SAFETY EVALUATION REPORT

STEAM GENERATOR WATER HAMMER

ZION GENERATING STATION

UNITS 1 AND 2

SEPTEMBER 1979

DOCKET NOS. 50-295 AND 50-304

1. Introduction

Steam generator water hammer has occurred in certain nuclear power plants as a result of the rapid condensation of steam in a steam generator feedwater line and the consequent acceleration of a slug of water which, upon impact within the piping system, causes undue stresses in the piping and its support system. The significance of these events varies from plant to plant. Since the total loss of feedwater could affect the ability of the plant to cool down after a reactor shutdown, the NRC is concerned about these events occurring, even though an event with potentially serious consequences is unlikely to happen.

Because of the continuing occurrence of water hammer events, the NRC, in September 1977, informed all PWR licensees that water hammer events due to the rapid condensation of steam in the feedwater lines of steam generators represented a safety concern and that further actions by licensees for Westinghouse and Combustion Engineering designed nuclear steam supply systems are warranted to assure that an acceptably low risk to public safety due to such events is maintained. Accordingly, these licensees were requested to submit proposed hardware and/or procedural modifications, if any, which would be necessary to assure that the feedwater lines and feedrings remain filled with water during normal as well as transient operating conditions. At the same time, the NRC provided each PWR licensee with a copy of its consultant's report, "An Evaluation of PWR Steam Generator Water Hammer," NUREG-0291.

The means employed at the Zion Generating Station to reduce the potential for steam generator water hammer include: a top discharge feedwater ring (J-tubes) in one steam generator, automatic initiation of auxiliary feedwater flow, the limited length (less than 8 feet) of horizontal feedwater piping adjacent to the steam generators and an administrative limit on the flow of auxiliary feedwater whenever the water level in the steam generator is below the feedwater ring. In addition, Commonwealth Edison Company is planning to install J-tubes in the remaining steam generators in both units at the rate of one steam generator per refueling outage.

2. Evaluation

Our consultant, EG&G Idaho, Inc., prepared the attached evaluation of steam generator water hammer at the Zion Generating Station Units 1 and 2 as part of our technical assistance program. We have reviewed this report together with the licensee's submittals listed under item 4.0.

Our consultant concluded that the present means for reducing the potential for steam generator water hammer at this facility are inadequate and recommended the installation of J-tubes on all steam generator feedrings. We agree with our consultant that the present means for reducing the potential for steam generator water hammer are inadequate. The Zion Units have a history of repeated water hammers. In addition to the water hammer events listed in Table I of our consultants' report, steam generator water hammers also occurred on March 2 and 16, 1979 and June 8, 1979.

The staff met with the licensee on May 30, 1979 and pointed out that with the exception of the Zion Power Station, all operating nuclear power stations that had experienced steam generator water hammer were modified and, subsequently, did not experience water hammer. All of these plants except two had installed feedrings that discharge water from the top of the ring rather than from the bottom. Furthermore, 12 cases of steam generator water hammer that have occurred at the Zion Power Station comprise approximately 50% of all steam generator water hammer events that have been reported in the U. S. We also noted that the administrative limit on auxiliary feedwater flow has proven to be ineffective in preventing steam generator water hammer at the Zion Power Station.

Based on this history of repeated water hammer events at the Zion Power Station and the success of top discharge feedrings for preventing water hammer, we recommended that top discharge feedrings be employed in all eight steam generators at the Zion Power Station. In order to assure that the J-tubes would be fully effective under all operating conditions, we also requested that the licensee consider raising the set-point for steam generator water level actuation of auxiliary feedwater so that auxiliary feedwater flow would be automatically introduced whenever the water level might drop below some set-point that is above the top of the feedwater nozzle.

In its letter of June 20, 1979, Commonwealth Edison Company commited to install J-tubes in all Zion Station steam generators. They will be installed at the rate of one steam generator per refueling outage in

order to minimize the loss of energy production, the annual radiation exposure of craftsmen and the overall cost. The licensee argued that a shorter schedule is not necessary because: (1) analysis of the Zion piping system showed that the safety related portions of the feedwater piping could withstand the most intense credible water hammer; (2) although the Zion units have experienced several water hammers that resulted in damage to snubber mountings, there was no damage to safety-related piping; and (3) water hammers do not appear to be a factor in the recently discovered cracks in feedwater pipes at other plants.

