DISCUSSION OF LEAK-BEFORE-BREAK

1.0 Background

By Staff Requirements Memorandum (SRM) M100415 dated May 17, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML101370261), the U.S. Nuclear Regulatory Commission (NRC) requested that the staff report on a number of aspects of the sump performance issue as it is preparing to close out Generic Safety Issue (GSI) -191, "Assessment of Debris Accumulation on Pressurized-Water Reactor Sump Performance." Among those aspects is the potential application of General Design Criterion (GDC) 4, "Environmental and Dynamic Effects Design Bases," in Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," to sump performance evaluations. In the SRM, the Commission also asked the staff discuss letters from the Nuclear Energy Institute (NEI) dated April 7, 2010 and April 27, 2010 (ADAMS Accession Nos. ML101050354 and ML102280039), and from the Union of Concerned Scientists (UCS) dated April 14, 2010 (ADAMS Accession No. ML101680215). The UCS submitted an additional letter dated April 26, 2010 (ADAMS Accession No. ML101680254), which this enclosure also discusses.

The concept of leak-before-break (LBB) as implemented in GDC 4 is based on the experimental testing and fracture mechanics analyses of pipes that have demonstrated that certain pipe material has sufficient fracture toughness (ductility) to resist a through-wall crack from becoming unstable and uncontrollable so as to prevent pipe rupture. The other aspect of LBB technology depends on the capability of the reactor coolant leakage detection system to detect the leak early enough to allow the operator to take corrective actions to avoid pipe rupture. The combination of fracture mechanics analysis and the reactor coolant leakage detection system demonstrates that the probability of a rupture for LBB-qualified piping is extremely low. After the NRC approves a licensee's LBB evaluation, the licensee may remove pipe whip restraints and jet impingement barriers.

GDC 4 and the associated Statement of Considerations provide the technical basis of the LBB application. Section 3.6.3 of NUREG-0800, "Standard Review Plan (SRP) for the Review of Safety Analysis Reports (SAR) for Nuclear Power Plants: LWR Edition" (hereafter referred to as the SRP), presents the regulatory guidance for LBB. Volume 3 of NUREG/CR-1061 describes the LBB analytical analyses.

The industry first proposed to credit LBB in the resolution of GSI-191 in a 1997 letter from the Pressurized-Water Reactor Owners Group (PWROG) and later in related letters in 2002 and 2003 from NEI. By letter dated March 4, 2004, the NRC provided four reasons for not accepting the industry's proposal (ADAMS Accession No. ML040410433). By letters dated April 7, 2010, and April 27, 2010, the industry requested that the NRC staff reconsider LBB application to the resolution of GSI-191. By letter dated April 14, 2010, UCS suggested that the NRC not give LBB credit in the resolution of GSI-191. However, in a subsequent letter dated April 26, 2010, UCS suggested that LBB credit may be appropriate in some instances.

The purpose of this enclosure is to discuss the acceptability of the LBB technology as an approach to addressing the debris generation aspect of sump strainer evaluations and thus to

support closure of GSI-191 as suggested in the NEI letters. This enclosure also discusses the UCS suggestions.

2.0 Industry's Leak-before-Break Proposal

2.1 Nuclear Energy Institute Letter Dated April 7, 2010

NEI stated in its April 7, 2010, letter that it believes that GDC 4 allows local dynamic effects associated with pipe ruptures in LBB-qualified piping to be excluded from the design bases. NEI stated that debris generation is a dynamic effect and as such should be excluded from the design basis for addressing emergency core cooling system (ECCS) performance concerns under GSI-191. This argument was similar to the arguments NEI had made in its earlier correspondence on the subject. In its March 4, 2004, letter to NEI, the staff raised concerns regarding the acceptability of applying GDC 4 to resolve the GSI-191 issues. In its April 7, 2010, letter, NEI grouped the staff's concerns into four reasons for not accepting the industry's proposal. These reasons, and the results of the NRC staff's reconsideration of each reason in light of recent NEI requests and developments since 2004, are provided below.

Reason No. 1: Application to loss-of-coolant accident (LOCA)-generated debris is not the intent of current GDC 4 rule.

