

EVALUATION OF OPPORTUNITIES TO EXPEDITE AVAILABILITY OF ASME SECTION XI CODE CASES

September 2022

All or a portion of the requirements of the EPRI Nuclear
Quality Assurance Program apply to this product.

YES



Background

In the United States (U.S.), requirements for inspection, engineering assessment and repair / replacement activities at nuclear power plants are based on Section XI of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (the Code) [1]. The nature of the Code process is such that modifications to Code requirements are often introduced in the form of Code Cases prior to adoption within the Code itself. Often, the alternatives to existing Code requirements provided by Code Cases offer significant benefits to both U.S. licensees as well as the U.S. Nuclear Regulatory Commission (NRC). Optimally, licensees would be able to implement Code Cases immediately, or very soon after, publication of the approved Code Case by ASME. However, U.S. regulation does not permit generic use of any published Section XI Code Case until it is identified as acceptable within NRC Regulatory Guide 1.147 [2]. This regulatory guide identifies the ASME Code Cases that the NRC has determined to be acceptable, or conditionally acceptable, alternatives to applicable criteria of Section XI. Once a Code Case is included in a revision to Regulatory Guide 1.147 and that revision has been incorporated by reference into 10 CFR 50.55a [3], U.S. licensees may use the Code Case without requesting authorization from the NRC, provided that Code Case implementation complies with any conditions specified in the regulatory guide.

Over the course of the last 15 years, Regulatory Guide 1.147 has been revised on average once every 2 to 4 years (see Table 1 below). Since there is a cut-off date for inclusion of a Code Case of some number of months ahead of each revision to Regulatory Guide 1.147 and since each revised version of Regulatory Guide 1.147

must subsequently be incorporated into §50.55a using the normal rulemaking process for a change to the Code of Federal Regulations prior to a Code Case being available for use, the resulting delay between Code Case publication by ASME and approval for licensee use without a Request for Alternative is in the range of 3 to 6 years. During this interim period, use of a Code Case is permitted only on a plant-specific basis via a Request for Alternative. These Requests for Alternatives must be authorized by the Director of the Office of Nuclear Reactor Regulation, or the Director of the Office of New Reactors, as appropriate. Obtaining plant-specific approval for such an alternative can be a time and resource intensive process for both the NRC and licensees, even for published Code Cases that are supported by robust technical bases.

This substantial delay adversely impacts utility resources in the form of inspections, evaluations, or additional process requirements that must be continued until either a plant specific Request for Alternative is approved, or the Code Case is included in a revision of Regulatory Guide 1.147 that is recognized in §50.55a. Costs are also incurred through the Request for Alternative process since licensee resources are required to prepare the Request for Alternative and NRC resources are required for review and approval. As a result, an effort was initiated to assess options for expediting the availability of Code Cases for implementation with the goal of reducing or, optimally, eliminating the waiting period. The purpose of this white paper is to document the results of this evaluation and associated conclusions and recommendations.

Table 1. Recent Regulatory Guide 1.147 Revisions

Revision	Revision Date
19	October 2019
18	March 2017
17	August 2014
16	October 2010
15	October 2007

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Regulatory precedent is often applied as a method of assessing regulatory acceptance of an aging management approach. For example, regulatory precedent is often leveraged, either directly or indirectly, by licensees during the license renewal process. In this example,

although the proposed aging management approach is still subject to regulatory approval, the use of precedent generally ensures regulatory acceptance since it is reasonable to conclude that previously accepted approaches remain acceptable unless there are new regulatory concerns not previously identified. To further streamline the license renewal process, the NRC issued the Generic Lessons Learned (GALL) Report [4]. This report includes comprehensive tables of recommended aging management approaches, that, if implemented without exception, generally ensure staff acceptance without the need to issue requests for additional information and with minimal review time. Precedent based on previous NRC approval is also often cited by licensees within submitting requests for relief from regulatory requirements. These approaches reduce the resource burden associated with both licensee preparation of submittal documents and regulatory review and approval.

