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ENGINEERING EVALUATION REPORT

PARTIAL FAILURES OF CONTROL ROD SYSTEMS TO SCRAM

by

OFFICE FOR ANALYSIS AND EVALUATION
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NOTE: This document supports ongoing AEOD and NRC activities and does not represent the positions or requirements of the responsible NRC program office.

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SUMMARY

This report documents the identification and review of events at operating nuclear plants involving partial failures of the reactor control rod system to perform its intended scram function. The events under consideration are those that have occurred in U.S. reactors (with one exception) since the Salem ATWS events of February 1983. The scope of the report does not include individual component failures in the scram system, such as scram breakers, nor failures in the trip logic equipment.

To identify the events, AEOD has conducted a search of available operational experience data (Licensee Event Reports, Preliminary Notifications and 10 CFR 50.72 Notifications) from February 1983 to December 1984. Thirteen (13) events involving failures of control rods to perform their trip function properly were identified. A brief description of these events with the names of the plants involved and the dates of the events are listed in Appendix A.

Of the 13 events, six occurred during an actual scram demand. In all these six cases, the reactor was safely shut down by the proper functioning of the remaining operable control rods. The other seven events occurred during testing of the control rod systems. These events are of concern and significance because of the number of potential common-cause failure mechanisms that were identified and the potential generic implications associated with them. Four of the 13 events are seen to have common-cause failure implications and three of them (two at Boiling Water Reactor units and one at a Pressurized Water reactor unit) were determined to have generic implications applicable to other light water reactors.

The three potential common-cause failures that affect light water reactors were: 1) failure of scram pilot solenoid valves because of the presence of Loctite in the mechanism, 2) failure of scram pilot solenoid valves because of sticking disc holder subassemblies, and 3) looseness of rod assembly guide screws. In all three cases, actions have been or are planned to be taken by the NRC and the industry to inform other operating nuclear plant licensees of the potential problem as follows: 1) IE Information Notice 84-53, "Information Concerning the Use of Loctite 242 and Other Anaerobic Adhesive/Sealants" was issued on July 5, 1984; 2) General Electric issued a Service Information Letter (SIL) on October 16, 1984 on T-ASCO solenoid valves; and 3) Westinghouse has advised the appropriate utilities, and the Office of Inspection and Enforcement intends to issue an Information Notice regarding the potential problem with the guide screws of Control Rod Drive Mechanism (CRDM) drive rod assemblies.

The fourth event that was identified to have a common-cause failure implication was the June 23, 1984 event at Fort St. Vrain. The event involved the failure of six out of 37 rod pairs during a reactor trip. Since the rod system at Fort St. Vrain is unique to that unit, this problem has no generic applicability. Fort St. Vrain has been shut down since the date of the event, undergoing maintenance, repair and testing of the control rod system.

An additional problem with potential common-cause failure implication was identified in the reserve shutdown system at Fort St. Vrain. The problem involved the failure of a shutdown hopper to discharge the designed amount of shutdown material during testing on November 5, 1984. The cause of this failure is under investigation. This system, which is an independent and redundant system, is also unique to Fort St. Vrain, and thus the problem does not have any generic implication. The licensee will obtain NRC approval of all corrective actions taken prior to reactor startup.

In addition to the concern regarding potential common-cause failure, the event at Susquehanna on October 6, 1984, raised two other items of concern. The first item is regarding the inadequacy of post-scram review practiced at the station which was identified by NRC Region I during a special inspection following the event. The inspection found that during a scram of Susquehanna 1 on June 13, 1984, one 2 X 2 control rod array exceeded the specified scram insertion time limit. On June 25, 1984, the data obtained from this scram was used to demonstrate compliance with certain technical specification surveillance requirements. The slow scram time was overlooked by the licensee's staff. The significance of this was that two of the four control rods that failed to scram during the October 6, 1984 event were in the 2 X 2 rod array that exceeded the scram insertion time during the June 13, 1984 scram.

