Combustion Engineering, Inc.

Results of the CEA Guide Tube
Inspection Program
Calvert Cliffs Unit No. 2
Docket No. 50-318

CEN-118(B)-NP

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I. Summary

A total of 128 irradiated fuel assemblies and 5 control element assemblies were examined at Calvert Cliffs II during the EOC-2 refueling period. The purpose of this inspection program was to:

a) Determine the condition of sleeves after one cycle of operation with respect to crimp size, wear and ability to resist axial movement.

b) Monitor CEA condition after operation in sleeved and/or unsleeved assemblies.

c) Determine the condition of the unsleeved demonstration assemblies.

The results of the sleeved assembly inspection confirmed that:

a) There was no observed sleeve wear from control rod motion during operation.

b) There is adequate resistance to axial movement for sleeves with the new crimp geometry after one cycle of operation.

c) Assemblies sleeved in 1978 in the unirradiated condition had acceptable crimp sizes.

d) The new procedures used for sleeve installation in irradiated guide tubes produce adequate crimp sizes.

The results of the CEA inspection showed light control element wear comparable to that observed at other sites.

The inspection of the unsleeved demonstration assemblies [

]

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II. Introduction

Past inspections of sleeves installed and operated in the guide tubes of Combustion Engineering (CE) fuel assemblies confirm that the sleeve is effective in protecting the guide tube from wear in control element assembly (CEA) locations. This conclusion is based on inspections of [ ] sleeved guide tubes that have been operated in CEA locations in Calvert Cliffs-1, Millstone-2, and St. Lucie-1.

These inspections did reveal, however, that some sleeves, particulary those installed in irradiated fuel assemblies, had retaining crimps that were shallower than specified. Because at less than operating temperatures the shallow crimp could conceivably allow the sleeve seating to be shifted by CEA drag forces, CEA movement was restricted for system temperatures less than 400F. This restriction was instituted at Calvert Cliffs-2 as well as other CE plants as a preventive measure, although there were no indications that any such sleeve movement had actually occured.

For Cycle 3 at Calvert Cliffs-2, sleeved fuel assemblies carried over from Cycle 2 and sleeved, fresh Batch E assemblies will continue to be used in CEA locations. Table 1 lists by batch the quantity of fuel assemblies containing sleeves for Cycle 3 as well as the time of sleeve installation. In light of the shallow crimp findings, the Calvert Cliffs-2 inspection program at end-of-Cycle 2 was intended to determine the crimp sizes in sleeves installed at the beginning of Cycle 2, allowing CE to re-crimp where necessary. This would obviate any need to continue the CEA movement restriction. The categories of sleeved fuel assemblies inspected include: (1a) fuel sleeved prior to irradiation, exclusively Batch D, and, (1b) fuel sleeved after irradiation, Batch C. An inspection of CEA's was also included to monitor for any wear effect of sleeves on the CEA finger.

In addition to examining sleeved fuel assembly performance, the program also examines the guide tube wear performance of the modified test assemblies (Category 2). These assemblies have been modified to [ ] This design is intended to reduce CEA/guide tube wear by [ ]

The locations of the fuel categories of interest placed under CEA's remain as pictured in the Cycle 3 Core Map supplied earlier in CEN-116(B)-P,[1] October 8, 1979. The methods used to conduct the inspections of fuel and CEA's include visual examinations and eddy current measuring techniques. These techniques and the devices employed are discussed at length in the appendix to this report. The eddy current techniques developed for these inspections have also been incorporated as a quality control step for the initial installation of sleeves and for any re-crimping repairs.

[1] Ltr. R.C.L. Olson (BG&E) to R. W. Reid (NRC) dated 10/10/79.

