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FROM: Carolina Power & Light Co Raleigh, N.C. 27602 E.E. Utley	DATE OF DOC 6-12-75	DATE REC'D 6-19-75	LTR XX	TWX	RPT	OTHER
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CLASS: UNCLASS XXX	PROP INFO	INPUT	NO CYS REC'D 40	DOCKET NO: ~~50-XXX~~ 50-261		

DESCRIPTION: Ltr trans the following:

ENCLOSURES: Abnormal Occurrence Report AO-50-261/75-9(revised)6-4-75 which occurred on 5-1-75 re failure of reactor coolant pump seal resulting in discharge of reactor coolant fluid to containment floor..

ACKNOWLEDGED

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50-261

CP&L

Carolina Power & Light Company

June 12, 1975

File: NG-3513 (R)

Serial: NG-75-858

Mr. Norman C. Moseley, Director
U. S. Nuclear Regulatory Commission
Region II, Suite 818
230 Peachtree Street, N. W.
Atlanta, Georgia 30303

Dear Mr. Moseley:

H. B. ROBINSON UNIT NO. 2
LICENSE NO. DPR-23
FAILURE OF "C" REACTOR COOLANT PUMP SEAL SYSTEM

In accordance with 6.6.2.a of the Technical Specifications for H. B. Robinson Unit No. 2, the attached Abnormal Occurrence Report is submitted for your information. This report has been revised, as requested, to include information which was unavailable or not evaluated in the short period prior to its initial submittal.

Yours very truly,

E. E. Utley
Vice-President
Bulk Power Supply

DBW:bn

Attachment

cc: Mr. N. B. Bessac
Mr. P. W. Howe
Mr. R. E. Jones
Mr. D. Knuth
Mr. J. B. McGirt
Mr. D. B. Waters

6632

336 Fayetteville Street • P. O. Box 1551 • Raleigh, N. C. 27602

ABNORMAL OCCURRENCE REPORT

1. Report Number 50-261/75-9 (Revised)

2a. Report Date June 4, 1975 (Revised)

2b. Occurrence Date May 1, 1975

6-12-75

3. Facility H. B. Robinson Unit No. 2
Hartsville, South Carolina 29550

4. Identification of Occurrence

Failure of reactor coolant pump (RCP) seal resulting in discharge of reactor coolant fluid to containment floor.

5. Conditions Prior to Occurrence

The reactor was operating at full power. All systems were normal. Dilution of the primary coolant boron concentration was in progress to compensate for the buildup of Xenon. The plant had just reached full power operation early in the morning on May 1, 1975 following a maintenance outage.

During dilution, No. 1 seal leakoff flow from "C" RCP responded sensitively to all reactor coolant system additions. This response had been present since seal replacement earlier in the week. However, variations were slow and leakoff flow was within prescribed limits so pump operation was continued.

6. Description of Occurrence

The dilution referred to above was still in process when the following events transpired:

May 1, 1975:

1750 - "C" RCP No. 1 seal leakoff flow "spiked" several times on the RTGB recorder. The pump was monitored for vibrations and found to be normal.

1811 - "C" RCP seal leakoff oscillated full range several times and then went off scale at the high end indicating a seal flow greater than 6 gpm. A load reduction was commenced at a rate of 10% per minute so that "C" pump could be idled as per plant operating procedures.

1818 - "C" RCP was deenergized at 36% power and load reduction stopped.

1819 - A reactor trip occurred due to a turbine trip. The load reduction rate compounded by steam dump operation and the stopping of "C" RCP caused a high level condition in "B" steam generator, and the turbine trip ensued.

