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RECIP.NAME RECIPIENT AFFILIATION
SCHWENCER,A. Licensing Branch 2

SUBJECT: Forwards response to NUREG-0619 re feedwater nozzle & control rod drive return line nozzle cracking,completing action on SER Outstanding Issue 20.

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June 11, 1981

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U.S. NUCLEAR REGULATORY COMMISSION

Mr. A. Schwencer, Chief
Licensing Branch No. 2
Division of Licensing
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

SUSQUEHANNA STEAM ELECTRIC STATION
SER OUTSTANDING ISSUE NO. 20
ER 100450 FILE 841-2
PLA-807

Dear Mr. Schwencer:

Attached is Pennsylvania Power and Light Company's response to NUREG-0619.

This completes our action on SER Outstanding Issue #20.

Very truly yours,

N. W. Curtis
Vice President-Engineering and Construction-Nuclear

cc: R. M. Stark - NRC.

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E

PP&L RESPONSE TO NUREG-0619

BWR FEEDWATER NOZZLE AND CRDRL NOZZLE CRACKING

SUSQUEHANNA STEAM ELECTRIC STATION

Following are PP&L's response to NRC recommendations outlined in NUREG-0619.

I. Part I Feedwater Nozzle (Section 4.4, NUREG-0619)

A. Design

1. The feedwater nozzles on Susquehanna Reactor Pressure Vessels supplied by GE were not cladded. Therefore, they are not prone to cracking as evaluated by NRC and the design is acceptable to the NRC.

2. The original thermal sleeve and the sparger have been replaced with a new GE Triple-Sleeve-Sparger design. The NRC has evaluated GE triple-sleeve design and has concluded that it may be used without further justification beyond that given by GE in NEDE-21821-A as amended by Appendix C. Also, NRC has concurred with GE assessment of the need for system modifications and plant operating procedural changes. These changes are beneficial in decreasing the magnitude and frequency of temperature fluctuations and thus preventing crack initiation and also limiting crack growth. In order to meet the intent of the NUREG-0619 requirements, PP&L has considered the changes/alternatives on the system modifications and the procedural changes as outlined in Item B below.

B. System Modifications and Operating Procedural Changes

1. In Reference 2, NRC has stated that the following modifications would be beneficial to limit the crack growth.

   a. Installation of a new low-flow controller having the six characteristics as stated in Section 3.4.4.3 of GE Report NEDE-21821-A.

   b. Use of the existing flow controller (or a controller modified to meet the basis stated above but not possessing all six characteristics of NEDE-21821-A) will be acceptable to NRC based upon plant specific fracture mechanics analysis or application of the analysis as already existing in NEDE-21821-A, Section 4. In order to be considered acceptable to NRC, this analysis must show that stresses from conservative controller temperature and flow profiles, when added to those resulting from other crack growth phenomena, such as start-up and shutdown cycles, do not result in the growth of a crack to greater than one inch during the forty year life of the plant.

2. A plant specific fracture mechanics analysis as described in Item B.1.b above is being considered. PP&L will confirm that the present Susquehanna RWCU system configuration is in accordance with GE/NRC recommendations. In our opinion, Susquehanna RWCU system design, as shown in FSAR Figure 5.1-3a, satisfies GE recommendations.

   We believe, the existing flow controller will satisfy most of the six characteristics of low flow controller, as defined in Section 3.4.4.3 of GE Report NEDE-21821-A. We present below each of these six characteristics from the GE Document (NEDE-21821-A) along with our comments/justification with regard to use of the existing controller.

   a. Confirm modify or suitably install a low feedwater control system. It should be controllable from 10% to 0.5% of rated feedwater flow under either automatic or manual modes. It is to be operated during all startup, standby and shutdown periods when feedwater demand is 10%.