In its April 2010 report, "Reconsideration of Application of GDC-4 Exclusion of Local Dynamic Effects to Local Debris Generation" (ADAMS Accession No. ML101050356), NEI cited the NRC LBB Knowledge Management Document, page 3 (Memorandum, Evans to Grobe, "Leak-Before-Break Knowledge Management Document," dated May 29, 2007, ADAMS Accession No. ML092430585) as demonstrating that application of GDC 4 extends beyond removal of pipe whip restraints and jet impingement barriers. Section C2, page 3, of the LBB Knowledge Management Document states the following:

> When LBB is approved for a particular piping system, applicants are to exclude from the design basis only local dynamic effects associated with postulated pipe ruptures in that system in the nuclear power unit. The local dynamic effects are:
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> - Missiles,
> - Pipe whipping,
> - Pipe break reaction forces, and
> - Discharging fluids.
>
> For each local dynamic effect listed above, the applicant, upon NRC approval, is permitted to perform a well-defined plant activity as a result of excluding this dynamic effect from the design basis. The permitted plant activities are, in the order of local dynamic effects:
>
> - Remove jet impingement barriers or shields,
> - Remove pipe whip restraints,
> - Redesign pipe connected components their supports and their internals, and other related changes, and

- Disregard jet impingement forces on adjacent components, decompression waves within the intact portion of the piping system, and dynamic or nonstatic pressurization in cavities, subcompartments, and compartments.

NEI also stated in its letter that local dynamic effects were excluded from LBB piping for the design of the sump strainers at Oconee Units 1 and 2.

The NRC staff does not dispute the point made by NEI that the generation of debris from jet impingement and generation of acoustic/rarefaction waves could logically be considered a dynamic effect associated with the postulated pipe rupture. However, the NRC staff did not consider the application of LBB in the LOCA-generated debris evaluations at the time the changes to GDC 4 were enacted. The NRC staff's intent when GDC 4 was modified can best be summarized by the following excerpt from the Statement of Considerations (Volume 52, page 41288, of the *Federal Register*) accompanying the final rule modifying GDC 4:

> *The Commission recognizes the need to address whether and to what extent leak-before-break analysis techniques may be used to modify present requirements relating to other features of facility design. However, this is a longer term evaluation. For the present, the proposed rule allows the removal of plant hardware which it is believed negatively affects plant performance, while not affecting emergency core cooling systems, containments, and environmental qualification of mechanical and electrical equipment*.

The staff's position is that the dynamic effects of the LBB piping can be excluded from the design basis if they are local phenomena. However, debris generation can be a global phenomenon. When a pipe ruptures, the steam/water jet exiting from the break will impinge on fibrous insulation on adjacent pipes, and some insulation will become liberated from the pipe as small pieces of transportable debris. This debris will likely fall into the sump pool or be washed into the sump pool via containment spray. Some of this debris will then transport to ECCS strainers via recirculation currents in the sump pool where clogging of the sumps can occur. Clogging of the sump strainer would lead to common-mode failure of the ECCS system and core damage. The intent of LBB technology as approved by the NRC was to eliminate pipe whip restraints and impingement barriers in nuclear power plants so that licensees have access to perform nondestructive examinations of pipes, thus increasing plant safety. It was not the intent of the GDC 4 rule to credit LBB for the containment design, ECCS performance, or post-LOCA analyses.

By letters dated August 18, 2005, and September 15, 2005, Duke Energy Corporation submitted a request to modify Oconee Nuclear Station, Units 1 and 2, Technical Specifications (TS) 3.5.2.6 and 3.5.3.6. The requested changes to the TS sections were related to the replacement of the reactor building emergency sump suction inlet trash racks and screens with new sump strainers. By letter dated November 1, 2005, the NRC approved the TS changes. Oconee demonstrated that the design function of the sump strainers would not be compromised by jet impingement or pipe whip from any pipes in the vicinity of the emergency sump. For the reactor coolant system (RCS) cold leg, the staff based its conclusion on crediting LBB technology. The staff permitted the exclusion of the dynamic effects from LBB piping for the design of the sump strainers at Oconee, Units 1 and 2, because the Oconee situation was

related to local dynamic effects on the specific equipment (the sump strainers) and is confined to the certain location of the containment. Oconee did not ask for or receive LBB credit for application to debris generation calculations, so the NRC's approval of Oconee's application does not support NEI's view that LBB should be credited for debris generation evaluations.

In the staff's opinion, one significant difference between the Commission's intent when the GDC 4 rule change was enacted to permit the use of LBB to address the dynamic effects of pipe rupture versus the current proposal made by the industry is documented in the Statement of Considerations accompanying the final rule modifying GDC 4, as quoted above. The GDC 4 rule change allowed for the removal of, for example, pipe whip restraints, which in some cases severely restricted access to the associated piping impacting inservice inspection. Hence, the Commission found enabling the use of LBB to the extent provided for in the GDC 4 rulemakings offered a potential safety benefit associated with the ability to better inspect the LBB piping and thereby reduce the likelihood of pipe rupture through the early identification of degradation mechanisms. The industry's request to expand the LBB scope does not enhance any safety benefit which has not already been realized by the original scope of LBB. The staff is unaware of any safety benefit that would be realized by expanding LBB scope to be used as the basis for not making modifications to address the sump performance issue (e.g., further enlarging strainers or replacing fibrous insulation with reflective metal insulation). On the contrary, application of LBB credit to debris generation evaluations appears to only result in a decrease in defense-in-depth.

