April 26, 2005

Mr. Gary C. Park, Chairman
ASME Subcommittee on Nuclear Inservice Inspection
Monticello Nuclear Generating Facility
2807 W. County Rd 75
Monticello, MN 55362-9601

Dear Mr. Park:

The ASME Section XI Task Group on Alloy 600/182/82 Issues was created to address the safety concerns associated with primary water stress corrosion cracking in the areas of examination, repair and replacement requirements that modify or supplement current requirements of the ASME Code for Alloy 600/182/82 pressure boundary applications. In the area of long-term reactor pressure vessel upper head inspections, proposed Code Case N-729, "Alternative Examination Requirements for PWR Reactor Vessel Upper Heads With Nozzles Having Pressure-Retaining Partial-Penetration Welds," was developed and is currently under consideration by the Section XI Subcommittee.

Various representatives of the EPRI Materials Reliability Program, the Nuclear Energy Institute, and individuals who have been involved in the technical development of Code Case N-729 met with members of the Nuclear Regulatory Commission (NRC) staff on March 22, 2005, in Rockville, Maryland, to discuss NRC staff comments on the proposed Code Case. The issues discussed involved inspection requirements with which the NRC had previously expressed concern during past Section XI Subcommittee and Task Group meetings. Overall, the Code Case represents a significant step forward in addressing inspection requirements for reactor vessel head penetrations and welds. However, the NRC continues to believe that certain provisions in the Code Case are not appropriate at this time. Enclosed are the NRC staff's recommendations resulting from the March 22 meeting. My staff and I look forward to continuing our discussions on these issues during the next ASME Code Meetings in May.

Sincerely,

/RA/

Michael E. Mayfield, Director
Division of Engineering
Office of Nuclear Reactor Regulation
U.S. Nuclear Regulatory Commission

Enclosure: As stated

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SUMMARY OF ISSUES WITH CODE CASE N-729, ALTERNATIVE EXAMINATION REQUIREMENTS FOR PRESSURIZED-WATER REACTOR (PWR) CLOSURE HEADS WITH NOZZLES HAVING PRESSURE-RETAINING PARTIAL-PENETRATION WELDS

The Nuclear Regulatory Commission (NRC) staff is in favor of the development of ASME Code inspection requirements and criteria for upper vessel heads and penetrations. However, the basis of the proposed Code Case requirements would imply that leakage is acceptable as long as ejection and structural integrity due to wastage isn't likely to occur. All of the reactor pressure vessel (RPV) head penetration and associated weld examinations required by the NRC to date, have been based on the premise of preventing leakage from these components as well as assuring their structural integrity. Therefore, the NRC staff's position for reactor pressure vessel upper head inspections is that if an active degradation mechanism is identified as present, any long term inspection plan should be based on assuring an extremely low probability of abnormal leakage rather than allowing leakage and demonstrating the acceptability of its occurrence. Consistent with this position, the staff offers the following comments on the proposed Code Case.

1. The NRC staff disagrees with a nondestructive examination (NDE) reinspection frequency of every 10 calendar years for "resistant" materials beyond the first 10 years.

   The NRC staff recommends changing the "Extent and Frequency of Examination" of Item No. B4.40 in Table 1 to be every fourth refueling outage or seven calender years, whichever is less, after the first ten-year inspection interval.

   The recommendation is based on limited crack initiation and growth data on the Alloy 152/52 weld metal and anticipated increased susceptibility of replaced U.S. RPV heads versus international experience. Consensus primary water stress-corrossion cracking (PWSCC) crack growth rates for Alloy 152/52 weld metal have not been developed. Also, it is known that a number of replacement RPV heads in the U.S., recently placed into service, have J-groove welds that have undergone repairs and which contain a number of fabrication flaws acceptable to construction standards. The NRC staff acknowledges that current operating experience shows the resistance of Alloy 152/52 weld material to PWSCC to be superior to that of Alloy 82/182. However, short term operating experience does not exist for components that contain Alloy 52/152 materials with flaws and repairs of the scope and nature found in recently replaced U.S. RPV heads. Therefore, until sufficient experience exists for components with these types of repairs and flaws, the staff finds that a long term inspection plan which conservatively assumes flaw susceptibility increases similar to Alloy 600 is appropriate for the short term.

