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WESTINGHOUSE CLASS 3

REACTOR CAVITY NEUTRON MEASUREMENT PROGRAM
FOR
WISCONSIN ELECTRIC POWER COMPANY
POINT BEACH UNIT 2

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EXECUTIVE SUMMARY

At the conclusion of Fuel Cycle 14, a reactor cavity measurement program was instituted at Point Beach Unit 2 to provide continuous monitoring of the beltline region of the reactor pressure vessel and reactor vessel support structure. 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.

During the first cycle of irradiation (Cycle 15), the reactor was operating with a conventional low leakage fuel management strategy. At the onset of Cycle 16 additional neutron flux reduction at the beltline circumferential weld was achieved by the introduction of part length hafnium absorbers in selected peripheral fuel assemblies. A direct comparison of the Cycles 15, 16, and 17 cavity measurements demonstrated the following incremental flux reduction for the circumferential weld.

MEASURED CAVITY FLUX (E > 1.0 MeV)
[n/cm2-sec]

	CYCLE 15	CYCLE 16	16/15	CYCLE 17	17/15
0 Degrees	1.85E+09	1.28E+09	0.692	1.37E+09	0.741
15 Degrees	1.67E+09	1.22E+09	0.731	1.15E+09	0.689
30 Degrees	1.21E+09	9.32E+08	0.770	1.05E+09	0.868
45 Degrees	1.08E+09	9.52E+08	0.881	9.84E+08	0.911

Due to the relatively short axial extent of the hafnium inserts, the flux reduction impact on the intermediate and lower shell forgings is less dramatic than in the case of the circumferential weld.

Based on the continued use of the current (Average of Cycles 16 and 17) fuel loading pattern with the part length hafnium absorbers, the projected maximum fast neutron exposure of the vessel beltline materials at 32 and 48 effective full power years of operation is summarized as follows:

NEUTRON FLUENCE (E > 1.0 MeV)

[n/cm2]

	32 EFPY	48 EFPY
Beltline Circumferential Weld	2.52E+19	3.39E+19
Intermediate Shell Forging	2.88E+19	4.12E+19
Lower Shell Forging	2.62E+19	3.64E+19
Upper/Int. Shell Circ. Weld	3.70E+18	5.00E+18
Lower Shell/Head Circ. Weld	< 1.00E+17	< 1.00E+17

As further data are accumulated from subsequent irradiations, the neutron environment in the vicinity of the Unit 2 pressure 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.

In addition, the excellent three-dimensional fluence profiles established by the measurements, enables the true effects of three-dimensional and potentially non-symmetric flux reduction measures to be accurately accounted for in a manner that would be difficult using analysis alone.

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SECTION 1.0

OVERVIEW OF THE PROGRAM

The Reactor Cavity Neutron Measurement Program [1] initiated at Point
Beach Unit 2 at the start of Fuel Cycle 15 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 previously withdrawn internal
surveillance capsules and with the results of neutron transport
calculations, the reactor cavity neutron dosimetry provides the means for
determination of the neutron exposure of the pressure vessel and the
projection of 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 Response Guidline (ERG) pressure/temperature limit
> curves.

> 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.

Within the nuclear industry it has been common practice to base estimates
of the fast neutron exposure of pressure vessels either directly on the

results of neutron transport calculations or on the analytical results normalized to measurements obtained from internal surveillance capsules. However, there are potential drawbacks associated with both of these approaches to exposure assessment.

In performing neutron transport calculations for pressurized water reactors, several design and operational variables have an impact on the magnitude of the analytical prediction of exposure rates within the pressure vessel wall as well as on the uncertainties associated with that prediction. Of particular note in this regard are cycle to cycle variations in core power distributions (particularly with implementation of low leakage loading patterns), variations of water temperature in the downcomer regions of the reactor internals, and deviations in as-built versus design dimensions for the reactor internals and pressure vessel. The manner in which these important variables are treated in the analysis may lead to an increased uncertainty in the exposure evaluations for the pressure vessel; and, these increased uncertainties may well result in the use of overly conservative estimates of vessel embrittlement in the assessment of pressure temperature limitations as well as of the expected service life of the component.

The reactor vessel materials surveillance program [2] consisting of several surveillance capsules attached to the thermal shield in the downcomer region near the pressure vessel wall has been in service since the initial startup of the reactor. The neutron dosimetry contained in these capsules provides measurement capability to determine the fast neutron exposure of the materials test specimens also located within the capsules, but at the same time produces measured data only at a single location within the reactor geometry. Therefore, the surveillance capsule dosimetry, by itself, cannot provide information regarding the azimuthal, radial, and axial gradients of neutron exposure within the pressure vessel. Furthermore, data from internal surveillance capsules are, by design, obtained at rather infrequent intervals; and surveillance measurement locations may not be in proximity to critical areas on the pressure vessel. These limitations place a heavy reliance on analytical

results to project exposure levels to the vessel wall as well as to provide predictions of vessel exposure for time periods beyond the last scheduled capsule withdrawal.

With the addition of supplementary passive neutron sensors in the reactor cavity annulus between the reactor vessel wall and the biological shield, the deficiencies in both surveillance dosimetry and analytical prediction can be mitigated and the uncertainties associated with exposure estimates for the pressure vessel can be minimized. With state of the art neutron sensors deployed to establish the absolute magnitude of the azimuthal and axial exposure rate distributions in the reactor cavity, the burden placed on the neutron transport calculation is reduced to the determination of relative neutron energy spectra for sensor set interpretation and relative spatial distributions for extrapolation of the measurement results to positions at the inner radius and through the thickness of the pressure vessel wall. Studies have shown that the operational and design variables cited above that have a strong impact on the calculated magnitude of exposure rates have only a minor effect on both the interpretation of cavity dosimetry and on the extrapolation of measurement results to key vessel locations. It is possible, therefore, to employ cavity measurements and a set of reference neutron transport calculations to produce vessel exposure projections with a reduced uncertainty over that inherent in an approach based on analysis alone. Furthermore, since the cavity neutron measurements are not directly tied to the materials surveillance program, measurement intervals can be chosen to easily provide integral vessel exposure over plant lifetime.

The use of fast neutron fluence (E > 1.0 MeV) to correlate measured materials properties changes to the neutron exposure of the material for light water reactor applications has traditionally been accepted for development of damage trend curves as well as for the implementation of trend curve data to assess vessel condition. In recent years, however, it has been suggested that an exposure model that accounts for differences in neutron energy spectra between surveillance capsule locations and positions within the vessel wall could lead to an improvement in the

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uncertainties associated with damage trend curves as well as to a more accurate evaluation of damage gradients through the pressure vessel wall.

Because of this potential shift away from threshold fluence toward an energy dependent damage function for data correlation, ASTM Standard Practice E853, "Analysis and Interpretation of Light Water Reactor Surveillance Results", recommends reporting displacements per iron atom (dpa) along with fluence (E > 1.0 MeV) to provide a data base for future reference. The energy dependent dpa function to be used for this evaluation is specified in ASTM Standard Practice E693, "Characterizing Neutron Exposures in Ferritic Steels in Terms of Displacements per Atom". The application of the dpa parameter to the assessment of embrittlement gradients has already been promulgated in Revision 2 to Regulatory Guide 1.99, "Radiation Damage to Reactor Vessel Materials".

With the aforementioned views in mind, the Reactor Cavity Measurement Program was established to meet the following objectives:

1 - Determine azimuthal and axial gradients of fast neutron exposure over the beltline region of the reactor pressure vessel.

2 - Provide measurement capability sufficient to allow the determination of pressure vessel exposure in terms of both fluence (E > 1.0 MeV) and iron displacements per atom.

3 - Establish a methodology for the projection of exposure gradients through the thickness of the pressure vessel wall.

4 - Provide a long term continuous monitoring capability for the beltline region of the pressure vessel.

This report provides the results of neutron dosimetry evaluations performed subsequent to the completion of Fuel Cycle 17. 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 pressure vessel wall is described and used to project the Cycle 17 exposure of the vessel itself.

Results of exposure evaluations from surveillance capsule dosimetry withdrawn at the end of Fuel Cycles 1, 3, 5, and 16 as well as cavity dosimetry results from Cycles 15 and 16 are incorporated to provide the integrated exposure of the pressure vessel from plant startup through the end of Cycle 17. Also, uncertainties associated with the derived exposure parameters at the measurement locations and with the projected exposure of the pressure vessel are provided.

In addition to the evaluation of the current exposure of the reactor vessel beltline materials, projections of the future exposure of the vessel are provided based on the measured flux reduction achieved by the insertion of part length hafnium absorbers in selected fuel assemblies at the onset of Cycle 16. Current evaluations and future projections are provided for the beltline circumferential weld as well as for both the intermediate and lower shell forgings that comprise the highly irradiated portions of the reactor vessel.

SECTION 2.0

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) and solid state track recorders (SSTR) 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 four 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 pressure vessel. Due to the irregular shape of the reactor core, water thickness varies significantly as a function of azimuthal angle. In addition to the four midplane sensor sets, two multiple foil packages were positioned opposite the top and bottom of the active core at the azimuthal angle corresponding to the maximum neutron flux. Here the intent was to measure variations in neutron spectra over the the core height; particularly near the top of the fuel where backscattering of neutrons from primary loop nozzles and vessel support structures could produce significant perturbations. At each of the four azimuthal locations selected for core midplane spectra measurements, gradient chains extended over a fourteen foot height centered on the core midplane.

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 pressure vessel. During the Cycle 15
irradiation an additional multiple foil sensor set was included in the
vicinity of the reactor vessel supports in order to determine the exposure
rate and neutron spectrum at this location well above the beltline region
of the reactor vessel. This capsule placement represented a one time
measurement that was not repeated as a part of the long term monitoring
efforts.

2.1.1 Sensor Placement in the Reactor Cavity

A detailed description of the cavity dosimetry hardware and plant specific
installation can be found in Reference 1. 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 Figures 2.1-1 and
2.1-2. In Figure 2.1-1 a plan view of the azimuthal locations of the
four strings of sensor sets is depicted. The strings were located at
azimuthal positions of 0, 15, 30, and 45 degrees relative to the core
cardinal axis. The sensor strings were hung in the annular gap between
the pressure vessel insulation and the primary biological shield at a
nominal radius of 79 inches relative to the core centerline.

In Figure 2.1-2 the axial extent of each of the sensor set strings is
illustrated along with the locations of the multiple foil holders. At the
0 degree azimuth, multiple foil sets were positioned at the core midplane,
opposite the top and bottom of the active fuel, and, during Cycle 15 only,
at the elevation of the reactor vessel support. At the 15, 30, and 45
degree azimuthal locations, multiple foil sets were positioned only
opposite the core midplane. In all cases, stainless steel gradient chains
extended $\pm$ 7 feet relative to the midplane of the active core.

The sensor sets and gradient chains were suspended from two support bars mounted on a support frame assembled around the outlet nozzle support shoe of primary loop A. The bottom edges of the support bars were positioned 26.625 inches above the top of the active fuel. The sensor sets and gradient chains were retained and supported at the bottom by chain clamps attached to stainless steel eye nuts with stainless steel threaded chain connectors. The eye nuts were, in turn, attached to threaded studs embedded in the sump wall. The design of the dosimetry support bars and frames along with the gradient chains and stops ensured correct axial and azimuthal positioning of the dosimetry relative to well known reactor support features.

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 x 1.00 inch x 0.50 inch rectangular aluminum 6061 capsules such as that shown in Figure 2.1-3. Each capsule included three compartments to hold the neutron sensors. The top compartment (position 1) was intended to accomodate bare radiometric monitors and SSTR packages, whereas, the two remaining compartments (positions 2 and 3) were meant to house 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 four traverses. Subsequent to irradiation these gradient chains were removed from the cavity and segmented to provide neutron reaction rate measurements at 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 yielded activation results for the Fe-54 (n,p), Ni-58 (n,p), and Co-59 (n,γ) 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 an overcheck on the chemical analysis of the Type 304 steel.

FIGURE 2.1-1

AZIMUTHAL LOCATION OF SENSOR STRINGS

TOP VIEW

Indicates Location of
Axial Traverses
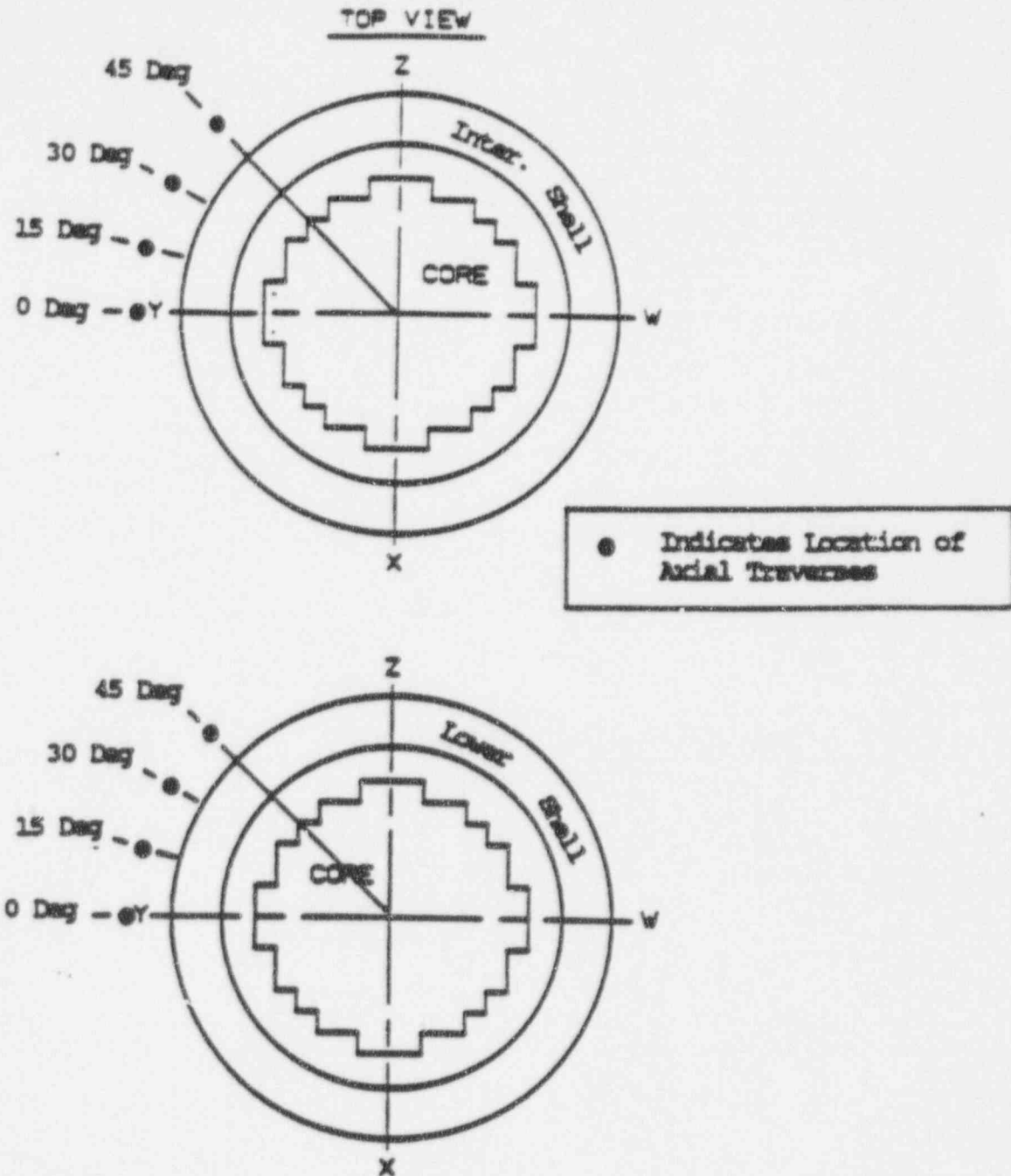
FIGURE 2.1-2

AXIAL LOCATION OF MULTIPLE FOIL SENSOR SETS
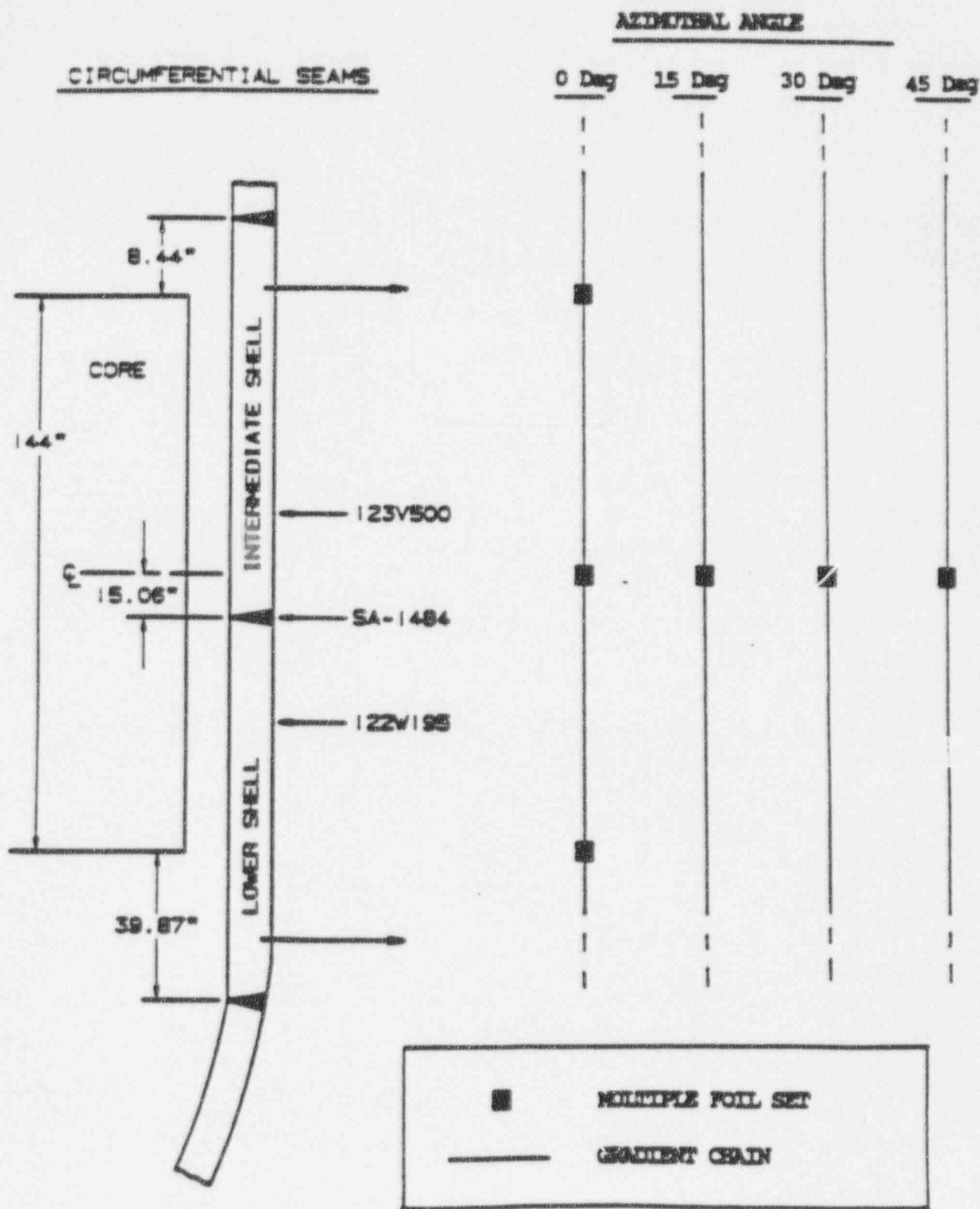
FIGURE 2.1-3

IRRADIATION CAPSULE FOR CAVITY SENSOR SETS
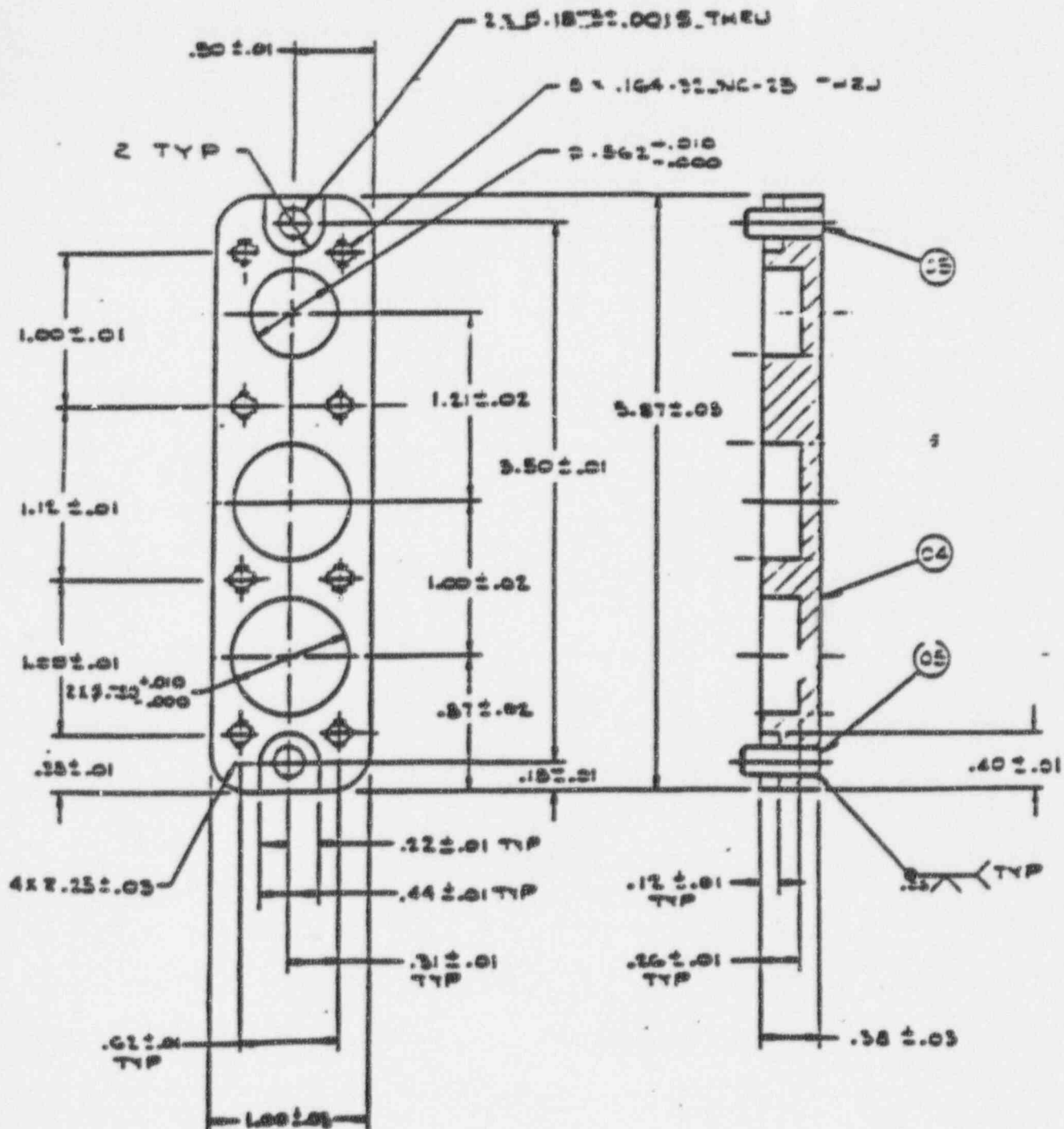
2.2 - Description of Surveillance Capsule Dosimetry

Over the course of the first 16 fuel cycles at Point Beach Unit 2, four materials surveillance capsules were withdrawn from their positions between the thermal shield and 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 startup of the reactor and the initiation of the Reactor Cavity Measurement Program. The specific withdrawal dates of these four capsules were as follows:

Capsule V	End of Cycle 1	10/74
Capsule T	End of Cycle 3	03/77
Capsule R	End of Cycle 5	03/79
Capsule S	End of Cycle 16	10/90

The type and location of the neutron sensors included in the materials surveillance program are described in some detail in Reference 2; and, are illustrated schematically in Figure 2.2-1 of this report.

Relative to Figure 2.2-1, copper, nickel, and cobalt-aluminum monitors, in wire form, were placed in holes drilled in spacers at several axial levels within each capsule. The cadmium-shielded uranium and neptunium fission monitors were accomodated within a dosimeter block located near the center of the capsule. In addition to these high purity sensors, iron dosimeters were also obtained by removing samples from several charpy test specimens from various locations within the capsule. Specific information pertinent to the individual sensor sets included in Capsules V, T, R, and S are provided in the appendices to this report.

FIGURE 2.2-1

NEUTRON SENSOR LOCATIONS WITHIN INTERNAL SURVEILLANCE CAPSULES
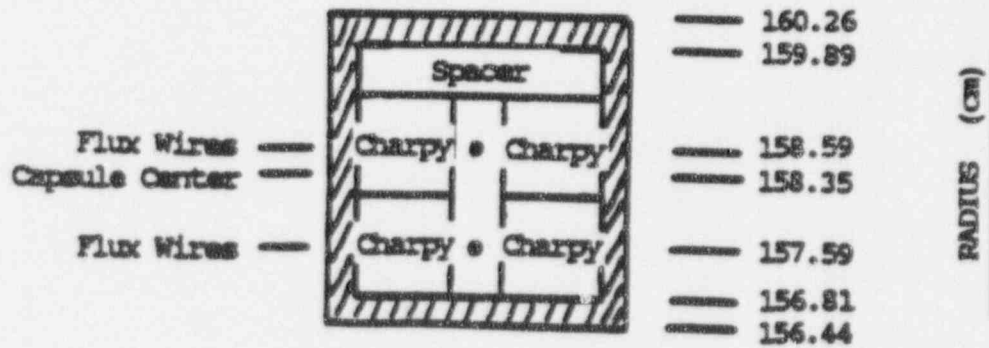
SECTION 3.0

NEUTRON TRANSPORT AND DOSIMETRY EVALUATION METHODOLOGIES

3.1 - Neutron Transport Analysis Methods

Fast neutron exposure calculations for the reactor and cavity geometry
were carried out using both forward and adjoint discrete ordinates
transport techniques. A single forward calculation provided the relative
energy distribution of neutrons and gamma rays 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 pressure vessel wall. A
series of adjoint calculations, on the other hand, established the means
to compute absolute exposure rate values using fuel cycle specific core
power distributions; thus, providing a direct comparison with all
dosimetry results obtained over the operating history of the reactor.

In combination, the absolute cycle specific data from the adjoint
evaluations together with relative 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 - Extrapolate dosimetry results to key locations at the inner
radius and through the thickness of the pressure vessel.

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

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3.1.1 - Reference Forward Calculation

A plan view of the reactor geometry at the core midplane elevation is shown in Figure 3.1-1. Since the reactor exhibits 1/8 core symmetry only a 0-45 degree sector is depicted. In addition to the core, reactor internals, pressure vessel, and the primary biological shield, the model also included explicit representations of the surveillance capsules, the pressure vessel cladding, and the mirror insulation located external to the vessel.

A description of a single surveillance capsule attached to the thermal shield is shown in Figure 3.1-2. 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 and gamma ray 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 model was not required.

The forward transport calculation for the reactor model depicted in Figures 3-1 and 3-2 was carried out in R,θ geometry using the DOT two-dimensional discrete ordinates code [3] and the SAILOR cross-section library [4]. The SAILOR library is a 67 group coupled neutron-gamma ray ENDFB-IV based data set produced specifically for light water reactor applications. In these analyses, anisotropic scattering was treated with a P3 expansion of the cross-sections and the angular discretization was

modeled with an S8 order of angular quadrature. The reference forward
calculation was normalized to a core midplane power density characteristic
of operation at a thermal power level of 1518 MWt.

The spatial core power distribution utilized in the reference forward
calculation was derived from statistical studies of long-term operation of
Westinghouse 2-loop plants. Inherent in the development of this reference
core power distribution was the use of an out-in fuel management strategy;
i.e., fresh fuel on the core periphery. Furthermore, for the peripheral
fuel assemblies, a 2σ uncertainty derived from the statistical
evaluation of plant to plant and cycle to cycle variations in peripheral
power was used.

Due to the use of this bounding spatial power distribution, the results
from the reference forward calculation establish conservative exposure
projections for reactors of this design operating at 1518 MWt. Since it
is unlikely that actual reactor operation would result in the
implementation of a power distribution at the nominal + 2σ level for
a large number of fuel cycles and, further, because of the widespread
implementation of low leakage fuel management strategies, the fuel cycle
specific calculations for this reactor result in exposure rates well below
these conservative predictions. This difference between the conservative
forward calculation and the fuel cycle specific best estimate computations
is illustrated by a comparison of the analytical results given in Section
4.0 of this report.

3.1.2 - Cycle Specific Adjoint Calculations

All adjoint analyses were also carried out using an S8 order of angular
quadrature and the P3 cross-section approximation from the SAILOR library.
Adjoint source locations were chosen at each of the azimuthal locations
containing cavity dosimetry (0, 15, 30, and 45 degrees) as well as at the
corresponding azimuths on the pressure vessel inner radius. In addition,
adjoint calculations were carried out for sources positioned at the

geometric center of surveillance capsules located at 13, 23, and 33 degrees relative to the core cardinal axes. Again, these calculations were run in R,θ geometry to provide neutron source distribution importance functions for the exposure parameter of interest; in this case, ϕ (E > 1.0 MeV).

The importance functions generated from these eleven individual adjoint analyses provided the basis for all absolute exposure projections and comparison with measurement. These importance functions, when combined with cycle specific neutron source distributions, yielded absolute predictions of neutron exposure at the locations of interest for each of the fuel cycles to date; and, established the means to perform similar predictions and dosimetry evaluations for all subsequent fuel cycles.

Having the importance functions and appropriate core source distributions, the response of interest can be calculated as:

$$\phi(R,\theta) = \int_R \int_\theta \int_E I(R,\theta,E) \ S(R,\theta,E) \ R \ dR \ d\theta \ dE$$

where: $\phi(R,\theta)$ = Flux (E > 1.0 MeV) at radius R and azimuthal angle θ.

        $I(R,\theta,E)$ = Adjoint importance function at radius R, azimuthal angle θ, and neutron source energy E.

        $S(R,\theta,E)$ = Neutron source strength at core location R,θ and energy E.

It is important to note that the cycle specific neutron source distributions, $S(R,\theta,E)$, utilized with the adjoint importance functions, $I(R,\theta,E)$, permitted the use not only of fuel cycle specific spatial variations of fission rates within the reactor core; but, also allowed for the inclusion of the effects of the differing neutron yield per fission and the variation in fission spectrum introduced by the build-in of plutonium isotopes as the burnup of

individual fuel assemblies increased.

Although the adjoint importance functions used in these analyses were
based on a response function defined by the threshold neutron flux
($E > 1.0$ MeV), prior calculations have shown that, while the
implementation of low leakage loading patterns significantly impact the
magnitude and the spatial distribution of the neutron field, changes in
the relative neutron energy spectrum are of second order. Thus, for a
given location the exposure parameter ratios such as
[dpa/sec]/[ϕ ($E > 1.0$ MeV)] are insensitive to changing core source
distributions. In the application of these adjoint importance functions
to the current evaluations, therefore, calculation of the iron
displacement rates (dpa/sec) and the neutron flux ($E > 0.1$ MeV) were
computed on a cycle specific basis by using the appropriate
[dpa/sec]/[ϕ ($E > 1.0$ MeV)] and [ϕ ($E > 0.1$ MeV)]/[ϕ ($E > 1.0$
MeV)] ratios from the reference forward analysis in conjunction with the
cycle specific ϕ ($E > 1.0$ MeV) solutions from the individual adjoint
evaluations.

In particular, after defining the following exposure rate ratios,

$$R_1 = \frac{[dpa/sec]}{[\phi \, (E > 1.0 \text{ MeV})]}$$

$$R_2 = \frac{[\phi \, (E > 0.1 \text{ MeV})]}{[\phi \, (E > 1.0 \text{ MeV})]}$$

the corresponding fuel cycle specific exposure rates at the adjoint source
locations were computed from the following relations:

$$dpa/sec = [\phi \, (E > 1.0 \text{ MeV})]_{adjoint} \, R_1$$

$$\phi \, (E > 0.1 \text{ MeV}) = [\phi \, (E > 1.0 \text{ MeV})]_{adjoint} \, R_2$$

FIGURE 3.1-1

REACTOR GEOMETRY SHOWING A 45° R,θ SECTOR

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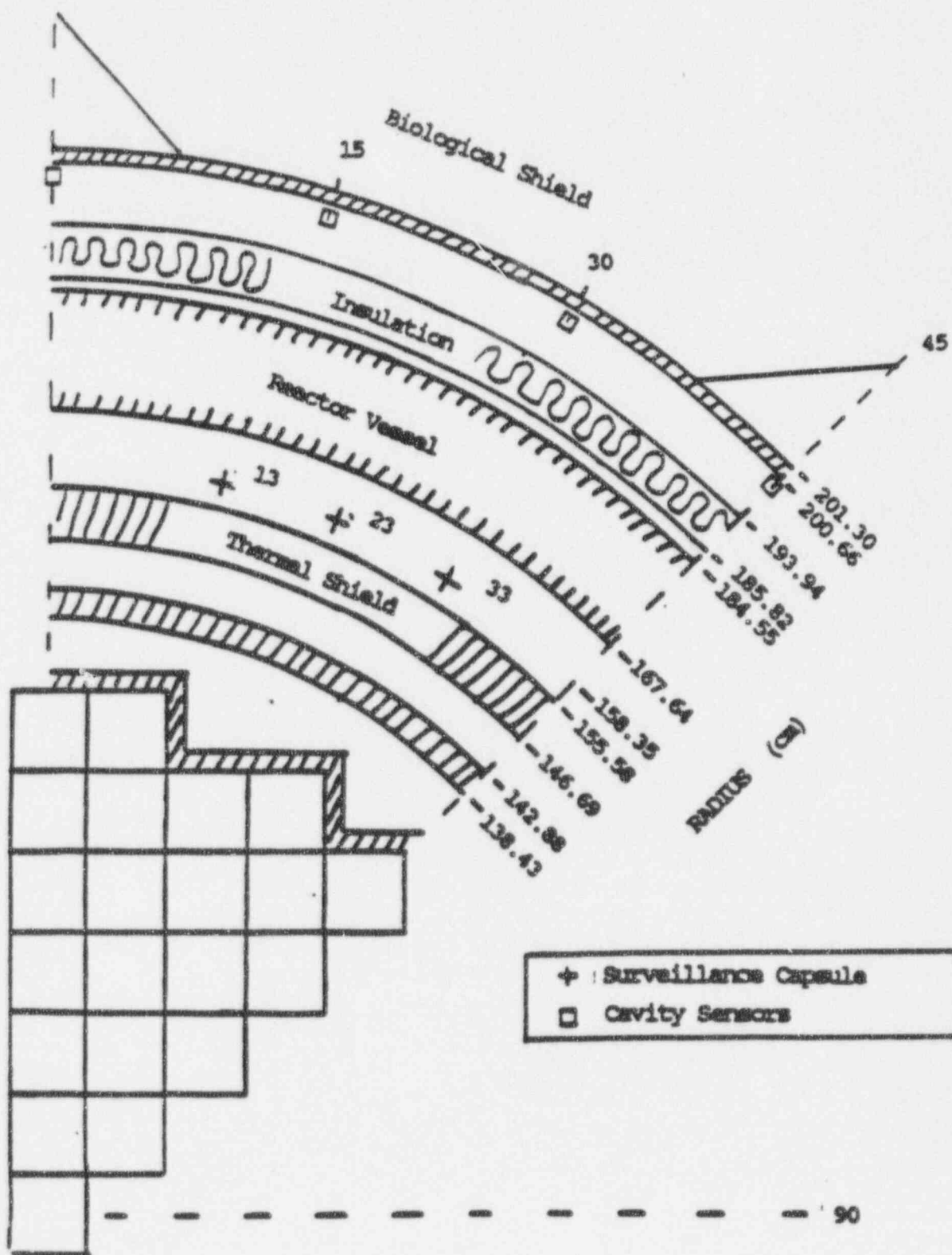
FIGURE 3.1-2

INTERNAL SURVEILLANCE CAPSULE GEOMETRY
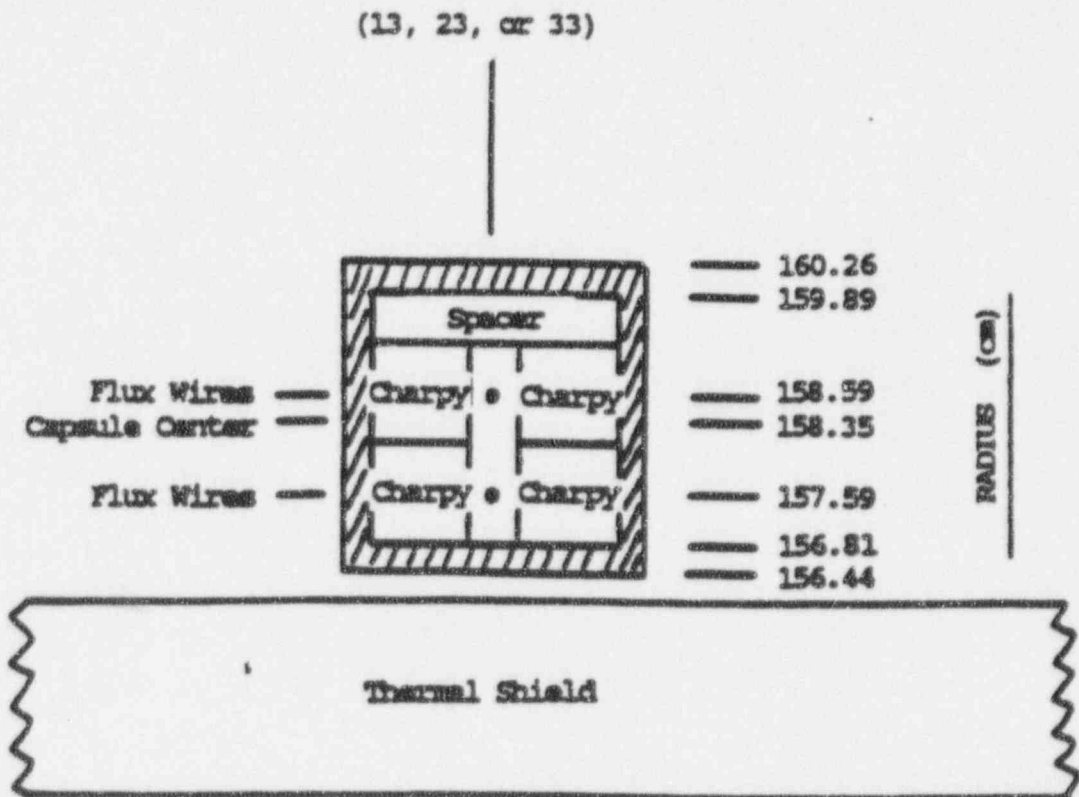
3.2 - Neutron Dosimetry Evaluation Methodology

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 some cases, the specific activities pertaining to individual internal serveillance capsules were determined from prior analysis by a radiochemical laboratory other than Westinghouse. In those cases, 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 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; while the evaluation of the SSTR sensors from the cavity irradiations was carried out at the Westinghouse Science and Technology Center Track Recorder 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 [5 through 15]. 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 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 U-238 and Np-237 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 cavity irradiations, individual sensors were obtained by cutting the chains into a series of segments to provide data points at one foot intervals over an axial span encompassing $\pm$ 7 feet relative to the reactor core midplane.

The irradiation history of the reactor over its operating lifetime was obtained from NUREG-0020, "Licensed Operating Reactors Status Summary Report". In particular, operating data were extracted from that report on a monthly bases 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

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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 1518 MWt were determined from the following equation:

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

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 ϕ (E > 1.0 MeV) during irradiation period j to the time weighted average ϕ (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 adjoint 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

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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 - Solid State Track Recorders

Following preparation of the mica discs, all of the solid state track recorders were scanned either manually or with the Westinghouse STC Automated Track Scanner to determine the number of fissions that occured during the course of the irradiation of the sensor sets. Since the SSTR sensors are integrating devices not susceptible to radioactive decay of a product isotope, the measurements of total fissions per atom, A, were converted directly to reaction rates using the following relationship:

$$R = \frac{A}{\sum_j [P_j/P_{ref}] \, t_j}$$

where the denominator in the above equation represents the total effective full power seconds of reactor operation during the irradiation of the solid state track recorders.

The SSTR fissionable deposits were designed for reuse in the long term monitoring program. Therefore, following processing each sensor was carefully examined to assure that the deposits were neither damaged nor contaminated during irradiation, handling, and post-irradiation processing.

In particular, these examinations were designed to assure that, in all cases, the fission tracks were confined to an area corresponding to the active portion of the fissionable deposit and that the edges of the active area were sharply defined with a sufficient drop-off in track density to

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indicate acceptable signal to background ratios for the measurements. Each mica SSTR and fissionable deposit was also closely inspected under a microscope to verify that no physical damage had occured during exposure or shipment. Selected deposits were also subjected to mass recalibration to verify that no deposit mass had been lost during shipping or exposure.

3.2.1.3 - 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 U-238 foil and SSTR measurements to account for the presence of U-235 impurities in the sensors as well as to adjust for the build-in of plutonium isotopes over the course of the irradiation. Likewise, corrections were made to both U-238 and Np-237 sensors to account for gamma ray induced fission reactions occuring over the course of the irradiation. These corrections were location and fluence dependent and were derived from a combination of data from the reference forward transport calculation and the cycle specific adjoint analyses as well as from measurements made with the U-235 solid state track recorders.

In performing the dosimetry evaluations for the internal surveillance capsules, the sensor reaction rates measured at the locations shown in Figure 2.2-1 were indexed to the geometric center of the capsules prior to use in the spectrum adjustment procedure. This procedure required correcting the measured reaction rates by the application of analytically determined spatial gradients. For the Point Beach Unit 2 surveillance capsules, the gradient correction factors for each sensor reaction were obtained from the reference forward transport calculation and were used in a multiplicative fashion to relate individual measured reaction rates to the corresponding value at the geometric center of the surveillance capsule. In the case of the reactor cavity sensors, all of the monitors were located at the same radial location. Thus, gradient corrections were not required in the evaluation of these dosimetry sets.

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 [16]. The FERRET approach used the measured reaction rate data and the calculated neutron energy spectrum at the sensor set locations as input and proceeded to adjust a priori (calculated) group fluxes to produce a best fit (in a least squares sense) to the reaction rate data. The exposure parameters along with associated uncertainties were then obtained from the adjusted spectra.

In the FERRET evaluations, a log-normal least-squares algorithm weights both the a priori 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 cross section σ_{ig}. (In this case, FERRET also adjusts the cross-sections.) The log-normal approach automatically accounts for the physical constraint of positive fluxes, even with

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large assigned uncertainties.

In the FERRET analysis of the dosimetry data, the continuous quantities (i.e., fluxes and cross-sections) were approximated in 53 groups. The calculated fluxes from the reference forward calculation were expanded into the FERRET group structure using the SAND-II code [17]. This procedure was carried out by first expanding the a priori spectrum into the SAND-II 620 group structure using a SPLINE interpolation procedure for interpolation in regions where group boundaries do not coincide. The 620-point spectrum was then easily collapsed to the group scheme used in FERRET.

The cross-sections were also collapsed into the 53 energy-group structure using SAND II with calculated spectra (as expanded to 620 groups) as weighting functions. The cross sections were taken from the ENDF/B-V dosimetry file. Uncertainty estimates and 53 x 53 covariance matrices were constructed for each cross section. Correlations between cross sections were neglected due to data and code limitations, but this omission does not significantly impact the results of the adjustment.

For each set of data or a priori values, the inverse of the corresponding relative covariance matrix M is used as a statistical weight. In some cases, as for the cross sections, a multigroup covariance matrix is used. More often, a simple parameterized form is employed:

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

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

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$$P_{gg'} = (1-\theta) \, \delta_{gg'} + \theta \, e^{\left[\frac{-(g-g')^2}{2\gamma^2}\right]}$$

The first term specifies purely random uncertainties while the second term describes short-range correlations over a range γ (θ specifies the strength of the latter term).

For the a priori calculated fluxes, a short-range correlation of $\gamma = 6$ groups was used. This choice implies that neighboring groups are strongly correlated when θ is close to 1. Strong long-range correlations (or anticorrelations) were justified based on information presented by R.E. Maerker[18]. 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 input spectra from the reference forward transport calculation were normalized to the measured Fe-54 (n,p) Mn-54 reaction rates to remove any constant calculation to measurement bias and, thus, to permit the adjustment to take place on a relative basis. The specific normalization factors for individual evaluations depended on the location of the sensor set as well as on the neutron flux level at that location.

The specific assignment of uncertainties in the measured reaction rates and the input (a priori) 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 se. ˑ ː 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.

SECTION 4.0

RESULTS OF NEUTRON TRANSPORT CALCULATIONS

4.1 Reference Forward Calculation

As noted in Section 3.0 of this report, data from the reference forward
transport calculation 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 pressure
vessel wall. In this section, the key data extracted from the reference
forward calculation is presented and its relevance to the dosimetry
evaluations and vessel exposure projections is discussed. The reader
should recall that the results of the reference forward transport
calculation were intended for use on a relative basis and, therefore,
should not be used for absolute comparison with measurement. All absolute
comparisons were based on the results of the fuel cycle specific adjoint
calculations discussed in Section 4.2.

4.1.1 - Cavity Sensor Set Locations

Data from the reference forward calculation pertinent to cavity sensor
evaluations are provided in Tables 4.1-1 and 4.1-2.

In Table 4.1-1, the calculated neutron energy spectra applicable to sensor
locations at 0, 15, 30, and 45 degrees relative to the core cardinal axes
are listed. These data represent the a priori spectra used as the
starting guess in the FERRET least squares adjustment evaluations of the
cavity sensor sets. On a relative basis these calculated energy
distributions establish a baseline against which adjusted spectra may be
compared; and, when coupled with the adjoint results of Section 4.2,
provide an analytical prediction of absolute neutron spectra at the sensor
set locations for each irradiation period.

In Table 4.1-2, the calculated neutron sensor reaction rates associated with the spectra from Table 4-1 are provided along with the reference exposure rates in terms of ϕ (E > 1.0 MeV), ϕ (E < 0.1 MeV) and dpa/sec. Also listed are the associated exposure rate ratios calculated for each of the cavity sensor set locations.

The reference reaction rates, exposure rates, and exposure rate ratios were used in conjunction with fuel cycle specific adjoint transport calculations from Section 4.2 to provide calculated sensor set reaction rates and to project sensor set exposures in terms of ϕ (E > 0.1 MeV) and dpa/sec for each irradiation period. In addition, the ratios of U238(γ,f)/U238(n,f) and Np237(γ,f)/Np237(n,f) were used to make photo-fission corrections to measured reaction rates in the U238 and Np237 fission monitors prior to use in the FERRET adjustment procedure.

