WOLF CREEK
NUCLEAR OPERATING CORPORATION

Otto L. Maynard
Vice President Plant Operations

April 15, 1993
WO 93-0080

U. S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Mail Station P1-137
Washington, D. C. 20555

Subject: Docket No. 50-482: Licensee Event Report 93-004-00

Gentlemen:

The attached Licensee Event Report (LER) is being submitted pursuant to 10 CFR 50.73(a)(2)(ii) concerning a significant degradation of the fuel cladding.

Very truly yours,

Otto L. Maynard
Vice President
Plant Operations

OLM/jan

Attachment

cc: W. D. Johnson (NRC), w/a
J. L. Milhoan (NRC), w/a
G. A. Pick (NRC), w/a
W. D. Reckley (NRC), w/a

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NRC Form 366 (9-83)

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES: 8/31/88

LICENSEE EVENT REPORT (LER)

FACILITY NAME (1)	DOCKET NUMBER (2)	PAGE (3)
Wolf Creek Generating Station	0 5 0 0 0 4 8 2	1 OF 1 4

TITLE (4): Grid-To-Rod Fretting Results In Broken Fuel Rod

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MONTH	DAY	YEAR	FACILITY NAMES	DOCKET NUMBER(S)
0 3	1 6	9 3	9 3	0 0 4	0 0	0 4	1 5	9 3		0 5 0 0 0
										0 5 0 0 0

OPERATING MODE (9): 6
POWER LEVEL (10): 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR §: (Check one or more of the following) (11)

	20.402(b)		20.405(c)		50.73(a)(2)(iv)		73.71(b)
	20.405(a)(1)(i)		50.36(c)(1)		50.73(a)(2)(v)		73.71(c)
	20.405(a)(1)(ii)		50.36(c)(2)		50.73(a)(2)(vii)		OTHER (Specify in Abstract below and in Text, NRC Form 366A)
	20.405(a)(1)(iii)		50.73(a)(2)(i)		50.73(a)(2)(viii)(A)		
	20.405(a)(1)(iv)	X	50.73(a)(2)(ii)		50.73(a)(2)(viii)(B)		
	20.405(a)(1)(v)		50.73(a)(2)(iii)		50.73(a)(2)(x)		

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER
Kevin J. Moles - Manager Regulatory Services	316 364-8831

COMPLETE ONE LINE FOR EACH COMPONENT FAILURE DESCRIBED IN THIS REPORT (13)

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO NPRDS
X	AC	ROD	W120	N					

SUPPLEMENTAL REPORT EXPECTED (14)

☐ YES (If yes, complete EXPECTED SUBMISSION DATE) ☒ NO

EXPECTED SUBMISSION DATE (15): MONTH / DAY / YEAR

ABSTRACT (Limit to 1400 spaces, i.e., approximately fifteen single-space typewritten lines) (16)

On March 16, 1993, at 1045 CST, during fuel off-load operations following operating Cycle 6, it was discovered that a broken fuel rod segment, approximately 11-12 inches in length, was protruding out of fuel assembly F67 at core position H-6. Inspection activities resulted in the discovery of additional defective fuel rods in fuel assemblies F43, F54, and F67.

From the various investigations and evaluations conducted, grid-to-rod fretting has been identified as the principle failure mechanism. Extensive investigations into previously identified (i.e., following Cycle 5) fuel defects and the current evaluations have been indeterminate in identifying the exact root cause(s) for this failure mechanism. However, fluid elastic instability of the fuel rods in the reactor core is considered to be a potential cause of the grid-to-rod fretting condition.

PLANT CONDITIONS AT TIME OF EVENT

Mode 6, Refueling

Reactor Coolant System Pressure - 0 pounds per square inch gauge

Reactor Coolant System Temperature - less than 100 degrees Fahrenheit

Reactor Coolant System Level - 23 feet above the Reactor Vessel Flange

BASIS FOR REPORTABILITY

On March 16, 1993, at 1045 CST, during fuel off-load operations following operating Cycle 6, it was discovered that a broken fuel rod [AC-ROD] segment, approximately 11-12 inches in length, was protruding out of fuel assembly F67 [AC-*] at core position H-6. This condition is considered to be a significant degradation of a principal safety barrier; i. e., the fuel cladding, and therefore is being reported pursuant to 10 CFR 50.73(a)(2)(ii).

