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February 11, 1994
BVY 94-07

United States Nuclear Regulatory Commission
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References:
(a) License No. DPR-28 (Docket No. 50-271)
(b) NUREG-0619, BWR Feedwater Nozzle and Control Rod Drive Return Line Nozzle Cracking, dated 11/13/80
(c) USNRC Generic Letter 81-11 to all Power Reactor Licenses & License Applicants, dated 02/20/81

Subject: **REQUEST FOR RELIEF FROM NUREG-0619 INSPECTION REQUIREMENTS**

As a result of reactor vessel feedwater nozzle inner radius and bore cracking experienced in the period of 1974 through 1980, the NRC issued NUREG-0619, dated November 13, 1980 [Reference (b)]. The NUREG described the appropriate actions to minimize or eliminate feedwater nozzle cracking concerns. The NUREG concluded that implementation of the recommended actions was considered by the NRC to satisfactorily resolve the issue, with the exception of the development of improved nondestructive examination (NDE) techniques. Because of the state of ultrasonic testing (UT) technology in use at the time NUREG-0619 was issued, the NRC required periodic liquid penetrant (PT) examination at a frequency determined by the feedwater sparger design.

Vermont Yankee has determined reliable technology is now available to ultrasonically inspect the feedwater nozzle inner radius and bore region. Consequently, Vermont Yankee requests relief from the PT examination requirement and the ultrasonic examination schedule contained in NUREG-0619, as modified by NRC Generic Letter 81-11, [Reference (c)]. The relief request, the technical basis, and proposed alternative actions are provided in the enclosure. The proposed alternative action is to perform ultrasonic examination on the ID of the reactor vessel in a one inch annular space between the sparger thermal sleeve and the nozzle bore. This type of examination is superior to the typical ultrasonic inspection performed from the OD of the nozzle surface and vessel shell.

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The PT examination is scheduled to be performed during the Spring 1995 refueling outage. The relief from the PT requirement will prevent the unnecessary personnel radiation exposure and expense involved in the performance of the PT examination and sparger removal. In lieu of the PT examinations, Vermont Yankee will perform automated, enhanced UT examinations from the inside of the reactor pressure vessel.

Vermont Yankee plans to request bids for this UT examination in February, 1994. The reason for this lead time is to give the vendor time to design a particular automated technique with adequate time allowed prior to the scheduled Spring 1995 examination. It is also recognized that 1994 and 1995 will be busier than usual for inspection vendors due to preparations for implementing requirements of ASME Section XI, Appendix VIII. The lead time is also desired to allow for the contingency to prepare for performing UT from the OD of the nozzle, if this becomes necessary.

Because of these scheduling factors, Vermont Yankee requests prompt consideration of this relief request.

We trust that the information provided herein adequately addresses our request. However, if you have any questions in this regard, please contact us.

Sincerely,

VT YANKEE NUCLEAR POWER CORP.

James P. Pelletier

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Vice President, Engineering

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Enclosure

cc: USNRC Region I Administrator
USNRC Resident Inspector - VYNPS
USNRC Project Manager - VYNPS

ENCLOSURE

NUREG-0619 - FEEDWATER NOZZLE EXAMINATION RELIEF REQUEST

REQUIREMENT FROM WHICH RELIEF IS REQUESTED:

NUREG-0619 was issued by the NRC for implementation by letter dated November 13, 1980 and was later modified by Generic Letter 81-11. NUREG-0619, Section 4.3.2, Table 2 specified inspection frequencies for the visual inspection of the sparger, and the liquid penetrant testing (PT) and ultrasonic testing (UT) of the feedwater nozzle inner radius and bore. These requirements replaced the American Society of Mechanical Engineers (ASME) Code Section XI requirements with more stringent requirements.

In a letter dated January 5, 1987, Vermont Yankee requested permanent relief from the invessel PT. The NRC granted a six fuel-cycle extension in a letter dated August 7, 1987 (a PT would be required in the Spring 1995 refueling outage), but did not grant permanent relief based on the following conclusions:

1. They did not have reasonable assurance and confidence that the UT method being employed would replace the PT method in accurately detecting minor surface flaws.

2. Stainless steel clad may lead to cracking due to normal aging processes and adversely affect the environment between the two dissimilar metals. The PT examination offers defense in depth.

3. As the reactor ages, the interference fit thermal sleeve may develop gaps which will eventually lead to cracks.

4. The feedwater nozzle is an integral part of the reactor vessel pressure boundary. It is important to the public safety to have a redundant PT examination of the nozzle.

Relief is being sought from the requirement to perform a PT examination of the feedwater inner radius and bore, and the schedule imposed by Table 2 of Section 4.3.2 for the performance of the UT examination. Relief is also requested from the requirement to remove or repair detected flaws if they can be shown to be acceptable for service.