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TABLE 1

Sleeved Fuel Assemblies in Calvert Cliffs-2, Cycle 3

Batch	Number of Assemblies in Cycle 3	Number of Assemblies containing sleeves	time of sleeve installation[1]	Fuel assembly status at time of installation	Number of assemblies under CEA's in Cycle 3
B	1		BOC3	irradiated	1
C	68		BOC2	irradiated	12
			BOC3	irradiated	16
D	84		BOC2	unirradiated	24
E	64		BOC3	unirradiated	24
TOTALS	217				77

[1]BOC, beginning of cycle

[2]unsleeved D assemblies are the modified test assemblies

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III. Results and Discussion

A. Fuel Assembly Inspection

1. Eddy Current Test Results for Wear Sleeves

A total of [ ] guide tube wear sleeves were inspected, including all sleeves returning to the core for Cycle 3. All sleeves had the short (3/8") crimp geometry. The results of the inspection for crimp size are listed by assembly type in Table 1.

The table demonstrates that all sleeves in assemblies returning to CEA locations for Cycle 3 satisfy the [10] mil minimum crimp size criterion. The data also confirm the fact that the Batch D assemblies sleeved in the unirradiated condition in 1978 had acceptable crimp sizes. All 1979 sleeve installations in irradiated fuel assemblies were performed under a revised procedure, which produced the desired crimp geometry.

As expected from observations on other plants, undersize crimps were observed in the Batch B and C assemblies in which sleeves had been installed in 1978 after irradiation. These sleeves were successfully recrimped for those bundles scheduled to return to CEA locations.

No wear was detected on any of the inspected sleeves which had been used in CEA locations during Cycle 2. The sensitivity of the ECT equipment to sleeve wear was not as great as during the Spring, 1979 inspections at Millstone 2, Calvert Cliffs 1, and St. Lucie 1, due to the fact that the thrust of the sleeve inspection at Calvert Cliffs 2 was toward crimp size. To be as accurate as possible, this required somewhat modified equipment and calibrations. Significant wear on the sleeves would still have been observed, if present.

The installed sleeves have between [

]

In the case of the [

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]

2. Demonstration Assembly Eddy Current Test Results

Eddy current test results for the [ ] demonstration assemblies [

] are summarized below.

Assembly	CEA Type	[Bobbin Coil Voltage] Range	Average
[			]

[

] These assemblies are not returning to CEA locations for Cycle 3.

[

]

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3. Sleeve Pull Test Results

A total of[ ]sleeves were pull-tested to a[ ] All sleeves were in discharged Batch B fuel assemblies.

As expected, these sleeves with their improved crimp geometry exhibited at least as much resistance to pullout after operation as sleeves with the old crimp type. As noted in figure 1, the pull test results of sleeves with the long crimp geometry indicate that no movement occurred with a minimum crimp size of[ ]. The testing performed on the 16 sleeves with the new crimp type where the crimp size ranged from[ ]resulted in no detectable movement.
These results further support the [ ] mil minimum crimp requirement, and justify the replacement of the pull test during installation with the eddy current inspection for correct material upset.

IV. Conclusions

1. All sleeves in fuel assemblies returning to CEA locations have acceptable crimp sizes.

2. The revised procedure for the installation of new sleeves results in the proper crimp sizes.

3. There was no observed sleeve wear from control rod motion during operation.

4. The performance of the unsleeved demonstration assemblies [ ]

5. Resistance to axial movement for sleeves with the new crimp geometry was verified. Since all sleeves in CEA locations for Cycle 3 have adequate crimps, the 400°F operating restriction on control rod movement need not be imposed.

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TABLE 1

Category	Number Assys. Inspected	Under CEA Cycle 3	Crimp Size Range	Average Crimp Size
1. Sleeved in 1978				
a. Batch D (sleeved fresh)		24 yes, 44 no		
b. Batch C (sleeved irradiated)				
1. Worn Assemblies		no		
2. Unworn Assemblies		12 yes		
c. Batch B (sleeved irradiated)		Discharged		
3. Sleeved in 1979				
a. Batch E (sleeved fresh)		24 yes, 40 no		
b. Batch C (sleeved irradiated)		yes		
c. Batch B (sleeved irradiated)		yes		1