DESCRIPTION OF EVENT

On March 16, 1993, at approximately 0441 CST, with the unit in Mode 6, Refueling, a damaged fuel rod was observed by a member of the refueling crew to be sticking out of core position H-6 approximately 3 inches. This condition was observed while off-loading fuel from the reactor vessel [AB-RPV] during the Sixth Refueling Outage. The fuel assembly in core position H-7 adjacent to core position H-6 was in the process of being off-loaded when the damaged fuel rod was discovered. Fuel movement was immediately suspended until the exact location of the damaged fuel rod could be determined and an action plan could be developed for its removal. Plans for inspecting the affected assembly with an underwater video camera were then initiated to provide as much information as possible to assist in formulating the action plan for removing the damaged fuel rod segment from the reactor vessel.

At 1045 CST, on March 16, 1993, the underwater video inspection of the damaged fuel rod confirmed that the damaged fuel rod was located in fuel assembly F67 at core position H-6. Based on the information obtained from the underwater video inspection, an action plan for removal of the broken fuel rod segment was formulated. The action plan involved

attempting to remove the protruding section of the fuel rod with air-operated grips and placing a catch pan on the lower core plate of the reactor vessel to catch the broken fuel rod segment in case the segment fell during the retrieval process. At 1700 CST, on March 16, 1993, the action plan was commenced by lowering the catch pan into the reactor vessel.

At approximately 1839 CST, during attempts to retrieve the broken fuel rod segment, the segment was dislodged from fuel assembly F67 and descended down into the lower portions of the reactor vessel. Although the catch pan was in place on the lower core plate to catch the segment, the segment bypassed the pan during its descent. During the retrieval process it was determined that the rod segment was approximately 11-12 inches in length. At 2158 CST, following an inspection of the lower core plate, the broken fuel rod segment could not be found and fuel off-load was recommenced. It was determined that the broken fuel rod segment would be more easily retrievable after all fuel assemblies were off-loaded from the reactor core.

On March 19, 1993, at 0325 CST, off-loading of fuel from the core was completed. At approximately 0500 CST, Foreign Object Search And Retrieval (FOSAR) of the reactor vessel was commenced to locate and remove the broken fuel rod segment and to confirm accountability of all fuel pellets. On March 20, 1993, at 0850 CST, the broken fuel rod segment was retrieved from the reactor vessel and was transferred to the Spent Fuel Pool [ND-*] for storage. The complete rod segment was recovered, with no indication of loose pellets.

CYCLE 6 CHEMISTRY

Prior to plant shutdown for the Sixth Refueling Outage, the iodine activity in the Reactor Coolant System (RCS) [AB] indicated that there were 3 defective fuel rods in the core. However, the noble gas activity in the RCS indicated that there were 7-11 defective fuel rods. Based on past operating experience, the noble gas activity level is a better indicator of the actual number of defective fuel rods. This activity level met the requirements of Action Level 2 per procedure ADM 01-221, "Failed Fuel Action Plan." Action Level 2 is defined as a RCS Activity level of greater than 6.9 microCuries per milliliter and sustained at Steady-State Operation for more than seven days. This action level requires, in part, maximum activity removal through increased letdown to the Chemical and Volume Control System Demineralizer [CB-FDM]. Also, due to the projected number of defective fuel rods, the rate at which power was reduced leading into the outage was limited to approximately 3 percent per hour to avoid further damage to the fuel rods. The

projection of 7-11 defective fuel rods, as projected by the noble gas activity level, compared favorably with the actual number of defective fuel rods discovered during the outage. The chemical conditions during Cycle 6 operations were similar to those experienced during previous operating cycles at Wolf Creek Generating Station. There were no chemistry trends which could have caused adverse affects on fuel integrity.

DEFECTIVE FUEL EVALUATION

During and following completion of the core off-load to the Fuel Building [ND], all fuel assemblies were inspected utilizing a through transmission ultrasonic technique and visual inspection using a remote underwater video camera. These inspection activities resulted in the discovery of additional defective fuel rods (leakers) in fuel assemblies F43 and F54, as well as in defective fuel assembly F67 with the broken fuel rod. Figure 1, "Fuel Locations," provides a diagram of the operating Cycle 6 core loading, including the locations of the three fuel assemblies with defective fuel rods.

