POLICY ISSUE
(Notation Vote)

July 9, 2012 SECY-12-0093

FOR: The Commissioners

FROM: R. W. Borchardt
Executive Director for Operations

SUBJECT: CLOSURE OPTIONS FOR GENERIC SAFETY ISSUE - 191, ASSESSMENT OF DEBRIS ACCUMULATION ON PRESSURIZED-WATER REACTOR SUMP PERFORMANCE

PURPOSE:

This paper responds to Staff Requirements Memorandum (SRM)-SECY-10-0113, "Closure Options for Generic Safety Issue [GSI] - 191, Assessment of Debris Accumulation on Pressurized Water Reactor [PWR] Sump Performance," dated December 23, 2010 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML103570354), and requests a decision on policy issues and options for resolving GSI-191. This paper does not address any new commitments.

SUMMARY:

The staff last provided recommendations to the Commission for the resolution of GSI-191 in SECY-10-0113, "Closure Options for Generic Safety Issue - 191, Assessment of Debris Accumulation on Pressurized Water Reactor Sump Performance," dated August 26, 2010 (ADAMS Accession No. ML101820212). On September 29, 2010, the Commission held a meeting with the staff and industry representatives to discuss options to resolve GSI-191. As indicated above, the Commission issued SRM-SECY-10-0113 directing the staff to consider alternative options for resolving GSI-191 that are innovative and creative, as well as risk informed and safety conscious, while the industry completed testing in 2011.

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Since the issuance of the SRM, the staff has interacted with the industry and stakeholders to develop options for the resolution of GSI-191. The staff is currently working with the South Texas Project Nuclear Operating Company (STP) to develop a “no transition break size” analysis using the methods described in Regulatory Guide (RG) 1.174, Revision 2, “An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis” (ADAMS Accession No. ML100910006), for the resolution of GSI-191. STP plans to submit the analysis by December 2012 for U.S. Nuclear Regulatory Commission (NRC) review and approval. If approved, the staff plans to use STP as a pilot for other licensees choosing to use this approach. Enclosure 3 provides a more detailed description of this approach.

The staff issued a *Federal Register* (FR) notice on May 3, 2011 (76 FR 24925), to request stakeholder input on alternative approaches to resolving GSI-191, and it has held numerous public meetings to discuss the topic. The staff also interacted frequently with industry representatives as the industry completed the committed-to generic testing in 2011. Enclosure 1 discusses the interactions between the staff and industry since the issuance of SRM-SECY-10-0113.

Resolution of GSI-191 continues to be more difficult than anticipated. The industry’s testing on in-vessel effects (the potential for debris to lodge in the core and restrict flow), which was generic and performed to bound all PWRs, failed to show that more than very low amounts of fiber are acceptable. The Pressurized-Water Reactor Owners Group (PWROG) submitted Topical Report (TR) WCAP-16793, Revision 2, “Evaluation of Long-Term Cooling Considering Particulate, Fibrous and Chemical Debris in the Recirculating Fluid,” in October 2011 (ADAMS Accession No. ML11292A021), which summarized the testing, and requested NRC review and approval. The staff is currently reviewing the TR and expects to issue its safety evaluation by September 2012. The thermal-hydraulics subcommittee of the Advisory Committee on Reactor Safeguards (ACRS) held a meeting on May 8 and 9, 2012, to discuss the TR with both the industry and staff. The ACRS subcommittee raised concerns that the TR lacked sufficient information to justify even the low fiber amount on a generic basis. The restrictive fiber limits will make in-vessel effects the limiting factor for many plants, which has led many licensees to plan plant-specific testing to reduce the scope of modifications (e.g., insulation modifications, installation of a bypass eliminator). The ACRS plans to issue a letter on this subject in the short term. Furthermore, the industry in-vessel effects testing did not attempt to differentiate between smaller break loss-of-coolant accidents (LOCAs) (which are more likely but are judged to be less severe) and the less-likely larger breaks (which are typically judged to be limiting for strainer performance and in-vessel effects), and did not address the potential for debris in the core to cause boric acid precipitation to occur earlier than currently predicted. These considerations have made it difficult to justify alternatives for resolving GSI-191.

