Illinois Power Company
Clinton Power Station
P.O. Box 678
Clinton, IL 61727
Tel 217 935-8881

ILLINOIS POWER

U-601958
L30-92(03-30)-LP
8G.130

JSP-164-92
March 30, 1992

Docket No. 50-461

Nuclear Regulatory Commission
Document Control Desk
Washington, DC 20555

Subject: Clinton Power Station (CPS)
Revision of Response to Bulletin 88-08, Supplement 3

Dear Sir:

Illinois Power (IP) provided its response to Supplement 3 of Bulletin 88-08 by letter U-601492 dated August 17, 1989, and supplements U-601623 and U-601693 dated March 16 and June 22, 1990, respectively. IP's response was reviewed by the NRC Staff, and by letter dated November 26, 1991, the NRC Staff provided its evaluation of IP's response. Therein it was stated that IP's "response to Action 3 of the bulletin does not provide sufficient assurance that unisolable portions of all piping connected to the RCS [reactor coolant system] will not be subjected to combined cyclic and static thermal stresses and other stresses that could cause fatigue failure during the remaining life of the unit." It was also stated in the letter that "inservice inspection [as IP had previously committed to do to address the problem of potential cracks in piping] is not an acceptable technique...for preventing such cracks." The letter included criteria for IP to consider in preparing an acceptable response.

This letter provides IP's revised response to Supplement 3 of Bulletin 88-08 with respect to Action 3 of the bulletin. IP's revised response, provided in Attachment 1 to this letter, is based on the evaluation criteria provided in the NRC's November 26, 1991 letter and on additional, clarifying guidance provided via several telephone discussions conducted during January and February 1992 between IP and NRC Staff personnel, i.e., Mr. A. T. Gody, Jr. (NRC Licensing Project Manager for CPS) and Reactor Systems Branch personnel.

Application of the above guidance has resulted in conclusions and actions significantly different than described in IP's

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previous response to Supplement 3 of the bulletin. In particular, with respect to process piping connected to the RCS, IP previously identified six subsystems of potential concern. Of these, 1RH-34 was determined by analysis not to be a concern on the basis that the piping welds would not be subjected to excessive stresses over the lifetime of the plant. This determination remains unchanged. Subsystems 1LP-01, 1HP-01, 1RH-01, 1RH-03 and 1RH-05 were previously evaluated by performing a bounding, conservative analysis of 1LP-01. IP's previously performed analysis of this subsystem yielded high stresses and cyclical loadings with a limited subsystem lifetime due to fatigue (relative to plant life). However, after considering the additional, clarifying guidance obtained from the NRC Staff (particularly with respect to the distance between the isolation valve and the connection to the RCS), IP has now concluded that none of the above subsystems are susceptible to the cracking or fatigue failure caused by thermal stratification as addressed by Bulletin 88-08. Therefore, it is not necessary to perform periodic inspections of the welds in these subsystems as IP previously committed to do in its June 2?, 1990 letter.

Provided in Attachment 2 is a summary of IP's previous analysis of subsystem 1RH-34. As noted above, IP's analysis of this subsystem confirmed that it should not be susceptible to fatigue failure due to thermal stratification over the lifetime of the plant. This summary is provided (for information purposes only) because, during the telephone discussions conducted between the NRC Staff and IP, it was determined that IP did not provide sufficient detail concerning this analysis in its previous response to Supplement 3 of Bulletin 88-08. Additionally, the 1RH-34 subsystem configuration was the subject of much discussion between IP and the NRC Staff due to some similarity to the configuration addressed in Supplement 3.

This letter, together with the information provided in its attachments, serves to complete IP's response to Supplement 3 of Bulletin 88-08 and resolves the concerns expressed in the NRC Staff's letter dated November 26, 1991.

I hereby affirm that the information in this letter is correct to the best of my knowledge.

