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L-01-122

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555-0001

**Subject: Beaver Valley Power Station, Unit No. 1**
**BV-1 Docket No. 50-334, License No. DPR-66**
**Response to a Request for Additional Information**
**In Support of LAR No. 292**

This letter provides the FirstEnergy Nuclear Operating Company (FENOC) response to a NRC Request for Additional Information (RAI) in support of License Amendment Request (LAR) No. 292. The LAR was submitted by FENOC letter L-01-087 dated June 29, 2001. The LAR updates the technical specification heatup and cooldown curves and the overpressure protection system setpoints to apply for up to 22 effective full power years. The applicability of the current curves will expire at 16 effective full power years.

The FENOC responses are provided in Attachment A of this letter. FENOC requests NRC approval of the proposed changes by February 1, 2002, to implement the amendment and allow continued operation beyond the current period of 16 effective full power years. An implementation period of up to 60 days is requested following the effective date of this amendment.

This information does not change the evaluations or conclusions presented in FENOC letter L-01-006. If there are any questions concerning this matter, please contact Mr. Thomas S. Cosgrove, Manager Regulatory Affairs at 724-682-5203.

Sincerely,

Lew W. Myers

Attachment

c: Mr. L. J. Burkhart, Project Manager
Mr. D. M. Kern, Sr. Resident Inspector
Mr. H. J. Miller, NRC Region I Administrator
Mr. D. A. Allard, Director BRP/DEP
Mr. L. E. Ryan (BRP/DEP)

A001

**Subject:** **Beaver Valley Power Station, Unit No. 1**
**BV-1 Docket No. 50-334, License No. DPR-66**
**Response to a Request for Additional Information**
**In Support of LAR No. 292**

I, Lew W. Myers, being duly sworn, state that I am Senior Vice President of FirstEnergy Nuclear Operating Company (FENOC), that I am authorized to sign and file this submittal with the Nuclear Regulatory Commission on behalf of FENOC, and that the statements made and the matters set forth herein pertaining to FENOC are true and correct to the best of my knowledge and belief.

FirstEnergy Nuclear Operating Company

Lew W. Myers
Senior Vice President - FENOC

COMMONWEALTH OF PENNSYLVANIA

COUNTY OF BEAVER

Subscribed and sworn to me, a Notary Public, in and for the County and State above named, this 4 th day of October, 2001.

My Commission Expires:

Notarial Seal
Sheila M. Fattore, Notary Public
Shippingport Boro, Beaver County
My Commission Expires Sept. 30, 2002
Member, Pennsylvania Association of Notaries

**Response to Request For Additional Information Pertaining to LAR 292**
**Beaver Valley Unit 1: PT Curves and LTOP Setpoints for 22 EFPY**

FENOC, the licensee for the Beaver Valley plant, requested TS changes to update the PT curves and the LTOP setpoints for 22 EFPYs. The fluence values were derived from the results of capsule Y (reported in WCAP-15571) and updated Capsules V, W and U.

1 **The original capsule fluences (reported in WCAP-9860 for capsule V, WCAP-10867 for capsule U and WCAP-12005 for capsule W) do not agree with the corresponding values in WCAP-15571. What was updated in the old capsules?**

The following table provides a comparison of the fluence values reported in the reference WCAP reports for each of the capsules withdrawn from Beaver Valley Unit 1:

| Capsule | Reported Fluence (E > 1.0 MeV) [n/cm$^2$] | | | |
|---|---|---|---|---|
| | **WCAP-9860 (1981)** | **WCAP-10867 (1985)** | **WCAP-12005 (1988)** | **WCAP-15571 (2000)** |
| **V** | $2.55 \times 10^{18}$ | $2.91 \times 10^{18}$ | $2.91 \times 10^{18}$ | $3.23 \times 10^{18}$ |
| **U** | | $6.54 \times 10^{18}$ | $6.54 \times 10^{18}$ | $6.46 \times 10^{18}$ |
| **W** | | | $9.49 \times 10^{18}$ | $9.86 \times 10^{18}$ |
| **Y** | | | | $2.15 \times 10^{19}$ |