The second item of concern is the lack of attention given to lessons learned from previous experience. On March 14, 1980, the NRC issued IE Information Notice 80-11 entitled, "Generic Problems with ASCO Valves in Nuclear Applications Including Fire Protection Systems." This information notice described a potential deficiency of ASCO NP-1 solenoid valves regarding the effects of oil on ethylene propylene (EPR) elastomer materials which expands or swells when brought into contact with oils, possibly causing valve failure. The notice also stated that Viton elastomer replacement kits were available from ASCO for NP-1 solenoid valves. The information notice had an attachment which identified the potential incompatibility of solenoid valves with oil contamination in air systems. The licensee did investigate the problem of ASCO solenoid valves in 1981 and identified several valves at the Susquehanna station which had ethylene propylene (EPR) seals and which did fail due to oil contamination. However, the licensee's review did not identify the T-ASCO solenoid valves which employed polyurethane seals, other than EPR seals. These valves, containing polyurethane seals, were installed in all Unit 1 control rod drive (CRD) assemblies and in about one half of the Unit 2 CRD assemblies.

The remaining nine events are considered to be caused by random failures which do not appear to have common-cause failure or generic implications. The corrective actions taken by the licensees in addressing these failures appear to be adequate. However, one of these events, the October 25, 1984 event at Quad Cities 2, did raise a concern regarding the adequacy of post-trip review at that station because the plant operators were not aware, until 30 minutes after the event, that a control rod remained at the fully withdrawn position following the scram. NRC Region III closely followed this event, and a Confirmatory Action Letter was issued and an Enforcement Conference was held to address the event and corrective actions.

The potential common-cause failure mechanisms were identified promptly in most cases and the corrective actions regarding them were adequately implemented. However, the very existence of such potential common-cause failure mechanisms in such an established and safety significant system as the control rod system remains a serious concern. Even though the Salem ATWS events and follow-up actions have made the licensees, vendors and NRC more responsive to events involving failures in the reactor trip systems, concerns identified after the Salem events, such as inadequacies in post-trip review, post-maintenance testing, and identification of root cause of failure are still being noted. When the actions discussed in the staff's Generic Letter 83-28 (Required Actions Based on Generic Implications of Salem ATWS Events) are established and fully implemented, these concerns should be alleviated.

Additionally, AEOD has established an in-depth periodic analysis of unplanned reactor scrams as a major product of the Trends and Patterns Program. A pilot study covering the first three months of 1984 was issued for staff comment in late November 1984. The next effort, which includes a comparison with foreign experience, will cover all of 1984. This report will provide an overview of the U.S. experience and the root causes of unplanned reactor scrams.

1.0 INTRODUCTION

During the semiannual briefing by the Office for Analysis and Evaluation of Operational Data (AEOD) to the Commissioners on November 20, 1984, Commissioner Zech requested a listing and analysis of events that have occurred since the Salem-1 ATWS events involving failures of control rods to perform their scram function properly. This study was initiated in response to that request.

To identify the events of interest, AEOD conducted a search of operational experience data bases such as Licensee Event Reports, Preliminary Notifications and 10 CFR 50.72 Notifications. As a result, 13 events involving partial failures of control rods to perform their trip function properly were obtained. A brief description of these events with the name of the plants involved, the type of reactor unit, and the date of the event are listed in Appendix A.

Of the 13 events in Appendix A, six occurred during actual scram demand. These six events are listed in Table 1.

Table 1

Failure of Control Rods to Scram Upon Demand

Plant Name	Date of Event	No. of Control Rods Affected	Type of Failure	Cause of Failure
1. Quad Cities 2	12/22/84	3	Not fully inserted	Not known.
2. Quad Cities 2	10/25/84	1	Stuck rod	Scram discharge riser valve closed.
3. Dresden 3	10/20/84	1	Stuck rod	Manual isolation valve failure.
4. LaCrosse	07/16/84	1	Stuck rod	Loose roller nut assembly.
5. Fort St. Vrain	06/23/84	6	Stuck rods	Under investigation
6. Peach Bottom 3	11/17/83	2	Slow scram time	Scram solenoid valve failure due to foreign material.