      The present Susquehanna Feedwater System design incorporates a low flow (below 20% of rated feedwater flow) feedwater control system consisting of a start-up control valve and a start-up control valve bypass valve. The startup control valve (LV-10641) is capable of controlling flow from 0 to 10,000 gpm which is equivalent to 0 to 37% of rated feedwater flow. The startup control valve bypass valve (HV-10640) is capable of controlling flow from 0 to 700 gpm which is equivalent to 0 to 2.6% of rated feedwater flow. These valves could be controlled either in automatic or manual modes and operated during all startup, standby, and shutdown periods. Therefore, PP&L is of the opinion that these control valves satisfy the above GE recommendations.

   b. For effective control, the system must operate around a main feedwater line valve which has a positive shutoff capability. This control capability must be achieveable with any feedpump operable in this range.

      The valves HV-10603 A, B, and C and HV-10650 will provide the necessary positive shutoff capability during low flow operating range. Thus, the present system meets the above GE requirements.

   c. The flow controller shall be operable with the top feedwater heaters either in service or bypassed and shall provide capability for a constant minumum feedwater flow of 0.5% of rated. Vessel water level control at very low powers (1%) may require discharge from the vessel to the main condenser via the reactor water cleanup system.

Feedwater flow to the feedwater heaters cannot be bypassed. Feedwater heaters can only be isolated in strings which include all the five feedwater heaters per string. There are three strings of feedwater heaters upstream of the feedpump. Low flow controller capability is as described in Item (a) above. Present Susquehanna design has the capability of vessel water level control at very low powers (<1%) to discharge water from the vessel into the main condenser via the reactor water cleanup system. Again, Susquehanna design satisfies the above GE requirement.

d. Reliability shall be provided through necessary redundancy, testing and/or component reliability such that low flow control capability shall be available ~95% of the time when feedwater flow demand is less than 5% of rated.

Adequate reliability has been built into the existing low flow controller to assure that it will be available for flow control when feedwater flow demand is less than 5% of rated. Susquehanna plant procedures will provide for calibration of these low flow control system valves.

e. Transfer between the low flow control and the main feedwater control shall be bumpless. An interlock shall prevent main feedwater control valve regulation when the low flow control system is in use, where applicable.

Bumpless transfer between low feedwater flow control and main feedwater control is achieved administratively by zeroing the set point Manual/Automatic station 'Deviation' meter before transferring. The main feedwater control is accomplished via variable speed turbine driven reactor feed pumps. It is required that the low feedwater flow control system be in operation while the reactor feed pump turbines are brought into service. Therefore, it is not feasible to prevent main feedwater flow while the low feedwater flow control system is in operation.

The controller shall be capable of maintaining the feedwater flow rate within the allowable peak to peak variation tabulated below for stated conditions of steady low feedwater flow demand. Percentages are of rated feedwater flow.

RWCU FLOW (%)	STEADY FW FLOW DEMAND (%)	MAXIMUM PEAK TO PEAK FW FLOW VARIATION (%)
1	1%	0.20
	3%	0.70
	5%	1.00
2	1%	0.25
	3%	0.55
	5%	0.80
3	1%	0.30
	3%	0.45
	5%	0.70

PP&L has requested GE further clarification of the above and PP&L will perform system analysis of the existing GE furnished single mode low flow control system for accuracy and system stability characteristics compared with the allowable peak to peak variation in feedwater flow.

Figure 1 represents the GE proposed new low flow control design as applied to a feedwater delivery system configuration. Figure 2 represents the existing low flow control system (supplied by GE) as installed at Susquehanna plant.

PP&L, after evaluating the options, will implement either Item B.1.a or Item B.1.b above to meet the intent of NUREG-0619, since both are acceptable to NRC.

3. Proposed Alternate Operating Procedure, Section 3.3.3 of Appendix C, NUREG-0619.

PP&L has evaluated the proposed alternate operating procedures outlined in Section 3.3.3 of Appendix C, NUREG-0619. We present below each of the proposed operating procedures along with our comments/ justification:

a. RWCU flow would be directed to all feedwater nozzles at maximum flow rate and exit temperature during all low flow conditions prior to turbine loading. Some plant designs would require piping changes to achieve this.