*data from a representative sample of five

**data from a representative sample of seventeen

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FIGURE 1

B) CEA Inspection

1) Eddy Current Test Results

[ ] CEA's were eddy current tested during the Calvert Cliffs II EOC 2 shutdown, to detect [ ]. [ ] of the CEA's were located in sleeved assemblies during the second cycle and [ ] of the CEA's were located in unsleeved demonstration assemblies of a modified design. The CEA's operated at essentially the all rods out "ARO" position for Cycles 1 and 2. This operating mode corresponds to a nominal CEA insertion into the assembly of 16 ± 2 inches. However since January 1978, the CEA programming sequence has been modified by [.] The CEA's inspected, eddy current test [ ] and [ ] of any indications observed are presented in Table 2. The indications are located approximately at [CEA exit from the top of the fuel assembly considering the modified CEA]

A total of [ ] indications were observed on the [ ] fingers tested, ranging from [ ] [.] These were probably caused by the CEA programming during Cycle 1 and 2 as well as [ ] between Cycles 1 and 2.

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The average indication is [ ] with a standard deviation of [ ] Based on the ECT signal [ ] (Table 1), the average indication corresponds to [

] of the CEA finger. [ ] leading to some [ ] of the actual wear see Reference 1. No ECT indications associated with [ ] wear were observed.

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TABLE 1

Calvert Cliffs II, EOC-2 Eddy Current Signal [ ]

Correlation for CEA Test Calibration

Wear Simulations [ ]	Calibration [ ] ± Standard Deviation
[	]

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TABLE 2

Calvert Cliffs 2 CEA [ ] Eddy Current Results

CEA Number	In Cycle 2 Assembly	CEA Bank	Maximum [ ]	Distance Above [ ] of CEA ± 1 in.

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CEA Number	In Cycle 2 Assembly	CEA Bank	Maximum [ ]	Distance Above [ ] of CEA ± 1 in.

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2) Visual Inspection Results

[ ] CEA's were visually inspected using an underwater periscope. [ ] were examined in detail over their entire length. In additi fingers on [ ] were examined in detail over the [ ] The results of these visual examinations are summarized in Table 3 and confirm satisfactory operation. [

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3) Discussion

Both the visual inspection and eddy current test results were, in general, similar to those observed at Millstone II and Calvert Cliffs I earlier in 1979 (See Reference 1). The maximum eddy current signal of [

] This estimate neglects the effect of any [ ] on the ECT signal and is well under the [ ] discussed in Reference 1.

The visual examinations also confirmed satisfactory CEA performance after two operating cycles and no anomalies were observed. The [ ] found at the [ ] elevations as well as the CEA [ ] were similar in nature to those observed at Millstone II and Calvert Cliffs I during previous inspections.

Reference

1. "Response to Request for Additional Information CEA Guide Tube Inspection Program Calvert Cliffs No. 2," Docket No. 50-313, CEN-116 (B)-P dated October 8, 1979 (Ltrs. R.C.L. Olson (BG&E) to R. W. Reid (NRC) dated 10/10/79)

TABLE 3

CEA Visual Inspection Results from Calvert Cliffs II EOC-2

CEA	Finger	Description	Extent[1]	Approximate Elevation From[ ]

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TABLE 3 (cont.)

CEA Visual Inspection Results from Calvert Cliffs II EOC-2

CEA	Finger	Description	Extent 1	Approximate Elevation From[ ]

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TAB . 3 (cont.)

CEA Visual Inspection Results from Calvert Cliffs II EOC-2

CEA	Finger	Description	Extent[1]	Approximate Elevation From

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APPENDIX

Eddy Current Testing [ ] of sleeved guide tubes is performed for the purposes of determining if sleeve wear has occurred or if an adequate guide tube expansion (crimp) exists. The ET systems employed for each of these purposes are nearly identical, the differences being [

] Both systems can be employed for qualitative estimates of features other than their primary purposes, i.e., the [

] A more detailed discussion of each system follows.