The remaining seven events occurred during the performance of control rod tests, and are listed in Table 2.

Table 2

Failure of Control Rods to Scram Upon Test

Plant Name	Date of Event	No. of Control Rods Affected	Type of Failure	Cause of Failure
1. Monticello	12/05/84	Several rods	Slow scram time	Plugged screens in hydraulic control units.
2. Ko-Ri 5	11/19/84	1	Stuck rod	Loose assembly guide screw.
3. Susquehanna 1	10/06/84	Several rods	Sticking rods and slow scram time	Sticking scram pilot solenoid valve disc holder subassembly.
4. Trojan	08/18/84	1	Stuck rod	Top hat pin misalignment.
5. Surry 1	06/20/84	1	Stuck rod	Obstruction by foreign object.
6. Browns Ferry 2	03/22/83	1	Stuck rod	Manual isolation valve failure.
7. Browns Ferry 3	03/12/83	1	Stuck rod	Scram solenoid valve O-ring failure.

2.0 DISCUSSION

The data in Table 1 can be put into perspective by comparing the six events of failures on actual scram demand to the total number of scrams experienced by domestic nuclear plants. There were 499 unplanned reactor trips in 1983 and almost an equal number in 1984. Of these approximately 1000 scrams over this two year period, 280 were experienced by General Electric Boiling Water Reactor units, 16 by LaCrosse BWR (an Allis-Chalmers unit), six by Fort St. Vrain (an HTGR unit), and the remainder (approximately 700) by Pressurized Water Reactor units. (LaCrosse and Fort St. Vrain are one-of-a kind reactors with unique rod drive systems). Of the six events of rod failures that occurred during an actual scram demand, four occurred at GE BWR units, and one each at LaCrosse and Fort St. Vrain. PWR units had no failures on actual scram demand.

In the staff's review of these events, the real concern has been the potential generic common-cause failure implication associated with them. Of the 13 events, three were identified by the staff to have such potential generic implications. Two of these events occurred at General Electric designed Boiling Water Reactor (BWR) units (Peach Bottom 3 and Susquehanna 1), and the third occurred at a foreign reactor, a Westinghouse designed Pressurized Water Reactor (PWR) unit (Ko-Ri 5). The three common-cause failures were: 1) failure of the scram solenoid valve because of Loctite, 2) failure of the scram solenoid valve due to sticking of the disc holder assembly, and 3) looseness of rod assembly guide screws. The details of these three events and the generic actions taken to address the potential common-cause failure concerns are discussed below.

The event that occurred at Peach Bottom 3 on November 17, 1983, is described in LER 83-018. As described in the LER, during a post-scram investigation of scram insertion times, two control rods were found to have exceeded the allowable time limit of 7.00 seconds. The cause was identified as the failure of a scram solenoid valve in the hydraulic control unit (HCU) of both rods. An examination by the vendor, General Electric, determined the cause of failure as foreign material associated with maintenance activities (Loctite 242). Loctite 242 was used to secure the acorn nut on all solenoid housings and the excess Loctite 242 had apparently migrated when the solenoid was returned to service. The migrated Loctite eventually caused sticking of the solenoid plunger and failure of the scram pilot solenoid valve. Failure of all valves for the same cause could not be ruled out. Further, since Loctite 242 was utilized at other operating reactor facilities for similar applications, the staff determined that this problem had generic safety implications and as a result issued IE Information Notice 84-53, "Information Concerning the Use of Loctite 242 and Other Anaerobic Adhesive/Sealants." The vendor, General Electric, issued a Service Information Letter also addressing the problem.