Based on the interactions described above and the results of the recent industry testing, the staff developed three options that will be effective ways to resolve GSI-191. The first option is similar to Option 1 of SECY-10-0113. This option would require licensees to demonstrate compliance with Title 10 of the *Code of Federal Regulations* (10 CFR) 50.46, “Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors,” through approved models and test methods. This option is the most clearly defined path for resolution of GSI-191, but will likely result in the most extensive modifications and occupational dose. The second option requires implementation of additional mitigative measures and allows additional time for licensees to resolve issues through further industry testing or use of the STP approach,

either of which may reduce the scope of modifications and occupational dose. The third option involves separating the regulatory treatment of the sump strainer and in-vessel effects, which also is expected to reduce the scope of modifications and occupational dose. The staff anticipates the first option would take two refueling outages (RFOs) to implement. For licensees choosing the deterministic approach of Option 2, the staff anticipates it would take three RFOs to complete. Licensees using risk-informed Options 2 and 3 will need to be completed with all modifications one RFO after the NRC decision on the analysis. The staff recommends that the Commission allow licensees the flexibility to choose one of the above options to resolve GSI-191 at its plant(s), subject to the conditions and schedules discussed in this paper.

Given the potential for post-LOCA debris to block flow in the emergency core cooling system (ECCS), the containment spray system (CSS), and the reactor core, the staff maintains that it is not acceptable to allow debris-generating materials to remain within containment in quantities greater than those demonstrated to provide reasonable assurance that long-term cooling will be maintained in accordance with 10 CFR 50.46(b)(5).

BACKGROUND:

GSI-191 concluded that debris could clog the containment sump strainers in PWRs, leading to the loss of net positive suction head for the ECCS and CSS pumps. The NRC issued Generic Letter (GL) 2004-02, “Potential Impact of Debris Blockage on Emergency Recirculation During Design Basis Accidents at Pressurized-Water Reactors” (ADAMS Accession No. ML042360586), dated September 13, 2004, requesting that licensees address the issues raised by GSI-191. GL 2004-02 was focused on demonstrating compliance with 10 CFR 50.46.

The staff recognizes that significant cost and occupational dose are associated with replacing or reinforcing insulation, and it acknowledges that compensatory actions and modifications made to date have reduced the risk of strainer clogging. All PWR licensees have made their sump strainers substantially larger. Some licensees removed fibrous or particulate insulation, changed their sump pH buffers to reduce chemical effects, or installed debris interceptors to reduce the amount of debris that can reach the strainers. The industry also has spent considerable effort trying to reduce the uncertainties and conservatisms in the standard models for assessing GSI-191. Licensees have made, and will continue to make modifications and develop analyses to resolve GSI-191 in accordance with the regulations. Each plant will document these actions in its updated final safety analysis report, in accordance with 10 CFR 50.71(e). However, the resolution of GSI-191 has been challenging because of a history of unexpected test results (e.g., sensitivities to debris types and time of arrival of the debris at the sump strainer or reactor core). The testing in 2011 continued this trend, and in-vessel effects will be the limiting factor for many plants. Even latent debris (which does not include accident-generated debris) can cause a reduction in core flow if conservative assumptions are made regarding the amount of latent fiber, the fiber transport, and the percent of fiber passing through the strainer.

Licensees implemented compensatory measures in response to Bulletin 2003-01, “Potential Impact of Debris Blockage on Emergency Sump Recirculation at Pressurized-Water Reactors” (ADAMS Accession No. ML031600259), dated June 9, 2003, and GL 2004-02 to address the potential for sump strainer blockage. Additional compensatory measures could be developed by licensees to specifically address in-vessel blockage. PWRs have instrumentation to monitor core water levels and temperatures following a LOCA and operating procedures to initiate hot-

leg injection, which may provide an alternate flowpath that bypasses core inlet blockage. For these reasons and others documented in GL 2004-02 that are still applicable, continued operation is justified for each of the recommended options and schedules to resolve GSI-191.

