September 5, 2002

Mr. Thomas Coutu
Site Vice President and Interim Plant Manager
Kewaunee Nuclear Power Plant
Nuclear Management Company, LLC
N490 State Highway 42
Kewaunee, WI 54216

SUBJECT: KEWAUNEE NUCLEAR POWER PLANT - REVIEW OF LEAK-BEFORE-BREAK EVALUATION FOR THE RESIDUAL HEAT REMOVAL, ACCUMULATOR INJECTION LINE, AND SAFETY INJECTION SYSTEM (TAC NO. MB1301)

Dear Mr. Coutu:

By letter dated February 23, 2001, supplements dated February 28, and June 24, 2002, the Nuclear Management Company, LLC (NMC) submitted a request for the Nuclear Regulatory Commission (NRC) to review and approve the leak-before-break (LBB) evaluation at the Kewaunee Nuclear Power Plant (KNPP) for portions of the residual heat removal, accumulator injection line, and safety injection system piping. The submittal was made in accordance with the provisions of Title 10 of the *Code of Federal Regulations*, Part 50, Appendix A, General Design Criteria 4, which permits licensees to exclude the dynamic effects associated with postulated pipe ruptures from the facility's licensing basis if "analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping." The NRC has accepted the use of LBB evaluations consistent with the guidance provided in NRC NUREG-1061, Volume 3, "Report of the U.S. Nuclear Regulatory Commission Piping Review Committee, Evaluation of Potential for Pipe Breaks," and Draft Standard Review Plan Section 3.6.3, "Leak-Before-Break Evaluation Procedures," as providing such a demonstration.

The NRC staff has completed its evaluation of the information submitted by NMC. The information provided by NMC was sufficient for the NRC staff to verify, through the use of independent NRC staff evaluations, that NMC's evaluation was consistent with the aforementioned NRC staff guidance and that the results of the NMC and NRC staff's evaluations support the approval of LBB for the KNPP piping segments addressed in the submittal.

The enclosed safety evaluation documents the NRC staff's conclusions. This completes our efforts for TAC No. MB1301.

Sincerely,

/RA/

John G. Lamb, Project Manager, Section 1
Project Directorate III
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-305

Enclosure: Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION OF THE REQUEST TO APPLY LEAK-BEFORE-BREAK

STATUS TO THE RESIDUAL HEAT REMOVAL (RHR), ACCUMULATOR INJECTION LINE,

AND SAFETY INJECTION SYSTEM (SIS) PIPING AT

KEWAUNEE NUCLEAR POWER PLANT

1.0 INTRODUCTION

By letter dated February 23, 2001, the Nuclear Management Company, LLC (NMC), the licensee for the Kewaunee Nuclear Power Plant (KNPP), submitted a request for the United States Nuclear Regulatory Commission (NRC) review and approval of their leak-before-break (LBB) evaluations for portions of the KNPP residual heat removal (RHR), accumulator injection, and safety injection system (SIS) piping.[1] In their submittal, NMC included Structural Integrity Associates topical report SIR-00-045, "Leak-Before-Break Evaluation, 6-inch to 12-inch Safety Injection and Residual Heat Removal Piping Attached to the Reactor Coolant System (RCS), Kewaunee Nuclear Power Plant," which provided the technical basis for their request. The NRC issued requests for additional information (RAIs) regarding the licensee's submittal on January 31, 2002, and May 23, 2002.[2,3] NMC supplemented the information in their original submittal by letters dated February 28, 2002, and June 24, 2002, in response to the NRC staff's RAI.[4,5] The June 24, 2002, NMC submittal also included Revision 1 to SIR-00-045. The NMC submittal was made to support the exclusion of the dynamic effects of pipe rupture from the KNPP licensing basis.

2.0 REGULATORY EVALUATION

As addressed in Title 10 of the Code of Federal Regulations Part 50, Appendix A, General Design Criteria 4, nuclear power plant structures, systems, and components important to safety shall be appropriately protected against dynamic effects, including the effects of missiles, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit. However, dynamic effects associated with postulated pipe ruptures may be excluded from the facility design (or licensing) basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping. Formal, rigorous, LBB evaluations consistent with NRC staff guidance (e.g., NUREG-1061, Volume 3, draft Standard Review Plan 3.6.3) have been accepted by the staff as an acceptable demonstration of this extremely low probability of piping rupture.[6,7]

LBB evaluations also rely in part on the capability of a facility's RCS leakage detection system. NRC Regulatory Guide 1.45 provides staff guidance on the design and evaluation of RCS leakage detection systems.[8]

3.0 TECHNICAL EVALUATION

3.1 Licensee's Evaluation

This section of this safety evaluation (SE) describes: (1) the scope (i.e., piping segments evaluated) of the licensee's LBB evaluations, (2) the licensee's evaluation of the RCS leakage detection system capability, (3) the analysis methodology used by the licensee in their LBB evaluation, and (4) the results of the licensee's analysis and their conclusions regarding the application of LBB to the subject piping segments.

