September 1983

IMPLEMENTATION OF NUREG-0619

FEEDWATER NOZZLE CRACKING

PEACH BOTTOM ATOMIC POWER STATION, UNITS 2 & 3

Docket Nos. 50-277
50-278
Philadelphia Electric Company

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I. Background

Feedwater nozzle cracking at boiling water reactors has been detected during plant inspections. NUREG-0619 (reference 1) describes the nozzle cracking problem and recommends system design modifications and operating procedure changes to minimize the probability for crack initiation and limit crack growth rates to acceptable levels. Subsequent to NUREG-0619, Generic Letter 81-11 (reference 2) was issued which indicated that strict compliance with the specific requirements of NUREG-0619 and recommendations of NEDE-21821-A (reference 3) was not necessary provided that a plant specific analysis is performed to demonstrate that crack initiation and growth rates are acceptable.

This report provides Philadelphia Electric Company's assessment of the NUREG-0619 requirements regarding the feedwater nozzles and provides the justification to demonstrate that system design modifications as implemented at Peach Bottom Units 2 & 3 comply with the intent of NUREG-0619 and Generic Letter 81-11.

II. Summary of NUREG-0619 Implementation for Feedwater Nozzles

The following is a description of the implementation program at Peach Bottom for feedwater nozzles and is an update of the reference 5 letter:

A. Nozzle Modification - Clad removal and installation of "triple sleeve" spargers was completed on Unit 2 in July 1980 an on Unit 3 in July 1981.

B. System Modifications

1. Feedwater system low flow control - A low flow control valve has been installed on the discharge line from the "C" reactor feed pump on each reactor unit. Each reactor has three steam turbine driven reactor feed pumps. Installation on Unit 2 was completed in June 1982 and on Unit 3 in June 1983. The low flow controller does not meet all six criteria specified in references 1 and 6. However, a plant specific fracture mechanics analysis for the feedwater nozzles has been performed by General Electric Company which indicates that the Peach Bottom design meets the crack growth criteria of NUREG-0619. This item is discussed in more detail in Section III of this report.

2. Reroute of the Reactor Water Cleanup System (RWCU) Return Line - The RWCU return line has not been modified to reroute flow to both feedwater lines. A plant specific feedwater nozzle fatigue analysis has been completed by General Electric Company, concluding that the benefit from a reroute is insignificant. This item is discussed in more detail in Section IV of this report.

C. Operating Procedures

1. The Peach Bottom heat cycle consists of three trains of five feedwater heaters, each having drains which cascade to the next lower pressure heater and an alternate drain to the main condenser. Sufficient extraction steam pressure must be available to establish proper drain flows

during unit startup. Normally, sufficient pressure does not exist until the turbine has been loaded to 15%. Therefore it is our intent to place the feedwater heaters in service as soon as practical with the fifth heaters valved into service at about 15% turbine load, the fourth heater at about 20%, and the third heater at approximately 25% turbine load.

2. A low flow feedwater control system has been installed on one of the three reactor feed pumps for each unit. This system is designed to facilitate control of reactor water level during unit startups and minimize feedwater temperature fluctuations.

3. It is the intent of Philadelphia Electric Company to operate the Peach Bottom units to minimize the amount of time during which highly subcooled feedwater is supplied to the reactor vessel as described in section III of this report.

D. Inspection - We will initiate an inspection program as described in Table 2 of the NUREG for "triple-sleeve spargers with two piston-ring seals, clad removed". This inspection program will ensure the continued integrity of the feedwater nozzles. Therefore installation of a leak detection system is not necessary (NUREG-0619 para. 4.3.2.4).

III. Low Flow Controller

A. Operation Prior to Controller Installation

Installation of the low flow controller was completed on Unit 2 in June 1982 and on Unit 3 in June 1983. Prior to the installation of the controller on each unit, feedwater flow to the reactor was controlled by throttling flow through the reactor feed pump discharge gate valves. This method of operation was included in the plant operating procedures and implemented to control level as well as minimize thermal cycling in the feedwater nozzles. On/off reactor feed pump operation for batch feeding feedwater was not permitted.

