UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

March 21, 2000

LICENSEE: Baltimore Gas and Electric Company

FACILITY: Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2

SUBJECT: SUMMARY OF THE DECEMBER 14, 1999, MEETING REGARDING CORROSION BEHAVIOR OF FUEL CLADDING AT CALVERT CLIFFS NUCLEAR POWER PLANT, UNIT NOS. 1 AND 2 (TAC NOS. MA6875 AND MA6876)

On December 14, 1999, the Nuclear Regulatory Commission (NRC) staff held a meeting at the NRC offices in Rockville, Maryland with representatives from Baltimore Gas and Electric Company (BGE) the licensee for Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2 and their consultants ABB - Combustion Engineering Nuclear Power, Inc. (ABB - CENP) to discuss corrosion behavior of fuel cladding at Calvert Cliffs Nuclear Power Plant, Unit Nos. 1 and 2. Enclosure 1 is a list of attendees. Enclosure 2 is a copy of the nonproprietary viewgraphs distributed at the meeting.

The licensee stated that an inspection was performed on fuel that had been discharged from Unit 2 at the end of Cycle 12 and on a lead assembly. As part of the inspection, visual examinations were performed on several high duty fuel assemblies, assemblies that had seen a high rate of burnup in the two cycles in which they were in the core. The visual examinations resulted in the observation that some fuel rods exhibited blistering of the oxide layer, and some fuel rods showed evidence of early stages of spalling.

Based on these observations, several assemblies were taken apart for more detailed inspection of individual fuel rods. The fuel rods were visibly examined and the oxide layer thickness were measured on some of the rods. Some fuel rods, particularly peripheral fuel rods, had measured oxide thicknesses that were higher than predicted by the vendor's corrosion model.

The licensee then described the immediate actions taken which included a voluntary Licensee Event Report (LER), initiating a root cause evaluation and performing an operability evaluation to support current cycles operation. The root cause evaluation concluded that the factors affecting fuel duty are the primary contributors to the unexpected behavior. These factors include: improved operating history, reduced reactor coolant system flow due to plugged steam generator tubes, rod location within the assembly, rod power and adjacent rod power, subcooled boiling and thermal hydraulics effects due to geometry. The operability evaluation determined that there was no concern for normal operation. In addition, it addressed accidents and transients. A preliminary fuel duty model was developed by ABB CENP which uses an improved corrosion model. A fuel duty index was evaluated which is a function of time and temperature. Fuel duty comparisons were made between CC2N and past and current batches which showed fuel duties for current cycles and CC2N are similar. Based on these comparisons, the licensee concluded that the current cores are operable. Finally, the licensee indicated that near term cores (up to and including Unit 2 Cycle 14 (U2C14)) will be evaluated

DF01

Template # NRR-058

March 21, 2000

by the same approach under 10 CFR 50.59. Beyond U2C14 fuel behavior is expected to be different due to replacement of steam generators (greater flow), use of the TURBO assembly design and use of an advanced cladding alloy. In addition, the licensee stated its intention to continue to examine the fuel and to keep the NRC informed of its findings.

/RA/

Alexander W. Dromerick, Sr. Project Manager, Section 1
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-317 and 50-318

Enclosures: 1. List of Attendees
2. Licensee's Handout

cc w/encls: See next page

DISTRIBUTION:

E-Mail (w/encl.1)
J. Zwolinski/S. Black
E. Adensam (e-mail)
M. Gamberoni (A)
S. Little
A. Dromerick
S. Wu
M. Chatterton
H. Scott
M. Tschiltz
M. Oprendek, RGN-I

Hard Copy (w/all encls.)
File Center
PUBLIC
PDI-1 R/F
A. Dromerick
OGC
ACRS

cc: Licensee & Service List

DOCUMENT NAME: G:\PDI-1\CC1-2\MTS121499.wpd

To receive a copy of this document, indicate in the box: "C" = Copy without attachment/enclosure "E" = Copy with attachment/enclosure "N" = No copy

OFFICE	PDI-1/PM	PDI-1/LA	PDI-1/SC (A)	
NAME	ADromerick:lcc	SLittle	MGamberoni	
DATE	3-20-00	3/20/00	3/21/00	

OFFICIAL RECORD COPY

by the same approach under 10 CFR 50.59. Beyond U2C14 fuel behavior is expected to be different due to replacement of steam generators (greater flow), use of the TURBO assembly design and use of an advanced cladding alloy. In addition, the licensee stated its intention to continue to examine the fuel and to keep the NRC informed of its findings.