The changes in the assigned capsule fluences are due in part to a continuous methodology improvement over the last 18 years as well as to change in NRC staff philosophy relative to the use of measured or best estimate fluence in PTS assessments. The methodologies reflected in each of these WCAP reports are summarized as follows:

| WCAP | Basis for Capsule Fluence | Transport Calculation Methodology | Transport X-Sec Basis | Dosimetry Evaluation Methodology | Dosimetry X-Sec Basis |
|---|---|---|---|---|---|
| 9860 | Measurement | $S_n$ Transport | ENDF/B-II | Spectrum Averaged X-Sec based On $S_n$ calc. | ENDF/B-II |
| 10867 | Measurement | $S_n$ Transport | ENDF/B-IV (SAILOR) | Spectrum Averaged X-Sec based On $S_n$ calc. | ENDF/B-IV |
| 12005 | Measurement | $S_n$ Transport | ENDF/B-IV (SAILOR) | Least Squares (Cap W Only) | ENDF/B-V |
| 15571 | Calculation | $S_n$ Transport | ENDF/B-VI (BUGLE-96) | Least Squares (All Caps) | ENDF/B-VI (SNLRML) |

In summary, the changes in assigned capsule fluences are due to an improvement in transport cross-sections (ENDF/B-II to ENDF/B-IV to ENDF/B-VI), improvements in dosimetry cross-sections (ENDF/B-II to ENDF/B-V to ENDF/B-VI), improvements in dosimetry evaluation methodology (spectrum averaged cross-section to least squares evaluations), and to the requirement of the NRC staff to use calculated rather than measured or best estimate values for capsule fluence.

**2 How were the averaged values of the BE/C calculated in the Y capsule report for E > 1.0 MeV (Table 6-12) from the values shown in Table 6-10?**

In Table 6-10 of WCAP-15571, direct comparisons of measurement and calculated sensor reaction rates prior to application of the least squares are provided for each of the surveillance capsules withdrawn from Beaver Valley Unit 1. These comparisons, presented as measurement to calculation (M/C) ratios for each threshold sensor set, are summarized in Table 2-1:

Table 2-1

Threshold Foil M/C Comparisons Prior to the Least Squares Evaluation

| | **M/C Ratio** | | | | | |
|---|---|---|---|---|---|---|
| **Sensor Reaction** | **Cap. V** | **Cap. U** | **Cap. W** | **Cap. Y** | **Average** | **std dev (%)** |
| $^{63}Cu(n,\alpha)$ | 0.97 | 1.07 | 1.01 | 1.05 | 1.03 | 3.9 |
| $^{54}Fe(n,p)$ | 0.92 | 0.97 | 0.90 | 0.99 | 0.94 | 4.7 |
| $^{58}Ni(n,p)$ | 0.92 | 0.99 | 0.89 | 1.01 | 0.95 | 6.0 |
| $^{238}U(n,f)$ (Cd) | 0.95 | 1.00 | | 0.89 | 0.95 | 6.0 |
| $^{237}Np(n,f)$ (Cd) | 1.03 | 1.20 | 0.99 | 1.07 | 1.07 | 8.9 |
| **Threshold Foil Avg.** | 0.96 | 1.05 | 0.95 | 1.00 | **0.99** | **7.7** |
| **Std dev (%)** | 4.6 | 9.0 | 6.4 | 7.0 | | |

The M/C comparisons from Table 2-1 provide confirmation that the absolute transport calculations performed for Beaver Valley Unit 1 are consistent with the Regulatory Guide 1.190 requirement that differences between calculation and measurement should not exceed 20%. Of the 19 sensor comparisons tabulated, 18 fall within 11% of the calculation and a single neptunium M/C ratio indicates a 20% difference. None of the M/C comparisons exceed 20%. Considering the four capsule data set as a whole, the average M/C ratios for the five foil types fall within 7% of prediction. The overall average of the 19 M/C comparisons is 0.99 with an associated standard deviation of 7.7%.

