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U. S. Nuclear Regulatory Commission
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Calvert Cliffs Nuclear Power Plant, Unit No. 2
Renewed Facility Operating License No. DPR-69
NRC Docket No. 50-318

Subject: Long Term Coupon Surveillance Program

Reference: 1. Letter from D. V. Pickett (NRC) to J. A. Spina (CCNPP), dated August 27, 2008, Amendment re: Long-Term Coupon Surveillance Program

This letter is submitted as required by Reference 1, the results of the coupon surveillance program are provided in Attachment (1).

There are no regulatory commitments contained in this letter.

Should you have questions regarding this matter, please contact Mr. Larry D. Smith at (410) 495-5219.

Respectfully,

Patrick D. Navin
Site Vice President

PDN/LDS/lmd

Attachment: (1) Long Term Coupon Surveillance Program Results

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NRC 22-012

ATTACHMENT (1)

LONG TERM COUPON SURVEILLANCE PROGRAM RESULTS

Attachment (1)
Long Term Coupon Surveillance Program Results

The analysis of the initial coupons for Engineering Test Procedure 86-003R "Analysis of Neutron Absorbing Material in the Spent Fuel Storage Racks and Management of the Neutron Poison Sample Coupon Trees" was completed on 4/19/2022. The initial results of coupon dimension and weight measurements did not meet the acceptance criteria listed in the long-term coupon surveillance program (approved by Reference 1). The specific criterion is, "Any change in weight of ± 26-percent compared to baseline".

Weight loss values for the coupons in packet 24 are as follows:

- Coupon 2U from packet 24 indicates an approximate 28% weight loss. This weight loss exceeds the acceptance criterion of 26%.
- Coupons 2L from packet 24 indicates an approximate 18% weight loss, which does not exceed the acceptance criteria of 26%.

A recovery plan has been initiated to expand the scope of testing by pulling additional coupons in 2022 in accordance with the long-term coupon surveillance program. The 1U and 1L coupons from packet 24 were previously pulled as part of the expanded scope in 2013.

This document provides the initial results for coupon weight loss and B-10 areal density while the expanded scope is in progress.

Coupon Weight Loss

The coupon weight characteristics for packet 24 are shown in Table 1. As can be seen in Table 1, the weight loss of Coupon 24-2U did not meet the limit, mainly due to the flow induced erosion caused by an inspection hole in the coupon bracket cover. This flow induced erosion was previously identified in past coupon campaigns at Calvert Cliffs. As communicated previously, the neutron absorbing material in the spent fuel racks is not susceptible to this erosion because there are no inspection holes in the active fuel region. Note that the criticality analysis of record does not credit neutron absorbing material located outside the active fuel region of fuel assemblies seated in the rack. The hole caused by flow induced erosion is shown in Figure 1 below. The coupon weight characteristics for packet 24, after weight adjustment for inspection hole, is shown in Table 2. It is shown the criterion is met for adjusted weights. In summary, the average weight loss before adjustment was 23.00% which was reduced to 20.05% after adjustment.

Table 1
Packet 24 Coupon Weight Characterization, Before Adjustment for Inspection Hole

Coupon	Pre-Irradiation Weight (g)	Irradiated-Dried Weight (g)	Change (%)	Change Limit (%)
24-2U	8.88	6.37	-28.27	±26
24-2L	9.14	7.52	-17.72	±26

Table 2
Packet 24 Coupon Weight Characterization, After Adjustment for Inspection Hole (Note 1)

Coupon	Adjusted Pre-Irradiation Weight (g)	Irradiated-Dried Weight (g)	Change (%)	Change Limit (%)
24-2U	8.514	6.37	-25.18	±26
24-2L	8.842	7.52	-14.95	±26
Note 1. To adjust the pre-irradiated coupon weight, weight loss from erosion (in fraction) was calculated by the estimated inspection hole area divided by the pre-irradiated coupon area. Then, the "*adjusted pre-irradiation weight*" was calculated by multiplying the "*pre-irradiation weight*" by "*1- calculated weight loss fraction.*"				