4.1.2 - Surveillance Capsule Locations

Data from the reference forward calculation pertinent to surveillance capsule evaluations are provided in Tables 4.1-3 through 4.1-5.

In Table 4.1-3, the calculated neutron energy spectra at the geometric center of surveillance capsules located at 13, 23, and 33 degrees relative to the core cardinal axes are listed. In Table 4.1-4, the calculated neutron sensor reaction rates and exposure rate ratios associated with the spectra from Table 4.1-3 are provided along with the calculated exposure rates in terms of ϕ (E > 1.0 MeV), ϕ (E < 0.1 MeV) and dpa/sec. Again, these data are applicable to the geometric center of each surveillance capsule. These tabulated data were used in the surveillance capsule dosimetry evaluations and exposure calculations in the same fashion as was the case for the cavity sensor sets.

As noted earlier in this report, surveillance capsule dosimetry evaluations also require spatial gradient corrections to be applied to measured reaction rates in sensors dispersed throughout the capsule.

In the case of the Point Beach Unit 2 surveillance capsules, neutron sensors were positioned within the specimen array as shown in Figure 2.2-1. In Table 4.1-5, gradient correction factors applicable to the various dosimetry locations are provided for each sensor reaction. These factors were used in a multiplicative fashion to relate measured reaction rates to the corresponding value at the geometric center of the capsules.

4.1.3 - Pressure Vessel Wall

Data from the reference forward calculation pertinent to the pressure vessel wall are provided in Tables 4.1-6 through 4.1-10.

In Table 4.1-6, the calculated azimuthal distribution of fast neutron flux (E > 1.0 MeV) is listed for the center of the vessel cladding, at the pressure vessel clad/base metal interface, and at the center of the first mesh interval in the base metal. The interface information (base metal inner radius) was obtained by averaging the two sets of data obtained directly from the reference forward calculation. In this detailed tabulation, calculated flux levels are given for each of the 51 azimuthal mesh intervals included in the analytical model model.

In Table 4.1-7, the calculated azimuthal distribution of exposure rates in terms of ϕ (E > 1.0 MeV), ϕ (E > 0.1 MeV), and dpa/sec are listed at approximately 5 degree intervals over the reactor geometry. These data are applicable to the clad/base metal interface. Also given in Table 4.1-7 are the exposure rate ratios [ϕ (E > 0.1 MeV)]/[ϕ (E > 1.0 MeV)] and [dpa/sec]/[ϕ (E > 1.0 MeV)] that provide an indication of the variation in neutron spectrum as a function of azimuthal angle at the pressure vessel inner radius.

Radial gradient information for ϕ (E > 1.0 MeV), ϕ (E > 0.1 Mev), and dpa/sec is given in Tables 4.1-8, 4.1-9, and 4.1-10, respectively. These data are presented on a relative basis for each exposure parameter at the 0, 15, 30, and 45 degree azimuthal locations. Exposure rate

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distributions within the vessel wall were obtained by normalizing the calculated or projected exposure at the vessel inner radius to the gradient data given in Tables 4.1-8 through 4.1-10.

TABLE 4.1-1

CALCULATED REFERENCE NEUTRON ENERGY SPECTRA AT CAVITY SENSOR SET LOCATIONS
1518 MWt; F_a = 1.2

LOWER ENERGY (Mev)	AZIMUTHAL ANGLE				LOWER ENERGY (Mev)	AZIMUTHAL ANGLE			
	0 DEG	15 DEG	30 DEG	45 DEG		0 DEG	15 DEG	30 DEG	45 DEG
1.42E+1	9.07E+5	7.07E+5	5.54E+5	5.30E+5	2.97E-1	3.68E+9	3.13E+9	2.20E+9	1.72E+9
1.22E+1	3.25E+6	2.53E+6	2.00E+6	1.89E+6	1.83E-1	3.87E+9	3.47E+9	2.48E+9	1.86E+9
1.00E+1	9.58E+6	7.25E+6	5.61E+6	5.24E+6	1.11E-1	4.67E+9	4.14E+9	2.97E+9	2.27E+9
8.61E+0	1.59E+7	1.19E+7	9.14E+6	8.45E+6	6.74E-2	3.87E+9	3.45E+9	2.49E+9	1.92E+9
7.41E+0	2.33E+7	1.73E+7	1.31E+7	1.20E+7	4.09E-2	2.20E+9	2.02E+9	1.47E+9	1.11E+9
6.07E+0	4.56E+7	3.37E+7	2.53E+7	2.28E+7	3.18E-2	6.53E+8	6.11E+8	4.47E+8	3.34E+8
4.97E+0	5.56E+7	4.11E+7	3.05E+7	2.69E+7	2.61E-2	3.79E+8	3.58E+8	2.64E+8	1.97E+8
3.68E+0	1.04E+8	7.70E+7	5.58E+7	4.83E+7	2.42E-2	1.39E+9	1.18E+9	8.48E+8	6.84E+8
3.01E+0	9.63E+7	7.14E+7	5.10E+7	4.36E+7	2.19E-2	9.09E+8	8.06E+8	5.76E+8	4.45E+8
2.73E+0	8.52E+7	6.31E+7	4.23E+7	3.79E+7	1.50E-2	1.78E+9	1.66E+9	1.19E+9	8.77E+8
2.47E+0	1.05E+8	7.89E+7	5.56E+7	4.67E+7	7.10E-3	1.67E+9	1.60E+9	1.17E+9	8.67E+8
2.37E+0	5.44E+7	4.12E+7	2.89E+7	2.42E+7	3.36E-3	2.33E+9	2.16E+9	1.59E+9	1.22E+9
2.35E+0	1.87E+7	1.38E+7	9.56E+6	8.07E+6	1.59E-3	1.98E+9	1.84E+9	1.36E+9	1.05E+9
2.23E+0	9.34E+7	6.97E+7	4.85E+7	4.09E+7	4.54E-4	2.70E+9	2.51E+9	1.87E+9	1.45E+9
1.92E+0	2.28E+8	1.71E+8	1.20E+8	1.01E+8	2.14E-4	1.47E+9	1.37E+9	1.03E+9	7.96E+8
1.65E+0	3.56E+8	2.69E+8	1.87E+8	1.56E+8	1.01E-4	1.50E+9	1.39E+9	1.04E+9	8.18E+8
1.35E+0	5.64E+8	4.37E+8	3.04E+8	2.49E+8	3.73E-5	1.96E+9	1.80E+9	1.35E+9	1.07E+9
1.00E+0	1.34E+9	1.06E+9	7.34E+8	5.95E+8	1.07E-5	2.29E+9	2.10E+9	1.58E+9	1.26E+9
8.21E-1	1.25E+9	1.00E+9	6.95E+8	5.57E+8	5.04E-6	1.27E+9	1.16E+9	8.71E+8	6.95E+8
7.43E-1	5.98E+8	5.06E+8	3.55E+8	2.72E+8	1.86E-6	1.46E+9	1.34E+9	1.01E+9	8.05E+8
6.08E-1	2.96E+9	2.41E+9	1.67E+9	1.34E+9	8.76E-7	9.28E+8	8.52E+8	6.42E+8	5.15E+8
4.98E-1	2.25E+9	1.92E+9	1.35E+9	1.04E+9	4.14E-7	7.66E+8	7.04E+8	5.30E+8	4.28E+8
3.69E-1	2.96E+9	2.76E+9	1.77E+9	1.38E+9	1.00E-7	1.35E+9	1.21E+9	9.04E+8	7.49E+8
					0.00	3.68E+9	2.90E+9	2.14E+9	2.04E+9

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

TABLE 4.1-2

CALCULATED NEUTRON SENSOR REACTION RATES AND EXPOSURE RATES
AT THE CAVITY SENSOR SET LOCATIONS
1518 MWt; F_u = 1.20

AZIMUTHAL ANGLE

	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
Reaction Rate (rps/nucleus)				
Cu63(n,α)	1.84E-18	1.39E-18	1.05E-18	9.72E-19
Ti46(n,p)	2.79E-17	2.10E-17	1.56E-17	1.41E-17
Fe54(n,p)	1.63E-16	1.22E-16	8.88E-17	7.81E-17
Ni58(n,p)	2.28E-16	1.72E-16	1.24E-16	1.08E-16
U238(n,f) (Cd)	9.55E-16	7.31E-16	5.12E-16	4.32E-16
Np237(n,f) (Cd)	1.41E-14	1.15E-14	8.01E-15	6.42E-15
Co59(n,γ)	2.60E-13	2.30E-13	1.68E-13	1.44E-13
Co59(n,γ) (Cd)	1.46E-13	1.36E-13	1.01E-13	7.97E-14
U238(γ,f)	3.88E-17	3.13E-17	2.32E-17	2.12E-17
Np237(γ,f)	1.10E-16	8.84E-17	6.54E-17	5.98E-17
Neutron Flux (n/cm^2)				
ϕ (E > 1.0 MeV)	3.20E+09	2.53E+09	1.73E+09	1.43E+09
ϕ (E > 0.1 MeV)	2.54E+10	2.17E+10	1.52E+10	1.19E+10
dpa/sec				
Displacement rate	9.71E-12	8.14E-12	5.70E-12	4.52E-12
Exposure Rate Ratios				
ϕ(E > 0.1)/ϕ(E > 1.0)	7.94	8.58	8.79	8.32
[dpa/sec]/ϕ(E > 1.0)	3.03E-21	3.22E-21	3.29E-21	3.16E-21
U238(γ,f)/U238(n,f)	0.0406	0.0428	0.0453	0.0491
Np237(γ,f)/Np237(n,f)	0.00780	0.00769	0.00816	0.00931

TABLE 4.1-3

CALCULATED REFERENCE NEUTRON ENERGY SPECTRA AT SURVEILLANCE CAPSULE LOCATIONS
1518 MWt; $F_a = 1.2$

LOWER ENERGY (Mev)	AZIMUTHAL ANGLE 13 DEG	23 DEG	33 DEG	LOWER ENERGY (Mev)	AZIMUTHAL ANGLE 13 DEG	23 DEG	33 DEG
1.42E+1	2.31E+07	1.89E+07	1.66E+07	2.97E-1	4.86E+10	2.53E+10	2.34E+10
1.22E+1	8.46E+07	6.90E+07	6.05E+07	1.83E-1	6.29E+10	3.28E+10	3.04E+10
1.00E+1	3.02E+08	2.38E+08	2.08E+08	1.11E-1	6.11E+10	3.15E+10	2.92E+10
8.61E+0	5.52E+08	4.34E+08	3.79E+08	6.74E-2	4.91E+10	2.52E+10	2.34E+10
7.41E+0	9.48E+08	7.19E+08	6.30E+08	4.09E-2	3.71E+10	1.90E+10	1.77E+10
6.07E+0	2.14E+09	1.60E+09	1.40E+09	3.18E-2	1.28E+10	6.56E+09	6.09E+09
4.97E+0	3.03E+09	2.19E+09	1.93E+09	2.61E-2	7.27E+09	3.74E+09	3.47E+09
3.68E+0	7.83E+09	4.30E+09	3.84E+09	2.42E-2	1.38E+10	7.01E+09	6.52E+09
3.01E+0	5.90E+09	3.76E+09	3.40E+09	2.19E-2	8.52E+09	4.31E+09	4.01E+09
2.73E+0	4.83E+09	3.05E+09	2.76E+09	1.50E-2	2.17E+10	1.11E+10	1.03E+10
2.47E+0	5.75E+09	3.57E+09	3.26E+09	7.10E-3	3.39E+10	1.74E+10	1.61E+10
2.37E+0	2.86E+09	1.78E+09	1.62E+09	3.36E-3	4.51E+10	2.31E+10	2.14E+10
2.35E+0	8.75E+08	5.44E+08	4.95E+08	1.59E-3	4.00E+10	2.04E+10	1.89E+10
2.23E+0	4.31E+09	2.66E+09	2.43E+09	4.54E-4	6.16E+10	3.12E+10	2.90E+10
1.92E+0	1.12E+10	6.84E+09	6.25E+09	2.14E-4	3.55E+10	1.80E+10	1.67E+10
1.65E+0	1.45E+10	8.86E+09	8.13E+09	1.01E-4	3.75E+10	1.90E+10	1.76E+10
1.35E+0	2.25E+10	1.31E+10	1.21E+10	3.73E-5	5.02E+10	2.53E+10	2.35E+10
1.00E+0	4.64E+10	2.62E+10	2.42E+10	1.07E-5	6.10E+10	3.07E+10	2.86E+10
8.21E-1	3.49E+10	1.92E+10	1.78E+10	5.04E-6	3.52E+10	1.76E+10	1.64E+10
7.43E-1	1.69E+10	9.27E+09	8.60E+09	1.86E-6	4.31E+10	2.16E+10	2.01E+10
6.08E-1	5.52E+10	2.94E+10	2.72E+10	8.76E-7	2.90E+10	1.46E+10	1.36E+10
4.98E-1	4.10E+10	2.30E+10	2.13E+10	4.14E-7	2.52E+10	1.27E+10	1.18E+10
3.69E-1	5.17E+10	2.72E+10	2.52E+10	1.00E-7	5.48E+10	2.79E+10	2.57E+10
				0.00	1.25E+11	6.52E+10	5.91E+10

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

TABLE 4.1-4

CALCULATED NEUTRON SENSOR REACTION RATES AND EXPOSURE RATES
AT THE CENTER OF THE SURVEILLANCE CAPSULES

AZIMUTHAL ANGLE

	13 DEGREES	23 DEGREES	33 DEGREES
	Reaction Rate (rps/nucleus)		
Cu63(n,α)	6.82E-17	5.25E-17	4.60E-17
Fe54(n,p)	8.40E-15	5.80E-15	5.17E-15
Ni58(n,p)	1.16E-14	7.82E-15	7.00E-15
U238(n,f) (Cd)	4.42E-14	2.78E-14	2.??E-14
Np237(n,f) (Cd)	4.04E-13	2.31E-13	2.??E-13
Co59(n,γ)	8.81E-12	4.53E-12	4.16E-12
Co59(n,γ) (Cd)	3.76E-12	1.90E-12	1.77E-12
U238(γ,f)	2.23E-15	1.29E-15	1.19E-15
Np237(γ,f)	6.23E-15	3.60E-15	3.32E-15
	Neutron Flux (n/cm^2)		
ϕ (E > 1.0 MeV)	1.33E+11	7.99E+10	7.31E+10
ϕ (E > 0.1 MeV)	5.08E+11	2.78E+11	2.56E+11
	dpa/sec		
Displacement rate	2.46E-10	1.41E-10	1.29E-10
	Exposure Rate Ratios		
ϕ(E > 0.1)/ϕ(E > 1.0)	3.82	3.48	3.50
[dpa/sec]/ϕ(E > 1.0)	1.85E-21	1.76E-21	1.76E-21
U238(γ,f)/U238(n,f)	0.0505	0.0464	0.0472
Np237(γ,f)/Np237(n,f)	0.0154	0.0156	0.0157

TABLE 4.1-5

RADIAL GRADIENT CORRECTIONS FOR SENSORS CONTAINED IN
POINT BEACH UNIT 2 INTERNAL SURVEILLANCE CAPSULES

	RADIAL LOCATION (cm)		
	157.59	158.35	158.59
13 DEGREE CAPSULE			
Cu63(n,α)	0.866	1.000	1.040
Fe54(n,p)	0.856	1.000	1.045
Ni58(n,p)	0.857	1.000	1.046
U238(n,f) (Cd)	0.856	1.000	1.049
Np237(n,f) (Cd)	0.862	1.000	1.050
Co59(n,γ)	0.950	1.000	0.977
Co59(n,γ) (Cd)	0.860	1.000	1.047
23 DEGREE CAPSULE			
Cu63(n,α)	0.865	1.000	1.040
Fe54(n,p)	0.356	1.000	1.044
Ni58(n,p)	0.856	1.000	1.045
U238(n,f) (Cd)	0.858	1.000	1.048
Np237(n,f) (Cd)	0.866	1.000	1.050
Co59(n,γ)	0.963	1.000	0.972
Co59(n,γ) (Cd)	0.873	1.000	1.042
33 DEGREE CAPSULE			
Cu63(n,α)	0.867	1.000	1.040
Fe54(n,p)	0.856	1.000	1.045
Ni58(n,p)	0.856	1.000	1.046
U238(n,f) (Cd)	0.856	1.000	1.048
Np237(n,f) (Cd)	0.863	1.000	1.050
Co59(n,γ)	0.956	1.000	0.975
Co59(n,γ) (Cd)	0.868	1.000	1.045

TABLE 4.1-6

AZIMUTHAL VARIATION OF FAST NEUTRON FLUX (E > 1.0 MeV)
AT THE PRESSURE VESSEL INNER RADIUS

THETA	RADIUS (cm)			THETA	RADIUS (cm)		
(Deg)	167.84	168.04	168.27	(Deg)	167.84	168.04	168.27
0.25	4.47E+10	4.41E+10	4.35E+10	23.00	1.97E+10	1.95E+10	1.93E+10
0.75	4.46E+10	4.40E+10	4.34E+10	23.43	1.97E+10	1.94E+10	1.92E+10
2.00	4.42E+10	4.37E+10	4.31E+10	23.72	1.98E+10	1.95E+10	1.91E+10
4.00	4.32E+10	4.27E+10	4.22E+10	23.90	1.97E+10	1.94E+10	1.91E+10
6.00	4.18E+10	4.13E+10	4.07E+10	24.11	1.96E+10	1.93E+10	1.90E+10
8.00	3.96E+10	3.91E+10	3.86E+10	24.61	1.94E+10	1.92E+09	1.90E+10
10.00	3.66E+10	3.62E+10	3.57E+10	26.00	1.93E+10	1.91E+09	1.89E+10
11.39	3.41E+10	3.37E+10	3.32E+10	28.00	1.91E+10	1.89E+09	1.86E+10
11.84	3.32E+10	3.27E+10	3.22E+10	30.00	1.86E+10	1.84E+09	1.82E+10
12.06	3.29E+10	3.24E+10	3.19E+10	31.39	1.81E+10	1.79E+10	1.76E+10
12.28	3.24E+10	3.19E+10	3.14E+10	31.89	1.79E+10	1.77E+10	1.74E+10
12.57	3.16E+10	3.12E+10	3.08E+10	32.10	1.79E+10	1.76E+10	1.73E+10
13.00	3.03E+10	3.00E+10	2.96E+10	32.28	1.79E+10	1.76E+10	1.73E+10
13.44	2.94E+10	2.91E+10	2.87E+10	32.57	1.77E+10	1.75E+10	1.72E+10
13.72	2.90E+10	2.85E+10	2.80E+10	33.00	1.74E+10	1.72E+10	1.70E+10
13.90	2.86E+10	2.82E+10	2.77E+10	33.44	1.73E+10	1.71E+10	1.69E+10
14.12	2.81E+10	2.77E+10	2.73E+10	33.72	1.74E+10	1.71E+10	1.68E+10
14.61	2.71E+10	2.68E+10	2.65E+10	33.90	1.73E+10	1.70E+10	1.67E+10
16.00	2.50E+10	2.47E+10	2.44E+10	34.12	1.72E+10	1.70E+10	1.67E+10
18.00	2.29E+10	2.26E+10	2.23E+10	34.61	1.71E+10	1.69E+10	1.67E+10
20.00	2.12E+10	2.10E+10	2.07E+10	36.00	1.69E+10	1.67E+10	1.65E+10
21.39	2.06E+10	2.04E+10	2.01E+10	38.00	1.66E+10	1.64E+10	1.62E+10
21.88	2.04E+10	2.01E+10	1.98E+10	40.00	1.63E+10	1.61E+10	1.59E+10
22.10	2.03E+10	2.00E+10	1.97E+10	42.00	1.60E+10	1.58E+10	1.56E+10
22.28	2.03E+10	2.00E+10	1.96E+10	44.00	1.58E+10	1.56E+10	1.54E+10
22.56	2.00E+10	1.98E+10	1.95E+10				

Note: The vessel clad/base metal interface is located at
a radius of 168.04 cm.

TABLE 4.1-7

SUMMARY OF EXPOSURE RATES AT THE PRESSURE VESSEL
CLAD/BASE METAL INTERFACE

THETA (Deg)	Flux (n/cm2-sec) (E > 1.0)	(E > 0.1)	dpa/sec	(E > 0.1) (E > 1.0)	dpa/sec (E > 1.0)
0.25	4.41E+10	1.20E+11	7.26E-11	2.72	1.65E-21
4.00	4.27E+10	1.16E+11	7.04E-11	2.72	1.65E-21
10.00	3.62E+10	1.01E+11	6.04E-11	2.79	1.67E-21
14.61	2.68E+10	7.83E+10	4.57E-11	2.92	1.71E-21
20.00	2.10E+10	5.84E+10	3.53E-11	2.78	1.68E-21
24.61	1.92E+10	5.32E+10	3.22E-11	2.77	1.68E-21
30.00	1.84E+10	4.96E+10	3.05E-11	2.70	1.66E-21
34.61	1.69E+10	4.66E+10	2.82E-11	2.76	1.67E-21
40.00	1.61E+10	4.19E+10	2.64E-11	2.60	1.64E-21
44.00	1.56E+10	4.06E+10	2.56E-11	2.60	1.64E-21

TABLE 4.1-8

RELATIVE RADIAL DISTRIBUTION OF NEUTRON FLUX (E > 1.0 MeV) WITHIN THE PRESSURE VESSEL WALL

RADIUS (cm)	AZIMUTHAL ANGLE			
	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
168.04	1.000	1.000	1.000	1.000
168.27	0.986	0.988	0.987	0.988
168.88	0.972	0.976	0.975	0.975
169.75	0.922	0.929	0.927	0.928
170.89	0.841	0.850	0.847	0.850
172.17	0.734	0.744	0.740	0.745
173.49	0.621	0.631	0.627	0.633
174.90	0.519	0.530	0.525	0.531
176.30	0.426	0.437	0.431	0.438
177.50	0.348	0.359	0.353	0.359
178.91	0.291	0.302	0.296	0.302
180.42	0.235	0.247	0.242	0.246
181.51	0.187	0.197	0.192	0.196
182.60	0.156	0.167	0.163	0.165
183.90	0.129	0.141	0.137	0.139
184.55	0.101	0.113	0.111	0.112

Note: Base Metal Inner Radius = 168.04 cm.
     1/4 T Location   = 172.17 cm.
     1/2 T Location   = 176.30 cm.
     3/4 T Location   = 180.42 cm.
     Base Metal Outer Radius = 184.55 cm.

TABLE 4.1-9

RELATIVE RADIAL DISTRIBUTION OF NEUTRON FLUX (E > 0.1 MeV)
WITHIN THE PRESSURE VESSEL WALL

RADIUS (cm)	AZIMUTHAL ANGLE 0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
168.04	1.000	1.000	1.000	1.000
168.27	1.005	1.006	1.007	1.007
168.88	1.009	1.013	1.014	1.014
169.75	1.006	1.012	1.014	1.015
170.89	0.981	0.992	0.996	0.998
172.17	0.934	0.949	0.955	0.959
173.49	0.872	0.891	0.898	0.903
174.90	0.803	0.827	0.834	0.840
176.30	0.729	0.757	0.764	0.769
177.50	0.657	0.687	0.695	0.700
178.91	0.595	0.629	0.638	0.641
180.42	0.524	0.562	0.572	0.572
181.51	0.452	0.492	0.503	0.500
182.60	0.400	0.442	0.454	0.450
183.90	0.347	0.393	0.407	0.400
184.55	0.282	0.331	0.350	0.343

Note: Base Metal Inner Radius = 168.04 cm.
      1/4 T Location   = 172.17 cm.
      1/2 T Location   = 176.30 cm.
      3/4 T Location   = 180.42 cm.
      Base Metal Outer Radius = 184.55 cm.

TABLE 4.1-10

RELATIVE RADIAL DISTRIBUTIONS OF IRON DISPLACEMENT RATE (dpa)
WITHIN THE PRESSURE VESSEL WALL

RADIUS	AZIMUTHAL ANGLE			
(cm)	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
168.04	1.000	1.000	1.000	1.000
168.27	0.988	0.990	0.990	0.990
168.88	0.977	0.981	0.980	0.980
169.75	0.937	0.945	0.943	0.943
170.89	0.874	0.886	0.882	0.883
172.17	0.790	0.806	0.801	0.303
173.49	0.701	0.720	0.713	0.715
174.90	0.617	0.639	0.630	0.632
176.30	0.536	0.561	0.552	0.553
177.50	0.465	0.491	0.482	0.482
178.91	0.409	0.437	0.429	0.428
180.42	0.350	0.380	0.372	0.370
181.51	0.294	0.324	0.318	0.314
182.60	0.256	0.287	0.282	0.277
183.90	0.219	0.251	0.249	0.243
184.55	0.177	0.210	0.211	0.205

Note: Base Metal Inner Radius = 168.04 cm.

1/4 T Location = 172.17 cm.

1/2 T Location = 176.30 cm.

3/4 T Location = 180.42 cm.

Base Metal Outer Radius = 184.55 cm.

4.2 - Fuel Cycle Specific Adjoint Calculations

Results of the fuel cycle specific adjoint transport calculations for the first 17 cycles of operation at Point Beach Unit 2 are summarized in Tables 4.2-1 through 4.2-18. The data listed in these tables establish the means for absolute comparison of analysis and measurement for the Cycles 15, 16, and 17 cavity dosimetry irradiations as well as for the four sets of surveillance capsule dosimetry withdrawn to date. These results also provide the fuel cycle specific relationship among the surveillance capsule and reactor cavity measurement locations and key positions at the inner radius of the pressure vessel wall.

The core power distributions used in the cycle specific fast neutron exposure calculations for Fuel Cycles 1 through 17 were taken from the fuel cycle design reports applicable to Point Beach Unit 2 [19 through 35]. The data extracted from the fuel cycle design reports represented cycle averaged relative fuel assembly powers and burnups as well as cycle averaged relative axial distributions. Therefore, the results of the adjoint evaluation provided data in terms of fuel cycle averaged neutron flux which, when multiplied by the appropriate fuel cycle length, produced the incremental fast neutron exposure for the fuel cycle.

The calculated fast neutron flux (E > 1.0 MeV) and cumulative fast neutron fluence at the center of surveillance capsules located at 13, 23, and 33 degrees are provided for each of the 17 operating fuel cycles in Tables 4.2-1 and 4.2-2, respectively. The data as tabulated are applicable to the axial core midplane. Similar data applicable to the pressure vessel inner radius are given in Tables 4.2-3 and 4.2-4 and data pertinent to the cavity dosimetry sensor locations are listed in Tables 4.2-5 and 4.2-6.

Exposure parameter ratios necessary to convert the cycle specific data listed in Tables 4.2-1 through 4.2-6 to other key fast neutron exposure units are given in Section 4.1 of this report. Application of these ratios to the data from Tables 4.2-1 through 4.2-6 yielded corresponding exposure data in terms of flux/fluence (E > 0.1 MeV) (Tables 4.2.7 through 4.2.12) and iron atom

displacements (Tables 4.2.13 through 4.2.18).

TABLE 4.2-1

CALCULATED FAST NEUTRON FLUX (E > 1.0 MeV) AT THE
CENTER OF REACTOR VESSEL SURVEILLANCE CAPSULES

ϕ (E > 1.0 MeV) [n/cm2-sec]

CYCLE No	13 DEGREES	23 DEGREES	33 DEGREES
1	1.10E+11	6.45E+10	5.86E+10
2	1.12E+11	6.83E+10	6.41E+10
3	1.11E+11	6.70E+10	6.34E+10
4	1.05E+11	6.46E+10	6.07E+10
5	1.10E+11	6.77E+10	6.09E+10
6	8.41E+10	6.36E+10	6.24E+10
7	8.50E+10	5.58E+10	5.27E+10
8	8.59E+10	5.48E+10	5.04E+10
9	8.93E+10	5.58E+10	5.10E+10
10	8.05E+10	5.47E+10	5.22E+10
11	7.62E+10	5.64E+10	5.15E+10
12	8.00E+10	5.61E+10	4.92E+10
13	7.39E+10	5.29E+10	4.65E+10
14	7.60E+10	5.51E+10	5.07E+10
15	7.34E+10	5.32E+10	4.64E+10
16	5.91E+10	4.31E+10	4.05E+10
17	5.89E+10	4.38E+10	4.17E+10

TABLE 4.2-2

CALCULATED FAST NEUTRON FLUENCE (E > 1.0 MeV) AT THE
CENTER OF REACTOR VESSEL SURVEILLANCE CAPSULES

CYCLE No	CYCLE LENGTH (EFPS)	Φ (E > 1.0 MeV) [n/cm2] 13 DEGREES	23 DEGREES	33 DEGREES
1	4.81E+07	5.30E+18	3.10E+18	2.82E+18
2	3.32E+07	9.01E+18	5.37E+18	4.95E+18
3	2.75E+07	1.21E+19	7.21E+18	6.69E+18
4	2.74E+07	1.49E+19	8.98E+18	8.35E+18
5	2.79E+07	1.80E+19	1.09E+19	1.00E+19
6	2.73E+07	2.03E+19	1.26E+19	1.17E+19
7	2.82E+07	2.27E+19	1.42E+19	1.32E+19
8	2.70E+07	2.50E+19	1.57E+19	1.46E+19
9	2.50E+07	2.72E+19	1.71E+19	1.59E+19
10	3.77E+07	3.03E+19	1.91E+19	1.78E+19
11	2.68E+07	3.23E+19	2.06E+19	1.92E+19
12	2.52E+07	3.43E+19	2.20E+19	2.05E+19
13	2.55E+07	3.62E+19	2.34E+19	2.16E+19
14	2.72E+07	3.83E+19	2.49E+19	2.30E+19
15	2.54E+07	4.01E+19	2.62E+19	2.42E+19
16	2.70E+07	4.18E+19	2.74E+19	2.53E+19
17	2.66E+07	4.33E+19	2.86E+19	2.64E+19

TABLE 4.2-3

CALCULATED FAST NEUTRON FLUX (E > 1.0 MeV) AT THE
PRESSURE VESSEL CLAD/BASE METAL INTERFACE

ϕ (E > 1.0 MeV) [n/cm2-sec]

CYCLE No	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
1	3.69E+10	2.16E+10	1.48E+10	1.29E+10
2	3.76E+10	2.21E+10	1.60E+10	1.41E+10
3	3.74E+10	2.18E+10	1.58E+10	1.41E+10
4	3.51E+10	2.07E+10	1.51E+10	1.33E+10
5	3.58E+10	2.17E+10	1.54E+10	1.26E+10
6	2.66E+10	1.74E+10	1.55E+10	1.31E+10
7	2.92E+10	1.72E+10	1.33E+10	1.26E+10
8	3.01E+10	1.74E+10	1.28E+10	1.20E+10
9	3.10E+10	1.80E+10	1.29E+10	1.22E+10
10	2.76E+10	1.65E+10	1.31E+10	1.22E+10
11	2.30E+10	1.60E+10	1.32E+10	1.13E+10
12	2.50E+10	1.66E+10	1.27E+10	1.06E+10
13	2.31E+10	1.54E+10	1.21E+10	1.02E+10
14	2.33E+10	1.58E+10	1.30E+10	1.17E+10
15	2.26E+10	1.54E+10	1.21E+10	9.94E+09
16	1.84E+10	1.24E+10	1.03E+10	9.36E+09
17	1.84E+10	1.24E+10	1.05E+10	9.84E+09

TABLE 4.2-4

CALCULATED FAST NEUTRON FLUENCE (E > 1.0 MeV) AT THE
PRESSURE VESSEL CLAD/BASE METAL INTERFACE

CYCLE No	CYCLE LENGTH (EFPS)	Φ (E > 1.0 MeV) [n/cm2]			
		0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
1	4.81E+07	1.78E+18	1.04E+18	7.09E+17	6.19E+17
2	3.32E+07	3.02E+18	1.77E+18	1.24E+18	1.09E+18
3	2.75E+07	4.05E+18	2.37E+18	1.68E+18	1.48E+18
4	2.74E+07	5.02E+18	2.94E+18	2.09E+18	1.84E+18
5	2.79E+07	6.01E+18	3.54E+18	2.52E+18	2.19E+18
6	2.73E+07	6.74E+18	4.02E+18	2.95E+18	2.55E+18
7	2.82E+07	7.56E+18	4.51E+18	3.32E+18	2.91E+18
8	2.70E+07	8.38E+18	4.97E+18	3.66E+18	3.23E+18
9	2.50E+07	9.15E+18	5.43E+18	3.99E+18	3.53E+18
10	3.77E+07	1.02E+19	6.05E+18	4.48E+18	3.99E+18
11	2.68E+07	1.08E+19	6.47E+18	4.83F+18	4.30E+18
12	2.52E+07	1.14E+19	6.89E+18	5.15E+18	4.56E+18
13	2.55E+07	1.20E+19	7.29E+18	5.46E+18	4.82E+18
14	2.72E+07	1.27E+19	7.72E+18	5.82E+18	5.14E+18
15	2.54E+07	1.32E+19	8.11E+18	6.12E+18	5.40E+18
16	2.70E+07	1.37E+19	8.44E+18	6.40E+18	5.65E+18
17	2.66E+07	1.42E+19	8.77E+18	6.68E+18	5.91E+18

TABLE 4.2-5

CALCULATED FAST NEUTRON FLUX (E > 1.0 MeV) AT THE
CAVITY SENSOR SET LOCATIONS

ϕ (E > 1.0 MeV) [n/cm2-sec]

CYCLE No	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
1	2.68E+09	2.04E+09	1.40E+09	1.17E+09
2	2.73E+09	2.10E+09	1.50E+09	1.27E+09
3	2.71E+09	2.07E+09	1.48E+09	1.27E+09
4	2.55E+09	1.97E+09	1.41E+09	1.20E+09
5	2.62E+09	2.04E+09	1.43E+09	1.17E+09
6	1.99E+09	1.66E+09	1.39E+09	1.18E+09
7	2.11E+09	1.66E+09	1.24E+09	1.10E+09
8	2.17E+09	1.66E+09	1.21E+09	1.05E+09
9	2.24E+09	1.72E+09	1.23E+09	1.07E+09
10	2.00E+09	1.58E+09	1.22E+09	1.07E+09
11	1.75E+09	1.49E+09	1.20E+09	1.02E+09
12	1.88E+09	1.55E+09	1.18E+09	9.71E+08
13	1.73E+09	1.43E+09	1.11E+09	9.28E+08
14	1.76E+09	1.48E+09	1.19E+09	1.04E+09
15	1.71E+09	1.43E+09	1.11E+09	9.15E+08
16	1.39E+09	1.17E+09	9.44E+08	8.28E+08
17	1.40E+09	1.17E+09	9.68E+08	8.60E+08

TABLE 4.2-6

CALCULATED FAST NEUTRON FLUENCE (E > 1.0 MeV) AT THE
CAVITY SENSOR SET LOCATIONS

CYCLE No	CYCLE LENGTH (EFPS)	Φ (E > 1.0 MeV) [n/cm2]			
		0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
1	4.81E+07	1.29E+17	9.82E+16	6.75E+16	5.61E+16
2	3.32E+07	2.19E+17	1.68E+17	1.17E+17	9.83E+16
3	2.75E+07	2.94E+17	2.25E+17	1.58E+17	1.33E+17
4	2.74E+07	3.64E+17	2.79E+17	1.97E+17	1.66E+17
5	2.79E+07	4.37E+17	3.36E+17	2.37E+17	1.99E+17
6	2.73E+07	4.91E+17	3.81E+17	2.75E+17	2.31E+17
7	2.82E+07	5.51E+17	4.28E+17	3.10E+17	2.62E+17
8	2.70E+07	6.09E+17	4.73E+17	3.42E+17	2.90E+17
9	2.50E+07	6.65E+17	5.16E+17	3.73E+17	3.17E+17
10	3.77E+07	7.41E+17	5.75E+17	4.19E+17	3.57E+17
11	2.68E+07	7.88E+17	6.15E+17	4.51E+17	3.85E+17
12	2.52E+07	8.35E+17	6.54E+17	4.81E+17	4.09E+17
13	2.55E+07	8.79E+17	6.90E+17	5.09E+17	4.33E+17
14	2.72E+07	9.27E+17	7.31E+17	5.42E+17	4.61E+17
15	2.54E+07	9.71E+17	7.67E+17	5.70E+17	4.84E+17
16	2.70E+07	1.01E+18	7.99E+17	5.95E+17	5.07E+17
17	2.66E+07	1.05E+18	8.30E+17	6.21E+17	5.30E+17

TABLE 4.2-7

CALCULATED FAST NEUTRON FLUX (E > 0.1 MeV) AT THE
CENTER OF REACTOR VESSEL SURVEILLANCE CAPSULES

ϕ (E > 0.1 MeV) [n/cm2-sec]

CYCLE No	13 DEGREES	23 DEGREES	33 DEGREES
1	4.21E+11	2.25E+11	2.05E+11
2	4.26E+11	2.38E+11	2.24E+11
3	4.23E+11	2.33E+11	2.22E+11
4	4.00E+11	2.25E+11	2.12E+1
5	4.18E+11	2.35E+11	2.12E+11
6	3.21E+11	2.21E+11	2.18E+11
7	3.25E+11	1.94E+11	1.84E+11
8	3.28E+11	1.91E+11	1.76E+11
9	3.41E+11	1.94E+11	1.79E+11
10	3.08E+11	1.90E+11	1.83E+11
11	2.91E+11	1.96E+11	1.80E+11
12	3.06E+11	1.95E+11	1.72E+11
13	2.82E+11	1.84E+11	1.63E+11
14	2.90E+11	1.92E+11	1.78E+11
15	2.80E+11	1.85E+11	1.63E+11
16	2.26E+11	1.50E+11	1.42E+11
17	2.25E+11	1.52E+11	1.46E+11

TABLE 4.2-8

CALCULATED FAST NEUTRON FLUENCE (E > 0.1 MeV) AT THE
CENTER OF REACTOR VESSEL SURVEILLANCE CAPSULES

CYCLE No	CYCLE LENGTH (EFPS)	Φ (E > 0.1 MeV) [n/cm2] 13 DEGREES	23 DEGREES	33 DEGREES
1	4.81E+07	2.03E+19	1.08E+19	9.87E+18
2	3.32E+07	3.44E+19	1.87E+19	1.73E+19
3	2.75E+07	4.60E+19	2.51E+19	2.34E+19
4	2.74E+07	5.70E+19	3.13E+19	2.92E+19
5	2.79E+07	6.87E+19	3.78E+19	3.52E+19
6	2.73E+07	7.74E+19	4.39E+19	4.11E+19
7	2.82E+07	8.66E+19	4.94E+19	4.63E+19
8	2.70E+07	9.55E+19	5.45E+19	5.11E+19
9	2.50E+07	1.04E+20	5.94E+19	5.56E+19
10	3.77E+07	1.16E+20	6.65E+19	6.24E+19
11	2.68E+07	1.23E+20	7.18E+19	6.73E+19
12	2.52E+07	1.31E+20	7.67E+19	7.16E+19
13	2.55E+07	1.38E+20	8.14E+19	7.58E+19
14	2.72E+07	1.46E+20	8.66E+19	8.06E+19
15	2.54E+07	1.53E+20	9.13E+19	8.47E+19
16	2.70E+07	1.60E+20	9.54E+19	8.86E+19
17	2.66E+07	1.66E+20	9.94E+19	9.24E+19

TABLE 4.2-9

CALCULATED FAST NEUTRON FLUX (E > 0.1 MeV) AT THE
PRESSURE VESSEL CLAD/BASE METAL INTERFACE

ϕ (E > 0.1 MeV) [n/cm2-sec]

CYCLE No	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
1	1.00E+11	6.31E+10	3.98E+10	3.34E+10
2	1.02E+11	6.45E+10	4.33E+10	3.68E+10
3	1.02E+11	6.38E+10	4.26E+10	3.67E+10
4	9.56E+10	6.04E+10	4.08E+10	3.45E+10
5	9.74E+10	6.33E+10	4.17E+10	3.27E+10
6	7.24E+10	5.08E+10	4.20E+10	3.42E+10
7	7.93E+10	5.03E+10	3.58E+10	3.28E+10
8	8.20E+10	5.07E+10	3.45E+10	3.12E+10
9	8.44E+10	5.27E+10	3.47E+10	3.17E+10
10	7.49E+10	4.81E+10	3.54E+10	3.17E+10
11	6.25E+10	4.66E+10	3.56E+10	2.95E+10
12	6.81E+10	4.84E+10	3.44E+10	2.75E+10
13	6.27E+10	4.51E+10	3.28E+10	2.65E+10
14	6.33E+10	4.63E+10	3.50E+10	3.05E+10
15	6.14E+10	4.49E+10	3.28E+10	2.59E+10
16	5.00E+10	3.60E+10	2.77E+10	2.43E+10
17	5.02E+10	3.61E+10	2.84E+10	2.56E+10

TABLE 4.2-10

CALCULATED FAST NEUTRON FLUENCE (E > 0.1 MeV) AT THE
PRESSURE VESSEL CLAD/BASE METAL INTERFACE

CYCLE No	CYCLE LENGTH (EFPS)	ϕ (E > 0.1 MeV) [n/cm2]			
		0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
1	4.81E+07	4.83E+18	3.03E+18	1.92E+18	1.61E+18
2	3.32E+07	8.22E+18	5.18E+18	3.35E+18	2.83E+18
3	2.75E+07	1.10E+19	6.93E+18	4.52E+18	3.84E+18
4	2.74E+07	1.36E+19	8.58E+18	5.64E+18	4.78E+18
5	2.79E+07	1.64E+19	1.03E+19	6.81E+18	5.70E+18
6	2.73E+07	1.83E+19	1.17E+19	7.95E+18	6.63E+18
7	2.82E+07	2.06E+19	1.32E+19	8.96E+18	7.55E+18
8	2.70E+07	2.28E+19	1.45E+19	9.89E+18	8.40E+18
9	2.50E+07	2.49E+19	1.58E+19	1.08E+19	9.19E+18
10	3.77E+07	2.77E+19	1.77E+19	1.21E+19	1.04E+19
11	2.68E+07	2.94E+19	1.89E+19	1.30E+19	1.12E+19
12	2.52E+07	3.11E+19	2.01E+19	1.39E+19	1.19E+19
13	2.55E+07	3.27E+19	2.13E+19	1.48E+19	1.25E+19
14	2.72E+07	3.44E+19	2.25E+19	1.57E+19	1.34E+19
15	2.54E+07	3.60E+19	2.37E+19	1.65E+19	1.40E+19
16	2.70E+07	3.73E+19	2.46E+19	1.73E+19	1.47E+19
17	2.66E+07	3.87E+19	2.55E+19	1.80E+19	1.54E+19

TABLE 4.2-11

CALCULATED FAST NEUTRON FLUX (E > 0.1 MeV) AT THE
CAVITY SENSOR SET LOCATIONS

ϕ (E > 0.1 MeV) [n/cm2-sec]

CYCLE No	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
1	2.13E+10	1.75E+10	1.23E+10	9.71E+09
2	2.17E+10	1.80E+10	1.32E+10	1.06E+10
3	2.15E+10	1.78E+10	1.30E+10	1.05E+10
4	2.02E+10	1.69E+10	1.24E+10	9.96E+09
5	2.08E+10	1.75E+10	1.26E+10	9.75E+09
6	1.58E+10	1.43E+10	1.22E+10	9.84E+09
7	1.68E+10	1.42E+10	1.09E+10	9.12E+09
8	1.72E+10	1.43E+10	1.06E+10	8.76E+09
9	1.78E+10	1.47E+10	1.08E+10	8.89E+09
10	1.59E+10	1.35E+10	1.07E+10	8.90E+09
11	1.39E+10	1.27E+10	1.05E+10	8.52E+09
12	1.49E+10	1.33E+10	1.03E+10	8.08E+09
13	1.37E+10	1.23E+10	9.79E+09	7.72E+09
14	1.40E+10	1.27E+10	1.04E+10	8.63E+09
15	1.36E+10	1.23E+10	9.73E+09	7.61E+09
16	1.10E+10	1.00E+10	8.30E+09	6.89E+09
17	1.11E+10	1.01E+10	8.51E+09	7.16E+09

TABLE 4.2-12

CALCULATED FAST NEUTRON FLUENCE (E > 0.1 MeV) AT THE
CAVITY SENSOR SET LOCATIONS

CYCLE No	CYCLE LENGTH (EFPS)	Φ (E > 0.1 MeV) [n/cm2]			
		0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
1	4.81E+07	1.02E+18	8.42E+17	5.94E+17	4.67E+17
2	3.32E+07	1.74E+18	1.44E+18	1.03E+18	8.18E+17
3	2.75E+07	2.33E+18	1.93E+18	1.39E+18	1.11E+18
4	2.74E+07	2.89E+18	2.39E+18	1.73E+18	1.38E+18
5	2.79E+07	3.47E+18	2.88E+18	2.08E+18	1.65E+18
6	2.73E+07	3.90E+18	3.27E+18	2.42E+18	1.92E+18
7	2.82E+07	4.37E+18	3.67E+18	2.72E+18	2.18E+18
8	2.70E+07	4.84E+18	4.06E+18	3.01E+18	2.41E+18
9	2.50E+07	5.28E+18	4.42E+18	3.28E+18	2.64E+18
10	3.77E+07	5.88E+18	4.93E+18	3.68E+18	2.97E+18
11	2.68E+07	6.25E+18	5.28E+18	3.97E+18	3.20E+18
12	2.52E+07	6.63E+18	5.61E+18	4.23E+18	3.40E+18
13	2.55E+07	6.98E+18	5.92E+18	4.48E+18	3.60E+18
14	2.72E+07	7.36E+18	6.27E+18	4.76E+18	3.84E+18
15	2.54E+07	7.71E+18	6.58E+18	5.01E+18	4.03E+18
16	2.70E+07	8.00E+18	6.85E+18	5.23E+18	4.22E+18
17	2.66E+07	8.30E+18	7.12E+18	5.46E+18	4.41E+18

TABLE 4.2-13

CALCULATED IRON ATOM DISPLACEMENT RATE AT THE
CENTER OF REACTOR VESSEL SURVEILLANCE CAPSULES

Displacement Rate [dpa/sec]

CYCLE No	13 DEGREES	23 DEGREES	33 DEGREES
1	2.04E-10	1.14E-10	1.03E-10
2	2.06E-10	1.20E-10	1.13E-10
3	2.05E-10	1.18E-10	1.12E-10
4	1.94E-10	1.14E-10	1.07E-10
5	2.03E-10	1.19E-10	1.07E-10
6	1.56E-10	1.12E-10	1.10E-10
7	1.57E-10	9.82E-11	9.28E-11
8	1.59E-10	9.64E-11	8.87E-11
9	1.65E-10	9.82E-11	8.98E-11
10	1.49E-10	9.62E-11	9.19E-11
11	1.41E-10	9.93E-11	9.06E-11
12	1.48E-10	9.87E-11	8.66E-11
13	1.37E-10	9.32E-11	8.19E-11
14	1.41E-10	9.69E-11	8.93E-11
15	1.36E-10	9.37E-11	8.17E-11
16	1.09E-10	7.59E-11	7.14E-11
17	1.09E-10	7.70E-11	7.33E-11