Using this method of operations a typical startup would be conducted as follows:

1. Up to a reactor pressure of 600 psig, condensate pump(s) supply feedwater to the reactor through the reactor feed pump (RFP) bypass control valve shown in Figure 1. The RFP's cannot be used during the early stages of startup because they are steam turbine driven and sufficient steam pressure and flow to drive the turbines are not available. The condensate pumps develop sufficient head to pump to the reactor up to a reactor pressure of about 600 psig. The RFP bypass control valve is automatically modulated to maintain a pre-established reactor water level. Several systems using reactor steam are operated in a manner which creates a stable demand for steam to minimize reactor level and feedwater flow fluctuations. This minimizes temperature cycling on the feedwater nozzles. The controls for the RFP bypass control valve are shown in Figure 2.

2. At a reactor pressure of 600 psig, a previously warmed RFP is started to pump to the reactor through it's throttled discharge gate valve. The discharge valve is opened sufficiently to maintain RFP speed at about 3000 rpm, and maintain proper water level in the reactor.

3. The RFP discharge gate valve is opened far enough to supply the entire feedwater demand, causing the RFP bypass control valve to automatically close. The RFP bypass control valve is then transferred to manual control and secured, and the RFP is transferred from manual to single element automatic level control. Systems using reactor steam are operated to maintain a stable feedwater demand.

4. In response to increasing feedwater demand, the RFP discharge valve is manually repositioned further open to maintain RFP speed near 3000 rpm.

5. As the feedwater demand increases the second and third RFP's are placed in service pumping to the reactor through their full open discharge gate valves.

The above method of operation proved to be satisfactory for minimizing thermal cycling in the feedwater system.

B. Low Flow Controller Description

A low flow controller has been installed on the "C" RFP for each unit. The system consists of a control valve installed in parallel with the pump discharge gate valve and a control system to automatically position the control valve to maintain reactor water level. Simplified piping and controls for the low flow controller are shown in Figures 1 and 2.

The control valve is an air operated 8 inch "drag" valve manufactured by Control Components Inc., and is capable of maintaining a constant minimum flow of about 0.5% to a maximum of about 10% of rated feedwater flow. The valve can be operated in either the manual or automatic modes.

The valve is controlled by a level setpoint controller which receives its input from one of the reactor water level transmitters. Valve position indication is provided in the control room.

C. Operation of the Low Flow Controller

The low flow control system is designed to operate during startup, standby, and shutdown periods when feedwater demand is less than 10%. A typical startup using the low flow controller is conducted as follows, with the low flow control valve in automatic control and the "C RFP in single element automatic level control:

1. Up to a reactor pressure of 600 psig, condensate pump(s) provide feedwater to the reactor through the RFP bypass control valve, which automatically maintains reactor water level. Several systems using reactor steam are operated to create a stable demand for steam to minimize reactor level and feedwater flow fluctuations.

2. At a reactor pressure of 600 psig, the low flow control valve is partially opened and the "C" RFP started. Speed of the "C" RFP is increased manually to the point where it begins to pump to the reactor, causing the RFP bypass control valve to close.

3. The controls for the low flow control valve are placed in the automatic mode and the "C" RFP is placed in

single element automatic level control. Systems using reactor steam are operated to maintain a stable feedwater demand.

4. As the startup progresses and feedwater demand approaches the capacity of the low flow control valve, a second RFP is started. Transfer from the low flow control valve to the normal feedwater flow path is accomplished by increasing the speed of the second RFP to the point where it begins pumping to the reactor through its discharge gate valve. Speed of the second RFP is then slowly increased causing the low flow control valve to slowly close. The second RFP is then placed in single element automatic level control. The "C" RFP and low flow control valve are maintained on standby, with the "C" RFP recirculating flow to the condenser.

5. As feedwater demand increases the second and third RFP's are placed in service pumping to the reactor through their respective discharge gate valves.

