ENCLOSURE 1: CHANGED TEXT TO RESOLVE ACRS COMMENTS

Revisions to Draft Final Regulatory Guide 1.229 to Address Comments from the Advisory Committee on Reactor Safeguards

This document provides a summary of changes made to the draft final regulatory guide (RG) 1.229 to address comments from the Advisory Committee on Reactor Safeguards (ACRS).

In its letter dated April 19, 2016 (“Regulatory Guide 1.229, "Risk-Informed Approach for Addressing the Effects of Debris on Post-Accident Long-Term Core Cooling," Agencywide Documents Management System (ADAMS) Accession No. ML16102A163), the ACRS provided several recommendations for improving the clarity of RG 1.229. The table below summarizes the ACRS comments and how each was resolved.

Crosswalk of RG 1.229 Changes to Address ACRS Recommendations

Recommendation	**Description of Changes in RG 1.229**
1. Clarify expectations for the assessment of scenarios that involve recirculation from the containment sump, but are not initiated by a loss-of-coolant accident (LOCA).	C.2 – added up-front paragraph to remind the reader that all hazards, initiating events, and plant operating modes were “in scope” until screened. Created new sub-sections C.2.1 and C.2.2 to further emphasize that the scope is not limited to LOCA events.
	C.2.1 – provides generally applicable guidance for determining initiating event frequencies. Removed reference to Appendix C (LOCA frequency partitioning).
	C.2.2 – specific guidance related to LOCAs (not changed) in separate section for clarity.
2. Clarify expectations for the assessment of uncertainties, with particular attention to how uncertainties about debris generation, transport, and deposition on strainers and downstream coolant flow paths are used to support the risk-informed conclusions.	C.4 – clarified that a quantitative assessment of parametric uncertainty may not be necessary for the simplified approach due to the amount of conservatism in that approach.
	C.4 – corrected the text to say that model uncertainty does not need to be considered for consensus methods (original text also excluded parametric uncertainty).
3. Clarify how the “base PRA [probabilistic risk assessment]” or other techniques should be used to define the most limiting equipment operating configurations and flow scenarios for a simplified assessment.	C.1.d(4) – added the idea of “most limiting configurations of operating equipment” as another example use of the PRA for the simplified approach.
	Appendix A – moved *Scenario Development* to A-2 and re-numbered the affected steps.
	Appendix B – changed the titles of B-1.b and B-1.c due to re-numbering in Appendix A.
	B-2.a – added discussion of conservatism in NEI 04-07 and the associated NRC safety evaluation.

Crosswalk of RG 1.229 Changes to Address ACRS Recommendations	
Recommendation	**Description of Changes in RG 1.229**
	B-2.b – added specific guidance that each group of scenarios in the simplified approach should be analyzed for the most limiting configurations of operating equipment, operator actions, flow rates, timing, etc.
4. Clarify that the post-assessment PRA models should be updated to include the risk from debris-related scenarios consistently with the scope and level of detail applied in these analyses.	A-14.h – Added that, prior to use in future risk-informed licensing applications, the base PRA should be updated to reflect the detailed assessment of debris effects for the as-left condition of the plant.
	B-3.e - Added that, prior to use in future risk-informed licensing applications, the base PRA should be updated to reflect the detailed assessment of debris effects for the as-left condition of the plant.
Other changes (not directly related to ACRS comments)	Added definition of *scenario* to C.1.b (it was already in Appendix A) and clarified the caution against screening scenarios based on partitioning of a plant-wide initiating event frequency.

The following changes are proposed to RG 1.229, Section C, "Staff Regulatory Guidance:"

1. Systematic risk assessment of debris.

The rule requires that systematic processes be used to evaluate the risk from debris in terms of core damage frequency (CDF) and large early release frequency (LERF).

a. The systematic risk assessment should …

b. A screening process may be used to justify removing certain hazards, initiating events and plant operating modes based on not being relevant or affected by debris; insignificant contribution, or otherwise not being important to the regulatory decision. One acceptable approach is described in NUREG-1855, "Guidance on the Treatment of Uncertainties Associated with PRAs in Risk-Informed Decision Making" (Ref. 17). PRA information used to support the screening process should meet the technical adequacy guidance contained in RG 1.200.

