e-14	1.79e-14	1.86e-14
-5.0						
-5.5	1.36e-14	1.43e-14	1.40e-14	1.39e-14	1.31e-14	1.27e-14

TABLE 6.3-5

^{54}Fe (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL LONG GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

	Reaction Rate (rps/nucleus)						
Feet from Midplane	Ref. 90° FOE 0°	Ref. 260° FOE 10°	Ref. 340° FOE 20°	Ref. 30° FOE 30°	Ref. 150° FOE 30°	Ref. 210° FOE 30°	Average FOE 30°
+8.0	1.31e-19	1.15e-19	1.50e-19	1.02e-19	1.27e-19	1.12e-19	1.14e-19
+7.5	1.46e-19	1.87e-19	2.13e-19	1.76e-19	1.87e-19	1.93e-19	1.85e-19
+7.0							
+6.5	4.48e-19	4.24e-19	4.18e-19	4.49e-19	4.56e-19	3.90e-19	4.31e-19
+6.0							
+5.5	8.33e-19	8.19e-19	7.70e-19	8.48e-19	8.94e-19	8.62e-19	8.68e-19
+5.0							
+4.5	1.32e-18	1.24e-18	1.16e-18	1.22e-18	1.32e-18	1.29e-18	1.27e-18
+4.0							
+3.5	1.56e-18	1.53e-18	1.45e-18	1.41e-18	1.51e-18	1.54e-18	1.49e-18
+3.0							
+2.5	1.71e-18	1.57e-18	1.58e-18	1.59e-18	1.74e-18	1.53e-18	1.62e-18
+2.0							
+1.5	1.81e-18	1.57e-18	1.58e-18	1.58e-18	1.64e-18	1.67e-18	1.63e-18
+1.0							
+0.5	1.67e-18	1.65e-18	1.67e-18	1.52e-18	1.74e-18	1.68e-18	1.65e-18
0.0	1.72e-18	1.59e-18	1.72e-18	1.53e-18	1.70e-18	1.83e-18	1.69e-18
-0.5	1.67e-18	1.65e-18	1.68e-18	1.63e-18	1.66e-18	1.67e-18	1.65e-18
-1.0							
-1.5	1.65e-18	1.68e-18	1.65e-18	1.58e-18	1.63e-18	1.69e-18	1.63e-18
-2.0							
-2.5	1.54e-18	1.49e-18	1.59e-18	1.48e-18	1.59e-18	1.58e-18	1.55e-18
-3.0							
-3.5	1.37e-18	1.32e-18	1.42e-18	1.52e-18	1.42e-18	1.33e-18	1.43e-18
-4.0							
-4.5	1.07e-18	9.31e-19	1.19e-18	1.08e-18	1.06e-18	1.05e-18	1.06e-18

TABLE 6.3-6

^{58}Ni (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL LONG GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

	Reaction Rate (rps/nucleus)						
Feet from Midplane	Ref. 90° FOE 0°	Ref. 260° FOE 10°	Ref. 340° FOE 20°	Ref. 30° FOE 30°	Ref. 150° FOE 30°	Ref. 210° FOE 30°	Average FOE 30°
+8.0	2.14e-18	2.59e-18	2.53e-18	2.12e-18	2.48e-18	1.94e-18	2.18e-18
+7.5	3.33e-18	3.48e-18	4.30e-18	3.47e-18	3.64e-18	3.72e-18	3.61e-18
+7.0							
+6.5	7.32e-18	7.95e-18	8.41e-18	7.61e-18	8.56e-18	7.77e-18	7.98e-18
+6.0							
+5.5	1.54e-17	1.43e-17	1.38e-17	1.50e-17	1.60e-17	1.58e-17	1.56e-17
+5.0							
+4.5	2.32e-17	2.21e-17	2.14e-17	2.14e-17	2.23e-17	2.45e-17	2.28e-17
+4.0							
+3.5	2.57e-17	2.69e-17	2.55e-17	2.55e-17	2.82e-17	2.74e-17	2.70e-17
+3.0							
+2.5	3.03e-17	2.80e-17	2.79e-17	2.57e-17	2.82e-17	2.82e-17	2.74e-17
+2.0							
+1.5	3.11e-17	2.83e-17	2.88e-17	2.68e-17	2.88e-17	2.85e-17	2.80e-17
+1.0							
+0.5	2.90e-17	2.69e-17	2.88e-17	2.62e-17	2.85e-17	2.96e-17	2.81e-17
0.0	2.84e-17	2.78e-17	2.85e-17	2.68e-17	2.88e-17	2.94e-17	2.83e-17
-0.5	2.82e-17	2.80e-17	2.93e-17	2.73e-17	2.72e-17	2.91e-17	2.79e-17
-1.0							
-1.5	2.84e-17	2.88e-17	2.79e-17	2.59e-17	2.71e-17	2.85e-17	2.72e-17
-2.0							
-2.5	2.64e-17	2.62e-17	2.74e-17	2.72e-17	2.82e-17	2.80e-17	2.78e-17
-3.0							
-3.5	2.49e-17	2.30e-17	2.46e-17	2.51e-17	2.45e-17	2.35e-17	2.44e-17
-4.0							
-4.5	1.79e-17	1.79e-17	2.16e-17	1.87e-17	1.89e-17	1.93e-17	1.90e-17

TABLE 6.3-7

^{59}Co (n,γ) REACTION RATES DERIVED FROM THE STAINLESS STEEL LONG GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

	Reaction Rate (rps/nucleus)						
Feet from Midplane	Ref. 90° FOE 0°	Ref. 260° FOE 10°	Ref. 340° FOE 20°	Ref. 30° FOE 30°	Ref. 150° FOE 30°	Ref. 210° FOE 30°	Average FOE 30°
+8.0	1.08e-14	1.06e-14	1.01e-14	1.03e-14	1.09e-14	1.04e-14	1.05e-14
+7.5	1.26e-14	1.19e-14	1.13e-14	1.19e-14	1.24e-14	1.20e-14	1.21e-14
+7.0							
+6.5	1.55e-14	1.44e-14	1.43e-14	1.44e-14	1.57e-14	1.53e-14	1.51e-14
+6.0							
+5.5	1.82e-14	1.68e-14	1.72e-14	1.69e-14	1.83e-14	1.79e-14	1.77e-14
+5.0							
+4.5	2.11e-14	1.89e-14	2.01e-14	1.95e-14	2.13e-14	2.12e-14	2.07e-14
+4.0							
+3.5	2.37e-14	2.10e-14	2.26e-14	2.19e-14	2.42e-14	2.35e-14	2.32e-14
+3.0							
+2.5	2.63e-14	2.27e-14	2.47e-14	2.35e-14	2.62e-14	2.57e-14	2.51e-14
+2.0							
+1.5	2.85e-14	2.38e-14	2.69e-14	2.47e-14	2.79e-14	2.74e-14	2.67e-14
+1.0							
+0.5	2.97e-14	2.45e-14	2.84e-14	2.60e-14	2.91e-14	2.84e-14	2.78e-14
0.0	2.97e-14	2.47e-14	2.88e-14	2.64e-14	2.94e-14	2.86e-14	2.81e-14
-0.5	3.02e-14	2.52e-14	2.91e-14	2.64e-14	2.96e-14	2.89e-14	2.83e-14
-1.0							
-1.5	3.04e-14	2.45e-14	2.88e-14	2.67e-14	2.94e-14	2.84e-14	2.81e-14
-2.0							
-2.5	2.89e-14	2.36e-14	2.76e-14	2.55e-14	2.84e-14	2.72e-14	2.70e-14
-3.0							
-3.5	2.61e-14	2.16e-14	2.55e-14	2.37e-14	2.57e-14	2.47e-14	2.47e-14
-4.0							
-4.5	2.03e-14	1.84e-14	2.19e-14	2.03e-14	2.24e-14	2.06e-14	2.11e-14

TABLE 6.3-8

DERIVED EXPOSURE RATES FROM CAPSULE O DOSIMETRY EVALUATION
6° AZIMUTH - 270° REFERENCE - CORE MIDPLANE

	Trial Value	Adjusted Value	1 σ Uncertainty
ϕ(E > 1.0 MeV)	6.97e+08	6.43e+08	8%
ϕ(E > 0.1 MeV)	6.66e+09	5.90e+09	17%
ϕ(E < 0.414 eV)	1.72e+09	4.22e+08	28%
dpa/sec	2.31e-12	2.05e-12	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
6° AZIMUTH - 270° REFERENCE - CORE MIDPLANE

	Reaction Rate (rps/nucleus)				
	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	5.20e-19	5.36e-19	5.13e-19	0.97	1.01
^{46}Ti (n,p) Cd	7.02e-18	7.42e-18	6.97e-18	0.95	1.01
^{54}Fe (n,p) Cd	3.62e-17	4.09e-17	3.71e-17	0.89	0.98
^{58}Ni (n,p) Cd	5.03e-17	5.71e-17	5.12e-17	0.88	0.98
^{238}U (n,f) Cd	2.16e-16	2.06e-16	1.93e-16	1.05	1.12
^{237}Np (n,f) Cd	2.57e-15	2.94e-15	2.61e-15	0.87	0.98
^{59}Co (n,γ)	2.84e-14	8.56e-14	2.88e-14	0.33	0.99
^{59}Co (n,γ) Cd	1.84e-14	3.96e-14	1.83e-14	0.46	1.01

TABLE 6.3-9

DERIVED EXPOSURE RATES FROM CAPSULE P DOSIMETRY EVALUATION
16° AZIMUTH - 280° REFERENCE - CORE MIDPLANE

	Trial Value	Adjusted Value	1σ Uncertainty
$\phi(E > 1.0\ MeV)$	7.65e+08	6.51e+08	8%
$\phi(E > 0.1\ MeV)$	7.01e+09	5.97e+09	17%
$\phi(E < 0.414\ eV)$	1.68e+09	3.91e+08	29%
dpa/sec	2.45e-12	2.07e-12	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
16° AZIMUTH - 280° REFERENCE - CORE MIDPLANE

Reaction Rate (rps/nucleus)

	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
$^{63}Cu\ (n,\alpha)$ Cd	5.42e-19	5.80e-19	5.38e-19	0.93	1.01
$^{46}Ti\ (n,p)$ Cd	7.52e-18	8.09e-18	7.45e-18	0.93	1.01
$^{54}Fe\ (n,p)$ Cd	3.83e-17	4.49e-17	3.91e-17	0.85	0.98
$^{58}Ni\ (n,p)$ Cd	5.48e-17	6.27e-17	5.48e-17	0.87	1.00
$^{238}U\ (n,f)$ Cd	1.97e-16	2.27e-16	1.95e-16	0.87	1.01
$^{237}Np\ (n,f)$ Cd	2.73e-15	3.16e-15	2.69e-15	0.86	1.01
$^{59}Co\ (n,\gamma)$	2.74e-14	8.39e-14	2.78e-14	0.33	0.99
$^{59}Co\ (n,\gamma)$ Cd	1.82e-14	3.89e-14	1.81e-14	0.47	1.01

TABLE 6.3-10

DERIVED EXPOSURE RATES FROM CAPSULE Q DOSIMETRY EVALUATION
16° AZIMUTH - 280° REFERENCE - CORE BOTTOM

	Trial Value	Adjusted Value	1σ Uncertainty
$\phi(E > 1.0\ MeV)$	7.65e+08	1.79e+08	11%
$\phi(E > 0.1\ MeV)$	7.01e+09	2.05e+09	25%
$\phi(E < 0.414\ eV)$	1.68e+09	2.10e+08	29%
dpa/sec	2.45e-12	6.80e-13	21%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
16° AZIMUTH - 280° REFERENCE - CORE BOTTOM

	Reaction Rate (rps/nucleus)				
	Measured	Trial[1] Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	1.31e-19	5.80e-19	1.33e-19	0.23	0.98
^{46}Ti (n,p) Cd	1.98e-18	8.09e-18	1.92e-18	0.24	1.03
^{54}Fe (n,p) Cd	9.91e-18	4.49e-17	1.00e-17	0.22	0.99
^{58}Ni (n,p) Cd	1.47e-17	6.27e-17	1.45e-17	0.23	1.01
^{238}U (n,f) Cd	4.73e-17	2.27e-16	5.11e-17	0.21	0.93
^{59}Co (n,γ)	1.54e-14	8.39e-14	1.56e-14	0.18	0.99
^{59}Co (n,γ) Cd	1.04e-14	3.89e-14	1.03e-14	0.27	1.01

[1] Calculated using midplane reference spectrum without axial adjustment

TABLE 6.3-11

DERIVED EXPOSURE RATES FROM CAPSULE R DOSIMETRY EVALUATION
26° AZIMUTH - 290° REFERENCE - CORE MIDPLANE

	Trial Value	Adjusted Value	1σ Uncertainty
$\phi(E > 1.0\ MeV)$	7.06e+08	6.05e+08	8%
$\phi(E > 0.1\ MeV)$	6.59e+09	5.73e+09	17%
$\phi(E < 0.414\ eV)$	1.66e+09	3.45e+08	30%
dpa/sec	2.29e-12	1.97e-12	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
26° AZIMUTH - 290° REFERENCE - CORE MIDPLANE

Reaction Rate (rps/nucleus)

	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
$^{63}Cu\ (n,\alpha)$ Cd	4.95e-19	5.44e-19	4.93e-19	0.91	1.00
$^{46}Ti\ (n,p)$ Cd	7.11e-18	7.54e-18	6.98e-18	0.94	1.02
$^{54}Fe\ (n,p)$ Cd	3.53e-17	4.16e-17	3.59e-17	0.85	0.98
$^{58}Ni\ (n,p)$ Cd	4.87e-17	5.81e-17	4.94e-17	0.84	0.99
$^{238}U\ (n,f)$ Cd	1.85e-16	2.09e-16	1.80e-16	0.89	1.03
$^{237}Np\ (n,f)$ Cd	2.61e-15	2.94e-15	2.56e-15	0.89	1.02
$^{59}Co\ (n,\gamma)$	2.58e-14	8.25e-14	2.63e-14	0.31	0.98
$^{59}Co\ (n,\gamma)$ Cd	1.78e-14	3.80e-14	1.77e-14	0.47	1.01

TABLE 6.3-12

DERIVED EXPOSURE RATES FROM CAPSULE S DOSIMETRY EVALUATION
36° AZIMUTH - 300° REFERENCE - CORE MIDPLANE

	Trial Value	Adjusted Value	1σ Uncertainty
$\phi(E > 1.0\ MeV)$	6.16e+08	4.89e+08	8%
$\phi(E > 0.1\ MeV)$	6.00e+09	4.82e+09	17%
$\phi(E < 0.414\ eV)$	1.65e+09	3.15e+08	31%
dpa/sec	2.07e-12	1.65e-12	14%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
36° AZIMUTH - 300° REFERENCE - CORE MIDPLANE

Reaction Rate (rps/nucleus)

	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
$^{63}Cu\ (n,\alpha)$ Cd	4.15e-19	4.65e-19	4.09e-19	0.89	1.01
^{46}Ti (n,p) Cd	5.54e-18	6.45e-18	5.50e-18	0.86	1.01
^{54}Fe (n,p) Cd	2.80e-17	3.58e-17	2.88e-17	0.78	0.97
^{58}Ni (n,p) Cd					
^{238}U (n,f) Cd	1.52e-16	1.82e-16	1.46e-16	0.84	1.04
^{237}Np (n,f) Cd	2.09e-15	2.62e-15	2.08e-15	0.80	1.00
$^{59}Co\ (n,\gamma)$	2.52e-14	8.19e-14	2.57e-14	0.31	0.98
$^{59}Co\ (n,\gamma)$ Cd	1.80e-14	3.75e-14	1.78e-14	0.48	1.01

TABLE 6.3-13

DERIVED EXPOSURE RATES FROM CAPSULE T DOSIMETRY EVALUATION
39° AZIMUTH - 315° REFERENCE - CORE MIDPLANE

	Trial Value	Adjusted Value	1σ Uncertainty
ϕ(E > 1.0 MeV)	5.84e+08	4.64e+08	8%
ϕ(E > 0.1 MeV)	5.80e+09	4.60e+09	17%
ϕ(E < 0.414 eV)	1.66e+09	4.48e+08	28%
dpa/sec	2.00e-12	1.58e-12	14%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
39° AZIMUTH - 315° REFERENCE - CORE MIDPLANE

	Reaction Rate (rps/nucleus)				
	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	3.70e-19	4.38e-19	3.72e-19	0.84	0.99
^{46}Ti (n,p) Cd	5.51e-18	6.07e-18	5.39e-18	0.91	1.02
^{54}Fe (n,p) Cd	2.73e-17	3.38e-17	2.77e-17	0.81	0.99
^{58}Ni (n,p) Cd	3.83e-17	4.73e-17	3.85e-17	0.81	0.99
^{238}U (n,f) Cd	1.40e-16	1.72e-16	1.38e-16	0.81	1.01
^{237}Np (n,f) Cd	1.99e-15	2.51e-15	1.98e-15	0.79	1.01
^{59}Co (n,γ)	2.94e-14	8.22e-14	2.98e-14	0.36	0.99
^{59}Co (n,γ) Cd	1.86e-14	3.75e-14	1.85e-14	0.50	1.01

TABLE 6.3-14

DERIVED EXPOSURE RATES FROM CAPSULE U DOSIMETRY EVALUATION
24° AZIMUTH - 330° REFERENCE - CORE MIDPLANE

	Trial Value	Adjusted Value	1σ Uncertainty
ϕ(E > 1.0 MeV)	6.84e+08	5.46e+08	8%
ϕ(E > 0.1 MeV)	6.45e+09	4.82e+09	17%
ϕ(E < 0.414 eV)	1.69e+09	4.79e+08	27%
dpa/sec	2.24e-12	1.70e-12	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
24° AZIMUTH - 330° REFERENCE - CORE MIDPLANE

Reaction Rate (rps/nucleus)

	Measured	Trial Calc.	Adjusted Calc.	M/C Trial	M/C Adjusted
^{63}Cu (n,α) Cd	4.48e-19	5.19e-19	4.46e-19	0.86	1.00
^{46}Ti (n,p) Cd	6.40e-18	7.22e-18	6.30e-18	0.89	1.02
^{54}Fe (n,p) Cd	3.20e-17	4.01e-17	3.29e-17	0.80	0.97
^{58}Ni (n,p) Cd	4.54e-17	5.60e-17	4.58e-17	0.81	0.99
^{238}U (n,f) Cd	1.86e-16	2.03e-16	1.68e-16	0.92	1.11
^{237}Np (n,f) Cd	2.04e-15	2.86e-15	2.12e-15	0.71	0.96
^{59}Co (n,γ)	3.08e-14	8.38e-14	3.11e-14	0.37	0.99
^{59}Co (n,γ) Cd	1.92e-14	3.83e-14	1.91e-14	0.50	1.01

TABLE 6.3-15

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

Feet from	Neutron Flux (n/cm^2-sec)					
Midplane	6°	16°	24°	26°	36°	39°
+0.5	6.48e+08	6.66e+08	5.28e+08	5.94e+08	4.95e+08	4.59e+08
-0.5	6.38e+08	6.37e+08	5.64e+08	6.15e+08	4.83e+08	4.69e+08
-1.0						
-1.5	5.52e+08	6.44e+08	5.25e+08	6.22e+08	4.68e+08	4.24e+08
-2.0						
-2.5	4.76e+08	5.52e+08	5.33e+08	5.59e+08	4.77e+08	3.55e+08
-3.0						
-3.5	3.63e+08	4.87e+08	4.52e+08	4.88e+08	3.90e+08	3.16e+08
-4.0						
-4.5	2.28e+08	3.15e+08	3.33e+08	3.75e+08	3.11e+08	2.71e+08
-5.0						
-5.5	1.13e+08	1.25e+08	1.59e+08	2.03e+08	1.81e+08	1.33e+08

TABLE 6.3-16

FAST NEUTRON FLUX (E > 0.1 MeV) AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

Feet from	Neutron Flux (n/cm^2-sec)					
Midplane	6°	16°	24°	26°	36°	39°
+0.5	5.94e+09	6.10e+09	4.67e+09	5.63e+09	4.88e+09	4.55e+09
-0.5	5.85e+09	5.83e+09	4.98e+09	5.83e+09	4.76e+09	4.65e+09
-1.0						
-1.5	5.06e+09	5.90e+09	4.63e+09	5.89e+09	4.62e+09	4.21e+09
-2.0						
-2.5	4.36e+09	5.05e+09	4.71e+09	5.29e+09	4.71e+09	3.52e+09
-3.0						
-3.5	3.33e+09	4.46e+09	3.99e+09	4.62e+09	3.85e+09	3.14e+09
-4.0						
-4.5	2.09e+09	2.89e+09	2.94e+09	3.55e+09	3.07e+09	2.69e+09
-5.0						
-5.5	1.03e+09	1.15e+09	1.41e+09	1.92e+09	1.78e+09	1.32e+09

TABLE 6.3-17

IRON ATOM DISPLACEMENT RATE AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

Feet from	Displacement Rate (dpa/sec)					
Midplane	6°	16°	24°	26°	36°	39°
+0.5	2.06e-12	2.12e-12	1.64e-12	1.94e-12	1.67e-12	1.56e-12
-0.5	2.03e-12	2.03e-12	1.75e-12	2.01e-12	1.63e-12	1.60e-12
-1.0						
-1.5	1.76e-12	2.05e-12	1.63e-12	2.03e-12	1.58e-12	1.44e-12
-2.0						
-2.5	1.52e-12	1.76e-12	1.66e-12	1.83e-12	1.62e-12	1.21e-12
-3.0						
-3.5	1.16e-12	1.55e-12	1.41e-12	1.59e-12	1.32e-12	1.08e-12
-4.0						
-4.5	7.28e-13	1.00e-12	1.04e-12	1.22e-12	1.05e-12	9.22e-13
-5.0						
-5.5	3.59e-13	3.99e-13	4.96e-13	6.62e-13	6.12e-13	4.52e-13

TABLE 6.3-18

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION WITHIN THE REACTOR CAVITY LONG GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

Feet from Midplane	Neutron Flux (n/cm^2-sec) 0°	10°	20°	30°
+8.0	4.89e+07	4.63e+07	5.67e+07	4.07e+07
+7.5	5.45e+07	7.57e+07	8.05e+07	6.63e+07
+7.0				
+6.5	1.67e+08	1.72e+08	1.58e+08	1.55e+08
+6.0				
+5.5	3.11e+08	3.31e+08	2.91e+08	3.11e+08
+5.0				
+4.5	4.92e+08	5.01e+08	4.37e+08	4.57e+08
+4.0				
+3.5	5.84e+08	6.19e+08	5.49e+08	5.32e+08
+3.0				
+2.5	6.38e+08	6.34e+08	5.96e+08	5.81e+08
+2.0				
+1.5	6.75e+08	6.36e+08	5.96e+08	5.84e+08
+1.0				
+0.5	6.22e+08	6.68e+08	6.31e+08	5.91e+08
0.0	6.43e+08	6.43e+08	6.51e+08	6.05e+08
-0.5	6.23e+08	6.68e+08	6.36e+08	5.93e+08
-1.0				
-1.5	6.17e+08	6.80e+08	6.24e+08	5.84e+08
-2.0				
-2.5	5.75e+08	6.03e+08	6.00e+08	5.55e+08
-3.0				
-3.5	5.12e+08	5.33e+08	5.36e+08	5.11e+08
-4.0				
-4.5	4.00e+08	3.77e+08	4.51e+08	3.81e+08

TABLE 6.3-19

FAST NEUTRON FLUX (E > 0.1 MeV) AS A FUNCTION OF AXIAL POSITION WITHIN THE REACTOR CAVITY LONG GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

Feet from	Neutron Flux (n/cm^2-sec)			
Midplane	0°	10°	20°	30°
+8.0	4.48e+08	4.25e+08	5.19e+08	3.85e+08
+7.5	5.00e+08	6.94e+08	7.37e+08	6.28e+08
+7.0				
+6.5	1.53e+09	1.57e+09	1.45e+09	1.46e+09
+6.0				
+5.5	2.85e+09	3.04e+09	2.66e+09	2.94e+09
+5.0				
+4.5	4.51e+09	4.59e+09	4.00e+09	4.33e+09
+4.0				
+3.5	5.35e+09	5.68e+09	5.03e+09	5.04e+09
+3.0				
+2.5	5.85e+09	5.81e+09	5.46e+09	5.50e+09
+2.0				
+1.5	6.19e+09	5.83e+09	5.46e+09	5.53e+09
+1.0				
+0.5	5.71e+09	6.13e+09	5.78e+09	5.60e+09
0.0	5.90e+09	5.90e+09	5.97e+09	5.73e+09
-0.5	5.71e+09	6.12e+09	5.83e+09	5.61e+09
-1.0				
-1.5	5.65e+09	6.24e+09	5.71e+09	5.53e+09
-2.0				
-2.5	5.27e+09	5.52e+09	5.50e+09	5.26e+09
-3.0				
-3.5	4.69e+09	4.88e+09	4.91e+09	4.84e+09
-4.0				
-4.5	3.67e+09	3.45e+09	4.13e+09	3.60e+09

TABLE 6.3-20

IRON ATOM DISPLACEMENT RATE AS A FUNCTION OF AXIAL POSITION WITHIN THE REACTOR CAVITY LONG GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

Feet from	Displacement Rate (dpa/sec)			
Midplane	0°	10°	20°	30°
+8.0	1.56e-13	1.48e-13	1.80e-13	1.33e-13
+7.5	1.74e-13	2.41e-13	2.56e-13	2.17e-13
+7.0				
+6.5	5.32e-13	5.47e-13	5.03e-13	5.05e-13
+6.0				
+5.5	9.90e-13	1.06e-12	9.26e-13	1.02e-12
+5.0				
+4.5	1.57e-12	1.60e-12	1.39e-12	1.49e-12
+4.0				
+3.5	1.86e-12	1.97e-12	1.75e-12	1.74e-12
+3.0				
+2.5	2.03e-12	2.02e-12	1.90e-12	1.90e-12
+2.0				
+1.5	2.15e-12	2.03e-12	1.90e-12	1.91e-12
+1.0				
+0.5	1.98e-12	2.13e-12	2.01e-12	1.93e-12
0.0	2.05e-12	2.05e-12	2.07e-12	1.97e-12
-0.5	1.99e-12	2.13e-12	2.03e-12	1.94e-12
-1.0				
-1.5	1.96e-12	2.17e-12	1.99e-12	1.91e-12
-2.0				
-2.5	1.83e-12	1.92e-12	1.91e-12	1.81e-12
-3.0				
-3.5	1.63e-12	1.70e-12	1.71e-12	1.67e-12
-4.0				
-4.5	1.27e-12	1.20e-12	1.43e-12	1.24e-12

FIGURE 6.3-1

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 6.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

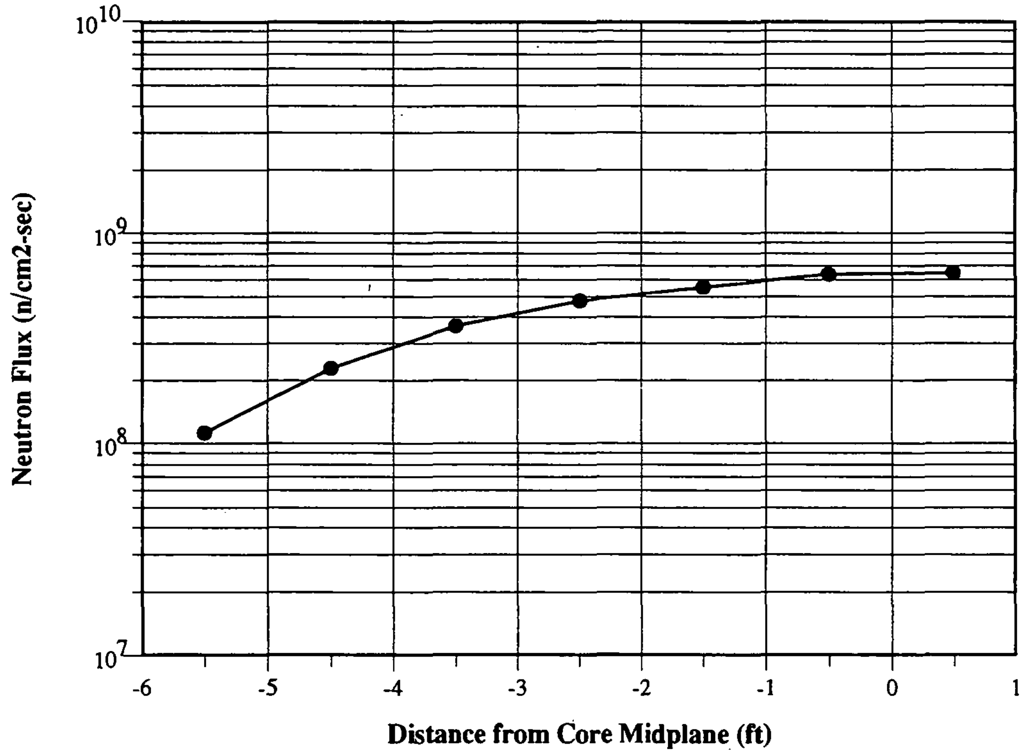


FIGURE 6.3-2

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 16.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

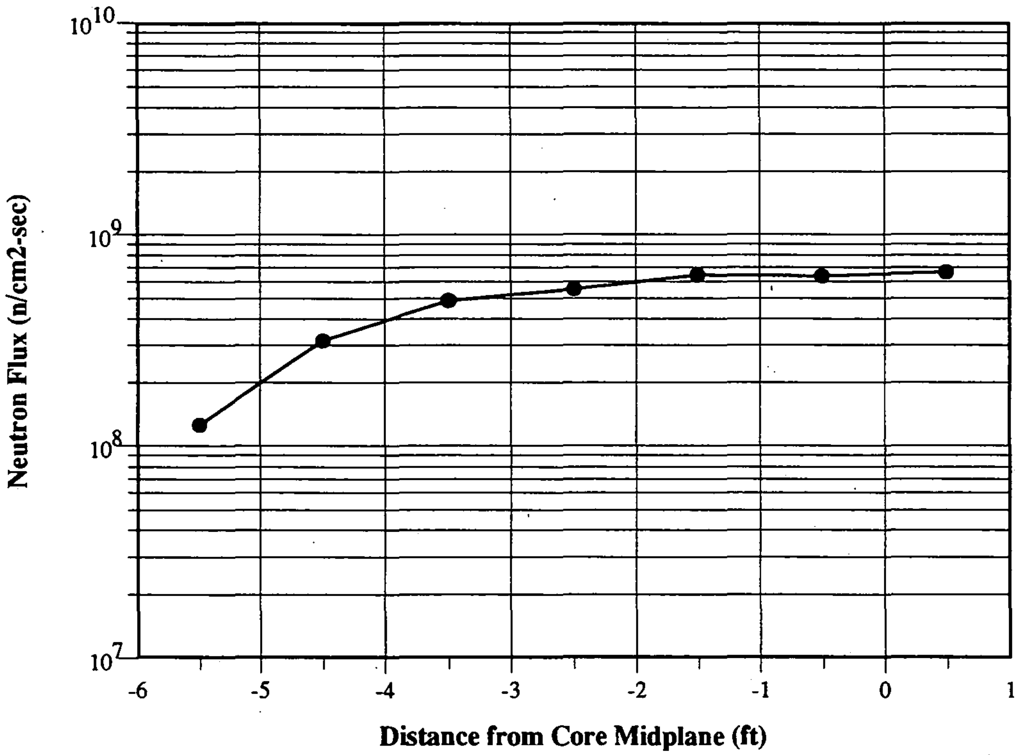


FIGURE 6.3-3

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 24.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

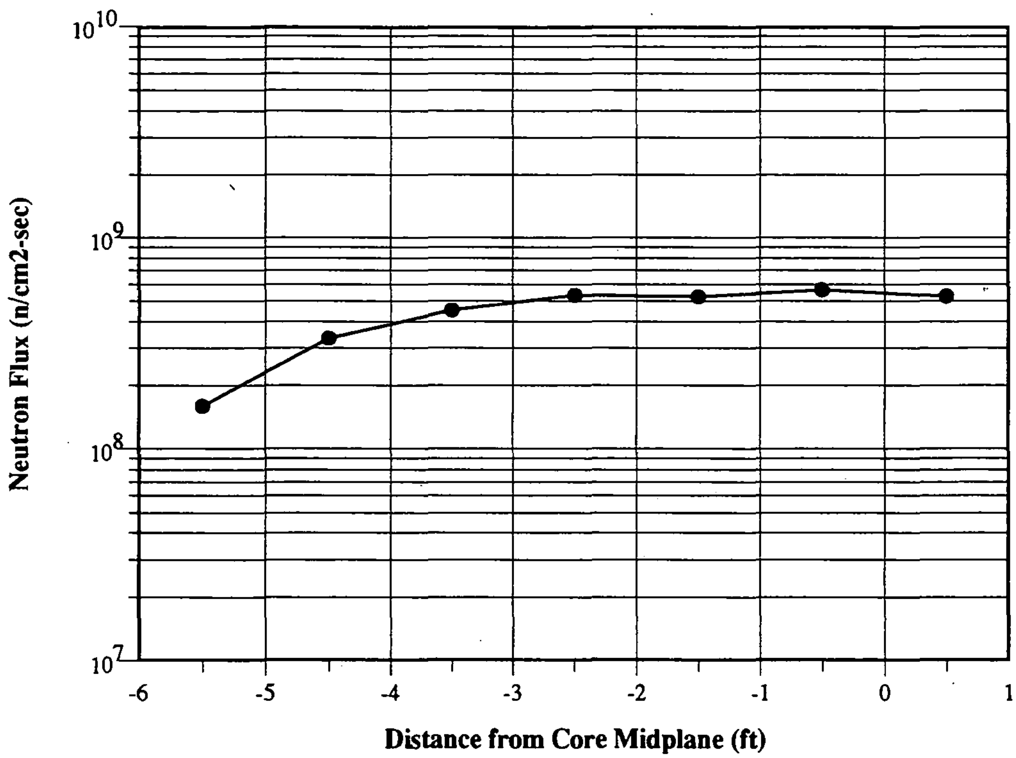


FIGURE 6.3-4

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION ALONG THE 26.0 DEGREE TRAVERSE IN THE REACTOR CAVITY SHORT GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