Alexander W. Dromerick

Alexander W. Dromerick, Sr. Project Manager, Section 1
Project Directorate I
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket Nos. 50-317 and 50-318

Enclosures: 1. List of Attendees
2. Licensee's Handout

cc w/encls: See next page

Calvert Cliffs Nuclear Power Plant
Unit Nos. 1 and 2

President
Calvert County Board of
Commissioners
175 Main Street
Prince Frederick, MD 20678

James P. Bennett, Esquire
Counsel
Baltimore Gas and Electric Company
P.O. Box 1475
Baltimore, MD 21203

Jay E. Silberg, Esquire
Shaw, Pittman, Potts, and Trowbridge
2300 N Street, NW
Washington, DC 20037

Mr. Bruce S. Montgomery, Director
NRM
Calvert Cliffs Nuclear Power Plant
1650 Calvert Cliffs Parkway
Lusby, MD 20657-4702

Resident Inspector
U.S. Nuclear Regulatory
Commission
P.O. Box 287
St. Leonard, MD 20685

Mr. Richard I. McLean, Manager
Nuclear Programs
Power Plant Research Program
Maryland Dept. of Natural Resources
Tawes State Office Building, B3
Annapolis, MD 21401

Regional Administrator, Region I
U.S. Nuclear Regulatory Commission
475 Allendale Road
King of Prussia, PA 19406

Mr. Joseph H. Walter, Chief Engineer
Public Service Commission of
Maryland
Engineering Division
6 St. Paul Centre
Baltimore, MD 21202-6806

Kristen A. Burger, Esquire
Maryland People's Counsel
6 St. Paul Centre
Suite 2102
Baltimore, MD 21202-1631

Patricia T. Birnie, Esquire
Co-Director
Maryland Safe Energy Coalition
P.O. Box 33111
Baltimore, MD 21218

Mr. Loren F. Donatell
NRC Technical Training Center
5700 Brainerd Road
Chattanooga, TN 37411-4017

Mr. Charles H. Cruse
Vice President, Nuclear Energy
Baltimore Gas & Electric Company
Calvert Cliffs Nuclear Power Plant
1650 Calvert Cliffs Parkway
Lusby, MD 20657

LIST OF ATTENDEES

BALTIMORE GAS AND ELECTRIC COMPANY

DECEMBER 14, 1999

NAME	ORGANIZATION
Alexander W. Dromerick	NRC/DLPM
Norton Shapiro	ABB CENP
Zeser Karoutas	ABB CENP
John Osborne	BGE
Matthew Kattic	BGE
Penney File	BGE
Ian Rickard	ABB CENP
George Smith, Jr.	ABB CENP
Muffet Chatterton	NRC/SRXB
Shih-Liang Wu	NRR/SRXB
Jeff Isakson	ABB CENP
Harold Scott	NRC/RES

Enclosure 1

Corrosion Behavior of OPTIN Cladding at Calvert Cliffs

Presented by Penney File

BGE

December 14, 1999

Enclosure 2

Purpose

- Describe Inspections and Observations
- Summarize Evaluation Supporting Operability of Current Cores
- Describe Approach for U1C15

