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Dresden Nuclear Power Station
R. R. #1
Morris, Illinois 60450
May 16, 1975

Mr. James G. Keppler, Regional Director
Directorate of Regulatory Operations-Region III
U. S. Nuclear Regulatory Commission
799 Roosevelt Road
Glen Ellyn, Illinois 60137

SUBJECT: License DPR-19, Dresden Nuclear Power Station, Unit 2, Control Rod Drive Inspection Report

References:
1) Letter from W. P. Worden to A. Giambusso dated March 13, 1973.
2) GE trip report on inspection of uncoupled drives dated April 4, 1973
3) Letter from W. P. Worden to A. Giambusso dated May 8, 1973
4) Letter from W. P. Worden to A. Giambusso dated July 17, 1973
5) Letter from B. B. Stephenson to J. F. O'Leary dated March 21, 1974
6) GE trip report on inspection of uncoupled drive, B-11, dated June 21, 1974
7) Letter from B. B. Stephenson to J. G. Keppler dated August 30, 1974
8) Letter from B. B. Stephenson to J. F. O'Leary dated June 24, 1974
9) GE trip report on inspection of uncoupled drives L-9 and K-11 dated September 17, 1974
10) Letter from B. B. Stephenson to J. G. Keppler dated August 9, 1974
11) Letter from B. B. Stephenson to J. G. Keppler dated October 31, 1974
12) Letter from B. B. Stephenson to J. G. Keppler dated November 12, 1974 letter #807-74
13) Letter from B. B. Stephenson to J. G. Keppler dated November 12, 1974. Letter #812-74

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Dear Mr. Keppler:

In the above referenced letters 8,10,11&12, the station had committed to submitting a letter detailing the mode of failure of four control rod drives dating back from June 15, 1974 thru November 2, 1974. This letter will review, in detail, the history of the control rod drive anomaly from the first occurrence on February 19, 1973 thru November 2, 1974, the results of each control drive inspection subsequent to removal from the reactor, failure of three CRD's to fully insert on a scram, and the overall inspection of 137 control rod drives removed and overhauled during the winter 1974 refueling outage.

The first occurrence at Dresden of an apparent uncoupling of a control rod drive (CRD) occurred on February 19, 1973 when three control rod drives (B-6(#20), K-8 (#656C), L-11 (#91)) gave indication of an uncoupled condition when they were withdrawn during a startup of the unit. (Referred to in ref. 1, 2, 3, and 4).

The three CRD's that were withdrawn to position "48" gave an overtravel alarm annunciation when the overtravel check was performed. Both the four rod and full core display for the CRD's were lost, giving an indication of an apparent uncoupled condition. The drives were successfully recoupled on the first attempt and uncoupling was never experienced again even though each drive was subjected to twenty-five uncoupling checks on February 20, and an uncoupling check once per day for a period of one week and once per week thereafter until their removal on March 30, 1973.

The results of the visual inspection of the three (3) drives and the conclusions reached by General Electric (GE) representatives are as follows:

1. CRD K-8 (Flange No. 656C)

This CRD had a measured overall length of 174-1/8 inches with the inner filter installed and 173-3/8 inches without the filter. Adding the incremental length to account for a properly seated filter to the latter measurement results in a corrected overall length of approximately 173-7/16 inches which is within the allowable tolerance range for this measurement when the filter is properly seated. The filter removal tool was engaged in the filter. Prior to any removal attempt, the filter was determined to have approximately 1/2 to 3/4 inch axial movement. In addition, when removal was attempted by 90° rotation of the tool, no spring tension was felt against the stop piston connector flats as it should have been. Removal was then achieved by simply withdrawing the filter removal tool until the filter was removed. Close visual examination (use of the eye piece) of the filter assembly was performed at a distance of one foot through a plexiglass shield. The retainer spring at the base of the filter was distorted. The spring surfaces which mate with the flats on the stop piston connector were deflected up and out into the filter. This filter is considered to have been disconnected from the stop piston connector prior to removal identified above.

The damaged spring indicates that the filter could have been improperly installed prior to installation in the reactor.

2. CRD B-6 (Flange No. 20)

The second CRD inspected had an overall measured length of 173-3/4 inches, which also exceeds the specified dimension of 173.406 ± .031. However, this filter was tight (approximately 1/8 inch axial movement) and was considered firmly attached to the stop piston connector. The filter was rotated 90° and removed from the index tube. Observation of this filter also revealed a slightly bent retainer spring. Although it was concluded that this filter was properly attached at the time of its removal, the damaged spring indicates that the filter could have been improperly installed prior to installation in the reactor.

