Regulatory Analysis for the Final Rule: Approval of American Society of Mechanical Engineers Code Cases

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U.S. Nuclear Regulatory Commission
Office of Nuclear Material Safety and Safeguards
Division of Rulemaking

Abstract

The U.S. Nuclear Regulatory Commission (NRC) is amending its regulations to incorporate by reference the latest revisions to three regulatory guides (RGs) that approve new, revised, and reaffirmed American Society of Mechanical Engineers (ASME) Code Cases. The NRC finds these ASME Code Cases acceptable or acceptable with NRC-specified conditions (i.e., "conditionally acceptable"). The NRC is issuing three RGs with the final rule that identify the ASME Code Cases approved by the agency:

(1) RG 1.84, "Design, Fabrication, and Materials Code Case Acceptability, ASME Section III," Revision 38 (ADAMS Accession No. ML19128A276), supersedes the incorporation by reference in RG 1.84, Revision 37, issued March 2017.

(2) RG 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," Revision 19 (ADAMS Accession No. ML19128A244), supersedes the incorporation by reference in RG 1.147, Revision 18, issued March 2017.

(3) RG 1.192, "Operation and Maintenance Code Case Acceptability, ASME OM Code," Revision 3 (ADAMS Accession No. ML19128A261), supersedes the incorporation by reference in RG 1.192, Revision 2, issued March 2017.

This document presents a regulatory analysis of the final rule for the three RGs that list the ASME Code Cases approved by the NRC. To improve the credibility of the NRC's cost estimates for this regulatory action, the NRC conducted an uncertainty analysis to consider the effects of input uncertainty on the cost estimate and a sensitivity analysis to identify the variables that most affect the cost estimate (i.e., the cost drivers).

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Abbreviations and Acronyms

ADAMS	Agencywide Documents Access and Management System
ASME	American Society of Mechanical Engineers
ASME BPV Code	ASME Boiler and Pressure Vessel Code
ASME Codes	ASME BPV and OM Codes
ASME OM Code	ASME Operation and Maintenance Code
ASME OM Committee	ASME Committee on Operation and Maintenance of Nuclear Power Plants
BLS	Bureau of Labor Statistics (U.S. Department of Labor)
BWR	boiling-water reactor
BWRVIP	Boiling-Water Reactor Vessel Internals Project
C	Celsius
CASS	cast austenitic stainless steel
CC	concrete containment
CFR	*Code of Federal Regulations*
CPI	Consumer Price Index
CPI-U	Consumer Price Index for All Urban Consumers
CRGR	Committee to Review Generic Requirements
DMW	dissimilar metal weld
E	energy
EPRI	Electric Power Research Institute
eV	electron volt
F	Fahrenheit
GDC	general design criterion/criteria
ID	inner diameter
IGSCC	intergranular stress-corrosion cracking
ISI	inservice inspection
IST	inservice testing
K_{Ic}	plane strain fracture toughness
K_{Jc}	plane strain fracture toughness characterized by J-integral
kHz	kilohertz
ksi	kilopounds per square inch
LOE	level of effort
MC	metal containment
MeV	million electron volts
MRP	Materials Reliability Program
n/cm^2	neutrons per square centimeter
NAICS	North American Industry Classification System

NPV	net present value
NRC	U.S. Nuclear Regulatory Commission
NSAC	Nuclear Safety Analysis Center (within EPRI)
NTTAA	National Technology Transfer and Advancement Act of 1995
NUREG	NRC technical report
OMB	U.S. Office of Management and Budget
PERT	program evaluation and review technique
PWR	pressurized-water reactor
PWSCC	primary water stress-corrosion cracking
RG	regulatory guide
RMS	root mean square
RT_{NDT}	nil-ductility transition reference temperature
R/t	radius-to-thickness ratio
t	thickness
T	temperature
T_o	master curve-based reference temperature
UTS	ultimate tensile strength
VT	visual testing

Executive Summary

The U.S. Nuclear Regulatory Commission (NRC) is amending its regulations to incorporate by reference the latest revisions to three NRC regulatory guides (RGs) that approve new, revised, and reaffirmed American Society of Mechanical Engineers (ASME) Code Cases. The NRC will incorporate by reference the following three RGs, issued with the final rule:

(1) RG 1.84, "Design, Fabrication, and Materials Code Case Acceptability, ASME Section III," Revision 38 (ADAMS Accession No. ML19128A276)

(2) RG 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," Revision 19 (ADAMS Accession No. ML19128A244)

(3) RG 1.192, "Operation and Maintenance Code Case Acceptability, ASME OM Code," Revision 3 (ADAMS Accession No. ML19128A261)

This regulatory action allows nuclear power plant licensees and applicants for construction permits, operating licenses, combined licenses, standard design certifications, standard design approvals, and manufacturing licenses to use the ASME Code Cases newly listed in these RGs as voluntary alternatives to engineering standards for the construction, inservice inspection, and inservice testing of nuclear power plant components.

The analysis presented in this document examines the benefits and costs of the final rule and implementing guidance relative to the baseline case (i.e., the no-action alternative).

The NRC has made the following key findings:

- Final Rule Analysis. The final rule recommended by the staff would result in a cost-justified change (i.e., accounting for both costs and benefits) based on a net benefit to the industry that ranges from $4.47 million using a 7-percent discount rate to $5.08 million using a 3-percent discount rate. Compared to the regulatory baseline, the NRC would realize a net averted cost that ranges from $1.87 million using a 7-percent discount rate to $2.12 million using a 3-percent discount rate. Table 1 shows the total costs and benefits to the industry and the NRC of proceeding with the final rule. The final rule alternative would result in net averted costs to the industry and the NRC that range from $6.34 million using a 7-percent discount rate to $7.20 million using a 3-percent discount rate.

Table 1 Total Costs and Benefits for Alternative 2, The Final Rule

Attribute	Costs		
	Undiscounted	7% NPV	3% NPV
Total Industry Costs:	($580,000)	($460,000)	($520,000)
Total NRC Costs:	($270,000)	($210,000)	($240,000)
Total Costs:	($850,000)	($670,000)	($760,000)

Attribute	Benefits		
	Undiscounted	7% NPV	3% NPV
Total Industry Benefits:	$6,200,000	$4,930,000	$5,600,000
Total NRC Benefits:	$2,620,000	$2,080,000	$2,360,000
Total Benefits:	$8,820,000	$7,010,000	$7,960,000

Attribute	Net Benefits (Costs)		
	Undiscounted	7% NPV	3% NPV
Industry	$5,620,000	$4,470,000	$5,080,000
NRC	$2,350,000	$1,870,000	$2,120,000
Total	$7,970,000	$6,340,000	$7,200,000

Note: Totals may differ between tables because of rounding.

- Nonquantified Benefits. Other benefits of the final rule include the NRC's continued ability to meet its goal of ensuring the protection of public health and safety and the environment through the approval of new editions of the ASME Boiler and Pressure Vessel Code and ASME Operation and Maintenance Code, which allow the use of the most current methods and technology. The final rule is consistent with the provisions of the National Technology Transfer and Advancement Act of 1995 and implementing guidance in U.S. Office of Management and Budget Circular A-119, "Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities," dated January 27, 2016, which encourage Federal regulatory agencies to consider adopting voluntary consensus standards as an alternative to *de novo* agency development of standards affecting an industry. Finally, the ASME Code consensus process is an important part of the regulatory framework.

- Uncertainty Analysis. The regulatory analysis contains a simulation analysis that shows that the estimated mean benefit for this final rule is $6.34 million with greater than 99-percent confidence that the total net benefit is greater than $1.98 million using a 7-percent discount rate. A reasonable inference from the uncertainty analysis is that proceeding with the final rule represents an efficient use of resources and averted costs to the NRC and the industry. The factor that is responsible for the largest variation in averted costs is the hours for relief request preparation and submission by industry.

- Decision Rationale. When comparing the final rule to the no-action baseline, the NRC concludes that the final rule is justified from a quantitative standpoint because its provisions would result in millions of dollars of net averted costs (i.e., net benefits) to the NRC and the industry. In addition, the NRC concludes that the final rule is also justified when considering nonquantified costs and benefits because the significance of the nonquantified benefits outweighs those of the nonquantified costs.

1. Introduction

This document presents the regulatory analysis of the final rule for the American Society of Mechanical Engineers (ASME) Code Cases (Agencywide Documents Access and Management System (ADAMS) Accession No. ML19156A147 (package)) and the following three associated regulatory guides (RGs) from the U.S. Nuclear Regulatory Commission (NRC), to be issued with the final rule:

- RG 1.84, "Design, Fabrication, and Materials Code Case Acceptability, ASME Section III," Revision 38 (ADAMS Accession No. ML19128A276)

- RG 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," Revision 19 (ADAMS Accession No. ML19128A244)

- RG 1.192, "Operation and Maintenance Code Case Acceptability, ASME OM Code," Revision 3 (ADAMS Accession No. ML19128A261)

The regulatory action will incorporate by reference the latest revisions to the three RGs listed above so that the NRC approves the newly identified ASME Code Cases as alternatives for use to the ASME Boiler and Pressure Vessel Code (ASME BPV Code) and ASME Operations and Maintenance Code (ASME OM Code) editions and addenda.

2. Statement of the Problem and Objective

2.1 Background

The general design criteria (GDC) for nuclear power plants in Appendix A, "General Design Criteria for Nuclear Power Plants," to Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," or, as appropriate, similar requirements in the licensing basis for a reactor facility provide the bases and requirements for the NRC's assessment of the use of generally recognized codes and standards and the potential for, and consequences of, degradation of the reactor coolant pressure boundary. The applicable GDC include GDC 1, "Quality Standards and Records"; GDC 14, "Reactor Coolant Pressure Boundary"; and GDC 32, "Inspection of Reactor Coolant Pressure Boundary."