Reason No. 2: Application of LBB to LOCA-generated debris is a detriment to defense-in-depth principles and would require Commission approval.

The staff believes excluding consideration of debris generated from LOCAs in LBB qualified piping is inconsistent with the agency's longstanding implementation of basic defense-in-depth principles. Specifically, an important consideration in defense-in-depth is that the initiating event for accidents included in a plant's licensing analyses should not result in core damage in the absence of additional independent failures. Strainer testing however has repeatedly demonstrated a significant potential for causing sump failure from LOCA-generated debris and, given a LOCA, no additional independent protection system failures are needed for debris-induced sump failure.

A second consideration in defense-in-depth is the independence of features that prevent severe accidents from those features that mitigate accident consequences. Implementation of the principle of independence of prevention and mitigation features means minimizing the likelihood that failure of a prevention feature will also fail a mitigation feature. Sump failure however causes a loss of the ECCS core cooling (a prevention feature) and also results in the loss of the containment spray system (a mitigation feature).

Therefore, the staff believes that excluding consideration of debris from LOCAs in LBB-qualified piping is inconsistent with the agency's longstanding implementation of basic defense-in-depth principles in that an initiating event in the licensing basis could proceed to a severe accident state without any additional protection system failures and could, at the same time, degrade accident mitigation systems.

In its April 7, 2010, letter, NEI stated that since 2004 every pressurized-water reactor (PWR) has installed significantly larger strainers, enhanced operational and emergency procedures, and performed conservative design analyses to demonstrate the capability of the ECCS to withstand postulated LOCAs with no credit taken for the GDC 4 exclusion. NEI suggested that application of the GDC 4 exclusion today no longer presents the potential for a significant reduction in defense-in-depth that was possible in 2003.

The staff acknowledges that PWR licensees have achieved significant progress toward resolving GSI-191 issues by installing larger strainers at all plants, reducing debris sources at some plants, and enhancing plant procedures. However, the staff does not agree that all plants have performed conservative analyses to demonstrate the capability of ECCS sump performance. Further, the significance of various aspects of the sump performance issue, such as chemical effects, is greater than was known at the time the staff denied the earlier request for LBB credit. If the staff agreed with the NEI statement that all plants have demonstrated conservative analyses, GSI-191 would be closed for all plants. Additionally, the staff does not agree with NEI that, if the GDC 4 exclusion were permitted today, defense-in-depth would not be reduced significantly. The staff believes that if the dynamic effects of LBB-qualified piping are excluded from the design basis, defense-in-depth will be reduced, notwithstanding the reduced debris sources and increased strainer size, because strainer tests have repeatedly shown that relatively small amounts of the right combination of debris types can lead to significant strainer headloss that can challenge the ECCS system. If a large break were to occur in LBB-qualified piping, it would likely generate large quantities of debris.

In addition, if LBB is permitted to be used for the global ECCS performance issue of GSI-191, it may set a precedent to apply LBB to other aspects of the plant design, such as containment design, ECCS design, or post-LOCA analyses.

Reason No. 3: Primary water stress-corrosion cracking (PWSCC) is a concern.

In its April 2010 report, NEI stated that PWSCC is a generic issue potentially affecting all past and future approval of piping systems. NEI also acknowledged that PWSCC potentially affects the piping systems for which the GDC 4 exclusion can be applied. In September 2005, the Electric Power Research Institute's Materials Reliability Program issued MRP-139, "Materials Reliability Program: Primary System Piping Butt Weld Inspection and Evaluation Guideline," which all PWR plants agreed to implement under the industry's Materials Initiative. MRP-139 provides industry guidance for the inspections of dissimilar metal butt welds in PWR primary systems and discusses volumetric inspection techniques that the industry has qualified for the detection of PWSCC. PWR licensees are addressing the potential for PWSCC to occur in Alloy 82/182 butt welds through a rigorous program of inspecting and mitigating susceptible welds.

The staff notes that piping containing Alloy 82/182 dissimilar metal welds (which exist in some LBB-qualified piping) is susceptible to PWSCC. The staff acknowledges that, since the issuance of the staff's March 4, 2004 letter, the industry and the NRC have made significant progress in resolving PWSCC in PWRs. Some PWR owners have mitigated susceptibility of PWSCC at Alloy 82/182 dissimilar butt welds by installing weld overlays or applying the mechanical stress improvement process in some LBB-qualified piping (e.g., pressurizer surge lines).