The Nuclear Energy Institute (NEI) submitted a letter on May 4, 2012 (ADAMS Accession No. ML12142A316), recommending actions for resolving GSI-191 that a licensee would select based on the amount of fiber in containment. The letter stated that all licensees would submit by December 31, 2012, a plant-specific path and schedule for resolution of GSI-191. Licensees that do not meet the deterministic criteria today either have, or will implement additional defense-in-depth measures to mitigate risk while they either continue testing or pursue a risk-informed approach. Licensees of "high fiber" plants would take measurements at the next opportunity to prepare to replace fibrous insulation, if necessary.

DISCUSSION:

Staff Recommended Options to Resolve GSI-191

All of the options discussed below will be effective in resolving GSI-191. Enclosure 2 describes the options in more detail, including pros and cons.

- *Option 1: Compliance with 10 CFR 50.46 Based on Approved Models*

  This option is similar to Option 1 presented in SECY-10-0113. Licensees will demonstrate compliance with 10 CFR 50.46 through approved models for analyses, strainer headloss testing, and in-vessel effects. This option is the best defined and will lead to the quickest resolution of GSI-191, but will likely require the most extensive plant modifications and receive the highest amount of occupational dose in comparison with other options presented in this paper. Under this option, the staff will continue to use the holistic integrated review process described in Enclosure 2.

  The staff recently approved "clean-plant" criteria that provide guidance to resolve the strainer and in-vessel issues (NRC letter to NEI dated May 2, 2012, ADAMS Accession No. ML120730181). The in-vessel guidance is based on WCAP-16793, Revision 2, which is still under staff review, and plants using the criteria will need to address any limitations placed on use of the WCAP based on the staff review and acceptance. Plants would need very low fiber amounts and strict containment cleanliness programs to use the clean-plant approach. Plants not meeting the clean-plant criteria would be required to demonstrate compliance through deterministic testing for the sump strainer performance and in-vessel effects. Some plants have installed strainer design features such as bypass eliminators that significantly reduce the amount of debris that passes through the sump strainer and reaches the core, such that the in-vessel limits can be met even with high fiber loads in containment.

  The staff proposes that two RFOs is a reasonable time to plan, design, and install modifications using methods that maintain dose as low as reasonably achievable.

- *Option 2: Mitigative Measures and Alternative Methods Approach*

  Option 2 is a graded approach in which licensees' actions and schedules are based on the amount of fibrous insulation in the plant. Importantly, licensees would implement mitigative measures for strainer blockage and in-vessel effects, whichever are not resolved, while they complete their analyses and plant modifications. Enclosure 2 discusses mitigative measures in more detail. Plants with a high fiber load are generally recognized as having higher risk of strainer and in-vessel issues than plants with relatively low fiber amounts; therefore, higher fiber plants would take measurements at the first opportunity in preparation for insulation modifications. In parallel, licensees could continue to pursue refinements to the evaluation methods (e.g., continue testing and analyses of in-vessel effects), or licensees could use the STP risk-informed approach (described in Enclosure 3), which focuses plant modifications on the most risk-significant aspects of GSI-191 for each plant. Option 2 is in general alignment with the closeout path proposed in the NEI May 4, 2012, letter. Licensees that pursue a risk-informed approach would need to inform the staff of their intent by December 31, 2012, consistent with the NEI proposal in its letter dated May 4, 2012. The staff would work with interested licensees to develop a submittal schedule and would conduct preapplication meetings to reach agreement on plant-specific testing and analyses. Licensees would submit their risk-informed analyses in a staggered schedule all within one year following the staff's decision on the STP approach, which is projected to be completed by December 2014.

  Licensees interested in following the STP approach would need to satisfy specified entry conditions on items such as the quality of the plant-specific probabilistic risk assessment. Licensees would also need to commit to develop a model of plant piping and insulation, sufficient to follow the STP approach, in their next RFO after January 1, 2013, and commit to perform any plant-specific testing needed to justify major assumptions (e.g., chemical effects or strainer headloss correlation) within two RFOs after January 1, 2013. Plants that pursue a risk-informed approach would need to be prepared to implement a deterministic approach in case the risk-informed approach is not viable. This would become evident during the plant-specific testing that would be completed within two RFOs. Since plant measurements would be available, a licensee could default to the already-established deterministic methods and complete modifications by the third RFO after January 1, 2013. If it becomes apparent that a risk-informed approach will not be successful (e.g., unexpected test results), licensees would be required to pursue a deterministic approach for resolution of GSI-191, and finish by the end of the third RFO after January 1, 2013.