GDC 1 requires, in part, the following:

> Structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Where generally recognized codes and standards are used, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product in keeping with the required safety function.

GDC 14 establishes the following:

> The reactor coolant pressure boundary shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, and of gross rupture.

Additionally, GDC 32 establishes the following:

> Components which are part of the reactor coolant pressure boundary shall be designed to permit (1) periodic inspection and testing of important areas and features to assess their structural and leaktight integrity, and (2) an appropriate material surveillance program for the reactor pressure vessel.

The National Technology Transfer and Advancement Act of 1995 (Public Law 104-113) (NTTAA) mandates the following:

> All Federal agencies and departments shall use technical standards that are developed or adopted by voluntary consensus standards bodies, using such technical standards as a means to carry out policy objectives or activities determined by the agencies and departments.

In carrying out this legislation, Federal agencies are to consult with voluntary consensus standards bodies and participate with such bodies in developing technical standards when such participation is in the public interest and is compatible with the agency mission, priorities, and budget resources. If the technical standards are inconsistent with applicable law or are otherwise impractical, a Federal agency may elect to use technical standards that are not developed or adopted by voluntary consensus bodies.

Provisions of the ASME BPV Code have been used since 1971 as one part of the framework to establish the necessary design, fabrication, construction, testing, and performance requirements for structures, systems, and components important to safety. The ASME standards committees that develop, among other things, improved methods for the construction and inservice inspection (ISI) of ASME Code Class 1, 2, and 3; metal containment (MC); and concrete containment (CC) nuclear power plant components represent various technical interests (e.g., utility, manufacturing, insurance, regulatory). This broad spectrum of stakeholders ensures that these various technical interests are considered.

A directive from the ASME Board on Nuclear Codes and Standards transferred responsibility for the development and maintenance of rules for the inservice testing (IST) of pumps and valves from the ASME Section XI Subcommittee on Nuclear Inservice Inspection to the ASME Committee on Operation and Maintenance of Nuclear Power Plants (ASME OM Committee). This led to the development of the ASME OM Code. In 1990, ASME published the initial edition of the ASME OM Code that provides rules for the IST of pumps and valves. The ASME OM Committee continues to maintain the ASME OM Code. ASME's intent was that the ASME OM Code would replace ASME BPV Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," for the IST of pumps and valves. The ASME OM Committee no longer updates the ASME BPV Code, Section XI, rules for the IST of pumps and valves that were previously incorporated by reference into NRC regulations.

Under 10 CFR 50.55a, "Codes and Standards," the NRC requires nuclear power plant owners to construct ASME Code Class 1, 2, and 3 components in accordance with ASME BPV Code,

Section III, “Rules for Construction of Nuclear Power Plant Components,” Division 1. Under 10 CFR 50.55a, the NRC also requires applicants or licensees to perform ISI of ASME Code Class 1, 2, 3, MC, and CC components in accordance with ASME BPV Code, Section XI, Division 1, and to perform IST of Class 1, 2, and 3 safety-related pumps and valves in accordance with the ASME OM Code. ASME develops Code Cases to gain experience with new technology before incorporating it into the ASME Code, permit licensees to use advances in ISI and IST, provide alternative examinations for older plants, respond promptly to user needs, and offer a limited and clearly focused alternative to specific ASME Code provisions.

2.2 Statement of the Problem

ASME may revise Code Cases for many reasons, such as incorporating operational examination and testing experience into them or updating material requirements based on research results. Occasionally, an inaccuracy in an equation is discovered or an examination, as practiced, is found to be inadequate in detecting a newly discovered degradation mechanism. Therefore, it follows that, when a licensee initially implements an ASME Code Case, 10 CFR 50.55a requires the licensee to implement the most recent version of that Code Case as listed in the approved or conditionally approved tables in 10 CFR 50.55a. An alternative could be submitted and approved through alternative requests under 10 CFR 50.55a(z); in this case, a licensee could request the use of a previous Code Case, and the NRC would evaluate such a request on a case-by-case basis.

ASME BPV Code, Section III, only applies to new construction (i.e., the selection of the edition and addenda to be used in the construction of a plant is based on the date of the construction permit, and the edition and addenda chosen are not changed after that date except voluntarily by the licensee). Therefore, if a licensee implements a Code Case related to ASME BPV Code, Section III, and if the NRC incorporates by reference a later version of that Code Case into 10 CFR 50.55a and lists it in the tables in RG 1.84, RG 1.147, and RG 1.192, that licensee may use either version of the Code Case.

Licensee programs under ASME BPV Code, Section XI, ISI and ASME OM Code IST are updated every 10 years to the latest edition and addenda of ASME BPV Code, Section XI, that were incorporated by reference into 10 CFR 50.55a and are in effect 12 months before the start of the next inspection interval. Licensees that were using an ASME Code Case before the effective date of its revision may continue to use the previous version for the remainder of the 120-month ISI or IST interval to relieve them of the burden of having to update their ISI or IST program each time ASME revises a Code Case. Because Code Cases apply to specific editions and addenda and because ASME may revise Code Cases that are no longer accurate or adequate, licensees that choose to continue using a Code Case during the subsequent ISI interval must either (1) implement the latest version incorporated by reference into 10 CFR 50.55a and listed in the RGs or (2) apply for an alternative request under 10 CFR 50.55a(z).

2.3 Objective

The objective of the final rule is to incorporate by reference the latest revisions to three RGs that list Code Cases published by ASME and approved by the NRC:

(1) RG 1.84, Revision 38
(2) RG 1.147, Revision 19
(3) RG 1.192, Revision 3

These revisions supersede the incorporation by reference of RG 1.84, Revision 37, issued March 2017 (NRC 2017a); RG 1.192, Revision 2, issued March 2017 (NRC 2017b); and RG 1.147, Revision 18, issued March 2017 (NRC 2017c). This regulatory action improves the effectiveness of future licensing actions, is consistent with the provisions of the NTTAA that encourage Federal regulatory agencies to consider adopting voluntary consensus standards as an alternative to *de novo* agency development of standards affecting an industry, and is consistent with the NRC policy of evaluating the latest version of consensus standards already approved by the NRC in terms of their suitability for endorsement by regulation or RG.

3. Identification and Preliminary Analysis of Alternative Approaches

Based on the existing data and information, the NRC considers a rule change to be the most effective way to implement the NRC-approved ASME Code Cases. The NRC has identified two alternatives to this action: (1) Alternative 1 is the no-action alternative (i.e., status quo, regulatory baseline), and (2) Alternative 2 uses rulemaking to incorporate by reference into 10 CFR 50.55a the NRC-approved ASME Code Cases in RG 1.84, Revision 38, and RG 1.147, Revision 19, and the ASME OM Code Cases in RG 1.192, Revision 3.

3.1 Alternative 1—No Action

The no-action alternative (i.e., status quo, regulatory baseline) is a nonrulemaking alternative. The no-action alternative would not revise the NRC's regulations to incorporate by reference the latest revisions to these three RGs and would not make conforming changes to 10 CFR 50.55a to comply with guidance from the Office of the Federal Register for incorporating by reference multiple standards into regulations. The no-action alternative would cause licensees and applicants that want to use these ASME Code Cases to request and receive approval from the NRC for the use of alternatives under 10 CFR 50.55a(z). The NRC does not recommend this alternative for the following reasons:

- Licensees and applicants would need to submit requests for alternatives to apply ASME Code Cases under 10 CFR 50.55a(z) because those Code Cases have not been approved in the RGs and have not been incorporated by reference into 10 CFR 50.55a. This process would result in increased regulatory burden to licensees, applicants, and the NRC.

- Alternative 1 may reduce public confidence in the NRC as an effective regulator because ASME periodically publishes, revises, and annuls its Code Cases. Under Alternative 1, outdated material and possibly inaccurate information would remain incorporated by reference into the *Code of Federal Regulations*.

The no-action alternative does not meet the intent of the NTTAA, which encourages Federal regulatory agencies to consider adopting voluntary consensus standards as an alternative to *de novo* agency development of standards affecting an industry.

3.2 Alternative 2—Incorporate by Reference NRC-Approved ASME BPV and OM Code Cases

Alternative 2 would incorporate by reference the latest revisions to the RGs that list NRC-approved ASME Code Cases. This alternative would allow licensees and applicants to implement these ASME Code Cases and their conditions and modifications, if any, without seeking prior NRC approval. This alternative continues the NRC's use of periodic rulemakings

to incorporate by reference in 10 CFR 50.55a the latest versions of RGs that list NRC-approved alternatives to the provisions of the ASME BPV and OM Codes.

The NRC is pursuing the rulemaking alternative for the following reasons:

- This alternative reduces the regulatory burden on applicants or holders of licenses for nuclear power plants by eliminating the need to submit plant-specific requests for alternatives in accordance with 10 CFR 50.55a(z), and it reduces the need for the NRC to review those submittals.

- This alternative meets the NRC's goal of ensuring the protection of public health and safety and the environment by continuing to provide NRC approval of new ASME Code editions that allow the use of the most current methods and technology.

- This alternative supports the NRC's goal of maintaining an open regulatory process by informing the public about the process and by giving the public the opportunity to participate in it.

- This alternative supports the NRC's commitment to participating in the national consensus standard process through the approval of these ASME Code editions, and it conforms to NTTAA requirements.