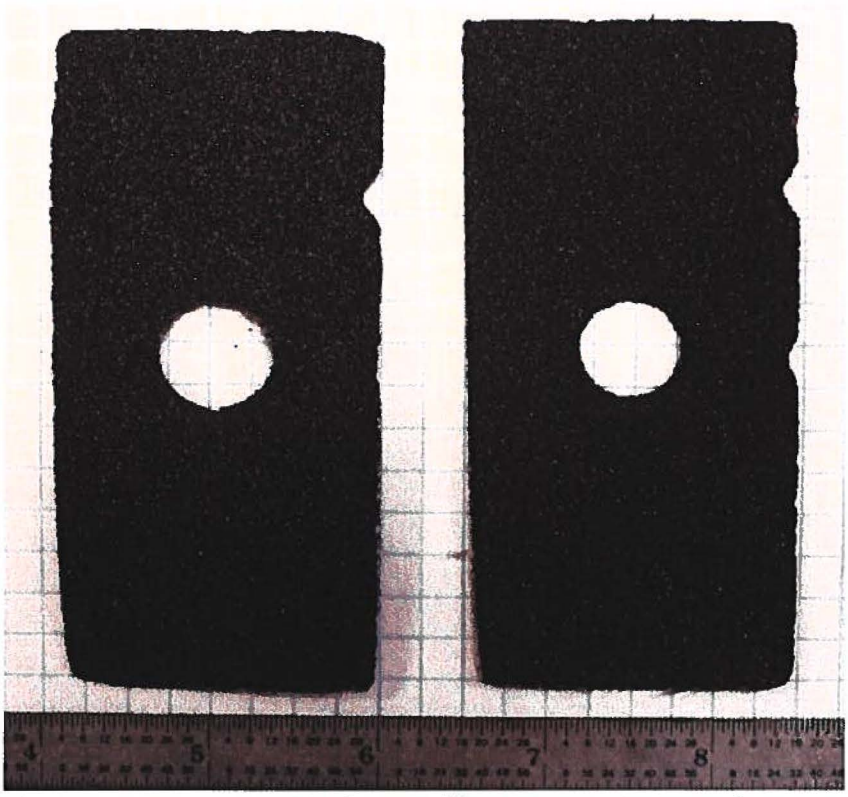

Photo 1: Coupons 24-2U & 24-2L (Front, Ambient Light, Light Background)

Figure 1. Irradiated Coupons 24-2U (on the Left) and 24-2L (on the Right)

Coupon Weight Loss Limit

The current coupon weight loss limit of ±26% originated following the license renewal of Calvert Cliffs. During plant license renewal, Calvert Cliffs agreed to evaluate the Carborundum for a service life of ten years after the period of extended operation (ML20217H598, page 11 [2]). The Carborundum manufacturer's original test program had shown that the only notable changes in the sheet material with irradiation to 10^{11} rad (simulating a 40-year lifetime) were a 20% weight loss and 15% boron reduction (ML071440224 [3], Enclosure 1, pages 9 and 15). Based on this information, a boron loss of 26% was calculated as 70/40 x 15% (15% areal density loss over 40 years, extrapolated to 70 years) for use following license renewal. Therefore, the Calvert Cliffs Unit 1 criticality analysis performed after plant license renewal (ML031270300 [4]) evaluated a boron areal density of 0.0177 $g^{10}B/cm^2$, which represented a 26% reduction over the 0.09" thick material with 0.024 $g^{10}B/cm^2$ required by the specification. Since weight loss exceeded boron reduction under the carborundum manufacturers test conditions, use of a 26% reduction for the weight loss criteria in the aging management program was considered conservative during a time when areal density testing was not being performed. Following the first areal density test required by Amendment 288 [5], manufacturing information located in plant history revealed that the Carborundum sheets installed in the Unit 1 SFP racks consisted of two layers, each 0.045" thick with an original B-10 areal density of 0.0144 g/cm^2 to 0.0153 g/cm^2. This information also indicated that similar material demonstrated a minimum of 0.012 $g^{10}B/cm^2$ after 10^{11} rad gamma exposure. Thus, the weight loss acceptance criterion that was based on a reduction from 0.024 g/cm^2 (combination of two layers) is highly conservative.

