NRC Form 366
(9-83)

U.S. NUCLEAR REGULATORY COMMISSION
APPROVED OMB NO. 3150-0104
EXPIRES: 8/31/85

# LICENSEE EVENT REPORT (LER)

| FACILITY NAME (1) | DOCKET NUMBER (2) | PAGE (3) |
|---|---|---|
| Palisades Plant | 0 5 0 0 0 2 5 5 | 1 OF 0 8 |

TITLE (4) FUEL ROD FAILURE AND SUBSEQUENT LOSS OF SPECIAL NUCLEAR MATERIAL DISCOVERED FOLLOWING REFUELING OPERATIONS - SUPPLEMENTAL REPORT

| EVENT DATE (5) | | | LER NUMBER (6) | | | REPORT DATE (8) | | | OTHER FACILITIES INVOLVED (8) | |
|---|---|---|---|---|---|---|---|---|---|---|
| MONTH | DAY | YEAR | YEAR | SEQUENTIAL NUMBER | REVISION NUMBER | MONTH | DAY | YEAR | FACILITY NAMES | |
| | | | | | | | | | N/A | 0 5 0 0 0 |
| 0 6 | 3 0 | 9 3 | 9 3 | 0 0 4 | 0 1 | 1 0 | 1 4 | 9 3 | N/A | 0 5 0 0 0 |

OPERATING MODE (9): N

POWER LEVEL (10):

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 (AREA CODE) |
|---|---|
| Cris T. Hillman, Staff Licensing Engineer | 6 1 6 7 6 4 - 8 9 1 3 |

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 |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | |
| | | | | | | | | | |

| SUPPLEMENTAL REPORT EXPECTED (14) | | EXPECTED SUBMISSION DATE (15) | MONTH | DAY | YEAR |
|---|---|---|---|---|---|
| YES (If yes, complete EXPECTED SUBMISSION DATE) | X NO | | | | |

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


On June 30, 1993, at approximately 2300 hours, while draining the refueling cavity in preparation for re-attaching the reactor head to the reactor vessel, an object located in the reactor cavity tilt pit exhibited contact dose rates of approximately 7000R/hr. A review of a remote camera inspection video tape led to the postulation that the object was a piece of fuel rod. Further remote camera inspection of the tilt pit resulted in the discovery of three additional pieces of what appeared to be a fuel rod. Subsequent investigation determined that fragmented pieces of failed fuel rod S-15 dislodged from fuel assembly I-024 during refueling operations.

The failure of the fuel rod was caused by a core shroud and fuel assembly interface problem that resulted in the wear and failure of a single fuel rod. The damaged fuel rod became dislodged from the fuel assembly during refueling operations.

Corrective action for this event includes increased fuel assembly inspections, inspection of the core shroud during the next full core offload, Cycle 11 core redesign incorporating stainless steel rods in selected fuel assemblies, limiting the use of the standard bi-metallic fuel assembly design to four cycles or less, continued periodic reactor noise analysis, procedure changes, and implementation of the Failed Fuel Response Plan.

EVENT DESCRIPTION

On June 30, 1993, at approximately 2300 hours, while draining the refueling cavity in preparation for re-attaching the reactor head to the reactor vessel, radiological dose rates in the reactor cavity near the tilt pit [DF] exceeded the dose rates typically experienced during previous similar refueling cavity draining evolutions. At the time of the event the reactor head was in place over the reactor vessel resting on shims. Typical dose rates at the floor level of the refueling cavity near the tilt pit (elev. 625-feet) are 200-300 mR/hr; however, during this event the dose rate on the refueling machine bridge (elev. 649-feet) was 700 mR/hr with no water in the tilt pit. An object located on the tilt pit floor (elev. 610-feet), exhibited contact dose rates of approximately 7000R/hr. The refueling cavity was immediately evacuated and the radiological conditions assessed. Approximately two feet of water was added to the tilt pit to provide shielding. Proper radiological postings and boundaries were established, and access to the containment area was controlled. At the time of the event the reactor was in a refueling mode. There was no radiological release to the environment as a result of this event, and there were no personnel exposures that exceeded either 10 CFR Part 20 limits or CPCo administrative limits. This event had no adverse effect on the health and safety of the public.

