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Rules and Directives Branch
Office of Administration
U. S. Nuclear Regulatory Commission
Washington, DC 20555

SUBJECT: Comments on Draft Regulatory Guide DG-1107, *Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident,* (68 *Fed. Reg.* 13338)
Response to Request for Comments

PROJECT NUMBER: 689

Enclosed are the Nuclear Energy Institute's (NEI)[1] comments on draft Regulatory Guide DG-1107, issued for public comment on March 19, 2003.

Draft Regulatory Guide 1107 (DG-1107) describes methods acceptable to the NRC staff for implementing requirements with respect to the sumps and suppression pools performing the functions of water sources for emergency core cooling, containment heat removal, or containment atmosphere clean up. DG-1107 incorporates a number of changes to guidance applicable to Pressurized Water Reactors (PWRs) that address the potential for blockage of containment debris interceptors. The draft guidance, while updated to address containment debris effects, has not been updated to readily accommodate sump screen designs that are specifically designed to address these same detrimental effects. The guidance maintains an unintended preference toward traditional, vertical screen designs. We believe that the guidance should be revised to facilitate the incorporation of alternative screen designs for PWRs.

An important aspect of the guidance is treatment of debris generation for Leak-Before-Break (LBB) qualified piping. Most, if not all, PWR plants have

[1] NEI is the organization responsible for establishing unified nuclear industry policy on matters affecting the nuclear energy industry, including the regulatory aspects of generic operational and technical issues. NEI's members include all utilities licensed to operate commercial nuclear power plants in the United States, nuclear plant designers, major architect/engineering firms, fuel fabrication facilities, materials licensees, and other organizations and individuals involved in the nuclear energy industry.

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utilized the LBB exclusion of GDC-4 to remove local dynamic effects from the design basis of qualified piping. This allows the exclusion or removal of devices such as pipe whip restraints and jet impingement shields designed to mitigate the impact of these dynamic effects. Section 1.3.2.2 of the draft regulatory guide calls for the inclusion of local dynamic effects for all postulated break locations, irrespective of whether the piping is LBB qualified. Given the central role of local dynamic effects in debris generation and consequential evaluation of sump performance, it is inappropriate to treat LBB qualified piping in the same manner as non-qualified piping and it is inconsistent with the current LBB piping design bases.

Section D of the guidance states that no backfitting is intended or approved in connection with the issuance of the guidance. Section D also states that the active guide will also be used by the NRC staff to evaluate licensees' compliance with 10 CFR 50.46. Many licensed PWR plants contain design attributes that do not fully conform to the draft guidance. Full conformance with the proposed guidance for these plants would necessitate significant design modification. While use of the guidance by NRC staff to evaluate compliance with 10 CFR 50.46 can facilitate any such evaluations, it is important that the guidance be viewed as one method of demonstrating regulatory compliance. The NRC staff must remain open to alternative methods not prescribed by the guidance.

NRC has stated an intention to issue generic communications addressing PWR sump performance and compliance with applicable regulations. In anticipation that the guidance provided in DG-1107 will be referenced in support of the generic communications, we reserve the opportunity to supplement our comments following receipt of the planned generic communication.

NEI and the PWR Owners Groups are developing evaluation guidance to support resolution of GSI-191 and are actively engaged in discussion with NRC staff on a number of technical and regulatory attributes that impact guidance contained in DG-1107. As such, we believe it advisable to delay finalization of the guidance until after resolution is reached on these areas.

Please direct questions on the enclosed comments and recommendations to John Butler (202-739-8108, jcb@nei.org) or me (202-739-8081, arp@nei.org).

Sincerely,

Anthony R. Pietrangelo

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Enclosures

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Enclosure

NEI comments on DG1107, *Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident*

1. **General Application of Guidance to Expected Modification in Sump Screen Designs**
   The draft guidance, while updated to address the detrimental effects caused by debris accumulation on debris interceptors has not been updated to readily accommodate newer sump screen designs (stacked disc, perforated pipe, etc.) that are specifically designed to address these same detrimental effects. The guidance maintains an unintended preference toward vertical screen designs. The guidance should be revised to address alternative screen designs.