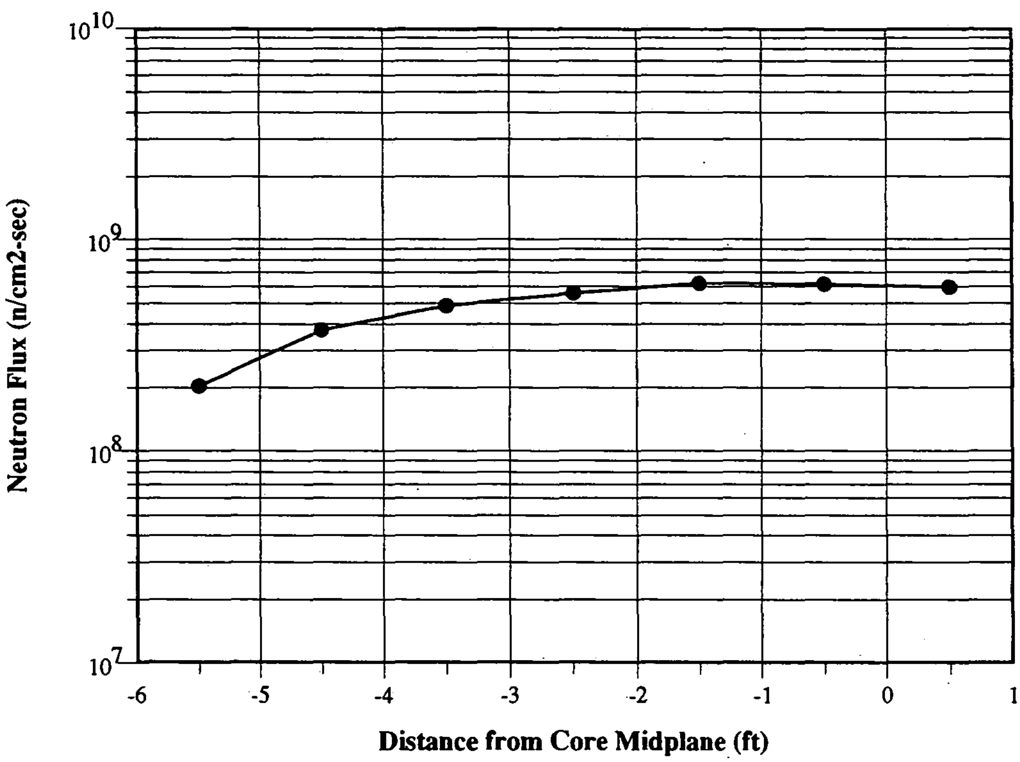


FIGURE 6.3-5

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION ALONG THE 36.0 DEGREE TRAVERSE IN THE REACTOR CAVITY SHORT GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

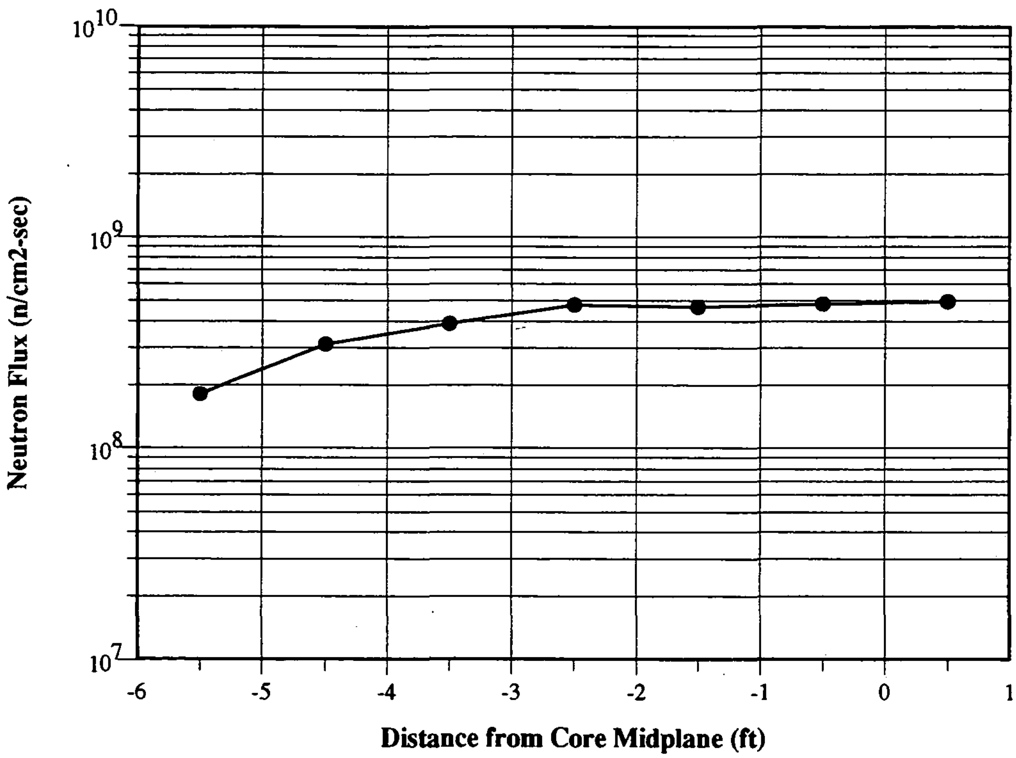


FIGURE 6.3-6

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 39.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
SHORT GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

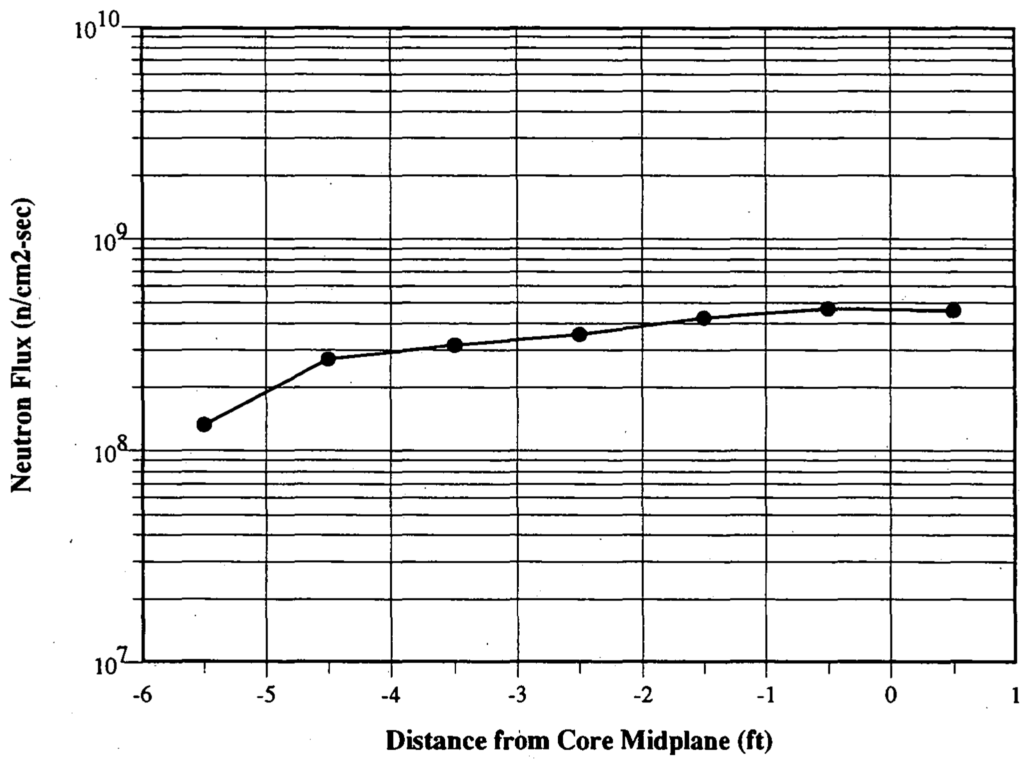


FIGURE 6.3-7

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION ALONG THE 0.0 DEGREE TRAVERSE IN THE REACTOR CAVITY LONG GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

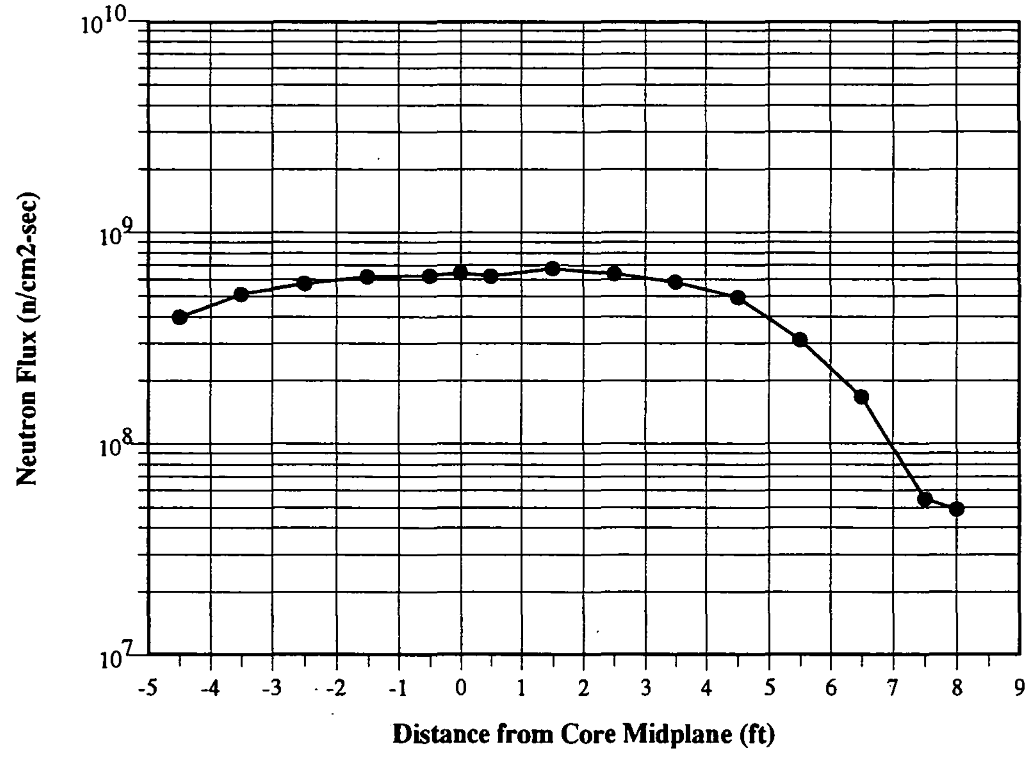


FIGURE 6.3-8

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 10.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
LONG GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

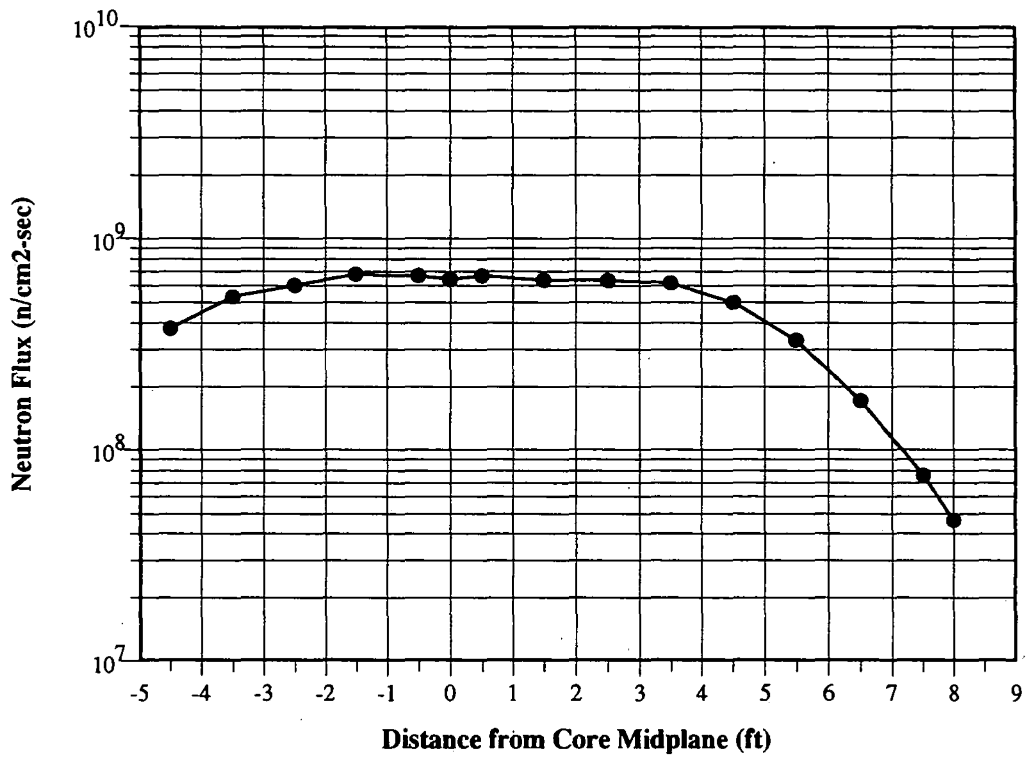


FIGURE 6.3-9

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION ALONG THE 20.0 DEGREE TRAVERSE IN THE REACTOR CAVITY LONG GRADIENT CHAINS - CYCLE 10/11 IRRADIATION

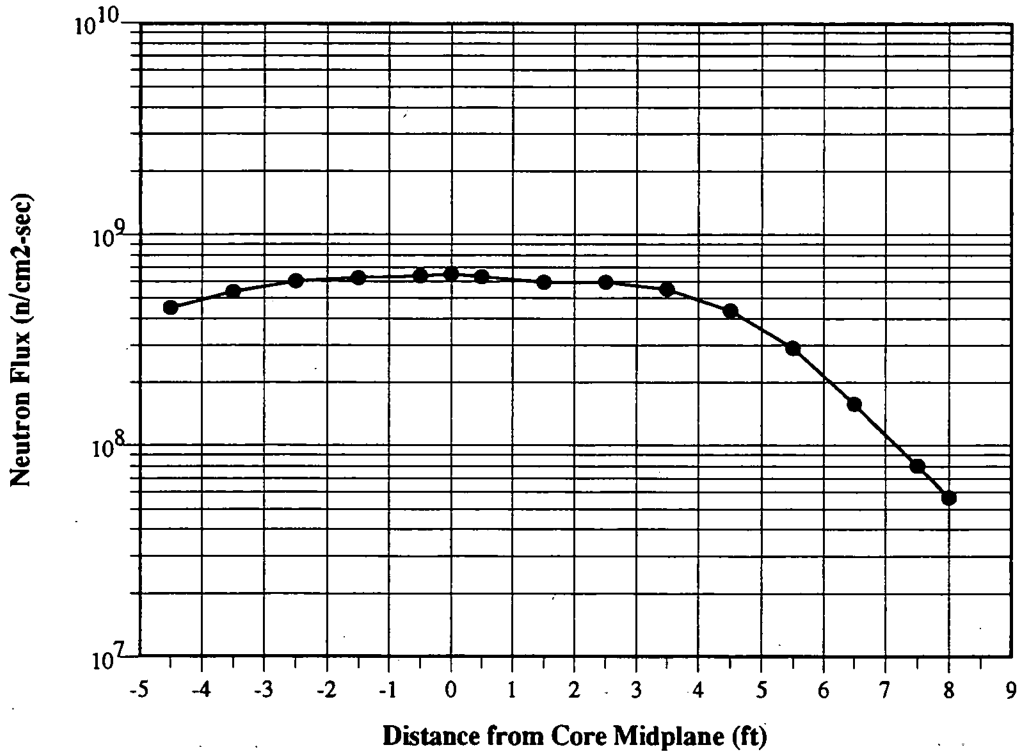
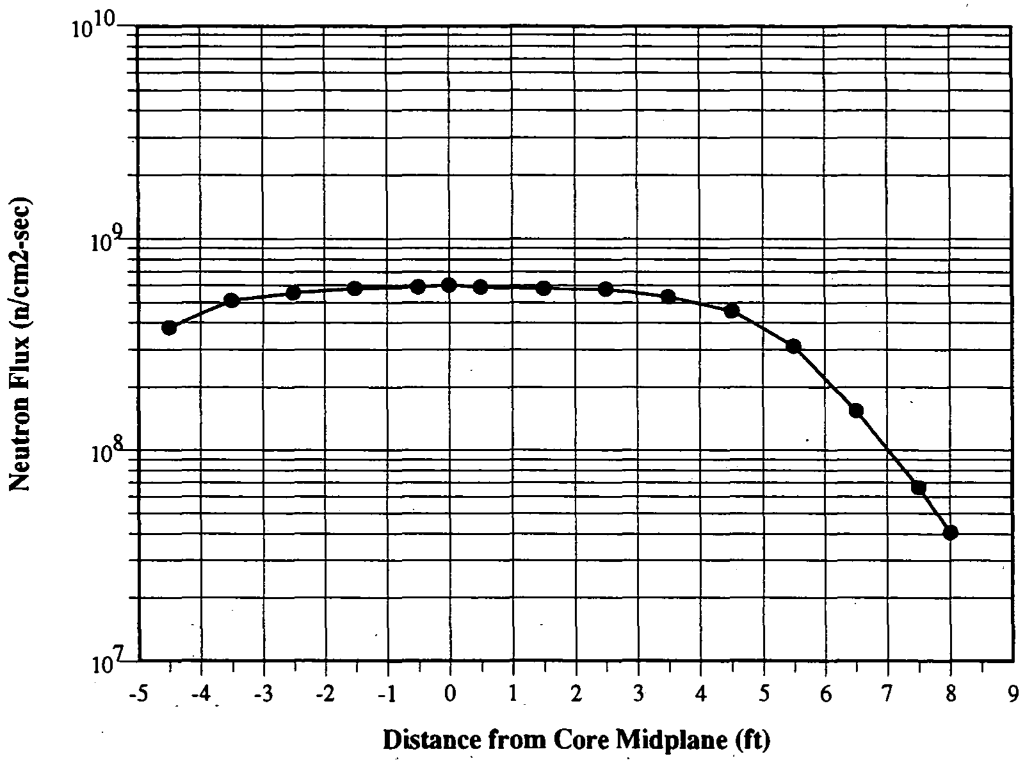


FIGURE 6.3-10

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 30.0 DEGREE TRAVERSE IN THE REACTOR CAVITY
LONG GRADIENT CHAINS - CYCLE 10/11 IRRADIATION



SECTION 7

COMPARISON OF CALCULATIONS WITH MEASUREMENTS

As described in Section 3.3, the best estimate neutron exposure projections for the Palisades reactor vessel were based on a combination of plant specific neutron transport calculations and plant specific measurements. Direct comparisons of the transport calculations with the Palisades measurement data base were used to quantify the biases that may exist due to the transport methodology, reactor modeling, and/or reactor operating characteristics over the respective irradiation periods.

In this section, comparisons of the measurement results from surveillance capsule and reactor cavity dosimetry with corresponding analytical predictions at the measurement locations are presented. These comparisons are provided on two levels. In the first instance, predictions of fast neutron exposure rates in terms of $\phi(E > 1.0\ MeV)$, $\phi(E > 0.1\ MeV)$, and dpa/sec are compared with the results of the FERRET least squares adjustment procedure; while, in the second case, calculations of individual sensor reaction rates are compared directly with the measured data from the counting laboratories. It is shown that these two levels of comparison yield consistent and similar results, indicating that the least squares adjustment methodology is producing accurate exposure results and that the measurement/calculation (M/C) comparisons yield an accurate plant specific bias factor that can be applied to neutron transport calculations performed for the Palisades reactor to produce "best estimate" exposure projections for the reactor vessel wall.

7.1 Comparison of Least Squares Adjustment Results with Calculation

In Table 7.1-1, comparisons of measured and calculated exposure rates for the four surveillance capsule dosimetry sets withdrawn to date as well as for the three cycles of reactor cavity midplane dosimetry sets irradiated during Cycles 8, 9, and 10/11 are given. In all cases, the calculated values were based on the fuel cycle specific exposure calculations averaged over the appropriate irradiation period.

An examination of Table 7.1-1 indicates that, considering all of the available core midplane data, the measured exposure rates were less than the calculated values by factors of 0.831, 0.819, and 0.820 for $\phi(E > 1.0\ MeV)$, $\phi(E > 0.1\ MeV)$, and dpa/sec, respectively. The standard deviations associated with each of the 17 sample data sets were ±0.067 (8.1%), ±0.136 (16.6%), and ±0.100 (12.2%), respectively.

7.2 Comparisons of Measured and Calculated Sensor Reaction Rates

In Table 7.2-1, measurement/calculation (M/C) ratios for each fast neutron sensor reaction rate from the surveillance capsule and reactor cavity irradiations are listed. This tabulation, provides a direct comparison, on an absolute basis, of calculation and measurement prior to the application of the least squares adjustment procedure as represented in the FERRET evaluations.

An examination of Table 7.2-1 shows consistent behavior for all reactions and all measurement points. The overall average M/C ratio for the entire data set has an associated 1σ standard deviation of ±0.072 (8.1%). Furthermore, the average M/C bias of 0.879 observed in the reaction rate comparisons is in excellent agreement with the values of 0.831, 0.819, and 0.820 observed in the exposure rate comparisons shown in Table 7.1-1.

TABLE 7.1-1

COMPARISON OF MEASURED AND CALCULATED EXPOSURE RATES FROM SURVEILLANCE CAPSULE AND CAVITY DOSIMETRY IRRADIATIONS

	ϕ(E > 1.0 MeV) [n/cm^2-sec]		
	Calculated	Measured	M/C
Internal Capsules			
A240 (30°)	6.29e+11	5.36e+11	0.852
W290 (20°)	6.69e+10	5.63e+10	0.842
W290-9 (20°)	3.82e+10	3.12e+10	0.818
W110 (20°)	6.12e+10	5.06e+10	0.826
6° Cavity			
Cycle 8			
Cycle 9	1.11e+09	9.57e+08	0.863
Cycle 10/11	6.97e+08	6.43e+08	0.922
16° Cavity			
Cycle 8	1.52e+09	1.34e+09	0.883
Cycle 9	1.07e+09	8.56e+08	0.801
Cycle 10/11	7.65e+08	6.51e+08	0.851
24° Cavity			
Cycle 8			
Cycle 9			
Cycle 10/11	6.84e+08	5.46e+08	0.798
26° Cavity			
Cycle 8	1.19e+09	9.97e+08	0.835
Cycle 9	9.06e+08	7.83e+08	0.864
Cycle 10/11	7.06e+08	6.05e+08	0.856
36° Cavity			
Cycle 8			
Cycle 9			
Cycle 10/11	6.16e+08	4.89e+08	0.794
39° Cavity			
Cycle 8	8.60e+08	6.94e+08	0.807
Cycle 9	6.70e+08	4.87e+08	0.727
Cycle 10/11	5.84e+08	4.64e+08	0.794
		Average Bias Factor (K)	0.831
		Standard Deviation (1σ)	±0.067

TABLE 7.1-1 (continued)

COMPARISON OF MEASURED AND CALCULATED EXPOSURE RATES FROM SURVEILLANCE CAPSULE AND CAVITY DOSIMETRY IRRADIATIONS

	$\phi(E > 0.1\ MeV)$ [n/cm^2-sec]		
	Calculated	Measured	M/C
Internal Capsules			
A240 (30°)	1.38e+12	1.18e+12	0.855
W290 (20°)	1.24e+11	1.06e+11	0.852
W290-9 (20°)	6.99e+10	5.76e+10	0.824
W110 (20°)	1.14e+11	9.51e+10	0.836
6° Cavity			
Cycle 8			
Cycle 9	1.07e+10	8.58e+09	0.804
Cycle 10/11	6.66e+09	5.90e+09	0.886
16° Cavity			
Cycle 8	1.34e+10	1.18e+10	0.878
Cycle 9	9.63e+09	7.36e+09	0.764
Cycle 10/11	7.01e+09	5.97e+09	0.851
24° Cavity			
Cycle 8			
Cycle 9			
Cycle 10/11	6.45e+09	4.82e+09	0.748
26° Cavity			
Cycle 8	1.14e+10	9.48e+09	0.834
Cycle 9	8.55e+09	6.86e+09	0.803
Cycle 10/11	6.59e+09	5.73e+09	0.870
36° Cavity			
Cycle 8			
Cycle 9			
Cycle 10/11	6.00e+09	4.82e+09	0.804
39° Cavity			
Cycle 8	9.08e+09	7.52e+09	0.828
Cycle 9	6.98e+09	4.88e+09	0.698
Cycle 10/11	5.80e+09	4.60e+09	0.793
		Average Bias Factor (K)	0.819
		Standard Deviation (1σ)	±0.136

TABLE 7.1-1 (continued)

COMPARISON OF MEASURED AND CALCULATED EXPOSURE RATES FROM SURVEILLANCE CAPSULE AND CAVITY DOSIMETRY IRRADIATIONS

Iron Displacements (dpa/sec)

	Calculated	Measured	M/C
Internal Capsules			
A240 (30°)	9.06e-10	7.83e-10	0.865
W290 (20°)	9.63e-11	8.25e-11	0.857
W290-9 (20°)	5.50e-11	4.59e-11	0.834
W110 (20°)	8.81e-11	7.44e-11	0.844
6° Cavity			
Cycle 8			
Cycle 9	3.68e-12	2.99e-12	0.811
Cycle 10/11	2.31e-12	2.05e-12	0.888
16° Cavity			
Cycle 8	4.70e-12	4.09e-12	0.872
Cycle 9	3.37e-12	2.59e-12	0.769
Cycle 10/11	2.45e-12	2.07e-12	0.848
24° Cavity			
Cycle 8			
Cycle 9			
Cycle 10/11	2.24e-12	1.70e-12	0.757
26° Cavity			
Cycle 8	3.93e-12	3.25e-12	0.827
Cycle 9	2.97e-12	2.40e-12	0.808
Cycle 10/11	2.29e-12	1.97e-12	0.861
36° Cavity			
Cycle 8			
Cycle 9			
Cycle 10/11	2.07e-12	1.65e-12	0.798
39° Cavity			
Cycle 8	3.09e-12	2.52e-12	0.817
Cycle 9	2.38e-12	1.67e-12	0.702
Cycle 10/11	2.00e-12	1.58e-12	0.790
	Average Bias Factor (K)		0.820
	Standard Deviation (1σ)		±0.100

TABLE 7.2-1

COMPARISON OF MEASURED AND CALCULATED NEUTRON SENSOR REACTION RATES FROM SURVEILLANCE CAPSULE AND CAVITY DOSIMETRY IRRADIATIONS

	Cu63(n,α)	Ti46(n,p)	Fe54(n,p)	Ni58(n,p)	U238(n,f)	Np237(n,f)
Internal						
A240 (30°)	0.982	1.069	0.900	0.863		
W290 (20°)	0.979	0.962	0.856	0.878	0.858	
W290-9 (20°)	0.978	1.009	0.814	0.860	0.871	0.817
W110 (20°)	0.997	0.993	0.852	0.865		
6° Cavity						
Cycle 8						
Cycle 9	0.938	0.964	0.868	0.844	0.875	0.932
Cycle 10/11	0.970	0.946	0.885	0.881	1.049	0.874
16° Cavity						
Cycle 8	0.904	0.948	0.854	0.852	0.833	1.083
Cycle 9	0.883	0.911	0.821	0.830	0.753	0.900
Cycle 10/11	0.934	0.930	0.853	0.874	0.868	0.864
24° Cavity						
Cycle 8						
Cycle 9						
Cycle 10/11	0.863	0.886	0.798	0.811	0.916	0.713
26° Cavity						
Cycle 8	0.887	0.933	0.830	0.825	0.797	0.992
Cycle 9	0.896	0.919	0.815	0.834	0.873	0.982
Cycle 10/11	0.910	0.943	0.849	0.838	0.885	0.888
36° Cavity						
Cycle 8						
Cycle 9						
Cycle 10/11	0.892	0.859	0.782		0.835	0.798
39° Cavity						
Cycle 8	0.922	0.940	0.840	0.822	0.771	0.934
Cycle 9	0.891	0.896	0.794	0.798	0.708	0.752
Cycle 10/11	0.845	0.908	0.808	0.810	0.814	0.793
Average	0.922	0.942	0.836	0.843	0.847	0.880
Std. Dev. (1σ)	0.046	0.049	0.033	0.026	0.079	0.101

Average Bias Factor (K)	0.879
Standard Deviation (1σ)	±0.072

SECTION 8

BEST ESTIMATE NEUTRON EXPOSURE OF THE REACTOR VESSEL

In this section the measurement results provided in Sections 5 and 6 are combined with the results of the neutron transport calculations described in Section 4 to establish a mapping of the best estimate neutron exposure of the beltline region of the Palisades reactor vessel for Cycle 11.

8.1 Exposure Distributions Within the Beltline Region

As described in Section 3.3 of this report, the best estimate vessel exposure was determined from the following relationship:

$$\Phi_{Best Est.} = K \, \Phi_{Calc.}$$

where: $\Phi_{Best\ Est.}$ = The best estimate fast neutron exposure at the location of interest.

K = The plant specific measurement/calculation (M/C) bias factor derived from all available surveillance capsule and reactor cavity dosimetry data.

$\Phi_{Calc.}$ = The absolute calculated fast neutron exposure at the location of interest.

From the data provided in Table 7.1-1, the plant specific bias factors (K) to be applied to the calculated exposure values given in Section 4 and the axial variations in Section 6 were as follows:

$\Phi(E > 1.0\ MeV)$	0.831 ± 0.067 (8.1%)
$\Phi(E > 0.1\ MeV)$	0.819 ± 0.136 (16.6%)
dpa	0.820 ± 0.100 (12.2%)

These bias factors were based on the results of the continuous monitoring program at Palisades that has provide measured data from four internal surveillance capsules and thirteen reactor cavity sensor sets through the first 11 cycles of operation.

The uncertainties listed with the individual bias factors are at the 1σ level and are given on an absolute.

8.1.1 Exposure Accrued During Cycles 1 through 11

To assess the incremental exposure resulting from irradiation during Cycles 1 through 11, the bias factors listed in Section 8.1 were applied directly to the calculated values from Section 4.1 including the axial peaking factor for the vessel clad/base metal interface to produce best estimate fluence levels characteristic of the midplane of the reactor core. The axial gradient chain measurements were then employed to develop the complete axial traverse along the vessel wall. The best estimate results applicable to the vessel inner surface are incorporated into Tables 8.1-1 through 8.1-3 to establish the exposure accrued by the reactor vessel through the end of Cycle 11. The azimuthal locations presented in the tables represent 15° intervals of a quadrant, where the 75° azimuthal location is the maximum azimuthal flux position on the reactor vessel wall.

Exposure distributions through the vessel wall, can be developed using these surface exposures and radial distribution functions from Section 4. This exposure information, applicable through the end of Cycle 11, was derived from an extensive set of measurements and assures that embrittlement gradients can be established with a minimum uncertainty. Further, as the monitoring program continues and additional data become available, the overall plant specific data base for Palisades will expand resulting in reduced uncertainties and an improved accuracy in the assessment of vessel condition.

TABLE 8.1-1

SUMMARY OF BEST ESTIMATE FAST NEUTRON (E > 1.0 MeV) EXPOSURE PROJECTIONS FOR THE BELTLINE REGION OF THE PALISADES REACTOR VESSEL THROUGH CYCLE 11

$\Phi(E > 1.0\ MeV)\ [n/cm^2]$

Z (ft)	0°	15°	30°	45°	60°	75°[1]	90°
+8.0	6.96e+17	9.70e+17	7.16e+17	4.54e+17	7.22e+17	9.75e+17	6.97e+17
+7.5	9.81e+17	1.37e+18	1.01e+18	6.40e+17	1.02e+18	1.37e+18	9.82e+17
+7.0	1.53e+18	2.13e+18	1.57e+18	9.99e+17	1.59e+18	2.14e+18	1.53e+18
+6.5	2.35e+18	3.27e+18	2.42e+18	1.53e+18	2.44e+18	3.29e+18	2.35e+18
+6.0	3.29e+18	4.58e+18	3.38e+18	2.14e+18	3.41e+18	4.60e+18	3.29e+18
+5.5	4.53e+18	6.32e+18	4.66e+18	2.96e+18	4.70e+18	6.35e+18	4.54e+18
+5.0	5.57e+18	7.76e+18	5.73e+18	3.63e+18	5.78e+18	7.80e+18	5.58e+18
+4.5	6.78e+18	9.44e+18	6.97e+18	4.42e+18	7.03e+18	9.49e+18	6.79e+18
+4.0	7.40e+18	1.03e+19	7.61e+18	4.83e+18	7.67e+18	1.04e+19	7.41e+18
+3.5	8.30e+18	1.16e+19	8.53e+18	5.41e+18	8.61e+18	1.16e+19	8.31e+18
+3.0	8.61e+18	1.20e+19	8.86e+18	5.62e+18	8.93e+18	1.21e+19	8.62e+18
+2.5	9.02e+18	1.26e+19	9.27e+18	5.88e+18	9.35e+18	1.26e+19	9.03e+18
+2.0	8.98e+18	1.25e+19	9.23e+18	5.85e+18	9.31e+18	1.26e+19	8.99e+18
+1.5	9.12e+18	1.27e+19	9.38e+18	5.95e+18	9.46e+18	1.28e+19	9.13e+18
+1.0	9.06e+18	1.26e+19	9.32e+18	5.91e+18	9.40e+18	1.27e+19	9.07e+18
+0.5	9.26e+18	1.29e+19	9.53e+18	6.04e+18	9.61e+18	1.30e+19	9.28e+18
0.0	9.46e+18	1.32e+19	9.73e+18	6.17e+18	9.82e+18	1.32e+19	9.47e+18
-0.5	9.40e+18	1.31e+19	9.67e+18	6.13e+18	9.75e+18	1.32e+19	9.41e+18
-1.0	9.28e+18	1.29e+19	9.55e+18	6.06e+18	9.63e+18	1.30e+19	9.30e+18
-1.5	9.20e+18	1.28e+19	9.47e+18	6.00e+18	9.55e+18	1.29e+19	9.22e+18
-2.0	9.02e+18	1.26e+19	9.27e+18	5.88e+18	9.35e+18	1.26e+19	9.03e+18
-2.5	8.64e+18	1.20e+19	8.89e+18	5.64e+18	8.96e+18	1.21e+19	8.65e+18
-3.0	8.07e+18	1.12e+19	8.30e+18	5.26e+18	8.37e+18	1.13e+19	8.08e+18
-3.5	7.77e+18	1.08e+19	7.99e+18	5.07e+18	8.06e+18	1.09e+19	7.78e+18
-4.0	6.74e+18	9.38e+18	6.93e+18	4.39e+18	6.99e+18	9.43e+18	6.75e+18
-4.5	5.87e+18	8.17e+18	6.04e+18	3.83e+18	6.09e+18	8.22e+18	5.88e+18

[1] Peak azimuthal fluence location.

