UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

MAY 16 1988

MEMORANDUM FOR: Edward L. Jordan, Chairman
Committee to Review Generic Requirements

FROM: James H. Sniezek, Deputy Director
Office of Nuclear Reactor Regulation

SUBJECT: REQUEST FOR REVIEW OF A DRAFT BULLETIN ON THERMAL STRESSES IN PIPING CONNECTED TO REACTOR COOLANT SYSTEMS

On January 27, 1988, the NRC issued Information Notice 88-01, "Safety Injection Pipe Failure," which alerted licensees to a potentially generic problem that had occurred at Farley 2. The problem was the result of leakage of relatively cold water through a valve, which caused thermal cycling and failure of a section of safety injection piping connected to the reactor coolant system. The section of failed piping was downstream from the last check valve and could not be isolated from the reactor coolant system. The piping was repaired after the reactor was shut down and the reactor coolant system was partially drained.

The problem at Farley is considered to be generically significant because it is difficult to ensure that there will never be leakage across seated valves. However, because of the ductility of piping materials, catastrophic failure of fatigued piping is not considered to be likely. Nevertheless, the experience at Farley indicates that some water-cooled reactors may not comply entirely with General Design Criterion 14 of 10 CFR 50, Appendix A, which requires that the reactor coolant pressure boundary be designed to have an extremely small probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

The enclosed draft bulletin would ensure that compliance is achieved. It would be addressed to all holders of operating licenses and construction permits for water-cooled power reactors and would request that they take action to preclude significant thermal cycling, which might otherwise lead to high-cycle fatigue and failure of unisolable piping connected to the reactor coolant system.

The proposed bulletin and background information required by the CRGR Charter are enclosed.

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We request that review of this package be scheduled at CRGR's earliest convenience. The bulletin is sponsored by Charles E. Rossi, Director, Division of Operational Events Assessment.

Frank J. Miraglia
for James H. Sniezek, Deputy Director
Office of Nuclear Reactor Regulation

Enclosures:
1. NRC Bulletin No. 88-XX, Thermal Stresses in Piping Connected to Reactor Coolant Systems
2. CRGR Item IV.B. Contents of Packages Submitted to CRGR

Enclosure 1

UNITED STATES
NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
WASHINGTON, DC 20555

May XX, 1988

NRC BULLETIN NO. 88-XX: THERMAL STRESSES IN PIPING CONNECTED TO REACTOR COOLANT SYSTEMS

Addressees:

All holders of operating licenses or construction permits for light-water-cooled nuclear power reactors.

Purpose:

The purpose of this bulletin is to request that licensees (1) review their reactor coolant systems (RCSs) to identify any connected, unisolable piping that could be subjected to temperature distributions which would result in unacceptable thermal stresses and (2) take action, where such piping is identified, to ensure that the piping will not be subjected to unacceptable thermal stresses.

Description of Circumstances:

On December 9, 1987, while Farley 2 was operating at 33 percent power, the licensee noted increased moisture and radioactivity within containment. The unidentified leak rate was determined to be 0.7 gpm. The source of leakage was a circumferential crack extending through the wall of a short, unisolable section of emergency core cooling system (ECCS) piping that is connected to the cold leg of loop B in the RCS. This section of piping, consisting of a nozzle, two pipe spools, an elbow, and a check valve, is shown in Figure 1. The crack resulted from high-cycle thermal fatigue that was caused by relatively cold water leaking through a closed globe valve at a pressure sufficient to open the check valve. The leaking globe valve is in the bypass pipe around the boron injection tank (BIT) as shown in Figure 2. During normal operation this valve and others isolate the ECCS piping from the discharge pressure of the charging pumps. With a charging pump running and the valve leaking, temperature stratification occurred in the ECCS pipe as indicated in Figure 1. In addition, temperature fluctuations were found at the location of the failed weld with peak-to-peak amplitudes as large as 70 degrees F and with periods between 2 and 20 minutes.