3. CRD L-11 (Flange No. 91)

The third CRD inspected had an overall measured length of 173-½ inches. The filter was tight (approximately 1/8 inch axial movement) and firmly attached. The filter was rotated 90° and removed from the index tube. The filter retainer spring was not damaged on this CRD.

The conclusions from the initial inspection are summarized as follows:

1. Review of the engineering evaluation of the new CRD inner filter design reveals that damage occurred during testing to a retainer spring similar to that observed on the subject CRD's. This damage occurred when the filter was installed without utilizing a rotating technique simultaneously with inserting the filter. This motion centers the spring on the connector and prevents flush contact of the spring and flat top of the connector.

2. Two (2) CRD's contained inner filters with damaged retainer springs possibly caused by improper installation.

3. The inner filter of CRD Flange No. 656C was determined by measurement and orientation not to be coupled to the stop piston connector.

4. The uncoupled condition of Flange No. 656C could be a result of failure to lock the filter on the connector following installation.

5. A drive in the condition in which 656C was discovered (i.e., detached filter with bent spring preventing engagement of filter to connector) effectively had a "long" uncoupling rod setting. This could produce an actual uncoupling incident as the drive withdrew to position "48". If so, it is hard to explain the proper engagement of the filter the next time the coupling test was repeated as the bent spring would continue to interfere.

6. It may be surmised, based on the coupling spring damage only, that drive#20 could have experienced a similar sequence. This is believed very unlikely, however, as some mechanism must be postulated to cause rotation of the filter to a locked position following the first uncouple alarm.

7. Drive#91 gave no evidence that the filter had ever been detached, and there was no evidence in the drive to indicate an uncoupling event ever occurred.

The following is the sequence of events which would have had to occur in order to have an uncoupling. This postulated sequence is based, mainly, on finding one filter disconnected from the stop piston in the above CRD inspection.

1. Filter seated on stop-piston but not rotated and locked.

2. Friction or filter Δp pulls filter off the stop-piston connector.

3. As CRD approaches position "48" the filter jams on top of the stop-piston connector.

4. The uncoupling rod lifts the coupling lock plug, uncoupling the CRD. The alarm sounds.

5. On the second withdraw, the filter re-seats on the stop-piston correctly.

6. The filter either remains in place on the stop piston or, if it comes off, it never jams again.

7. Two of the filters return to the locked position and one filter comes off again (during the drive removal operation).

From the analysis at the time of the uncoupling indication and the continued investigation, it is G.E.'s conclusion that although unlikely, the most likely explanation was that a rod uncoupling did occur regarding drives #20 and #91.

The second occurrence of an apparent uncoupled CRD occurred on March 14, 1974 when control rod B-11, SN 761C, gave indication of an uncoupled condition when it was withdrawn following a routine 25 CRD scram test. (Referred to in Ref. 5, 6, and 7). While CRD B-11 was in the process of withdrawing to position "48", a "rod overtravel" alarm annunicated and both the four rod and full core displays for the rod were lost. The drive was successfully recoupled on the first attempt and subsequent attempts to withdraw at position "48" verified that a positive coupling had been obtained. During the overtravel check time span, the drive was inserted and withdrawn in 6 notch increments. The reactivity changes were being monitored by the TIP system and it was verified that the blade followed the CRD. In addition to the uncoupling checks, the CRD was scrammed three (3) times to test the possibility of recurrence. The drive was scrammed successfully two (2) times, however, after the third scram, while withdrawing, the drive went to overtravel. At this time friction test equipment was set-up to determine pressure drop across the drive which would indicate if the CRD had uncoupled. The test results showed that the blade was uncoupled but recoupled when the CRD was moved past position "48".

Following these tests, the drive was inserted to position "00", electrically disarmed and removed from service until June 10, 1974 when the drive was removed from the reactor.

The results of the visual inspection of CRD B-11 and the conclusions reached by GE representatives are as follows:

> The uncoupling rod was confirmed to be properly seated against the inner filter prior to installation of the measuring gage. The overall length

(173.406 ± .031) was measured several times and determined to be 173.890 inch or approximately .5 inch longer than the maximum allowable overall dimension. The outer filter and the spud were then removed for decontamination. In an attempt to determine if the filter was inserted on the stop piston connector to any degree, a hooked shaped piece of weld wire was engaged in the filter and an attempt was made to withdraw the filter. The filter moved freely with a minimum of force. Normal disassembly of the CRD continued with the resulting observations.