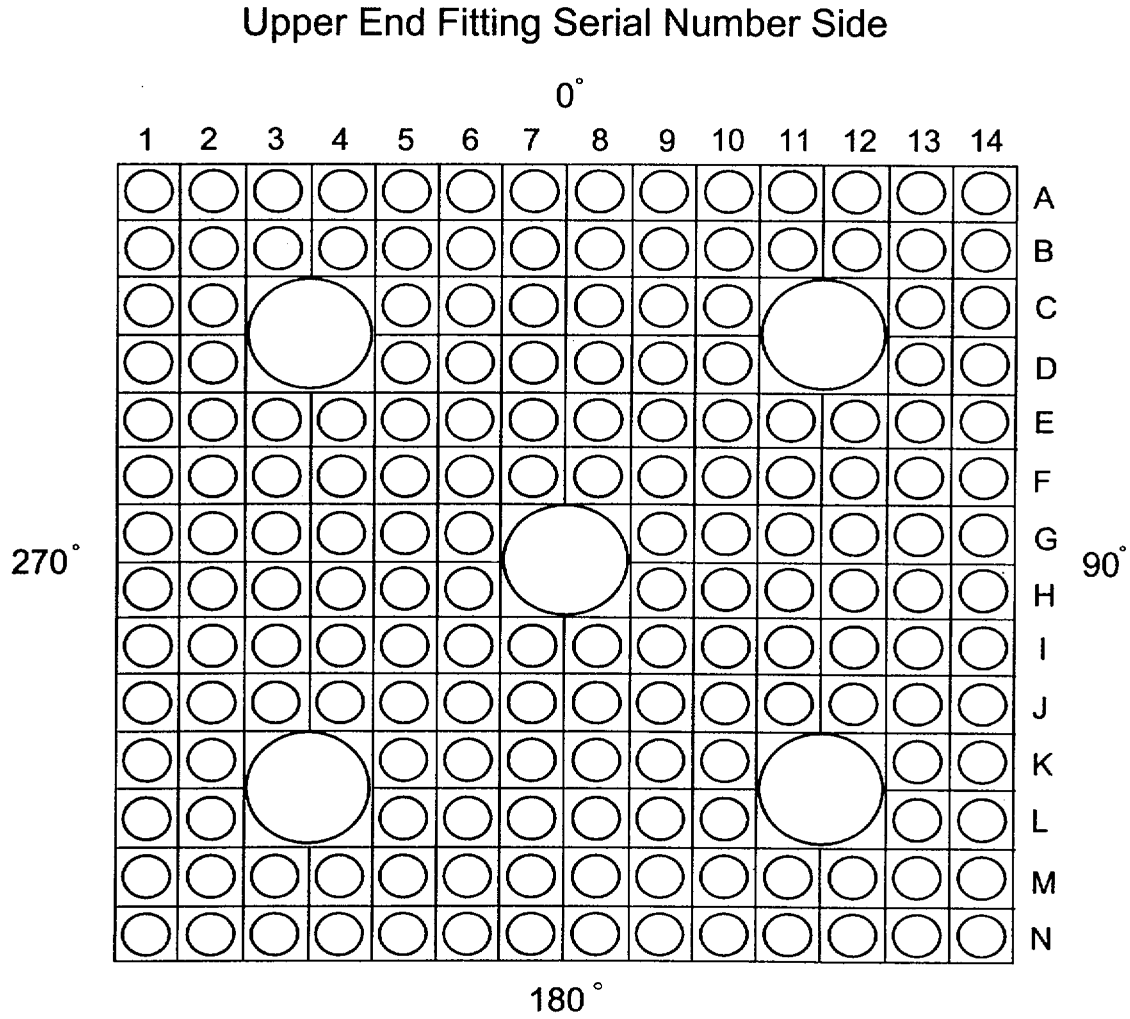
Outline

- Describe Inspections and Observations
- Describe Immediate Actions
- Describe Longer Term Actions
- Summarize

Calvert Cliffs Background

- 24 Month Cycles
- 650 EFPD
- Tcold - 546.5
- Thot - 592
- Average LHGR - 6.25 Kw/Ft
- Tech Spec Fr - 1.65
- High Duty - 2 24 Month Cycles
- Low Duty - 3 24 Month Cycles

Calvert Cliffs Fuel Assembly Schematic



Outline

- Describe Inspections and Observations
- Describe Immediate Actions
- Describe Longer Term Actions
- Summarize

July 1999 Initial Inspection Scope

- C2NT Test Assemblies Discharged in Spring 1999
  - 4 Assemblies Visually Examined
  - 1 Assembly Reconstituted to Allow ECT and Oxide Thickness Measurement [ ]
- Visual Examination of Discharged Assemblies to Characterize the Effects of Duty
  - C1 Batch N and P (4 total, Assembly Average Burnups [ ] GWD/MTU)
  - C2 Batch M and N (4 total, Assembly Average Burnups [ ] GWD/MTU)