2. **General Application of Guidance to ECCS and CSS**
   DG-1107 needs a clear explanation of how the ECCS and containment heat removal systems affect the long-term core cooling requirement in 10CFR50.46. A section with definitions and licensing requirements is warranted. Further, DG-1107 needs to clarify differences in requirements for ECCS versus containment heat removal systems. For example, Regulatory Positions 1.1.1.13 and 1.1.1.14 state that the design considerations are applicable to ECCS pumps. While the intent may be to apply them to the containment heat removal pumps, it's not explicit. In other areas of the guide, conditions are placed on analysis requirements for all pumps based on the time of ECCS switchover to the sump, while the containment heat removal systems may take suction from the sump much earlier than ECCS switchover. In general, DG-1107 should distinguish between design and analytical requirements for the sump based on differences in the design and operation of ECCS and containment heat removal systems.

3. **Section B,Page 3, First Paragraph**
   The draft guidance states that all potential debris sources should be evaluated for the potential blockage of the debris interceptors. Examples of potential debris sources are provided. The guidance does not address transient debris sources. Plant personnel and their attendant equipment are used to perform work within containment during operation (e.g., operation rounds, radiation protection surveys, emergency maintenance). The guidance should identify that plant personnel and attendant equipment, due to the limited window of exposure, are not addressed as potential debris sources.

4. **Section B, Page 3, First Paragraph:**
   The Discussion section provides a list of references that provide additional information relative to the concerns addressed by the regulatory guide. We recommend that this list be revised to include Generic Letter 98-04, *Potential for Degradation of the Emergency Core Cooling System and the Containment Spray System After a Loss-of-Coolant Accident Because of Construction and Protective Coating Deficiencies and Foreign Material in Containment.*

5. **Section B,Page 3, Second Paragraph:**

We recommend rewording the last sentence of the paragraph as follows: "Therefore, for advanced PWR and BWR designs, the guidance provided in both the PWR and BWR sections of this regulatory guide ~~*should be considered*~~ that is appropriate and consistent with the plant's design features, *should be considered*."

6. **Section B, Page 4, sixth paragraph**
The reference to "static" NPSH calculations could be misinterpreted as meaning zero flow conditions. The term "steady state" may be more appropriate for use in this paragraph.

7. **Section B, Page 4 and page 7**
The draft guidance uses the following statement to define NPSH:

> *The available NPSH is a function of the static head of water above the pump suction, the pressure of the atmosphere above the sump water surface, and the temperature of the pumped water at the suction of the pump.*

The statement is not complete and may lead to confusion or misinterpretation. The following is a suggested rewrite to clarify and define available NPSH:

> *Available NPSH is the total suction head available at the pump impeller centerline (or other reference pump location) less the vapor pressure of the liquid being pumped. In the application to long-term recirculation, available NPSH is a function of*
> *a) Static head of sump water above the pump impeller centerline (or other reference pump location)*
> *b) The containment pressure above the sump water surface*
> *c) The vapor pressure of the sump water*
> *d) Head loss in the suction piping, including entrance losses at the suction pipe*
> *e) Head loss through the sump structure and screens/strainers*

8. **Page 5, Third Paragraph; Page 9, Section 1.1.1.6:**
The guidance states, "*Isolation of the ECC sumps from high-energy pipe lines is an important consideration in protection against missiles, and it is necessary to shield the screens and racks adequately from impacts of ruptures high-energy piping and associated jet loads from the break.*"

The guidance also states: *The strength of the trash racks should be adequate to protect the debris screens from missiles and other large debris. Trash racks and sump screens should be capable of withstanding the load imposed by expanding jets, missiles... under design-basis flow conditions."*

While we agree that this is an important consideration, it is possible that design constraints may exist for some plants that would limit or make impractical the

changes necessitated by this guidance to fully isolate or shield the sumps from local dynamic effects of high-energy pipe lines. The guidance should acknowledge the potential for circumstances that would inhibit the strict adherence to the guidance and allow for consideration of the low frequency of rupture of high energy line piping in a manner similar to that which is allowed by GDC-4.