Inner Filter: The inner filter wiper ring did not exhibit a 360° wear pattern (i.e., approximately 1/2 - 3/4 inches on circumference of ring was not sealing in bore of index tube). The land of the filter (i.e., outer diameter) just below the wiper ring and the outer filter diameter just above the ring exhibited a wear pattern which could be caused by misorienting (i.e., cocking) the filter in the bore of the index tube. One leg of the filter retaining spring was displaced inward approximately 1/4 to 3/8 inches and spread out radially about 3/8 of an inch. Some raised metal was observed on both legs of the spring. No damage to the back side of the spring (i.e., damage which would be caused if the filter was pulled off stop piston connector) could be observed. The inner filter was very clean indicating that a large degree of bypass flow had occurred.

Stop Piston: The stop piston connector was observed to have two (2) areas on the flat which exhibited signs of impact with the retainer spring (i.e., raised metal) and two (2) scored areas leading from these impact areas across the chamfer and down the connector outer diameter. There was no sign of distortion or raised metal on the lip of the connector head which would be indicative of the filter being removed from a properly engaged position on the stop piston connector.

Index Tube: There was a scored area in the bore of the index tube which started approximately one foot from the spud end and ran for approximately two feet. This indication could have been caused by the misorientation of the inner filter.

In summary, CRD S/N 761C is considred to have uncoupled as a result of detachment of the inner filter. This detachment is considered to have occurred as a result of improper assembly which damaged the filter retainer spring (i.e., spring repair techniques when used were not effective) or improper assembly which resulted from a failure to securely lock the filter after engagement on the stop piston connector. This conclusion has been reached as a result of the following:

1) No evidence of damage was observed which would have resulted if a properly locked filter had been pulled off the stop piston connector.

2) No vehicle for rotating a properly locked filter is known to exist. Observations of index tubes following testing at San Jose and in the field have to date always identified a singular wear pattern caused by the collet fingers which verifies that no random rotation of the index tube has occurred.

CONCLUSIONS

1) CRD S/N 761C did inadvertently uncouple as a result of detachment of the inner filter.

2) Detachment of the inner filter is considered to have been caused by improper assembly of this filter during the spring 1972 outage for filter modification.

The third occurrence of an apparent uncoupled CRD occurred on June 15, 1975 when control rod L-9, SN 620 C, gave indication of an uncoupled condition when it was withdrawn during the startup sequence of the unit. (Referred to in Ref. 8 and 9). While CRD L-9 was in the process of being withdrawn from position "14" to "48", a "rod overtravel" alarm annunciated and both the four rod and full core displays for the rod went blank.

The initial action taken was to attempt to recouple by inserting and withdrawing the rod three (3) times. On each series of insert and withdraw, the rod went into overtravel on the coupling check.

The corrective action taken was to insert the rod to position "00", electrically disarm it and remove from service until August 26, 1974 when the drive was removed from reactor.

The results of the visual inspection of CRD L-9 and the conclusions reached by GE representatives and CECo personnel are as follows:

Immediately after removal of the CRD from the reactor vessel, a visual inspection of the spud end was performed. It was noted that the uncoupling rod was distorted (bent) above the point at which it is supported in the spud. In addition, an attempt was made to pull the uncoupling rod but it was found to be tight. This indicated that the uncoupling rod may also be distorted on the lower end which lies inside the index tube.

On disassembly of the drive, it was noted that the inner filter was lodged in the bore of the index tube, approximately 1.25 inches from the spud end. The wiper ring on the inner filter was forced up and out of the groove by displacing the top lip of the wiper groove in a localized area. The wiper ring was wedged into the index tube such that the filter had to be removed by force. Normal disassembly of the CRD was continued with the resulting observations:

Inner Filter:

The dimple at the base of the filter, which covers the stop piston connector and contacts the uncoupling rod, had been reversed (i.e., upset) by apparent contact with the uncoupling rod. The uncoupling rod had been distorted (bent) relative to its centerline both above and below the point at which it is supported in the spud. The bottom of the filter can was bulged outward apparently caused by contact of the dimple with the uncoupling rod. The retainer spring was distorted in a manner similar to that previously observed on other uncoupled CRD's. The filter mesh was slightly collapsed (bulged) inward; however, relative cleanliness of this filter could not be determined since it had been ultrasonically cleaned prior to inspection.