Discussion:

At Farley 2, dual-purpose pumps are used for charging the RCS with coolant from the chemical and volume control system during normal operation and injecting emergency core coolant at high pressure during a loss-of-coolant accident (LOCA). Separate runs of piping from these pumps are connected to separate nozzles on the RCS piping for normal charging flow, backup charging flow, and hot- and cold-leg ECCS injection and to a nozzle on the pressurizer for auxiliary pressurizer spray. All of these runs of piping, downstream from the last check valve in each pipe, are susceptible to the kind of failure that occurred in the ECCS piping connected to the cold leg of loop B.

In any light-water-cooled power reactor, thermal fatigue of unisolable piping connected to the RCS can occur when the connected piping is isolated by a leaking block valve, the pressure upstream from the block valve is higher than RCS pressure, and the temperature upstream is significantly cooler than RCS temperature. Because valves often leak, an unreviewed safety question may exist for those reactors that can be subjected to these conditions. Under these conditions, thermal fatigue of the unisolable piping can result in crack initiation as experienced at Farley 2. Subjecting flawed piping to excessive stresses induced by a seismic event, waterhammer, or some other cause conceivably could result in double-ended failure of the pipe.

General Design Criterion 14 of Appendix A to Part 50 of Title 10 of the Code of Federal Regulations requires that the reactor coolant pressure boundary be designed so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture. At Farley 2, the pressure boundary failed well within its design life.

Actions Requested:

1. 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 requested except for the report required below.

2. For any unisolable sections of safety injection piping that may have been subjected to excessive thermal stresses, examine nondestructively the welds and heat-affected zones in that piping to provide assurance that there are no existing flaws.

3. 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 and other stresses that could cause fatigue failure during the remaining life of the unit. This assurance may be provided by (1) redesigning and modifying these sections of piping to withstand combined stresses caused by various loads including temporal and spatial distributions of temperature resulting from leakage across valve seats, (2) instrumenting this piping to detect adverse temperature distributions and establishing appropriate

limiting conditions for operation on temperature distributions, or (3) providing means for ensuring that pressure upstream from block valves which might leak is monitored and does not exceed RCS pressure.

4. For operating plants not in extended outages, Action 1 should be completed within 60 days of receipt of this bulletin, and Actions 2 and 3, if required, should be completed before the end of the next refueling outage. If the next refueling outage ends within 90 days after receipt of this bulletin, then Actions 2 and 3 may be completed before the end of the following refueling outage.

   For operating plants in extended outages and for plants under construction, Action 1 should be completed within 60 days of receipt of this bulletin or before achieving criticality, whichever is later, and Actions 2 and 3 should be completed before achieving criticality, unless criticality is scheduled to occur within 90 days of receipt of this bulletin. In that case, Actions 2 and 3 should be completed before the end of the next refueling outage.

Reporting Requirements:

1. Within 30 days of completion of Action 1, each addressee shall submit a letter confirming that the action has been completed and describing the results of the review. If the review performed under Action 1 indicates that a potential problem exists, the confirmatory letter shall include a schedule for completing Actions 2 and 3.

2. Those addressees who determine that there are unisolable sections of piping that 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 shall submit a letter within 30 days of completion of Actions 2 and 3. This letter should confirm that Actions 2 and 3 have been completed and describe the actions taken.

The written reports, required above, shall be addressed to the U. S. Nuclear Regulatory Commission, ATTN: Document Control Desk, Washington, DC 20555, under oath or affirmation under the provisions of Section 182a, Atomic Energy Act of 1954, as amended. In addition, a copy shall be submitted to the appropriate Regional Administrator.

This requirement for information was approved by the Office of Management and Budget under clearance number 3150-0011.

If you have any questions regarding this matter, please contact one of the technical contacts listed below or the Regional Administrator of the appropriate NRC Regional Office.