The event at Susquehanna 1 occurred on October 6, 1984. The problem with the rods was discovered during scram time surveillance testing and involved the failure of four control rods to scram and several control rods with slow scram insertion times. The failures were determined to be due to failures of the T-ASCO scram pilot solenoid valves to actuate and vent air from the scram valves. Preliminary analysis performed by the vendor, General Electric, indicated that the failure mode was sticking of the polyurethane disc holder subassembly (DHS) to the exhaust port of the solenoid valve probably due to the combination of temperature, time and oil and/or water contamination in the instrument air supply. The licensee shut down both units to replace the polyurethane DHS with Viton-A which has better temperature resistant and hardness properties than the polyurethane (note - all scram valves on Unit 1 had identical polyurethane disc holders - about one-half of the scram valves in Unit 2 also had these holders). NRC Region I issued a Confirmatory Action Letter on October 17, 1984, and held an Enforcement Conference on November 30, 1984 concerning T-ASCO Scram Pilot Solenoid Valves at Susquehanna 1 & 2.

T-ASCO solenoids are used in the newer BWR units only in the control rod system and are intended as an improvement on the dual ASCO Solenoid Valves used in earlier BWR units. Other BWR plants that use polyurethane DHS in T-ASCO solenoids are plants that have not loaded fuel and include Hope Creek, Nine Mile Point 2, Grand Gulf 2, Perry, Clinton and River Bend 1. In Taiwan, Kousheng 1 & 2 have been in operation since 1981-82 with T-ASCO polyurethane seals. The vendor, General Electric, issued a Service Information Letter (SIL) on October 16, 1984, which (1) describes the problem, (2) recommends replacement of T-ASCO seals with repair kits containing Viton-A, and (3) suggests verification of this application by all plants.

In addition to the concern regarding potential common-cause failure, the event at Susquehanna raised two other items of concern. The first item is regarding the inadequacy of the post-scram review practiced at the station which was identified by NRC Region I during a special inspection that reviewed the event of October 6, 1984. The inspection found that during a scram of Susquehanna 1 on June 13, 1984, one 2 X 2 control rod array exceeded the specified scram insertion time limit. However, the slow scram time was overlooked by the licensee's staff, and the data from this scram was subsequently used to demonstrate compliance with certain technical specification surveillance requirements. The significance of this was that two of the four control rods that failed to scram during the October 6, 1984 event were in the 2 X 2 rod array that exceeded the scram insertion time during the June 13, 1984 scram.

The second item of concern is the lack of attention given to lessons learned from previous experience. On March 14, 1980, the NRC issued IE Information Notice 80-11 entitled, "Generic Problems with ASCO Valves in Nuclear Applications Including Fire Protection Systems." This information notice described a potential deficiency of ASCO NP-1 solenoid valves regarding the effects of oil on ethylene propylene elastomer (EPR) materials which expands or swells when brought into contact with oils possibly causing valve failure. The notice also stated that Viton elastomer replacement kits were available from ASCO for NP-1 solenoid valves. Attached to the information notice was a letter from EG&G Idaho, providing the results of an LER review of failure of solenoid valves. The letter identified the cause of many solenoid valve failures to be apparent incompatibility of solenoid valve materials with foreign material, specifically oil, which can be present in the air supply system. The licensee did investigate the problem of ASCO solenoid valves in 1981 and identified several valves at the Susquehanna station which had ethylene propylene seals and which did fail due to oil contamination. However, the licensee review did not identify the T-ASCO solenoid valves which use polyruethane material as having this potential problem.

The event at the foreign reactor occurred at Ko-Ri 5 in Korea during pre-critical testing. It was determined that a rod assembly guide screw which guides and aligns the breech components of the drive had fallen out and prevented rod movement. A check of another Korean unit, Ko-Ri 6, identified a number of such breech guide screws to be 'finger-tight' only. Preliminary information indicates that in the United States, the following reactor units have the same type of control rod drive mechanism: Catawba 1 and 2, McGuire 2, Watts Bar 1 and 2, and Seabrook 1 and 2. The licensees of all these units have been informed of the problem by the vendor and the NRC Regional Offices. The vendor has initiated corrective actions which are planned to be implemented at all these units. The NRC Regional Offices are actively following up the corrective actions at the above plants. The Office of Inspection and Enforcement is planning to issue an Information Notice on the subject.