Stop Piston:

The stop piston connector was observed to have no sign of damage to the locking flats (i.e., surface which retains filter by contact with retainer spring).

The top or flat of the connector was observed to contain slight indications of contact with the retainer spring and the previously observed scored area which progressed down the chamfer and onto the major diameter of the connector.

In summary, damage to the inner filter and uncoupling rod of CRD S/N 620C has not been observed on other CRDs. The probable cause of this condition is considered to be a result of the inner filter, once uncoupled, being jammed in the index tube on the chamfer below the threads (i.e., spud coupling). In this position the full weight of the CR plus momentum of the translating assembly could be exerted on the inner filter.

Conclusions:

1) CRD SN 620C was determined to have been uncoupled when inspected and detachment is considered to have occurred as a result of contact with the uncoupling rod. This damage is considered to have occurred as a result of the free floating (i.e., detached filter) inner filter sticking at the top of the index tube bore and impacting on the uncoupling rod when scrammed.

The fourth occurrence of an apparent uncoupled CRD occurred on August 2, 1974 when control rod K-11, S.N. 930, gave indication of an uncoupled condition when it was withdrawn during a unit power increase. (Referred to in Ref. 9 and 10).

While CRD K-11 was in the process of being withdrawn from position "42" to "48", a "rod overtravel" alarm annunciated and both the four rod and full core displays for the rod went blank.

The initial action taken was to attempt to recouple by inserting and withdrawing the rod five (5) times. On four series of inserts and withdrawals, the rod went into overtravel on the uncoupling check. The fifth attempt, however, was successful in getting the CRD coupled.

The corrective action taken was to insert the rod to position "00", electrically disarm it and remove from service until August 26, 1974 when the drive was removed from the reactor.

The results of the visual inspection of CRD K-11 and the conclusions reached by GE representatives and CECo personnel are as follows:

During the removal phase of the CRD on August 26, it was noted that the uncoupling rod was extended above the spud fingers about 1 $\frac{1}{4}$ inches which is approximately $\frac{1}{2}$ inch longer than is designed.

VISUAL INSPECTION

The uncoupling rod was determined to be properly seated against the inner filter prior to installation of the gage which measures overall CRD length. The measurement was taken and found to exceed drawing requirements (i.e., 173.406 $\pm$ .031 inches) by approximately 5/8 inches (i.e., 174.181). The outer filter and spud were then removed and placed in the ultrasonic cleaner. The inner filter was determined to be uncoupled from the stop piston during its removal. The filter was also observed to be relatively clean and free of the normal deposit of various contaminants.

INNER FILTER

No unusual wear pattern was observed on the land of the filter near the wiper ring. The filter retaining spring was deflected outward (radially) and displaced inward similar to that described in the referenced report No. 6. A slight bulging (radially inward) of the filter mesh (i.e., wire cloth) was observed.

STOP PISTON

The stop piston connector was observed to have no sign of damage to locking flats and, in general, to have the same indications observed on S/N 620C and all other stop pistons removed from CRDs which have experienced inadvertent uncouplings.

In summary, CRD SN930 is considered to have been in a similar condition to that of other uncoupled CRDs previously observed.

CONCLUSION

1) CRD SN 930 was determined to have been uncoupled when inspected and detachment was considered to have occurred as a result of improper assembly.

The fifth occurrence of an apparent uncoupled CRD occurred on October 23, 1974 when control rod P-12, SN 54, gave indication of an uncoupled condition when it was withdrawn following a scram test.

While CRD P-12 was being withdrawn from position "00" to "48", a"rod overtravel" alarm annunciated and both the four rod and full core displays for the rod went blank.

The initial action taken was to immediately insert the CRD to position "00", electrically disarm it and remove from service until January 29, 1975 when the drive was removed from the reactor.

The results of the visual inspection of CRD P-12 and the conclusions reached by GE representatives, who were contracted to overhaul one hundred-thirty seven (137) CRDs, and CECo personnel are as follows:

During the removal phase of the CRD, it was noted that the uncoupling rod was extended above the spud fingers about 1-$\frac{1}{4}$ inches. This distance should normally be about 3/4 inch.

VISUAL INSPECTION

Upon disassembly, it was found that the inner filter was uncoupled from the stop piston. The filter could be moved by hand. The filter was also observed to have a minimal amount of crud deposit.

INNER FILTER

No unusual wear pattern was observed on the land of the filter near the wiper ring. The filter retaining spring was in satisfactory condition showing no signs of the distortion noted in previous uncoupled CRD's.