- The initial burden on the NRC to update the regulations by incorporating by reference the editions and addenda of the ASME BPV and OM Codes cited here is more than offset by the reduction in the number of plant-specific alternative requests that the NRC would otherwise evaluate. Section 5 of this regulatory analysis discusses the costs and benefits of this alternative relative to the regulatory baseline (Alternative 1).

4. Estimation and Evaluation of Costs and Benefits

This section presents the process for evaluating the costs and benefits expected to result from each alternative relative to the regulatory baseline (Alternative 1). All costs and benefits are monetized, when possible. The total costs and benefits are then summed to determine whether the difference between the costs and benefits results in a positive benefit. In some cases, costs and benefits are not monetized because meaningful quantification is not possible.

4.1 Identification of Affected Attributes

This section identifies the components of the public and private sectors, commonly referred to as attributes, that are expected to be affected by the alternatives identified in Section 3. The alternatives would apply to licensees and applicants for nuclear power plants and nuclear power plant design certifications. The NRC believes that nuclear power plant licensees would be the primary beneficiaries. The NRC developed an inventory of the impacted attributes using the list in NUREG/BR-0058, "Regulatory Analysis Guidelines of the U.S. Nuclear Regulatory Commission," draft Revision 5, issued March 2018 (NRC 2018a).

The rule would affect the following attributes:

- Public Health (Accident). This attribute accounts for expected changes in radiation exposure to the public caused by changes in accident frequencies or accident consequences associated with the alternative (i.e., delta risk). Alternative 2, as

compared to the regulatory baseline (Alternative 1), meets the NRC's goal of ensuring the protection of public health and safety and the environment by continuing to provide the NRC's approval of new ASME Code Cases that allow the use of the most current methods and technology and that may decrease the likelihood of an accident and, therefore, decrease the overall risk to public health.

- Occupational Health (Accident). This attribute measures immediate and long-term health effects experienced by site workers because of changes in accident frequency or accident consequences associated with the alternative (i.e., delta risk). A decrease in worker radiological exposure is a decrease in risk (i.e., a benefit); an increase in worker exposures is an increase in risk (i.e., a negative benefit). The use of ASME Code Cases may decrease the incremental risk to occupational health following an accident, but this effect is not easily quantifiable. For example, advances in ISI and IST may lead to an incremental decrease in the frequency of an accident, thus resulting in averted worker postaccident radiological exposure, as compared to the regulatory baseline.

- Occupational Health (Routine). This attribute accounts for radiological exposures to workers during normal facility operations (i.e., nonaccident situations). Some operations will cause an increase in worker exposures; sometimes this increase will be a one-time effect (e.g., installation or modification of equipment in a radiation area), and sometimes it will be an ongoing effect (e.g., routine surveillance or maintenance of contaminated equipment or equipment in a radiation area). The use of ASME Code Cases may affect occupational health as a result of radiological exposure during the time required to perform additional weld examinations and pressure testing called for in the Code Case conditions. This additional work will result in increased occupational radiation exposure, as compared to the regulatory baseline.

- Industry Implementation. This attribute accounts for the projected net economic effect on the affected licensees as they implement the mandated changes. Costs include procedural and administrative activities related to maintenance, inspection, or testing procedures.

- Industry Operation. This attribute accounts for the projected net economic effect on all affected licensees caused by routine and recurring activities required by the alternative. Under Alternative 2, a licensee of a nuclear power plant would no longer be required to submit an ASME Code Case alternative request under 10 CFR 50.55a(z), which would provide a net benefit (i.e., averted cost) to the licensee.

  Under 10 CFR 50.55a, the NRC requires nuclear power plant applicants and licensees to construct Class 1, 2, and 3 components in accordance with ASME BPV Code, Section III, Division 1. Under 10 CFR 50.55a, the NRC also requires applicants and licensees to perform ISI of Class 1, Class 2, Class 3, Class MC, and Class CC components in accordance with ASME BPV Code, Section XI, Division 1, and to perform IST of Class 1, Class 2, and Class 3 safety-related pumps and valves in accordance with the ASME OM Code. Until 2012, ASME issued new editions of the ASME BPV Code every 3 years and addenda to the editions annually except in the years when it issued a new edition. Similarly, ASME has published new editions and addenda of the ASME OM Code regularly. Starting in 2012, ASME decided to issue editions of its BPV and OM Codes (no addenda) every 2 years. ASME also publishes Code Cases quarterly (ASME BPV Code, Sections III and XI) or every 2 years (ASME OM Code) to provide alternatives to existing ASME Code requirements developed and approved by ASME.

ASME develops Code Cases to allow licensees to gain experience with new technology before its incorporation into the ASME Code, permit licensees to use advances in ISI and IST, provide alternative examinations for older plants, respond promptly to user needs, and offer a limited and clearly focused alternative to specific ASME Code provisions.

Under Alternative 2, applicants and licensees are allowed to implement endorsed ASME Code Cases and their conditions and modifications without seeking prior NRC approval. This alternative continues the NRC's use of periodic rulemakings to incorporate by reference in 10 CFR 50.55a the latest RGs that list NRC-approved alternatives to the provisions of the ASME BPV and OM Codes.

The NRC considers ASME Code Case requests and subsequent costs as "sunk" costs (i.e., costs that have already been incurred) for issued design certifications, submitted design certifications under review, and reactor applications submitted to the agency.

- NRC Implementation. This attribute accounts for the projected net economic effect on the NRC to place the alternative into operation. To implement Alternative 2, the NRC incurs a cost in relation to Alternative 1 (i.e., regulatory baseline) for developing the proposed and final rule and for updating the corresponding guidance in RG 1.84, RG 1.147, and RG 1.192. At the final rule stage, these costs are considered sunk costs and are not included in the cost estimate.

- NRC Operation. This attribute accounts for the projected net economic effect on the NRC after the alternative is implemented. If the NRC does not approve an ASME Code Case that a licensee or applicant wants to use, the licensee or applicant would need to request, under 10 CFR 50.55a(z), permission to use the ASME Code Cases through a submittal. This submittal requires additional NRC staff time to evaluate the Code Case to determine its acceptability and whether any limitations or modifications should apply. Under Alternative 2, these Code Case alternative requests would not be required, which results in a net benefit (i.e., averted cost) for the NRC.

  Because the NRC's costs to review requests for ASME Code Case alternatives submitted to the agency before the effective date of the final rule are sunk costs, this regulatory analysis does not consider them further.

- Improvements in Knowledge. This attribute accounts for improvements in knowledge by industry and the NRC gaining experience with new technology before its incorporation into the ASME Codes and by permitting licensees to use advances in ISI and IST. Improvements in ISI and IST may also result in the earlier identification of material or equipment degradation that, if it should remain undetected, could cause further degradation that eventually leads to a plant transient or the unavailability of plant equipment to respond to a plant transient.

- Regulatory Efficiency. This attribute accounts for regulatory and compliance improvements resulting from the implementation of Alternative 2, as compared to the regulatory baseline. Alternative 2 would increase regulatory efficiency because licensees and applicants that wish to use NRC-approved ASME Code Cases would not require 10 CFR 50.55a(z) alternative requests. Further, Alternative 2 is consistent with the NTTAA provisions that encourage Federal agencies to consider adopting voluntary consensus standards as an alternative to *de novo* agency development of standards

affecting an industry. Alternative 2 is consistent with the NRC's policy of evaluating the latest versions of consensus standards in terms of their suitability for endorsement by regulations and RGs. In addition, Alternative 2 is consistent with the NRC's goal to harmonize with international standards to improve regulatory efficiency for both the NRC and international standards groups.

- Other Considerations. This attribute accounts for considerations that are not captured in the preceding attributes. Specifically, this attribute accounts for how Alternative 2 meets specific requirements of the Commission, helps achieve NRC policy, and provides other advantages or detriments.

- Attributes with No Effects. Attributes that are not expected to contribute to the results under any of the alternatives include public health (routine); offsite property; onsite property; other Government, general public, safeguards, and security considerations; and environmental considerations that address Section 102(2) of the National Environmental Policy Act of 1969.

4.2 Analytical Methodology

This section describes the process used to evaluate costs and benefits associated with the alternatives. The benefits include any desirable changes in affected attributes (e.g., monetary savings, improved safety, and improved security). The costs include any undesirable changes in affected attributes (e.g., monetary costs, increased exposures).

The analysis quantitatively evaluates 4 of the 10 affected attributes: (1) industry implementation, (2) industry operation, (3) NRC implementation, and (4) NRC operation. Quantitative analysis requires a baseline characterization of the affected society, including factors such as the number of affected entities, the nature of the activities currently performed, and the types of systems and procedures that licensees or applicants would implement or would no longer implement because of the alternatives. Where possible, the NRC calculated costs for these four attributes using three-point estimates to quantify the uncertainty in these estimates. The individual sections for each of the provisions include the detailed cost tables used in this regulatory analysis. The NRC evaluated the remaining six attributes qualitatively because the benefits that relate to consistent policy application and improvements in ISI and IST techniques as they affect these six attributes are not easily quantifiable or because the data necessary to quantify and monetize the impacts are not available.

The NRC documented its assumptions throughout this regulatory analysis. For reader convenience, Appendix A summarizes the major assumptions and input data used in this analysis.

4.2.1 Regulatory Baseline

This regulatory analysis provides the incremental impacts of the final rule relative to a baseline that reflects anticipated behavior if the NRC does not undertake regulatory or nonregulatory action. The regulatory baseline assumes full compliance with existing NRC requirements, including current regulations and relevant orders. This is consistent with NUREG/BR-0058, (NRC 2018a), which states that "in evaluating a new requirement, the staff should assume that all existing NRC and Agreement State requirements have been implemented." Section 5. of this regulatory analysis presents the estimated incremental costs and benefits of the alternatives compared to this baseline.