TABLE 4.2-14

CALCULATED IRON ATOM DISPLACEMENTS AT THE
CENTER OF REACTOR VESSEL SURVEILLANCE CAPSULES

	CYCLE LENGTH	Displacements [dpa]		
CYCLE No	(EFPS)	13 DEGREES	23 DEGREES	33 DEGREES
1	4.81E+07	9.81E-03	5.46E-03	4.96E-03
2	3.32E+07	1.67E-02	9.45E-03	8.71E-03
3	2.75E+07	2.23E-02	1.27E-02	1.18E-02
4	2.74E+07	2.76E-02	1.58E-02	1.47E-02
5	2.79E+07	3.33E-02	1.91E-02	1.77E-02
6	2.73E+07	3.75E-02	2.22E-02	2.07E-02
7	2.82E+07	4.19E-02	2.50E-02	2.33E-02
8	2.70E+07	4.62E-02	2.76E-02	2.57E-02
9	2.50E+07	5.04E-02	3.00E-02	2.79E-02
10	3.77E+07	5.60E-02	3.36E-02	3.14E-02
11	2.68E+07	5.98E-02	3.63E-02	3.38E-02
12	2.52E+07	6.35E-02	3.88E-02	3.60E-02
13	2.55E+07	6.70E-02	4.12E-02	3.81E-02
14	2.72E+07	7.08E-02	4.38E-02	4.05E-02
15	2.54E+07	7.42E-02	4.62E-02	4.26E-02
16	2.70E+07	7.73E-02	4.82E-02	4.45E-02
17	2.66E+07	8.02E-02	5.03E-02	4.65E-02

TABLE 4.2-15

CALCULATED IRON ATOM DISPLACEMENT RATE AT THE
PRESSURE VESSEL CLAD/BASE METAL INTERFACE

Displacement Rate [dpa/sec]

CYCLE No	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
1	6.09E-11	3.67E-11	2.45E-11	2.11E-11
2	6.20E-11	3.76E-11	2.66E-11	2.32E-11
3	6.17E-11	3.71E-11	2.62E-11	2.31E-11
4	5.80E-11	3.51E-11	2.51E-11	2.18E-11
5	5.91E-11	3.69E-11	2.56E-11	2.07E-11
6	4.39E-11	2.96E-11	2.58E-11	2.15E-11
7	4.81E-11	2.93E-11	2.20E-11	2.07E-11
8	4.97E-11	2.95E-11	2.12E-11	1.97E-11
9	5.12E-11	3.07E-11	2.14E-11	2.00E-11
10	4.55E-11	2.80E-11	2.18E-11	2.00E-11
11	3.79E-11	2.71E-11	2.19E-11	1.86E-11
12	4.13E-11	2.82E-11	2.11E-11	1.73E-11
13	3.80E-11	2.63E-11	2.01E-11	1.67E-11
14	3.84E-11	2.69E-11	2.15E-11	1.93E-11
15	3.72E-11	2.61E-11	2.02E-11	1.63E-11
16	3.04E-11	2.12E-11	1.75E-11	1.61E-11
17	3.04E-11	2.12E-11	1.75E-11	1.61E-11

TABLE 4.2-16

CALCULATED IRON ATOM DISPLACEMENTS AT THE
PRESSURE VESSEL CLAD/BASE METAL INTERFACE

CYCLE No	CYCLE LENGTH (EFPS)	Displacements [dpa]			
		0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
1	4.81E+07	2.93E-03	1.77E-03	1.18E-03	1.01E-03
2	3.32E+07	4.99E-03	3.01E-03	2.06E-03	1.78E-03
3	2.75E+07	6.69E-03	4.03E-03	2.78E-03	2.42E-03
4	2.74E+07	8.28E-03	5.00E-03	3.47E-03	3.02E-03
5	2.79E+07	9.92E-03	6.03E-03	4.18E-03	3.59E-03
6	2.73E+07	1.11E-02	6.83E-03	4.89E-03	4.18E-03
7	2.82E+07	1.25E-02	7.66E-03	5.51E-03	4.76E-03
8	2.70E+07	1.38E-02	8.46E-03	6.08E-03	5.30E-03
9	2.50E+07	1.51E-02	9.22E-03	6.62E-03	5.80E-03
10	3.77E+07	1.68E-02	1.03E-02	7.44E-03	6.55E-03
11	2.68E+07	1.78E-02	1.10E-02	8.02E-03	7.05E-03
12	2.52E+07	1.89E-02	1.17E-02	8.56E-03	7.49E-03
13	2.55E+07	1.98E-02	1.24E-02	9.07E-03	7.91E-03
14	2.72E+07	2.09E-02	1.31E-02	9.66E-03	8.44E-03
15	2.54E+07	2.18E-02	1.38E-02	1.02E-02	8.85E-03
16	2.70E+07	2.27E-02	1.44E-02	1.06E-02	9.26E-03
17	2.66E+07	2.35E-02	1.50E-02	1.11E-02	9.69E-03

TABLE 4.2-17

CALCULATED IRON ATOM DISPLACEMENT RATE AT THE
CAVITY SENSOR SET LOCATIONS

Displacement rate [dpa/sec]

CYCLE No	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
1	8.12E-12	6.57E-12	4.62E-12	3.69E-12
2	8.27E-12	6.76E-12	4.94E-12	4.02E-12
3	8.21E-12	6.67E-12	4.86E-12	4.00E-12
4	7.71E-12	6.34E-12	4.65E-12	3.78E-12
5	7.93E-12	6.56E-12	4.72E-12	3.70E-12
6	6.04E-12	5.36E-12	4.58E-12	3.74E-12
7	6.39E-12	5.34E-12	4.07E-12	3.46E-12
8	6.57E-12	5.35E-12	3.98E-12	3.33E-12
9	6.80E-12	5.53E-12	4.05E-12	3.38E-12
10	6.07E-12	5.09E-12	4.02E-12	3.38E-12
11	5.30E-12	4.78E-12	3.94E-12	3.24E-12
12	5.69E-12	4.99E-12	3.87E-12	3.07E-12
13	5.25E-12	4.62E-12	3.67E-12	2.93E-12
14	5.34E-12	4.78E-12	3.90E-12	3.28E-12
15	5.18E-12	4.60E-12	3.64E-12	2.89E-12
16	4.22E-12	3.75E-12	3.10E-12	2.62E-12
17	4.23E-12	3.77E-12	3.18E-12	2.72E-12

TABLE 4.2-18

CALCULATED IRON ATOM DISPLACEMENTS AT THE
CAVITY SENSOR SET LOCATIONS

	CYCLE LENGTH	Displacements [dpa]			
CYCLE No	(EFPS)	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
1	4.81E+07	3.90E-04	3.16E-04	2.22E-04	1.77E-04
2	3.32E+07	6.65E-04	5.41E-04	3.86E-04	3.11E-04
3	2.75E+07	8.91E-04	7.24E-04	5.20E-04	4.21E-04
4	2.74E+07	1.10E-03	8.98E-04	6.48E-04	5.24E-04
5	2.79E+07	1.32E-03	1.08E-03	7.79E-04	6.28E-04
6	2.73E+07	1.49E-03	1.23E-03	9.04E-04	7.30E-04
7	2.82E+07	1.67E-03	1.38E-03	1.02E-03	8.27E-04
8	2.70E+07	1.85E-03	1.52E-03	1.13E-03	9.17E-04
9	2.50E+07	2.02E-03	1.66E-03	1.23E-03	1.00E-03
10	3.77E+07	2.24E-03	1.85E-03	1.38E-03	1.13E-03
11	2.68E+07	2.39E-03	1.98E-03	1.48E-03	1.22E-03
12	2.52E+07	2.53E-03	2.11E-03	1.58E-03	1.29E-03
13	2.55E+07	2.66E-03	2.22E-03	1.68E-03	1.37E-03
14	2.72E+07	2.81E-03	2.35E-03	1.78E-03	1.46E-03
15	2.54E+07	2.94E-03	2.47E-03	1.87E-03	1.53E-03
16	2.70E+07	3.05E-03	2.57E-03	1.96E-03	1.60E-03
17	2.66E+07	3.17E-03	2.67E-03	2.04E-03	1.67E-03

SECTION 5.0

EVALUATIONS OF SURVEILLANCE CAPSULE DOSIMETRY

In this section, the results of the evaluations of the four neutron sensor
sets withdrawn as a part of the Point Beach Unit 2 Reactor Vessel
Materials Surveillance Program are presented. The capsule designation,
location within the reactor, and time of withdrawal of each of these
dosimetry sets were as follows:

CAPSULE ID	AZIMUTHAL LOCATION	WITHDRAWAL TIME	IRRADIATION TIME (EFPS)
V	13 DEGREES	END OF CYCLE 1	4.81E+07
T	23 DEGREES	END OF CYCLE 3	1.09E+08
R	13 DEGREES	END OF CYCLE 5	1.64E+08
S	33 DEGREES	END OF CYCLE 16	4.66E+08

5.1 - Measured Reaction Rates

With the exception of Capsule V, radiometric counting of each of these
data sets was accomplished by Westinghouse [35, through 37] using t
procedures discussed in Section 3.0 of this report. The measured specific
activities are included in Appendix A to this report. Radiometric
counting of the sensors from Capsule V, on the other hand, was carried out
by the Battelle Memorial Institute [38]. However, in this case, the
measured specific activities were not published.

The irradiation history of the Point Beach Unit 2 reactor during the first
16 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 T, R, and S),
the flux level adjustment factors for each cycle are also tabulated in

5-1

Appendix A. These adjustment factors were determined from the fuel cycle specific adjoint calculations described in Section 4.0 of this report.

Based on the irradiation history and associated flux level adjustment factors, the individual sensor characteristics, and the measured specific activities, reaction rates averaged over the appropriate irradiation periods and referenced to a core power level of 1518 MWt were computed for the sensor sets removed from Capsules T, R, and S. In the case of Capsule V, reaction rates were developed directly from the derived neutron flux and spectrum averaged reaction cross-sections reported in Reference 38. 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 U-238 sensors include corrections for U-235 impurities, for the build-in of Plutonium isotopes during the long irradiations, and for the effects of γ,f reactions. Likewise, the fission rate measurements for the Np-237 include adjustments for γ,f reactions occuring over the respective irradiation periods.

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 Tables 5.2-1 through 5.2-4. In these tables, the derived exposure experienced by each capsule along with data illustrating the fit of both the a priori 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 5.2-1 through 5.2-4, it should be noted that the columns labeled "a priori calc" were obtained by normalizing the neutron spectral data from Table 4.1-3 to the measured

Fe-54 (n,p) reaction rates from each sensor set as discussed in Section 3.0. Thus, the comparisons illustrated in Tables 5.2-1 through 5.2-4 indicate only the degree to which the relative neutron energy spectra matched the measured sensor data before and after adjustment. These data are not meant to provide an absolute comparison of calculation and measurement. Absolute comparisons are discussed in Section 7.0 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	CAPSULE V	CAPSULE T	CAPSULE R	CAPSULE S
*Cu63(nα)Co60	6.28E-17	4.86E-17	6.78E-17	4.29E-17
*Fe54(np)Mn54	7.74E-15	5.53E-15	7.79E-15	
*Ni58(np)Co58		7.29E-15	1.11E-14	7.14E-15
U238(nf)Cs137	5.04E-14	2.71E-14	4.64E-14	2.52E-14
Np237(nf)Cs137	3.93E-13	2.30E-13	4.12E-13	1.88E-13
*Co59(nγ)Co60	7.63E-12	5.08E-12	9.39E-12	3.78E-12
Co59(nγ)Co60	3.21E-12	2.02E-12	3.93E-12	1.68E-12

* - Bare foil, all others were cadmium covered

TABLE 5.2-1

DERIVED EXPOSURE RATES FROM SURVEILLANCE CAPSULE V DOSIMETRY
WITHDRAWN AT THE END OF FUEL CYCLE 1

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	1.24E+11	1.48E+11	6%
ϕ (E > 0.1 Mev)	4.76E+11	5.36E+11	13%
ϕ (E < 0.414 ev)	1.65E+11	1.82E+11	19%
ϕ (Total)	1.23E+12	1.28E+12	13%
dpa/sec	2.24E-10	2.53E-10	9%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
SURVEILLANCE CAPSULE V

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	6.28E-17	8.67E-17	6.41E-17	1.38	1.02
Fe-54 (n,p)	7.74E-15	8.14E-15	7.88E-15	1.05	1.02
U-238 (n,f) (Cd)	5.04E-14	4.08E-14	4.78E-14	0.81	0.95
Np-237 (n,f) (Cd)	3.93E-13	3.65E-13	4.01E-13	0.93	1.02
Co-59 (n,γ)	7.63E-12	7.09E-12	7.62E-12	0.93	1.00
Co-59 (n,γ) (Cd)	3.21E-12	3.15E-12	3.21E-12	0.98	1.00

TABLE 5.2-2

DERIVED EXPOSURE RATES FROM SURVEILLANCE CAPSULE T DOSIMETRY
WITHDRAWN AT THE END OF FUEL CYCLE 3

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	7.43E+10	8.23E+10	6%
ϕ (E > 0.1 Mev)	2.62E+11	2.84E+11	13%
ϕ (E < 0.414 ev)	8.57E+10	1.23E+11	18%
u (Total)	6.48E+11	7.26E+11	13%
dpa/sec	1.29E-10	1.40E-10	8%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
SURVEILLANCE CAPSULE T

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	4.86E-17	6.64E-17	5.04E-17	1.37	1.04
Fe-54 (n,p)	5.50E-15	5.31E-15	5.34E-15	0.97	0.97
Ni-58 (n,p)	7.29E-15	7.08E-15	7.21E-15	0.97	0.99
U-238 (n,f) (Cd)	2.71E-14	2.53E-14	2.73E-14	0.93	1.01
Np-237 (n,f) (Cd)	2.30E-13	2.10E-13	2.31E-13	0.91	1.00
Co-59 (n,γ)	5.08E-12	3.66E-12	5.07E-12	0.72	1.00
Co-59 (n,γ) (Cd)	2.02E-12	1.60E-12	2.02E-12	0.79	1.00

TABLE 5.2-3

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

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	1.28E+11	1.42E+11	6%
ϕ (E > 0.1 Mev)	4.90E+11	5.40E+11	13%
ϕ (E < 0.414 ev)	1.69E+11	2.22E+11	18%
ϕ (Total)	1.26E+12	1.40E+12	13%
dpa/sec	2.31E-10	2.51E-10	9%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES SURVEILLANCE CAPSULE R

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	6.78E-17	8.92E-17	6.90E-17	1.32	1.02
Fe-54 (n,p)	7.79E-15	8.37E-15	7.89E-15	1.07	1.01
Ni-58 (n,p)	1.11E-14	1.13E-14	1.10E-14	1.01	0.99
U-238 (n,f) (Cd)	4.64E-14	4.19E-14	4.52E-14	0.90	0.98
Np-237 (n,f) (Cd)	4.06E-13	3.76E-13	4.10E-13	0.93	1.01
Co-59 (n,γ)	9.39E-12	7.30E-12	9.37E-12	0.78	1.00
Co-59 (n,γ) (Cd)	3.93E-12	3.24E-12	3.92E-12	0.82	1.00

TABLE 5.2-4

DERIVED EXPOSURE RATES FROM SURVEILLANCE CAPSULE S DOSIMETRY WITHDRAWN AT THE END OF FUEL CYCLE 16

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	7.48E+10	7.44E+10	6%
ϕ (E > 0.1 Mev)	2.66E+11	2.41E+11	13%
ϕ (E < 0.414 ev)	8.58E+10	8.64E+10	19%
ϕ (Total)	6.58E+11	6.01E+11	13%
dpa/sec	1.30E-10	1.22E-10	8%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES SURVEILLANCE CAPSULE S

REACTION	REACTION RATE (rps/nucleus)			C/M	
	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	4.29E-17	6.39E-17	4.45E-17	1.49	1.04
Ni-58 (n,p)	7.14E-14	6.96E-14	6.86E-14	0.98	0.96
U-238 (n,f) (Cd)	2.52E-14	2.52E-14	2.50E-14	1.00	0.99
Np-237 (n,f) (Cd)	1.88E-13	2.12E-13	1.92E-13	1.13	1.02
Co-59 (n,γ)	3.78E-12	3.69E-12	3.78E-12	0.98	1.00
Co-59 (n,γ) (Cd)	1.68E-12	1.63E-12	1.68E-12	0.97	1.00

SECTION 6.0

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 Point Beach Unit 2 the program was initiated at the beginning of Fuel Cycle 15; and, to date, has included measurement evaluations at the conclusion of Cycles 15, 16, and 17. The evaluation of each set of data was accomplished using a consistent approach based on the methodology discussed in Section 3.0, resulting in an accurate data base defining the exposure of the reactor vessel wall.

6.1 - Cycle 15 Results

6.1.1 - Measured Reaction rates

During the Cycle 15 irradiation, seven multiple foil sensor sets and four stainless steel gradient chains were deployed in the reactor as depicted in Figures 2.1-1 and 2.1-2. The capsule identifications associated with each of the multiple foil sensor sets were as follows [1]:

AZIMUTH (degrees)	VESSEL SUPPORT	CAPSULE IDENTIFICATION CORE TOP	CORE MIDPLANE	CORE BOTTOM
0	XX	G	H	I
15			J	
30			K	
45			L	

The contents of each of these irradiation capsules is specified in Reference 1 and, for completeness, is also included in Appendix B to this report.

The irradiation history of the Point Beach Unit 2 reactor during Cycle 15 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 1518 MWt were computed for each multiple foil sensor and gradient chain segment.

The computed reaction rates for the multiple foil sensor sets, including radiometric foils and solid state track recorders, irradiated during Cycle 15 are provided in Table 6.1-1. Corresponding reaction rate data from the the four stainless steel gradient gradient chains are recorded in Tables 6.1-2 through 6.1-4 for the Fe-54 (n,p), Ni-58 (n,p), and Co-59 (n,γ) reactions. respectively.

In regard to the data listed in Table 6.1-1, the Fe-54 (n,p) reaction rates represent an average of the bare and cadmium covered measurements for each capsule. Likewise, the U-238 (n,f) and Np-237 (n,f) reaction rates were obtained by averaging the results of the radiometric foil and solid state track recorder data. In addition, the fission rate measurements include corrections for U-235 impurities and the effects of γ,f reactions in the U-238 sensors as well for the effects of γ,f reactions in the Np-237 monitors.

6.1.2 - 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 15 irradiation are provided in Tables 6.1-5 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 a priori 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 6.1-5 through 6.1-11, it should be noted that the columns labeled "a priori calc" were obtained by normalizing the neutron spectral data from Table 4.1-1 to the measured Fe-54 (n,p) reaction rates from each sensor set as discussed in Section 3.0. Thus, the comparisons illustrated in Tables 6.1-5 through 6.1-11 indicate only the degree to which the relative neutron energy spectra matched the measured data before and after adjustment. These data are not meant to provide an absolute comparison of calculation and measurement. Absolute comparisons are discussed in Section 7.0 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 Fe-54 (n,p) and Ni-58 (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 ϕ (E > 1.0 MeV), ϕ (E > 0.1 MeV), and dpa/sec in the reactor cavity.

The resultant axial distributions of ϕ (E > 1.0 MeV), ϕ (E > 0.1 MeV), and dpa/sec are given in Tables 6.1-12, 6.1-13, and 6-14, respectively. The distributions of ϕ (E > 1.0 MeV) are depicted graphically in Figures 6.1-1 through 6.1-4. In these graphical presentations, the solid symbols represent the explicit results of the FERRET evaluations, while the open symbols depict the normalized data from the gradient chains.

TABLE 6.1-1

SUMMARY OF REACTION RATES DERIVED FROM MULTIPLE FOIL SENSOR SETS
IRRADIATED DURING CYCLE 15

REACTION RATE (rps/nucleus)

REACTION	CAPSULE H	CAPSULE J	CAPSULE K	CAPSULE L	CAPSULE G	CAPSULE I	CAPSULE XX
Cu63(n,α)	1.07E-18	9.86E-19	7.45E-19	7.15E-19	3.86E-19	3.83E-19	3.72E-20
Ti46(n,p)	1.62E-17	1.49E-17	1.12E-17	1.06E-17	6.44E-18	6.37E-18	6.11E-19
Fe54(n,p)	9.46E-17	8.49E-17	6.56E-17	5.51E-17	3.38E-17	3.62E-17	3.75E-18
Ni58(n,p)	1.38E-16	1.21E-16	9.00E-17	8.04E-17	5.34E-17	5.23E-17	5.91E-18
U238(n,f)	5.21E-16	4.54E-16	3.35E-16	3.11E-16	2.08E-16	1.87E-16	2.38E-17
Np237(n,f)	7.60E-15	7.55E-15	5.31E-15	4.63E-15	3.21E-15	3.06E-15	7.20E-16
*Co59(n,γ)	1.13E-13	1.42E-13	1.16E-13	7.34E-14	3.86E-14	4.53E-14	1.41E-14
Co59(n,γ)	6.71E-14	8.12E-14	6.60E-14	4.81E-14	2.85E-14	2.94E-14	1.01E-14
*U235(nf)	9.61E-13	1.18E-12	1.19E-12	5.45E-13	3.09E-13	3.52E-13	1.16E-13
U235(nf)	3.12E-13	4.05E-13	3.12E-13	2.05E-13	8.25E-14	7.52E-14	5.16E-14

* - Bare foil, all others were cadmium covered

TABLE 6.1-2

Fe-54 (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL
GRADIENT CHAINS IRRADIATED DURING CYCLE 15

FEET FROM MIDPLANE	REACTION RATE (rps/nucleus)			
	0 DEG	15 DEG	30 DEG	45 DEG
+6.5	1.98E-17	1.53E-17	1.30E-17	1.14E-17
+5.5	4.83E-17	4.24E-17	3.16E-17	2.64E-17
+4.5	7.08E-17	6.44E-17	4.85E-17	4.24E-17
+3.5	8.29E-17	7.14E-17	5.34E-17	4.71E-17
+2.5	9.25E-17	7.72E-17	5.70E-17	5.20E-17
+1.5	9.12E-17	7.59E-17	5.43E-17	4.97E-17
+0.5	8.87E-17	7.65E-17	5.49E-17	4.99E-17
-0.5	9.25E-17	8.16E-17	5.93E-17	5.13E-17
-1.5	8.48E-17	7.91E-17	5.66E-17	5.03E-17
-2.5	8.10E-17	7.84E-17	6.01E-17	4.95E-17
-3.5	7.97E-17	7.33E-17	5.14E-17	4.72E-17
-4.5	7.14E-17	6.70E-17	4.50E-17	4.52E-17
-5.5	4.82E-17	4.30E-17	2.84E-17	2.83E-17
-6.5	1.77E-17	1.65E-17	1.24E-17	1.17E-17

TABLE 6.1-3

Ni-58 (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL GRADIENT CHAINS IRRADIATED DURING CYCLE 15

FEET FROM MIDPLANE	REACTION RATE (rps/nucleus)			
	0 DEG	15 DEG	30 DEG	45 DEG
+6.5	2.95E-17	2.34E-17	1.91E-17	1.76E-17
+5.5	7.33E-17	5.80E-17	4.87E-17	4.06E-17
+4.5	1.08E-16	9.37E-17	6.93E-17	6.14E-17
+3.5	1.20E-16	1.01E-16	7.78E-17	6.82E-17
+2.5	1.32E-16	1.14E-16	8.41E-17	7.33E-17
+1.5	1.30E-16	1.12E-16	8.52E-17	7.16E-17
+0.5	1.22E-16	1.10E-16	8.07E-17	7.10E-17
-0.5	1.28E-16	1.15E-16	8.35E-17	7.50E-17
-1.5	1.18E-16	1.11E-16	8.07E-17	7.22E-17
-2.5	1.21E-16	1.06E-16	8.01E-17	7.10E-17
-3.5	1.15E-16	1.06E-16	7.61E-17	6.59E-17
-4.5	1.06E-16	9.72E-17	6.82E-17	6.19E-17
-5.5	7.10E-17	6.42E-17	4.51E-17	4.29E-17
-6.5	2.78E-17	2.56E-17	1.88E-17	1.72E-17

TABLE 6.1-4

Co-59 (n,γ) REACTION RATES DERIVED FROM THE STAINLESS STEEL GRADIENT CHAINS IRRADIATED DURING CYCLE 15

FEET FROM MIDPLANE	REACTION RATE (rps/nucleus)			
	0 DEG	15 DEG	30 DEG	45 DEG
+6.5	2.40E-14	2.47E-14	2.18E-14	1.83E-14
+5.5	5.40E-14	7.97E-14	6.11E-14	3.75E-14
+4.5	6.95E-14	1.15E-13	8.76E-14	5.21E-14
+3.5	8.54E-14	1.33E-13	1.03E-13	5.99E-14
+2.5	9.50E-14	1.44E-13	1.10E-13	6.73E-14
+1.5	9.78E-14	1.44E-13	1.15E-13	7.07E-14
+0.5	1.01E-13	1.40E-13	1.19E-13	7.07E-14
-0.5	1.14E-13	1.44E-13	1.17E-13	7.18E-14
-1.5	1.06E-13	1.37E-13	1.14E-13	7.01E-14
-2.5	1.01E-13	1.29E-13	1.09E-13	6.73E-14
-3.5	9.27E-14	1.20E-13	9.89E-14	6.16E-14
-4.5	7.46E-14	1.00E-13	7.86E-14	5.11E-14
-5.5	4.94E-14	7.12E-14	4.21E-14	3.63E-14
-6.5	3.81E-14	3.86E-14	2.93E-14	2.76E-14

TABLE 6.1-5

DERIVED EXPOSURE RATES FROM THE CAPSULE H DOSIMETRY EVALUATION
0 DEGREE AZIMUTH - CORE MIDPLANE

	A PRIORI	ADJUSTED	
PARAMETER	VALUE	VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	1.89E+09	1.87E+09	
ϕ (E > 0.1 Mev)	1.52E+10	1.38E+10	14%
ϕ (E < 0.414 ev)	2.89E+09	1.83E+09	24%
ϕ (Total)	4.13E+10	3.77E+10	14%
dpa/sec	6.35E-12	5.87E-12	12%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
0 DEGREE AZIMUTH - CORE MIDPLANE

	REACTION RATE (rps/nucleus)			C/M	
		A PRIORI	ADJUSTED		
REACTION	MEASURED	CALC.	CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	1.07E-18	1.41E-18	1.12E-18	1.32	1.04
Ti-46 (n,p)	1.62E-17	1.70E-17	1.60E-17	1.05	0.99
Fe-54 (n,p)	9.46E-17	9.35E-17	9.28E-17	0.99	0.98
Ni-58 (n,p)	1.38E-16	1.28E-16	1.33E-16	0.93	0.97
U-238 (n,f) (Cd)	5.21E-16	5.47E-16	5.37E-16	1.05	1.03
Np-237 (n,f) (Cd)	7.60E-15	8.11E-15	7.62E-15	1.07	1.00
Co-59 (n,γ)	1.13E-13	1.54E-13	1.14E-13	1.37	1.01
Co-59 (n,γ) (Cd)	6.71E-14	7.73E-14	6.72E-14	1.15	1.00
U-235 (n,f)	9.61E-13	1.40E-12	9.61E-13	1.46	1.00
U-235 (n,f) (Cd)	3.12E-13	2.96E-13	3.09E-13	0.95	0.99

TABLE 6.1-6

DERIVED EXPOSURE RATES FROM THE CAPSULE J DOSIMETRY EVALUATION
15 DEGREE AZIMUTH - CORE MIDPLANE

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	1.76E+09	1.69E+09	6%
ϕ (E > 0.1 Mev)	1.58E+10	1.45E+10	15%
ϕ (E < 0.414 ev)	2.86E+09	2.29E+09	24%
ϕ (Total)	3.85E+10	3.82E+10	12%
dpa/sec	5.60E-12	5.21E-12	11%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
15 DEGREE AZIMUTH - CORE MIDPLANE

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	9.86E-19	1.28E-18	1.03E-18	1.30	1.05
Ti-46 (n,p)	1.49E-17	1.53E-17	1.46E-17	1.03	0.98
Fe-54 (n,p)	8.49E-17	8.41E-17	8.26E-17	0.99	0.97
Ni-58 (n,p)	1.21E-16	1.16E-16	1.17E-16	0.96	0.97
U-238 (n,f) (Cd)	4.54E-16	5.01E-16	4.73E-16	1.10	1.04
Np-237 (n,f) (Cd)	7.55E-15	7.97E-15	7.54E-15	1.06	1.00
Co-59 (n,γ)	1.42E-13	1.61E-13	1.40E-13	1.14	0.98
Co-59 (n,γ) (Cd)	8.12E-14	8.63E-14	8.26E-14	1.06	1.02
U-235 (n,f)	1.18E-12	1.38E-12	1.19E-12	1.17	1.01
U-235 (n,f) (Cd)	4.05E-13	3.16E-13	3.98E-13	0.78	0.98

TABLE 6.1-7

DERIVED EXPOSURE RATES FROM THE CAPSULE K DOSIMETRY EVALUATION
30 DEGREE AZIMUTH - CORE MIDPLANE

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	1.30E+09	1.23E+09	6%
ϕ (E > 0.1 Mev)	1.16E+10	1.02E+10	15%
ϕ (E < 0.414 ev)	2.22E+09	2.24E+09	22%
ϕ (Total)	2.92E+10	2.87E+10	12%
dpa/sec	4.11E-12	3.69E-12	11%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
30 DEGREE AZIMUTH - CORE MIDPLANE

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	7.45E-19	1.03E-18	7.83E-19	1.38	1.05
Ti-46 (n,p)	1.12E-17	1.21E-17	1.11E-17	1.08	0.99
Fe-54 (n,p)	6.56E-17	6.45E-17	6.28E-17	0.98	0.96
Ni-58 (n,p)	9.00E-17	8.83E-17	8.77E-17	0.98	0.97
U-238 (n,f) (Cd)	3.35E-16	3.72E-16	3.49E-16	1.11	1.04
Np-237 (n,f) (Cd)	5.31E-15	5.85E-15	5.32E-15	1.10	1.00
Co-59 (n,γ)	1.16E-13	1.26E-13	1.23E-13	1.09	1.06
Co-59 (n,γ) (Cd)	6.60E-14	6.80E-14	6.44E-14	1.03	0.98
U-235 (n,f)	1.19E-12	1.08E-12	1.15E-12	0.90	0.97
U-235 (n,f) (Cd)	3.12E-13	2.49E-13	3.11E-13	0.80	1.00

TABLE 6.1-8

DERIVED EXPOSURE RATES FROM THE CAPSULE L DOSIMETRY EVALUATION
45 DEGREE AZIMUTH - CORE MIDPLANE

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	1.03E+09	1.10E+09	6%
ϕ (E > 0.1 Mev)	8.66E+09	8.66E+09	14%
ϕ (E < 0.414 ev)	1.95E+09	9.89E+08	25%
ϕ (Total)	2.20E+10	2.12E+10	12%
dpa/sec	3.12E-12	3.15E-12	11%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
45 DEGREE AZIMUTH - CORE MIDPLANE

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	7.15E-19	9.03E-19	7.44E-19	1.26	1.04
Ti-46 (n,p)	1.06E-17	1.05E-17	1.04E-17	0.99	0.98
Fe-54 (n,p)	5.51E-17	5.41E-17	5.50E-17	0.98	1.00
Ni-58 (n,p)	8.04E-17	7.37E-17	7.83E-17	0.92	0.97
U-238 (n,f) (Cd)	3.?1E-16	3.01E-16	3.16E-16	0.97	1.02
Np-237 (n,f) (Cd)	4.63E-15	4.48E-15	4.64E-15	0.97	1.00
Co-59 (n,γ)	7.34E-14	1.03E-13	7.34E-14	1.41	1.00
Co-59 (n,γ) (Cd)	4.81E-14	5.13E-14	4.82E-14	1.07	1.00
U-235 (n,f)	5.45E-13	9.35E-13	5.47E-13	1.72	1.00
U-235 (n,f) (Cd)	2.05E-13	1.88E-13	2.03E-13	0.92	0.99

TABLE 6.1-9

DERIVED EXPOSURE RATES FROM THE CAPSULE G DOSIMETRY EVALUATION
0 DEGREE AZIMUTH - CORE TOP

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	6.75E+08	7.56E+08	6%
ϕ (E > 0.1 Mev)	5.43E+09	5.60E+09	14%
ϕ (E < 0.414 ev)	1.03E+09	5.63E+08	22%
ϕ (Total)	1.47E+10	1.33E+10	14%
dpa/sec	2.27E-12	2.33E-12	12%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
0 DEGREE AZIMUTH - CORE TOP

	REACTION RATE (rps/nucleus)			C/M	
		A PRIORI	ADJUSTED		
REACTION	MEASURED	CALC.	CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	3.86E-19	5.04E-19	4.05E-19	1.31	1.05
Ti-46 (n,p)	6.44E-18	6.07E-18	6.21E-18	0.94	0.96
Fe-54 (n,p)	3.38E-17	3.34E-17	3.44E-17	0.99	1.02
Ni-58 (n,p)	5.34E-17	4.58E-17	5.12E-17	0.86	0.96
U-238 (n,f) (Cd)	2.08E-16	1.95E-16	2.12E-16	0.94	1.02
Np-237 (n,f) (Cd)	3.21E-15	2.89E-15	3.19E-15	0.90	0.99
Co-59 (n,γ)	3.86E-14	5.51E-14	4.22E-14	1.43	1.09
Co-59 (n,γ) (Cd)	2.85E-14	2.76E-14	2.69E-14	0.97	0.94
U-235 (n,f)	3.09E-13	5.00E-13	2.98E-13	1.62	0.96
U-235 (n,f) (Cd)	8.25E-14	1.06E-13	8.41E-14	1.28	1.02

TABLE 6.1-10

DERIVED EXPOSURE RATES FROM THE CAPSULE I DOSIMETRY EVALUATION
O DEGREE AZIMUTH - CORE BOTTOM

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	7.24E+08	7.04E+08	6%
ϕ (E > 0.1 Mev)	5.83E+09	5.16E+09	14%
ϕ (E < 0.414 ev)	1.11E+09	6.86E+08	20%
ϕ (Total)	1.58E+10	1.26E+10	14%
dpa/sec	2.43E-12	2.17E-12	12%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
O DEGREE AZIMUTH - CORE BOTTOM

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	3.83E-19	5.41E-19	4.05E-19	1.41	1.06
Ti-46 (n,p)	6.37E-18	6.50E-18	6.20E-18	1.02	0.97
Fe-54 (n,p)	3.52E-17	3.58E-17	3.51E-17	0.99	0.97
Ni-58 (n,p)	5.23E-17	4.91E-17	5.04E-17	0.94	0.96
U-238 (n,f) (Cd)	1.87E-16	2.09E-16	1.98E-16	1.12	1.06
Np-237 (n,f) (Cd)	3.06E-15	3.10E-15	3.02E-15	1.01	0.99
Co-59 (n,γ)	4.53E-14	5.91E-14	4.74E-14	1.30	1.05
Co-59 (n,γ) (Cd)	2.94E-14	2.96E-14	2.84E-14	1.01	0.97
U-235 (n,f)	3.52E-13	5.36E-13	3.45E-13	1.52	0.98
U-235 (n,f) (Cd)	7.52E-14	1.13E-13	7.67E-14	1.51	1.02

TABLE 6.1-11

DERIVED EXPOSURE RATES FROM THE CAPSULE XX DOSIMETRY EVALUATION
O DEGREE AZIMUTH - VESSEL SUPPORT ELEVATION

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	7.50E+07	1.08E+08	7%
ϕ (E > 0.1 Mev)	6.04E+08	1.26E+09	15%
ϕ (E < 0.414 ev)	1.15E+08	1.73E+08	24%
ϕ (Total)	1.64E+09	3.97E+09	12%
dpa/sec	2.52E-13	4.85E-13	14%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
O DEGREE AZIMUTH - VESSEL SUPPORT ELEVATION

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	3.72E-20	5.60E-20	3.95E-20	1.51	1.06
Ti-46 (n,p)	6.11E-19	6.74E-19	5.98E-19	1.10	0.98
Fe-54 (n,p)	3.75E-18	3.71E-18	3.70E-18	0.99	0.99
Ni-58 (n,p)	5.91E-18	5.09E-18	5.64E-18	0.86	0.95
U-238 (n,f) (Cd)	2.38E-17	2.17E-17	2.57E-17	0.91	1.08
Np-237 (n,f) (Cd)	7.20E-16	3.22E-16	6.92E-16	0.45	0.96
Co-59 (n,γ)	1.41E-14	6.12E-15	1.46E-14	0.43	1.03
Co-59 (n,γ) (Cd)	1.01E-14	3.07E-15	9.92E-15	0.30	0.98
U-235 (n,f)	1.16E-13	5.56E-14	1.14E-13	0.48	0.99
U-235 (n,f) (Cd)	5.16E-14	1.17E-14	5.07E-14	0.23	0.98

TABLE 6.1-12

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION
OF AXIAL POSITION WITHIN REACTOR CAVITY
CYCLE 15 IRRADIATION

AZIMUTHAL ANGLE

HEIGHT (ft)	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
+7.8	1.08E+08			
+6.5	4.18E+08	3.78E+08	2.75E+08	2.46E+08
+6.0	7.56E+08			
+5.5	1.03E+09	9.28E+08	6.76E+08	6.04E+08
+4.5	1.56E+09	1.41E+09	1.02E+09	9.15E+08
+3.5	1.73E+09	1.57E+09	1.14E+09	1.02E+09
+2.5	1.90E+09	1.71E+09	1.25E+09	1.12E+09
+1.5	1.86E+09	1.68E+09	1.22E+09	1.09E+09
+0.5	1.82E+09	1.65E+09	1.20E+09	1.07E+09
0.0	1.87E+09	1.69E+09	1.23E+09	1.10E+09
-0.5	1.92E+09	1.73E+09	1.26E+09	1.13E+09
-1.5	1.83E+09	1.65E+09	1.20E+09	1.07E+09
-2.5	1.82E+09	1.64E+09	1.19E+09	1.07E+09
-3.5	1.71E+09	1.55E+09	1.13E+09	1.01E+09
-4.5	1.57E+09	1.42E+09	1.03E+09	9.22E+08
-5.5	1.03E+09	9.30E+08	6.77E+08	6.05E+08
-6.0	7.04E+08			
-6.5	4.13E+08	3.73E+08	2.72E+08	2.43E+08

TABLE 6.1-13

FAST NEUTRON FLUX (E > 0.1 MeV) AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
CYCLE 15 IRRADIATION

AZIMUTHAL ANGLE

HEIGHT (ft)	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
+7.8	1.26E+09			
+6.5	3.09E+09	3.24E+09	2.28E+09	1.94E+09
+6.0	5.60E+09			
+5.5	7.58E+09	7.96E+09	5.60E+09	4.76E+09
+4.5	1.15E+10	1.21E+10	8.49E+09	7.20E+09
+3.5	1.28E+10	1.34E+10	9.45E+09	8.03E+09
+2.5	1.40E+10	1.47E+10	1.03E+10	8.78E+09
+1.5	1.37E+10	1.44E+10	1.01E+10	8.60E+09
+0.5	1.34E+10	1.41E+10	9.94E+09	8.44E+09
0.0	1.38E+10	1.45E+10	1.02E+10	8.66E+09
-0.5	1.41E+10	1.49E+10	1.05E+10	8.87E+09
-1.5	1.35E+10	1.42E+10	9.97E+09	8.46E+09
-2.5	1.34E+10	1.41E+10	9.90E+09	8.41E+09
-3.5	1.26E+10	1.33E+10	9.35E+09	7.94E+09
-4.5	1.16E+10	1.22E+10	8.55E+09	7.26E+09
-5.5	7.59E+09	7.98E+09	5.61E+09	4.76E+09
-6.0	5.16E+09			
-6.5	3.05E+09	3.20E+09	2.25E+09	1.91E+09

TABLE 6.1-14

IRON ATOM DISPLACEMENT RATE (dpa/sec) AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
CYCLE 15 IRRADIATION

AZIMUTHAL ANGLE

HEIGHT (ft)	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
+7.8	4.85E-13			
+6.5	1.31E-12	1.16E-12	8.25E-13	7.04E-13
+6.0	2.33E-12			
+5.5	3.22E-12	2.86E-12	2.03E-12	1.73E-12
+4.5	4.88E-12	4.33E-12	3.07E-12	2.62E-12
+3.5	5.44E-12	4.83E-12	3.42E-12	2.92E-12
+2.5	5.95E-12	5.28E-12	3.74E-12	3.19E-12
+1.5	5.83E-12	5.17F-12	3.66E-12	3.13E-12
+0.5	5.72E-12	5.08E-12	3.60E-12	3.07E-12
0.0	5.87E-12	5.21E-12	3.69E-12	3.15E-12
-0.5	6.01E-12	5.34E-12	3.78E-12	3.23E-12
-1.5	5.74E-12	5.09E-12	3.61E-12	3.08E-12
-2.5	5.70E-12	5.06E-12	3.58E-12	3.06E-12
-3.5	5.38E-12	4.77E-12	3.38E-12	2.89E-12
-4.5	4.92E-12	4.37E-12	3.09E-12	2.64E-12
-5.5	3.23E-12	2.87E-12	2.03E-12	1.73E-12
-6.0	2.17E-12			
-6.5	1.30E-12	1.15E-12	8.15E-13	6.96E-12

FIGURE 6.1-1

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 0 DEGREE TRAVERSE IN THE REACTOR CAVITY
CYCLE 15 IRRADIATION
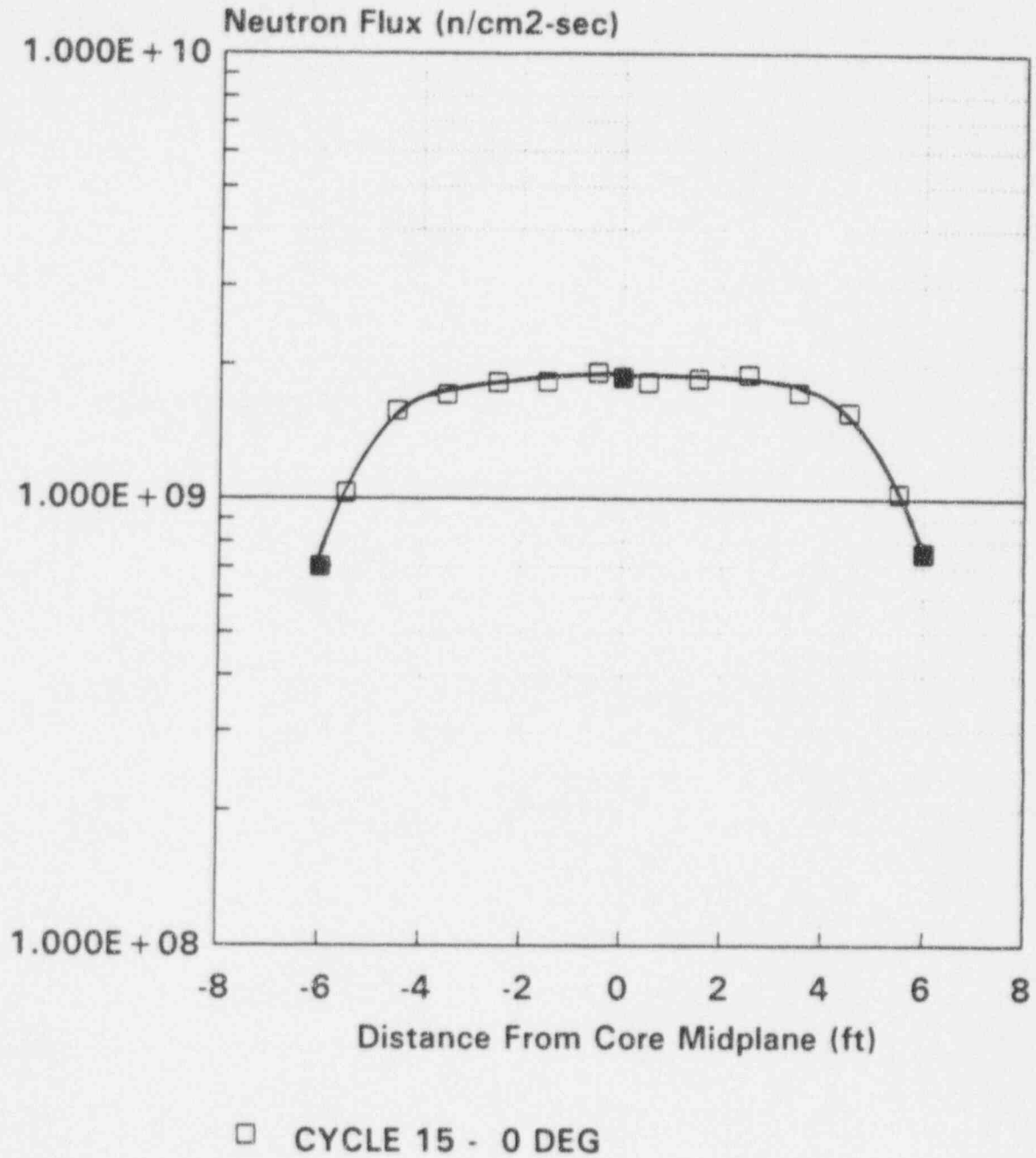
FIGURE 6.1-2