   PP&L is of the opinion and will confirm that the present Susquehanna RWCU system design satisfies GE/NRC recommendations.

b. The turbine would be accelerated, synchronized and loaded at a reduced reactor pressure of 600 psig (instead of 1000 psig). Main steam bypass just prior to turbine acceleration would be the minimum compatible with that action (approximately 5%). Operating plant procedure changes would be required to achieve this. To our knowledge, early turbine roll has not been attempted yet at any operating facility.

   The above proposed procedure is no longer feasible as noted in Section 4.2 of NUREG-0619 (Page 16).

c. Turbine extraction heaters (at least the top heater) would be in service at the time of, or before, turbine loading to 5%. Most feedwater train designs, including heater drain characteristics, are compatible with this operation. Some heater equipment change might be required in a few cases to achieve this.

   Turbine extraction heaters are in service as soon as extraction steam is available from the respective turbine stages. Effective feedwater heating occurs only after reaching approximately 20% of turbine load. Plant startup and heat-up and plant operating procedures will be used to administratively control Feedwater heating and to assure it occurs as soon as possible.

d. For startups and shutdown, the feedwater control system would be capable of low flow control sufficient to eliminate on-off feedwater operation and with sufficient controllability to preclude greater than 25oF peak-to-peak mixture temperature variations during steady demand. Through this feature contributes some benefit toward reduction of high cycle fatigue, it is the single most effective feature applied to mitigate the low cycle fatigue problem discussed in other secitons.

   PP&L is still evaluating the above procedure and will advise the NRC of PP&L findings with respect to its feasibility along with implementation of new low flow control system or use of the existing low flow control system.

e. Plant operating procedures generally would be modified to minimize the total time spent at large subcooling and to reduce the subcooling experienced for long periods of time, particularly at high feedwater flow rates.

   Plant operating procedures have already been modified to incorporate the above proposed procedure.

PP&L will continue to research and pursue any other system modifications or plant operating procedures for limiting crack initiation and crack growth in the feedwater nozzles.

4. Inspections

Augmented Pre-Service Inspection and In-Service Inspection Programs were established by PP&L in response to FSAR Question 121.7, which is included as attachment "A". PP&L intends to implement these programs to meet the intent of NUREG-0619 requirements with the following exception:

a. Verification for leak testing or on-line leak monitoring as part of ISI program will not be provided since this is no longer a NRC requirement. In Reference 2, NRC has deleted the requirement of a leak detection system, such as on-line monitoring system (GE-NEDE-24265P), as originally needed by NUREG-0619. The installation of leak detection system was intended for detecting significant leakage through degraded seals or a crack(s) in the thermal sleeve weld.

System modificaitons and operating procedural changes will be completed prior to June 30, 1983 and a report will be submitted in accordance with Section 4.4.3.1 of NUREG-0619.

II. Part II: Control Rod Drive Return Line (CRDRL) Nozzle (Section 8, NUREG-0619)

A. Design

The CRDRL nozzle has been cut and capped without rerouting the CRD return line. This was permitted by the NRC for implementaiton of the GE recommendation to cut and cap the CRDRL recommendation to cut and cap the CRDRL nozzle without rerouting CRDRL for certain classes of BWR's, such as Susquehanna BWR which is a 251-inch BWR/4. However, NRC required certain system modifications and test prodedure changes in order for the cut and cap design to be acceptable to the NRC. These changes are delineated in Item B below.

B. System Modifications and Test Procedure Changes

1. As required by NUREG-0619, PP&L will demonstrate by testing the following:

   a) Concurrent two-CRD-pump operation (if necessary to fulfill the required flow capacity).

   b) Satisfactory CRD system operation.

   c) Required return-flow capacity into the vessel.

   The plant test procedure has been modified to incorporate the above. This procedure has been reviewed by the NRC representative at the Site.

2. Equalizing valves have been installed between the cooling water header and the normal drive movement exhaust water header as per GE recommendations. Stainless steel piping has been used from the inlet nozzle of the CRD pump discharge filter up to the vessel. Therefore, flush ports at high and low points of the normal drive movement exhaust water header, as recommended in the NUREG-0619, are not needed.