The above procedure is typical, however, it should be recognized that other options are available. Both the low flow control valve and RFP can operate in either the automatic or manual modes resulting in three optional procedures: control valve in auto/RFP in manual; control valve in manual/RFP in auto; and control valve in manual/RFP in manual. Each of these options provides acceptable system response to maintain reactor water level and minimize system thermal cycles.

In the event the "C" RFP or low flow control valve is not available when required during operations at low feedwater flows, the procedure described in paragraph III.A using a RFP discharge gate valve to throttle flow would be utilized.

D. Justification for Low Flow Controller Design

A feedwater nozzle fracture mechanics analysis for Peach Bottom Unit 2 was performed by General Electric Company. The results of this analysis are provided in NEDE-30224, "Peach Bottom Atomic Power Station, Unit 2, Feedwater Nozzle Fracture Mechanics Analysis to Show Compliance with NUREG-0619", (Proprietary) copy attached. The analysis shows that stress

cycling from conservative temperature and flow profiles, when added to those resulting from other crack growth phenomena, such as startup and shutdown cycles, do not result in the growth of an assumed initial 0.25 inch crack to greater than a one inch crack size during the remaining life of the plant. Using the design data in NEDE-30224 the predicted crack size at the end of 40 years is only 0.29 inch. Using more conservative methodology of ASME Section XI, the predicted crack size is 0.37 inch.

The fracture mechanics analysis was performed for Unit 2 only. However, the Unit 3 low flow controller design is identical to the Unit 2 controller and is tuned and operated in the same manner. Therefore the fracture mechanics analysis is also considered to apply to Unit 3.

Based on the above, the low flow controllers at Peach Bottom Units 2 and 3 are in compliance with NUREG-0619 and Generic Letter 81-11 by meeting the requirement of an end-of-life crack size of less than one inch in the feedwater nozzles.

IV. Reactor Water Cleanup System Reroute

A. General

The RWCU system at Peach Bottom Units 2 & 3 is designed to return flow to the reactor through the "B" feedwater loop on each unit immediately outside the feedwater containment penetration, as shown on Figure 1. NUREG-0619 recommends that RWCU return flow to the reactor be routed so that flow is delivered to all feedwter nozzles. The theoretical benefit from this recommended modification is a reduction in usage factor, with respect to crack initiation, of about 34%. A reduction of this magnitude would only be achieved by directing RWCU flow to all nozzles at maximum flow rates and exit temperatures during all low feedwater flow conditions prior to turbine roll.

A review of RWCU operations at Peach Bottom indicates that it is not always possible or desirable to return full RWCU flow to the reactor vessel. Particularly during startup, control of reactor water level and water quality require discharging some of the RWCU return flow to the condenser. Therefore, to determine the benefit to be realized by discharging RWCU flow to both the A and B feedwater loops, a fatigue analysis was performed.

B. Fatigue Analysis

The fatigue analysis, references 4 & 5, was performed by General Electric Company using the FWNOZ computer program. The basis for the analysis and FWNOZ program is described in detail in reference 6. The results of this analysis show that rerouting produces relatively small changes in the nozzle fatigue usage factor.

The fatigue analysis considers two sources of feedwater nozzle thermal cycling - system cycling and rapid cycling. System cycles result from changes in pressure, flow and temperature of the feedwater and reactor water as a result of operational transients such as startups, scrams. The system cycle transients cause the maximum thermal stresses. Rapid cycling results from turbulent mixing of hot and cold water around the feedwater nozzles at steady state operating conditions. The stresses and fatigue damage due to system cycling and rapid cycling are calculated independently and fatigue usage factors added.

Most of the fatigue usage is accumulated at high feedwater flow rates. Since the RWCU flow is a small portion of the total feedwater flow at high feedwater flow conditions, the feedwater temperature is only slightly affected (2°F) by RWCU reroute. At low feedwater flow conditions, little fatigue usage is accumulated. Although at low feedwater flow conditions there is a substantial increase in feedwater temperature due to RWCU reroute, there is no significant potential for fatigue usage improvement at these conditions.

