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November 24, 1999

PG&E Letter DCL-99-139

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Docket No. 50-323, OL-DPR-82
Diablo Canyon Unit 2
Licensee Event Report 2-1999-002-00
Reactor Fuel Assembly Damage Due to Baffle Jetting

Dear Commissioners and Staff:

In accordance with guidance provided in NUREG-1022, draft Revision 1, Section 2.9, PG&E is submitting the enclosed voluntary licensee event report regarding reactor fuel assembly damage due to baffle jetting.

This event did not adversely affect the health and safety of the public.

Sincerely,

D Millerst for

Lawrence F. Womack

cc: Steven D. Bloom
Ellis W. Merschoff
David L. Proulx
Diablo Distribution
INPO

Enclosure

TLHH/2246/N0002106

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LICENSEE EVENT REPORT (LER)

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TITLE (4)

Reactor Fuel Assembly Damage Due to Baffle Jetting

EVENT DATE (5)			LER NUMBER (6)			REPORT DATE (7)			OTHER FACILITIES INVOLVED (8)	
MO	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REVISION NUMBER	MO	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
10	04	1999	1999	- 0 0 2 -	0 0	11	24	1999		

OPERATING MODE (9): 6

POWER LEVEL (10): 0 0 0

THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR: (11)

10 CFR

X OTHER Voluntary

(SPECIFY IN ABSTRACT BELOW AND IN TEXT, NRC FORM 366A)

LICENSEE CONTACT FOR THIS LER (12)

NAME	TELEPHONE NUMBER AREA CODE	
Roger Russell - Senior Regulatory Services Engineer	805	545-4327

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

CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANUFACTURER	REPORTABLE TO EPIX
B	A C	R O D	W 1 2 0	N					

SUPPLEMENTAL REPORT EXPECTED (14)		EXPECTED SUBMISSION DATE (15)	MON	DAY	YR
[ ] YES (If yes, complete EXPECTED SUBMISSION DATE)	[X] NO				

ABSTRACT (Limit to 1400 spaces. i.e., approximately 15 single-spaced typewritten lines.) (16)

On October 4, 1999, with Unit 2 in Mode 6 (Refueling), during the ninth refueling outage, PG&E identified two damaged reactor fuel assemblies. Initial inspection revealed that assembly V03 (location L-15) contained two damaged rods and assembly V02 (location E-1) contained three damaged rods. On October 7, 1999, PG&E reviewed video tapes of fuel inspections taken during the Unit 2 eighth refueling outage. The tapes indicated that assembly U13 (location L-15 during the previous fuel cycle) contained one damaged fuel rod.

PG&E discovered the damage to assemblies V02 and V03 during an off load foreign materials check. Damage to assembly U13 was discovered as a result of further investigation.

PG&E and Westinghouse attributed the cause of fuel damage to fretting due to baffle jetting.

Unit 1 is not expected to experience baffle jetting due to a different baffle configuration.

Fuel rod clips were installed on eight fuel assemblies at locations with the same baffle configuration as locations E-1 and L-15. Loose parts and reactor core integrity evaluations were completed and indicated no adverse effects to the reactor coolant system components or fuel. As a precautionary measure, fuel assemblies in locations susceptible to baffle jetting will be inspected for wear and degradation during the next Unit 2 refueling outage. The continued use of fuel clips will be evaluated based on the results the inspection.

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I. Plant Conditions

Unit 2 was in Mode 6 (Refueling) during the ninth refueling outage (2R9).

II. Description of Problem

A. Summary

On October 4, 1999, with Unit 2 in Mode 6, during 2R9, PG&E identified two damaged reactor fuel assemblies (AC). Initial inspection revealed that assembly V03 (location L-15) contained two damaged rods (ROD) and assembly V02 (location E-1) contained three damaged rods. On October 7, 1999, PG&E reviewed the video tapes of fuel inspections taken during the Unit 2 eighth refueling outage (2R8). The tapes indicated that assembly U13 (location L-15 during the previous fuel cycle) contained one damaged fuel rod.

