

MEMORANDUM

Date: 10 July 2026

From: Mark Kirk, kirk@peaiconsulting.com

To: DCISC

Subj: Comparison of NRC Documents released on 2 June 2026 with the statement made by the NRC in SECY-22-0019

On 9 June 2026 Andrew Kadak and i sent to the DCISC a memorandum entitled “NRC Documents released on 2 June 2026 concerning “Potential Changes to RPV Embrittlement Regulations Under SRM-SECY-22-0019.” That memorandum summarized for the DCISC the contents of two documents the NRC issued on 2 June 2026 (a cover letter (ML26148A432) and a White Paper (ML26148A433)), that provided up-to-date information concerning the NRC staff’s current thinking on how they will execute the rulemaking plan described in SECY-22-0019 (ML21314A215: “*Rulemaking Plan for the Revision of Embrittlement and Surveillance Requirements for High-Fluence Nuclear Power Plants In Long-Term Operation*”) in a manner consistent with the Commissions direction described in (ML25196A437). That memorandum also assessed the expected impact of the changes that the NRC is considering on Diablo Canyon Unit 1 to be negligible.

Following receipt of this memorandum the DCISC asked me to perform an analysis that compares the information in the documents of 2 June 2026 with the statements made in SECY-22-0019 in early 2022. The purpose of this memorandum is to provide that comparison. I will first summarize the main changes proposed by the 2022 and 2026 documents. I will then discuss what has new proposals appear in the 2026 white paper (ML26148A433) that were not present in the 2022 rulemaking plan (ML21314A215). Finally, i will provide my assessment of these changes and how they compare with the current state of knowledge.

For brevity i will henceforth refer to these documents by their year of issuance only: 2022 and 2026.

It should be recognized that both the 2022 and 2026 documents reveal an NRC rulemaking process closer to its beginning than its ending. The staff only received authorization to begin work on rulemaking in 2025, and in the 2026 White Paper they are still seeking public comment before they enter their formal rulemaking process. Remaining steps include (A) the staff documenting a technical and regulatory basis for their changes, (B) the staff crafting new regulatory language, (C) seeking and addressing public comment on the first two steps, and (D) getting Commission approval for the final rule language. It is difficult to forecast with precision how along all of this might take, but in my opinion if they get to the final rule sometime in 2028 they will be doing well.

Common and evolving themes between 2022 and 2026

The main objective of both the 2022 and 2026 documents is to update NRC requirements and guidance on two topics:

- Embrittlement trend curve (ETC) predictions of ΔT_{41J} in [10CFR50.61] and in [RG1.99R2], and
- Surveillance monitoring of reactor pressure vessel embrittlement, particularly for periods of license renewal to 60-years and subsequent license renewal to 80-years of operation. Currently requirements and guidance on this topic appears in [10CFR50-AppH]

The NRC's proposed changes to address these issues, while not finalized¹, evolve toward greater specificity between the 2022 and 2026 documents, as summarized below:

- **Updating Embrittlement Trend Curves:** The NRC discusses revising the "fluence function fit, by which they mean the ETC, that is used to predict how the magnitude of embrittlement as quantified by Charpy transition temperature shift (ΔT_{41J}) depends on the amount of neutron irradiation damage (as quantified by neutron fluence) and other important embrittlement variables such as copper, nickel, irradiation temperature and so on. The 2022 document discusses a comprehensive NRC review [TLR-RES/DE/CIB-2019-2] of the fidelity of the [RG1.99R2] ETC, which finds that the ETC predictions become non-conservative (that is, ΔT_{41J} is under-predicted) "*at neutron fluence levels greater than $3\text{-}6\times 10^{19}\text{ n/cm}^2$.*" The NRC notes that this trend is more evident in data from base metals than in data for weld metals. In 2022 the NRC does not propose a solution to this problem. By 2026 a more specific proposal is made, as follows:

"The staff is considering a revision to 10 CFR Part 50.61 to remove the current prescriptive ETC requirements and require the use of an NRC-approved ETC augmented with the appropriate margins at high neutron fluences ($6\times 10^{19}\text{ n/cm}^2$). In conjunction with the changes to 10 CFR 50.61, the staff is considering an update to RG 1.99, Rev. 2, such that the use of the ETC in E900-15 would be approved for all neutron fluences up to $2\times 10^{20}\text{ n/cm}^2$, while the ETC in RG 1.99, Rev. 2, would be approved only for neutron fluence levels less than $6\times 10^{19}\text{ n/cm}^2$. Thus, the only ETC approved for neutron fluences greater than or equal to $6\times 10^{19}\text{ n/cm}^2$ would be the E900-15 ETC. Therefore, the updated RG 1.99 would contain two NRC-approved ETCs, but these ETCs would not be explicitly identified in 10 CFR 50.61."