TABLE 8.1-2

SUMMARY OF BEST ESTIMATE FAST NEUTRON (E > 0.1 MeV) EXPOSURE PROJECTIONS FOR THE BELTLINE REGION OF THE PALISADES REACTOR VESSEL THROUGH CYCLE 11

$\Phi(E > 0.1\ MeV)$ [n/cm^2]

Z (ft)	0°	15°	30°	45°	60°	75°[1]	90°
+8.0	1.35e+18	1.89e+18	1.40e+18	8.89e+17	1.41e+18	1.90e+18	1.35e+18
+7.5	1.90e+18	2.67e+18	1.98e+18	1.25e+18	1.99e+18	2.68e+18	1.91e+18
+7.0	2.97e+18	4.16e+18	3.08e+18	1.95e+18	3.11e+18	4.18e+18	2.98e+18
+6.5	4.57e+18	6.39e+18	4.74e+18	3.00e+18	4.77e+18	6.42e+18	4.57e+18
+6.0	6.38e+18	8.94e+18	6.62e+18	4.19e+18	6.66e+18	8.97e+18	6.38e+18
+5.5	8.81e+18	1.23e+19	9.13e+18	5.79e+18	9.20e+18	1.24e+19	8.81e+18
+5.0	1.08e+19	1.51e+19	1.12e+19	7.11e+18	1.13e+19	1.52e+19	1.08e+19
+4.5	1.32e+19	1.84e+19	1.37e+19	8.65e+18	1.37e+19	1.85e+19	1.32e+19
+4.0	1.44e+19	2.01e+19	1.49e+19	9.45e+18	1.50e+19	2.02e+19	1.44e+19
+3.5	1.61e+19	2.26e+19	1.67e+19	1.06e+19	1.68e+19	2.27e+19	1.61e+19
+3.0	1.67e+19	2.34e+19	1.73e+19	1.10e+19	1.75e+19	2.35e+19	1.67e+19
+2.5	1.75e+19	2.45e+19	1.82e+19	1.15e+19	1.83e+19	2.46e+19	1.75e+19
+2.0	1.74e+19	2.44e+19	1.81e+19	1.15e+19	1.82e+19	2.45e+19	1.74e+19
+1.5	1.77e+19	2.48e+19	1.84e+19	1.16e+19	1.85e+19	2.49e+19	1.77e+19
+1.0	1.76e+19	2.46e+19	1.83e+19	1.16e+19	1.84e+19	2.48e+19	1.76e+19
+0.5	1.80e+19	2.52e+19	1.87e+19	1.18e+19	1.88e+19	2.53e+19	1.80e+19
0.0	1.84e+19	2.57e+19	1.91e+19	1.21e+19	1.92e+19	2.59e+19	1.84e+19
-0.5	1.83e+19	2.56e+19	1.89e+19	1.20e+19	1.91e+19	2.57e+19	1.83e+19
-1.0	1.80e+19	2.53e+19	1.87e+19	1.19e+19	1.88e+19	2.54e+19	1.80e+19
-1.5	1.79e+19	2.50e+19	1.85e+19	1.18e+19	1.87e+19	2.51e+19	1.79e+19
-2.0	1.75e+19	2.45e+19	1.82e+19	1.15e+19	1.83e+19	2.46e+19	1.75e+19
-2.5	1.68e+19	2.35e+19	1.74e+19	1.10e+19	1.75e+19	2.36e+19	1.68e+19
-3.0	1.57e+19	2.20e+19	1.63e+19	1.03e+19	1.64e+19	2.20e+19	1.57e+19
-3.5	1.51e+19	2.11e+19	1.56e+19	9.92e+18	1.58e+19	2.12e+19	1.51e+19
-4.0	1.31e+19	1.83e+19	1.36e+19	8.60e+18	1.37e+19	1.84e+19	1.31e+19
-4.5	1.14e+19	1.60e+19	1.18e+19	7.49e+18	1.19e+19	1.60e+19	1.14e+19

[1] Peak azimuthal fluence location.

TABLE 8.1-3

SUMMARY OF BEST ESTIMATE IRON ATOM DISPLACEMENT [dpa] EXPOSURE PROJECTIONS FOR THE BELTLINE REGION OF THE PALISADES REACTOR VESSEL THROUGH CYCLE 11

	Displacements [dpa]						
Z (ft)	0°	15°	30°	45°	60°	75°[1]	90°
+8.0	1.05e-03	1.45e-03	1.08e-03	6.91e-04	1.09e-03	1.46e-03	1.05e-03
+7.5	1.48e-03	2.04e-03	1.52e-03	9.74e-04	1.53e-03	2.06e-03	1.48e-03
+7.0	2.32e-03	3.19e-03	2.37e-03	1.52e-03	2.39e-03	3.21e-03	2.32e-03
+6.5	3.56e-03	4.90e-03	3.64e-03	2.33e-03	3.67e-03	4.93e-03	3.56e-03
+6.0	4.97e-03	6.85e-03	5.08e-03	3.26e-03	5.13e-03	6.89e-03	4.97e-03
+5.5	6.86e-03	9.46e-03	7.02e-03	4.50e-03	7.08e-03	9.50e-03	6.87e-03
+5.0	8.42e-03	1.16e-02	8.62e-03	5.53e-03	8.69e-03	1.17e-02	8.43e-03
+4.5	1.03e-02	1.41e-02	1.05e-02	6.73e-03	1.06e-02	1.42e-02	1.03e-02
+4.0	1.12e-02	1.54e-02	1.14e-02	7.35e-03	1.15e-02	1.55e-02	1.12e-02
+3.5	1.26e-02	1.73e-02	1.28e-02	8.24e-03	1.30e-02	1.74e-02	1.26e-02
+3.0	1.30e-02	1.80e-02	1.33e-02	8.55e-03	1.34e-02	1.80e-02	1.30e-02
+2.5	1.36e-02	1.88e-02	1.40e-02	8.95e-03	1.41e-02	1.89e-02	1.37e-02
+2.0	1.36e-02	1.87e-02	1.39e-02	8.91e-03	1.40e-02	1.88e-02	1.36e-02
+1.5	1.38e-02	1.90e-02	1.41e-02	9.06e-03	1.42e-02	1.91e-02	1.38e-02
+1.0	1.37e-02	1.89e-02	1.40e-02	9.00e-03	1.41e-02	1.90e-02	1.37e-02
+0.5	1.40e-02	1.93e-02	1.43e-02	9.20e-03	1.45e-02	1.94e-02	1.40e-02
0.0	1.43e-02	1.97e-02	1.46e-02	9.40e-03	1.48e-02	1.98e-02	1.43e-02
-0.5	1.42e-02	1.96e-02	1.46e-02	9.34e-03	1.47e-02	1.97e-02	1.42e-02
-1.0	1.40e-02	1.94e-02	1.44e-02	9.22e-03	1.45e-02	1.95e-02	1.41e-02
-1.5	1.39e-02	1.92e-02	1.42e-02	9.14e-03	1.44e-02	1.93e-02	1.39e-02
-2.0	1.36e-02	1.88e-02	1.40e-02	8.96e-03	1.41e-02	1.89e-02	1.37e-02
-2.5	1.31e-02	1.80e-02	1.34e-02	8.58e-03	1.35e-02	1.81e-02	1.31e-02
-3.0	1.22e-02	1.68e-02	1.25e-02	8.02e-03	1.26e-02	1.69e-02	1.22e-02
-3.5	1.18e-02	1.62e-02	1.20e-02	7.72e-03	1.21e-02	1.63e-02	1.18e-02
-4.0	1.02e-02	1.40e-02	1.04e-02	6.69e-03	1.05e-02	1.41e-02	1.02e-02
-4.5	8.88e-03	1.22e-02	9.08e-03	5.83e-03	9.16e-03	1.23e-02	8.89e-03

[1] Peak azimuthal dpa location.

8.2 Uncertainties in Exposure Projections

The overall uncertainty in the best estimate exposure projections within the pressure vessel wall stem primarily from two sources; a) the uncertainty in the bias factor (K) derived from the plant specific measurement data base and b) the analytical uncertainty associated with relating the results at the measurement locations to the desired results within the pressure vessel wall. Uncertainty in the bias factor derives directly from the individual uncertainties in the measurement process, and in the least squares adjustment procedure, and in the location of the surveillance capsule and cavity dosimetry sensor sets. The analytical uncertainty in the relationship between the exposure of the pressure vessel and the exposure at the measurement locations are based on the vessel thickness tolerance and on the location of the dosimetry sensor sets for the cavity data; and on downcomer water density variations, vessel inner radius tolerance, cladding thickness tolerance, and dosimetry sensor set locations for the surveillance capsule data.

The 1σ uncertainties associated with the bias factors applicable to $\Phi(E > 1.0$ MeV), $\Phi(E > 0.1$ MeV), and dpa are as follows:

$\Phi(E > 1.0$ MeV)	8.1%
$\Phi(E > 0.1$ MeV)	16.6%
dpa	12.2%

The additional information pertinent to the required analytical uncertainty for vessel locations has been obtained from an analytical sensitivity study of the parameters important to the Palisades fluence evaluation. Based on these sensitivity studies the additional components to the overall uncertainty associated with the tolerances in dosimetry positioning, vessel thickness, vessel inner radius, cladding thickness and downcomer temperature are summarized in Table 8.2-1 for $\Phi(E > 1.0$ MeV), $\Phi(E > 0.1$ MeV), and dpa, respectively. In addition to the uncertainties derived from the analytical sensitivity analyses, a 5% uncertainty component was included to account for small factors not explicitly addressed.

Combining the uncertainties from the bias factor determination and the sensitivity studies results in the following total uncertainties associated with the neutron exposure projections at the pressure vessel clad/base metal interface:

$\Phi(E > 1.0\ MeV)$	14.5%
$\Phi(E > 0.1\ MeV)$	20.6%
dpa	17.3%

These uncertainty values are well within the 20% 1σ uncertainty required by the PTS rule for $\Phi(E > 1.0\ MeV)$ projections for the reactor pressure vessel.

Additionally, as part of the uncertainty examinations, gradient measurements for the 30°, 150°, and 210° azimuths were compared to determine if any effect of core centering offset was observable. The average gradient measurements for the three angles agree within ± 3%. Since the measurements, themselves, have a ± 5% measurement uncertainty, the impact of core offset is not evident.

TABLE 8.2-1

SUMMARY OF TOLERANCE UNCERTAINTY COMPONENT FOR $\Phi(E > 1.0\ MeV)$ PROJECTIONS AT THE VESSEL WALL

Cavity Components	
Dosimeter Position	4.6%
Vessel Thickness	8.3%
Miscellaneous Factors	5.0%
Wall Capsule Component	
Dosimeter Position	3.8%
Vessel Inner Radius	2.6%
Cladding Thickness	1.0%
Downcomer Water Temperature	1.0%
Miscellaneous Factors	5.0%
Accelerated Capsule Component	
Dosimeter Position	3.5%
Vessel Inner Radius	2.6%
Cladding Thickness	1.0%
Downcomer Water Temperature	2.5%
Miscellaneous Factors	5.0%

SECTION 9

REFERENCES

1. Fero, A. H., "Reactor Cavity Neutron Measurement Program for Consumers Power Company Palisades Nuclear Plant", WCAP-11911, December 1988.

2. Fero, A. H., "Reactor Cavity Neutron Measurement Program for Consumers Power Company Palisades Nuclear Plant", WCAP-12847, January 1991.

3. Fero, A. H., "Reactor Cavity Neutron Measurement Program for Consumers Power Company Palisades Nuclear Plant (As-Installed Description for Cycle 10)", WCAP-13552, November 1992.

4. Perrin, J. S., et. al., "Palisades Nuclear Plant Reactor Pressure Vessel Surveillance Program: Capsule A-240", BCL-585-12, March 13, 1979.

5. Kunka, M. K., Cheney, C. A., "Analysis of Capsules T-330 and W-290 from the Consumers Power Company Palisades Reactor Vessel Radiation Surveillance Program", WCAP-10637, September 1984.

6. Lippincott, E. P., et. al., "Palisades Nuclear Plant Reactor Vessel Neutron Fluence Measurement Program for Consumers Power Company, Results to End of Cycle 9", WCAP-13534, Rev. 2, March 1993.

7. Peter, P. A., et. al., "Analysis of Capsule W-110 from the Consumers Power Company Palisades Reactor Vessel Radiation Surveillance Program", WCAP-14014, May 1994.

8. RSIC Computer Code Collection CCC-543, "TORT-DORT Two- and Three-Dimensional Discrete Ordinates Transport, Version 2.8.14", January 1994.

9. RSIC Data Library Collection DLC-175, "BUGLE-93, Production and Testing of the VITAMIN-B6 Fine Group and the BUGLE-93 Broad Group Neutron/Photon Cross-Section Libraries Derived from ENDF/B-VI Nuclear Data", April 1994.

10. Snuggerud, R. D., "Cycle Averaged Source and Temperature Information for Cycles 1 through 11", from EA-DOR 95-01 and EOC 11 Update, transmitted by letter and electronic file August 2, 1995.

11. ASTM Designation E706-87 (Reapproved 1994), "Standard Master Matrix for Light-Water Reactor Pressure Vessel Surveillance Standards," in ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA, 1995

12. ASTM Designation E853-87, "Standard Practice for Analysis and Interpretation of Light -Water Reactor Surveillance Results," in ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA, 1995.

13. ASTM Designation E261-90, "Standard Practice for Determining Neutron flux, Fluence, and Spectra by Radioactivation Techniques," in ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA 1995.

14. ASTM Designation E262-86 (Reapproved 1991), "Standard Method for Measuring Thermal Neutron Reaction and Fluence Rates by Radioactivation Techniques," in ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA 1995.

15. ASTM Designation E263-93, "Standard Test Method for Measuring Fast Neutron Reaction Rates by Radioactivation of Iron," in ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA, 1995.

16. ASTM Designation E264-92, "Standard Test Method for Measuring Fast Neutron Reaction Rates by Radioactivation of Nickel," in ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA, 1995.

17. ASTM Designation E481-86 (Reapproved 1991), "Standard Test Method for Measuring Neutron Fluence Rate by Radioactivation of Cobalt and Silver," in ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA, 1995.

18. ASTM Designation E523-92, "Standard Test Method for Determining Fast Neutron Reaction Rate by Radioactivation of Copper," in ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA, 1995.

19. ASTM Designation E704-90, "Standard Test Method for Measuring Reaction Rates by Radioactivation of Uranium-238," in ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA, 1995.

20. ASTM Designation E705-90, "Standard Test Method for Measuring Reaction Rate by Radioactivation of Neptunium-237," in ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA, 1995.

21. ASTM Designation E1005-84 (Reapproved 1991), "Standard Method for Application and Analysis of Radiometric Monitors for Reactor Vessel Surveillance," in ASTM Standards, Section 12, American Society for Testing and Materials, Philadelphia, PA, 1995.

22. Snuggerud, R. D., "Palisades Operating Cycle 11 Irradiation History", personal communication via fax, August 17, 1995.

23. Schmittroth, E. A., "FERRET Data Analysis Code", HEDL-TME-79-40, Hanford Engineering Development Laboratory, Richland, Washington, September 1979.

24. McElroy, W. N., et. al., "A Computer-Automated Iterative Method of Neutron Flux Spectra Determined by Foil Activation," AFWL-TR-67-41, Volumes I-IV, Air Force Weapons Laboratory, Kirkland AFB, NM, July 1967.

25. RSIC Data Library Collection DLC-178, "SNLRML Recommended Dosimetry Cross-Section Compendium", July 1994.

26. Maerker, R. E. as reported by Stallman, F. W., "Workshop on Adjustment Codes and Uncertainties - Proc. of the 4th ASTM/EURATOM Symposium on Reactor Dosimetry," NUREG/CP-0029, NRC, Washington, D.C., July 1982.

27. Andrachek, J. D., et. al., "Methodology Used to Develop Cold Overpressure and Mitigating System Setpoints and RCS Heatup and Cooldown Limit Curves," WCAP-14040-NP-A, January 1996.

APPENDIX A

SPECIFIC ACTIVITIES AND IRRADIATION HISTORY OF SENSORS FROM SURVEILLANCE CAPSULES A240, W290, W290-9 AND W110

In this appendix, the irradiation history as extracted from NUREG-0020 and the measured specific activities of radiometric monitors irradiated in surveillance capsules A240, W290, W290-9, and W110 are provided.

The irradiation history of capsules withdrawn to date is as follows:

Cycle	Startup	Shutdown	Comment
1	12/31/71	12/20/75	
2	05/08/76	01/06/78	Capsule A240 Withdrawn
3	04/20/78	09/08/79	
4	05/24/80	08/29/81	
5	12/25/81	08/12/83	Capsule W290 Withdrawn
6	07/29/84	11/30/85	
7	03/02/86	08/08/88	
8	11/01/88	09/15/90	
9	03/10/91	02/06/92	Caps. W290-9 Installed/Withdrawn
10	04/18/92	06/05/93	Capsule W110 Withdrawn
11	11/06/93	05/22/95	

Reference Core Power = 2530 MWt

The monthly thermal generation applicable to the palisades reactor is provided in addition to the specific activities of the sensors on the following pages.

Since the in-vessel surveillance capsules were irradiated for multiple fuel cycles, the flux adjustment factors, C_j, defined in section 3.0 were employed in the reaction rate calculations for the individual sensor sets.

The quantity C_j is defined as the calculated ratio of $\phi(E > 1.0 \text{ MeV})$ during the irradiation period j to the time weighted average $\phi(E > 1.0 \text{ MeV})$ over the entire irradiation period. The values of C_j used in the evaluation of the Palisades surveillance capsules were as follows:

Flux Adjustment Factor C_j

Cycle	A 240	W 290	W 290-9	W 110
1		0.918		1.004
2		0.819		0.895
3		1.100		1.202
4		1.126		1.231
5		1.093		1.194
6				1.216
7				1.159
8				0.963
9			1.00	0.630
10				0.485

TABLE A-1

IRRADIATION HISTORY OF PALISADES INTERNAL SURVEILLANCE CAPSULES

Month	Thermal Generation (MW-hr)	Month	Thermal Generation (MW-hr)	Month	Thermal Generation (MW-hr)
Dec-71	625	Apr-75	967872	Aug-78	1049064
Jan-72	155642	May-75	1334640	Sep-78	556008
Feb-72	16679	Jun-75	873360	Oct-78	1172520
Mar-72	247284	Jul-75	1116216	Nov-78	1683216
Apr-72	519993	Aug-75	749376	Dec-78	849192
May-72	0	Sep-75	977856	Jan-79	1801656
Jun-72	684662	Oct-75	1135152	Feb-79	1604952
Jul-72	669575	Nov-75	1212960	Mar-79	1785288
Aug-72	792640	Dec-75	537672	Apr-79	1371072
Sep-72	490476	Jan-76	0	May-79	590664
Oct-72	731045	Feb-76	0	Jun-79	1297416
Nov-72	552165	Mar-76	0	Jul-79	1702776
Dec-72	1071439	Apr-76	0	Aug-79	1570656
Jan-73	667608	May-76	569280	Sep-79	322368
Feb-73	0	Jun-76	1520760	Oct-79	0
Mar-73	1059289	Jul-76	1052469	Nov-79	0
Apr-73	1549797	Aug-76	1260240	Dec-79	0
May-73	983014	Sep-76	1449288	Jan-80	0
Jun-73	1578251	Oct-76	1207248	Feb-80	0
Jul-73	1534211	Nov-76	1080384	Mar-80	0
Aug-73	476077	Dec-76	1531608	Apr-80	0
Sep-73	0	Jan-77	1426488	May-80	161088
Oct-73	0	Feb-77	1428888	Jun-80	1600296
Nov-73	0	Mar-77	1507152	Jul-80	1182912
Dec-73	0	Apr-77	1454856	Aug-80	1335552
Jan-74	0	May-77	1024776	Sep-80	1328640
Feb-74	0	Jun-77	1596000	Oct-80	1663008
Mar-74	0	Jul-77	1554528	Nov-80	0
Apr-74	0	Aug-77	1122840	Dec-80	920760
May-74	0	Sep-77	1431480	Jan-81	1777944
Jun-74	0	Oct-77	1630296	Feb-81	1684176
Jul-74	0	Nov-77	1457736	Mar-81	1867008
Aug-74	0	Dec-77	1703640	Apr-81	1750200
Sep-74	0	Jan-78	270336	May-81	1641384
Oct-74	387048	Feb-78	0	Jun-81	1531584
Nov-74	8400	Mar-78	0	Jul-81	604440
Dec-74	0	Apr-78	381600	Aug-81	845688
Jan-75	0	May-78	947376	Sep-81	0
Feb-75	0	Jun-78	1245312	Oct-81	0
Mar-75	0	Jul-78	1288344	Nov-81	0

TABLE A-1

IRRADIATION HISTORY OF PALISADES INTERNAL SURVEILLANCE CAPSULES

Month	Thermal Generation (MW-hr)	Month	Thermal Generation (MW-hr)	Month	Thermal Generation (MW-hr)
Dec-81	1104	Apr-85	1622592	Aug-88	444768
Jan-82	947952	May-85	1841352	Sep-88	0
Feb-82	168384	Jun-85	1708032	Oct-88	0
Mar-82	682224	Jul-85	1823376	Nov-88	29640
Apr-82	0	Aug-85	640848	Dec-88	454344
May-82	362304	Sep-85	1372872	Jan-89	1657920
Jun-82	1614336	Oct-85	1557216	Feb-89	0
Jul-82	581544	Nov-85	1744224	Mar-89	1248144
Aug-82	0	Dec-85	0	Apr-89	1392120
Sep-82	1558992	Jan-86	0	May-89	1499736
Oct-82	1669680	Feb-86	0	Jun-89	1457664
Nov-82	1802688	Mar-86	331392	Jul-89	1510872
Dec-82	1841424	Apr-86	1321872	Aug-89	1341864
Jan-83	1742448	May-86	1107336	Sep-89	1453344
Feb-83	1675200	Jun-86	0	Oct-89	504
Mar-83	1862568	Jul-86	0	Nov-89	0
Apr-83	1713816	Aug-86	0	Dec-89	502200
May-83	1688184	Sep-86	0	Jan-90	1372848
Jun-83	1761720	Oct-86	0	Feb-90	1352352
Jul-83	1735776	Nov-86	0	Mar-90	1378920
Aug-83	543720	Dec-86	0	Apr-90	741096
Sep-83	0	Jan-87	0	May-90	536208
Oct-83	0	Feb-87	0	Jun-90	1047984
Nov-83	0	Mar-87	0	Jul-90	1501584
Dec-83	0	Apr-87	951309	Aug-90	1501896
Jan-84	0	May-87	1454016	Sep-90	704184
Feb-84	0	Jun-87	1387536	Oct-90	0
Mar-84	0	Jul-87	875304	Nov-90	0
Apr-84	0	Aug-87	1410336	Dec-90	0
May-84	0	Sep-87	1566648	Jan-91	0
Jun-84	0	Oct-87	14832	Feb-91	0
Jul-84	9816	Nov-87	968160	Mar-91	480456
Aug-84	166704	Dec-87	197136	Apr-91	1809167
Sep-84	222792	Jan-88	204576	May-91	1885464
Oct-84	0	Feb-88	1484904	Jun-91	1818648
Nov-84	485160	Mar-88	1878312	Jul-91	1143408
Dec-84	1838256	Apr-88	1522344	Aug-91	1837560
Jan-85	1802520	May-88	1731336	Sep-91	1818984
Feb-85	1562424	Jun-88	1818696	Oct-91	1882521
Mar-85	1843632	Jul-88	1794168	Nov-91	1712592

TABLE A-1

IRRADIATION HISTORY OF PALISADES INTERNAL SURVEILLANCE CAPSULES

Month	Thermal Generation (MW-hr)
Dec-91	1513368
Jan-92	1867224
Feb-92	357888
Mar-92	0
Apr-92	620112
May-92	1878432
Jun-92	1819464
Jul-92	1392552
Aug-92	1459272
Sep-92	1260672
Oct-92	1779079
Nov-92	1326168
Dec-92	1880496
Jan-93	1879536
Feb-93	1698408
Mar-93	1880544
Apr-93	1688919
May-93	862632
Jun-93	237864

CHEMICAL ANALYSIS REPORT | WESTINGHOUSE … ANALYTICAL … SYSTEMS … RIES … WALT… SITE

ANAL. SERV. REQUEST NO. 11532 page 1 of

ORIGINATOR	DEPT. & GRP.	EXT.	ROOM NO.	FACILITY
S.L. ANDERSON	WIN 284-5165	BAY 478		MNC

APPROVAL SIGNATURE	DATE RECEIVED	DATE REPORTED
C. A. Blackburn	6-19-84	7-25-84

METHOD	ANALYST	REFERENCE	METHOD	ANALYST	REFERENCE
γ spec.	CAB	File.			

RESULTS OF ANALYSIS

PALISADES DOSIMETERS.

ANAL. SERV. LAB. NO.	ORIGINATOR'S SAMPLE NO. Location.	Code	Dosimeter	Isotope	dps/g @ June 27, 1984	dps/mg wire
84-1747	1A 73°+	2T	Ti	Sc-46	1.1×10^{5}	110
-1748	↓	3I	Fe	Mn-54	1.88×10^{6}	1880
-1750	↓	6NC	Ni(Cd)	Co-58	3.06×10^{6}	3060
-1751	↓	7CC	Cu(Cd)	Co-60	2.32×10^{5}	232
-1752	↓	Fe1	Fe	Mn-54	1.77×10^{6}	1770
-1753	↓	Fe2	Fe	↓	1.85×10^{6}	1850
-1754	↓	Fe3	Fe	↓	1.89×10^{6}	1890
-1755	↓	Fe4	Fe	↓	1.75×10^{6}	1750
-1756	↓	Fe5	Fe	↓	1.95×10^{6}	1950
-1758	1A41°	2T	Ti	Sc-46	1.06×10^{5}	106
-1759	↓	3I	Fe	Mn-54	1.88×10^{6}	1880
-1761	↓	6NC	Ni(Cd)	Co-58	3.05×10^{6}	3050
-1762	↓	7CC	Cu(Cd)	Co-60	2.39×10^{5}	239
-1763	↓	Fe1	Fe	Mn-54	1.86×10^{6}	1860
-1764A	?	Fe2	Fe	↓	1.86×10^{6}	1860
-1764B	?	Fe2	Fe	↓	1.66×10^{6}	1660
-1765	1A41°	Fe3	Fe	↓	1.75×10^{6}	1750
-1766	↓	Fe4	Fe	↓	1.91×10^{6}	1910
-1767	↓	Fe5	Fe	↓	1.66×10^{6}	1660
-1769	1A14*	2T	Ti	Sc-46	1.01×10^{5}	101
-1770	↓	3I	Fe	Mn-54	1.39×10^{6}	1390
-1772	↓	6NC	Ni(Cd)	Co-58	2.90×10^{6}	2900
-1773	↓	7CC	Cu(Cd)	Co-60	2.07×10^{5}	207
-1774	↓	Fe1	Fe	Mn-54	1.67×10^{6}	1670
-1776	↓	Fe3	Fe	↓	1.57×10^{6}	1570
-1777	↓	Fe4	Fe	↓	1.74×10^{6}	1740
84-1778	↓	Fe5	Fe	↓	1.47×10^{6}	1470

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CHEMICAL ANALYSIS REPORT	WESTINGHOUSE ADVANCED ENERGY SYSTEMS ANALYTICAL LABORATORIES WALTZ MILL SITE	ANAL. SERV. REQUEST: 11532. page 2

ORIGINATOR: S.L. ANDERSON | DEPT. & GRP.: | EXT.: | ROOM NO.: | LOCATION: MNC

APPROVAL SIGNATURE: C. A. Blackburn | DATE RECEIVED: 6-19-84 | DATE REPORTED: 7-25-84

METHOD	ANALYST	REFERENCE	METHOD	ANALYST	REFERENCE
γ spec.		LAB Book #07 page 40	LAB Book # 10 pages 30,31		
U by mass spec	WRM	LAB Book # 15 page 136,137			
		MASS SPEC FILE DATA3/11532			

RESULTS OF ANALYSIS

			RSAC	
ANAL. SERV. LAB. NO.				
	LOCATION	CODE DOSIMETER	Cs-137	dps/g
			dps/mg U-238	@ JUNE 27, 1984
84-1746	1 A 73°+	1 U U-238 S	1054	1.05×10^6
-1749	"	5 U U-238 (Cd)	556	5.56×10^5
-1757	1 A 41°	1 U U-238	982	9.82×10^5
-1760	"	5 U	(NOT RECEIVED FROM HOT CELLS)	
-1768	1 A 14*	1 U U-238	840	8.40×10^5
-1771	"	5 U U-238 (Cd)	536	5.36×10^5

CHEMICAL ... REPORT

ANALYTICAL LABORATORIES
WALTZ MILL SITE

ANAL. SERV. REQUEST NO. 11570

ORIGINATOR: S.L. ANDERSON | DEPT. & GRP. | EXT. | ROOM NO. MNC. | FACILITY

APPROVAL SIGNATURE: C. A. Blackburn | DATE RECEIVED: 7-17-84 | DATE REPORTED: 7-25-84

METHOD	ANALYST	REFERENCE	METHOD	ANALYST	REFERENCE
GAMMA SPEC.	CAB.	FILE.			

RESULTS OF ANALYSIS

ORIGINATOR'S SAMPLE NO.	13 C		RS...	
ANAL. SERV. LAB. NO.	84-1918			
ISOTOPE	dps / mg. on June 27, 1984			
Mn-54	0.002			
Co-60	0.061			

PALISADES SAMPLE 13C.

RSAG PAL / / 2

Westinghouse Electric Corporation
Advanced Programs - Analytical Laboratory
Waltz Mill Site

REPORT

Request# 14629

TO: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering and Analysis
Westinghouse Electric Corporation

Received: 4/1/92
Reported: 4/15/92

[RESULTS OF ANALYSIS]

Block# 1A7F

Palisades In-vessel Dosimetry

Originator ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 3/4/92) dps/mg *	2 sigma
Co-Al (Cd-V)	92-1148	Co-Al	Co-60	2.48E+03 +/-	3.2E+01
U (Cd-V)	92-1149	U	Zr-95	1.36E+03 +/-	1.8E+01
U (Cd-V)	92-1149	U	Ru-103	1.47E+03 +/-	1.9E+01
U (Cd-V)	92-1149	U	Cs-137	4.16E+01 +/-	4.6E+00
Ti (Bare)	92-1150	Ti	Sc-46	6.78E+02 +/-	1.0E+01
Fe (Bare)	92-1151	Fe	Mn-54	1.24E+03 +/-	8.9E+00
Co-Al (Bare)	92-1152	Co-Al	Co-60	1.75E+04 +/-	1.4E+02
U (V)	92-1153	U	Zr-95	1.26E+03 +/-	1.1E+01
U (V)	92-1153	U	Ru-103	1.40E+03 +/-	1.2E+01
U (V)	92-1153	U	Cs-137	4.48E+01 +/-	3.2E+00
Ni (Cd-V)	92-1154	Ni	Co-58	2.84E+04 +/-	1.4E+02
Cu (Cd-V)	92-1155	Cu	Co-60	3.83E+01 +/-	7.0E-01
Np (Cd-V)	92-1156	Np	Zr-95	5.83E+03 +/-	8.8E+01
Np (Cd-V)	92-1156	Np	Ru-103	4.98E+03 +/-	7.2E+01
Np (Cd-V)	92-1156	Np	Cs-137	1.90E+01 +/-	2.6E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).
1) All dosimeter material was analyzed after removal from Cadmium and Vanadium encapsulation

AL File: 14629
References: Lab.Book# 56 page 16.
Procedures: A-524.
Analyst: WTF,FRC,MRK.

Approved: Mark Kowalski

RSAC PAL 775

Westinghouse Electric Corporation
Advanced Programs - Analytical Laboratory
Waltz Mill Site

REPORT　　　　　　　　　　　　　　　　　　Request# 14629

TO: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering and Analysis
Westinghouse Electric Corporation

Received: 4/1/92
Reported: 4/15/92

[RESULTS OF ANALYSIS]

Block# 1A4F

Palisades In-vessel Dosimetry

Originator ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 3/4/92) dps/mg *		2 sigma
Co-Al (Cd-V)	92-1139	Co-Al	Co-60	2.52E+03	+/-	3.2E+01
U (Cd-V)	92-1140	U	Zr-95	1.35E+03	+/-	1.5E+01
U (Cd-V)	92-1140	U	Ru-103	1.38E+03	+/-	1.2E+01
U (Cd-V)	92-1140	U	Cs-137	4.79E+01	+/-	4.6E+00
Ti (Bare)	92-1141	Ti	Sc-46	6.97E+02	+/-	5.1E+00
Fe (Bare)	92-1142	Fe	Mn-54	1.28E+03	+/-	9.1E+00
Co-Al (Bare)	92-1143	Co-Al	Co-60	1.77E+04	+/-	2.4E+02
U (V)	92-1144	U	Zr-95	1.25E+03	+/-	1.3E+01
U (V)	92-1144	U	Ru-103	1.28E+03	+/-	1.1E+01
U (V)	92-1144	U	Cs-137	4.31E+01	+/-	3.9E+00
Ni (Cd-V)	92-1145	Ni	Co-58	2.74E+04	+/-	1.2E+02
Cu (Cd-V)	92-1146	Cu	Co-60	3.88E+01	+/-	5.5E-01
Np (Cd-V)	92-1147	Np	Zr-95	5.80E+03	+/-	8.7E+01
Np (Cd-V)	92-1147	Np	Ru-103	5.27E+00	+/-	9.4E+01
Np (Cd-V)	92-1147	Np	Cs-137	1.59E+02	+/-	2.3E+01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).
1) All dosimeter material was analyzed after removal from Cadmium and Vanadium encapsulation

AL File: 14629
References: Lab.Book# 56 page 16.
Procedures: A-524.
Analyst: WTF,FRC,MRK.

Approved: Mark Kowalski

RSAC PAL 775

Westinghouse Electric Corporation
Advanced Programs - Analytical Laboratory
Waltz Mill Site

REPORT

Request# 14629

TO: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering and Analysis
Westinghouse Electric Corporation

Received: 4/1/92
Reported: 4/15/92

[RESULTS OF ANALYSIS]

Block# 1A1F

Palisades In-vessel Dosimetry

Originator ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 3/4/92) dps/mg *		2 sigma
Co-Al (Cd-V)	92-1130	Co-Al	Co-60	2.48E+03	+/-	2.3E+01
U (Cd-V)	92-1131	U	Zr-95	1.20E+03	+/-	2.0E+01
U (Cd-V)	92-1131	U	Ru-103	1.31E+03	+/-	1.3E+01
U (Cd-V)	92-1131	U	Cs-137	3.39E+01	+/-	3.3E+00
Ti (Bare)	92-1132	Ti	Sc-46	6.28E+02	+/-	6.7E+00
Fe (Bare)	92-1133	Fe	Mn-54	1.12E+03	+/-	4.4E+00
Co-Al (Bare)	92-1134	Co-Al	Co-60	1.82E+04	+/-	1.9E+02
U (V)	92-1135	U	Zr-95	1.19E+03	+/-	1.7E+01
U (V)	92-1135	U	Ru-103	1.38E+03	+/-	1.4E+01
U (V)	92-1135	U	Cs-137	4.34E+01	+/-	4.2E+00
Ni (Cd-V)	92-1136	Ni	Co-58	2.71E+04	+/-	1.2E+02
Cu (Cd-V)	92-1137	Cu	Co-60	3.59E+01	+/-	6.0E-01
Np (Cd-V)	92-1138	Np	Zr-95	5.59E+03	+/-	7.4E+01
Np (Cd-V)	92-1138	Np	Ru-103	4.92E+03	+/-	4.5E+01
Np (Cd-V)	92-1138	Np	Cs-137	1.77E+02	+/-	1.7E+01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).
1) All dosimeter material was analyzed after removal from Cadmium and Vanadium encapsulation

AL File: 14629
References: Lab.Book# 56 page 16.
Procedures: A-524.
Analyst: WTF,FRC,MRK.