Charles E. Rossi, Director
Division of Operational Events Assessment
Office of Nuclear Reactor Regulation

Technical Contacts: Roger W. Woodruff, NRR
(301) 492-1180

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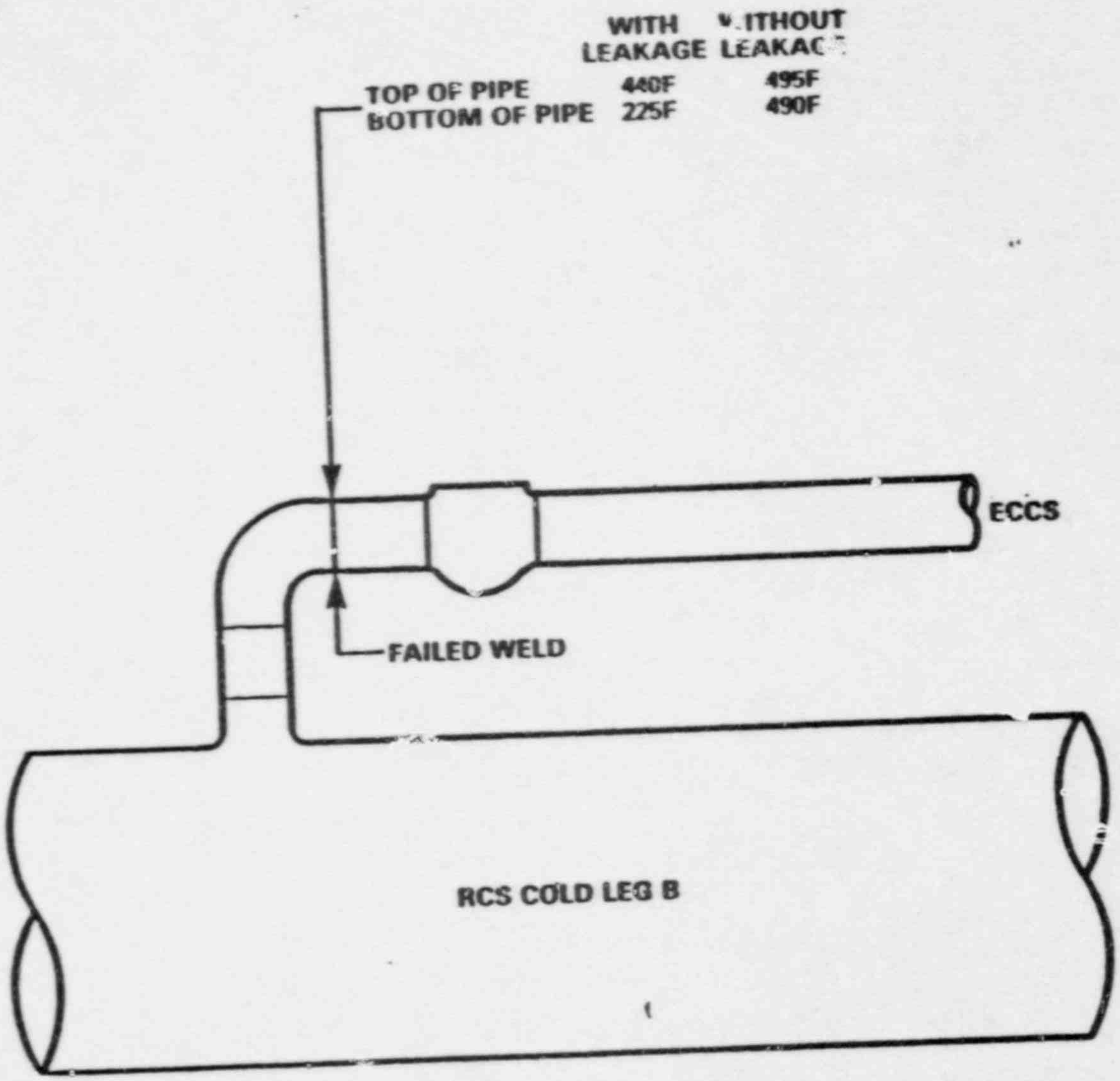
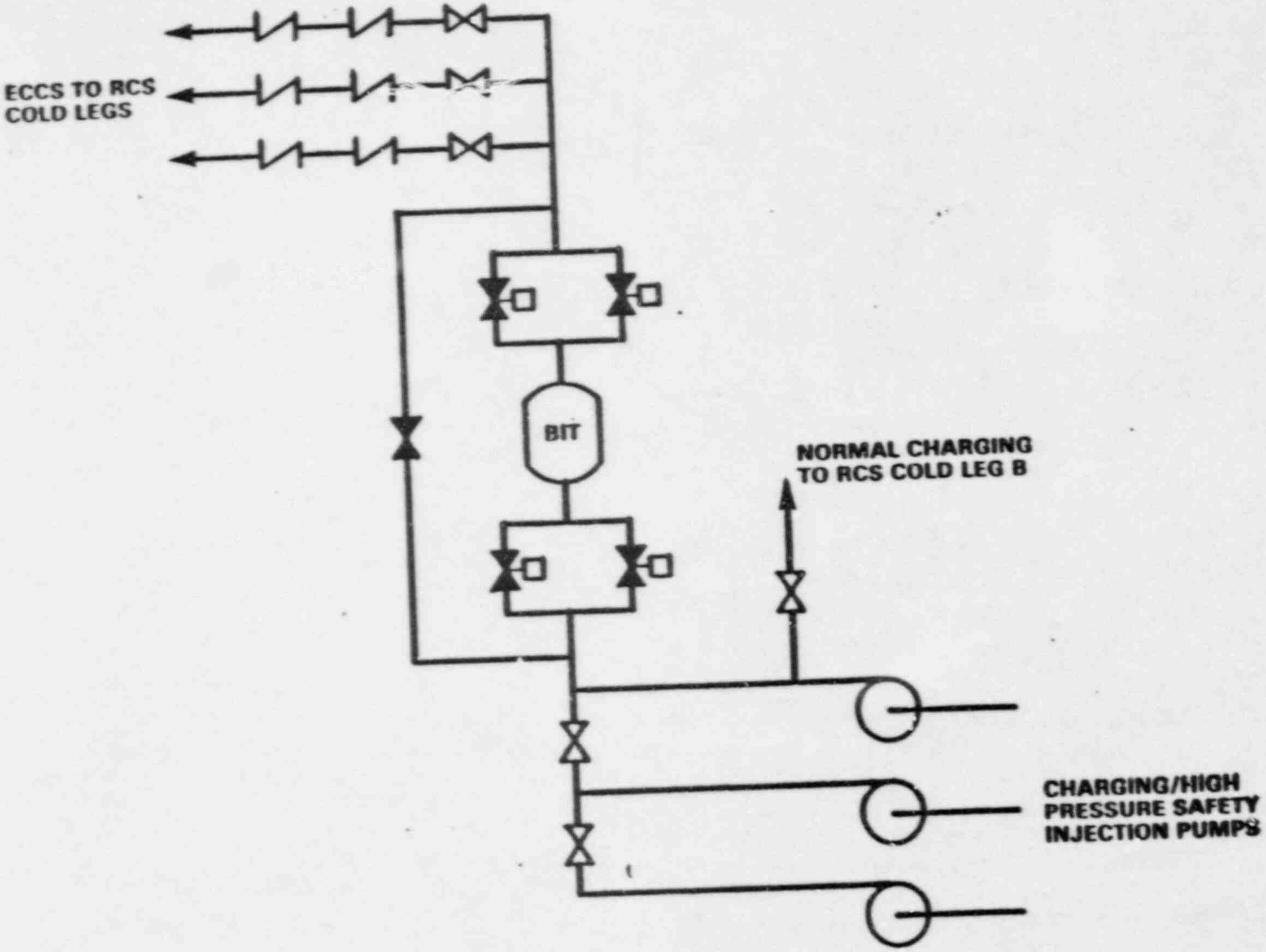
Attachments:
1. Figure 1 - Farley 2 Temperature Data
2. Figure 2 - Farley 2 ECCS
3. List of Recently Issued NRC Bulletins