[ ] Eddy Current Test for Sleeve Wear

The equipment used during Eddy Current Testing for sleeve wear consists of an [ ] Teac tape recorder, Brush strip chart recorder and a [ ] eddy current coil probe. Once the system components are interconnected, the probe is inserted into a standard to allow system balancing and calibration.

The standard used for calibration of the sleeve wear system consists of [

] Other minor adjustments are made to ensure a uniformity of testing and therefore reproducibility.

At this point the [

] and then withdrawn. As the probe is withdrawn the eddy current signals are recorded upon both magnetic tape for record purposes and upon a strip chart for immediate assessment of the test quality and general sleeve condition.

A typical eddy current trace from the [ ] is shown in Figure I below the sleeve wear standard diagram. Each portion of the signal is aligned with the applicable area of the standard for easy reference. In the event that wear is detected, a second trace is shown to indicate the differences from the unworn sleeve trace which would occur.

The traces taken from fuel assemblies which were being inspected for wear have been used for purposes other than that originally intended. An estimate of the guide tube [ ] was made in an effort to determine whether or not it was adequate for service under a Control Element Assembly (CEA). More recently a review of the traces for the sleeve expansion region was made to determine whether or not any sleeve [

] A typical trace for a [ ] is shown in Figure II.

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[ ] Eddy Current Test for Guide Tube Expansion (Crimp) Size

The same equipment as listed for sleeve wear testing with a[ ] is also used during an[ ] eddy current test. The[

] Again, the probe is inserted into a standard to allow system balancing and calibration.

The standard for calibration of the guide tube expansion size system consists of[

] Again, other minor adjustments are made to ensure a uniformity of testing and reproducibility. Set-up and calibration of the[ ] for determining guide tube expansion size is complete at this point.

During use, the probe is inserted into the desired sleeved guide tube to a point below the bottom of the sleeve and then withdrawn. As the probe is withdrawn the eddy current signals are recorded as they are in the sleeve wear test. A typical eddy current trace from the[ ] is shown in Figure III. Each area of the guide tube sleeve is aligned to a corresponding portion of the eddy current trace. [

]

The[ ] eddy current system for guide tube expansion size is calibrated for guide tube expansion sizes, but can be used to provide a qualitative estimate for the sleeve installation as a whole. [of

]

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FIGURE I
SLEEVE WEAR STANDARD AND TYPICAL ECT TRACE

FIGURE II

SLEEVE INSTALLATION WITH ABNORMAL CONDITIONS AND ECT TRACE [ ]

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FIGURE III

TYPICAL SLEEVE INSTALLATION AND ECT TRACE

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FIGURE IV

SLEEVE INSTALLATION WITH ABNORMAL CONDITIONS AND ECT TRACE [ ]

CALIBRATION CURVE FOR EDDY CURRENT TESTING
OF GUIDE TUBE EXPANSIONS

A group of[ ]sleeved guide tube sections were physically measured for the change in outside diameter as a result of guide tube expansion and were then eddy current tested. The attached graph depicts the actual data points and shows a best fit line as the result of a linear regression analysis. This resultant curve forms the basis for converting Eddy Current Testing data to best estimate guide tube expansion sizes (diametral).

ECT[ ] CALIBRATION CURVE

[ ]

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Eddy Current Testing of the Control Element Assemblies

[

]is used in conjunction with an EM3300 Eddy Current Tester, a FM magnetic tape recorder and a strip chart recorder to perform the eddy current testing upon CEAs.

[

]in preparation for eddy current testing of the CEA fingers. A standard (Fig. V) is employed to balance and calibrate the response from [.] The standard is fabricated from tubing of the same material and nominal dimensions (OD and wall thickness) as the CEA finger and incorporates machined features of various sizes and extent so that the CEA eddy current system response is known over a range of possible wear configurations .

When the system has been balanced and calibrated, a CEA is inserted into the [ ]until approximately the [

1

].

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CEA FINGER EDDY CURRENT TEST STANDARD

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FIGURE V