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 15 DEGREE TRAVERSE IN THE REACTOR CAVITY
CYCLE 15 IRRADIATION

□ CYCLE 15 - 15 DEG
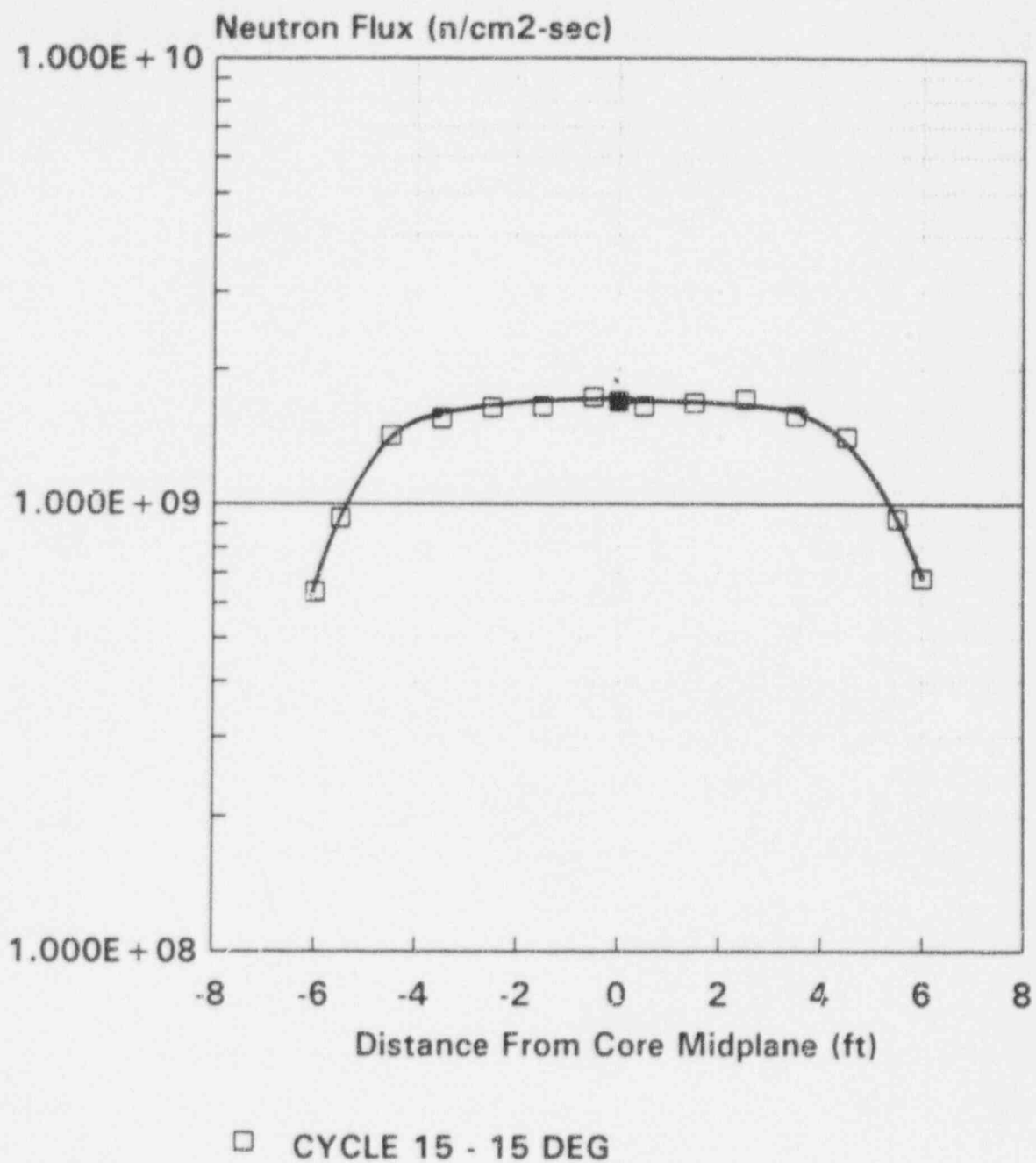
FIGURE 6.1-3

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 30 DEGREE TRAVERSE IN THE REACTOR CAVITY
CYCLE 15 IRRADIATION

□ CYCLE 15 - 30 DEG
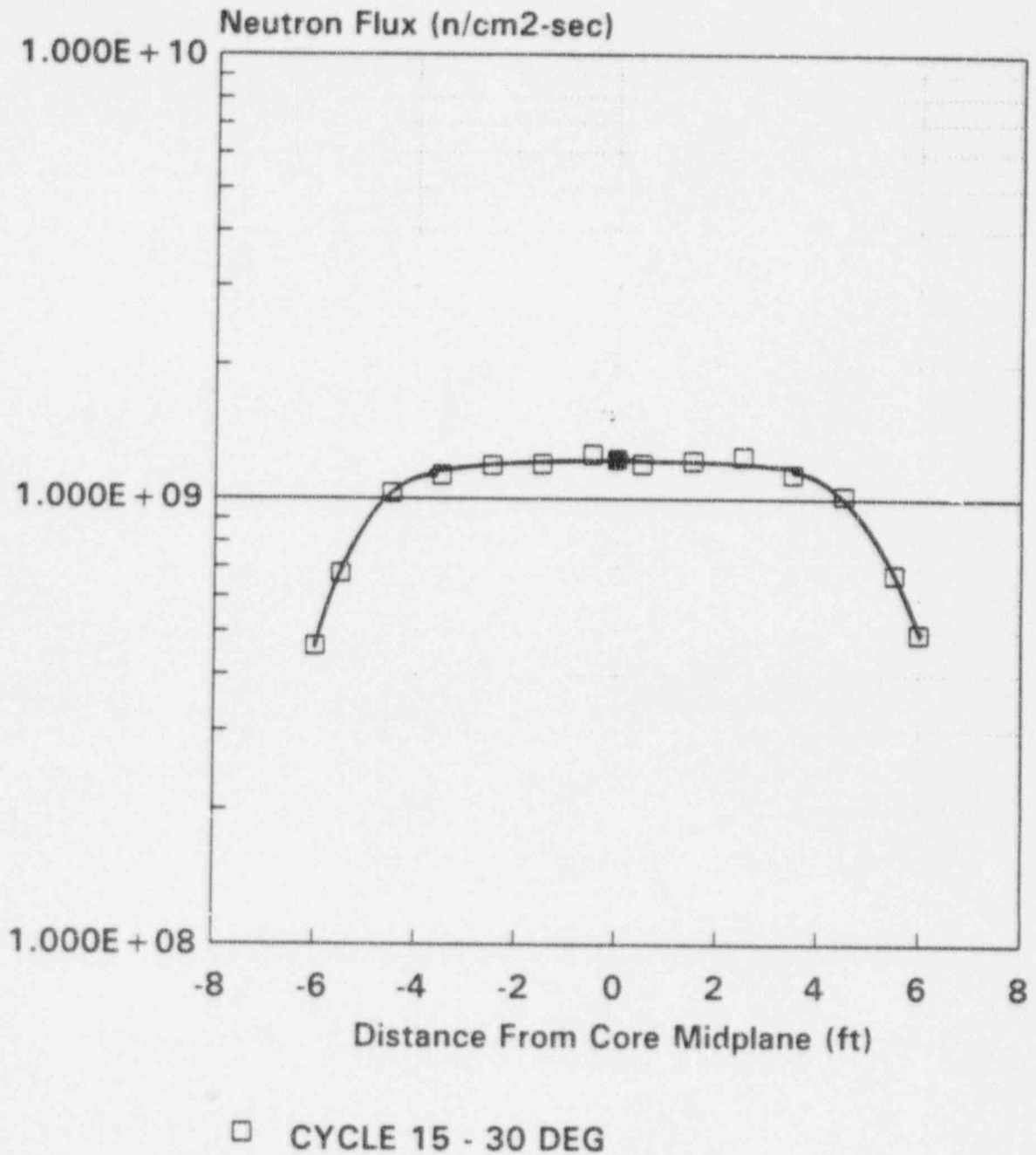
FIGURE 6.1-4

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 45 DEGREE TRAVERSE IN THE REACTOR CAVITY
CYCLE 15 IRRADIATION

□ CYCLE 15 - 45 DEG
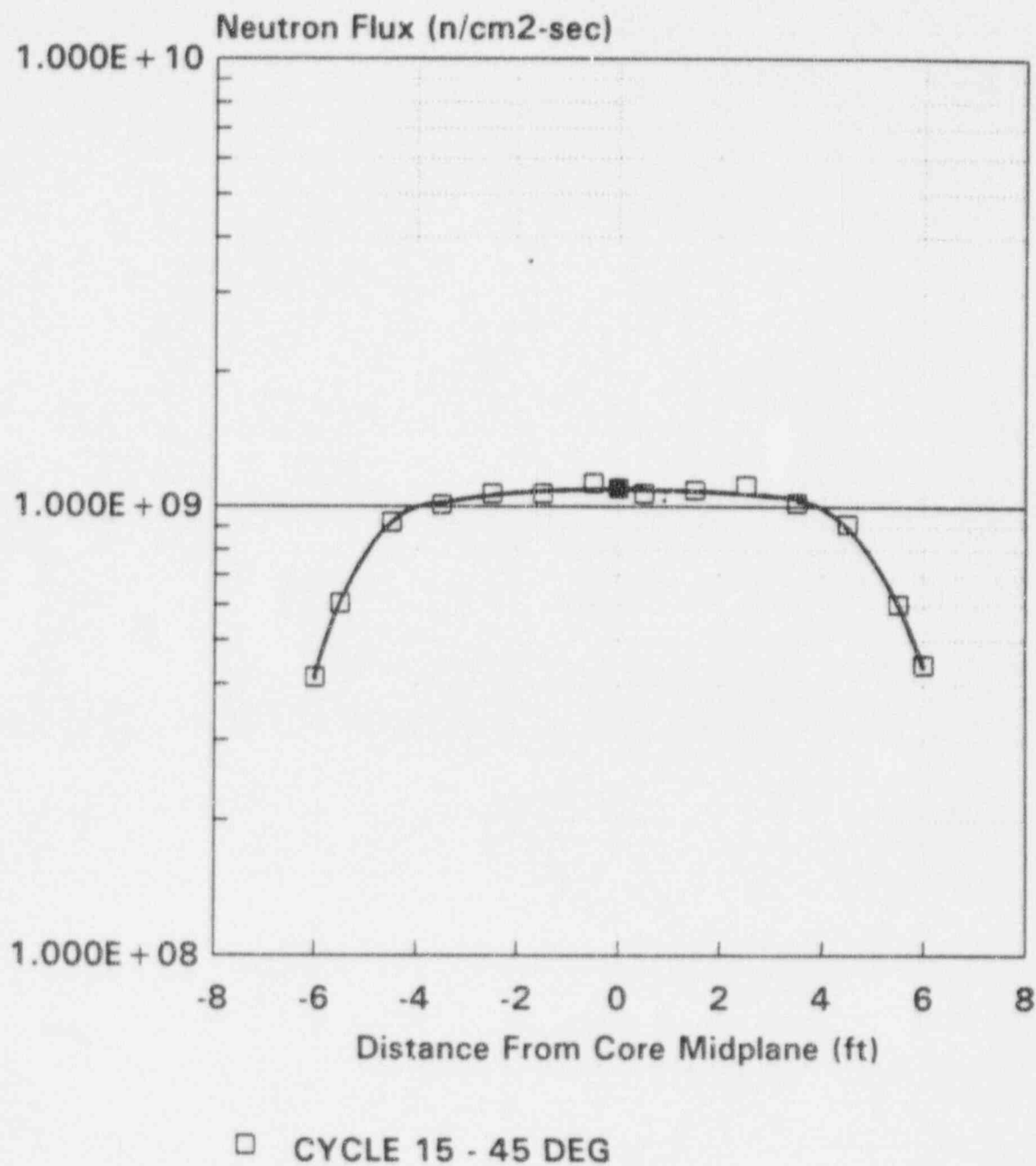
6.2 - Cycle 16 Results

6.2.1 - Measured Reaction rates

During the Cycle 16 irradiation, six multiple foil sensor sets and four
stainless steel gradient chains were deployed in the reactor cavity as depicted
in Figures 2.1-1 and 2.1-2. The capsule identifications associated with each
of the multiple foil sensor sets were as follows [1]:

AZIMUTH	CAPSULE IDENTIFICATION		
	CORE	CORE	CORE
(degrees)	TOP	MIDPLANE	BOTTOM
0	M	N	O
15		P	
30		Q	
45		R	

The contents of each of these irradiation capsules is specified in Reference 1
and, for completeness, is also included in Appendix B to this report.

The irradiation history of the Point Beach Unit 2 reactor during Cycle 16 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
1518 MWt were computed for each multiple foil sensor and gradient chain
segment.

The computed reaction rates for the multiple foil sensor sets, including
radiometric foils and solid state track recorders, irradiated during Cycle 16
are provided in Table 6.2-1. Corresponding reaction rate data from the the
four stainless steel gradient gradient chains are recorded in Tables 6.2-2
through 6.2-4 for the Fe-54 (n,p), Ni-58 (n,p), and Co-59 (n,γ) reactions,
respectively.

In regard to the data listed in Table 6.2-1, the Fe-54 (n,p) reaction rates represent an average of the bare and cadmium covered measurements for each capsule. Likewise, the U-238 (n,f) reaction rates were obtained by averaging the results of the radiometric foil and solid state track recorder data. In addition, the fission rate measurements include corrections for U-235 impurities and the effects of γ,f reactions in the U-238 sensors as well for the effects of γ,f reactions in the Np-237 monitors.

6.2.2 - 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 16 irradiation are provided in Tables 6.2-5 through 6.2-10. In these tables, the derived exposure experienced at each sensor set location along with data illustrating the fit of both the a priori 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 6.2-5 through 6.2-10, it should be noted that the columns labeled "a priori calc" were obtained by normalizing the neutron spectral data from Table 4.1-1 to the measured Fe-54 (n,p) reaction rates from each sensor set as discussed in Section 3.0. Thus, the comparisons illustrated in Tables 6.2-5 through 6.2-10 indicate only the degree to which the relative neutron energy spectra matched the measured data before and after adjustment. These data are not meant to provide an absolute comparison of calculation and measurement. Absolute comparisons are discussed in Section 7.0 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 Fe-54 (n,p) and Ni-58 (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 ϕ (E > 1.0 MeV), ϕ (E > 0.1 MeV), and dpa/sec in the reactor cavity.

The resultant axial distributions of ϕ (E > 1.0 MeV), ϕ (E > 0.1 MeV), and dpa/sec are given in Tables 6.2-11, 6.2-12, and 6.2-13, respectively. The distributions of ϕ (E > 1.0 MeV) are depicted graphically in Figures 6.2-1 through 6.2-4. In these graphical presentations, the solid symbols represent the explicit results of the FERRET evaluations, while the open symbols depict the normalized data from the gradient chains.

TABLE 6.2-1

SUMMARY OF REACTION RATES DERIVED FROM MULTIPLE FOIL SENSOR SETS
IRRADIATED DURING CYCLE 16

REACTION RATE (rps/nucleus)

REACTION	CAPSULE N	CAPSULE P	CAPSULE Q	CAPSULE R	CAPSULE M	CAPSULE O
Cu63(n,α)	8.59E-19	7.51E-19	6.7 E-19	6.61E-19	4.11E-19	3.69E-19
Ti46(n,p)	1.27E-17	1.10E-17	9.64E-18	9.20E-18	6.41E-18	5.79E-18
Fe54(n,p)	7.44E-17	6.33E-17	5.51E-17	5.23E-17	3.51E-17	3.48E-17
Ni58(n,p)	1.07E-16	9.24E-17	7.84E-17	7.43E-17	5.51E-17	5.07E-17
U238(n,f)	4.01E-16	3.60E-16	2.63E-16	2.66E-16	2.15E-16	1.84E-16
Np237(n,f)	6.01E-15	5.28E-15	4.27E-15	4.13E-15	2.95E-15	2.92E-15
*Co59(n,γ)	8.74E-14	1.12E-13	1.00E-13	6.23E-14	3.68E-14	4.08E-14
Co59(n,γ)	5.26E-14	6.71E-14	5.44E-14	4.14E-14	2.63E-14	2.65E-14
*U235(n,f)	8.28E-13	1.01E-12	9.96E-13	4.40E-13	2.61E-13	3.66E-13
U235(n,f)	2.66E-13	3.08E-13	2.32E-13	1.95E-13	7.73E-14	7.28E-14

* - Bare foil, all others were cadmium covered

TABLE 6.2-2

Fe-54 (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL
GRADIENT CHAINS IRRADIATED DURING CYCLE 16

FEET FROM MIDPLANE	REACTION RATE (rps/nucleus)			
	0 DEG	15 DEG	30 DEG	45 DEG
+6.5	1.92E-17	1.41E-17	1.19E-17	1.07E-17
+5.5	4.67E-17	3.51E-17	2.98E-17	2.56E-17
+4.5	7.37E-17	5.63E-17	4.32E-17	3.98E-17
+3.5	8.21E-17	6.74E-17	4.52E-17	4.18E-17
+2.5	8.74E-17	6.79E-17	5.00E-17	4.69E-17
+1.5	8.32E-17	6.42E-17	4.80E-17	4.65E-17
+0.5	7.48E-17	5.84E-17	5.02E-17	4.62E-17
-0.5	6.00E-17	5.21E-17	4.84E-17	4.55E-17
-1.5	5.90E-17	5.25E-17	4.69E-17	4.59E-17
-2.5	6.63E-17	5.13E-17	4.81E-17	4.39E-17
-3.5	6.90E-17	6.11E-17	4.35E-17	4.29E-17
-4.5	6.85E-17	5.84E-17	4.05E-17	4.04E-17
-5.5	4.65E-17	3.66E-17	2.69E-17	2.70E-17
-6.5	1.77E-17	1.56E-17	1.12E-17	1.07E-17

TABLE 6.2-3

Ni-58 (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL
GRADIENT CHAINS IRRADIATED DURING CYCLE 16

FEET FROM MIDPLANE	REACTION RATE (rps/nucleus)			
	0 DEG	15 DEG	30 DEG	45 DEG
+6.5	2.91E-17	2.11E-17	1.75E-17	1.54E-17
+5.5	7.09E-17	5.53E-17	4.33E-17	3.65E-17
+4.5	1.10E-16	8.62E-17	6.12E-17	5.74E-17
+3.5	1.18E-16	9.13E-17	6.65E-17	6.15E-17
+2.5	1.23E-16	9.51E-17	7.33E-17	6.59E-17
+1.5	1.15E-16	8.92E-17	7.04E-17	6.33E-17
+0.5	1.04E-16	8.42E-17	7.06E-17	6.33E-17
-0.5	8.68E-17	7.33E-17	7.09E-17	6.68E-17
-1.5	8.36E-17	7.59E-17	6.68E-17	6.27E-17
-2.5	9.18E-17	7.65E-17	6.74E-17	6.45E-17
-3.5	1.05E-16	8.42E-17	6.45E-17	6.12E-17
-4.5	9.80E-17	8.51E-17	6.01E-17	5.98E-17
-5.5	6.98E-17	5.42E-17	3.89E-17	3.97E-17
-6.5	2.86E-17	2.17E-17	1.60E-17	1.70E-17

TABLE 6.2-4

Co-59 (n,γ) REACTION RATES DERIVED FROM THE STAINLESS STEEL
GRADIENT CHAINS IRRADIATED DURING CYCLE 16

FEET FROM MIDPLANE	REACTION RATE (rps/nucleus)			
	0 DEG	15 DEG	30 DEG	45 DEG
+6.5	2.25E-14	2.25E-14	1.95E-14	1.67E-14
+5.5	5.14E-14	7.41E-14	5.53E-14	3.38E-14
+4.5	6.88E-14	1.06E-13	7.82E-14	4.68E-14
+3.5	7.98E-14	1.19E-13	8.97E-14	5.48E-14
+2.5	8.66E-14	1.25E-13	9.70E-14	5.89E-14
+1.5	8.40E-14	1.19E-13	9.60E-14	6.26E-14
+0.5	8.50E-14	1.13E-13	9.81E-14	6.21E-14
-0.5	8.34E-14	1.04E-13	9.54E-14	6.00E-14
-1.5	8.03E-14	9.96E-14	9.02E-14	6.05E-14
-2.5	7.88E-14	9.70E-14	8.97E-14	5.58E-14
-3.5	8.08E-14	9.91E-14	8.24E-14	5.27E-14
-4.5	6.62E-14	8.66E-14	6.47E-14	4.35E-14
-5.5	4.73E-14	6.36E-14	3.66E-14	3.24E-14
-6.5	3.48E-14	3.40E-14	2.59E-14	2.42E-14

TABLE 6.2-5

DERIVED EXPOSURE RATES FROM THE CAPSULE N DOSIMETRY EVALUATION
O DEGREE AZIMUTH - CORE MIDPLANE

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	1.49E+09	1.45E+09	6%
ϕ (E > 0.1 Mev)	1.20E+10	1.10E+10	14%
ϕ (E < 0.414 ev)	2.27E+09	1.52E+09	23%
ϕ (Total)	3.25E+10	3.07E+10	14%
dpa/sec	4.99E-12	4.66E-12	12%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
O DEGREE AZIMUTH - CORE MIDPLANE

REACTION RATE (rps/nucleus)　　　　C/M

REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	8.59E-19	1.11E-18	8.94E-19	1.29	1.04
Ti-46 (n,p)	1.27E-17	1.34E-17	1.26E-17	1.05	0.99
Fe-54 (n,p)	7.44E-17	7.35E-17	7.26E-17	0.99	0.98
Ni-58 (n,p)	1.07E-16	1.01E-16	1.04E-16	0.94	0.97
U-238 (n,f) (Cd)	4.01E-16	4.30E-16	4.15E-16	1.07	1.03
Np-237 (n,f) (Cd)	6.01E-15	6.38E-15	6.02E-15	1.06	1.00
Co-59 (n,γ)	8.74E-14	1.21E-13	9.05E-14	1.39	1.04
Co-59 (n,γ) (Cd)	5.26E-14	6.08E-14	5.18E-14	1.16	0.99
U-235 (n,f)	8.28E-13	1.10E-12	8.13E-13	1.33	0.98
U-235 (n,f) (Cd)	2.66E-13	2.33E-13	2.64E-13	0.88	0.99

TABLE 6.2-6

DERIVED EXPOSURE RATES FROM THE CAPSULE P DOSIMETRY EVALUATION
15 DEGREE AZIMUTH - CORE MIDPLANE

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	1.31E+09	1.28E+09	6%
ϕ (E > 0.1 Mev)	1.18E+10	1.03E+10	15%
ϕ (E < 0.414 ev)	2.13E+09	1.91E+09	23%
ϕ (Total)	2.86E+10	2.81E+10	12%
dpa/sec	4.17E-12	3.76E-12	11%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
15 DEGREE AZIMUTH - CORE MIDPLANE

REACTION		REACTION RATE (rps/nucleus) MEASURED	A PRIORI CALC.	ADJUSTED CALC.	C/M A PRIORI	ADJUSTED
Cu-63 (n,α)		7.51E-19	9.54E-19	7.80E-19	1.27	1.04
Ti-46 (n,p)		1.10E-17	1.14E-17	1.09E-17	1.04	0.99
Fe-54 (n,p)		6.33E-17	6.27E-17	6.24E-17	0.99	0.99
Ni-58 (n,p)		9.24E-17	8.62E-17	8.95E-17	0.93	0.97
U-238 (n,f)	(Cd)	3.60E-16	3.73E-16	3.67E-16	1.04	1.02
Np-237 (n,f)	(Cd)	5.28E-15	5.93E-15	5.33E-15	1.12	1.01
Co-59 (n,γ)		1.12E-13	1.20E-13	1.15E-13	1.07	1.03
Co-59 (n,γ)	(Cd)	6.71E-14	6.43E-14	6.63E-14	0.96	0.99
U-235 (n,f)		1.01E-12	1.03E-12	9.96E-13	1.02	0.99
U-235 (n,f)	(Cd)	3.08E-13	2.36E-13	3.06E-13	0.77	0.99

TABLE 6.2-7

DERIVED EXPOSURE RATES FROM THE CAPSULE Q DOSIMETRY EVALUATION
30 DEGREE AZIMUTH - CORE MIDPLANE

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	1.09E+09	9.73E+08	6%
ϕ (E > 0.1 Mev)	9.75E+09	8.16E+09	15%
ϕ (E < 0.414 ev)	1.87E+09	1.95E+09	21%
ϕ (Total)	2.45E+10	2.29E+10	12%
dpa/sec	3.45E-12	2.95E-12	11%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
30 DEGREE AZIMUTH - CORE MIDPLANE

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	6.71E-19	8.63E-19	7.02E-19	1.29	1.05
Ti-46 (n,p)	9.64E-18	1.02E-17	9.57E-18	1.05	0.99
Fe-54 (n,p)	5.51E-17	5.41E-17	5.29E-17	0.98	0.96
Ni-58 (n,p)	7.84E-17	7.41E-17	7.52E-17	0.95	0.96
U-238 (n,f) (Cd)	2.63E-16	3.12E-16	2.79E-16	1.19	1.06
Np-237 (n,f) (Cd)	4.27E-15	4.91E-15	4.26E-15	1.15	1.00
Co-59 (n,γ)	1.00E-13	1.06E-13	1.05E-13	1.06	1.05
Co-59 (n,γ) (Cd)	5.44E-14	5.70E-14	5.33E-14	1.05	0.98
U-235 (n,f)	9.96E-13	9.03E-13	9.70E-13	0.91	0.97
U-235 (n,f) (Cd)	2.32E-13	2.09E-13	2.32E-13	0.90	1.00

TABLE 6.2-8

DERIVED EXPOSURE RATES FROM THE CAPSULE R DOSIMETRY EVALUATION
45 DEGREE AZIMUTH - CORE MIDPLANE

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	9.76E+08	9.63E+08	6%
ϕ (E > 0.1 Mev)	8.22E+09	7.65E+09	15%
ϕ (E < 0.414 ev)	1.85E+09	7.53E+08	26%
ϕ (Total)	2.09E+10	1.91E+10	12%
dpa/sec	2.96E-12	2.78E-12	11%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
45 DEGREE AZIMUTH - CORE MIDPLANE

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	6.61E-19	8.57E-19	6.87E-19	1.30	1.04
Ti-46 (n,p)	9.20E-18	9.92E-18	9.15E-18	1.08	0.99
Fe-54 (n,p)	5.23E-17	5.14E-17	5.08E-17	0.98	0.97
Ni-58 (n,p)	7.43E-17	7.00E-17	7.18E-17	0.94	0.97
U-238 (n,f) (Cd)	2.66E-16	2.86E-16	2.77E-16	1.07	1.04
Np-237 (n,f) (Cd)	4.13E-15	4.25E-15	4.12E-15	1.03	1.00
Co-59 (n,γ)	6.23E-14	9.81E-14	6.11E-14	1.57	0.98
Co-59 (n,γ) (Cd)	4.14E-14	4.87E-14	4.22E-14	1.18	1.02
U-235 (n,f)	4.4CE-13	8.87E-13	4.47E-13	2.02	1.02
U-235 (n,f) (Cd)	1.95E-13	1.78E-13	1.92E-13	0.91	0.98

TABLE 6.2-9

DERIVED EXPOSURE RATES FROM THE CAPSULE M DOSIMETRY EVALUATION
O DEGREE AZIMUTH - CORE TOP

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	7.01E+08	7.53E+08	6%
ϕ (E > 0.1 Mev)	5.64E+09	5.19E+09	14%
ϕ (E < 0.414 ev)	1.07E+09	4.86E+08	23%
ϕ (Total)	1.53E+10	1.23E+10	14%
dpa/sec	2.35E-12	2.19E-12	12%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
O DEGREE AZIMUTH - CORE TOP

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	4.11E-19	5.23E-19	4.27E-19	1.27	1.04
Ti-46 (n,p)	6.41E-18	6.30E-18	6.27E-18	0.98	0.98
Fe-54 (n,p)	3.51E-17	3.47E-17	3.56E-17	0.99	1.01
Ni-58 (n,p)	5.51E-17	4.75E-17	5.28E-17	0.86	0.96
U-238 (n,f) (Cd)	2.15E-16	2.03E-16	2.17E-16	0.94	1.01
Np-237 (n,f) (Cd)	2.95E-15	3.01E-15	2.96E-15	1.02	1.00
Co-59 (n,γ)	3.68E-14	5.72E-14	3.84E-14	1.55	1.04
Co-59 (n,γ) (Cd)	2.63E-14	2.87E-14	2.54E-14	1.09	0.97
U-235 (n,f)	2.61E-13	5.19E-13	2.57E-13	1.99	0.98
U-235 (n,f) (Cd)	7.73E-14	1.10E-13	7.84E-14	1.42	1.01

TABLE 6.2-10

DERIVED EXPOSURE RATES FROM THE CAPSULE O DOSIMETRY EVALUATION
0 DEGREE AZIMUTH - CORE BOTTOM

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	6.95E+08	6.88E+08	6%
ϕ (E > 0.1 Mev)	5.59E+09	4.98E+09	14%
ϕ (E < 0.414 ev)	1.06E+09	6.93E+08	19%
ϕ (Total)	1.52E+10	1.22E+10	13%
dpa/sec	2.33E-12	2.09E-12	12%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
0 DEGREE AZIMUTH - CORE BOTTOM

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	3.69E-19	5.19E-19	3.87E-19	1.41	1.05
Ti-46 (n,p)	5.79E-18	6.24E-18	5.71E-18	1.08	0.99
Fe-54 (n,p)	3.48E-17	3.43E-17	3.37E-17	0.99	0.97
Ni-58 (n,p)	5.07E-17	4.71E-17	4.87E-17	0.93	0.96
U-238 (n,f) (Cd)	1.84E-15	2.01E-16	1.93E-16	1.09	1.05
Np-237 (n,f) (Cd)	2.92E-15	2.98E-15	2.89E-15	1.02	0.99
Co-59 (n,γ)	4.08E-14	5.67E-14	4.45E-14	1.39	1.09
Co-59 (n,γ) (Cd)	2.65E-14	2.84E-14	2.51E-14	1.07	0.95
U-235 (n,f)	3.66E-13	5.15E-13	3.51E-13	1.41	0.96
U-235 (n,f) (Cd)	7.28E-14	1.09E-13	7.44E-14	1.49	1.02

TABLE 6.2-11

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
CYCLE 16 IRRADIATION

AZIMUTHAL ANGLE

HEIGHT (ft)	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
+6.5	4.28E+08	3.34E+08	2.38E+08	2.26E+08
+6.0	7.53E+08			
+5.5	1.04E+09	8.56E+08	5.91E+08	5.39E+08
+4.5	1.63E+09	1.35E+09	8.47E+08	8.46E+08
+3.5	1.78E+09	1.52E+09	9.03E+08	8.94E+08
+2.5	1.87E+09	1.56E+09	9.97E+08	9.80E+08
+1.5	1.77E+09	1.47E+09	9.58E+08	9.56E+08
+0.5	1.59E+09	1.36E+09	9.81E+08	9.53E+08
0.0	1.45E+09	1.28E+09	9.73E+08	9.63E+08
-0.5	1.31E+09	1.20E+09	9.64E+08	9.72E+08
-1.5	1.27E+09	1.22E+09	9.21E+08	9.46E+08
-2.5	1.41E+09	1.22E+09	9.38E+08	9.38E+08
-3.5	1.54E+09	1.39E+09	8.72E+08	9.03E+08
-4.5	1.48E+09	1.37E+09	8.12E+08	8.66E+08
-5.5	1.03E+09	8.64E+08	5.33E+08	5.77E+08
-6.0	6.88E+08			
-6.5	4.08E+08	3.57E+08	2.21E+08	2.38E+08

TABLE 6.2-12

FAST NEUTRON FLUX (E > 0.1 MeV) AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
CYCLE 16 IRRADIATION

AZIMUTHAL ANGLE

HEIGHT (ft)	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
+6.5	3.25E+09	2.69E+09	2.00E+09	1.80E+09
+6.0	5.19E+09			
+5.5	7.90E+09	6.89E+09	4.96E+09	4.28E+09
+4.5	1.24E+10	1.09E+10	7.10E+09	6.72E+09
+3.5	1.35E+10	1.22E+10	7.57E+09	7.10E+09
+2.5	1.42E+10	1.25E+10	8.36E+09	7.79E+09
+1.5	1.34E+10	1.18E+10	8.03E+09	7.60E+09
+0.5	1.21E+10	1.09E+10	8.22E+09	7.57E+09
0.0	1.10E+10	1.03E+10	8.16E+09	7.65E+09
-0.5	9.90E+09	9.64E+09	8.09E+09	7.72E+09
-1.5	9.63E+09	9.86E+09	7.73E+09	7.51E+09
-2.5	1.07E+10	9.78E+09	7.86E+09	7.45E+09
-3.5	1.17E+10	1.12E+10	7.32E+09	7.17E+09
-4.5	1.12E+10	1.10E+10	6.81E+09	6.88E+09
-5.5	7.82E+09	6.95E+09	4.47E+09	4.58E+09
-6.0	4.98E+09			
-6.5	3.09E+09	2.88E+09	1.85E+09	1.89E+09

TABLE 6.2-13

IRON ATOM DISPLACEMENT RATE (dpa/sec) AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
CYCLE 16 IRRADIATION

AZIMUTHAL ANGLE

HEIGHT (ft)	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
+6.5	1.38E-12	9.82E-13	7.22E-13	6.53E-13
+6.0	2.19E-12			
+5.5	3.35E-12	2.51E-12	1.79E-12	1.56E-12
+4.5	5.23E-12	3.97E-12	2.57E-12	2.44E-12
+3.5	5.72E-12	4.47E-12	2.74E-12	2.58E-12
+2.5	6.02E-12	4.58E-12	3.02E-12	2.83E-12
+1.5	5.69E-12	4.31E-12	2.90E-12	2.76E-12
+0.5	5.13E-12	4.00E-12	2.97E-12	2.75E-12
0.0	4.66E-12	3.76E-12	2.95E-12	2.78E-12
-0.5	4.19E-12	3.52E-12	2.92E-12	2.80E-12
-1.5	4.08E-12	3.60E-12	2.79E-12	2.73E-12
-2.5	4.54E-12	3.57E-12	2.84E-12	2.71E-12
-3.5	4.95E-12	4.09E-12	2.65E-12	2.61E-12
-4.5	4.76E-12	4.02E-12	2.46E-12	2.50E-12
-5.5	3.31E-12	2.54E-12	1.62E-12	1.67E-12
-6.0	2.09E-12			
-6.5	1.31E-12	1.05E-12	6.70E-13	6.88E-13

FIGURE 6.2-1

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 0 DEGREE TRAVERSE IN THE REACTOR CAVITY
CYCLE 16 IRRADIATION
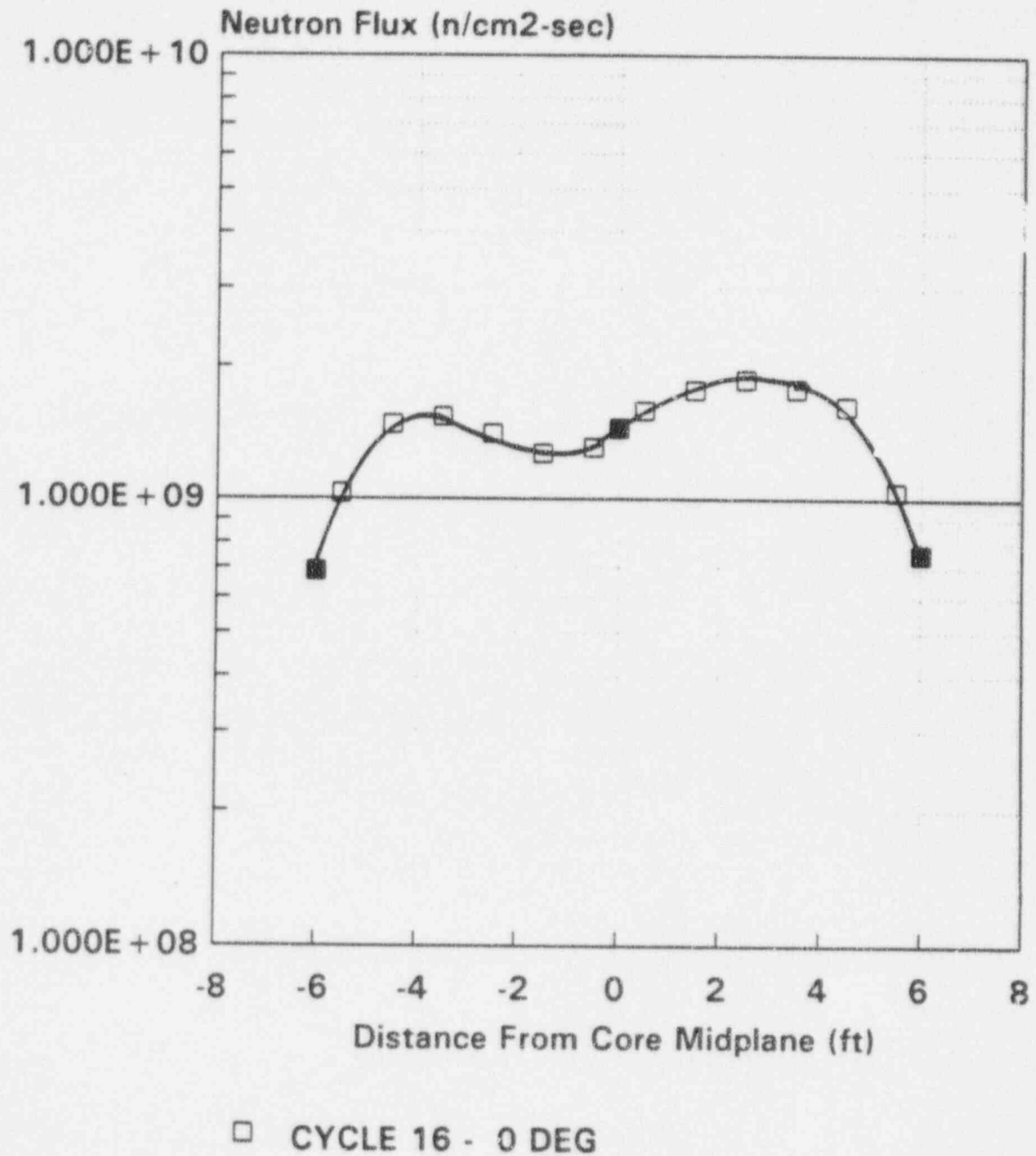
FIGURE 6.2-2

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 15 DEGREE TRAVERSE IN THE REACTOR CAVITY
CYCLE 16 IRRADIATION

Neutron Flux (n/cm2-sec)

CYCLE 16 - 15 DEG
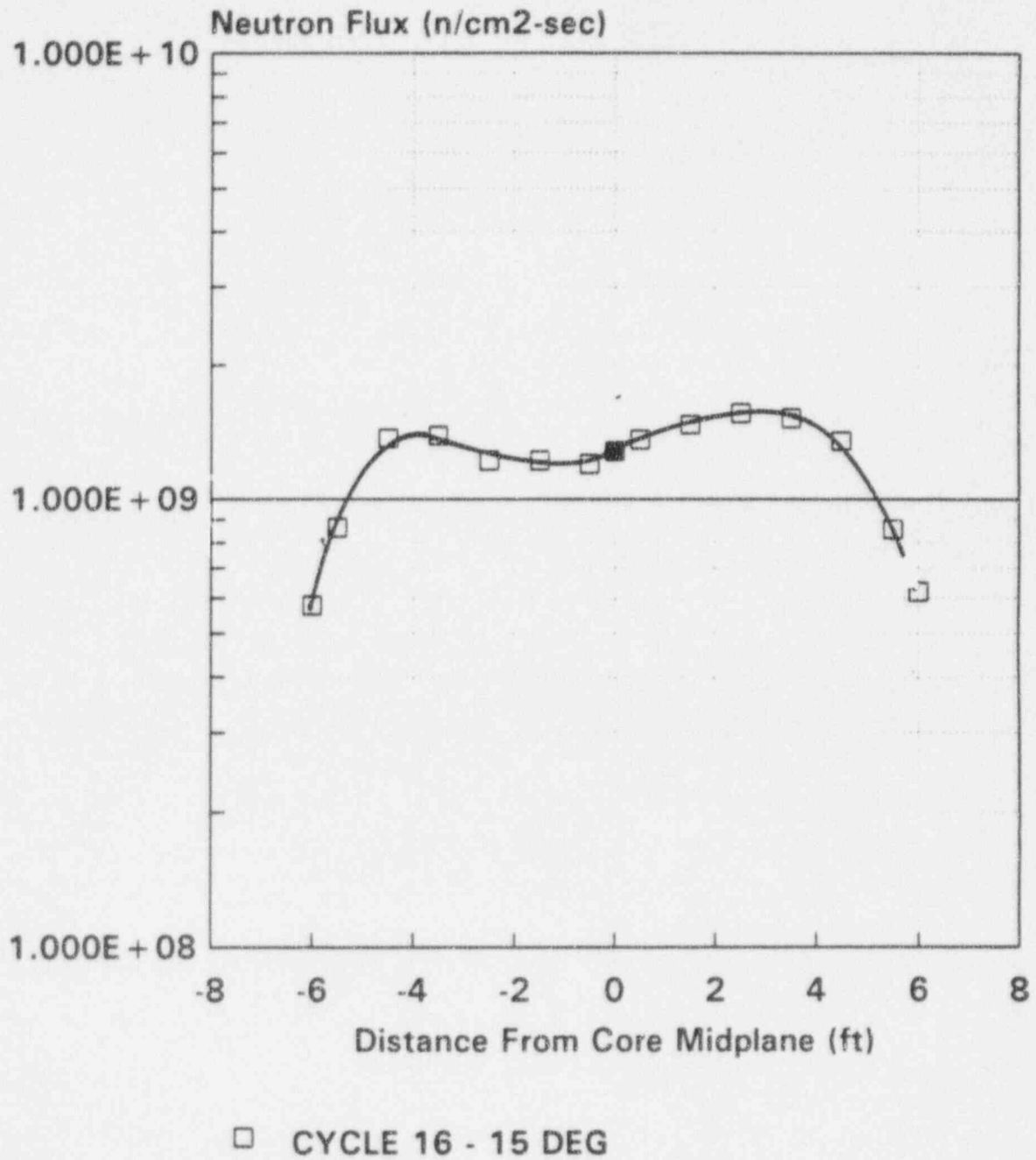
FIGURE 6.2-3

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 30 DEGREE TRAVERSE IN THE REACTOR CAVITY
CYCLE 16 IRRADIATION

□ CYCLE 16 - 30 DEG
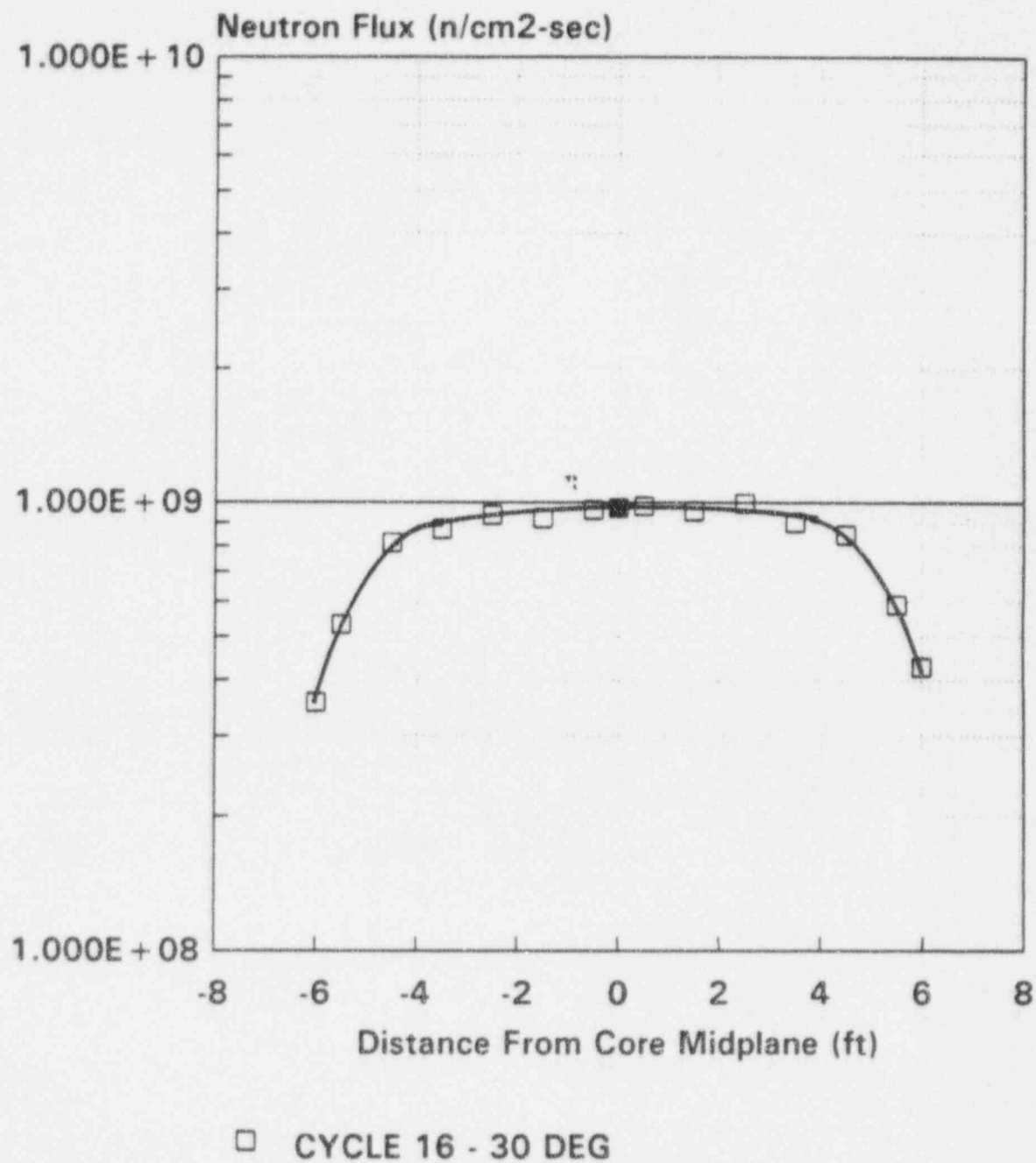
FIGURE 6.2-4

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 45 DEGREE TRAVERSE IN THE REACTOR CAVITY
CYCLE 16 IRRADIATION

□ CYCLE 16 - 45 DEG
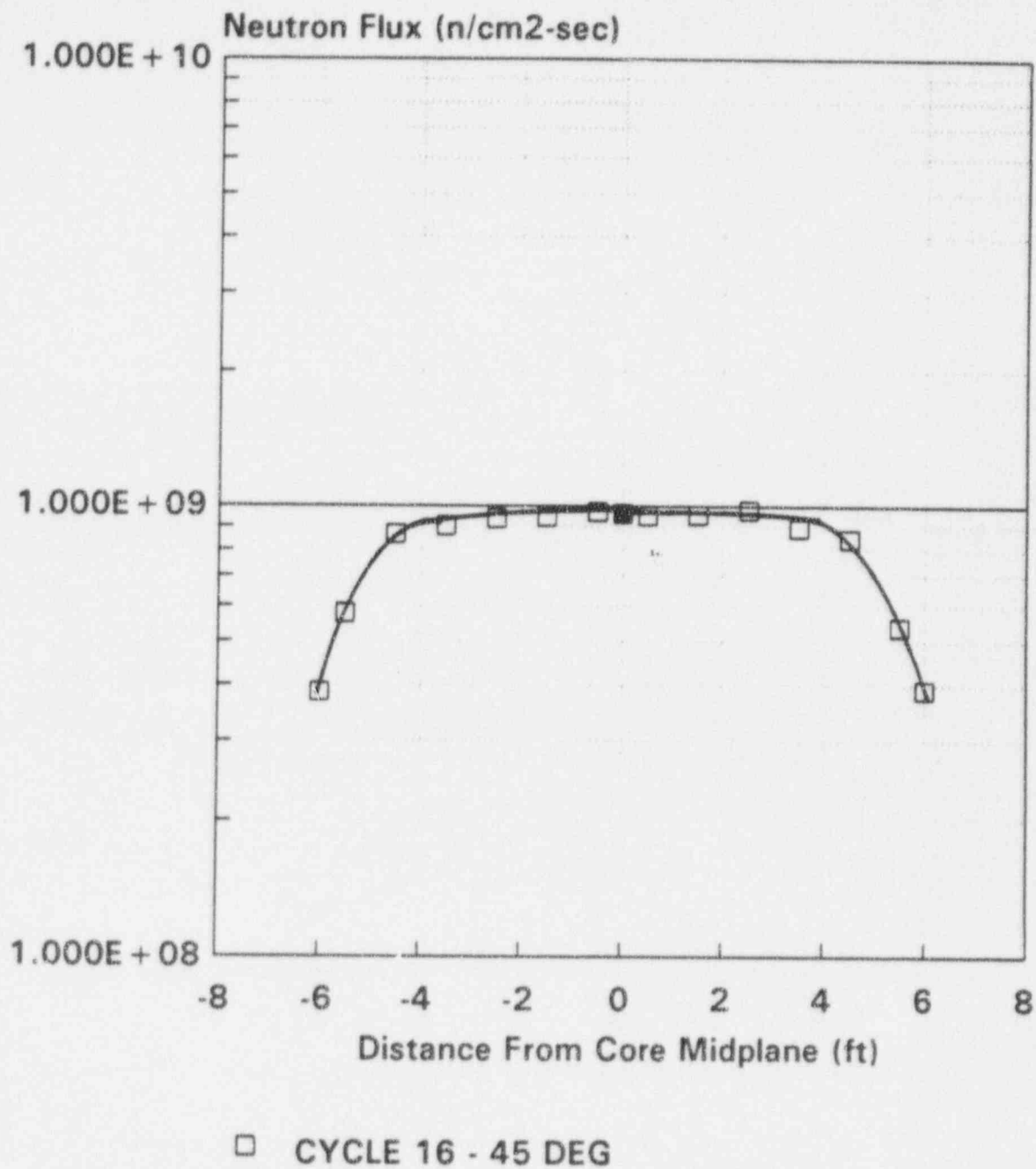
6.3 - Cycle 17 Results

6.2.1 - Measured Reaction rates

During the Cycle 17 irradiation, six multiple foil sensor sets and four stainless steel gradient chains were deployed in the reactor cavity as depicted in Figures 2.1-1 and 2.1-2. The capsule identifications associated with each of the multiple foil sensor sets were as follows [1]:

| | CAPSULE IDENTIFICATION | | |
AZIMUTH (degrees)	CORE TOP	CORE MIDPLANE	CORE BOTTOM
0	AA	BB	CC
15		DD	
30		EE	
45		FF	

The contents of each of these irradiation capsules is specified in Reference 1 and, for completeness, is also included in Appendix B to this report.