High Duty Fuel Observations

- Oxide [ ]
- No Evidence of [ ]
- More Detailed Examination Required

Expanded Examination Scope

- 2 High Duty and 1 Low Duty Assembly Reconstituted to Allow Single Rod Exams
  - [ ] Measured to Characterize Oxide Thickness
  - [ ] Visually Examined to Characterize Appearance
- Visual Examination of [ ] High Duty Assemblies to Quantify Population of [ ]

Cladding Oxide Thickness Determination

- ECT Technique Used to Measure Liftoff From Base Metal
- Measurements Performed on Individual Rods After Removal From Assembly
  - Four Full Length Axial Traces Performed at 90° Azimuthal Orientations
  - Thickness Data for Each Trace Stored Digitally as a Function of Elevation (0.050 Inch Intervals)
- Data Reduction
  - Axial Traces Combined to Generate Composite
  - Maximum Circumferentially Averaged Oxide Thickness Calculated From Digital Composite as Running Average Over 1 Inch Interval (80 Measurements)

Low Duty Observations

- Three Cycle Assembly
- [ ]
- Measured Oxide [ ]
- No Blistering/Spalling

High Duty Observations

- Two Cycle Assemblies
- [ ]
- Accuracy of Oxide Predictions Dependent on [ ]
- Blistering/Slight Spalling Observed, [ ]

Blistering/Spalling

- Spalling Is a Process That Begins [ ]
- [ ] Progresses To Blistering
- Blistering Progresses To "Spallation"