3.1.1 Scope of the Licensee's LBB Evaluation

In Reference 5, NMC defined the scope of the piping within the RHR, accumulator injection, and SI system piping for which they sought to apply LBB. For the RHR system, the licensee's LBB evaluation addressed the 8-inch diameter nominal pipe size (NPS) piping in RHR Loop A from its connection to the Loop A hot leg outlet nozzle to RHR isolation valve RHR-1A and the 8-inch NPS piping in RHR Loop B from its connection to the Loop B hot leg outlet nozzle to RHR isolation valve RHR-1B. For the SI system, the licensee's LBB evaluation addressed the 6-inch diameter NPS piping in SI Loop A from its connection to the Loop A cold leg inlet nozzle to SI check valve SI-13A and the 6-inch NPS piping in SI Loop B from its connection to the Loop B cold leg inlet nozzle to SI check valve SI-13B. For the accumulator injection system, the licensee's LBB evaluation addressed the 12-inch diameter NPS piping in accumulator injection Loop A from its connection to the Loop A cold leg to check valve SI-22A and the 12-inch NPS piping in accumulator Loop B from its connection to the Loop B cold leg to check valve SI-22B. Finally, the licensee's analysis addressed the application of LBB to one six-inch capped nozzle on each of the Loop A and Loop B hot legs.

Each of the piping sections which were analyzed for LBB behavior in this application was constructed from either schedule 140 or 160 wrought austenitic A-376, Type 316 stainless steel. The piping welds were fabricated using a gas tungsten arc welding process for the root pass and filled using a shielded metal arc welding (SMAW) process. No cast austenitic stainless steel (CASS) or Inconel Alloy 600 piping, elbows, or safe ends were used to construct the analyzed piping sections. Further, no Inconel Alloy 82 or 182 material was used in the fabrication of any welds in the analyzed piping sections.

3.1.2 Licensee Evaluation of the RCS Leakage Detection System

The capability of the RCS leakage detection system was addressed in Section 1.3 of SIR-00-045. The licensee noted that detailed information on the RCS leakage detection system is provided in Section 6.5 of the facility's Final Safety Analysis Report (FSAR) and provided their assessment regarding the four most important detection instruments/methods which contribute to the overall sensitivity of the RCS leakage detection system: (1) the R-11 Containment System Air Particulate Monitor, (2) the R-12 Containment Radiogas Monitor, (3) humidity detection instrumentation, and (4) monitoring of leakage into, and removal from, the containment sumps. As an integrated system, the licensee concluded that the RCS leakage detection system was capable of detecting a leak rate of 0.25 gallons per minute (gpm). In addition, the licensee noted that the NRC had previously acknowledged a 0.25 gpm sensitivity for the R. E. Ginna RCS leakage detection system.[9] NMC concluded that the R. E.

Ginna RCS leakage detection system was sufficiently similar to the KNPP RCS leakage detection system to also support the use of a corresponding 0.25 gpm leakage detection capability in the NMC LBB evaluation.

After reviewing the information in the licensee's submittal and the FSAR information, the NRC staff requested additional information regarding the capability and availability of those leak detection systems based on the plant operating experience. In response to the RAI, the licensee provided additional information in Reference 4 about the capability of the R-11 Containment System Air Particulate monitor, the R-12 Containment Radiogas Monitor, and the R-21 Containment Vent Monitor, under various conditions of dispersion (from 100 percent to 1 percent for particulate) and reactor coolant radioactivity (from 1 percent to 0.1 percent fuel failure). The lower bound dispersion factor value of 1 percent was corresponding to the worst case dispersion of the particulate to account for entrapment in piping insulation, plateout on containment structures and components, and sensor location mismatches. The licensee verified the assumption of complete mixing based on the sensor location and the design and operation of the containment fan coil units. The piping from containment to R-11, R-12, and R-21 is not insulated; therefore, the plateout of radionuclides on the pipe is minimized. Under the condition of 0.1 percent fuel failure along with 1 percent dispersion, the licensee has determined that R-11 is able to detect a 0.25 gpm RCS leak within 90 minutes.