9. Alternate ECC Sump Geometries

In a number of instances the guidance appears to focus unnecessarily on a sump design composed of a combination of vertical and horizontal screens. While this is the predominant sump design currently in use by PWR plants, it fails to adequately take into account alternate sump geometries now available for use. The guidance should identify the phenomena and processes that all sump designs need to address and avoid design guidance that is applicable to a subset of sump geometries. Guidance that is applicable to specific sump geometries should be identified as such.

The following portions of the draft regulatory guide should be reviewed to ensure that the guidance is appropriate for the broadest possible range of sump designs and geometries:

Page 5, last paragraph: *Therefore, in the computation of available interceptor surface area, no credit may be taken for any horizontal interceptor surface unless plant evaluations that adequately account for inherent water source uncertainties demonstrate that the horizontal surface will be submerged at the time of recirculation.*

Page 6, second paragraph: *A vertical or nearly vertical inner debris screen located above the containment floor level would minimize the deposition or settling of debris on screen surfaces and thus help to ensure the greatest possible free flow through the fine inner debris screen.*

Page 9, Section 1.1.1.3: *The sump outlet should be protected by at least two vertical or nearly vertical debris interceptors.*

Page 9, Section 1.1.1.7: *The top of the debris interceptor structures should be a solid cover plate that is designed to be fully submerged after a LOCA and completion of the ECC injection. It should be designed to ensure the venting of air trapped underneath the cover.*

10. Page 6, First paragraph

The last sentence of the first paragraph states "credit should only be given to the portion of the sump screen that is expected to be submerged at the beginning of recirculation." This statement provides no allowance for circumstances in which the level of submergence changes substantially following the beginning of recirculation. The water level in ice condenser containment designs, for

example, may continue to increase following initiation of recirculation as a result of continued ice melt. Provided that a conservative calculation of submergence is provided that accounts for water holdup and delivery, there should be no restriction on the level of submergence as currently stated in the draft guide.

11. Page 6, Fourth paragraph
Reference to NUREG 0837 should be NUREG 0897.

12. Page 9, Section 1.1.1.3
The last sentence states "A curb should be provided upstream of the trash racks to prevent high-density debris from being swept along the floor into the sump." The guidance would benefit from the addition of desirable characteristics of a debris curb.

13. Page 10, Section 1.1.1.11
The Regulatory Position referenced in the last line of this section should be 1.1.4, not 2.1.5.

14. Page 10, Section 1.1.1.12
Clearances in pumps and seals can be very small. For many current plants the screen hole size is larger than the minimum pump seal restriction. It is generally believed that tough, hard particles such as metals would not be transported to the screens. Some hard particles such as paint chips are brittle enough that the pump impeller would chop them up and if they made it to the reactor vessel they would drop out in the bottom head. Small soft particles would not damage impellers or seals. Having a screen that has openings smaller than seal or impeller clearances will be on the order of mils. Meshes this fine will have much higher pressure drops than current screens. Sump screen areas may have to be so large that it is not practical to install them. Also, having very small openings in the fine screens make them more susceptible to plugging than current screen designs. This position should be reconsidered to determine if it can be met given reasonable containment volumes, configurations, and water levels.