Since 2004, the staff has incorporated American Society of Mechanical Engineers (ASME) Code Case N-722, with conditions, by reference into 10 CFR 50.55a(g)(6)(ii)(E), which requires augmented visual inspection of Alloy 600 components, including Alloy 82/182 dissimilar metal welds. On June 8, 2010, the staff issued Regulatory Information Summary (RIS) 2010-07, "Regulatory Requirements for Application of Weld Overlays and Other Mitigation Techniques in Piping Systems Approved for Leak-Before-Break," which clarifies the regulatory requirements for updating the original LBB evaluation if weld overlay and other mitigation techniques have been applied to LBB piping. The staff is incorporating ASME Code Case N-770 in the proposed rule for 10 CFR 50.55a, "Codes and Standards." ASME Code Case N-770 requires PWR licensees to perform augmented inspection of Alloy 82/182 dissimilar metal welds. The staff believes that this is adequate, from a safety perspective, to address the current scope of LBB with respect to GDC 4.

However, since most PWR owners are still in the process of addressing PWSCC in Alloy 82/182 dissimilar welds in their large LBB piping (nominal diameter of 20 inches and greater) through mitigation, enhanced inspection, or both, the staff does not believe it is appropriate to expand the use of LBB beyond current application of GDC 4. If GDC 4 is expanded to be applied to resolving GSI-191 issues, the staff believes that the application of GDC 4 will require additional analyses, and potentially additional requirements and guidance, to address PWSCC in LBB piping. This may result in additional licensee costs and outage schedule impacts if the staff determines that mitigation of the nickel-Alloy 82/182 welds in LBB piping is needed to support GSI-191.

Reason No. 4: ECCS functional performance is directly affected by the containment sump performance.

In its April 7, 2010, letter, NEI stated that Section C3 of the NRC's LBB Knowledge Management Document covers the GDC 4 rule's limitations on applying LBB to containment design, ECCS, and equipment qualification. NEI stated that Section C3 of the NRC's LBB Knowledge Management Document allows local dynamic effects to be excluded from the design basis of ECCS hardware.

NEI's letter also stated that pipe rupture dynamic effects that can be excluded from an LBB applicant's plant design bases for containment, ECCS, and equipment qualification are further explained in a letter dated March 4, 2004, from Suzanne C. Black of the NRC to Anthony Pietrangelo of NEI, subject: "Nuclear Energy Institute's Proposals for Determining Limiting Pipe Break Size Used in Assessing Debris Generation Following a Design Basis LOCA." In the referenced letter, the NRC stated the following:

> Local dynamic effects uniquely associated with pipe rupture may be deleted from the design basis of containment systems, structures and boundaries, from the design basis of ECCS hardware (such as pumps, valves accumulators, and instrumentation). And from the design bases of safety related electrical and mechanical equipment when leak-before-break is accepted….

The staff notes that Section C3 of the NRC's LBB Knowledge Management Document states that "It is apparent that there is no inconsistency if one considers that although pipe whip effects and jet impingement effects are local, their effects on containment pressure boundaries and

primary structures are global…." The staff's position is that LBB may be applied to local dynamic effects but it cannot be applied to global dynamic effects. The containment systems, ECCS, and equipment qualifications are related to global effects; therefore, LBB cannot be applied to the containment systems, ECCS, and equipment qualifications. The staff considers debris generation in the GSI-191 issue to be a global effect.

Furthermore, Section C4 of the NRC's LBB Knowledge Management Document gives examples of LBB applications that have been approved and rejected and includes the following example in which an industry request to apply LBB to debris generation related to sump performance was rejected:

> Example 2: Containment sump performance
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> This issue concerns a proposed containment sump strainer performance requirement. Specifically, the industry requested that local debris generation due to the dynamic effects associated with the postulated double-ended guillotine breaks of LBB-approved piping be excluded from facility design and licensing basis. The LBB application was rejected in 2004 because: (1) although an acceptable LBB evaluation provides assurance with regard to the low probability of piping failure, it is consistent with the Commission's defense-in-depth principle, given the consequences of sump failure, to expect containment sump operability under such circumstances, (2) the NRC staff concluded that any decision to extend LBB for the purpose of addressing LOCA-generated debris and sump performance to the detriment of defense-in-depth principles is, at a minimum, a policy decision which would require Commission approval, and (3) PWSCC was a concern.
>
> Although one may not consider the sumps serving the ECCS and the containment spray system part of the ECCS, the ECCS functional performance is directly affected by the containment sump performance. Therefore, requiring the dynamic effects such as debris generation associated with the postulated DEGBs [double-ended guillotine breaks] of LBB-approved piping be included in the sump performance evaluation is a logical extrapolation of the Section C3 limitations on LBB.