1832 - CCW-626, component cooling water common return from all three RCP's, closed due to high flow from "C" RCP thermal barrier. Hot primary coolant (540°F) passing through the thermal barrier as a result of the failed No. 1 seal caused the component cooling water in the barrier coils to flash into steam cresting surges and the high flow conditions. Concurrently, flashing of primary coolant in the No. 1 seal leakoff common return to the volume control system was apparent as indicated by a high temperature indication (> 300°F) on TE-133 downstream of the seal water heat exchanger and high pressure in the volume control system. This condition threatened seal water flow to "A" and "B" RCP's. It was, therefore, the Shift Foreman's decision to secure these pumps. Valve CVC-303C, seal leakoff isolation from "C" RCP, remained open at this time.

1841 - Received automatic letdown isolation due to low level in the pressurizer. Supply to charging pump suction changed from volume control tank, (VCT), to refueling water storage tank, (RWST).

1854 - Pressurizer level returned above letdown isolation setpoint. Returned charging pump suction to VCT.

1915 - Seal flow was lost on "A" RCP. Closed valve 303C to decrease pressure surges in seal leakoff line.

1928 - Seal flow was lost on "B" RCP. Opened valve WD-1708 to relieve pressure in Reactor Coolant Drain Tank (RCDT). Pressure buildup was due to leakage of hot primary coolant through No. 2 seal of "C" RCP into the tank. WD-1708 allows drainage of RCDT to the containment sump.

1942 - First entry following seal failure was made into containment. Purpose of the entry was to observe "C" RCP and to close valve CCW-728C, "C" pump thermal barrier outlet manual isolation valve. The control panel-operated valve CVC-303C had not fully isolated the leakoff and was still causing steam formation in the thermal barrier. It was not possible to enter "C" RCP bay due to steam escaping from the pump seals. Personnel who entered containment were wearing full anticontamination clothing including half-face respirators.

1945 - In the period subsequent to the automatic closing of CCW-626 it was verified, using the Component Cooling Water Radiation Monitor (R-17), that the valve closing was caused by the flashing of steam, discussed above, as opposed to a thermal barrier failure. In the event that the thermal barrier had failed the component cooling water would have been contaminated and R-17 would have alarmed. Thus assured that the component cooling system was not contaminated valve CCW-626 was manually blocked open and operations personnel stationed at the valve. This allowed cooling water to flow through the thermal barriers thus reducing temperatures below the boiling point in "C" RCP. After temperatures were reduced CCW-626 was unblocked and returned to normal operation in the open position.

1950 - All personnel exited containment.

2000 - Breakers were pulled on containment sump pumps to prevent overfilling of waste holdup tank. Water was originating from reactor coolant, drain tank and floor drains in "C" RCP bay.

2007 - A second containment entry was made by personnel to obtain air samples and inspect the RCP's. Due to the steam observed on the first entry, Scott Air Packs and double "Anit-C" clothing were utilized on this entry. At this time no steam or water leakage was seen coming from the pumps.

2013 - Started "B" RCP bearing oil lift pump in an attempt to lower the shaft and provide more seal clearance to reestablish seal flow.

2015 - Stopped "B" RCP bearing oil lift pump upon failure to establish seal flow through No. 1 seal.

2026 - Personnel exited containment.

2110 - A third entry was made into containment in an attempt to reestablish seal flow in "A" and "B" RCP's by rotating them. The results of the air samples taken during the second entry indicated no need for self-contained air supplies. Therefore, all subsequent entries were made in double "Anti-C" clothing and half-face respirators. "A" and "B" pumps could not be rotated which resulted in another failure to reestablish seal flow through the No. 1 seals.

2206 - Personnel exited containment.

2215 - At this point, conditions pointed to the conclusion that although RCP "C" No. 1 seal had failed, the No. 2 seal was intact and holding. These conditions were:

a. Thermal barrier ΔP indicated about 1 inch of water (in all probability, actually zero).

b. No. 1 seal ΔP was zero.

c. Low standpipe level alarm existed.

