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June 10, 2005

PG&E Letter HBL-05-020

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

Docket No. 50-133, OL-DPR-7
Humboldt Bay Power Plant, Unit 3
Licensee Event Report 2004-001-02
Three Missing Fuel Rod Segments

Dear Commissioners and Staff:

In accordance with 10 CFR 20.2201, PG&E is submitting the enclosed Revision 2 to licensee event report (LER) 2004-001, regarding three missing 18-inch fuel rod segments. This LER revision supersedes LER 2004-001-01 submitted in PG&E Letter HBL-04-26, dated November 19, 2004. This LER revision provides further details related to the investigation and includes the cause analysis and corrective actions. Revision bars in the left hand margin note the changes.

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

Sincerely,

Gregory M. Rueger

Enclosure

cc: Emilio M. Garcia
John B. Hickman
Bruce S. Mallett
PG Fossil Gen HBPP Humboldt Distribution

IE22

NRC FORM 366 (6-2004) U.S. NUCLEAR REGULATORY COMMISSION

APPROVED BY OMB: NO. 3150-0104 EXPIRES: 06/30/2007

Estimated burden per response to comply with this mandatory collection request: 50 hours. Reported lessons learned are incorporated into the licensing process and fed back to industry. Send comments regarding burden estimate to the Records and FOIA/Privacy Service Branch (T-5 F52), U.S. Nuclear Regulatory Commission, Washington, DC 20555-0001, or by internet e-mail to infocollects@nrc.gov, and to the Desk Officer, Office of Information and Regulatory Affairs, NEOB-10202, (3150-0104), Office of Management and Budget, Washington, DC 20503. If a means used to impose an information collection does not display a currently valid OMB control number, the NRC may not conduct or sponsor, and a person is not required to respond to, the information collection.

LICENSEE EVENT REPORT (LER)

(See reverse for required number of digits/characters for each block)

1. FACILITY NAME	2. DOCKET NUMBER	3. PAGE
Humboldt Bay Power Plant Unit 3	05000133	1 OF 19

4. TITLE
Three Missing Fuel Rod Segments

5. EVENT DATE			6. LER NUMBER			7. REPORT DATE			8. OTHER FACILITIES INVOLVED	
MONTH	DAY	YEAR	YEAR	SEQUENTIAL NUMBER	REV NO.	MONTH	DAY	YEAR	FACILITY NAME	DOCKET NUMBER
06	30	2004	2004	- 001 -	02	06	10	2005	FACILITY NAME	DOCKET NUMBER

9. OPERATING MODE
N/A

10. POWER LEVEL
0

11. THIS REPORT IS SUBMITTED PURSUANT TO THE REQUIREMENTS OF 10 CFR§: *(Check all that apply)*

- ☐ 20.2201(b)
- ☒ 20.2201(d)
- ☐ 20.2203(a)(1)
- ☐ 20.2203(a)(2)(i)
- ☐ 20.2203(a)(2)(ii)
- ☐ 20.2203(a)(2)(iii)
- ☐ 20.2203(a)(2)(iv)
- ☐ 20.2203(a)(2)(v)
- ☐ 20.2203(a)(2)(vi)
- ☐ 20.2203(a)(3)(i)
- ☐ 20.2203(a)(3)(ii)
- ☐ 20.2203(a)(4)
- ☐ 50.36(c)(1)(i)(A)
- ☐ 50.36(c)(1)(ii)(A)
- ☐ 50.36(c)(2)
- ☐ 50.46(a)(3)(ii)
- ☐ 50.73(a)(2)(i)(A)
- ☐ 50.73(a)(2)(i)(B)
- ☐ 50.73(a)(2)(i)(C)
- ☐ 50.73(a)(2)(ii)(A)
- ☐ 50.73(a)(2)(ii)(B)
- ☐ 50.73(a)(2)(iii)
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- ☐ 50.73(a)(2)(v)(A)
- ☐ 50.73(a)(2)(v)(B)
- ☐ 50.73(a)(2)(v)(C)
- ☐ 50.73(a)(2)(v)(D)
- ☐ 50.73(a)(2)(vii)
- ☐ 50.73(a)(2)(viii)(A)
- ☐ 50.73(a)(2)(viii)(B)
- ☐ 50.73(a)(2)(ix)(A)
- ☐ 50.73(a)(2)(x)
- ☐ 73.71(a)(4)
- ☐ 73.71(a)(5)
- ☐ OTHER

Specify in Abstract below or in NRC Form 366A

12. LICENSEE CONTACT FOR THIS LER

FACILITY NAME	TELEPHONE NUMBER (Include Area Code)
David Sokolsky – Senior Regulatory Services Engineer	(707) 444-0801

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

CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX	CAUSE	SYSTEM	COMPONENT	MANU-FACTURER	REPORTABLE TO EPIX
N/A									

14. SUPPLEMENTAL REPORT EXPECTED

[ ] YES *(If yes, complete 15. EXPECTED SUBMISSION DATE)* NO X

15. EXPECTED SUBMISSION DATE

MONTH	DAY	YEAR

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

This Revision 2 to LER 2004-001 provides further details related to the investigation of the three missing fuel rod segments and includes the cause analysis and corrective actions.