The irradiation history of the Point Beach Unit 2 reactor during Cycle 17 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 1518 MWt were computed for each multiple foil sensor and gradient chain segment.

The computed reaction rates for the multiple foil sensor sets, including radiometric foils and solid state track recorders, irradiated during Cycle 17 are provided in Table 6.3-1. Corresponding reaction rate data from the the four stainless steel gradient gradient chains are recorded in Tables 6.3-2 through 6.3-4 for the Fe-54 (n,p), Ni-58 (n,p), and Co-59 (n,γ) reactions, respectively.

In regard to the data listed in Table 6.3-1, the Fe-54 (n,p) reaction rates represent an average of the bare and cadmium covered measurements for each capsule. Likewise, the U-238 (n,f) reaction rates were obtained by averaging the results of the radiometric foil and solid state track recorder data. In addition, the fission rate measurements include corrections for U-235 impurities and the effects of γ,f reactions in the U-238 sensors as well for the effects of γ,f reactions in the Np-237 monitors.

6.3.2 - 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 17 irradiation are provided in Tables 6.3-5 through 6.3-10. In these tables, the derived exposure experienced at each sensor set location along with data illustrating the fit of both the a priori 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 6.3-5 through 6.3-10, it should be noted that the columns labeled "a priori calc" were obtained by normalizing the neutron spectral data from Table 4.1-1 to the measured Fe-54 (n,p) reaction rates from each sensor set as discussed in Section 3.0. Thus, the comparisons illustrated in Tables 6.3-5 through 6.3-10 indicate only the degree to which the relative neutron energy spectra matched the measured data before and after adjustment. These data are not meant to provide an absolute comparison of calculation and measurement. Absolute comparisons are discussed in Section 7.0 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 Fe-54 (n,p) and Ni-58 (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 ϕ (E > 1.0 MeV), ϕ (E > 0.1 MeV), and dpa/sec in the reactor cavity.

The resultant axial distributions of ϕ (E > 1.0 MeV), ϕ (E > 0.1 MeV), and dpa/sec are given in Tables 6.3-11, 6.3-12, and 6.3-13, respectively. The distributions of ϕ (E > 1.0 MeV) are depicted graphically in Figures 6.3-1 through 6.3-4. In these graphical presentations, the solid symbols represent the explicit results of the FERRET evaluations, while the open symbols depict the normalized data from the gradient chains.

TABLE 6.3-1

SUMMARY OF REACTION RATES DERIVED FROM MULTIPLE FOIL SENSOR SETS
IRRADIATED DURING CYCLE 17

REACTION RATE (rps/nucleus)

REACTION	CAPSULE BB	CAPSULE DD	CAPSULE EE	CAPSULE FF	CAPSULE AA	CAPSULE CC
Cu63(n,α)	9.04E-19	8.01E-19	6.79E-19	6.97E-19	4.23E-19	3.92E-19
Ti46(n,p)	1.32E-17	1.16E-17	1.00E-17	9.83E-18	6.56E-18	6.08E-18
Fe54(n,p)	7.79E-17	6.79E-17	5.6 E-17	5.41E-17	3.55E-17	3.62E-17
Ni58(n,p)	1.10E-16	9.61E-17	8.01E-17	7.65E-17	5.66E-17	5.22E-17
U238(n,f)	3.74E-16	3.09E-16	2.78E-16	2.58E-16	2.12E-16	1.78E-16
Np237(n,f)	6.20E-15	5.01E-15	4.41E-15	3.66E-15		2.54E-15
*Co59(n,γ)	9.31E-14	1.17E-13	1.05E-13	6.50E-14	3.89E-14	4.25E-14
Co59(n,γ)	5.52E-14	6.68E-14	5.76E-14	4.41E-14	2.79E-14	2.79E-14
*U235(n,f)	7.83E-13	9.11E-13	1.02E-12	4.52E-13	3.32E-13	3.95E-13
U235(n,f)	2.63E-13	2.98E-13	2.66E-13	1.97E-13	9.87E-14	7.12E-14

* - Bare foil, all others were cadmium covered

TABLE 6.3-2

Fe-54 (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL
GRADIENT CHAINS IRRADIATED DURING CYCLE 17

FEET FROM MIDPLANE	REACTION RATE (rps/nucleus)			
	0 DEG	15 DEG	30 DEG	45 DEG
+6.5	2.02E-17	1.52E-17	1.17E-17	1.09E-17
+5.5	5.04E-17	3.84E-17	2.96E-17	2.52E-17
+4.5	7.48E-17	5.23E-17	4.49E-17	3.94E-17
+3.5	8.36E-17	6.31E-17	5.28E-17	4.53E-17
+2.5	8.80E-17	6.99E-17	4.94E-17	5.04E-17
+1.5	8.41E-17	6.80E-17	5.04E-17	4.69E-17
+0.5	7.83E-17	6.41E-17	5.38E-17	4.58E-17
-0.5	6.75E-17	6.11E-17	5.33E-17	5.28E-17
-1.5	6.65E-17	5.53E-17	5.09E-17	4.89E-17
-2.5	6.55E-17	6.21E-17	5.18E-17	5.14E-17
-3.5	7.24E-17	6.11E-17	4.86E-17	4.73E-17
-4.5	7.04E-17	6.11E-17	4.61E-17	4.17E-17
-5.5	4.99E-17	4.06E-17	2.79E-17	2.90E-17
-6.5	2.07E-17	1.49E-17	1.13E-17	1.27E-17

TABLE 6.3-3

Ni-58 (n,p) REACTION RATES DERIVED FROM THE STAINLESS STEEL
GRADIENT CHAINS IRRADIATED DURING CYCLE 17

FEET FROM MIDPLANE	REACTION RATE (rps/nucleus)			
	0 DEG	15 DEG	30 DEG	45 DEG
+6.5	3.13E-17	2.33E-17	1.87E-17	1.64E-17
+5.5	7.50E-17	5.99E-17	4.23E-17	3.68E-17
+4.5	1.14E-16	9.06E-17	6.49E-17	5.82E-17
+3.5	1.19E-16	9.48E-17	7.20E-17	6.53E-17
+2.5	1.28E-16	1.03E-16	7.56E-17	7.46E-17
+1.5	1.22E-16	9.38E-17	7.89E-17	7.12E-17
+0.5	1.09E-16	9.00E-17	7.30E-17	6.69E-17
-0.5	9.40E-17	8.29E-17	7.95E-17	7.24E-17
-1.5	9.10E-17	7.99E-17	7.48E-17	7.32E-17
-2.5	1.03E-16	8.35E-17	7.68E-17	7.10E-17
-3.5	1.05E-16	9.12E-17	7.06E-17	6.83E-17
-4.5	1.08E-16	8.43E-17	6.71E-17	6.05E-17
-5.5	7.22E-17	5.88E-17	4.43E-17	2.06E-17
-6.5	2.95E-17	2.35E-17	1.79E-17	1.86E-17

TABLE 6.3-4

Co-59 (n,γ) REACTION RATES DERIVED FROM THE STAINLESS STEEL
GRADIENT CHAINS IRRADIATED DURING CYCLE 17

FEET FROM MIDPLANE	REACTION RATE (rps/nucleus)			
	0 DEG	15 DEG	30 DEG	45 DEG
+6.5	2.11E-14	2.19E-14	1.81E-14	1.55E-14
+5.5	3.93E-14	7.05E-14	5.06E-14	3.13E-14
+4.5	5.32E-14	9.92E-14	7.31E-14	4.20E-14
+3.5	6.16E-14	1.12E-13	8.56E-14	5.03E-14
+2.5	6.68E-14	1.18E-13	9.19E-14	5.59E-14
+1.5	6.63E-14	1.15E-13	9.45E-14	5.90E-14
+0.5	6.68E-14	1.07E-13	9.45E-14	5.90E-14
-0.5	6.63E-14	8.46E-14	7.62E-14	4.92E-14
-1.5	6.42E-14	7.93E-14	7.41E-14	4.83E-14
-2.5	6.47E-14	7.88E-14	7.15E-14	4.63E-14
-3.5	6.37E-14	7.73E-14	6.53E-14	4.31E-14
-4.5	5.32E-14	6.68E-14	5.32E-14	3.51E-14
-5.5	3.64E-14	4.92E-14	2.88E-14	1.13E-14
-6.5	3.39E-14	2.63E-14	2.03E-14	1.93E-14

TABLE 6.3-5

DERIVED EXPOSURE RATES FROM THE CAPSULE BB DOSIMETRY EVALUATION
0 DEGREE AZIMUTH - CORE MIDPLANE

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	1.56E+09	1.50E+09	8%
ϕ (E > 0.1 Mev)	1.25E+10	1.13E+10	16%
ϕ (E < 0.414 ev)	2.38E+09	1.49E+09	25%
ϕ (Total)	3.40E+10	3.10E+10	15%
dpa/sec	5.23E-12	4.79E-12	14%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
0 DEGREE AZIMUTH - CORE MIDPLANE

REACTION	REACTION RATE (rps/nucleus) MEASURED	A PRIORI CALC.	ADJUSTED CALC.	C/M A PRIORI	C/M ADJUSTED
Cu-63 (n,α)	9.04E-19	1.16E-18	9.39E-19	1.29	1.04
Ti-46 (n,p)	1.32E-17	1.40E-17	1.31E-17	1.06	0.99
Fe-54 (n,p)	7.79E-17	7.70E-17	7.57E-17	0.99	0.97
Ni-58 (n,p)	1.10E-16	1.06E-16	1.07E-16	0.96	0.97
U-238 (n,f) (Cd)	3.74E-16	4.51E-16	4.30E-16	1.21	1.15
Np-237 (n,f) (Cd)	6.20E-15	6.68E-15	6.22E-15	1.08	1.00
Co-59 (n,γ)	9.31E-14	1.27E-13	9.33E-14	1.37	1.00
Co-59 (n,γ) (Cd)	5.52E-14	6.37E-14	5.53E-14	1.15	1.00
U-235 (n,f)	7.83E-13	1.16E-12	7.87E-13	1.48	1.01
U-235 (n,f) (Cd)	2.63E-13	2.44E-13	2.54E-13	0.93	0.97

TABLE 6.3-6

DERIVED EXPOSURE RATES FROM THE CAPSULE DD DOSIMETRY EVALUATION
15 DEGREE AZIMUTH - CORE MIDPLANE

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	1.40E+09	1.25E+09	8%
ϕ (E > 0.1 Mev)	1.25E+10	9.91E+09	16%
ϕ (E < 0.414 ev)	2.27E+09	1.87E+09	24%
ϕ (Total)	3.05E+10	2.72E+10	13%
dpa/sec	4.45E-12	3.64E-12	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
15 DEGREE AZIMUTH - CORE MIDPLANE

REACTION RATE (rps/nucleus)   C/M

REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	8.01E-19	1.02E-18	8.34E-19	1.27	1.04
Ti-46 (n,p)	1.16E-17	1.21E-17	1.15E-17	1.05	0.99
Fe-54 (n,p)	6.79E-17	6.68E-17	6.57E-17	0.98	0.97
Ni-58 (n,p)	9.61E-17	9.18E-17	9.29E-17	0.96	0.97
U-238 (n,f) (Cd)	3.09E-16	3.97E-16	3.61E-16	1.29	1.17
Np-237 (n,f) (Cd)	5.01E-15	6.32E-15	5.17E-15	1.26	1.03
Co-59 (n,γ)	1.17E-13	1.28E-13	1.15E-13	1.10	0.98
Co-59 (n,γ) (Cd)	6.68E-14	6.85E-14	6.76E-14	1.02	1.01
U-235 (n,f)	9.11E-13	1.10E-12	9.49E-13	1.21	1.04
U-235 (n,f) (Cd)	2.98E-13	2.51E-13	2.84E-13	0.84	0.95

TABLE 6.3-7

DERIVED EXPOSURE RATES FROM THE CAPSULE EE DOSIMETRY EVALUATION
30 DEGREE AZIMUTH - CORE MIDPLANE

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	1.12E+09	1.08E+09	8%
ϕ (E > 0.1 Mev)	9.99E+09	8.74E+09	16%
ϕ (E < 0.414 ev)	1.91E+09	1.94E+09	23%
ϕ (Total)	2.51E+10	2.44E+10	13%
dpa/sec	3.54E-12	3.17E-12	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
30 DEGREE AZIMUTH - CORE MIDPLANE

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	6.79E-19	8.84E-19	7.09E-19	1.30	1.04
Ti-46 (n,p)	1.00E-17	1.04E-17	9.87E-18	1.04	0.99
Fe-54 (n,p)	5.64E-17	5.54E-17	5.50E-17	0.98	0.98
Ni-58 (n,p)	8.01E-17	7.59E-17	7.78E-17	0.95	0.97
U-238 (n,f) (Cd)	2.78E-16	3.20E-16	3.10E-16	1.15	1.11
Np-237 (n,f) (Cd)	4.41E-15	5.02E-15	4.54E-15	1.14	1.03
Co-59 (n,γ)	1.05E-13	1.09E-13	1.07E-13	1.03	1.02
Co-59 (n,γ) (Cd)	5.76E-14	5.84E-14	5.72E-14	1.01	0.99
U-235 (n,f)	1.02E-12	9.28E-13	9.73E-13	0.91	0.95
U-235 (n,f) (Cd)	2.66E-13	2.14E-13	2.59E-13	0.80	0.97

TAILE 6.3-8

DERIVED EXPOSURE RATES FROM THE CAPSULE FF DOSIMETRY EVALUATION
45 DEGREE AZIMUTH - CORE MIDPLANE

| | A PRIORI | ADJUSTED | |
PARAMETER	VALUE	VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	1.01E+09	9.55E+08	8%
ϕ (E > 0.1 Mev)	8.50E+09	7.04E+09	1.%
ϕ (E < 0.414 ev)	1.92E+09	8.03E+08	27%
ϕ (Total)	2.16E+10	1.82E+10	13%
dpa/sec	3.06E-12	2.62E-12	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
45 DEGREE AZIMUTH - CORE MIDPLANE

REACTION RATE (rps/nucleus)   C/M

| | | | A PRIORI | ADJUSTED | | |
REACTION	MEASURED	CALC.	CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	6.97E-19	8.87E-19	7.24E-19	1.27	1.04
Ti-46 (n,p)	9.83E-18	1.03E-17	9.74E-18	1.04	0.99
Fe-54 (n,p)	5.41E-17	5.31E-17	5.28E-17	0.98	0.98
Ni-58 (n,p)	7.65E-17	7.24E-17	7.42E-17	0.95	0.97
U-238 (n,f) (Cd)	2.58E-16	2.95E-16	2.84E-16	1.15	1.10
Np-237 (n,f) (Cd)	3.66E-15	4.40E-15	3.79E-15	1.20	1.03
Co-59 (n,γ)	6.50E-14	1.02E-13	6.48E-14	1.56	1.00
Co-59 (n,γ) (Cd)	4.41E-14	5.04E-14	4.43E-14	1.14	1.01
U-235 (n,f)	4.52E-13	9.21E-13	4.65E-13	2.04	1.03
U-235 (n,f) (Cd)	1.97E-13	1.84E-13	1.89E-13	0.94	0.96

TABLE 6.3-9

DERIVED EXPOSURE RATES FROM THE CAPSULE AA DOSIMETRY EVALUATION
0 DEGREE AZIMUTH - CORE TOP

PARAMETER	A PRIORI VALUE	ADJUSTED VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	7.11E+08	7.91E+08	11%
ϕ (E > 0.1 Mev)	5.72E+09	5.88E+09	22%
ϕ (E < 0.414 ev)	1.09E+09	5.49E+08	25%
ϕ (Total)	1.55E+10	1.45E+10	18%
dpa/sec	2.39E-12	2.45E-12	19%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
0 DEGREE AZIMUTH - CORE TOP

	REACTION RATE (rps/nucleus)			C/M	
REACTION	MEASURED	A PRIORI CALC.	ADJUSTED CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	4.23E-19	5.31E-19	4.40E-19	1.25	1.04
Ti-46 (n,p)	6.56E-18	6.39E-18	6.41E-18	0.97	0.98
Fe-54 (n,p)	3.55E-17	3.51E-17	3.62E-17	0.99	1.02
Ni-58 (n,p)	5.66E-17	4.82E-17	5.41E-17	0.85	0.96
U-238 (n,f) (Cd)	2.12E-16	2.06E-16	2.24E-16	0.97	1.06
Co-59 (n,γ)	3.89E-14	5.81E-14	4.13E-14	1.49	1.06
Co-59 (n,γ) (Cd)	2.79E-14	2.91E-14	2.68E-14	1.04	0.96
U-235 (n,f)	3.32E-13	5.29E-13	3.02E-13	1.59	0.91
U-235 (n,f) (Cd)	9.87E-14	1.11E-13	1.02E-13	1.13	1.03

TABLE 6.3-10

DERIVED EXPOSURE RATES FROM THE CAPSULE CC DOSIMETRY EVALUATION
0 DEGREE AZIMUTH - CORE BOTTOM

| | A PRIORI | ADJUSTED | |
PARAMETER	VALUE	VALUE	UNCERTAINTY
ϕ (E > 1.0 Mev)	7.24E+08	6.82E+08	8%
ϕ (E > 0.1 Mev)	5.83E+09	4.53E+09	16%
ϕ (E < 0.414 ev)	1.11E+09	6.85E+08	21%
ϕ (Total)	1.58E+10	1.15E+10	14%
dpa/sec	2.43E-12	1.95E-12	13%

COMPARISON OF MEASURED AND CALCULATED SENSOR REACTION RATES
0 DEGREE AZIMUTH - CORE BOTTOM

	REACTION RATE (rps/nucleus)			C/M	
		A PRIORI	ADJUSTED		
REACTION	MEASURED	CALC.	CALC.	A PRIORI	ADJUSTED
Cu-63 (n,α)	3.92E-19	5.41E-19	4.10E-19	1.38	1.05
Ti-46 (n,p)	6.08E-18	6.50E-18	6.00E-18	1.07	0.99
Fe-54 (n,p)	3.62E-17	3.58E-17	3.52E-17	0.99	0.97
Ni-58 (n,p)	5.22E-17	4.91E-17	5.04E-17	0.94	0.96
U-238 (n,f) (Cd)	1.78E-16	2.09E-16	2.00E-16	1.18	1.12
Np-237 (n,f) (Cd)	2.54E-15	3.10E-15	2.60E-15	1.22	1.02
Co-59 (n,γ)	4.25E-14	5.92E-14	4.57E-14	1.39	1.07
Co-59 (n,γ) (Cd)	2.79E-14	2.96E-14	2.66E-14	1.06	0.95
U-235 (n,f)	3.95E-13	5.38E-13	3.48E-13	1.36	0.88
U-235 (n,f) (Cd)	7.12E-14	1.13E-13	7.66E-14	1.59	1.08

TABLE 6.3-11

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
CYCLE 17 IRRADIATION

AZIMUTHAL ANGLE

HEIGHT (ft)	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
+6.5	4.39E+08	3.20E+08	2.50E+08	2.18E 08
+6.0	7.91E+08			
+5.5	1.07E+09	8.15E+08	5.98E+08	4.96E+08
+4.5	1.61E+09	1.17E+09	9.12E+08	7.81E+08
+3.5	1.74E+09	1.31E+09	1.04E+09	8.86E+08
+2.5	1.85E+09	1.44E+09	1.03E+09	1.00E+09
+1.5	1.77E+09	1.36E+09	1.07E+09	9.42E+08
+0.5	1.61E+09	1.29E+09	1.06E+09	9.02E+08
0.0	1.50E+09	1.25E+09	1.08E+09	9.55E+08
-0.5	1.39E+09	1.21E+09	1.10E+09	1.01E+09
-1.5	1.36E+09	1.13E+09	1.04E+09	9.75E+08
-2.5	1.43E+09	1.22E+09	1.07E+09	9.85E+08
-3.5	1.52E+09	1.27E+09	9.90E+08	9.26E+08
-4.5	1.52E+09	1.22E+09	9.40E+08	8.19E+08
-5.5	1.05E+09	8.30E+08	5.95E+08	4.22E+08
-6.0	6.82E+08			
-6.5	4.31E+08	3.18E+08	2.41E+08	2.51E+08

TABLE 6.3-12

FAST NEUTRON FLUX (E > 0.1 MeV) AS A FUNCTION
OF AXIAL POSITION WITHIN THE REACTOR CAVITY
CYCLE 17 IRRADIATION

AZIMUTHAL ANGLE

HEIGHT (ft)	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
+6.5	3.30E+09	2.54E+09	2.02E+09	1.61E+09
+6.0	5.88E+09			
+5.5	8.07E+09	6.46E+09	4.84E+09	3.66E+09
+4.5	1.21E+10	9.31E+09	7.38E+09	5.75E+09
+3.5	1.31E+10	1.04E+10	8.44E+09	6.53E+09
+2.5	1.39E+10	1.14E+10	8.36E+09	7.37E+09
+1.5	1.33E+10	1.08E+10	8.63E+09	6.95E+09
+0.5	1.21E+10	1.02E+10	8.58E+09	6.65E+09
0.0	1.13E+10	9.91E+09	8.74E+09	7.04E+09
-0.5	1.05E+10	9.59E+09	8.90E+09	7.43E+09
-1.5	1.02E+10	8.95E+09	8.44E+09	7.19E+09
-2.5	1.08E+10	9.70E+09	8.63E+09	7.26E+09
-3.5	1.15E+10	1.01E+10	8.01E+09	6.83E+09
-4.5	1.15E+10	9.67E+09	7.61E+09	6.04E+09
-5.5	7.88E+09	6.58E+09	4.81E+09	3.11E+09
-6.0	4.53E+09			
-6.5	3.25E+09	2.52E+09	1.95E+09	1.85E+09

TABLE 6.3-13

IRON ATOM DISPLACEMENT RATE (dpa/sec) AS A FUNCTION OF AXIAL POSITION WITHIN THE REACTOR CAVITY CYCLE 17 IRRADIATION

AZIMUTHAL ANGLE

HEIGHT (ft)	0 DEGREES	15 DEGREES	30 DEGREES	45 DEGREES
+6.5	1.40E-12	9.31E-13	7.34E-13	5.98E-13
+6.0	2.45E-12			
+5.5	3.42E-12	2.37E-12	1.73E-12	1.36E-12
+4.5	5.14E-12	3.42E-12	2.68E-12	2.14E-12
+3.5	5.55E-12	3.83E-12	3.06E-12	2.43E-12
+2.5	5.91E-12	4.20E-12	3.03E-12	2.74E-12
+1.5	5.64E-12	3.95E-12	3.13E-12	2.59E-12
+0.5	5.14E-12	3.76E-12	3.11E-12	2.48E-12
0.0	4.79E-12	3.64E-12	3.17E-12	2.62E-12
-0.5	4.44E-12	3.52E-12	3.23E-12	2.76E-12
-1.5	4.33E-12	3.29E-12	3.06E-12	2.68E-12
-2.5	4.58E-12	3.56E-12	3.13E-12	2.70E-12
-3.5	4.85E-12	3.69E-12	2.91E-12	2.54E-12
-4.5	4.86E-12	3.55E-12	2.76E-12	2.25E-12
-5.5	3.34E-12	2.42E-12	1.75E-12	1.16E-12
-6.0	1.95E-12			
-6.5	1.38E-12	9.26E-13	7.06E-13	6.87E-13

FIGURE 6.3-1

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 0 DEGREE TRAVERSE IN THE REACTOR CAVITY
CYCLE 17 IRRADIATION
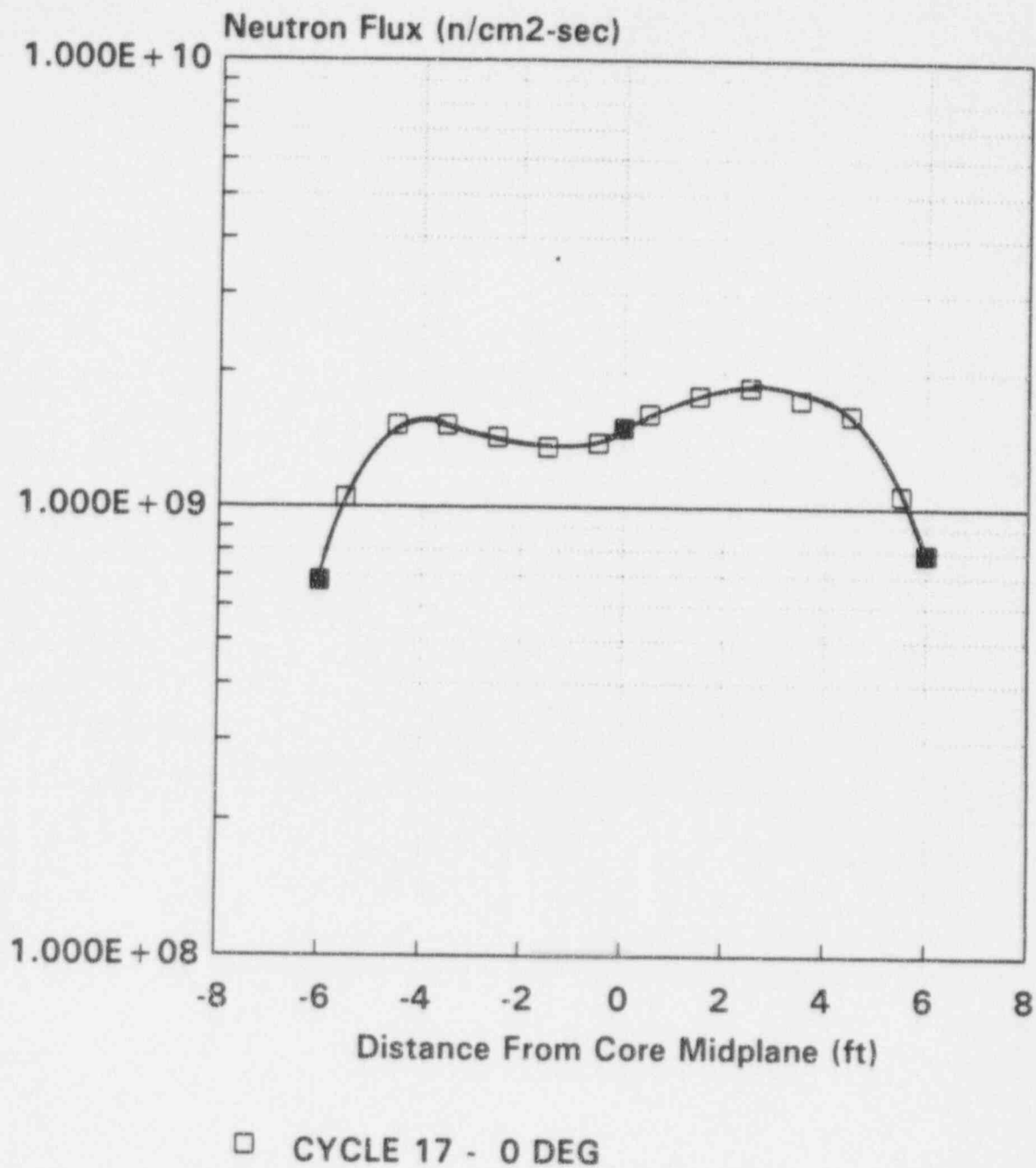
FIGURE 6.3-2

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 15 DEGREE TRAVERSE IN THE REACTOR CAVITY
CYCLE 17 IRRADIATION

□ CYCLE 17 - 15 DEG
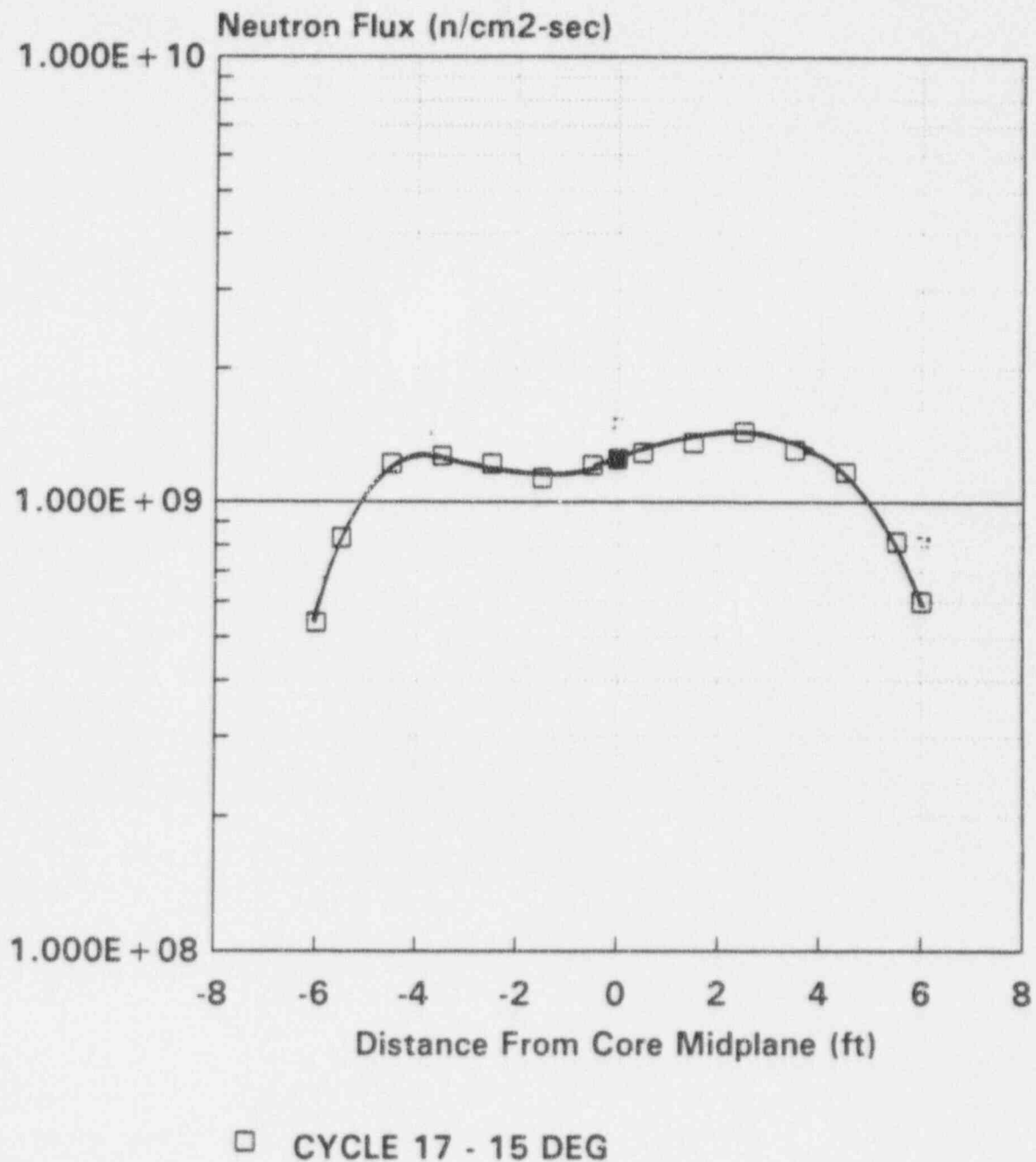
FIGURE 6.3-3

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 30 DEGREE TRAVERSE IN THE REACTOR CAVITY
CYCLE 17 IRRADIATION

□ CYCLE 17 - 30 DEG
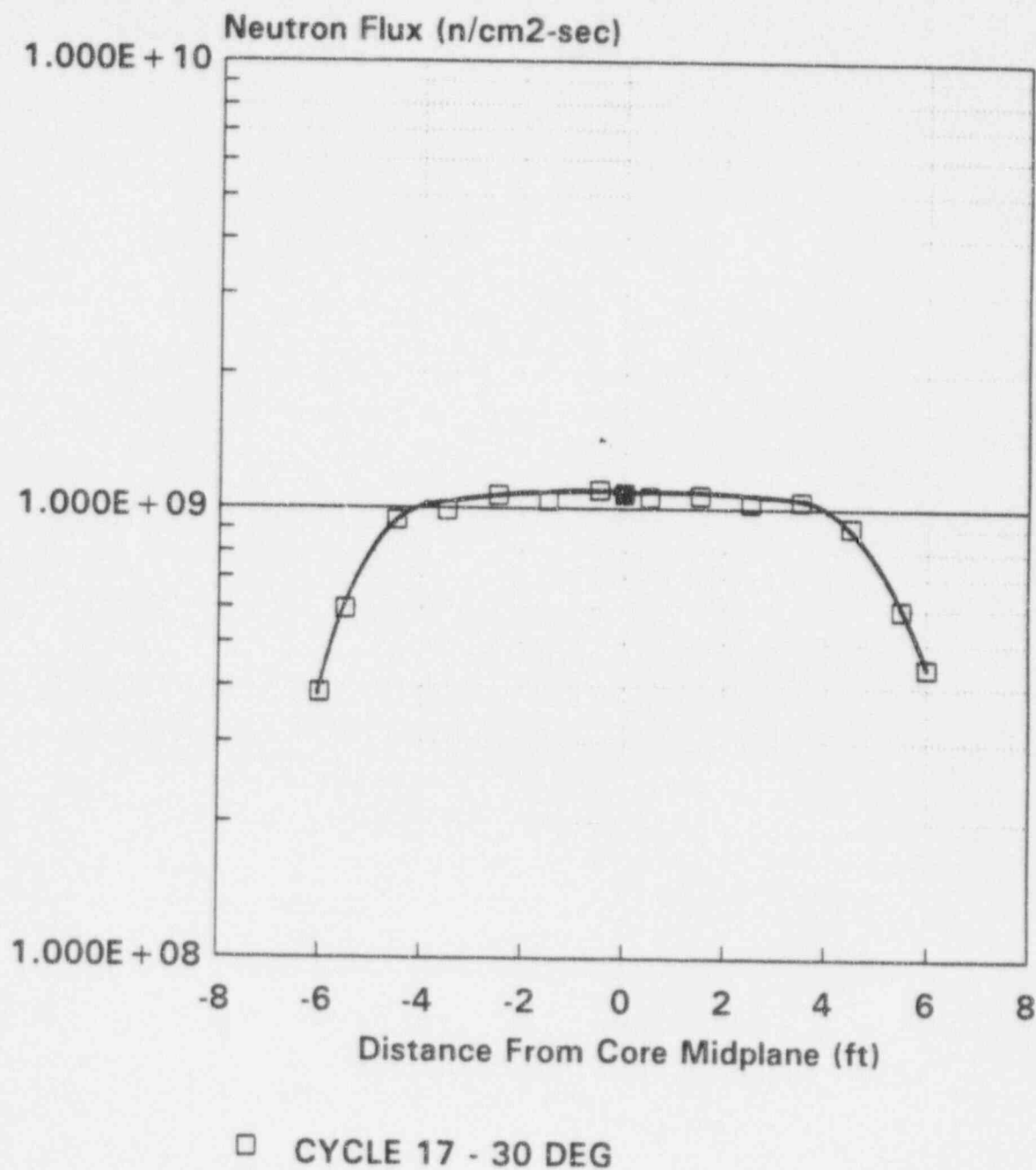
FIGURE 6.3-4

FAST NEUTRON FLUX (E > 1.0 MeV) AS A FUNCTION OF AXIAL POSITION
ALONG THE 45 DEGREE TRAVERSE IN THE REACTOR CAVITY
CYCLE 17 IRRADIATION

CYCLE 17 - 45 DEG
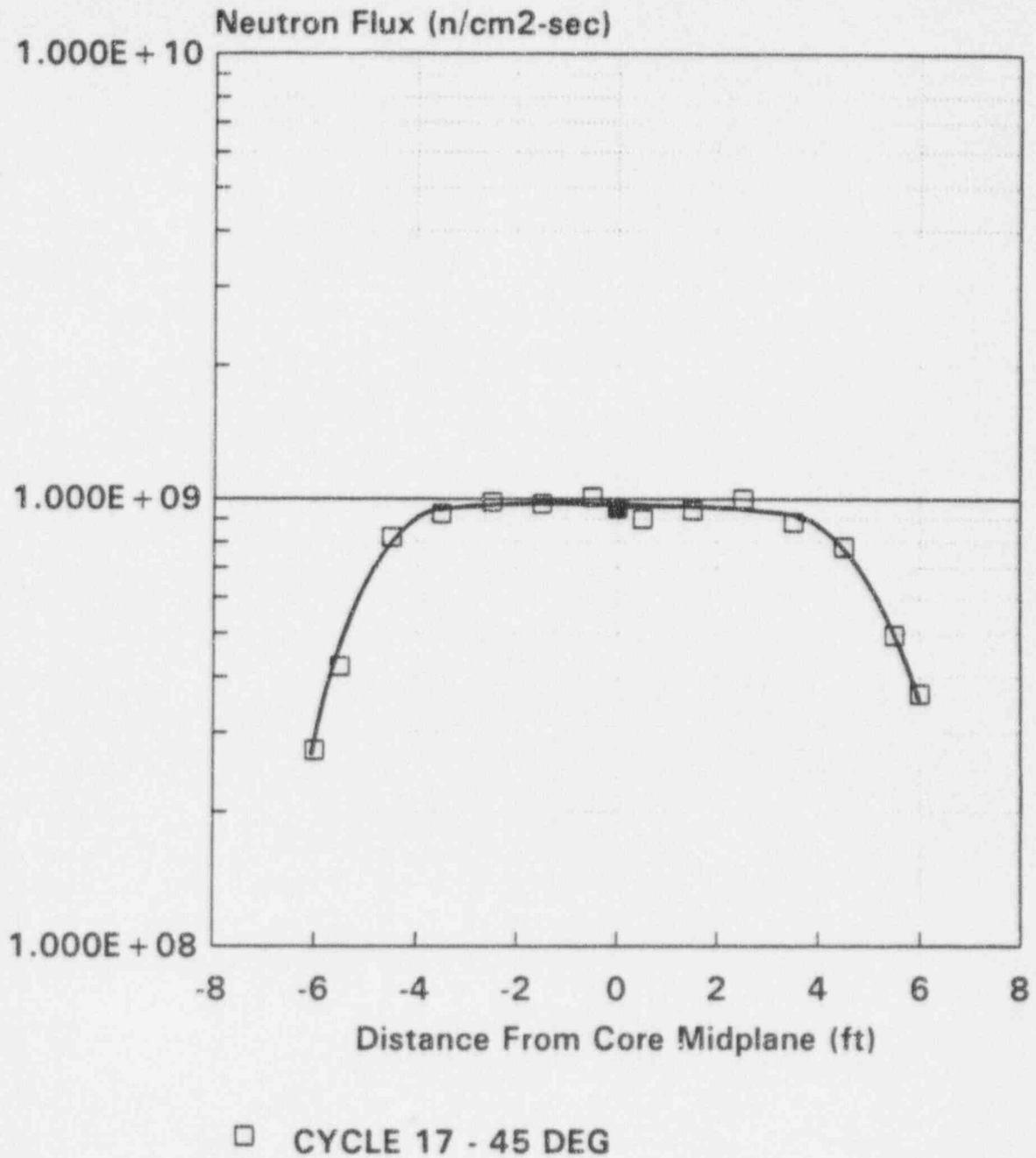
SECTION 7.0

COMPARISON OF CALCULATIONS WITH MEASUREMENTS

In order to develop accurate neutron exposure profiles at the inner
diameter and through the thickness of the pressure vessel wall, the
measurement results provided in Sections 5.0 and 6.0 must be combined with
analytically determined spatial gradients provided in Section 4.0. In
essence, this approach accepts the measurement results as the best
available exposure rate information for the irradiation period in question
and assumes that the analytically determined radial distribution functions
provide accurate representations of the spatial gradients that exist among
the measurement locations and the points of interest within the pressure
vessel wall. This approach is analagous to the common practice of
normalizing a cycle specific forward neutron transport calculation to
available measurements from either surveillance capsule or reactor cavity
dosimetry programs.

An indication of the acceptability of this method of exposure
determination can be gained by an absolute comparison of the results of
neutron transport calculations with all measured results applicable to a
given reactor. These comparisons quantify the biases that may exist due
to the transport methodology, reactor modeling, and/or reactor operating
characteristics over the respective irradiation periods; and, furthermore,
demonstrate the degree of consistency among the measurements obtained from
different geometric locations and varying irradiation intervals.

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 ϕ (E > 1.0 MeV), ϕ (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

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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 calculation/measurement comparisons are yielding accurate bias factors that can be applied to neutron transport calculations performed for the Point Beach Unit 2 reactor.

7.1 Comparison of Least Squares Adjustment Results with Calculation

In Table 7.1-1, comparisons of calculated and measured exposure rates for the four surveillance capsule dosimetry sets and for the three cycles of reactor midplane dosimetry sets irradiated during Cycles 15, 16, and 17 are given. In all cases, the calculated values were based on the fuel cycle specific exposure calculations averaged over the appropriate irradiation period. That is, the Capsule V values apply to Cycle 1, the Capsules T, R, and S values represent averages over Cycles 1 through 3, 1 through 5, and 1 through 16, respectively; and, the cavity measurements directly apply to Cycles 15, 16, and 17.

An examination of Table 7.1-1 indicates that, considering all of the available core midplane data, the calculated exposure rates underpredicted measurements by factors of 0.869, 0.915, and 0.918 for ϕ (E > 1.0 MeV), ϕ (E > 0.1 MeV), and dpa/sec, respectively. The standard deviations associated with each of the 16 sample data sets were 8.3%, 9.3%, and 8.8%, respectively.

The data comparisons provided in Table 7.1-1 also indicate a bias between the surveillance capsule and reactor cavity dosimetry comparisons; where the agreement between calculation and measurement is best at the cavity sensor locations and somewhat worse at the surveillance capsules. The reasons for this apparent bias cannot be acertained at this time, but may be due to the complexities in modeling the Point Beach Unit 2 surveillance capsules and support structure that exhibit a variable geometry over the capsule height. In contrast, the sensor holders used in the cavity

irradiations were designed to provide free field measurements by minimizing perturbations in the neutron field and, thus, simplifying the neutron transport calculations. In any event, the inclusion of both sets of measurements in the data base listed in Table 7.1-1 results in an acceptable determination of calculation to measurement bias factors with standard deviations of better than 10% in all cases.