  For licensees that pursue a deterministic approach under Option 2, the staff would expect all analyses, testing, and modifications to be completed by the third RFO after January 1, 2013. The additional RFO (compared to Option 1) would be used to refine methods and conduct plant-specific testing.

- *Option 3: Different Regulatory Treatment for Suction Strainer and In-Vessel Effects*

  New information since the preparation of SECY-10-0113, including insights from the STP risk-informed analysis (still preliminary), suggests that different regulatory treatment

for the containment sump and in-vessel effects may be warranted. Even though WCAP-16793, Revision 2, only supports low amounts of fiber that reach the core, the STP preliminary analysis indicates that in-vessel effects are only problematic for a small population of break sizes and locations. WCAP-16793, Revision 2, also does not consider event timing, but the STP analysis shows that timing is important. Enclosure 2 contains a more detailed explanation of Option 3.

In this option, suction strainer blockage is treated in a deterministic fashion. Blockage of sump strainers would result in a significant reduction in defense-in-depth and challenge the integrity of multiple barriers; therefore, sump strainers (the original scope of GSI-191) are handled in a conservative, deterministic fashion. However, if the ECCS and CSS pumps have adequate net positive suction head, but the core inlet becomes blocked, then the following apply:

– Containment cooling remains operable, so containment remains within its design basis and equipment remains within its environmental qualification.

– Containment spray remains operable providing fission product scrubbing.

– The reactor vessel downcomer and lower plenum remain filled and cooled for almost all PWR designs (although the core may uncover).

– Alternative flowpaths (such as hot-leg injection) are available to allow core cooling for most break locations.

Under Option 3, licensees could pursue a risk assessment of in-vessel effects. Timing is important because of the reduction in decay heat, the onset of chemical effects, and operator actions. A risk-informed approach would evaluate the timing and potential mitigative actions associated with the event, rather than assuming worst-case conditions throughout. For some plants, it may be sufficient to show that hot-leg injection is initiated before core blockage occurs. Other plants may require a more rigorous evaluation of break sizes and locations, chemical effects, and debris flowpaths, and they may need supplemental in-vessel effects tests. However, the staff anticipates that the in-vessel risk assessment will be smaller in scope than the overall STP approach discussed in Enclosure 3. The staff would seek a licensee or several licensees to pilot this approach and develop guidance for industry to follow.

For licensees that pursue Option 3, the staff would expect implementation to be consistent with Option 2 regarding the incorporation of mitigative measures. The staff would expect the deterministic strainer evaluation to be completed within two RFOs after January 1, 2013, and all analyses, testing, modifications, and NRC approval to be completed for the in-vessel evaluation on a schedule consistent with the risk-informed approach of Option 2.

On March 1, 2012, the staff provided SECY-12-0034, “Proposed Rulemaking - 10 CFR 50.46(c): Emergency Core Cooling System Performance During Loss-of-Coolant Accidents (RIN 3150-AH42)” (ADAMS Accession No. ML112520186), to the Commission for review and approval. The 10 CFR 50.46(c) proposed rule would expand the applicability of the rule, account for research findings, and address two petitions for rulemaking. The proposed rule

would also provide performance-based requirements and would not be an optional rule. GSI-191 is focused on the long-term cooling aspect of 10 CFR 50.46. The options presented in this paper are consistent with SECY-12-0034. If licensees resolve GSI-191 using deterministic methods, the in-vessel effects would be measured against performance-based criteria submitted for staff review and approval. This was the approach used by the PWROG in developing WCAP-16793, Revision 2. If licensees elect to use a risk-informed approach that would require an exemption from 10 CFR 50.46(c), the exemption would be based on meeting the criteria in RG 1.174.