15. Page 10, Section 1.1.2.2 and Page 11, Section 1.2
The guidance states, *Procedures should be established for using alternative water sources to be activated when unacceptable head loss renders the sump inoperable. The valves needed to align the ECCS with an alternative water source should be periodically inspected and maintained.*

This guidance is associated with actions that could be taken in response to a loss of sump operation. Except in cases where a loss of sump operation is assumed as part of the design basis, these actions go "beyond design basis" and should either be removed or clearly identified as recommendations for actions to address conditions that are beyond the design-basis.

16. Page 12, Section 1.31.1

The statement "no increase in containment pressure from that present prior to the postulated LOCAs" is not consistent with the licensing basis for subatmospheric containment plants, which can operate as low as 9 psia air partial pressure. This discussion is also inconsistent with Standard Review Plan 6.2.2 and Generic Letter 97-04. GL 97-04 states that NPSH should be based on the assumption that the containment pressure equals the vapor pressure of the sump water. This is consistent with SRP 6.2.2; which states that available NPSH should be determined assuming maximum expected temperature of pumped fluid with atmospheric pressure in containment. This statement should be modified to be consistent with current guidance and plant licensing bases.

17. Page 12, Section 1.31.3

This section limits credit for operation of pumps in cavitation to time periods equal to or less than the time the pump was run during confirmatory tests. There should be credit for the results of the teardown/inspection results following confirmatory testing. If no abnormal post-test wear or degradation is observed, and no performance related problems are observed, the pump is defensibly not near failure at the end of the test period. Trending/projection of wear or performance should be taken into account in establishing this limit.

18. Page 13, Section 1.3.2.2

A wide range and variety of materials that have the potential to contribute to the debris source term are used in PWR containments. While it is desirable that key characteristics of potential debris sources (e.g., destruction pressure, size distribution, and minimum transport velocity) be determined experimentally, this would impose a significant experimental burden for materials used in small quantities in containment or materials expected to marginally impact the overall debris loading for ECC sumps. The guidance should provide an allowance for conservative treatment of miscellaneous debris sources.

19. Page 13, Section 1.3.2. and Section 1.3.2.2

The 1987 revision to General Design Criterion (GDC) 4 in Appendix A to 10 C.F.R. Part 50 allowed the use of leak-before-break (LBB) technology to exclude local dynamic effects such as shock wave and jet impingement from the design basis of qualified piping. Most, if not all, PWR plants have utilized the LBB exclusion of GDC-4 to remove local dynamic effects from the design basis of qualified piping. This allows the exclusion or removal of devices such as pipe whip restraints and jet impingement shields designed to mitigate the impact of these dynamic effects.

Section 1.3.2.2 of the regulatory guide calls for the inclusion of these same local dynamic effects for all postulated break locations, irrespective of whether the piping is LBB qualified. Any requirement that calls for local

dynamic effects to be returned to the design basis for LBB qualified piping would be a design backfit and subject to the provisions of 10 CFR 50.109.

The exclusion of local dynamic effects from the design basis of qualified piping allowed by GDC-4 is not conditional in the sense that it can only be applied to the removal specific hardware devices. As stated in 53 FR 11311,

> "*...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*" (emphasis added).

The Federal Register Notice also stated that

> *"... while functional and performance requirements for containment, ECCS, and EQ remain unchanged under the now effective modification of GDC-4, the design bases for these aspects of facility design have been modified in that local dynamic effects uniquely associated with ruptures in piping which qualified for leak-before-break may be excluded from consideration."*

Very simply stated, the functional and performance requirements for containment, ECCS and EQ that were retained with the modification of GDC-4, explicitly excludes local dynamic effects associated with ruptures in LBB piping. Local debris generation is a direct consequence of these local dynamic effects.