FIGURE 1



FARLEY 2 TEMPERATURE DATA



FARLEY 2 ECCS

FIGURE 2

Enclosure 2

CRGR Item IV.B. Contents of Packages Submitted to CRGR
(Rev. 4, Stello to List 042387, dcs 41860 342 ff)

The following requirements apply for proposals to reduce existing requirements or (regulatory) positions as well as proposals to increase requirements or (regulatory) positions. Each package submitted to the CRGR for review shall include fifteen (15) copies of the following information:

SUBJECT: BULLETIN REGARDING THERMAL STRESSES IN PIPING CONNECTED TO REACTOR COOLANT SYSTEMS

Question (i):

The proposed generic requirement or staff position as it is proposed to be sent out to licensees.

Response:

The proposed requirements are set forth in the bulletin (Enclosure 1).

Question (ii):

Draft staff papers or other und[illegible]ng staff documents supporting the requirements or staff positions. (A cop[illegible] of all materials referenced in the document sha[illegible]l be made available upon [illegible]quest to the CRGR staff. Any committee member may [illegible]quest CRGR staff to obtain a copy of any referenced material for his or her [illegible]se.)

Response:

1. Reportable Event 10919 (50.72 Report), December 9, 1987,
2. Preliminary Notification PNO-II-87-80, December 9, 1987,
3. Inspection Reports 50-348/87-36 and 50-364/87-36 describing inspections conducted between December 12 and 16, 1987,
4. Preliminary Notification PNO-II-87-80A, December 14, 1987,
5. Memorandum from Reyes to Varga, "HPSI Pipe Crack - Farley Nuclear Plant," December 18, 1987,
6. Memorandum from Lainas to Richardson, "TIA - Review of Farley SI Line Pipe Crack," December 28, 1987,
7. Summary (dated February 8, 1988) of meeting held on January 15, 1988 between NRC and APCo representatives to discuss the generic implications of a cracked 6-inch safety injection pipe at Farley 2 (TAC 66773),
8. NRC Information Notice No. 88-01, "Safety Injection Pipe Failure," January 27, 1988,
9. Event Followup Report 88-018, "Safety Injection Pipe Crack," February 29, 1988.

Question (iii):

Each proposed requirement or staff position shall contain the sponsoring office's position as to whether the proposal would increase staff requirements or staff positions, would implement existing staff requirements or positions, or would relax or reduce existing requirements or staff positions.

Response:

Action items in the proposed bulletin will implement existing regulatory requirements as follows:

Action 1

10 CFR 50.34(a)(3)(i) requires that principal design criteria meet or exceed requirements established in Appendix A to 10 CFR 50 and that these criteria be identified in the preliminary safety analysis report (PSAR). Appendix A, General Design Criterion (GDC) 14, requires that the reactor coolant pressure boundary be designed so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture. 10 CFR 50.34(a)(4) requires that the PSAR include a preliminary analysis of the design of systems with the objective of assessing the risk to public health and safety. 10 CFR 50.34(b)(4) requires that the final safety analysis report (FSAR) include a final analysis of the design of systems with the same objective. Notwithstanding these existing regulatory requirements, the reactor coolant pressure boundary did leak abnormally because of a leaking valve in another system. The design of the failed unisolable piping at Farley 2 does not comply entirely with GDC 14. It is likely that other licensees have similar problems.

Action 2

10 CFR 55a(g)(6)(ii) allows the Commission to require licensees to follow an augmented inservice inspection program for systems and components for which the Commission deems that added assurance of structural reliability is necessary.

