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A WISCONSIN ENERGY COMPANY

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Ladies and Gentlemen:

DOCKETS 50-266 AND 50-301
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION
TECHNICAL SPECIFICATIONS CHANGE REQUEST 219
ADOPTION OF PRESSURE AND TEMPERATURE LIMITS REPORT
AND REVISED P-T AND LTOP LIMITS (TAC NOS. MA8459 AND MA8460)
POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

By submittal dated March 10, 2000, Wisconsin Electric Power Company (Licensee) requested amendments to Facility Operating Licenses DPR-24 and DPR-27 for Point Beach Nuclear Power Plant, Units 1 and 2, respectively, to incorporate changes to the plant Operating Licenses and Technical Specifications. The purpose of the proposed amendments was to implement a Pressure and Temperature Limits Report (PTLR) concurrent with implementation of Improved Standard Technical Specifications at the Point Beach Nuclear Plant (PBNP).

By letter dated June 21, 2000, the staff requested additional information related to the proposed changes. Attachment 1 contains our response to the staff's request for additional information (RAI).

Please contact us if you have any questions.

Sincerely,

Mark A. Reddemann
Vice President
Point Beach Nuclear Plant

Attachment

Subscribed and sworn before me on
this 31st day of July, 2000.
Christine K. Pozorski
Notary Public, State of Wisconsin

My Commission expires on 8-25-2002

cc: NRC Regional Administrator NRC Project Manager NRC Resident Inspector PSCW

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DOCKETS 50-266 AND 50-301
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ADOPTION OF PRESSURE AND TEMPERATURE LIMITS REPORT
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POINT BEACH NUCLEAR PLANT, UNITS 1 AND 2

The following information is provided in response to the Nuclear Regulatory Commission (NRC) staff's request for additional information dated June 21, 2000, related to Wisconsin Electric's request for amendments dated March 10, 2000. The purpose of the requested amendment was to implement a Pressure and Temperature Limits Report (PTLR) concurrent with implementation of Improved Standard Technical Specifications at the Point Beach Nuclear Plant (PBNP).

Each question is restated below with Wisconsin Electric's response following.

1. **The cavity dosimetry for Unit 1 (WCAP-12794 Revision 4), in addition to the normal compliment of dosimeters, employed solid-state track recorders (SSTRs). As far as the staff is aware, the SSTRs were disqualified more than 15 years ago due to U-235 weight-deposition measurement problems. Why are they now qualified for service and what is the supporting documentation?**

Response:

Westinghouse is not aware of any published information that would indicate that a blanket disqualification of SSTRs for Light Water Reactor (LWR) application is or was warranted. In fact, Section 2.1.1.5 of Draft Regulatory Guide DG-1053, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence," (September 1999 version), includes the following statement relative to the use of SSTRs:

"2.1.1.5 Solid-State Track Recorders. Solid state track recorders (SSTRs) are integral detectors that employ fission reactions. These sensors directly record the tracks of fission fragments from a thin fissionable deposit (Ref. 75). The principal advantages of these detectors are wide sensitivity ranges and a permanent measurement record. Because the application of SSTRs employs fissionable deposits in the nanogram to picogram range, details of the measurements should be well documented and standard neutron field calibration should be performed prior to the application. ASTM Standard E 854 (Ref. 76) provides additional information concerning the use of SSTRs."

Additionally, the current version of Draft ANS Standard 19.10, "Fast Neutron Fluence in Light Water Reactor Pressure Vessels," includes the following discussion pertaining to the use of SSTRs:

"4.3 Solid State Track Recorders. In addition to activation detectors, integral detectors employing fission reactions make use of solid state track recorders (SSTRs). These sensors directly record fission fragments from a thin fissionable deposit. Advantages of these detectors are wide sensitivity ranges, a permanent measurement record, and convenient application of fission reaction dosimetry in remote and hostile environments. Because the application is new and employs fissionable deposits in the nanogram to picogram range, details of the measurements should be well documented, and

standard neutron field calibration prior to application should be performed. ASTM Standard E 854 provides additional information concerning the use of SSTRs."

Westinghouse is in total agreement with the inclusion of these statements in both of these important documents; and is not aware of any objections to these statements that have been raised by representatives of industry, government, or academia who have participated in the review and comment of these documents over the last several years. The inclusion of these statements in both the Draft Regulatory Guide and the Draft ANS Standard indicates that the use of SSTRs, if implemented properly according to ASTM Standard E 854, is appropriate and acceptable for LWR dosimetry applications.

