Technical Report

STEAM GENERATOR WATER HAMMER EVALUATION
H. B. ROBINSON STEAM ELECTRIC PLANT UNIT NO. 2

by

Joe W. Reece

under a consulting agreement with

U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Reece Engineering Associates
242 Conrey Drive
Auburn, Alabama 36830

Report No. 6-2 March 13, 1980

8003180482

CONTENTS

I. INTRODUCTION 1

II. FEEDWATER SYSTEM 3

A. Description 3

B. Normal Operation 5

C. The Water Hammer Phenomenon 8

III. WATER HAMMER HISTORY AND MITIGATING FEATURES OF HBR 13

A. Research Recommendations 13

B. Regulatory Positions 13

C. Vendor Recommendations 14

D. Licensee Action 18

IV. PLANT RESPONSE DURING TRANSIENTS AND CONDITIONS MOST LIKELY TO CAUSE WATER HAMMER 22

A. Loss of Main Feedwater Flow 22

B. Reactor Trip 23

C. Loss-of-Coolant Accident (LOCA) 23

D. Loss of Offsite Power 23

E. Main Steam Line Break 24

F. Operator Error 25

V. CONCLUSIONS AND RECOMMENDATIONS 26

VI. REFERENCES 28

LIST OF FIGURES

1. Simplified Auxiliary Feedwater System Schematic 6

2. Counter-current Flow into Piping 11

3. Isolation of Steam Void 11

4. Acceleration of Water Slug 12

5. Slug Impact 12

6. J-tubes Similar to those used at Indian Point Unit 2 15

7. HBR Feedring and Piping Sketch 17

LIST OF TABLES

1. Reactor Trips Caused by Loss of Feedwater or Related Occurrences 19

I. INTRODUCTION

This report contains results of an evaluation of the H. B. Robinson Steam Electric Plant, Unit 2 (HBR), performed for the purpose of assessing the potential for water hammer in the feedwater system. Of specific interest is the question of whether or not the plant is susceptible to this water slugging phenomenon in the horizontal runs of piping supplying the steam generator feedrings. Such occurrences have led to damage in other units. So far as is known, however, no such water hammer has ever occurred at HBR and no damage has ever been found which could be attributed to this phenomenon.

HBR is a nuclear power station plant operated by Carolina Power and Light Company at Hartsville, South Carolina. The plant has a three-loop Westinghouse (W) nuclear steam supply system (NSSS) and has operated since 1970.

An understanding of the fluid dynamics of the feedwater system and the water hammer phenomenon leads to the conclusion that no hammer can occur in the feedring and its horizontal piping if the system is maintained full of water. However, it is by no means certain that hammers will occur if it is not possible to do this. This evaluation is based on the overall characteristics of the HBR system and offers an explanation for the absence of water hammers at the facility.

Several sources of information have been considered in this review:

(1) the "H. B. Robinson Nuclear Power Plant Final Safety Analysis Report," (FSAR) [1][1]

(2) "An Evaluation of PWR Steam Generator Water Hammer," NUREG-0291 [2]

(3) Westinghouse Technical Bulletin, NSD-TB-75-7 [3]

(4) licensee submittals of July 23, 1975 [4], and January 2, 1978 [5]

(5) discussions with licensee plant personnel [6]

(6) "TMI-2 Lessons Learned Task Force Status Report and Short Term Recommendations," NUREG-0578 [7]

(7) licensee submittals of November 16, 1979 [8] and July 10, 1979 [9].

Section II of this report is a description of the feedwater system hardware at HBR and of its operating characteristics. Section III contains a description of known water hammer mitigating measures and an assessment of how HBR makes use of some of these measures. Section IV is a summary of the main feedwater and auxiliary feedwater response during several normal and design basis accident transients, with an assessment of whether or not conditions arise conducive to water hammer in the feedwater system. Conclusions and recommendations are contained in Section V for HBR.

---

[1] References are denoted by square brackets, [ ].

II. FEEDWATER SYSTEM

The feedwater system and its operating characteristics are described in this section.

A. Description

The purpose of the feedwater system at HBR is to provide the necessary flow of water to the three steam generators during all normal and accident conditions. For ease of description the system is usually conceived as being comprised of two separate systems: the main feedwater system and the auxiliary feedwater system.

The main feedwater system contains two barrel-type, single stage centrifugal pumps, each capable of supplying 12,690 gpm at 2400 feet of fluid head. They are driven by 6000 horsepower electric motors normally powered by the plant generator through the main auxiliary transformer. If the plant turbine trips, power is supplied from the reserve auxiliary transformer with offsite power. Feedwater is supplied to the pumps from the low pressure headers by the condensate pumps and the heater drain pumps. From the main feedwater pumps water flows through the high pressure heaters to the main header. The main header supplies three sixteen-inch feedwater lines which pass through containment and are routed to each of the three steam generators. Each line is routed upward to the feedring elevation so that there is no horizontal run of pipe at the feedring level. Only the feedwater nozzle, a reducer and a downward turning elbow are present. Each line supplies a feedring made from a standard ten-inch diameter

pipe with bottom discharge holes of the type found in the Westinghouse Model 44 steam generators. The main feedwater pumps trip on the following signals:

(1) Low suction pressure
(2) Low lube oil pressure
(3) Loss of condensate pump
(4) Electrical overload
(5) Bus undervoltage
(6) Safety actuation signal
(7) Minimum flow (blocked for 30 seconds)
(8) High steam generator level

The plant has not had a loss of main feedwater event during the last three years of operation.