Action 3

This action item requires those licensees who are not complying with GDC 14 to comply.

Question (iv):

The proposed method of implementation with the concurrence (and any comments) of OGC on the method proposed.

Response:

The method of implementation will be the proposed bulletin (Enclosure 1 to the request for review). There are no issues with the bulletin that require OGC concurrence.

Question (v):

Regulatory analyses generally conforming to the directives and guidance of NUREG/BR-0058 and NUREG/CR-3568.

Response:

This is a compliance issue. No value/impact analysis was made.

Question (vi):

Identification of the category of reactor plants to which the generic requirements or staff position is to apply (that is, whether it is to apply to new plants only, new OLs [operating licenses] only, OLs after a certain date, all OLs, all plants under construction, all plants, all water reactors, all PWRs [pressurized water reactors] only, some vendor types, some vintage types such as BWR 6 and 4, jet pump and nonjet pump plants, etc).

Response:

The proposed bulletin would apply to all holders of operating licenses or construction permits for LWRs.

Question (vii):

For each such category of reactor plants, an evaluation which demonstrates how the action should be prioritized and scheduled in light of other ongoing regulatory activities. The evaluation shall document for consideration information available concerning any of the following factors as may be appropriate and any other information relevant and material to the proposed action:

(a) Statement of the specific objectives that the proposed action is designed to achieve...

Response:

The event at Farley 2 demonstrates that operating conditions can exist at LWRs that result in noncompliance with GDC 14. The objective of the proposed action is to ensure that licensees comply and remain in compliance.

Continuation of Question (vii):

(b) General description of the activity that would be required by the licensee or applicant in order to complete the action...

Response:

To complete the action, licensees with piping that does not meet GDC 14 would be required to provide assurance that GDC 14 is met by (1) redesigning and modifying unisolable sections of piping connected to the RCS so that these sections of piping will withstand combined stresses caused by various loads including temporal and spatial distributions of temperature resulting from leakage across valve seats, (2) instrumenting this piping to detect adverse temperature distributions and establishing appropriate limiting conditions for operation on temperature distributions, or (3) providing means to ensure that upstream pressure is monitored and does not exceed RCS pressure.

Continuation of Question (vii):

(c) Potential change in the risk to the public from the accidental offsite release of radioactive material...

Response:

At present, the risk to the public, from the accidental offsite release of radioactive material due to a LOCA, exceeds that which is implicit in GDC 14. Compliance with the regulations, as required by the proposed bulletin, would reduce the risk to that intended by promulgation of GDC 14.

Continuation of Question (vii):

(d) Potential impact on radiological exposure of facility employees and other onsite workers...

Response:

The potential radiological exposure for each action item is:

Action 1, Review of Systems

No radiological exposure will result from this action.

Action 2, Nondestructive Examination of Welds

At Farley 2, a three-loop unit, the licensee estimated that the accumulated dose for examination of emergency core cooling system piping connected to the three RCS cold legs was 3 to 4 person-rem. Farley 2 also has ECCS piping connected to the three RCS hot legs, two charging pipes connected to the RCS cold legs, and one spray pipe connected to the pressurizer. Unisolable sections of piping in each of these pipe runs could be subjected to thermal fatigue caused by leaking valves. For four-loop PWRs, there would be two additional ECCS pipes making a total of 11 sections of connected piping that might require examination. For a PWR that may have had all of these sections of piping subjected to excessive thermal stresses, the expected accumulated exposure in doing the nondestructive examination would be approximately 11 to 15 person-rem. For BWRs, a problem similar to the Farley 2 problem has not been identified and radiological dose has not been estimated.

Action 3, Elimination of the Potential for Excessive Thermal Stresses

At Farley 2, the licensee instrumented two ECCS pipes connected to the RCS cold leg and estimated that the accumulated dose was 2 to 3 person-rem. If 11 sections of piping connected to the RCS piping and pressurizer at a PWR were instrumented, then the expected accumulated exposure would be 11 to 17 person-rem.

