REF: WATER HAMMER INFORMATION

T. M. Peckles

December 2, 1977

Mr. Eason Y. Case
Acting Director of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Serial No. 193/050377
PSAR/IAP:wbk
Docket No. 50-320
50-321
License No. DPR-32
DPR-37

Attention: Mr. Robert W. Reid, Chief
Operating Reactors Branch 4

Dear Mr. Case:

This letter is in response to your request for an in depth study of feed water system water hammer potential at our Crystal River Station. The study has been completed by my staff with the assistance of our architect engineer and is attached.

As our feed water system presently incorporates the recommendations of the GPU study and our heavy precautions are compatible with those successfully tested at our North Anna Unit No. 1, no further changes are required.

Very truly yours,

C. M. Stallings
Vice President-Power Supply
and Production Operations

Attachment

cc: Mr. J. P. O'Reilly

bc: Mr. C. M. Stallings)
Mr. I. R. Sylvia) I
Mr. T. L. Beucom
Mr. J. T. Beaton
Mr. E. A. Hahn
Mr. T. A. Peckles

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ATTACHMENT

3 pages

SERIAL NO. 393/090277

RESPONSE TO NRC REQUEST FOR INFORMATION
FEEDWATER SYSTEM WATER HAMMER

Comparison of Feedwater System Design at Surry Power Station, with CREARE Recommendations

The steam generators presently installed at Surry Power Station utilize top discharge feed water spargers (J-tubes) to reduce the likelihood of feed-ring drainage. These modifications were completed during scheduled outages from late 1975 to early 1976.

Surry Power Station also utilizes inverted loop seals to provide the "short pipe" effect and to minimize slug propagation. These loops are installed in accordance with the Westinghouse recommended piping layouts indicated in Figure 7 of the CREARE study.

The auxiliary feedwater system is automatically initiated by: a low level indication for the steam generators; a loss of off-site power; an opening of the main feed pump breakers; or through a delay, by any safety injection signal.

Operating procedures are in effect at Surry Power Station which control operator action in the event of low steam generator water level. Abnormal Procedure AP-21 details the steps to be taken by an operator in the event of complete loss of flow to a steam generator to ensure prompt restoration of feedwater.

Operating Procedure OP-31.2 details the steps to be followed for auxiliary feedwater initiation. This procedure limits the auxiliary feedwater flow to less than 200 gpm under conditions of start-up, steam generator isolation, or hot standby. This would also apply following a unit trip on low steam generator level.

The "subjective" ranking of recommendations developed by CREARE in Table 19 of the report is based on an evaluation of the effect on water-hammer probability resulting in piping system overstress. The combinations are ranked from best (1) to worst (13). The feedwater system features employed at Surry Power Station (J-tubes, flow-on-soon, short pipe, and flow restriction) optimize the present state-of-the-art recommendations established in the report.

The replacement steam generators to be installed at Surry Power Station during 1978-1979 will incorporate two additional design features for water-hammer prevention. The proposed steam generator modifications will include the use of a replacement feedwater nozzle which incorporates a full penetration weld between the nozzle and feed ring rather than the present thermal sleeve. In addition, the proposed new feed rings will be offset approximately 2 1/2 in. in elevation above the center line of the feed nozzle. This offset will also minimize the possibility of draining the feed piping.

II. Review of Steam Generator Water-Hammer Demonstration Test Conducted at North Anna Power Station - Unit 1

On March 17, 1977, tests were performed at North Anna Power Station - Unit 1 to demonstrate that the possibility of water hammer in the feedwater system following feed-ring recovery has been eliminated by J-tube and loop seal installation. The tests were performed during the Hot Functional Testing period.

In summary, the test consisted of operating the steam generators at normal level while dumping steam to the main condenser. One steam generator was then isolated on the secondary side and the blowdown valve opened to drain the steam generator to a level of three to five percent of narrow range (below the bottom of the feed ring). Following a 30-minute period to allow any feed ring drainage to occur, auxiliary feedwater was initiated at a flow rate of 220 gpm. At the time of auxiliary feedwater initiation, vibration recorders attached to the piping system were started to record any abnormal pressure pulses occuring in the system. The complete test was then repeated with maximum auxiliary feedwater flow to the steam generator.

These tests were performed at two different operating conditions. Phase 1 was completed with the RCS average temperature at 445 $\pm 5^{o}$F and a steam pressure of 380 psig. The second phase of the test was performed at RCS average temperature at 547 $\pm$5F and a steam pressure of 1,005 psig. During this phase, a drain time of two hours was used instead of 30 minutes to provide a better indication of the effects of sparger draining.

The tests performed at North Anna Power Station indicated no signs of water hammer occurring following feed-ring recovery. Temperature measurements made throughout the tests of the loop seals indicate that no pipe drainage occurred. The conclusion of the tests indicates that the J-tube and loop seal arrangements will effectively preclude operational water-hammer events.

III. Comparison of the Feedwater Piping Systems at Surry and North Anna Power Stations

Surry and North Anna Power Stations are very similar in overall design: both plants employ subatmospheric containments of the same basic dimensions and utilize three loop Westinghouse NSSS system with Model 51 series steam generators.

The present steam generators at both plants use cloverleaf shaped feed rings equipped with J-tubes. The feed rings are attached to the inlet nozzle through a thermal sleeve. The radial pipe run from the containment penetrations to the steam generators is similar for both stations with the exception of the loop seals at the feedwater inlet.

The loop seals at Surry are inverted upward; whereas the seals installed at North Anna are opposite. Both arrangements are acceptable piping configurations to Westinghouse specifications, and both funtion to limit the length of straight pipe at the steam generator.

Essentially, the feedwater systems for Surry and North Anna Power Stations are so similar that the test data from North Anna can be reasonably applied to Surry Power Station.

IV. Conclusions

As stated in Part I of this response, the feedwater systems for Surry Power Station incorporate all four of the recommendations addressed in the CREARE report.

In addition, test data from North Anna Power Station - Unit 1, a unit very similar to Surry, indicate no water-hammer occurrence under varying flow and pressure conditions with an uncovered feed ring.

Operating experience at Surry Power Station, since the J-tube and loop seal modifications were installed, indicates that no appreciable water hammer or damage has occurred.

In conclusion, since the current state-of-the-art features are installed at Surry Power Station and in view of the above testing and operating experience, no further design or procedural changes are considered necessary. Consequently, there will be no impact on the design basis and supporting safety analysis for the station.