Approved: Mark Kurdziel

Westinghouse Electric Corporation
Chemistry & Materials Technology - Analytical Laboratory
REPORT Waltz Mill Site Request# 15214

Originator: Ed Terek (W)NTD
Structural Reliability & Plant Life Optimization Received: 10/11/93
Westinghouse Electric Corporation Reported: 1/11/94

[RESULTS OF ANALYSIS]

Dosimetry: Pallisades In-vessel Dosimetry

Originator ID	Lab Sample #	Dosimeter Material	Nuclide	(October 12, 1993) dps/mg	+/-	2 sigma
#1414 TOP						
U-238(1 ring)	93-4192	U-238	Zr-95	7.09E+02	+/-	3.0E+00
			Ru-103	3.26E+02	+/-	2.9E+00
			Cs-137	1.23E+03	+/-	2.4E+00
Ti (2 rings)	93-4193	Ti	Sc-46	1.98E+02	+/-	2.7E+00
Fe (4 rings)	93-4194	Fe	Mn-54	1.34E+03	+/-	1.2E+01
U-238 (Cd) (5 rings)	93-4195	U-238	Zr-95	6.95E+01	+/-	1.5E+00
			Ru-103	3.46E+01	+/-	1.3E+00
			Cs-137	1.30E+02	+/-	1.0E+00
Ni (Cd) (6 rings)	93-4196	Ni	Co-58	7.01E+03	+/-	6.6E+01
Cu (Cd) (7 rings)	93-4197	Cu	Co-60	2.22E+02	+/-	2.7E+00
Glass Sulphur	93-4198	S	NA	NA		
Fe (1 ring)t	93-4199	Fe	Mn-54	1.31E+03	+/-	1.5E+01
Fe (2 rings)t	93-4200	Fe	Mn-54	1.31E+03	+/-	1.5E+01
Fe (3 rings)t	93-4201	Fe	Mn-54	1.28E+03	+/-	1.5E+01
Fe (4 rings)t	93-4202	Fe	Mn-54	1.39E+03	+/-	1.6E+01
Fe (5 rings)t	93-4203	Fe	Mn-54	1.22E+03	+/-	1.4E+01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).
Combustion Engineering Capsule Design
"t" denotes thin rings

Procedures:A-512,A-513,A-524
Analyst:WTF,FRC,MRK
Page 1

Approved: Mark Korchak

Westinghouse Electric Corporation
Chemistry & Materials Technology - Analytical Laboratory
REPORT Waltz Mill Site Request# 15214

Originator: Ed Terek (W)NTD
Structural Reliability & Plant Life Optimization
Westinghouse Electric Corporation

Received: 10/11/93
Reported: 1/11/94

[RESULTS OF ANALYSIS]

Dosimetry: Pallisades In-vessel Dosimetry W-110

Originator ID	Lab Sample #	Dosimeter Material	Nuclide	(October 12, 1993) dps/mg	+/-	2 sigma
#1441 MID						
U-238(1 ring)	93-4204	U-238	Zr-95	6.69E+02	+/-	7.0E+00
			Ru-103	3.06E+02	+/-	7.6E+00
			Cs-137	1.30E+03	+/-	5.9E+00
Ti (2 rings)	93-4205	Ti	Sc-46	1.99E+02	+/-	2.8E+00
Fe (3 rings)	93-4206	Fe	Mn-54	1.41E+03	+/-	1.2E+01
U-238 (Cd) (5 rings)	93-4208	U-238	Zr-95	7.49E+01	+/-	5.6E-01
			Ru-103	3.49E+01	+/-	5.6E-01
			Cs-137	1.60E+02	+/-	4.6E-01
Ni (Cd) (6 rings)	93-4209	Ni	Co-58	7.11E+03	+/-	6.7E+01
Cu (Cd) (7 rings)	93-4210	Cu	Co-60	2.58E+02	+/-	3.1E+00
Glass Sulphur	93-4208	S	NA	NA		
Fe (1 ring)t	93-4211	Fe	Mn-54	1.42E+03	+/-	1.5E+01
Fe (2 rings)t	93-4212	Fe	Mn-54	1.42E+03	+/-	1.5E+01
Fe (3 rings)t	93-4213	Fe	Mn-54	1.40E+03	+/-	1.5E+01
Fe (4 rings)t	93-4214	Fe	Mn-54	1.51E+03	+/-	1.6E+01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).
Combustion Engineering Capsule Design
"t" denotes thin rings

Procedures:A-512,A-513,A-524
Analyst:WTF,FRC,MRK
Page 2

Approved: [signature]

Westinghouse Electric Corporation
Chemistry & Materials Technology - Analytical Laboratory
REPORT Waltz Mill Site Request# 15214

Originator: Ed Terek (W)NTD
Structural Reliability & Plant Life Optimization Received: 10/11/93
Westinghouse Electric Corporation Reported: 1/11/94

[RESULTS OF ANALYSIS]

Dosimetry: Pallisades In-vessel Dosimetry

Originator ID	Lab Sample #	Dosimeter Material	Nuclide	(October 12, 1993) dps/mg	+/-	2 sigma
#1473 807						
U-238(1 ring)	93-4215	U-238	Zr-95	7.53E+02	+/-	1.2E+01
			Ru-103	3.55E+02	+/-	1.1E+01
			Cs-137	1.41E+03	+/-	8.2E+00
Ti (2 rings)	93-4216	Ti	Sc-46	1.98E+02	+/-	2.7E+00
Fe (3 rings)	93-4217	Fe	Mn-54	1.37E+03	+/-	1.2E+01
U-238 (Cd) (5 rings)	93-4218	U-238	Zr-95	7.97E+01	+/-	2.1E+00
			Ru-103	3.69E+01	+/-	1.8E+00
			Cs-137	1.65E+02	+/-	1.4E+00
Ni (Cd) (6 rings)	93-4219	Ni	Co-58	7.02E+03	+/-	6.6E+01
Cu (Cd) (7 rings)	93-4220	Cu	Co-60	2.50E+02	+/-	3.1E+00
Glass Sulphur	93-4221	S	NA	NA		
Fe (1 ring)t	93-4222	Fe	Mn-54	1.42E+03	+/-	1.5E+01
Fe (2 rings)t	93-4223	Fe	Mn-54	1.41E+03	+/-	1.5E+01
Fe (3 rings)t	93-4224	Fe	Mn-54	1.38E+03	+/-	1.5E+01
Fe (4 rings)t	93-4225	Fe	Mn-54	1.53E+03	+/-	1.6E+01
Fe (5 rings)t	93-4226	Fe	Mn-54	1.31E+03	+/-	1.5E+01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).
Combustion Engineering Capsule Design
"t" denotes thin rings

Procedures:A-512,A-513,A-524
Analyst:WTF,FRC,MRK
Page 3

Approved: [signature]

APPENDIX B

SPECIFIC ACTIVITIES AND IRRADIATION HISTORY OF REACTOR CAVITY SENSOR SETS - CYCLE 8

In this appendix, the irradiation history as extracted from NUREG-0020 and the measured specific activities of radiometric monitors irradiated in the reactor cavity during Cycle 8 are provided.

The irradiation history of Cycle 8 was as follows:

Cycle	Startup	Shutdown	Comment
8	11/01/88	09/15/90	

Reference Core Power = 2530 MWt

The monthly thermal generation applicable to the Palisades reactor is provided in addition to the specific activities of the sensors on the following pages.

TABLE B-1

IRRADIATION HISTORY OF REACTOR CAVITY SENSOR SETS

Cycle 8

Date	Thermal Generation MW-hr
Sep-88	0
Oct-88	0
Nov-88	29640
Dec-88	454344
Jan-89	1657920
Feb-89	0
Mar-89	1248144
Apr-89	1392120
May-89	1499736
Jun-89	1457664
Jul-89	1510872
Aug-89	1341864
Sep-89	1453344
Oct-89	504
Nov-89	0
Dec-89	502200
Jan-90	1372848
Feb-90	1352352
Mar-90	1378920
Apr-90	741096
May-90	536208
Jun-90	1047984
Jul-90	1501584
Aug-90	1501896
Sep-90	704184

TABLE B-2

CONTENTS OF MULTIPLE FOIL SENSOR SETS
CYCLE 8 IRRADIATION

Capsule ID/ Position	Bare or Cd Shielded	Radiometric Monitor Foil ID Fe	Ni	Cu	Ti	Nb	Co	^{238}U (nat)	^{238}U (dep)	NBS PUD	^{237}Np
A-1	B	A	-	-	-	-	A	-	-	-	-
A-2	Cd	K	A	BA	AK	BA	K	AA	BG	-	-
A-3	Cd	-	-	-	-	-	-	-	-	11N1	8
B-1	B	B	-	-	-	-	B	-	-	-	-
B-2	Cd	L	B	BB	AL	BB	L	AB	BH	-	-
B-3	Cd	-	-	-	-	-	-	-	-	12N2	9
C-1	B	C	-	-	-	-	C	-	-	-	-
C-2	Cd	M	C	BC	AM	BC	M	AC	BI	-	-
C-3	Cd	-	-	-	-	-	-	-	-	13N3	10
D-1	B	D	-	-	-	-	D	-	-	-	-
D-2	Cd	N	D	BD	AN	BD	N	AD	BJ	-	-
D-3	Cd	-	-	-	-	-	-	-	-	14N4	11
E-1	B	E	-	-	-	-	E	-	-	-	-
E-2	Cd	O	E	BE	AO	BE	O	AE	AL	-	-
E-3	Cd	-	-	-	-	-	-	-	-	15N5	12
F-1	B	F	-	-	-	-	F	-	-	-	-
F-2	Cd	P	F	BF	AP	BF	P	AF	AM	-	-
F-3	Cd	-	-	-	-	-	-	-	-	16N6	13
G-1	B	G	-	-	-	-	G	-	-	-	-
G-2	Cd	R	G	BG	AR	BG	R	AG	U	-	-
G-3	Cd	-	-	-	-	-	-	-	-	17N7	14

RSAC PAL 671

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT

Request# 14175

TO: A.H.Fero (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 12/21/90

[RESULTS OF ANALYSIS]
Palisades Cycle 8 Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 12/12/90) dps/mg *		2 sigma
B	90-1857	Fe	Mn-54	17.43	+/-	0.19
L	90-1858	Fe	Mn-54	17.23	+/-	0.19
D	90-1870	Fe	Mn-54	13.20	+/-	0.16
N	90-1871	Fe	Mn-54	12.97	+/-	0.14
E	90-1883	Fe	Mn-54	4.28	+/-	0.07
O	90-1884	Fe	Mn-54	3.89	+/-	0.05
G	90-1896	Fe	Mn-54	9.36	+/-	0.07
R	90-1897	Fe	Mn-54	9.35	+/-	0.07
B	90-1859	Ni	Co-58	201.10	+/-	1.43
D	90-1872	Ni	Co-58	151.20	+/-	1.76
E	90-1885	Ni	Co-58	49.72	+/-	0.55
G	90-1898	Ni	Co-58	106.70	+/-	1.49
BB	90-1860	Cu	Co-60	0.745	+/-	0.010
BD	90-1873	Cu	Co-60	0.573	+/-	0.003
BE	90-1886	Cu	Co-60	0.152	+/-	0.003
BG	90-1899	Cu	Co-60	0.422	+/-	0.010
AL	90-1861	Ti	Sc-46	4.57	+/-	0.07
AN	90-1874	Ti	Sc-46	3.50	+/-	0.03
AO	90-1887	Ti	Sc-46	1.05	+/-	0.01
AR	90-1900	Ti	Sc-46	2.48	+/-	0.02
B	90-1863	AlCo	Co-60	270.7	+/-	4.1
L	90-1864	AlCo	Co-60	179.7	+/-	3.2
D	90-1876	AlCo	Co-60	253.4	+/-	4.2
N	90-1877	AlCo	Co-60	174.7	+/-	3.4
E	90-1889	AlCo	Co-60	151.5	+/-	3.3
O	90-1890	AlCo	Co-60	101.9	+/-	2.0
G	90-1902	AlCo	Co-60	281.4	+/-	2.8
R	90-1903	AlCo	Co-60	169.6	+/-	2.3

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14175
References: Lab.Book# 35 page 298 - 300
Procedures: A-524.
Analyst: WTF, CAB.

Approved: C.A. Blackburn 12-21-90

RSAC PAL 671

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT Request# 14175

TO: A.H.Fero (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 12/20/90

[RESULTS OF ANALYSIS]

Palisades Cycle 8 Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 12/12/90) dps/mg *		2 sigma
AB	90-1865	U(2)	Zr-95	41.60	+/-	0.07
BH	90-1866	U(2)	Zr-95	12.40	+/-	0.10
12	90-1867	U(1)	Zr-95	12.17	+/-	0.05
N2	90-1868	U(2)	Zr-95	40.21	+/-	0.07
AD	90-1878	U(2)	Zr-95	36.71	+/-	0.19
BJ	90-1879	U(2)	Zr-95	9.75	+/-	0.10
14	90-1880	U(1)	Zr-95	9.75	+/-	0.05
N4	90-1881	U(2)	Zr-95	36.62	+/-	0.21
AE	90-1891	U(2)	Sample lost during inspection			
AL	90-1892	U(2)	Zr-95	3.78	+/-	0.05
15	90-1893	U(1)	Zr-95	3.22	+/-	0.04
N5	90-1894	U(2)	Zr-95	19.02	+/-	0.10
AG	90-1904	U(2)	Zr-95	34.40	+/-	0.17
U	90-1905	U(2)	Zr-95	7.48	+/-	0.06
17	90-1906	U(1)	Zr-95	6.19	+/-	0.05
N7	90-1907	U(2)	Zr-95	35.87	+/-	0.18
AB	90-1865	U(2)	Ru-103	17.49	+/-	0.04
BH	90-1866	U(2)	Ru-103	8.64	+/-	0.07
12	90-1867	U(1)	Ru-103	8.88	+/-	0.04
N2	90-1868	U(2)	Ru-103	16.92	+/-	0.04
AD	90-1878	U(2)	Ru-103	14.80	+/-	0.11
BJ	90-1879	U(2)	Ru-103	6.78	+/-	0.06
14	90-1880	U(1)	Ru-103	6.95	+/-	0.03
N4	90-1881	U(2)	Ru-103	14.82	+/-	0.13
AE	90-1891	U(2)	Sample lost during inspection			
AL	90-1892	U(2)	Ru-103	2.46	+/-	0.03
15	90-1893	U(1)	Ru-103	2.29	+/-	0.02
N5	90-1894	U(2)	Ru-103	6.97	+/-	0.06
AG	90-1904	U(2)	Ru-103	13.03	+/-	0.09
U	90-1905	U(2)	Ru-103	4.86	+/-	0.04
17	90-1906	U(1)	Ru-103	4.39	+/-	0.03
N7	90-1907	U(2)	Ru-103	13.45	+/-	0.13

Remarks: * The U foils turned to a powder during irradiation. Oxide form unknown.
U(1) For the PUD depleted foils (#12,#14,#15,#17), the foils were counted unopened, and the results calculated using the Net U3O8 weight supplied by A.Fero.
U(2) For all other U foils, the foils were opened and the recovered powder weighed. The results were calculated using the recovered powder weight.

AL File: 14175. References: Lab.Book# 35 page 298 - 300
Procedures: A-524.
Analyst: WTF, CAB.

Approved: C.A. Blackburn 12-20-90

RSAC PAL 671 9

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT

Request# 14175

TO: A.H.Fero (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 12/20/90

Palisades Cycle 8 Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 12/12/90) dps/mg *		2 sigma
AB	90-1865	U(2)	Cs-137	3.700	+/-	0.021
BH	90-1866	U(2)	Cs-137	1.300	+/-	0.031
12	90-1867	U(1)	Cs-137	1.272	+/-	0.019
N2	90-1868	U(2)	Cs-137	3.572	+/-	0.021
AD	90-1878	U(2)	Cs-137	3.237	+/-	0.060
BJ	90-1879	U(2)	Cs-137	0.975	+/-	0.027
14	90-1880	U(1)	Cs-137	0.981	+/-	0.017
N4	90-1881	U(2)	Cs-137	3.192	+/-	0.059
AE	90-1891	U(2)	Sample lost during inspection			
AL	90-1892	U(2)	Cs-137	0.346	+/-	0.014
15	90-1893	U(1)	Cs-137	0.303	+/-	0.013
N5	90-1894	U(2)	Cs-137	1.537	+/-	0.029
AG	90-1904	U(2)	Cs-137	2.980	+/-	0.053
U	90-1905	U(2)	Cs-137	0.764	+/-	0.018
17	90-1906	U(1)	Cs-137	0.651	+/-	0.016
N7	90-1907	U(2)	Cs-137	3.105	+/-	0.072

Remarks: * The U foils turned to a powder during irradiation. Oxide form unknown.
U(1) For the PUD depleted foils (#12,#14,#15,#17), the foils were counted unopened, and the results calculated using the Net U3O8 weight supplied by A.Fero.
U(2) For all other U foils, the foils were opened and the recovered powder weighed. The results were calculated using the recovered powder weight.

AL File: 14175. References: Lab.Book# 35 page 298 - 300
Procedures: A-524.
Analyst: WTF, CAB.

Approved: C.A. Blackburn 12-20-90

RSAC PAL 671[10]

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT

Request# 14175

TO: A.H.Fero (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 12/20/90

[RESULTS OF ANALYSIS]

Palisades Cycle 8 Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 12/12/90) dps/mg *		2 sigma
9	90-1869	Np-237	Zr-95	238.8	+/-	1.4
11	90-1882	Np-237	Zr-95	175.0	+/-	1.5
12	90-1895	Np-237	Zr-95	60.3	+/-	1.1
14	90-1908	Np-237	Zr-95	129.6	+/-	1.3
9	90-1869	Np-237	Ru-103	144.2	+/-	0.9
11	90-1882	Np-237	Ru-103	106.4	+/-	1.4
12	90-1895	Np-237	Ru-103	39.5	+/-	0.8
14	90-1908	Np-237	Ru-103	79.8	+/-	1.2
9	90-1869	Np-237	Cs-137	24.01	+/-	0.47
11	90-1882	Np-237	Cs-137	17.97	+/-	0.77
12	90-1895	Np-237	Cs-137	5.94	+/-	0.40
14	90-1908	Np-237	Cs-137	12.82	+/-	0.61

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14175. References: Lab.Book# 35 page 298 - 300
Procedures: A-524.
Analyst: WTF, CAB.

Approved: C. A. Blackburn 12-20-90

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RSAC PAL 671

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT

Request# 14175

TO: E.P.Lippincott (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 4/3/91

[RESULTS OF ANALYSIS]

(10 DEG.)

Palisades Cycle 8 Reactor Cavity Dosimetry

Azimuth: 280 deg.
Bead Chain Tag ID: 280 deg.

Feet from Midplane	Lab Sample#	[<—— dps/mg of chain @ 12/12/90 Mn-54 dps/mg	2 sigma	Co-58 dps/mg	2 sigma	Co-60 dps/mg ——>	2 sigma
+0.5	90-1915A	1.14E+01 +/-	7.0E-01	1.92E+01 +/-	1.0E+00	1.01E+02 +/-	9.9E-01
-0.5	90-1915B	1.16E+01 +/-	5.9E-01	1.99E+01 +/-	1.3E+00	1.01E+02 +/-	7.7E-01
-1.0	90-1915C	1.16E+01 +/-	7.0E-01	1.88E+01 +/-	9.1E-01	1.01E+02 +/-	9.1E-01
-1.5	90-1915D	1.13E+01 +/-	6.0E-01	1.79E+01 +/-	1.3E+00	9.90E+01 +/-	7.7E-01
-2.0	90-1915E	1.09E+01 +/-	6.5E-01	1.73E+01 +/-	8.6E-01	9.62E+01 +/-	8.9E-01
-2.5	90-1915F	9.19E+00 +/-	5.5E-01	1.72E+01 +/-	1.2E+00	9.34E+01 +/-	7.4E-01
-3.0	90-1915G	8.84E+00 +/-	5.0E-01	1.49E+01 +/-	7.0E-01	8.95E+01 +/-	7.2E-01
-3.5	90-1915H	8.44E+00 +/-	6.5E-01	1.43E+01 +/-	1.1E+00	8.63E+01 +/-	7.1E-01
-4.0	90-1915I	6.17E+00 +/-	3.9E-01	1.19E+01 +/-	7.0E-01	8.07E+01 +/-	6.8E-01
-4.5	90-1915J	5.10E+00 +/-	3.8E-01	8.90E+00 +/-	7.3E-01	6.87E+01 +/-	4.1E-01
-5.0	90-1915K	3.43E+00 +/-	3.4E-01	5.92E+00 +/-	5.2E-01	5.86E+01 +/-	5.8E-01
-5.5	90-1915L	2.27E+00 +/-	1.9E-01	4.24E+00 +/-	4.3E-01	5.39E+01 +/-	2.7E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14175
References: Lab.Book# 49 pages 3-20.

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RSAC PAL 671

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT

Request# 14175

TO: E.P.Lippincott (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 4/3/91

[RESULTS OF ANALYSIS]

(20 DEG.)

Palisades Cycle 8 Reactor Cavity Dosimetry

Azimuth: 290 deg.
Bead Chain Tag ID: 290 deg.

Feet from Midplane	Lab Sample#	Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
		[<— dps/mg of chain @ 12/12/90 —>]					
+0.5	90-1916A	8.36E+00 +/-	5.2E-01	1.45E+01 +/-	7.4E-01	9.08E+01 +/-	7.3E-01
-0.5	90-1916B	8.52E+00 +/-	3.1E-01	1.40E+01 +/-	6.7E-01	9.06E+01 +/-	4.1E-01
-1.0	90-1916C	8.68E+00 +/-	5.8E-01	1.41E+01 +/-	6.6E-01	9.09E+01 +/-	7.2E-01
-1.5	90-1916D	8.52E+00 +/-	3.2E-01	1.46E+01 +/-	7.4E-01	8.96E+01 +/-	4.2E-01
-2.0	90-1916E	8.32E+00 +/-	5.0E-01	1.45E+01 +/-	7.3E-01	8.90E+01 +/-	7.1E-01
-2.5	90-1916F	7.84E+00 +/-	5.3E-01	1.39E+01 +/-	1.1E+00	8.57E+01 +/-	7.2E-01
-3.0	90-1916G	7.46E+00 +/-	3.0E-01	1.28E+01 +/-	4.5E-01	8.49E+01 +/-	4.9E-01
-3.5	90-1916H	7.26E+00 +/-	5.8E-01	1.22E+01 +/-	1.2E+00	8.16E+01 +/-	7.0E-01
-4.0	90-1916I	6.15E+00 +/-	4.9E-01	1.15E+01 +/-	1.1E+00	7.72E+01 +/-	6.8E-01
-4.5	90-1916J	5.17E+00 +/-	2.8E-01	8.91E+00 +/-	4.0E-01	7.23E+01 +/-	4.6E-01
-5.0	90-1916K	3.45E+00 +/-	2.2E-01	5.99E+00 +/-	2.9E-01	5.79E+01 +/-	3.3E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14175
References: Lab.Book# 49 pages 3-20.
Procedures: A-524.
Analyst: WTF,TK.

Approved: Bertram Murphy

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RSAC P L 671

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT

Request# 14175

TO: E.P.Lippincott (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 4/3/91

[RESULTS OF ANALYSIS]

(45 DEG.)

Palisades Cycle 8 Reactor Cavity Dosimetry

Azimuth: 315 deg.
Bead Chain Tag ID: 315 deg.

Feet from Midplane	Lab Sample#	[<— dps/mg of chain @ 12/12/90 —>] Mn-54 dps/mg		Mn-54 2 sigma	Co-58 dps/mg		Co-58 2 sigma	Co-60 dps/mg		Co-60 2 sigma
+0.5	90-1918A	6.19E+00	+/-	5.6E-01	1.06E+01	+/-	1.1E+00	1.02E+02	+/-	7.8E-01
-0.5	90-1918B	6.07E+00	+/-	5.4E-01	9.43E+00	+/-	1.1E+00	1.03E+02	+/-	7.7E-01
-1.0	90-1918C	6.07E+00	+/-	6.1E-01	9.12E+00	+/-	1.2E+00	1.01E+02	+/-	8.7E-01
-1.5	90-1918D	5.42E+00	+/-	4.8E-01	9.61E+00	+/-	1.1E+00	1.01E+02	+/-	7.8E-01
-2.0	90-1918E	5.71E+00	+/-	3.2E-01	9.42E+00	+/-	4.7E-01	9.81E+01	+/-	5.3E-01
-2.5	90-1918F	5.03E+00	+/-	5.2E-01	8.21E+00	+/-	1.1E+00	9.54E+01	+/-	7.5E-01
-3.0	90-1918G	4.93E+00	+/-	4.1E-01	8.23E+00	+/-	7.9E-01	8.91E+01	+/-	5.3E-01
-3.5	90-1916H	4.40E+00	+/-	2.9E-01	7.49E+00	+/-	4.2E-01	8.66E+01	+/-	5.0E-01
-4.0	90-1916I	3.84E+00	+/-	3.3E-01	7.13E+00	+/-	7.3E-01	7.92E+01	+/-	4.4E-01
-4.5	90-1916J	3.53E+00	+/-	2.9E-01	5.94E+00	+/-	3.6E-01	7.38E+01	+/-	4.6E-01
-5.0	90-1916K	2.50E+00	+/-	2.6E-01	4.44E+00	+/-	3.2E-01	5.92E+01	+/-	4.1E-01
-5.5	90-1916L	1.85E+00	+/-	1.9E-01	3.64E+00	+/-	5.0E-01	5.02E+01	+/-	3.1E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14175
References: Lab.Book# 49 pages 3-20.
Procedures: A-524.
Analyst: WTF,TK.

Approved: [signature]

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RSAC PAL 671

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT

Request# 14175

TO: E.P.Lippincott (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 3/13/91

[RESULTS OF ANALYSIS]

(15 DEG.)

Palisades Cycle 8 Reactor Cavity Dosimetry

Azimuth: 330 deg.
Bead Chain Tag ID: 330 deg.

Feet from Midplane	Lab Sample#	[<— dps/mg of chain @ 12/12/90 —>] Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
+0.5	90-1919A	8.69E+00 +/-	5.7E-01	1.51E+01 +/-	1.2E+00	1.14E+02 +/-	8.2E-01
0.0	90-1919B	9.69E+00 +/-	6.6E-01	1.44E+01 +/-	1.0E+00	1.14E+02 +/-	8.3E-01
-0.5	90-1919C	9.19E+00 +/-	5.8E-01	1.56E+01 +/-	1.1E+00	1.14E+02 +/-	8.2E-01
-1.0	90-1919D	9.32E+00 +/-	6.1E-01	1.48E+01 +/-	1.0E+00	1.11E+02 +/-	8.1E-01
-1.5	90-1919E	8.24E+00 +/-	5.3E-01	1.39E+01 +/-	1.1E+00	1.09E+02 +/-	8.0E-01
-2.0	90-1919F	7.85E+00 +/-	5.4E-01	1.43E+01 +/-	1.0E+00	1.05E+02 +/-	7.9E-01
-2.5	90-1919G	7.34E+00 +/-	3.3E-01	1.30E+01 +/-	6.5E-01	9.96E+01 +/-	4.9E-01
-3.0	90-1919H	6.68E+00 +/-	3.5E-01	1.16E+01 +/-	6.9E-01	9.38E+01 +/-	5.5E-01
-3.5	90-1919I	5.52E+00 +/-	3.3E-01	9.69E+00 +/-	7.0E-01	8.75E+01 +/-	5.2E-01
-4.0	90-1919J	4.74E+00 +/-	3.9E-01	8.09E+00 +/-	5.9E-01	8.03E+01 +/-	5.0E-01
-4.5	90-1919K	3.37E+00 +/-	2.7E-01	5.40E+00 +/-	5.0E-01	6.45E+01 +/-	4.5E-01
-5.0	90-1919L	2.44E+00 +/-	2.6E-01	4.30E+00 +/-	5.0E-01	5.52E+01 +/-	4.1E-01
-5.5	90-1919M	1.46E+00 +/-	2.5E-01	3.12E+00 +/-	4.2E-01	5.08E+01 +/-	4.0E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14175
References: Lab.Book# 49 pages 3-20.
Procedures: A-524.
Analyst: WTF,TK.

Approved: [signature]

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RSAC PAL 671

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT Request# 14175

TO: E.P.Lippincott (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 4/2/91

(30 DEG.)

[RESULTS OF ANALYSIS]

Palisades Cycle 8 Reactor Cavity Dosimetry

Azimuth: 30 deg.
Bead Chain Tag ID: (30).

Feet from Midplane	Lab Sample#	Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
		[<— dps/mg of chain @ 12/12/90 —>]					
+8.0	90-1909A	4.32E-01 +/-	1.2E-01	9.65E-01 +/-	3.0E-01	3.05E+01 +/-	2.3E-01
+7.5	90-1909B	5.75E-01 +/-	1.1E-01	1.09E+00 +/-	2.4E-01	3.31E+01 +/-	1.7E-01
+7.0	90-1909C	1.11E+00 +/-	1.5E-01	1.94E+00 +/-	3.5E-01	3.92E+01 +/-	2.6E-01
+6.5	90-1909D	1.38E+00 +/-	1.4E-01	2.40E+00 +/-	2.9E-01	4.06E+01 +/-	1.8E-01
+6.0	90-1909E	2.33E+00 +/-	2.0E-01	3.92E+00 +/-	3.9E-01	4.65E+01 +/-	2.9E-01
+5.5	90-1909F	2.94E+00 +/-	1.6E-01	5.56E+00 +/-	3.5E-01	4.77E+01 +/-	2.0E-01
+5.0	90-1909G	3.81E+00 +/-	2.2E-01	6.61E+00 +/-	4.5E-01	5.50E+01 +/-	3.2E-01
+4.5	90-1909H	4.72E+00 +/-	2.3E-01	8.38E+00 +/-	4.9E-01	5.90E+01 +/-	3.3E-01
+4.0	90-1909I	5.04E+00 +/-	2.0E-01	8.84E+00 +/-	3.9E-01	5.85E+01 +/-	2.2E-01
+3.5	90-1909J	5.98E+00 +/-	2.9E-01	1.02E+01 +/-	5.6E-01	6.53E+01 +/-	3.4E-01
+3.0	90-1909K	6.28E+00 +/-	3.2E-01	1.05E+01 +/-	5.2E-01	6.80E+01 +/-	3.5E-01
+2.5	90-1909L	6.64E+00 +/-	3.5E-01	1.06E+01 +/-	8.0E-01	6.97E+01 +/-	4.0E-01
+2.0	90-1909M	6.57E+00 +/-	3.1E-01	1.04E+01 +/-	5.6E-01	7.36E+01 +/-	3.7E-01
+1.5	90-1909N	6.46E+00 +/-	3.1E-01	1.07E+01 +/-	5.3E-01	7.58E+01 +/-	3.7E-01
+1.0	90-1909O	6.59E+00 +/-	3.6E-01	1.12E+01 +/-	7.6E-01	7.61E+01 +/-	4.1E-01
+0.5	90-1909P	6.77E+00 +/-	2.8E-01	1.09E+01 +/-	5.5E-01	7.93E+01 +/-	3.8E-01
0.0	90-1909Q	6.89E+00 +/-	2.8E-01	1.12E+01 +/-	6.0E-01	8.02E+01 +/-	3.8E-01
-0.5	90-1909R	6.84E+00 +/-	3.7E-01	1.14E+01 +/-	9.0E-01	7.94E+01 +/-	4.5E-01
-1.0	90-1909S	6.90E+00 +/-	2.7E-01	1.14E+01 +/-	5.9E-01	8.18E+01 +/-	3.8E-01
-1.5	90-1909T	6.50E+00 +/-	3.5E-01	1.24E+01 +/-	8.4E-01	7.93E+01 +/-	4.3E-01
-2.0	90-1909U	6.93E+00 +/-	2.8E-01	1.17E+01 +/-	5.8E-01	7.98E+01 +/-	3.8E-01
-2.5	90-1909V	6.64E+00 +/-	2.8E-01	1.18E+01 +/-	6.4E-01	7.83E+01 +/-	3.8E-01
-3.0	90-1909W	6.33E+00 +/-	3.7E-01	1.10E+01 +/-	7.5E-01	7.40E+01 +/-	4.1E-01
-3.5	90-1909X	6.06E+00 +/-	2.7E-01	9.96E+00 +/-	5.3E-01	7.17E+01 +/-	3.6E-01
-4.0	90-1909Y	5.47E+00 +/-	2.6E-01	9.27E+00 +/-	4.7E-01	6.70E+01 +/-	3.5E-01
-4.5	90-1909Z	4.38E+00 +/-	3.2E-01	8.24E+00 +/-	7.7E-01	5.98E+01 +/-	3.7E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14175
References: Lab.Book# 49 pages 3-20.
Procedures: A-524.
Analyst: WTF,TK.

Approved: [signature]

8/ ✓

RSAC L 671

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT Request# 14175

TO: E.P.Lippincott (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 4/2/91

[RESULTS OF ANALYSIS]

(0 DEG.)

Palisades Cycle 8 Reactor Cavity Dosimetry

Azimuth: 90 deg.
Bead Chain Tag ID: (90).

Feet from Midplane	Lab Sample#	Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
		dps/mg of chain @ 12/12/90					
+8.0	90-1910A	6.42E-01	+/- 7.6E-02	1.20E+00	+/- 1.4E-01	4.55E+01	+/- 1.9E-01
+7.5	90-1910B	8.34E-01	+/- 8.2E-02	1.65E+00	+/- 1.8E-01	4.99E+01	+/- 1.2E-01
+7.0	90-1910C	1.39E+00	+/- 2.1E-01	2.98E+00	+/- 4.1E-01	5.93E+01	+/- 3.3E-01
+6.5	90-1910D	2.10E+00	+/- 2.7E-01	3.83E+00	+/- 5.4E-01	6.38E+01	+/- 3.9E-01
+6.0	90-1910E	3.12E+00	+/- 2.4E-01	5.18E+00	+/- 4.3E-01	7.13E+01	+/- 3.3E-01
+5.5	90-1910F	3.90E+00	+/- 3.4E-01	6.85E+00	+/- 6.8E-01	7.62E+01	+/- 4.2E-01
+5.0	90-1910G	4.74E+00	+/- 2.4E-01	8.35E+00	+/- 4.9E-01	8.65E+01	+/- 5.1E-01
+4.5	90-1910H	5.74E+00	+/- 2.5E-01	9.69E+00	+/- 5.3E-01	9.18E+01	+/- 3.8E-01
+4.0	90-1910I	6.32E+00	+/- 3.7E-01	1.07E+01	+/- 7.7E-01	9.63E+01	+/- 4.7E-01
+3.5	90-1910J	6.97E+00	+/- 4.9E-01	1.26E+01	+/- 1.0E+00	1.05E+02	+/- 7.2E-01
+3.0	90-1910K	7.25E+00	+/- 4.1E-01	1.30E+01	+/- 8.9E-01	1.08E+02	+/- 5.0E-01
+2.5	90-1910L	7.52E+00	+/- 5.2E-01	1.31E+01	+/- 1.1E+00	1.17E+02	+/- 7.5E-01
+2.0	90-1910M	7.65E+00	+/- 5.6E-01	1.42E+01	+/- 1.4E+00	1.26E+02	+/- 7.8E-01
+1.5	90-1910N	7.44E+00	+/- 4.3E-01	1.26E+01	+/- 9.0E-01	1.18E+02	+/- 5.3E-01
+1.0	90-1910O	7.15E+00	+/- 5.5E-01	1.36E+01	+/- 1.0E+00	1.30E+02	+/- 7.9E-01
+0.5	90-1910P	7.55E+00	+/- 4.5E-01	1.31E+01	+/- 9.3E-01	1.28E+02	+/- 5.4E-01
0.0	90-1910Q	8.43E+00	+/- 6.0E-01	1.25E+01	+/- 1.1E+00	1.32E+02	+/- 8.0E-01
-0.5	90-1910R	7.96E+00	+/- 5.5E-01	1.30E+01	+/- 1.2E+00	1.34E+02	+/- 8.1E-01
-1.0	90-1910S	7.24E+00	+/- 4.6E-01	1.27E+01	+/- 1.1E+00	1.32E+02	+/- 8.1E-01
-1.5	90-1910T	7.33E+00	+/- 5.4E-01	1.18E+01	+/- 1.1E+00	1.31E+02	+/- 8.0E-01
-2.0	90-1910U	7.02E+00	+/- 5.4E-01	1.20E+01	+/- 1.2E+00	1.27E+02	+/- 7.9E-01
-2.5	90-1910V	7.04E+00	+/- 5.3E-01	1.26E+01	+/- 1.3E+00	1.22E+02	+/- 7.7E-01
-3.0	90-1910W	6.01E+00	+/- 3.8E-01	1.13E+01	+/- 9.9E-01	1.13E+02	+/- 5.2E-01
-3.5	90-1910X	6.64E+00	+/- 5.5E-01	1.07E+01	+/- 9.9E-01	1.09E+02	+/- 7.2E-01
-4.0	90-1910Y	5.58E+00	+/- 4.1E-01	8.90E+00	+/- 8.4E-01	9.91E+01	+/- 4.9E-01
-4.5	90-1910Z	4.57E+00	+/- 4.8E-01	7.31E+00	+/- 9.8E-01	9.15E+01	+/- 6.7E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14175
References: Lab.Book# 49 pages 3-20.
Procedures: A-524.
Analyst: WTF,TK.

