NRC FORM 366 (7-77)

U. S. NUCLEAR REGULATORY COMMISSION

LER 79-01/1T 2/28/79

LICENSEE EVENT REPORT

CONTROL BLOCK: (1) (PLEASE PRINT OR TYPE ALL REQUIRED INFORMATION)

0 1 | C T H N P 1 (2) | 0 0 - 0 0 0 0 0 - 0 0 (3) | 4 1 1 1 1 (4) | (5)

LICENSEE CODE | LICENSE NUMBER | LICENSE TYPE | CAT

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0 1 | REPORT SOURCE L (6) | 0 5 0 - 0 2 1 3 (7) | 0 2 1 4 7 9 (8) | 0 7 2 4 7 9 (9)

DOCKET NUMBER | EVENT DATE | REPORT DATE

EVENT DESCRIPTION AND PROBABLE CONSEQUENCES (10)

0 2 | See Attachment

0 3 |

0 4 |

0 5 |

0 6 |

0 7 |

0 8 |

0 9 | SYSTEM CODE R C (11) | CAUSE CODE E (12) | CAUSE SUBCODE C (13) | COMPONENT CODE F U E L X X (14) | COMP. SUBCODE Z (15) | VALVE SUBCODE Z (16)

(17) LER/RO REPORT NUMBER: EVENT YEAR 7 9 (21-22) | — (23) | SEQUENTIAL REPORT NO. 0 0 1 (24-26) | / (27) | OCCURRENCE CODE 9 9 (28-29) | REPORT TYPE X (30) | — (31) | REVISION NO. 1 (32)

ACTION TAKEN C (18) | FUTURE ACTION X (19) | EFFECT ON PLANT Z (20) | SHUTDOWN METHOD Z (21) | HOURS 0 0 0 0 (22) | ATTACHMENT SUBMITTED Y (23) | NPRD-4 FORM SUB. N (24) | PRIME COMP. SUPPLIER X (25) | COMPONENT MANUFACTURER Z 9 9 9 (26)

CAUSE DESCRIPTION AND CORRECTIVE ACTIONS (27)

1 0 | See Attachment

1 1 |

1 2 |

1 3 |

1 4 |

1 5 | FACILITY STATUS H (28) | % POWER 0 0 0 (29) | OTHER STATUS (30) N/A | METHOD OF DISCOVERY C (31) | DISCOVERY DESCRIPTION (32) See Attached

1 6 | ACTIVITY RELEASED Z (33) | CONTENT OF RELEASE Z (34) | AMOUNT OF ACTIVITY (35) N/A | LOCATION OF RELEASE (36) N/A

1 7 | PERSONNEL EXPOSURES NUMBER 0 0 0 (37) | TYPE Z (38) | DESCRIPTION (39) Fuel failures have resulted in increased plant radiation levels.

1 8 | PERSONNEL INJURIES NUMBER 0 0 0 (40) | DESCRIPTION (41) N/A

1 9 | LOSS OF OR DAMAGE TO FACILITY TYPE Z (42) | DESCRIPTION (43) N/A

2 0 | PUBLICITY ISSUED Y (44) | DESCRIPTION (45) Articles in Hartford Courant and Middletown Press

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UPDATE ON CY BATCH 8 FUEL FAILURE EVALUATION

Reference

1. Connecticut Yankee Atomic Power Company Licensee Event Report for Reportable Occurrence LER 79-01/1T, CYH 79-093, February 28, 1979.

I. INTRODUCTION

The purpose of this report is to provide an update to the Licensee Event Report of Reportable Occurrence LER 79-01/1T[1] for the Connecticut Yankee Batch 8 fuel failure analysis program. Although the cause of the CY Batch 8 fuel failures has not yet been conclusively established, several additional investigative efforts have been completed. Actions have been taken to prevent similar recurrences of failures, and results previously reported as preliminary have been verified. A possible failure mechanism has been identified and efforts are currently underway which will hopefully either substantiate the cause or reveal new information which may identify another failure mechanism. The results of completed efforts, the current status of the investigations, planned additional efforts and tentative conclusions are summarized briefly below.

II. ADDITIONAL INVESTIGATIONS AND ANALYSES COMPLETED

Table 1 outlines the scope of the CY Batch 8 fuel failure analysis program and also indicates the status of the various efforts. As indicated thereon, all the short-term efforts and some of the medium-term efforts have been completed.

Short Term Efforts:

The fuel sipping and visual exam results were reported in Reference 1. Reviews of fuel sipping and visual exam results by the Plant Operations Review Committee and the offsite Nuclear Review Board have been completed, and general concurrence has been indicated with the current program. Specific operating events from past cycles were reviewed, with the resulting information factored into other analyses. Meetings were held with various supplier organizations as well as outside consultants to help define appropriate action to identify the failure cause and initiate remedial action to prevent subsequent failures in future operating cycles. The efforts resulted in Interim Power Ascension Restrictions to limit the rate of plant power increases until the cause of the Batch 8 fuel failures is better defined. The restrictions are based in large part on current zircaloy clad fuel recommendations and the known differences in creep response characteristics between zircaloy and stainless steel cladding.