In the event of loss of main feedwater flow, decay heat removal is accomplished by the auxiliary feedwater system (AFWS). This system is also used during startup, shutdown and for low power operation. The system consists of two redundant piping networks with two electric pumps in one network and a single steam driven pump in the second network. Each of the electric pumps has a rated capacity of 300 gpm at a delivery head of 1300 psi. The steam driven pump delivers 600 gpm at 1300 psi. The electric pumps are supplied with power from offsite and can operate with power from the diesel generators (one per pump). The turbine driven pump is supplied steam from all three steam generators. The steam is routed from the steam lines upstream of the main steam isolation valves (MSIV) via a motor operated valve,

and a check valve into a common header. The primary source of water for the AFWS is the 200,000 gallon condensate storage tank (CST). The secondary source of water is the service water system and the ultimate heat sink (Lake Robinson). A third back-up system is a deep-well system with a 600 gpm delivery capacity. Presently, these two back-up sources of water are isolated by locked closed manually operated valves. After passing through the AFWS pumps the water is routed through containment to join the main feedwater lines at points between the crane wall and the containment wall. The junction is about 25 feet below the steam generator feedwater nozzle. It would be difficult to reroute the AFWS lines to achieve AFW injection any closer to the nozzles as the crane wall would have to be penetrated.

Figure 1 shows a simplified schematic for the AFWS.

B. Normal Operation

During power operation of the NSSS, feedwater is supplied by the main feedwater pumps in amounts matched to the demands of the steam generators. The flow is regulated individually in each of the three generators by a regulating valve that is actuated by a three-element controller which senses steam generator water level, feedwater flow and steam flow.

For low power operations such as startup and shutdown, the AFWS is used to supply water via the auxiliary feedwater pumps. During a normal startup and ascent to power this feedwater flow is adjusted

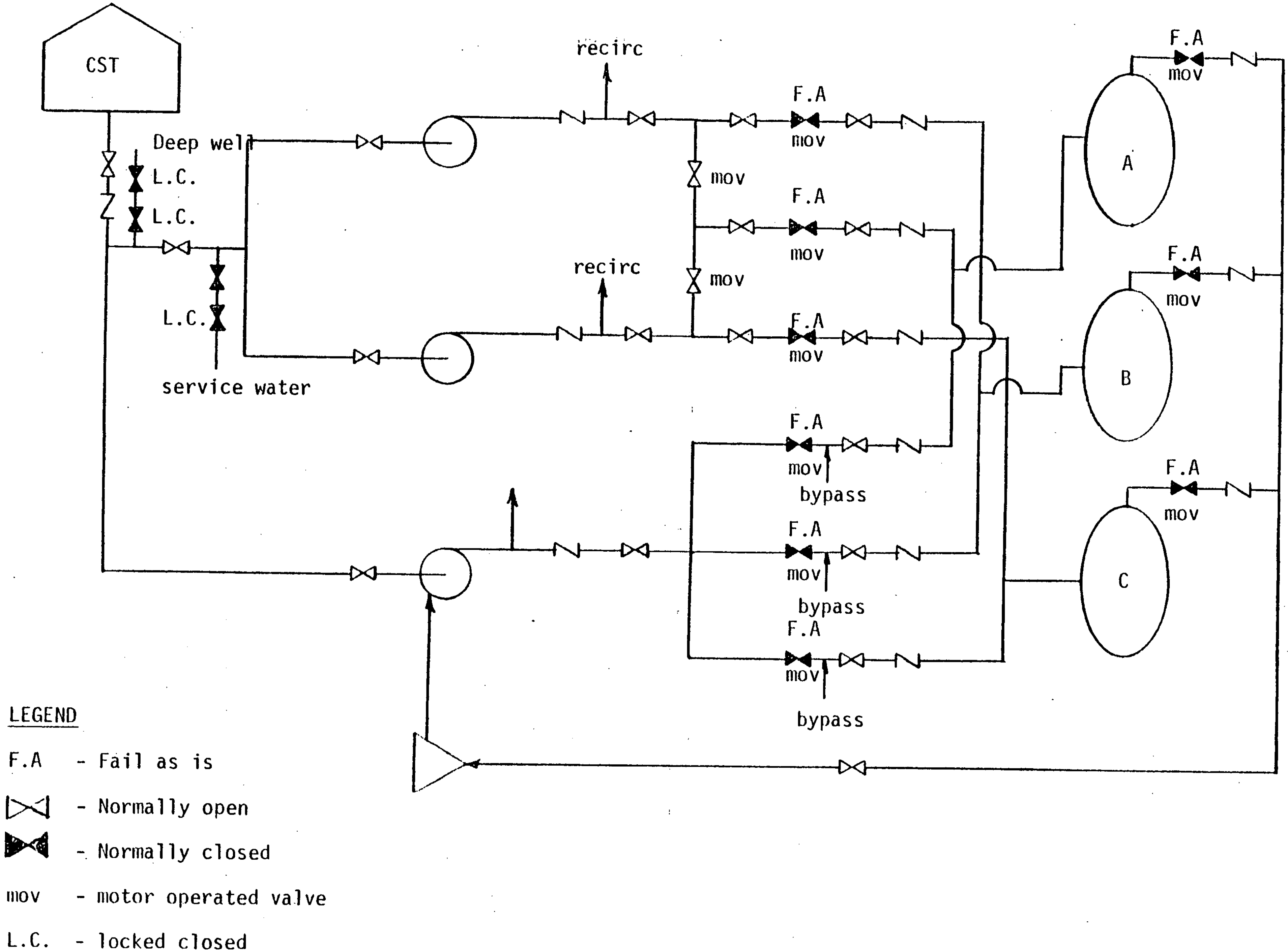

Figure 1. Simplified Auxiliary Feedwater System Schematic

manually from the control room as long as it is being supplied by the AFWS. The steam driven pump is not normally used during a startup.

