Issue 41: BWR Scram Discharge Volume Systems

DESCRIPTION

Historical Background

On June 28, 1980, during a routine shutdown of the Browns Ferry Unit 3 reactor, a manual scram from approximately 36% power failed to insert about 40% of the control rods. Two additional manual scrams followed by an automatic scram were required before all control rods were fully inserted. Subsequent investigations

by the licensee, GE, and the NRC staff narrowed the cause of the problem to an accumulation of water in the east-side SDV header at the time of the first scram. This accumulation reduced the available free volume for discharge of scram water, which inhibited insertion of control rods. It is believed that water accumulated because the SDV system venting and/or draining were obstructed. Furthermore, the accumulation of water was not detected by scram level instruments which input to the reactor protection system.

As part of the response to this event at Browns Ferry Unit 3, followup investigations and tests were performed by the licensees. As a result, a number of other deficiencies were uncovered. At Duane Arnold, a scram discharge volume drain valve was found to be incorrectly installed which resulted in a potential for off-normal response. A single rod failed to scram at Nine Mile Point 1 due to a faulty scram pilot solenoid. At Millstone 1, the circuit for RPS reset did not have the 10-second delay relay connected. (The 10-second time delay provides assurance that a scram signal is not reset until the rods can be fully inserted.) The scram test results at Dresden Unit 3

and Browns Ferry 1 appeared to indicate that a vacuum was being created in the scram discharge volume that restricted draining after scram. At Peach Bottom 2 and 3, incorrect parts installed in the backup scram valve solenoids rendered these valves inoperable. On a walk-through of the Fitzpatrick plant, a loop seal was discovered in the drain line between the east SDV header and the instrumented volume. At Hatch Unit 2, two

of the four SDV level switches which are a part of the RPS were found to be inoperable as a result of collapsed floats. Several actions were taken in response to these events.[1,2,3] However, this issue is comprised of efforts undertaken in response to AEOD's investigation of the events.[4]

Safety Significance

When a BWR is scrammed, the scram inlet and outlet valves associated with each control rod drive are opened. This results in the application of high pressure water under the control rod drive piston and the ventilation of the upper side of the piston to the SDV which is normally at atmospheric pressure. The result is a large upward force on the piston which drives the control rod up into its fully inserted position.

The purpose of the SDV is to receive the "exhaust" water from all of the control rod drives during a scram. The SDV must be large enough to accommodate all of this water so that the scram motion is not

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[1] AEOD/C001, "Report on the Browns Ferry 3 Partial Failure to Scram Event on June 28, 1980," Office for Analysis and Evaluation of Operational Data, U.S. Nuclear Regulatory Commission, July 30, 1980. [8008140575]
[2] IE Bulletin 80-14, "Degradation of BWR Scram Discharge Volume Capability," U.S. Nuclear Regulatory Commission, June 12, 1980. [ML031210540]
[3] IE Bulletin 80-17, "Failure of 76 of 185 Control Rods to Fully Insert During Scram at BWR," U.S. Nuclear Regulatory Commission, July 3, 1980. [ML031210596]
[4] AEOD/C001, "Report on the Browns Ferry 3 Partial Failure to Scram Event on June 28, 1980," Office for Analysis and Evaluation of Operational Data, U.S. Nuclear Regulatory Commission, July 30, 1980. [8008140575]

impeded. It must also be a closed volume, both to prevent significant coolant inventory loss and to prevent the release of potentially contaminated water to the environment. After a scram, there is enough leakage through the control rod drives to pressurize the SDV up to reactor pressure.

The primary safety significance of this issue lies in the potential for scram failure. The scram function is necessary in many transients to prevent core uncovery and/or overheating of the suppression pool. Detailed

discussions of accident sequences involving scram failure can be found in NUREG-0460.[5]

In addition, the AEOD report identified a potential for an unisolable reactor coolant leak outside of primary

containment if the single isolation valve in the scram system piping should fail.[6] This aspect is discussed separately under Issue 40.

Possible Solutions

The corrective measures are divided into a short-term program and a long-term program.[7] The short-term actions were implemented by I&E Bulletins.[8,9] The long-term program is the concern of this issue.

The objective of the long-term program was the improvement of the SDV design.[10] (SDV design details vary from plant to plant.) The first concern was to improve the hydraulic coupling between the SDV headers (which comprise most of the free volume in the SDV) and the instrumented volume, which is physically lower than the headers and is intended to detect any water accumulation (and scram the reactor) before the headers fill. It was discovered that, at many sites, the relatively long pipes connecting the SDV headers to the instrumented volume had considerably greater hydraulic resistance than the instrumented volume drain line. Thus, a rapid ingress of water tended to fill up the headers, with the instrumented volume draining as fast as water spilled in through the long connecting pipe.

Secondly, the reliability of the float switches in the instrumented volume needed to be improved. The recommended solution was the addition of redundant and diverse water sensors.

Finally, it was recommended that the instrumented volumes be modified to prevent damage to the level sensors by hydrodynamic forces and water hammer in the instrumented volume during a scram.

CONCLUSION

The long-term program was devised by an NRR task force working with a subgroup of the BWR Owners' Group

and with OIE. Their generic recommendations have been published.[11] Implementation is in progress, scheduled to be complete in 1985, and is being tracked by MPA No. B-58. Because all generic work is complete and implementation is in progress, this issue is considered RESOLVED.

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[5] IE Bulletin 80-24, "Prevention of Damage Due to Water Leakage Inside Containment (October 17, 1980 Indian Point 2 Event)," U.S. Nuclear Regulatory Commission, November 21, 1980. [ML080310722]

[6] AEOD/C001, "Report on the Browns Ferry 3 Partial Failure to Scram Event on June 28, 1980," Office for Analysis and Evaluation of Operational Data, U.S. Nuclear Regulatory Commission, July 30, 1980. [8008140575]

[7] Letter to All BWR Licensees from U.S. Nuclear Regulatory Commission, "BWR Scram Discharge System," December 9, 1980. [8102190299]

[8] IE Bulletin 80-14, "Degradation of BWR Scram Discharge Volume Capability," U.S. Nuclear Regulatory Commission, June 12, 1980. [ML031210540]

[9] IE Bulletin 80-17, "Failure of 76 of 185 Control Rods to Fully Insert During Scram at BWR," U.S. Nuclear Regulatory Commission, July 3, 1980. [ML031210596]

[10] Letter to All BWR Licensees from U.S. Nuclear Regulatory Commission, "BWR Scram Discharge System," December 9, 1980. [8102190299]

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