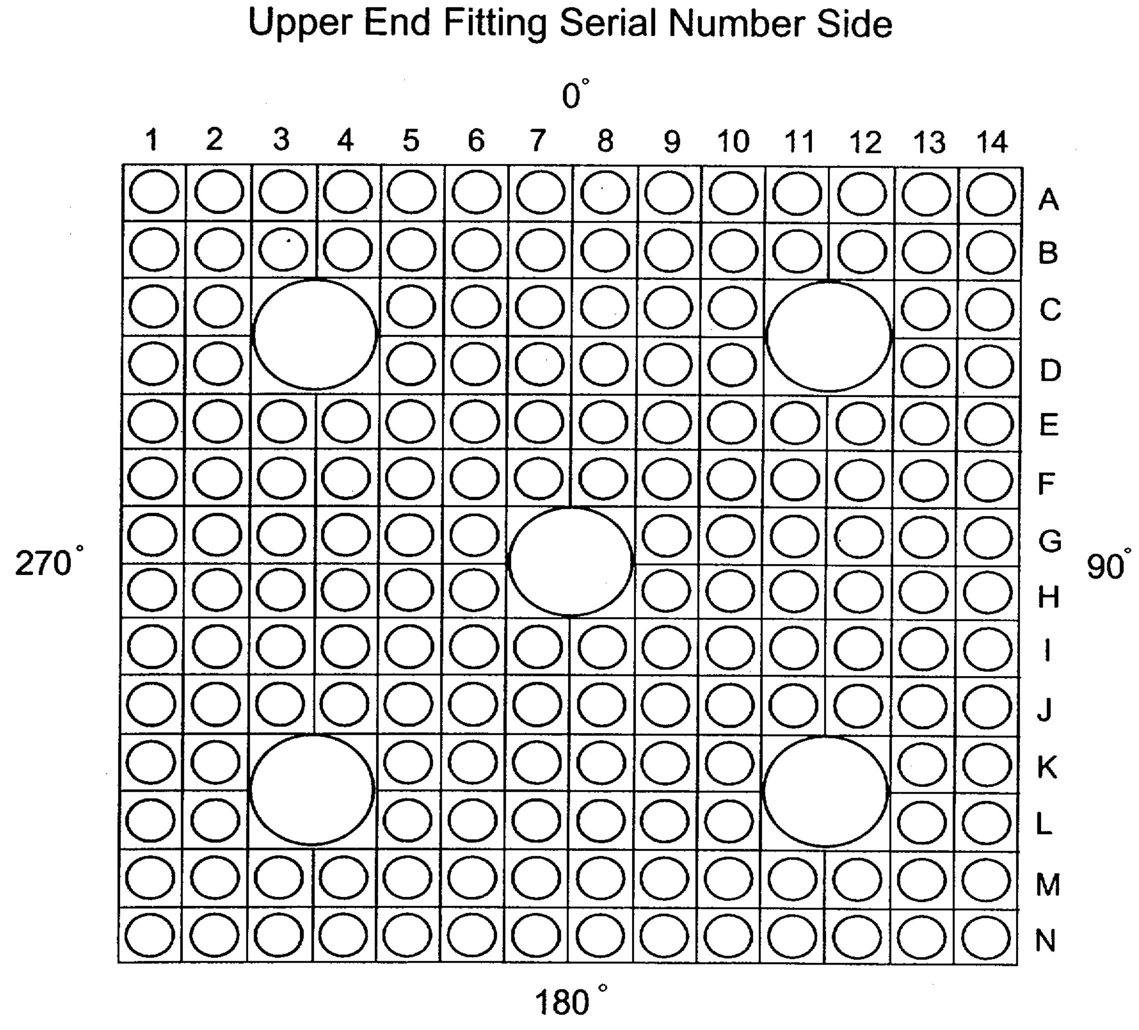
Photograph not provided in handout

High Duty Corrosion Results

Oxide Traces for Adjacent CC2N [ ] Rods

[ ]