The staff is in general agreement with these points except for the implication that the most intense credible water hammer has been analyzed by the licensee. The analysis shows that the piping system would withstand a pressure pulse of 3200 psia, but a value has not been established for the most intense credible water hammer. However, although a more intense water hammer may be possible, the analysis does provide assurance that the piping system will withstand a water hammer of this intensity. We have, therefore, concluded that the installation of J-tubes at the rate of one steam generator per refueling outage as proposed by the licensee is adequate.

In its letter of August 8, 1979, the licensee presented arguments showing that it is not necessary to raise the steam generator water level set point for the actuation of the auxiliary feedwater system. Two situations were considered wherein raising the actuation setpoint after installation of J-tubes on all steam generators could possibly

prevent future water hammer incidents:

(1) Hot standby or low power operation in which, with automatic auxiliary feedwater flow secured, operator inattention to steam generator level results in the level dropping below the top of the feedring; and

(2) Reactor trips from power ranges between 15 and 27% power may result in partial uncovery of the feedring, but the water level does not fall sufficiently to actuate feedwater flow automatically.

At Zion Station, both of these situations are considered to be very low probability cases. For instance, during low power operation an operator is normally assigned full time to monitor steam generator level to ensure that the feedring remains full of water. With regard to reactor trips from power ranges between 15 and 27% power, Zion Station is normally base loaded at full-rated power and encounters the subject range only for brief periods several times a year during reactor startups and shutdowns. In addition, Zion operating procedures require manual initiation of auxiliary feedwater flow after any reactor trip, thus ensuring that a feedring equipped with J-tubes remains full of water. For these reasons, Commonwealth Edison concluded that raising the actuation setpoint for automatic auxiliary feedwater flow after J-tube installation has been completed is not warranted.

With regard to raising this actuation point for the operating period before the J-tubes are installed, the licensee pointed out that changes in the actuation point would not have precluded any of the water-hammer events that occurred at the Zion station.

We have concluded that the installation of J-tubes will effect a major reduction in the probability of occurrence of steam generator water hammer in conjunction with the present set point for the actuation of the auxiliary feedwater system. However, we will continue to monitor reports from the Zion Power Station for indications of damaging water hammer. If such an event should occur, the actuation point for the auxiliary feedwater system will be reconsidered at that time.

With regard to recently discovered cracks in feedwater piping, there is at this time no significant correlation between steam generator water hammers and pipe cracks. Of the 33 operating CE and Westinghouse units that have been inspected; 16 have had service induced cracks, 15 have had no cracks and two have had fabrication defects. Of the 16 that have had service induced cracks; four units had reported steam generator water hammers. Temperature data and analyses for several units indicate that the cracks are primarily due to thermal stress.

Inspection of Zion Units 1 and 2 in October and November 1979 revealed significant cracks in all feedwater nozzles. All cracked piping will be replaced prior to startup.

3. Conclusion

The licensee has committed to the installation of top discharge feedwater rings (J-tubes) in all of the steam generators at the Zion Generating Station at the rate of one steam generator per refueling outage.

Based on our knowledge of water hammer phenomena, our review of the licensee's reponses and the enclosed evaluation report, our consideration of the licensee's program for modifying the feedwater rings and the prompt repairs being made to feedwater piping, we have concluded that adequate measures are being taken at Zion Generating Station to prevent the rupture of a feedwater pipe due to water hammer. We, therefore, find that there is reasonable assurance that the Zion Power Station, Units 1 and 2 will continue to operate without undue risk of a pipe rupture as a result of steam generator water hammer.

4.0 References

1. G. J. Pliml ltr to R. A. Purple, Subject - "Response to May 13, 1975 NRC letter of Steam Generator Water Hammer", July 17, 1975.

2. R. L. Bolger of Commonwealth Edison Company to A. Schwencer, NRC, Subject, "Water Hammer Analysis", August 17, 1976.

3. J. A. Block, et al, An Evaluation of PWR Steam Generator Water Hammer, Creare, Inc., NUREG-0291, December 1976.

4. D. E. O'Brien ltr to A. Schwencer, Subject - "Response to September 2, 1977 NRC letter on Steam Generator Water Hammer", January 20, 1978.

5. C. Reed of Commonwealth Edison Company to A. Schwencer, NRC, "Feedwater Nozzle Inspection and Steam Generator Water Hammer", June 20, 1979.

6. C. Reed of Commonwealth Edison Company to A. Schwencer, NRC, "Additional Information on Steam Generator Water Hammer Evaluations", August 8, 1979.