Sincerely yours,

J. S. Perry
Vice President

WTD/alh
WSI19:WTD16

Attachments

cc: NRC Clinton Licensing Project Manager
NRC Resident Office
Regional Administrator, Region III, USNRC
Illinois Department of Nuclear Safety

Clarification of Response to NRC Bulletin 88-08 Supplement 3 in Response to the NRC's Letter Dated November 26, 1991

BACKGROUND

NRC Bulletin 88-08, Supplement 3, documented an event at a foreign reactor facility which raised new concerns on thermal stratification in unisolable piping connected to the Reactor Coolant System (RCS). At this foreign facility, cracks were found in piping connected to the RCS. The cracks resulted from thermal fatigue caused by hot water, which was drawn periodically from the RCS hot leg, leaking through the packing gland of a Residual Heat Removal (RHR) valve. The hot fluid flowed on top of the cool fluid in the pipe and produced a temperature gradient between the top and bottom of the pipe resulting in thermal stresses on the pipe. The valve leakage and resultant thermal stresses were cyclic due to the thermal expansion and contraction of the RHR valve disk.

This event is different than the event documented in the original NRC Bulletin 88-08 where thermal stratification resulted from leakage of higher-pressure cold water into hot RCS water. The NRC has requested that the three actions in the original bulletin be addressed for the event documented in Supplement 3. These actions are as follows:

A. <u>Action 1</u> - Review systems connected to the RCS to determine whether unisolable sections of piping connected to the RCS can be subjected to stresses from temperature stratification or temperature oscillations that could be induced by leaking valves and that were not evaluated in the design analysis of the piping. For those addressees who determine that there are no unisolable sections of piping that can be subjected to such stresses, no additional actions are required.

B. <u>Action 2</u> - For any unisolable sections of piping connected to the RCS that may have been subjected to excessive thermal stresses, examine non-destructively the welds, heat-affected zones and high stress locations (including geometric discontinuities) in that piping to provide assurance that there are no existing flaws.

C. <u>Action 3</u> - Plan and implement a program to provide continuing assurance that unisolable sections of all piping connected to the RCS will not be subjected to combined cyclic and static thermal stresses and other stresses that could cause fatigue failure during the remaining life of the unit.

Attachment 1 to Supplement 3 of Bulletin 88-08 identified various approaches that might be used to address configurations like the one that existed at the foreign reactor and provide continuing assurance that fatigue failure would not occur during the remaining life of the unit. One approach was to revise the piping arrangement to minimize the effects of thermal stratification by moving the valve "sufficiently" far away from the hot source. An indication of what was "sufficient", however, was not given. As a result, when Illinois Power (IP) performed its evaluation of potentially vulnerable piping configurations at CPS, IP adopted a very conservative approach which did not consider the distance between the valve and source.

The conclusions of IP's analysis were transmitted to the NRC on June 22, 1990. IP's response identified welds in subsystems 1LP-01, 1HP-01, 1RH-01, 1RH-03 and 1RH-05 as a potential concern based on the conservative analysis. The analysis determined that these five subsystems had a fatigue life of four years with the occurrence of stratification. Illinois Power indicated that Action 3 of Bulletin 88-08 Supplement 3 would be satisfied by adding these welds to the Clinton Inservice Inspection (ISI) Program such that they would be inspected once every two refueling outages. It was felt that this would provide continuing assurance that piping/weld fatigue would not go undetected and would permit action to be taken prior to the occurrence of fatigue failure, thus meeting the intent of Action 3.

By letter dated November 26, 1991, the NRC indicated that IP's response to Action 3 of Bulletin 88-08 for Supplement 3 "does not provide sufficient assurance that unisolable portions of all piping connected to the RCS will not be subjected to combined cyclic and static thermal stresses and other stresses that could cause fatigue failure during the remaining life of the unit." Pursuant to this evaluation of IP's response, evaluation criteria were provided in the NRC's letter to assist in preparing an acceptable response. These included a criterion which provided an indication of what distance between the isolation valve in the subject piping and the hot source (RCS) is "sufficient" to alleviate concerns. A better understanding of this evaluation criterion was gained in subsequent telephone discussions with the NRC Staff. It was thus confirmed that the concerns presented in Bulletin 88-08 would not be applicable when the isolation valve was greater than 25 pipe diameters from the hot source. This criterion forms the basis for IP's revised response to Action 3 of Bulletin 88-08 for Supplement 3, as discussed below.