Calvert Cliffs Fuel Assembly Schematic

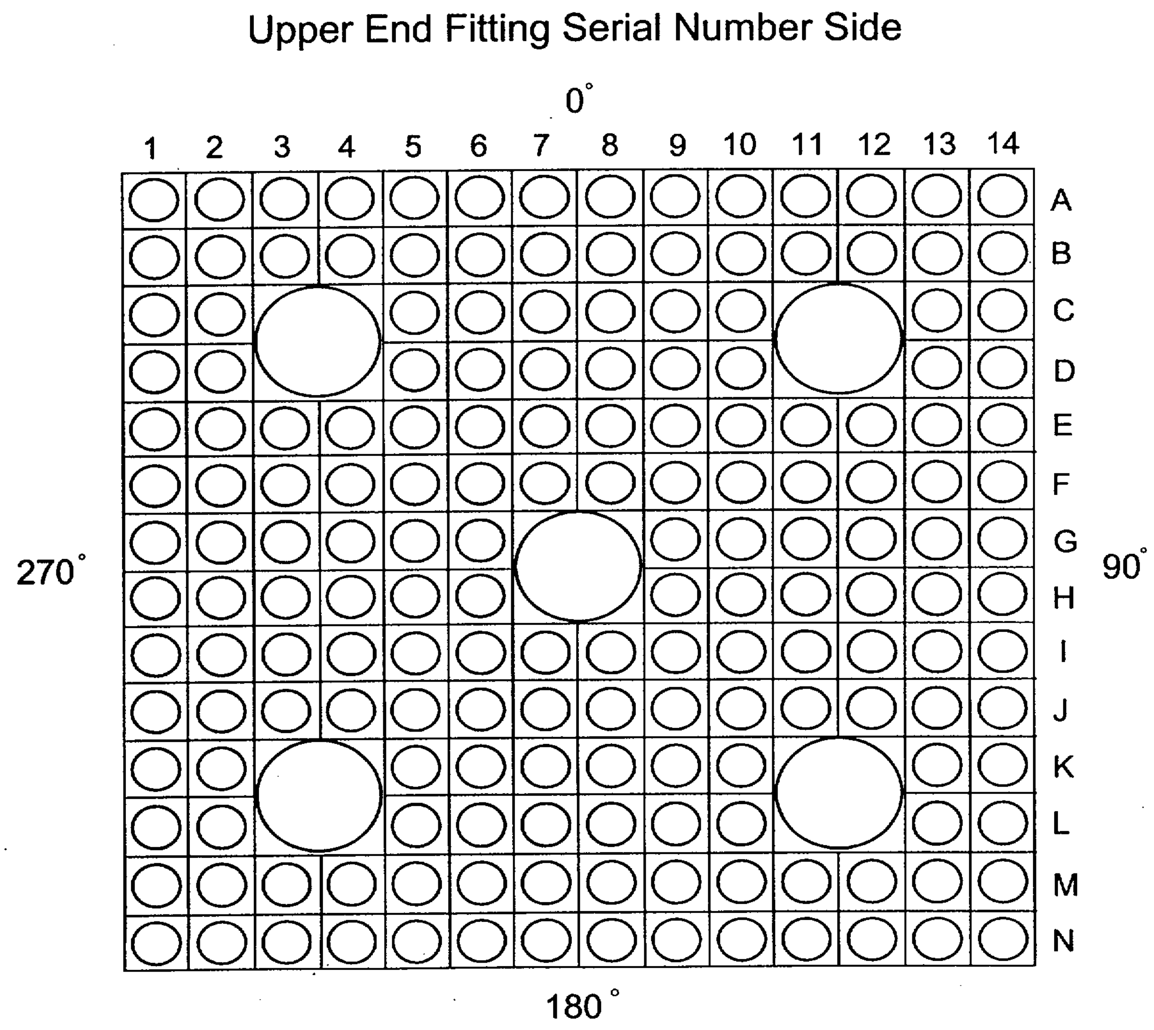


OPTIN Corrosion Performance in Calvert Cliffs-1 & 2

High Duty Blistering/Spalling

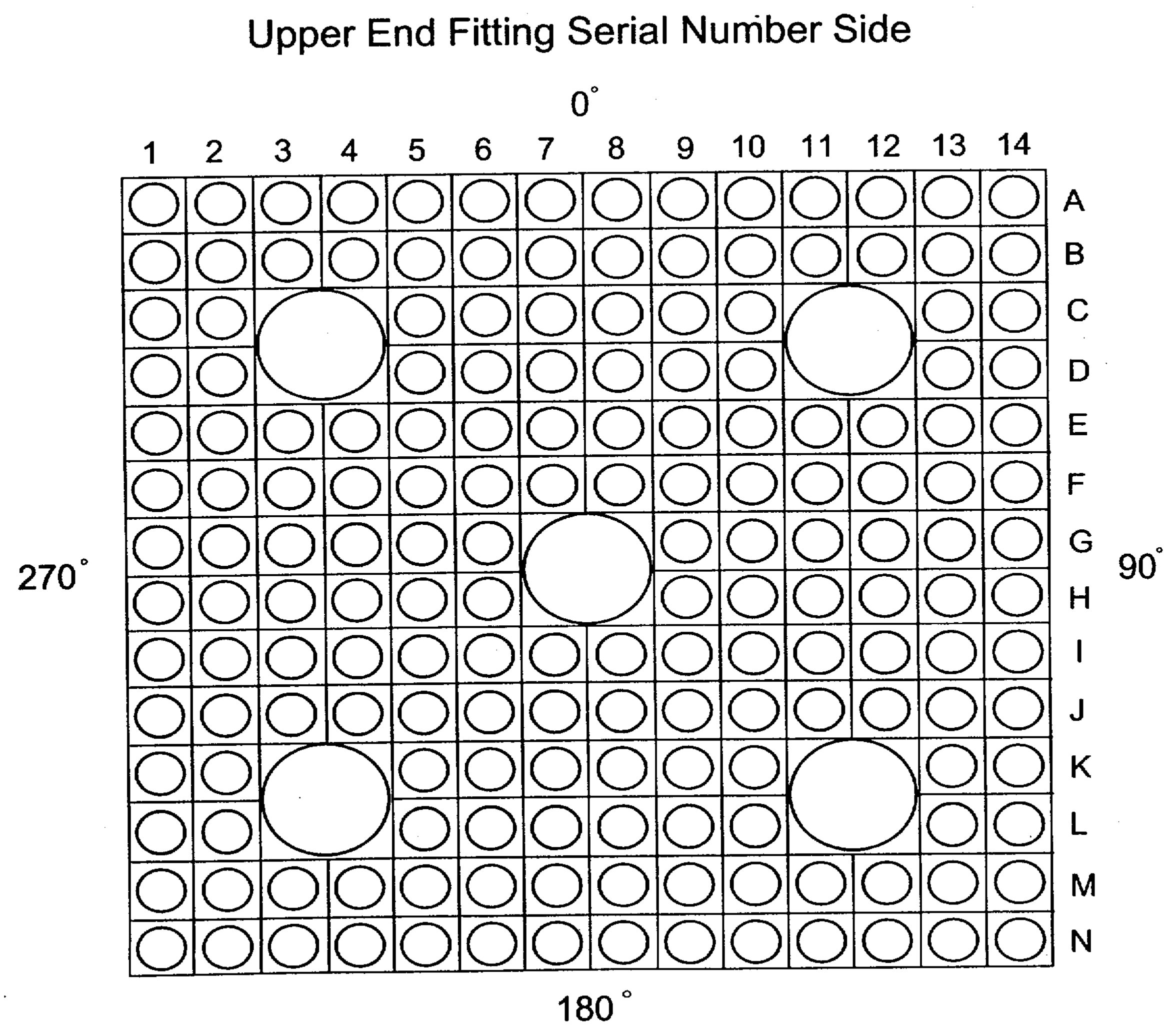
- Blistering/Spalling [ ]
- Behavior Observed on Rods With 57 Microns of Oxide at 51 GWD/MTU