Another event that had common-cause failure implication was the one that occurred at Fort St. Vrain on June 23, 1984. However, this event was considered not to have generic implications since it occurred at the only operating High Temperature Gas-Cooled Reactor (HTGR) unit in the U.S. The event involved the failure of six out of 37 rod pairs to drop when a reactor trip occurred. After verifying adequate shutdown margin, the shift supervisor, according to procedure, pulled fuses to the drive mechanisms but the rods failed to drop. All six pairs were then inserted to the full-in position by running the drive motor. All rods were inserted within 20 minutes of the reactor trip. The licensee had verified that cold shutdown margin was achieved and maintained before manual insertion of the six affected rods. Additionally, the reserve shutdown system, independent and redundant to the control rod system, was available. The licensee has committed to fully investigate the event, examine all six affected control rod mechanisms and obtain NRC approval prior to reactor startup. The reactor has been shut down since June 23, 1984, and the Office of Nuclear Reactor Regulation (NRR) and Region IV are actively involved in the resolution of the problem with the control rods at Fort St. Vrain.

An additional problem was identified at Fort St. Vrain during the investigation following the June 23 event. While the reactor was shut down for control rod drive inspection and maintenance, two reserve shutdown hoppers (CROOA #26 and CROOA #21) were functionally tested in the hot service facility on November 5, 1984. During testing of CROOA #26 all of the reserve shutdown material (20 weight percent boron) was released from the hopper;

however, hopper assembly CROOA #21 (40 weight percent boron) did not discharge the full 80 pounds of the material as designed, but only 40 pounds. The material that failed to discharge has been collected for licensee analysis and for independent analysis by the NRC. The investigation by the licensee to determine why some of the reserve shutdown material was retained inside the hopper assembly is also being closely followed by NRR and Region IV.

A review of the remaining nine events shows that the events were caused by apparently random independent failures which do not appear to have generic implications. In seven of these events, the failure involved one stuck control rod which is an analyzed condition. Hence, these events are of low safety significance. The seven events are as follows:

	Plant	Date
1)	Quad Cities 2	October 25, 1984
2)	Dresden 3	October 20, 1984
3)	Trojan	August 18, 1984
4)	LaCrosse	July 16, 1984
5)	Surry 1	June 20, 1984
6)	Browns Ferry 2	March 22, 1983
7)	Browns Ferry 3	March 12, 1983

The corrective actions taken by the licensees appear to be adequate in addressing the problems that caused these events. However, one of these events, the one that occurred at Quad Cities 2 on October 25, 1984, raised a concern regarding adequacy of post-trip review at the station. During this event, the plant operators were not aware until 30 minutes after reactor scram that one control rod remained at the fully withdrawn position. The event details and follow-up corrective actions were closely followed by NRC Region III and a Confirmatory Action Letter dated October 26, 1984 was issued to the licensee to confirm the corrective actions being taken by the licensee in addressing the rod failure that occurred during the event. An Enforcement Conference was held on November 5, 1984 to discuss the event.

The event at Dresden 3 that occurred on October 20, 1984, and the Browns Ferry 2 event of March 22, 1983, both involved the failure of a manual valve in the scram discharge line of the rod's hydraulic control unit (HCU). The valve involved was the same model in both cases, -- Hancock 950W; and the failure mode was also similar -- separation of the valve stem from the valve disc, blocking the scram discharge water path and causing failure to scram. At Dresden 3, the licensee inspected 10% of the control rod HCUs to verify the integrity of similar valves on these units. No other failures were found. Dresden 3 has 177 control rods and corresponding HCUs. Each HCU has seven such manual isolation valves, and these are only used when an

HCU is isolated for maintenance. The HCUs at all operating General Electric BWRs typically use the same isolation valves. Hence, there is a large population of these valves (approaching 30,000) at operating BWRs. However, AEOD knows of only these two failures that have contributed to failure of a control rod to scram. Thus, based on operating experience, AEOD considers these two failures as low probability failures and no further action is considered necessary at present.