When the steam supply is adequate to start the main turbine, one main feedwater pump is started and used to supply water up to 50% power. The second main feedwater pump is started at 50% power. During this phase of startup, feedwater flow is controlled by making use of the valves in the bypass lines for the main feedwater flow control valves. These four-inch bypass lines permit finer control of flow than the main feedwater valves which are in sixteen-inch lines. When the turbine-generator is synchronized with the grid, the flow of feedwater is shifted to the automatic three-element controller.

The AFWS is automatically started by one or more of the following signals:

Both motor driven pumps start as a result of:

(1) Two out of three low-low steam generator water level signals (any one of three generators)

(2) Loss of voltage to both main feed pumps

(3) Safety injection signal

(4) Loss of offsite power

Steam driven pump starts as a result of:

(1) Two out of three low-low steam generator water level (on <u>two</u> of the three generators)

(2) Loss of voltage on buses 1 and 4.

No operator action is required to initiate these systems, although manual action is required to control the individual steam generator flow. An exception to this occurs upon complete loss of all AC power. In this case the valves supplying steam to the steam driven pump must be opened manually.

Delivery of auxiliary feedwater flow to each steam generator should occur within one minute of a system startup signal. There are presently no administrative controls on the rate of flow for recovery from a generator low level situation. If all three generators are operable, i.e., no single unit has been isolated, the maximum delivery rate would be 400 gpm to each unit if all three AFWS pumps start. If one generator is blown down and isolated due to a mainsteam line (MSL) break the delivery rate could be as high as 600 gpm to each of the remaining two generators. This will be discussed later.

C. The Water Hammer Phenomenon

The dynamic event considered here is that occurrence which has been observed several times in PWR's both in the United States and abroad in which a water slug is accelerated by the differential pressure caused by the condensation of an isolated steam pocket. The accelerated water slug can impact the piping or water and cause damage to the piping system. Reported cases in other units (there have been no reported cases at HBR) have led to associated damages such as bent piping supports and a cracked feedwater line.

The event is typically initiated by a turbine trip which causes the water level to fall in the steam generators to a point below the feedring. Feedwater flow is discontinuous as a result of the trip and then the feedwater quickly drains from the ring through bottom discharge holes so that when the cold auxiliary feedwater arrives, the ring runs only partially full of water during recovery. The auxiliary feedwater flow rate at HBR is not sufficient to fill the ring while it is draining. As steam generator water level recovery proceeds, at least three mechanisms have been cited which could lead to the aforementioned steam void isolation and collapse:

(1) The flow of steam into the feedring through the discharge holes which are not flowing water and around the feedring into feedwater piping is counter to the flow of water toward the holes. This counter-current flow can cause waves on the surface which can build up to block the ring and isolate a steam pocket in the upstream portion of piping.

(2) As the level in the steam generator rises to the bottom of the feedring, an isolation of the steam in the ring occurs.

(3) Unsteady flow in the horizontal portion of the feedring and feedwater piping can, solely by hydraulic instabilities, cause a sealing off of a steam pocket as the recovering flow nears the top of the piping or as the incoming flow rate is changed by a controlling valve adjustment.

Figures 2, 3, 4, and 5 taken from the Creare Report [2] show these mechanisms.

None of the above initiating mechanisms can cause a water hammer if the feedring is kept full of water during the transient.

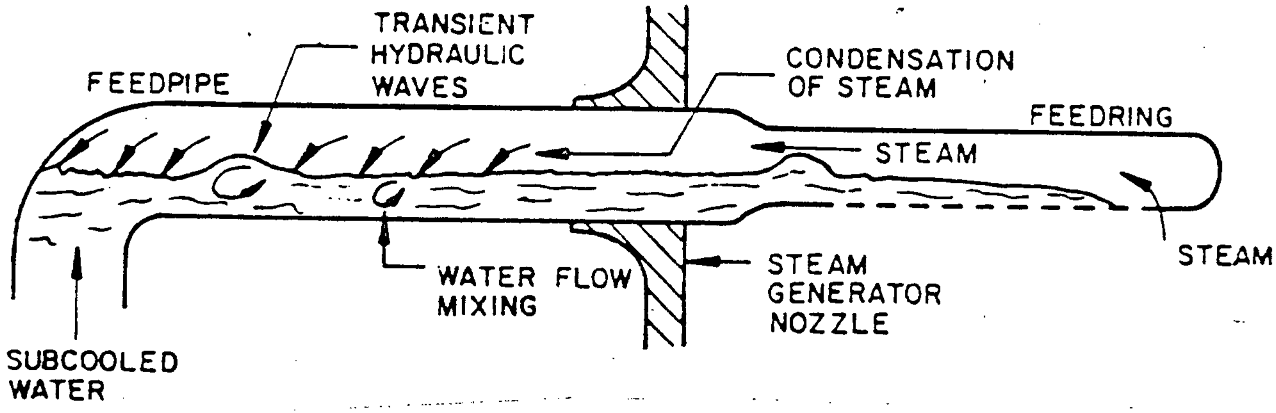

Figure 2. Counter-current Flow into Piping [2]