Medium Term Efforts:

More recent efforts have included investigations into archive samples, design, and manufacturing records to determine what, if any, differences exist in the Batch 8 fuel relative to previous batches which would have led to the observed failures. Included in this investigation was a review of available manufacturing information, specifications, Q.A. records, and as-built data. Specifications and drawings checks for the pellet, cladding, and fuel rods for Batches 7, 8 and 9 indicate that all dimensions and parameters, as well as specification requirements that could relate to in-reactor performance, have remained unchanged. Therefore, changes in fuel design can be ruled out as a cause for the Batch 8 failures.

Available as-built data and manufacturing information on Batches 7, 8 and 9 were also examined. Although certain significant differences distinguish Batch 8 fuel pellets and cladding from other batches, none of these are currently felt to be of sufficient substance to have caused the failures. The pellets are unique in that they were manufactured by British Nuclear Fuel Limited (BNFL) using a controlled porosity (CONPOR) process. However, no problems or deficiencies have been identified with the pellets which could have caused the failures. However, cladding contamination and end weld discrepancies have been identified. The clad contamination and end weld discrepancies were corrected during the fabrication campaign and specification requirements were met. Examination of manufacturing data on the four visually failed fuel assemblies indicated eleven different tubing lots and four different pellet lots were involved in fourteen failed rods. Thus the failures cannot be attributed to one particular lot of fuel or cladding.

The examination of manufacturing records also revealed that there are six Batch 9 fuel assemblies still in the core which contain a total of 162 fuel rods with residual BNFL fuel pellets. However this represents less than one percent of the fuel in the core.

BNFL has conducted a review of the CY Batch 8 fuel operating history, in particular, the departures from steady state full power operation. The most significant departure from such steady state full power operation was a 10-day period of operation at ~65% power towards the end of Cycle 7. Using a rough estimate of the irradiation history, the performance of Batch 8 fuel in CY was analyzed using the SLEUTH-SEER 77 fuel performance computer code. BNFL has concluded that the failures in this batch of fuel could have been caused by the power ramp near the end of Cycle 7 following the reduced power operation. Excessive local clad strains could have been produced which may have led to the observed defects. Power ascension restrictions analogous to those presently in effect were not existent at that time. Additional efforts, which are outlined below, are required to either substantiate or refute this postulated failure mechanism.

A statistical analysis of the CY I-131 coolant activity data leads to a somewhat contradictory conclusion. This analysis was conducted to determine if the Batch 8 fuel failure-time distribution pattern was of a chance or random nature, or of a "wear out" nature. Plotting the primary coolant activity data on a Weibull Failure-Time Distribution plot demonstrated that infant mortality and random event failures are not significant, whereas a very definite "Wear-Out" or "Life-Limited" nature is indicated near end of Cycle 7 and thereafter. This wear-out characteristic could be indicative of either design deficiencies or component defects. Further investigations are required to pinpoint the cause and reconcile "apparent" discrepancies with the BNFL scenario.

III. CURRENT STATUS

The coolant activity for Connecticut Yankee Cycle 9 is being closely monitored to provide an early indication of fuel integrity and possible deterioration of performance. The Iodine activity levels are currently significantly below those at the end of Cycle 8, lending confidence that most, if not all, of the defective assemblies have been removed from the core.

In view of the visual appearance characteristics of the CY failed fuel rods, the increase in coolant activity after certain plant operational events, and the success of operational restrictions in mitigating Pellet-Clad Interaction (PCI) type fuel failures in zircaloy clad plants, Interim Power Ascension Restrictions were made before start of Cycle 9 to limit the rate of plant power increases until the cause of the Batch 8 fuel failures could be better defined. These restrictions will remain in effect as a precautionary measure until the mechanism of the Batch 8 fuel defects is better understood or new information becomes available which would indicate their modification or elimination.

At the present time, the BNFL predicted operational event scenario, possibly combined with other unidentified causes, is the most plausible explanation of the CY Batch 8 fuel failures. CYAPCO recognizes that under this scenario the fuel in the core could be as susceptible to operationally induced failures as the Batch 8 fuel. Therefore, the following action has been taken to preclude the possibility of a recurrence of similar fuel failures. Additional calculations have been performed by BNFL to more completely define plant operational maneuvers which could lead to subsequent clad deterioration. A power-time operating map has been generated which defines the maximum time period of operation allowed at specified reduced power levels from which the plant may subsequently be restored to full power without restricting the ramp rate. Reduced power operation for longer times would require an extremely slow ramp back to full power. Additional operating restrictions have been imposed based on these calculations which outline action to be taken following extended operation at reduced power in order to preclude potential fuel failures for future plant power maneuvers.

Information currently available is not considered adequate to conclusively verify the cause of the Batch 8 failures. Additional efforts, described below, are therefore underway or under consideration which are intended to provide information on reasonably short schedules which will hopefully either substantiate the current failure scenario, or provide evidence for a different one.