B. Background

For the Diablo Canyon Power Plant (DCPP) Unit 2 reactor vessel internals design, coolant from the cold leg enters the vessel and flows downward on either side of the thermal pads. A small portion of coolant on the inside of the shield is diverted horizontally through the core barrel and then downward through the holes on the former plates. This small amount of the coolant flow between the baffle plates and the core barrel, provides additional cooling for the barrel. However, most of the coolant flow from the vessel cold leg inlet nozzles is directed downward through the annulus between the core barrel and the vessel walls, then into a plenum at the bottom of the vessel. Coolant then flows upward through the core. A pressure differential is thereby established between the downward coolant flow in the vessel barrel annulus through the "former" plates, and the upward flow through the core. The pressure differential is greatest at the top of the baffle and decreases along the axis of the baffle plate. The differential pressure can cause undesired coolant flow through baffle joint gaps which can result in jetting. This baffle jet flow can induce unstable, large amplitude vibrations which can result in fuel rod and grid strap failures.

Two mechanisms for baffle gap related rod failures have been previously identified: outside corner and inside corner, or center injection and corner injection. During outside corner or “center-injection” jetting failure, a water jet impacts the third rod from the corner of the fuel assembly. The direct water impingement causes rod whirling and vibration which can result in rod failure. During inside corner or "corner-injection" jetting, a jet of water flows parallel to the fuel bundle perimeter face between the fuel and the adjacent baffle plate. This flow may also cause fuel rod whirling and vibration at the first few rod locations. Water jetting parallel to these rods can result in rod failure and may propagate to adjacent rods. In general, the water-jetting-induced rod motion causes fuel rod fretting because of wear against the grid assemblies, which consist of slotted straps interlocked in an "egg-crate" arrangement.

In 1981, prior to startup, PG&E added edge bolts to center injection joints to provide bolting along the full length of the joint in accordance with the recommended Westinghouse resolution. This effectively eliminated center injection jetting as a damage mechanism. However, eight corner injection joint locations remained unbolted due to inaccessibility (L-1, E-1, A-5, A-11, E-15, L-15, R-11 and R-5). These inside corner joints were peened to minimize jetting problems.

Westinghouse, in a letter to the NRC dated June 19, 1980 (NS-TMA-2262), evaluated the potential impacts of baffle jetting on DNBR, peak clad temperature (PCT), water logging (water-fuel pellet interaction), control rod operation, and coolant activity. Westinghouse concluded that baffle jetting, even if it results in the worst possible fuel rod damage, does not constitute a safety concern.

DCPP Unit 1 is not expected to be susceptible to baffle jetting due to its design configuration of the internals (all baffle joints have edge bolts along their full length). No evidence of fuel rod degradation or grid strap failures due to baffle jetting have been observed.

C. Event Description

On October 4, 1999, during refueling operations, PG&E and Westinghouse observed foreign objects protruding through the upper nozzle, which were determined to be fuel plenum springs from two damaged reactor fuel assemblies. Initial visual inspection revealed that assembly V03 (location L-15) contained two damaged rods and assembly V02 (location E-1) contained three damaged rods. The initial visual inspections were later supplemented using detailed video inspections and ultrasonic testing.

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On October 7, 1999, based on damage to the fuel assemblies installed in locations E-1 and L15 during Cycle 9, PG&E and Westinghouse performed inspections of the fuel assemblies U02 and U13 which were installed in locations L-15 and E-15 during Cycle 8. The inspections revealed damage to fuel assembly U13.

On October 12, 1999, an inventory of damaged parts was conducted. All of the damaged parts, with the exception of the following, were accounted for and retrieved: (1) two end portions of rods, (2) a small portion of fuel cladding from one pin, and (3) small pieces from two grid straps.

On October 12 and 13, 1999, fuel rod clips were installed on the eight fuel assemblies to be loaded in the core locations susceptible to baffle jetting. Details of the installation are provided in Section V.B.2.

On October 21, 1999, Westinghouse provided a letter to PG&E which contained the results of their previous review of video tapes of the four damaged fuel assemblies. A summary of the damage to each assembly is described below.

1. Assembly V02 (location E-1 during Cycle 9)

   Rods A16, A15, and A14 showed baffle jetting damage. The top of rod A16 (from the top of the rod down to the top the grid [grid 8]) was missing. The plenum spring was trapped in a flow hole and was protruding above the nozzle. Below the grid, the rod showed a clean horizontal break and a shiny rod surface indicative of rod whirling in the grid. Rod A15 was leaning against rod A16. A portion of grid strap 7 was missing at rod A16 and A15 locations. The rod was contacting the bottom nozzle and almost the entire length of the bottom end plug had worn away.