F~~or LOCA events or other~~In this RG, the term *scenario* means an initiating event followed by a plant response (e.g., combination of equipment successes, failures, and human actions) leading to a specified end state (e.g., success, core damage, large early release). For scenarios where the effects of debris may be location-dependent~~, the amount of debris generated and transported for each such location should be determined by~~ (e.g., LOCAs), the analyst may partition the plant-wide initiating frequency and ~~included as part~~allocate portions of ~~the license application (see C.9). In the case~~ that frequency to each location of ~~LOCAs, for example, the analyst should determine the locations where a LOCA could occur (both piping and non-piping). Due to inherent uncertainties associated with LOCA frequencies~~interest. When this step is performed, no ~~break~~ location or ~~LOCA~~ scenario should be screened from the analysis strictly due to its assumed low frequency; this restriction is needed because any frequency-based screening criteria could be met simply by continuing to partition the plant-wide frequency into smaller and smaller pieces. The sum of ~~occurrence.~~ all location-specific frequencies should equal the original (i.e., pre-partitioned) plant-wide initiating event frequency.

c. The increase in risk from debris …

d. The rule requires that, at a minimum, … It is consistent with the rule and therefore acceptable to assess the risk of debris in a simplified manner and to use the PRA required by the rule to provide insights, for example, to:

(1) estimate the internal events portion of total plant CDF and LERF, which are used along with ΔCDF and ΔLERF from debris when using Figures 4 and 5 of RG 1.174;

(2) ensure completeness of internal initiating events considered in the risk evaluation;

(3) aid in screening of scenarios from further consideration;

(4) determine the most limiting configurations of operating equipment and the relative frequencies of being in a given plant operating condition; and,

(5) justify LERF estimates based on the type of sequences affected by debris.

e. The rule allows other risk assessment techniques …

f. The risk evaluation may rely on engineering calculations … .

g. The rule requires any risk increase attributable to debris …

h. Specific approaches for the systematic risk assessment …

2. Initiating Event Frequencies[1].

As stated in Section C.1, the risk assessment must consider all hazards, initiating events, and plant operating modes. The results of the screening process should result in a reduced set of scenarios, such as LOCA events, main steam or main feed line ruptures inside containment, or other events where the recirculation mode of operation of the ECCS or CSS could provide some mitigation of the event. General guidance on determining initiating event frequencies is contained in Section C.2.1. This guidance should be used for non-LOCA events that are retained after the

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1 Several paragraphs in this section of the RG contain guidance on partitioning LOCA frequencies to specific locations. This guidance is included for licensees that may wish to propose more detailed methods for partitioning LOCA frequencies than contained in Appendix C.

screening performed in Section C.1. NRC staff experience to date with the application of a risk-informed approach to address the effects of debris on post-accident long-term core cooling indicates that LOCA events are likely to remain after screening and that specific guidance on developing the LOCA frequencies would be useful to analysts. This specific guidance on determining LOCA frequencies is provided in Section C.2.2.

2.1 Initiating event frequencies should be developed consistent with the ASME/ANS PRA Standard, as endorsed by RG 1.200[2]. In general, initiating event frequencies are plant-wide. However, the effect of some initiating events important to generating or transporting debris, such as a pipe break, may be highly location-dependent. Therefore, it may be necessary for the analyst to partition the overall initiating event frequency to specific locations. Appendix C provides guidance on When a partitioning approach is used to assign portions of the plant-wide initiating event frequencies. If another method not contained in Appendix C is proposed for partitioning initiating event frequencies frequency to specific locations, the analyst should ensure that such partitioning preserves the overall initiating event frequency and does not result in truncation of sequences based solely on the low frequency resulting from the partitioning.