The Westinghouse solid state track recorder technology follows the guidance specified in ASTM Standard E 854, "Standard Test Method for Application and Analysis of Solid State Track Recorder (SSTR) Monitors for Reactor Vessel Surveillance, E706(IIIB),". The latest approved version of this standard is designated E 854 – 98 and is included in the 1999 Annual Book of ASTM Standards, Section 12, Volume 12.02. The stated scope of this standard test method includes SSTR applications that *"extend from low neutron fluence to high neutron fluence, including high power pressure vessel surveillance and test reactor irradiations as well as low power benchmark field measurement."*

In addition to the application of procedures specified in the latest approved ASTM standards to the manufacture and analysis of the SSTRs deployed in reactor cavity irradiations, calibration of the sensors in standard neutron fields as suggested by DG-1053 and ANS 19.10 is also carried out. To accomplish these independent calibrations, irradiations were performed in a thermal neutron field or in a U-235 standard neutron fission spectrum at the National Institute of Standards and Technology (NIST). The results of these benchmark irradiations which also serve as an independent check on the processing and track counting methods have been published in the open literature in the following peer reviewed article: "Benchmark Referencing of Solid State Track Recorder Neutron Dosimeters in Standard Neutron Fields," Frank H. Ruddy and E. D. McGarry, Proceedings of the Seventh ASTM-EURATOM Symposium on Reactor Dosimetry, Kluwer Academic Publishers, Dordrecht, 1992. Page 825.

The results of these benchmark irradiations are summarized as follows:

SSTR Sensor	Ratio SSTR/NIST	% Standard Deviation
U-238	1.044	3.5
Np-237	1.064	2.1
U-235	1.005	1.1

These benchmark referencing results are used as part of the calibration of SSTR sensors that are deployed to the field.

A further evaluation of the U-238 and NP-237 SSTRs has been performed by irradiation of radiometric foils in tandem with the SSTRs in the actual cavity dosimetry irradiations. In the case of Point Beach Units 1 and 2, U-238 fission foils were included along with U-238 SSTRs in all measurement locations for all irradiation cycles. In the case of Np-237, radiometric foils were included with the SSTRs for all measurement locations for the Cycle 15 irradiation. Comparisons of

the spectral indices (see the response to Request 2 for a definition of spectral index) of the U-238(n,f) and Np-237(n,f) reactions relative the Fe-54(n,p) reaction at the various measurement locations as measured by SSTRs and radiometric foils are provided in Table 1-1. An examination of Table 1-1 shows that the radiometric sensors and SSTRs are yielding equivalent results within the uncertainties associated with the measurements.

Also included in Table 1-1 are the calculated spectral indices taken from the neutron transport calculations documented in WCAP-12794, Rev. 4 and WCAP-12795, Rev. 3 for Point Beach Units 1 and 2, respectively. As shown in Table 1-1, the calculated spectral indices for the fission reactions are likewise in very good agreement with the measured values.

Based on the endorsements provided in DG-1053 and ANS 19.10, on the use of an approved industry consensus standard (ASTM E854) for the manufacture and analysis of SSTRs, on the NIST standard neutron field calibration of the U-238, Np-237, and U-235 SSTR sensors, and on the comparisons of spectral indices as determined by SSTR measurements, radiometric foil measurements, and ENDF/B-VI based neutron transport calculations, it is concluded that the SSTR sensors are suitable for application in LWR reactor cavity irradiations.

Table 1-1

Summary of Spectral Indices Measured by SSTRs and Fission Foils

Reaction	Measured Spectral Index Relative to Fe-54(n,p)Mn-54			
	0.0 Degrees	15.0 Degrees	30.0 Degrees	45.0 Degrees
Point Beach Unit 1				
U-238(n,f)Cs-137 Cd	5.71	5.93	5.84	5.78
U-238(n,f)SSTR Cd	5.86	6.03	5.84	5.79
U-238(n,f)Calc. Cd (a)	6.11	6.22	6.06	5.86
Point Beach Unit 2				
U-238(n,f)Cs-137 Cd	5.83	6.12	5.77	5.65
U-238(n,f)SSTR Cd	5.48	6.10	5.40	5.67
U-238(n,f)Calc. Cd (b)	5.93	6.02	5.87	5.68
Np-237(n,f)Cs-137 Cd	87.0	95.7	85.3	91.1
Np-237(n,f)SSTR Cd	82.4	85.5	84.0	80.4
Np-237(n,f)Calc. Cd (b)	80.9	86.7	84.3	77.8

(a) Calculated value based on BUGLE-96 transport cross-sections.
(b) Calculated value based on BUGLE-93 transport cross-sections.