In Reference 4, the licensee also determined the availability of the R-11 Containment System Air Particulate Monitor to be 98.5 percent, which was based on the data from its plant information system and plant process computer system for the period from 1997 - 2001. The licensee further discussed the redundancy and diversity of its leak detection systems as specified in its plant technical specifications. There are two RCS leak detection systems of different operating principles at the plant, and one of the two systems is sensitive to radioactivity. Either system may be out of operation for up to 12 hours provided at least one system is operational. If R-11 is found to be out-of-service (OOS), the plant can only continue to operate if within 12 hours another RCS leak detection system sensitive to radiation is placed in service. At the KNPP, this other leak detection system is a gaseous radiation monitor, R-12, or containment vent monitor, R-21. The plant operating procedures state that if R-11 is found OOS, the operators are directed to align R-21 to sample containment. The licensee also stated that both R-21 and R-12 are capable of detecting RCS leakage of 0.25 gpm within 20 minutes assuming 0.1 percent fuel failure and 100 percent dispersion.

3.1.3 Licensee's LBB Evaluation Methodology

The licensee's LBB evaluation methodology is summarized in topical report SIR-00-045 and additional information regarding it was provided in Reference 5. The following description briefly addresses general aspects of the licensee's methodology which are consistent with methodologies which have served as the basis for prior LBB submittals by other licensees.[9] Specific aspects of the licensee's methodology, which are atypical when compared to the methodologies used to support a majority of prior NRC staff LBB approvals, are discussed in additional detail.

The licensee's general methodology was constructed around analytical concepts consistent with the guidance provided in References 6 and 7. First, the licensee established that for the subject piping segments that no active degradation mechanisms (flow accelerated corrosion, stress corrosion cracking, fatigue) were expected in the subject piping. Further, the licensee established that no unanalyzable loading events (water hammer) would be expected to occur in the subject piping systems. The evaluation of these topics was provided in Section 3.0 of SIR-00-0145.

Next, the licensee established material property parameters, operating conditions, and piping moments and membrane stresses for use in their LBB analyses. The material property parameters used in the licensee's analysis were given in Section 4.2 and summarized in Table 4-2 of SIR-00-145. The material property parameters used addressed both the tensile and fracture toughness properties of the SMAW welds. The licensee chose to only analyze the SMAW welds (and not the wrought austenitic base metal material) because of their potential for low initial toughness and susceptibility to loss of toughness through thermal aging, and the SMAW welds were expected to be the most limiting material with regard to achieving acceptable margins in the LBB analysis. The licensee concluded that the tensile and fracture toughness properties used in their analysis would bound the expected behavior for fully aged SMAW weld material.

The operating conditions for which the subject piping was analyzed included 100 percent power operation at normal operating condition (NOP) and 100 percent power operation in conjunction with a safe shutdown earthquake (NOP+safe shutdown earthquake (SSE)). Although this submittal was initially made prior to the replacement of the KNPP stream generators (which occurred in Fall 2001), the pressure and temperature conditions assumed in the analysis were chosen to bound the post-steam generator replacement operating conditions. The piping moments (summed algebraically) considered in the licensee's LBB evaluation included those due to pressure, dead weight, and thermal expansion under NOP conditions and pressure, dead weight, thermal expansion, and SSE inertia under NOP+SSE conditions. The piping membrane stresses (as related to axial loads and summed algebraically) used in the analyses were limited to the contribution from internal pressure since the "[a]xial loads due to dead weight, thermal expansion, and seismic were not available from the piping stress analysis....The stresses due to axial loads [from these sources] are not significant compared to those from pressure loads, so their exclusion does not significantly affect the results of the evaluation." Since the NRC staff guidance on LBB evaluations effectively requests that all axial loading sources be considered in an LBB evaluation, the NRC staff requested additional information from the licensee to support this assumption.[6,7] NMC provided additional information to support their assumption in their response to NRC staff Question #5 in Reference 5.