To be consistent with GDC-4, the regulatory guide should incorporate language that acknowledges treatment of debris generation under the LBB provisions of GDC-4. We recommend that section 1.3.2.1 be revised as follows:

> "*Consistent with the requirements of 10 CFR 50.46, debris generation should be calculated for a number of postulated LOCAs of different sizes, locations, and other properties sufficient to provide assurance that the most severe postulated LOCAs are calculated. In accordance with GDC-4, dynamic effects associated with postulated pipe ruptures (including local debris generation) may be excluded from the design 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. Some PWRs may require recirculation from the sump for licensing basis events other than LOCAs. Therefore, plants should review the licensing basis and include potential break locations in the main steam and main feedwater lines as well in determining the most limiting conditions for sump operation."*

Additional information on the basis for application of GDC-4 exclusions of local dynamic effects to debris generation were provided by NEI in an October 4, 2002 letter to G. Holahan (Accession Number ML022880011).

20. Page 13, Section 1.3.2.3

The last bullet defines a minimum uniform thin bed as 1/8-inch of fiber but does not have a supporting technical basis and/or reference to supporting basis. Please add a technical basis/reference to this value and to similar numerical values used throughout the document.

21. Page 14, Section 1.3.3

This section does not address treatment of floating/buoyant debris. Containment designs with remote sumps could include "weir" features that protect sump screens from floating debris.

22. Page 14, Section 1.3.3.4

Section 1.3.3.4 identifies computational fluid dynamic (CFD) simulations as an acceptable analytical approach for predicting debris transport. Section 1.3.3.8 identifies that in lieu of performing a debris transport analysis, it should be assumed that all debris will be transported to the sump screen.

While CFD simulations provide one means of predicting debris transport, these simulations are not the only means to conservatively predict debris transport. Section 1.3.3.4 should be revised to acknowledge that other calculational techniques that are properly supported by experimental debris transport data and conservatively predict debris transport behavior are acceptable.

23. Page 15, Section 1.3.3.6

This section states "All debris (e.g., fine fibrous, particulates) that is assumed or demonstrated to suspend indefinitely or to sink very slowly should be considered to reach the sump screen." As worded, the statement is subjective without a definition of "sink very slowly." Significant settling can occur, and should be credited, in zones with low pool flow velocities. In addition, credit for retention in dead volumes should be acknowledged.

The draft guidance addresses only debris that is "demonstrated to suspend indefinitely or to sink very slowly." This specification should address the full range of debris types and settling characteristics by merely requiring "experimental or analytical evidence of debris water pool settling characteristics credited in the debris transport analysis" similar to what is specified in Section 2.3.2.4.

24. Page 15, Section 1.3.3.8

Section 1.3.3.8 states "in lieu of performing debris transport analyses, it should be assumed that all debris will be transported to the sump screen." This is an unnecessarily conservative assumption that does not allow the conservative

incorporation of experimental transport data, phenomenological analysis and engineering judgement based upon detailed knowledge of plant design.

Similar to the analysis performed in NUREG/CR 6762, conservative debris transport fractions can be determined in a manner that does not require detailed computational fluid dynamic calculations.

We recommend that section 1.3.3.8 be revised as follows:

"In lieu of performing debris transport analyses, conservative debris transport fractions supported by experimental debris transport data may be used ~~it should be assumed that all debris will be transported to the sump screen.~~"

25. Page 15, Section 1.3.4

This section states that for partially submerged sumps, credit should only be given to that portion of the screen submerged at the beginning of recirculation. For licensees that are able to show a worst-case accumulation debris rate, credit for subsequent sump water sources (e.g., continued ice melt in Ice Condenser containment designs) should be allowed in determining the area of submerged screen. The licensee is incumbent to provide a time line of head loss over critical points of the post-LOCA recovery and to demonstrate sufficient NPSH margin exists throughout this time line consistent with Regulatory Position 1.3.1.9.