On June 23-25, 2004, Humboldt Bay Power Plant (HBPP) personnel discovered conflicting information regarding segments cut from spent fuel assembly A-49. One document indicated that the segments were stored in the spent fuel pool (SFP) in 1968, while another document indicated the A-49 assembly was shipped in its entirety for reprocessing in 1969. The NRC was notified on July 16, 2004, pursuant to 10 CFR 20.2201(a)(1)(ii) and 10 CFR 50.72(b)(2)(xi). (Reference NRC Event Notification 40877).

HBPP personnel have searched the SFP, but the intact segments have not been located. It is believed that the segments are either safely stored in the SFP, perhaps in an altered configuration, or were shipped to a facility licensed to accept radioactive material. Therefore, there is no undue risk to the health and safety of the public and licensed facility workers.

The causes were determined to be lack of procedures, a less procedure-oriented plant culture, inadequate training of SNM Custodians, lack of regulatory guidance, and lack of industry experience and standards. Corrective actions have been developed as a part of the HBPP corrective action program.

TEXT

I. Plant Conditions

Humboldt Bay Power Plant (HBPP), Unit 3, was shut down in 1976, and has been maintained in SAFSTOR since 1988.

II. Description of Problem

A. Background

During 2003, PG&E plant personnel initiated a review and cataloging of the contents of the spent fuel pool (SFP) in preparation for the planned decommissioning of the plant, including the transfer of spent fuel into an onsite Independent Spent Fuel Storage Installation. As a result of the documentation search and review conducted as part of that process, PG&E identified a discrepancy in plant records that called into question the location of three 18-inch segments of a single spent fuel rod removed from fuel assembly A-49 in 1968 and stored in the SFP. Based on a subsequent review of available records and interviews with employees, there is no firm evidence regarding the location of the three segments. A recently completed comprehensive search of the SFP and nearby plant areas has not located the three segments. PG&E submitted a Final Report on this issue to the NRC in PG&E Letter HBL-05-017 on May 27, 2005.

B. Event Description

On June 23, 2004, plant personnel identified Onsite Review Committee (OSRC) meeting minutes dated October 2, 1968, that describe cutting three 18-inch segments from one fuel rod located in spent fuel assembly A-49. These segments were placed into a small container (1-1/2-inch diameter, schedule 40 steel pipe with a welded cap on one end and a threaded cap on the other) in preparation for shipment to the Battelle Memorial Institute in Columbus, Ohio, for performance of an experiment to determine potential cask coolant contamination from failed fuel shipments. The meeting minutes further state that the shipment to Battelle was subsequently cancelled and the small container with the three 18-inch fuel rod segments was returned to the SFP. The specific location of this container in the SFP was not identified. Subsequent interviews with the former HBPP engineer who developed the plan used to perform the cuts of A-49 and oversaw the work, support that the cuts were made, but indicate that each segment may have been a few inches shorter than the 18 inches in length specified in the OSRC meeting minutes.

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On June 25, 2004, after further research, plant personnel found shipping records indicating that on August 7, 1969, the A-49 fuel assembly was included in a shipment of 18 fuel assemblies to Nuclear Fuel Services Inc. (NFS) in West Valley, New York, for reprocessing. No mention was made in the shipping record that the A-49 assembly had been shipped with portions of one of its rods left behind in the SFP. This potentially contradicts the October 2, 1968, OSRC meeting minutes. No records were found that indicated that the removed portions of the fuel rod were subsequently shipped to NFS.

Further review of records did not resolve the discrepancy. Therefore, on June 29, 2004, PG&E verbally notified NRC Region IV of the discrepancy in records and the uncertainty regarding the specific location of the fuel rod segments removed from A-49. PG&E personnel developed a plan to search the SFP for the segments.

On July 7, 2004, PG&E began a physical search of the central storage container (CSC), a high probability location for the remnant portions of the A-49 rod, as well as the three 18-inch segments. On July 9-11, 2004, PG&E recovered several fuel rod fragments from the CSC, some of which PG&E believes are probably remnants from the cut A-49 rod. However, three intact 18-inch segments were not found in the CSC.

