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VICE PRESIDENT
SUPPLY

June 11, 1981

Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

ATTENTION: Mr. R. A. Clark, Chief
Operating Reactors Branch #3
Division of Licensing

SUBJECT: Calvert Cliffs Nuclear Power Plant
Unit No. 1 and Unit No. 2
Docket Nos. 50-318 and 50-319
Core Misloading Analysis

REFERENCE (A): R. A. Clark to A. E. Lundvall letter dated 12/12/80

(B): R. A. Clark to A. E. Lundvall letter dated 2/10/81

Gentlemen:

References (A) and (B) issued amendments to the operating licenses. A condition of those amendments was the submittal of an analysis of a core misloading event. The purpose of the analysis was to evaluate all significant misorientations of a fuel assembly or interchange of two fuel assemblies and show that the misloading was either detectable during low power physics testing or that it was of no signifcant consequence. That analysis has been completed and a summary of the method of analysis and results is attached hereto.

Very truly yours,

BALTIMORE GAS AND ELECTRIC COMPANY

A. E. Lundvall, Jr.
Vice President - Supply

WJL/AEL/djw
Attachment

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ATTACHMENT

CORE MISLOADING EVENT

INTRODUCTION

The primary safeguards against core loading errors are design features and operational procedures to minimize the likelihood of the event. These procedures and design features include:

1. Fuel shuffling instructions which result in all, or nearly all, fuel assemblies facing in the same direction (i.e., all serial numbers on the same side).

2. Visual core loading verification to insure proper core loading. This check not only verifies the placement of assemblies in the proper core location but also verifies the proper orientation of each assembly.

3. CEA symmetry checks performed to insure detection of core loading errors which might cause a sufficient deviation from the planned design power distributions to impact the safety analyses.

For those postulated loading errors which would not be detected by the CEA symmetry checks, an analysis was performed to determine the consequences of normal operation with an undetectable loading error. This analysis is described below.

Method of Analysis

The analysis of the core misloading event is done in two basic steps. The first step is to determine which core loading errors are detectable. This is done by calculating symmetric dual CEA rod worths for a variety of misloaded cores at hot zero power, beginning of cycle conditions using 2-D full core ROCS. The criterion for detectability was chosen as a 3.5¢ difference between the worth of any dual CEA and the average worth of all dual CEA's within a given CEA bank. This criterion is sufficiently low to allow for detection of major core loading errors and sufficiently high to preclude false indication of core loading errors due to measurement uncertainties and normal power tilts.

The second step of the analysis is the evaluation of the consequences of normal operation with an undetectable core loading error. This is done by calculating the change in maximum 1-pin peaks at hot full power for the misloaded cores using assembly power densities from 2-D PDQ calculations. The increase in the maximum radial pin peaking factor is then compared to the initial steady state thermal margin maintained by the limiting conditions for operation.

Results

Figure 1 shows the normal loading for Calvert Cliffs Unit 2, Cycle 4 along with the loading errors which were analyzed. These analyses indicate that the interchange of assemblies with large reactivity differences produce CEA worth asymmetries which exceed the 3.5¢ detectability criterion and are therefore detectable. The interchanges which fall into this category are:

- interchange of an F assembly with any other assembly,
- interchange of an F/ assembly with an E/ or D assembly, and
- interchange of an E assembly with a D assembly.

These loading errors would be detected during hot zero power testing and would be corrected or otherwise mitigated prior to power generation.

The interchange of assemblies with similar reactivities do not produce CEA worth asymmetries in excess of the 3.5¢ detectability criterion and are therefore undetectable. The interchanges which fall into this category are:

- interchange of assemblies within the same exposure batch,
- misorientation of an assembly, and
- interchange of an F/ assembly with an E assembly.

The most adverse loading error(s) within each of the above types of undetectable loading errors were analyzed to determine the consequences of normal operation with an undetectable loading error. The results of these analyses are summarized in Table 1.