Summary of Options

	Suction Strainer Resolution Method	**In-Vessel Effects Resolution Method**	**Resolution Period**
Option 1	Deterministic (Approved Models)	Deterministic (Approved Models)	2 RFOs after January 1, 2013
Option 2	Deterministic (Potential to Refine Models) OR Risk-Informed (STP) Approach	Deterministic (Plant-Specific Testing and Analyses) OR Risk-Informed (STP) Approach	3 RFOs after January 1, 2013 OR 1 RFO after NRC decision
Option 3	Deterministic (Approved Models)	Risk-Informed Assessment of In-Vessel Effects	1 RFO after NRC decision

Under Option 1, licensees would complete all work by January 1, 2017 (two RFOs after January 1, 2013, assuming a two-year cycle). Under Option 2, licensees that pursue a deterministic approach would complete all work by January 1, 2019 (three RFOs after January 1, 2013, assuming a two-year cycle). Licensees that pursue a risk-informed approach under Option 2 would complete all work by the end of 2019 (licensees would submit by December 2015, staff review is expected to exceed one year, followed by one two-year cycle to implement modifications). Under Option 3, all work related to the sump strainers would be completed by January 1, 2017, and all work related to in-vessel effects would be completed by the end of 2019.

Backfit Considerations and the Committee to Review Generic Requirements

Adequate sump performance is necessary following a LOCA to maintain long-term core cooling as required by 10 CFR 50.46(b)(5). When the staff issued GL 2004-02, it determined that the actions and information requested were necessary for the NRC to verify licensee compliance with 10 CFR 50.46(b)(5) and, therefore, fell under the compliance exception of the backfit rule (10 CFR 50.109(a)(4)(i)). The staff believes that additional information requests are needed to determine compliance with 10 CFR 50.46, and that such requests are within the scope of GL 2004-02, so the compliance backfit exception remains applicable.

Several times during the staff's consideration of GSI-191, the staff consulted with the Committee to Review Generic Requirements (CRGR) regarding GSI-191. At each consultation, the CRGR

concurred with the staff's determination that information requests were justified to determine compliance with 10 CFR 50.46. The CRGR also agreed that the compliance backfit exception applied to any actions that may be imposed on a licensee to resolve GSI-191.

Dose Considerations

In SECY-10-0113, the staff noted differences between the doses estimated by industry for insulation removal associated with GSI-191 activities and historical doses reported for similar activities. In SRM-SECY-10-0113, the Commission directed the staff to provide the best possible estimate of the occupational dose that would be realized if plants were to undertake plant modifications to remove insulation and to explain the apparent differences between staff and industry occupational dose estimates. Models for resolving GSI-191 are still being developed and licensees are still performing their evaluations; therefore, the scope of modifications has not been determined at this time. As a result, the staff is not in a position at this time to provide a sound and independent estimate of the additional total occupational dose associated with resolution of GSI-191. The industry estimates that replacing the necessary amount of the remaining insulation would result in 80 to 525 person-rem for each plant. The staff does not have a basis to believe that the industry estimates are unreasonable. Enclosure 4 further discusses this issue.

POLICY DISCUSSION:

Under the risk-informed path in Option 2, licensees would need an exemption from certain requirements of 10 CFR 50.46. The exemption would be based on meeting the guidance in RG 1.174. The proposed change would allow fibrous insulation to remain in containment. Although a fundamental principle of RG 1.174 is that the proposed change meets the current regulations, a licensee can use RG 1.174 to support an exemption request or rule change. In accordance with 10 CFR 50.12, "Specific exemptions," the staff would consult with the Commission before issuing this exemption. Industry representatives have indicated that approximately six plants may pursue this approach, so the staff does not anticipate the need for a rule change at this time.

Option 3 allows separate regulatory treatment of sump strainer issues and in-vessel effects. The policy implications for Option 3 are similar to the risk-informed path of Option 2, with two exceptions: (1) it is not clear whether a licensee would need an exemption for the reduced scope of the change and (2) STP is not explicitly piloting this approach. If Option 3 is selected, the staff requests that identified licensees be permitted to pilot the approach.