The more appropriate weight loss limit, which is based on as-built boron areal density is 38.5%. It is calculated as (0.0288 – 0.0177) *100/0.0288, where 0.0288 g/cm^2 is the rack Carborundum minimum areal density, and 0.0177 g/cm^2 is the Carborundum areal density credited in criticality analyses of record.

Coupon Weight Loss as a Function of Coupon Service Life

Figure 2 provides weight loss as a function of coupon service life. The plots in this figure show while the average unadjusted weight loss is not projected to meet the current criterion of 26% after 2023, the coupons with adjusted weight loss are projected to meet the adjusted weight loss limit based on boron areal density beyond the period of extended operation.

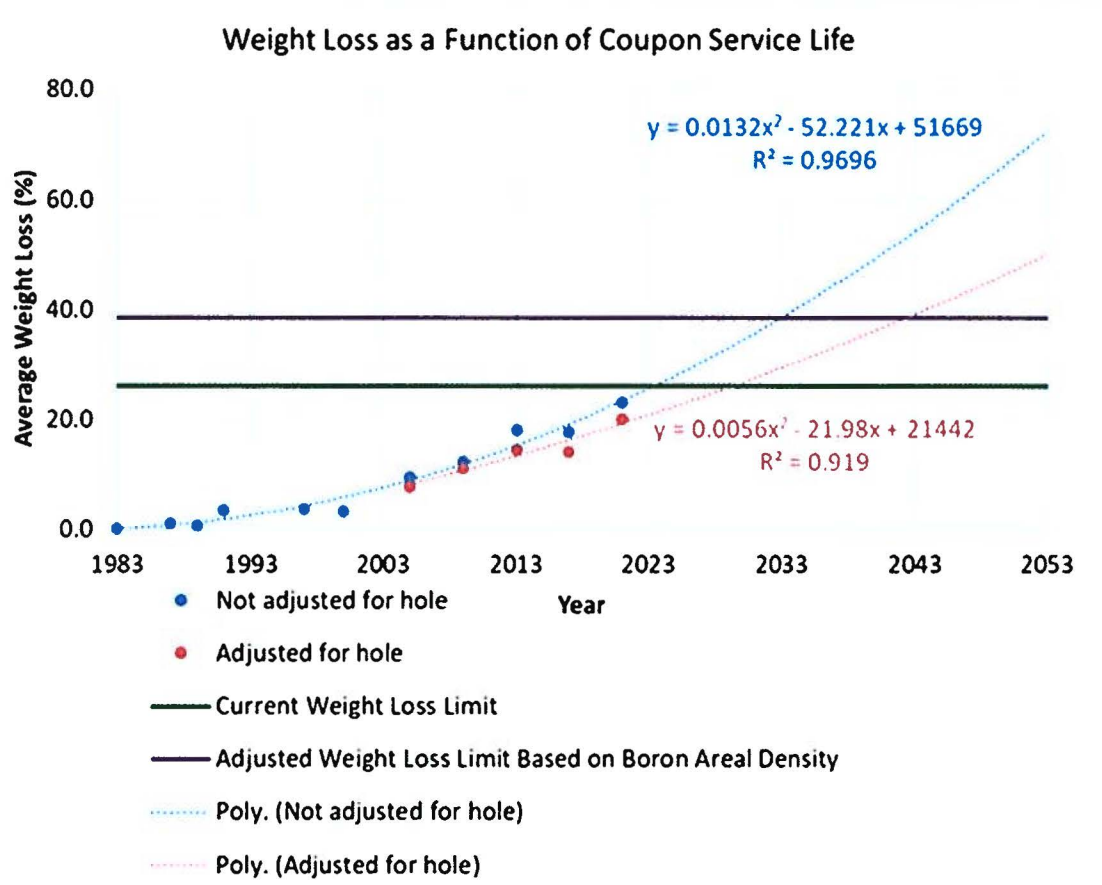

Figure 2. Weight Loss as a Function of Coupon Service Life (Notes 1 to 3)

Note 1: The weight loss was adjusted for the flow induced erosion if the hole was all the way through the coupon; otherwise, an unadjusted value was used.
Note 2: The current weight loss limit is for each individual coupon, not for average weight loss.
Note 3: The end of life for the spent fuel pool is 60 years plant operation + 10 years = 2046.

Coupon Boron-10 Areal Density as a Function of Coupon Service Life

Areal density testing was performed on 24-2U and 24-2L coupons by NETCO's laboratory facilities at Pennsylvania State University. The results for the individual coupons, as well as the total areal density are provided in Table 3. As can be seen, the total areal density is more than the limit of 0.0177 g/cm^2. An evaluation of Carborundum coupons after the 2013 surveillance revealed that the majority of the coupon weight loss was due to flow induced erosion caused by an inspection hole in the coupon bracket cover. The neutron absorbing material in the spent fuel rack is not susceptible to this erosion because there are no inspection holes in the active fuel region. Note that the criticality analysis of record does not credit neutron absorbing material located outside the active fuel region of fuel assemblies seated in the rack.

Figure 3 shows the change in B-10 areal density over time, and its limit of 0.0177 g/cm^2. This plot, which is conservatively drawn, shows the coupons would not fail for more than 20 years (approximately 2042).

Table 3
Packet 24 Coupon B-10 Areal Density

Coupon	Minimum B-10 Areal Density (g^{10}B/cm^2)
24-2U	0.0122
24-2L	0.0130
24-2U + 24-2L = 0.0252 g^{10}B/cm^2	