REVISED RESPONSE

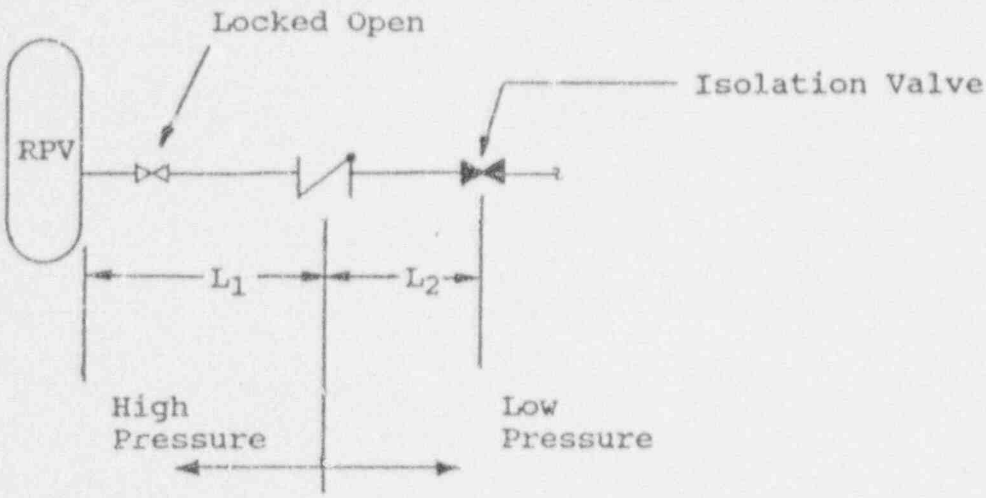
As shown in Figure 1 (p. 4 of 4 of this attachment), the configuration of the five subsystems in question consists of a locked-open gate valve, a check valve, and an isolation valve. It is postulated that a small amount of leakage could flow past the check valve to the isolation valve and then past the valve disk and out the stem of the isolation valve. This leak would slowly heat up the disk causing it to seat tightly. Leakage flow would then cease, allowing the disk to cool and subsequently contract. This cycle would then resume after the disk cooled. This cyclic phenomenon would reduce the life of the associated piping between the reactor pressure vessel (RPV) and the isolation valve due to fatigue. If, however, the isolation valve was of sufficient distance from the hot source (the RPV in this case), enough heat would be lost to the environment and enough mixing would occur such that there would be insufficient heat available to drive this cycle. The distances between the RPV and the isolation valves for our five applicable subsystems are significantly greater than 25 pipe diameters. This puts these five subsystems outside the scope of Bulletin 88-08, Supplement 3, based on the evaluation criteria provided by the NRC. Increased surveillance through IP's ISI Program as discussed in IP's response to Action 3 of Bulletin 88-08 for Supplement 3 (letter U-601693 dated June 22, 1990) will consequently not be necessary.

CONCLUSION

Based on the NRC-provided evaluation criteria, Supplement 3 of Bulletin 88-08 requires no further action for the five subsystems noted above.

SUBSYSTEM 1RH-34

It should be noted that not all piping which connects to the RCS at Clinton meets the 25 pipe diameter criterion. Those configurations that do not, however, have been analyzed as discussed in IP's June 22, 1990 transmittal, and they have been shown not to be a concern. Most notable of these cases is subsystem 1RH-34 since it is analogous to the case presented in Bulletin 88-08, Supplement 3. Although this subsystem was shown by analysis not to be a concern, it was brought up in discussions with the NRC due to its similarity with the case that led to Supplement 3. A brief discussion of the analysis used to evaluate this subsystem is therefore provided in Attachment 2.