One of the two remaining events occurred at Monticello on December 5, 1984 where, during post-outage surveillance testing of the control rod system to verify scram times, several rods were found to have slow response times. The plant had been shutdown since February 3, 1984 for an extended outage which included replacement of major portions of the recirculation system piping. Investigation following the event revealed the cause to be plugging of screens in the hydraulic flow path of the control rod drive mechanism. The primary coolant system was cleaned up to remove the fibers that had clogged the screens and all control rod drives were either modified or had new 10 mil inner screens installed in them. The plant was returned to operation on January 17, 1985.

The last of these nine events occurred at Quad Cities 2 on December 22, 1984 and involved the failure of three rods to fully insert following a manual scram. The rods inserted to the 02 position (one step or six inches short of full insertion) and had to be driven in the final step. This problem is generally due to the failure of the control rod drive stop piston seals due to dirt particles. The failure of the seal results in water at reactor pressure being introduced between two sets of stop piston seals. Upon scram, this pressure between the seals does not create a problem until the rod moves past position 02 on the way to notch position 00, the fully inserted position. At notch position 02, the buffer holes in the stop piston are designed to vent the water above the drive piston assembly, thus, slowing the control rod at the end of its scram stroke. Due to the failure of the seals, the buffering will not occur properly and the rod will stop between 02 and 00 notch positions, and eventually settle into position 02. This problem occurs occasionally at BWR units due to failure of the drive inner filter which allows dirt particles into the stop piston seals. Normal corrective action for this problem consists of replacement of seals and filters. Regularly scheduled maintenance of the control rod drive system also tends to reduce the incidence of this problem. This problem is of low safety consequence since analyses have shown that adequate shutdown margin is present even with all rods in position 02.

Failures of control rods and other failures in the reactor protection system that occur during unscheduled reactor shutdowns are part of the ongoing NRC and licensee activities in implementing the actions discussed in Generic Letter 83-28, "Required Actions Based on Generic Implications of Salem ATWS Events." The actions required would include generic consideration of post-trip review, post-maintenance testing verification, technical specification changes, reactor trip system reliability including trip breaker problems. Events such as the potentially significant failure that occurred at Sequoyah 2 on January 12, 1985, where a component (transistor) in one trip logic circuit failed, resulting in the failure of one trip breaker to operate, would fall into Generic Letter 83-28 activities.

Additionally, AEOD has established an in-depth periodic analysis of unplanned reactor scrams as a major product of the Trends and Patterns Program. A pilot study covering the first three months of 1984 was issued for staff comment in late November 1984. The next report will cover all of 1984, including a comparison with foreign experience. This report will provide an overview of the U.S. experience and address the root causes of unplanned reactor scrams.

3.0 FINDINGS AND CONCLUSIONS

During the approximately two year period covered in this study, a total of 13 events were found where there was a partial failure of the control rods to properly perform their reactor scram function. In six of these events, the failures occurred during an actual scram demand, and in the remaining seven events the failures were discovered during surveillance testing activities. In all cases, the plant was safely shut down by the proper functioning of the remaining operable control rods.

The real concerns associated with such failures are the potential for common-cause failure, e.g., an inability to insert sufficient control rods to assure reactor shutdown due to a single type or cause of failure; and generic implications, e.g., other reactors may be susceptible to the same type of failures. Even though the design and manufacture of control rod systems are certainly mature, it is of concern and significance that 13 events over a two year period involved four potential common-cause failure mechanisms, three of which have generic implications on similar reactors.

In addition to these potential common-cause failures of control-rod scram systems, another potential common-cause failure mode was identified at Fort St. Vrain when one reserve shutdown hopper failed to discharge all of the boron balls as designed. This design is unique to Fort St. Vrain; and thus, while the event is of concern because of the potential common-cause failure mechanism, it does not have generic implications.

For the three events that involved potential common-cause failure mechanisms which had generic implications, adequate corrective actions and actions to alert other reactor units have been taken. Fort St. Vrain has remained shut down since the event and will startup only after all corrective actions have been completed and approved by the NRC. The remaining nine events were caused by random failures which do not appear to represent common-cause failure or generic implications.

