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

July 29, 1999

LICENSEE: Entergy Operations, Inc.

FACILITY: River Bend Station, Unit 1

SUBJECT: SUMMARY OF MEETING BETWEEN THE NUCLEAR REGULATORY COMMISSION (NRC) STAFF AND ENTERGY OPERATIONS, INC. (EOI), RIVER BEND STATION MANAGEMENT, JUNE 22, 1999

On Tuesday, June 22, 1999, a meeting was held between members of the NRC staff and representatives of EOI, the licensee for the River Bend Station (RBS). The purpose of the meeting was to permit representatives from RBS to brief the NRC staff on, and to discuss issues associated with, the root cause investigation into fuel cladding failures that occurred during the recent cycle 8 operation. A portion of the meeting involved discussions pertaining to proprietary information and was closed to the public. The meeting lasted approximately 5 hours.

The meeting began at 9:00 a.m. in the Commissioners' Hearing Room located at NRC Headquarters, Rockville, Maryland. A list of meeting attendees is provided as Enclosure 1 to this summary. EOI presented a nonproprietary information overview of their root cause investigation. Topics during this session included:

- Background
- Inspection Findings
- Licensee's Response
- Evaluation Approach
- Core Design
- Conclusions

EOI opened by characterizing the issue as (1) a higher-than-expected and non-uniform deposition of corrosion products on the fuel pins, and (2) the occurrence of fuel cladding perforations in several once-burned, higher heat flux fuel rod locations. A total of seven fuel bundles were discovered with cladding perforations, which correlated to the number of suspected failures suspected prior to the plant shutting down in April 1999. All seven bundles were "first burned" fuel coming from the "HGE" batch. The cladding perforations observed in these fuel bundles were attributed to an insulating thermal barrier failure mechanism.

Following an exchange of background information and initial inspection findings, EOI reviewed its organizational response, causal investigation approach, and various core design issues. EOI formed a root cause investigation team, comprising of members from EOI, General Electric (GE), Electric Power Research Institute (EPRI), and other independent consultants. The investigation was headed by Mr. Dan Pace, Director, Engineering (RBS).

EOI continued with a discussion on the various differences between Cycle 7 and Cycle 8 operations. Some of the differences included the removal of low cross-linked resins from the demineralizers, initiation of zinc injection into the primary water, use of the extended operating domain—Maximum Extended Load Line Limit Analysis (MELLA)—operating strategy, extended control blade sequence exchange intervals, and higher iron and copper concentrations in the reactor water than in previous cycles. This discussion was followed by an overview of various chemistry issues.

Based upon the information uncovered to date, as well as the conclusions drawn by EOI and outside consultants, EOI has determined that the most probable cause of the fuel cladding perforations was a result of "thermally-induced accelerated corrosion, due to the combined effects of elevated iron and copper deposits with a chemistry excursion early in the operating cycle." Consequently, EOI has decided to undertake the following actions:

1. Remove all once-burned fuel assemblies from the HGE batch;
2. Redesign the reactor core to accommodate a new reload batch for Cycle 9;
3. Change the RBS chemistry program to (a) reduce metals transport to the reactor, (b) improve chemistry monitoring capability, and (c) increase chemistry monitoring;
4. Cycle 9 will operate as a "short cycle" (approximately half of the normal 18-month operating cycle); and
5. RBS will perform confirmatory inspection during the ninth refueling outage.

The public portion of the meeting was concluded and members of the public were given the opportunity to provide comments to the NRC staff. A copy of the slides used during the public, nonproprietary session are provided as Enclosure 2. The meeting reconvened with a briefing on additional details, including information requested by EOI to be considered proprietary under Title 10 of the Code of Federal Regulations, Section 2.790. The briefing included presentations by EOI and GE.