7.2 Comparisons of Measured and Calculated Sensor Reaction Rates

In Table 7.2-1, calculation/measurement 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 standard deviations observed for the six fast neutron reactions range from 4% to 12% on an individual reaction basis; whereas, the overall average C/M ratio for the entire data set has an associated 1σ standard deviation of approximately 8.5%. Furthermore, the average C/M bias of 0.892 observed in the reaction rate comparisons is in excellent agreement with the values of 0.869, 0.915, and 0.918 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

FAST NEUTRON FLUX (E > 1.0 MeV)

	ϕ [n/cm2-sec]		
	MEASURED	CALCULATED	C/M
13 DEGREE CAPSULE (V)	1.48E+11	1.10E+11	0.743
23 DEGREE CAPSULE (T)	8.23E+10	6.61E+10	0.803
13 DEGREE CAPSJLE (R)	1.42E+11	1.10E+10	0.775
33 DEGREE CAPSULE (S)	7.44E+10	5.43E+10	0.730
0 DEGREE CAVITY (CY15)	1.87E+09	1.71E+09	0.914
15 DEGREE CAVITY (CY15)	1.69E+09	1.43E+09	0.846
30 DEGREE CAVITY (CY15)	1.23E+09	1.11E+09	0.902
45 DEGREE CAVITY (CY15)	1.10E+09	9.15E+08	0.832
0 DEGREE CAVITY (CY16)	1.45E+09	1.39E+09	0.960
15 DEGREE CAVITY (CY16)	1.28E+09	1.17E+09	0.910
30 DEGREE CAVITY (CY16)	9.73E+08	9.44E+08	0.970
45 DEGREE CAVITY (CY16)	9.63E+08	8.28E+08	0.860
0 DEGREE CAVITY (CY17)	1.50E+09	1.40E+09	0.930
15 DEGREE CAVITY (CY17)	1.25E+09	1.17E+09	0.937
30 DEGREE CAVITY (CY17)	1.08E+09	9.68E+08	0.896
45 DEGREE CAVITY (CY17)	9.55E+08	8.60E+08	0.901

AVERAGE C/M RATIO   0.869

1σ VARIATION   ± 0.072

TABLE 7.1-1 (Continued)

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

FAST NEUTRON FLUX (E > 0.1 MeV)

	ϕ [n/cm2-sec]		
	MEASURED	CALCULATED	C/M
13 DEGREE CAPSULE (V)	5.36E+11	4.21E+11	0.785
23 DEGREE CAPSULE (T)	2.84E+11	2.30E+11	0.810
13 DEGREE CAPSULE (R)	5.40E+11	4.19E+11	0.776
33 DEGREE CAPSULE (S)	2.41E+11	1.90E+11	0.788
0 DEGREE CAVITY (CY15)	1.38E+10	1.36E+10	0.986
15 DEGREE CAVITY (CY15)	1.45E+10	1.23E+10	0.848
30 DEGREE CAVITY (CY15)	1.02E+10	9.73E+09	0.954
45 DEGREE CAVITY (CY15)	8.66E+09	7.61E+09	0.879
0 DEGREE CAVITY (CY16)	1.10E+10	1.10E+10	1.004
15 DEGREE CAVITY (CY16)	1.03E+10	1.00E+10	0.971
30 DEGREE CAVITY (CY16)	8.16E+09	8.30E+09	1.017
45 DEGREE CAVITY (CY16)	7.65E+09	6.89E+09	0.900
0 DEGREE CAVITY (CY17)	1.13E+10	1.11E+10	0.978
15 DEGREE CAVITY (CY17)	9.91E+09	1.01E+10	1.009
30 DEGREE CAVITY (CY17)	8.74E+09	8.51E+09	0.949
45 DEGREE CAVITY (CY17)	7.04E+09	7.16E+09	0.978

AVERAGE C/M RATIO   0.915

1σ VARIATION $\pm$ 0.085

TABLE 7.1-1 (Continued)

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

IRON ATOM DISPLACEMENT RATE

	[dpa/sec]		
	MEASURED	CALCULATED	C/M
13 DEGREE CAPSULE (V)	2.53E-10	2.04E-10	0.806
23 DEGREE CAPSULE (T)	1.40E-10	1.17E-10	0.836
13 DEGREE CAPSULE (R)	2.51E-10	2.03E-10	0.809
33 DEGREE CAPSULE (S)	1.22E-10	9.55E-10	0.783
0 DEGREE CAVITY (CY15)	5 87E-12	5.18E-12	0.882
15 DEGREE CAVITY (CY15)	5.21E-12	4.60E-12	0.883
30 DEGREE CAVITY (CY15)	3.69E-12	3.64E-12	0.986
45 DEGREE CAVITY (CY15)	3.15E-12	2.89E-12	0.917
0 DEGREE CAVITY (CY16)	4.66E-12	4.22E-12	0.905
15 DEGREE CAVITY (CY16)	3.76E-12	3.75E-12	0.998
30 DEGREE CAVITY (CY16)	2.95E-12	3.10E-12	1.053
45 DEGREE CAVITY (CY16)	2.78E-12	2.62E-12	0.941
0 DEGREE CAVITY (CY17)	4.79E-12	4.23E-12	0.880
15 DEGREE CAVITY (CY17)	3.64E-12	3.77E-12	1.031
30 DEGREE CAVITY (CY17)	3.17E-12	3.18E-12	0.979
45 DEGREE CAVITY (CY17)	2.62E-12	2.72E-12	0.998

AVERAGE C/M RATIO			0.918
1σ VARIATION			± 0.081

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)
CAPSULES						
V	0.898		0.898		0.724	0.850
T	0.893		0.873	0.888	0.849	0.830
R	0.832		0.892	0.864	0.787	0.823
S	0.797			0.728	0.742	0.835
CY15 CAVITY						
0 DEGREE	0.919	0.920	0.920	0.884	0.979	0.992
15 DEGREE	0.796	0.799	0.812	0.803	0.910	0.862
30 DEGREE	0.905	0.893	0.867	0.884	0.982	0.968
45 DEGREE	0.870	0.851	0.907	0.859	0.887	0.888
CY16 CAVITY						
0 DEGREE	0.932	0.955	0.952	0.927	1.034	1.021
15 DEGREE	0.852	0.879	0.887	0.858	0.935	1.004
30 DEGREE	0.854	0.883	0.879	0.863	1.062	1.023
45 DEGREE	0.852	0.887	0.864	0.841	0.940	0.900
CY17 CAVITY						
0 DEGREE	0.885	0.919	0.909	0.902	1.109	0.990
15 DEGREE	0.799	0.834	0.827	0.825	1.090	1.058
30 DEGREE	0.844	0.851	0.858	0.845	1.005	0.991
45 DEGREE	0.808	0.830	0.835	0.817	0.969	1.016
AVERAGE C/M	0.859	0.875	0.879	0.853	0.938	0.941
1σ	± 0.043	± 0.042	± 0.036	± 0.046	± 0.113	± 0.080

TOTAL C/M RATIO   0.892

1σ VARIATION   ± 0.076

SECTION 8.0

BEST ESTIMATE NEUTRON EXPOSURE OF PRESSURE VESSEL MATERIALS

In this section the measurement results provided in Sections 5.0 and 6.0 are combined with the results of the neutron transport calculations described in Section 4.0 to establish a mapping of the best estimate neutron exposure of the beltline region of the Point Beach Unit 2 reactor pressure vessel through the completion of Cycle 17. Based on the continued use of the Cycle 16-17 fuel loading patterns incorporating part length hafnium absorbers, projections of future vessel exposure to 32 and 48 effective full power years of operation are also provided. In addition to the spatial mapping over the beltline region, data pertinent to the maximum exposure experienced by the upper and lower shell forgings and the beltline circumferential weld are highlighted.

8.1 Exposure Distributions Within the Beltline Region

In essence, an approach using analytically determined gradient information to extrapolate measurement results to locations of interest within the pressure vessel is based on the assertion that the measured values of exposure rates in the reactor cavity represent the best available neutron flux data for the irradiation period in question and, further, on the assumption that the analytically determined radial distribution functions provide accurate representations of the spatial gradients that exist among the measurement locations and points of interest within the pressure vessel wall. This method is analagous to the common practice of normalizing a cycle specific forward neutron transport calculation to available measurements from either surveillance capsule or reactor cavity dosimetry programs.

This approach provides accurate assessments of vessel exposure with associated uncertainties for periods of operation during which continuous

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monitoring has occured. In the case of Point Beach Unit 2, the cavity
dosimetry program providing a complete spatial mapping of a sector of the
beltline region of the pressure vessel was installed at the start of Cycle
15. Additional monitoring was limited to the four scheduled surveillance
capsule withdrawals described in preceding sections of this report. The
dosimetry data from these capsules provide measurement information at a
single point within the reactor geometry for the four extended irradiation
periods, but cannot be used to establish a verification of the exposure of
the vessel at azimuthal locations far removed from the measurement point.
Therefore, in order to establish a baseline exposure of the pressure
vessel applicable to the onset of the reactor cavity measurement program,
all available core midplane measured data were combined with fuel cycle
specific transport calculations to provide best estimate exposures for the
first 14 cycles of operation. The reactor cavity measurements were then
used directly to provide the continuous monitoring capability for Cycles
15 and beyond.

8.1.1 Baseline Exposure at the End of Cycle 14

In Table 7.1-1, comparisons of calculated and measured exposure rates for
the four surveillance capsule dosimetry sets and for the twelve cavity
dosimetry sets that were located on the core midplane are given. From
Table 7.1-1, it was noted that, considering all of the midplane data, the
calculated exposure values underpredicted measurement by factors of 0.869,
0.915, and 0.918 for ϕ (E > 1.0 MeV), ϕ (E > 0.1 MeV), and
dpa/sec, respectively. The corresponding 1σ standard deviations in
these averages of the twelve sample data sets were $\pm$ 8.3%, $\pm$ 9.3%, and
$\pm$ 8.8%.

In developing the best estimate baseline exposure for the Point Beach Unit
2 reactor pressure vessel these ratios were employed as bias factors to
scale the cycle specific neutron transport calculations documented in
Section 4.0 of this report. In particular, the following bias factors
were employed to establish the baseline exposures of the vessel wall:

	M/C BIAS
Φ (E > 1.0 MeV)	1.151
Φ (E > 0.1 MeV)	1.093
dpa	1.089

The end of Cycle 14 best estimate exposures at the pressure vessel clad/base metal interface are provided in Tables 8.1-1 through 8.1-4 for Φ (E > 1.0 MeV), in Tables 8.1-5 through 8.1-8 for Φ (E > 0.1 MeV), and in Tables 8.1-9 through 8.1-12 for dpa. In these data tables, exposures are presented as a function of axial position for four azimuthal locations around the circumference of the vessel. From these tabulations, the locations of maximum exposure of the various materials comprising the beltline region can easily be determined. Exposure distributions through the vessel wall can be developed by normalizing the surface exposures from Tables 8.1-1 through 8.1-12 to the appropriate radial distribution functions given in Section 4.0 of this report.

8.1.2 Exposure Accrued During Cycles 15, 16, and 17

To assess the incremental exposure resulting from the Cycles 15, 16, and 17 irradiations, the measured results from the reactor cavity multiple foil sensor sets were directly extrapolated to the vessel clad/base metal interface using the analytically derived gradient data from Section 4.0 of this report. The axial gradient chain measurements were, of course, employed to develop the axial traverses along the vessel wall. The extrapolated results applicable to the vessel inner surface are also incorporated into Tables 8.1-1 through 8.1-12 to establish the best estimate exposure accrued by the reactor vessel through the end of Cycles 15, 16, and 17, respectively.

Again, as noted above, exposure distributions through the vessel wall, can be developed using these surface exposures and radial distribution functions from Section 4.0. This exposure information, applicable through the end of Cycle 17, 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 Point
Beach Unit 2 will expand resulting in reduced uncertainties and an
improved accuracy in the assesment of vessel condition.

8.1.3 Projection of Future Vessel Exposure

At the end of Cycle 17, the Point Beach Unit 2 reactor had accrued 15.6
effective full power years (EFPY) of operation. In order to establish a
framework for the assessment of future vessel condition, exposure
projections to 32 and 48 EFPY are included in Tables 8.1-1 through 8.1-12
in addition to the plant specific exposure assessments through the end of
Cycle 17.

These temporal extrapolations into the future were based on the assumption
that the measured data averaged over the Cycles 16 and 17 irradiations
were representative of all future fuel cycles. That is, that future fuel
designs would incorporate the low leakage fuel management concept
including part length hafnium absorbers designed to provide flux reduction
measures at the maximum exposure locations along the beltline
circumferential weld. Examination of these projected exposure levels
establishes the long term effectiveness of flux reduction measures
incorporated to date and can be used as a guide in assessing strategies
for future vessel exposure management. The validity of these projections
for future operation will be confirmed via the continued cavity monitoring
program.

TABLE 8.1-1

SUMMARY OF BEST ESTIMATE FAST NEUTRON (E > 1.0 MeV) EXPOSURE
PROJECTIONS FOR THE BELTLINE REGION OF THE POINT BEACH UNIT 2
REACTOR PRESSURE VESSEL - 0 DEGREE AZIMUTHAL ANGLE

HEIGHT (ft)	Φ (E > 1.0 MeV) [n/cm2]					
	EOC 14	EOC 15	EOC 16	EOC 17	32 EFPY	48 EFPY
+6.0	4.27E+18	4.52E+18	4.79E+18	5.07E+18	1.03E+19	1.55E+19
+5.5	8.32E+18	8.66E+18	9.03E+18	9.41E+18	1.66E+19	2.36E+19
+4.5	1.22E+19	1.27E+19	1.33E+19	1.39E+19	2.49E+19	3.57E+19
+3.5	1.37E+19	1.42E+19	1.49E+19	1.55E+19	2.75E+19	3.92E+19
+2.5	1.42E+19	1.48E+19	1.55E+19	1.61E+19	2.88E+19	4.12E+19
+1.5	1.44E+19	1.50E+19	1.56E+19	1.62E+19	2.83E+19	4.01E+19
+0.5	1.45E+19	1.52E+19	1.57E+19	1.63E+19	2.72E+19	3.79E+19
0.0	1.45E+19	1.52E+19	1.57E+19	1.62E+19	2.63E+19	3.61E+19
-0.5	1.45E+19	1.52E+19	1.57E+19	1.61E+19	2.53E+19	3.43E+19
-1.5	1.45E+19	1.52E+19	1.56E+19	1.61E+19	2.51E+19	3.38E+19
-2.5	1.44E+19	1.51E+19	1.56E+19	1.61E+19	2.57E+19	3.52E+19
-3.5	1.42E+19	1.47E+19	1.53E+19	1.58E+19	2.62E+19	3.64E+19
-4.5	1.30E+19	1.35E+19	1.40E+19	1.46E+19	2.48E+19	3.48E+19
-5.5	9.10E+18	9.45E+18	9.82E+18	1.02E+19	1.73E+19	2.42E+19
-6.0	4.44E+18	4.68E+18	4.93E+18	5.16E+18	9.83E+18	1.44E+19

Note: Height is provided relative to the axial
      midplane of the active core.

TABLE 8.1-2

SUMMARY OF BEST ESTIMATE FAST NEUTRON (E > 1.0 MeV) EXPOSURE PROJECTIONS FOR THE BELTLINE REGION OF THE POINT BEACH UNIT 2 REACTOR PRESSURE VESSEL - 15 DEGREE AZIMUTHAL ANGLE

HEIGHT (ft)	Φ (E > 1.0 MeV) [n/cm2]					
	EOC 14	EOC 15	EOC 16	EOC 17	32 EFPY	48 EFPY
+6.0	2.61E+18	2.80E+18	2.98E+18	3.15E+18	6.49E+18	9.76E+18
+5.5	5.08E+18	5.34E+18	5.58E+18	5.81E+18	1.04E+19	1.49E+19
+4.5	7.44E+18	7.83E+18	8.21E+18	8.54E+18	1.54E+19	2.22E+19
+3.5	8.34E+18	8.77E+18	9.21E+18	9.58E+18	1.73E+19	2.49E+19
+2.5	8.62E+18	9.09E+18	9.53E+18	9.94E+18	1.82E+19	2.62E+19
+1.5	8.77E+18	9.23E+18	9.65E+18	1.00E+19	1.78E+19	2.54E+19
+0.5	8.85E+18	9.30E+18	9.69E+18	1.01E+19	1.73E+19	2.44E+19
0.0	8.89E+18	9.35E+18	9.71E+18	1.01E+19	1.70E+19	2.38E+19
-0.5	8.89E+18	9.36E+18	9.70E+18	1.00E+19	1.66E+19	2.31E+19
-1.5	8.87E+18	9.32E+18	9.67E+18	9.98E+18	1.64E+19	2.27E+19
-2.5	8.80E+18	9.25E+18	9.59E+18	9.94E+18	1.66E+19	2.31E+19
-3.5	8.61E+18	9.03E+18	9.43E+18	9.79E+18	1.71E+19	2.42E+19
-4.5	7.93E+18	8.32E+18	8.71E+18	9.06E+18	1.62E+19	2.31E+19
-5.5	5.55E+18	5.81E+18	6.06E+18	6.29E+18	1.09E+19	1.55E+19
-6.0	2.72E+18	2.90E+18	3.06E+18	3.21E+18	6.27E+18	9.26E+18

Note: Height is provided relative to the axial
midplane of the active core.

TABLE 8.1-3

SUMMARY OF BEST ESTIMATE FAST NEUTRON (E > 1.0 MeV) EXPOSURE
PROJECTIONS FOR THE BELTLINE REGION OF THE POINT BEACH UNIT 2
REACTOR PRESSURE VESSEL - 30 DEGREE AZIMUTHAL ANGLE

HEIGHT (ft)	ϕ (E > 1.0 MeV) [n/cm2]					
	EOC 14	EOC 15	EOC 16	EOC 17	32 EFPY	48 EFPY
+6.0	1.99E+18	2.12E+18	2.25E+18	2.38E+18	4.82E+18	7.21E+18
+5.5	3.85E+18	4.04E+18	4.21E+18	4.39E+18	7.73E+18	1.10E+19
+4.5	5.62E+18	5.90E+18	6.15E+18	6.42E+18	1.14E+19	1.62E+19
+3.5	6.29E+18	6.61E+18	6.87E+18	7.17E+18	1.26E+19	1.80E+19
+2.5	6.51E+18	6.85E+18	7.15E+18	7.44E+18	1.31E+19	1.87E+19
+1.5	6.61E+18	6.94E+18	7.23E+18	7.53E+18	1.32E+19	1.88E+19
+0.5	6.67E+18	7.01E+18	7.30E+18	7.60E+18	1.33E+19	1.89E+19
0.0	6.69E+18	7.03E+18	7.32E+18	7.63E+18	1.34E+19	1.90E+19
-0.5	6.69E+18	7.04E+18	7.33E+18	7.64E+18	1.34E+19	1.91E+19
-1.5	6.68E+18	7.02E+18	7.29E+18	7.59E+18	1.31E+19	1.85E+19
-2.5	6.62E+18	6.95E+18	7.23E+18	7.54E+18	1.32E+19	1.87E+19
-3.5	6.49E+18	6.80E+18	7.06E+18	7.34E+18	1.26E+19	1.77E+19
-4.5	5.99E+18	6.27E+18	6.51E+18	6.78E+18	1.17E+19	1.65E+19
-5.5	4.20E+18	4.38E+18	4.54E+18	4.71E+18	7.88E+18	1.10E+19
-6.0	2.07E+18	2.20E+18	2.31E+18	2.42E+18	4.50E+18	6.54E+18

Note: Height is provided relative to the axial
midplane of the active core.

TABLE 8.1-4

SUMMARY OF BEST ESTIMATE FAST NEUTRON (E > 1.0 MeV) EXPOSURE
PROJECTIONS FOR THE BELTLINE REGION OF THE POINT BEACH UNIT 2
REACTOR PRESSURE VESSEL - 45 DEGREE AZIMUTHAL ANGLE

HEIGHT (ft)	Φ (E > 1.0 MeV) [n/cm2]					
	EOC 14	EOC 15	EOC 16	EOC 17	32 EFPY	48 EFPY
+6.0	1.75E+18	1.87E+18	1.99E+18	2.10E+18	4.33E+18	6.50E+18
+5.5	3.40E+18	3.57E+18	3.73E+18	3.88E+18	6.92E+18	9.90E+18
+4.5	4.96E+18	5.22E+18	5.47E+18	5.71E+18	1.05E+19	1.52E+19
+3.5	5.56E+18	5.84E+18	6.12E+18	6.39E+18	1.16E+19	1.67E+19
+2.5	5.75E+18	6.06E+18	6.36E+18	6.66E+18	1.25E+19	1.82E+19
+1.5	5.84E+18	6.14E+18	6.43E+18	6.72E+18	1.23E+19	1.77E+19
+0.5	5.90E+18	6.19E+18	6.48E+18	6.76E+18	1.22E+19	1.75E+19
0.0	5.92E+18	6.22E+18	6.51E+18	6.81E+18	1.24E+19	1.79E+19
-0.5	5.92E+18	6.23E+18	6.53E+18	6.83E+18	1.27E+19	1.83E+19
-1.5	5.91E+18	6.20E+18	6.49E+18	6.79E+18	1.24E+19	1.79E+19
-2.5	5.86E+18	6.15E+18	6.44E+18	6.74E+18	1.24E+19	1.79E+19
-3.5	5.74E+18	6.02E+18	6.29E+18	6.58E+18	1.20E+19	1.72E+19
-4.5	5.29E+18	5.54E+18	5.81E+18	6.06E+18	1.10E+19	1.58E+19
-5.5	3.72E+18	3.88E+18	4.06E+18	4.19E+18	7.12E+18	9.99E+18
-6.0	1.84E+18	1.95E+18	2.07E+18	2.15E+18	4.09E+18	5.98E+18

Note: Height is provided relative to the axial
midplane of the active core.

TABLE 8.1-5

SUMMARY OF BEST ESTIMATE FAST NEUTRON (E > 0.1 MeV) EXPOSURE
PROJECTIONS FOR THE BELTLINE REGION OF THE POINT BEACH UNIT 2
REACTOR PRESSURE VESSEL - 0 DEGREE AZIMUTHAL ANGLE

HEIGHT (ft)	Φ (E > 0.1 MeV) [n/cm2]					
	EOC 14	EOC 15	EOC 16	EOC 17	32 EFPY	48 EFPY
+6.0	1.10E+19	1.17E+19	1.23E+19	1.30E+19	2.60E+19	3.86E+19
+5.5	2.15E+19	2.24E+19	2.34E+19	2.43E+19	4.30E+19	6.13E+19
+4.5	3.15E+19	3.28E+19	3.43E+19	3.57E+19	6.45E+19	9.25E+19
+3.5	3.54E+19	3.69E+19	3.85E+19	4.01E+19	7.13E+19	1.02E+20
+2.5	3.66E+19	3.82E+19	3.99E+19	4.16E+19	7.45E+19	1.07E+20
+1.5	3.72E+19	3.87E+19	4.04E+19	4.20E+19	7.33E+19	1.04E+20
+0.5	3.75E+19	3.91E+19	4.06E+19	4.20E+19	7.04E+19	9.81E+19
0.0	3.76E+19	3.92E+19	4.06E+19	4.19E+19	6.81E+19	9.36E+19
-0.5	3.76E+19	3.93E+19	4.05E+19	4.17E+19	6.56E+19	8.90E+19
-1.5	3.76E+19	3.92E+19	4.04E+19	4.16E+19	6.48E+19	8.75E+19
-2.5	3.73E+19	3.88E+19	4.01E+19	4.14E+19	6.66E+19	9.12E+19
-3.5	3.65E+19	3.79E+19	3.93E+19	4.07E+19	6.79E+19	9.45E+19
-4.5	3.36E+19	3.49E+19	3.63E+19	3.77E+19	6.43E+19	9.03E+19
-5.5	2.35E+19	2.44E+19	2.53E+19	2.63E+19	4.47E+19	6.26E+19
-6.0	1.15E+19	1.21E+19	1.27E+19	1.32E+19	2.44E+19	3.53E+19

Note: Height is provided relative to the axial
midplane of the active core.

TABLE 8.1-6

SUMMARY OF BEST ESTIMATE FAST NEUTRON (E > 0.1 MeV) EXPOSURE PROJECTIONS FOR THE BELTLINE REGION OF THE POINT BEACH UNIT 2 REACTOR PRESSURE VESSEL - 15 DEGREE AZIMUTHAL ANGLE

HEIGHT (ft)	Φ (E > 0.1 MeV) [n/cm2]					
	EOC 14	EOC 15	EOC 16	EOC 17	32 EFPY	48 EFPY
+6.0	7.21E+18	7.76E+18	8.20E+18	8.65E+18	1.72E+19	2.56E+19
+5.5	1.41E+19	1.48E+19	1.54E+19	1.61E+19	2.84E+19	4.05E+19
+4.5	2.05E+19	2.17E+19	2.27E+19	2.36E+19	4.24E+19	6.07E+19
+3.5	2.31E+19	2.43E+19	2.55E+19	2.65E+19	4.75E+19	6.80E+19
+2.5	2.39E+19	2.52E+19	2.65E+19	2.75E+19	4.97E+19	7.14E+19
+1.5	2.43E+19	2.56E+19	2.68E+19	2.78E+19	4.87E+19	6.92E+19
+0.5	2.45E+19	2.58E+19	2.68E+19	2.78E+19	4.74E+19	6.65E+19
0.0	2.46E+19	2.59E+19	2.69E+19	2.79E+19	4.66E+19	6.49E+19
-0.5	2.46E+19	2.60E+19	2.69E+19	2.78E+19	4.56E+19	6.30E+19
-1.5	2.45E+19	2.58E+19	2.67E+19	2.76E+19	4.50E+19	6.21E+19
-2.5	2.43E+19	2.43E+19	2.52E+19	2.62E+19	4.42E+19	6.19E+19
-3.5	2.38E+19	2.50E+19	2.61E+19	2.71E+19	4.68E+19	6.61E+19
-4.5	2.19E+19	2.31E+19	2.41E+19	2.50E+19	4.42E+19	6.29E+19
-5.5	1.53E+19	1.61E+19	1.67E+19	1.74E+19	2.99E+19	4.22E+19
-6.0	7.53E+18	8.06E+18	8.49E+18	8.85E+18	1.65E+19	2.39E+19

Note: Height is provided relative to the axial midplane of the active core.

TABLE 8.1-7

SUMMARY OF BEST ESTIMATE FAST NEUTRON (E > 0.1 MeV) EXPOSURE
PROJECTIONS FOR THE BELTLINE REGION OF THE POINT BEACH UNIT 2
REACTOR PRESSURE VESSEL - 30 DEGREE AZIMUTHAL ANGLE

HEIGHT (ft)	Φ (E > 0.1 MeV) [n/cm2]					
	EOC 14	EOC 15	EOC 16	EOC 17	32 EFPY	48 EFPY
+6.0	5.09E+18	5.45E+18	5.74E+18	6.05E+18	1.19E+19	1.76E+19
+5.5	9.83E+18	1.03E+19	1.08E+19	1.12E+19	1.96E+19	2.79E+19
+4.5	1.44E+19	1.52E+19	1.58E+19	1.65E+19	2.90E+19	4.12E+19
+3.5	1.61E+19	1.69E+19	1.76E+19	1.84E+19	3.22E+19	4.56E+19
+2.5	1.67E+19	1.76E+19	1.83E+19	1.91E+19	3.35E+19	4.76E+19
+1.5	1.69E+19	1.78E+19	1.85E+19	1.93E+19	3.36E+19	4.77E+19
+0.5	1.71E+19	1.80E+19	1.87E+19	1.95E+19	3.39E+19	4.81E+19
0.0	1.72E+19	1.81E+19	1.88E+19	1.96E+19	3.42E+19	4.84E+19
-0.5	1.72E+19	1.81E+19	1.88E+19	1.96E+19	3.43E+19	4.86E+19
-1.5	1.71E+19	1.80E+19	1.87E+19	1.94E+19	3.33E+19	4.70E+19
-2.5	1.70E+19	1.79E+19	1.86E+19	1.93E+19	3.35E+19	4.74E+19
-3.5	1.66E+19	1.74E+19	1.81E+19	1.88E+19	3.20E+19	4.49E+19
-4.5	1.53E+19	1.61E+19	1.67E+19	1.74E+19	2.98E+19	4.19E+19
-5.5	1.08E+19	1.13E+19	1.17E+19	1.21E+19	2.01E+19	2.79E+19
-6.0	5.32E+18	5.64E+18	5.90E+18	6.15E+18	1.10E+19	1.57E+19

Note: Height is provided relative to the axial
midplane of the active core.

TABLE 8.1-8

SUMMARY OF BEST ESTIMATE FAST NEUTRON (E > 0.1 MeV) EXPOSURE
PROJECTIONS FOR THE BELTLINE REGION OF THE POINT BEACH UNIT 2
REACTOR PRESSURE VESSEL - 45 DEGREE AZIMUTHAL ANGLE

HEIGHT (ft)	Φ (E > 0.1 MeV) [n/cm2]					
	EOC 14	EOC 15	EOC 16	EOC 17	32 EFPY	48 EFPY
+6.0	4.33E+18	4.64E+18	4.91E+18	5.16E+18	1.02E+19	1.51E+19
+5.5	8.40E+18	8.82E+18	9.22E+18	9.57E+18	1.69E+19	2.40E+19
+4.5	1.23E+19	1.29E+19	1.35E+19	1.41E+19	2.55E+19	3.67E+19
+3.5	1.38E+19	1.45E+19	1.51E+19	1.58E+19	2.83E+19	4.05E+19
+2.5	1.42E+19	1.49E+19	1.57E+19	1.64E+19	3.03E+19	4.39E+19
+1.5	1.44E+19	1.52E+19	1.59E+19	1.66E+19	2.99E+19	4.30E+19
+0.5	1.45E+19	1.53E+19	1.60E+19	1.66E+19	2.97E+19	4.24E+19
0.0	1.46E+19	1.54E+19	1.61E+19	1.68E+19	3.03E+19	4.34E+19
-0.5	1.46E+19	1.54E+19	1.61E+19	1.69E+19	3.08E+19	4.43E+19
-1.5	1.45E+19	1.53E+19	1.60E+19	1.67E+19	3.02E+19	4.33E+19
-2.5	1.44E+19	1.52E+19	1.59E+19	1.66E+19	3.01E+19	4.33E+19
-3.5	1.42E+19	1.48E+19	1.55E+19	1.62E+19	2.90E+19	4.16E+19
-4.5	1.31E+19	1.37E+19	1.44E+19	1.49E+19	2.68E+19	3.84E+19
-5.5	9.17E+18	9.58E+18	1.00E+19	1.03E+19	1.74E+19	2.43E+19
-6.0	4.53E+18	4.81E+18	5.09E+18	5.26E+18	9.58E+18	1.38E+19

Note: Height is provided relative to the axial
midplane of the active core.

TABLE 8.1-9

SUMMARY OF BEST ESTIMATE IRON ATOM DISPLACEMENT
PROJECTIONS FOR THE BELTLINE REGION OF THE POINT BEACH UNIT 2
REACTOR PRESSURE VESSEL - 0 DEGREE AZIMUTHAL ANGLE

HEIGHT	IRON ATOM DISPLACEMENTS [dpa]					
(ft)	EOC 14	EOC 15	EOC 16	EOC 17	32 EFPY	48 EFPY
+6.0	6.67E-03	7.09E-03	7.52E-03	7.98E-03	1.66E-02	2.50E-02
+5.5	1.30E-02	1.36E-02	1.43E-02	1.49E-02	2.75E-02	3.98E-02
+4.5	1.90E-02	1.99E-02	2.09E-02	2.19E-02	4.12E-02	6.00E-02
+3.5	2.14E-02	2.24E-02	2.35E-02	2.45E-02	4.55E-02	6.60E-02
+2.5	2.21E-02	2.31E-02	2.43E-02	2.54E-02	4.76E-02	6.93E-02
+1.5	2.24E-02	2.35E-02	2.46E-02	2.57E-02	4.68E-02	6.73E-02
+0.5	2.26E-02	2.37E-02	2.47E-02	2.57E-02	4.48E-02	6.34E-02
0.0	2.27E-02	2.38E-02	2.47E-02	2.56E-02	4.32E-02	6.04E-02
-0.5	2.27E-02	2.38E-02	2.47E-02	2.55E-02	4.15E-02	5.72E-02
-1.5	2.27E-02	2.38E-02	2.46E-02	2.54E-02	4.10E-02	5.63E-02
-2.5	2.25E-02	2.36E-02	2.45E-02	2.53E-02	4.23E-02	5.89E-02
-3.5	2.21E-02	2.30E-02	2.40E-02	2.49E-02	4.31E-02	6.10E-02
-4.5	2.03E-02	2.12E-02	2.21E-02	2.30E-02	4.09E-02	5.84E-02
-5.5	1.42E-02	1.48E-02	1.54E-02	1.61E-02	2.84E-02	4.05E-02
-6.0	6.94E-03	7.34E-03	7.74E-03	8.11E-03	1.56E-02	2.30E-02

Note: Height is provided relative to the axial
midplane of the active core.

TABLE 8.1-10

SUMMARY OF BEST ESTIMATE IRON ATOM DISPLACEMENT
PROJECTIONS FOR THE BELTLINE REGION OF THE POINT BEACH UNIT 2
REACTOR PRESSURE VESSEL - 15 DEGREE AZIMUTHAL ANGLE

HEIGHT	IRON ATOM DISPLACEMENTS [dpa]					
(ft)	EOC 14	EOC 15	EOC 16	EOC 17	32 EFPY	48 EFPY
+6.0	4.20E-03	4.49E-03	4.74E-03	5.00E-03	9.86E-03	1.46E-02
+5.5	8.18E-03	8.60E-03	8.98E-03	9.33E-03	1.64E-02	2.34E-02
+4.5	1.20E-02	1.26E-02	1.32E-02	1.37E-02	2.45E-02	3.50E-02
+3.5	1.34E-02	1.41E-02	1.48E-02	1.54E-02	2.75E-02	3.93E-02
+2.5	1.39E-02	1.47E-02	1.54E-02	1.60E-02	2.88E-02	4.13E-02
+1.5	1.41E-02	1.49E-02	1.55E-02	1.61E-02	2.81E-02	3.99E-02
+0.5	1.42E-02	1.49E-02	1.56E-02	1.61E-02	2.74E-02	3.85E-02
0.0	1.43E-02	1.51E-02	1.56E-02	1.62E-02	2.70E-02	3.75E-02
-0.5	1.43E-02	1.51E-02	1.56E-02	1.61E-02	2.64E-02	3.64E-02
-1.5	1.43E-02	1.50E-02	1.56E-02	1.61E-02	2.61E-02	3.59E-02
-2.5	1.41E-02	1.48E-02	1.54E-02	1.59E-02	2.63E-02	3.65E-02
-3.5	1.38E-02	1.45E-02	1.51E-02	1.57E-02	2.70E-02	3.81E-02
-4.5	1.27E-02	1.34E-02	1.40E-02	1.45E-02	2.56E-02	3.63E-02
-5.5	8.94E-03	9.35E-03	9.74E-03	1.01E-02	1.73E-02	2.44E-02
-6.0	4.38E-03	4.66E-03	4.90E-03	5.11E-03	9.50E-03	1.38E-02

Note: Height is provided relative to the axial
midplane of the active core.

TABLE 8.1-11

SUMMARY OF BEST ESTIMATE IRON ATOM DISPLACEMENT
PROJECTIONS FOR THE BELTLINE REGION OF THE POINT BEACH UNIT 2
REACTOR PRESSURE VESSEL - 30 DEGREE AZIMUTHAL ANGLE

HEIGHT	IRON ATOM DISPLACEMENTS [dpa]					
(ft)	EOC 14	EOC 15	EOC 16	EOC 17	32 EFPY	48 EFPY
+6.0	3.12E-03	3.32E-03	3.50E-03	3.69E-03	7.18E-03	1.06E-02
+5.5	6.05E-03	6.33E-03	6.61E-03	6.86E-03	1.20E-02	1.70E-02
+4.5	8.83E-03	9.26E-03	9.66E-03	1.00E-02	1.76E-02	2.50E-02
+3.5	9.90E-03	1.04E-02	1.08E-02	1.12E-02	1.96E-02	2.77E-02
+2.5	1.02E-02	1.07E-02	1.12E-02	1.16E-02	2.03E-02	2.89E-02
+1.5	1.04E-02	1.09E-02	1.13E-02	1.18E-02	2.05E-02	2.90E-02
+0.5	1.05E-02	1.10E-02	1.14E-02	1.19E-02	2.07E-02	2.92E-02
0.0	1.05E-02	1.10E-02	1.15E-02	1.19E-02	2.07E-02	2.93E-02
-0.5	1.05E-02	1.10E-02	1.15E-02	1.19E-02	2.08E-02	2.94E-02
-1.5	1.05E-02	1.10E-02	1.14E-02	1.19E-02	2.03E-02	2.85E-02
-2.5	1.04E-02	1.09E-02	1.13E-02	1.18E-02	2.04E-02	2.88E-02
-3.5	1.02E-02	1.07E-02	1.11E-02	1.15E-02	1.95E-02	2.73E-02
-4.5	9.40E-03	9.84E-03	1.02E-02	1.06E-02	1.81E-02	2.55E-02
-5.5	6.60E-03	6.88E-03	7.13E-03	7.39E-03	1.22E-02	1.70E-02
-6.0	3.25E-03	3.45E-03	3.60E-03	3.75E-03	6.69E-03	9.56E-03

Note: Height is provided relative to the axial
midplane of the active core.

TABLE 8.1-12

SUMMARY OF BEST ESTIMATE IRON ATOM DISPLACEMENT
PROJECTIONS FOR THE BELTLINE REGION OF THE POINT BEACH UNIT 2
REACTOR PRESSURE VESSEL - 45 DEGREE AZIMUTHAL ANGLE

HEIGHT	IRON ATOM DISPLACEMENTS [dpa]					
(ft)	EOC 14	EOC 15	EOC 16	EOC 17	32 EFPY	48 EFPY
+6.0	2.72E-03	2.90E-03	3.07E-03	3.23E-03	6.34E-03	9.38E-03
+5.5	5.28E-03	5.53E-03	5.79E-03	6.00E-03	1.06E-02	1.50E-02
+4.5	7.71E-03	8.09E-03	8.49E-03	8.83E-03	1.60E-02	2.30E-02
+3.5	8.64E-03	9.05E-03	9.48E-03	9.86E-03	1.77E-02	2.53E-02
+2.5	8.92E-03	9.38E-03	9.85E-03	1.03E-02	1.90E-02	2.75E-02
+1.5	9.07E-03	9.52E-03	9.97E-03	1.04E-02	1.87E-02	2.69E-02
+0.5	9.16E-03	9.59E-03	1.01E-02	1.04E-02	1.86E-02	2.66E-02
0.0	9.18E-03	9.64E-03	1.01E-02	1.05E-02	1.89E-02	2.72E-02
-0.5	9.18E-03	9.65E-03	1.01E-02	1.05E-02	1.92E-02	2.77E-02
-1.5	9.17E-03	9.62E-03	1.01E-02	1.05E-02	1.89E-02	2.72E-02
-2.5	9.10E-03	9.53E-03	9.98E-03	1.04E-02	1.88E-02	2.71E-02
-3.5	8.91E-03	9.32E-03	9.76E-03	1.02E-02	1.82E-02	2.60E-02
-4.5	8.21E-03	8.59E-03	9.01E-03	9.36E-03	1.68E-02	2.40E-02
-5.5	5.76E-03	6.01E-03	6.29E-03	6.47E-03	1.09E-02	1.52E-02
-6.0	2.85E-03	3.02E-03	3.19E-03	3.30E-03	6.01E-03	8.65E-03

Note: Height is provided realative to the axial
      midplane of the active core.

8.2 Exposure of Specific Beltline Materials

As shown in Figure 2.1-2, the beltline region of the Point Beach Unit 2 reactor pressure vessel is comprised of an intermediate shell forging (123V500), a lower shell forging (122W195), and a circumferential weld (SA-1484) joining the two ring forgings. The circumferential weld is centered 15.06 inches below the axial midplane of the active core; while the intermediate shell forging extends upward to an elevation 8.44 inches above the active fuel and the lower shell forging extends downward to an elevation 39.87 inches below the bottom of the active fuel. The maximum neutron exposure experienced by each of these beltline materials can be extracted from the data provided in Tables 8.1-1 through 8.1-12. Also considered part of the beltline region is the circumferential weld located at the top of the intermediate shell forging 8.44 inches above the active fuel. The corresponding circumferential weld at the bottom of the lower shell forging 39.87 inches below the active fuel experiences neutron radiation levels low enough that the lifetime exposure of the weld will remain below $1.0E+17$ n/cm^2. Therefore, this weldment is not considered to be part of the beltline region.

8.2-1 Circumferential Weld (SA-1484)

The current (End of Cycle 17) and projected maximum exposures of the beltline circumferential weld are listed in Table 8.2-1 and illustrated graphically in Figures 8.2-1 through 8.2-3. In this table and the accompanying figures, the weld exposure is expressed in terms of Φ (E > 1.0 MeV), Φ (E > 0.1 MeV), and dpa.

In developing the exposure profiles for the circumferential weld, it is noted that, although the flux reduction afforded by the Cycle 16-17 fuel loading patterns with part length hafnium absorbers has lessened the exposure rates within the 0-15 degree azimuthal sector, the maximum exposure point on the weld remains at the 0 degree azimuth throughout the service life of the unit. However, the magnitude of the projected

exposures are significantly lower than would be the case had the flux eduction measures not been implemented.

8.2-2 Intermediate Shell Forging (123V500)

The current and projected maximum exposures of the intermediate shell forging are given in Table 8.2-2. Again, all three exposure parameters are provided. In the case of the intermediate forging, it can be noted from Table 8.1-1, that, due to the introduction of the part length absorbers and the corresponding redution in exposure rates in the vicinity of the circumferential weld, the axial location of the maximum exposure at at the 0 and 15 degree azimuthal angles shifts from an elevation near core midplane to an elevation approximately 2.5 ft. above core midplane as the lifetime of the unit increases. Corresponding variations at the 30 and 45 degree azimuths are less evident. Since the maximum exposure point for the intermediate shell forging is variable due to the flux reduction measures, these values are not illustrated graphically, but are presented only in tabular form.

8.2-3 Lower Shell Forging (122W195)

The current and and projected exposures for the lower shell forging are listed in Table 8.2-3. As in the case of the intermediate forging, all three exposure parameters are tabulated. In the case of the lower shell forging, the part length absorbers cause the maximum exposure location at 0 and 15 degrees to shift from the top of the forging to a position 3.5 feet below the active core midplane. However, the absorbers have a negligible impact at the 30 and 45 degree azimuths, resulting in the maximum exposure location remaining at the top of the forging adjacent to the circumferential weld. Again, due to this shift in the maximum exposure elevation, the data applicable to the lower shell forging are not illustrated graphically, but, rather, are presented only in tabular form.

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8.2-4 Upper/Intermediate Shell Circumferential Weld

The current and and projected exposures for the lower shell forging are listed in Table 8.2-4. As in the case of the intermediate forging, all three exposure parameters are tabulated. Due to its location above the top of the reactor core, the inclusion of the part length hafnium absorbers in the fuel cycle design has a negligible impact on the fast neutron exposure experienced by this weld.