Lastly, the staff has noted the following Commission's statement in the SRM dated July 1, 2004, related to SECY-04-0037, "Issues Related to Proposed Rulemaking to Risk-Inform Requirements Related to Large Break Loss-Of-Coolant Accident (LOCA) Break Size and Plans for Rulemaking on LOCA with Coincident Loss-Of-Offsite Power," dated March 3, 2004, regarding the risk informing of ECCS acceptance criteria:

> Licensees should be required, by regulation, to retain the capability to successfully mitigate the full spectrum of LOCAs for break sizes between the new maximum break size and the double-ended guillotine break of the largest pipe in the reactor coolant system

The staff believes that allowing LBB to be used as the basis for not removing sources of debris, such as fibrous insulation, which may prevent the ECCS system from performing its design

function in the event of a double-ended guillotine break of the largest pipe in the RCS, would seem contrary to the ability of licensees to "successfully mitigate the full spectrum of LOCAs," even under severe accident mitigation strategies.

The staff concludes that the above four reasons and considerations are still appropriate today; therefore, they do not support a basis to expand the application of LBB to GSI-191.

2.2 Nuclear Energy Institute Letter Dated April 27, 2010

In a letter dated April 27, 2010, NEI provided information to support the two resolution paths discussed during the Commission briefing on April 15, 2010: (1) use of the GDC 4 rule, and (2) potential use of proposed changes to 10 CFR 50.46, "Acceptance Criteria for Emergency Core Cooling Systems for Light-Water Nuclear Power Reactors" (e.g., redefine large break LOCA). NEI cited the NRC LBB Knowledge Management Document, which permits the local dynamic effects from the break of a LBB piping to be excluded from the debris generation calculation.

NEI stated the following:

> To deny application of GDC-4 to debris generation introduces a major inconsistency in the rule application…Several PWRs currently exclude, under GDC-4, local dynamic effects from breaks that would directly impinge upon the strainers. Local dynamic effects that directly impact strainer operation are allowed to be excluded, yet exclusion of local dynamic effects that indirectly impact the strainers through debris generation is not allowed….

As discussed under Reason No. 1 in Section 2.1 of this enclosure, the NRC staff approved the use of LBB in the strainer modification at Oconee because Oconee was able to demonstrate that the jet impingement from the LBB pipe on the strainer was a local dynamic effect. In general, the NRC staff considers use of LBB on the plant-specific strainers acceptable within the GDC 4 rule; however, use of LBB on debris generation is beyond the scope of the GDC 4 rule, as discussed above. The jet exiting from certain pipe break locations that directly impinges on the sump strainer may be considered a local dynamic effect. However, debris generation is a global dynamic effect because the fibrous insulation could travel in the containment over a much wider area. The debris could eventually clog the sump strainer and degrade the ECCS performance. The staff's position is that LBB would not be permitted to be applied to this global dynamic effect.

NEI further stated the following:

> because PWR designs and supporting analyses do not exclude debris generation for GDC-4 qualified piping systems, the designs conservatively account for debris generation for the full spectrum of breaks, up to and including a full double-ended guillotine break of the largest pipe in the reactor coolant system.

The NRC staff agrees that PWRs are conservatively designed to consider the full spectrum of pipe breaks, and this design approach should continue to be maintained.

According to NEI, in applying GDC 4 to debris generation, the existing debris generation calculations and strainer designs, based on the full break spectrum, would continue to stand. To demonstrate compliance with 10 CFR 50.46 and resolve GSI-191, a licensee would need to show that existing calculations conservatively bound debris generation for breaks in piping systems that do not meet GDC 4 qualification requirements. This could be accomplished using debris generation modeling readily acceptable to the NRC staff, and any deltas between calculated and tested debris volumes would be retained as margin. If GDC 4 credit is applied for GSI-191, the NRC staff agrees with NEI that, for those pipes that have not been approved for LBB, pipe breaks will have to be postulated and debris generation resulting from the breaks should be evaluated.

NEI stated the following:

> Although local debris generation would be excluded for LBB-qualified piping, debris generation would continue to be assessed for non-LBB qualified piping systems. For most PWRs, the largest non-LBB piping is approximately 12" in diameter. The debris generation assessment for non-LBB piping is greatly simplified in instances where it can be shown that current calculations and strainer test results for postulated breaks in large bore piping (LBB qualified piping) bound the debris generation for postulated breaks in non-LBB piping. Such bounding assessments would enable PWRs to demonstrate that current designs meet 10 CFR 50.46 acceptance criteria, using NRC approved methods, with minimal additional effort….