Any option selected requires a policy decision on schedule.

NEW REACTORS:

New reactor designs are being evaluated using the deterministic methods that were developed for operating reactors. To date, new reactor applicants use large area strainers and their design approach is to minimize or eliminate fibrous insulation within the zone of influence. The remaining fibrous debris source comes primarily from latent or resident debris and is controlled through containment cleanliness programs. In-vessel effects are being considered for all new reactor designs. In December 2011, the AP1000 standard design certification was amended via rulemaking. This amendment resolved GSI-191 including debris strainers and in-vessel effects.

The AP1000 passive design established well-defined limits for debris through design-specific testing and analysis of screens and fuel assemblies. The remaining new PWR applicants (U.S. EPR and US-APWR), given their limited debris source term, are expecting to resolve GSI-191 in a similar manner appropriate to active plants and those reviews are on-going.

RECOMMENDATION:

All three options presented in this paper are viable paths for resolving GSI-191. The staff recommends that the Commission allow licensees the flexibility to choose any of the options discussed to resolve GSI-191 at its plant(s), subject to the conditions and schedules discussed in this paper.

The NEI letter dated May 4, 2012, indicates that licensees will request a variety of paths to resolution of GSI-191 – all encompassed by the options described in this paper. According to NEI, and other informal discussions between the staff and industry, plants would pursue resolutions in the following manner. Of the 69 units affected by GSI-191, approximately half of licensees would currently meet the "clean plant" criteria and are expected to seek resolution under Option 1. These plants should be able to submit documentation to resolve GSI-191 much sooner than the Option 1 end date. Under Option 2, approximately one quarter of plants would seek to continue in-vessel effects testing to demonstrate that the current plant condition meets the requirements. Approximately six plants would pursue a risk-informed approach being piloted by STP. Licensees have also expressed interest in pursuing Option 3.

Upon Commission approval, the staff will ensure that each plant's GSI-191 chosen resolution option and associated implementation schedule are submitted to the NRC by December 31, 2012. The Director of the Office of Nuclear Reactor Regulations (NRR) would use the appropriate regulatory tools to ensure that safety is maintained and schedules are met as plants resolve GSI-191.

RESOURCES:

Approximately six full-time equivalents (FTEs) are included in the fiscal year (FY) 2013 President's budget. FY 2014 resources and beyond will be addressed through the agency's Planning, Budgeting, and Performance Management Process. NRR has verified that adequate resources are available within the FY 2013 and 2014 budgets to address the proposed options, including the most likely "Combination of Options."

FTE Estimates for Resolution of GSI-191

Fiscal Year	Option 1	Option 2	Option 3	Combination of Options
FY 2013	4.0 FTE	5.0 FTE	5.0 FTE	6.0 FTE
FY 2014	4.0 FTE	6.0 FTE	6.0 FTE	6.0 FTE
FY 2015	2.0 FTE	6.0 FTE	4.0 FTE	6.0 FTE
FY 2016	—	4.0 FTE	1.0 FTE	4.0 FTE

The current staff that review risk-informed license applications are fully loaded on a number of significant applications, including 10 CFR 50.48(c) (National Fire Protection Association 805), 10 CFR 50.69 pilot, and risk-managed technical specification (RITS Initiative 4B) pilot. Some of these activities are being supported with staff detailed from other offices. The staff is attempting to recruit and develop additional PRA experts to be able to support these reviews, but it is recognized that there is limited risk expertise available, both inside and outside the agency. There will also be additional time needed to qualify and train new staff assigned to these application reviews.

COORDINATION:

The Office of the General Counsel has reviewed this paper and has no legal objection. The Office of the Chief Financial Officer has reviewed this paper for resource implications and concurred.

/RA/

R. W. Borchardt
Executive Director
for Operations

Enclosures:
1. Background Discussion and Technical Issues
2. Evaluation of Generic Safety Issue-191 Closure Options
3. Risk-Informed Approach to Address GSI-191, South Texas Project
4. Estimating the Dose for GSI-191

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