On July 16, 2004, HBPP notified the NRC of the potentially lost or missing licensed material in accordance with 10 CFR 20.2201(a)(1)(ii) and 10 CFR 50.72(b)(2)(xi) regarding a planned press release (NRC Event Notification 40877).

Of the 175 fuel fragments found, 10 fuel fragments ranging in length from 2-1/2 inches to 11 inches (total length of the 10 fragments is approximately 50 inches) appear to have been cut. Independent analyses of these fragments were done in August and October 2004, with differing results. The earlier analysis, conducted by a PG&E metallurgist from the Diablo Canyon Power Plant, concluded that these segments had fractured, and not cut, ends. The latter analysis, conducted by two outside metallurgical experts and a fuels expert previously with General Electric (GE), came to a different conclusion – that some of the fragments were cut and are quite possibly remnants or pieces of the fuel rod segments cut from the A-49 fuel rod (original length 84 inches). All of the A-49 remnants may not be included in these fragments, because the procedure used for the cutting called for remnants that were still held firm in the A-49 grid spacers after the cutting were to be left in A-49.

TEXT

From early July 2004 through February 2005, PG&E performed an expanded physical search of the SFP. The search plan for the SFP considered whether any or all of the three unaccounted for fuel rod segments remain in the SFP. Each location and container in the SFP was searched with the idea that the fuel rod segments could be in one or more of three physical configurations: (A) intact approximately 18-inch long fuel rod segments, (B) damaged (broken or crushed) fuel rod segments (i.e., fragments), or (C) in the pipe container they were last known to be in.

The thorough SFP inspections and examinations did not result in location of the three intact fuel rod segments or the pipe container they were originally stored in. However, it was determined that a number of the fuel fragments recovered from the CSC in the SFP may be from the A-49 fuel rod.

In parallel with the search of the SFP, HBPP personnel continued their review of historical documents and interviewed former employees who were associated with SFP and radioactive waste operations at HBPP. In addition, HBPP personnel asked companies such as NFS and Battelle to review their records to determine if the three fuel rod segments were received at their location. Though much information was uncovered that sheds light on what transpired in 1968 and beyond that was helpful in PG&E's search, none of this information has definitively identified the location of the unaccounted for fuel rod segments.

The status of PG&E's investigation into the missing fuel rod segments was discussed in a public meeting in Eureka, California, on September 29, 2004. The meeting was attended by representatives from the NRC and PG&E, the public, and the media.

10 CFR 20.2201(b) requires a written report within 30 days after the initial notification for the occurrence of any lost, stolen, or missing licensed material that was reported under 10 CFR 20.2201(a)(1)(ii) for licensed material in a quantity greater than 10 times the quantity specified in Appendix C to Part 20. The written report must contain responses to six specific items listed in 10 CFR 20.2201 (b). The six items are identified below, along with PG&E's responses:

(i) A description of the licensed material involved, including kind, quantity, and chemical and physical form

Assembly A-49 was removed from the core in the fall of 1965. The amount of fuel in question consists of three approximately 1/2-inch-diameter by 18-inch-long segments, weighing a total of about 4 pounds,

which were cut from a single, 84-inch fuel rod. The three segments come from a fuel rod that is clad in type 304 stainless steel. For purposes of analysis, PG&E conservatively assumes the segments were 18-inches long each, though interview evidence suggests they were probably shorter. Table 1 contains a detailed physical description, Table 2 contains the isotopic inventory of each missing fuel rod segment and total for the three segments, and Table 3 contains the estimated dose rate summary, unshielded, for each segment, assuming they were all 18 inches in length.

(ii) A description of the circumstances under which the loss or theft occurred

According to the October 2, 1968, OSRC meeting minutes, the three approximately 18-inch segments from assembly A-49 were placed in a pipe for shipment to Battelle Memorial Institute in Columbus, Ohio, for analysis. The shipment was cancelled and the last written record shows that the pipe container with the fuel rod segments was returned to the SFP for storage on September 27, 1968. A former HBPP engineer recalls that the pipe container with the fuel rod segments was hung on the side of the SFP by a lanyard and tagged. Shortly after this, the HBPP engineer left HBPP for another job.

In 1968, HBPP received a license from the Atomic Energy Commission (AEC) to ship spent fuel to NFS for reprocessing in a water-filled (for cooling) cask designed to hold 18 fuel assemblies. The license specified coolant radioactivity limits and specified that failed fuel was to be encapsulated before placement into the cask and shipment. Encapsulation was interpreted to mean that each failed fuel assembly was to be enclosed in its own container, and sealed by welding, an expensive process that HBPP and Battelle believed was unnecessary. Battelle's calculations showed that the coolant radioactivity limits could be met without failed fuel "encapsulation." HBPP submitted an application to the AEC for a license amendment that would allow it to ship failed spent fuel assemblies in special containers designed by Battelle laboratories that would be individually sealed (bolted lid, not welded) and loaded into the 18 fuel assembly shipping cask.