SUBSYSTEM	L_1	L_2	Remarks
1LP-01	>25D	>>25D	L_1+L_2>>25D
1HP-01	>25D	>>25D	L_1+L_2>>25D
1RH-01	>25D	>19D	L_1+L_2>>25D
1RH-03	>25D	>>25D	L_1+L_2>>25D
1RH-05	>15D	>>25D	L_1+L_2>>25D

Figure 1

Analysis of 1RH-34

STRATIFIED FLOW PHENOMENA (Background)

Thermal stratification is a phenomenon resulting from the lack of mixing between the stagnant fluid in a horizontal pipe and the incoming, relatively hot, very slow moving fluid from any leakage source. The denser cold fluid occupies the bottom portion of the horizontal pipe while the more buoyant hot fluid occupies the upper portion of the same pipe. Accordingly, the top side of the pipe, which is hotter, would expand significantly more than the cooler bottom side. This creates an upward bowing if the horizontal stratified pipe was simply supported, and a downward bowing if the horizontal stratified pipe was supported as a cantilever. With the exception of a stratified water/steam interface surface, the surface interface between the stratified denser cold fluid and lighter hot fluid is not generally distinct due to the heat conduction between the fluid layers. In addition, the leakage flow disturbs this hot/cold interface surface and creates standing wave-like surface oscillations within it. This oscillatory motion of the hot/cold interface surface, scanning the pipe inside wall, generates a localized thermal transient which is commonly known as thermal striping. This thermal striping generates a concern with regard to thermal fatigue cracking.

SUBSYSTEM 1RH-34 ANALYSIS

Subsystem 1RH-34 begins at the connection to the 20-inch Reactor Recirculation (RR) Pump "B" suction line and ends at the penetration anchor for containment penetration 1MC-14. The portion of piping considered as unisolable from the Reactor Coolant System (RCS) includes the portion of the line from the RPV up to valve 1E12-F009. A simplified schematic is shown in Figure A (p. 3 of 5 of this attachment).

Analysis of subsystem 1RH-34 was conservatively based on the following scenario:

A. With the system stagnant at a temperature of 130°F, leakage develops through the seat of valve 1E12-F009 and the stem of valve 1E12-F008. This starts the stratification cycle

B. The leaking water, at a temperature of 550°F RPV temperature, flows at the top of cold water in horizontal piping runs.

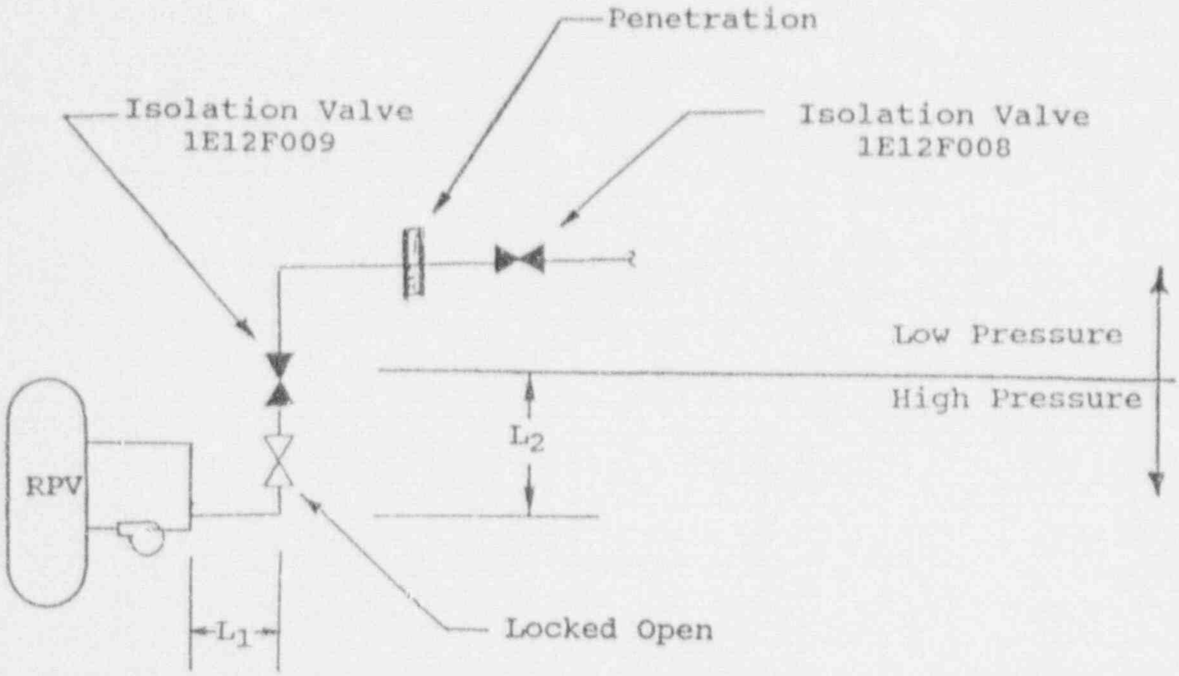
C. The total number of stratification cycles based on a conservative analysis was 15,000 over 40 years. Striping, thermal fluctuations at the hot-cold interface, was calculated to occur at a rate of 200 cycles per stratification cycle for a total of 3,000,000 striping cycles.