   The top of rod A15 (from the top of the rod down to grid 8) was missing. The plenum spring was trapped in a flow hole and was protruding above the top nozzle. Immediately below grid 8, rod A15 showed a clean horizontal break and a shiny rod surface, indicative of rod whirling in the grid. The rod was contacting the bottom nozzle and a significant portion of the bottom end plug had worn away.

   The top of rod A14 (approximately 1 in.) had broken off and was

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trapped in the top nozzle. The plenum spring was exposed below the broken rod piece. A piece of grid strap was missing at rod A14. The rod was contacting the bottom nozzle and a significant portion of the bottom end plug had worn away.

Rod A13 showed a slight slippage toward the bottom nozzle but was intact.

2. Assembly V03 (location L-15 during Cycle 9)

The periphery rods Q2 and Q3 showed baffle jetting damage.

The top of rod Q2 (approximately 1 in.) had broken off and was trapped in a top nozzle flow hole. The plenum spring was exposed below the broken piece. Immediately below grid 8, the rod showed a clean horizontal break. At grid 7, a portion of the outer strap was missing (the entire length of the strap and about one width of the rod) at Q2, exposing the rod. The rod was contacting the bottom nozzle and a significant portion of the bottom end plug had worn away.

The top of rod Q3 (from the top of the rod down to grid 8) was missing. The plenum spring was protruding through a top nozzle flow hole. Grid 7 was missing an outer grid spring at the rod Q3 cell location. The rod was contacting the bottom nozzle and a significant portion of the bottom end plug had worn away.

Rod Q4 showed a slight slippage toward the bottom nozzle but was intact.

3. Assembly U03 (location E-1 during Cycle 8)

This assembly and assembly U13 discussed below were reviewed during a further investigation of assemblies located in areas susceptible to baffle jetting in past cycles.

Rod A16 was in contact with the bottom flow nozzle. No damage to the fuel assembly was observed.

4. Assembly U13 (location L-15 during Cycle 8)

The top (approximately 1 in.) of Rod Q1, on face 3, had broken away and was trapped in the top nozzle. The plenum spring was exposed below the broken rod piece. Grid 7 showed a missing outer grid spring at the rod Q1 location. Rod Q1 was in contact with the bottom nozzle. On October 21, 1999, the PSRC approved a Westinghouse Safety Evaluation Check List (SECL). The SECL concluded that the unaccounted for loose parts would not have an adverse impact on reactor coolant system (RCS) components or fuel.

D. Inoperable Structures, Components, or Systems that Contributed to the Event

None.

E. Dates and Approximate Times for Major Occurrences

1. October 4, 1999:	PG&E discovered two damaged fuel assemblies.
2. October 7, 1999:	PG&E discovers one additional damaged fuel assembly which had been previously installed.
3. October 12, 1999:	PG&E inventoried for all damaged parts.
4. October 12 and 13, 1999:	PG&E installed fuel rod clips on eight fuel assemblies.

F. Other Systems or Secondary Functions Affected

None.

G. Method of Discovery

PG&E discovered the damage to assemblies V02 and V03 during an off load foreign materials check. Assembly U13 damage was discovered as a result of further investigation.

H. Operator Actions

None.

I. Safety System Responses

None.

III. Cause of the Problem

A. Immediate Cause

The cause of damage was attributed to vibration due to baffle jetting.

B. Root Cause

PG&E postulates that the baffle jetting is a result of core barrel design. Industry experience indicates that core barrels with full length edge bolting (e.g., Unit 1) are much less susceptible to this phenomenon than those without the full length edge bolting.

IV. Analysis of the Event

The accident analysis for the large break loss of coolant accident (LOCA) assumes 25 percent of the core iodine and 100 percent of the core noble gases are released to the containment atmosphere as described in NRC Regulatory Guide 1.4 position. For a small break LOCA, the radiological source term assumes 2 percent of the core iodine and noble gases are released to the containment atmosphere. In addition, the preaccident source term is conservatively assumed to be consistent with operation with 1 percent failed fuel. A 1 percent fuel defect would be equivalent to approximately 500 rods operating at average power. Therefore, it can be concluded that five failed fuel rods (all operating at low power) are well within the accident analysis assumptions.