¹ The Executive Summary of the 2026 document states the following, with **emphasis added**: "*This white paper discusses NRC staff's preliminary technical perspectives developed in response to the direction in SRM-SECY-22-0019. These considerations are intended solely to describe the staff's initial thoughts and to support stakeholder engagement. **Its contents should not be interpreted as official agency positions or an indication regarding the direction or scope of any upcoming rulemaking effort, and they may be refined as the NRC staff continues its evaluation.***"

- **Surveillance Program Testing and Withdrawal Schedules:** In the 2022 document the NRC describes how under the existing regulatory requirements of [10CFR50-AppH], some licensees have repeatedly deferred withdrawing or testing their remaining capsules to ensure adequate surveillance monitoring for extended operations to 60- or 80- years. The NRC notes that these deferrals have been accepted based on a Commission decision in 1996 that permitted licensees to change the withdrawal schedule without prior NRC approval provided the changes conform to the requirements of [ASTM E185], which is incorporated into [10CFR50-AppH] by reference. The 2022 document states that this policy has resulted in plants being allowed to operate to fluences that extend beyond that for which a surveillance capsule has been withdrawn and tested. In the 2022 document the NRC states the following:

“During the review of two subsequent license renewal applications, the staff found that the withdrawal of a capsule intended for the original 40-year surveillance program and credited for aging management under their 60-year renewed operating license had been extended, in some cases several times, until the capsule achieved the 80-year projected peak neutron fluence of interest for the RPV. Some licensees have adopted this practice of repeatedly extending the withdrawal of the same capsule - without the withdrawal and testing of any surveillance capsules in the intervening time to verify the current embrittlement status of the RPVs - with the last available surveillance data in some cases representing less than 30 years of plant operation. One licensee, under its subsequently renewed license issued in 2019, extended the withdrawal schedule of a particular capsule until approximately 2026; based on this schedule, the RPVs at the site will have been in service for approximately 53 years, and approximately 25 years would have elapsed since the last time the licensee withdrew and tested a capsule (i.e., 2001). Another licensee, under its subsequently renewed license issued in 2021, adopted a similar practice. The schedules approved by the NRC allow the licensee to withdraw a capsule from one unit in 2027 and from the other unit in 2032. Based on these approved schedules, approximately 41 and 30 years will have elapsed since the last capsule with relevant information was withdrawn and tested (1986 and 2002, respectively).”

Citing these examples, the 2022 document concluded that

“It has been demonstrated that there exists (1) an increasing gap in plant-specific surveillance data, (2) a lack of knowledge of the current embrittlement status of RPV material properties based on surveillance data, and (3) an increased uncertainty in the embrittlement projections of the RPV in the intervening time.”

While the 2022 document offered no changes to address these issues, the 2026 document is more specific, stating the following:

In order to address this issue, the staff is considering a revision to Appendix H to 10 CFR Part 50 to ensure that adequate surveillance data is collected. One option is to delineate separate surveillance requirements for the initial licensed period (first 40 years) and any periods of extended operation granted in accordance with 10 CFR Part 54. During the initial licensed period, the requirements would remain unchanged. However, during periods of extended operation, the requirements would be revised to ensure that data

from additional surveillance capsule(s) with a neutron fluence equal or greater than the peak RPV neutron fluence for extended operation is tested at an appropriate periodicity (e.g., every 20 years) to ensure adequate performance monitoring. It would be expected that under such a revision to the requirements, the withdrawal and testing of any surveillance capsules would occur prior to the end of the renewed license period. Such a change in requirements would ensure that adequate performance monitoring occurs over the lifetime of the RPV while recognizing that some licensees may have already obtained surveillance data that supports long term operation of the RPV.

The statements that an “*appropriate periodicity*” for surveillance monitoring is “*every 20-years,*” suggests that if rulemaking is undertaken future surveillance requirements will mandate the withdrawal and testing of one additional surveillance capsule for each 20-year extension of the license period. If implemented this would increase the requirements for surveillance monitoring relative to those currently in place.

New Proposals in the 2026 Document

The 2026 document includes as section identified as “3.3 *Technical areas related to voluntary adoption of alternative vessel embrittlement approaches for operating and new reactors.*” The topics discussed in this section did not appear in the 2022 document. They are as follows:

- **Direct Fracture Toughness:** Section 3.3.1 presents the staff’s views on adopting measurements of the fracture toughness transition temperature of RPV steels (T_0) according to ASTM Test Method E1921. Such measurements would replace or supplement the conservative and correlative methods based on RT_{NDT} and Charpy data that have long formed the basis for RPV integrity assessment. These methods are referred to as “direct toughness” because fracture toughness, which is a needed input for the fracture mechanics equations used in ASME flaw tolerance and operating limits assessments, is measured *directly* using ASTM Test Method E1921 rather than being inferred conservatively using RT_{NDT} and Charpy data. As correctly noted by the 2026 document, these methods “*provide a more accurate index of the materials fracture toughness transition temperature compared to RT_{NDT} .*” The 2026 document further points out that “*while the NRC has not generically approved the use of direct fracture toughness {in the past}, there are instances where the staff has approved either a plant-specific application, topical report, of ASME Boiler and Pressure Vessel Code application.*” The 2026 document concludes by saying that “*the staff is considering a revision of ... regulations to approve the use of direct fracture toughness as an alternative to the typical RT_{NDT} toughness relationships without the need for exemptions.*”
- **Reconstitution:** Section 3.3.1 also expresses the staff’s receptivity to reconstitution as a process to obtain more Charpy specimens out of already broken samples. ASTM Standard E1253 provides the consensus international standard for Charpy reconstitution. The 2026 document makes no comments concerning how this change would manifest in revised or new regulations.

- Design of Reactor Vessel Material Surveillance Programs: Section 3.3.2 states that 10 CFR 50 Appendix H may be modified to incorporate the by reference the current editions of ASTM guidance for surveillance program design [E185-25] and surveillance program conduct [E2215-24]. This would represent a significant modernization of NRC guidance, which currently references only the 1982 edition of E185. The document notes that this more up-to-date guidance “*would allow the use of current standardized methods that improve the quality and coverage of surveillance programs.*” Specific improvements cited include better procedures for adjusting withdrawal schedules to extended lifetimes, the allowance of reconstitution to extend the timeframe over which the surveillance program can operate, and the allowance of higher lead factors, which allows earlier collection of capsules that have reached 60- and 80- year fluences.
- Regulatory flexibility for both extended lifetime and new reactors: Section 3.3.3 discusses options to introduce options of flexibility into what has been, heretofore, a highly prescriptive regulatory strategy. Possibilities discussed include the following:
 - Altering 10 CFR 50.60(b) to allow alternatives to the current requirements of Appendices H and G to 10 CFR Part 50 without the need for an exemption review. Appendices H and G to 10 CFR Part 50 establish requirements for the RPV surveillance program and for the fracture toughness required of RPV steels.
 - Altering 10 CFR 50.61 (that is: the PTS rule) to allow licenses to propose alternative analysis methods and to allow the use of alternative ETCs to those currently allowed. Alternative analysis methods may be needed by new reactor designs that may not experience PTS in the same manner, or at all, as current generation reactors. Alternative ETCs may be needed by new reactor designs such as small modular reactors that operate at temperatures lower than those for which experience exists.
 - Revising 10 CFR Part 50 Appendix H to “*clarify the existing requirements for an integrated surveillance program (ISP) and ensure that they better reflect current best practices and future plant configurations.*”
- Artificial intelligence and machine learning: Section 3.4 discusses the possibility of using AI and ML to “*analyze existing data on embrittlement as a supplement to future coupon sampling and analysis.*” The document observes that “*Overall ML methods show significant promise for developing more accurate ETCs in the future. However, use of ML methods cannot compensate for the scarcity of data for high-fluence light water reactor conditions.*”

Assessment of these proposals

The NRC’s proposals summarized in the preceding sections describe an effort that, if undertaken, will bring NRC guidance and requirements up to date with the current state of practice as reflected by consensus guidance already in place or, i believe, soon to be adopted by ASTM and ASME. The extensive changes described by the NRC are necessary

because the NRC's regulatory framework on embrittlement prediction [RG1.99R2], on surveillance monitoring [10CFR50-AppH], and on RPV integrity assessment [10CFR50.61, 10CFR50-AppG] was established by the mid to late 1980s and has not been substantially updated since that time. Over the last four decades considerable advances in the state and extent of knowledge, availability of pertinent data, measurement techniques for fracture toughness, and analytical techniques has occurred – advances that can improve the safety of reactor operation.

I would observe the following concerning the NRC's technical proposals:

- The evolution in content between the 2022 and 2026 documents on the topic of **embrittlement trend prediction** represents a natural increase in specificity that occurs as an agency moves from broadly stated goals towards specific regulatory changes. The changes described in the 2026 document will align NRC requirements more closely with the current state-of-practice understanding as documented in ASTM Standard Guide E900. The database assembled by this Guide and the ETC prediction model it contains have, since 2015, become the *de facto* reference for embrittlement data and ΔT_{41J} predictions.
- The evolution in content between the 2022 and 2026 documents on the topic of **surveillance program withdrawal schedules** shown an effort by the NRC to bring needed clarity to what constitutes adequate surveillance monitoring for plants that have been licensed to operate beyond their initial 40-year license. This topic has not yet, in my opinion, been proactively addressed by either NRC or ASTM. When plants pursued initial license extension (that is: from 40- to 60-years) in the mid-2000s most had plenty of standby surveillance capsules (that is, capsules placed in the reactor to address unforeseen future needs) and so only limited guidance was given. However, as plants have received 80-year licenses, and as discussions have started about the possibility of 100-year licenses it has become increasingly clear that more creative options are needed to allow the finite stock of surveillance samples that were prepared for the original 40-year programs to last for 100 years, or longer. The 2022 and 2026 documents represent the NRC's contribution to this evolution of requirements and guidance. ASTM is also addressing this topic, with revisions to Standard Guide E2215 expected in the next year or so.
- Section 3.3 of the 2026 document summarizes several proposals that did not appear in the 2022 document. Specifically:
 - The NRC discusses greater acceptance without case-specific review of **direct fracture toughness** approaches based on the transition fracture toughness index temperature T_0 as determined by ASTM Standard Method E1921. These proposals represent a logical evolution building from plant-specific exemptions using these methods beginning in the mid 1990s. This technology, new and innovative in the 1990s, has become routine today thanks to extensive work within ASTM on testing techniques and within ASME on assessment strategies. In 2024 the NRC published a rulemaking on 10 CFR 50.55a in which they stated that certain direct toughness approaches

would no longer require case specific review [89 FR 70449]. The proposals in the 2026 document represent a natural evolution of these ideas and are consistent with on-going work in ASME on Code Case N-914 [PVP2026-177478].

- Without stating specifically how their regulations would be impacted, the NRC indicates greater receptivity to the idea of **reconstitution** of Charpy specimens. Whatever is done on this topic will largely be an acknowledgement of what has already been accepted on a case specific basis. ASTM Standard Guide E1253 on reconstitution was first published in 1999 [ASTM E1253]. Reconstitution has been used to extend the utility of the limited supply of surveillance materials in several programs, including the integrated surveillance program that provides monitoring for all boiling water reactors operating in the USA. And, of course, most the from Capsule B in Diablo Canyon Unit 1 were tested.
- Concerning the **design of reactor vessel material surveillance programs** the NRC has stated its intention to endorse the current versions of the most recent ASTM standards E185 and E2215. This is a welcome and long overdue change that will go a long way to keeping NRC requirements up-to-date with current best practice guidance.
- The NRC has offered several proposals under the heading **regulatory flexibility for both extended lifetime and new reactors**, as follows:
 - NRC has suggested that alternatives to the current requirements of Appendices H and G to 10 CFR Part 50 might be accepted without exemption review for new reactor designs. While there is not enough detail in their current proposal to justify and detailed comments, these alternatives would need to address whatever embrittlement issues new reactor designs may present.
 - NRC has suggested that they may accept the use of alternative ETCs in their PTS rule [10 CFR 50.61]. Such a change would allow embrittlement predictions made in PTS evaluations to adopt current ASTM consensus models. Also, this suggestion would permit flexibility in how PTS is addressed in new reactor designs, which may not experience PTS in the same way, or at all, as current generation reactors. For example, some advanced reactors do not use water as the coolant, but may nevertheless pose different reactor vessel integrity issues.
 - NRC has suggested a clarification of their guidance for integrated surveillance programs (ISP) in [10CFR50-AppH]. Such an evolution in regulatory requirements is welcome and long overdue. Two large ISPs exist in the USA; one provides surveillance for all BWRs while the other provides surveillance for 10-20 PWRs having a particular type of weld in their RPV. These ISPs have been in place since the late 1990s and cover nearly half of the operating fleet; they have been effective in providing relevant data in advance of need. This experience, plus

modern understandings of what constitutes a “similar” material from an embrittlement point-of-view can be used to formulate new considerations for and guidance on ISPs. The NRC’s efforts parallel on-going work in ASTM. Such guidance is needed at this time because the future may bring large numbers of small modular reactors (SMRs) into operation, with each unit having an RPV fabricated from embrittlement-similar materials. In such a situation, an ISP would be a logical and efficient means to provide surveillance monitoring.

- The NRC has commented on the use of **artificial intelligence and machine learning** to support ETC models. In the past ~5 years published work on this topic reports predictive accuracy that improves on conventional ETCs like in ASTM E900. By using ML interpretability metrics, it is possible to link ML predictions to a physical understanding of embrittlement mechanisms [references]. This linkage helps eliminate the “black box” aspect of ML and helps instill confidence in the results. The NRC’s comments on ML indicate an awareness of these recent trends, providing further evidence of the NRC’s desire to keep its regulations current with the state of knowledge.

Impact of these proposals on Diablo Canyon Unit 1

A memorandum to the DCISC dated 9 June 2026 from myself and Dr. Kadak assessed the possible impact of the 2026 document on Diablo Canyon Unit 1. That memorandum concluded that the NRC proposals made in the 2026 document have no foreseeable impact on Diablo Canyon Unit 1. Please see the 9 June 2026 memorandum for full details.