Approved: [signature]

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RSAC [illegible] 671

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT

Request# 14175

TO: E.P.Lippincott (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 3/13/91

[RESULTS OF ANALYSIS]

(30 DEG.)

Palisades Cycle 8 Reactor Cavity Dosimetry

Azimuth: 150 deg.
Bead Chain Tag ID: (NONE).

Feet from Midplane	Lab Sample#	dps/mg of chain @ 12/12/90 Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
+8.0	90-1911A	6.13E-01 +/-	1.3E-01	9.66E-01 +/-	2.3E-01	3.28E+01 +/-	2.2E-01
+7.5	90-1911B	9.30E-01 +/-	1.5E-01	1.75E+00 +/-	2.8E-01	3.78E+01 +/-	2.4E-01
+7.0	90-1911C	1.77E+00 +/-	1.8E-01	3.22E+00 +/-	3.1E-01	4.81E+01 +/-	2.7E-01
+6.5	90-1911D	1.70E+00 +/-	1.7E-01	3.27E+00 +/-	2.8E-01	4.81E+01 +/-	2.7E-01
+6.0	90-1911E	2.50E+00 +/-	1.6E-01	4.51E+00 +/-	3.5E-01	5.24E+01 +/-	2.8E-01
+5.5	90-1911F	3.80E+00 +/-	3.0E-01	6.34E+00 +/-	5.9E-01	5.56E+01 +/-	3.8E-01
+5.0	90-1911G	4.53E+00 +/-	2.5E-01	7.93E+00 +/-	3.9E-01	6.11E+01 +/-	3.0E-01
+4.5	90-1911H	4.99E+00 +/-	4.4E-01	1.02E+01 +/-	7.5E-01	6.54E+01 +/-	5.0E-01
+4.0	90-1911I	5.76E+00 +/-	4.3E-01	1.08E+01 +/-	8.2E-01	6.93E+01 +/-	5.1E-01
+3.5	90-1911J	6.89E+00 +/-	4.5E-01	1.13E+01 +/-	8.5E-01	7.38E+01 +/-	5.3E-01
+3.0	90-1911K	6.75E+00 +/-	4.8E-01	1.21E+01 +/-	8.3E-01	7.79E+01 +/-	5.5E-01
+2.5	90-1911L	7.02E+00 +/-	4.7E-01	1.19E+01 +/-	7.4E-01	8.07E+01 +/-	5.5E-01
+2.0	90-1911M	7.32E+00 +/-	4.6E-01	1.29E+01 +/-	9.5E-01	8.37E+01 +/-	5.6E-01
+1.5	90-1911N	7.23E+00 +/-	4.9E-01	1.21E+01 +/-	8.3E-01	8.66E+01 +/-	5.9E-01
+1.0	90-1911O	7.61E+00 +/-	5.4E-01	1.18E+01 +/-	8.5E-01	8.88E+01 +/-	5.8E-01
+0.5	90-1911P	7.35E+00 +/-	5.0E-01	1.21E+01 +/-	9.4E-01	9.06E+01 +/-	5.8E-01
0.0	90-1911Q	7.67E+00 +/-	5.6E-01	1.32E+01 +/-	1.1E+00	9.16E+01 +/-	5.9E-01
-0.5	90-1911R	7.26E+00 +/-	4.3E-01	1.27E+01 +/-	1.0E+00	9.19E+01 +/-	5.9E-01
-1.0	90-1911S	7.38E+00 +/-	5.0E-01	1.14E+01 +/-	9.1E-01	9.13E+01 +/-	5.9E-01
-1.5	90-1911T	7.20E+00 +/-	4.9E-01	1.18E+01 +/-	8.6E-01	8.98E+01 +/-	5.8E-01
-2.0	90-1911U	7.02E+00 +/-	4.7E-01	1.22E+01 +/-	8.9E-01	8.89E+01 +/-	5.8E-01
-2.5	90-1911V	6.94E+00 +/-	5.1E-01	1.15E+01 +/-	7.9E-01	8.59E+01 +/-	5.7E-01
-3.0	90-1911W	6.22E+00 +/-	3.7E-01	1.19E+01 +/-	8.0E-01	8.43E+01 +/-	5.1E-01
-3.5	90-1911X	6.15E+00 +/-	5.0E-01	1.08E+01 +/-	8.1E-01	7.89E+01 +/-	5.5E-01
-4.0	90-1911Y	5.67E+00 +/-	3.2E-01	9.58E+00 +/-	5.8E-01	7.49E+01 +/-	4.8E-01
-4.5	90-1911Z	4.78E+00 +/-	4.0E-01	8.45E+00 +/-	8.2E-01	6.80E+01 +/-	5.1E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14175
References: Lab.Book# 49 pages 3-20.
Procedures: A-524.

Approved: [signature]

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RSAC PAL 671

REVISED @ REPORT

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

Request# 14175

TO: E.P.Lippincott (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 5/13/91

[RESULTS OF ANALYSIS]

Palisades Cycle 8 Reactor Cavity Dosimetry

Azimuth: 210 deg.
Bead Chain Tag ID: 210 deg.

Feet from Midplane	Lab Sample#	[<— dps/mg of chain @ 12/12/90 — Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg —>]	Co-60 2 sigma
+8.0	90-1912A	5.16E-01 +/-	1.0E-01	9.26E-01 +/-	1.3E-01	4.20E+01 +/-	1.9E-01
+7.5	90-1912B	7.64E-01 +/-	1.0E-01	1.35E+00 +/-	1.5E-01	4.83E+01 +/-	2.1E-01
+7.0	90-1912C	1.04E+00 +/-	1.9E-01	1.93E+00 +/-	4.2E-01	5.57E+01 +/-	4.2E-01
+6.5	90-1912D	1.47E+00 +/-	2.4E-01	3.00E+00 +/-	4.6E-01	6.22E+01 +/-	4.4E-01
+6.0	90-1912E	2.48E+00 +/-	2.7E-01	4.68E+00 +/-	5.1E-01	6.70E+01 +/-	4.5E-01
+5.5	90-1912F	3.39E+00 +/-	2.9E-01	5.92E+00 +/-	5.5E-01	7.21E+01 +/-	4.3E-01
+5.0	90-1912G	4.31E+00 +/-	3.4E-01	7.77E+00 +/-	6.4E-01	7.82E+01 +/-	4.9E-01
+4.5	90-1912H	5.22E+00 +/-	3.7E-01	9.40E+00 +/-	6.7E-01	8.56E+01 +/-	5.1E-01
+4.0	90-1912I	5.73E+00 +/-	6.4E-01	9.71E+00 +/-	7.8E-01	9.06E+01 +/-	5.6E-01
+3.5	90-1912J	6.35E+00 +/-	3.6E-01	1.04E+01 +/-	6.8E-01	9.68E+01 +/-	5.5E-01
+3.0	90-1912K	6.50E+00 +/-	4.9E-01	1.13E+01 +/-	8.8E-01	9.97E+01 +/-	6.3E-01
+2.5	90-1912L	7.28E+00 +/-	5.0E-01	1.07E+01 +/-	9.4E-01	1.04E+02 +/-	6.4E-01
+2.0	90-1912M	6.76E+00 +/-	4.8E-01	1.19E+01 +/-	9.1E-01	1.07E+02 +/-	6.4E-01
+1.5	90-1912N	6.96E+00 +/-	5.2E-01	1.17E+01 +/-	9.3E-01	1.12E+02 +/-	6.5E-01
+1.0	90-1912O	6.86E+00 +/-	5.0E-01	1.12E+01 +/-	9.5E-01	1.14E+02 +/-	6.7E-01
+0.5	90-1912P	6.98E+00 +/-	5.5E-01	1.22E+01 +/-	9.4E-01	1.16E+02 +/-	6.8E-01
0.0	90-1912Q	6.62E+00 +/-	6.4E-01	1.17E+01 +/-	1.4E+00	1.21E+02 +/-	1.1E+00
-0.5	90-1912R	7.29E+00 +/-	7.2E-01	1.19E+01 +/-	1.1E+00	1.20E+02 +/-	1.1E+00
-1.0	90-1912S	6.89E+00 +/-	6.9E-01	1.18E+01 +/-	1.3E+00	1.20E+02 +/-	1.1E+00
-1.5	90-1912T	6.92E+00 +/-	7.2E-01	1.27E+01 +/-	1.3E+00	1.18E+02 +/-	1.1E+00
-2.0	90-1912U	7.16E+00 +/-	8.0E-01	1.19E+01 +/-	1.3E+00	1.16E+02 +/-	1.1E+00
-2.5	90-1912V	6.51E+00 +/-	6.9E-01	1.09E+01 +/-	1.2E+00	1.11E+02 +/-	1.0E+00
-3.0	90-1912W	6.19E+00 +/-	4.1E-01	1.04E+01 +/-	7.1E-01	1.05E+02 +/-	5.7E-01
@ -3.5	90-1912X	6.26E+00 +/-	4.4E-01	9.99E+00 +/-	7.2E-01	1.00E+02 +/-	5.6E-01
-4.0	90-1912Y	5.14E+00 +/-	3.4E-01	9.45E+00 +/-	7.0E-01	9.28E+01 +/-	5.4E-01
-4.5	90-1912Z	4.21E+00 +/-	3.3E-01	8.06E+00 +/-	6.3E-01	8.42E+01 +/-	5.1E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).
@ Sample #90-1912-X: Corrected Co-60 value.

AL File: 14175
References: Lab.Book# 49 pages 3-20.
Procedures: A-524.
Analyst: WTF,TK.

Approved: [signature]

RSAC FAL 671 86

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT — Request# 14175

TO: E.P.Lippincott (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 3/13/91

[RESULTS OF ANALYSIS]

(10 DEG.)

Palisades Cycle 8 Reactor Cavity Dosimetry

Azimuth: 260 deg.
Bead Chain Tag ID: (NONE)

Feet from Midplane	Lab Sample#	Mn-54 dps/mg (dps/mg of chain @ 12/12/90)	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
+8.0	90-1913A	6.58E-01	+/- 1.6E-01	1.36E+00	+/- 3.0E-01	3.44E+01	+/- 3.2E-01
+7.5	90-1913B	8.56E-01	+/- 1.0E-01	1.58E+00	+/- 2.3E-01	3.94E+01	+/- 2.1E-01
+7.0	90-1913C	1.33E+00	+/- 2.1E-01	2.34E+00	+/- 4.3E-01	4.29E+01	+/- 3.6E-01
+6.5	90-1913D	1.77E+00	+/- 2.0E-01	2.65E+00	+/- 3.9E-01	4.49E+01	+/- 3.6E-01
+6.0	90-1913E	8.96E-01	+/- 2.0E-01	2.25E+00	+/- 4.1E-01	4.09E+01	+/- 3.5E-01
+5.5	90-1913F	5.38E-01	+/- 1.8E-01	1.35E+00	+/- 3.3E-01	3.68E+01	+/- 3.3E-01
+5.0	90-1913G	5.42E-01	+/- 1.5E-01	9.06E-01	+/- 2.9E-01	3.10E+01	+/- 2.1E-01
+4.5	90-1913H	4.69E-01	+/- 1.4E-01	5.91E-01	+/- 2.3E-01	2.77E+01	+/- 2.0E-01
+4.0	90-1913I	2.73E-01	+/- 7.5E-02	4.49E-01	+/- 1.6E-01	2.63E+01	+/- 1.7E-01
+3.5	90-1913J	1.74E-01	+/- 9.4E-02	5.05E-01	+/- 2.1E-01	2.15E+01	+/- 1.7E-01
+3.0	90-1913K	1.68E-01	+/- 7.8E-02	4.23E-01	+/- 1.5E-01	2.06E+01	+/- 1.5E-01
+2.5	90-1913L	1.93E-01	+/- 8.7E-02	2.08E-01	+/- 1.7E-01	1.69E+01	+/- 1.5E-01
+2.0	90-1913M	1.27E-01	+/- 8.9E-02	2.88E-01	+/- 1.8E-01	1.51E+01	+/- 1.8E-01
+1.5	90-1913N	1.32E-01	+/- 6.0E-02	ND		1.25E+01	+/- 1.3E-01
+1.0	90-1913O	ND		ND		1.06E+01	+/- 1.2E-01
+0.5	90-1913P	ND		ND		8.97E+00	+/- 1.1E-01
0.0	90-1913Q	ND		ND		8.03E+00	+/- 1.1E-01
-0.5	90-1913R	ND		ND		7.07E+00	+/- 9.9E-02
-1.0	90-1913S	ND		8.13E-02	+/- 5.2E-02	7.00E+00	+/- 8.7E-02
-1.5	90-1913T	5.91E-02	+/- 3.6E-02	ND		6.31E+00	+/- 8.4E-02
-2.0	90-1913U	ND		ND		5.87E+00	+/- 8.1E-02
-2.5	90-1913V	ND		ND		5.42E+00	+/- 7.7E-02
-3.0	90-1913W	ND		ND		5.22E+00	+/- 7.6E-02
-3.5	90-1913X	ND		ND		4.83E+00	+/- 7.3E-02
-4.0	90-1913Y	ND		ND		4.44E+00	+/- 7.0E-02
-4.5	90-1913Z	ND		ND		4.28E+00	+/- 6.9E-02

ND- Not Detected

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14175
References: Lab.Book# 49 pages 3-20.
Procedures: A-524.
Analyst: WTF,TK.

Approved: [signature]

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RSAC PAL 671

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT

Request# 14175

TO: E.P.Lippincott (W)Energy Center - East (4-17)

Received: 9/27/90
Reported: 4/2/91

[RESULTS OF ANALYSIS]

(20 DEG.)

Palisades Cycle 8 Reactor Cavity Dosimetry

Azimuth: 340 deg.
Bead Chain Tag ID: (150).

Feet from Midplane	Lab Sample#	[<— Mn-54 dps/mg	2 sigma	dps/mg of chain @ 12/12/90 Co-58 dps/mg	2 sigma	Co-60 dps/mg	2 sigma —>]
+8.0	90-1920A	7.82E-01 +/-	1.5E-01	1.27E+00 +/-	3.0E-01	4.25E+01 +/-	2.6E-01
+7.5	90-1920B	8.18E-01 +/-	2.3E-01	2.32E+00 +/-	5.2E-01	4.65E+01 +/-	3.3E-01
+7.0	90-1920C	1.36E+00 +/-	1.6E-01	2.55E+00 +/-	3.7E-01	5.38E+01 +/-	2.9E-01
+6.5	90-1920D	2.05E+00 +/-	1.6E-01	3.53E+00 +/-	3.5E-01	5.62E+01 +/-	2.2E-01
+6.0	90-1920E	2.68E+00 +/-	2.0E-01	5.55E+00 +/-	4.7E-01	6.53E+01 +/-	3.2E-01
+5.5	90-1920F	3.98E+00 +/-	2.3E-01	7.26E+00 +/-	4.7E-01	6.82E+01 +/-	3.3E-01
+5.0	90-1920G	4.92E+00 +/-	3.2E-01	8.42E+00 +/-	7.6E-01	7.57E+01 +/-	4.2E-01
+4.5	90-1920H	5.65E+00 +/-	2.6E-01	1.02E+01 +/-	5.8E-01	8.19E+01 +/-	3.6E-01
+4.0	90-1920I	6.61E+00 +/-	4.5E-01	1.07E+01 +/-	8.8E-01	8.78E+01 +/-	6.6E-01
+3.5	90-1920J	7.20E+00 +/-	4.0E-01	1.15E+01 +/-	7.4E-01	9.01E+01 +/-	4.7E-01
+3.0	90-1920K	7.88E+00 +/-	5.1E-01	1.24E+01 +/-	1.0E+00	9.73E+01 +/-	6.9E-01
+2.5	90-1920L	8.08E+00 +/-	4.7E-01	1.32E+01 +/-	8.6E-01	9.98E+01 +/-	4.9E-01
+2.0	90-1920M	8.21E+00 +/-	4.9E-01	1.34E+01 +/-	1.1E+00	1.07E+02 +/-	7.2E-01
+1.5	90-1920N	8.18E+00 +/-	5.2E-01	1.34E+01 +/-	1.1E+00	1.11E+02 +/-	7.4E-01
+1.0	90-1920O	7.65E+00 +/-	4.0E-01	1.35E+01 +/-	9.5E-01	1.12E+02 +/-	5.2E-01
+0.5	90-1920P	7.89E+00 +/-	5.4E-01	1.36E+01 +/-	1.2E+00	1.18E+02 +/-	7.6E-01
0.0	90-1920Q	8.29E+00 +/-	4.6E-01	1.29E+01 +/-	1.1E+00	1.20E+02 +/-	7.6E-01
-0.5	90-1920R	8.00E+00 +/-	4.8E-01	1.39E+01 +/-	8.9E-01	1.19E+02 +/-	5.3E-01
-1.0	90-1920S	7.96E+00 +/-	5.4E-01	1.40E+01 +/-	1.2E+00	1.22E+02 +/-	7.7E-01
-1.5	90-1920T	7.96E+00 +/-	4.1E-01	1.45E+01 +/-	8.9E-01	1.18E+02 +/-	5.3E-01
-2.0	90-1920U	8.22E+00 +/-	6.0E-01	1.42E+01 +/-	1.2E+00	1.19E+02 +/-	7.7E-01
-2.5	90-1920V	8.09E+00 +/-	5.2E-01	1.36E+01 +/-	1.1E+00	1.16E+02 +/-	7.5E-01
-3.0	90-1920W	7.31E+00 +/-	4.6E-01	1.25E+01 +/-	9.9E-01	1.09E+02 +/-	5.3E-01
-3.5	90-1920X	6.94E+00 +/-	5.1E-01	1.09E+01 +/-	9.5E-01	1.07E+02 +/-	7.2E-01
-4.0	90-1920Y	6.14E+00 +/-	2.9E-01	1.05E+01 +/-	6.0E-01	9.83E+01 +/-	4.3E-01
-4.5	90-1920Z	2.02E+00 +/-	1.5E-01	3.22E+00 +/-	2.7E-01	3.24E+01 +/-	1.7E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14175
References: Lab.Book# 49 pages 3-20.
Procedures: A-524.
Analyst: WTF,TK.

Approved: Bertram [signature]

RSAC. AL671

WESTINGHOUSE ELECTRIC CORPORATION
NUCLEAR & ADVANCED TECHNOLOGY DIVISION
AES ANALYTICAL LABORATORY
WALTZ MILL SITE

ARNOLD FERO | AL REQUEST 14175

W NATD, RADIATION ENGINEERING
W284-4891

Receipt Date May 20, 1991
Report Date May 24, 1991

MATERIAL DESCRIPTION
PALISADES CAVITY DOSIMETRY ...... CHAINS

Al Serv. #	Chain Identification Azimuth	ID Tag	ANALYSIS ... WEIGHT PERCENT (%) ... Fe	Ni	Co
91- 1909 S	30o	30	64.4	8.74	0.126
1910 S	90o	90	67.7	9.10	0.187
1911 K	~~none~~ 150°	none	66.7	9.06	0.131
1912 B	210o	210	66.5	8.65	0.179
1915 D	280o	280	70.6	8.81	0.176
1916 D	290o	290	68.3	9.20	0.174
1918 C	315o	315	67.3	8.68	0.164
1919 M	330o	330	68.7	9.35	0.164
1920 Z	340o	150	68.4	9.41	0.186
	Average chain value		67.2	9.00	0.165
	1 sigma		±1.7	±0.29	±0.022
NBS 1154	Certified		64.3	12.26	0.101
	Measured		61.6	11.77	0.099
NBS 160b	Certified		65.1	10.25	0.12
	Measured		66.1	10.25	0.1198
ICPS measurement at 2 sigma deviation			± 2.6	± 0.56	± 0.016

Method of Analysis	Operator	File
Metals ICPS	RMck	AL14175

Approved by *Lawrence Kardos*
Lawrence Kardos, Sr Scientist

APPENDIX C

SPECIFIC ACTIVITIES AND IRRADIATION HISTORY OF REACTOR CAVITY SENSOR SETS - CYCLE 9

In this appendix, the irradiation history as extracted from NUREG-0020 and the measured specific activities of radiometric monitors irradiated in the reactor cavity during Cycle 9 are provided.

The irradiation history of Cycle 9 was as follows:

Cycle	Startup	Shutdown	Comment
9	03/10/91	02/06/92	

Reference Core Power = 2530 MWt

The monthly thermal generation applicable to the Palisades reactor is provided in addition to the specific activities of the sensors on the following pages.

TABLE C-1

IRRADIATION HISTORY OF REACTOR CAVITY SENSOR SETS

Cycle 9

Date	Thermal Generation MW-hr
Oct-90	0
Nov-90	0
Dec-90	0
Jan-91	0
Feb-91	0
Mar-91	480456
Apr-91	1809167
May-91	1885464
Jun-91	1818648
Jul-91	1143408
Aug-91	1837560
Sep-91	1818984
Oct-91	1882521
Nov-91	1712592
Dec-91	1513368
Jan-92	1867224
Feb-92	357888

TABLE C-2

CONTENTS OF MULTIPLE FOIL SENSOR SETS
CYCLE 9 IRRADIATION

Capsule ID/ Position	Bare or Cd Shielded	Fe	Ni	Cu	Ti	Nb	Co	^{238}U (nat)	^{238}U (dep)	NBS PUD	^{237}Np
		Radiometric Monitor Foil ID									
A-1	B	A	-	-	-	-	A	-	-	-	-
A-2	Cd	K	A	BA	AK	BA	K	AA	BG	-	-
A-3	Cd	-	-	-	-	-	-	-	-	11N1	8
C-1	B	C	-	-	-	-	C	-	-	-	-
C-2	Cd	M	C	BC	AM	BC	M	AC	BI	-	-
C-3	Cd	-	-	-	-	-	-	-	-	13N3	10
F-1	B	F	-	-	-	-	F	-	-	-	-
F-2	Cd	P	F	BF	AP	BF	P	AF	AM	-	-
F-3	Cd	-	-	-	-	-	-	-	-	16N6	13
J-1	B	C	-	-	-	-	O	-	-	-	-
J-2	Cd	M	O	AO	BE	AC	AO	C	C	-	-
J-3	Cd	-	-	-	-	-	-	-	-	-	16
K-1	B	D	-	-	-	-	P	-	-	-	-
K-2	Cd	N	P	AP	BF	AD	AP	D	D	-	-
K-3	Cd	-	-	-	-	-	-	-	-	-	17
L-1	B	E	-	-	-	-	R	-	-	-	-
L-2	Cd	O	R	AR	BG	AE	AR	E	E	-	-
L-3	Cd	-	-	-	-	-	-	-	-	-	18
N-1	B	G	-	-	-	-	T	-	-	-	-
N-2	Cd	R	T	AT	BI	AG	AT	G	U	-	-
N-3	Cd	-	-	-	-	-	-	-	-	-	20

RSAC PAL 115

Westinghouse Electric Corporation
Advanced Programs - Analytical Laboratory
Waltz Mill Site

REPORT Request# 14601

TO: A.H.Fero (W)Energy Center - East (4-17)

Received: 3/3/92
Reported: 3/6/92

[RESULTS OF ANALYSIS]
Palisades Cycle 9 Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 3/4/92) dps/mg *	2 sigma
A	92-725	Co-Al	Co-60	4.27E+02 +/-	3.9E+00
K	92-726	Co-Al	Co-60	2.69E+02 +/-	3.4E+00
C	92-738	Co-Al	Co-60	2.15E+02 +/-	3.0E+00
M	92-739	Co-Al	Co-60	1.49E+02 +/-	2.5E+00
F	92-751	Co-Al	Co-60	3.14E+02 +/-	3.7E+00
P	92-752	Co-Al	Co-60	2.16E+02 +/-	3.1E+00
O	92-764	Co-Al	Co-60	1.77E+02 +/-	2.7E+00
AO	92-765	Co-Al	Co-60	1.17E+02 +/-	1.6E+00
P	92-777	Co-Al	Co-60	1.58E+02 +/-	1.8E+00
AP	92-778	Co-Al	Co-60	1.13E+02 +/-	1.6E+00
R	92-790	Co-Al	Co-60	9.50E+01 +/-	1.4E+00
AR	92-791	Co-Al	Co-60	6.43E+01 +/-	1.2E+00
T	92-803	Co-Al	Co-60	1.76E+02 +/-	2.0E+00
AT	92-804	Co-Al	Co-60	1.11E+02 +/-	1.6E+00
AK	92-723	Ti	Sc-46	6.73E+00 +/-	7.2E-02
AM	92-736	Ti	Sc-46	1.14E+00 +/-	1.7E-02
AP	92-749	Ti	Sc-46	2.07E+00 +/-	2.6E-02
BE	92-762	Ti	Sc-46	7.24E+00 +/-	7.5E-02
BF	92-775	Ti	Sc-46	6.12E+00 +/-	7.0E-02
BG	92-788	Ti	Sc-46	1.82E+00 +/-	2.7E-02
BI	92-801	Ti	Sc-46	4.16E+00 +/-	4.1E-02

Remarks: * Results are in units of dps/(mg of Dosimrter Material).

AL File: 14601
References: Lab.Book# 49 pages 300-301,LB #51 page 32..
Procedures: A-524.
Analyst: WTF,FRC,MRK.

Approved: Mark Kowalski

RSAC PAL 115

Westinghouse Electric Corporation
Advanced Programs - Analytical Laboratory
Waltz Mill Site

REPORT

Request# 14601

TO: A.H.Fero (W)Energy Center - East (4-17)

Received: 3/3/92
Reported: 3/6/92

[RESULTS OF ANALYSIS]
Palisades Cycle 9 Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 3/4/92) dps/mg *		2 sigma
A	92-719	Fe	Mn-54	1.91E+01	+/-	1.5E-01
K	92-720	Fe	Mn-54	1.84E+01	+/-	1.4E-01
C	92-732	Fe	Mn-54	3.59E+00	+/-	8.0E-02
M	92-733	Fe	Mn-54	3.22E+00	+/-	6.4E-02
F	92-745	Fe	Mn-54	7.72E+00	+/-	7.0E-02
P	92-746	Fe	Mn-54	7.51E+00	+/-	6.5E-02
C	92-758	Fe	Mn-54	1.48E+01	+/-	9.8E-02
M	92-759	Fe	Mn-54	1.44E+01	+/-	1.3E-01
D	92-771	Fe	Mn-54	1.22E+01	+/-	1.3E-01
N	92-772	Fe	Mn-54	1.21E+01	+/-	1.2E-01
E	92-784	Fe	Mn-54	3.95E+00	+/-	8.2E-02
O	92-785	Fe	Mn-54	3.69E+00	+/-	7.1E-02
G	92-797	Fe	Mn-54	8.58E+00	+/-	1.2E-01
R	92-798	Fe	Mn-54	8.22E+00	+/-	1.0E-01
A	92-721	Ni	Co-58	3.16E+02	+/-	2.0E+00
C	92-734	Ni	Co-58	6.02E+01	+/-	8.7E-01
F	92-747	Ni	Co-58	1.04E+02	+/-	1.1E+00
O	92-760	Ni	Co-58	3.48E+02	+/-	2.1E+00
P	92-773	Ni	Co-58	2.94E+02	+/-	1.9E+00
R	92-786	Ni	Co-58	9.52E+01	+/-	1.0E+00
T	92-799	Ni	Co-58	2.01E+02	+/-	1.6E+00
BA	92-722	Cu	Co-60	9.62E-01	+/-	1.5E-02
BC	92-735	Cu	Co-60	1.46E-01	+/-	4.5E-03
BF	92-748	Cu	Co-60	4.86E-01	+/-	7.6E-03
AO	92-761	Cu	Co-60	4.65E-01	+/-	7.6E-03
AP	92-774	Cu	Co-60	3.99E-01	+/-	7.0E-03
AR	92-787	Cu	Co-60	1.11E-01	+/-	2.9E-03
AT	92-800	Cu	Co-60	2.76E-01	+/-	6.0E-03

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14601
References: Lab.Book# 49 pages 300-301,LB #51 page 32..
Procedures: A-524.
Analyst: WIF,FRC,MRK.

Approved: Mark Kawchak

RSAC PAL 112

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT Request# 14601

TO: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/9/92

[RESULTS OF ANALYSIS]

Palisades Cycle 9 Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 3/4/92) dps/mg *		2 sigma
8	92-731	Np-237	Zr-95	3.28E+02	+/-	2.6E+00
10	92-744	Np-237	Zr-95	7.95E+01	+/-	1.6E+00
13	92-757	Np-237	Zr-95	1.24E+02	+/-	1.7E+00
16	92-768	Np-237	Zr-95	3.65E+02	+/-	2.9E+00
17	92-781	Np-237	Zr-95	2.82E+02	+/-	2.7E+00
18	92-794	Np-237	Zr-95	1.17E+02	+/-	1.3E+00
20	92-807	Np-237	Zr-95	2.13E+02	+/-	6.0E+00
8	92-731	Np-237	Ru-103	3.08E+02	+/-	2.2E+00
10	92-744	Np-237	Ru-103	8.40E+01	+/-	1.1E+00
13	92-757	Np-237	Ru-103	1.16E+02	+/-	1.5E+00
16	92-768	Np-237	Ru-103	3.42E+02	+/-	2.4E+00
17	92-781	Np-237	Ru-103	2.86E+02	+/-	1.8E+00
18	92-794	Np-237	Ru-103	1.13E+02	+/-	1.1E+00
20	92-807	Np-237	Ru-103	2.22E+02	+/-	4.2E+00
8	92-731	Np-237	Cs-137	2.81E+01	+/-	1.2E+00
10	92-744	Np-237	Cs-137	7.03E+00	+/-	6.1E-01
13	92-757	Np-237	Cs-137	1.57E+01	+/-	8.8E-01
16	92-768	Np-237	Cs-137	1.15E+01	+/-	1.0E+00
17	92-781	Np-237	Cs-137	1.09E+01	+/-	9.0E-01
18	92-794	Np-237	Cs-137	3.40E+00	+/-	4.7E-01
20	92-807	Np-237	Cs-137	6.45E+00	+/-	1.5E+00

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14601
References: Lab.Book# 49 pages 300-301,LB #51 page 32..
Procedures: A-524.
Analyst: WTF,FRC,MRK.