The AEC was reviewing the license amendment application when HBPP and Battelle decided to perform some experiments on segments of an actual fuel rod to provide additional evidence to the AEC that supported licensing of the Battelle canister. It is for this purpose that the A-49 fuel rod was cut and the three segments prepared for shipment to Battelle. Though documentation has not been found that indicates why the experiment at Battelle was subsequently cancelled, both HBPP and

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Battelle records verify that the fuel rod segments were never sent to Battelle. In December of 1968 the AEC approved HBPP's license amendment to ship failed fuel to NFS in the Battelle-designed canister. The Battelle-designed canister was used for the NFS shipment in 1969 that contained assembly A-49. Though no one interviewed recalled adding individual rods or segments to shipments of spent fuel assemblies and no records have been found indicating that this took place, doing so would have been possible and consistent with the motivation behind the experiment for which the fuel rod was initially cut.

Between 1971 and 1974, HBPP made 11 shipments containing 66 individual fuel rods to GE's Vallecitos facility in Livermore, California, for analysis and final storage. PG&E allowed GE to remove fuel rods to assist GE in improving the design of the fuel they provided to plants using their reactor design. Though it was not likely the A-49 fuel rod segments were sent to GE (they would have rejected the receipt of any fuel rods not expected in a shipment), GE was requested to search their fuel receipt records to ensure they did not receive and store the unaccounted for A-49 fuel rod segments. PG&E has received the review results from GE, which indicate they did not receive or store the A-49 fuel rod segments. PG&E has reviewed the GE results and determined they are complete. Thus, shipment of the fuel rod segments to GE is considered implausible.

From 1968 to 1986, HBPP made over 400 shipments of low-level radioactive waste (LLRW) to facilities licensed to receive such materials located in Beatty, Nevada (Beatty); Richland, Washington (Hanford); and Barnwell, South Carolina (Barnwell). The majority of these shipments did not contain material that was taken from the SFP.

In 1985, in preparation for entering SAFSTOR, plant personnel removed all items that were attached to the SFP railing. Each item was either shipped to the Barnwell LLRW facility or was returned to another location in the SFP. Recent visual observation has confirmed that no containers are currently attached to the SFP railing. No documentation has been found describing the movement of the three 18-inch segments in the container, hanging on the SFP railing, to any other location in the SFP.

Shipments to Barnwell, Beatty, and Hanford were reviewed and evaluated to determine if the three fuel rod segments could have possibly been included in any of the LLRW shipments. After investigation and analysis, shipment of the three rod segments to the Beatty facility was deemed implausible based on the dates, dose rates, contents and origins of the shipments. For more details, refer to Chapter 4 of the PG&E Special

TEXT

Nuclear Material Control and Accountability Project Final Report, submitted to the NRC in PG&E Letter HBL-05-017 on May 27, 2005.

The available information also supports the conclusion that neither the fuel rod segments nor the pipe container were knowingly loaded into any of the LLRW shipments. However, an opportunity for the inadvertent shipment of either the segments or the pipe container would appear to have been possible in each of the three 1983 and one 1985 Barnwell shipments and in each of the five Hanford shipments during 1986 where the material dose rates exceeded the dose rate screen (See PG&E Calculation NX-292, "Estimated Shielded Dose from A-49 Fuel Rod Segments"). The likelihood of an inadvertent loading of the segments or pipe container and subsequent shipment to those LLRW facilities was therefore concluded to be possible, but not likely.

Other direct shipments (ODS) are defined as radioactive material shipments from HBPP to another licensee that is not an LLRW facility. The majority of ODS differ from LLRW shipments for the primary reason that the radioactive material being shipped is not waste, but is material that will be used or processed, which requires unpacking or handling of the material. If the three fuel rod segments or pipe container were included in an ODS, the receiving licensee, with the exception of shipment of assemblies for reprocessing, would have found and identified the fuel rod segments or pipe container as they were not expected to be a part of the shipment.

Of the ODS made by HBPP, only the 15 spent fuel shipments to NFS for reprocessing are considered as plausible candidates for having contained the fuel rod segments and pipe container. It is believed that the cask contents were probably not carefully examined upon receipt for reprocessing by NFS. Interviews with employees who worked at HBPP in the 1960s and subsequent years provided speculative evidence that concluded that the fuel rod segments and pipe container could have been included in any of the 15 shipments to NFS and not been detected. Therefore, PG&E concluded that it is possible, but not likely, that the three A-49 fuel rod segments were shipped to NFS for reprocessing.