2.2 It is anticipated that many of the initiating events that remain after screening will involve LOCAs. NUREG-1829, "Estimating Loss-of-Coolant Accident Frequencies Through the Elicitation Process" (Ref. 18), may be employed as the source document for plant-wide LOCA frequencies. The following guidance should be applied when using the NUREG-1829 LOCA frequencies:

a. Break locations: …

b. Aggregation method for LOCA frequencies: … .

c. Interpolation of NUREG-1829 plant-wide LOCA frequencies: …

d. Apportionment of LOCA frequencies: …

e. Parametric uncertainty: …

f. Applicability of NUREG-1829 results: …

g. Site-specific LOCA contributors: …

h. If the information from NUREG-1829 is not used …

i. NUREG-1829 contains different summary tables …

3. Defense in Depth and Safety Margins. …

4. Uncertainty.

Consistent with RG 1.174, comparisons to the risk acceptance guidelines should be made with appropriate consideration of the uncertainties involved. The fundamental objective of an uncertainty evaluation is to provide confidence that the risk acceptance guidelines are met. For

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2 The reference to the ASME/ANS PRA standard is intended to refer to the revision of the ASME/ANS PRA standard that is endorsed in the current revision of RG 1.200.

the purposes of this application, NUREG-1855 provides an acceptable method for treating uncertainty. Approaches other than NUREG-1855 that achieve this objective may also be used subject to NRC review and approval.

Analysts should note that "consideration" of a source of uncertainty does not necessarily mean that its effect is quantified. Bounding approaches, screening, and sensitivity studies are examples of alternative methods that are acceptable, provided the guidance in NUREG-1855 is followed. If the inherent uncertainties are not evaluated quantitatively for each element of the scenario analyses, qualitative assessments can provide important information about the amount of conservatism in the nominal analyses and the available margins to regulatory acceptance criteria. Note that for the simplified approach (Appendix B), there should be sufficient conservatisms to obviate the need for a quantitative assessment of parametric uncertainty.

In addition, portions of the analysis using NRC staff-accepted deterministic methods do not require quantification of model uncertainty ~~(model or parametric).~~because they are considered consensus models. The ~~NRC considers the~~ accepted deterministic methods ~~to be~~are conservative enough to compensate for model uncertainty. ~~The NRC recognizes that some methods that were accepted in the past are currently not considered to contain significant conservatism; however, the most recent methods, for~~ For example ~~those~~, methods accepted in RG 1.82, are considered to be adequately conservative.

Analysts should apply their chosen approach to all sources of uncertainty (e.g. parametric and modeling) that could affect the decision being made (i.e., whether the RG 1.174 risk acceptance guidelines are met). This includes, but is not necessarily limited to:

- initiating event frequency (plant-wide and location-specific)
- debris generation
- debris transport
- head loss at strainer
- chemical effects
- strainer penetration
- downstream effects (in-vessel and ex-vessel)
- calculation of the increases in CDF and LERF (for comparison to risk acceptance guidelines)

NUREG-1855 contains guidance …

5. Monitoring Program. …

6. Quality Assurance. …

7. Periodic Update of Risk-Informed Analysis. …

8. Reporting and Corrective Actions. …

9. License Application. …

The following changes are proposed to RG 1.229, Appendix A, "A Detailed Approach for Conducting the Risk-Informed Analysis of Debris for PWRs:"

A-1. Scope: …

A-2. Scenario Development: The analyst should develop descriptions of the as-built and as-operated nuclear power plant including the phenomenological, physical, and mathematical models to be developed under Paragraph A-5 of this Appendix. The analyst should define the following:

a. plant operating modes and operating components that were not screened out of the risk-informed analysis of debris effects;

b. long-term period of performance, including a definition of the safe and stable end-state of the nuclear power plant (i.e., safe state after mitigation of the event); the 24-hour mission time typically used in PRAs may not be applicable if long-term effects (e.g., chemical precipitation) are expected to occur outside of this time frame;

c. human actions that are part of the accident sequence; and,

d. the set of assumptions and considerations relevant to the development of the systematic risk assessment.