2. **In Section 6, "Evaluation of Cavity Dosimetry" (WCAP-12795 Revision 3), Tables 6.2-5 through 6.2-10 include M/C terms with significant deviation from unity, (example Table 6.2-8 line on U-235(n,f)). What are the criteria for accepting (or rejecting) a measurement? These measurements are consistently lower than the corresponding calculated values. Are they indicative of a systematic error in the measurement or the calculation?**

Response:

The overall uncertainty associated with the measured reaction rates includes components due to the basic measurement process, the irradiation history corrections, and the corrections for competing reactions. A high level of accuracy in the reaction rate determinations is assured by utilizing laboratory procedures that conform to the ASTM national consensus standards to perform measurements of sensor specific activities and to determine reaction rates from the measured activities. After combining the individual uncertainties associated with the measurement and data evaluation processes, the final sensor reaction rates typically have the following net uncertainties:

Reaction	Reaction Rate Uncertainty
Cu-63(n,α)Co-60	5%
Ti-46(n,p)Sc-46	5%
Fe-54(n,p)Mn-54	5%
Ni-58(n,p)Co-58	5%
U-238(n,f)FP	10%
Np-237(n,f)FP	10%
Co-59(n,γ)Co-60	5%
U-235(n,f)FP	10%

In the evaluation of individual dosimeter sets, an additional test on the measured reaction rates is performed using the concept of a measured spectral index. If the reaction rate for a given sensor (either calculated or measured) is defined as the product of a spectrum averaged reaction cross-section and the corresponding threshold neutron flux, the following relationship holds:

$$R_i = \sigma_i \, \phi$$

where: R_i = The reaction rate for sensor i (for example Cu-63(n,α))
σ_i = The spectrum averaged reaction cross-section for sensor i
ϕ = The threshold neutron flux of interest ($\phi(E > 1.0$ MeV)

For different sensors irradiated in the same neutron spectrum, the spectral index can then be defined as the ratio of RI to the corresponding reaction rate for a reference sensor. In the case of the Point Beach dosimetry evaluations, the Fe-54(n,p)Mn-54 reaction rate has been taken as the reference. Thus, for the Point Beach application, the spectral indices for the individual sensors is given by:

$$SI_i = [R_i]/[R_{Fe}]$$

$$SI_i = [\sigma_i \, \phi]/[\sigma_{Fe} \, \phi]$$

$$SI_I = [\sigma_i]/[\sigma_{Fe}]$$

These spectral indices depend only on the relative energy distribution of the neutron field and not on the absolute magnitude of the neutron flux. Therefore, for a constant relative spectrum, the spectral indices would be expected to remain constant.

Using the Point Beach Unit 2 data from WCAP-12795 as an example, it is noted that four cycles of measurements at four azimuthal locations were obtained in the reactor cavity opposite the core midplane; 16 measurement points in all. Tables 2-1 through 2-4 provide the measured spectral indices for each of these sensor sets at the 0.0°, 15.0°, 30.0°, and 45.0° azimuthal locations. The average spectral indices for all four azimuthal angles are listed in Table 2-5. An examination of Tables 2-1 through 2-5 shows that the measured results are consistent and repeatable over several cycles of irradiation. The observed variations are likewise consistent with the uncertainties in the individual measured reaction rates.

As a further point of comparison the average measured spectral indices from five cycles of measurements in the reactor cavity at Point Beach Unit 1, a total of 20 measurement points, are listed in Table 2-6. A comparison of the data in Table 2-6 with that of Table 2-5 shows that the measured spectral indices in the reactor cavities of the two sister plants are quite similar.

As a test for acceptance or rejection of data from a newly irradiated sensor sets, the measured spectral indices for the data set are compared with the data provided in Tables 2-1 through 2-4. Significant deviations (> 3σ) from the nominal spectral index for the appropriate location are grounds for rejection of the measurement.

An additional reason for rejection of measured data is an observation of obvious physical damage or contamination of the sensor that would make an accurate measurement of the reaction rate impossible. For example, in some cases for in-vessel surveillance capsules U-238 foils have been observed to decompose and combine with the cadmium thermal neutron shield. In this instance, an accurate measurement of the activity of the sensor as well as of the weight of the target material is extremely difficult. Thus, data from these damaged sensors would not be included in the evaluations.