BASIS FOR RELIEF

Background

Vermont Yankee has a single sleeve sparger design. According to NUREG-0619, Table 2, Vermont Yankee is required to ultrasonically inspect the feedwater nozzle inner radius every refueling outage and visually examine the sparger every two refueling outages. Vermont Yankee has followed this schedule since 1977. As noted above, the NUREG-0619 PT requirements were amended by the 1987 NRC letter. Under these new requirements, the next PT examination is to be done in 1995. In addition, as recommended by the NRC, a specially developed leak detection system was added in 1982. This system uses thermocouples to monitor vessel temperature at the nozzle metal surface to provide indication of thermal sleeve leak tightness. Vermont Yankee has been collecting and monitoring data from this system from 1982 through the present date.

Technical

The August 7, 1987 letter from the NRC to Vermont Yankee and Section 4.3.1 of NUREG-0619 states that the confidence in the UT capabilities available at the time the NUREG was issued was unacceptably low. NUREG inspection requirements were based on the technology in use at that time. The required inspection program included both UT and PT examination criteria. NUREG-0619 concluded that should future developments and the results of inservice UT examinations demonstrate that UT techniques can detect small thermal fatigue cracks with acceptable reliability and consistency, these techniques could form the basis for modification of the inspection criteria.

Since the issuance of NUREG-0619 and since Vermont Yankee's last request for exemption in 1987, improvements in the area of UT, both manual and automated, have occurred. Automated UT techniques are capable of detecting and sizing small (0.25" deep in the base material and smaller) fatigue cracks. Furthermore, technology has progressed to where UT can be performed in very small spaces. An ID examination in the one inch gap between the sparger and the nozzle bore (the sparger reduces down at the interference fit) will give excellent sensitivity to small flaws, much better than typically achieved on an OD examination. Small cracks can be detected and sized, even with the cladding present in the inner radius. Although a special manipulator will be necessary, this type of technology has been proven in PWR nozzle inner radius inspections.

Given that the PT requirements were due to a lack of confidence in the available UT techniques, and that the new enhanced automated UT techniques can now adequately examine the areas of concern, the PT requirement is unwarranted. Therefore, modifying the inspection criteria is justifiable.

Performance of a PT examination on the inner radius constitutes an undue burden without providing a commensurate increase in safety.

- Due to the high frequency nature of high cycle mixing, it is expected that once started, the shallow cracks progress to the 0.25" depth very quickly--in a matter of months. Because of the postulated rapid initial growth, it does not make sense to attempt to detect flaws smaller than this value, such as could be detected by PT.

- Clad cracking alone does not necessarily indicate active fatigue crack growth. IGSCC clad cracking has been seen frequently in many vessels. Therefore, PT examination will only serve to confirm the existence of cracking in the nonstructural (cladding) portion of the vessel. The radiation exposure and expense of removing PT indications, which may be benign, is unwarranted.

- Additionally, performance of a PT examination in accordance with NUREG-0619 requires that if any cracks are detected, all spargers are to be removed, and all nozzles inspected and repaired as necessary. There is a high likelihood that clad cracking would be detected due to IGSCC in the stainless clad, thus forcing sparger removal. Removal of flaws would be very difficult, if not impossible, in the one inch gap. This will involve substantial personnel radiation exposure, significant effort to remove spargers, and a high cost for the re-installation of spargers.

- Vermont Yankee estimates that there would be an accumulation of 10 manRem to PT only the accessible areas of the four nozzle inner radii. To additionally remove and replace all four spargers would add an estimated dose of 100 manRem. The work would cost several million dollars. Performance of an automated ID UT would accumulate less than 1 manRem.

- The PT will not provide information as to the depth of detected flaws, and therefore their acceptability for service.

It is more prudent to take advantage of the sizing capability of the UT to track the growth of any identified flaws and take action when necessary. This is especially true in light of the fact that both Vermont Yankee's experience to date and the plant specific fracture mechanics analysis indicate that small cracks will grow very slowly with the current inconel interference fit thermal sleeve configuration.

The problem of internal surface cracking on BWR feedwater nozzles initiated extensive research concerning the nozzle cracking and bypass leakage in the late 1970's. This research determined that the fatigue effects of bypass leakage would be minimal if the quantity of leakage was low. At Vermont Yankee the original stainless steel thermal sleeves were machined to have an 0.004" average gap. In the original design calculations, GE calculated the bypass leakage with this gap to be in excess of 100 GPM. Therefore, in 1976 when the feedwater inspection and repair work was performed, a significantly improved design was used for the replacement thermal sleeves.

The original feedwater nozzle stainless steel thermal sleeves were replaced in 1976 with the inconel interference fit assemblies. These assemblies were machined oversize, 0.010" ±0.003", nitrogen cooled, and press fit into position. Inconel material was selected over stainless steel due to its more desirable thermal characteristics. Inconel has a lower coefficient of thermal expansion than stainless steel. The interference fit inconel sleeve will maintain a tighter fit than a sleeve made of stainless steel, significantly reducing or eliminating bypass leakage.