No evidence has been uncovered to support the possibility of theft or diversion of the unaccounted for fuel rod segments. Due to the high radioactivity of the material, in order to be handled safely, the segments would have to be encased in a heavy-shielded container that would have to be moved with special handling equipment designed for this purpose, precluding an abrupt loss. Since plant startup, HBPP has been equipped

with a system of radiation monitors for the refueling building (where the SFP is located), with alarm setpoints that are capable of alerting plant personnel of the movement of highly radioactive material should the fuel rod segments have been removed from the SFP without being in a shielded container. This could not have occurred casually without plant staff or security personnel being aware of the movement.

In conclusion, the analyses show that the integrity of applicable barriers was sufficient to deter, prevent, and detect any attempted theft or diversion for unauthorized disposal. The investigations and analyses support the conclusion that the theft or diversion of the fuel rod segments is highly unlikely.

(iii) A statement of disposition, or probable disposition, of the licensed material involved

The search plan for the SFP considered whether any or all of the three unaccounted for fuel rod segments remain in the SFP. Each location and container in the SFP was searched with the idea that the A-49 segments could be in one or more of three possible physical configurations: (A) intact approximately 18-inch long fuel rod segments, (B) damaged (broken or crushed) fuel rod segments (i.e., fragments), or (C) in the pipe container they were last known to be in. As described below, PG&E has determined that two reasonably possible scenarios exist for the disposition of the fuel rod segments.

The thorough SFP inspections and examinations did not result in location of the three intact fuel rod segments or the pipe container in which they were originally stored. However, it was determined that several of the fuel fragments recovered from the CSC in the SFP may be from the assembly A-49 cut fuel rod. Based on the physical characteristics of fuel fragments found in the SFP and an independent review performed by ATI Consulting (ATI), experts in metallurgy who also enlisted the assistance of a consultant experienced with nuclear fuel issues, PG&E concludes that it is reasonably possible that some or all of the A-49 fuel rod segments and the remnants from the cutting process have been found in the SFP as fragments rather than intact segments.

PG&E has concluded that when the shipments to Barnwell, Hanford, and NFS are considered in the aggregate, it becomes reasonably possible that the pipe container or the segments themselves could have been shipped to either the Hanford or Barnwell LLRW facilities or to the NFS reprocessing facility. This is not to say that it was considered reasonably

possible that the three segments were sent to one of these facilities when considered on an individual basis. However, when considered as a combined possibility, coupled with the fact that no record of the pipe container has been located subsequent to September 1968, and the pipe container was not found in the SFP, it is the judgment of PG&E that the possibility increases from possible, but not likely, to reasonably possible.

(iv) Exposures of individuals to radiation, circumstances under which the exposures occurred, and the possible total effective dose equivalent to persons in unrestricted areas

If the fuel rod segments remain in the SFP at HBPP, there are no likely circumstances that would lead to exposures of workers or the public.

If the fuel rod segments were shipped to NFS, they would have been reprocessed, resulting in no increased exposure to workers or the public.

If the fuel rod segments were inadvertently shipped to the Barnwell or Hanford LLRW facilities, the environmental, radiological, and safety programs at these facilities are sufficient to ensure safe long-term storage of the relatively small amount of radioactive material in the segments. PG&E concludes that if the three fuel rod segments are buried at an LLRW facility:

- The overall risk from the fuel rod segments is minimal to past, present, and future workers and generations of the public.
- There is a very low probability of inadvertent intruder scenarios resulting in doses in excess of regulatory limits.
- Retrieval of the fuel rod segments would not be justified by arguments concerning public health and safety as a result of the very low risk that the fuel rod segments pose.

(v) Actions that have been taken, or will be taken, to recover the material

PG&E implemented an aggressive action plan with three major elements: (1) perform a detailed physical inspection of the SFP, (2) collect and perform document reviews onsite and at NFS, Battelle, and GE Vallcecitos, and (3) conduct interviews with present and former employees and contractors who have been associated with SFP and radioactive waste operations at HBPP.

TEXT

(1) SFP Inspection - On July 7, 2004, plant personnel began a physical search of the SFP to locate the three 18-inch segmented fuel rods from assembly A-49, as well as any remnants of the rod. The SFP, which is from 26 to 36-feet deep and 22-feet wide by 28-feet long, was searched slowly and methodically, using underwater cameras and remote-controlled tools. There are 390 used fuel assemblies stored in the SFP, with numerous spaces between and around them. In addition, there were six storage containers, five of which were filled with various irradiated hardware and components. The sixth storage container held fuel rods from assembly UD-6N that was damaged in 1975 plus fuel fragments from other assemblies. Each of these storage containers was emptied piece-by-piece to conduct a complete search for the fuel rod segments. These storage containers are approximately 8-feet long and range in dimension from approximately 4 to 7-inches square.