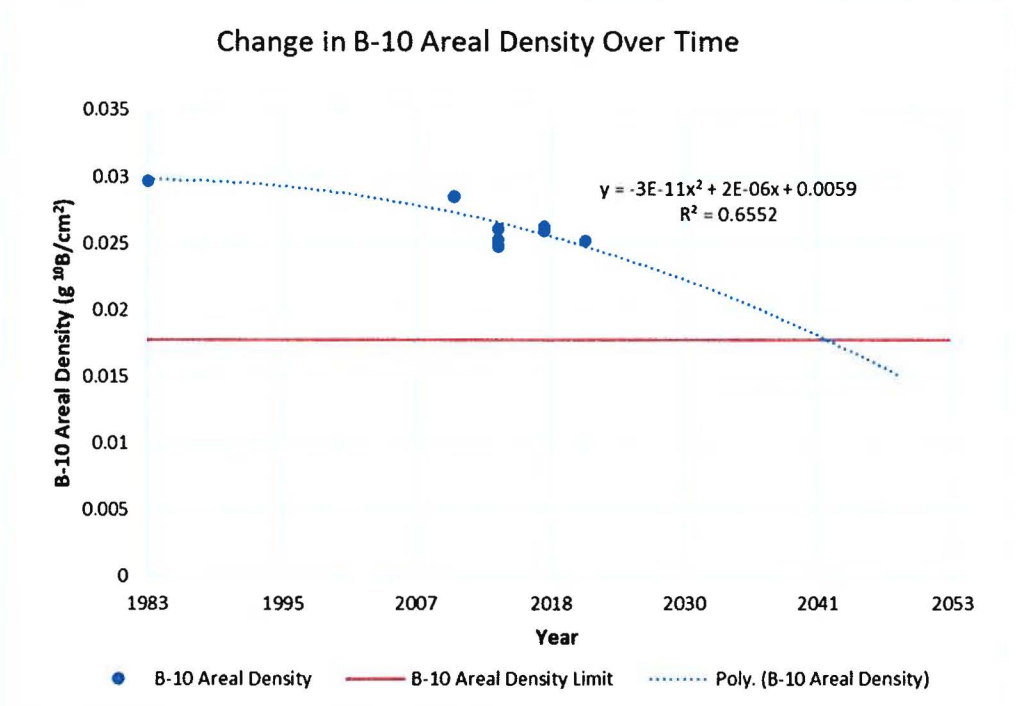

Figure 3. Change in B-10 Areal Density Over Time

Visual and Dimensional Results

The acceptance criterion for visual inspection is no visual evidence of gross changes and deterioration. However, there is a hole through center coincident with packet inspection hole, as well as edge erosion. So, the result of the visual inspection is considered as unsatisfactory.

The acceptance criterion for any change in the length and width of the coupon is ±0.5 inches compared to the baseline. The results, from 1983 until now are provided in Figures 4 and 5. As can be seen, the limit is met for both coupon's length and width.