Robert J. Fretz, Project Manager, Section 1
Project Directorate IV & Decommissioning
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-458

Enclosures: 1. List of Meeting Attendees
2. EOI Slide Presentation

cc w/encls: See next page

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LIST OF ATTENDEES
NRC - EOI MEETING ON FUEL INTEGRITY ISSUES
JUNE 22, 1999

NRC Staff

Stuart Richards	Project Director, Project Directorate IV & Decommissioning
Dale Powers	Chief, Engineering and Maintenance Branch, Region IV
Robert Gramm	Section Chief, Project Directorate IV, Section 1
Ralph Caruso	Section Chief, Reactor Systems Branch
Robert Fretz	RBS Project Manager, Project Directorate IV, Section 1
Muffet Chatterton	Nuclear Engineer, Reactor Systems Branch
Shih-Lang Wu	Nuclear Engineer, Reactor Systems Branch
Joseph Donoghue	Reactor Engineer, Reactor Systems Branch
Anthony Ulses	Nuclear Engineer, Reactor Systems Branch
Edward Kendrick	Reactor Engineer, Reactor Systems Branch
Ronald Framm	Reactor Engineer, Reactor Systems Branch
H. F. Conrad	Senior Materials Engineer, Materials and Chemical Engineering Branch
K. Parczewski	Senior Chemical Engineer, Materials and Chemical Engineering Branch
Edward Goodwin	Senior Reactor Engineer, Events Assessment Branch
Robert Spence	Reactor Systems Engineer, Office of Nuclear Regulatory Research
Carl Beyer	NRC Consultant, Pacific Nothwest Laboratory

Entergy Operations, Inc.

Fred Titus	VP, Engineering (Corporate)
Dan Pace	Director, Engineering (RBS)
Dwight Mims	RBS Plant Manager
Rick King	Director, Nuclear Safety and Regulatory Affairs
Brian Thumm	Licensing Engineer
David Smith	Senior Engineer
Jerome Holmes	Manager, Radiation Protection/Chemistry
C. B. Franklin	Manager, Nuclear Engineering (Corporate)
Dean Burnett	Chemistry Specialist

General Electric Corporation

G. A. Watford	Manager, Nuclear Fuel Engineering
G. A. Potts	Fuel Performance
Robert Cowan	Chief Technologist

Public Observers

David Stellfox	McGraw-Hill

ENCLOSURE 1

ENCLOSURE 2

ENTERGY OPERATIONS, INC.

SLIDE PRESENTATION

Chemistry Program

- Based on BWR Water Chemistry Guidelines
- Monitors iron and copper parameters
  - Reactor water
  - Feedwater / condensate chemistry
- Identified an increase in feedwater metals average
  - Higher than in previous cycles
  - Within guidelines
  - Related to resin usage

Chemistry Review

- October 15-17, 1997 (during refueling outage 7 (RF-7))
  - Conductivity excursion (6.1 µS/cm peak)
  - Associated with chemicals introduced by residual heat removal (RHR) heat exchanger cleaning
- October 24-26, 1997 (startup from RF-7)
  - Conductivity excursion (0.946 µS/cm peak)
  - Contaminants in extraction/drain piping

Chemistry Summary

- Chemistry parameters monitored consistent with BWR Guidelines
- High iron and copper
- Chemical excursion at startup from previous outage appears to have added additional corrosion products

BWR Operating Parameter Comparison

- Extensive comparisons to operating BWRs
  - Core design/operation
  - Chemistry
  - Plant configuration
- River Bend core design and operation consistent with other operating BWRs
- Average operating parameters within established limits

Cause of Fuel Clad Perforations

Thermally-induced accelerated corrosion, due to the combined effects of elevated iron and copper deposits with a chemistry excursion early in the operating cycle

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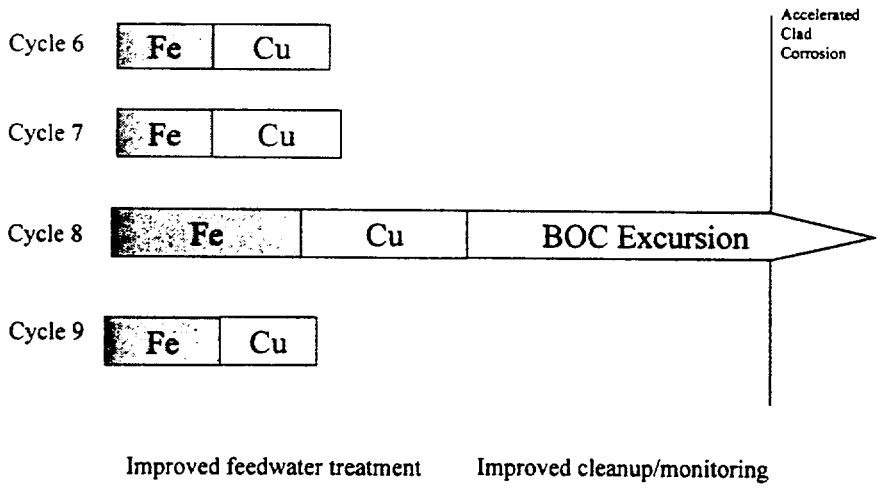
Cause of Fuel Clad Perforations