Calvert Cliffs Fuel Assembly Schematic



Observed Blisters on [ ] Rods

Calvert Cliffs Fuel Assembly Schematic



Fraction of Examined [ ]

[ ]

Corrosion Performance of C2N High Duty Fuel Rods

Comparison of Measured to Predicted Oxide Using Current Model

Summary Of Observations

- Low Duty Fuel Exhibits Expected Corrosion Behavior
- High Duty Fuel Exhibits Variable Behavior
- Some Populations of Rods Exhibit Higher Than Expected Corrosion and Blistering/ Spalling Behavior

Outline

- Describe Inspections and Observations
- Describe Immediate Actions
- Describe Longer Term Actions
- Summarize

Immediate Actions Taken

- Voluntary LER
- Root Cause Evaluation Initiated
- Operability Evaluation Performed to Support Current Cycles of Operation

Root Cause Conclusions

- Factors Such as [ ] Not Identified as Primary Contributors
- Factors Affecting Fuel Duty (Time and Cladding Temperature) Are Primary Contributors

Factors Affecting Fuel Duty

- Improved Operating History
- Reduced RCS Flow Due to Plugged Steam Generator Tubes
- Rod Location Within The Assembly
- Rod Power and Adjacent Rod Power
- Subcooled Boiling
- T-H Effects Due to Geometry
- Others

Operability Evaluation

- No Concern For Normal Operation
- Addressed Accidents and Transients

Operability Evaluation - Accidents and Transients

- Effect of [ ]
- Effect of [ ]
- Effect of [ ]
- Bottom Line Operability Issue - [ ]

PROTOTYPE Test Rods

- Test Rods With High Tin Zr-4 Clad/Modified Pellet Designs
  - Irradiated for 5 Cycles, Discharged 1988
- [ ]
- Subset of Rods Examined in Hot Cell (Rod Average Burnups of [ ] GWD/MTU)
- Mechanical Property Tests Indicate

[ ]

Photograph not provided in handout

[ ] Evaluation for Operability

[ ]

Operability - Accidents and Transients

- [ ] Demand Calculated at [ ]
- Even Heavily Spalled Prototype Rod [ ]
- CC2N Rod Capability [ ]

[ ] in CC1 Prototype and CC2N Models

[ ]

[ ] for Prototype and CC2N Spalled Rods

[ ]

[ ] in CC1 Prototype and CC2N Models

Clad [ ]

[ ]

Total [ ] due to Spalling

Operability (Continued)

- Current Cycles - U1C14 and U2C13
- CC2M Fuel - 580/638 EFPD (U2C10/11)
- CC2N Fuel - 638/640 EFPD (U2C11/12)
- U1C13/C14 Fuel - 590/620 EFPD
- U2C12/C13 Fuel - 640/658 EFPD
- Key Parameters - [ ]