4.2.2 Affected Entities

This final rule could affect all operating light-water nuclear power reactors and new reactors expected to begin commercial operation within the next 6 years, as follows:

- Nuclear Facilities. The analysis models 57 plant sites that contain one or more operating U.S. light-water nuclear power reactor units in 2020, which decreases to 53 plant sites in 2025.[1]

- Operating Reactor Units. The analysis models 93 reactor units at the time of the issuance of the final rule in 2020, which decreases to 88 reactor units in 2025.

- Future Operating Reactor Units. The NRC assumes that Vogtle Units 3 and 4 will commence commercial operation in 2021 and 2022, respectively. As of April 2019, there are six power reactor licensees that hold combined licenses for Fermi, Unit 3; North Anna Power Station, Unit 3; William States Lee III Nuclear Station, Units 1 and 2; and Turkey Point Nuclear Generating Station, Units 6 and 7. These six units have no published construction schedule and would not be operational within the time horizon of this analysis.

Table 2 lists the number of operating plants and the number of sites that the NRC used in performing this analysis and includes Vogtle Electric Generating Plant (Vogtle), Units 3 and 4, which are projected to commence commercial operation in the years 2021 and 2022.

Table 2 Current and Future Operating Reactor and Site Information

Year	Operating Plants	Sites
2020	93	57
2021	90	54
2022	90	54
2023	90	54
2024	89	54
2025	88	53

1 The Pilgrim Nuclear Power Station and the Three Mile Island Nuclear Station, Unit 1, closed in 2019. The NRC assumes that Davis-Besse Nuclear Power Station, Unit 1, will close in 2020 based on FirstEnergy Nuclear Operating Company's announcement (http://www.firstenergycorp.com) and that Duane Arnold Energy Center will close in 2020 based on NextEra Energy Resources' announcement (https://www.nexteraenergyresources.com). The NRC assumes that Perry Nuclear power Plant, Unit 1, and Beaver Valley Power Station, Units 1 and 2, will shut down in 2021, based on FirstEnergy Nuclear Operating Company's announcement (http://www.firstenergycorp.com). The NRC assumes that Indian Point Nuclear Generating Station (Indian Point), Unit 2, will shut down in 2020; Indian Point, Unit 3, will shut down in 2021; and Palisades Nuclear Plant will shut down in 2022, based on Entergy Nuclear Operations, Inc.'s, announcement (http://www.entergy.com). The NRC assumes Diablo Canyon Power Plant, Units 1 and 2, will shut down in 2024 and 2025, respectively, based on Pacific Gas & Electric Company's announcement (http://www.pge.com).

4.2.3 Base Year

All monetized costs are expressed in 2019 dollars. Ongoing costs of operation related to the alternative being analyzed are assumed to begin no earlier than 30 days after publication of the final rule in the *Code of Federal Regulations* unless otherwise stated, and they are modeled on an annual cost basis. The NRC assumes that the rule will be effective in late 2019.

Estimates are made for recurring annual operating expenses. The values for annual operating expenses are modeled as a constant expense for each year of the analysis horizon. The NRC performed a discounted cash flow calculation to discount these annual expenses to 2019 dollar values.

4.2.4 Discount Rates

In accordance with guidance from U.S. Office of Management and Budget (OMB) Circular No. A-4, "Regulatory Analysis," issued September 2003 (OMB 2003), and NUREG/BR-0058, draft Revision 5, net present value (NPV) calculations are used to determine how much society would need to invest today to ensure that the designated dollar amount is available in a given year in the future. By using NPVs, costs and benefits (regardless of when they are incurred) are valued to a reference year for comparison. The choice of a discount rate and its associated conceptual basis is a topic of ongoing discussion within the Federal Government. Based on OMB Circular No. A-4 and consistent with NRC past practice and guidance, present-worth calculations in this analysis use 3-percent and 7-percent real discount rates. A 3-percent discount rate approximates the real rate of return on long-term Government debt, which serves as a proxy for the real rate of return on savings to reflect reliance on a social rate of time preference discounting concept.[2] A 7-percent discount rate approximates the marginal pretax real rate of return on an average investment in the private sector, and it is the appropriate discount rate whenever the main effect of a regulation is to displace or alter the use of capital in the private sector. A 7-percent rate is consistent with an opportunity cost[3] of capital concept to reflect the time value of resources directed to meet regulatory requirements.

4.2.5 Cost/Benefit Inflators

The NRC estimated the analysis inputs for some attributes based on the values published in NUREG/BR-0058 (NRC 2018a), or other sources as referenced, which are provided in prior-year dollars. To evaluate the costs and benefits consistently, these inputs are put into base-year dollars. The most common inflator is the Consumer Price Index for All Urban Consumers (CPI-U), which was developed by the U.S. Department of Labor, Bureau of Labor Statistics (BLS, 2018). Using the CPI-U, the prior-year dollars are converted to 2019 dollars. The following formula is used to determine the amount in 2019 dollars:

$$\frac{CPI-U_{2019}}{CPI-U_{Base\ Year}} x\ Value_{Base\ Year} = Value_{2019}$$

2 The "social rate of time preference" discounting concept refers to the rate at which society is willing to postpone a marginal unit of current consumption in exchange for more future consumption.

3 The "opportunity cost" represents what is foregone by undertaking a given action. If the licensee's personnel were not engaged in revising procedures, other work activities would occupy them. Throughout the analysis, the NRC estimates the opportunity cost of performing these incremental tasks as the industry personnel's pay for the designated unit of time.

Table 3 summarizes the values of CPI-U used in this regulatory analysis.

Table 3 CPI-U Inflator

Base Year	CPI-U Annual Average[a]	Actual/Forecast Percent Change from Previous Year
2016	240.007	
2017	245.120	2.13%
2018	251.107	2.44%
2019	256.129	2.00%

[a] BLS Statistics, "Databases, Tables & Calculators by Subject: One-Screen Data Search: CPI-All Urban Consumers, U.S. city average/All Items, not seasonally adjusted" (BLS 2019b).

4.2.6 Labor Rates

For the purposes of this regulatory analysis, the NRC applied strict incremental cost principles to develop labor rates that include only labor and material costs that are directly related to the implementation and operation and maintenance of the final rule requirements. This approach is consistent with the guidance in NUREG/CR-3568, "A Handbook for Value-Impact Assessment," issued December 1983 (NRC 1983), and general cost-benefit methodology. The NRC incremental labor rate is $129 per hour.[4]

The NRC used the 2018 BLS Occupational Employment and Wages data (https://www.bls.gov), which provided labor categories and the mean hourly wage rate by job type, and used the inflator discussed above to inflate the labor rate data to 2019 dollars. The labor rates used in the analysis reflect total hourly compensation, which includes wages and nonwage benefits (using a burden factor of 2.4 that applies to contract labor and is generally applicable to regular nuclear power plant employees). The NRC used the BLS data tables to select appropriate hourly labor rates for performing the estimated procedural-, licensing-, and plant-related work necessary during and following implementation of the alternative. In establishing this labor rate, wages paid to the individuals performing the work plus the associated fringe benefit component of labor cost (i.e., the time for plant management over and above those directly expensed) are considered incremental expenses and are included. Table 4 summarizes the BLS labor categories that the NRC used to estimate industry labor costs to implement this final rule, and Appendix A lists the industry labor rates that the NRC used in the analysis. The NRC performed an uncertainty analysis, which is discussed in Section 5.13.

4 The NRC labor rates presented here differ from those developed under the NRC's license fee recovery program (10 CFR Part 170, "Fees for Facilities, Materials, Import and Export Licenses, and Other Regulatory Services under the Atomic Energy Act of 1954, as Amended"). NRC labor rates for fee recovery purposes are appropriately designed for full-cost recovery of the services rendered and, therefore, include nonincremental costs (e.g., overhead, administrative, and logistical support costs).

Table 4 Position Titles and Occupations

Position Title (in This Regulatory Analysis)	Standard Occupational Classification
Managers	Top Executives (111000)
	Chief Executives (111011)
	General and Operations Managers (111021)
	Industrial Production Managers (113051)
	First-Line Supervisors of Mechanics Installers and Repairers (491011)
	First-Line Supervisors of Production and Operating Workers (511011)
Technical Staff	Nuclear Engineers (172161)
	Physicists (192012)
	Nuclear Technicians (194051)
	Industrial Machinery Mechanics (499041)
	Nuclear Power Reactor Operators (518011)
Administrative Staff	Office and Administrative Support Occupations (430000)
	First-Line Supervisors of Office and Administrative Support Workers (431011)
	Office Clerks, General (439061)
Licensing Staff	Lawyers (231011)
	Paralegals and Legal Assistants (232011)

Source: BLS, "NAICS Code: North American Industry Classification System Code," issued January 2019 (BLS 2019a).

4.2.7 Sign Conventions

The sign conventions used in this analysis are that all favorable consequences for the alternative are positive and all adverse consequences for the alternative are negative. Negative values are shown using parentheses (e.g., negative $500 is displayed as ($500)).

4.2.8 Analysis Horizon

The ASME Code Cases are in effect for a span of 3 years following the issuance of the final rule and are renewable once for 3 additional years for a total of 6 years.

4.2.9 Cost Estimation

To estimate the costs associated with the evaluated alternatives, the NRC used a work breakdown approach to deconstruct each requirement down to its mandated activities. For each required activity, the NRC further subdivided the work across labor categories (i.e., executives, managers, technical staff, administrative staff, and licensing staff). The NRC estimated the required level of effort (LOE) for each required activity and used a blended labor rate to develop cost estimates.