3. The flow stabilizer loop is also made from stainless steel piping and has been routed to the cooling water header per recommendations of GE.

C Inspections

As required by NUREG-0619 the penetrant testing of the area on the vessel beneath the nozzle has been satisfactorily completed.

A complete report with the results of the system testing and the inspection will be submitted to the NRC prior to June 30, 1982.

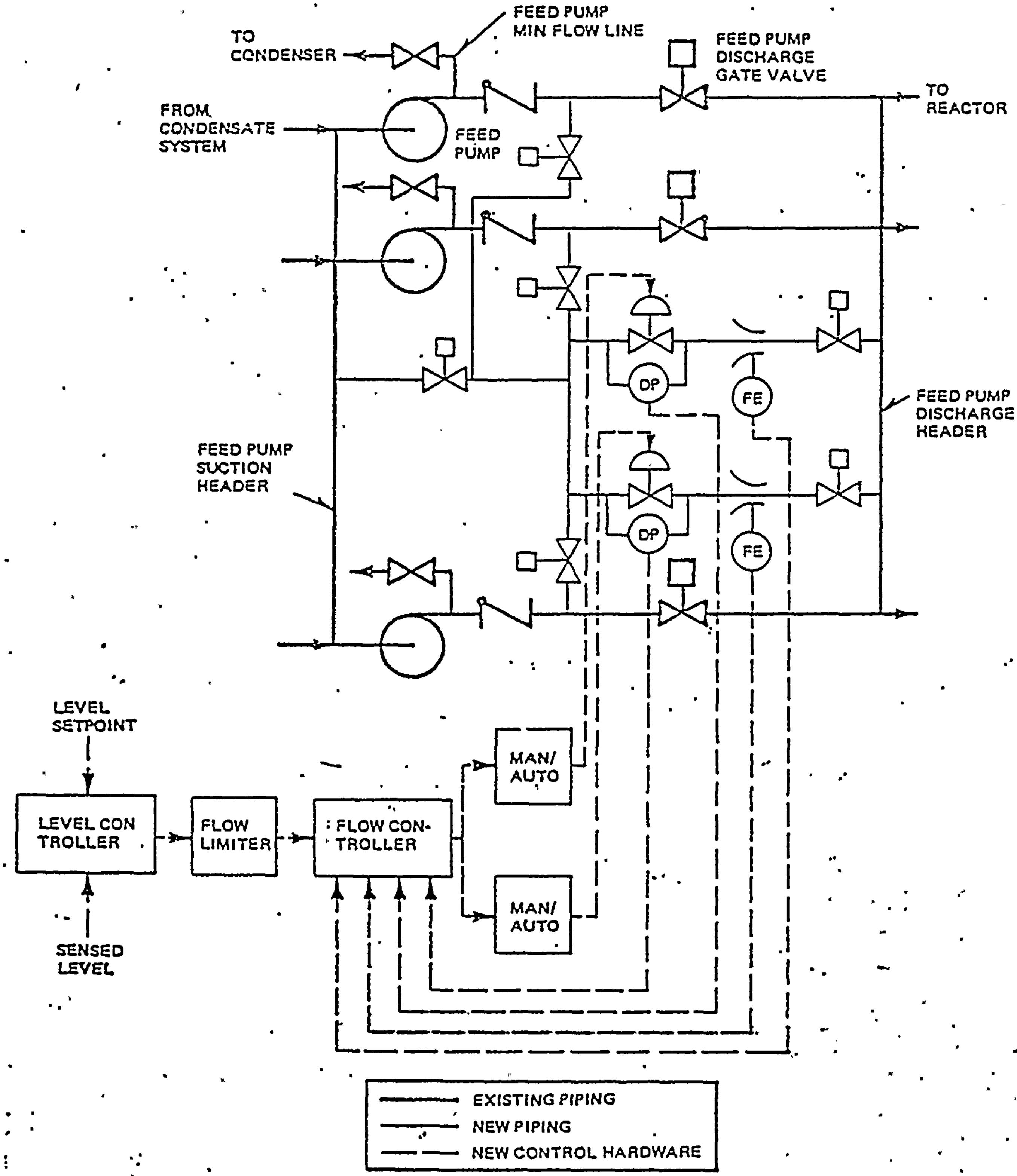

Figure 1. Three Feedpump Plant Configuration with GE proposed new low flow control design