Also provided in Table 6-10 of WCAP-15571 are comparisons of measured reaction rates to the best estimate calculation after application of the least squares evaluations for each of the capsule sensor sets. In Table 6-10, these comparisons are listed in terms of best estimate to measurement (BE/Meas) ratios. To provide compatibility with Table 2-1, the reciprocals of these comparisons are provided in Table 2-2 as measurement to best estimate ratios M/BE.

Table 2-2

Threshold Foil M/BE Comparisons After the Least Squares Evaluation

| Sensor Reaction | M/BE Ratio | | | | | |
|---|---|---|---|---|---|---|
| | **Cap. V** | **Cap. U** | **Cap. W** | **Cap. Y** | **Average** | **std dev (%)** |
| $^{63}Cu(n,\alpha)$ | 1.02 | 1.03 | 1.03 | 1.02 | 1.02 | 0.9 |
| $^{54}Fe(n,p)$ | 0.98 | 0.97 | 0.98 | 0.99 | 0.98 | 0.9 |
| $^{58}Ni(n,p)$ | 0.99 | 0.99 | 0.98 | 1.01 | 0.99 | 1.4 |
| $^{238}U(n,f)$ (Cd) | 1.01 | 0.99 | | 0.90 | 0.97 | 6.0 |
| $^{237}Np(n,f)$ (Cd) | 1.03 | 1.08 | 1.04 | 1.05 | 1.05 | 1.9 |
| **Threshold Foil Avg.** | 1.01 | 1.01 | 1.01 | 0.99 | **1.00** | **3.8** |
| **Std dev (%)** | 2.1 | 4.3 | 3.3 | 5.6 | | |

The M/BE comparisons from Table 2-2 demonstrate improved consistency as well as reduced data scatter both for separate foils within individual capsules as well as for similar foils from different capsules. Of the 19 sensor comparisons tabulated, 16 of the measured reaction rates fall within 5% of the best estimate (or adjusted) calculation. None of the M/BE comparisons differ from the best estimate calculation by more than 10%. Considering the four capsule data set as a whole, the average M/BE ratios for the five foil types fall within 5% of adjusted calculation. The overall average of the 19 M/BE comparisons is 1.00 with an associated standard deviation of 3.8%. Thus, as would be expected from a least squares evaluation, the added information provided by the measurements when combined with the calculation at the measurement locations results in an adjusted calculation with reduced uncertainty.

The data comparisons provided in Table 2-1 provide confidence, on a plant-specific basis, that the calculated sensor reaction rates and, by inference, the calculated neutron fluence (E > 1.0 MeV) is consistent with expected uncertainties. These comparisons, by themselves, do nothing to reduce the uncertainty in the predicted fluence. However, the least squares evaluations do provide the means to combine the measurements and calculations in a fashion that results in a reduced uncertainty solution for the neutron fluence (E > 1.0 MeV) at the surveillance capsule locations. In Table 2-3, the calculated and adjusted neutron fluence (E > 1.0 MeV) values for each of the Beaver Valley Unit 1 surveillance capsules are provided along with their associated uncertainties.

Table 2-3

Comparison of Calculated and Best Estimate Neutron Fluence (E > 1.0 MeV)
For the Beaver Valley Unit 1 Surveillance Capsules

| Capsule | Calculated | | Best Estimate | | BE/C |
|---|---|---|---|---|---|
| | **Fluence [n/cm$^2$]** | **Uncertainty (%)** | **Fluence [n/cm$^2$]** | **Uncertainty (%)** | |
| V | $3.23 \times 10^{18}$ | 15 | $3.06 \times 10^{18}$ | 6 | 0.95 |
| U | $6.46 \times 10^{18}$ | 15 | $6.60 \times 10^{18}$ | 6 | 1.02 |
| W | $9.86 \times 10^{18}$ | 15 | $8.99 \times 10^{18}$ | 6 | 0.91 |
| Y | $2.15 \times 10^{19}$ | 15 | $2.12 \times 10^{19}$ | 6 | 0.99 |
| **Average** | | | | | **0.97** |
| **% std dev** | | | | | **4.9** |