A Westinghouse pump representative was contacted for advice on running "C" RCP for the cooldown. At least one pump was needed to circulate the reactor coolant to equalize temperatures and boron concentrations in the system and seal water flow could not be established on "A" or "B" RCP. The advice was that there was some risk that No. 2 and 3 seals would be damaged by running the pump. However, pumps in this condition have been successfully run before with the No. 2 seal having held full system pressure. It was further advised that the pump could be operated with No. 1 seal leakoff isolated as long as No. 2 seal remained intact. With this information the decision was made to start "C" RCP.

2242 - Started "C" RCP.

2250 - Safety Injection (SI) was blocked at 1900 psig in the reactor coolant system as part of the normal cooldown procedure.

2257 - Prepared for cooldown by use of the secondary system.

2308 - Valve CCW-626 was electrically blocked open to prevent possible loss of thermal barrier cooling water. Radiation monitor R-17 was observed during this time to determine if conditions would arise requiring closing of CCW-626.

2310 - Increased seal water injection flow to "C" RCP to 20 gpm in order to prevent possible overheating of pump bearing.

2316 - Received control panel indication of 0.5 ft. of water in containment sump.

May 2, 1975:

0011 - The fourth containment entry was made in an attempt to identify any leaks in addition to the "C" RCP seal. "A" and "B" RCP bays were inspected, however, personnel was unable to enter "C" pump bay due to the steam. No additional leak was found and personnel exited containment at 0023.

0015 - Received high standpipe level alarm on "C" RCP indicating failure of No. 2 seal. Stopped "C" RCP. Pressurizer level started to fall rapidly when the pump was stopped.

0016 - Started "A" safety injection (SI) pump. Opened valves SI-866A and SI-866B, hot leg safety injection to loops "B" and "C". Safety Injection was lined up to the hot leg in order to bypass the boron injection tank. The additional boron (21,000 ppm in the tank) was not required at this point.

0018 - Started "B" and "C" safety injection pumps. Pressurizer level decrease stopped. Lowest level reached in pressurizer was 6% on level indicator LI-462 (cold calibration). Strip chart indication reached zero and remained there for about 10 minutes.

0030 - Reactor Coolant System Boron Concentration was 1225 ppm.

0036 - Diverted charging flow from the cold leg of loop "B" to auxiliary pressurizer spray (opened valve CVC-311) to reduce Reactor Coolant System pressure, (1150 psig at this time). The pressurizer steam void was rapidly collapsed by the auxiliary spray and pressure dropped accordingly. It was necessary to use auxiliary spray since normal spray was lost when the coolant pumps were stopped.

0039 - Stopped "C" S.I. pump due to rising pressurizer level. The safety injection pumps and valve CVC-311 were used during the remainder of the cooldown to control pressurizer level and pressure.

0043 - Started HVH unit No. 4, (containment recirculation fan and cooler) to reduce containment pressure and temperature. Prior to startup of the fourth unit, three HVH units were in operation.

0048 - The S.I. accumulators discharged approximately 13% of their water volumes into the Reactor Coolant System. Their discharge valves were closed at 550 psig to terminate this injection. These valves were not closed at 1000 psig as required by normal cooldown procedures.

0100 - Reactor coolant system boron concentration at 1521 ppm. Containment internal pressure reached a maximum of 3 psig.

0112 - Use of the RHR system was delayed due to the normal letdown valve CVCS-460B being shut as a result of the air line to the operator being broken. This valve is required to establish letdown and equalize pressure between the reactor coolant system and the RHR system. It does not, however, prohibit use of RHR as a S.I. or cooldown system.

At this time the fifth entry into containment was made to repair the valve. Pressure in containment was about 3 psig (highest indication on RTGB) and temperature was estimated to be above 100° (the RTGB indicator had failed). With these conditions it took approximately 60 minutes to effect repairs.

0145 - Opened condenser vacuum breaker in preparation to terminate cooldown using the secondary plant.

0151 - Started "D" Service Water Pump and "B" Service Water Booster Pump (cooling water to HVH units) to aid in the reduction of containment pressure and temperature.

0212 - Repairs to CVCS-460B were complete.