Approved: [signature]

RSAC PAL 115

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT Request# 14601

TO: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/16/92

[RESULTS OF ANALYSIS]

Palisades Cycle 9 Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 3/4/92) dps/mg *		2 sigma
AA	92-727	U (nat)	Zr-95	6.22E+01	+/-	1.5E-01
BG	92-728	U (dep)	Zr-95	2.01E+01	+/-	9.9E-02
11	92-729	U (dep)	Zr-95	2.10E+01	+/-	1.9E-01
N1	92-730	U (nat)	Zr-95	6.18E+01	+/-	2.5E-01
AC	92-740	U (nat)	Zr-95	3.32E+01	+/-	7.7E-02
BI	92-741	U (dep)	Zr-95	5.66E+00	+/-	8.8E-02
13	92-742	U (dep)	Zr-95	4.76E+00	+/-	9.1E-02
N3	92-743	U (nat)	Zr-95	3.15E+01	+/-	2.1E-01
AF	92-753	U (nat)	Zr-95	3.67E+01	+/-	9.2E-02
AM	92-754	U (dep)	Zr-95	7.43E+00	+/-	6.8E-02
16	92-755	U (dep)	Zr-95	6.63E+00	+/-	4.3E-02
N6	92-756	U (nat)	Zr-95	3.48E+01	+/-	8.8E-02
C	92-766	U (nat)	Zr-95	6.66E+01	+/-	1.5E-01
C	92-767	U (dep)	Zr-95	2.32E+01	+/-	1.3E-01
D	92-779	U (nat)	Zr-95	6.11E+01	+/-	3.3E-01
D	92-780	U (dep)	Zr-95	2.21E+01	+/-	1.2E-01
E	92-792	U (nat)	Zr-95	3.50E+01	+/-	1.9E-01
E	92-793	U (dep)	Zr-95	7.33E+00	+/-	6.8E-02
G	92-805	U (nat)	Zr-95	1.62E+02	+/-	9.0E-01
U	92-806	U (dep)	Zr-95	1.42E+01	+/-	9.7E-02

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14601
References: Lab.Book# 49 pages 261-265; 300-301: LB #51 page 32
Procedures: A-524.
Analyst: WTF,FRC,MRK,TRK

Approved: Mark Kowchak

RSAC PAL 775

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT

Request# 14601

TO: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/16/92

[RESULTS OF ANALYSIS]

Palisades Cycle 9 Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 3/4/92) dps/mg *		2 sigma
AA	92-727	U (nat)	Ru-103	4.37E+01	+/-	9.1E-02
BG	92-728	U (dep)	Ru-103	2.08E+01	+/-	9.9E-02
I1	92-729	U (dep)	Ru-103	2.20E+01	+/-	1.6E-01
N1	92-730	U (nat)	Ru-103	4.26E+01	+/-	1.6E-01
AC	92-740	U (nat)	Ru-103	1.73E+01	+/-	5.8E-02
BI	92-741	U (dep)	Ru-103	5.12E+00	+/-	7.0E-02
I3	92-742	U (dep)	Ru-103	4.70E+00	+/-	7.8E-02
N3	92-743	U (nat)	Ru-103	1.63E+01	+/-	1.6E-01
AF	92-753	U (nat)	Ru-103	2.12E+01	+/-	7.0E-02
AM	92-754	U (dep)	Ru-103	6.91E+00	+/-	4.7E-02
I6	92-755	U (dep)	Ru-103	7.19E+00	+/-	3.8E-02
N6	92-756	U (nat)	Ru-103	1.96E+01	+/-	6.7E-02
C	92-766	U (nat)	Ru-103	4.70E+01	+/-	9.5E-02
C	92-767	U (dep)	Ru-103	2.31E+01	+/-	1.1E-01
D	92-779	U (nat)	Ru-103	4.17E+01	+/-	2.1E-01
D	92-780	U (dep)	Ru-103	1.94E+01	+/-	8.0E-02
E	92-792	U (nat)	Ru-103	1.96E+01	+/-	1.4E-01
E	92-793	U (dep)	Ru-103	6.87E+00	+/-	5.8E-02
G	92-805	U (nat)	Ru-103	1.02E+02	+/-	5.7E-01
U	92-806	U (dep)	Ru-103	1.29E+01	+/-	6.8E-02

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14601
References: Lab.Book# 49 pages 261-265; 300-301: LB #51 page 32.
Procedures: A-524.
Analyst: WTF,FRC,MRK,TRK

Approved: Mark Kurchak

RSAC PAL 1125

Westinghouse Electric Corporation
Advanced Energy Systems - Analytical Laboratory
Waltz Mill Site

REPORT — Request# 14601

TO: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/16/92

[RESULTS OF ANALYSIS]

Palisades Cycle 9 Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 3/4/92) dps/mg *	2 sigma
AA	92-727	U (nat)	Cs-137	5.42E+00 +/-	5.3E-02
BG	92-728	U (dep)	Cs-137	1.68E+00 +/-	5.0E-02
11	92-729	U (dep)	Cs-137	1.84E+00 +/-	8.2E-02
N1	92-730	U (nat)	Cs-137	5.36E+00 +/-	8.8E-02
AC	92-740	U (nat)	Cs-137	2.32E+00 +/-	3.0E-02
BI	92-741	U (dep)	Cs-137	4.17E-01 +/-	3.0E-02
13	92-742	U (dep)	Cs-137	3.46E-01 +/-	4.2E-02
N3	92-743	U (nat)	Cs-137	2.19E+00 +/-	8.5E-02
AF	92-753	U (nat)	Cs-137	3.61E+00 +/-	3.9E-02
AM	92-754	U (dep)	Cs-137	8.97E-01 +/-	3.1E-02
16	92-755	U (dep)	Cs-137	9.21E-01 +/-	2.0E-02
N6	92-756	U (nat)	Cs-137	3.57E+00 +/-	3.7E-02
C	92-766	U (nat)	Cs-137	2.21E+00 +/-	4.8E-02
C	92-767	U (dep)	Cs-137	7.35E-01 +/-	3.8E-02
D	92-779	U (nat)	Cs-137	1.92E+00 +/-	9.8E-02
D	92-780	U (dep)	Cs-137	7.16E-01 +/-	3.8E-02
E	92-792	U (nat)	Cs-137	9.48E-01 +/-	6.5E-02
E	92-793	U (dep)	Cs-137	2.10E-01 +/-	2.4E-02
G	92-805	U (nat)	Cs-137	5.16E+00 +/-	2.69E-01
U	92-806	U (dep)	Cs-137	4.67E-01 +/-	3.54E-02

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14601
References: Lab.Book# 49 pages 261-265; 300-301: LB #51 page 32.
Procedures: A-524.
Analyst: WTF,FRC,MRK,TRK

Approved: Mark Kumlah

RSAC PAL 775

Westinghouse Electric Corporation
Advanced Programs - Analytical Laboratory
Waltz Mill Site

REPORT
REVISION

Request# 14175

TO: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 9/27/90
Reported: 12/16/92

[RESULTS OF ANALYSIS]

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 12/12/90) Bq/mg *		2 sigma
BB	90-1862	Nb-93(Cd)	Nb-93m	8.09E+01	+/-	3.7E+00
BD	90-1875	Nb-93(Cd)	Nb-93m	5.60E+01	+/-	3.1E+00
BE	90-1888	Nb-93(Cd)	Nb-93m	1.67E+01	+/-	1.7E+00
BG	90-1901	Nb-93(Cd)	Nb-93m	3.85E+01	+/-	2.6E+00

Remarks: * Results are in units of Bq/(mg of Dosimeter Material).
Nb-93m half-life: 5890 days

AL File: Request# 14175
References: Lab.Book# 51 page 61
Procedures: OI-Nb
Analyst: WTF,FRC,MRK

Approved: [signature]

[illegible]

Westinghouse Electric Corporation
Advanced Programs - Analytical Laboratory
Waltz Mill Site

REPORT
REVISION

Request# 14601

TO: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/4/92
Reported: 12/17/92

[RESULTS OF ANALYSIS]

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 3/4/92) Bq/mg *		2 sigma
BA	92-724	Nb-93(Cd)	Nb-93m	1.28E+02	+/-	4.6E+00
BC	92-737	Nb-93(Cd)	Nb-93m	2.50E+01	+/-	2.1E+00
BF	92-750	Nb-93(Cd)	Nb-93m	5.58E+01	+/-	3.1E+00
AC	92-763	Nb-93(Cd)	Nb-93m	4.37E+01	+/-	2.8E+00
AD	92-776	Nb-93(Cd)	Nb-93m	4.55E+01	+/-	2.9E+00
AE	92-789	Nb-93(Cd)	Nb-93m	1.59E+01	+/-	1.8E+00
AG	92-802	Nb-93(Cd)	Nb-93m	2.87E+01	+/-	2.3E+00

Remarks: * Results are in units of Bq/(mg of Dosimeter Material).
Nb-93m half-life: 5890 days

AL File: Request# 14601
References: Lab.Book# 51 page 61
Procedures: OI-Nb
Analyst: WTF,FRC,MRK

Approved: Mark Kurzhals

RSAC PAL 775

REPORT

Westinghouse Advanced Energy Systems
Analytical Laboratory - Waltz Mill Site

Request# 14601

Originator: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/16/92

[RESULTS OF ANALYSIS]

PALISADES CYCLE 9 REACTOR CAVITY DOSIMETRY

Bead Chain Tag ID: S-1 270 Degrees

Feet from Midplane	Lab Sample#	Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
		[<-------------- dps/mg of chain @ 3/4/92				-------------->]	
+0.5	92-712A	1.18E+01 +/-	7.1E-01	2.91E+01 +/-	8.9E-01	1.54E+02 +/-	9.8E-01
-0.5	92-712C	1.15E+01 +/-	7.0E-01	2.84E+01 +/-	8.6E-01	1.54E+02 +/-	9.8E-01
-1.0	92-712D	1.13E+01 +/-	7.4E-01	2.76E+01 +/-	8.6E-01	1.51E+02 +/-	9.7E-01
-1.5	92-712E	1.10E+01 +/-	7.6E-01	2.53E+01 +/-	8.6E-01	1.47E+02 +/-	9.7E-01
-2.0	92-712F	9.39E+00 +/-	6.1E-01	2.50E+01 +/-	8.4E-01	1.45E+02 +/-	9.5E-01
-2.5	92-712G	8.79E+00 +/-	7.1E-01	2.20E+01 +/-	8.4E-01	1.33E+02 +/-	1.2E+00
-3.0	92-712H	7.09E+00 +/-	6.1E-01	1.82E+01 +/-	7.2E-01	1.35E+02 +/-	9.2E-01
-3.5	92-712I	6.70E+00 +/-	6.6E-01	1.62E+01 +/-	7.4E-01	1.26E+02 +/-	8.7E-01
-4.0	92-712J	6.42E+00 +/-	6.8E-01	1.48E+01 +/-	7.2E-01	1.15E+02 +/-	8.4E-01
-4.5	92-712K	3.93E+00 +/-	4.7E-01	1.02E+01 +/-	5.6E-01	9.38E+01 +/-	7.6E-01
-5.0	92-712L	2.76E+00 +/-	4.2E-01	7.33E+00 +/-	5.4E-01	8.33E+01 +/-	7.2E-01

Remarks: *Results are in units of dps /(mg of Dosimeter Material)

AL File: 14601
References: Lab Book# 49 pages 261-265; 300-301; Lab Book#51 page 32
Procedures: A-524.
Analyst: WTF, TRK, MRK, FRC

Approved: [signature]

NUMUIMLII

REPORT	Westinghouse Advanced Energy Systems Analytical Laboratory - Waltz Mill Site	Request# 14601

Originator: Arnold Fero
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/9/92

[RESULTS OF ANALYSIS]

PALLISADES CYCLE 9 REACTOR CAVITY DOSIMETRY

Bead Chain Tag ID: S-2 280 Degrees

Feet from Midplane	Lab Sample#	Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
		[<-------------- dps/mg of chain @ 3/4/92					-------------->]
+0.5	92-713A	9.33E+00 +/-	2.8E-01	3.25E+01 +/-	3.7E-01	4.83E+01 +/-	3.1E-01
-0.38	92-713X	9.75E+00 +/-	3.1E-01	3.26E+01 +/-	4.1E-01	4.86E+01 +/-	3.3E-01
-0.5	92-713C	9.43E+00 +/-	2.8E-01	3.20E+01 +/-	3.6E-01	4.84E+01 +/-	3.1E-01
-1.0	92-713D	9.41E+00 +/-	2.8E-01	3.11E+01 +/-	3.6E-01	4.79E+01 +/-	3.1E-01
-1.5	92-713E	8.97E+00 +/-	2.7E-01	3.03E+01 +/-	3.5E-01	4.71E+01 +/-	3.0E-01
-2.0	92-713F	8.29E+00 +/-	2.7E-01	2.87E+01 +/-	3.4E-01	4.60E+01 +/-	3.0E-01
-2.5	92-713G	7.84E+00 +/-	2.6E-01	2.69E+01 +/-	3.3E-01	4.49E+01 +/-	2.9E-01
-3.0	92-713H	7.00E+00 +/-	2.4E-01	2.49E+01 +/-	3.2E-01	4.32E+01 +/-	2.9E-01
-3.5	92-713I	6.53E+00 +/-	2.5E-01	2.29E+01 +/-	3.1E-01	4.10E+01 +/-	3.8E-01
-4.0	92-713J	5.38E+00 +/-	2.1E-01	1.90E+01 +/-	2.9E-01	3.88E+01 +/-	3.7E-01
-4.5	92-713K	3.93E+00 +/-	1.8E-01	1.48E+01 +/-	2.6E-01	3.37E+01 +/-	2.5E-01
-5.0	92-713L	2.81E+00 +/-	1.9E-01	1.03E+01 +/-	2.3E-01	2.84E+01 +/-	2.3E-01
-5.5	92-713M	2.15E+00 +/-	1.7E-01	7.58E+00 +/-	2.1E-01	2.69E+01 +/-	2.2E-01

Remarks:

AL File: 14601
References: Lab Book#49 pages 262-265; Lab Book#51 page 32
Procedures: A-524.
Analyst: WTF, TRK, MRK, FRC

Approved: [signature]

RSACPAL775

REPORT

Westinghouse Advanced Energy Systems
Analytical Laboratory - Waltz Mill Site

Request# 14601

Originator: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/16/92

[RESULTS OF ANALYSIS]

PALISADES CYCLE 9 REACTOR CAVITY DOSIMETRY

Bead Chain Tag ID: S-2 290 Degrees

Feet from Midplane	Lab Sample#	dps/mg of chain @ 3/4/92 Mn-54 dps/mg		2 sigma	Co-58 dps/mg		2 sigma	Co-60 dps/mg		2 sigma
+0.5	92-714A	7.93E+00	+/-	2.7E-01	2.67E+01	+/-	3.4E-01	4.38E+01	+/-	2.9E-01
-0.5	92-714C	8.12E+00	+/-	3.3E-01	2.71E+01	+/-	4.3E-01	4.43E+01	+/-	3.6E-01
-1.0	92-714D	7.64E+00	+/-	3.3E-01	2.70E+01	+/-	4.3E-01	4.44E+01	+/-	3.7E-01
-1.5	92-714E	7.98E+00	+/-	3.4E-01	2.64E+01	+/-	4.3E-01	4.37E+01	+/-	3.6E-01
-2.0	92-714F	7.39E+00	+/-	3.0E-01	2.55E+01	+/-	4.1E-01	4.31E+01	+/-	3.6E-01
-2.5	92-714G	6.99E+00	+/-	3.2E-01	2.46E+01	+/-	4.2E-01	4.18E+01	+/-	3.5E-01
-3.0	92-714H	6.42E+00	+/-	2.9E-01	2.32E+01	+/-	4.0E-01	4.11E+01	+/-	3.5E-01
-3.5	92-714I	6.01E+00	+/-	2.4E-01	2.19E+01	+/-	3.2E-01	3.94E+01	+/-	2.8E-01
-4.0	92-714J	5.61E+00	+/-	2.4E-01	1.93E+01	+/-	3.0E-01	3.75E+01	+/-	2.7E-01
-4.5	92-714K	4.58E+00	+/-	2.1E-01	1.65E+01	+/-	2.8E-01	3.52E+01	+/-	2.6E-01
-5.0	92-714L	3.20E+00	+/-	1.8E-01	1.12E+01	+/-	2.5E-01	2.85E+01	+/-	2.3E-01

Remarks: *Results are in units of dps /(mg of Dosimeter Material)

AL File: 14601
References: Lab Book# 49 pages 261-265; 300-301; Lab Book#51 page 32
Procedures: A-524.
Analyst: WTF, TRK, MRK, FRC

Approved: Mark Krawchak

Westinghouse Advanced Energy Systems
REPORT Analytical Laboratory - Waltz Mill Site Request# 14601

Originator: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/16/92

[RESULTS OF ANALYSIS]

PALISADES CYCLE 9 REACTOR CAVITY DOSIMETRY

Bead Chain Tag ID: S-1 300 Degrees

Feet from Midplane	Lab Sample#	Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
		dps/mg of chain @ 3/4/92					
+0.5	92-715A	5.38E+00 +/-	5.1E-01	1.33E+01 +/-	6.5E-01	1.18E+02 +/-	8.5E-01
-0.5	92-715C	4.68E+00 +/-	5.5E-01	7.21E+00 +/-	6.1E-01	1.07E+02 +/-	8.0E-01
-1.0	92-715D	3.73E+00 +/-	5.5E-01	5.10E+00 +/-	5.8E-01	1.05E+02 +/-	7.9E-01
-1.5	92-715E	3.49E+00 +/-	5.3E-01	3.10E+00 +/-	5.0E-01	1.03E+02 +/-	7.9E-01
-2.0	92-715F	2.52E+00 +/-	4.6E-01	2.50E+00 +/-	5.0E-01	1.00E+02 +/-	7.8E-01
-2.5	92-715G	2.46E+00 +/-	4.5E-01	1.75E+00 +/-	3.8E-01	9.62E+01 +/-	7.6E-01
-3.0	92-715H	2.13E+00 +/-	4.6E-01	1.13E+00 +/-	3.0E-01	9.23E+01 +/-	7.5E-01
-3.5	92-715I	2.10E+00 +/-	4.7E-01	1.20E+00 +/-	4.1E-01	8.82E+01 +/-	7.3E-01
-4.0	92-715J	2.13E+00 +/-	4.9E-01	7.81E-01 +/-	3.0E-01	8.40E+01 +/-	7.1E-01
-4.5	92-715K	1.65E+00 +/-	2.5E-01	8.00E-01 +/-	2.0E-01	7.84E+01 +/-	3.9E-01
-5.0	92-715L	1.32E+00 +/-	3.2E-01	6.05E-01 +/-	2.9E-01	6.89E+01 +/-	6.5E-01
-5.5	92-715M	8.33E-01 +/-	3.3E-01	7.42E-01 +/-	2.9E-01	5.97E+01 +/-	6.0E-01

Remarks: *Results are in units of dps /(mg of Dosimeter Material)

AL File: 14601
References: Lab Book# 49 pages 261-265; 300-301; Lab Book#51 page 32
Procedures: A-524.
Analyst: WTF, TRK, MRK, FRC

Approved: Mark Kaurhak

RSACPAL775

REPORT

Westinghouse Advanced Energy Systems
Analytical Laboratory - Waltz Mill Site

Request# 14601

Originator: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/16/92

[RESULTS OF ANALYSIS]

PALISADES CYCLE 9 REACTOR CAVITY DOSIMETRY

Bead Chain Tag ID: S-2 315 Degrees

Feet from Midplane	Lab Sample#	[<--- dps/mg of chain @ 3/4/92 --->] Mn-54 dps/mg		Mn-54 2 sigma	Co-58 dps/mg		Co-58 2 sigma	Co-60 dps/mg		Co-60 2 sigma
+0.5	92-716A	5.52E+00	+/-	2.4E-01	1.84E+01	+/-	3.2E-01	4.85E+01	+/-	3.0E-01
-0.5	92-716C	5.58E+00	+/-	2.5E-01	1.83E+01	+/-	3.2E-01	4.89E+01	+/-	3.1E-01
-1.0	92-716D	5.46E+00	+/-	2.5E-01	1.80E+01	+/-	3.1E-01	4.83E+01	+/-	3.1E-01
-1.5	92-716E	4.82E+00	+/-	2.1E-01	1.71E+01	+/-	3.1E-01	4.77E+01	+/-	3.0E-01
-2.0	92-716F	4.68E+00	+/-	2.4E-01	1.66E+01	+/-	3.2E-01	4.65E+01	+/-	3.0E-01
-2.5	92-716G	4.42E+00	+/-	2.3E-01	1.53E+01	+/-	3.0E-01	4.51E+01	+/-	2.9E-01
-3.0	92-716H	4.37E+00	+/-	2.3E-01	1.45E+01	+/-	2.9E-01	4.33E+01	+/-	2.9E-01
-3.5	92-716I	3.90E+00	+/-	2.4E-01	1.34E+01	+/-	2.9E-01	4.12E+01	+/-	2.8E-01
-4.0	92-716J	3.30E+00	+/-	2.1E-01	1.16E+01	+/-	2.7E-01	3.85E+01	+/-	2.7E-01
-4.5	92-716K	2.82E+00	+/-	2.0E-01	1.01E+01	+/-	2.6E-01	3.54E+01	+/-	2.6E-01
-5.0	92-716L	2.16E+00	+/-	1.8E-01	7.35E+00	+/-	2.2E-01	2.72E+01	+/-	2.3E-01
-5.5	92-716M	1.66E+00	+/-	1.8E-01	5.67E+00	+/-	2.0E-01	2.38E+01	+/-	2.1E-01

Remarks: * Results are in units dps /(mg of Dosimeter Material)

AL File: 14601
References: Lab Book#49 pages 261-272; 300-301; Lab Book#51 page 32
Procedures: A-524.
Analyst: WTF, TRK, MRK, FRC

Approved: Mark Kamlah

RSAC PAL 775

Westinghouse Advanced Energy Systems
REPORT — Analytical Laboratory - Waltz Mill Site — Request# 14601

Originator: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/16/92

[RESULTS OF ANALYSIS]

PALISADES CYCLE 9 REACTOR CAVITY DOSIMETRY

Bead Chain Tag ID: S-2 330 degrees

Feet from Midplane	Lab Sample#	Mn-54 dps/mg		Mn-54 2 sigma	Co-58 dps/mg		Co-58 2 sigma	Co-60 dps/mg		Co-60 2 sigma
		[<-------------- dps/mg of chain @ 3/4/92 -------------->]								
+0.5	92-717A	7.92E+00	+/-	5.4E-01	2.68E+01	+/-	6.3E-01	5.43E+01	+/-	5.6E-01
0.0	92-717B	8.07E+00	+/-	2.9E-01	2.68E+01	+/-	3.7E-01	5.36E+01	+/-	3.2E-01
-0.5	92-717C	7.76E+00	+/-	2.8E-01	2.64E+01	+/-	3.6E-01	5.39E+01	+/-	3.2E-01
-1.0	92-717D	7.93E+00	+/-	2.7E-01	2.62E+01	+/-	3.6E-01	5.34E+01	+/-	3.2E-01
-1.5	92-717E	7.69E+00	+/-	2.8E-01	2.61E+01	+/-	3.7E-01	5.26E+01	+/-	3.2E-01
-2.0	92-717F	7.51E+00	+/-	2.8E-01	2.54E+01	+/-	3.4E-01	5.13E+01	+/-	3.1E-01
-2.5	92-717G	6.93E+00	+/-	2.6E-01	2.40E+01	+/-	3.4E-01	4.97E+01	+/-	3.1E-01
-3.0	92-717H	6.49E+00	+/-	2.5E-01	2.24E+01	+/-	3.4E-01	4.75E+01	+/-	3.0E-01
-3.5	92-717I	5.82E+00	+/-	2.4E-01	2.05E+01	+/-	3.2E-01	4.49E+01	+/-	2.9E-01
-4.0	92-717J	5.01E+00	+/-	2.2E-01	1.78E+01	+/-	2.8E-01	4.18E+01	+/-	2.6E-01
-4.5	92-717K	4.01E+00	+/-	2.1E-01	1.47E+01	+/-	2.8E-01	3.84E+01	+/-	2.7E-01
-5.0	92-717L	2.68E+00	+/-	1.7E-01	9.75E+00	+/-	2.4E-01	2.96E+01	+/-	2.4E-01
-5.5	92-717M	2.11E+00	+/-	1.7E-01	7.11E+00	+/-	2.1E-01	2.64E+01	+/-	2.2E-01

Remarks: * Results are in units dps /(mg of Dosimeter Material)

AL File: 14601
References: Lab Book#49 pages 261-272; 300-301; Lab Book#51 page 32
Procedures: A-524.
Analyst: WTF, TRK, MRK, FRC

Approved: [signature]

RSAC PAL ((Ↄ

REPORT

Westinghouse Advanced Energy Systems
Analytical Laboratory - Waltz Mill Site

Request# 14601

Originator: A.H.Fero (W)Energy Center - East (4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/17/92

[RESULTS OF ANALYSIS]

PALISADES CYCLE 9 REACTOR CAVITY DOSIMETRY

Bead Chain Tag ID: S-2 30 Degrees

Feet from Midplane	Lab Sample#	Mn-54 dps/mg (dps/mg of chain @ 3/4/92)	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
+8.0	92-707A	4.54E-01	+/- 7.0E-02	1.72E+00	+/- 9.8E-02	1.96E+01	+/- 1.2E-01
+7.5	92-707B	6.33E-01	+/- 9.6E-02	2.50E+00	+/- 1.4E-01	2.24E+01	+/- 1.6E-01
+7.0	92-707C	1.02E+00	+/- 1.1E-01	3.82E+00	+/- 1.5E-01	2.47E+01	+/- 1.7E-01
+6.5	92-707D	1.56E+00	+/- 1.3E-01	5.63E+00	+/- 1.6E-01	2.68E+01	+/- 1.8E-01
+6.0	92-707E	2.29E+00	+/- 1.9E-01	7.69E+00	+/- 2.3E-01	2.88E+01	+/- 2.3E-01
+5.5	92-707F	2.98E+00	+/- 2.0E-01	1.09E+01	+/- 2.5E-01	3.15E+01	+/- 2.5E-01
+5.0	92-707G	3.84E+00	+/- 2.3E-01	1.31E+01	+/- 2.8E-01	3.41E+01	+/- 2.6E-01
+4.5	92-707H	4.38E+00	+/- 2.2E-01	1.56E+01	+/- 2.8E-01	3.64E+01	+/- 2.6E-01
+4.0	92-707I	5.09E+00	+/- 2.4E-01	1.72E+01	+/- 3.0E-01	3.84E+01	+/- 2.7E-01
+3.5	92-707J	5.48E+00	+/- 2.4E-01	1.88E+01	+/- 3.0E-01	4.02E+01	+/- 2.8E-01
+3.0	92-707K	5.77E+00	+/- 2.3E-01	1.93E+01	+/- 3.1E-01	4.20E+01	+/- 2.8E-01
+2.5	92-707L	6.00E+00	+/- 2.5E-01	2.03E+01	+/- 3.3E-01	4.34E+01	+/- 2.9E-01
+2.0	92-707M	5.89E+00	+/- 2.7E-01	2.08E+01	+/- 3.4E-01	4.48E+01	+/- 2.9E-01
+1.5	92-707N	6.10E+00	+/- 2.7E-01	2.08E+01	+/- 3.4E-01	4.64E+01	+/- 3.0E-01
+1.0	92-707O	6.14E+00	+/- 2.7E-01	2.11E+01	+/- 3.4E-01	4.74E+01	+/- 3.0E-01
+0.5	92-707P	6.28E+00	+/- 2.5E-01	2.13E+01	+/- 3.4E-01	4.88E+01	+/- 3.0E-01
0.0	92-707Q	6.33E+00	+/- 2.7E-01	2.08E+01	+/- 3.4E-01	4.90E+01	+/- 3.1E-01
-0.5	92-707R	6.37E+00	+/- 2.8E-01	2.12E+01	+/- 3.5E-01	4.97E+01	+/- 3.1E-01
-1.0	92-707S	6.09E+00	+/- 2.6E-01	2.14E+01	+/- 3.4E-01	4.95E+01	+/- 3.1E-01
-1.5	92-707T	6.30E+00	+/- 2.6E-01	2.14E+01	+/- 3.5E-01	4.95E+01	+/- 3.1E-01
-2.0	92-707U	6.16E+00	+/- 2.6E-01	2.14E+01	+/- 3.5E-01	4.91E+01	+/- 3.1E-01
-2.5	92-707V	6.06E+00	+/- 2.7E-01	2.10E+01	+/- 3.5E-01	4.79E+01	+/- 3.0E-01
-3.0	92-707W	6.00E+00	+/- 2.5E-01	1.98E+01	+/- 3.4E-01	4.63E+01	+/- 3.0E-01
-3.5	92-707X	5.21E+00	+/- 2.4E-01	1.81E+01	+/- 3.1E-01	4.40E+01	+/- 2.9E-01
-4.0	92-707Y	4.62E+00	+/- 2.4E-01	1.66E+01	+/- 3.0E-01	4.13E+01	+/- 2.8E-01
-4.5	92-707Z	4.08E+00	+/- 2.3E-01	1.40E+01	+/- 3.0E-01	3.79E+01	+/- 2.7E-01

Remarks:

AL File: 14601
References: Lab Book#49 pages 259-271.
Procedures: A-524.
Analyst: WTF, TRK, MRK

Approved: Mark Kowalchak

RSAC PAL 115

REPORT

Westinghouse Advanced Energy Systems
Analytical Laboratory - Waltz Mill Site

Request# 14601

Originator: A.H.Fero (W)Energy Center (4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/18/92

[RESULTS OF ANALYSIS]

PALISADES CYCLE 9 REACTOR CAVITY DOSIMETRY

Bead Chain Tag ID: S-2 90 Degrees

Feet from Midplane	Lab Sample#	dps/mg of chain @ 3/4/92: Mn-54 dps/mg		Mn-54 2 sigma	Co-58 dps/mg		Co-58 2 sigma	Co-60 dps/mg		Co-60 2 sigma
+8.0	92-708A	5.52E-01	+/-	1.2E-01	2.17E+00	+/-	1.7E-01	2.14E+01	+/-	2.0E-01
+7.5	92-708B	8.56E-01	+/-	1.4E-01	3.56E+00	+/-	1.8E-01	2.49E+01	+/-	2.2E-01
+7.0	92-708C	1.43E+00	+/-	1.6E-01	5.09E+00	+/-	2.1E-01	2.77E+01	+/-	2.3E-01
+6.5	92-708D	2.16E+00	+/-	1.9E-01	7.36E+00	+/-	2.2E-01	3.05E+01	+/-	2.4E-01
+6.0	92-708E	3.11E+00	+/-	2.1E-01	1.04E+01	+/-	2.5E-01	3.31E+01	+/-	2.5E-01
+5.5	92-708F	4.06E+00	+/-	2.2E-01	1.38E+01	+/-	2.7E-01	3.64E+01	+/-	2.6E-01
+5.0	92-708G	4.93E+00	+/-	2.4E-01	1.73E+01	+/-	3.1E-01	3.93E+01	+/-	2.7E-01
+4.5	92-708H	5.91E+00	+/-	2.4E-01	2.05E+01	+/-	3.3E-01	4.25E+01	+/-	2.9E-01
+4.0	92-708I	6.33E+00	+/-	2.6E-01	2.27E+01	+/-	3.5E-01	4.55E+01	+/-	3.0E-01
+3.5	92-708J	7.11E+00	+/-	2.6E-01	2.45E+01	+/-	3.6E-01	4.80E+01	+/-	3.1E-01
+3.0	92-708K	7.43E+00	+/-	2.9E-01	2.57E+01	+/-	3.7E-01	5.10E+01	+/-	3.1E-01
+2.5	92-708L	7.68E+00	+/-	2.8E-01	2.59E+01	+/-	3.7E-01	5.30E+01	+/-	3.2E-01
+2.0	92-708M	7.70E+00	+/-	2.8E-01	2.59E+01	+/-	3.8E-01	5.31E+01	+/-	3.2E-01
+1.5	92-708N	7.79E+00	+/-	3.0E-01	2.65E+01	+/-	3.9E-01	5.76E+01	+/-	3.3E-01
+1.0	92-708O	8.04E+00	+/-	5.3E-01	2.69E+01	+/-	6.9E-01	5.95E+01	+/-	6.0E-01
+0.5	92-708P	7.96E+00	+/-	5.3E-01	2.68E+01	+/-	6.8E-01	6.04E+01	+/-	6.0E-01
0	92-708Q	8.05E+00	+/-	5.5E-01	2.64E+01	+/-	6.9E-01	6.13E+01	+/-	6.0E-01
-0.5	92-708R	8.01E+00	+/-	5.3E-01	2.63E+01	+/-	7.0E-01	6.13E+01	+/-	6.2E-01
-1.0	92-708S	8.02E+00	+/-	5.6E-01	2.61E+01	+/-	6.9E-01	6.16E+01	+/-	6.0E-01
-1.5	92-708T	7.13E+00	+/-	4.8E-01	2.48E+01	+/-	6.7E-01	6.08E+01	+/-	6.0E-01
-2.0	92-708U	6.96E+00	+/-	5.0E-01	2.40E+01	+/-	7.0E-01	5.95E+01	+/-	6.0E-01
-2.5	92-708V	6.40E+00	+/-	2.9E-01	2.30E+01	+/-	3.7E-01	5.69E+01	+/-	3.3E-01
-3.0	92-708W	6.42E+00	+/-	3.8E-01	2.16E+01	+/-	5.0E-01	5.46E+01	+/-	4.5E-01
-3.5	92-708X	6.01E+00	+/-	2.8E-01	2.02E+01	+/-	3.5E-01	5.14E+01	+/-	3.2E-01
-4.0	92-708Y	5.33E+00	+/-	2.8E-01	1.83E+01	+/-	3.5E-01	4.84E+01	+/-	3.1E-01
-4.5	92-708Z	4.57E+00	+/-	2.5E-01	1.56E+01	+/-	3.1E-01	4.31E+01	+/-	2.9E-01

Remarks:

AL File: 14601
References: Lab Book#49 pages 259-271.
Procedures: A-524.
Analyst: WTF, TRK, MRK

Approved: Mark Kurchak

RSAC PAL775

REPORT

Westinghouse Advanced Energy Systems
Analytical Laboratory - Waltz Mill Site

Request# 14601

Originator: A.H.Fero (W)Energy Center (E 4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/20/92

[RESULTS OF ANALYSIS]

PALISADES CYCLE 9 REACTOR CAVITY DOSIMETRY

Bead Chain Tag ID: S-2 150 Degrees

Feet from Midplane	Lab Sample#	dps/mg of chain @ 3/4/92 Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
+8.0	92-709A	4.67E-01 +/-	1.3E-01	1.75E+00 +/-	1.6E-01	1.99E+01 +/-	1.9E-01
+7.5	92-709B	7.16E-01 +/-	1.3E-01	2.48E+00 +/-	1.8E-01	2.32E+01 +/-	2.1E-01
+7.0	92-709C	1.16E+00 +/-	1.6E-01	4.17E+00 +/-	2.2E-01	2.69E+01 +/-	2.2E-01
+6.5	92-709D	1.75E+00 +/-	1.7E-01	5.98E+00 +/-	2.4E-01	2.95E+01 +/-	2.4E-01
+6.0	92-709E	2.29E+00 +/-	2.1E-01	8.35E+00 +/-	2.5E-01	3.18E+01 +/-	2.5E-01
+5.5	92-709F	3.11E+00 +/-	2.2E-01	1.15E+01 +/-	2.8E-01	3.45E+01 +/-	2.6E-01
+5.0	92-709G	3.89E+00 +/-	2.1E-01	1.42E+01 +/-	3.0E-01	3.70E+01 +/-	2.7E-01
+4.5	92-709H	4.84E+00 +/-	2.5E-01	1.69E+01 +/-	3.1E-01	4.03E+01 +/-	2.8E-01
+4.0	92-709I	5.21E+00 +/-	2.4E-01	1.81E+01 +/-	3.3E-01	4.30E+01 +/-	2.9E-01
+3.5	92-709J	5.66E+00 +/-	2.3E-01	2.08E+01 +/-	3.5E-01	4.56E+01 +/-	3.0E-01
+3.0	92-709K	5.95E+00 +/-	2.6E-01	2.19E+01 +/-	3.6E-01	4.79E+01 +/-	3.0E-01
+2.5	92-709L	6.50E+00 +/-	2.4E-01	2.27E+01 +/-	3.6E-01	4.95E+01 +/-	3.1E-01
+2.0	92-709M	6.57E+00 +/-	2.6E-01	2.28E+01 +/-	3.7E-01	5.14E+01 +/-	3.2E-01
+1.5	92-709N	6.94E+00 +/-	2.9E-01	2.30E+01 +/-	3.8E-01	5.31E+01 +/-	3.2E-01
+1.0	92-709O	6.48E+00 +/-	2.6E-01	2.30E+01 +/-	3.8E-01	5.46E+01 +/-	3.3E-01
+0.5	92-709P	6.66E+00 +/-	2.9E-01	2.36E+01 +/-	3.9E-01	5.54E+01 +/-	3.3E-01
0.0	92-709Q	6.76E+00 +/-	2.8E-01	2.37E+01 +/-	3.8E-01	5.63E+01 +/-	3.3E-01
-0.5	92-709R	6.99E+00 +/-	2.8E-01	2.38E+01 +/-	3.8E-01	5.68E+01 +/-	3.3E-01
-1.0	92-709S	7.01E+00 +/-	2.9E-01	2.34E+01 +/-	3.7E-01	5.60E+01 +/-	3.3E-01
-1.5	92-709T	6.52E+00 +/-	2.7E-01	2.28E+01 +/-	3.8E-01	5.50E+01 +/-	3.3E-01
-2.0	92-709U	6.63E+00 +/-	2.7E-01	2.25E+01 +/-	3.8E-01	5.58E+01 +/-	3.3E-01
-2.5	92-709V	6.31E+00 +/-	2.7E-01	2.22E+01 +/-	3.7E-01	5.36E+01 +/-	3.2E-01
-3.0	92-709W	6.06E+00 +/-	2.8E-01	2.13E+01 +/-	3.7E-01	5.24E+01 +/-	3.2E-01
-3.5	92-709X	5.83E+00 +/-	2.5E-01	2.03E+01 +/-	3.5E-01	4.96E+01 +/-	3.1E-01
-4.0	92-709Y	5.02E+00 +/-	2.4E-01	1.82E+01 +/-	3.4E-01	4.67E+01 +/-	3.0E-01
-4.5	92-709Z	4.57E+00 +/-	2.5E-01	1.53E+01 +/-	3.2E-01	4.30E+01 +/-	2.9E-01