Table 2-1

Measured Spectral Indices at the 0.0 Degree Cavity Location

	Measured Spectral Index Relative to Fe-54(n,p)Mn-54					
Reaction	**Cycle 15**	**Cycle 16**	**Cycle 17**	**Cycles 18-20**	**Average**	**% Standard Deviation**
Cu-63(n,α)Co-60 Cd	0.0112	0.0115	0.0116	0.0119	0.0115	2.2
Ti-46(n,p)Sc-46 Cd	0.174	0.173	0.171	0.181	0.175	2.4
Fe-54(n,p)Mn-54 Cd	1.0	1.0	1.0	1.0	1.0	
Ni-58(n,pCo-58 Cd	1.45	1.43	1.41	1.45	1.44	1.4
U-238(n,f)Cs-137 Cd	5.86	6.12	5.48	5.83	5.83	4.5
U-238(n,f)SSTR Cd	5.69	5.23	4.68	6.30	5.48	12.5
Np-237(n,f)Cs-137 Cd	87.0				87.0	
Np-237(n,f)SSTR Cd	81.9	86.4	85.4	76.1	82.4	5.6
Co-59(n,γ)Co-60	1200	1170	1190	1160	1180	1.6
Co-59(n,γ)Co-60 Cd	707	704	706	706	706	0.2
U-235(n,f)SSTR	10100	11100	10000	11600	10700	7.0
U-235(n,f)SSTR Cd	3290	3560	3360	2900	3280	8.5

Table 2-2

Measured Spectral Indices at the 15.0 Degree Cavity Location

	Measured Spectral Index Relative to Fe-54(n,p)Mn-54					
Reaction	Cycle 15	Cycle 16	Cycle 17	Cycles 18-20	Average	% Standard Deviation
Cu-63(n,α)Co-60 Cd	0.0116	0.0118	0.0118	0.0123	0.0119	2.6
Ti-46(n,p)Sc-46 Cd	0.178	0.176	0.173	0.180	0.177	1.6
Fe-54(n,p)Mn-54 Cd	1.0	1.0	1.0	1.0	1.0	
Ni-58(n,pCo-58 Cd	1.42	1.46	1.41	1.44	1.43	1.4
U-238(n,f)Cs-137 Cd	5.95	6.56	5.77	6.20	6.12	5.6
U-238(n,f)SSTR Cd	5.82	5.83		6.66	6.10	7.9
Np-237(n,f)Cs-137 Cd	95.7				95.7	
Np-237(n,f)SSTR Cd	87.7	89.2	79.0	86.1	85.5	5.2
Co-59(n,γ)Co-60	1670	1770	1720	1690	1710	2.6
Co-59(n,γ)Co-60 Cd	952	1060	980	972	990	4.6
U-235(n,f)SSTR	13900	16000	16100	18200	16100	10.9
U-235(n,f)SSTR Cd	4760	4860	4370	4700	4670	4.6

Table 2-3

Measured Spectral Indices at the 30.0 Degree Cavity Location

	Measured Spectral Index Relative to Fe-54(n,p)Mn-54					
Reaction	Cycle 15	Cycle 16	Cycle 17	Cycles 18-20	Average	% Standard Deviation
Cu-63(n,α)Co-60 Cd	0.0113	0.0121	0.0120	0.0127	0.0120	4.8
Ti-46(n,p)Sc-46 Cd	0.174	0.177	0.181	0.186	0.179	2.9
Fe-54(n,p)Mn-54 Cd	1.0	1.0	1.0	1.0	1.0	
Ni-58(n,pCo-58 Cd	1.37	1.42	1.42	1.43	1.41	2.0
U-238(n,f)Cs-137 Cd	5.67	5.73	5.83	5.87	5.77	1.5
U-238(n,f)SSTR Cd	5.65	4.65	5.07	6.23	5.40	12.7
Np-237(n,f)Cs-137 Cd	85.3				85.3	
Np-237(n,f)SSTR Cd	84.8	83.0	83.2	84.9	84.0	1.2
Co-59(n,γ)Co-60	1760	1810	1850	1750	1790	2.5
Co-59(n,γ)Co-60 Cd	1000	983	1020	974	994	2.0
U-235(n,f)SSTR	18100	18000	18000	19800	18500	4.7
U-235(n,f)SSTR Cd	4730	4190	4690	4440	4520	5.6