The NRC gathered data from several sources and consulted ASME Code working group members to develop LOE and unit cost estimates in accordance with the Paperwork Reduction Act of 1980. The NRC applied several cost-estimation methods in this analysis and used its collective professional knowledge and judgment to estimate many of the costs and benefits.

Additionally, the NRC used an engineering buildup method, informal discussions with licensees, and extrapolation techniques to estimate costs and benefits.

The NRC began by estimating some activities using the engineering buildup method of cost estimation, which combines incremental costs of an activity from the bottom up to estimate a total cost. For this step, the NRC reviewed previous license submittals, determined the number of pages in each section, and then used these data to develop preliminary LOEs.

The NRC consulted subject-matter experts within and outside the agency to develop most of the LOE estimates used in the analysis. For example, to estimate licensee costs and averted costs (benefits) related to the NRC conditions on the ASME Codes in the final rule, the NRC consulted licensees for information on the associated LOE. The NRC contributed to the estimation of LOE for review-related activities.

The NRC extrapolated some estimations of cost activities by using actual past or current costs to estimate the future cost of similar activities. For example, to calculate the estimated averted costs of alternative requests, the NRC used data from past projects to determine the labor categories of the NRC who would perform the work and to estimate the amount of time required under each category to complete the work. If data were not available, the NRC estimated the LOE based on similar steps in the process for which data were available.

To evaluate the effect of uncertainty in the model, the NRC used Monte Carlo simulation, which is an approach to uncertainty analysis in which input variables are expressed as distributions. The NRC ran the simulation 10,000 times and chose values at random from the distributions of the input variables provided in Table 20. The result was a distribution of values for the output variable of interest. Monte Carlo simulation also enables users to determine the input variables that have the greatest effect on the value of the output variable. Section 5.13 describes the Monte Carlo simulation methods in detail and presents the results.

4.2.10 NRC-Conditioned ASME Code Cases

The NRC analyzes ASME Code Cases to determine whether the Code Cases are (1) acceptable without conditions, (2) generally acceptable with conditions, or (3) not approved. When the NRC generally approves ASME Code Cases with conditions, licensees may incur additional regulatory burden to meet the NRC-conditioned ASME Code Cases (i.e., Code Cases with new conditions as a result of this final rule). The conditions would specify (for each applicable Code Case) the additional activities that must be performed, the limits on the activities specified in the Code Case, and the supplemental information needed to provide clarity. Table 2 in RG 1.84, RG 1.147, and RG 1.192 lists the ASME Code Cases that are acceptable as long as licensees use them with the identified conditions. The final rule and the RGs discuss the NRC's evaluation of the Code Cases and the reasons for the agency's conditions. The NRC-conditioned ASME Code Cases place an additional resource burden on applicants and licensees under the affected attribute of industry operation. Table 5 lists the NRC-conditioned ASME Code Cases that are included in this rule.

Table 5 NRC-Conditioned ASME Code Cases

RG Listing	NRC-Conditioned ASME Code Case Number	New Condition Description[a]	Incremental Resources Required[b]
RG 1.84	N-71-19	1. The maximum measured ultimate tensile strength (UTS) of the component support material must not exceed 170 kilopounds per	1. This condition is identical to the condition in the previous version of the

RG Listing	NRC-Conditioned ASME Code Case Number	New Condition Description[a]	Incremental Resources Required[b]
		square inch (ksi) in view of the susceptibility of high strength materials to brittleness and stress-corrosion cracking. 2. In the last sentence of paragraph 5.2 of Code Case N-71-19, reference must be made to paragraph 5.3.2.3, "Alternative Atmosphere Exposure Time Periods Established by Test," of the AWS D1.1 Code for the evidence presented to and accepted by the Authorized Inspector concerning exposure of electrodes for a longer period of time. 3. Paragraph 16.2.2 of Code Case N-71-19 is not acceptable as written and must be replaced with the following: "When not exempted by 16.2.1 above, the post weld heat treatment must be performed in accordance with NF-4622 except that ASTM A-710 Grade A Material must be at least 1000°F (540°C) and must not exceed 1150°F (620°C) for Class 1 and 2 material and 1175°F (640°C) for Class 3 material." 4. The new holding time-at-temperature for weld thickness (nominal) must be 30 minutes for welds 0.5 inch or less, 1 hour per inch of thickness for welds over 0.5 inch to 5 inches, and for thicknesses over 5 inches, 5 hours plus 15 minutes for each additional inch over 5 inches. 5. The fracture toughness requirements as listed in this Code Case apply only to piping supports and not to Class 1, 2 and 3 component supports. 6. When welding P-Number materials listed in the Code Case, the corresponding S-Number welding requirements shall apply.	Code Case; therefore, no incremental resources are expected. 2. This condition is identical to another condition in the previous version of the Code Case; therefore, no incremental resources are expected. 3. This condition is identical to another condition in the previous version of the Code Case; therefore, no incremental resources are expected. 4. This condition is functionally identical to another condition in the previous version of the Code Case except for the correction of a typo; therefore, no incremental resources are expected. 5. This condition is identical to another condition in the previous version of the Code Case; therefore, no incremental resources are expected. 6. This new condition is an administrative change to address the relabeling of S-number materials to P-number materials; therefore, no incremental resources are expected.
RG 1.147	N-516-4	1. Licensees must obtain NRC approval in accordance with 10 CFR 50.55a(z) regarding the welding technique to be used prior to performing welding on ferritic material exposed to fast neutron fluence greater than 1×10^{17} n/cm^2 (E > 1 MeV). 2. Licensees must obtain NRC approval in accordance with 10 CFR 50.55a(z) regarding the welding technique to be used prior to performing welding on austenitic material other than P-No. 8 material exposed to thermal neutron fluence greater than 1×10^{17} n/cm^2 (E < 0.5 eV). 3. Licensees must obtain NRC approval in accordance with 10 CFR 50.55a(z) regarding the welding technique to be used prior to performing welding on P-No. 8 austenitic material exposed to thermal neutron fluence greater than 1×10^{17} n/cm^2 (E < 0.5 eV) and measured or calculated helium concentration of the material greater than 0.1 atomic parts per million.	Conditions 1–3 clarify the existing condition of N-516-3 to be consistent with the existing requirements in ASME BPV Code, Section XI, IWA-4660.
RG 1.147	N-597-3	1. The use of N-597-3 for any degradation mechanisms other than flow accelerated corrosion is not authorized unless an alternative	1. A substantively similar condition exists in N-597-2; therefore, no incremental

RG Listing	NRC-Conditioned ASME Code Case Number	New Condition Description[a]	Incremental Resources Required[b]
		is proposed and approved in accordance with 10 CFR 50.55a(z). 2. The Code Case must be supplemented by the provisions of EPRI/Nuclear Safety Analysis Center Report EPRI/NSAC-202L-2 for developing the inspection requirements, the method of predicting the rate of wall thickness loss, and the value of the predicted remaining wall thickness. 3. Components affected by flow-accelerated corrosion to which this Code Case is applied must be repaired or replaced in accordance with the Construction Code of Record and the owner's requirements or a later NRC-approved edition of Section III [of the ASME Code] before the value of t_p reaches the allowable minimum wall thickness, t_{min}, as specified in Figure-3622.1(a)(1) of this Code Case. 4. For those components that do not require immediate repair or replacement, the rate of wall thickness loss is to be used to determine a suitable inspection frequency so that repair or replacement occurs prior to reaching allowable minimum wall thickness, t_{min}. 5. Allows the use of this Code Case to calculate wall thinning for moderate-energy Class 2 and 3 piping using criteria in Code Case N-513-4, for temporary acceptance until the next refueling outage. 6. Prohibits the use of this Code Case in evaluating through-wall leakage conditions.	resources are expected. 2. An identical condition exists in N-597-2; therefore, no incremental resources are expected. 3. An identical condition exists in N-597-2; therefore, no incremental resources are expected. 4. A substantively identical condition exists in N-597-2; therefore, no incremental resources are expected. 5. A substantively identical condition exists in N-597-2; therefore, no incremental resources are expected. 6. A substantially similar condition exists in N-597-2; therefore, no incremental resources are expected.
RG 1.147	N-606-2	1. Prior to welding, an examination or verification must be performed to ensure proper preparation of the base metal, and that the surface is properly contoured so that an acceptable weld can be produced. This verification is to be required in the welding procedure.	1. An identical condition exists in N-606-1; therefore, no incremental resources are expected.
RG 1.147	N-638-7	1. Demonstration for ultrasonic examination of the repaired volume is required using representative samples which contain construction type flaws.	1. An identical condition exists in N-638-6; therefore, no incremental resources are expected.
RG 1.147	N-648-2	1. This Code Case shall not be used to eliminate the preservice or inservice volumetric examination of plants with a combined operating license under 10 CFR Part 52, or a plant that receives its operating license after October 22, 2015.	1. Incremental resources exist for inservice examinations but not for preservice examinations, which were already prohibited by the previous version of the Code Case.
RG 1.147	N-695-1	1. Examiners qualified using the 0.25 RMS error for measuring the depths of flaws using Code Case N-695-1 are not qualified to depth-size inner diameter (ID) surface breaking flaws greater than 50-percent through-wall in dissimilar metal welds 2.1 inches or greater in thickness. If an inspector qualified using Code Case N-695-1 measures a flaw as greater than 50-percent through-wall in a dissimilar metal weld from the inner diameter, the flaw shall be considered to	1. This condition would require a verbal review of the weld with the NRC staff and, therefore, would require incremental resources. However, in over 15 years of operating experience, this situation has not occurred. Incremental resources