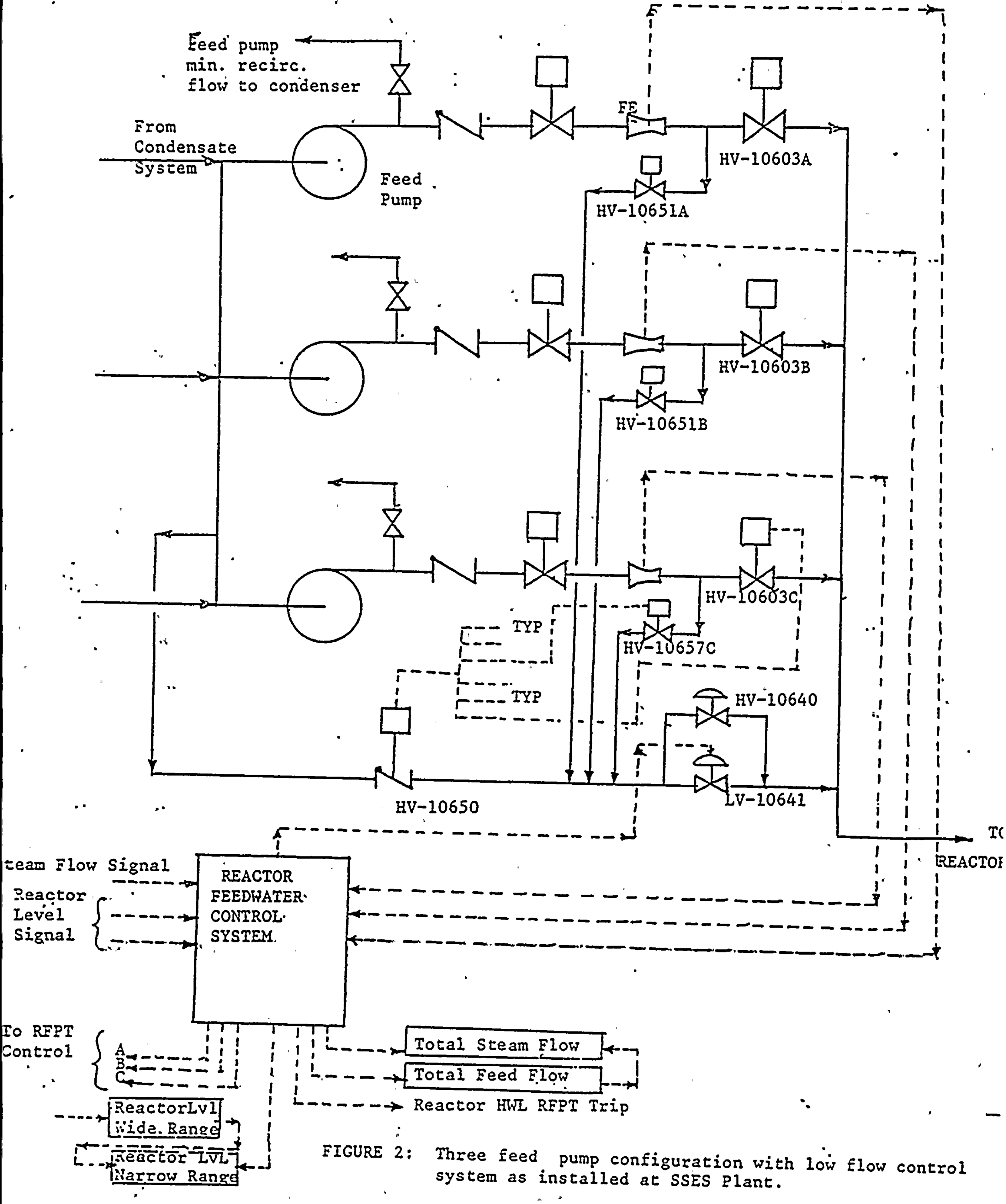

FIGURE 2: Three feed pump configuration with low flow control system as installed at SSES Plant.