Table 1 shows that the most adverse undetectable loading error is the interchange of a Batch F/ assembly (fresh, shimmed fuel) with a Batch E assembly (unshimmed fuel with one cycle of exposure) thereby producing an island of five Batch F/ assemblies (see Figure 1). This type of loading error is undetectable at beginning of cycle due to the similar reactivities of the Batch F/ and E assemblies. However, the reactivity difference between the Batch F/ and E assemblies increases with burnup due to the burnout of the burnable poison shims within the F/ assembly. This, in turn, causes the power distribution differences between the normally loaded and misloaded cores to increase with burnup. Although undetectable by the CEA symmetry test at beginning of cycle, this type of loading error would most likely be identified by incore instrumentation and/or by tilt monitoring before the maximum peaking increase identified in Table 1 was reached. The interchange of assemblies within a batch and the misorientation of an assembly are considerably less adverse than the interchange of a fresh, shimmed assembly with an exposed assembly.

The most adverse undetectable loading error for Calvert Cliffs Unit 2, Cycle 4 results in a maximum change in the pin peaking factor within the misloaded assembly (F/) of 13% (Table 1). Since the peak pin in this assembly in the normally loaded core operates at a maximum power density during the cycle which is approximatley 5% below the maximum pin power density within the core during the cycle, the resulting increase in the calculated maximum radial pin peaking factor increase results in a calculated radial peaking factor which is 1% above the Technical Specification limit including appropriate uncertainties. This small increase in radial peaking above the Technical Specification limit does not cause the fuel safety limits to be exceeded because of the initial steady state thermal margin maintained by the limiting conditions for operation. These limiting conditions for operation provide 17% margin on DNB and 35% margin on peak linear heat generation rate.

Extension to Calvert Cliffs Unit 1, Cycle 5

The Calvert Cliffs Unit 1, Cycle 5 normal core loading is shown in Figure 2. Examination of this core loading shows that the worst undetectable loading error of the type analyzed above would result in smaller power distribution changes for Calvert Cliffs Unit 1, Cycle 5 than for Calvert Cliffs Unit 2, Cycle 4 because the worst undetectable loading error would result in an island of three fresh, shimmed assemblies as compared to five for Calvert Cliffs Unit 2, Cycle 4. Therefore, the largest pin peak change for any assembly in Unit 1, Cycle 5 would be considerably less than 13% (see Table 1). Even if the misloaded assembly was the limiting assembly in the normally loaded core and its peak pin was at the Technical Specification limit, which is not expected, the resulting maximum radial peaking factor would be considerably less than 13% above the Technical Specification limit. Therefore, the initial steady state thermal margin maintained by the limiting conditions for operation (17% for DNB and 35% for peak linear heat generation rate) is sufficient to prevent the fuel safety limits from being exceeded during normal operation of Calvert Cliffs Unit 1, Cycle 5 with an undetectable loading error.

