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BVY 11-078

December 9, 2011

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

SUBJECT: Response to Request for Additional Information for Core Plate Hold Down Bolt Inspection Plan and Analysis
Vermont Yankee Nuclear Power Station
Docket No. 50-271
License No. DPR-28

REFERENCES:
1. Letter, Entergy to USNRC, "License Renewal Application, Amendment 11," BVY 06-079, dated August 22, 2006
2. Letter, Entergy to USNRC, "License Renewal Application Annual Update," BVY 10-069, dated December 30, 2010
3. Letter, Entergy to USNRC, "Core Plate Hold Down Bolt Inspection Plan and Analysis," BVY 11-021, dated March 18, 2011

Dear Sir or Madam:

In Amendment 11 to the Vermont Yankee Nuclear Power Station (VY) License Renewal Application, Entergy committed to either install core plate wedges or complete a plant-specific analysis to determine the acceptance criteria for continued inspection of the core plate hold down bolts in accordance with BWR Vessel and Internals Project, BWR Core Plate Inspection and Flaw Evaluation Guidelines (BWRVIP-25) and submit the inspection plan and analysis to the NRC two years prior to the period of extended operation (PEO) for NRC review and approval (Reference 1). In Reference 2, Entergy provided an update to the commitment to indicate that the inspection plan and analysis would be provided one year prior to the PEO. Entergy submitted the inspection plan and analysis in Reference 3.

A teleconference was held on October 3, 2011 to discuss NRC staff questions on the analysis and inspection plan. Attachment 1 of this letter contains the responses to these questions.

This letter contains no new regulatory commitments.

Should you have any questions or require additional information concerning this submittal, please contact Mr. Robert Wanczyk at 802-451-3166.

Sincerely,

[CJW/PLC]

Attachments: 1. Core Plate Hold Down Bolt Inspection Plan and Analysis Response to Request for Additional Information

cc: Mr. William M. Dean, Regional Administrator
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475 Allendale Road
King of Prussia, PA 19406-1415

Mr. James S. Kim, Project Manager
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USNRC Resident Inspector
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Ms. Elizabeth Miller, Commissioner
VT Department of Public Service
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Attachment 1

Vermont Yankee Nuclear Power Station
License No. DPR-28 (Docket No. 50-271)

Core Plate Hold Down Bolt Inspection Plan and Analysis Response to Request for Additional Information

RAI 1:

Provide the details of the flux evaluation that was used to determine projected total fast neutron fluence of 5.2 x 10^{19} n/cm^2 for a 60-year plant life.

Specifically, Section 6.7 of Attachment 1 to Reference 1 indicates that for the Vermont Yankee Nuclear Power Station (VYNPS) extended power uprate, the best-estimate fast flux was evaluated for the vessel inside surface, shroud inside surface, and surveillance capsule. How was the core plate bolt peak total fast neutron fluence projected or extrapolated based on these flux values for other locations? State the assumptions made in performing the projection.

Response

Analysis

In 2003, General Electric (GE) performed a best-estimate flux evaluation for the extended power uprate (EPU) equilibrium core configuration of VYNPS using the Regulatory Guide 1.190 compliant and NRC-approved GE fluence methodology. Based on that evaluation, best-estimate fast flux (E>1 MeV) at a thermal power of 1,912 MWt was evaluated for the vessel inside surface, shroud inside surface, and surveillance capsule. Flux results from the 2003 flux calculation were used to estimate the flux and fluence for the core plate bolts at VYNPS.

Hardware Location

The limiting radius for the core plate bolts is 77.126 inches from reactor pressure vessel (RPV) centerline to bolt centerline, and the region of interest is 24.2 inches long, with elevations from 202.6 inches to 178.4 inches above vessel 0. Because the elevation for the bottom of active fuel (BAF) is 207.5 inches, the top and bottom of the bolts are at 4.9 inches and 29.1 inches below BAF, respectively. Flux at peak azimuth was used to bound all bolts.

Flux

The calculation basis 2003 EPU flux evaluation is derived from an (r,θ) and an (r,z) 2D flux distribution. The estimation of fluxes for core plate bolts was based on a simple linear interpolation of 2D fluxes from the (r,θ) flux distribution at the core midplane elevation, plus the estimation of axial flux factor from the (r,z) flux results.

From the (r,θ) flux results, the nearest two radial nodes for the radius of 77.126 inches are determined, as is the peak azimuth from the (r,θ) results. Peak azimuthal fluxes for the two nodes are then determined, and a simple linear interpolation results in a flux of 2.63E11 at the radius of interest. Because the 2D discrete ordinate transport (DORT) calculation was done using a fixed source of 1E17 and the calculated total source for the (r,θ) model is 1.176E17, the estimated flux at midplane is then (2.63E11)(1.176)=3.09E11.