Table 2-4

Measured Spectral Indices at the 45.0 Degree Cavity Location

	Measured Spectral Index Relative to Fe-54(n,p)Mn-54					
Reaction	Cycle 15	Cycle 16	Cycle 17	Cycles 18-20	Average	% Standard Deviation
Cu-63(n,α)Co-60 Cd	0.0129	0.0126	0.0128	0.0133	0.0129	2.3
Ti-46(n,p)Sc-46 Cd	0.196	0.178	0.184	0.185	0.186	3.9
Fe-54(n,p)Mn-54 Cd	1.0	1.0	1.0	1.0	1.0	
Ni-58(n,pCo-58 Cd	1.46	1.42	1.41	1.44	1.43	1.6
U-238(n,f)Cs-137 Cd	5.98	5.53	5.31	5.78	5.65	5.2
U-238(n,f)SSTR Cd	6.01	5.52	4.94	6.19	5.67	9.9
Np-237(n,f)Cs-137 Cd	91.1				91.1	
Np-237(n,f)SSTR Cd	85.8	85.1	71.8	78.9	80.4	8.1
Co-59(n,γ)Co-60	1330	1190	1200	1180	1220	5.8
Co-59(n,γ)Co-60 Cd	871	789	811	832	826	4.2
U-235(n,f)SSTR	9900	8410	8320	10200	9210	10.7
U-235(n,f)SSTR Cd	3710	3710	3630	3580	3660	1.7

Table 2-5

Summary of Measured Spectral Indices Point Beach Unit 2

	Measured Spectral Index Relative to Fe-54(n,p)Mn-54			
Reaction	0.0 Degrees	15.0 Degrees	30.0 Degrees	45.0 Degrees
Cu-63(n,α)Co-60 Cd	0.0115	0.0119	0.0120	0.0129
Ti-46(n,p)Sc-46 Cd	0.175	0.177	0.179	0.186
Fe-54(n,p)Mn-54 Cd	1.0	1.0	1.0	1.0
Ni-58(n,pCo-58 Cd	1.44	1.43	1.41	1.43
U-238(n,f)Cs-137 Cd	5.83	6.12	5.77	5.65
U-238(n,f)SSTR Cd	5.48	6.10	5.40	5.67
Np-237(n,f)Cs-137 Cd	87.0	95.7	85.3	91.1
Np-237(n,f)SSTR Cd	82.4	85.5	84.0	80.4
Co-59(n,γ)Co-60	1180	1710	1790	1220
Co-59(n,γ)Co-60 Cd	706	990	994	826
U-235(n,f)SSTR	10700	16100	18500	9210
U-235(n,f)SSTR Cd	3280	4670	4520	3660

Table 2-6

Summary of Measured Spectral Indices
Point Beach Unit 1

	Measured Spectral Index Relative to Fe-54(n,p)Mn-54			
Reaction	0.0 Degrees	15.0 Degrees	30.0 Degrees	45.0 Degrees
Cu-63(n,α)Co-60 Cd	0.0117	0.0121	0.0123	0.0128
Ti-46(n,p)Sc-46 Cd	0.171	0.177	0.177	0.180
Fe-54(n,p)Mn-54 Cd	1.0	1.0	1.0	1.0
Ni-58(n,pCo-58 Cd	1.41	1.43	1.42	1.43
U-238(n,f)Cs-137 Cd	5.71	5.93	5.84	5.78
U-238(n,f)SSTR Cd	5.86	6.03	5.84	5.79
Np-237(n,f)Cs-137 Cd				
Np-237(n,f)SSTR Cd	77.6	78.2	83.5	77.4
Co-59(n,γ)Co-60	1280	1770	1680	1220
Co-59(n,γ)Co-60 Cd	714	899	888	771
U-235(n,f)SSTR	13900	21500	18900	12900
U-235(n,f)SSTR Cd	3480	5040	4150	3920

To aid in the discussion of whether the M/C comparisons are indicative of a systematic error in the measurements or the calculations, consider the case of the measurement point summarized in Table 6.2-8 of WCAP-12795, Rev. 3. This data point represents the 45.0 degree cavity midplane location for the Cycle 16 irradiation period and was highlighted as a point of concern in Request 2. The conclusions drawn from the evaluation of this data set are typical of all of the measurements obtained from the Point Beach Unit 1 and 2 measurement programs. The contents of the multiple foil sensor set included in the 45.0 degree, Cycle 16 irradiation are summarized as follows:

		90% Response Range	
Reaction	M/C	Lower Energy [MeV]	Upper Energy [MeV]
Cu-63(n,α)Co-60 Cd	1.09	5.10	12.4
Ti-46(n,p)Sc-46 Cd	1.07	4.10	11.0
Fe-54(n,p)Mn-54 Cd	0.97	2.10	9.10
Ni-58(n,pCo-58 Cd	0.97	1.40	8.90
U-238(n,f)FP Cd	0.95	1.20	7.30
Np-237(n,f)FP Cd	1.07	0.15	3.00
U-235(n,f)FP Cd	0.99	5.75e-07	0.12
Co-59(n,γ)Co-60 Cd	0.74	1.28e-06	1.43e-4
Co-59(n,γ)Co-60	0.51	8.40e-09	1.43e-4
U-235(n,f)FP	0.38	5.50e-09	1.20e-4