TABLE 1

MAXIMUM PIN PEAKING FACTOR INCREASES

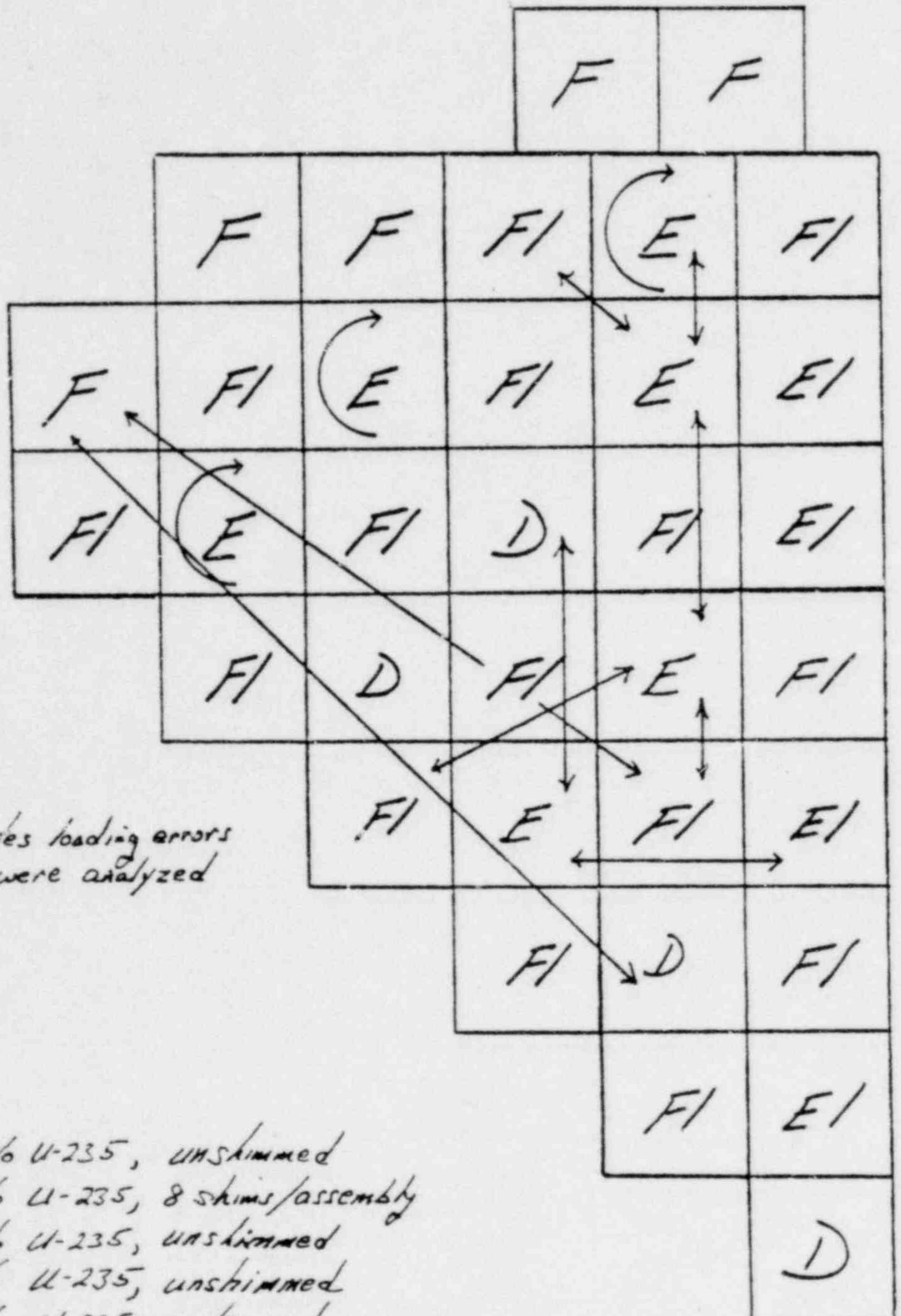
Type of Misloading	Calculated Pin Peaking Factor Increase at HFP, %		
	For Entire Core (1)	Relative to Technical Spec. (2)	Within Misloaded or (3) Potentially Limiting Assemblies
Interchange of Two Assemblies Within An Exposure Batch	< 2	more than 5% below	3
Misrotation of An Assembly	3	4% below	4
Interchange of a Fresh Shimmed Assembly With An Exposed Assembly	8	1% above	13

1. Percent increase in the maximum pin power in the core during the cycle for the misloaded core as compared to the maximum pin power in the core during the cycle for the normally loaded core.

2. Percent difference between the maximum pin peaking factor in the core during the cycle for the misloaded core and the Technical Specification limit.

3. Maximum increase in the peak pin within an assembly as compared to the peak pin within the same assembly in the normally loaded core at the same time in the cycle.

Calvert Cliffs II Cycle 4
Core Loading



⟷ indicates loading errors which were analyzed

F = 3.65 w/o U-235, unshimmed
F/ = 3.03 % U-235, 8 shims/assembly
E = 3.03 % U-235, unshimmed
E/ = 2.73 % U-235, unshimmed
D = [illegible] % U-235, unshimmed
(NOTE: Indicated enrichments are nominal and initial)

Figure 1

POOR ORIGINAL

Calvert Cliffs I Cycle 5

Core Loading

			G	G	
	G	G	G/	F	F/
G	G/	F/	G/	E	G/
F	F/	G/	E	F	F
	F	E	F	E	F
		G/	E	G/	E/
			F	E	F
				G/	F/
					D

G = 3.65 w/o U-235, unshimmed
G/ = 3.03 w/o U-235, 8 shims/assembly
F = 3.03 w/o U-235, unshimmed
F/ = 2.73 w/o U-235, unshimmed
E = 3.03 w/o U-235, unshimmed
E/ = 2.73 w/o U-235, unshimmed
D = 3.03 w/o U-235, unshimmed

(NOTE: Indicated enrichments are nomial and initial)

Figure 2

POOR ORIGINAL