UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

| | | |
|---|---|---|
| In the Matter of<br><br>GEORGIA POWER CO.<br>et al.<br><br>(Vogtle Electric Generating Plant,<br>Units 1 and 2) | )<br>)<br>)<br>)<br>)<br>)<br>) | Docket Nos. 50-424<br>50-425<br>(OL) |

AFFIDAVIT OF WILLIAM T. LEFAVE IN
SUPPORT OF NRC STAFF RESPONSE TO APPLICANTS'
MOTION FOR SUMMARY DISPOSITION OF CONTENTION 11

I, William T. LeFave, being duly sworn, depose and state:

1. I am employed by the U. S. Nuclear Regulatory Commission as a Senior Mechanical Engineer (Auxiliary Systems) in the Auxiliary Systems Branch, Division of Systems Integration, Office of Nuclear Reactor Regulation. A copy of my professional qualifications is attached.

2. The purpose of this affidavit is to provide the results of the Staff's review of that portion of the Applicants' design that provides for the avoidance of steam generator (SG) water hammer (steam bubble collapse), and to respond to that portion of Joint Intervenors' Contention 11 which addresses the issue of water hammer.

3. Joint Intervenor's Contention 11 states:

   Applicants have not demonstrated their basis for confidence that no uncacceptable radiation releases will occur as the result of steam generator tube failures occasioned by vibration-induced fatigue cracking and by bubble collapse within the Vogtle steam generators.

4. "Bubble collapse" refers to a type of water hammer occurrence induced by condensation of a steam pocket in the steam generator feedring or the feedwater piping leading to the steam generator. Bubble collapse water hammer was one of several types of water hammer which the Staff evaluated in the process of resolving Unresolved Safety Issue (USI) A-1. This USI has been resolved by the Staff; its resolution is documented in NUREG-0927, "Evaluation of Water Hammer Occurrence In Nuclear Power Plants - Technical Findings Relevant to Unresolved Safety Issue A-1" (Revision 1, March 1984), and NUREG-0993, "Regulatory Analysis For USI A-1, 'Water Hammer'" (Revision 1, March 1984).

5. One of the results of the Staff's resolution of USI A-1 was the establishment of the design considerations and preoperational test recommendations described in Branch Technical Position (BTP) ASB 10-2, "Design Guidelines For Avoiding Water Hammer in Steam Generators." The Branch Position, which is attached to Standard Review Plan Section 10.4.7,

"Condensate And Feedwater System," was upgraded in April 1984 to include all types of steam generators currently utilized in nuclear power plants in the United States. The Staff has determined that compliance with BTP ASB 10-2 provides an acceptable means of protection against water hammer events. A copy of BTP ASB 10-2 is attached to this Affidavit.

6. As evaluated by the Staff in Section 10.4.7 of the Vogtle Safety Evaluation Report (NUREG-1137), the Vogtle design follows the guidance of BTP ASB 10-2, and the Applicants have committed to perform preoperational testing to verify that the unit operating procedures do not result in water hammer (steam bubble collapse) in the main or auxiliary feedwater systems.

7. The potential for bubble collapse water hammer in the feedring of the Model F steam generator used at Vogtle has been minimized by the use of J-tubes and a welded thermal sleeve (to prevent draining the feedring when no flow is present), thereby preventing steam bubble formation. In addition, by introducing auxiliary feedwater (AFW) flow into a separate steam generator nozzle in lieu of the feedring, the colder auxiliary feedwater will not contact the warmer feedwater in the feedring or any steam in the feedring, thereby minimizing the possibility of condensation-induced bubble collapse (water hammer). The probability of steam bubble collapse water hammer has been significantly reduced in the Vogtle design by these measures.

8. The Vogtle design also follows the recommendations of BTP ASB 10-2 regarding the shortest possible horizontal run of inlet piping to the steam generator feedring and auxiliary feedwater nozzle, to prevent highpoint steam pockets. During normal plant operation, the AFW inlet piping is kept full of water by the main feedwater system via bypass piping. The discharge end of the inlet piping in the steam generator is below the normal operating water level. Additionally, four check valves in series are provided between the AFW inlet nozzle and the AFW pump recirculation lines to minimize the possibility of backleakage under no flow conditions. Thus, steam bubble formation in the AFW inlet nozzle and piping is not expected to occur.

9. The Staff reviewed the Vogtle design features intended to minimize the potential for bubble collapse water hammer described above. As indicated in Section 10.4.7 of the Vogtle SER, the Staff has concluded that the Vogtle design meets the Staff's criteria with respect to the prevention of bubble collapse water hammer as set forth in BTP ASB 10-2, and that the design is acceptable. Based on the above, the staff concludes that there is reasonable assurance that the health and safety of the public will not be endangered by steam generator tube degradation due to bubble collapse water hammer at the Vogtle units.