When coupled with dosimetry reaction cross-sections, the calculated fluence values listed in Table 2-3 produce the reaction rate comparisons given in Table 2-1, while the best estimate fluence values result in the comparisons provided in Table 2-2. These BE/C comparisons given in Table 2-3 provide confidence that , in addition to the calculated sensor reaction rates, the calculated neutron fluence (E > 1.0 MeV) itself is also consistent with expected uncertainties.

The data given in Table 2-3 also show that the addition of information via measurement results in a reduction in the uncertainty in capsule fluence from 15% to 6%. While the magnitude of the best estimate fluence values are slightly different than the calculated values (BE/C ratios ranging from 0.91 to 1.02), the final best estimate results are well within the uncertainty assigned to the stand alone calculation. Thus, the calculated and best estimate fluences are fully consistent with one another. The four capsule data set shows that, on average, the best estimate fluences at the capsule locations are 3% less than the corresponding calculations and also provide a data set with reduced uncertainty.

The fluence comparisons provided in Table 2-3 form the basis for the average BE/C ratios listed in Table 6-12 of WCAP-15571.

**3 How were the best estimate neutron spectra (shown in Table 6-11) obtained? What is the physics behind the input to the FERRET code for the estimation of the best estimate spectra?**

The best estimate neutron spectra were obtained directly from the output of the FERRET least squares adjustment code.

Least squares adjustment methods provide the capability of combining the capsule-specific measurement data with the plant-specific neutron transport calculation resulting in a best estimate neutron energy spectrum with associated uncertainties. Best estimates for key exposure parameters such as $\phi(E > 1.0 \text{ MeV})$ or dpa/s along with their uncertainties are then easily obtained from the adjusted spectrum. In general, the least squares methods, as applied to reactor dosimetry evaluations, act to reconcile the measured sensor reaction rate data, dosimetry reaction cross-sections, and the calculated neutron energy spectrum within their respective uncertainties. For example,

$$R_i \pm \delta_{R_i} = \sum_g (\sigma_{ig} \pm \delta_{\sigma_{ig}})(\phi_g \pm \delta_{\phi_g})$$

relates a set of measured reaction rates, $R_i$, to a single neutron spectrum, $\phi_g$, through the multigroup dosimeter reaction cross-section, $\sigma_{ig}$, each with an uncertainty $\delta$. The primary objective of the least squares evaluation is to produce unbiased estimates of the neutron exposure parameters at the location of the measurement.

The application of the least squares methodology requires the following input:

1 - The calculated neutron energy spectrum and associated uncertainties at the measurement location.
2 - The measured reaction rates and associated uncertainty for each sensor contained in the multiple foil set.
3 - The energy dependent dosimetry reaction cross-sections and associated uncertainties for each sensor contained in the multiple foil sensor set.

For the Beaver Valley Unit 1 application described in WCAP-15571, the calculated neutron spectrum was obtained from the results of plant and fuel cycle-specific neutron transport calculations using the DORT $S_n$ transport code and the BUGLE-96 ENDF/B-VI based transport cross-section library. The calculated spectrum at each sensor set location was input in an absolute sense (rather than as simply a relative spectral shape). Therefore, within the constraints of the assigned uncertainties, the calculated data were treated equally with the measurements. The sensor reaction rates were derived from the measured specific activities of each sensor set and the operating history of the reactor. The dosimetry reaction cross-sections were obtained from the SNLRML dosimetry cross-section library.

In addition to the magnitude of the calculated neutron spectra, the measured sensor set reaction rates, and the dosimeter set reaction cross-sections, the least squares procedure requires uncertainty estimates for each of these input parameters. The following provides a summary of the uncertainties associated with the least squares evaluation of the Beaver Valley Unit 1 dosimetry.