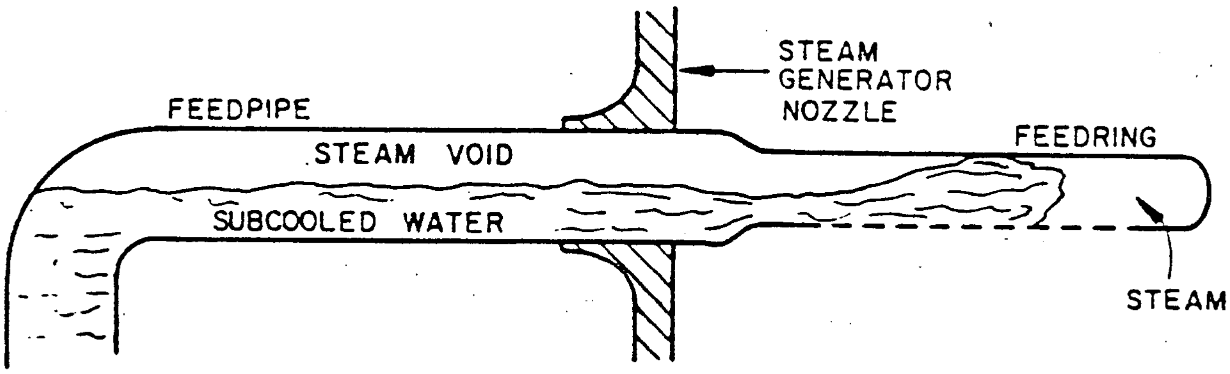

Figure 3. Isolation of Steam Void [2]

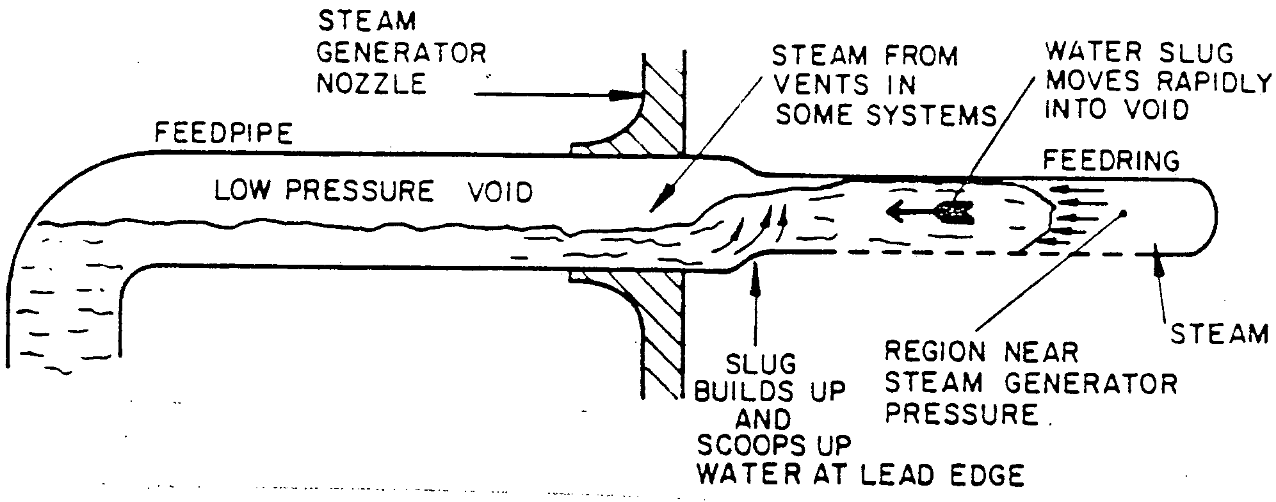

Figure 4. Acceleration of Water Slug [2]

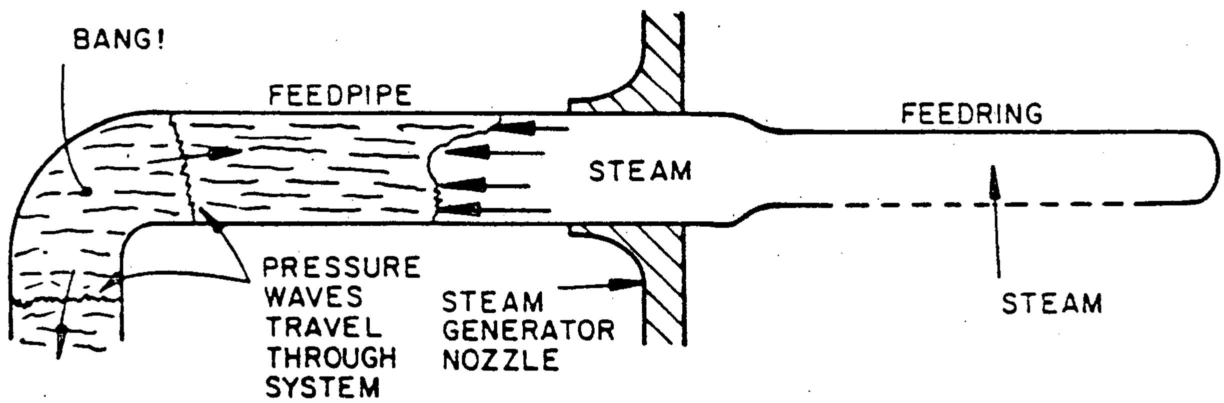

Figure 5. Slug Impact [2]

III. WATER HAMMER HISTORY AND MITIGATING FEATURES OF HBR

In this section, the effectiveness and applicability of various means to reduce the likelihood of a damaging water hammer event at HBR are discussed. How the plant responds to transients most conducive to water hammer and the plant history of operations with respect to these transients will be discussed in the next section.

A. Research Recommendations

In the interest of helping to keep the feedring from draining it has been recommended in the Creare Report [2] to install "J-tubes" similar to those shown in Figure 6. Currently, HBR does not plan to do this because of other mitigating features of the plant and the absence of any damaging hammer in the plant history [4].