ATTACHMENT "A"
(1)

RESPONSE 121.7

Note: All responses are presented in the order they are found in the Question.

Q.1) Discuss the technical basis to assure the structural integrity of both the feedwater inlet nozzle and the sparger, including:

a) A description of the nozzle and sparger design including dimensions, materials of construction and weld locations.

Description of feed water inlet nozzle.

Part	Material
Nozzle Forging	SA508CL II
Safe End	SA508CL I

Dimensions, location of weld and other details are provided in the following attached drawings:

7942902, Sheet 1 SSES Units 1 and 2- Figure(s) 121.7-1a,b
137C5543 PT No. 4 SSES Units 1 and 2- Figure(s) 121.7-2

Description of sparger material, basic dimensions and weld locations are presented in the attached drawings:

Susquehanna Unit 1 - Figure(s) 121.7-3a,b,c
Susquehanna Unit 2 - Figure(s) 121.7-4a,b,c

b) A description of analysis and test data referencing, if necessary, data previously submitted to the staff where directly appropriate for this.

The information for part b has been provided in the response and reference document cited for mini-review question 112.7.

c) Projected crack growth rates, stress levels and usage factors for both the nozzle and the sparger should be described in detail.

The information for part c has been provided in the response and reference document cited for mini-review question 112.7

d) Any plant modifications that are planned to reduce the feedwater to reactor water temperature differential during low power operation.

SSES is currently evaluating specific modifications to fluid systems and operating procedures as discussed in General Electric Document NEDE-21821A.

e) Any instrumentation that will be installed in the reactor to verify the conclusions of the design analysis should be identified.

Due to demonstrated benefits from nozzle cracking fixes, no instrumentation has been installed for design verification.

Q.2) Evaluate the feasibility of automated ultrasonic testing (UT) fixtures installed on all feedwater inlet nozzles with particular attention on examination of the nozzle bore region.

Currently, automated ultrasonic examination of the feedwater nozzle inner radii, safe-end, and bore region is not feasible. Preservice examinations on the nozzles will be performed utilizing a General Electric developed ultrasonic testing (UT) procedure. This procedure divides the nozzle inner surface into three regions, each of which is examined separately by a single angle beam shear wave technique. Current state of the art technology does not allow for automation of this technique due to the complexity of the technique and various scanning patterns involved; also, computer assisted signal discrimination equipment is not yet available for field usage.

Scanning solely of the nozzle bore region may be accomplished from the cylindrical section of the nozzle forging utilizing a temporary, removable track scanner. In terms of radiation exposure, (examination/set up time) and examination coverage, automation of only this portion of the examination is not beneficial and is not being considered for preservice activities.

Q.3) Evaluate the feasibility of performing the internal surface examination by magnetic particle methods.

Magnetic prod inspection methods are not acceptable in this area. Due to limited access in which to perform the examination, maintenance of proper prod contact with the nozzle surface is difficult, possibly resulting in arc-strikes below the electrodes. These surface defects are localized heat affected zones of higher hardness than the surrounding metal. Should the arc strike be accompanied by localized cracking, then surface grinding would be necessary to restore the nozzle to its original surface condition.

Handheld magnetic yokes will not readily fit in the area between the sparger body and the nozzle radius while maintaining proper contact with the nozzle surface and still allow adequate access to perform the examination. Based on the above, magnetic particle examination methods are not considered feasible inside the reactor vessel with the present sparger configuration.

Q.4) Define the specific ultrasonic testing procedure that will be used for Susquehanna Unit Nos. 1 and 2. Discuss the influence of local grindouts on crack detection on your ultrasonic testing method.