Concerns regarding post trip review, post-maintenance testing, and identification of root cause of failure are evident in some of the 13 events reviewed. Lessons learned from past experiences have still not resulted in complete correction of the problems identified as illustrated by the fact that failure of valves, similar to that experienced by T-ASCO valves at Susquehanna Station in October 1984, was the subject of IE Information Notice 80-11 issued in March 1980. When the actions discussed in staff's Generic Letter 83-28 (Required Actions Based on Generic Implications of Salem ATWS Events) are established and fully implemented, these persisting concerns should be alleviated.

APPENDIX - A

Events Involving Control Rod System Failures In The Performance Of Reactor Trip Function

No.	Plant Name and (Type of Reactor)	Date of Event	Brief Description of Event
1.	Quad Cities 2 (BWR)	Dec. 22, 1984	Reactor manually tripped from 3% power as part of normal shutdown procedure. Three rods inserted to the 02 position (one step from full insertion) and eventually had to be driven in manually the final step.
2.	Monticello (BWR)	Dec. 5, 1984	The plant had been shut down since February 3, 1984 for an extended outage which included the replacement of major portions of the recirculation system piping. On December 5, 1984, during surveillance testing of the Control Rod System to verify that the scram times were within the Technical Specification requirements (90% inserted within 3.8 seconds), it was found that the scram time on several of the rods was excessive (nearly 10 seconds). Investigation revealed that the cause was partial plugging of the screens in the hydraulic flow path of the control rod drive mechanisms. The source of the minute particles plugging the screens was the primary coolant system which, although cleaned and flushed after refilling following the recirculation system piping replacement, still had particles present. The primary coolant system has been further cleaned up. Fifty seven control rod drive units have had new

No.	Plant Name (Type of Reactor)	Date of Event	Brief Description of Event
			10 mil screens installed and the other sixty four units have been modified with a different screen system.
3.	Ko-Ri 5 (PWR - Korean)	Nov. 19, 1984	While performing hot rod drops as part of pre-operational testing, a control rod became stuck during downward stepping. Investigation had determined that the control rod drive mechanism (CRDM) heavy drive rod assembly guide screw rotated out of position, and fell from the drive rod landing on top of the CRDM latch assembly where it lodged and prevented drive motion. A check of another Korean Unit, Ko-Ri 6, identified a number of guide screws to be "finger tight." Preliminary information indicates that Catawba 1 and 2, McGuire 2, Watts Bar 1 and 2, and Seabrook 1 and 2 have the same type of CRDMs. McGuire 2 is the only operating reactor, and Catawba has been granted its low power testing license.
4.	Quad Cities 2 (BWR)	Oct. 25, 1984	With the unit in Hot-Standby and all outboard Main Steam Isolation Valves closed, the reactor scrammed due to an increase in reactor pressure resulting from a procedure deficiency. During the scram, one control rod was not inserted because its scram discharge riser valve was mispositioned. The procedure is being

No.	Plant Name and (Type of Reactor)	Date of Event	Brief Description of Event
			revised and necessary measures have been taken to guard against a recurrence of this event.
5.	Dresden 3 (BWR)	Oct. 20, 1984	Following a feedwater system transient caused by a faulty master level controller, a low reactor water level signal scram occurred. One control rod failed to insert. It was determined that a manual valve downstream of the scram outlet valve had failed with the valve disc disengaging from its stem.
6.	Susquehanna 1 (BWR)	Oct. 6, 1984	During the normal 120 day scram time surveillance testing, four control rods failed to scram and several control rods showed hesitation. The four failures were determined to be due to failure of the scram pilot solenoid valves to activate and vent air from the scram valve. General Electric, the vendor indicates that the failure was due to sticking of the polyurethane disc holder subassembly (DHS) to the exhaust port of the solenoid valve. The licensee decided to shut down both units and change out the polyurethane DHS with Viton A material.
7.	Trojan (PWR)	Aug. 18, 1984	During preparation for startup following the completion of the annual refueling outage, control rod L-3, Bank D, stuck at 210 steps (almost fully withdrawal position) during cold drop tests.