To the extent these statements can be shown to be true for a given plant, the staff agrees that expansion of LBB to debris generation evaluations would simplify that licensee's resolution of sump performance issues. The staff does not know the extent of this benefit for a given plant. The staff notes that one plant's limiting break for GSI-191 is a 3-inch break. The staff also notes that another plant's analysis of a 6-inch postulated break was predicted to generate twice the amount of fibrous insulation necessary to generate a filtering bed on the largest strainer (over 8,000 square feet) currently installed in the PWR fleet. Additionally, other potential debris generation sources exist for which LBB credit is not applicable, including failed pump seals; leaking valve packing; blow out of valve bonnets, flange connections, bellows, manways, and rupture discs; and actuation of valves that discharge directly into containment atmosphere (e.g., safety/relief and squib valves). Therefore, additional modifications at some high-fiber plants might still be required. Thus, removal of large breaks from consideration might or might not substantially assist a particular plant. In any event, as stated above, the staff believes that the global dynamic effects (such as debris generation) from breaks of the LBB-approved piping and non-LBB qualified piping must be considered for the debris generation calculation.

3.0 Union of Concerned Scientists Letters

3.1 Union of Concerned Scientists Letter Dated April 14, 2010

In its April 14, 2010, letter, UCS recommended that the NRC reject the industry's proposal of using GDC 4 to close out GSI-191 because leakage from LBB pipes may not trigger the timely response (i.e., safe shutdown and depressurization) necessary to preclude the pipe break. UCS cited instances for which leakage occurred but the plant did not shut down until hours after

the required shutdown period in the plant's TS. Examples cited included control rod drive mechanism (CRDM) nozzle leakage at Davis Besse in 2002; pressurizer heater sleeve leakage at Calvert Cliffs, Unit 1, in 2008; CRDM leakage at Oconee, Unit 1, in 2005; pressurizer heater sleeve leakage at Palo Verde, Unit 3, in 2004; and CRDM housing leakage at Palisades in 2002.

The staff notes that the leakage cases discussed in the USC letter dated April 14, 2010, were related to either the CRDM nozzles or pressurizer heater sleeve nozzles. These leakage events are not relevant to LBB piping, the LBB technical basis, or the GDC 4 rule. The GDC 4 rule is not applicable to leakage from the CRDM nozzles or pressurizer heater sleeve nozzles. The CRDM cracking and leakage are inspected to the requirements of 10 CFR 50.55a (g)(6)(ii)(D). The pressurizer heater sleeve nozzles that contain Alloy 82/182 welds are inspected to the requirements of 10 CFR 50.55a (g)(6)(ii)(E). Nevertheless, the Davis Besse situation does serve as a reminder that new phenomena and failure modes can appear.

UCS cited through-wall cracking in an Alloy 82/182 dissimilar metal weld of the RCS loop A hot-leg pipe at V.C. Summer. This leakage event is applicable to GDC 4 because the hot-leg pipe at V.C. Summer had been approved for LBB. PWR operating experience has shown that Alloy 82/182 is susceptible to PWSCC. Since the V.C. Summer event, the NRC has actively engaged the industry and national laboratories to resolve the issue of PWSCC. The strategy has been to investigate PWSCC growth rates to assist in analytical prediction, implement enhanced examination requirements, and apply mitigation methods such as weld overlay on the existing Alloy 82/182 welds. The NRC is incorporating ASME Code Case N-770 into the current 10 CFR 50.55a rulemaking to require PWR licensees to inspect more frequently the unmitigated Alloy 82/182 dissimilar metal welds.

UCS also cited the inadequacy of the reactor coolant leakage detection system as a basis for not permitting LBB in the resolution of sump performance issues. The staff notes that the leak rate in the LBB analysis is assumed to be sufficiently large to enable the RCS leakage detection system to detect it accurately and reliably. The RCS leakage detection system for most of PWRs can detect 1 gallon per minute (gpm) within 1 hour. In general, the RCS leakage detection system consists of a containment gaseous monitor, a containment atmosphere particulate radioactivity monitor, containment sump monitors, and a containment fan cooler condensate collection monitor. The technical basis for LBB approval is that the RCS leakage detection system should have the capability of detecting 1 gpm in 1 hour. However, the staff has allowed 1 gpm in 7 hours because it has determined that current RCS leakage detection systems would allow operators sufficient time to safely shut down the plant before a crack in an LBB pipe would grow to become unstable and cause pipe rupture. Based on the fracture mechanics evaluation of the applied loads and pipe material properties, the staff believes that LBB pipes have sufficient fracture toughness (ductility) to resist uncontrollable crack propagation for a considerable amount of time.
Nevertheless, the staff does not believe allowing PWR licensees to use LBB to resolve GSI-191 is prudent, based on the reasons cited in Section 2.1 of this document.