SSES will perform preservice examinations of all feedwater nozzle inner radii, safe end, and bore regions to provide a baseline for routine augmented inservice inspections outlined later in this response. Feedwater nozzle safe end examinations will be performed in accordance with ASME Section XI requirements to General Electric Company Procedure #ISE-QAI-322 "Ultrasonic Examinations of Similar and Dissimilar Metal Welds." The inner radii and bore regions will be performed in accordance with General Electric Company Generic Procedures listed below:

TP-508-0173	Rev. D	"Procedure for Nozzle Inner Radii Zone 1 Ultrasonic Testing"
TP-508-0174	Rev. D	"Procedure for Nozzle Bore Zone 2 Ultrasonic Testing"
E50YP14	Rev. 0	"U.T. Examination of RPV Nozzle Cylindrical Portion".

SSES site specific procedures technically in accordance with these generic procedures are being generated.

For examination purposes, the inner surface has been divided into three regions' each of which is examined separately by a single angle beam-shear wave technique. Examination of the nozzle inner radius will be performed by pulse-echo ultrasonic techniques from the exterior of the reactor pressure vessel by contacting the vessel plate surface. The nozzle inner bore region shall be examined from the outer blend radius and the cylindrical portion of the nozzle - the former requiring a special transducer wedge that complements the curvature of the contact area radius.

Should local grindouts be made in the examination surface creating a depression with definable sides, depth, and length, the ultrasonic techniques being used would obtain reflections from these cavities. Such reflections will be minimized by blending the grind cavity into the surrounding base metal in accordance with ASME requirements. This should result in improved detection sensitivity to actual cracking in the grindout area by eliminating spurious geometric indications from the grindout.

Q.5) Provide a description of the augmented inservice inspection (ISI) program to be implemented including scheduled surface examination, ultrasonic testing, and verification of the leak tight integrity of the thermal sleeve to safe end joint on all nozzles.

AUGMENTED INSERVICE INSPECTION PROGRAM

SSES will implement the reactor feedwater (RFW) nozzle inspection program described below. Justification for any deviations from recommended inspections in NUREG 0619 are presented following the response.

PRESERVICE EXAMINATION

SSES will perform a preservice ultrasonic examination of reactor feedwater nozzle inner radii, bore, and safe end regions. All U.T. personnel and procedures will be fully qualified as required. In addition, a preservice liquid penetrant examination will be performed on accessible areas of all Unit #1 feedwater nozzle inner radius surfaces. Also, all nozzle forgings have previously been fully shop magnetic particle inspected and have met ASME Section III requirements. Full liquid penetrant examination will be performed on all Unit #2 feedwater nozzle forgings prior to installation of the spargers.

Inservice Examination

SSES-1 will perform the following routine inservice inspections as follows:

1. Ultrasonic examination of the reactor feedwater nozzle inner radii and bore region will be performed every two (2) refueling cycles on one (1) RFW nozzle. The inspection interval begins with the first refueling cycle since the unclad nozzle and triple sleeve sparger was installed prior to plant start up. Safe end examinations will continue to be performed in accordance with ASME Section XI requirements.

2. Penetrant testing of the nozzle inner radii and bore region will be performed only as required to verify and characterize U.T. indications.

3. Visual inspection of the sparger will continue to be performed in accordance with ASME Section XI requirements.

4. Verification of the thermal sleeve to safe end joint ~~shall~~ may be made by performance of in-vessel physical leak testing or some alternate method such as on-line leaking monitoring. SSES is presently pursuing the feasibility of the latter.

In the event an indication is discovered by UT and found to result from service induced cracks propagating from the nozzle inner surfaces, the following action will be taken:

All accessible areas of remaining feedwater nozzles will be examined using penetrant techniques during the refueling outage in which the cracking is verified.

All surface indications determined to be service induced cracks will be removed by local grinding.

A NEW nozzle examination program for subsequent refueling outages will include the external ultrasonic examination of all feedwater nozzle inner radii, bore and safe end regions for each scheduled refueling outage for 3 consecutive outages. If no new indications are discovered, or if new indications are determined to not result from service induced cracks at the nozzle inner surfaces, the aforementioned program will be resumed. If, after 3 additional outages no new indications resulting from surface induced cracks are detected, subsequent examinations will be scheduled in accordance with normal ASME Section XI requirements.