No.	Plant Name and (Type of Reactor)	Date of Event	Brief Description of Event
			The reactor was fully loaded and at cold shutdown at this time.
8.	LaCrosse (BWR)	Jul. 16, 1984	During a reactor shutdown, control rod #29 would not insert from its fully withdrawn position electrically. It did not insert hydraulically, either, in response to a manual scram signal. The malfunction was found to be in the upper control rod drive (UCRD) mechanism. One of the three roller assemblies in the roller nut assembly was found to be loosely assembled, which had allowed the bottom ball bearings to fall out of the roller assembly. A ball had lodged against one of the lead screw threads, causing the rod to jam. All three roller assemblies were missing a catch pin. The three roller assemblies were replaced and catch pins installed. The UCRD was reinstalled and successfully scram tested. Three other UCRDs were inspected. Their roller assemblies were in good condition.
9.	Fort St. Vrain (HTGR)	Jun. 23, 1984	On June 22, 1984, the reactor was being shut down in a controlled manner due to a problem of high moisture in the helium coolant. On June 23, 1984, the reactor tripped on a high pressure signal resulting from a combination of increased helium inventory and programming down of the high pressure trip

No.	Plant Name and (Type of Reactor)	Date of Event	Brief Description of Event
			point as reactor power was reduced. When the reactor trip occurred, six of the 37 control rod pairs failed to drop. The shift supervisor, after verifying adequate shutdown margin and in accordance with procedure, pulled fuses to the drive mechanisms, but the rod pairs failed to drop. He then replaced the fuses and successfully lowered all six failed rod pairs to their full-in position by running the drive motors. All rods were inserted within 20 minutes of the reactor trip.
10.	Surry 1 (PWR)	Jun. 20, 1984	With the reactor at 29% power, a quadrant power tilt of greater than 2% existed for greater than 24 hours because control rod B-6 was stuck at step position 56. During a subsequent refueling outage, the cause of the stuck rod was found to be due to a foreign object (a hold down spring) obstructing rod motion.
11.	Peach Bottom 3 (BWR)	Nov. 17, 1983	A post-scram investigation of scram insertion times identified that control rods 34-35 and 34-27 exceeded the allowable limit of 7.0 seconds. Reactor shutdown was in progress and no additional control rod drive problems were identified. The rate of reactor shutdown was not noticeably affected by the excessive scram time. These control rods did scram because of the proper operation of the back up scram solenoid valves. Cause was failure of a scram solenoid valve (ASCO HVA-405) in both hydraulic control units. Both solenoids in both HCUs were replaced. GE examination has determined the cause of failure as foreign material associated with maintenance activities (Loctite 242).

No.	Plant Name and (Type of Reactor)	Date of Event	Brief Description of Event
12.	Browns Ferry 2 (BWR)	Mar. 22, 1983	With Unit 2 at 38.5% power for refueling tests, CRD 10-39 failed to scram while performing tests. The scram signal was initiated from the auxiliary instrument room. All other CRDs were operable. The redundant system (Standby Liquid Control) was available and operable. Technical Specification 3.3.A.2.F allows plant operation with an inoperable control rod. Valve 85-617 (Hancock 950W) was found to have the valve disc separated from the valve seat, blocking the scram discharge water path and causing failure to scram. The CRD was inserted to '00' with drive pressure and the valve was repaired and successfully tested. This appears to be a random event and, as such, no action to prevent recurrence is required.
13.	Browns Ferry 3 (BWR)	Mar. 12, 1983	During normal operation while performing scram timing surveillance CRD 38-31 failed to scram upon initiation of a scram signal. The CRD was inserted with normal drive pressure to '00' position and tagged out for maintenance. Technical Specification 3.3.A.2.F permits operation with inoperable control rods. The scram solenoid valve was inspected and the O-ring on the inlet air side was found out of position which apparently caused the failure. The valve was rebuilt and the CRD successuffly tested. This is considered a random failure and, as such, no action to prevent recurrence is required.