Based on the material property, operation condition, and loading information noted above, the licensee implemented their LBB evaluation. Their process involved first defining the "critical crack lengths," the length of a throughwall circumferential crack at every SMAW weld (nodal) location in the analyzed piping which would be predicted to lead to gross piping failure under NOP+SSE loading conditions. The licensee analyzed each nodal location for its critical flaw length using both elastic-plastic fracture mechanics (EPFM) techniques and net section collapse techniques. The final "critical crack length" for each nodal location was then taken as the minimum of the EPFM and net section collapse results. The licensee then reduced the calculated critical crack lengths by a factor of 2 and defined this quantity to be the "leakage crack lengths" for each nodal location. This relationship between the critical crack length and leakage crack length results from the guidance in References 6 and 7 which specifies that a "margin" or "safety factor" of 2 should exist between the critical and leakage crack lengths in an acceptable LBB evaluation.

Having now defined the leakage crack length for each nodal location, the licensee then assessed the rate of leakage (in gpm) expected from the leakage crack length at each nodal location based on the NOP moments and stresses and assumed crack morphology parameters. The important crack morphology parameters required for an LBB evaluation are the surface roughness and number of turns (45 degree and/or 90 degree) along the plane of the crack. The crack morphology parameters are important because they define the impedance to fluid flow which occurs as a result of the crack not being a smooth throughwall slit in the piping. The licensee concluded that the crack morphology parameters assumed in their LBB analysis in Reference 1 were consistent with fatigue or corrosion-fatigue crack morphology observations. The licensee then determined the projected leakage at each nodal location through the use of the PICEP (Pipe Crack Evaluation Program), Revision 1 analytic code.[10] The rate of leakage calculated for each nodal locations' leakage crack length was then compared to the established sensitivity of the KNPP RCS leakage detection system (see Section 3.1.2 of this SE). For an acceptable LBB evaluation, the rate of leakage from each nodal location's leakage crack length should be greater than the facility's leakage detection capability by a factor of 10.[6,7] Hence, for KNPP, the licensee demonstrated that each nodal location's leakage crack length would leak at a rate equal to, or greater than 2.5 gpm under NOP loading conditions.

Two additional considerations, which were not addressed in prior LBB evaluations because they either did not apply or because a technical issue was not known to exist, were then addressed by the licensee. The first of these was addressed in the licensee's initial submittal and resulted from the licensee's request to apply LBB to unusually small diameter piping systems, in particular the 6-inch NPS lines. This consideration is termed "restraint of pressure-induced bending." Pressure-induced bending occurs when, due to the presence of a flaw at a specific location, the neutral bending axis of the pipe's cross-section becomes displaced from the pipe pressure center. This displacement causes a resultant bending moment at the flawed location. For large diameter, thick-walled piping, this effect is negligible. For small diameter piping which may have a relatively thin wall thickness, the effect may be significant. If the piping were perfectly free to rotate at the plane of a throughwall flaw, as is assumed in the computer codes used to evaluate leakage in the LBB analysis, the moment due to pressure-induced bending would increase the crack opening and increase the amount of leakage for a given leakage crack length. However, in general, facility piping systems are not perfectly free to rotate at any given location to due the presence of anchors attached to the piping system. These anchors provide a "restraint" to the pressure-induced bending and serve to reduce the crack opening area for a throughwall flaw. This restraint effect must be accounted for when LBB is applied to lines which may exhibit pressure-induced bending effects because, if it were not, a non-conservative (i.e., greater than actual) evaluation of the leakage would result.

Consistent with guidance provided in NUREG/CR-6443, the licensee evaluated the effect of the restraint of pressure-induced bending on both the 8-inch and 6-inch NPS lines in the KNPP LBB evaluation.[11] To do this, NMC evaluated lines for both KNPP and Prairie Island Units 1 and 2 (at the time SIR-00-0145 and the KNPP LBB submittal were being developed, a similar LBB application was being prepared by NMC for the Prairie Island units) to determine which of the potentially affected lines exhibited the greatest degree of stiffness, with the stiffer lines exhibiting the greatest restraint to pressure-induced bending. The licensee assessed the inherent stiffness of the KNPP and Prairie Island piping systems by examining the thermal anchor stresses at anchor locations. Based on this assessment, the licensee took the “bounding” characteristics of the stiffest systems and determined what the maximum reduction in leakage rates would be expected to be for each of the subject piping systems due to restraint of pressure-induced bending.

