Regulatory Guide Number: **RG 1.99, Revision 2**

Title: **Radiation Embrittlement of Reactor Vessel Materials**

Office/division/branch: **NRR/DNRL/NVIB**

Technical Lead: **David Rudland**

Staff Action Decided: **Reviewed with issues identified for future consideration**

1. What are the known technical or regulatory issues with the current version of the Regulatory Guide (RG)?

The U.S. Nuclear Regulatory Commission (NRC) issued Regulatory Guide (RG) 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials," in 1988 (Agencywide Documents Access and Management System (ADAMS) Accession Number ML003740284). RG 1.99 provides guidance to licensees of light-water reactors (LWRs) in the United States to predict the change in materials properties due to irradiation. RG 1.99 provides a methodology to determine the reference temperature, nil ductility transition (RTNDT) of irradiated materials and the upper shelf energy (USE) of irradiated materials. In RG 1.99, the RTNDT adjusted for the effects of neutron irradiation is called the adjusted reference temperature. RG 1.99 also provides guidance on the use of surveillance program data on plant-specific materials to adjust the prediction of RTNDT and USE.

In 2019, the NRC staff completed an assessment of the adequacy of RG 1.99, which it documented in "Assessment of the Continued Adequacy of Revision 2 of Regulatory Guide 1.99—Technical Letter Report" (ML19203A089). The assessment identified a few issues for further consideration. The most significant of these is the performance of the embrittlement trend correlation at higher neutron fluences (greater than $6x10^{19}$ neutrons per square centimeter (n/cm2), (energy (E) > 1 mega electron-volt (MeV)).

As a result of this 2019 evaluation, the staff initiated an effort to evaluate a potential alternative to RG 1.99, and whether formal implementation of such an alternative was necessary, based on both technical adequacy and probabilistic fracture mechanics considerations. The report, "Basis for a Potential Alternative to Revision 2 of Regulatory Guide 1.99," (ML20345A003), documents the technical basis of a potential alternative to RG 1.99 that was developed to address the issues for further consideration. This report also documents the results of a study of the fleet impact if the potential alternative were implemented. This report does not address whether implementation of a revision or alternative to RG 1.99 is necessary from a safety or risk perspective. However, the results of the related risk assessment contained in TLR-RES-DE-CIB-2020-09, "RG-1.99R2 Update FAVOR Scoping Study," dated October 26, 2020 (ML20300A551), supported the decision by the staff, at that time, not to pursue implementation of a potential alternative to RG 1.99, Revision 2.

More recently, the staff submitted SECY-22-0019, "Rulemaking Plan for the Revision of Embrittlement and Surveillance Requirements for High-Fluence Nuclear Power Plants in Long-Term Operation," to the Commission on March 8, 2022 (ML21314A215). The staff requested Commission approval to conduct rulemaking to amend the reactor pressure vessel (RPV) embrittlement and surveillance requirements in Title 10 of the Code of Federal Regulations (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," for high-fluence

plants in long-term operation. In its evaluation of the embrittlement issue, the staff considered maintaining the status quo and two rulemaking alternatives as follows:

Alternative 1, Status Quo: Make no changes to Appendix H to 10 CFR Part 50, 10 CFR 50.61, or RG 1.99. To address plant-specific circumstances, the staff would evaluate proposed plant-specific actions in accordance with Management Directive 8.4, "Management of Backfitting, Forward Fitting, Issue Finality, and Information Requests," dated September 20, 2019. In addition, the staff would consider generic communications, such as bulletins and generic letters, to address the issue. Bulletins are intended for significant issues that have great urgency, and generic letters are intended for emergent or routine technical issues with generic applicability or risk-significant compliance matters that should be brought to the attention of licensees promptly.

Alternative 2, Focused Solution: Revise Appendix H to 10 CFR Part 50 to include additional surveillance testing requirements for long-term operation. A revised fluence function fit (e.g., a new ETC or an update to existing ETCs) would be developed for only RPV materials that will experience high neutron fluence levels and would be appropriately implemented in a manner to be determined in the applicable regulations and guidance.

Alternative 3, Comprehensive Solution: Revise Appendix H to 10 CFR Part 50 to include additional surveillance testing requirements for long-term operation, update the applicable regulations (e.g., 10 CFR 50.61) to require all licensees to use an NRC-approved ETC that properly accounts for radiation effects, update RG 1.99 to contain an ETC (and associated technical requirements) that appropriately accounts for radiation effects, and update implementing guidance.

At this time, a review and vote from the Commission on SECY-22-0019 is pending for the foreseeable future.

2. What is the impact on internal and external stakeholders of <u>not</u> updating the RG for the known issues, in terms of anticipated numbers of licensing and inspection activities over the next several years?

SECY-22-0019 summarizes the impacts of not updating Appendix H to 10 CFR Part 50, 10 CFR 50.61, or RG 1.99 as follows:

- A rulemaking to address the varying plant-specific circumstances that can affect embrittlement of the RPV could be complex. The staff could continue to use existing guidance and procedures, to the extent applicable. Thus, agency resources would be spent on a plant-specific basis to determine appropriate action, including consideration of backfitting implications. This alternative would be an advantage only if a limited number of licensees continue to pursue long-term operation.

- Existing NRC licensing processes would continue to be used to address this issue on a case-by-case basis in instances where an affected licensee applies for long-term operation.

3. What is an estimate of the level of effort needed to address identified issues in terms of full-time equivalent (FTE) and contractor resources?

As discussed above, the staff is currently awaiting the Commission review and vote on the alternatives identified in SECY-22-0019. After the Commission responds, resource estimates to update RG 1.99 will be determined by the staff.

4. Based on the answers to the questions above, what is the staff action for this guide (Reviewed with no issues identified, Reviewed with issues identified for future consideration, Revise, or Withdraw)?

Reviewed with issues identified for future consideration.

5. Provide a conceptual plan and timeframe to address the issues identified during the review.

As discussed in SECY-22-0019, the staff will develop a detailed schedule if the Commission approves the staff's rulemaking plans. At this time, the NRC staff will continue to await the Commission review and vote on SECY-22-0019, which will inform any near-term decision to revise RG 1.99 accordingly.

NOTE: This review was conducted in November 2023 and reflects the staff's plans as of that date. These plans are tentative and subject to change.