From the (r,z) flux results, the nearest limiting radial node at the bolt radius of 77.126 inches is determined. This node is used to extract the axial flux shape. To obtain the axial average over the bolt length, the bolt length was divided into 20 evenly spaced axial sections. The axial flux factor for each section was calculated with a simple linear interpolation of nearest two axial nodes with respect to the mid elevation of each section and the midplane flux of 1.99E8. The interpolated results are shown as follows:

Section	Elevation above BAF (inches)	Axial Flux Factor	Synthesized Flux (n/cm²-s)
Top of Bolt	-4.9	7.51E-02	3.48E10
1	-5.505	6.71E-02	3.11E10
2	-6.715	5.39E-02	2.50E10
3	-7.925	4.29E-02	1.99E10
4	-9.135	3.38E-02	1.57E10
5	-10.345	2.64E-02	1.22E10
6	-11.555	2.05E-02	9.52E09
7	-12.765	1.59E-02	7.39E09
8	-13.975	1.23E-02	5.70E09
9	-15.185	9.44E-03	4.38E09
10	-16.395	7.20E-03	3.34E09
11	-17.605	5.50E-03	2.55E09
12	-18.815	4.20E-03	1.95E09
13	-20.025	3.19E-03	1.48E09
14	-21.235	2.42E-03	1.12E09
15	-22.445	1.82E-03	8.45E08
16	-23.655	1.38E-03	6.39E08
17	-24.865	1.05E-03	4.84E08
18	-26.075	7.87E-04	3.65E08
19	-27.285	5.89E-04	2.73E08
20	-28.495	4.36E-04	2.02E08
Bottom of Bolt	-29.1	3.70E-04	1.72E08
Bolt Average		1.55E-02	7.20E09

The synthesized flux value is the product of the axial flux factor and the peak azimuthal (r,θ) flux of 3.09E11 n/cm^2-s at the bolt radial location. A safety factor of 1.5 was also included to bound the uncertainty associated with flux calculation for regions beyond the core beltline. The axial average for the bolt was calculated as the arithmetic average of the 20 section mid elevation flux values. The synthesized flux for the bolt is 3.48E10 n/cm^2-s at the axial peak and 7.20E09 n/cm^2-s averaged over the axial length.

Flux values at the previous VYNPS operating power state of 1,593 MWt and the projected transition cycle at 1,752 MWt (an assumption made in the 2003 EPU calculation), are derived by the application of power adjustment factors to the above calculated results; the power adjustment factors are calculated as (1,593)/(1,912)=0.83 and (1,752)/(1,912)=0.92, respectively. These values are conservative in that VYNPS actually operated at 1,593 MWt during the period for which it was projected to operate at 1,752 MWt. Applying these factors to the 2003 EPU flux calculation results yields the following:

	1,593 MWt	1,752 MWt
Core Plate Bolt Peak Fast Flux (n/cm²-s)	2.89E10	3.20E10
Core Plate Bolt Axial Average Fast Flux (n/cm²-s)	5.98E09	6.62E09

Fluence

Cycle-dependent energy generation data are required to convert the flux data to fluence. For the calculation of 40-year neutron fluence, the following equation was used to convert flux to fluence:

Total fluence = [(25.20)*(1,593 MWt flux) + (1.16)*(1,752 MWt flux) + (6.74)*(EPU Flux)]*365.24*86400.

Where, 25.20 is the effective full power years (EFPY) for pre-EPU cycles with a rated thermal power of 1,593 MWt, 1.16 is the EFPY for transition cycles with a rated thermal power of 1,752 MWt, and 6.74 is the remainder of the 40-year life at a projected EPU thermal power of 1,912 MWt.

Similarly, for the calculation of 60-year neutron fluence, the following equation was used to convert flux to fluence:

Total fluence = [(25.20)*(1,593 MWt flux) + (1.16)*(1,752 MWt flux) + (25.34)*(EPU Flux)]*365.24*86400.

Based on these equations, the following best-estimate fluence values are obtained:

	Peak	Axial Average
40 Year Core Plate Bolt Total Fast Fluence (n/cm²)	3.16E19	6.53E18
60 Year Core Plate Bolt Total Fast Fluence (n/cm²)	5.20E19	1.08E19

Summary

Details of the flux evaluation used in determining the projected total fast neutron fluence values for VYNPS core plate bolts are provided in the preceding subsections of this RAI response. A detailed description of the method of extrapolation of flux values from the calculation basis 2003 EPU flux evaluation is provided in the Flux subsection.

Assumptions made in performing the core plate bolt flux estimate are detailed throughout and include:

- Flux at peak azimuth used to bound all bolts.
- Inclusion of safety factor of 1.5 to bound the uncertainty associated with flux calculation for regions beyond the core beltline.

RAI 2:

"BWR Vessel and Internals Project BWR Core Plate Inspection and Flaw Evaluation Guidelines" (BWRVIP-25) (Reference 2) stated that General Electric (GE) has determined that a 5-19% reduction in core plate bolt stress due to thermal and irradiation effects should be expected over the 40-year life of a plant. The predicted loss of preload due to irradiation given in Attachment 1 to Reference 1 is 14 % which is bounded by the BWRVIP-25 prediction. However, BWRVIP-25 does not provide the neutron fluence value on which the loss of preload prediction was based. BWRVIP-25 provides a reference for the loss of preload range to an internal GE calculation.