Also recommended in the Creare Report [2] are administrative controls which would limit AFWS flow to less than 150 gpm per steam generator during steam generator level recovery. These controls are not now in place at HBR and the licensee does not propose to implement them for the same reason as cited in the preceding paragraph.

B. Regulatory Positions

In its Lessons Learned Report [7] the NRC takes the position that the initiation of AFWS should be automatic. HBR currently meets this position except in the case of loss of all AC power.

In its latest request for information (letter to the licensee of September 18, 1979) the NRC indicates that automatic initiation of AFW should occur before the steam generator level drops below the feedring but the licensee does not indicate in his reply [8] any plans to change the set point. While being of some advantage for low-power operations, changing the set point for automatic AFW initiation would still not prevent feedring uncovery during a trip from full power. The plant's history of recovering from such trips without experiencing a water hammer supports the position of leaving the set point as is.

C. Vendor Recommendations

Westinghouse cited [3] the probable causes for the water hammers which had been experienced in W plants and mentions test evidence from their work. Claims are made that

(1) The resulting forces are dependent on the length of horizontal feedwater line which can drain.

(2) Water slugging was not observed at reduced flow rates.

(3) Slug formation is most likely to occur during recovery of the feedring.

The Indian Point Tests are cited [3] where no water hammer was detected at or below 200 gpm per generator. W recommended that a flow rate limitation be administratively enforced to limit the flow to below 150 gpm during feedring recovery. HBR has not proposed to do this because of the other mitigating features of the plant and its history showing an absence of water hammers.

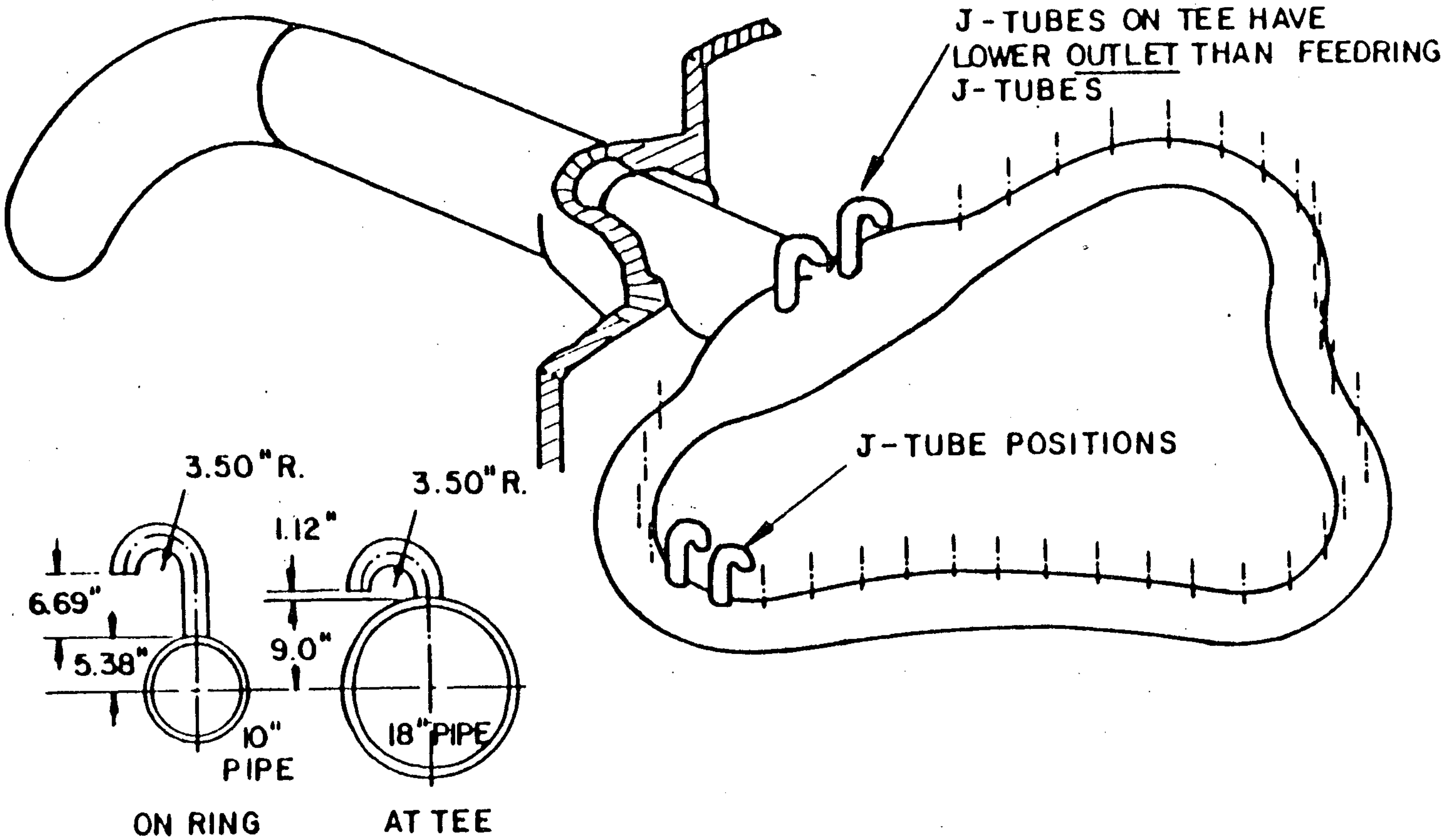

Figure 6. J-tubes Similar to those used at Indian Point Unit 2. [2]

Westinghouse also notes [3] that another step may be taken which will lessen the likelihood of a water hammer and lessen its severity should one occur in the feedwater system. This involves modifying the feedwater piping to make the horizontal drainable lengths as short as possible. This was done in the original piping design for HBR producing for each of the three generators the configuration shown in Figure 7. (Taken from [4] and [5].) There is no horizontal run of pipe at all and the drainable volume is at a minimum. The horizontal length of reservoir in the tee, the nozzle and the reducer is only about 7.3 feet. This provides such a small steam condensing area during AFW flow that waves produced by countercurrent flow are not likely to cause slug formation. Also, the short horizontal section provides a minimal volume in which a steam void could collapse and accelerate a slug. This is probably why the plant has never experienced a damaging water hammer. Conversations with the licensee indicate that one has never been heard.