A remote camera inspection of the tilt pit was conducted and a cylindrical object approximately five (5) feet in length and approximately four-tenths (0.4) inch in diameter was identified. It was suspected that the object was a piece of a fuel rod [AC]. On July 1, 1993 the NRC was notified of the possibility of a fuel rod in the reactor cavity tilt pit.

Further remote camera inspection of the tilt pit resulted in the identification of three more pieces of what appeared to be a fuel rod. The total length of all four pieces was estimated to be about 12 feet. A review of the video tape from the remote camera inspection of the three additional objects revealed that one of the pieces had an end cap and the serial number was visible. Based on the serial number, it was determined that the fuel rod came from fuel assembly I-024 which was in the reactor core. The I-024 fuel assembly had been removed from the reactor during refueling, taken to the tilt pit, rotated 180 degrees and returned to its core position.

In response to these developments, CPCo formed a project team to develop an action plan for recovery of the fuel rod pieces from the tilt pit, recovery of the damaged fuel assembly from the reactor core, and analysis of the entire event.

On July 4, 1993 the three fuel rod fragments were retrieved and relocated to storage baskets in the tilt pit. It was determined the fourth piece was not a fuel rod fragment and it was not recovered. By July 6, 1993 a plan had been developed and approved by the Plant General Manager and the NRC for the recovery of fuel assembly I-024 from the reactor core. The reactor head was removed and placed on the reactor head stand. Preparations were then made to remove the Upper Guide Structure (UGS) from the reactor vessel. During the lift of the UGS, the load cell readout indicated a load greater than anticipated. A remote camera inspection of the underside of the UGS confirmed that a fuel assembly still in its core position was being lifted with the UGS. The UGS lift was halted and the containment was evacuated. An Unusual Event was

declared at 2254 hours on July 6, 1993. There was no radiological release to the environment as a result of the lifting of a fuel assembly with the UGS, and there were no exposures that exceeded either 10 CFR Part 20 limits or CPCo administrative limits. The lifting of a fuel assembly with the UGS had no adverse effect on the health and safety of the public.

A closer examination of the location of the fuel assembly attached to the UGS indicated that the fuel assembly was attached to the UGS in a location where fuel assemblies had been stuck to the UGS on two previous occasions. (See LERs 88015, dated October 3, 1988 and 92017, dated March 30, 1992.) All reactor vessel work was stopped pending recovery of the fuel assembly stuck to the UGS. Containment integrity was established by closing the equipment hatch and routine work activities in the containment were suspended. Procedures were then developed for the recovery of the stuck fuel assembly.

On July 8, 1993 the fuel assembly, while still in its core position, was successfully removed from the UGS and placed on the reactor vessel core support plate. The UGS was then lifted without further incident and was placed in its storage location in the reactor cavity. The fuel assembly that was lifted with the UGS was then moved to the spent fuel pool for examination. Also on July 8, 1993, an NRC Augmented Inspection Team (AIT) arrived at Palisades to investigate the broken fuel rod found in the reactor cavity tilt pit, the lifting of a fuel assembly during removal of the UGS, and other recent issues.

On July 13, 1993 fuel assembly I-024 was removed from the reactor core. Prior to removal from the reactor core, fuel assembly I-024 had been visually inspected to ensure that additional fuel rods would not be damaged during removal from the reactor core. The visual inspection of fuel assembly I-24 while it was in the reactor core was accomplished by removing an adjacent fuel assembly and an adjacent control rod. Prior to removal, it was noted that the upper end piece of the failed fuel rod was still contained within the uppermost spacer grid of the I-024 fuel assembly. During the removal of the I-24 fuel assembly from the reactor core, this piece of fuel rod dropped from the fuel assembly and landed on top of another fuel assembly tieplate in the core. The piece that had fallen from fuel assembly I-024 was retrieved from the core and was stored with the other three fuel rod pieces. The I-024 fuel assembly was subsequently relocated to the spent fuel pool, along with the pieces of damaged fuel rod, where inspections by CPCo personnel and the fuel vendor could be conducted.