A-2

A-3: Failure Mode Identification: …

A-34. PRA Model Changes: …

A-45. Submodel Development: …

A-5. Scenario Development: The analyst should develop descriptions of the as-built and as-operated nuclear power plant including the phenomenological, physical, and mathematical models identified under Paragraph A-4 of this Appendix. The analyst should define the following:

a. plant operating modes and operating components that were not screened out of the risk-informed analysis of debris effects;

b.a. long-term period of performance, including a definition of the safe and stable end-state of the nuclear power plant (i.e., safe state after mitigation of the event); the 24-hour mission time typically used in PRAs may not be applicable if long-term effects (e.g., chemical precipitation) are expected to occur outside of this time frame;

c.a. human actions that are part of the accident sequence; and,

d. the set of assumptions and considerations relevant to the development of the systematic risk assessment.

A-6. Debris Source Term: …

A-7. Debris Transport: …

A-8. Strainer Evaluation: …

A-9. Impact of Debris: …

A-10. Chemical Effects: …

A-11. Debris Penetration Evaluation: …

A-12. Debris Penetration Effects: …

A-13. Submodel Integration: …

A-14. Systematic Risk Assessment: …

The following changes are proposed to RG 1.229, Appendix B, "A Simplified Approach for Conducting the Risk-Informed Analysis of Debris for PWRs:"

B-1. Scope, Failure Modes, Scenarios, and Debris: The analyst would use the following guidance of Appendix A to this RG in order to determine the overall scope of the risk assessment.

a. A-1, Scope

b. A-2, ~~Failure Mode Identification~~Scenario Development

c. A-~~5, Scenario Development~~3, Failure Mode Identification

d. A-6, Debris Source Term

e. A-7, Debris Transport – the analyst may evaluate transport or assume that all of the debris generated, for which limits are necessary, transports to the strainer.

B-2. Impact of Debris: The analyst determines …

a. The analyst should define a range of loads, debris types, debris combinations, debris arrival sequences, and interactions with chemicals in the fluid where the strainer is not expected to fail and net positive suction head (NPSH) margins can be maintained. Strainer failure may be structural or be attributed to degasification or voiding that results in excessive void fraction at the pumps. Testing should be done per guidance in RG 1.82, "Water Sources for Long-Term Recirculation Cooling Following a Loss-of-Coolant Accident," Section 1.3.12, to support conclusions of strainer performance. Specifically, RG 1.82, Section C.1.3.12.a refers to Nuclear Energy Institute (NEI) 04-07, "Pressurized Water Reactor Sump Performance Evaluation Methodology" and the associated NRC staff safety evaluation for direction on performing head loss evaluations for sump strainers. The NEI guidance, as supplemented by the safety evaluation, contains conservatism in each subpart of the evaluation including debris generation and debris transport. Implementation of this guidance should result in the analyst considering the most limiting equipment operating configuration when using the simplified approach.

b. ~~The analyst should determine when an initiating event~~In performing step A-1 of Appendix A to this RG, as referenced in B-1 above, the analyst identified one or more groups of scenarios that are in-scope for the simplified analysis. The analyst should determine which of the scenarios within each group could result in debris loads at the strainer greater than those shown acceptable under Paragraph B-2.a of this appendix, and assume system failure whenever those conditions are predicted to occur. These analyses should be performed for the most limiting configurations of operating equipment, operator actions, flow rates, timing, etc., considering the group of scenarios being evaluated. . For example, the likelihood of plant operational states may be taken from the PRA, but other parameters like flow rates, timing, operator actions should be set at limiting values. The base PRA model may be useful in identifying limiting scenarios. Other engineering analysis, including thermal-hydraulic calculations, may also be used.

c. The analyst should evaluate …

d. The analyst should define a range …

e. The analyst should determine conditions …

f. If the analyst considers timing in the assessment …

B-3. Systematic Risk Assessment: …