The spectrum coverage of the sensor set, as determined by the calculated spectrum at the measurement location, is summarized above as the 90% response range of each sensor. The 90% response range, a common means of characterizing spectral coverage, is defined such that 90% of the total response of the sensor occurs between the specified energy limits, with 5% of the response occurring above the upper limit and 5% occurring below the lower limit. It is noted that six of the sensor reactions provide significant overlapping spectral coverage in the energy range above 1.0 MeV. It is further noted neither the bare nor cadmium covered Co-59(n,γ) or U-235(n,f) sensors

exhibit significant response above the 1.0 MeV threshold and, therefore, only provide data supporting the evaluation of the lower end of the neutron spectrum.

Also included in the above tabulation are the observed M/C ratios for the individual reactions comprising the sensor package. As can be seen from these comparisons, the large discrepancies between calculation and measurement are limited to reactions that have an upper response range limit below 1.5e-04 MeV and becomes larger for the sensors having a significant response induced by thermal neutrons, i.e., the bare Co-59(n,γ) and U-235(n,f) reactions. For all reactions with an upper energy response limit above 0.1 MeV (including the cadmium covered U-235 reaction the M/C ratios fall within the range of 0.95 to 1.09.

The observation of low M/C ratios for sensors with a significant response to thermal neutrons is consistent for all of the data points from the Point Beach Unit 1 and 2 cavity irradiations, The effect is largest at 0° and 45° where the measurements are made in front of ex-core detector wells and less at 15° and 30° degrees where the measurements are made directly in front of the concrete biological shield. These observations indicate a systematic overprediction of the calculated thermal neutron flux in the reactor cavity. This would not be totally unexpected given that both the BUGLE-93 and BUGLE-96 cross-section libraries have only two groups below the cadmium cutoff energy of 0.414 eV.

The discrepancies observed in the thermal region have an insignificant impact on the fast neutron exposure parameters determined from the least squares evaluation of the dosimetry sets. This conclusion is discussed further in the reply to Request 3.

3. **In view of the large adjustments (nearly 300 percent for the U-235 measurement of item 2 above), explain why such adjustments are necessary and how they are justified.**

Response:

To aid in the discussion of the adjustments resulting from the least squares evaluation of the dosimetry sensor sets, again consider the case of the measurement point summarized in Table 6.2-8 of WCAP-12795, Rev. 3. This data point represents the 45.0 degree cavity midplane location for the Cycle 16 irradiation period and was also highlighted as a point of concern in Request 3.

As discussed in the reply to Request 3, the large adjustments noted were confined to the thermal neutron energy region where the calculation would tend to be most suspect. This is most easily observed by a comparison of the exposure parameter results provided in Table 6.2-8 of WCAP-12795, Rev. 3. This comparison is summarized as follows:

			[BE-C] / C	
Parameter	Calculated	Best Est.	Absolute	Percent
$\phi(E > 1.0\ MeV)\ [n/cm^2\text{-}s]$	1.06e+09	1.03e+09	-0.0283	2.8
$\phi(E > 0.1\ MeV)\ [n/cm^2\text{-}s]$	8.70e+09	9.06e+09	0.0414	4.1
dpa/s	3.11e-12	3.17e-12	0.0193	1.9
$\phi(E < 0.4\ eV)\ [n/cm^2\text{-}s]$	2.49e+09	8.11e+08	-0.674	67.4

This tabulation shows that the adjustments of the fast neutron exposure parameters $\phi(E > 1.0$ MeV), $\phi(E > 0.1$ MeV), and dpa/s are all below 5% and well within the uncertainty constraints placed on the high energy range of the calculated spectrum. The large adjustment has occurred only in the thermal energy range where the assigned calculational uncertainty was 100%.

This observation can be further demonstrated by an examination of the calculated and adjusted neutron spectrum associated with this data set. This comparison is provided in Table 3-1. From the data listed in Table 3-1, it is seen that large adjustments in the spectrum are confined to the region just below 1.0e-03 MeV and to the thermal region below 1.0e-06 MeV. As is the case with the individual exposure parameter data discussed above, the adjustments to the neutron spectrum are well within the energy dependent uncertainty assignments applied to the calculated spectrum.

This behavior is also observed by a comparison of the adjustments made to the individual sensor reaction rates. This comparison is provided in Table 3-2. The data comparisons in Table 3.2 again show the largest adjustments for sensors with significant response at the lower energy end of the neutron spectrum where the calculation is expected to have the highest uncertainty. The final adjustments are again well within the uncertainty constraints placed on the inputs to the least squares adjustment procedure.