TABLE 8.2-1

MAXIMUM FAST NEUTRON EXPOSURE OF POINT BEACH UNIT 2
BELTLINE CIRCUMFERENTIAL WELD (SA-1484)

Φ (E > 1.0 MeV) [n/cm2]

AZIMUTHAL ANGLE	EOC 17 15.6 EFPY	32.0 EFPY	48.0 EFPY
0 DEGREES	1.61E+19	2.52E+19	3.39E+19
15 DEGREES	9.99E+18	1.65E+19	2.28E+19
30 DEGREES	7.60E+18	1.32E+19	1.87E+19
45 DEGREES	6.80E+18	1.25E+19	1.80E+19

Φ (E > 0.1 MeV) [n/cm2]

AZIMUTHAL ANGLE	EOC 17 15.6 EFPY	32.0 EFPY	48.0 EFPY
0 DEGREES	4.16E+19	6.50E+19	8.79E+19
15 DEGREES	2.77E+19	4.52E+19	6.23E+19
30 DEGREES	1.95E+19	3.36E+19	4.74E+19
45 DEGREES	1.68E+19	3.04E+19	4.36E+19

IRON ATOM DISPLACEMENTS [dpa]

AZIMUTHAL ANGLE	EOC 17 15.6 EFPY	32.0 EFPY	48.0 EFPY
0 DEGREES	2.54E-02	4.11E-02	5.65E-02
15 DEGREES	1.61E-02	2.62E-02	3.60E-02
30 DEGREES	1.19E-02	2.04E-02	2.87E-02
45 DEGREES	1.05E-02	1.90E-02	2.73E-02

TABLE 8.2-2

MAXIMUM FAST NEUTRON EXPOSURE OF POINT BEACH UNIT 2
INTERMEDIATE SHELL FORGING (123V500)

Φ (E > 1.0 MeV) [n/cm2]

AZIMUTHAL ANGLE	EOC 17 15.6 EFPY	32.0 EFPY	48.0 EFPY
0 DEGREES	1.63E+19	2.88E+19	4.12E+19
15 DEGREES	1.01E+19	1.82E+19	2.62E+19
30 DEGREES	7.64E+18	1.34E+19	1.91E+19
45 DEGREES	6.83E+18	1.27E+19	1.83E+19

Φ (E > 0.1 MeV) [n/cm2]

AZIMUTHAL ANGLE	EOC 17 15.6 EFPY	32.0 EFPY	48.0 EFPY
0 DEGREES	4.20E+19	7.45E+19	1.07E+20
15 DEGREES	2.79E+19	4.97E+19	7.14E+19
30 DEGREES	1.96E+19	3.43E+19	4.86E+19
45 DEGREES	1.69E+19	3.08E+19	4.43E+19

IRON ATOM DISPLACEMENTS [dpa]

AZIMUTHAL ANGLE	EOC 17 15.6 EFPY	32.0 EFPY	48.0 EFPY
0 DEGREES	2.57E-02	4.76E-02	6.93E-02
15 DEGREES	1.62E-02	2.88E-02	4.13E-02
30 DEGREES	1.19E-02	2.08E-02	2.94E-02
45 DEGREES	1.05E-02	1.92E-02	2.77E-02

TABLE 8.2-3

MAXIMUM FAST NEUTRON EXPOSURE OF POINT BEACH UNIT 2
LOWER SHELL FORGING (122W195)

Φ (E > 1.0 MeV) [n/cm2]

AZIMUTHAL ANGLE	EOC 17 15.6 EFPY	32.0 EFPY	48.0 EFPY
0 DEGREES	1.61E+19	2.62E+19	3.64E+19
15 DEGREES	9.99E+18	1.71E+19	2.42E+19
30 DEGREES	7.60E+18	1.32E+19	1.87E+19
45 DEGREES	6.80E+18	1.25E+19	1.80E+19

Φ (E > 0.1 MeV) [n/cm2]

AZIMUTHAL ANGLE	EOC 17 15.6 EFPY	32.0 EFPY	48.0 EFPY
0 DEGREES	4.16E+19	6.79E+19	9.45E+19
15 DEGREES	2.77E+19	4.68E+19	6.61E+19
30 DEGREES	1.95E+19	3.36E+19	4.74E+19
45 DEGREES	1.68E+19	3.04E+19	4.36E+19

IRON ATOM DISPLACEMENTS [dpa]

AZIMUTHAL ANGLE	EOC 17 15.6 EFPY	32.0 EFPY	48.0 EFPY
0 DEGREES	2.54E-02	4.31E-02	6.10E-02
15 DEGREES	1.61E-02	2.70E-02	3.81E-02
30 DEGREES	1.19E-02	2.04E-02	2.88E-02
45 DEGREES	1.05E-02	1.90E-02	2.73E-02

TABLE 8.2-4

MAXIMUM FAST NEUTRON EXPOSURE OF POINT BEACH UNIT 2
UPPER/INTERMEDIATE SHELL CIRCUMFERENTIAL WELD

Φ (E > 1.0 MeV) [n/cm2]

AZIMUTHAL ANGLE	EOC 17 15.6 EFPY	32.0 EFPY	48.0 EFPY
0 DEGREES	2.27E+18	3.70E+18	5.00E+18
15 DEGREES	1.51E+18	2.33E+18	3.15E+18
30 DEGREES	1.07E+18	1.73E+18	2.33E+18
45 DEGREES	9.40E+17	1.56E+18	2.10E+18

Φ (E > 0.1 MeV) [n/cm2]

AZIMUTHAL ANGLE	EOC 17 15.6 EFPY	32.0 EFPY	48.0 EFPY
0 DEGREES	6.17E+18	1.01E+19	1.36E+19
15 DEGREES	4.39E+18	6.78E+18	9.17E+18
30 DEGREES	2.89E+18	4.67E+18	6.29E+18
45 DEGREES	2.44E+18	4.06E+18	5.46E+18

IRON ATOM DISPLACEMENTS [dpa]

AZIMUTHAL ANGLE	EOC 17 15.6 EFPY	32.0 EFPY	48.0 EFPY
0 DEGREES	3.75E-03	6.11E-03	8.25E-03
15 DEGREES	2.58E-03	3.98E-03	5.39E-03
30 DEGREES	1.78E-03	2.87E-03	3.87E-03
45 DEGREES	1.54E-03	2.56E-03	3.44E-03

FIGURE 8.2-1

FAST NEUTRON FLUENCE (E > 1.0 MeV) AS A FUNCTION OF AZIMUTHAL
ANGLE AT THE INNER RADIUS OF THE BELTLINE CIRCUMFERENTIAL WELD
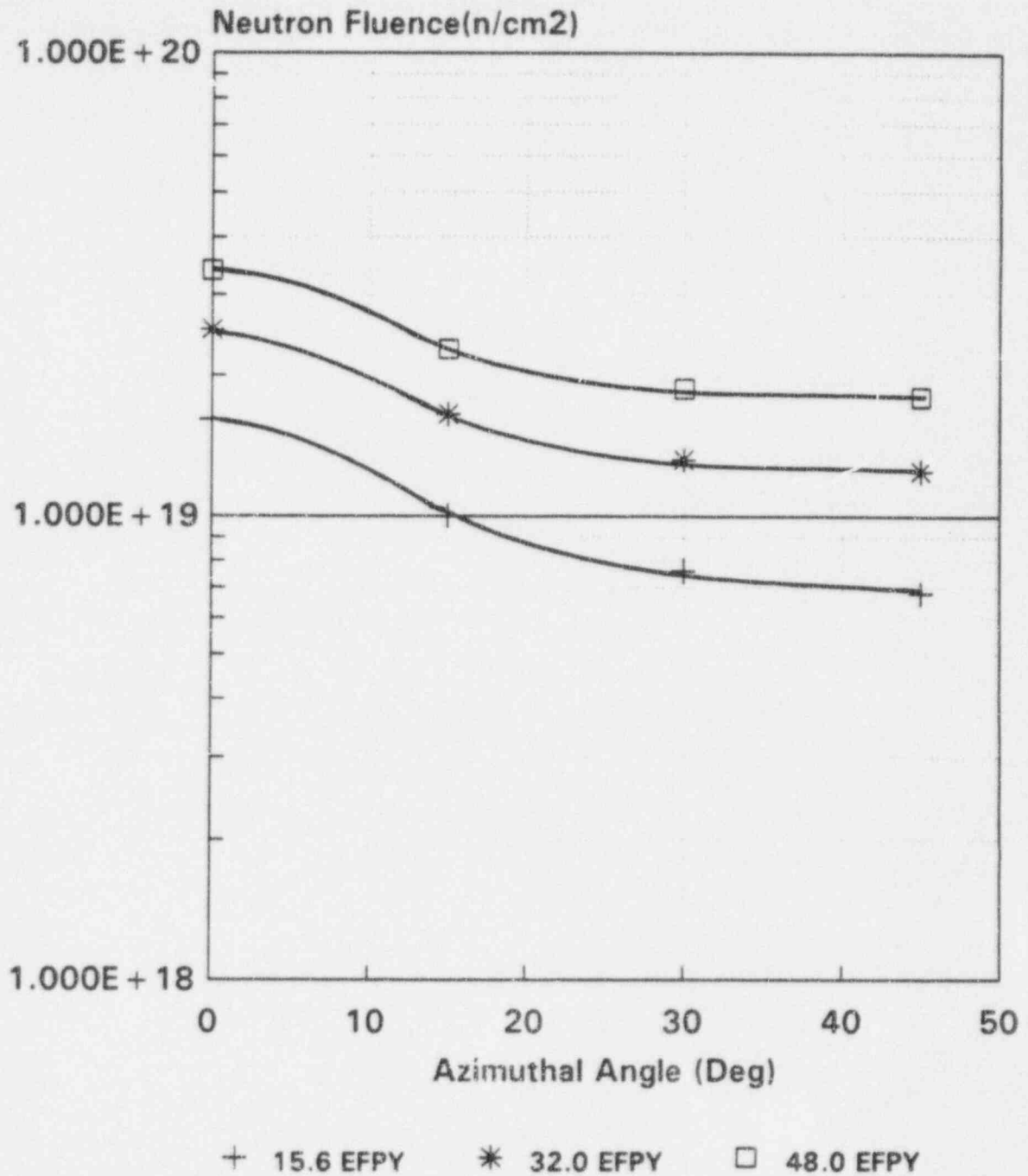
FIGURE 8.2-2

FAST NEUTRON FLUENCE (E > 0.1 MeV) AS A FUNCTION OF AZIMUTHAL
ANGLE AT THE INNER RADIUS OF THE BELTLINE CIRCUMFERENTIAL WELD
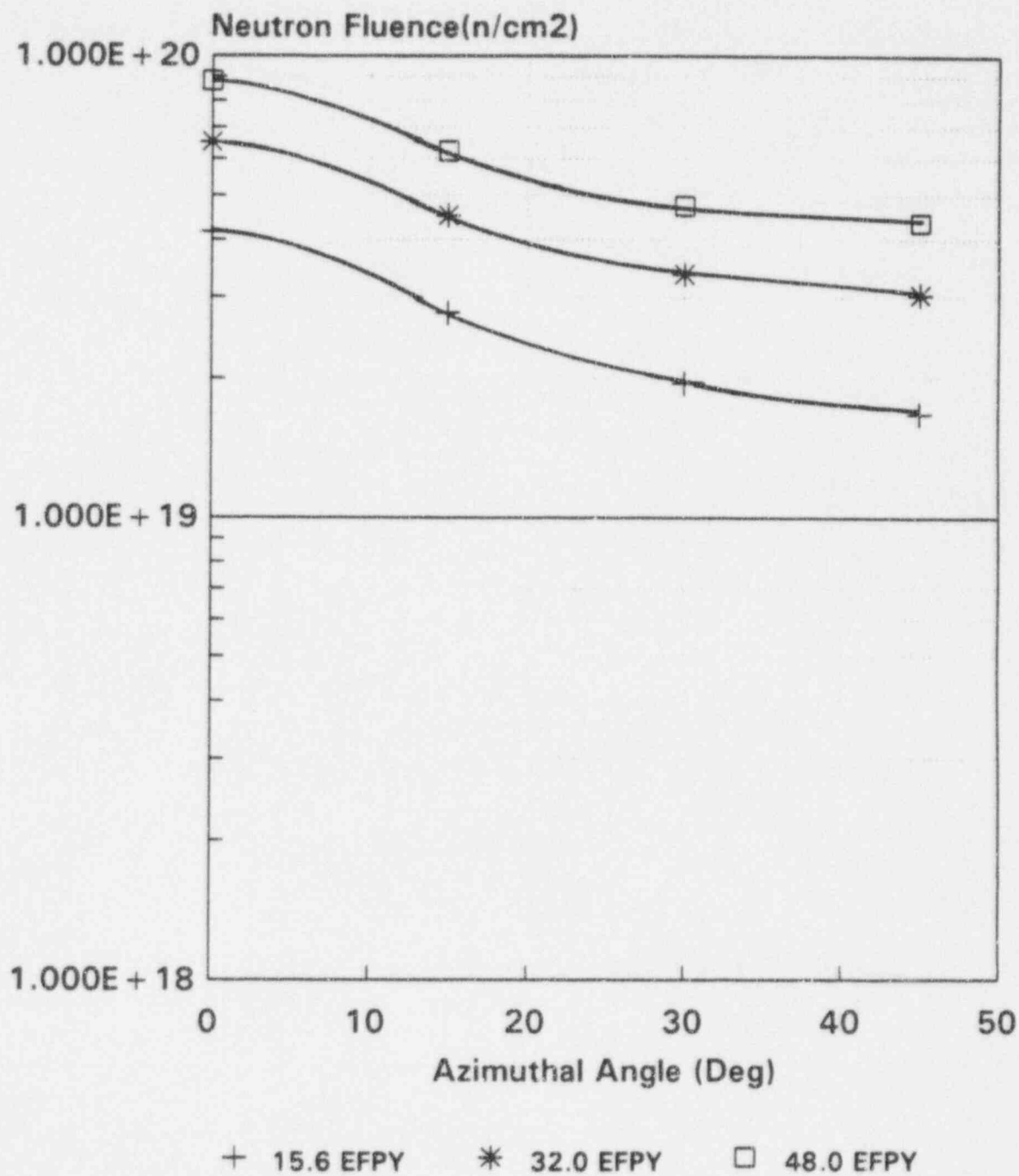
FIGURE 8.2-3

IRON ATOM DISPLACEMENTS [dpa] AS A FUNCTION OF AZIMUTHAL
ANGLE AT THE INNER RADIUS OF THE BELTLINE CIRCUMFERENTIAL WELD
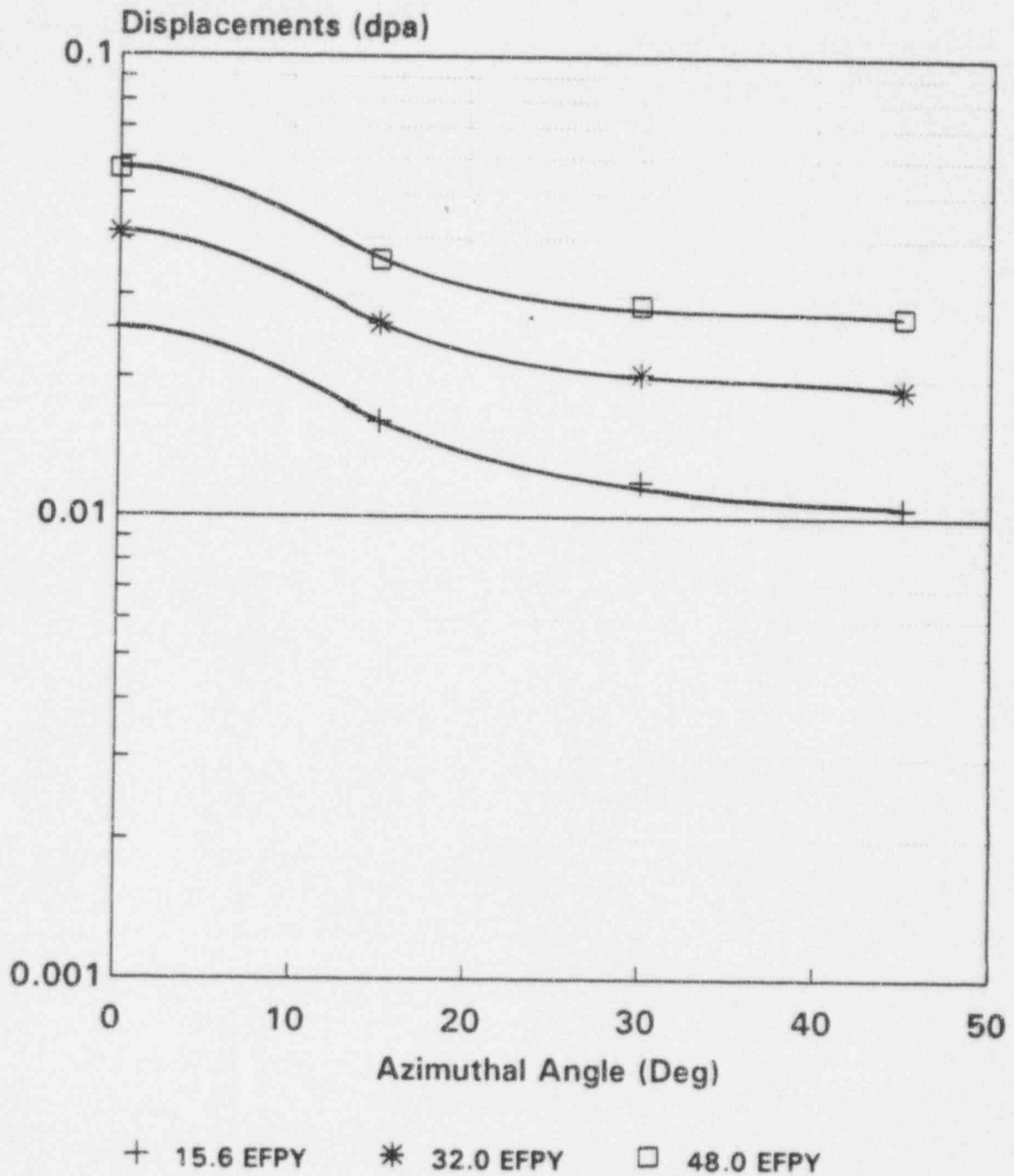
8.3 Uncertainties in Exposure Projections

The overall uncertainties associated with the exposure rates and integrated exposures determined for Point Beach Unit 2 stem from two basic sources; the accuracy of the neutron flux measurements at the sensor set locations and the accuracy of the radial gradient projections derived from the use of the transport code. Based on the least squares adjustment approach used in the FERRET analyses the 1 sigma uncertainties in the measured data were as follows:

<div align="center">

1σ UNCERTAINTY

	CAPSULE	CAVITY
Flux (E > 1.0 MeV)	6%	6%
Flux (E > 0.1 MeV)	13%	15%
dpa/sec	9%	12%

</div>

These values represent uncertainties derived from the reaction rate measurements and from the least squares fit of the output spectrum to the measured data. As additional data is obtained from the ongoing measurement program, the knowledge of the neutron spectra at the measurement locations will increase and the uncertainties in the measured exposure parameters will be reduced somewhat.

Since the ultimate goal of the cavity measurement program is the evaluation of the exposure of the vessel itself, an additional uncertainty associated with the ability to translate results from the measurement locations to the points of interest within the vessel must be included along with the measurement uncertainties listed above. Information pertinent to this extrapolation uncertainty has been obtained from benchmarking studies using the Westinghouse neutron transport methodology and from several comparisons of power reactor internal surveillance capsule dosimetry and reactor cavity dosimetry for which the irradiation history of all sensors was the same.

Based on these benchmarking evaluations the uncertainty or bias associated with the calculated slope through the steel vessel was estimated to be approximately 5% for all exposure parameters. Thus, the total uncertainty associated with projections at the clad/base metal interface is estimated to be as follows for each exposure parameter of interest.

1σ UNCERTAINTY

	VESSEL IR
Flux (E > 1.0 MeV)	11%
Flux (E > 0.1 MeV)	20%
dpa/sec	17%

Use of these values represents the bounding 1σ uncertainties for vessel exposure, since with penetration into the vessel wall the extrapolation uncertainty lessens until at the outer surface the overall uncertainty reverts simply to the measurement uncertainty. Again, as more data are accumulated from both reactor cavity and surveillance capsule dosimetry sets, the extrapolation uncertainty will also be reduced resulting in higher levels of accuracy in the vessel exposure projections.

SECTION 9.0

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APPENDIX A

SPECIFIC ACTIVITIES AND IRRADIATION HISTORY OF SENSORS
FROM SURVEILLANCE CAPSULES V, T, R AND S

In this appendix, the irradiation history as extracted from NUREG-0020 and the measured specific activities of radiometric sensors irradiated in surveillance Capsules V, T, R and S are provided.

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

CYCLE NO.	STARTUP	SHUTDOWN	COMMENT
1	05/30/72	10/17/74	CAPSULE V WITHDRAWN
2	12/20/74	02/26/76	
3	03/26/76	03/04/77	CAPSULE T WITHDRAWN
4	04/19/77	03/22/78	
5	04/17/78	03/23/79	CAPSULE R WITHDRAWN
6	04/19/79	04/11/80	
7	05/13/80	04/17/81	
8	05/21/81	04/16/82	
9	05/26/82	03/25/83	
10	07/05/83	09/28/84	
11	11/19/84	10/05/85	
12	11/24/85	09/27/86	
13	12/01/86	10/03/87	
14	11/17/87	10/08/88	
15	11/21/88	09/23/89	
16	11/24/89	10/06/90	CAPSULE S WITHDRAWN

REF. CORE POWER = 1518 MWt

The monthly thermal generation applicable to the Point Beach Unit 2 reactor is provided on pages A-2 and A-3. Pages A-4 through A-7 contain the measured specific activities ofsensors removed from Capsules T, R, and S.

MONTHLY THERMAL GENERATION DURING THE FIRST SIXTEEN FUEL CYCLES
OF THE POINT BEACH UNIT 2 REACTOR

MONTH	THERMAL GENERATION (MW-hr)	MONTH	THERMAL GENERATION (MW-hr)	MONTH	THERMAL GENERATION (MW-hr)	MONTH	THERMAL GENERATION (MW-hr)
5/72-3/74	13508112	4/76	972825	5/78	1099610	6/80	1065238
4/74	1076568	5/76	956959	6/78	1044078	7/80	1114363
5/74	1111056	6/76	1007721	7/78	1040240	8/80	1124200
6/74	885000	7/76	1026604	8/78	1054425	9/80	1047595
7/74	954648	8/76	1022317	9/78	1059006	10/80	1112514
8/74	1111608	9/76	1005046	10/78	1104830	11/80	989299
9/74	1054224	10/76	1116240	11/78	1079867	12/80	1114432
10/74	557784	11/76	1064445	12/78	1074069	1/81	1115599
11/74	0	12/76	1102576	1/79	1116477	2/81	1008189
12/74	302016	1/77	1102848	2/79	1010047	3/81	1112552
1/75	1113456	2/77	1001354	3/79	746785	4/81	559549
2/75	881295	3/77	100292	4/79	585747	5/81	186873
3/75	1081779	4/77	214373	5/79	1071794	6/81	1047500
4/75	916898	5/77	1108075	6/79	1021650	7/81	1112509
5/75	880266	6/77	1066583	7/79	408680	8/81	1092410
6/75	914234	7/77	1072410	8/79	1114720	9/81	988920
7/75	1063799	8/77	973371	9/79	1032935	10/81	1088553
8/75	748416	9/77	1039145	10/79	1117434	11/81	1080909
9/75	997380	10/77	1109781	11/79	1045777	12/81	1073535
10/75	989176	11/77	1062668	12/79	1095273	1/82	1106250
11/75	974925	12/77	1106636	1/80	1111502	2/82	1005969
12/75	1114475	1/78	1066993	2/80	974189	3/82	1091347
1/76	1070693	2/78	1000903	3/80	613022	4/82	528202
2/76	929464	3/78	723452	4/80	328351	5/82	124874
3/76	115451	4/78	352782	5/80	539505	6/82	1074941

MONTHLY THERMAL GENERATION DURING THE FIRST SIXTEEN FUEL CYCLES
OF THE POINT BEACH UNIT 2 REACTOR

MONTH	THERMAL GENERATION (MW-hr)	MONTH	THERMAL GENERATION (MW-hr)	MONTH	THERMAL GENERATION (MW-hr)	MONTH	THERMAL GENERATION (MW-hr)
7/82	1117700	8/84	1126993	9/86	945202	10/88	229686
8/82	1052625	9/84	921284	10/86	0	11/88	229879
9/82	864026	10/84	0	11/86	10240	12/88	1113148
10/82	1094393	11/84	252959	12/86	1088521	1/89	1127540
11/82	1089345	12/84	1062541	1/87	1037881	2/89	1018557
12/82	1109078	1/85	1103110	2/87	1017595	3/89	1030496
1/83	1121499	2/85	1015875	3/87	1066056	4/89	1008555
2/83	1016200	3/85	1121631	4/87	1091705	5/89	1117762
3/83	869556	4/85	1089086	5/87	1031289	6/89	1089331
4/83	0	5/85	1125089	6/87	1090934	7/89	1126185
5/83	0	6/85	1081247	7/87	1120329	8/89	1078103
6/83	0	7/85	1104022	8/87	1033949	9/89	776161
7/83	883944	8/85	1125504	9/87	1092960	10/89	0
8/83	1075582	9/85	1090774	10/87	70587	11/89	141690
9/83	1087367	10/85	141568	11/87	382736	12/89	1123322
10/83	1115645	11/85	95661	12/87	1067563	1/90	1127322
11/83	1088861	12/85	1033331	1/88	1123573	2/90	1018430
12/83	1120529	1/86	1096374	2/88	1055151	3/90	1118045
1/84	1109752	2/86	1001623	3/88	1127373	4/90	1090485
2/84	1052908	3/86	1120825	4/88	949345	5/90	1127775
3/84	1125590	4/86	1037164	5/88	1127476	6/90	1080806
4/84	1068842	5/86	1110585	6/88	1091026	7/90	1128256
5/84	934923	6/86	1024233	7/88	1126029	8/90	1129766
6/84	1083029	7/86	1069310	8/88	1129392	9/90	1120491
7/84	1119374	8/86	1083054	9/88	1072861	10/90	162384

WESTINGHOUSE ADVANCED REACTOR DIVISION
ANALYTICAL LABORATORIES
WALTZ MILL SITE

ANAL. SERV. REQUEST NO.
7317

ORIGINATOR	DEPT. & GRP.	EXT.	ROOM NO.	FACILITY
STAN ANDERSON				Monroeville Nuclear Center

OVAL SIGNATURE			DATE RECEIVED	DATE REPORTED
C. O. Blackburn			3-15-78	4-7-78

METHOD	ANALYST	AUTHORIZED	METHOD	ANALYST	REFERENCE
Gamma Spectrometry	CAB	File			

RESULTS OF ANALYSIS

ORIGINATOR'S SAMPLE NO.	ANAL. SERV. LAB. NO.	DOSIMETER MATERIAL	Co-60	Co-58			
TOP -24	78-688	Al-Co	3.22×10^4		DPS / mg of wire MAR. 30, 1978		
" -26	78-689	Cu	91.1		↑		
TOP-MID -24	78-690	Al-Co	2.01×10^4				
" -25	78-691	Al-Co (Cd)	1.01×10^4				
" -26	78-692	Cu	82.3				
MID -24	78-693	Al-Co	2.09×10^4				
" -25	78-694	Al-Co (cd)	1.07×10^4				
" -26	78-695	Ni		1.02×10^3			
BOTTOM MID -24	78-696	Al-Co	2.62×10^4				
" -25	78-697	Al-Co (cd)	1.17×10^4				
" -26	78-698	Cu	95.0				
BOTTOM -24	78-699	Al-Co	2.48×10^4				
-25	78-700	Al-Co (Cd)	1.12×10^4				
-26	78-701	Cu	103		↓		
U-238 CAPSULE	78-702	369 DPS / mg U-238 } ON MAR. 30, 1978					
Np-237 "	78-703	2830 DPS / mg Np-237 }					

REMARKS:

CHARPY			Mn-54				
W-32	78-704	Fe	1.17×10^3	DPS/mg Fe MAR. 30, 1978			
H-25	78-705	Fe	1.23×10^3				
E-47	78-706	Fe	1.44×10^3				
V-37	78-707	Fe	1.41×10^3				
R-30	78-708	Fe	1.11×10^3				
E-37	78-709	Fe	1.38×10^3				

POINT BEACH UNIT #2, "T" CAPSULE

CHECK COPIES FOR LEGIBILITY

ANALYTICAL LABORATORIES
WALTZ MILL SITE

ANAL. SERV. REQUEST NO.
8143

ORIGINATOR	DEPT. & GRP.			EXT.	ROOM NO.	FACILITY
S. L. ANDERSON					BAY 478	MNC

APPROVAL SIGNATURE			DATE RECEIVED	DATE REPORTED
C. G. Blackburn			6-5-79	6-22-79

METHOD	ANALYST	REFERENCE	METHOD	ANALYST	REFERENCE
Gamma Spectrometry	WTF	FILE			
	CAB				

RESULTS OF ANALYSIS

ORIGINATOR'S SAMPLE NO.	ANAL. SERV. LAB. NO.	$Co-60$	$Co-58$				
Top C.	79-1648	3.09×10^7		dpm/in of wire on 6-15-79 ±1.%			
Co(cd)	1649	3.15×10^4					
Cu	1650	196					
Top/Mid Co	1651	5.62×10^4					
Co(cd)	1652	3.04×10^4					
Cu	1653	-177					
Mid Co	1654	5.94×10^4					
Co(cd)	1655	2.93×10^4					
	1656	—	3.13×10^4				
Mid/Bot Co	1657	*					
Co(cd)	1658	3.49×10^4					
Cu	1654	196					
Bottom Co	1660	7.88×10^4					
Co(cd)	1661	3.31×10^4					
Cu	79-1662	-208					

REMARKS:

U-238	79-1663	1.00×10^3	dpm/mg U-238	on 6-15-79	±1.%
Np-237	79-1664	3.52×10^3	dpm/mg Np-237		

POINT BEACH UNIT #2 "R" CAPSULE

* WIRE REPORTED NOT FOUND BY R&D HOT CELLS.

CHECK COPIES FOR LEGIBILITY

ORIGINATOR COPY

ANALYTICAL LABORATORIES
WALTZ MILL SITE

ANAL. SERV. REQUEST NO.
8289

ORIGINATOR	DEPT. & GRP.		EXT.	ROOM NO.	FACILITY
S.L. ANDERSON			BAY 478		MNC

APPROVAL SIGNATURE			DATE RECEIVED	DATE REPORTED
C.G. Blackburn			9-27-79	9-30-79

METHOD	ANALYST	REFERENCE	METHOD	ANALYST	REFERENCE
Gamma Spectrometry	WTF GAS	FILE			
Fe	FRC				

RESULTS OF ANALYSIS

ORIGINATOR'S SAMPLE NO.	ANAL. SERV. LAB. NO.		MN-54			
Capsule Specimens			DIS/min mg e - c Aug 29 1972 08:00 t 1/2			
V-13	79-3450		3850			
E-23	3451		3560			
E-13	3452		3090			
H-9	3453		2900			
R-14	3454		3970			
W-16	79-3455		3870			

REMARKS:

POINT BEACH UNIT #2 "R" CAPSULE

(SEE REQUEST # 8143 FOR WIRES + FISSION CAPSULE RESULTS.)

CHECK COPIES FOR LEGIBILITY

ORIGINATOR COPY

[RESULTS OF ANALYSIS]

Dosimetry: Point Beach Unit #2 Capsule S

Originator ID	Lab. Sample #	Dosimeter Material	Nuclide	(May 20, 1991) dpa/mg *		2 sigma
FISSON MONITORS						
U-238	91-1035	U-238	Cs-137	1.37E+03	+/-	2.3E+01
Np-237	91-1036	Np-237	Cs-137	8.55E+03	+/-	1.2E+02
TOP WIRES						
Co/Al (Cd)	91-1037	Co/Al	Co-60	1.93E+04	+/-	2.4E+02
Co/Al	91-1038	Co/Al	Co-60	4.13E+04	+/-	3.4E+02
Cu	91-1039	Cu	Co-60	1.83E+02	+/-	2.2E+00
TOP MID WIRES						
Co/Al (Cd)	91-1040	Co/Al	Co-60	1.86E+04	+/-	2.3E+02
Co/Al	91-1041	Co/Al	Co-60	3.39E+04	+/-	3.2E+02
Cu	91-1042	Cu	Co-60	1.53E+02	+/-	2.1E+00
MID WIRES						
Co/Al (Cd)	91-1043	Co/Al	Co-60	1.73E+04	+/-	2.2E+02
Co/Al	91-1044	Co/Al	Co-60	3.38E+04	+/-	2.8E+02
Ni	91-1045	Ni	Co-58	2.95E+03	+/-	3.8E+01
BOT MID WIRES						
Co/Al (Cd)	91-1046	Co/Al	Co-60	2.12E+04	+/-	2.2E+02
Co/Al	91-1047	Co/Al	Co-60	4.43E+04	+/-	3.3E+02
Cu	91-1048	Cu	Co-60	1.68E+02	+/-	2.1E+00
BOT WIRES						
Co/Al (Cd)	91-1049	Co/Al	Co-60	1.90E+04	+/-	2.1E+02
Co/Al	91-1050	Co/Al	Co-60	4.12E+04	+/-	3.2E+02
Cu	91-1051	Cu	Co-60	1.91E+02	+/-	2.7E+00

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

Since surveillance Capsules T, R, and S 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 ϕ (E > 1.0 MeV) during irradiation period j to the time weighted average ϕ (E > 1.0 MeV) over the entire irradiation period. The values of C_j used in the evaluation of the Point Beach Unit 2 surveillance capsules were as follows:

		C_j	
	CAPSULE T	CAPSULE R	CAPSULE S
CYCLE 1	0.973	1.000	1.081
CYCLE 2	1.030	1.018	1.183
CYCLE 3	1.011	1.009	1.170
CYCLE 4		0.955	1.124
CYCLE 5		1.009	1.121
CYCLE 6			1.151
CYCLE 7			0.972
CYCLE 8			0.930
CYCLE 9			0.941
CYCLE 10			0.963
CYCLE 11			0.950
CYCLE 12			0.908
CYCLE 13			0.858
CYCLE 14			0.935
CYCLE 15			0.856
CYCLE 16			0.747

APPENDIX B

MEASURED SPECIFIC ACTIVITY AND IRRADIATION HISTORY
OF REACTOR CAVITY SENSOR SETS

In this appendix, the irradiation history as extracted from NUREG-0020 and the measured specific activities of radiometric sensors irradiated in the reactor cavity during Cycles 15, 16,and 17 are provided.

The irradiation history of the three fuel cycles was as follows:

	CYCLE 15	CYCLE 16	CYCLE 17
CYCLE STARTUP	11/21/88	11/24/89	11/17/90
CYCLE SHUTDOWN	09/23/89	10/06/90	09/27/91
REF. CORE POWER	1518 MWt	1518 MWt	1518 MⱮt

CYCLE 15		CYCLE 16		CYCLE 17	
	THERMAL GENERATION		THERMAL GENERATION		Thermal GENERATION
MONTH	(MW-hr)	MONTH	(MW-HR)	MONTH	(MW-HR)
11/88	2298,?	11/89	141690	11/90	405311
12/88	1113148	12/89	1123322	12/90	1120800
1/89	1127540	1/90	1127322	1/91	1123755
2/89	1018557	2/90	1018430	2/91	1013700
3/89	1030496	3/90	1118045	3/91	1110255
4/89	1008555	4/90	1090485	4/91	1087195
5/89	1117762	5/90	1127775	5/91	1124595
6/89	1089331	6/90	1080806	6/91	1080040
7/89	1126185	7/90	1128256	7/91	1100758
8/89	1078103	8/90	1129766	8/91	1087688
9/89	776161	9/90	1120491	9/91	941710
		10/90	162384		
TOTAL	10715717		11368772		11195800

The irradiation capsule loading diagram and the measured specific activities of the radiometric monitors from the Cycle 15 irradiation are provided on pages B-3 through B-10. Similar data from the Cycle 16 and Cycle 17 irradiations are given on pages B-11 through B-17 and B-18 through B-24, respectively. For the multiple foil sensor sets, the individual foil ID can be correlated with the capsule loading diagrams provided in Sections 6.1.1, 6.2.1, and 6.3.1 in order to determine the location of the foil within the reactor cavity during irradiation.

REPORT

Request# 13910

TO: A.H.Fero   (W)NATD, Energy Center (East ^-17)

Received: 1/19/90
Reported: 2/20/90

[RESULTS OF ANALYSIS]
Point Beach Unit 2 Cycle 15 Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 2/1/90) dps/mg foil		2 sigma
AT	90-233	Ni	Co-58	10.5	+/-	0.1
AG	90-243	Ni	Co-58	94.9	+/-	1.1
AH	90-253	Ni	Co-58	245.4	+/-	3.1
AI	90-263	Ni	Co-58	93.0	+/-	1.4
AJ	90-273	Ni	Co-58	215.3	+/-	2.1
AK	90-283	Ni	Co-58	160.3	+/-	1.4
AL	90-293	Ni	Co-58	143.0	+/-	1.7
AT	90-234	Cu	Co-60	0.0233	+/-	0.0005
AG	90-244	Cu	Co-60	0.242	+/-	0.007
AH	90-254	Cu	Co-60	0.670	+/-	0.011
AI	90-264	Cu	Co-60	0.240	+/-	0.007
AJ	90-274	Cu	Co-60	0.618	+/-	0.011
AK	90-284	Cu	Co-60	0.467	+/-	0.010
AL	90-294	Cu	Co-60	0.448	+/-	0.007
T	90-235	Ti	Sc-46	0.190	+/-	0.011
G	90-245	Ti	Sc-46	2.00	+/-	0.05
H	90-255	Ti	Sc-46	5.05	+/-	0.15
I	90-265	Ti	Sc-46	1.98	+/-	0.07
J	90-275	Ti	Sc-46	4.64	+/-	0.12
K	90-285	Ti	Sc-46	3.49	+/-	0.11
L	90-295	Ti	Sc-46	3.30	+/-	0.08

Remarks:

AL File: 13910
References: Lab.Book#41p74. LB#35p213-216.
Procedures: A-524.
Analyst: WTF, WRM, CAB.

Approved: C.A. Blackburn 2-20-90

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

Received: 1/19/90
Reported: 2/20/90

[RESULTS OF ANALYSIS]
Point Beach Unit 2 Cycle 15 Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 2/1/90) dps/mg foil		2 sigma
BA	90-237	AlCo	Co-60	65.1	+/-	1.1
DA	90-238	AlCo	Co-60	47.0	+/-	0.9
BM	90-247	AlCo	Co-60	178.8	+/-	4.6
DM	90-248	AlCo	Co-60	131.5	+/-	1.6
BL	90-257	AlCo	Co-60	525.6	+/-	8.3
DL	90-258	AlCo	Co-60	310.6	+/-	6.1
BK	90-267	AlCo	Co-60	209.8	+/-	3.6
DK	90-268	AlCo	Co-60	136.3	+/-	3.3
BI	90-277	AlCo	Co-60	657.6	+/-	8.9
DI	90-278	AlCo	Co-60	375.8	+/-	7.0
BJ	90-287	AlCo	Co-60	537.8	+/-	8.2
DJ	90-288	AlCo	Co-60	305.9	+/-	6.1
BH	90-297	AlCo	Co-60	339.9	+/-	6.6
DH	90-298	AlCo	Co-60	222.8	+/-	5.3
CT	90-231	Fe	Mn-54	0.757	+/-	0.016
DT	90-232	Fe	Mn-54	0.912	+/-	0.016
CG	90-241	Fe	Mn-54	6.72	+/-	0.12
DG	90-242	Fe	Mn-54	8.33	+/-	0.09
CH	90-251	Fe	Mn-54	20.81	+/-	0.37
DH	90-252	Fe	Mn-54	21.31	+/-	0.29
CI	90-261	Fe	Mn-54	8.39	+/-	0.19
DI	90-262	Fe	Mn-54	7.73	+/-	0.14
CJ	90-271	Fe	Mn-54	19.07	+/-	0.27
DJ	90-272	Fe	Mn-54	18.72	+/-	0.24
CK	90-281	Fe	Mn-54	15.15	+/-	0.13
DK	90-282	Fe	Mn-54	13.98	+/-	0.17
CL	90-291	Fe	Mn-54	12.41	+/-	0.22
DL	90-292	Fe	Mn-54	12.10	+/-	0.24

Remarks:

AL File: 13910
References: Lab.Book#41p74. LB#35p213-216.
Procedures: A-524.
Analyst: WTF, WRM, CAB.   Approved: _C. A. Blackburn_ 2-20-90

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

Received: 1/19/90
Reported: 2/20/90

[RESULTS OF ANALYSIS]
Point Beach Unit 2 Cycle 15 Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 2/1/90) dps/mg foil		2 sigma
T	90-239	U-238	Zr-95	1.40	+/-	0.01
G	90-249	U-238	Zr-95	7.74	+/-	0.07
H	90-259	U-238	Zr-95	19.59	+/-	0.13
I	90-269	U-238	Zr-95	7.90	+/-	0.07
J	90-279	U-238	Zr-95	17.76	+/-	0.13
K	90-289	U-238	Zr-95	13.32	+/-	0.11
L	90-299	U-238	Zr-95	11.69	+/-	0.08
T	90-239	U-238	Ru-103	0.544	+/-	0.005
G	90-249	U-238	Ru-103	3.780	+/-	0.040
H	90-259	U-238	Ru-103	9.308	+/-	0.075
I	90-269	U-238	Ru-103	3.801	+/-	0.038
J	90-279	U-238	Ru-103	8.259	+/-	0.074
K	90-289	U-238	Ru-103	6.082	+/-	0.063
L	90-299	U-238	Ru-103	5.451	+/-	0.048
T	90-239	U-238	Cs-137	0.114	+/-	0.003
G	90-249	U-238	Cs-137	0.680	+/-	0.019
H	90-259	U-238	Cs-137	1.843	+/-	0.036
I	90-269	U-238	Cs-137	0.677	+/-	0.021
J	90-279	U-238	Cs-137	1.683	+/-	0.036
K	90-289	U-238	Cs-137	1.241	+/-	0.030
L	90-299	U-238	Cs-137	1.102	+/-	0.021
1	90-240	Np	Cs-137	2.33	+/-	0.32
2	90-250	Np	Cs-137	10.59	+/-	0.53
3	90-260	Np	Cs-137	24.07	+/-	0.64
4	90-270	Np	Cs-137	9.69	+/-	0.58
5	90-280	Np	Cs-137	23.84	+/-	0.78
6	90-290	Np	Cs-137	16.37	+/-	0.59
7	90-300	Np	Cs-137	14.66	+/-	0.55

Remarks:

AL File: 13910
References: Lab.Book#41p74. LB#35p213-216.
Procedures: A-524.
Analyst: WTF, WRM, CAB.

Approved: C.A. Blackburn 2-20-90

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

Received: 1/19/90
Reported: 2/20/90

[RESULTS OF ANALYSIS]

Point Beach Unit 2 Cycle 15 Reactor Cavity Dosimetry

Bead Chain Tag ID: S-2, 0 degree.

Feet from Midplane	Lab Sample#	[<———————— dps/mg of chain @ 2/1/90 ————————>]					
		Mn-54 dps/mg	2 sigma	Co-58 dps/mg	2 sigma	Co-60 dps/mg	2 sigma
+6.5	90-301	3.11 +/-	0.11	5.20 +/-	0.12	42.4 +/-	0.3
+5.5	90-302	7.58 +/-	0.40	12.89 +/-	0.53	95.6 +/-	1.1
+4.5	90-303	11.07 +/-	0.53	18.96 +/-	0.63	122.7 +/-	1.1
+3.5	90-304	12.96 +/-	0.85	21.20 +/-	0.84	151.0 +/-	1.7
+2.5	90-305	14.50 +/-	0.63	23.24 +/-	0.72	168.4 +/-	1.4
+1.5	90-306	14.26 +/-	0.82	22.83 +/-	0.97	173.3 +/-	1.8
+0.5	90-307	13.88 +/-	0.69	21.38 +/-	0.65	177.5 +/-	1.4
-0.5	90-308	14.53 +/-	0.86	22.45 +/-	0.97	200.7 +/-	2.0
-1.5	90-309	13.29 +/-	0.60	20.72 +/-	0.65	187.0 +/-	1.4
-2.5	90-310	12.70 +/-	0.63	21.29 +/-	0.64	178.1 +/-	1.4
-3.5	90-311	12.50 +/-	0.60	20.34 +/-	0.64	163.6 +/-	1.3
-4.5	90-312	11.24 +/-	0.52	18.61 +/-	0.57	131.6 +/-	1.2
-5.5	90-313	7.55 +/-	0.42	12.54 +/-	0.44	87.4 +/-	1.0
-6.5	90-314	2.78 +/-	0.22	4.90 +/-	0.24	67.4 +/-	0.8

NOTE: For the gamma counts, 6 beads were cut from the chain at the designated
points of "Feet from Midplane" (3 beads on each side of the point).
6 beads are about 1.4 inches long and weigh about 1.2 grams.

Remarks:

AL File: 13910
References: Lab.Book#41p74. LB#35p213-216.
Procedures: A-524.
Analyst: WTF, WRM, CAB.   Approved: _C.A. Blackburn 2-20-90_

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

Received: 1/19/90
Reported: 2/20/90

[RESULTS OF ANALYSIS]

Point Beach Unit 2 Cycle 15 Reactor Cavity Dosimetry

Bead Chain Tag ID: S-2, 15 degree.

Feet from Midplane	Lab Sample#	dps/mg of chain @ 2/1/90					
		Mn-54		Co-58		Co-60	
		dps/mg	2 sigma	dps/mg	2 sigma	dps/mg	2 sigma
+6.5	90-315	2.40 +/-	0.20	4.11 +/-	0.23	43.7 +/-	0.5
+5.5	90-316	6.64 +/-	0.51	10.19 +/-	0.53	141.4 +/-	1.3
+4.5	90-317	10.05 +/-	0.62	16.52 +/-	0.63	203.6 +/-	1.6
+3.5	90-318	11.15 +/-	0.98	17.72 +/-	0.94	236.1 +/-	2.3
+2.5	90-319	12.09 +/-	1.03	20.12 +/-	1.08	253.7 +/-	2.3
+1.5	90-320	11.87 +/-	0.92	19.71 +/-	0.99	253.9 +/-	2.3
+0.5	90-321	12.04 +/-	0.97	19.37 +/-	1.06	247.4 +/-	2.3
-0.5	90-322	12.84 +/-	1.03	20.33 +/-	1.08	253.9 +/-	2.3
-1.5	90-323	12.41 +/-	0.97	19.61 +/-	1.06	241.9 +/-	2.3
-2.5	90-324	12.26 +/-	0.92	18.61 +/-	1.05	227.6 +/-	2.2
-3.5	90-325	11.54 +/-	0.85	18.61 +/-	0.93	212.3 +/-	2.1
-4.5	90-326	10.52 +/-	0.87	17.06 +/-	0.94	176.8 +/-	1.9
-5.5	90-327	6.74 +/-	0.40	11.32 +/-	0.37	125.9 +/-	0.8
-6.5	90-328	2.58 +/-	0.21	4.50 +/-	0.22	68.2 +/-	0.5

NOTE: For the gamma counts, 6 beads were cut from the chain at the designated
points of "Feet from Midplane" (3 beads on each side of the point).
6 beads are about 1.4 inches long and weigh about 1.2 grams.

Remarks:

AL File: 13910
References: Lab.Book#41p74. LB#35p213-216.
Procedures: A-524.
Analyst: WIF, WRM, CAB.   Approved: _C.A.Blackburn 2-20-90_

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

Received: 1/19/90
Reported: 2/20/90

[RESULTS OF ANALYSIS]

Point Beach Unit 2 Cycle 15 Reactor Cavity Dosimetry

Bead Chain Tag ID: S-2, 30 degree.

| Feet from Midplane | Lab Sample# | [<——— dps/mg of chain @ 2/1/90 ———>] | | | | | |
| | | Mn-54 | | Co-58 | | Co-60 | |
		dps/mg	2 sigma	dps/mg	2 sigma	dps/mg	2 sigma
+6.5	90-329	2.03 +/-	0.11	3.36 +/-	0.11	38.5	0.3
+5.5	90-330	4.95 +/-	0.33	8.58 +/-	0.37	108.2	0.8
+4.5	90-331	7.60 +/-	0.38	12.21 +/-	0.51	154.5	0.9
+3.5	90-332	8.37 +/-	0.67	13.71 +/-	0.54	183.4	1.2
+2.5	90-333	8.93 +/-	0.46	14.84 +/-	0.54	195.0	1.1
+1.5	90-334	8.51 +/-	0.78	14.97 +/-	0.98	204.0	2.0
+0.5	90-335	8.60 +/-	0.84	14.18 +/-	0.93	210.6	2.1
-0.5	90-336	9.30 +/-	0.65	14.69 +/-	0.70	206.6	1.6
-1.5	90-337	8.88 +/-	0.68	14.16 +/-	0.70	201.7	1.5
-2.5	90-338	9.42 +/-	0.66	14.13 +/-	0.61	192.8	1.5
-3.5	90-339	8.06 +/-	0.54	13.38 +/-	0.65	175.1	1.4
-4.5	90-340	7.05 +/-	0.35	11.97 +/-	0.43	138.9	0.9
-5.5	90-341	4.45 +/-	0.27	7.94 +/-	0.32	74.5	0.7
-6.5	90-342	1.94 +/-	0.20	3.31 +/-	0.26	51.9	0.6

NOTE: For the gamma counts, 6 beads were cut from the chain at the designated points of "Feet from Midplane" (3 beads on each side of the point). 6 beads are about 1.4 inches long and weigh about 1.2 grams.

Remarks:

AL File: 13910
References: Lab.Book#41p74. LB#35p213-216.
Procedures: A-524.
Analyst: WTF, WRM, CAB.

Approved: C.A.Blackburn 2-20-90

REPORT

Request# 13910

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

Received: 1/19/90
Reported: 2/20/90

[RESULTS OF ANALYSIS]

Point Beach Unit 2 Cycle 15 Reactor Cavity Dosimetry

Bead Chain Tag ID: S-2, 45 degree.

Feet from Midplane	Lab Sample#	[←————————— dps/mg of chain @ 2/1/90 —————————→]					
		Mn-54		Co-58		Co-60	
		dps/mg	2 sigma	dps/mg	2 sigma	dps/mg	2 sigma
+6.5	90-343	1.79 +/-	0.14	3.09 +/-	0.19	32.4 +/-	0.3
+5.5	90-344	4.14 +/-	0.24	7.15 +/-	0.29	66.4 +/-	0.6
+4.5	90-345	6.64 +/-	0.43	10.80 +/-	0.49	92.1 +/-	1.0
+3.5	90-346	7.39 +/-	0.32	12.00 +/-	0.47	105.9 +/-	0.8
+2.5	90-347	8.16 +/-	0.38	12.88 +/-	0.43	119.2 +/-	0.9
+1.5	90-348	7.79 +/-	0.28	12.58 +/-	0.35	125.1 +/-	0.8
+0.5	90-349	7.83 +/-	0.35	12.51 +/-	0.37	124.9 +/-	0.8
-0.5	90-350	8.05 +/-	0.39	13.16 +/-	0.45	127.1 +/-	0.9
-1.5	90-351	7.89 +/-	0.40	12.74 +/-	0.45	123.5 +/-	0.9
-2.5	90-352	7.76 +/-	0.47	12.49 +/-	0.55	119.3 +/-	1.2
-3.5	90-353	7.40 +/-	0.50	11.63 +/-	0.56	109.2 +/-	1.1
-4.5	90-354	7.09 +/-	0.44	10.93 +/-	0.49	90.4 +/-	1.0
-5.5	90-355	4.44 +/-	0.22	7.55 +/-	0.25	64.3 +/-	0.5
-6.5	90-356	1.83 +/-	0.17	3.02 +/-	0.17	48.9 +/-	0.4

NOTE: For the gamma counts, 6 beads were cut from the chain at the designated
points of "Feet from Midplane" (3 beads on each side of the point).
6 beads are about 1.4 inches long and weigh about 1.2 grams.

Remarks:

AL File: 13910
References: Lab.Book#41p74. LB#35p213-216.
Procedures: A-524.
Analyst: WTF, WRM, CAB.