Another process that leverages the concept of precedent to reduce regulatory burden is the document screening criteria contained within Appendix C of NEI 03-08, Rev. 4 [5]. NEI 03-08, Guideline for the Management of Materials Issues, describes a voluntary industry initiative designed to ensure that management of materials degradation and aging issues is conducted in a forward-looking manner and research activities supporting resolution of materials issues is coordinated to the maximum extent practical. Aging management guidance issued by materials issue programs governed by the NEI 03-08 initiative¹ has often been subject to NRC review and approval. A primary driver for development of the NEI 03-08 Appendix C document screening criteria was an observation that NRC reviews of revisions to BWRVIP Inspection and Flaw Evaluation (I&E) Guidelines were routinely requiring multiple years to complete. These guideline revisions were based on evaluation of extensive inspection data collected over 20+ years. In most cases, evaluation demonstrated that initial guideline requirements were very conservative due to a lack of operating experience and experimental data and that, for some inspection locations, significant reductions in inspection requirements were appropriate. Although these guideline revisions were approved by NRC without substantial changes from the version initially submitted for review, the topical review and approval process required multiple years, during which

time U.S. plants continued to implement overly conservative inspection requirements. As a means of reducing the burden on plants associated with multi-year implementation delays, screening criteria were developed to identify cases where guidance revisions should be released for implementation without NRC review and approval. The document screening process relies on two primary elements: regulatory acceptance precedent and evaluation of risk.

The ASME Code Case implementation process implementation issue was observed to be similar in nature, specifically that the current process results in multi-year implementation delays, even where NRC staff conditions for approval are clearly understood and/or robust risk-based technical bases exist to support use of a Code Case.

Investigations Performed to Identify Solution Options

Using the NEI 03-08 document screening process as a conceptual template, an effort was initiated by EPRI to explore options for screening of ASME Section XI Code Cases that would benefit both industry and NRC. The approach envisioned was intended to mirror the NEI 03-08 document screening process in that it included an initial evaluation using administrative acceptance criteria (i.e., identification of prior precedent of NRC acceptance), with analytical methods for acceptance applied for cases that could not be screened using the administrative acceptance criteria. A review of a sample of ASME Section XI Code Cases was performed as a means of assessing the potential for successful use of either administrative or analytical screening options. This review and the resulting observations and conclusions is summarized below.

Review of NRC Approval Status for Code Cases Not Included in Regulatory Guide 1.147

It seems reasonable that where there is a documented record of NRC acceptance of a Code Case or NRC acceptance with specific conditions that have been subsequently addressed by a change to the Code Case, there should not be an extended delay between Code Case publication by ASME and approval for licensee implementation without a Request for Alternative. To assess the options potentially available, the set of published Code Cases not included in Regulatory Guide 1.147 as of 2021 was reviewed to assess information related to the NRC position on acceptability of each Code Case. The evaluation focused on elements previously found useful in development of the NEI 03-08 document screening process:

¹ EPRI materials issue programs governed by NEI 03-08 include: Boiling Water Reactor Vessel and Internals Project (BWRVIP), Materials Reliability Program (MRP), Steam Generator Management Program (SGMP), Non-Destructive Evaluation Program (NDE), Water Chemistry Control Program, and Welding and Repair Technology Center (WRTC). Visit www.epri.com for additional information.

(1) regulatory precedent defined by NRC approval of a Code Case during the ASME approval process and (2) the capability to define risk-based criteria that would assure Code Case implementation would not have a significant detrimental effect.

The set of Code Cases not included in Regulatory Guide 1.147 were reviewed to determine the numbers and percentages of Code Cases that were:

1. Approved by NRC based on U.S. NRC vote to approve at ASME Section XI Standards Committee without comment or condition.
2. Approved by NRC based on U.S. NRC vote to approve at ASME Section XI Standards Committee with commentary provided that clearly explains the staff intent to condition the Code Case in Regulatory Guide 1.147 with sufficient explanation that a revised Code Case could be developed that addresses the NRC staff comments such that the revised Code Case would be unconditionally approved by NRC.
3. Disapproved by NRC with comments provided that clearly explain the basis for the NRC's disapproval such that a Code Case revision could be developed that would be expected to be approved by NRC without any comments or conditions.
4. Disapproved by NRC with extensive or complex comments such that a clear path to understanding whether or not a revised Code Case would be accepted by NRC does not exist.

The key assumption for this review is that the NRC vote at the Section XI Standards Committee represents the agency's entire position on the proposed Code Case. This was judged to be a reasonable assumption since once an action reaches the Section XI Standards Committee, the NRC representative on the Section XI Standards Committee typically discusses each proposed action with appropriate NRC staff to determine the regulatory position for each action prior to the representative voting on the action. As such, this vote should reflect the overall agency position, regardless of votes cast by NRC representatives in lower-tier groups. Also assumed is that the position of the NRC with regard to the basis for disapproval or detailed input regarding conditions the staff intends to impose on use of the Code Case in Regulatory Guide 1.147 are not likely to change over time.