On March 14, 1993, fuel assembly F43 was ultrasonically examined. The results of the examination indicated one failed fuel rod. The location of the failed fuel rod within the assembly is position J13 (Reference Figure 2 for location of the F43 defective fuel rod). This is an interior rod; therefore, no visual inspection was possible.

On March 14, 1993, fuel assembly F54 was ultrasonically examined. The results of this examination indicated nine failed fuel rods (Reference Figure 3 for location of the F54 defective fuel rods). These rods could be divided into three groups. The largest group contains seven rods on Face 3. Two rods (at positions Q5, Q6) are located on the fuel assembly periphery and five rods (at positions P3, P4, P5, P6, P7) are located on the second row behind the other two rods. The second and third groups contain a single rod each on the second and fourteenth rows respectively. Rod P14 is near Face 3 and rod L2 is near Face 4. From the visual inspections, there was extensive evidence that the cladding on these fuel rods had failed. Hydride blisters were present in the middle spans and rod Q5 was noticeably loose in the bottom grid.

On March 17, 1993, fuel assembly F67, which contained the broken fuel rod, was removed from the reactor core and ultrasonically examined. The results of this examination determined that there were four failed rods (Reference Figure 4 for location of the F67 defective fuel rods). These rods were located on Face 3 in positions Q5, Q12 (broken fuel rod), Q13, and Q14. A full length visual inspection of Face 3 was conducted. The

review of that inspection confirmed the identified rod failures. Hydride blisters were found on all of the failed fuel rods. Furthermore, rod Q12 had approximately 11-12 inches of the rod missing above grid 5 and rod Q13 was fractured below grid 6. Rods Q5 and Q14 were observed to be loose in grid 1.

ROOT CAUSE AND CORRECTIVE ACTIONS

Licensee Event Report (LER) 91-019-00 describes a condition in which fuel cladding defects (i. e., leaking rods) were discovered in fuel assemblies F05, F17, and F31 during the Fifth Refueling Outage, following plant operating Cycle 5. Following the Fifth Refueling Outage, Wolf Creek Nuclear Operating Corporation (WCNOC) with the support of the fuel manufacturer, Westinghouse Electric Corporation, conducted an extensive evaluation of the fuel failures in an effort to determine the root cause(s) of the grid-to-rod fretting which was also identified as the principle failure mechanism of these fuel rods. Due to the number of individual fuel rod failures associated with fuel assembly F17 (32 failed fuel rods), the majority of the evaluation effort was concentrated on this assembly. The examination of the assembly included the following (Reference Figure 5 for a schematic diagram of a fuel assembly):

1. A detailed remote visual inspection was conducted to visually characterize the F17 assembly and to identify any fuel rods that should not be removed as part of the examination. The visual inspection revealed no apparent damage to the fuel assembly itself.

2. The top and bottom nozzle from the F17 assembly were removed and visually inspected to identify and characterize any anomalous flow or contact marks. This also permitted a detailed visual inspection of the top of the bottom nozzle, the bottom of the fuel rods (bottom end plugs) and the bottom grid of the F17 assembly. The visual inspections revealed no apparent damage to the top nozzle hold down springs. The visual inspection of the bottom of the bottom nozzle revealed no indications of abnormal flow or contact. The visual inspection of the top of the bottom nozzle revealed patterns that appeared to be related to wear of the fuel rod bottom end plugs against the bottom nozzle. There were leaking rods that exhibited significant wear patterns. However, there were also leaking rods that did not exhibit any wear. Attempts were made to characterize the direction of motion which caused the observed wear patterns; however, no consensus was reached.

3. Eighty fuel rods were lifted from assembly F17 approximately 8 inches to obtain breakaway and withdrawal forces. Due to the large variations in the breakaway and withdrawal force data, the data was considered indeterminate and was excluded from the evaluation.

4. Twenty-six fuel rods (17 leaking and 9 non-leaking) were removed from assembly F17 and visually inspected to characterize the extent of damage on the leaking rods and to look for similarities on the non-leaking rods. All of the inspected leaking rods from assembly F17 exhibited through-wall grid-to-rod fretting at the bottom grid. Additionally, several of the rods exhibited through-wall grid-to-rod fretting at the second grid elevation. The fretting occurred at both the spring and dimple locations, although the most severe wear appeared to occur at the springs. Some of the non-leaking rods also exhibited minor fretting.