IV. ADDITIONAL EFFORTS UNDERWAY AND ALTERNATIVE PLANS

Current and Planned additional examinations and studies are summarized on Table 2. The planned archive examinations include both pellet and clad determinations. Clad grain size determinations would provide clues to any potential stress corrosion susceptibility. Pellet grain size and pore size determinations would provide clues to in-reactor fuel densification and swelling behavior.

Pellet thermal simulation or resintering tests are planned to provide direct side-by-side densification information for fuel from different batches (and manufacturers) resintered under identical conditions. Poolside rod diameter measurements are intended to provide supplementary information on in-reactor densification and fuel pellet swelling behavior. These measurements are primarily intended to rule out gross swelling as a failure cause. Initial measurements were made in May 1979, and the data are currently being assessed.

Additional analytical efforts are also underway. These include both independent modeling studies of CY operational power events, as well as efforts directed towards benchmarking the BNFL SLEUTH-SEER code. The benchmarking efforts are directed towards providing additional confidence in the BNFL code's predictive capabilities, and will hopefully include comparisons between code predictions and measured test results or results from other operating commercial power plants. Independent calculational results from either in-house COMETHE III K analysis, or consultants calculations possibly using other codes, may yield confirmatory results of predicted high clad strain rates, or if not, provide other insights into potential different failure causes.

When the above efforts are completed, the situation will be reassessed to determine if additional efforts are necessary. If information to define the cause of the failures cannot be adequately established from current and planned programs, additional efforts would be necessary to protect against future occurrences of such fuel failures, so alternative options would be evaluated. These options could include both, additional poolside examinations such as detailed periscope visual exams, rod by rod profilometry, eddy current tests, ultrasonic testing, and detailed hot cell metallography.

V. SUMMARY AND CONCLUSIONS TO DATE

The fuel performance in Connecticut Yankee Cycle 9 appears to be satisfactory to date, and current levels of coolant activity indicate that most, if not all, defective assemblies have been removed from the core. Although the cause of the CY Batch 8 fuel failures has

not yet been conclusively established, much additional information has been gained and ongoing investigative programs are continuing to yield new information. Changes in fuel design have been ruled out as a cause for the Batch 8 failures. However, the characteristics of the as-fabricated fuel from the different vendors is still being evaluated. A rather unique operating event has been identified as a plausible cause. Additional efforts are required to substantiate this possible failure cause, or to reveal new information which may identify another failure cause. Ongoing or planned efforts are identified above which will hopefully provide the required information. Should these efforts prove inadequate, alternative plans are available which may be undertaken after a subsequent reassessment of the situation. Actions identified herein are felt to provide adequate protection against future occurrences of similar fuel failures during the interim period until the cause of the Batch 8 failures is more conclusively established.

TABLE 1

CY FAILURE ANALYSIS PROGRAM

	Status		
	Under Consideration	Initiated On-Going	Complete
I. Short Term			
1. Fuel Sipping			x
2. Visual Exams (Poolside, TV, In-Containment Periscope)			x
3. PORC & NRB Review (Concurrence with recommended action)			x
4. Operational Record Review			x
5. NU Initial Analysis/Power Ascension Restrictions			x
II. Medium Term			
1. QA Records Check and Archive Search			x
2. Outside Consultation Assistance		x	
3. MIT Performance Evaluations		x	
4. BNFL Preliminary Analysis		x	
5. Archive Examinations		x	
6. Thermal Simulation Tests		x	
7. In-House Modeling Studies		x	
8. Poolside Examinations (Rod Diameter Measurements)		x	
9. Cycle 9 Coolant Activity Tracking		x	
III. Contingency Longer Term Possibilities			
1. Periscope Visual Exams (Fuel Pool)	x		
2. Additional Poolside Examinations (ECT, UT)	x		
3. Hot Cell Metallography	x		
4. Fuel Design Changes	x		

TABLE 2

CURRENT AND PLANNED ADDITIONAL EFFORTS

(PHASE II)

1. ARCHIVE EXAMINATIONS
   - A. CLAD GRAIN SIZE DETERMINATION
   - B. PELLET GRAIN SIZE AND PORE SIZE DETERMINATION

2. THERMAL SIMULATION TESTS
   - A. PELLET DENSIFICATION CHARACTERISTICS (RESINTER TESTS)
   - B. IN-REACTOR DATA VERIFICATION

3. MODELING STUDIES
   - A. COMETHE VERSION III K CALCULATIONS (EPRI ASSISTANCE)
   - B. DISCUSSION OF FOLLOW-UP RESULTS WITH BNFL
   - C. MIT PERFORMANCE EVALUATIONS

4. POOLSIDE FUEL ROD DIAMETER DETERMINATIONS AND ASSESSMENT

REASSESS SITUATION

EVALUATE ADDITIONAL OPTIONS

UNDERTAKE ADDITIONAL EFFORTS IF REQUIRED