RG Listing	NRC-Conditioned ASME Code Case Number	New Condition Description[a]	Incremental Resources Required[b]
		have an indeterminate depth.	would be required based on an assumption that this condition would happen one time in 6 years.
RG 1.147	N-696-1	1. Examiners qualified using the 0.25 RMS error for measuring the depths of flaws using Code Case N-696-1 in dissimilar metal or austenitic welds are not qualified to depth-size inner diameter (ID) surface breaking flaws greater than 50-percent through-wall in dissimilar metal or austenitic welds 2.1 inches or greater in thickness. When an examiner qualified using Code Case N-696-1 measures a flaw as greater than 50-percent through-wall in a dissimilar metal or austenitic weld from the ID, the flaw shall be considered to have an indeterminate depth.	1. This condition would require a verbal review of the weld with NRC staff and, therefore, would require incremental resources. However, in over 15 years of operating experience, this situation has not occurred. Incremental resources would be required based on an assumption that this condition would happen one time in 6 years.
RG 1.147	N-702	1. The applicability of Code Case N-702 for the first 40 years of operation must be demonstrated by satisfying the criteria in Section 5.0 of NRC Safety Evaluation regarding BWRVIP-108 dated December 18, 2007 (ADAMS Accession No. ML073600374) or Section 5.0 of NRC Safety Evaluation regarding BWRVIP-241 dated April 19, 2013 (ADAMS Accession No. ML13071A240). 2. The use of Code Case N-702 in the period of extended operation is not approved. 3. If VT-1 is used, it shall utilize Code Case N-648-2, “Alternative Requirements for Inner Radius Examination of Class 1 Reactor Vessel Nozzles, Section XI Division 1,” with associated required conditions specified in Regulatory Guide 1.147.	1. This condition is consistent with the approach that licensees used before the Code Case existed; therefore, no incremental resources are expected. 2. This condition is consistent with the approach that licensees used before the Code Case existed; therefore, no incremental resources are expected. 3. This condition is consistent with the approach that licensees used before the Code Case existed; therefore, no incremental resources are expected.
RG 1.147	N-705	1. The Code repair or replacement activity that was temporarily deferred under the provisions of this Code Case shall be performed during the next scheduled refueling outage for through-wall flaws.	1. There is no incremental cost impact.
RG 1.147	N-711-1	1. Code Case N-711-1 shall not be used to redefine the required examination volume for preservice examinations or when the postulated degradation mechanism for piping welds is PWSCC, or crevice corrosion degradation mechanisms.	1. This condition clarifies that no degradation mechanism is present during preservice examinations; the Code Case refers to the owner’s program for intergranular stress-corrosion cracking (IGSCC) and does not provide a direction for crevice corrosion. Therefore, there is no cost impact.
RG 1.147	N-754-1	1. The conditions imposed on the optimized weld	1. An identical condition

RG Listing	NRC-Conditioned ASME Code Case Number	New Condition Description[a]	Incremental Resources Required[b]
		overlay design in NRC safety evaluation for the topical report, "Materials Reliability Program (MRP): Technical Basis for Preemptive Weld Overlays for Alloy 82/182 Butt Welds in PWRs (MRP-169)," Revision 1-A, Electric Power Research Institute (ADAMS Accession Nos. ML101620010 and ML101660468) must be satisfied. 2. In lieu of the preservice and inservice examinations as specified in Section 3(c) of the Code Case, the optimized weld overlay must be examined in accordance with 10 CFR 50.55a(g)(6)(ii)(F).	exists in N-754; therefore, no incremental resources are expected. 2. An identical condition exists in N-754; therefore, no incremental resources are expected.
RG 1.147	N-766-1	1. Credit cannot be taken to reduce preservice and inservice inspection requirements specified by this Code Case on an inlay or onlay if an inlay or onlay is applied to an Alloy 82/182 dissimilar metal weld that contains an axial indication that has a depth of more than 25 percent of the pipe wall thickness and a length of more than one-half of the axial width of the dissimilar metal weld, or a circumferential indication that has a depth of more than 25 percent of the pipe wall thickness and a length of more than 20 percent of the circumference of the pipe. 2. In lieu of paragraph 2(e) of the Code Case, pipes with any thickness of inlay or onlay must be evaluated for weld shrinkage, pipe system flexibility, and additional weight of the inlay or onlay. 3. If an inlay or onlay is applied to an Alloy 82/182 dissimilar metal weld that contains an indication that exceeds the acceptance standards of Section XI, IWB-3514 and that is accepted for continued service in accordance with Section XI, IWB-3132.3 or IWB-3142.4, the subject weld must be inspected in three successive examinations after inlay or onlay installation. 4. Any detectable subsurface indication discovered by eddy current testing in the inlay or onlay during acceptance examinations is prohibited to remain in service. 5. The flaw analysis of paragraph 2(d) of the Code Case shall also consider primary water stress corrosion-cracking growth in the circumferential and axial directions, in accordance with Section XI, IWB-3640.	1. Incremental resources are needed to use N-754-1 for welds that do not meet these requirements. 2. This condition clarifies the weld examination process; therefore, no incremental resources are expected. 3. This condition clarifies the existing requirements; therefore, no incremental resources are expected. 4. This condition clarifies the expectations of the welding process; therefore, no incremental resources are expected. 5. This condition clarifies the expectations of Paragraph 2d of the Code Case; therefore, no incremental resources are expected.
RG 1.147	N-824	1. Instead of Paragraph 1(c)(1)(–c)(–2), licensees shall use a phased array search unit with a center frequency of 500 kilohertz (kHz) with a tolerance of ± 20 percent for piping greater than 1.6 in (41 mm) thick. 2. Instead of Paragraph 1(c)(1)(–d), the phased array search unit must produce angles including those at, but not limited to, 30 to 55 degrees with a maximum increment of 5 degrees.	1. This condition is already incorporated by reference into 10 CFR 50.55a; therefore, no incremental resources are expected. 2. The condition is already incorporated by reference into 10 CFR 50.55a; therefore, no incremental resources are expected.

RG Listing	NRC-Conditioned ASME Code Case Number	New Condition Description[a]	Incremental Resources Required[b]
RG 1.147	N-829	1. The provisions of this Code Case, paragraph 3(e)(2) or 3(e)(3) may only be used when it is impractical to use the interpass temperature measurement methods described in paragraph 3(e)(1), such as in situations where the weldment area is inaccessible or when there are extenuating radiological conditions.	1. There is no appreciable cost difference between the temperature measurement techniques of these paragraphs; therefore, no incremental resources are expected.
RG 1.147	N-830	1. The use of the provision in Paragraph (f) of the Code Case, which provides for an alternative to limiting the lower shelf of the 95% lower tolerance bound Master Curve toughness, K_{JC}-lower 95%, to a value consistent with the current plane strain fracture toughness (K_{IC}) curve is prohibited.	1. This condition clarifies the use of the provision in Paragraph (f) of N-830 to ensure that the analysis uses a single methodology applied to the entire curve; therefore, no incremental resources are expected.
RG 1.147	N-831	1. The Code Case is prohibited for use in new reactor construction.	1. New reactors can use radiography instead of N-831; therefore, no incremental costs or resources are expected because shutting down or lengthening an outage would not be necessary.
RG 1.147	N-838	1. Code Case N-838 shall not be used to evaluate flaws in cast austenitic stainless steel piping where the delta ferrite content exceeds 25 percent.	1. Incremental costs would be expected for the submittal of a relief request to the NRC before the Code Case can be used.
RG 1.147	N-843	1. If the portions of the system that requires pressure testing are associated with more than one safety function, the pressure test and visual examination VT-2 shall be performed during a test conducted at the higher of the operating pressures for the respective system safety functions.	1. This condition clarifies that a test should be performed at the higher pressure in accordance with the standard procedure; therefore, no incremental costs are expected.
RG 1.147	N-849	1. Use of Code Case N-849 is limited to plants that are designed with accessible core support structures to allow for in-situ inspection. 2. Before the initial plant startup, a VT-3 examination shall be performed with the core support structure removed, as required by ASME Section XI, IWB-2500-1, and shall include all surfaces that are accessible when the core support structure is removed, including all load bearing and contact surfaces.	1. This condition clarifies the intent of the Code Case as it passed through committee. This Code Case does not apply to the current operating fleet; therefore, no incremental resources are expected. 2. This condition clarifies existing code requirements; therefore, no incremental resources are expected.
RG 1.192	OMN-13	1. This Code Case is applicable to the editions and addenda of the OM Code listed in §50.55a(a)(1)(iv). Although Code Case OMN-13 has an applicability statement in its inquiry and reply, the guidance in Code Case OMN-13 is acceptable for application at nuclear power plants with a Code of Record of any edition or addenda of the OM Code incorporated by reference in §50.55a as listed in paragraph 10 CFR 50.55a(a)(1)(iv).	1. This condition relaxes the applicability requirements that will avert relief requests from three sites or less.
RG 1.192	OMN-20	1. This Code Case is applicable to the editions	1. This condition relaxes the

RG Listing	NRC-Conditioned ASME Code Case Number	New Condition Description[a]	Incremental Resources Required[b]
		and addenda of the OM Code listed in §50.55a(a)(1)(iv). Although Code Case OMN-20 has an applicability statement in its inquiry and reply, the guidance in Code Case OMN-20 is acceptable for application at nuclear power plants with a Code of [R]ecord of any edition or addenda of the OM Code incorporated by reference in §50.55a as listed in paragraph (a)(1)(iv).	applicability requirements that will avert relief requests from three sites or less.