Assuming the highest RWCU flowrate and temperature available for return to all nozzles, the usage factor is reduced from 0.84 to 0.78 with the reroute. This factor is the highest calculated and occurs at the nozzle blend radius. When actual operation of the RWCU system is considered for reactor level maintenance and water quality, the net reduction will be less than 0.06 as calculated above. Since at high feedwater conditions the feedwater temperature is unaffected and at low feedwater flow conditions the fatigue usage is small, RWCU reroute cannot significantly reduce the usage factor. Therefore, rerouting the RWCU return lines is not justified.

V. Summary

Philadelphia Electric Company has implemented operating procedures and system design modifications at Peach Bottom 2 & 3 necessary to comply with the intent of NUREG-0619 and Generic Letter 81-11. Peach Bottom specific fatigue and fracture mechanics analyses for the feedwater nozzles have been completed to demonstrate that RWCU reroute is not necessary and the design for the low flow controller is satisfactory. No further system modifications or procedure changes are required to comply with the crack initiation and growth rate criteria provided in NUREG-0619.

This report completes the reporting requirement of NUREG-0619, paragraph 4.4.3.1(1).

VI. References

1. NUREG-0619 "BWR Feedwater Nozzle and Control Rod Drive Line Nozzle Cracking" Issued November 13, 1980

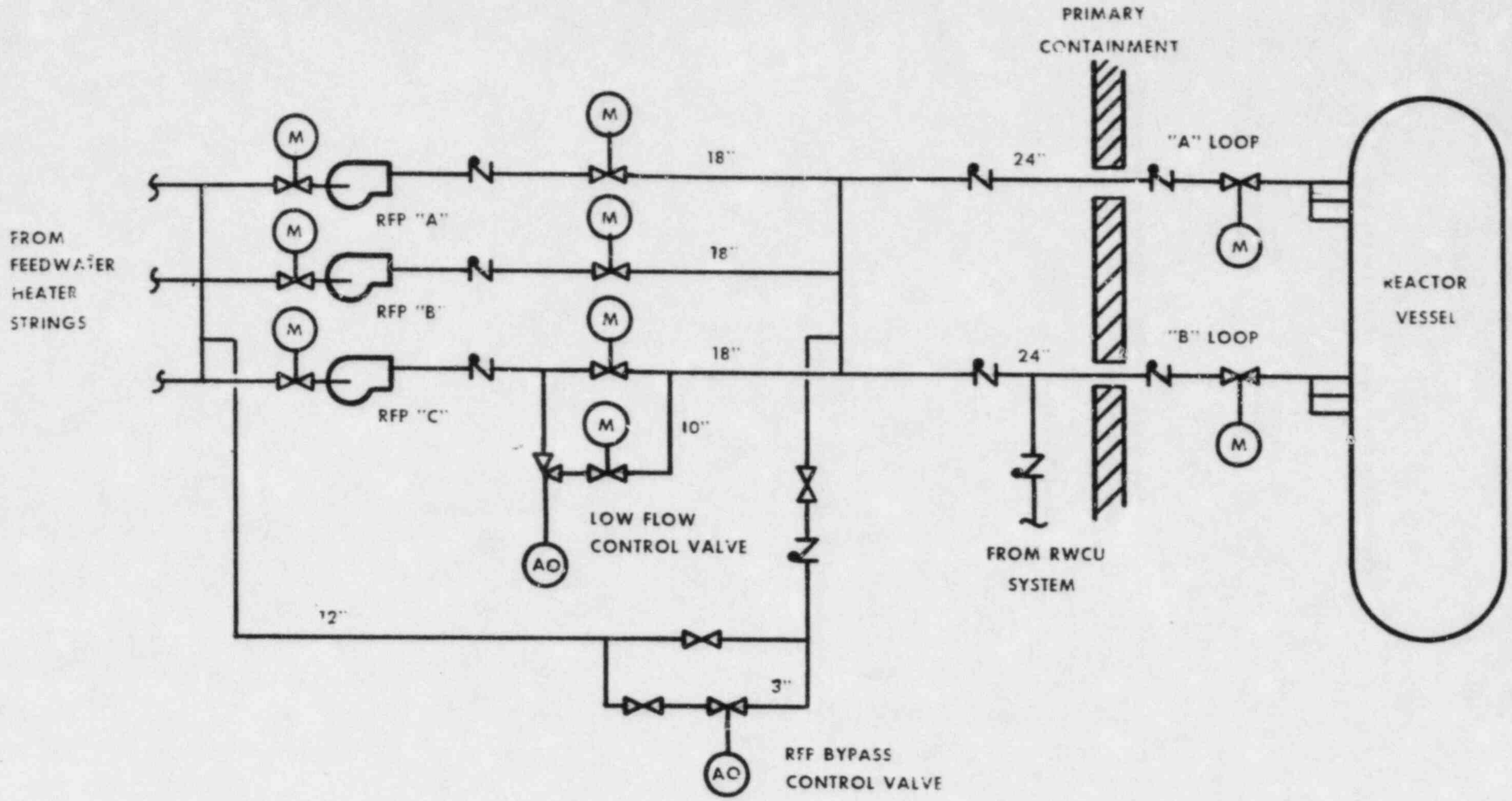
2. NRC Generic Letter 81-11 dated February 20, 1981