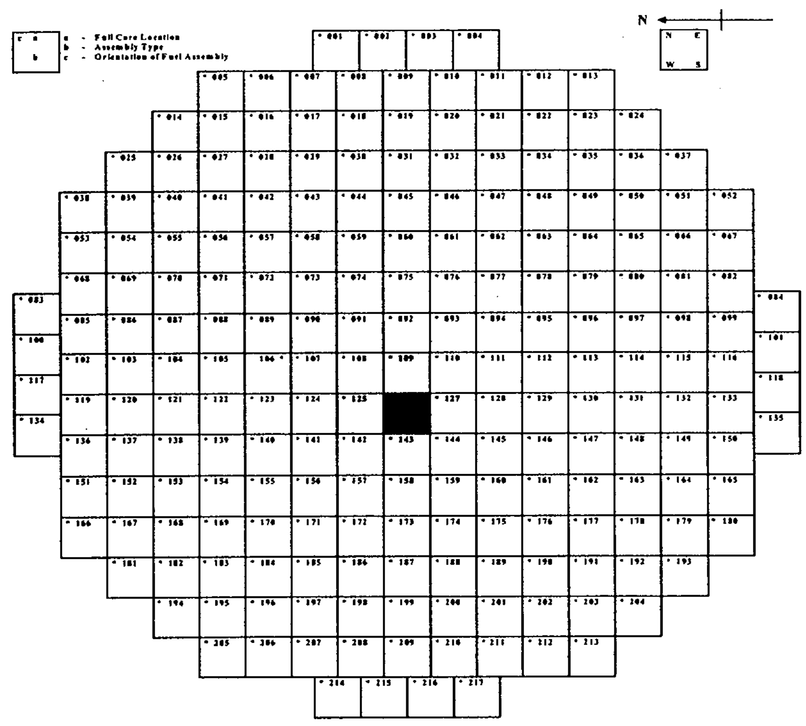
Fuel Duty Comparisons

- Fuel Duty Comparisons Were Made Between CC2N and Past & Current Batches
- A Preliminary Fuel Duty Model Was Developed by ABB CENP Which Uses an Improved Corrosion Model
- A Fuel Duty Index Was Evaluated Which is an [ ] Temperature and Time
- Results Show That Fuel Duties are Similar to CC2N for Current Cycles

Fraction of Examined [ ]

[ ]

Unit 2 Cycle 12 Core Schematic



High Duty Assembly (Second Cycle of Operation)

Calvert Cliffs Fuel Assembly Schematic

Summary of Operability Evaluation

- [ ] Demand Evaluated
- PROTOTYPE [ ] Show Heavily Spalled Rod [ ] Matches Demand
- [ ]
- Current Operating Cores Projected to Have Similar Fuel Duty to CC2N
- Conclusion - Current Cores are Operable

Outline

- Describe Inspections and Observations
- Describe Immediate Actions
- Describe Longer Term Actions
- Summarize

10CFR50.59 Approach for U1C15/U2C14

- Assess Fuel Duty Based on [ ]
- Evaluate Impact of Incremental Increase in Duty on Anticipated Corrosion Behavior Including Blistering/Spalling
- Ensure [ ]
- Acquire Data on CC1R Fuel at EOC14 (Spring 2000) to Further Characterize Phenomenon

Beyond U2C14

- Replacement Steam Generators
- Evaluate TURBO Assembly Design
- Pursue Advanced Cladding Alloy

Summary

- [ ]
- Current Cores Operable
- Subsequent Cores Will Be Handled Under 10CFR50.59
- Longer Term Actions Expected To Mitigate Problem

Questions

C1G006: PROTOTYPE ROD

[

]

Typical Lamination of ZrO_2 Layer[ ] **Photo 1**

C/G006 : PROTOTYPE ROD

[ ]

Typical Appearance of Region [ ]

Photo 2

C2N639 Rod M14 91 um

Photo 3

C2N639 ROD M14 91 μm

Photo 4

C2N618

180° FACE, SPAN 7

Photo 5