Inspection of the I-024 fuel assembly and the broken fuel rod have been completed. Inspection of the reactor core and lower vessel area for loose fuel pellets, other debris, and other indications of fuel damage has been completed. The results of these inspections were used to determine a root cause for the failure of fuel assembly I-024 and to develop corrective actions associated with this event.

This event is reportable to the NRC in accordance with 10CFR50.73(a)(2)(ii) as an event wherein a principal safety barrier (i.e., fuel cladding) was seriously degraded.

## CAUSE OF THE EVENT

The failure of the fuel rod from fuel assembly I-024 was caused by a core shroud and fuel assembly interface problem that resulted in the wear and failure of a single fuel rod.

This event involved the failure of a principal safety barrier (fuel cladding) and is considered a failure of equipment important to safety.

## ANALYSIS OF THE EVENT

Fragmented pieces of failed fuel rod S-15 from fuel assembly I-024 were found in the reactor side tilt pit following the initial draining of the reactor cavity near the end of Cycle 10 refueling outage. Based on inspections of the failed fuel assembly, fragmented fuel rod pieces, and the core shroud corner location where fuel assembly I-024 was located, the following conclusions have been made:

1. The fuel rod was failed and severely damaged during Cycle 10 operation.

2. The upper portion of the fuel rod and the associated corners of spacers 6 through 9 were rubbing against the core shroud during Cycle 10 operation.

3. A circumferential break in Span 9 existed on the failed rod during Cycle 10 operation. This is believed to be due to secondary hydriding. The initial primary failure is believed to have originated in Span 5 or 6 due to rod fretting against the core shroud.

4. The rod was peeled from the fuel assembly while being handled over the reactor side tilt pit during the initial end of Cycle 10 core fuel shuffle.

5. As the rod was peeled from the fuel assembly, it was broken into several pieces. This peeling is believed to be the cause of damage to the corners of spacers 1 through 5.

6. A total of six fragmented rod pieces were found. The entire length of the failed rod has been accounted for; however, approximately three feet of partial circumferential cladding (1/3 to 1/2 circumference) remains missing.

7. The missing partial cladding is believed to have worn or broken away during Cycle 10 operation. One to three cladding shards may exist that are equivalent in size to one of the shards found (which was one-foot long, about 90 degrees circumference, and worn down by the core shroud).

8. Approximately five feet of fuel, 213 pellets, is missing from the retrieved fragmented rod pieces.

**Root Causes That Are Considered Likely**

A core shroud and fuel assembly interface problem is considered the likely proximate cause. The root cause(s) must still be determined considering potential contributing factors.

**Root causes being considered:**

1. Shroud distortion due to operating conditions.
2. Shroud distortion due to loose or broken bolting.
3. Misalignment between the UGS and the core support barrel.
4. The problem may have always existed from the original as-built conditions; however, the addition of some contributing factors caused the I-024 failed rod event.

**Contributing factors being considered:**

1. Fuel assembly I-024 was in the core five cycles.
2. Minor damage on fuel assembly I-024 may have existed from a handling event.
3. Fuel assembly I-024 had loose spacer grids.
4. Increased PCS flow due to the steam generator replacement after Cycle 9.
5. Core barrel vibration changes.
6. Localized PCS flow changes due to introduction of (HTP) High Thermal Performance fuel assemblies.
7. Fuel assembly bow.
8. Fuel assembly twist.

Six of the above contributing factors 1, 3, 4, 5, 6, and 7 are considered key factors to be specifically addressed for operation of Cycle 11 and future cycles. Contributing factor 2 was addressed to some extent during the root cause analysis. Refueling equipment was inspected for damage or snag hazards to verify no generic handling damage issue existed. Contributing factor 8 may have some subtle contribution with respect to how a fuel assembly interfaces with its surroundings; however, fuel assembly twist was a minor contributor to the failed rod event since the fuel assembly's upper and lower tie plates are held in position by the Upper Guide Structure lower alignment plate and the lower core support plate, respectively. Any fuel assembly twist would tend to be reduced or eliminated due to the tight positioning tolerance provided by the alignment pins and alignment holes.