[a] This information is taken from the respective RG.

[b] These incremental resources are the additional resources necessary to conform to the NRC-conditioned ASME Code Case when using (1) the same Code Case with no NRC conditions as the baseline, (2) new Code Cases with the unconditioned new Code Case as the baseline, or (3) the existing edition of the Code Case as the baseline if the Code Case is not new.

4.3 Data

This analysis discusses the data and assumptions used in analyzing the quantifiable impacts associated with each alternative. The NRC used data from subject-matter experts, knowledge gained from past rulemakings, and information gathered during public meetings and from correspondence to collect data for this analysis. Quantitative and qualitative (i.e., nonquantified) information on attributes affected by the evaluated alternatives came from the NRC and from public comments on the regulatory analyses provided with the proposed rule. The NRC considered the potential differences between the new requirements and the current requirements and incorporated the incremental changes into this regulatory analysis.

5. Results

This section presents the quantitative and qualitative results by attribute relative to the regulatory baseline. As described in the previous sections, costs and benefits are quantified where possible and can have either a positive or a negative algebraic sign, depending on whether the alternative has a favorable or adverse effect compared to the regulatory baseline (Alternative 1). This section discusses, qualitatively, those attributes that are not easily represented in monetary values. Although this ex ante cost-benefit analysis[5] provides information that can be used when deciding whether to select an alternative, the analysis is based on estimates of the future costs and benefits. Whether the estimates hold in the future, the process of conducting regulatory analyses has value in and of itself because it helps decisionmakers think indepth about specific alternatives and their associated results.

NUREG/BR-0058, Appendix D, states that the NRC's periodic review and endorsement of consensus standards, such as new versions of the ASME Code and the associated Code Cases, are special cases because consensus standards have already undergone extensive external review and have been endorsed by industry. In addition, endorsement of the ASME Code and Code Cases has been a longstanding NRC policy. Licensees and applicants participate in the development of the ASME Code and Code Cases and are aware that the periodic updating of the ASME Code is part of the regulatory process. Code Cases are ASME-developed alternatives to the ASME BPV and OM Codes that licensees and applicants may voluntarily choose to adopt without an alternative request if the Code Cases are approved

5 An ex ante cost-benefit analysis is prepared before a policy, program, or alternative is in place and can assist in the decision about whether resources should be allocated to that alternative.

through incorporation by reference into the NRC's regulations. Finally, endorsement of the ASME Code and Code Cases is consistent with the NTTAA because the NRC has determined that sound regulatory reasons exist for establishing regulatory requirements for design, maintenance, ISI, and IST and examination by rulemaking.

In a typical incorporation of Code Cases, the NRC endorsements can involve hundreds, if not thousands, of individual provisions. Evaluating the benefit in relation to the cost of each individual provision in this regulatory analysis would be prohibitive, and such an exercise would have limited value. Therefore, this regulatory analysis does not evaluate the individual requirements of the consensus standards.

However, when the NRC either (1) imposes conditions or exceptions on the use of an ASME Code provision or (2) requires licensees to adopt provisions of the ASME Code on an expedited schedule (i.e., sooner than the 120-month updating interval in 10 CFR 50.55a), the agency prepares a regulatory analysis that is limited to the consideration of those provisions or circumstances for which the NRC is imposing conditions. Both cases—the NRC's imposition of a new condition on an ASME Code provision that has already been incorporated by the NRC or the required adoption of provisions on an expedited schedule—represent situations where a regulatory analysis would be justified as a matter of regulatory policy.

5.1 Public Health (Accident)

Industry practice to adopt ASME BPV and OM Code Cases through their incorporation by reference into the regulations may incrementally reduce the likelihood of a radiological accident in a positive, but not easily quantifiable, manner. Pursuing Alternative 2 would continue to meet the NRC's goal of maintaining safety by still providing the NRC's approval of new ASME Code Cases to allow licensees to gain experience with new technology before its incorporation into the ASME Codes. Alternative 2 would also permit licensees to use advances in ISI and IST, provide alternative examinations for older plants, respond promptly to user needs, and offer a limited and clearly focused alternative to specific ASME Code provisions. Improvements in ISI and IST may also result in the earlier identification of material degradation that, if undetected, could lead to further degradation that eventually causes a plant transient. For these reasons, Alternative 2 maintains the same level of, or may provide an incremental improvement in, safety as compared to the regulatory baseline.

5.2 Occupational Health (Accident and Routine)

The NRC's practice of reviewing ASME BPV and OM Code Cases, determining their acceptability, and specifying its findings in RGs that are incorporated by reference into the regulations ensures that the mandated ASME Code requirements and approved ASME Code alternatives result in an acceptable level of quality and safety. Pursuing Alternative 2 (the rule alternative) would continue to meet the NRC's goal of maintaining safety, permitting licensees to use ISI and IST advancements, providing alternative examinations, responding to user needs, and offering alternatives to ASME Code provisions. The NRC expects that the voluntary use of NRC-approved Code Cases by licensees and applicants would reduce occupational radiation exposure in a positive, but not easily quantifiable, manner. For example, the NRC expects that the use of the approved ASME Code Cases would result in an incremental decrease in the likelihood of an accident and would reduce worker radiological exposures during routine inspections or testing as compared to the regulatory baseline.

Alternative 2 would allow licensees and applicants to voluntarily apply NRC-approved ASME Code Cases, sometimes with NRC-specified conditions. The NRC lists the approved ASME Code Cases in RG 1.84, RG 1.147, and RG 1.192, which are incorporated by reference into 10 CFR 50.55a.

5.3 Industry Implementation

This attribute accounts for the projected net economic effect on the affected licensees resulting from their implementation of the regulatory changes (conditions on the ASME Code editions). Additional costs above the regulatory baseline are negative, and cost savings and averted costs are positive.

5.3.1 Additional Materials for Subsection NF, Class 1, 2, 3, and Metal Containment Supports Fabricated by Welding

The first condition on ASME Code Case N-71-19 is identical to the first condition on ASME Code Case N-71-18, which the NRC first approved in RG 1.84, Revision 33, issued August 2005. The condition states the following:

> The maximum measured ultimate tensile strength (UTS) of the component support material must not exceed 170 ksi in view of the susceptibility of high-strength materials to brittleness and stress corrosion cracking.

ASME Code Case N-71-19 does not address the reasons for imposing this condition; therefore, RG 1.84, Revision 38, will retain this condition.

The second condition on ASME Code Case N-71-19 is an update to the third condition in Revision 18 of the Code Case. This condition has been modified to reference the correct sentence and paragraph of the revised Code Case and to refer to Paragraph 5.2 of the Code Case instead of Paragraph 5.5 to cite the following:

> 5.3.2.3, "Alternative Atmosphere Exposure Time Periods Established by Test," of the American Welding Society D1.1 Code for the evidence presented to and accepted by the Authorized Inspector concerning exposure of electrodes for a longer period of time.

The basis for this change is that ASME has renumbered Paragraph 5.5 of the Code Case as Paragraph 5.2. ASME Code Case N-71-19 does not address the reasons for imposing this condition; therefore, RG 1.84, Revision 38, will retain this condition.

The third condition on ASME Code Case N-71-19 is substantively the same as the fourth condition on ASME Code Case N-71-18, which the NRC first approved in RG 1.84, Revision 33, except that it now references the renumbered paragraphs of the revised Code Case. The condition now reads as follows:

> Paragraph 16.2.2 of Code Case N-71-19 is not acceptable as written and must be replaced with the following: "When not exempted by 16.2.1 above, the post weld heat treatment must be performed in accordance with NF-4622 except that ASTM A-710 Grade A Material must be at least 1000°F (540°C) and must not exceed 1150°F (620°C) for Class 1 and 2 material and 1175°F (640°C) for Class 3 material."

ASME Code Case N-71-19 does not address the reasons for imposing this condition; therefore, RG 1.84, Revision 38, will retain this condition.

The fourth condition on ASME Code Case N-71-19 is identical to the fifth condition on ASME Code Case N-71-18, which the NRC first approved in RG 1.84, Revision 33. The condition states the following:

> The new holding time-at-temperature for weld thickness (nominal) must be 30 minutes 1/2 inch or less, 1 hour per inch of thickness for welds over 1/2 inch to 5 inches, and for thicknesses over 5 inches, 5 hours plus 15 minutes for each additional inch over 5 inches.

ASME Code Case N-71-19 does not address the reasons for imposing this condition; therefore, RG 1.84, Revision 38, will retain this condition.

The fifth condition on ASME Code Case N-71-19 is identical to the sixth condition on ASME Code Case N-71-18, which the NRC first approved in RG 1.84, Revision 33. The condition states the following:

> The fracture toughness requirements as listed in this Code Case apply only to piping supports and not to Class 1, 2 and 3 component supports.

ASME Code Case N-71-19 does not address the reasons for imposing this condition; therefore, RG 1.84, Revision 38, will retain this condition.

The new sixth condition states that, when welding the P-number materials listed in the ASME Code Case, the corresponding S-number welding requirements shall apply. This Code Case revision and all previous revisions provide for the use of materials not listed in ASME BPV Code, Section II, Part D, and provide exemptions to the postweld heat treatment requirements listed in ASME BPV Code, Section III, Article NF-4622, for materials that are up to 10.16 centimeters (4 inches) in thickness. Therefore, if a user applies this Code Case as written and uses a P-number material (listed in the tables) that was previously assigned an S-number, the user does not have to follow the special welding requirements unless it wishes to be exempted from the postweld heat treatment requirements listed in ASME BPV Code, Section III, Article NF-4622. Using materials assigned an S-number in the Code Case would still require the user to follow all special welding requirements regardless of whether postweld heat treatment is exempted. The NRC believes that these special welding requirements should apply to P-number materials, regardless of whether or not the user wants to be exempted from postweld heat treatment, given that the materials have not changed. An additional condition on the use of this Code Case is necessary to address the issues above. This new condition would not impose any additional restrictions on the use of this Code Case from those already placed on the previous revisions.