5. Profilometry of assembly F17 was performed on six of the nine non-leaking rods to measure the average rod diameter. The reduction in rod diameter was calculated from this examination. The results were consistent with expectations.

6. A fiberscopic inspection of assembly F17 was performed on all vacated bottom (1st) grid cells to identify any damaged grid springs or dimples. Additionally, the second, third, and fourth grids were inspected in three cell locations to identify and characterize any damage. All springs and dimples appeared normal, with the exception of two cocked dimples located in two different cells. One of the cells contained a leaking rod and the other a non-leaking rod. The direction of the dimple damage appeared to result from the initial rod loading process.

7. Following the fiberscopic examination of assembly F17, all vacated cells were measured in the X and Y direction at the first grid with a "go/no-go" pin gage to determine the cell size. All vacated cells were also measured with an 8-step pull pin which served as a second check of the cell size measurements. The cell sizes were considered to be within normal tolerances.

8. Detailed visual examinations of the other leaking fuel assemblies (F05 and F31) were conducted and a sample of other non-leaking region "F" assemblies was taken to characterize their overall condition. Information from these visual examinations was indeterminate in deriving a definitive root cause of the fuel rod failures.

9. Additional non-leaking assemblies were also visually inspected to characterize the position and orientation of the fuel rods. Again, this information could not definitively identify a probable root cause.

These various examinations conclusively confirmed that grid-to-rod fretting was the principle failure mechanism. However, a root cause could not be definitively determined.

Further analytical evaluations by Westinghouse were then performed. These analyses were directed at determining the stability of the fuel rods under various assembly flow conditions. The Westinghouse core flow evaluations included appropriate considerations of the as-built core geometry and design specifications. The following applies to these evaluations:

- Utilizing Cycle 1 and 2 flow data, the THINC computer code was used to obtain core flow characteristics. The flow characteristics were then evaluated using the VIBAMP computer code to analyze fuel rod stability. Sensitivities (parameters) that were varied to analyze the fuel rod stability included: (1) maximum axial core flow; (2) Reactor Coolant System lower plenum flow anomaly; (3) grid spring force; and (4) bottom nozzle to rod gap.

- Results of the core flow evaluation indicated:
  - Fuel rods may become unstable with a combination of high axial and high cross flows;
  - Fuel rods indicated decreasing stability with decreasing spring force; and
  - There was no change in rod stability with a reduction in the rod gap (gap between bottom nozzle and the fuel rod).

- Conclusions:
  - Visual observations of grid-to-rod fretting supports the analysis of rod instability; and
  - This analysis demonstrates that a combination of high cross flows, high axial flows and normal grid spring relaxation <u>may</u> result in rod instability.

The results from these analyses determined that fluid elastic instability is a potential cause of the grid-to-rod fretting failures.

Upon identification of the defective (13 leaking and one broken) fuel rods found during the Sixth Refueling Outage, Westinghouse Electric Corporation was requested to review the fabrication history of the affected rods and region "F" assemblies. The three affected assemblies

(fuel assemblies F43, F54, and F67) were built on Fixture 5 on different days. There were multiple pellet "lots" loaded into the affected fuel rods. There was no rework required or performed by Westinghouse during the fabrication process. As with the Cycle 5 root cause evaluation, no significant process deviations were identified by the vendor. Additionally, no common fabrication links to the Cycle 5 failed region "F" fuel assemblies were identified, except that all of the assemblies were manufactured during the same "campaign".

The current Cycle 6 failures are similar to the previous Cycle 5 failures in several respects. The rod failures have all occurred in region "F" fuel assemblies (<u>NOTE: All region "F" fuel assemblies have now been discharged from the reactor core</u>). The pattern of the failures within assemblies F54 and F67 is clustered about the fifth cell from the corner. This is identical to the pattern seen previously within fuel assembly F17. The observation of loose rods in the first grid is the same as the previous fuel rod conditions. The extensive damage to a few rods was also similar. Based on these observations, grid-to-rod fretting is considered to be the principle failure mechanism for the Cycle 6 failures. Fluid elastic instability is a potential cause of the failure mechanism.

Evaluations into the root cause(s) of this event are continuing by WCNOC and the vendor. If these evaluations result in the determination of a more definitive root cause or significant additional corrective action(s), a supplement to this report will be submitted.