In 1982, Vermont Yankee added a specially developed leak detection system. This system uses thermocouples to monitor vessel temperature at the nozzle metal surface. During steady state conditions, when feedwater flow and reactor and feedwater temperature are constant, changes in metal temperature readings at these thermocouples are indicative of changes in bypass leakage. Vermont Yankee has monitored this system on a weekly basis since 1982.

It has been generally concluded, after much research on the feedwater nozzle fatigue cracking issue, that shallow cracks in the 0.25" and smaller range are primarily caused by high cycle mixing of reactor water and cooler feedwater. As mentioned previously, the high frequency nature of this mixing is expected to propagate shallow cracks to a depth of 0.25" through the cladding in a matter of months. At this point, the effect of high cycle mixing diminishes, and system cycling, such as heatup/cooldown or scram events, is required to cause further fatigue crack growth. Because system cycles such as scrams and heatup/cooldowns are typically infrequent, crack growth in this stage is at a much slower process.

Vermont Yankee has also developed a detailed fracture mechanics model to estimate future fatigue crack growth based on projected feedwater nozzle and reactor operating cycles, projected bypass leak rate, and flaw size.

Since Vermont Yankee's last relief request, specific evaluations to determine flaw growth over a startup/shutdown cycle for Vermont Yankee have been conducted using a conservative representation of startup/shutdown transients based on Vermont Yankee experience.

The allowable flaw size for the Vermont Yankee feedwater nozzles, determined using the methodology of ASME Section XI, was found to be 0.823", (0.635" subclad flaw depth considering the nominal 3/16" clad thickness).

Based on a flaw depth of 0.50" (0.312" in the base material), the plant specific fracture mechanics analysis concludes that it would require in excess of 35 startup/shutdown cycles before ASME Section XI allowable flaw size by analysis is reached. Because the UT exam method can confidently identify flaws in excess of 0.25" in the base metal, a 0.50" flaw size was used to envelope clad plus base metal flaw depths. Based on Vermont Yankee's recent operating record, it would require more than 5 operating cycles for an undetected flaw to grow to the ASME Section XI (by analysis) allowable flaw size of 0.823" (0.635" subclad flaw depth).

This evaluation indicates that if a UT examination is performed which can confidently identify flaws that are 0.25" or greater, and if no flaws are detected, then Vermont Yankee can safely operate many additional fuel cycles without exceeding the allowable 0.823" flaw size.

The manual UT examinations that have been performed to date at Vermont Yankee have not detected any recordable indications. The most recent examination (1992) was enhanced by using search units that were optimized using computer aided design (CAD). The technique is capable of detecting EDM notches in the Vermont Yankee feedwater nozzle mockup. There were no scanning restrictions for the manual UT examination.

It is Vermont Yankee's position that the combination of improved thermal sleeve design and improvements in feedwater system operation to minimize thermal cycling have successfully eliminated significant flaw growth in the reactor pressure vessel feedwater nozzles. Any additional invessel work, including PT examination, clad removal, or thermal sleeve replacement would only be warranted if additional flaw growth is detected.

Therefore, Vermont Yankee concludes that the nozzle cracking issue has been adequately addressed by:

1. Reducing or eliminating the flaw initiating leakage by replacement of the original sparger design with the improved press fit design.

2. Incorporation of the thermal leakage detection monitoring program.

3. Improving system operations to minimize thermal cycling.

4. Performing the enhanced manual UT examinations.

5. Showing by analysis that an assumed flaw even as large as 0.50" would not grow to exceed the allowable 0.823" in 35 startup/shutdown cycles.

ACTIONS IN LIEU OF REQUIREMENT

In lieu of draining the vessel to expose the nozzles, removing spargers as necessary, performing in-vessel PT examinations, and performing manual UT examinations from the vessel exterior every outage, the following plan is proposed:

1. Perform the automated UT in 1995 and at intervals not to exceed every fourth refueling cycle.

2. Future automated UT's will be performed at conservative intervals based on:

    a. Largest undetected flaw size.

    b. Projected startup/shutdown cycles.

    c. ASME allowable flaw size by calculations.

    d. Fracture mechanics crack growth model.

    The longest inspection interval will not exceed four operating cycles. In the event relevant service-induced indications are discovered in the inner radius or nozzle bore, the inspection frequency will be adjusted to ensure adequate tracking and assessment of those indications. The flaw size used for analysis purposes will be that determined by the ultrasonic sizing technique.

3. Maintain a cumulative account of the number of thermal cycles to ensure that current thermal duty is enveloped by the design basis duty used in the fracture mechanics flaw growth prediction and that additional analysis is initiated, if necessary.

4. Maintain the existing thermal leakage monitoring system program.

5. Continue to perform the in-vessel visual examination of the spargers on the current two cycle interval.