3. Philadelphia Electric Company Letter, J. W. Gallagher to D. G. Eisenhut, NRC dated January 21, 1981

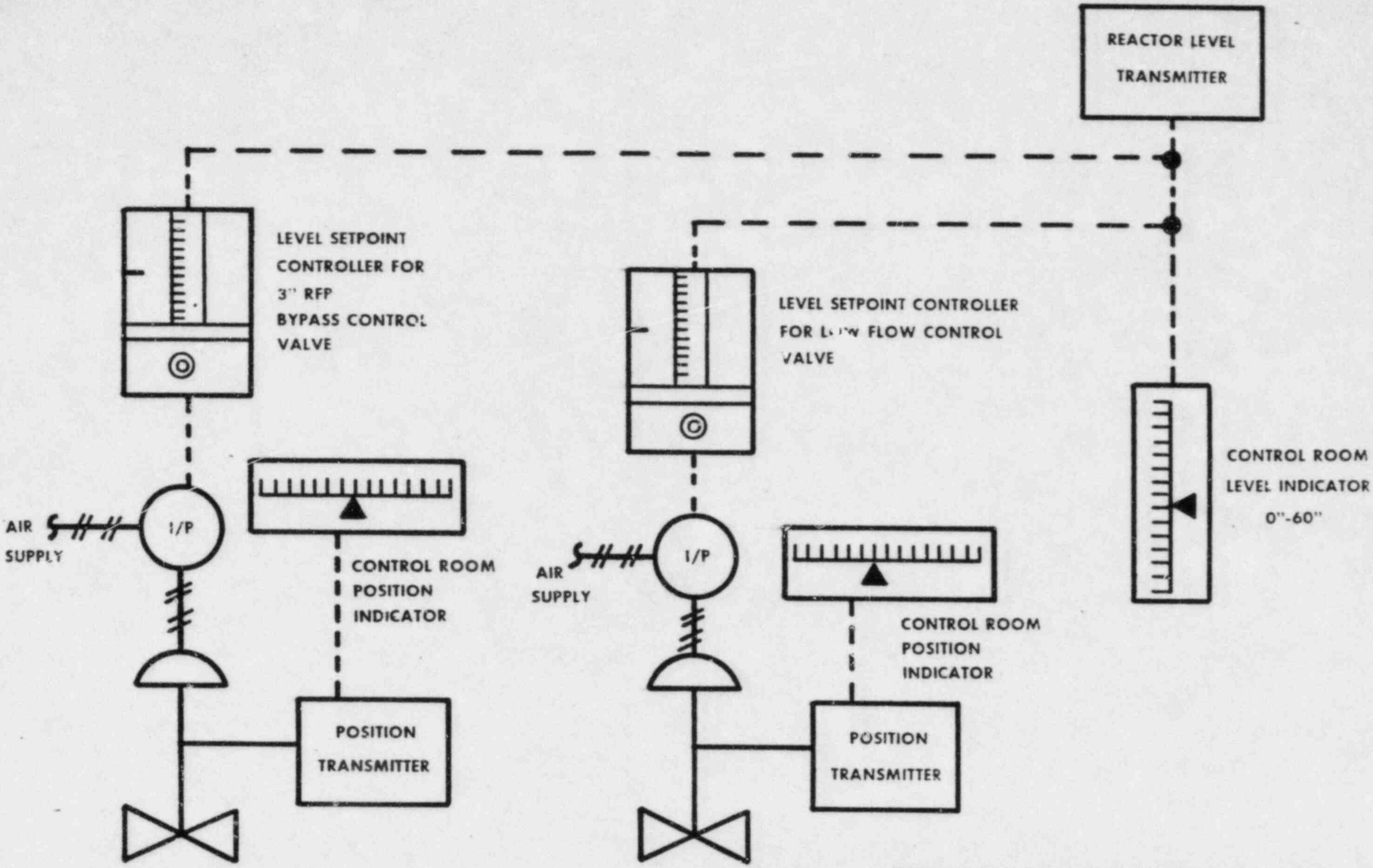
4. NSEO-39-0483, "Effects of Reactor Water Cleanup Reroute on Feedwater Nozzle Fatigue Usage, Peach Bottom Atomic Power Station Unit 2", June 1983