Continuation of Question (vii):

(e) Installation and continuing costs associated with the action, including the cost of facility downtime or the cost of construction delay...

Response:

Actions 2 and 3 are to be completed within 3 months to 17 months of receipt of the proposed bulletin for plants with operating licenses. Assuming that a licensee has a four-loop PWR, does the nondestructive examination, installs thermocouples with power supplies that are not environmentally qualified, and plans efficiently, facility downtime would be minimal. Assuming that the plant is a four-loop PWR, 11 lines have 4 suspect welds per line, and 2 persons spend 8 hours to prepare for and examine each weld on the average, then the time required for nondestructive examination would be 704 person-hours. Assuming that 5 thermocouples are installed on each line and 2 persons spend 2 hours to prepare for and install each thermocouple on the average, then 220 person-hours are required for a total of approximately 1000 direct person-hours. Assuming that planning, purchasing, and other indirect costs are 150% of direct costs, then total time charges would be 2500 person-hours. At $20 per hour, cost for manpower would be $50,000. Assuming material and equipment costs are equal to manpower costs, the total cost for a four-loop PWR with 11 suspect lines with 4 welds each would be $100,000.

Continuation of Question (vii):

(f) The potential safety impact of changes in plant or operational complexity, including the relationship to proposed and existing regulatory requirements and staff positions...

Response:

Assuming that a licensee elects to install temperature sensors, a modest increase in operational complexity will result from the need to monitor the additional sensors and take corrective action when limits are exceeded. However, this will again establish the margin of safety intended in Appendix A, GDC 14.

Continuation of Question (vii):

(g) The estimated resource burden on the NRC associated with the proposed action and the availability of such resources...

Response:

Licensees would be required to submit letters confirming that the required actions have been completed and describing the actions taken. NRR would identify a lead project manager to coordinate the review of the licensees' reports by their project managers. The estimated time required for review by the staff is 240 person-hours. No requirement for regional review will be necessary.

Continuation of Question (vii):

(h) The potential impact of differences in facility type, design, or age on the relevancy and practicality of the proposed action...

Response:

The problem may be relevant to all LWRs. Type, design, and age are not expected to be significant factors with regard to the practicality of the proposed action.

Continuation of Question (vii):

(i) Whether the proposed action is interim or final, and if interim, the justification for imposing the proposed action on an interim basis.

Response:

The proposed action is final.

Question (viii):

For each evaluation conducted pursuant to 10 CFR 50.109, the proposing Office Director's determination together with the rationale for the determination based on the considerations of paragraph (i) through (vii) above that:

(a) there is a substantial increase in the overall protection of public health and safety or the common defense and security to be derived from the proposal; and

(b) the direct and indirect costs of implementation, for the facilities affected, are justified in view of this increased protection.

Response:

Because valves often leak, it is likely as a result of fatigue that cracking of piping connected to the reactor coolant systems in a few plants in addition to Farley will occur before end of reactor life if preventive action is not taken. Based on leak-before-break, it is likely that such cracks will be found and repaired before the piping fails completely. However, in the unlikely event that repair is not timely, a severe small-break LOCA could occur. We believe that expenditure by the industry of $10,000,000 is reasonable for the increased protection that would result from the proposed bulletin.

Question (ix):

For each evaluation conducted for proposed relaxations or decreases in current requirements or staff positions, the proposing Office Director's determination, together with the rationale for the determination based on the considerations of paragraphs (i) through (vii) above, that:

(a) the public health and safety and the common defense and security would be adequately protected if the proposed reduction in requirements or positions were implemented, and

(b) the cost savings attributed to the action would be substantial enough to justify taking the action.

Response:

Relaxations or decreases in current requirements or staff positions are not proposed.