In the Creare Report [2] mention is made of adding the length of the feedring itself to the total "horizontal" run of drainable pipe when considering the water hammer potential. We have concluded that this is not correct. Steam void collapse (should any occur in the feedring) would accelerate a slug of water to produce only internal momentum transfer. While external pressure pulses could occur they would be much less than those generated by a water hammer in an external feedwater pipe section. Also, no known damage has been traced to water hammers originating in the feedring sparger.

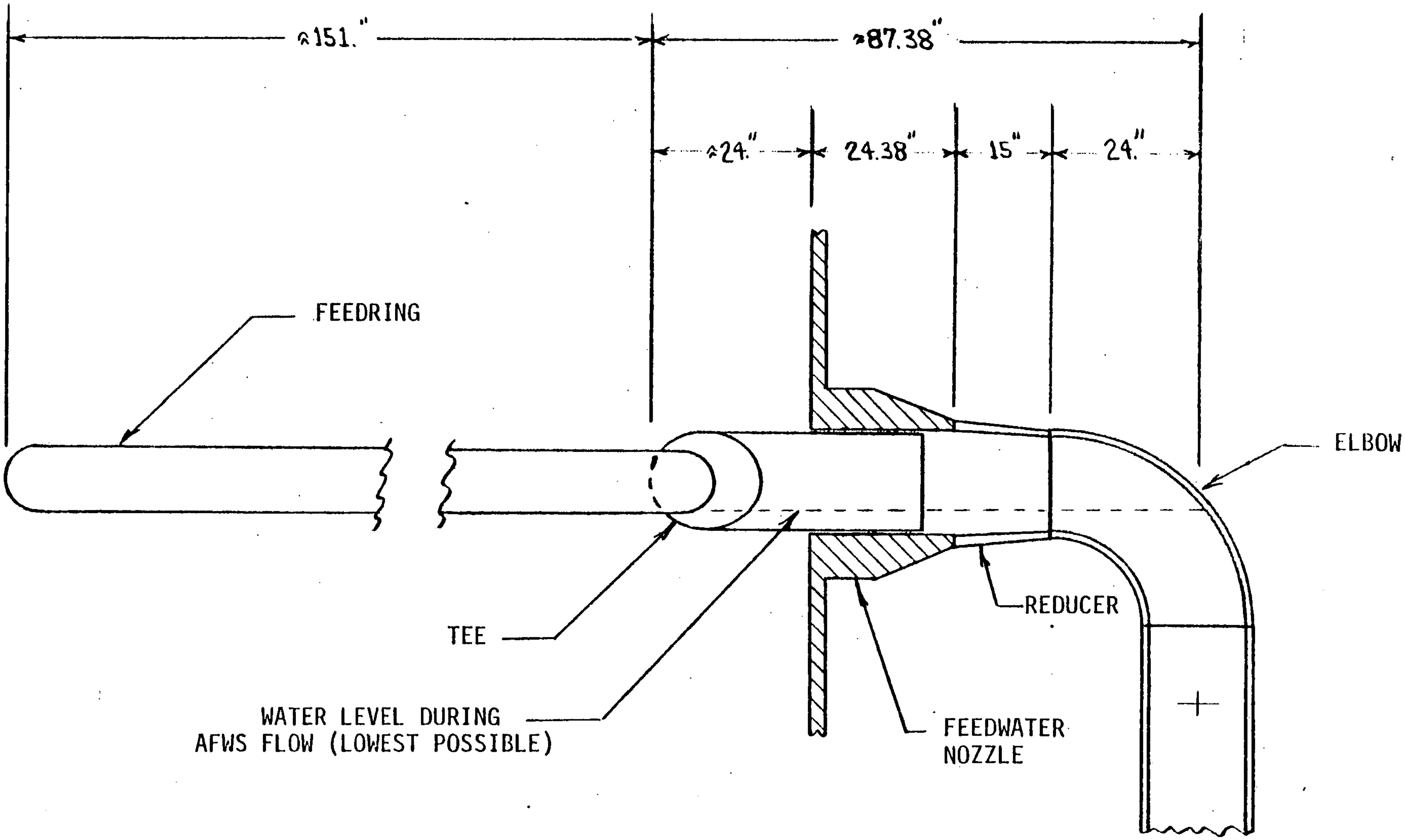

Figure 7. HBR Feedring and Piping Sketch

The model test results reported do not show a reduced likelihood of water hammer occurrence with decreasing external piping horizontal length. However, the over-pressure did decrease. Also, these model tests did not accurately simulate the feedring geometry. A simple straight pipe was used to model the feedring which allowed its total length to act as a direct extension of the external "horizontal" piping. Thus, it can be seen how in this case the simulated feedring length contributed to the mechanisms initiating water hammer and allowed a direct linear communication between feedring and external piping facilitating momentum transfer.

D. Licensee Action

To date the licensee has responded to all NRC requests for information about plant operation, [4] and [8]. The plant history is discussed and details of plant geometry and operating history are provided.