Remarks:

AL File: 14601
References: Lab Book#49 pages 261-265; Lab Book#51 page 32
Procedures: A-524.
Analyst: WTF, TRK, MRK, FRC

Approved: [signature]

RSAC PAL775

REPORT — Westinghouse Advanced Energy Systems, Analytical Laboratory - Waltz Mill Site — Request# 14601

Originator: A.H.Fero (W)Energy Center (E 4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/23/92

[RESULTS OF ANALYSIS]

PALISADES CYCLE 9 REACTOR CAVITY DOSIMETRY

Bead Chain Tag ID: S-2 260 Degrees

Feet from Midplane	Lab Sample#	Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
		[<-------------- dps/mg of chain @ 3/4/92 -------------->]					
+8.0	92-711A	5.01E-01	+/- 1.1E-01	1.89E+00	+/- 1.6E-01	2.16E+01	+/- 2.0E-01
+7.5	92-711B	7.43E-01	+/- 1.4E-01	2.89E+00	+/- 1.9E-01	2.42E+01	+/- 2.1E-01
+7.0	92-711C	1.22E+00	+/- 1.6E-01	4.40E+00	+/- 2.1E-01	2.68E+01	+/- 2.2E-01
+6.5	92-711D	1.92E+00	+/- 1.9E-01	6.63E+00	+/- 2.4E-01	2.95E+01	+/- 2.4E-01
+6.0	92-711E	2.65E+00	+/- 2.2E-01	9.44E+00	+/- 2.7E-01	3.19E+01	+/- 2.5E-01
+5.5	92-711F	3.70E+00	+/- 2.3E-01	1.26E+01	+/- 2.9E-01	3.44E+01	+/- 2.6E-01
+5.0	92-711G	4.62E+00	+/- 2.4E-01	1.66E+01	+/- 3.1E-01	3.68E+01	+/- 2.7E-01
+4.5	92-711H	5.47E+00	+/- 2.3E-01	1.94E+01	+/- 3.2E-01	3.93E+01	+/- 2.7E-01
+4.0	92-711I	6.20E+00	+/- 2.6E-01	2.17E+01	+/- 3.4E-01	4.12E+01	+/- 2.8E-01
+3.5	92-711J	6.73E+00	+/- 2.5E-01	2.37E+01	+/- 3.5E-01	4.31E+01	+/- 2.9E-01
+3.0	92-711K	7.34E+00	+/- 2.7E-01	2.49E+01	+/- 3.7E-01	4.51E+01	+/- 2.9E-01
+2.5	92-711L	7.62E+00	+/- 2.6E-01	2.56E+01	+/- 3.8E-01	4.66E+01	+/- 3.0E-01
+2.0	92-711M	7.46E+00	+/- 2.7E-01	2.58E+01	+/- 3.7E-01	4.82E+01	+/- 3.1E-01
+1.5	92-711N	7.53E+00	+/- 2.9E-01	2.62E+01	+/- 3.8E-01	4.93E+01	+/- 3.1E-01
+1.0	92-711O	7.90E+00	+/- 2.9E-01	2.64E+01	+/- 3.8E-01	5.07E+01	+/- 3.1E-01
+0.5	92-711P	8.08E+00	+/- 2.8E-01	2.66E+01	+/- 3.9E-01	5.16E+01	+/- 3.2E-01
0	92-711Q	8.04E+00	+/- 3.0E-01	2.68E+01	+/- 4.0E-01	5.18E+01	+/- 3.2E-01
-0.5	92-711R	8.04E+00	+/- 2.4E-01	2.70E+01	+/- 3.6E-01	5.25E+01	+/- 2.9E-01
-1.0	92-711S	8.07E+00	+/- 3.0E-01	2.73E+01	+/- 3.8E-01	5.21E+01	+/- 3.2E-01
-1.5	92-711T	8.20E+00	+/- 3.0E-01	2.73E+01	+/- 3.9E-01	5.15E+01	+/- 3.2E-01
-2.0	92-711U	7.96E+00	+/- 2.9E-01	2.63E+01	+/- 3.9E-01	5.05E+01	+/- 3.1E-01
-2.5	92-711V	7.47E+00	+/- 2.8E-01	2.51E+01	+/- 3.8E-01	4.94E+01	+/- 3.1E-01
-3.0	92-711W	7.05E+00	+/- 2.8E-01	2.42E+01	+/- 3.8E-01	4.73E+01	+/- 3.0E-01
-3.5	92-711X	6.68E+00	+/- 2.7E-01	2.24E+01	+/- 3.5E-01	4.53E+01	+/- 3.0E-01
-4.0	92-711Y	5.72E+00	+/- 2.5E-01	2.03E+01	+/- 3.5E-01	4.27E+01	+/- 2.8E-01
-4.5	92-711Z	4.84E+00	+/- 2.4E-01	1.72E+01	+/- 3.3E-01	3.89E+01	+/- 2.7E-01

Remarks:

AL File: 14601
References: Lab Book#49 pages 259-271.
Procedures: A-524.
Analyst: WTF, TRK, MRK

Approved: Mark Kuvchak

RSAC PAL 775

REPORT

Westinghouse Advanced Energy Systems
Analytical Laboratory - Waltz Mill Site

Request# 14601

Originator: A.H.Fero (W)Energy Center (E 4-17)
Radiation Engineering & Analysis
Westinghouse Electric Corporation

Received: 3/3/92
Reported: 3/25/92

[RESULTS OF ANALYSIS]

PALISADES CYCLE 9 REACTOR CAVITY DOSIMETRY

ead Chain Tag ID: S-2 340 Degrees

Feet from idplane	Lab Sample#	[<-------------- dps/mg of chain @ 3/4/92 -------------->] Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
+8.0	92-718A	5.44E-01 +/-	6.9E-02	2.08E+00 +/-	1.1E-01	2.04E+01 +/-	1.2E-01
+7.5	92-718B	7.77E-01 +/-	7.4E-02	3.11E+00 +/-	1.2E-01	2.29E+01 +/-	1.3E-01
+7.0	92-718C	1.06E+00 +/-	1.2E-01	4.63E+00 +/-	2.1E-01	2.53E+01 +/-	2.2E-01
+6.5	92-718D	1.87E+00 +/-	1.6E-01	6.90E+00 +/-	2.5E-01	2.82E+01 +/-	2.3E-01
+6.0	92-718E	2.72E+00 +/-	2.1E-01	9.86E+00 +/-	2.6E-01	3.09E+01 +/-	2.4E-01
+5.5	92-718F	3.67E+00 +/-	2.1E-01	1.30E+01 +/-	3.0E-01	3.40E+01 +/-	2.5E-01
+5.0	92-718G	4.83E+00 +/-	2.3E-01	1.68E+01 +/-	3.3E-01	3.64E+01 +/-	2.7E-01
+4.5	92-718H	5.73E+00 +/-	2.4E-01	1.99E+01 +/-	3.4E-01	3.91E+01 +/-	2.7E-01
+4.0	92-718I	6.50E+00 +/-	2.5E-01	2.21E+01 +/-	3.6E-01	4.15E+01 +/-	2.8E-01
+3.5	92-718J	6.94E+00 +/-	2.6E-01	2.40E+01 +/-	3.6E-01	4.38E+01 +/-	2.9E-01
+3.0	92-718K	7.25E+00 +/-	2.7E-01	2.52E+01 +/-	3.8E-01	4.58E+01 +/-	2.9E-01
+2.5	92-718L	7.30E+00 +/-	2.7E-01	2.58E+01 +/-	3.8E-01	4.81E+01 +/-	3.1E-01
+2.0	92-718M	7.63E+00 +/-	2.6E-01	2.64E+01 +/-	3.6E-01	5.01E+01 +/-	2.9E-01
+1.5	92-718N	7.64E+00 +/-	2.8E-01	2.68E+01 +/-	4.0E-01	5.16E+01 +/-	3.2E-01
+1.0	92-718O	7.79E+00 +/-	3.0E-01	2.67E+01 +/-	4.0E-01	5.31E+01 +/-	3.2E-01
+0.5	92-718P	7.68E+00 +/-	3.0E-01	2.68E+01 +/-	4.1E-01	5.45E+01 +/-	3.3E-01
0	92-718Q	8.05E+00 +/-	3.1E-01	2.73E+01 +/-	4.1E-01	5.49E+01 +/-	3.3E-01
-0.5	92-718R	8.14E+00 +/-	2.9E-01	2.69E+01 +/-	4.2E-01	5.56E+01 +/-	3.3E-01
-1.0	92-718S	8.26E+00 +/-	3.0E-01	2.73E+01 +/-	4.1E-01	5.53E+01 +/-	3.3E-01
-1.5	92-718T	8.18E+00 +/-	2.9E-01	2.70E+01 +/-	4.2E-01	5.50E+01 +/-	3.3E-01
-2.0	92-718U	7.93E+00 +/-	2.9E-01	2.70E+01 +/-	4.1E-01	5.34E+01 +/-	3.2E-01
-2.5	92-718V	7.52E+00 +/-	2.9E-01	2.61E+01 +/-	4.1E-01	5.21E+01 +/-	3.2E-01
-3.0	92-718W	7.06E+00 +/-	2.8E-01	2.46E+01 +/-	3.9E-01	5.03E+01 +/-	3.1E-01
-3.5	92-718X	6.59E+00 +/-	2.6E-01	2.28E+01 +/-	3.7E-01	4.78E+01 +/-	3.0E-01
-4.0	92-718Y	5.66E+00 +/-	2.5E-01	2.01E+01 +/-	3.6E-01	4.49E+01 +/-	2.9E-01
-4.5	92-718Z	5.13E+00 +/-	2.3E-01	1.71E+01 +/-	3.4E-01	4.09E+01 +/-	2.8E-01

Remarks:

AL File: 14601
References: Lab Book#49 pages 259-271.
Procedures: A-524.
Analyst: WTF, TRK, MRK

Approved: Mark Kawchak

RSAC PAL 112

WESTINGHOUSE ELECTRIC CORPORATION
NUCLEAR & ADVANCED TECHNOLOGY DIVISION
AES ANALYTICAL LABORATORY
WALTZ MILL SITE

ARNIE FERRO / M. Kawchek — AL REQUEST 14601

W NATD Energy Center — Receipt March 13, 1992
W284-4891 msE417 — Report March 17, 1992

MATERIAL DESCRIPTION
STAINLESS STEEL DOSIMETRY REACTOR CHAIN BEADS

Al Serv. #	W NATD Identification CHAIN	LOCATION	WEIGHT PERCENT (%) Fe	Ni	Co	
92- 707	S-2	30o	71.67	9.729	0.1345	
92- 708	S-2	90o	71.36	9.781	0.1387	
92- 709	S-2	150o	72.07	9.873	0.1430	
92- 711	S-2	260o	71.16	9.581	0.1384	
92- 712	S-2 1	270o	70.88	9.768	0.1745	*
92- 713	S-2	280o	72.13	9.887	0.1430	
92- 714	S-2	290o	69.13	10.184	0.1385	
92- 715	S-2 1	300o	71.97	10.234	0.1784	*
92- 716	S-2	315o	70.73	10.112	0.1404	
92- 717	S-2	330o	72.93	10.402	0.1417	
92- 718	S-2	340o	70.01	9.986	0.1363	
		aver	71.28	9.958	0.1394	0.1461 *
		std dev	±1.07	±0.250	±0.0029	±0.0152 *
		%RSD	1.5%	2.5%	2.0%	10.4% *

* two cobalt values significantly different than group, calculated average with and without * values.

			Fe	Ni	Co
NIST 121d SS Control		certified	68.23	11.17	0.10
	aver	measured	69.67	11.463	0.0959
		± std dev	±0.92	±0.270	±0.0011
		% RSD	1.3%	2.4%	1.2%

S-2 210o received empty bag, no sample (92-710)

Method of Analysis — Metals ICPS
Operator — RMcK
File — AL 14601

Approved by Lawrence Kardos

Lawrence Kardos, Sr Scientist

APPENDIX D

SPECIFIC ACTIVITIES AND IRRADIATION HISTORY OF REACTOR CAVITY SENSOR SETS - CYCLES 10 & 11

In this appendix, the irradiation history as extracted from NUREG-0020 and the measured specific activities of radiometric monitors irradiated in the reactor cavity during Cycles 10 and 11 are provided.

The irradiation history of Cycles 10 and 11 were as follows:

Cycle	Startup	Shutdown	Comment
10	04/18/92	06/05/93	
11	11/06/93	05/22/95	

Reference Core Power = 2530 MWt

The monthly thermal generation applicable to the Palisades reactor is provided in addition to the specific activities of the sensors on the following pages.

TABLE D-1

IRRADIATION HISTORY OF REACTOR CAVITY SENSOR SETS

Cycle 10		Cycle 11	
Date	Thermal Generation MW-hr	Date	Thermal Generation MW-hr
Mar-92	0	Jul-93	0
Apr-92	620112	Aug-93	0
May-92	1878432	Sep-93	0
Jun-92	1819464	Oct-93	0
Jul-92	1392552	Nov-93	1242336
Aug-92	1459272	Dec-93	1876608
Sep-92	1260672	Jan-94	1844112
Oct-92	1779079	Feb-94	1004688
Nov-92	1326168	Mar-94	0
Dec-92	1880496	Apr-94	0
Jan-93	1879536	May-94	0
Feb-93	1698408	Jun-94	666768
Mar-93	1880544	Jul-94	1874208
Apr-93	1688919	Aug-94	1874448
May-93	862632	Sep-94	1812408
Jun-93	237864	Oct-94	1869960
		Nov-94	1813872
		Dec-94	1867368
		Jan-95	1874304
		Feb-95	1655688
		Mar-95	1871832
		Apr-95	1811689
		May-95	1170744

TABLE D-2

CONTENTS OF MULTIPLE FOIL SENSOR SETS
CYCLES 10/11 IRRADIATION

Capsule ID/ Position	Bare or Cd Shielded	Radiometric Monitor Foil ID Fe	Ni	Cu	Ti	Nb	Co	^{238}U	^{237}Np
O-1	B	D	-	-	-	-	A	-	-
O-2	Cd	N	AN	AN	BD	AN	N	-	-
O-3	Cd	-	-	-	-	-	-	1	1
P-1	B	E	-	-	-	-	B	-	-
P-2	Cd	O	AO	AO	BE	AO	O	-	-
P-3	Cd	-	-	-	-	-	-	2	2
Q-1	B	F	-	-	-	-	C	-	-
Q-2	Cd	P	AP	AP	BF	AP	P	-	-
Q-3	Cd	-	-	-	-	-	-	3	-
R-1	B	G	-	-	-	-	D	-	-
R-2	Cd	R	AR	AR	BG	AR	R	-	-
R-3	Cd	-	-	-	-	-	-	4	3
S-1	B	H	-	-	-	-	E	-	-
S-2	Cd	S	AS	AS	BH	AS	S	-	-
S-3	Cd	-	-	-	-	-	-	5	4
T-1	B	I	-	-	-	-	F	-	-
T-2	Cd	T	AT	AT	BI	AT	T	-	-
T-3	Cd	-	-	-	-	-	-	6	5
U-1	B	J	-	-	-	-	G	-	-
U-2	Cd	U	AU	AU	BJ	AU	U	-	-
U-3	Cd	-	-	-	-	-	-	7	6

REPORT

Westinghouse Electric Corporation
Chemistry Operations Technology & Analysis
Waltz Mill Site

Request# 15753

Originator: J. Perock (W)NTD, Energy Center (4-36)

Received: 6/29/95
Reported: 8/24/95

[RESULTS OF ANALYSIS]
Palisades Reactor Cavity Dosimetry - Cycle 10

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 8/15/95) dps/mg *		2 sigma
D	95-1495	Fe	Mn-54	1.29E+01	+/-	1.2E-01
N	95-1496	Fe	Mn-54	1.24E+01	+/-	1.2E-01
E	95-1505	Fe	Mn-54	1.34E+01	+/-	1.6E-01
O	95-1506	Fe	Mn-54	1.30E+01	+/-	1.5E-01
F	95-1515	Fe	Mn-54	3.62E+00	+/-	8.5E-02
P	95-1516	Fe	Mn-54	3.31E+00	+/-	8.2E-02
G	95-1524	Fe	Mn-54	1.22E+01	+/-	1.5E-01
R	95-1525	Fe	Mn-54	1.19E+01	+/-	1.4E-01
H	95-1534	Fe	Mn-54	9.48E+00	+/-	1.4E-01
S	95-1535	Fe	Mn-54	9.64E+00	+/-	1.3E-01
I	95-1544	Fe	Mn-54	9.43E+00	+/-	1.4E-01
T	95-1545	Fe	Mn-54	9.19E+00	+/-	1.3E-01
J	95-1554	Fe	Mn-54	1.11E+01	+/-	1.5E-01
U	95-1555	Fe	Mn-54	1.08E+01	+/-	1.4E-01
A	95-1501	AlCo	Co-60	3.16E+02	+/-	4.6E+00
N	95-1502	AlCo	Co-60	2.04E+02	+/-	3.6E+00
B	95-1511	AlCo	Co-60	3.04E+02	+/-	4.5E+00
O	95-1512	AlCo	Co-60	2.02E+02	+/-	3.7E+00
C	95-1521	AlCo	Co-60	1.71E+02	+/-	3.3E+00
P	95-1522	AlCo	Co-60	1.15E+02	+/-	2.7E+00
D	95-1530	AlCo	Co-60	2.85E+02	+/-	4.2E+00
R	95-1531	AlCo	Co-60	1.97E+02	+/-	3.5E+00
E	95-1540	AlCo	Co-60	2.81E+02	+/-	4.1E+00
S	95-1541	AlCo	Co-60	2.00E+02	+/-	3.5E+00
F	95-1550	AlCo	Co-60	3.25E+02	+/-	4.4E+00
T	95-1551	AlCo	Co-60	2.06E+02	+/-	3.5E+00
G	95-1560	AlCo	Co-60	3.41E+02	+/-	4.5E+00
U	95-1561	AlCo	Co-60	2.13E+02	+/-	3.6E+00

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 15753
Procedures: A-524
Analyst: WTF

Approved: [signature]

REPORT

Westinghouse Electric Corporation
Chemistry Operations Technology & Analysis
Waltz Mill Site

Request# 15753

Originator: J. Perock (W)NTD, Energy Center (4-36)

Received: 6/29/95
Reported: 8/24/95

[RESULTS OF ANALYSIS]

Palisades Reactor Cavity Dosimetry - Cycle 10

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 8/15/95) dps/mg *		2 sigma
BD	95-1499	Ti	Sc-46	3.08E+00	+/-	8.8E-02
BE	95-1509	Ti	Sc-46	3.23E+00	+/-	8.9E-02
BF	95-1519	Ti	Sc-46	8.49E-01	+/-	4.3E-02
BG	95-1528	Ti	Sc-46	3.01E+00	+/-	8.5E-02
BH	95-1538	Ti	Sc-46	2.34E+00	+/-	7.5E-02
BI	95-1548	Ti	Sc-46	2.33E+00	+/-	7.6E-02
BJ	95-1558	Ti	Sc-46	2.72E+00	+/-	8.2E-02
AN	95-1497	Ni	C0-58	1.35E+02	+/-	1.7E+00
AO	95-1507	Ni	C0-58	1.44E+02	+/-	1.7E+00
AP	95-1517	Ni	C0-58	3.94E+01	+/-	9.0E-01
AR	95-1526	Ni	C0-58	1.26E+02	+/-	1.6E+00
AS	95-1536	Ni	C0-58	1.99E+02	+/-	2.0E+00
AT	95-1546	Ni	C0-58	9.92E+01	+/-	1.4E+00
AU	95-1556	Ni	C0-58	1.18E+02	+/-	1.6E+00
AN	95-1498	Cu	C0-60	7.67E-01	+/-	2.0E-02
AO	95-1508	Cu	C0-60	7.98E-01	+/-	2.1E-02
AP	95-1518	Cu	C0-60	1.93E-01	+/-	1.0E-02
AR	95-1527	Cu	C0-60	7.28E-01	+/-	1.9E-02
AS	95-1537	Cu	C0-60	6.10E-01	+/-	1.8E-02
AT	95-1547	Cu	C0-60	5.43E-01	+/-	1.7E-02
AU	95-1557	Cu	C0-60	6.59E-01	+/-	1.9E-02

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 15753
Procedures: A-524
Analyst: WTF

Approved: [signature]

REPORT

Westinghouse Electric Corporation
Chemistry Operations Technology & Analysis
Waltz Mill Site

Request# 15753

Originator: J. Perock (W)NTD, Energy Center (4-36)

Received: 6/29/95
Reported: 8/24/95

[RESULTS OF ANALYSIS]

Palisades Reactor Cavity Dosimetry - Cycle 10

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 8/15/95) dps/mg *		2 sigma
1	95-1503	UO2	Cs-137	1.55E+00	+/-	2.3E-01
2	95-1513	UO2	Cs-137	1.41E+00	+/-	2.2E-01
3	95-1523	UO2	Cs-137	3.38E-01	+/-	1.3E-01
4	95-1532	UO2	Cs-137	1.32E+00	+/-	1.6E-01
5	95-1542	UO2	Cs-137	1.09E+00	+/-	1.8E-01
6	95-1552	UO2	Cs-137	1.01E+00	+/-	1.6E-01
7	95-1562	UO2	Cs-137	1.33E+00	+/-	2.9E-01
1	95-1503	UO2	Ru-103	5.73E+00	+/-	3.6E-01
2	95-1513	UO2	Ru-103	5.78E+00	+/-	3.9E-01
3	95-1523	UO2	Ru-103	1.74E+00	+/-	1.6E-01
4	95-1532	UO2	Ru-103	5.37E+00	+/-	2.8E-01
5	95-1542	UO2	Ru-103	4.14E+00	+/-	2.9E-01
6	95-1552	UO2	Ru-103	3.96E+00	+/-	2.3E-01
7	95-1562	UO2	Ru-103	4.94E+00	+/-	3.9E-01
1	95-1503	UO2	Zr-95	7.60E+00	+/-	5.2E-01
2	95-1513	UO2	Zr-95	8.16E+00	+/-	6.0E-01
3	95-1523	UO2	Zr-95	2.32E+00	+/-	2.5E-01
4	95-1532	UO2	Zr-95	7.81E+00	+/-	4.5E-01
5	95-1542	UO2	Zr-95	5.75E+00	+/-	4.2E-01
6	95-1552	UO2	Zr-95	5.87E+00	+/-	3.8E-01
7	95-1562	UO2	Zr-95	6.07E+00	+/-	5.7E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 15753
Procedures: A-524
Analyst: WTF

Approved: [signature]

REPORT

Westinghouse Electric Corporation
Chemistry Operations Technology & Analysis
Waltz Mill Site

Request# 15753

Originator: J. Perock (W)NTD, Energy Center (4-36)

Received: 6/29/95
Reported: 8/24/95

[RESULTS OF ANALYSIS]

Palisades Reactor Cavity Dosimetry - Cycle 10

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 8/15/95) dps/mg *		2 sigma
1	95-1504	NpO2	Cs-137	1.92E+01	+/-	2.1E+00
2	95-1514	NpO2	Cs-137	2.04E+01	+/-	1.8E+00
3	95-1533	NpO2	Cs-137	1.95E+01	+/-	1.7E+00
4	95-1543	NpO2	Cs-137	1.56E+01	+/-	1.4E+00
5	95-1553	NpO2	Cs-137	1.49E+01	+/-	1.9E+00
6	95-1563	NpO2	Cs-137	1.52E+01	+/-	1.6E+00
1	95-1504	NpO2	Ru-103	7.48E+01	+/-	3.6E+00
2	95-1514	NpO2	Ru-103	7.54E+01	+/-	3.2E+00
3	95-1533	NpO2	Ru-103	6.76E+01	+/-	3.4E+00
4	95-1543	NpO2	Ru-103	5.62E+01	+/-	2.7E+00
5	95-1553	NpO2	Ru-103	5.29E+01	+/-	3.0E+00
6	95-1563	NpO2	Ru-103	6.26E+01	+/-	3.0E+00
1	95-1504	NpO2	Zr-95	1.20E+02	+/-	5.0E+00
2	95-1514	NpO2	Zr-95	1.26E+02	+/-	5.0E+00
3	95-1533	NpO2	Zr-95	1.11E+02	+/-	4.7E+00
4	95-1543	NpO2	Zr-95	9.55E+01	+/-	4.5E+00
5	95-1553	NpO2	Zr-95	9.13E+01	+/-	4.7E+00
6	95-1563	NpO2	Zr-95	1.05E+02	+/-	4.6E+00

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 15753
Procedures: A-524
Analyst: WTF

Approved: [signature]

REVISED REPORT

Westinghouse Electric Corporation
Chemistry Operations Technology & Analysis
Waltz Mill Site

Request# 15753

Originator: J. Perock (W)NTD, Energy Center (4-36)

Received: 6/29/95
Reported: 11/27/95

[RESULTS OF ANALYSIS]

Palisades Reactor Cavity Dosimetry - Cycle 10

Bead Chain Tag ID: 270 deg.

Feet from Midplane	Lab Sample#	Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
		dps/mg of chain @ 8/15/95					
+0.5	95-1488-A	8.40E+00	+/- 4.9E-01	1.21E+01	+/- 5.4E-01	1.10E+02	+/- 1.1E+00
-0.5	95-1488-B	8.27E+00	+/- 5.1E-01	1.18E+01	+/- 5.9E-01	1.07E+02	+/- 1.1E+00
-1.5	95-1488-C	7.15E+00	+/- 4.3E-01	1.05E+01	+/- 5.0E-01	1.05E+02	+/- 1.1E+00
-2.5	95-1488-D	6.17E+00	+/- 4.4E-01	9.82E+00	+/- 4.9E+00	9.79E+01	+/- 9.4E-01
-3.5	95-1488-E	4.70E+00	+/- 3.8E-01	7.39E+00	+/- 4.9E-01	8.76E+01	+/- 8.9E-01
-4.5	95-1488-F	2.96E+00	+/- 3.1E-01	4.54E+00	+/- 3.5E-01	6.64E+01	+/- 7.7E-01
-5.5	95-1488-G	1.46E+00	+/- 1.5E-01	2.38E+00	+/- 1.6E-01	5.64E+01	+/- 4.1E-01

Bead Chain Tag ID: 280 deg.

Feet from Midplane	Lab Sample#	Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
		dps/mg of chain @ 8/15/95					
+0.5	95-1489-A	8.81E+00	+/- 4.8E-01	1.32E+01	+/- 5.3E-01	1.02E+02	+/- 9.6E-01
-0.5	95-1489-B	8.42E+00	+/- 4.9E-01	1.31E+01	+/- 6.0E-01	1.01E+02	+/- 9.7E-01
-1.5	95-1489-C	8.52E+00	+/- 6.1E-01	1.24E+01	+/- 5.6E-01	9.99E+01	+/- 9.8E-01
-2.5	95-1489-D	7.30E+00	+/- 5.3E-01	1.08E+01	+/- 5.7E-01	9.40E+01	+/- 9.4E-01
-3.5	95-1489-E	6.44E+00	+/- 4.7E-01	9.89E+00	+/- 4.7E-01	8.74E+01	+/- 8.9E-01
-4.5	95-1489-F	4.17E+00	+/- 2.1E-01	6.79E+00	+/- 2.4E-01	7.27E+01	+/- 4.6E-01
-5.73	95-1489-G	1.66E+00	+/- 1.7E-01	2.69E+00	+/- 1.8E-01	5.57E+01	+/- 4.0E-01

Remarks:
* Results are in units of dps/(mg of Dosimeter Material).
* Correction of Co-58: 95-1489-F

AL File: 15753
Procedures: A-524
Analyst: WTF

Approved: L. F. Becker for 11/27/95

REPORT	Westinghouse Electric Corporation Chemistry Operations Technology & Analysis Waltz Mill Site	Request# 15753

Originator: J. Perock (W)NTD, Energy Center (4-36)

Received: 6/29/95
Reported: 8/28/95

[RESULTS OF ANALYSIS]

Palisades Reactor Cavity Dosimetry - Cycle 10

Bead Chain Tag ID: 290 deg.

Feet from Midplane	Lab Sample#	[<——— dps/mg of chain @ 8/15/95 ———>] Mn-54		Co-58		Co-60	
		dps/mg	2 sigma	dps/mg	2 sigma	dps/mg	2 sigma
+0.5	95-1490-A	7.39E+00	+/- 4.7E-01	1.10E+01	+/- 5.3E-01	9.48E+01	+/- 9.4E-01
-0.5	95-1490-B	7.65E+00	+/- 4.6E-01	1.11E+01	+/- 5.3E-01	9.58E+01	+/- 9.3E-01
-1.5	95-1490-C	7.73E+00	+/- 4.8E+00	1.12E+01	+/- 5.1E-01	9.38E+01	+/- 9.3E-01
-2.5	95-1490-D	6.95E+00	+/- 4.6E-01	1.02E+01	+/- 5.4E-01	9.09E+01	+/- 9.1E-01
-3.5	95-1490-E	6.07E+00	+/- 4.9E-01	9.26E+00	+/- 5.0E-01	8.53E+01	+/- 8.8E-01
-4.5	95-1490-F	4.66E+00	+/- 2.5E-01	7.36E+00	+/- 2.9E-01	7.64E+01	+/- 4.8E-01
-5.5	95-1490-G	2.52E+00	+/- 2.0E-01	4.04E+00	+/- 2.0E-01	5.74E+01	+/- 4.1E-01

Bead Chain Tag ID: 300 deg.

Feet from Midplane	Lab Sample#	[<——— dps/mg of chain @ 8/15/95 ———>] Mn-54		Co-58		Co-60	
		dps/mg	2 sigma	dps/mg	2 sigma	dps/mg	2 sigma
+0.5	95-1491-A	6.46E+00	+/- 4.3E-01	9.48E+00	+/- 4.9E-01	9.54E+01	+/- 9.3E-01
-0.5	95-1491-B	6.30E+00	+/- 4.1E-01	9.42E+00	+/- 4.6E-01	9.57E+01	+/- 9.3E-01
-1.5	95-1491-C	6.11E+00	+/- 3.9E-01	9.13E+00	+/- 4.7E-01	9.28E+01	+/- 9.2E-01
-2.5	95-1491-D	6.23E+00	+/- 4.8E-01	8.35E+00	+/- 4.5E-01	8.90E+01	+/- 9.1E-01
-3.5	95-1491-E	5.09E+00	+/- 2.1E-01	7.78E+00	+/- 2.6E-01	8.29E+01	+/- 4.9E-01
-4.5	95-1491-F	4.06E+00	+/- 2.1E-01	6.46E+00	+/- 2.4E-01	7.39E+01	+/- 4.6E-01
-5.5	95-1491-G	2.36E+00	+/- 1.8E-01	3.52E+00	+/- 1.8E-01	5.42E+01	+/- 4.0E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 15753
Procedures: A-524
Analyst: WTF

Approved: [signature]

REPORT

Westinghouse Electric Corporation
Chemistry Operations Technology & Analysis
Waltz Mill Site

Request# 15753

Originator: J. Perock (W)NTD, Energy Center (4-36)

Received: 6/29/95
Reported: 8/28/95

[RESULTS OF ANALYSIS]

Palisades Reactor Cavity Dosimetry - Cycle 10

Bead Chain Tag ID: 315 deg.

Feet from Midplane	Lab Sample#	[<---- dps/mg of chain @ 8/15/95 ---->] Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
+0.5	95-1492-A	6.05E+00	+/- 6.2E-01	8.90E+00	+/- 6.5E-01	1.07E+02	+/- 1.0E+00
-0.5	95-1492-B	6.18E+00	+/- 5.2E-01	8.41E+00	+/- 5.5E-01	1.07E+02	+/- 1.0E+00
-1.5	95-1492-C	5.59E+00	+/- 5.4E-01	8.37E+00	+/- 6.4E-01	1.03E+02	+/- 1.0E+00
-2.5	95-1492-D	4.68E+00	+/- 5.1E-01	7.75E+00	+/- 5.5E-01	9.83E+01	+/- 9.9E-01
-3.5	95-1492-E	4.17E+00	+/- 3.0E-01	6.78E+00	+/- 3.9E-01	8.90E+01	+/- 6.0E-01
-4.5	95-1492-F	3.57E+00	+/- 2.9E-01	5.56E+00	+/- 3.5E-01	7.68E+01	+/- 5.5E-01
-5.5	95-1492-G	1.75E+00	+/- 1.8E-01	3.09E+00	+/- 2.4E-01	5.23E+01	+/- 4.1E-01

Bead Chain Tag ID: 330 deg.

Feet from Midplane	Lab Sample#	[<---- dps/mg of chain @ 8/15/95 ---->] Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
+0.5	95-1493-A	6.66E+00	+/- 6.3E-01	9.80E+00	+/- 6.6E-01	1.13E+02	+/- 1.1E+00
-0.5	95-1493-B	7.11E+00	+/- 5.8E-01	1.01E+01	+/- 7.3E-01	1.14E+02	+/- 1.1E+00
-1.5	95-1493-C	6.61E+00	+/- 5.7E-01	9.97E+00	+/- 6.7E-01	1.12E+02	+/- 1.1E+00
-2.5	95-1493-D	6.72E+00	+/- 4.4E-01	1.01E+01	+/- 5.6E-01	1.07E+02	+/- 9.9E-01
-3.5	95-1493-E	5.70E+00	+/- 4.0E-01	8.94E+00	+/- 5.3E-01	9.56E+01	+/- 9.3E-01
-4.5	95-1493-F	4.20E+00	+/- 2.1E-01	6.63E+00	+/- 2.3E-01	8.13E+01	+/- 4.9E-01
-5.5	95-1493-G	2.01E+00	+/- 1.6E-01	3.31E+00	+/- 2.1E-01	5.79E+01	+/- 4.1E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 15753
Procedures: A-524
Analyst: WTF

Approved: M. Krasnkat

REPORT

Westinghouse Electric Corporation
Chemistry Operations Technology & Analysis
Waltz Mill Site

Request# 15753

Originator: J. Perock (W)NTD, Energy Center (4-36)

Received: 6/29/95
Reported: 8/30/95

[RESULTS OF ANALYSIS]

Palisades Reactor Cavity Dosimetry - Cycle 10 / Cycle 11

Bead Chain Tag ID: 30 deg.