   RPV head temperatures at numerous international plants with replaced RPV upper heads are significantly less than U.S. upper head temperatures. NRC staff's communications with foreign regulators, and analysis of head replacement data from MRP-110, international plant operating times and RPV upper head temperatures from MRP-44 Part 2, indicate that U.S. replaced RPV heads will, within 10 years, out pace

the majority of international replaced heads in accumulation of effective degradation years. The NRC staff recognizes that other components in high temperature areas have been replaced with Alloy 690 base material and its associated Alloy 152/52 weld metal. However, there have been limited visual and non-visual NDE inspections to identify PWSCC flaws in these components, with the exception of steam generator tubes. In the case of steam generator tubing though, the residual stresses are not comparable to those of RPV head penetrations. The staff finds there is sufficient Alloy 690 laboratory data and operational experience to extend the Alloy 690 inspection frequency beyond current requirements of NRC Order EA 03-009 (the Order), but there is insufficient operating experience at this time to support a 10 calendar year reinspection frequency beyond the first 10 years.

2. The NRC staff disagrees with Table 1, Notes (1)(a) and (b) that the volumetric examination coverage of > 95% is sufficient to ensure adequate examination coverage to identify PWSCC. Also, the staff recommends that a definition other than the Code definition of essentially 100% (i.e. > ~90%) is needed for Notes (7) and (9) to ensure adequacy of those examinations.

   The NRC staff recommends revising Table 1 such that 100% inspections are performed for volumetric and surface examinations. Further the staff recommends changes to Table 1 such that 100% inspections are performed for visual examinations of the penetration nozzle to RPV head interface.

   The recommendation for volumetric and surface examinations is based on the nature of PWSCC. The NRC staff's position for reactor pressure vessel upper head inspections is any long term inspection plan should have the goal of preventing or minimizing the probability of leakage rather than accepting that leaks will occur. The proposed coverage requirements don't achieve that goal.

   Review of licensee inspection reports and MRP-110 data analysis shows that approximately 20% of all leaking penetrations have also developed circumferential flaws in the base material at or above the J-groove weld level. Bare metal visual examinations for plants less than eight effective degradation years (EDY) are performed every five years and may be the only examinations performed to identify PWSCC in a penetration in an eight or ten year period. This visual examination and its associated method to detect leakage is significantly different than general ASME Code visual inspections of piping which would require large axial or circumferential flaws to challenge the pressure boundary or structural integrity. In performing a visual examination (VE) of only 90% of the penetration nozzle to RPV head interface, small amounts of leakage could be missed - leakage which could be the only indication of developing circumferential flaws and degradation of the RPV low alloy steel head. Relief would remain available if a nozzle could not be 100% bare metal visual (BMV) inspected and alternative inspections may be performed.

3. The NRC staff disagrees with the view that the reinspection interval of two outages after a plant has identified a PWSCC flaw is sufficient.

The NRC staff recommends that Table 1, Note (5) require that if PWSCC flaws have been detected, either acceptable or unacceptable for continued service under -3130 or -3140, then the reinspection interval should be each outage.

The recommendation is based upon operating experience and the fact that several elements of PWSCC susceptibility are not fully included in the susceptibility and probabilistic models of the proposed Code Case. At least nine plants have identified additional or increased occurrence of PWSCC after the first inspection which identified the degradation mechanism. One plant identified at least four new flaws greater than 50% through-wall in one operational cycle of crack growth. While there is a possibility that these flaws were present in the previous outage and not detected, absent compelling evidence to the contrary, this inspection data must be considered as valid. Therefore similarly sized flaws may be missed in examinations conducted at any other facility.