(1) History

Table 1 is a listing of the reactor trips caused by a loss of feedwater or related occurrences. HBR has experienced a total of eleven trips from thermal power levels of 80% or greater since plant startup. Eleven other trips have occurred from lesser power levels. No evidence of any water hammer has been detected.

There has been no occurrence of a loss of offsite power to the plant.

TABLE 1

Reactor (Rx) Trips Caused by Loss of Feedwater or Related Occurrences

DATE	EVENT	CAUSE	POWER LEVEL MWe	POWER LEVEL % THERMAL
9/26/70	Turbine & Rx Trip	Loss of mainfeed pump due to low suction pressure	0	12%
9/26/70	Same as above	Same as above	Same	
9/29/70	Rx Trip	Lo Level + SF/FF mismatch "B" SG	100	24%
10/1/70	Rx Trip	Same as 9/26/70	149	31%
10/29/70	Rx Trip	Lo-level & SF/FF mismatch "C" S/G Cycling MSIV	Normal	
10/25/70	Rx Trip	Lo-lo level C-SG-Loss of Main Feed Pump	0	5%
11/26/70	Rx Trip	"C" SG Lo-level with SF/FF mismatch Loss of Power -- Loss of main feed pump	52	18%
1/12/71	Rx Trip	Lo-lo "A" SG level	30	12%
1/28/71	Rx Trip	Lo level & SF/FF mismatch frozen reg. controller	452	71%
2/28/71	Rx Trip	Lo-lo level in "A" SG Loss of feed reg. valve linkage problem	735	99%
3/11/71	Rx Trip	"B" SG Lo-level & SF/FF mismatch loss of reg. valve due to I&C work being performed	715	100%
1/16/72	Rx Trip	Lo-lo SG Level - Due to failure of AFW discharge valve to open. Level being controlled by AFW pump.	0	
1/16/72	Rx Trip	Same	0	

TABLE 1 (Continued)

DATE	EVENT	CAUSE	POWER LEVEL MWe	POWER LEVEL % THERMAL
7/7/72	Rx Trip	Lo Level - SF/FF mismatch Loss of feedpump	670	99.9%
7/8/72	Rx Trip	Lo-Lo level stuck reg valve	50	12%
9/26/72	Rx Trip	Lo Level with SF/FF mismatch "B" SG - Reg. Block valve would not open	80	21%
8/26/73	Rx Trip	Same as 9/26/72	0	3%
4/1/75	Rx Trip	Lo Level & SF/FF mismatch Closure of "A" FW Reg. Valve	730	100%
4/1/75	Rx Trip	Same as above - Broken wire on solenoid valve	720	100%
4/5/75	Rx Trip	Lo-Lo Level due to I/P converter failure on S/G Reg. Valve	440	60%
5/30/75	Rx Trip	SG "B" Lo level & SF/FF due to Inst. Air loss	711	100%
8/27/75	Rx Trip	SG "B" Lo level & SF/FF Lost "S" condensate & "B" feed pump	649	100%
12/17/75	Rx Trip	Lo-Lo level SG #3 loss of "A" condensate pump due to faulty switch	600	89%
10/2/76	Rx Trip	SF/FF mismatch to level loss of feed pump due to faulty temperature indication	315	80%
1/3/78	Rx Trip	Lo-Lo level on "C" S/B - MSIV closed Bad Solenoid	180	100%
10/16/78	Rx Trip	"C" S/G Low level with SF/FF mismatch	682	100%
6/3/79	Rx Trip	"B" S/G SF/FF mismatch with low level - shutdown trip		

(2) Instrumentation

In the licensee's letter [9] concerning his instrumentation test program to identify any source of high cycle fatigue in the feedwater lines, it is indicated that acceleration, strain, displacement, pressure and temperature will be monitored in "B" and "C" feedwater lines during transients. Data gathered so far show no apparent water hammer. These data include a reactor trip from 30% power. Examination of the steam generator level data shows that the feedring was never uncovered during this trip. In the licensee submittal of November 16, 1979 [8] no further data gathering is indicated.

(3) Reporting

The licensee is required by HBR technical specifications to report by telephone within 24 hours any occurrence of a water hammer which results in a plant shutdown. Any other incident of a water hammer will be reported as an operating experience.

IV. PLANT RESPONSE DURING TRANSIENTS AND CONDITIONS MOST LIKELY TO CAUSE WATER HAMMER

There are several normal and design basis transients which could cause a steam generator level reduction to below the feedring. Also, these transients are likely to cause this level to remain below the feedring long enough to cause the water in the ring to drain and be replaced by steam. Under these conditions, the introduction of cooler feedwater flow can cause water hammer. In addition, operator error during low power operations can cause the same condition if an insufficient feedwater flow is allowed to occur.

A. Loss of Main Feedwater Flow

Several causes can result in loss of main feedwater flow such as

(1) Main feedwater valve closure

(2) Tripping of main feedwater pumps

(3) Loss of feedwater availability to these pumps.

Loss of main feedwater flow will result in a reactor trip and the steam generator level will shrink to below the feedring. At the low-low level the AFWS pumps automatically start (both electric and steam driven pumps would start since the level in all three generators would drop). The resulting flow would not be adequate to keep the feedrings full until recovery has submerged the rings, and thus, steam would enter the feedring while cold auxiliary feedwater is flowing from the other end. These are the conditions that might produce a water hammer. However, the operating experience described in Section III-D of this report indicates that no water hammer has ever resulted.

B. Reactor Trip

Again the steam generator levels would drop. If the initiating event caused the main feedwater valves to close or if they closed during the recovery period due to a low primary coolant average temperature or safety injection signal (SIS), then the flow would have to be recovered by the AFWS. This situation is similar to that in (A) and the same conclusion can be drawn.