The second additional consideration which the licensee addressed concerned the assumed crack morphology parameters in their leakage assessment. The licensee’s use of crack morphology parameters associated with fatigue or corrosion-fatigue flaws was consistent with prior LBB evaluations which have been found to be acceptable by the NRC staff. However, in Question #6 of Reference 3, the NRC staff noted that due to recent stress corrosion cracking (SCC) events in pressurized water reactor environments, some concern exists over the continued acceptability of the fatigue or corrosion-fatigue flaw assumption for LBB evaluations. However, since the materials and specific environmental conditions associated with the lines for which NMC is requesting LBB approval have not been demonstrated to be subject to any active SCC mechanisms, the NRC staff requested only that NMC perform a leakage rate sensitivity study to further investigate how assuming different crack morphology parameters, for example ones consistent with transgranular SCC of stainless steel, would affect the margins in their LBB analysis.

Using data on stainless steel SCC from several sources, the licensee developed flaw morphology parameters which were consistent with both intergranular and transgranular SCC and provided the requested sensitivity study results in Reference 5.[12,13]

The licensee then completed their LBB analysis by demonstrating that the leakage crack size defined for each nodal location would be stable under loading conditions greater than the NOP+SSE conditions. References 6 and 7 note that the leakage crack size for each location should be demonstrated to be stable under moments and stresses which a factor of $\sqrt{2}$ greater than the NOP+SSE loads when those loads are summed algebraically. The licensee chose to perform this analysis by determining the throughwall flaw size which would fail under $\sqrt{2}$ * (NOP+SSE) loads and demonstrate that it was consistently larger than the leakage flaw size.

3.1.4 Results/Conclusions from the Licensee’s LBB Analysis

The result of the licensee’s LBB analysis for all nodal locations in the KNPP 6-inch SI system lines, 12-inch accumulator injection system lines, 8-inch RHR system lines, and 6-inch nozzles attached to the RCS hot legs are given in Tables 5-10 through 5-12 of SIR-00-0145. Given the way in which the licensee’s analysis was conducted (as noted in Section 3.1.3 of this SE), an acceptable LBB analysis result was achieved if, for each nodal location, the leakage flaw size produced a leakage rate under NOP conditions of 2.5 gpm or greater (that is, a leakage rate which is a factor of 10 greater than the 0.25 gpm RCS leakage detection system sensitivity assumed by the licensee). For the 6-inch SI system piping, the minimum leakage rate from any nodal location was 5.189 gpm. For the 12-inch accumulator injections system piping, the minimum leakage rate from any nodal location was 30.128 gpm. For the 8-inch RHR system piping, the minimum leakage rate from any nodal location was 7.480 gpm. Finally, for the 6-inch nozzles attached to the RCS hot legs, the leakage rate for the single analyzed nodal location was 3.740 gpm.

The leakage rate information cited above does not include leakage rate modifications to address the issue of restraint of pressure-induced bending. The licensee provided separate information in Tables 5-16 and 5-17 of SIR-00-0145 which indicated that the maximum leakage rate reduction due to the restraint of pressure-induced bending would be expected to be less than 0.05 gpm for nodal locations in the 6-inch KNPP SI system piping and less than 1.7 gpm for nodal locations in the 8-inch KNPP RHR system piping. The 12-inch accumulator system piping was not analyzed since its diameter and wall thickness was judged to make the effects of pressure-induced bending negligible. The 6-inch nozzles attached to the RCS hot legs were not analyzed since their capped ends were unrestrained and free to rotate. Considering these adjustments, all nodal locations in each of the analyzed piping sections would still exceed the 2.5 gpm limit established by the licensee for an acceptable LBB evaluation.

Finally, as requested by the NRC staff, the licensee presented the results of their leakage rate sensitivity study in Reference 5. For their sensitivity analysis, the licensee focused on the 6-inch nozzles attached to the RCS hot legs, which their prior results indicated had the smallest "margin" in the baseline LBB analysis. As noted in Section 3.1.3 above, the license developed flaw morphology parameters consistent with both intergranular and transgranular SCC and determined what the leakage rate would be from the leakage size flaw (5.42 inches in length) and from a flaw 1.5 times the size of the leakage size flaw (8.13 inches in length). Based on their range of credible flaw morphology parameters, the licensee concluded that the leakage rate from the leakage flaw size, if it were a SCC-type flaw, could range from 0.33 to 0.60 gpm. For a flaw 1.5 times the size of the leakage size flaw, the range of leakage rates was 3.43 to 6.63 gpm.