Each Code Case included in the review was further categorized based on the relevant discipline and estimated overall industry value:

Discipline

- Non-Destructive Evaluation (NDE) / Inspection Scheduling
- Evaluation Standards
- Repair / Replacement
- "Other" (Code Cases not aligning with any of the first three types)

Industry Value

A qualitative assessment of the value of the Code Case to the industry was made based on an estimate of the overall economic benefit resulting from reductions in required inspections, improvements in evaluation methods, or availability of new and improved repair / replacement techniques that reduce the time and/or expense associated with a repair or replacement activity. It is recognized that this valuation is subjective, particularly since not all Code Cases are applicable to all reactor designs. In this evaluation, if the Code Case was judged to be of high value to at least one reactor design, it was categorized as high value, even if the value to other reactor designs was not significant.

The review included 52 Section XI Code Cases approved by NRC at Section XI Standards Committee, but not yet included in Regulatory Guide 1.147. Out of these 52 Code Cases, 43 were approved by NRC at ASME Section XI Standards Committee without comment and one additional NDE discipline Code Case was disapproved, but the comments associated with the NRC negative vote provided a clear pathway to resolution.² Assuming a scenario where Code Cases are immediately available for generic use upon NRC approval, this Code Case would likely have been revised quickly in order to make it available for use and it is included in the set of "Approved" Code Cases. Figures 1 and 2 provide a summary of the results obtained from this exercise. Almost 85% of the Code Cases reviewed were approved by NRC at ASME Section XI Standards Committee. Figure 2 also illustrates that high value Code Cases were not more likely to have disapprovals with complex and/or extensive comments than other value categories.

² For the single Code Case with a negative NRC vote judged to have a simple resolution path, the issue of contention was that the Code Case proposed elimination of future RPV flange thread examinations, but the NRC staff disagreed. The staff did agree that relaxation of inspection frequencies was warranted and proposed a 20-yr interval instead of the current 10-yr interval. In this case, the industry would clearly receive significant benefit from the Code Case, even if the case was revised to address the NRC comment by requiring inspections on a 20-yr interval.

Although this review represents the status at only a single point in time and it is acknowledged that the industry value categorization is subjective, the results strongly suggest that a simple change to the regulatory process that bypasses the Regulatory Guide 1.147 revision and Regulatory Guide 1.147 incorporation into §50.55a waiting periods would resolve the implementation delay issue for the majority of ASME Section XI Code Cases. In addition, if such a process was implemented, it is likely that the percentage of Code Cases with NRC approval without condition would increase since industry would be incentivized to resolve NRC comments on high value Code Cases.

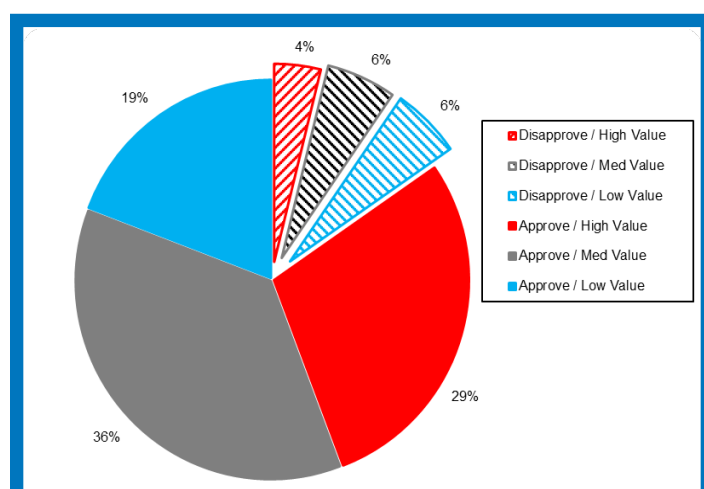


Figure 1. Percentage of Code Cases: NRC Approved (or disapproved with simple resolution) vs. NRC Disapproved with Complex or Extensive Comments