Based on the discussion provided above it is concluded that the least squares adjustments performed for the Point Beach Units 1 and 2 dosimetry sets are both reasonable and justified. Although the inclusion of sensors responding to the lower energy range of the neutron spectrum have an insignificant effect on the evaluation of the fast neutron exposure parameters ($\phi(E > 1.0$ MeV), $\phi(E > 0.1$ MeV), and dpa/s) there inclusion does provide valuable insight into the accuracy of the calculation in the thermal neutron energy range. Therefore, it is concluded that the inclusion of these sensors into the multiple foil sets should be continued.

Table 3-1

Comparison of the Calculated and Adjusted Neutron Spectra
45 Degree Reactor Cavity – Cycle 16
Point Beach Unit 2

Upper Energy [MeV]	Calc. Flux [n/cm²-s]	Best Est. Flux [n/cm²-s]	[BE-C]/C [%]	Upper Energy [MeV]	Calc. Flux [n/cm²-s]	Best Est. Flux [n/cm²-s]	[BE-C]/C [%]
17.3	1.23e+05	1.39e+05	12.9	9.12e-03	5.21e+08	5.37e+08	3.1
14.9	2.56e+05	2.89e+05	12.8	5.53e-03	5.72e+08	5.84e+08	2.1
13.5	8.39e+05	9.41e+05	12.2	3.36e-03	1.74e+08	1.75e+08	0.7
11.6	2.14e+06	2.37e+06	10.9	2.84e-03	1.63e+08	1.62e+08	-0.7
10.0	4.57e+06	4.98e+06	9.0	2.40e-03	1.57e+08	1.53e+08	-2.5
8.61	7.02e+06	7.47e+06	6.4	2.04e-03	4.67e+08	4.46e+08	-4.5
7.41	1.48e+07	1.53e+07	3.5	1.23e-03	4.64e+08	4.30e+08	-7.3
6.07	2.10e+07	2.10e+07	0.0	7.49e-04	4.29e+08	3.85e+08	-10.3
4.97	4.04e+07	3.92e+07	-3.1	4.54e-04	3.80e+08	3.30e+08	-13.1
3.68	4.63e+07	4.41e+07	-4.8	2.75e-04	3.92e+08	3.35e+08	-14.4
2.87	9.94e+07	9.37e+07	-5.7	1.67e-04	4.13e+08	2.89e+08	-30.1
2.23	1.45e+08	1.37e+08	-5.5	1.01e-04	4.04e+08	3.54e+08	-12.4
1.74	2.25e+08	2.15e+08	-4.6	6.14e-05	3.94e+08	3.67e+08	-6.7
1.35	2.53e+08	2.46e+08	-3.0	3.73e-05	3.85e+08	3.76e+08	-2.4
1.11	5.85e+08	5.79e+08	-0.9	2.26e-05	3.71e+08	3.75e+08	1.1
0.821	8.34e+08	8.44e+08	1.2	1.37e-05	3.52e+08	3.68e+08	4.7
0.639	1.03e+09	1.06e+09	3.0	8.32e-06	3.33e+08	3.38e+08	1.6
0.498	6.70e+08	7.00e+09	4.5	5.04e-06	3.20e+08	3.20e+08	0.1
0.388	1.28e+09	1.36e+09	5.9	3.06e-06	3.14e+08	3.07e+08	-2.2
0.302	1.56e+09	1.67e+09	6.9	1.86e-06	3.11e+08	2.98e+08	-4.0
0.183	1.65e+09	1.77e+09	7.4	1.13e-06	2.36e+08	2.23e+08	-5.5
0.111	1.12e+09	1.21e+09	7.5	6.83e-07	2.29e+08	1.57e+08	-31.7
0.0674	8.64e+08	9.24e+08	7.0	4.14e-07	4.27e+08	2.15e+08	-49.7
0.0409	5.10e+08	5.42e+08	6.3	2.51e-07	3.99e+08	1.67e+08	-58.2
0.0255	7.68e+08	8.08e+08	5.3	1.52e-07	3.74e+08	1.37e+08	-63.4
0.0199	3.92e+08	4.09e+08	4.2	9.24e-08	1.29e+08	2.93e+08	-77.2
0.0150	5.00e+08	5.14e+08	3.0				

Table 3-2

Comparison of the Calculated and Adjusted Sensor Reaction Rates
45 Degree Reactor Cavity – Cycle 16
Point Beach Unit 2