C. Loss-of-Coolant Accident (LOCA)

Following any loss of coolant accident that resulted in a reactor trip, the AFWS would be initiated and steam generator level recovery would commence with flow from both the motor driven and turbine driven pumps. A subsequent water hammer that ruptured a feedwater line inside containment might add to containment pressure because of a steam generator blowdown. Thus, it is important to assure that no damaging water hammer occurs in conjunction with a LOCA.

D. Loss of Offsite Power

This transient causes a reactor trip, a turbine trip and subsequent steam generator level shrinkage. The AFWS starts with power from the diesel generators and DC batteries and steam generator level recovers as in the other transients. Although this transient has never been experienced by the plant, similar hydraulic conditions have not resulted in a water hammer. Specifically, the loss of offsite power would result in loss of power to the feedwater pumps and the

plant would respond as described on the preceding page for a loss of feedwater event.

E. Main Steam Line Break

This transient could result in containment over-pressurization should a damaging water hammer cause a feedwater pipe rupture at the time of maximum pressurization due to a main steam line break. The steam generator level shrinkage occurs because of the reactor trip, turbine trip and isolation of main feedwater lines.

Feedwater is supplied by the automatically started AFWS including the turbine driven pump (since it can be supplied steam from the other two steam generators). There are adequate check valves to insure the supply of steam to the turbine driven pump. Level recovery occurs in the two unaffected steam generators producing the conditions most likely to initiate a water hammer. If a feedwater pipe to one of the two remaining steam generators should rupture, the plant cooling capability would be impaired. It should be noted that only one generator is required for decay heat removal. Operator action requires isolation of the affected steam generator so that AFW is not lost via the damaged steam generator. The plant has never experienced this transient, i.e., refilling the steam generator at the AFW flow rate greater than 400 gpm per steam generator has never occurred. This could result in the event of a steam line break with present plant operating procedures. However, the plant

operating procedures could be modified to avoid flowrates greater than 400 gpm per steam generator.[1]

F. Operator Error

During low power operation, feedwater is controlled manually providing a possibility for operator error that could result in feedring uncovery. If the steam generator level is allowed to remain below the feedring for more than about a minute, drainage will empty the feedring. Subsequent recovery could create the same conditions most favorable for a water hammer as before in all three loops.

---

[1] For example, this could be accomplished for the main steam line break transient by closing down the turbine driven AFW pump before isolating the leaking steam generator. The flow from the two remaining motor driven pumps would provide 300 gpm for each of the remaining two generators.

V. CONCLUSIONS AND RECOMMENDATIONS

The foregoing assessment of the likelihood of a damaging water hammer at HBR, and of the system capability to resist such events has been made by considering

(1) System characteristics

(2) Operating procedures

(3) Plant history and licensee proposals

(4) Events likely to cause feedring uncovering and draining.

This study has revealed that the plant has been subjected to those conditions most likely to cause steam generator water hammer. These same conditions would be expected in the future as a result of normal operations or transient or accident conditions. Since a water hammer has not occurred at HBR during such conditions, none is expected to occur in the future. The most likely cause of the absence of water hammers is the short (and identical) horizontal drainable portions of the feedwater inlet system.

The plant does not meet the vendor recommendation of reduced feedwater flow (150 gpm or below) during steam generator level recovery. The present normal rate of recovery with both motor driven pumps running, the steam driven pump on, and with all three steam generators taking water is 400 gpm. As noted before, many reactor trips have occurred resulting in this situation with no apparent water hammer. However, no evidence has been presented that will assure an absence of water hammer at recovery rates higher than this (e.g. if the flow is not administratively controlled following a

main steam line break with the affected steam generator being isolated the recovery rate could be higher than 400 gpm per generator.) It is recommended that

(1) The licensee be informed of this possibility so that the plant operational procedures can be surveyed for any needed adjustment.

(2) The licensee and the NRC continue to monitor pipe hanger, snubber and feedwater line related equipment reports for evidence of any damage from water hammer at HBR.

VI. REFERENCES

1. Final Safety Analysis Report, H. B. Robinson Steam Electric Plant Unit No. 2, Carolina Power and Light Company (CP & L), NRC Docket No. 50-261.
2. Block, J. B., et al, An Evaluation of PWR Steam Generator Water Hammer, Creare, Inc. NUREG-0291 (December 1976).
3. Bennett, W. E., Waterhammer in Steam Generator Feedwater Lines, Westinghouse Technical Bulletin, NSD-TB-75-7 (June 10, 1975).
4. Utley, E. E., (CP & L) letter to George Lear, NRC/DOR, "Response to NRC Request for Analysis to Determine Potential Occurrence of Secondary System Fluid Flow Instability", July 23, 1975. (Response to NRC letter request of May 15, 1975).
5. Utley, E. E., (CP & L) letter to Robert W. Reid, NRC/DOR, "Response to Steam Generator Water Hammer Request", January 2, 1978. (Response to NRC letter request of September 2, 1977.)
6. Discussions with licensee
7. TMI - 2 Lessons Learned Task Force Status Report and Short Term Recommendations, NUREG-0578 (July, 1979).
8. Utley, E. E., (CP & L) letter to Albert Schwencer, NRC/DOR, "Response to Request for Information - Steam Generator Water Hammer", November 16, 1979. (Response to NRC letter request of September 18, 1979.)
9. Utley, E. E., (CP & L) letter to Albert Schwencer, NRC/DOR, "Investigation of Feedwater Line Cracks", July 10, 1979.