The conduct of surface examinations of accessible nozzle inner radius surfaces will continue to be used throughout plant life only to confirm or characterize new ultrasonic indications which are suspected to result from service induced cracks at the nozzle inner surfaces.

Thermal Sleeve to Safe End Joint

SSES ~~shall~~ may verify the integrity of the thermal sleeve-to-safe end joint by performance of in-vessel physical leakage testing or alternate methods such as on-line periodic leakage monitoring.

Recording and Reporting Standards

SSES-1 will record crack indications and report inspection results in compliance with the requirements stated in NUREG 0619.

(6)

JUSTIFICATION OF DEVIATION FROM RECOMMENDATIONS

Ultrasonic Examinations Frequency

SSES will ultrasonically examine one RFW nozzle every second refueling outage. This is justified for the following reasons, which reflect a significant advance in the SSES design and operating procedures towards the long term solution of the BWR nozzle cracking problems per NUREG0619.

a. Improved Design: The SSES RFW thermal-sleeve-to-safe-end joint provides a near zero leakage design. This design essentially eliminates the primary historical initiating source of nozzle cracking in BWRs.

b. No Nozzle Cladding: The SSES-1 RFW nozzle surfaces are not clad. The likelihood of crack initiation in unclad nozzles is considerably reduced such that elimination of the nozzle cladding and installation of the triple sleeve sparger design may be all that is necessary to suppress cracking within the design lifetime.

c. Proven Examination Technique: The ultrasonic examination equipment and personnel to be used in performing both baseline and inservice ultrasonic examinations will be qualified on a full scale mock-up of the nozzle, simulating the nozzle geometry and anticipated fatigue crack defects. Since the SSES-1 reactor feedwater nozzles are unclad as stated in b) above, a more sensitive examination is possible due to lack of clad/basemetal interface.

d. Augmented Examination Frequency: The above stated program provides RFW nozzle examination coverage at approximately one and one half times the frequency of the ASME Section XI requirements, i.e., all RFW nozzles will be examined within approximately seven years rather than within ten years.

The above factors, when combined, provide adequate assurance that the factors which have led historically to BWR RFW nozzle cracking have been virtually eliminated. Furthermore, any cracking which might occur from unanticipated sources will be discovered before propagating to a significant depth utilizing an augmented examination schedule with state-of-the-art qualified ultrasonic examination techniques.

Surface Examinations

SSES-1 will perform liquid penetrant examinations of the accessible internal surfaces of all RFW nozzles during the preservice inspection activities. In-service surface examinations necessitating removal of the spargers, will be performed only when indications of service induced cracking are discovered ultrasonically. This is justified as follows:

a. Reduced probability of crack initiation and growth as stated in the justification above (Ultrasonic Examinations Frequency a thru f).

b. Access: In order to obtain access to perform a penetrant surface examination of the RFW nozzle surfaces during a refueling outage, the vessel water level would have to be lowered below the level of the spargers and hydrolaser decontamination performed. Special shielded platforms would be required to minimize exposures.

c. Removal of the current design sparger for routine penetrant examination may result in damage to the thermal sleeve sealing surface, resulting in increased likelihood of leakage.

Acceptance Standards

(1) All UT indications evaluated to be cracks should be verified by appropriate surface examination and removed by local grinding.

(2) All surface indications evaluated to be service induced cracks should be removed by local grinding.

(3) The UT inspection personnel should be required to demonstrate supplemental qualifications by either (i) past successful experience in locating and identifying cracks in BWR feedwater inlet nozzles or (ii) performing a qualification test on a full size - nozzle mock-up.

Response:

(1) SSES will comply with this criteria as stated in 2(a) above.

(2) SSES will comply with this criteria as stated in 2(a) above.

(3) SSES will utilize General Electric Company qualified procedures previously referenced. All personnel performing examinations at SSES will be qualified in accordance with these procedures on a full nozzle mock-up.

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