STOP PISTON

The stop piston connector was observed to have a longitudinal scratch running

down the chamfer. This scratch indicates that contact was made with the retainer springs but the filter was not properly installed.

CONCLUSION

CRD SN 54 was determined to have been uncoupled when inspected and detachment is considered to have occurred as a result of improper assembly.

The sixth and final occurrence of an apparent uncoupled CRD occurred on November 2, 1974 when control rod N-10, SN 275, gave an indication of an uncoupled condition when it was withdrawn following a unit scram.

While CRD N-10 was being withdrawn from position "00" to "48", a "rod overtravel" alarm annunciated and both the four rod and full core displays for the rod went blank.

The initial action taken was to immediately insert the CRD to position "00", electrically disarm it and remove from service until January 31, 1975 when the drive was removed from the reactor.

The results of the visual inspection of CRD N-10 and the conclusions reached by GE representatives, who were contracted to overhaul 137 CRD's, and CECo personnel are as follows:

> During the removal phase of the CRD, it was noted that the uncoupling rod was extended above the spud finger about $1\frac{1}{2}$ inches.

VISUAL INSPECTION

Upon disassembly, it was found that the inner filter was uncoupled from the stop piston. The filter could be moved by hand. The filter was also observed to have about $\frac{1}{4}$ inch of various contaminents contained in it.

INNER FILTER

No unusual wear pattern, as stated in CRD P-12 visual inspection, was observed on the land of the filter near the wiper ring. The filter retaining spring was distorted in the same manner as depicted in previous CRD findings.

STOP PISTON

As stated in the CRD P-12 uncoupling occurrence, the connector was observed to have a longitudinal scratch running down the chamfer.

CONCLUSION

CRD SN 275 was determined to have been uncoupled when inspected and detachment is considered to have occurred as a result of improper assembly.

To summarize the history of the station's uncoupling problem, all the uncoupled drives experienced at Dresden have been concluded to be a result of retainer spring damage and/or improper assembly techniques. No other problem areas were uncovered which could have produced this type of failure. The CRD's

which have experienced uncoupling were from a group of 81 drives rebuilt and modified (changed from a traveling filter to a stationary one) in the field during the same period of time (spring 1972 refueling outage) by General Electric.

As a result of these findings, all remaining CRD's overhauled by GE in 1972 were removed from the reactor during the winter 1974 refueling outage, inspected, overhauled and reinstalled into the reactor. **No other CRD's overhauled this outage, other than those discussed in this report, exhibited unattached inner filters.** A total of one hundred and thirty seven drives were overhauled by General Electric personnel, who were trained at a special CRD simulator, as a result of previous failures of CRD's to go to position "00" on a scram situation, drive pressure required to move the CRD greater than 250 psi, long scram times or electrically disarmed CRDs due to an uncoupling indication.

The general condition of the CRD's overhauled this outage was as follows:

1) Majority exhibited stop piston seal breakage.
2) Majority exhibited pitting of the nitrided surface on the piston tubes in a localized area. Six piston tubes were replaced due to severe pitting.
3) Minimum number exhibited drive piston seal damage.

Among the 137 CRD's overhauled, three of them were involved in an occurrence on November 2, 1974 when they failed to fully insert on a scram.

On November 2, 1974 unit 2 scrammed due to low water level in the reactor. Subsequent to the scram, it was noted that CRD F-6 stopped at position "04" and CRD's H-9 and G-8 at position "06". These drives were then inserted one-at-a-time to position "00".

The apparent cause of this problem relates to two factors:

1) The gradual deterioration of control rod stop piston seals.
2) The decreased time for the scram discharge volume high level alarm to annunciate.

These factors relate directly to the cause of this problem, in that, due to the degradation of the control rod seals and subsequent increased leakage, the scram discharge volume rapidly increases, resulting in pressurizing the system. With insufficient scram discharge volume, a high back pressure is developed relative to CRD **inserted** with the rods with the slowest scram times stopping at positions greater than "00" or "02".

To minimize the recurrence of this problem, the station's corrective action was to overhaul the CRD's whose performance indicated seal damage and also increase the scram discharge volume to handle the regular drive displaced water plus the high drive leakage due to seal wear. Note: The visual inspection of the three drives involved in this occurrence revealed stop piston seal breakage resulting in increased leakage and slower scram times.

for **B. B. Stephenson**
Superintendent
Dresden Nuclear Power Station

BBS:smp
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