10. I have reviewed that portion of the Statement of Material Facts attached to Applicants' Motion for Summary Disposition of Contention 11 that is related to the issue of bubble collapse water hammer. I am satisfied that each of Statements 8 through 15 is correct.

The above statements are true and correct to the best of my knowledge and belief.

William T. LeFave

William T. LeFave

Subscribed and sworn to before
me this 30th day of July, 1985

Malinda L. McDonald

Notary Public

My Commission expires: 7/1/86

WILLIAM T. LEFAVE

PROFESSIONAL QUALIFICATIONS

AUXILIARY SYSTEMS BRANCH

DIVISION OF SYSTEMS INTEGRATION

OFFICE OF NUCLEAR REACTOR REGULATION

I am a Senior Mechanical Engineer (Auxiliary Systems) in the Auxiliary Systems Branch and am responsible for the safety review of auxiliary systems and associated features of proposed design and operating procedures for nuclear power plants. The objective of these reviews is to assure no undue risk to the health and safety of the public.

I graduated from Massachusetts Bay Community College in 1964 with an Associate of Science Degree in Electronics. From 1964 to 1970 I attended naval nuclear power schools and was a reactor operator on an SSW submarine through new construction and while at sea. In 1973, I graduated from Lowell Technological Institute with a Bachelor of Science in Nuclear Engineering.

In October of 1973 I accepted a position with the Auxiliary Systems Branch of the Atomic Energy Commission and have remained there to the present as part of the Division of Systems Integration, Office of Nuclear Reactor Regulation.

During these years I have been responsible for the auxiliary system reviews of construction permits, preliminary design approvals, and operating license applications including the following: WPPSS Nuclear Project, Units 1 and 4; Susquehanna, Units 1 and 2; Fermi 2; RESAR-41; -3S and 414; GESSAR-238 and 251;

Floating Nuclear Plant; Callaway and Wolf Creek; GIBBSAR; Erie Units 1 and 2; Farley 2; South Texas, Units 1 and 2; and Pebble Springs 1 and 2. Primary review for these plants have included the design of the main and auxiliary feedwater systems and their design features for minimizing the potential for and the effects from steam generator water hammer. In addition to the above casework, I was responsible for or involved in the review and evaluation of the main and auxiliary feedwater systems and their response to plant transients at many Westinghouse reactors as part of the post-TMI Bulletin and Orders Task Force. Part of this responsibility included the review of measures taken by licensees to avoid steam generator water hammer as a result of cold auxiliary feedwater addition. Operating Westinghouse plants that I have been responsible for include Indian Point, Units 2 and 3, Turkey Point, Units 3 and 4, Point Beach, Units 1 and 2, Farley, Unit 1, Zion, Units 1 and 2, Haddam Neck and Trojan.

## BRANCH TECHNICAL POSITION ASB 10-2

## DESIGN GUIDELINES FOR AVOIDING WATER HAMMERS IN STEAM GENERATORS

### BACKGROUND

Plant operational experience has shown that top-feed steam generators containing feedwater spargers with bottom drain holes incur steam condensation induced water hammers. This type of water hammer has frequently occurred after the feedwater sparger was uncovered (due to some plant transient) and cold auxiliary feedwater flow was subsequently initiated. The initiation of the auxiliary feedwater flow into the steam generator produces a water slug in the sparger or feedwater piping, which is then accelerated by the unbalanced pressures produced by the condensation of a steam pocket in the line. The resultant impulse could be of a sufficient magnitude to cause damage to the steam generator internal components and feedwater systems piping. The most damaging of such water hammer incidents occurred at Indian Point No. 2 in 1973, where the water hammer loads resulted in rupture of an 18-inch feedwater pipe and damage to the containment inner liner. The repeated occurrence of such water hammers and potential severity such flow instabilities resulted in the NRC in engaging Creare Inc. in 1976 to evaluate causes and effects, and to develop recommendations for avoidance of top feed steam generator water hammer, and design methods minimize associated dynamic loads.