0215 - Shut main steam isolation valves. Cooldown using the secondary plant was terminated.

0223 - Started "A" component cooling water pump in preparation to go on residual heat removal system. (RHR)

0226 - Personnel who repaired CVCS 460B exited containment.

0230 - Started operating RHR pumps one at a time to warm up the RHR system. Pressure in the primary system was approximately 400 psig. Proceeded with plant cooldown as per General Operating Procedure CP-1D.

0330 - Reactor coolant system boron concentration at 1861 ppm.

0341 - Residual Heat Removal System in service. Cooldown proceeding on RHR.

0440 - Discontinued using S.I. system to maintain level.

0448 - Reactor coolant system at cold shutdown (less than 200°F).

0517 - Commenced decreasing primary system pressure from 100 psig to 0 psig.

0629 - A sixth entry into containment was made at this time for general inspection. The bottom floor of containment was flooded with approximately 8 to 10 inches of water. Very little vapor was present and ambient temperature was about 100°F. No further inspection was made at this time and personnel exited containment at 0642.

0850 - A seventh entry was made into containment for general inspection. At this time, no vapor was present, humidity was high, but pressure was near atmospheric. "C" RCP bay was entered and water was found to be spurting out of No. 3 seal to a height of about 6 inches. The water level on the bottom floor was measured to be about 12.5 inches. "A" and "B" RCP bays were inspected and no additional abnormal conditions were found. Personnel exited at 0925.

1000 - The reactor coolant system was drained to 50 inches above the reactor vessel flange and the leak was secured by this action. The boron concentration in the coolant was 1644 ppm. The containment vessel was at atmospheric pressure, and the ambient temperature was about 100°F. The containment floor contained about 12.5 inches of water. Approximately 132,500 gallons of water were spilled, and the maximum leak rate experienced was approximately 400 gpm. At this time Westinghouse was consulted for recovery advice.

7. Designation of Apparent Cause of Occurrence

The discharge of primary coolant to the containment floor was caused by the failure of "C" RCP seal system. The seal system failed when the pump was run with a leaking No. 1 seal. This seal is the normal point of primary pressure drop. The No. 2 seal, designed to maintain system pressure as well, was relied upon in order to operate the pump to equalize temperatures and boron concentrations during plant cooldown. Seal water flow could not be reestablished in either "A" or "B" RCP's.

In the ninety minutes that "C" RCP was run, subsequent damage was incurred by both No. 1 and No. 2 seals. The damage was further compounded by the apparent failure of the pump radial bearing. In addition, the failed bearing caused damage to the labyrinth seals of the thermal barrier adding to the excessive discharge.

The No. 1, No. 2 and No. 3 seals had been replaced in "C" RCP following seal failure just one week prior to this occurrence. However, no apparent cause for either failure of the No. 1 seal was evident.

8. Analysis of Occurrence

During the transient, the maximum temperature reached at the core exit was approximately 550°F which occurred shortly after the reactor trip. About the time that cold shutdown conditions were reached, it was determined that another steam bubble existed in the RCS. To reduce the leak rate it was desirable to reduce system pressure. This was attempted by opening the auxiliary spray valve to collapse the pressurizer bubble. When the valve was opened, the RCS pressure did not drop noticeably, but the pressurizer level increased rapidly (more rapidly than charging and SI would raise it). When the auxiliary spray valve was shut, pressurizer level decreased rapidly as the bubble reformed in the pressurizer. Core thermocouple temperatures showed the reactor temperature to be stable and later when the reactor head vent was opened, little gas or steam escaped. The second bubble probably existed in the steam generator tubes. Due to loss of RCS circulation and the limited steam that had been drawn during the cooldown (none after placing RHR in service), the steam generators remained relatively hot. When pressure in the system was reduced from 400 psig to 100 psig, a bubble could have formed in one or more steam generators.