3.2 Union of Concerned Scientists Letter Dated April 26, 2010

In its April 26, 2010, letter, UCS reiterated the concern that the RCS leakage detection system is not able to detect leakage in time to allow the operator to take corrective actions. UCS suggested that plant-specific analyses are needed for certain postulated leakage from a

segment of an LBB-qualified pipe to determine that the leakage could be detected within the allowed time at the TS action limit (1 gpm). UCS stated further that, if the plant-specific analyses are performed, there would be no need to do the zone-of-influence family of analyses currently needed to resolve GSI-191 for a postulated piping break in that segment. Therefore, there is no need for the insulation replacement driven by those analyses.

For the plant-specific analyses, UCS suggested the NRC consider the two following issues:

(1) Will any of the berms and barriers currently in containment to restrict the transport of debris to the containment sumps also impede the flow of leaked water to the leakage detection systems?

(2) Will allowable out-of-service periods for leakage detection systems in the TS cause a leak not to be detected in a sufficiently timely manner?

As discussed in the above staff response to the UCS letter dated April 14, 2010, nuclear plants have RCS leakage detection systems that maintain adequate detection capability. RCS leakage detection systems typically follow the guidance in Regulatory Guide (RG) 1.45, Revision 1, "Guidance on Monitoring and Responding to Reactor Coolant System Leakage," issued May 2008, in terms of sensitivity, diversity, and redundancy in the design and implementation of the leakage detection systems. Also, licensees are required for GSI-191 to evaluate all potential holdup locations for sources of water that might impact the final sump water level as part of the overall net positive suction head determinations for ECCS pumps. For this reason, installed debris interceptors are perforated or have floor openings or parallel flowpaths intended to allow passage of water to the sump. As such, there should be no new areas where water could collect undetected as a result of modifications performed in response to GSI-191.

In accordance with SRP Section 3.6.3, every LBB evaluation is required to include a leak rate calculation to demonstrate that the leak rate from the leakage crack is 10 times the detection capability of RCS leakage detection systems. SRP Section 3.6.3 recommends this safety margin for leakage detection. SRP Section 3.6.3.III.4 recommends that the RCS leakage detection system follow the guidance in RG 1.45, Revision 1, which specifies a detection capability of 1 gpm in 1 hour. NUREG/CR-1061, Volume 3, allows 1 gpm in 4 hours for plants that do not meet RG 1.45, Revision 1. The staff has approved plant-specific analysis in license amendment requests to allow 1 gpm in 7 hours.

The UCS statement regarding zone-of-influence analyses appears to imply that UCS might support the industry's proposed GDC 4 credit for resolution of GSI-191 to disregard the potential for debris generation for postulated breaks in LBB qualified piping in some instances. However, the staff does not agree that GDC 4 should be applied to GSI-191 for the reasons stated in Section 2.1 of this enclosure.

4.0 Discussion

The staff had not previously accepted the industry's proposal of using LBB in the GDC 4 rule to resolve GSI-191 concerns because the staff believes that such expansion would reduce defense-in-depth and might set a precedent for the use of GDC 4 that could affect other areas

of accident analyses. Expanding GDC 4 would also require a policy decision by the Commission and would require revision to the rule or a new Statement of Considerations to be issued for the rule. However, as stated in the SRM dated May 17, 2010, the Commission requested that the staff discuss the potential approaches and options to bring GSI-191 to closure. One of the means that the Commission requested the staff discuss in its response was the possibility of giving GDC 4 credit for the resolution of GSI-191.

The staff recognizes that the benefits of crediting GDC 4 are that some PWR owners potentially would not be required to remove fibrous insulations or perform additional plant-specific tests. This would expedite satisfaction of the requirements of GSI-191 by the industry.

However, the following concerns and considerations outweigh the potential benefits of crediting GDC 4 for sump debris generation evaluations:

(1) Approving LBB to close out GSI-191 would not be consistent with the Statement of Considerations for GDC 4, which specifically limits the scope of LBB to the removal of pipe whip restraints and jet impingement barriers. Therefore, it is inappropriate to use the GDC 4 criterion to support debris generation evaluations unless the course of action involves a deliberate rulemaking process that permits further staff evaluation while also considering stakeholder input. For the reasons stated in this enclosure, the staff does not recommend undertaking such rulemaking.