SAFETY ANALYSIS

The one broken fuel rod and various leaking fuel rods did <u>not</u> result in damage to plant equipment, excessive personnel exposure, or a release of radioactivity. Fuel recovery and failed fuel evaluations were well planned and their conduct was appropriately controlled. Had an adverse condition developed during the fuel off-load activity, there were sufficient safety-related equipment available and shutdown contingency plans in place to mitigate the consequences. Therefore, the health and safety of the public and plant safety were assured.

PREVIOUS SIMILAR OCCURRENCES

As discussed previously, LER 91-019-00 reported a previous similar occurrence when a broken fuel rod was discovered in fuel assembly F31 during the Fifth Refueling Outage. Also, fuel defects were discovered in fuel assemblies F05 and F17. During the first four operating cycles a total of five defects were discovered. The root cause of these

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LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

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TEXT (If more space is required, use additional NRC Form 366A's) (17)

defects were fabrication related or indeterminate. During the fifth operating cycle (cycle prior to the Fifth Refueling Outage) a total of 40 defects were discovered and during the sixth operating cycle (cycle prior to the Sixth Refueling Outage) a total of 14 defects were discovered.

ADDITIONAL INFORMATION

The fuel assemblies were supplied by Westinghouse Electric Corporation. The fuel assembly is a standard 17 by 17 array.

(Note from pages 2 and 3)

"*" No applicable component codes from IEEE standard 803A-1983 for these components.

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U.S. NUCLEAR REGULATORY COMMISSION

LICENSEE EVENT REPORT (LER) TEXT CONTINUATION

APPROVED OMB NO. 3150-0104
EXPIRES: 4/30/92

ESTIMATED BURDEN PER RESPONSE TO COMPLY WITH THIS INFORMATION COLLECTION REQUEST: 50.0 HRS. FORWARD COMMENTS REGARDING BURDEN ESTIMATE TO THE RECORDS AND REPORTS MANAGEMENT BRANCH (P-530), U.S. NUCLEAR REGULATORY COMMISSION, WASHINGTON, DC 20555, AND TO THE PAPERWORK REDUCTION PROJECT (3150-0104), OFFICE OF MANAGEMENT AND BUDGET, WASHINGTON, DC 20503.

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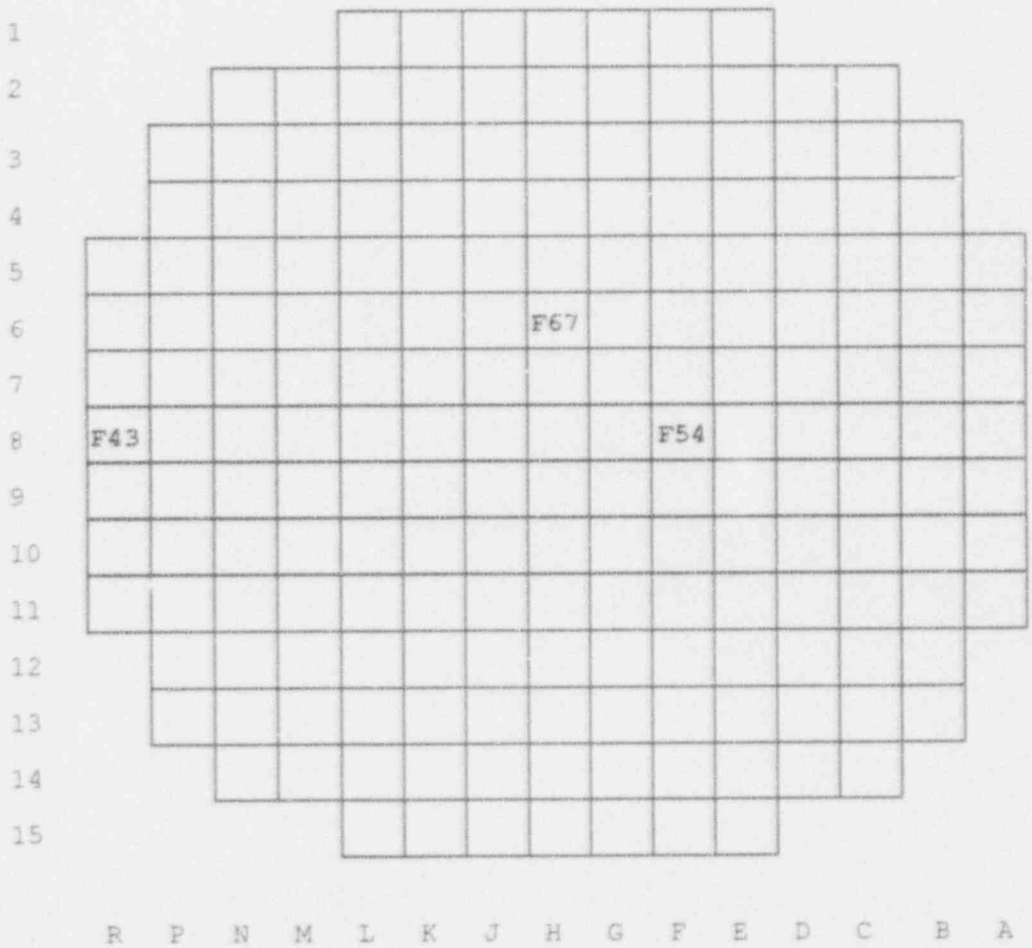
TEXT (If more space is required, use additional NRC Form 366A's) (17)