The underlying causes of water hammer in top-feed steam generators were extensively studied by Creare, Inc. who reported findings and recommended design modifications to minimize or preclude such water hammer occurrence in NUREG-0291 (1977). These recommendations called for: (a) use of J-tubes on the topside of the feedring to minimize loss of water when uncovered, (b) early initiation of auxiliary feedwater to keep piping and feedring full of water, (c) short horizontal FW pipe lengths at the SG nozzle to reduce magnitude of slug formation and impact, (d) limit FW recovery flow rates to less than 150 gpm/SG to minimize steam-water entrainment and subsequent formation of a water slug. The use of top discharge feed (i.e., tubes) makes flow rate limits practical because the limit only has to be imposed until the piping is full, regardless of steam generator water level. The design and operational modifications were implemented by plants experiencing SG water hammer and appear to have essentially eliminated SGWH. NUREG-0918 details plant specific modifications which were made. In addition, experience sustains maintaining preoperational tests to verify the absence of SGWH.

More recently, Westinghouse and Combustion Engineering have introduced steam generators of the preheat type, wherein the majority of feedwater enters the steam generator at the bottom through a preheater section. The potential for condensation-induced water hammer in preheat steam generators was studied by BNL and reported in NUREG/CR-1606, "An Evaluation of Condensation-Induced Water Hammer in Preheat Steam Generators," June 1980. This report, citing the lack of definitive experimental and analytical results, recommended full scale verification tests to demonstrate the absence of damaging water hammer in preheat steam generators and connecting feedwater piping (i.e., preoperational tests).

B&W steam generators, which are a "once through" flow design, have generally not reported water hammer occurrence. However, in May 1982, several B&W plants (following inservice inspection) reported damaged internal auxiliary feedwater headers and support structures. The cause was attributed to steam pocket collapse. The internal auxiliary feedring design concept is similar to CE & W top feedring concepts which have experienced water hammer before corrective design measures were implemented. For these B&W plants, the OTSG's are being modified to return to the previous design using auxiliary feedwater injection manifolds which are external to the steam generator.

The staff believes that SGWH evidence and studies performed to date warrant the establishment of design guidelines for steam generators and the associated piping. Guidelines have been developed that may be used to reduce the probability of a damaging steam condensation induced water hammer, particularly for the Westinghouse and Combustion Engineeering PWR designs which use top-feed steam generators.

BRANCH TECHNICAL POSITION

In CP and OL application reviews, the staff requires the applicant to provide the following design capability and verification:

Top-Feed Steam Generator Designs

To eliminate or reduce possible water hammer in the feedwater system:

a. Prevent or delay water draining from the feedring following a drop in steam generator water level by means such as top discharge J-Tubes and limitng feedring seal assembly leakage.

b. Minimize the volume of feedwater piping external to the steam generator which could pocket steam using the shortest possible (less than seven feet) horizontal run of inlet piping to the steam generator feedring.

c. Perform tests acceptable to NRC to verify that unacceptable feedwater hammer will not occur using the plant operating procedures for normal and emergency restoration of steam generator water level following loss of normal feedwater and possible draining of the feedring. Provide the procedures for these tests for approval before conducting the tests and submit the results from such tests.

d. Implement pipe refill flow limits where practical.

Preheat Steam Generator Designs

1. Minimize the horizontal lengths of feedwater piping between the steam generator and the vertical run of piping by providing downward turning elbows immediately upstream of the main and auxiliary feedwater nozzles.

2. Provide a check valve upstream of the auxiliary feedwater connection to the top feedwater line.

3. Maintain the top feedwater line full at all times.

4. Perform tests acceptable to NRC to verify that unacceptable feedwater hammer will not occur using plant operating procedures for normal and emergency restoration of steam generator water level following loss of normal feedwater. Also perform a water hammer test at *% of power by using feedwater through the auxiliary feedwater (top) nozzle at the lowest feedwater temperature that the plant standard operating procedure (SOP) allows and then switching the feedwater at that temperature from the auxiliary feedwater nozzle to the main feedwater (bottom) nozzle by following the SOP, and submit the results of such tests.

Once Through Steam Generator (OTSG) Designs

a. Provide auxiliary feedwater to the steam generator through an externally mounted supply top discharge header.

b. Perform tests acceptable to NRC to verify that unacceptable feedwater hammer will not occur using the plant operating procedures for normal and emergency restoration of steam generator water level following loss of normal feedwater. Provide the procedures for these tests for approval before conducting the tests, and submit the results of such tests.

REFERENCES

(1) Block, J. A. et.al., "An Evaluation of PWR Steam Generator Water Hammer," NUREG-0291, June 1977.

(2) Chapman, R. L., et.al., "Compilation of Data Concerning Known and Suspected Water Hammer Events in Nuclear Power Plants," NUREG/CR-2059, May 1982.

(3) Anderson, N. and Han, J. T., "Prevention and Mitigation of Steam Generator Water Hammer Events in PWR Plants," NUREG-0918, December 1982.

---

*The power level at which feedwater flow is transferred from the auxiliary feedwater nozzle to the main feedwater nozzle.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1984-421-297:3828