(2) The end result of the NEI proposal to extend LBB to cover debris generation would not be to justify "the removal of plant hardware which it is believed negatively affects plant performance," as was the Commission's intent with GDC 4. The staff notes that the NRC's approval of LBB has permitted the removal of pipe whip restraints and jet impingement barriers to allow enhanced accessibility for inservice inspection of safety-related structures, systems, and components. Rather, the staff believes that the NEI proposal would potentially permit licensees to alleviate the need to further modify their PWR containment sumps or remove fibrous pipe insulation that could threaten successful strainer performance. In effect, this could place the staff in the position of accepting large uncertainties in ECCS strainer performance in the event of a large-break LOCA. The staff does not find this reduction of defense-in-depth acceptable.

(3) GDC 4 provided an exception to the way in which dynamic effects of postulated pipe breaks were considered in the design of structures, systems, and components important to safety. It also provided a basis for removing plant hardware, specifically pipe whip restraints and jet impingement barriers, to permit enhanced accessibility of inservice inspection of safety-related structures, systems, and components that negatively affected plant performance. The NRC did not intend GDC 4 to be used as an equivalent alternative to the ECCS regulations. The NRC staff has not performed the longer term evaluation that is described in the Statement of Considerations for GDC 4 as necessary before allowing credit that would affect ECCS system performance. The longer term evaluation would involve analysis of the impact of relaxed pipe rupture requirements on the containment design, ECCS performance, and environmental qualification of electrical and mechanical equipment. This evaluation would incur staff and industry resources.

(4) The staff is unaware of any safety benefits of permitting LBB to be used for GSI-191 closure other than the potential elimination of occupational doses from future modifications that otherwise might be required. On the contrary, the staff believes that plant safety may be affected if LBB is expanded because fibrous insulation might not need to be removed from containment and more debris could be generated, potentially reducing ECCS performance should an unexpected large-break LOCA occur.

(5) Approving LBB for debris generation evaluations would be inconsistent with the proposed rulemaking, ""Risk-Informed Redefinition of Large Break LOCA ECCS Requirements," at 10 CFR 50.46a, regarding the performance of ECCS. The staff believes that the risk-informed approach in the proposed rule, which requires mitigation of large breaks (albeit with more realistic assumptions than for design-basis accident events), appropriately maintains a level of defense-in-depth that application of GDC 4 would not retain. Permitting licensees to remove, a priori, the calculated debris generation associated with some, or all, large-break LOCA scenarios from their licensing basis by application of LBB would appear to conflict with the Commission's statement in its SRM dated July 1, 2004, related to SECY-04-0037, in which the Commission requires that licensees "provide effective mitigation capabilities…directed at break sizes greater than the alternate maximum break size permitted by the rule, to maintain the core in a coolable geometry," upon application of 10 CFR 50.46a.

(6) Since 2004, the industry and the NRC have made significant progress in resolving PWSCC in PWRs. Some PWR licensees have addressed PWSCC by installing weld overlays, applying mechanical stress improvement process, and implementing augmented inspections. The staff has incorporated by reference ASME Code Case N-722 in 10 CFR 50.55a which requires augmented visual examination of Alloy 82, 182, and 600 components. The staff also incorporated by reference ASME Code Case N-770 in the proposed rule for 10 CFR 50.55a which requires augmented examination of Alloy 82/182 dissimilar metal welds. The staff believes that this is adequate from a safety perspective to address the current scope of LBB with respect to GDC 4. However, since most PWR owners are in the process of addressing PWSCC in Alloy 82/182 dissimilar welds in their large LBB piping (nominal diameter of 20 inches and greater) through mitigation, enhanced inspection, or both, the staff does not believe it is appropriate to expand the use of LBB beyond the current application of GDC 4. If GDC 4 is expanded to be applied to resolving GSI-191 issues, the staff believes that the application of GDC 4 will require additional analyses, and potentially additional requirements and guidance, to address PWSCC in LBB piping. This may result in additional licensee costs and outage schedule impacts if the staff determines that mitigation of the nickel-Alloy 82/182 welds in LBB piping is needed to support GSI-191.

(7) Allowing LBB credit for resolving ECCS performance issues would require revision to GDC 4 or a new Statement of Considerations to be issued for the rule. Additionally, the expansion in scope might set a precedent for the use of GDC 4 that could affect other areas of accident analyses.

For the reasons stated above, the NRC staff views the use of 10 CFR 50.46a as a more technically complete and defensible approach to assist in the resolution of the GSI-191 sump performance issue than would be implementation of LBB for this purpose. The 10 CFR 50.46a

rulemaking developments represent the agency's current approach to risk-informing ECCS performance issues.