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Summary of Key Actions

- Conservatively discharged all once burned fuel assemblies (HGE)
- Additional conservatism in core design
- Short operating cycle for Cycle 9
- Reducing metals transport to reactor
- Improving chemistry monitoring capability
- Increasing chemistry monitoring
- Performing confirmatory inspections during the ninth refueling outage

Cycle 9 Core Design

- Designed within approved methodologies
- Removed bundles with clad perforations
- Cycle 9 core
  - Discharged once burned batch (HGE)
  - Planned reload batch (IGE)
  - New reload batch (IGE+)
  - Twice burned batch (GGE)
  - Fuel pool batch (8x8)
- Startup by July 1; Operate until Spring 2000 (short cycle)

River Bend Station
Fuel Recovery

Overview

June 22, 1999

Overview

- Background
- Contingency Planning Prior to the Eighth Refueling Outage (RF-8)
- Inspection Findings
- Response to Inspection Findings
- Evaluation Approach
- Core Design
- Conclusions

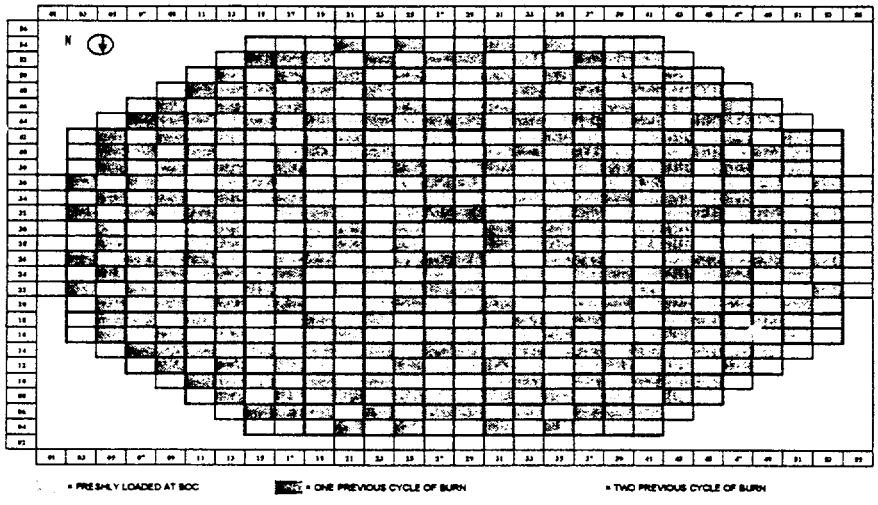
Problem Description

- A higher-than-expected deposition of corrosion products was observed on the fuel pins
- Clad perforations were observed in several once-burned, higher heat flux fuel rod locations

General Core Design

- 624 bundles in the core
  - 212 total HGEs - Once burned bundles (GE-11)
    - Fresh fuel beginning of Cycle 8
  - 232 total GGEs - Twice burned bundles (GE-11)
  - 180 total YJ8s - Thrice burned bundles (GE-8)
- Scatter bundle loading to levelize the power
- Approximately one third of the core is replaced each refueling

River Bend Core Map



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Fuel Performance Summary

- Good past fuel performance prior to Cycle 8
- No fuel clad perforation in over 1400 days of operation
- No previous corrosion-related clad perforations
- First fuel clad perforation identified Sept. 18, 1998, during Cycle 8
- Seven fuel bundles total suspected before end of cycle (EOC)

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Suppression Testing and Mitigation Actions

- Prompt detection
- Prompt identification of core location
- Effective power suppression
- Additional detection instrumentation installed
- Detailed monitoring for fuel washout
- Monitored levels less than 5% (peak) of the Technical Specifications (TS) offgas activity limit

Pre-RF-8 Contingency Planning

- Established fuel team
- Identified credible causes
- Developed 39 action plans to address each potential cause of the clad perforations
- Pre-staged material, personnel, and equipment where possible for "top 5 causes" (i.e., most likely suspects prior to outage)