RESULTS OF ANALYSIS

Per the analysis, bending moments due to bowing and the resulting thermal stresses, as well as localized thermal stresses due to striping, were calculated. These stresses were then combined with design-basis loadings. Both structural and fatigue aspects were then evaluated, with the following results:

A. Loadings at the connection between the RH piping and the 20" RR "B" suction line were unchanged.
B. Piping stresses and usage factors remained within the allowable ASME Code limits.
C. Load increases on supports were evaluated and were found to be acceptable.
D. Load increases at the containment penetration (1MC-14) from the subsystem 1RH-34 analysis were analyzed and were found to be acceptable.

NOTE: The first attempt to qualify the penetration itself was done using the fatigue cycle analysis discussed previously. This resulted in unacceptable fatigue loading. The original fatigue cycle analysis was revisited and a number of assumptions were determined to be overly conservative. In the new analysis, consideration was given to cooldown of the line and heat up of the valve disk as these mitigating effects were not included in the original analysis. A re-evaluation was performed to more accurately model the fatigue cycles. A graphical comparison of the two analyses is given by Figures B and C (pages 4 and 5 of this attachment). Based on the more accurate analysis, 6,739 stratification and 375,407 striping cycles would occur. The penetration was successfully qualified using the fatigue cycles from this more accurate analysis. Subsystem 1RH-34 was not reanalyzed using the more accurate fatigue analysis since the results using the original analysis were acceptable as is.