Westinghouse performed an evaluation of core integrity due to the condition of broken grid straps. At grid 7, the impact of seismic loading on assemblies with one missing portion (approximately the width of two rods) of outer grid strap was evaluated. The grid damage occurred in a corner, on a peripheral fuel assembly. The missing strap faced the baffle plate. This location was very limiting in terms of the grid impact load being subjected to a postulated LOCA pipe rupture transient. The design basis seismic/LOCA analyses performed for both DCPP units postulated grid crush in peripheral assemblies assuming normal grid strap conditions. Coolable geometry design criteria, including PCT limit, were used to assess the acceptance of fuel assembly design in DCPP units. The grid dynamic stiffness and grid strength will be reduced proportionally due to the missing partial

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outer strap. However, the maximum flow area reduction will not be affected. There will also be no impact due to the seismic or LOCA loading regarding coolable geometry design criteria with the missing partial outer strap in the peripheral assemblies. Therefore, the grid with the missing portion of outer strap is also acceptable for meeting the fuel assembly design geometry criteria. Discussions with Westinghouse regarding their preliminary evaluation conclude that the limited scope of fuel failures experienced at DCPP does not provide any indication that there has been an increase in the baffle joint gaps or associated baffle leakage flow. Westinghouse performed a preliminary evaluation to assess the potential implications on the core bypass flow fraction if the baffle gaps were hypothesized to increase in the future. Westinghouse determined that based on operational data for a similar four loop PWR which experienced worse fuel failures than DCPP, the characteristic baffle gap increase associated with significant baffle jetting problems could be from the current 3 mils value to about 7 mils. This hypothetical gap increase is estimated to increase the core bypass flow fraction about 0.9 percent. This increase in core bypass flow fraction could be accommodated with an approximate 1 percent penalty in the available DNBR margin. Since DCPP Unit 2 currently has over 7 percent DNBR margin available, even such a hypothetical onset of a baffle gap increase condition would not adversely impact the DCPP DNBR design basis.

Based on the above evaluations, this event did not adversely affect the health and safety of the public.

This event was evaluated using the proposed NRC's Significance Determination Process. Based on the guidance in SECY-99-007A, the event was screened out because the fuel barrier is evaluated as a performance indicator.

V. Corrective Actions

A. Immediate Corrective Actions

1. The two damaged fuel assemblies, V02 and V03, were removed from the core and will not be used again.

2. PG&E and Westinghouse performed a video tape inspection of the baffle and baffle joint areas. The tape showed minor indications of cross flow coming from the "corner-injection" location joints A-5, A-11, E-1, E-15, L-1, L-15, R-5, and R-11. However, no joint deformation or other damage was identified.

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3. An inspection of the remaining assemblies potentially exposed to baffle jetting was performed. The inspection of the top nozzles and faces indicated no signs of baffle jetting.

4. PG&E performed an inventory and evaluation of loose parts. The top most portion of the fuel rod had separated from five of the fuel rods. Three of the end sections were recovered or were retained in the assemblies. Two of the end sections were not recovered. Each end section includes a plug and a small portion of the rod. The fuel plenum springs from five rods were retained in the rods or assembly top nozzles. Portions of a grid in each of the two fuel assemblies were broken or worn away. Parts of two grid straps were not recovered. As stated in Section II.C.4, a loose parts evaluation showed there would be no damage to RCS components or to the fuel.

5. PG&E reviewed the fuel inspection video tapes for Unit 2, Cycles 7 and 8 for assemblies locate in locations E-1 and L-15. The fuel assemblies from Cycle 7 did not show evidence of baffle jetting. One assembly from Cycle 8 was damaged.

B. Corrective Actions to Prevent Recurrence

1. As a precautionary measure, fuel assemblies susceptible to baffle jetting will be inspected for wear and degradation during the next Unit 2 refueling outage. The continued use of fuel clips will be evaluated based on the results the inspection.

2. PG&E installed fuel rod clips on eight fuel assemblies (V-11, V-12, V-13, V-14, V-16, V-17, V-18, and V-19). Ten clips were installed on each of the eight assemblies for a total of eighty clips. The clips are designed to fasten on six fuel rods, closest to the baffle joint, at a position mid span between grids or grids and intermediate flow mixing grids. The clips are designed to increase the natural vibration frequency and dampen rod vibration.

VI. <u>Additional Information</u>

A. Failed Components

None.

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B. Previous Similar Events

None.