PG&E has completed its search of the accessible areas of the SFP. The following is a detailed account of the items and areas searched in the SFP.

1. Storage Containers 1 through 4 (formerly failed fuel cans)
2. Central Storage Container (CSC) (formerly called the garbage can)
3. Storage Container for UD-6N
4. All open spaces in the SFP
5. Accessible areas under the racks
6. On top of the fuel assemblies
7. All open cell locations
8. Visible areas under the energy absorber
9. Interim Storage Containers in the SFP used to store irradiated hardware
10. SFP sump
11. In and under accessible areas of the SFP resin pile
12. Under the fuel racks using remotely and manually controlled cameras.

Search of these areas has not located the three 18-inch segments. Additionally, PG&E has reviewed the video records taken in 2004 of each fuel assembly and the space under each fuel assembly (except for two assemblies that cannot easily be moved). In an effort to determine if the SFP contains fragments that show evidence of being mechanically cut, PG&E contracted with ATI. ATI reviewed digital video and still photographs of the fuel fragments to determine their potential of having been cut, and, subsequently, the possibility of the fuel fragments being a

TEXT

portion of the fuel rod from Assembly A-49. In a report submitted to PG&E on March 31, 2005, ATI concluded that "... there is reasonable evidence consistent with the proposition that fragments from the three 18-inch segments along with the remnants cut from the A-49 fuel rod may be amongst the fuel fragments in the HBPP spent fuel pool." PG&E submitted the ATI report to the NRC on April 12, 2005 in PG&E Letter HBL-05-010.

(2) Document Reviews – A review of HBPP documents was performed in an attempt to determine the source of the fuel fragments that have been found in the SFP since November 2003, and to resolve the discrepancy between the October 2, 1968, OSRC meeting minutes and the conflicting shipping record dated August 7, 1969, regarding the one rod in A-49. Though much information was located that was descriptive of HBPP activities related to SNM accountability, no records were located that addressed disposition of the three fuel rod segments or their pipe container since they were stored in the SFP on September 27, 1968.

Numerous other offsite documents were reviewed. PG&E requested NFS, Battelle, and GE Vallecitos to search their records. The status of these record searches is as follows: NFS did not retain HBPP fuel shipment records after transferring ownership/responsibility for its reprocessing facility to the state of New York in 1980, and available personnel do not recall a separate shipment relative to the A-49 segments (PG&E's copy of the NFS receipt record for assembly A-49 does not address the three unaccounted for fuel rod segments). Battelle records indicate that the shipping cask they sent to HBPP for transport of the three 18-inch segments was received back at Battelle empty (as intended, since the experiment had been cancelled). PG&E has received the review results from GE, which indicate they did not receive or store the A-49 fuel rod segments. PG&E has reviewed the GE results to ensure they are complete. No information was discovered related to the three fuel rod segments.

(3) Interview Personnel – PG&E interviewed the available OSRC members who attended the October 2, 1968, meeting, and one provided useful information concerning the location of the three fuel rod segments when they were initially returned to the SFP. In addition, PG&E has conducted approximately 60 interviews with former employees, current and former contract workers at HBPP, and personnel at interfacing facilities who were associated with SFP and radioactive waste operations at HBPP. The results of these interviews did not produce any definitive information regarding the disposition of the three fuel rod segments after their storage

in the SFP in September 1968. Some of the interviewees speculated that the fuel rod segments might have been included in the shipments to NFS for reprocessing, but they had no specific recollections regarding such a shipment. To the extent possible, the information derived from the interviews was used to help develop event scenarios and to help prove, disprove, or assess facts related to various scenarios.

(vi) Procedures or measures that have been, or will be, adopted to ensure against a recurrence of the loss or theft of licensed material

Prior to the discovery of fuel fragments in the SFP in November 2003, the scope of the HBPP material control and accountability program only included fuel assemblies, not fuel fragments. PG&E has recently revised HBPP procedures to ensure control and accountability of all SNM in PG&E's possession at HBPP. A full cataloging and characterization of the contents of the SFP has been performed. Also, a "qualification" will be created for the SNM Custodian and persons delegated to be the SNM Custodian.

C. Status of Inoperable Structures, Systems, or Components that Contributed to the Event

Although assembly A-49 was originally selected for analysis partially based upon noted fuel damage, this selection did not materially affect the proper tracking of the three 18-inch fuel rod segments once they were removed. The location, identification, and possible disposition of the remnants of A-49 were made more difficult by the fuel cladding damage known to affect a portion of the subject A-49 rod.