Feet from Midplane	Lab Sample#	[<------ dps/mg of chain @ 8/15/95 ------>] Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
+8.0	95-1483-A	4.10E-01 +/-	1.2E-01	7.56E-01 +/-	1.6E-01	4.25E+01 +/-	3.5E-01
+7.5	95-1483-B	7.09E-01 +/-	1.5E-01	1.24E+00 +/-	1.7E-01	4.89E+01 +/-	3.8E-01
+6.5	95-1483-C	1.81E+00 +/-	2.1E-01	2.72E+00 +/-	1.8E-01	5.95E+01 +/-	4.2E-01
+5.5	95-1483-D	3.42E+00 +/-	2.3E-01	5.36E+00 +/-	2.6E-01	6.97E+01 +/-	4.6E-01
+4.5	95-1483-E	4.91E+00 +/-	3.6E-01	7.66E+00 +/-	4.0E-01	8.04E+01 +/-	8.6E-01
+3.5	95-1483-F	5.68E+00 +/-	3.9E-01	9.11E+00 +/-	4.6E-01	9.01E+01 +/-	9.1E-01
+2.5	95-1483-G	6.42E+00 +/-	4.6E-01	9.20E+00 +/-	4.4E-01	9.70E+01 +/-	9.4E-01
+1.5	95-1483-H	6.36E+00 +/-	4.3E-01	9.57E+00 +/-	4.8E-01	1.02E+02 +/-	9.7E-01
+0.5	95-1483-I	6.15E+00 +/-	4.2E-01	9.37E+00 +/-	4.7E-01	1.07E+02 +/-	9.9E-01
0.0	95-1483-J	6.18E+00 +/-	4.5E-01	9.56E+00 +/-	5.4E-01	1.09E+02 +/-	1.0E+00
-0.5	95-1483-K	6.57E+00 +/-	4.2E-01	9.76E+00 +/-	4.7E-01	1.09E+02 +/-	1.0E+00
-1.5	95-1483-L	6.36E+00 +/-	4.4E-01	9.26E+00 +/-	5.0E-01	1.10E+02 +/-	1.0E+00
-2.5	95-1483-M	5.96E+00 +/-	4.0E-01	9.73E+00 +/-	5.8E-01	1.05E+02 +/-	9.9E-01
-3.5	95-1483-N	6.14E+00 +/-	5.0E-01	8.95E+00 +/-	5.8E-01	9.76E+01 +/-	9.5E-01
-4.5	95-1483-O	4.35E+00 +/-	4.3E-01	6.67E+00 +/-	4.5E-01	8.38E+01 +/-	8.8E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 15753
Procedures: A-524
Analyst: WTF

Approved: Mark Kowalski

REPORT

Westinghouse Electric Corporation
Chemistry Operations Technology & Analysis
Waltz Mill Site

Request# 15753

Originator: J. Perock (W)NTD, Energy Center (4-36)

Received: 6/29/95
Reported: 8/30/95

[RESULTS OF ANALYSIS]

Palisades Reactor Cavity Dosimetry - Cycle 10 / Cycle 11

Bead Chain Tag ID: 90 deg.

Feet from Midplane	Lab Sample#	dps/mg of chain @ 8/15/95								
		Mn-54			Co-58			Co-60		
		dps/mg		2 sigma	dps/mg		2 sigma	dps/mg		2 sigma
+8.0	95-1484-A	5.44E-01	+/-	1.2E-01	7.98E-01	+/-	1.5E-01	4.46E+01	+/-	3.6E-01
+7.5	95-1484-B	6.07E-01	+/-	1.4E-01	1.24E+00	+/-	1.7E-01	5.21E+01	+/-	3.9E-01
+6.5	95-1484-C	1.86E+00	+/-	1.9E-01	2.73E+00	+/-	2.1E-01	6.41E+01	+/-	4.4E-01
+5.5	95-1484-D	3.46E+00	+/-	2.1E-01	5.74E+00	+/-	3.0E-01	7.53E+01	+/-	4.8E-01
+4.5	95-1484-E	5.48E+00	+/-	4.4E-01	8.67E+00	+/-	6.1E-01	8.75E+01	+/-	9.1E-01
+3.5	95-1484-F	6.50E+00	+/-	5.2E-01	9.58E+00	+/-	6.4E-01	9.83E+01	+/-	9.7E-01
+2.5	95-1484-G	7.10E+00	+/-	5.8E-01	1.13E+01	+/-	7.0E-01	1.09E+02	+/-	1.0E+00
+1.5	95-1484-H	7.52E+00	+/-	6.3E-01	1.16E+01	+/-	6.9E-01	1.18E+02	+/-	1.1E+00
+0.5	95-1484-I	6.93E+00	+/-	5.7E-01	1.08E+01	+/-	6.4E-01	1.23E+02	+/-	1.1E+00
0.0	95-1484-J	7.16E+00	+/-	6.0E-01	1.06E+01	+/-	7.2E-01	1.23E+02	+/-	1.1E+00
-0.5	95-1484-K	6.94E+00	+/-	6.3E-01	1.05E+01	+/-	6.7E-01	1.25E+02	+/-	1.1E+00
-1.5	95-1484-L	6.86E+00	+/-	4.4E-01	1.06E+01	+/-	6.1E-01	1.26E+02	+/-	1.1E+00
-2.5	95-1484-M	6.40E+00	+/-	5.1E-01	9.84E+00	+/-	5.4E-01	1.20E+02	+/-	1.1E+00
-3.5	95-1484-N	5.70E+00	+/-	4.9E-01	9.30E+00	+/-	5.1E-01	1.08E+02	+/-	1.0E+00
-4.5	95-1484-O	4.45E+00	+/-	3.6E-01	6.68E+00	+/-	4.6E-01	8.43E+01	+/-	8.7E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 15753
Procedures: A-524
Analyst: WTF

Approved: [signature]

REPORT

Westinghouse Electric Corporation
Chemistry Operations Technology & Analysis
Waltz Mill Site

Request# 15753

Originator: J. Perock (W)NTD, Energy Center (4-36)

Received: 6/29/95
Reported: 8/30/95

[RESULTS OF ANALYSIS]

Palisades Reactor Cavity Dosimetry - Cycle 10 / Cycle 11

Bead Chain Tag ID: 340 deg.

Feet from Midplane	Lab Sample#	Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
		[<--- dps/mg of chain @ 8/15/95 --->]					
+8.0	95-1494-A	6.10E-01 +/-	1.1E-01	9.07E-01 +/-	1.4E-01	4.15E+01 +/-	3.4E-01
+7.5	95-1494-B	8.66E-01 +/-	1.3E-01	1.54E+00 +/-	1.8E-01	4.68E+01 +/-	3.7E-01
+6.5	95-1494-C	1.70E+00 +/-	1.8E-01	3.01E+00 +/-	1.7E-01	5.89E+01 +/-	4.1E-01
+5.5	95-1494-D	3.13E+00 +/-	1.9E-01	4.94E+00 +/-	2.1E-01	7.09E+01 +/-	4.5E-01
+4.5	95-1494-E	4.70E+00 +/-	2.2E-01	7.67E+00 +/-	2.7E-01	8.29E+01 +/-	4.9E-01
+3.5	95-1494-F	5.91E+00 +/-	4.3E-01	9.13E+00 +/-	4.4E-01	9.31E+01 +/-	9.2E-01
+2.5	95-1494-G	6.42E+00 +/-	3.3E-01	1.00E+01 +/-	4.0E-01	1.02E+02 +/-	7.3E-01
+1.5	95-1494-H	6.41E+00 +/-	4.5E-01	1.03E+01 +/-	5.5E-01	1.11E+02 +/-	1.0E+00
+0.5	95-1494-I	6.79E+00 +/-	4.5E-01	1.03E+01 +/-	5.6E-01	1.17E+02 +/-	1.0E+00
0.0	95-1494-J	7.01E+00 +/-	5.0E-01	1.02E+01 +/-	5.1E-01	1.19E+02 +/-	1.0E+00
-0.5	95-1494-K	6.85E+00 +/-	4.8E-01	1.05E+01 +/-	5.3E-01	1.20E+02 +/-	1.0E+00
-1.5	95-1494-L	6.71E+00 +/-	4.8E-01	1.00E+01 +/-	5.3E-01	1.19E+02 +/-	1.1E+00
-2.5	95-1494-M	6.46E+00 +/-	4.5E-01	9.82E+00 +/-	5.2E-01	1.14E+02 +/-	1.0E+00
-3.5	95-1494-N	5.77E+00 +/-	5.1E-01	8.81E+00 +/-	4.9E-01	1.05E+02 +/-	8.9E-01
-4.5	95-1494-O	4.85E+00 +/-	4.8E-01	7.73E+00 +/-	5.3E-01	9.05E+01 +/-	9.2E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 15753
Procedures: A-524
Analyst: WTF

Approved: Mark Kowalski

REPORT

Westinghouse Electric Corporation
Chemistry Operations Technology & Analysis
Waltz Mill Site

Request# 15753

Originator: J. Perock (W)NTD, Energy Center (4-36)

Received: 6/29/95
Reported: 8/31/95

[RESULTS OF ANALYSIS]

Palisades Reactor Cavity Dosimetry - Cycle 10 / Cycle 11

Bead Chain Tag ID: 150 deg.

Feet from Midplane	Lab Sample#	[<------ dps/mg of chain @ 8/15/95 ------>] Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
+8.0	95-1485-A	5.12E-01 +/-	1.3E-01	8.88E-01 +/-	1.5E-01	4.49E+01 +/-	3.6E-01
+7.5	95-1485-B	7.54E-01 +/-	1.2E-01	1.30E+00 +/-	1.5E-01	5.11E+01 +/-	3.9E-01
+6.5	95-1485-C	1.84E+00 +/-	1.5E-01	3.06E+00 +/-	2.2E-01	6.46E+01 +/-	4.3E-01
+5.5	95-1485-D	3.61E+00 +/-	2.1E-01	5.71E+00 +/-	2.5E-01	7.55E+01 +/-	4.7E-01
+4.5	95-1485-E	5.34E+00 +/-	4.6E-01	7.99E+00 +/-	5.1E-01	8.80E+01 +/-	9.0E-01
+3.5	95-1485-F	6.08E+00 +/-	4.1E-01	1.01E+01 +/-	5.4E-01	9.96E+01 +/-	9.5E-01
+2.5	95-1485-G	7.03E+00 +/-	4.7E-01	1.01E+01 +/-	6.1E-01	1.08E+02 +/-	1.0E+00
+1.5	95-1485-H	6.62E+00 +/-	4.6E-01	1.03E+01 +/-	5.8E-01	1.15E+02 +/-	1.0E+00
+0.5	95-1485-I	7.03E+00 +/-	4.3E-01	1.02E+01 +/-	5.9E-01	1.20E+02 +/-	1.1E+00
0.0	95-1485-J	6.88E+00 +/-	5.7E-01	1.03E+01 +/-	5.8E-01	1.21E+02 +/-	1.1E+00
-0.5	95-1485-K	6.72E+00 +/-	5.2E-01	9.72E+00 +/-	5.6E-01	1.22E+02 +/-	1.1E+00
-1.5	95-1485-L	6.59E+00 +/-	5.3E-01	9.69E+00 +/-	5.7E-01	1.21E+02 +/-	1.1E+00
-2.5	95-1485-M	6.41E+00 +/-	5.3E-01	1.01E+01 +/-	6.6E-01	1.17E+02 +/-	1.1E+00
-3.5	95-1485-N	5.75E+00 +/-	5.3E-01	8.75E+00 +/-	5.7E-01	1.06E+02 +/-	1.0E+00
-4.5	95-1485-O	4.29E+00 +/-	5.3E-01	6.77E+00 +/-	6.1E-01	9.24E+01 +/-	9.4E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 15753
Procedures: A-524
Analyst: WTF

Approved: M. Konold

REPORT

Westinghouse Electric Corporation
Chemistry Operations Technology & Analysis
Waltz Mill Site

Request# 15753

Originator: J. Perock (W)NTD, Energy Center (4-36)

Received: 6/29/95
Reported: 8/31/95

[RESULTS OF ANALYSIS]

Palisades Reactor Cavity Dosimetry - Cycle 10 / Cycle 11

ead Chain Tag ID: 210 deg.

Feet from idplane	Lab Sample#	Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
		[<--- dps/mg of chain @ 8/15/95					--->]
+8.0	95-1486-A	4.64E-01 +/-	1.5E-01	6.92E-01 +/-	1.4E-01	4.29E+01 +/-	3.6E-01
+7.5	95-1486-B	7.97E-01 +/-	1.7E-01	1.33E+00 +/-	1.7E-01	4.95E+01 +/-	3.9E-01
+6.5	95-1486-C	1.61E+00 +/-	2.0E-01	2.76E+00 +/-	2.3E-01	6.30E+01 +/-	4.4E-01
+5.5	95-1486-D	3.56E+00 +/-	2.0E-01	5.64E+00 +/-	2.7E-01	7.36E+01 +/-	4.6E-01
+4.5	95-1486-E	5.31E+00 +/-	4.0E-01	8.78E+00 +/-	5.1E-01	8.73E+01 +/-	8.9E-01
+3.5	95-1486-F	6.38E+00 +/-	4.2E-01	9.78E+00 +/-	4.9E-01	9.68E+01 +/-	9.5E-01
+2.5	95-1486-G	6.33E+00 +/-	4.4E-01	1.01E+01 +/-	5.0E-01	1.06E+02 +/-	9.8E-01
+1.5	95-1486-H	6.92E+00 +/-	4.7E-01	1.02E+01 +/-	5.8E-01	1.13E+02 +/-	1.0E+00
+0.5	95-1486-I	6.95E+00 +/-	5.3E-01	1.06E+01 +/-	6.2E-01	1.17E+02 +/-	1.0E+00
0.0	95-1486-J	7.55E+00 +/-	5.8E-01	1.05E+01 +/-	6.6E-01	1.18E+02 +/-	1.0E+00
-0.5	95-1486-K	6.90E+00 +/-	5.8E-01	1.04E+01 +/-	6.7E-01	1.19E+02 +/-	1.1E+00
-1.5	95-1486-L	6.96E+00 +/-	6.2E-01	1.02E+01 +/-	7.3E-01	1.17E+02 +/-	1.0E+00
-2.5	95-1486-M	6.54E+00 +/-	4.9E-01	1.00E+01 +/-	5.4E-01	1.12E+02 +/-	1.0E+00
-3.5	95-1486-N	5.49E+00 +/-	3.8E-01	8.42E+00 +/-	4.6E-01	1.02E+02 +/-	9.6E-01
-4.5	95-1486-O	4.32E+00 +/-	4.0E-01	6.91E+00 +/-	4.8E-01	8.51E+01 +/-	8.8E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 15753
Procedures: A-524
Analyst: WTF

Approved: [signature]

REVISED REPORT

Westinghouse Electric Corporation
Chemistry Operations Technology & Analysis
Waltz Mill Site

Request# 15753

Originator: J. Perock (W)NTD, Energy Center (4-36)

Received: 6/29/95
Reported: 10/3/95

[RESULTS OF ANALYSIS]

Palisades Reactor Cavity Dosimetry - Cycle 10 / Cycle 11

Bead Chain Tag ID: 260 deg.

Feet from Midplane	Lab Sample#	[<------ dps/mg of chain @ 8/15/95 ------>] Mn-54 dps/mg	Mn-54 2 sigma	Co-58 dps/mg	Co-58 2 sigma	Co-60 dps/mg	Co-60 2 sigma
+8.0	95-1487-A	4.70E-01 +/-	1.4E-01	9.61E-01 +/-	1.7E-01	4.62E+01 +/-	3.7E-01
+7.5	95-1487-B	7.68E-01 +/-	1.3E-01	1.29E+00 +/-	1.7E-01	5.18E+01 +/-	3.9E-01
+6.5	95-1487-C	1.74E+00 +/-	1.9E-01	2.95E+00 +/-	2.3E-01	6.30E+01 +/-	4.3E-01
+5.5	95-1487-D	3.36E+00 +/-	1.8E-01	5.30E+00 +/-	2.2E-01	7.32E+01 +/-	4.7E-01
+4.5	95-1487-E	5.08E+00 +/-	4.6E-01	8.21E+00 +/-	5.4E-01	8.26E+01 +/-	8.8E-01
+3.5	95-1487-F	6.28E+00 +/-	5.0E-01	9.99E+00 +/-	5.4E-01	9.18E+01 +/-	9.3E-01
+2.5	95-1487-G	6.43E+00 +/-	4.7E-01	1.04E+01 +/-	5.5E-01	9.93E+01 +/-	9.7E-01
+1.5	95-1487-H	6.45E+00 +/-	4.7E-01	1.05E+01 +/-	6.7E-01	1.04E+02 +/-	9.9E-01
+0.5	95-1487-I	6.78E+00 +/-	5.7E-01	9.96E+00 +/-	6.6E-01	1.07E+02 +/-	1.0E+00
0.0	95-1487-J	6.52E+00 +/-	5.8E-01	1.03E+01 +/-	6.7E-01	1.08E+02 +/-	1.0E+00
-0.5	95-1487-K	6.77E+00 +/-	6.1E-01	1.04E+01 +/-	6.7E-01	1.10E+02 +/-	1.0E+00
-1.5	95-1487-L	6.90E+00 +/-	5.8E-01	1.07E+01 +/-	6.9E-01	1.07E+02 +/-	1.0E+00
-2.5	95-1487-M	6.11E+00 +/-	6.3E-01	9.72E+00 +/-	6.9E-01	1.03E+02 +/-	1.0E+00
-3.5	95-1487-N	5.40E+00 +/-	4.6E-01	8.54E+00 +/-	6.2E-01	9.44E+01 +/-	9.7E-01
-4.5	95-1487-O	3.82E+00 +/-	4.7E-01	6.64E+00 +/-	5.2E-01	8.04E+01 +/-	9.0E-01

Remarks: * Results are in units of dps/(mg of Dosimeter Material).
* Corrections of Co-58: 95-1487-J and 95-1487-L.

AL File: 15753
Procedures: A-524
Analyst: WTF

Approved: M. Kornhost

Customer John Perock

AL Request # 15753

W NTD, Energy Center
win (8) 284-5788
fax (8) 284-4697

Receipt Date JUN.29,1995
Report Date DEC.11,1995

Nuclear Plant	Palisades - cycle #10	
Material Description	Stainless steel	Dosimetry Reactor Chain Beads

AL Service #		W NTD Identification Chain	Location	Weight Percent (%) Fe	Ni	Co
95-	1483	S-3	30	69.82	9.44	0.18
	1484	S-3	90	69.83	9.43	0.18
	1485	S-3	150	69.83	9.45	0.18
	1486	S-3	210	71.49	9.45	0.18
	1487	S-3	260	69.59	9.51	0.19
	1488	S-3	270	69.97	9.28	0.18
	1489	S-3	280	69.89	9.40	0.17
	1490	S-3	290	69.91	9.37	0.18
	1491	S-3	300	70.05	9.29	0.18
	1492	S-3	315	69.83	9.38	0.18
	1493	S-3	330	70.13	9.25	0.18
	1494	S-3	340	70.03	9.39	0.18
			Average	70.03	9.39	0.18
			std dev	0.48	0.08	0.00
			% RSD	0.69	0.84	2.37

Method of Analysis	Operator	File
Metals ICPS	R.W.MCKINNY	15753

Approved by Lawrence Becker
Lawrence Becker

APPENDIX E

Biological Shield Wall Heat Deposition

The presence of heat generated in the biological shield wall, along with the various material temperatures, results in thermal gradients within and between components. These thermal gradients result in thermal stresses and thermal growth which must be accounted for in the design and analysis of the various components. This appendix presents the results of analysis of the heat generation rates in selected biological shield wall components and is based on the use of a core power distribution provided by Consumers Power for Palisades Cycle 11. Note that the DORT model used a reactor vessel thickness of 8.5 inches, which is conservative for this analysis.

Calculation of Heat Generation Rates

The calculation of heat generation rates in the biological shield wall involves a number of different steps. First, the reactor core power distribution must be defined. Second, the energy and spatial distribution of the neutron flux must be calculated within the reactor and biological shield wall geometry. Third, the energy and spatial distribution of the gamma ray sources must be calculated. Fourth, the energy and spatial distribution of the gamma ray flux must be calculated. Finally, the neutron kinetic energy deposition and the gamma ray energy deposition in the wall must be calculated. The amount of energy deposited in a component per unit time is referred to as its heat generation rate.

Radiation Analysis

Gamma rays (photons) are born in the reactor in several ways. Prompt fission gamma rays are emitted at the instant of fission by the fissioning nucleus. Delayed gamma rays are emitted by the decaying fission products[1]. Secondary gamma rays are also produced in the core, reactor coolant, and the reactor components by neutron interactions other than fission and are the primary contributor to the heat generation outside the reactor vessel. The two most important of these

---

[1] This heat deposition calculation does not include delayed gamma rays, however, this source is judged to be negligible. The heat deposition in the biological shield region is dominated by secondary gamma rays produced in the reactor vessel and biological shield.

neutron interaction processes are radiative capture and inelastic scattering.

In radiative capture of neutrons by nuclei, the kinetic energy of the incident neutron and its binding energy in the compound nucleus are emitted as one or more, generally high-energy gamma rays.

In neutron inelastic scattering, part of the energy of the incident neutron is carried off by the scattered neutron, and part is absorbed by the target nucleus, which subsequently emits one or more, generally low-energy gamma rays.

In the present biological shield wall heat generation rate calculation, the core power distribution defines the fission neutron source and the fission gamma-ray source. Neutron transport calculations are required to define the distribution of the other gamma ray sources both inside and outside the core. Once all the sources of gamma rays are defined, gamma-ray transport calculations are performed to determine where the gamma ray energy is ultimately deposited. In practice, coupled neutron-gamma-ray transport calculations are run, wherein, gamma ray sources are represented as transfer matrices in the cross-section set from neutron groups to gamma ray groups.

There are three main mechanisms through which gamma rays interact with and deposit energy in the biological shield wall. These mechanisms are the photoelectric effect, pair production, and Compton scattering.

In the photoelectric process, the entire energy of the gamma ray is transferred to an orbital electron which is ejected from its shell and emerges from the atom as a photoelectron. The photoelectric process is important only at low gamma ray energies.

In the process of pair production, a gamma ray interacts with the electric field of atomic electrons or the nucleus. The incident gamma ray is completely annihilated, and its energy is converted into the mass and kinetic energy of an electron-positron pair. Pair production is important only at high gamma ray energies.. For the purposes of understanding biological shield heating, both the photoelectric effect and pair production may be regarded as a total absorption of the gamma ray energy at the point of interaction, which then appears as heat in the material.

The Compton effect is the scattering of a gamma ray by a free electron. The gamma ray imparts energy to the electron and is altered in direction and energy. The energy given to the electron appears as heat in the material. A very important feature of the Compton effect is the fact that, except when the scattering angle is large, the gamma ray emerges from the interaction with a significant fraction of the incident gamma ray energy. This fact accounts for much of the complexity associated with gamma ray transport analysis. Compton scattering is the most important gamma ray interaction process at intermediate gamma ray energies.

As with gamma rays, there are three main mechanisms through which neutron interact with and deposit energy in the biological shield wall. These mechanisms are elastic scattering, inelastic scattering, and radiative capture.

In the elastic scattering process (n,n), the incident neutron strikes a nucleus in its ground state and when the neutron reappears, the nucleus is left in its ground state. Thus, the kinetic energy of the process is conserved and accounted for in the neutron kerma factors.

In the inelastic scattering process (n,n′), the incident neutron strikes a nucleus in its ground state, however, when the neutron is emitted by the compound nucleus the nucleus is left in an excited state. Thus, the kinetic energy of the scattered neutron is accounted for as well as the kinetic energy imparted on the excited nucleus as gamma ray emissions during decay. Some kinetic energy is left behind in the recoiling nucleus, however, it is negligible.

In radiative capture (n,γ), the neutron is captured by the nucleus and one or more gamma rays are emitted. Some kinetic energy is left behind in the recoiling nucleus, however, it is negligible.

The gamma rays emitted due to the decay of the excited nucleus in both the inelastic scattering and radiative capture processes are accounted for in the gamma ray transport.

Results of Analysis

A complete two dimensional discrete ordinates transport theory calculation at core midplane was performed to determine the heat generation rate distribution in the Palisades plant biological shield wall. The model included the first 3½ ft of the biological shield wall. The biological shield geometry was modeled as eight separate zones.

This geometry is illustrated in Figures E-1 and E-2 which show the model and selected isometric heat deposition lines in the reactor cavity annulus and biological shield wall, respectively. These also show the azimuthal variation of the heat deposition (w/g of concrete) in the reactor cavity annulus and biological shield wall. Note that in Figure E-1 shows only the outer part of the model, i.e. from the reactor vessel line to the biological shield wall. The model was started with a boundary source at the reactor vessel liner inner radius (218.44 cm) from the neutron transport calculations for Cycle 11.

Material Zone	Inner radius[1] (cm)
Reactor Cavity Liner	335.28
Concrete	335.92
Homogenized Concrete, Cooling Coils, & Water	341.57
Concrete	344.23
Homogenized Concrete and Rebar (vertical & horizontal)	349.19
Homogenized Concrete and Rebar (radial)	351.85
Homogenized Concrete and Rebar (vertical & horizontal)	372.05
Homogenized Concrete and Rebar (radial)	374.71
End of model	429.48

Table E-1 presents the radial heat deposition in W/g of concrete through the biological shield wall. Figure E-3 shows the radial heat deposition (W/g of concrete) through the model at azimuthal locations of 16° (J=20) and 45° (J=68). Note that the heat deposition shows an analytical oscillation that is near the convergence criteria for the DORT model, i.e. the heat deposition at the maximum flux location 16° does not show the maximum heat deposition at all radial locations.

[1] Measured from the reactor vessel centerline

TABLE E-1

RADIAL VARIATION OF HEAT DEPOSITION IN THE BIOLOGICAL SHIELD WALL

	Heat Deposition (W/g of concrete)				
Radius (cm)	0°	15°	16°	30°	45°
335.60	9.77e-06	9.72e-06	9.71e-06	9.19e-06	8.76e-06
336.34	8.76e-06	8.75e-06	8.72e-06	8.20e-06	7.76e-06
337.38	7.31e-06	7.33e-06	7.30e-06	6.83e-06	6.42e-06
339.00	5.55e-06	5.59e-06	5.56e-06	5.18e-06	4.84e-06
340.79	4.04e-06	4.05e-06	4.05e-06	3.75e-06	3.47e-06
342.90	2.76e-06	2.80e-06	2.78e-06	2.57e-06	2.38e-06
344.62	2.06e-06	2.03e-06	2.08e-06	1.90e-06	1.71e-06
347.10	1.47e-06	1.50e-06	1.48e-06	1.36e-06	1.25e-06
350.52	9.29e-07	9.04e-07	9.17e-07	8.43e-07	7.54e-07
352.09	7.14e-07	6.99e-07	6.98e-07	6.39e-07	5.79e-07
356.16	4.04e-07	4.23e-07	4.15e-07	3.78e-07	3.47e-07
365.00	1.38e-07	1.28e-07	1.33e-07	1.21e-07	1.07e-07
371.03	7.55e-08	5.85e-08	6.89e-08	6.11e-08	5.04e-08
373.38	5.12e-08	4.36e-08	4.78e-08	4.17e-08	3.69e-08
377.86	2.80e-08	2.63e-08	2.76e-08	2.39e-08	2.18e-08
382.52	1.63e-08	1.47e-08	1.57e-08	1.37e-08	1.22e-08
385.54	1.11e-08	1.05e-08	1.09e-08	9.33e-09	8.64e-09
388.58	7.70e-09	7.52e-09	7.77e-09	6.68e-09	6.15e-09
391.61	5.49e-09	5.42e-09	5.59e-09	4.79e-09	4.41e-09
394.64	3.94e-09	3.91e-09	4.02e-09	3.46e-09	3.17e-09
397.67	2.83e-09	2.83e-09	2.91e-09	2.50e-09	2.30e-09
400.70	2.05e-09	2.06e-09	2.11e-09	1.82e-09	1.66e-09
403.73	1.48e-09	1.49e-09	1.53e-09	1.32e-09	1.21e-09
406.76	1.08e-09	1.09e-09	1.11e-09	9.60e-10	8.78e-10
409.79	7.82e-10	7.92e-10	8.12e-10	6.98e-10	6.39e-10
412.82	5.68e-10	5.77e-10	5.90e-10	5.09e-10	4.65e-10
415.85	4.12e-10	4.19e-10	4.29e-10	3.69e-10	3.38e-10
418.88	2.97e-10	3.03e-10	3.09e-10	2.67e-10	2.44e-10
421.91	2.11e-10	2.16e-10	2.20e-10	1.90e-10	1.74e-10
424.94	1.46e-10	1.49e-10	1.53e-10	1.32e-10	1.20e-10
427.97	9.00e-11	9.21e-11	9.38e-11	8.12e-11	7.43e-11

FIGURE E-1

BIOLOGICAL SHIELD WALL MODEL

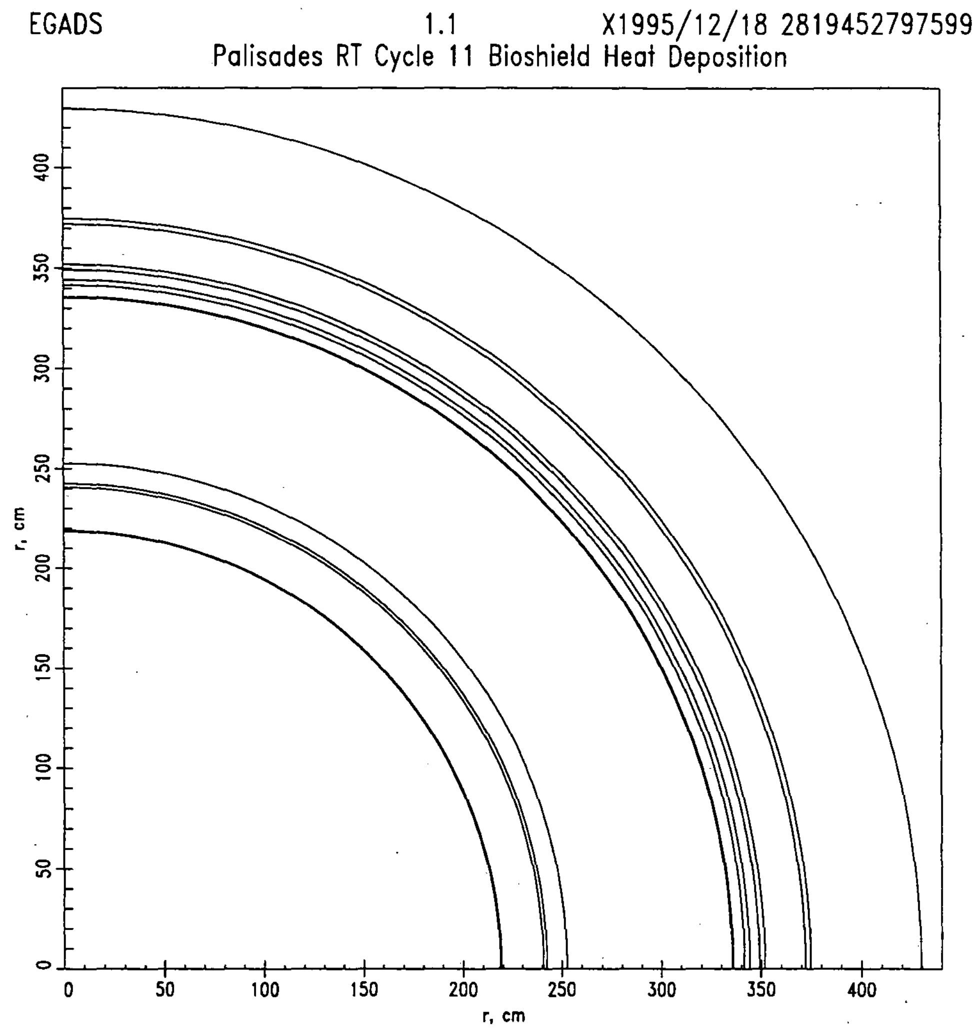

FIGURE E-2

BIOLOGICAL SHIELD WALL ISOMETRIC HEAT DEPOSITION VARIATION

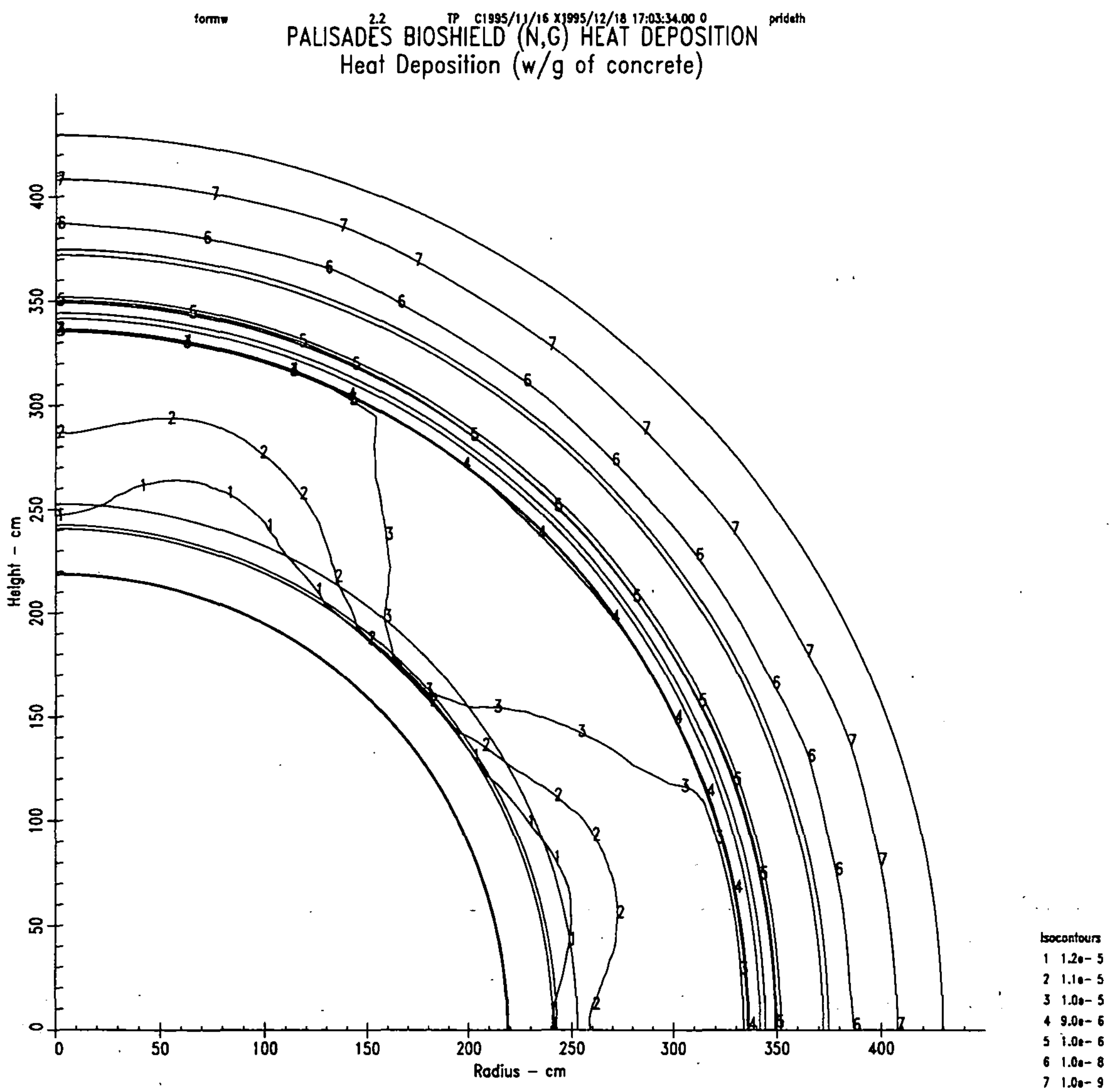

FIGURE E-3

BIOLOGICAL SHIELD WALL RADIAL HEAT DEPOSITION VARIATION
AT 16° (J=20) AND 45° (J=68)