The MRP-55 crack growth curve for Alloy 600 is not a bounding crack growth curve and is based on laboratory data. Additional factors may affect the PWSCC mechanism in RPV upper head penetrations which were not fully analyzed in the laboratory tested material. These factors include the welding process, heats of material with greater susceptibility to crack initiation and crack growth, and cold work in the field or during manufacturing conditions. If a plant is found to have a PWSCC flaw, the flaw may be due to any one or a combination of the above mentioned susceptibility factors. Therefore, the plant may not be bounded by the proposed Code Case's PWSCC model. As such, the NRC staff's recommendation for the proposed Code Case is that once a plant has identified PWSCC in a RPV head penetration or J-groove weld, that plant should perform visual and volumetric and/or surface examinations each outage, an approach consistent with the Order.

4. The NRC staff disagrees with the extended inspection regime of 3.0 reinspection years (RIY) and recommends that it be removed. Further the NRC recommends that for the proposed Code Case, surface examination of all J-groove welds in addition to a volumetric examination should be required.

The NRC staff recommends removal of Note (6) of Table 1 and Level 2 and 3 examinations under Note (1) of Table 1. The NRC staff also recommends modifying Note (1) to reflect the following, "**Volumetric or surface examination of the required examination volume or equivalent surfaces of the nozzle tube. Volumetric and surface examinations both include surface examination of all J-groove welds.** If a surface examination is being substituted for a volumetric examination on a portion of a penetration nozzle that is below the toe of the weld [E on Fig. 2], the surface examination shall be of the inside and outside surface of the penetration nozzle not examined volumetrically."

The NRC staff disagrees that surface examinations of welds in conjunction with the volumetric examination justifies an extension of one or two outages (i.e., 3.0 RIY) before performing non-visual NDE. This is based on the highly accelerated crack growth rates identified in Alloy 182/82 weld material and the heat effected zone of the Alloy 600 base material. These crack growth rates are such that a flaw could grow through-weld in less than one outage. A surface examination of the weld would not provide additional

assurance that a penetration nozzle will not develop flaws during the time between inspections associated with the inspection frequency of eight to ten years for cold head plants.

The MRP stated that their probabilistic analysis showed that relatively little difference exists between the risk of failure between a 2.25 RIY and 3.0 RIY reinspection frequency for non-visual NDE. As stated earlier, the staff's view is that the underlying premise of RPV head penetration and associated weld inspections is to prevent or minimize the probability of leakage from these locations, as well as to assure structural integrity.

The probabilistic model is based on an assumption of no cracking in colder RPV head penetrations or welds, an assumption that may be premature given that baseline non-visual NDE has not been performed on 23 of these colder head temperature plants. PWSCC flaws have been identified internationally in similarly cold head plants' penetration nozzles and associated welds. In the U.S., PWSCC has been identified in similarly cold temperature environments. Even a few instances of PWSCC in the colder RPV head sub-population could significantly change the probabilistic model on which the Code Case is based. Therefor the probabilistic model does not provide an adequate basis for extending the non-visual NDE inspection frequency at this time.

The recommendation for surface examinations of all J-groove welds is based on the need for a defense-in-depth method to back up the bare metal visual inspection for leakage through the J-groove weld. This is consistent with the Order which requires such a volumetric leak path assessment in conjunction with a volumetric examination of the penetration. Because of the surface examination technology available at the time the Order was developed, the NRC accepted ultrasonic (UT) leak path assessments as a surrogate for a surface examination of the J-groove weld. However, it has been asserted recently by members of the ASME Code Task Group on Alloy 600 that volumetric leak path assessments which indirectly assess the integrity of the J-groove weld have not been reliably demonstrated or qualified through the ASME Code process. Therefore, surface examinations of the J-groove weld provide a reasonable supplemental method to ensure an effective examination, rather than providing a basis to extend the reinspection frequency from 2.25 RIY to 3.0 RIY.

5. The NRC staff recommends that when relevant indications of leakage are identified, rounded surface indications in the J-groove weld be investigated.

The NRC staff recommends that Paragraph -3132.1 (b) should be revised to reflect the following, "A component whose surface examination of the partial-penetration weld detects linear indications of any size, **or rounded indications if other relevant indications of leakage exist,** shall be corrected in accordance with the provisions of -3132.2."