5. NSEO-38-0483, "Feedwater Nozzle Rapid Cycling Fatigue Analysis, Peach Bottom Power Station Units 2 and 3", June 1983

6. NEDE-21821-A "BWR Feedwater Nozzle/Sparger Final Report", February 1980



FEEDWATER LOW FLOW CONTROLLER
SIMPLIFIED PIPING DIAGRAM
PEACH BOTTOM ATOMIC
POWER STATION
FIGURE 1



FEEDWATER LOW FLOW CONTROLLER
SIMPLIFIED CONTROLS DIAGRAM
PEACH BOTTOM ATOMIC
POWER STATION

FIGURE 2

GENERAL ELECTRIC COMPANY

AFFIDAVIT

I, Ricardo Artigas, being duly sworn, depose and state as follows:

1. I am Manager of BWR Projects Licensing, General Electric Company, and have been delegated the function of reviewing the information described in paragraph 2 which is sought to be withheld and have been authorized to apply for its withholding.

2. The information sought to be withheld is contained in the report entitled, "Peach Bottom Atomic Power Station, Unit 2, Feedwater Nozzle Fracture Mechanics Analysis to Show Compliance with NUREG-0619," NEDE-30224.

3. In designating material as proprietary, General Electric utilizes the definition of proprietary information and trade secrets set forth in the American Law Institute's Restatement Of Torts, Section 757. This definition provides:

    "A trade secret may consist of any formula, pattern, device or compilation of information which is used in one's business and which gives him an opportunity to obtain an advantage over competitors who do not know or use it.... A substantial element of secrecy must exist, so that, except by the use of improper means, there would be difficulty in acquiring information.... Some factors to be considered in determining whether given information is one's trade secret are: (1) the extent to which the information is known outside of his business; (2) the extent to which it is known by employees and others involved in his business; (3) the extent of measures taken by him to guard the secrecy of the information; (4) the value of the information to him and to his competitors; (5) the amount of effort or money expended by him in developing the information; (6) the ease or difficulty with which the information could be properly acquired or duplicated by others."