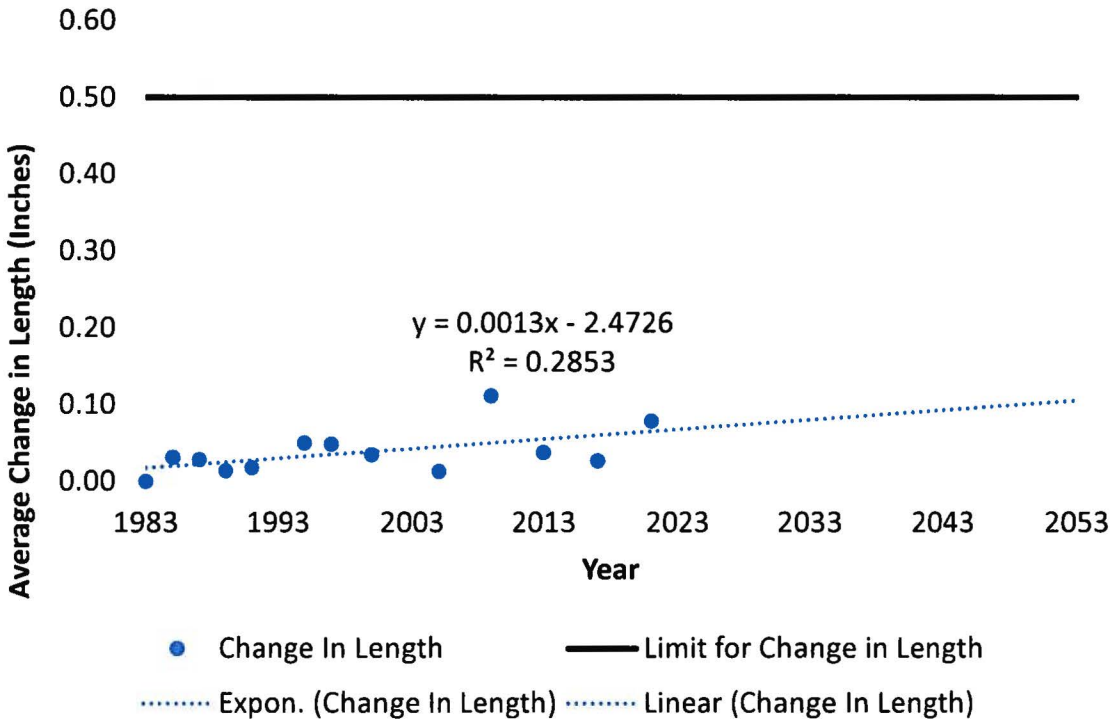

Figure 4. Change in Coupon Length as a Function of Coupon Service Life

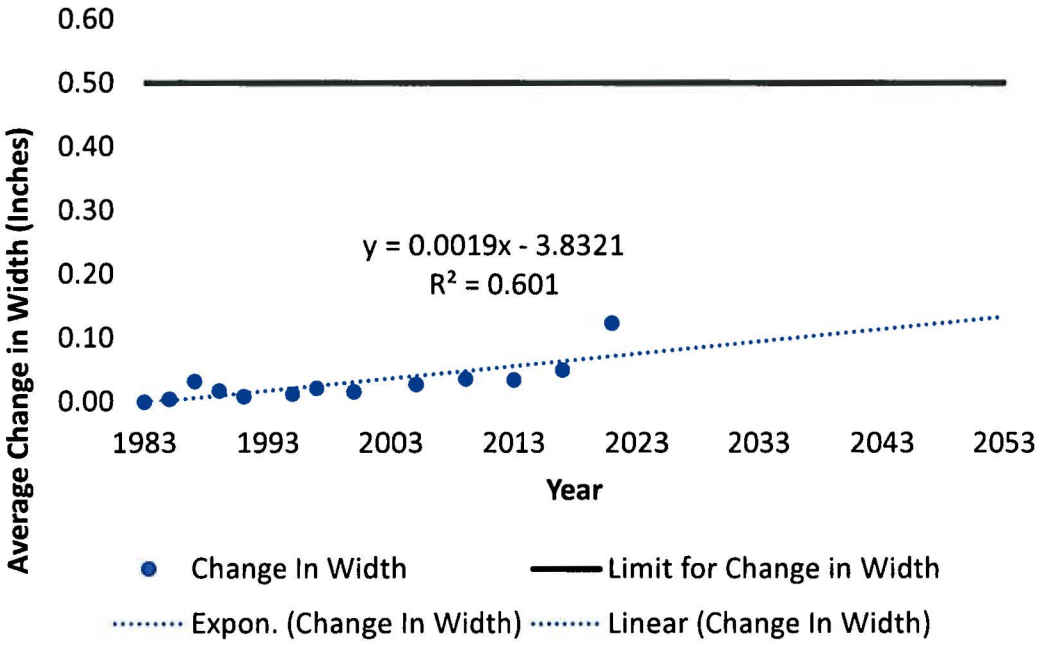

Figure 5. Change in Coupon Width as a Function of Coupon Service Life

Extended Action

While the coupon 24-2U weight loss (before adjusting the weight loss for the hole) failed to meet the weight loss criterion, the coupon is technically acceptable since the criterion for the weight loss is overly conservative, as discussed above, and the B-10 areal density requirement and dimensional criteria are met, as shown in the previous figure.

Nevertheless, per the current requirements, additional coupons will be pulled out of the spent fuel pool for further analysis. Subsequent steps are based on whether those coupons meet the acceptance criteria, and are listed in Amendment 288.

Reference

1. Letter from D. V. Pickett (NRC) to J. A. Spina (CCNPP), dated August 27, 2008, Amendment re: Long-Term Coupon Surveillance Program.
2. Baltimore Gas and Electric Company. "Calvert Cliffs Nuclear Power Plant, Request for Review and Approval of Commodity and System Reports and the Time-Limited Aging Analyses Evaluation for License Renewal," (ML20217H598), March 27, 1998.
3. Constellation Energy. "Long-Term Coupon Surveillance Program for the Unit 1 Spent Fuel Pool," (ML071440224), May 10, 2007.
4. "Calvert Cliffs, Units 1 - License Amendment Request re Increase to Spent Fuel Pool Maximum Enrichment Limit with Soluble Boron Credit, Attachments 1 Through G," (ML031270300), May 1, 2003.
5. Calvert Cliffs Nuclear Power Plant, Unit No. 1, Amendment to Renewed Facility Operating License, Amendment No. 288.