RF-8 Initial Inspection Findings

- Shutdown unit for RF-8 on 4/3/99
- Performed 100% core sipping
- 7 bundles with clad perforations - all identified during Cycle 8
- All were "first burned" fuel (HGE batch)
- Heavier-than-expected non-uniform crud patterns
- Result : clad perforation mechanism observed was attributed to an insulating thermal barrier

"CRUD"

- An industry term for corrosion and wear products
- Activated particles are referred to as "crud"
- Crud is present in all nuclear plants
- In a boiling water reactor (BWR), corrosion products plate out in the core because they do not carry over in the steam

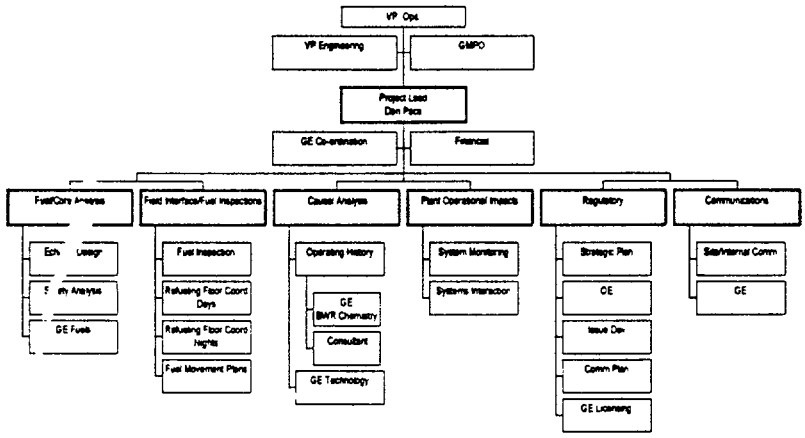
Situation Appraisal

- Expanded plan for broader response
  - Required core re-design activities
  - Determine source and impact of crud
  - Defined station interface

Response to Initial Inspection Findings

- Formed response organization
  - Multi-disciplined (Entergy, General Electric, Electric Power Research Institute (EPRI), others)
- Mobilized independent experts / oversight
- Outlined rigorous cause analysis process

Organization Structure



Independent Reviews / Oversight

- EPRI - Fuel Corrosion
- NWT Corporation - Radiochemistry
- G. Sossi - Core Design and Licensing
- Independent Lab - Materials
- Corrective Action Review Board
- Facility Review Committee
- Safety Review Committee
- S. Levy - Entergy Nuclear Committee of the Board of Directors

Evaluation Approach

- Fuel bundle inspection and material sampling
- Fuel operating experience review
- RBS operating history review
- BWR operating parameters comparison

RF-8 Fuel Bundle Inspection

- Crud loading - more than normal cycle
- Crud distribution - visual appearance
  - Heaviest: once-burned (HGE)
  - Lighter: twice-burned (GGE)
  - Lightest: thrice-burned (YJ8)
- Crud and corrosion correlate to power distribution

Fuel Operating Experience Review

- Foreign and domestic
- Various fuel types
- Search for similar conditions
- Parallel effort by General Electric
- Perspective
  - Foreign and domestic occurrences
  - Multiple causes

Fuel Operating Experience Review

- Results
  - Good team insights
  - No fuel performance experience parallels the River Bend condition
  - Fuel clad perforations typically caused by the combination of several factors
  - Broad response treats symptoms effectively
  - Root cause conclusions typically longer term

RBS Operating History Review

- Cycle 8 changes at River Bend
- Chemistry program
- Chemistry excursions

Cycle 8 Changes at River Bend

- Removed low cross-linked resins
- Injected depleted zinc
- Extended operating domain - Maximum Extended Load Line Limit Analysis (MELLLA)
- Extended control blade sequence exchange intervals
- Observed higher iron and copper values than in previous cycles

Conclusions

- Quickly and accurately identified and suppressed perforated fuel rods during Cycle 8
- Extensively investigated to determine the cause and to prevent recurrence
- Determined that an insulating thermal barrier of crud caused accelerated fuel rod corrosion
- Ultimately bounded the cause in order to attain reasonable assurance that no similar fuel clad perforations will occur
- Concluded that River Bend is safe to startup and operate