4. Some examples of categories of information which fit into the definition of proprietary information are:

    a. Information that discloses a process, method or apparatus where prevention of its use by General Electric's competitors without license from General Electric constitutes a competitive economic advantage over other companies;

    b. Information consisting of supporting data and analyses, including test data, relative to a process, method or apparatus, the application of which provide a competitive economic advantage, e.g., by optimization or improved marketability;

c. Information which if used by a competitor, would reduce his expenditure of resources or improve his competitive position in the design, manufacture, shipment, installation, assurance of quality or licensing of a similar product;

d. Information which reveals cost or price information, production capacities, budget levels or commercial strategies of General Electric, its customers or suppliers;

e. Information which reveals aspects of past, present or future General Electric customer-funded development plans and programs of potential commercial value to General Electric;

f. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection;

g. Information which General Electric must treat as proprietary according to agreements with other parties.

5. In addition to proprietary treatment given to material meeting the standards enumerated above, General Electric customarily maintains in confidence preliminary and draft material which has not been subject to complete proprietary, technical and editorial review. This practice is based on the fact that draft documents often do not appropriately reflect all aspects of a problem, may contain tentative conclusions and may contain errors that can be corrected during normal review and approval procedures. Also, until the final document is completed it may not be possible to make any definitive determination as to its proprietary nature. General Electric is not generally willing to release such a document to the general public in such a preliminary form. Such documents are, however, on occasion furnished to the NRC staff on a confidential basis because it is General Electric's belief that it is in the public interest for the staff to be promptly furnished with significant or potentially significant information. Furnishing the document on a confidential basis pending completion of General Electric's internal review permits early acquaintance of the staff with the information while protecting General Electric's potential proprietary position and permitting General Electric to insure the public documents are technically accurate and correct.

6. Initial approval of proprietary treatment of a document is made by the Subsection Manager of the originating component, the man most likely to be acquainted with the value and sensitivity of the information in relation to industry knowledge. Access to such documents within the Company is limited on a "need to know" basis and such documents at all times are clearly identified as proprietary.

7. The procedure for approval of external release of such a document is reviewed by the Section Manager, Project Manager, Principal Scientist or other equivalent authority, by the Section Manager of the cognizant Marketing function (or his delegate) and by the Legal Operation for technical content, competitive effect and determination of the accuracy of the proprietary designation in accordance with the

standards enumerated above. Disclosures outside General Electric are generally limited to regulatory bodies, customers and potential customers and their agents, suppliers and licensees only in accordance with appropriate regulatory provisions or proprietary agreements.

8. The document mentioned in paragraph 2 above has been evaluated in accordance with the above criteria and procedures and has been found to contain information which is proprietary and which is customarily held in confidence by General Electric.

9. The detailed design data, test data, test instrumentation drawings, and test process data are considered proprietary.

10. The information, to the best of my knowledge and belief, has consistently been held in confidence by the General Electric Company, no public disclosure has been made, and it is not available in public sources. Also, disclosures to third parties have been made pursuant to Regulatory provisions for proprietary agreements which provide for maintenance of the information in confidence.

11. Public disclosure of the information sought to be withheld is likely to cause substantial harm to the competitive position of the General Electric Company and deprive or reduce the availability of profit making opportunities because approximately 6 manmonths and $100,000 in test facilities were required to obtain the information.

STATE OF CALIFORNIA)
COUNTY OF SANTA CLARA) ss:

Ricardo Artigas, being duly sworn, deposes and says:

That he has read the foregoing affidavit and the matters stated therein are true and correct to the best of his knowledge, information, and belief.

Executed at San Jose, California, this 30th day of August, 1983.

R Artigas

Ricardo Artigas
General Electric Company

Subscribed and sworn before me this 30th day of August 1983.

Ruthe M. Kinnamon
NOTARY PUBLIC, STATE OF CALIFORNIA

OFFICIAL SEAL
RUTHE M KINNAMON
NOTARY PUBLIC - CALIFORNIA
SANTA CLARA COUNTY
My comm. expires APR 26, 1985
175 Curtner Avenue, San Jose, CA 95125

HTW:rm/A08257
8/25/83