FIGURE 1
FUEL LOCATIONS



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TEXT (If more space is required, use additional NRC Form 366A's) (17)

FIGURE 2
FUEL ASSEMBLY F43

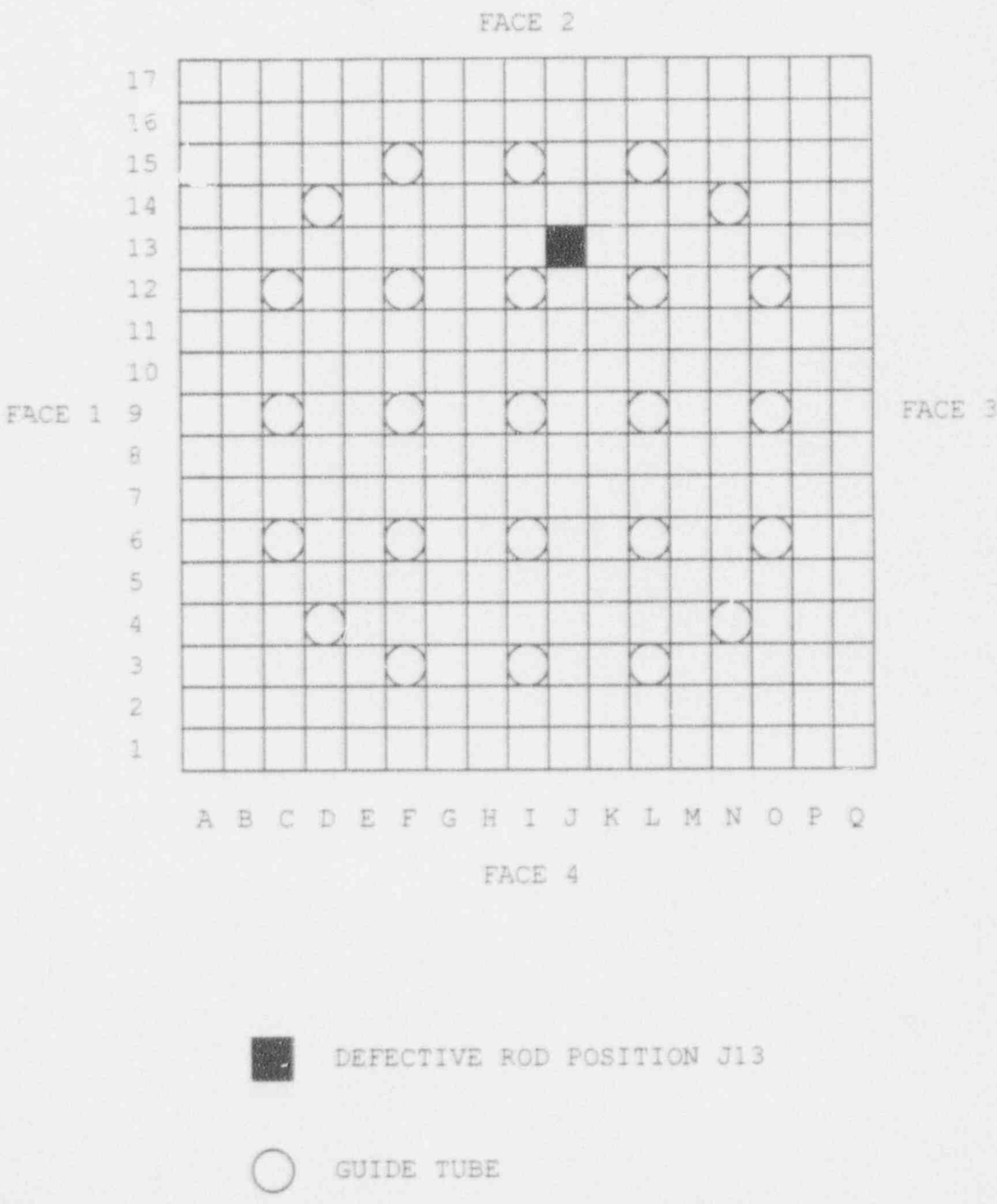
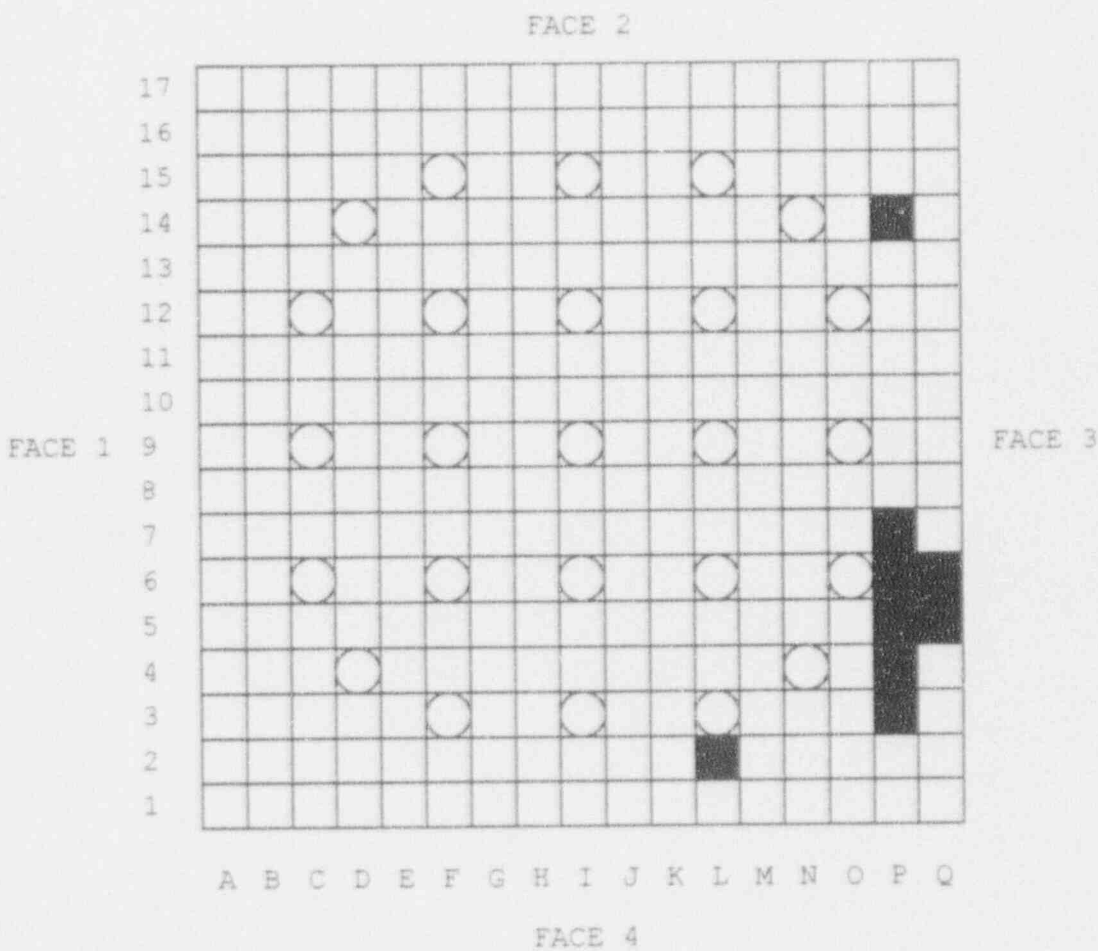