Based on these results, the licensee concluded that, when SCC flaw morphology parameters were considered: (1) the leakage rate from the leakage flaw size would still exceed the KNPP RCS leakage detection system capability and a margin of 2 between the leakage and critical size flaw would be maintained, or (2) a larger flaw (1.5 times the leakage size flaw) would produce sufficient leakage to maintain the prescribed margin of 10 on leakage detection while still maintaining some margin (in this case 1.33) on flaw size when compared to the critical size flaw.

3.2 <u>NRC Staff Evaluation</u>

3.2.1 Scope of the Licensee's LBB Evaluation

The NRC staff reviewed the scope of the NMC LBB evaluation and concluded that the licensee adequately defined the analyzable portions of the piping systems (as given in Section 3.1.1 of this SE) for which they sought LBB approval. The staff concluded that since the defined piping segments do not include any Inconel Alloy 600 components or Inconel Alloy 82/182 welds, they are candidates for LBB approval at this time. Inconel Alloy 600 components and Inconel Alloy 82/182 welds may be degraded by primary water SCC and are the ongoing topic of interactions between the NRC and the industry regarding actions necessary to support LBB approval on lines containing such materials.

Since no CASS piping, elbows, or safe ends were present in the piping sections that the licensee analyzed, the NRC staff agrees with the licensee's conclusion that the SMAW welds would be limiting with respect to LBB analyses when compared to the wrought austenitic base metal from which the piping was fabricated. In addition, the NRC staff reviewed the tensile and fracture toughness material property parameters provided in the licensee's analysis for aged

SMAW welds. The NRC staff concluded that the material property parameters used by the licensee were consistent with, or more conservative than, those used by the NRC staff for independent analyses in prior LBB applications.

3.2.2 NRC Staff Evaluation of the KNPP RCS Leakage Detection System

Based on the evaluation provided by the licensee regarding the KNPP RCS leakage detection system capability, availability, diversity, and redundancy, the NRC staff concluded that the KNPP leakage detection systems may be credited with the sensitivity to detect a leakage rate of 0.25 gpm in support of the requested LBB approval.

3.2.3 NRC Staff Independent LBB Evaluation Methodology

The NRC staff conducted an independent LBB analysis of limiting nodal locations in the subject piping segments as part of the review of the licencee's submittal. In this case, "limiting" nodal locations were defined as those locations for which the licensee's analysis demonstrated that the minimum margins existed for LBB approval. The NRC staff's analysis was performed in accordance with the guidance provided in NUREG-1061, Vol. 3. Based on the information submitted by the licensee, the NRC staff determined the critical flaw size at selected nodal locations for each piping system using the codes compiled in the NRC's Pipe Fracture Encyclopedia.[14] For evaluating the limiting SMAW pipe welds, the NRC staff used the LBB.ENG3 code developed by Battelle for that express purpose.[15] The LBB.ENG3 methodology is significantly different from the other codes in the Reference 13 and from the licensee's analysis in that LBB.ENG3 explicitly accounts for the differences in the stress-strain properties of the weld and an adjoining base material when determining the effective energy release from the structure with crack extension.

The NRC staff then compared the critical flaw size at the selected nodal locations to the leakage flaw size which provided 2.5 gpm of leakage under NOP conditions to determine whether the margin of 2 defined in NUREG-1061, Vol. 3 was achieved. The leakage flaw size calculation was carried out using the PICEP Program, Revision 1 analytic code.[10] The 2.5 gpm value was defined based upon the licensee's demonstration, and the NRC staff acceptance, of a 0.25 gpm leak rate detection sensitivity for the KNPP RCS leakage detection system and a factor of 10 applied to this 0.25 gpm detection capability to account for thermohydraulic uncertainties in calculating the leakage through small cracks. The stability of the leakage flaw size under loadings a factor of $\sqrt{2}$ greater than the combination of SSE+NOP loads was subsequently evaluated to check the final acceptance criteria of NUREG-1061, Vol. 3.

It should be noted that the NRC staff's evaluation did not independently address the leakage rate sensitivity study documented by the licensee in Reference 5, nor did it attempt to independently address the effect of the restraint of pressure-induced bending on the LBB analysis. Rather, concerning these issues, the NRC staff's review and conclusions were based on information provided by the licensee's analyses.