**Disposition of Missing Material**

Material missing from fuel assembly I-024 and failed fuel rod S-15 is summarized as:

| | |
|---|---|
| Missing Cladding | 51 grams |
| Missing Pellets | 938 grams |
| Missing Insulator Disk | 2 grams |
| Missing Spacer Pieces | (not quantified, see below) |

A total of six fragmented rod pieces were found and retrieved. The entire length of the failed fuel rod has been accounted for; however, approximately three feet of partial circumferential cladding (1/3 to 1/2 circumference) is missing. The missing partial cladding is believed to have worn away during Cycle 10 operation at least to some extent. We believe that one to three cladding shards may exist that are equivalent in size to one of the shards retrieved (which was one-foot long, about 90 degrees in circumference, and apparently worn away by interaction with the core shroud). The missing cladding shards may have broken into smaller pieces. Approximately five feet of fuel pellet material is missing from the retrieved fragmented fuel rod pieces. Remedial corrective action with respect to accountability and impact of the missing fuel is discussed in our September 30, 1993 letter.

In addition to the missing fuel rod material, spacer material is missing from the damaged corner of fuel assembly I-024. Most of the missing material consists of small portions of the side plates in the area of the failed fuel rod. A very small amount of internal strip material and one lantern spring from spacer 9 are also missing.

A search for missing material was performed in the core location where fuel assembly I-024 resided. The bottom of the reactor vessel under the core support plate, the top of the core, the reactor cavity tilt pit, the transfer tube, and the spent fuel pool side south tilt pit were also inspected. The missing partial cladding was not located. Three small pieces of spacer side plate material were located on the core shroud and on the core plate, and were retrieved using the normal vacuuming equipment. It is possible that other missing spacer pieces and small cladding pieces were retrieved during the several tilt pit, reactor cavity floor, or core region vacuumings that took place during the refueling outage.

Some spacer and cladding material has not been found. If this material still resides within the primary coolant system, the potential exists for fuel rod fretting after the primary coolant pumps are returned to service. The impact of fuel rod fretting will be mitigated since 136 of the 204 total fuel assemblies incorporate a debris resistant design.

Additionally, it is recognized that debris in the PCS has the potential to affect PCS internal components such as valve internals and steam generator tubes. The majority of

the 53 grams (0.12 pounds, plus a slight addition due to spacer material) of missing non-fuel material is zircaloy. The missing material will cause little fretting wear against stainless steel or Inconel components. The effect of the missing 53 grams of material on other components, such as valve internals, is considered to be minimal based on previous experience at Palisades.

CORRECTIVE ACTION

Corrective action for this event includes:

1. Inspection of a minimum of four fuel assemblies in the shroud corner locations every refueling outage.

2. Performing a detailed inspection of the core shroud after the next core offload.

3. Attempting to retrieve the as-built drawings and documentation of clearances between the core shroud and the fuel assemblies.

4. Limiting the use of the standard bi-metallic fuel assembly design to four cycles or less.
5. Continued inspection of the High Thermal Performance spacer grid assemblies to confirm they meet their design.

6. For Cycle 12, implement the planned shield fuel assembly design, or configure burned fuel assemblies placed in the shroud corner positions such that the fuel assembly bow is oriented toward the core and away from the shroud.

7. Continued periodic reactor noise analysis utilizing the ex-core neutron detectors.

In addition, 16 "L" fuel assemblies will be used in the Cycle 11 core design and will be located in the baffle corner locations. The 16 "L" fuel assemblies have 14 fuel rods replaced by oversized stainless steel rods. Eight of the stainless steel rods are oriented in the corner of the fuel assembly which interfaces with the shroud corner to mitigate the consequences of a potential fuel assembly failure similar to that experienced by the I-024 fuel assembly. The other three corners of each assembly have two stainless steel rods each.

Miscellaneous further corrective actions include:

1. Incorporating the lessons learned from this event into the fuel performance monitoring procedures.

2. Evaluating the need to perform supplemental noise monitoring during Cycle 11 utilizing externally mounted vibration monitoring equipment.

3. Implementation of the Failed Fuel Response Plan to monitor future fuel failure.

## ADDITIONAL INFORMATION

A detailed description and the results of the root cause analysis for this event are contained in a letter from Consumers Power Company to the NRC dated September 30, 1993.