26. Page 15, Section 1.3.4.4 and Appendix A

The draft guidance implies that "credit should be given to the portion of the sump screen that is expected to be submerged at the beginning of recirculation." Guidance provided in Section 1.3.4.4 and the last paragraph of Appendix A are predicated on the assumption that "information and time-dependent pool depths is difficult to obtain." Since time-dependent analysis is required to establish injection-to-recirculation switchover time to begin with, this assumption cannot be accepted as valid. Additionally, event specific time-dependent analysis of water pool level will likely be performed to evaluate potential benefits of specific operator actions or design changes (e.g., containment spray actuation setpoints) that could reduce risk associated with sump screen blockage. We suggest restating Section 1.3.4.4 to simply specify conservative event specific analysis of minimum pool depth when demonstrating a submerged sump condition or crediting increased wetted area. The last paragraph of Appendix A should also be modified consistent with recommended changes to Section 1.3.4.4.

27. Page 22, Implementation

Section D of the guidance states that no backfitting is intended or approved in connection with the issuance of the guidance. Section D also states that the active guide will also be used by the NRC staff to evaluate licensees' compliance with 10 CFR 50.46. Many licensed PWR plants contain design attributes that do not fully conform to the draft guidance. Full conformance with the guidance

would necessitate significant design modification. As such, we believe that use of the guidance by NRC staff to evaluate compliance with 10 CFR 50.46 will inevitably raise backfit concerns. NRC has stated an intention to issue generic communications addressing PWR sump performance and compliance with applicable regulations. In anticipation that the guidance provided in DG-1107 will be referenced in support of the generic communications, we reserve the opportunity to supplement our comments following receipt of the planned generic communication.

28. Pages 26 and 27, Figures 1 and 2
Add descriptive titles to Figures 1 and 2.

29. Page 28, Figure 3
The caption for the vertical piping in this figure contains typographical errors.

30. Pages 29 and 30, Figure 4 and Figure 5
The information provided in these figures is applicable to BWRs. The figure titles should be revised to identify the applicability to BWRs.

31. Appendix A, page A1, Second paragraph
Add a space between centerline and (s) (e.g., should be centerline (s)).

32. Appendix A, page A3
Page A-3 refers repeatedly to "sump failure." The considerations of Appendix A affect operation of one or more of the pumps that utilize the containment sump. Each pump will have different requirements for operation and different criteria for "failure." A failure to meet established criteria for one pump would not constitute a failure for all pumps and thus would not be a "sump failure." The terminology for "failure" used in the Appendix should be clarified.

Page A-3 uses the term $NPSH_{margin}$ without a clear definition. Is the term defined as NPSH available (NPSHa) minus NPSH required (NPSHr), where NPSHa already includes all other losses from piping friction, dimensional changes in the pump can, and the sump screens (without debris)? For clarity, the failure criterion may be defined plainly as "NPSH required cannot be satisfied".

What does it mean to reach the failure criterion and what kind of time-dependence is applied? While NPSHr may not be satisfied for a short period of time, sump conditions can change enough to shortly return to a positive NPSH margin condition. Regulatory Position 1.3.1.3 allows for credit to be taken for operation of pumps in cavitation for a limited time. If a plant has tested pumps in cavitation and can show that the sump failure criterion was met for a period of time shorter than the test time, then does 1.3.1.3 justify the conclusion that the acceptance criterion for long-term core cooling has been met? Clarify the use of the failure criterion relative to 1.3.1.3.

Provide a reference to the technical basis document for the statement "Numerical simulations confirm that an effective head loss across a debris bed approximately equal half the pool height is sufficient to prevent adequate water flow" on page A-3.

33. Appendix A, page A4

This section states "...because the most significant debris transport will occur early in the scenario when the pool is shallow, analysis should preferably be based on the pool depth at the time of switchover to ECCS recirculation...". Similar to the comment made on Section 1.3.4.4, licensees that are able to show a worst-case accumulation debris rate, credit for subsequent sump water sources (e.g., continued ice melting for ice condenser containments) should be allowed in determining the area of submerged screen. The licensee is incumbent to provide a time line of head loss over critical points of the post-LOCA recovery and to demonstrate sufficient NPSH margin throughout this time line consistent with Regulatory Position 1.3.1.9.