During the course of events "C" RCP radial bearing experienced three thermal cycles as indicated by the bearing water temperature. The maximum temperature recorded during these cycles was approximately 297°F which occurred when component cooling water was lost to the thermal barrier. Although they did not occur during pump operation, the high temperature conditions may have caused the subsequent bearing failure.

Inspection of "C" RCP after disassembly revealed extensive damage to pump and seal internals. The bearing was completely "wiped" and the thermal barrier labyrinths revealed wear beyond replacement. The seals were damaged to the extent that removal and disassembly was difficult. The shaft and other metal components were discolored from being subjected to high temperatures.

As a direct result of the seal failure, an abnormal occurrence transpired as defined by Technical Specification Section 1.8.e, abnormal degradation of one of several boundaries designed to contain the radioactive materials resulting from the fission process. Additionally, other Abnormal Occurrences took place:

1. The primary leakage exceeded those limits as given in Section 3.1.5 of the Technical Specifications.

2. As the leak progressed, the containment pressure exceeded 2 psig internal pressure (Section 3.6.2).

3. As a result of the subsequent cooldown, excessive cooldown rates were experienced in violation of Section 3.1.2.

All are classified as Abnormal Occurrences under Specification 1.8.b of the Technical Specifications.

Proper operation of safeguards equipment and actions taken by the control operators prevented more extensive damage after the seal failure. All systems functioned as designed during the transient and the expected results were achieved.

The occurrence resulted in no offsite releases or exposures. At no time was there any danger to the personnel involved. Due to the seal failure, overheating of the pump shaft and seal housing occurred. This will necessitate the replacement of the seals and housing, pump shaft, and associated equipment.

9. Corrective Action

The pump repair consisted of the replacement of seals, shaft, impeller, bearing and thermal barrier under the direction of pump vendor representatives. Special procedures were employed to test and inspect "C" RCP prior to returning to service. Portions of the seal water injection system which supplies water to the pump seals were thoroughly flushed to minimize the possibility of subsequent failure due to particulates entering the seals.

As a precautionary measure "A" and "B" RCP seals were disassembled and inspected. No evidence of damage beyond normal wear was present. Seals were replaced as necessary under the direction of vendor representatives.

A significant factor leading to the ultimate damage to "C" RCP seals and the subsequent discharge of reactor coolant was the loss of seal water flow to the two operable pumps "A" and "B". This might have been avoided if the leak-off isolation valve to "C" RCP had been shut immediately upon the indication of damage to No. 1 seal. To minimize the possibility of this recurring a Reactor Coolant Pump Abnormal Procedure has been implemented which directs to shut this valve as the first immediate action upon indicated damage to the No. 1 seal. Additionally, this procedure specifies actions for other abnormal conditions which might conceivably occur to an RCP.

Since this was the first major incident involving a sizable loss of coolant at H. B. Robinson, the procedures used to gain control over the transient were thoroughly reviewed. It is believed that the actions taken were in the best interest to maintain the reactor in a safe condition and minimize damage to vital equipment. However, as indicated above, areas requiring additional procedures have been revised.

10. Failure Data

The following information pertains to seal-related maintenance for the three Westinghouse Reactor Coolant Pumps, Model Number V1101-B1:

(a) March 14, 1971 - Following a reactor trip, a loss of seal flow to "A" and "C" RCP's was experienced. This resulted in bearing and seal damage to "A" RCP. "C" RCP suffered no adverse effects.

(b) March, 1973 - During the 1973 refueling outage all three RCP's were disassembled and inspected. Normal wear was apparent and seals were replaced as necessary.

(c) May, 1974 - Normal refueling outage maintenance.

(d) June 18, 1974 - RCP's were being started following system venting. Seal water flow became excessive (off-scale) on the running "C" RCP when "A" RCP was started. Subsequent inspection revealed a badly worn No. 1 seal and runner.

(e) April 24, 1975 - While preparing for reactor startup following a scheduled maintenance outage, "C" RCP seal water flow became excessive (off-scale). Seals were found to be excessively worn and were replaced.