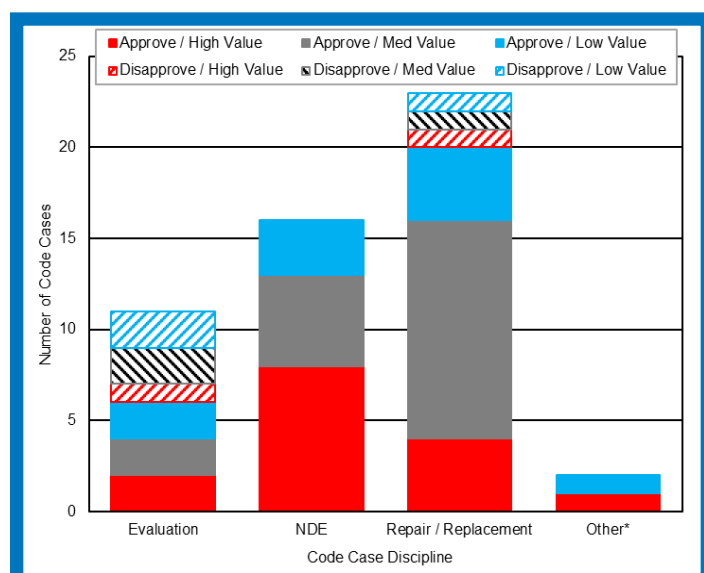


Figure 2. Code Case NRC Approval Status by Discipline and Industry Value

The eight Code Cases disapproved by NRC at ASME Section XI Standards Committee were reviewed to understand the NRC basis for disapproval as a way of assessing if some type of analytical screening criteria could be developed as a basis for expedited implementation.

The majority of these Code Cases (5 of 8) were related to evaluation methods. These included alternative rules for characterization of multiple subsurface flaws, crack growth rate correlations for irradiated austenitic stainless steels, evaluation of metal loss in buried piping, weld residual stress distributions for analysis of dissimilar metal butt welds, and elimination of room temperature fracture toughness testing requirements for modern steels. NRC concerns associated with these Code Cases were largely related to 1) the pedigree of test data and associated limitations that should be imposed on the Code Case based on the supporting data or 2) uncertainty related to the analytical methods that could be used to implement the Code Case (e.g., rules for estimating corrosion rates). These concerns were not quantified, nor were NRC concerns expressed with sufficient specificity to ensure that a revised Code Case attempting to address NRC concerns would be approved by NRC. Instead, a significant element of engineering judgement was found to be involved; with NRC staff maintaining that additional details or supporting data are needed, without quantifying the gap.

The remaining three Code Cases were related to repair / replacement alternatives. These included criteria for use of high-density polyethylene piping (multiple Code Case revisions), criteria for clad welding using temperbead techniques, and SCC mitigation using partial excavation and weld metal deposition. Again, NRC reasons for disapproval were associated with unquantified concerns regarding the pedigree of the supporting data. A clear path to resolution was not apparent.

Review of Administrative Acceptance Options

From this sample evaluation, it was apparent that most Code Case implementation delays would be eliminated through a change to regulation whereby NRC approval at ASME Section XI Standards Committee results in immediate approval of the Code Case for generic use by plants subject to U.S. regulations. This option would be applicable to a majority of the Code Cases reviewed and would be generally noncontroversial in that a similar approach was later recommended by NRC (see “U.S. NRC Activities” below).

Although other administrative acceptance options were considered (e.g., providing generic approval for Code Cases that have been approved by NRC for application at one or more plant sites), these alternative approaches would be rarely needed if the most obvious option of immediate availability for use with an NRC vote to approve the Code Case at ASME Section XI Standards Committee was implemented. Further, these alternatives would require extrapolation of precedent from NRC approvals of site-specific alternatives based on Code Cases or interpretation of the intent of NRC comments and conditions on Code Cases. These options are therefore complicated by the need to ensure generic applicability³ or the need to appropriately interpret NRC staff intent regarding Code Case use conditions.

Review of Technical/Analytical Acceptance Options

The NEI 03-08 document screening process described above permits use of either qualitative or quantitative risk assessments to permit implementation of revised aging management guidance without NRC review and approval. In this evaluation of options to expedite Code Case availability for implementation, effort was made to identify generic criteria that, if met, would ensure no significant adverse effect on safety as a result of Code Case implementation. Options considered to be plausible included quantitative probabilistic analysis, primarily probabilistic fracture mechanics (PFM), and qualitative risk evaluation using variations of failure modes and effects analysis (FMEA). Both of these approaches are permitted under the NEI 03-08 document screening process. Code Cases disapproved by NRC and Code Cases approved with condition in Regulatory Guide 1.147 were reviewed to determine if any pattern of analytical acceptance or rationales for disapproval could be identified. The issues preventing approval were found to be varied and often based on differences of professional opinion related to engineering judgement. As a result, no potential success path was identified from this review.