	Reaction Rate [rps/atom]		[BE-C] C	
Parameter	Calculated	Best Est.	Absolute	Percent
Cu-63(n,α)Co-60 Cd	6.05e-19	6.54e-19	0.0810	8.1
Ti-46(n,p)Sc-46 Cd	8.77e-18	9.27e-18	0.0570	5.7
Fe-54(n,p)Mn-54 Cd	5.40e-17	5.32e-17	-0.0148	-1.5
Ni-58(n,pCo-58 Cd	7.69e-17	7.50e-17	-0.0247	-2.5
U-238(n,f)FP Cd	3.07e-16	2.95e-16	-0.0391	-3.9
Np-237(n,f)FP Cd	4.20e-15	4.32e-15	0.0286	2.9
U-235(n,f)FP Cd	1.98e-13	1.87e-13	-0.0556	-5.6
Co-59(n,γ)Co-60 Cd	5.62e-14	4.18e-14	-0.2562	-25.6
Co-59(n,γ)Co-60	1.22e-13	6.19e-14	-0.4926	-49.3
U-235(n,f)FP	1.16e-12	4.62e-13	-0.6017	-60.2

4. Table 7.1-1 (WCAP-12794 Rev. 4) indicates that the cavity dosimetry measurements are consistently lower than the in-vessel dosimetry and on the average by an amount larger than the uncertainty indicated in Section 5 of the same report. In view of items 1, 2 and 3 above, why are the results of this cavity dosimetry acceptable?

Response:

In view of the responses to Requests 1, 2, and 3, the following summary is appropriate:

1) The application of SSTRs in LWR dosimetry programs is allowed by both Draft Regulatory Guide DG-1053 and Draft ANS Standard 19.10. Both of these documents state that the use of SSTRs in multiple foil sensor sets is acceptable as long as the manufacturing and evaluation procedures described in ASTM Standard Guide E 854 are followed and calibration is supported by irradiations in standard neutron fields. These conditions have been met for the SSTRs deployed in the Point Beach Unit 1 and 2 reactor cavity irradiations.

2) The large M/C discrepancies noted in Request 2 are confined to the lower regions of the neutron energy spectrum where the calculated neutron field has a higher uncertainty than is true of the fast neutron portion of the energy spectrum. The comparisons at these lower energies (E < 1e-03 MeV) have an insignificant impact on the evaluation of the fast neutron exposure parameters of interest (ϕ(E > 1.0 MeV), ϕ(E > 0.1 MeV), and dpa/s.

3) The large adjustments highlighted in Request 3 are limited to the energy region below 1e-03 MeV and are acceptable due to the larger calculational uncertainties in this energy region. For the higher energies the adjustments are much smaller and, in all cases, fall within the uncertainty constraints assigned to the inputs to the least squares adjustment. The results of the least squares evaluations are both reasonable and justified.

Based on this summary, it is concluded that the cavity dosimetry data bases for both Point Beach Units 1 and 2 are acceptable and provide valid comparisons.

The uncertainty values listed in Section 5.0 of WCAP-12794, Rev.4 pertain to the uncertainty (1σ) associated with the best estimate values derived from the least squares evaluation of the individual sensor sets. They do not contain any components that would account for variations in BE/C ratios for different measurement locations or for different irradiation cycles. Neither do they account for uncertainties in sensor positioning relative to the pressure vessel wall,

The data in Table 7.1-1 of WCAP-12794 Rev. 4 indicates that the overall $\phi(E > 1.0\ MeV)$ BE/C ratio for the entire Point Beach Unit 1 data base consisting of 24 samples is 0.836 with a 9.9% standard deviation. If the total data set is subdivided into in-vessel and ex-vessel components, the following comparison results:

	Average BE/C Ratio	Standard Deviation [%]
Total Data Set (24 Samples)	0.836	9.9
In-Vessel (4 Samples)	0.919	13.9
Ex-Vessel (20 Samples)	0.820	7.7

In Section 8.3 of WCAP-12794 Rev. 4, it is noted that for application at the pressure vessel surface an additional uncertainty of 6% is combined in quadrature to account for uncertainty in the location of the measurement point relative to the inner wall of the pressure vessel. After inclusion of that additional uncertainty, the following comparison results for projection to the vessel inner radius.

	Average PVIR BE/C Ratio	Standard Deviation [%]
Total Data Set (24 Samples)	0.836	11.6
In-Vessel (4 Samples)	0.919	15.1
Ex-Vessel (20 Samples)	0.820	9.8

The difference between the average BE/C ratio for the in-vessel and ex-vessel data sets is 10.8% using the in-vessel data as the base. This uncertainty level is consistent with the uncertainty projections at the vessel wall and is less than the uncertainty of 15% associated with the calculated value of $\phi(E > 1.0\ MeV)$.