D. Other Systems or Secondary Functions Affected

None

E. Method of Discovery

On June 23 through 25, 2004, while in the process of reviewing records and verifying the contents of the SFP in preparation for loading materials into dry cask storage, PG&E personnel identified documents containing conflicting information regarding the location of segments cut from a single fuel rod from spent fuel assembly A-49. One document indicated that three approximately 18-inch segments were removed from one fuel rod, placed in a shipping container and then returned to the SFP, while another document indicated the entire A-49 assembly was shipped offsite to NFS for reprocessing.

TEXT

F. Operator Actions

None

G. Safety System Responses

None

III. Cause of the Problem

A. Root Cause

Performance of a cause analysis resulted in determination of the following five causes for the missing fuel rod segments (no specific root cause was identified):

1. Plant management did not require development of procedures for control and accountability of fuel rod segments.

2. Plant culture in the 1960s and early 1970s encouraged individual problem solving, rather than development and use of procedures for non-complex evolutions. This approach resulted in activities that were either performed without procedures, or with procedures that would be considered inadequate by current standards.

3. The SNM Custodians were not adequately trained on control and accountability of SNM.

4. There was no specific regulatory guidance for the control and accountability of fuel rod segments.

5. There was no specific industry experience or standards for the control and accountability of fuel rod segments.

TEXT

IV. Assessment of Safety Consequences

It is unlikely that the three 18-inch fuel rod segments were taken from HBPP in an unauthorized manner. HBPP has a system of radiation monitors inside and outside the refueling building (where the SFP is located) with alarm set points that are capable of alerting plant personnel of the movement of highly radioactive material. Due to the radioactive nature of the material, in order to be handled safely, the segments would have to be encased in a heavy-shielded container that would have to be moved with special handling equipment designed for this purpose, thereby precluding an abrupt loss. This could not have occurred without plant staff or security personnel being aware of the movement.

The administrative, radiological, and security barriers in-place at HBPP add to the belief that the three fuel rod segments either remain in a currently unsearched area of the SFP; are currently in the SFP in the form of fragments, not intact 18" fuel rod segments; or were shipped offsite in an appropriate manner. The fuel rod segments may have been shipped to NFS for reprocessing. This would have been done using a licensed shipping cask that was properly (safely) transported. If the fuel rod segments were inadvertently included in a shipment to an LLRW disposal site at Barnwell or Hanford, the segments also would have been placed in a licensed shipping container that was properly (safely) transported to a restricted, and monitored storage facility licensed to receive radioactive material. The environmental, radiological, and safety programs at these facilities would assure safe storage of the relatively small amount of radioactive material in the three fuel rod segments.

Therefore, there is reasonable assurance that the public health and safety was not, is not, and will not be adversely affected by this event.

Table 3 provides the current estimated dose rates that would be encountered if handling the fuel rod segments outside of the SFP and not in a shielded cask.

V. Corrective Actions

A. Immediate Corrective Actions

HBPP programs, procedures, and personnel training have been revised to require specific detail(s) regarding the documentation of location of fuel components (e.g., fuel fragments, fuel rod segments, fuel pellets, etc.) as they are identified in the SFP. A full cataloging and characterization of the contents of the SFP was performed to ensure a complete and accurate accounting of all SNM in PG&E's possession at HBPP, down to the fragment level.

B. Corrective Actions to Prevent Recurrence

CAPR 1: Develop procedures that will measure and quantify SNM waste and fuel fragments. These procedures will result in corrections to the SNM inventory that will constitute an acceptable long-term corrective action.

CAPR 2: Complete a detailed SNM inventory based on results of the ongoing SFP work.

CAPR 3: Revise HBPP procedures to require specific detail(s) regarding the documentation of location of fuel components as they are identified in the SFP. A full cataloging and characterization of the contents was performed to ensure a complete and accurate accounting of all SNM in PG&E's possession at HBPP, down to the fragment level.

CAPR 4: Revise HBAP D-7 "Control and Accountability of Special Nuclear Material and Waste Shipments" and STP 3.6.6 "Annual Special Nuclear Materials Physical Inventory and Spent Fuel Pool Cover Seal Verification" to address the issue of the physical inventory of non-fuel SNM in the pool.

CAPR 5: Revise procedures EDOI B-3, EDOI B-5 and HBAP D-7 to ensure that procedures used for future work in the SFP and other areas where SNM may be located shall include provisions for control and accountability of fuel fragments and non-fuel SNM.

CAPR 6: Create a "qualification" for the SNM Custodian and persons designated to be SNM Custodian.