Regarding PFM, a review of the sample set of Code Cases not included in Regulatory Guide 1.147 identified that the number of Code Cases for which PFM-based criteria could be used as a basis for expedited implementation would likely be very small. All of the Code Cases in the sample set reviewed using PFM as a technical ba-

sis were either approved by NRC or disapproved with specific comments that provide a path to resolution, such that the administrative approval approach identified above would have been successful.

Another approach investigated was to review Regulatory Guide 1.245 [6] to identify generic criteria that potentially could be applied to Code Case screening. Regulatory Guide 1.245 provides guidance for the content needed to support NRC reviews of submittals that include PFM technical bases. Since any criteria would be applied without a detailed NRC review of the specific Code Case, it is reasonable to assume that any criteria developed to support Code Case screening would need to be well understood and accepted by NRC staff. Within Regulatory Guide 1.245, a graded approach to submittal requirements is outlined and it is reasonable to assume that for pre-defined criteria to have any potential for acceptance, the PFM analysis would need to satisfy the conditions for minimal NRC review. This would restrict screening to Code Cases with PFM technical bases where (1) the PFM code used has previously been used in NRC approved applications,⁴ (2) the PFM code application is confined to previously validated ranges, (3) inputs are well defined and not controversial, (4) treatments of uncertainties are consistent with regulatory precedents, and (5) there are no identified concerns regarding analysis convergence or sensitivities. Very few Code Cases are likely to have a PFM technical basis that meets all of these conditions. Even in this simplified application, NRC staff would likely have concerns about pre-defined criteria that may or may not adequately address every possible screening application.

For other risk evaluation approaches, specification of methods and acceptance criteria sufficiently structured so as to assuage any NRC staff concerns regarding the acceptability of a Code Case for expedited implementation was also found to be challenging. In contrast with the NEI 03-08 document screening process, which is an industry-controlled initiative, changes to regulations to permit analytical acceptance standards would be a substantial change requiring NRC approval and support as well as revisions to legal requirements associated with promulgation of regulations. All possible permutations of the screening process application would need to be described in substantial detail for there to be any possibility of acceptance by NRC. Furthermore, a change that reduces or eliminates direct NRC involvement in Code Case approvals would be subject to significant regulatory scrutiny and involve a lengthy approval process requiring

³ NRC reviews of Requests for Alternative based on Code Cases are typically limited to the plant design and configuration associated with the specific licensee request. As such, approval for use at one plant site does not necessarily provide a clear regulatory acceptance basis for all plants for which the Code Case is applicable.

⁴ NRC approved software listed in Regulatory Guide 1.245 Rev. 0 includes only xLPR, FAVOR, and SRRA.

significant investment of resources with a relatively low probability of success. As a result of these observations, further investigation into analytical screening methods was not considered to be justified.

U.S. NRC Activities

EMBARC Venture Studio (EMBARC) is an organization within the NRC Office of Nuclear Reactor Regulation created to spur innovative thinking. In 2020, EMBARK initiated a project to develop ideas for transforming how the NRC uses 10 CFR 50.55a to regulate. This project included consideration of options for addressing the issue of Code Case implementation timing. The EMBARK Venture Studio 10 CFR 50.55a Project Final Report [7] documents options considered by NRC and likely success paths. Two options were identified in this report: (1) developing a process outside of 10 CFR 50.55a that determines whether or not a Code Case may be used without NRC approval and (2) employing a direct final rule approach for noncontroversial Code Cases.

The administrative acceptance approach explored by EPRI that is described above would have been one way of implementing the first option since the approach would have been implemented as a new process for Code Case approvals incorporated by reference into 10 CFR 50.55a. This option was ultimately not recommended by EMBARK due to two primary concerns. First, it was observed that such a process would place more weight on NRC votes within ASME and could ultimately have the unintended consequence slowing down the ASME Code process. Second, there was concern that a process implemented outside 10 CFR 50.55a could face legal challenges, although the nature of these potential legal challenges was not described in the EMBARK Venture Studio 10 CFR 50.55a Project Final Report.