This recommendation is based on operational experience with rounded surface indications in J-groove welds which when further investigated, revealed linear extent and depth. At one plant, surface examinations of two penetration J-groove welds were performed due to relevant indications of leakage through the welds. Two rounded surface indications, one found in each penetration J-groove weld, were initially found to

be acceptable by ASME Code Section III. However, upon further evaluation, including mechanical removal methods, the rounded indications were found to be flaws that turned linear and became rejectable. Other plants have identified small surface indications which when further investigated lead to large PWSCC flaws in the weld metal. Therefore, rounded indications should be further investigated and dispositioned (removed/repaired) if other relevant indications of leakage from the penetration have been identified (e.g. masking boric acid around penetrations found during RPV head BMV, indications of leakage in RPV head BMV, positive signal from the UT leak path assessment).

6. The NRC staff recommends that during visual examinations, if a penetration nozzle's interface with the RPV head is masked by boron or other debris that cannot easily be removed, a volumetric and/or surface examination should be performed.

   The NRC staff recommends revising paragraph -3141(c) to state the following, "Relevant conditions for the purpose of the VE [visual examination] shall include areas of corrosion, boric acid deposits, discoloration, other evidence of nozzle leakage, **or masked conditions which prevent a fully effective VE**." The NRC staff also recommends changing paragraph -3142.1(c) to the following, "A nozzle whose VE indicates relevant conditions indicative of possible nozzle leakage **or masked conditions which prevent a fully effective visual examination** shall be unacceptable for continued service unless it meets the requirements of -3142.2 or -3142.3."

   This recommendation is provided to clarify the conditions which should require further investigation of a penetration nozzle if a fully effective visual examination for leakage from the penetration nozzle or associated J-groove weld is not possible. The issue addressed by this clarification is that leakage from above the head can mask indication of leakage from a penetration. This masking would therefore prevent a positive indication of leakage coming from the penetration nozzle or associated J-groove weld. The proposed Code Case would appear to allow classification of the leakage as coming from above without further justification, and thus, no further action would be required that outage. This situation is inconsistent with achieving the goal of effective examination. A more appropriate approach is that if a visual examination of a penetration nozzle to RPV head interface is masked, whether it is due to leakage from above or tightly adhering debris, then the inspection is not complete and a volumetric and or surface examination of the penetration nozzle and associated J-groove weld would be required.

7. The NRC staff disagrees with -2500 of the proposed Code Case which specifies that volumetric and surface examinations shall be qualified in accordance with the low rigor requirements of Article 14 of Section V. Because Section XI, Appendix VIII does not address the inspection requirements of these components, the NRC staff recommends revising -2500 to reflect that qualification of UT and ET personnel, procedures and equipment, consistent with the intent of Section XI, Appendix VIII.

This recommendation is provided to ensure reliable and effective examinations are performed. Performance demonstration requirements in the past have increased the effectiveness of examinations. Because of the emphasis placed on inspections of the penetrations, it is prudent to incorporate requirements for a robust demonstration of the ability of personnel, procedures and equipment to reliably detect and quantify cracking and leakage.

8. The NRC staff recommends adding a requirement to ensure the VEs performed under this proposed Code Case are applicable to RPV upper heads with penetration nozzles having interference fits which open up during operation to allow leakage to be detected through a visual examination.

   The NRC staff recommends adding a note to Table 1 applicable to the VE "Examination Method" for items B4.10 and B4.30 to ensure that these requirements apply to RPV upper heads with penetration nozzles having interference fits which open up to provide a leak path for leakage to be observed through the VE. If a penetration nozzle's interference fit is found not to provide a leak path for leakage to be observed through a VE, then that penetration nozzle would be required to be inspected in accordance with items B4.20 or B4.40 as applicable in lieu of the VE.

   This recommendation is necessary for current and future RPV heads to ensure an effective VE can be performed for all penetration nozzles. MRP-104, "Materials Reliability Program: RV Head Nozzle and Weld Safety Assessment for Westinghouse and Combustion Engineering Plants," Section 2.4.2, "Effect of Interference on Inspectability," indicates leakage may not be detectable by an external visual observation for about 5% of nozzles evaluated in the report.