The staff therefore requests the licensee provide the fluence value or range on which the BWRVIP-25 loss of preload range was based.

<u>Response</u>

GE evaluation of core plate bolt relaxation determined that the BWRVIP-25 maximum reported stress relaxation value of 19% is valid to an average neutron fluence level of 8E19 n/cm^2 or less. This fluence is an average fluence over the entire length of the core plate bolt, determined at the peak azimuthal fluence location.

RAI 3:

Reference 1 indicates that the sample size of VYNPS core plate hold down bolts inspected has been changed from 50 % to 25 %. The frequency and method of the inspections will remain the same (visual VT-3 inspection from the top of the bolts every other refueling outage). This represents a deviation from the BWRVIP-25 requirements for ultrasonic inspection. This level of inspection would probably reveal if there was widespread failure of the bolts but could miss partially cracked bolts or a small number of failed bolts.

BWRVIP-25, in the discussion of visual examination (VT) as an inspection option, states:

"The critical number of bolts is plant-specific (dependent on plant geometry, number of bolts, location of bolts intact, loading conditions). The conservative example analysis in Appendix A shows that about 80 % of the bolts at the allowable stress would react the applied load. A distributed inspection sample of 50 % of the bolts with none cracked assures the integrity of 80 % of the bolts with very high confidence. Therefore, inspection of 50 % of the bolts is recommended. If cracking is detected in any of these first 50 %, the remaining 50 % should be inspected."

Therefore, the staff requests the following information:

1. **Given that VYNPS has reduced the sample size for VT-3 from that recommended by BWRVIP-25, justify that the sample size of core plate hold down bolts being inspected is adequate to ensure that there will be sufficient intact bolts to meet the load requirements of the plant-specific stress analysis.**

2. **Justify that performing the VT-3 inspection from above the core plate will provide a sufficient level of assurance that cracked or broken bolts will be detected, given that BWRVIP-25 recommends performing the VT-3 inspection from below the core plate.**

3. **Does the core plate stress analysis account for some portion of the core plate bolts being either completely or partially cracked due to intergranular stress corrosion cracking or irradiation assisted stress corrosion cracking? If so, describe how the cracking was accounted for.**

4. **If cracking was not accounted for in the stress analysis, provide a justification for cracking not being considered.**

Response

1. VYNPS performed inspections of 50% of the core plate hold down bolts for four successive outages (RFO 21 in 1999, RFO 22 in 2001, RFO 23 in 2002 and RFO 24 in 2004) with no noted degradation. BWRVIP-25, Section 3.2.2.2, states that once the first VT inspection is completed, a reinspection schedule should be developed. BWRVIP-25, Section 3.2.2.2, also states that good inspection results combined with the good operating experience of BWR bolts and the degree of redundancy of the hold down bolts may justify elimination of any reinspection. Based on performance, VYNPS adjusted the inspection frequency (starting in RFO 26 in 2007) to inspect approximately 25% of the bolts every other outage and has performed these inspections since that time with no noted degradation. VYNPS will continue to inspect 25% of the core plate hold down bolts every other refueling outage using the VT-3 method in accordance with the VYNPS Reactor Vessel Internals Inspection Program as discussed in Reference 3. VYNPS believes this meets the intent of the guidance provided in BWRVIP-25.

2. VYNPS recognizes that BWRVIP-25, Table 3-2 recommends enhanced VT-1 inspection of the rim hold-down bolts from below the core plate (or ultrasonic (UT) inspection from above the core plate once the technique is developed). It is currently industry practice to only perform VT-3 inspections from the top of the core plate based on the need for extensive disassembly to access below the core plate and that the UT technique has yet to be developed. VYNPS documented a deviation from the BWRVIP-25 inspection requirements and associated justification in Reference 3.

3. The core plate stress analysis did not account for some portion of the core plate bolts being either completely or partially cracked due to intergranular stress corrosion cracking or irradiation assisted stress corrosion cracking.

4. The justification for stress corrosion cracking not being considered in the VYNPS analysis is that it is not an expectation of the analysis presented in BWRVIP-25. The potential for stress corrosion cracking of the core plate assembly is discussed in BWRVIP-25, Section 2. For the rim hold-down bolts, Section 2.2.9 notes that the bolts are subject to moderate tensile stress and that the bolts have threaded regions where

stress concentrations occur and where creviced water chemistry may exist. However, Section 2.2.9 also notes that the hold down bolt material is not sensitized, a fact that makes stress corrosion cracking susceptibility lower, and that there have been no instances of rim hold-down bolt cracking in the field. VYNPS is not aware of any instances of core plate hold down bolt cracking in the field subsequent to the BWRVIP-25 publication date of December 1996.

References

1. Vermont Yankee Core Plate Bolt Stress Analysis Report (Proprietary Version), Revision 0, March 2011

2. "BWR Vessel and Internals Project, BWR Core Plate Inspection and Flaw Evaluation Guidelines (BWRVIP-25)," EPRI Report TR-107284, December 1996

3. Letter, Entergy to USNRC, "Deviation from BWRVIP-25 Inspection Requirements,' BVY 11-024, dated March 18, 2011