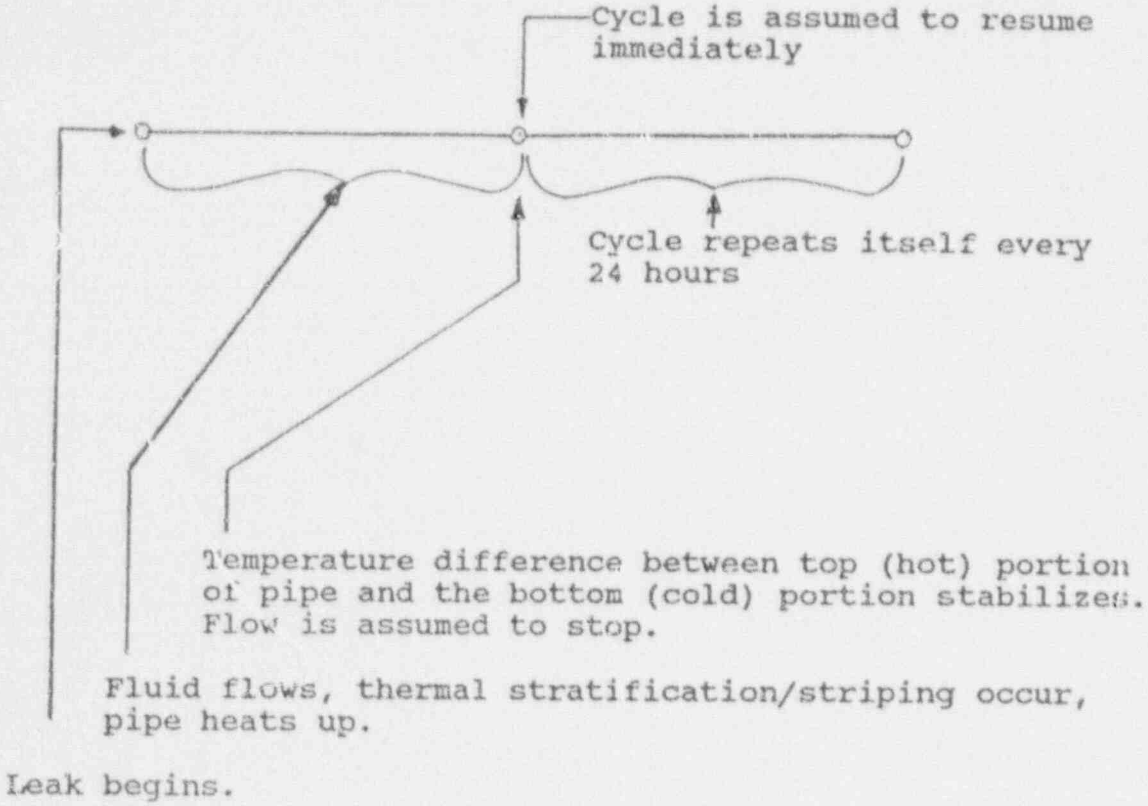


SUBSYSTEM	L_1	L_2	REMARKS
1RH-34	~ 4-1/2′	~ 16′	$L_1 + L_2 < 25D$

NOTE: L_1 is a Horizontal Run.
L_2 is a Vertical Run.
This case has been analyzed for thermal stratification and found to be acceptable.

Figure A

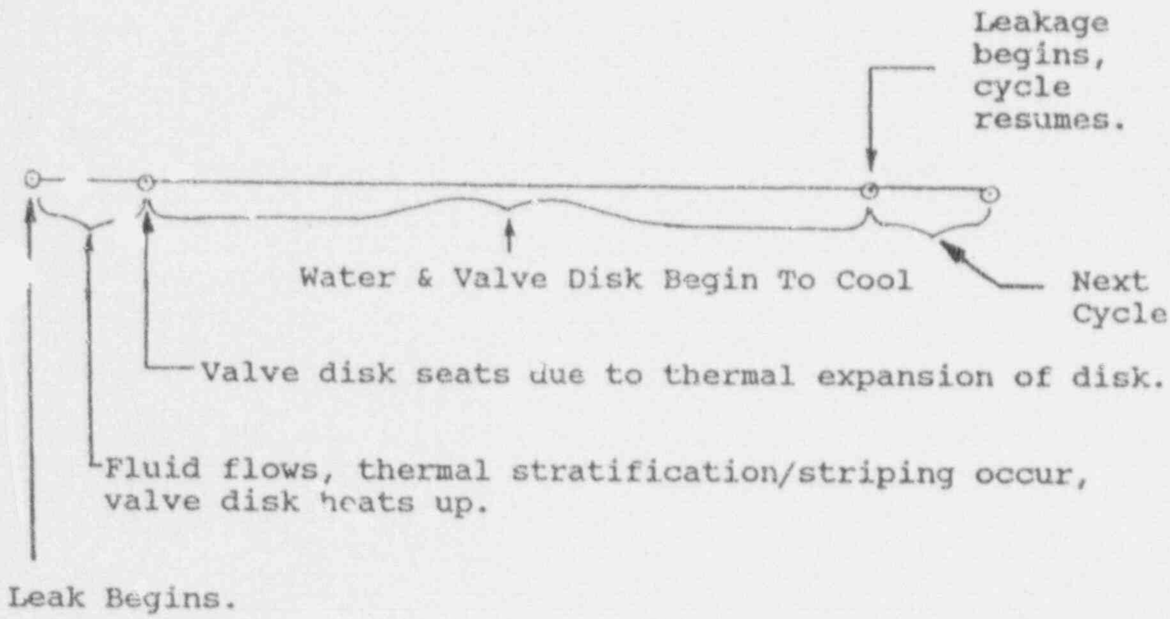
Original Analysis



- Piping is subjected to continuous fatigue cycles.
- Cycle restarts every 24 hours.

Figure B

More Accurate Analysis



- Piping experiences thermal fatigue cycles induced by thermal striping for a 7-hour duration.
- A 45-hour cooldown occurs. During this time period the piping does not experience fatigue cycles induced by thermal striping.
- The 7-hour cycle restarts after cooldown.

Figure C