Approved: _C.A.Blackburn 2-20-90_

CONTENTS OF MULTIPLE FOIL SENSOR SETS

CAPSULE ID and POSITION	BARE OR CADMIUM SHIELDED	RADIOMETRIC MONITOR ID								SSTR PACKAGE
		Fe	Ni	Cu	Ti	Nb	Co	U-238	Np-237	
G-1	B	CG	--	--	--	--	BM	--	--	PB-6B
G-2	Cd	DG	AG	AG	G	M	DM	G	--	--
G-3	Cd	--	--	--	--	--	--	--	2	PB-6C
H-1	B	CH	--	--	--	--	BL	--	--	PB-16B
H-2	Cd	DH	AH	AH	H	L	DL	H	--	--
H-3	Cd	--	--	--	--	--	--	--	3	PB-16C
I-1	B	CI	--	--	--	--	BK	--	--	PB-7B
I-2	Cd	DI	AI	AI	I	K	DK	I	--	--
I-3	Cd	--	--	--	--	--	--	--	4	PB-7C
J-1	B	CJ	--	--	--	--	BI	--	--	PB-17B
J-2	Cd	DJ	AJ	AJ	J	I	DI	J	--	--
J-3	Cd	--	--	--	--	--	--	--	5	PB-17C
K-1	B	CK	--	--	--	--	BJ	--	--	PB-18B
K-2	Cd	DK	AK	AK	K	J	DJ	K	--	--
K-3	Cd	--	--	--	--	--	--	--	6	PB-18C
L-1	B	CL	--	--	--	--	BH	--	--	PB-19B
L-2	Cd	DL	AL	AL	L	H	DH	L	--	--
L-3	Cd	--	--	--	--	--	--	--	7	PB-19C
XX-1	B	CT	--	--	--	--	BA	--	--	PB-1B
XX-2	Cd	DT	AT	AT	T	A	DA	T	--	--
XX-3	Cd	--	--	--	--	--	--	--	1	PB-1C

Originator: S.L.Anderson   (W)NTD, Energy Center (4-36)

Received: 1/14/91
Reported: 3/26/91

[RESULTS OF ANALYSIS]
Point Beach Reactor Cavity Dosimetry

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 12/12/90) dps/mg *		2 sigma
CM	91-254	Fe	Mn-54	9.09E+00	+/-	1.3E-01
DM	91-255	Fe	Mn-54	9.83E+00	+/-	1.4E-01
CN	91-263	Fe	Mn-54	2.04E+01	+/-	2.0E-01
DN	91-264	Fe	Mn-54	1.97E+01	+/-	1.9E-01
CO	91-272	Fe	Mn-54	9.93E+00	+/-	1.4E-01
DO	91-273	Fe	Mn-54	8.85E+00	+/-	1.3E-01
CP	91-281	Fe	Mn-54	1.75E+01	+/-	2.0E-01
DP	91-282	Fe	Mn-54	1.66E+01	+/-	1.7E-01
CS	91-290	Fe	Mn-54	1.47E+01	+/-	1.7E-01
DS	91-291	Fe	Mn-54	1.50E+01	+/-	1.7E-01
CR	91-299	Fe	Mn-54	1.42E+01	+/-	1.7E-01
DR	91-300	Fe	Mn-54	1.40E+01	+/-	1.6E-01
AM	91-257	Cu	Co-60	2.79E-01	+/-	4.7E-03
AN	91-266	Cu	Co-60	5.84E-01	+/-	8.4E-03
AO	91-275	Cu	Co-60	2.51E-01	+/-	5.6E-03
AP	91-284	Cu	Co-60	5.10E-01	+/-	6.4E-03
AS	91-293	Cu	Co-60	4.56E-01	+/-	7.5E-03
AR	91-302	Cu	Co-60	4.49E-01	+/-	7.3E-03
BG	91-260	AlCo	Co-60	1.85E+02	+/-	2.9E+00
DG	91-261	AlCo	Co-60	1.32E+02	+/-	2.4E+00
BF	91-269	AlCo	Co-60	4.39E+02	+/-	4.6E+00
DF	91-270	AlCo	Co-60	2.64E+02	+/-	3.5E+00
BE	91-278	AlCo	Co-60	2.05E+02	+/-	3.1E+00
DE	91-279	AlCo	Co-60	1.33E+02	+/-	2.5E+00
BD	91-287	AlCo	Co-60	5.63E+02	+/-	5.2E+00
DD	91-288	AlCo	Co-60	3.37E+02	+/-	3.3E+00
BC	91-296	AlCo	Co-60	5.03E+02	+/-	4.2E+00
DC	91-297	AlCo	Co-60	2.73E+02	+/-	3.0E+00
BB	91-305	AlCo	Co-60	3.13E+02	+/-	2.6E+00
DB	91-306	AlCo	Co-60	2.08E+02	+/-	2.0E+00

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

AL File: 14245
References: Lab.book# 46 pages 103-104.
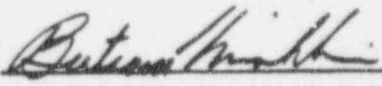Procedures: A-524.
Analyst: WTF, FRC

Approved: _____

Originator: S.L.Anderson   (W)NID, Energy Center (4-36)

Received: 1/14/91
Reported: 3/27/91

[RESULTS OF ANALYSIS]
Point Beach Reactor Cavity Dosimetry
(@ 12/12/90)

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	dps/mg *		2 sigma
M	91-262	U-238	Cs-137	7.63E-01	+/-	2.7E-02
N	91-271	U-238	Cs-137	1.61E+00	+/-	8.7E-02
O	91-280	U-238	Cs-137	7.30E-01	+/-	3.9E-02
P	91-289	U-238	Cs-137	1.47E+00	+/-	6.2E-02
S	91-298	U-238	Cs-137	1.12E+00	+/-	2.2E-02
R	91-307	U-238	Cs-137	1.03E+00	+/-	2.0E-02
M	91-262	U-238	Ru-103	1.26E+01	+/-	2.3E-01
N	91-271	U-238	Ru-103	2.28E+01	+/-	5.2E-01
O	91-280	U-238	Ru-103	1.11E+01	+/-	3.2E-01
P	91-289	U-238	Ru-103	1.92E+01	+/-	4.2E-01
S	91-298	U-238	Ru-103	1.58E+01	+/-	2.0E-01
R	91-307	U-238	Ru-103	1.48E+01	+/-	1.9E-01
M	91-262	U-238	Zr-95	1.63E+01	+/-	2.1E-01
N	91-271	U-238	Zr-95	3.10E+01	+/-	4.1E-01
O	91-280	U-238	Zr-95	1.52E+01	+/-	2.3E-01
P	91-289	U-238	Zr-95	2.72E+01	+/-	3.8E-01
S	91-298	U-238	Zr-95	2.24E+01	+/-	2.0E-01
R	91-307	U-238	Zr-95	2.07E+01	+/-	1.9E-01
M	91-258	Ti	Sc-46	3.50E+00	+/-	8.1E-02
N	91-267	Ti	Sc-46	6.94E+00	+/-	9.6E-02
O	91-276	Ti	Sc-46	3.16E+00	+/-	6.3E-02
P	91-285	Ti	Sc-46	5.99E+00	+/-	8.8E-02
S	91-294	Ti	Sc-46	5.26E+00	+/-	8.3E-02
R	91-303	Ti	Sc-46	5.02E+00	+/-	7.9E-02
AM	91-256	Ni	Co-58	1.89E+02	+/-	3.7E+00
AN	91-265	Ni	Co-58	3.67E+02	+/-	5.1E+00
AO	91-274	Ni	Co-58	1.74E+02	+/-	3.5E+00
AP	91-283	Ni	Co-58	3.17E+02	+/-	4.8E+00
AS	91-292	Ni	Co-58	2.69E+02	+/-	4.4E+00
AR	91-301	Ni	Co-58	2.55E+02	+/-	4.1E+00

Remarks: * Results are in units of dps/(mg of Dosimeter Material).
           * Sample #91-280,Zr-95 data corrected.

AL File: 14245
References: Lab.Book# 49 pages 32-37.
Procedures: A-524.
Analyst: WTF, TK

Approved: _Button Smith_

Originator: S.L.Anderson   (W)NTD, Energy Center (4-36)

Received: 1/14/91
Reported: 3/27/91

[RESULTS OF ANALYSIS]

Point Beach Reactor Cavity Dosimetry

Bead Chain Tag ID: 0 deg.

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
+7.5	91-65-A	1.15E+00 +/-	1.5E-01	3.26E+00 +/-	2.7E-01	3.01E+01 +/-	2.4E-01
+6.5	91-65-B	3.65E+00 +/-	1.9E-01	9.89E+00 +/-	4.2E-01	4.31E+01 +/-	2.8E-01
+5.5	91-65-C	8.87E+00 +/-	3.1E-01	2.41E+01 +/-	7.6E-01	9.86E+01 +/-	4.3E-01
+4.5	91-65-D	1.40E+01 +/-	5.6E-01	3.75E+01 +/-	1.2E+00	1.32E+02 +/-	7.0E-01
+3.5	91-65-E	1.56E+01 +/-	8.0E-01	4.00E+01 +/-	1.8E+00	1.53E+02 +/-	1.1E+00
+2.5	91-65-F	1.66E+01 +/-	7.2E-01	4.19E+01 +/-	1.8E+00	1.66E+02 +/-	9.9E-01
+1.5	91-65-G	1.58E+01 +/-	7.9E-01	3.89E+01 +/-	1.6E+00	1.61E+02 +/-	9.2E-01
+0.5	91-65-H	1.42E+01 +/-	7.2E-01	3.54E+01 +/-	1.7E+00	1.63E+02 +/-	9.8E-01
-0.5	91-65-I	1.14E+01 +/-	6.5E-01	2.95E+01 +/-	1.5E+00	1.60E+02 +/-	9.7E-01
-1.5	91-65-J	1.12E+01 +/-	6.6E-01	2.84E+01 +/-	1.4E+00	1.54E+02 +/-	9.6E-01
-2.5	91-65-K	1.26E+01 +/-	7.9E-01	3.12E+01 +/-	1.6E+00	1.51E+02 +/-	8.5E-01
-3.5	91-65-L	1.31E+01 +/-	6.9E-01	3.57E+01 +/-	1.5E+00	1.55E+02 +/-	9.6E-01
-4.5	91-65-M	1.30E+01 +/-	7.2E-01	3.33E+01 +/-	1.5E+00	1.27E+02 +/-	7.8E-01
-5.5	91-65-N	8.83E+00 +/-	5.5E-01	2.37E+01 +/-	1.2E+00	9.07E+01 +/-	7.3E-01
-6.5	91-65-O	3.36E+00 +/-	5.0E-01	9.73E+00 +/-	9.9E-01	6.68E+01 +/-	5.7E-01

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

AL File: 14220
References: Lab.Book# 49 pages 32-37.
Procedures: A-524.
Analyst: WIF, TK

Approved: _____

Originator: S.L.Anderson   (W)NTD, Energy Center (4-36)

Received: 1/14/91
Reported: 3/27/91

[RESULTS OF ANALYSIS]

Point Beach Reactor Cavity Dosimetry

Bead Chain Tag ID: 15 deg.

Feet from Midplane	Lab Sample#	[<———————— dps/mg of chain @ 12/12/90 ————————>]					
		Mn-54		Co-58		Co-60	
		dps/mg	2 sigma	dps/mg	2 sigma	dps/mg	2 sigma
+7.5	91-66-A	8.48E-01 +/- 1.7E-01		2.47E+00 +/- 3.9E-01		2.71E+01 +/- 2.9E-01	
+6.5	91-66-B	2.68E+00 +/- 3.5E-01		7.15E+00 +/- 7.2E-01		4.32E+01 +/- 4.1E-01	
+5.5	91-66-C	6.66E+00 +/- 5.5E-01		1.88E+01 +/- 1.3E+00		1.42E+02 +/- 9.1E-01	
+4.5	91-66-D	1.07E+01 +/- 7.3E-01		2.93E+01 +/- 1.7E+00		2.03E+02 +/- 1.1E+00	
+3.5	91-66-E	1.28E+01 +/- 1.4E+00		3.10E+01 +/- 2.6E+00		2.28E+02 +/- 1.7E+00	
+2.5	91-66-F	1.29E+01 +/- 9.8E-01		3.23E+01 +/- 2.3E+00		2.40E+02 +/- 1.5E+00	
+1.5	91-66-G	1.22E+01 +/- 1.2E+00		3.03E+01 +/- 2.6E+00		2.29E+02 +/- 1.6E+00	
+0.5	91-66-H	1.11E+01 +/- 9.9E-01		2.86E+01 +/- 1.8E+00		2.17E+02 +/- 1.5E+00	
-0.5	91-66-I	9.90E+00 +/- 1.1E+00		2.49E+01 +/- 2.4E+00		2.00E+02 +/- 1.5E+00	
-1.5	91-66-J	9.97E+00 +/- 6.5E-01		2.58E+01 +/- 1.6E+00		1.91E+02 +/- 1.1E+00	
-2.5	91-66-K	9.75E+00 +/- 9.6E-01		2.60E+01 +/- 2.2E+00		1.86E+02 +/- 1.2E+00	
-3.5	91-66-L	1.16E+01 +/- 7.3E-01		2.86E+01 +/- 1.6E+00		1.90E+02 +/- 1.1E+00	
-4.5	91-66-M	1.11E+01 +/- 6.8E-01		2.89E+01 +/- 1.6E+00		1.66E+02 +/- 1.0E+00	
-5.5	91-66-N	6.95E+00 +/- 5.5E-01		1.84E+01 +/- 1.3E+00		1.22E+02 +/- 8.5E-01	
-6.5	91-66-O	2.97E+00 +/- 4.2E-01		7.37E+00 +/- 8.1E-01		6.52E+01 +/- 5.1E-01	

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

AL File: 14220
References: Lab.Book# 49 pages 32-37.
Procedures: A-524.
Analyst: WIF, TK

Approved: Bateman Richlin

Originator: S.L.Anderson   (W).TD, Energy Center (4-36)

Received: 1/14/91
Reported: 3/27/91

[RESULTS OF ANALYSIS]

Point Beach Reactor Cavity Dosimetry

Bead Chain Tag ID: 30 deg.

| Feet from Midplane | Lab Sample# | [←——————— | | dps/mg of chain @ 12/12/90 | | ———————→] | |
| | | Mn-54 | | Co-58 | | Co-60 | |
		dps/mg	2 sigma	dps/mg	2 sigma	dps/mg	2 sigma
+7.5	91-67-A	7.58E-01 +/-	1.1E-01	2.13E+00 +/-	3.1E-01	2.29E+01 +/-	2.1E-01
+6.5	91-67-B	2.25E+00 +/-	2.2E-01	5.96E+00 +/-	5.3E-01	3.74E+01 +/-	2.9E-01
+5.5	91-67-C	5.66E+00 +/-	5.3E-01	1.47E+01 +/-	1.0E+00	1.06E+02 +/-	7.9E-01
+4.5	91-67-D	8.21E+00 +/-	6.1E-01	2.08E+01 +/-	1.4E+00	1.50E+02 +/-	9.4E-01
+3.5	91-67-E	8.59E+00 +/-	9.0E-01	2.26E+01 +/-	2.0E+00	1.72E+02 +/-	1.1E+00
+2.5	91-67-F	9.49E+00 +/-	6.7E-01	2.49E+01 +/-	1.5E+00	1.86E+02 +/-	1.1E+00
+1.5	91-67-G	9.11E+00 +/-	9.0E-01	2.39E+01 +/-	2.0E+00	1.84E+02 +/-	1.2E+00
+0.5	91-67-H	9.54E+00 +/-	6.4E-01	2.40E+01 +/-	1.5E+00	1.88E+02 +/-	1.1E+00
-0.5	91-67-I	9.19E+00 +/-	6.7E-01	2.41E+01 +/-	1.5E+00	1.83E+02 +/-	1.0E+00
-1.5	91-67-J	8.91E+00 +/-	9.2E-01	2.27E+01 +/-	2.1E+00	1.73E+02 +/-	1.1E+00
-2.5	91-67-K	9.13E+00 +/-	6.9E-01	2.29E+01 +/-	1.6E+00	1.72E+02 +/-	1.0E+00
-3.5	91-67-L	8.27E+00 +/-	6.3E-01	2.19E+01 +/-	1.4E+00	1.58E+02 +/-	9.8E-01
-4.5	91-67-M	7.70E+00 +/-	4.0E-01	2.04E+01 +/-	9.4E-01	1.24E+02 +/-	5.2E-01
-5.5	91-67-N	5.10E+00 +/-	2.3E-01	1.32E+01 +/-	5.2E-01	7.01E+01 +/-	3.6E-01
-6.5	91-67-O	2.13E+00 +/-	2.1E-01	5.42E+00 +/-	4.2E-01	4.97E+01 +/-	3.0E-01

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

AL File: 14220
References: Lab.Book# 49 pages 32-37.
Procedures: A-524.
Analyst: WTF, TK

Approved: _Bertram Mulholland_

Originator: S.L.Anderson   (W)NTD, Energy Center (4-36)

Received: 1/14/91
Reported: 3/27/91

[RESULTS OF ANALYSIS]

Point Beach Reactor Cavity Dosimetry

Bead Chain Tag ID: 45 deg.

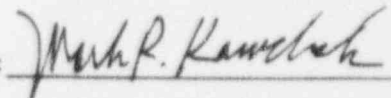| Feet from Midplane | Lab Sample# | [<———————————— dps/mg of chain @ 12/12/90 ————————————>] | | | | | |
| | | Mn-54 | | Co-58 | | Co-60 | |
		dps/mg	2 sigma	dps/mg	2 sigma	dps/mg	2 sigma
+7.5	91-68-A	6.41E-01 +/- 9.2E-02		1.78E+00 +/- 1.9E-01		2.05E+01 +/- 1.3E-01	
+6.5	91-68-B	2.04E+00 +/- 1.7E-01		5.23E+00 +/- 3.7E-01		3.20E+01 +/- 2.4E-01	
+5.5	91-68-C	4.86E+00 +/- 3.4E-01		1.24E+01 +/- 7.1E-01		6.48E+01 +/- 3.9E-01	
+4.5	91-68-D	7.55E+00 +/- 5.4E-01		1.95E+01 +/- 1.3E+00		8.97E+01 +/- 7.3E-01	
+3.5	91-68-E	7.94E+00 +/- 5.9E-01		2.09E+01 +/- 1.3E+00		1.05E+02 +/- 7.9E-01	
+2.5	91-68-F	8.91E+00 +/- 4.3E-01		2.24E+01 +/- 9.1E-01		1.13E+02 +/- 5.1E-01	
+1.5	91-68-G	8.84E+00 +/- 5.9E-01		2.15E+01 +/- 1.2E+00		1.20E+02 +/- 8.5E-01	
+0.5	91-68-H	8.78E+00 +/- 6.1E-01		2.15E+01 +/- 1.3E+00		1.19E+02 +/- 8.4E-01	
-0.5	91-68-I	8.65E+00 +/- 6.7E-01		2.27E+01 +/- 1.5E+00		1.15E+02 +/- 7.4E-01	
-1.5	91-68-J	8.71E+00 +/- 5.8E-01		2.13E+01 +/- 1.1E+00		1.16E+02 +/- 8.3E-01	
-2.5	91-68-K	8.34E+00 +/- 6.3E-01		2.19E+01 +/- 1.3E+00		1.07E+02 +/- 7.2E-01	
-3.5	91-68-L	8.15E+00 +/- 3.5E-01		2.08E+01 +/- 7.2E-01		1.01E+02 +/- 4.4E-01	
-4.5	91-68-M	7.68E+00 +/- 5.0E-01		2.03E+01 +/- 1.4E+00		8.34E+01 +/- 6.3E-01	
-5.5	91-68-N	5.12E+00 +/- 1.4E-01		1.35E+01 +/- 3.4E-01		6.22E+01 +/- 2.0E-01	
-6.5	91-68-O	2.03E+00 +/- 2.0E-01		5.78E+00 +/- 4.5E-01		4.63E+01 +/- 2.7E-01	

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

AL File: 14220
References: Lab.Book# 49 pages 32-37.
Procedures: A-524.
Analyst: WTF, TK

Approved: _____

CONTENTS OF MULTIPLE FOIL SENSOR SETS
CYCLE 16 IRRADIATION

CAPSULE ID and POSITION	BARE OR CADMIUM SHIELDED	RADIOMETRIC MONITOR ID							SSTR PACKAGE
		Fe	Ni	Cu	Ti	Nb	Co	U-238	
M-1	B	CM	--	--	--	--	BG	--	PB-4B
M-2	Cd	DM	AM	AM	M	G	DG	M	--
M-3	Cd	--	--	--	--	--	--	--	PB-4C
N-1	B	CN	--	--	--	--	BF	--	PB-12B
N-2	Cd	DN	AN	AN	N	F	DF	N	--
N-3	Cd	--	--	--	--	--	--	--	PB-12C
O-1	B	CO	--	--	--	--	BE	--	PB-5B
O-2	Cd	DO	AO	AO	O	E	DE	O	--
O-3	Cd	--	--	--	--	--	--	--	PB-5C
P-1	B	CP	--	--	--	--	BD	--	PB-13B
P-2	Cd	DP	AP	AP	P	D	DD	P	--
P-3	Cd	--	--	--	--	--	--	--	PB-13C
Q-1	B	CS	--	--	--	--	BC	--	PB-14B
Q-2	Cd	DS	AS	AS	S	C	DC	S	--
Q-3	Cd	--	--	--	--	--	--	--	PB-14C
R-1	B	CR	--	--	--	--	BB	--	PB-15B
R-2	Cd	DT	AT	AT	T	A	DA	T	--
R-3	Cd	--	--	--	--	--	--	--	PB-15C

Originator: S. Anderson (W)NTD, Energy Center

Received: 10/18/91
Reported: 12/12/91

[RESULTS OF ANALYSIS]
POINT BEACH UNIT 2 CYCLE 17 REACTOR CAVITY DOSIMETRY

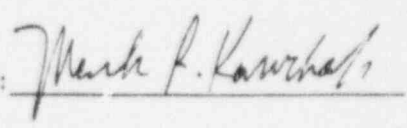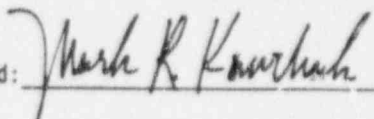| Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 10/24/91) dps/mg *	2 sigma
BG	91-1822	Fe	Mn-54	9.82E+00 +/-	1.1E-01
AG	91-1823	Fe	Mn-54	1.08E+01 +/-	1.1E-01
BH	91-1831	Fe	Mn-54	2.30E+01 +/-	1.6E-01
AH	91-1832	Fe	Mn-54	2.22E+01 +/-	1.6E-01
AI	91-1840	Fe	Mn-54	1.11E+01 +/-	1.2E-01
BI	91-1841	Fe	Mn-54	9.91E+00 +/-	1.1E-01
BJ	91-1849	Fe	Mn-54	1.98E+01 +/-	1.7E-01
AJ	91-1850	Fe	Mn-54	1.96E+01 +/-	1.5E-01
BK	91-1858	Fe	Mn-54	1.64E+01 +/-	1.5E-01
AK	91-1859	Fe	Mn-54	1.63E+01 +/-	1.4E-01
BL	91-1867	Fe	Mn-54	1.58E+01 +/-	1.4E-01
AL	91-1868	Fe	Mn-54	1.56E+01 +/-	1.3E-01
G	91-1824	Ni	Co-58	2.83E+02 +/-	1.6E+00
H	91-1833	Ni	Co-58	5.51E+02 +/-	2.2E+00
I	91-1842	Ni	Co-58	2.61E+02 +/-	1.5E+00
J	91-1851	Ni	Co-58	4.80E+02 +/-	2.0E+00
K	91-1860	Ni	Co-58	4.00E+02 +/-	1.5E+00
L	91-1869	Ni	Co-58	3.82E+02 +/-	1.8E+00
BG	91-1828	AlCo	Co-60	1.95E+02 +/-	1.9E+00
AG	91-1829	AlCo	Co-60	1.40E+02 +/-	1.6E+00
BH	91-1837	AlCo	Co-60	4.67E+02 +/-	3.0E+00
AH	91-1838	AlCo	Co-60	2.77E+02 +/-	2.3E+00
AI	91-1846	AlCo	Co-60	2.13E+02 +/-	2.0E+00
BI	91-1847	AlCo	Co-60	1.40E+02 +/-	1.6E+00
BJ	91-1855	AlCo	Co-60	5.89E+02 +/-	3.3E+00
AJ	91-1856	AlCo	Co-60	3.35E+02 +/-	2.6E+00
BK	91-1864	AlCo	Co-60	5.25E+02 +/-	3.2E+00
AK	91-1865	AlCo	Co-60	2.89E+02 +/-	2.3E+00
BL	91-1873	AlCo	Co-60	3.25E+02 +/-	2.5E+00
AL	91-1874	AlCo	Co-60	2.21E+02 +/-	2.1E+00

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

AL File: 14477
References: Lab Book#46 pages 246-247
Procedures: A-524.
Analyst: WTF, TRK, MRK

Approved: _Mark R. Kawelch_

[RESULTS OF ANALYSIS]

POINT BEACH UNIT 2 CYCLE 17 REACTOR CAVITY DOSIMETRY

Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 10/24/91) dps/mg *	2 sigma
G	91-1830	U-238	Cs-137	7.59E-01	+/- 2.21E-02
H	91-1839	U-238	Cs-137	1.49E+00	+/- 3.09E-02
I	91-1848	U-238	Cs-137	6.87E-01	+/- 2.34E-02
J	91-1857	U-238	Cs-137	1.37E+00	+/- 2.77E-02
K	91-1866	U-238	Cs-137	1.15E+00	+/- 2.52E-02
L	91-1875	U-238	Cs-137	1.01E+00	+/- 2.62E-02
G	91-1830	U-238	Ru-103	2.61E+01	+/- 1.09E-01
H	91-1839	U-238	Ru-103	4.67E+01	+/- 1.52E-01
I	91-1848	U-238	Ru-103	2.32E+01	+/- 1.18E-01
J	91-1857	U-238	Ru-103	4.22E+01	+/- 1.43E-01
K	91-1866	U-238	Ru-103	3.52E+01	+/- 1.32E-01
L	91-1875	U-238	Ru-103	3.19E+01	+/- 1.53E-01
G	91-1830	U-238	Zr-95	2.55E+01	+/- 1.25E-01
H	91-1839	U-238	Zr-95	4.70E+01	+/- 1.75E-01
I	91-1848	U-238	Zr-95	2.31E+01	+/- 1.35E-01
J	91-1857	U-238	Zr-95	4.38E+01	+/- 1.63E-01
K	91-1866	U-238	Zr-95	3.69E+01	+/- 1.50E-01
L	91-1875	U-238	Zr-95	3.23E+01	+/- 1.65E-01
G	91-1826	Ti	Sc-46	4.91E+00	+/- 4.79E-02
H	91-1835	Ti	Sc-46	8.84E+00	+/- 6.94E-02
I	91-1844	Ti	Sc-46	4.35E+00	+/- 4.62E-02
J	91-1853	Ti	Sc-46	8.68E+00	+/- 6.50E-02
K	91-1862	Ti	Sc-46	7.50E+00	+/- 6.02E-02
L	91-1871	Ti	Sc-46	7.36E+00	+/- 5.95E-02

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

Originator: S. Anderson (W)NTD, Energy Center

Received: 10/18/91
Reported: 12/12/91

[RESULTS OF ANALYSIS]

POINT BEACH UNIT 2 CYCLE 17 REACTOR CAVITY DOSIMETRY

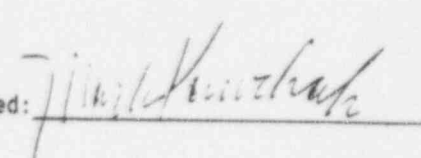| Foil ID	Lab Sample#	Dosimeter Material	Nuclide	(@ 10/24/91) dps/mg *	2 sigma
G	91-1825	Cu	Co-60	2.87E-01	+/- 3.79E-03
H	91-1834	Cu	Co-60	6.14E-01	+/- 5.53E-03
I	91-1843	Cu	Co-60	2.66E-01	+/- 3.63E-03
J	91-1852	Cu	Co-60	5.44E-01	+/- 5.19E-03
K	91-1861	Cu	Co-60	4.61E-01	+/- 4.85E-03
L	91-1870	Cu	Co-60	4.73E-01	+/- 4.83E-03

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

AL File: 14477
References: Lab Book#46 pages 246-247
Procedures: A-524.
Analyst: WTF, TRK, MRK

Approved: _Mark R. Kaurhah_

[RESULTS OF ANALYSIS]

POINT BEACH UNIT 2 CYCLE 17 REACTOR CAVITY DOSIMETRY

Bead Chain Tag ID: 0 deg.

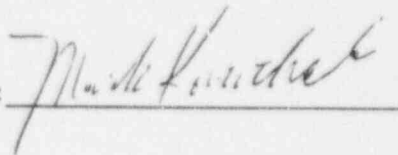| Feet from Midplane	Lab Sample#	[<---------------- dps/mg of chain @ 10/24/91 ---------------->]					
		------- Mn-54 -------		------- Co-58 -------		------- Co-60 -------	
		dps/mg	2 sigma	dps/mg	2 sigma	dps/mg	2 sigma
+7.5	91-1818A	1.25E+00 +/-	1.2E-01	4.79E+00 +/-	2.9E-01		
+6.5	91-1818B	4.13E+00 +/-	2.4E-01	1.55E+01 +/-	5.9E-01	2.80E+01 +/-	1.6E-01
+5.5	91-1818C	1.03E+01 +/-	3.5E-01	3.71E+01 +/-	8.8E-01	4.05E+01 +/-	2.7E-01
+4.5	91-1818D	1.53E+01 +/-	9.9E-01	5.65E+01 +/-	2.2E+00	7.52E+01 +/-	3.8E-01
+3.5	91-1818E	1.71E+01 +/-	1.1E+00	5.90E+01 +/-	2.5E+00	1.02E+02 +/-	1.0E+00
+2.5	91-1818F	1.80E+01 +/-	1.1E+00	6.33E+01 +/-	2.6E+00	1.18E+02 +/-	1.1E+00
+1.5	91-1818G	1.72E+01 +/-	1.1E+00	6.01E+01 +/-	2.5E+00	1.28E+02 +/-	1.1E+00
+0.5	91-1818H	1.60E+01 +/-	1.0E+00	5.39E+01 +/-	2.5E+00	1.27E+02 +/-	1.1E+00
-0.5	91-1818I	1.38E+01 +/-	1.1E+00	4.65E+01 +/-	2.5E+00	1.28E+02 +/-	1.1E+00
-1.5	91-1818J	1.36E+01 +/-	1.1E+00	4.50E+01 +/-	2.6E+00	1.27E+02 +/-	1.1E+00
-2.5	91-1818K	1.34E+01 +/-	9.4E-01	5.07E+01 +/-	2.4E+00	1.23E+02 +/-	1.1E+00
-3.5	91-1818L	1.48E+01 +/-	9.8E-01	5.20E+01 +/-	2.3E+00	1.24E+02 +/-	1.1E+00
-4.5	91-1818M	1.44E+01 +/-	8.9E-01	5.34E+01 +/-	2.4E+00	1.02E+02 +/-	1.0E+00
-5.5	91-1818N	1.02E+01 +/-	4.5E-01	3.57E+01 +/-	1.0E+00	6.97E+01 +/-	4.7E-01
-6.5	91-1818O	4.23E+00 +/-	4.1E-01	1.46E+01 +/-	8.4E-01	6.49E+01 +/-	4.5E-01

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

AL File: 14477
References: Lab Book#46 pages 246-247
Procedures: A-524.
Analyst: WTF, TRK, MRK

Approved: _____

Originator: S. Anderson (W)NATD, Energy Center
            Radiation Engineering & Analysis   Received: 10/18/91
            Westinghouse Electric Corporation   Reported: 2/18/92

[RESULTS OF ANALYSIS]

POINT BEACH UNIT 2 CYCLE 17 REACTOR CAVITY DOSIMETRY

Bead Chain Tag ID: 15 deg.

Feet from Midplane	Lab Sample#	[<-------------- dps/mg of chain @ 10/24/91 -------------->]					
		Mn-54		Co-58		Co-60	
		dps/mg	2 sigma	dps/mg	2 sigma	dps/mg	2 sigma
+7.5	91-1819A	1.11E+00 +/-	1.1E-01	4.14E+00 +/-	2.6E-01	2.56E+01 +/-	1.5E-01
+6.5	91-1819B	3.10E+00 +/-	2.3E-01	1.15E+01 +/-	5.5E-01	4.19E+01 +/-	2.8E-01
+5.5	91-1819C	7.86E+00 +/-	7.1E-01	2.96E+01 +/-	1.8E+00	1.35E+02 +/-	9.0E-01
+4.5	91-1819D	1.07E+01 +/-	7.8E-01	4.48E+01 +/-	2.2E+00	1.90E+02 +/-	1.1E+00
+3.5	91-1819E	1.29E+01 +/-	7.0E-01	4.69E+01 +/-	1.9E+00	2.15E+02 +/-	9.3E-01
+2.5	91-1819F	1.43E+01 +/-	1.3E+00	5.09E+01 +/-	3.0E+00	2.26E+02 +/-	1.5E+00
+1.5	91-1819G	1.39E+01 +/-	9.3E-01	4.64E+01 +/-	2.2E+00	2.20E+02 +/-	1.2E+00
+0.5	91-1819H	1.31E+01 +/-	8.9E-01	4.45E+01 +/-	2.2E+00	2.05E+02 +/-	1.1E+00
-0.5	91-1819I	1.25E+01 +/-	9.0E-01	4.10E+01 +/-	1.9E+00	1.62E+02 +/-	9.9E-01
-1.5	91-1819J	1.13E+01 +/-	7.4E-01	3.95E+01 +/-	2.0E+00	1.52E+02 +/-	9.5E-01
-2.5	91-1819K	1.27E+01 +/-	7.7E-01	4.13E+01 +/-	1.8E+00	1.51E+02 +/-	9.6E-01
-3.5	91-1819L	1.25E+01 +/-	8.4E-01	4.51E+01 +/-	2.0E+00	1.48E+02 +/-	9.5E-01
-4.5	91-1819M	1.25E+01 +/-	7.6E-01	4.17E+01 +/-	1.9E+00	1.28E+02 +/-	8.8E-01
-5.5	91-1819N	8.30E+00 +/-	6.7E-01	2.91E+01 +/-	1.5E+00	9.42E+01 +/-	7.5E-01
-6.5	91-1819O	3.04E+00 +/-	2.4E-01	1.16E+01 +/-	6.2E-01	5.03E+01 +/-	3.1E-01

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

AL File: 14477
References: Lab Book#46 pages 246-247
Procedures: A-524.
Analyst: WTF, TRK, MRK   Approved: _____

Originator: S. Anderson (W)NATD, Energy Center
            Radiation Engineering & Analysis   Received: 10/18/91
            Westinghouse Electric Corporation   Reported: 2/18/92

[RESULTS OF ANALYSIS]

POINT BEACH UNIT 2 CYCLE 17 REACTOR CAVITY DOSIMETRY

Bead Chain Tag ID: 30 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
+7.5	91-1820A	8.05E-01 +/-	1.1E-01	3.07E+00 +/-	2.7E-01	2.10E+01 +/-	1.4E-01
+6.5	91-1820B	2.39E+00 +/-	1.5E-01	9.26E+00 +/-	4.0E-01	3.47E+01 +/-	1.8E-01
+5.5	91-1820C	6.06E+00 +/-	5.7E-01	2.09E+01 +/-	1.4E+00	9.70E+01 +/-	7.7E-01
+4.5	91-1820D	9.17E+00 +/-	7.7E-01	3.21E+01 +/-	1.8E+00	1.40E+02 +/-	9.3E-01
+3.5	91-1820E	1.08E+01 +/-	8.0E-01	3.56E+01 +/-	1.8E+00	1.64E+02 +/-	9.1E-01
+2.5	91-1820F	1.01E+01 +/-	8.3E-01	3.74E+01 +/-	2.1E+00	1.76E+02 +/-	1.0E+00
+1.5	91-1820G	1.03E+01 +/-	7.9E-01	3.90E+01 +/-	2.3E+00	1.81E+02 +/-	1.0E+00
+0.5	91-1820H	1.10E+01 +/-	8.3E-01	3.61E+01 +/-	2.1E+00	1.81E+02 +/-	1.0E+00
-0.5	91-1820I	1.09E+01 +/-	8.7E-01	3.93E+01 +/-	2.1E+00	1.46E+02 +/-	9.4E-01
-1.5	91-1820J	1.04E+01 +/-	7.2E-01	3.70E+01 +/-	1.8E+00	1.42E+02 +/-	9.2E-01
-2.5	91-1820K	1.06E+01 +/-	8.2E-01	3.80E+01 +/-	2.0E+00	1.37E+02 +/-	9.1E-01
-3.5	91-1820L	9.93E+00 +/-	7.1E-01	3.49E+01 +/-	1.9E+00	1.26E+02 +/-	8.8E-01
-4.5	91-1820M	9.42E+00 +/-	6.7E-01	3.32E+01 +/-	1.7E+00	1.02E+02 +/-	7.8E-01
-5.5	91-1820N	5.71E+00 +/-	3.2E-01	2.19E+01 +/-	7.0E-01	5.51E+01 +/-	3.2E-01
-6.5	91-1820O	2.30E+00 +/-	2.1E-01	8.87E+00 +/-	5.1E-01	3.89E+01 +/-	2.7E-01

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

Approved: _____

Originator: S. Anderson (W)NATD, Energy Center
Radiation Engineering & Analysis
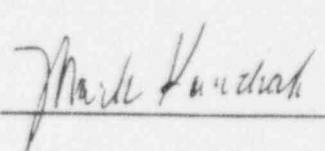Westinghouse Electric Corporation

Received: 10/18/91
Reported: 2/18/92

[RESULTS OF ANALYSIS]

POINT BEACH UNIT 2 CYCLE 17 REACTOR CAVITY DOSIMETRY
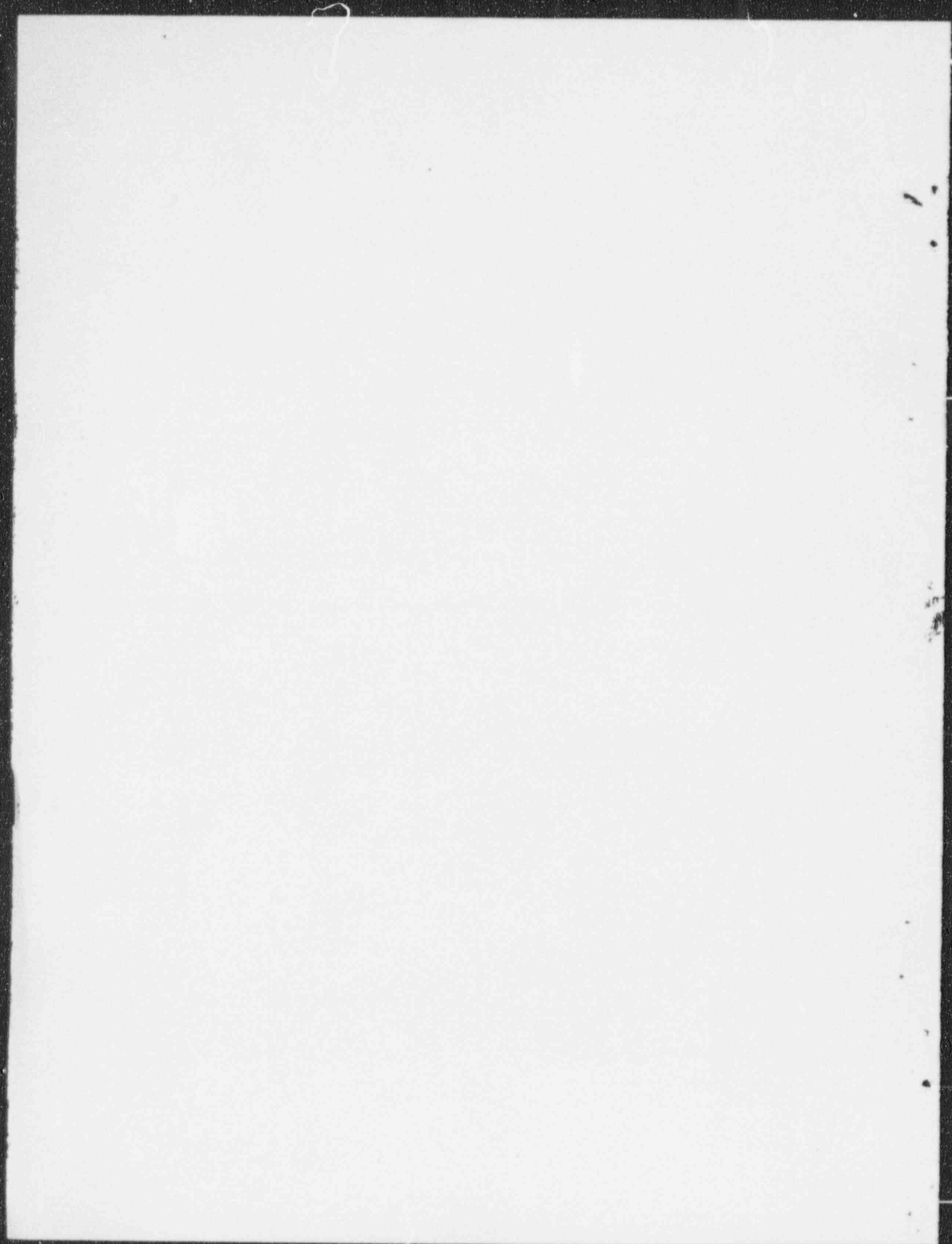
Bead Chain Tag ID: 45 deg.

Feet from Midplane	Lab Sample#	[<------------- dps/mg of chain @ 10/24/91 ------------->]					
		------- Mn-54 -------		------- Co-58 -------		------- Co-60 -------	
		dps/mg	2 sigma	dps/mg	2 sigma	dps/mg	2 sigma
+7.5	91-1821A	7.41E-01 +/- 9.0E-02		2.43E+00 +/- 1.9E-01		2.01E+01 +/- 1.2E-01	
+6.5	91-1821B	2.22E+00 +/- 1.2E-01		8.10E+00 +/- 2.8E-01		2.97E+01 +/- 1.5E-01	
+5.5	91-1821C	5.15E+00 +/- 2.9E-01		1.82E+01 +/- 7.0E-01		6.00E+01 +/- 3.4E-01	
+4.5	91-1821D	8.05E+00 +/- 3.5E-01		2.88E+01 +/- 8.3E-01		8.04E+01 +/- 3.9E-01	
+3.5	91-1821E	9.27E+00 +/- 5.8E-01		3.23E+01 +/- 1.7E+00		9.63E+01 +/- 7.6E-01	
+2.5	91-1821F	1.03E+01 +/- 7.2E-01		3.69E+01 +/- 1.9E+00		1.07E+02 +/- 8.0E-01	
+1.5	91-1821G	9.59E+00 +/- 6.5E-01		3.52E+01 +/- 1.8E+00		1.13E+02 +/- 8.3E-01	
+0.5	91-1821H	9.36E+00 +/- 6.4E-01		3.31E+01 +/- 1.7E+00		1.13E+02 +/- 8.2E-01	
-0.5	91-1821I	1.08E+01 +/- 6.5E-01		3.58E+01 +/- 1.6E+00		9.42E+01 +/- 7.5E-01	
-1.5	91-1821J	1.00E+01 +/- 6.0E-01		3.62E+01 +/- 1.7E+00		9.26E+01 +/- 7.5E-01	
-2.5	91-1821K	1.05E+01 +/- 7.5E-01		3.51E+01 +/- 1.5E+00		8.86E+01 +/- 7.3E-01	
-3.5	91-1821L	9.67E+00 +/- 6.2E-01		3.38E+01 +/- 1.6E+00		8.25E+01 +/- 7.0E-01	
-4.5	91-1821M	8.53E+00 +/- 3.5E-01		2.99E+01 +/- 8.5E-01		6.73E+01 +/- 3.6E-01	
-5.5	91-1821N	5.93E+00 +/- 2.7E-01		1.02E+01 +/- 1.2E+00		2.17E+01 +/- 6.9E-01	
-6.5	91-1821O	2.60E+00 +/- 1.5E-01		9.18E+00 +/- 3.8E-01		3.69E+01 +/- 1.9E-01	

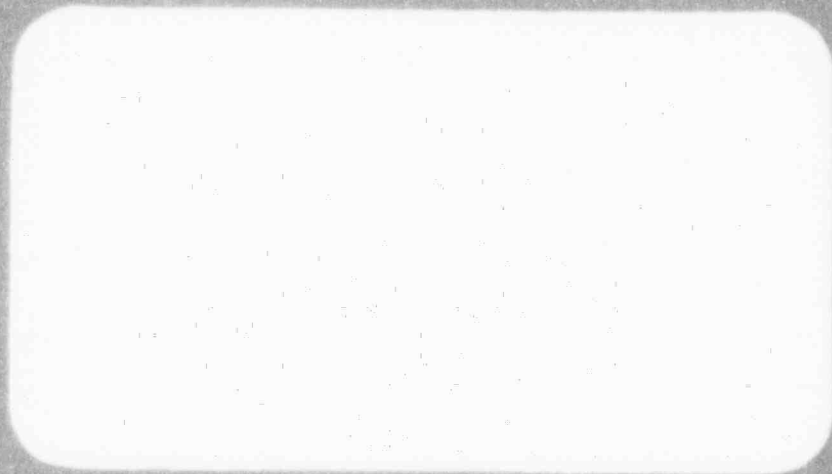Remarks: * Results are in units of dps/(mg of Dosimeter Material).

AL File: 14477
References: Lab Book#46 pages 246-247
Procedures: A-524.
Analyst: WTF, TRK, MRK

Approved: _____

CONTENTS OF MULTIPLE FOIL SENSOR SETS
CYCLE 17 IRRADIATION

CAPSULE ID and POSITION	BARE OR CADMIUM SHIELDED	RADIOMETRIC MONITOR ID							SSTR PACKAGE
		Fe	Ni	Cu	Ti	Nb	Co	U-238	
AA-1	B	BG	--	--	--	--	BG	--	PB-27B
AA-2	Cd	AG	G	G	G	G	AG	G	--
AA-3	Cd	--	--	--	--	--	--	--	PB-27C
BB-1	B	BH	--	--	--	--	BH	--	PB-29B
BB-2	Cd	AH	H	H	H	H	AH	H	--
BB-3	Cd	--	--	--	--	--	--	--	PB-29C
CC-1	B	BI	--	--	--	--	BI	--	PB-28B
CC-2	Cd	AI	I	I	I	I	AI	I	--
CC-3	Cd	--	--	--	--	--	--	--	PB-28C
DD-1	B	BJ	--	--	--	--	BJ	--	PB-30B
DD-2	Cd	AJ	J	J	J	J	AJ	J	--
DD-3	Cd	--	--	--	--	--	--	--	PB-30C
EE-1	B	BK	--	--	--	--	BK	--	PB-31B
EE-2	Cd	AK	K	K	K	K	AK	K	--
EE-3	Cd	--	--	--	--	--	--	--	PB-31C
FF-1	B	BL	--	--	--	--	BL	--	PB-32B
FF-2	Cd	AL	L	L	L	L	AL	L	--
FF-3	Cd	--	--	--	--	--	--	--	PB-32C

Westinghouse Energy Systems