FIGURE 3
FUEL ASSEMBLY F54



DEFECTIVE ROD POSITION L2, P3, P4 P5, P6, P7, P14, Q5, and Q6

GUIDE TUBE

FIGURE 4
FUEL ASSEMBLY F67

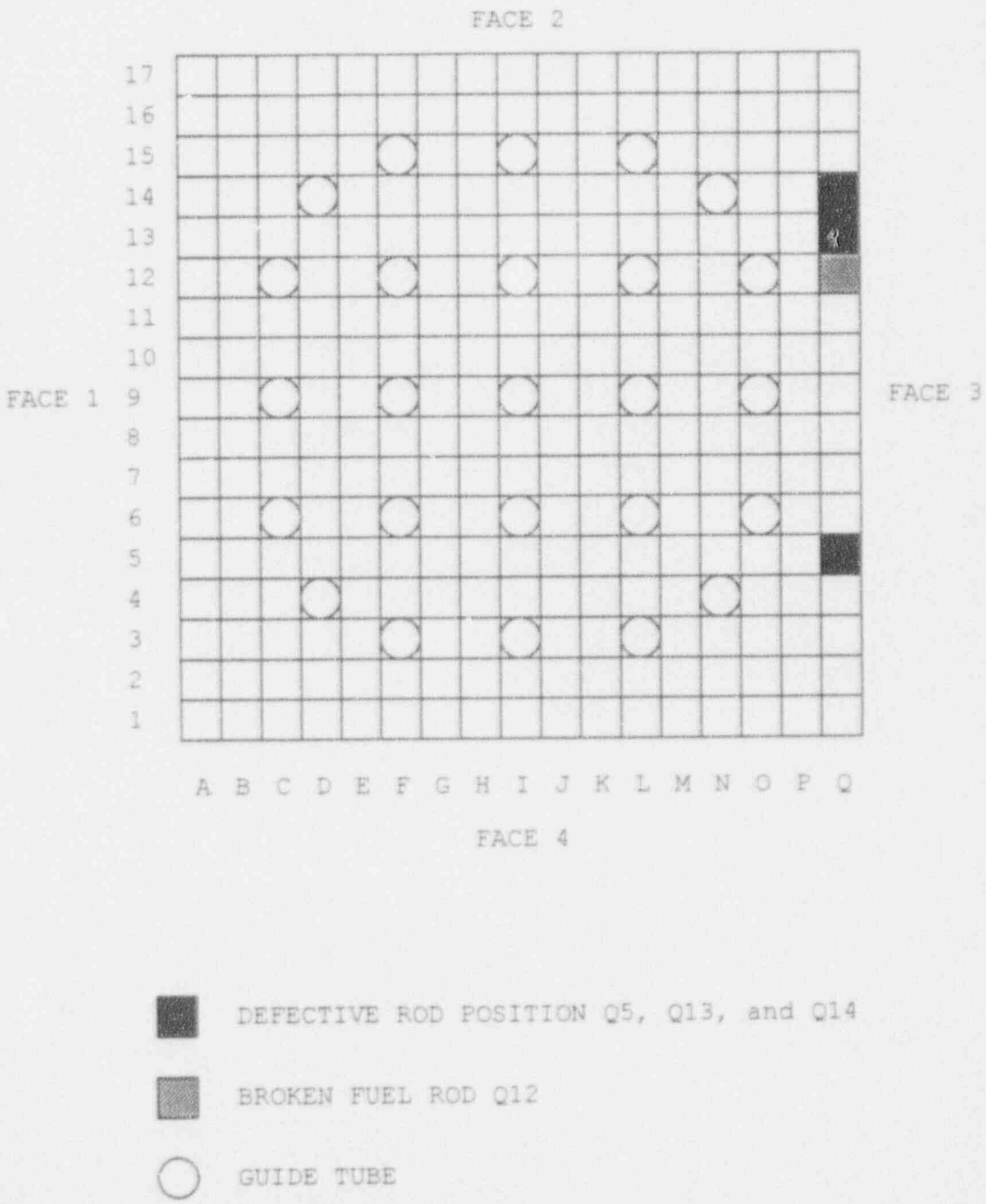


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FIGURE 5
WESTINGHOUSE
FUEL ASSEMBLY