3.2.4 NRC Staff Results and Conclusions

The results of the NRC staff's independent LBB evaluation confirmed the licensee's conclusion that the subject piping sections can be shown to exhibit LBB behavior consistent with the guidance in References 6 and 7. The NRC staff's conclusion was based on the NRC staff's calculations (which used flaw morphology parameters consistent with fatigue or corrosion-fatigue flaws for the leakage evaluation) as modified by the information provided by the licensee regarding reductions in leakage rates for each which would result from the restraint of pressure-induced bending. For the portion of each system covered under the NMC submittal, the NRC staff was able to show that a margin of 2 on flaw size between the critical size flaw and leakage size flaw existed, while a margin of 10 existed between the projected leakage rate and the sensitivity of the KNPP RCS leakage detection system. Based upon this information, the NRC staff concluded that LBB had been demonstrated for the analyzed portions of the KNPP RHR, SI, and accumulator injection systems.

As supplemental information, the NRC staff also evaluated the information provided by the licensee in Reference 5 regarding the sensitivity of their LBB analysis to changing flaw morphology parameters. The changes in leakage identified in the licensee's analysis when going from fatigue flaw morphology to a SCC flaw morphology were consistent with NRC staff expectations. The NRC staff concluded that, although the licensee's analysis did not demonstrate that the standard margins of 2 and 10 on flaw size and leakage, respectively, would be met if a SCC-type flaw were assumed, the licensee's analysis did confirm that some lesser margins would be maintained.

Considering the types of material from which the subject KNPP piping segments were constructed and their operating environment, no operating experience exists which would indicate the presence of any active SCC mechanism in these lines. Based on this experience, the NRC staff concluded that there is a lower likelihood of SCC in these lines, when compared to traditional fatigue or corrosion-fatigue cracking mechanisms, such that the NRC staff can accept that the lesser margins demonstrated by the licensee's analysis were sufficient to confirm that LBB may still be granted on the portions of the piping systems for which it was requested.

4.0 CONCLUSION

The NRC concludes that based on the licensee's submittal and independent NRC staff evaluation that LBB behavior has been demonstrated for the portions of the KNPP RHR, SI, and accumulator injection systems defined in Section 3.1.1 of this SE. Based on this conclusion and consistent with 10 CFR Part 50, Appendix A, General Design Criteria 4, the licensee shall be permitted to exclude consideration of the dynamic effects associated with the postulated rupture of the analyzed portions of these KNPP systems from the KNPP design and/or licensing basis.

5.0 REFERENCES

[1] M. E. Reddemann (NMC) to U.S. Nuclear Regulatory Commission Document Control Desk, “Request to Exclude Dynamic Effects Associated with Postulated Pipe Ruptures From Licensing Basis For Residual Heat Removal, Accumulator Injection, and Safety Injection System Piping Based Upon Leak Before Break Analysis,” February 23, 2001.

[2] J. G. Lamb (USNRC) to M. Reddemann (NMC), “Kewaunee Nuclear Power Plant - Request For Additional Information Related To Request To Exclude Dynamic Effects Associated With Postulated Pipe Ruptures From Licensing Basis For Residual Heat Removal, Accumulator Injection, and Safety Injection System Piping Based On Leak Before Break Analysis (TAC No. MB1301),” January 31, 2002.

[3] J. G. Lamb (USNRC) to M. Warner (NMC), “Kewaunee Nuclear Power Plant - Request For Additional Information Related To Request To Exclude Dynamic Effects Associated With Postulated Pipe Ruptures From Licensing Basis For Residual Heat Removal, Accumulator Injection, and Safety Injection System Piping Based On Leak Before Break Analysis (TAC No. MB1301),” May 23, 2002.

[4] M. E. Warner (NMC) to U.S. Nuclear Regulatory Commission Document Control Desk, “Response to NRC Request For Additional Information Concerning Leak Before Break Analysis For Kewaunee Nuclear Power Plant,” February 28, 2002.

[5] M. E. Warner (NMC) to U.S. Nuclear Regulatory Commission Document Control Desk, “Response to NRC Request For Additional Information Concerning Leak Before Break Analysis For Kewaunee Nuclear Power Plant,” June 24, 2002.

[6] United States Nuclear Regulatory Commission NUREG-1061, Volume 3, ”Report of the U.S. Nuclear Regulatory Commission Piping Review Committee, Evaluation of Potential for Pipe Breaks,” November 1984.

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[8] United States Nuclear Regulatory Commission Regulatory Guide 1.45, “Reactor Coolant Pressure Boundary Leakage Detection Systems,” 1973.

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