Ultimately the EMBARK Venture Studio 10 CFR 50.55a Project Final Report identified the direct final rule option as the most promising approach. The direct final rule process allows an agency to issue a rule without having to go through the review process twice (i.e., at the proposed and final rule stages), while at the same time offering the public the opportunity to challenge the agency's view that the rule is non-controversial. Changes to regulation using the direct final rule process become effective in a relatively short period of time, usually 75 days after publication, unless significant adverse comments are received during a short comment period. (<https://www.nrc.gov/about-nrc/regulatory/rulemaking/rulemaking-process/direct-final-rule.html>)

Under the direct final rule approach recommended within the EMBARK Venture Studio 10 CFR 50.55a Project Final Report, rulemaking would occur annually for unconditionally approved Code Cases and rulemaking for other Code Cases using the "standard rule" approach would occur every other year. The result for unconditionally approved Code Cases would be that the period between ASME publishing of a Code Case and regulatory approval of unconditionally approved Code Cases would be reduced to approximately one year or less, depending on the Code Case publish date in comparison with the cut-off date for inclusion in the annual direct final rule.

Discussion

From the beginning of this evaluation of options to expedite Code Case availability for implementation, the EPRI team recognized that making a fundamental change to the current rulemaking process had a low probability of success. The evaluations and recommendations contained in the EMBARK Venture Studio 10 CFR 50.55a Project Final Report confirm this situation. However, the EPRI investigation did spur serious consideration of this issue by NRC and the proposed direct final rule approach does substantially improve upon the current rulemaking process. Although the proposed direct final rule approach would provide significant benefit only for unconditionally approved Code Cases, the sample evaluation of Code Cases performed by EPRI found that over 80% of Code Cases not yet included in Regulatory Guide 1.147 had been unconditionally approved. In addition, were the direct final rule approach implemented, there would be additional pressure to resolve NRC comments associated with high value Code Cases, likely resulting in a higher percentage of unconditionally approved Code Cases in the future.

Although the annual direct final rulemaking timing is not optimal and could still have a negative impact on some plant activities, it is judged to be a reasonable compromise provided that the schedule proposed within the 10 CFR 50.55a Final Report is maintained. This process ensures that the largest delay period between ASME publishing a Code Case and availability for use is reduced from several years to no more than about 18 months. The proposed schedule in the final report also proposes standard rulemaking for Code Cases every 2 years. This would also be an improvement since historically, Regulatory Guide 1.147 has been revised only every 3 to 4 years.

Conclusions and Recommendations

Options for expedited implementation of ASME Code Cases were explored by EPRI. Review of Code Cases not yet available for use (i.e., not included in Regulatory Guide 1.147) determined that most Code Cases would be made available for use quickly under a process where unconditional approval of a Code Case by NRC at ASME Section XI Standards Committee resulted in direct use approval. Other administrative and technical / analytical acceptance options were considered but were deemed complex and unlikely to be successful.

In part as a result of the investigation undertaken by EPRI, NRC's EMBARK Venture Studio initiated a parallel investigation of options to resolve this issue. The EMBARK Venture Studio 10 CFR 50.55a Project Final Report concluded that moving Code Case approvals outside of the 10 CFR 50.55a process would be challenging due largely to unspecified legal concerns. A direct final rule approach for unconditionally approved Code Cases was proposed. Using this approach, rulemaking for unconditionally approved Code Cases would occur annually and standard rulemaking for other Code Cases would occur every other year. Based on the sample set of Code Cases reviewed, EPRI concludes that although this approach is not optimal, it would provide significant benefits since unconditional approval appears to occur for most Code Cases and such a rulemaking change would encourage industry / NRC cooperation during the ASME approval process.

It is recommended that NRC efforts to implement the proposed direct final rule approach be supported by industry and monitored to ensure that implementation meets industry needs.

References

- [1] ASME Boiler and Pressure Vessel Code, Section XI, Rules for Inservice Inspection of Nuclear Power Plant Components, ASME, Three Park Ave., New York, NY.
- [2] U.S. Nuclear Regulatory Commission, Regulatory Guide 1.147, Rev. 19, Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1, Oct. 2019.
- [3] Title 10 of Code of Federal Regulations, § 50.55a, Codes and Standards.
- [4] NUREG-1801, Rev. 2, Generic Aging Lessons Learned Report, U.S. NRC, Dec. 2010 (ML103490041).
- [5] NEI 03-08, Rev. 4, *Guideline for the Management of Materials Issues*, Rev. 4, Nuclear Energy Institute, Washington D.C., Oct. 2020.
- [6] U.S. Nuclear Regulatory Commission, Regulatory Guide 1.245, Rev. 0, *Preparing Probabilistic Fracture Mechanics Submittals*, Jan. 2022.
- [7] U.S. Nuclear Regulatory Commission, "10 CFR 50.55a Project Final Report – Embark Venture Studio," June 2021 (ML20153A752).

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