- **Reaction Rate Uncertainties**

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 for reaction rate determinations for each sensor type.

After combining all of these uncertainty components, the sensor reaction rates derived from the counting and data evaluation procedures were assigned the following net uncertainties for input to the least squares evaluation:

| Reaction | Uncertainty |
|---|---|
| $Cu^{63}(n,\alpha)Co^{60}$ | 5% |
| $Fe^{54}(n,p)Mn^{54}$ | 5% |
| $Ni^{58}(n,p)Co^{58}$ | 5% |
| $U^{238}(n,f)Cs^{137}$ | 10% |
| $Np^{237}(n,f)Cs^{137}$ | 10% |
| $Co^{59}(n,\gamma)Co^{60}$ | 5% |

These uncertainties are given at the $1\sigma$ level.

- **Dosimetry Cross-Section Uncertainties**

As noted above, the reaction rate cross-sections used in the least squares evaluations were taken from the SNLRML library. This data library provides reaction cross-sections and associated uncertainties, including covariances, for 66 dosimetry sensors in common use. Both cross-sections and uncertainties are provided in a fine multigroup structure for use in least squares adjustment applications. These cross-sections were compiled from the most recent cross-section evaluations and they have been tested with respect to their accuracy and consistency for least squares evaluations. Further, the library has been empirically tested for use in fission spectra determination as well as in the fluence and energy characterization of 14 MeV neutron sources.

For sensors included in the Beaver Valley Unit 1 dosimetry, the following uncertainties in the fission spectrum averaged cross-sections are provided in the SNLRML documentation package.

| Reaction | Uncertainty |
|---|---|
| $Cu^{63}(n,\alpha)Co^{60}$ | 4.08-4.16% |
| $Fe^{54}(n,p)Mn^{54}$ | 3.05-3.11% |
| $Ni^{58}(n,p)Co^{58}$ | 4.49-4.56% |
| $U^{238}(n,f)FP$ | 0.54-0.64% |
| $Np^{237}(n,f)FP$ | |
| $Co^{59}(n,\gamma)Co^{60}$ | 0.79-3.59% |

These tabulated ranges provide an indication of the dosimetry cross-section uncertainties associated with the sensor sets used in LWR irradiations.

- **Calculated Neutron Spectrum Uncertainties**

While the uncertainties associated with the reaction rates were obtained from the measurement procedures and counting benchmarks and the dosimetry cross-section uncertainties were supplied directly with the SNLRML library, the uncertainty matrix for the calculated spectrum was constructed from the following relationship:

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

where $R_n$ specifies an overall fractional normalization uncertainty and the fractional uncertainties $R_{g'}$ and $R_g$ specify additional random groupwise uncertainties that are correlated with a correlation matrix given by:

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

where

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

The first term in the correlation matrix equation specifies purely random uncertainties, while the second term describes the short range correlations over a group range $\gamma$ ($\theta$ specifies the strength of the latter term). The value of $\delta$ is 1.0 when g = g' and 0.0 otherwise.

The set of parameters defining the input covariance matrix for the Beaver Valley Unit 1 calculated spectra was as follows:

| | |
|---|---|
| Flux Normalization Uncertainty ($R_n$) | 15% |
| Flux Group Uncertainties ($R_g$, $R_{g'}$) | |
| (E > 0.0055 MeV) | 15% |
| (0.68 eV < E < 0.0055 MeV) | 29% |
| (E < 0.68 eV) | 52% |
| Short Range Correlation ($\theta$) | |
| (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 ($\gamma$) | |
| (E > 0.0055 MeV) | 6 |
| (0.68 eV < E < 0.0055 MeV) | 3 |
| (E < 0.68 eV) | 2 |

These uncertainty assignments are consistent with an overall calculational uncertainty of 15-20% ($1\sigma$) for the fast neutron portion of the spectrum and provide for a reasonable increase in the uncertainty for neutrons in the intermediate and thermal energy ranges.