TEXT

VI. Additional Information

A. Failed Components

None

B. Previous Similar Events

None

TEXT

TABLE 1

DESCRIPTION OF 18-INCH SEGMENTS FROM ASSEMBLY A-49

Type of Special Nuclear Material	Spent Fuel Rods, GE Bundle	
Material	Uranium Dioxide, initially enriched to 2.578 percent, encased in 304 stainless steel cladding	
Physical Form	Solid	
	Each Fuel Segment	Total of three Fuel Rod Segments
Length of Fuel Rod Segments	18 inches	54 inches
Fuel Rod Radial Dimensions	Fuel OD - 0.420 inches Cladding ID - 0.423 inches Cladding OD - 0.464 inches	Same
Burnup	12,980 MWD/MTU	Same
Current Weight of SNM	7.5 grams	22.5 grams

Note: SNM weights have been decay-corrected to year 2005.

TABLE 2

ISOTOPIC INVENTORY OF 18-INCH SEGMENTS FROM ASSEMBLY A-49

Nuclide	Each 18-inch Segment		Total of three 18-inch Segments	
	Mass (grams)	Activity (Curies)	Mass (grams)	Activity (Curies)
U-235	5.53E+00	1.19E-05	1.66E+01	3.57E-05
U-238	3.70E+02	1.24E-04	1.11E+03	3.72E-04
Pu-239	1.52E+00	9.41E-02	4.56E+00	2.82E-01
Pu-240	3.63E-01	8.25E-02	1.09E+00	2.48E-01
Pu-241	2.80E-02	2.90E+00	8.40E-02	8.70E+00
Pu-242	2.80E-01	1.11E-04	8.40E-01	3.33E-04
Am-241	1.63E-01	5.61E-01	4.89E-01	1.68E+00
Cm-242	1.78E-07	5.89E-04	5.34E-07	1.77E-03
Sr-90	3.45E-02	4.87E+00	1.04E-01	1.46E+01
Cs-137	7.46E-02	6.49E+00	2.24E-01	1.95E+01
Co-60	1.59E-07	1.80E-04	4.77E-07	5.40E-04
Ni-63	2.44E-03	1.38E-01	7.32E-03	4.14E-01
Ni-59	1.76E-02	1.43E-03	5.28E-02	4.29E-03
Nb-94	6.29E-08	1.18E-08	1.89E-07	3.54E-08
Tc-99	1.27E-01	2.18E-03	3.81E-01	6.54E-03
I-129	2.62E-02	4.63E-06	7.86E-02	1.39E-05

Notes:

1. Weights and activities have been decay-corrected to year 2005.
2. The isotopic inventory for the 18-inch fuel rod segments was calculated by ORIGEN

TEXT

TABLE 3

CALCULATED DOSE RATES – UNSHIELDED IN AIR
ONE 18-INCH SEGMENT FROM ASSEMBLY A-49*

	One 18-inch Fuel Rod Segment (REM/hr in air)**		
Years of Decay***	Dose Rate at 1 cm	Dose Rate at 1 ft	Dose Rate at 3 ft
1	1.2E+04	3.0E+02	3.9E+01
2	5.8E+03	1.5E+02	1.9E+01
3 (1968)	4.0E+03	1.1E+02	1.4E+01
5	2.8E+03	6.9E+01	9.0E+00
10	1.8E+03	4.5E+01	5.9E+00
11 (1974)	1.7E+03	4.3E+01	5.7E+00
15	1.5E+03	3.7E+01	4.9E+00
20	1.3E+03	3.3E+01	4.3E+00
21 (1986)	1.3E+03	3.2E+01	4.2E+00
25	1.2E+03	2.9E+01	3.8E+00
30	1.0E+03	2.6E+01	3.3E+00
35	9.1E+02	2.3E+01	3.0E+00
40 (2005)	8.1E+02	2.0E+01	2.6E+00
50	6.4E+02	1.6E+01	2.1E+00

*PG&E Calculation NX-289 was used to develop this table. The dose rates in this table have been corrected from the previous LER revision, as described in PG&E Calculation NX-289. PG&E Calculation NX-293 calculates underwater dose rates associated with A-49 fuel rod segments. When compared with the actual measured dose rates taken at 6 inches from the surface of the fuel fragments in the HBPP SFP in 2004-05, reasonable agreement exists between the calculated and measured values.

**Also called R/hr in this report (multiply by 1.0 to convert to Roentgens)

***The A-49 assembly was removed from the core during a refueling outage that began September 20, 1965. The specific years shown (1968, 1974, 1986, and 2005 are used in the Theft or Diversion Scenario Analyses)