The NRC does not expect industry to incur incremental implementation costs as a result of these identical, substantively identical, or administrative conditions.

5.3.2 Underwater Welding, Section XI, Division 1

RG 1.147 conditionally accepted the previously approved revision of ASME Code Case N-516-3 to require licensees to obtain NRC approval in accordance with 10 CFR 50.55a(z) for the

technique to be used in the weld repair or replacement of irradiated material underwater. The rationale for this condition was the knowledge that materials subjected to high neutron fluence could not be welded without cracking. However, the condition applied to ASME Code Case N-516-3 did not provide any guidance on what level of neutron irradiation could be considered a threshold for weldability.

The technical basis for imposing conditions on the welding of irradiated materials is that neutrons can generate helium atoms within the metal lattice through transmutation of various isotopes of boron or nickel. At high temperatures, such as those that occur during welding, these helium atoms rapidly diffuse though the metal lattice, forming helium bubbles. In sufficient concentration, these helium atoms can cause grain boundary cracking in the fusion zones and heat affected zones during the heatup/cooldown cycle.

During rulemaking for the 2009–2013 Editions of the ASME BPV Code, in "Final Regulatory Analysis for Final Rule: Incorporation by Reference of American Society of Mechanical Engineers Codes and Code Cases," issued April 2017 (NRC 2017d), the NRC adopted conditions that should be applied to Section XI, Article IWA-4660, for underwater welding on irradiated materials. These conditions provide guidance on what level of neutron irradiation or helium content would require approval by the NRC because of the impact of neutron fluence on weldability. They also give separate criteria for three generic classes of material: (1) ferritic material, (2) austenitic material other than P-number 8 (e.g., nickel-based alloys), and (3) P-number 8 austenitic material (e.g., stainless steel alloys). These conditions are currently listed in 10 CFR 50.55a(b)(2)(xii), and although they apply to underwater welding performed in accordance with IWA-4660, they do not apply to underwater welding performed in accordance with ASME Code Case N-516-4.

Therefore, the NRC approves ASME Code Case N-516-4 with the following three conditions for underwater welding:

(1) The first condition captures the 10 CFR 50.55a(b)(2)(xii) requirement for underwater welding of ferritic materials and states that licensees must obtain NRC approval in accordance with 10 CFR 50.55a(z) for the welding technique to be used before they can perform welding on ferritic material exposed to fast neutron fluence greater than $1x10^{17}$ neutrons per square centimeter (n/cm^2) (energy (E) > 1 million electron volts (MeV)).

(2) The second condition captures the 10 CFR 50.55a(b)(2)(xii) requirement for underwater welding of austenitic materials that are not P-number 8 materials and states that licensees must obtain NRC approval in accordance with 10 CFR 50.55a(z) for the welding technique to be used before they can perform welding on austenitic material other than P-number 8 materials exposed to thermal neutron fluence greater than $1x10^{17}$ n/cm^2 (E < 0.5 eV).

(3) The third condition captures the 10 CFR 50.55a(b)(2)(xii) requirement for underwater welding of austenitic P-number 8 materials and states that licensees must obtain NRC approval in accordance with 10 CFR 50.55a(z) for use of the welding technique before performing welding on P-number 8 austenitic materials exposed to thermal neutron fluence greater than $1x10^{17}$ n/cm^2 (E < 0.5 eV) and measured or calculated helium concentration of the materials greater than 0.1 atomic part per million.

Because these conditions capture existing requirements, the NRC does not expect industry to incur incremental implementation costs.

5.3.3 Evaluation of Pipe Wall Thinning, Section XI

The conditions on ASME Code Case N-597-3 are carried over from the previous version of ASME Code Case N-597-2; however, the NRC made revisions to clarify the intent of the conditions. The first condition on ASME Code Case N-597-3 addresses the NRC's concerns about how the corrosion rate and associated uncertainties will be determined when ASME Code Case N-597-3 is applied to evaluate the wall thinning in pipes for degradation mechanisms other than flow-accelerated corrosion. Therefore, the agency is imposing a condition that requires the NRC to review and approve the corrosion rate before application of the Code Case.

The second condition on ASME Code Case N-597-3 has two parts that allow the use of this Code Case to mitigate flow-accelerated corrosion but only if both of the requirements of the condition are met. Because the calculation of wall thinning is inherently difficult, the first part of Condition 2 requires that the use of ASME Code Case N-597-3 on flow-accelerated corrosion piping must be supplemented by the provisions of Electric Power Research Institute (EPRI) Nuclear Safety Analysis Center (NSAC)-202L-2, "Recommendations for an Effective Flow-Accelerated Corrosion Program," issued April 1999 (EPRI 1999), which includes rigorous provisions to minimize wall thinning.

The first part of Condition 2 (i.e., Condition 2(a)) on ASME Code Case N-597-3 is identical to the first condition on ASME Code Case N-597-2 that was first approved by the NRC in RG 1.147, Revision 15, issued October 2007. The condition states the following:

> Code Case must be supplemented by the provisions of EPRI Nuclear Safety Analysis Center Report 202L-2, "Recommendations for an Effective Flow Accelerated Corrosion Program," April 1999, for developing the inspection requirements, the method of predicting the rate of wall thickness loss, and the value of the predicted remaining wall thickness. As used in NSAC-202L-R2, the term "should" is to be applied as "shall" (i.e., a requirement).

ASME Code Case N-597-3 does not address the NRC's reasons for imposing this condition; therefore, RG 1.147, Revision 19, will retain this condition.

The second part of Condition 2 (i.e., Condition 2(b)) on ASME Code Case N-597-3 is identical to the second condition on ASME Code Case N-597-2 that was first approved by the NRC in RG 1.147, Revision 15. The condition states the following:

> Components affected by flow-accelerated corrosion to which this Code Case are applied must be repaired or replaced in accordance with the construction code of record and owner's requirements or a later NRC approved edition of Section III, "Rules for Construction of Nuclear Power Plant Components," of the ASME Code prior to the value of t_p reaching the allowable minimum wall thickness, t_{min}, as specified in -3622.1(a)(1) of this Code Case.

Alternatively, use of the ASME Code Case is subject to NRC review and approval in accordance with 10 CFR 50.55a(z). ASME Code Case N-597-3 does not address the NRC's reasons for imposing this condition; therefore, RG 1.147, Revision 19, will retain this condition.

The third condition on ASME Code Case N-597-3 is identical to the fourth condition on ASME Code Case N-597-2 that was first approved by the NRC in RG 1.147, Revision 15. The condition stated that, for those components that do not require immediate repair or replacement, the rate of wall thickness loss is to be used to determine a suitable inspection frequency so that repair or replacement occurs before the value of t_p reaches the allowable minimum wall thickness, t_{min}. ASME Code Case N-597-3 does not address the NRC's reasons for imposing this condition; therefore, RG 1.147, Revision 19, will retain this condition.

The fourth condition on ASME Code Case N-597-3 is updated from the sixth condition on ASME Code Case N-597-2 that was first approved by the NRC in RG 1.147, Revision 17, issued August 2014. This condition allows the use of ASME Code Case N-597-3 to calculate wall thinning for moderate-energy Class 2 and 3 piping, using criteria in ASME Code Case N-513-2, for temporary acceptance (i.e., until the next refueling outage). ASME Code Case N-597-3 does not address the NRC's reasons for imposing this condition; therefore, RG 1.147, Revision 19, will retain this condition.

The fifth condition is also an update from the sixth condition on ASME Code Case N-597-2 that was first approved by the NRC in RG 1.147, Revision 17, and prohibits the use of this Code Case in evaluating through-wall leakage conditions. The NRC finds it difficult to authorize the use of this Code Case for evaluation of through-wall leakage in high-energy piping because of the consequences and safety implications associated with pipe failure.

Because all of the conditions on ASME Code Case N-597-3 are either identical or substantively identical to conditions on ASME Code Case N-597-2, the NRC does not expect industry to incur incremental implementation costs as a result of these conditions.

5.3.4 Similar and Dissimilar Metal Welding Using an Ambient Temperature Machine Gas Tungsten Arc Welding Temper Bead Technique for Boiling-Water Reactor Control Rod Drive Housing/Stub Tube Repairs

The condition on ASME Code Case N-606-2 is identical to the condition on ASME Code Case N-606-1, which the NRC first approved in RG 1.147, Revision 13, issued January 2004 (reprint). The condition states the following:

> Prior to welding, an examination or verification must be performed to ensure proper preparation of the base metal, and that the surface is properly contoured so that an acceptable weld can be produced. This verification is to be required in the welding procedure.

ASME Code Case N-606-2 does not address the reasons for imposing this condition; therefore, RG 1.147, Revision 19, will retain this condition. The NRC does not expect industry to incur incremental implementation costs associated with this identical condition.

5.3.5 Similar and Dissimilar Metal Welding Using an Ambient Temperature Machine Gas Tungsten Arc Welding Temper Bead Technique

The condition on ASME Code Case N-638-7 is identical to the condition on ASME Code Case N-638-6, which the NRC first approved in the final rule for RG 1.147, Revision 18 (NRC 2017e). The condition states the following:

Demonstration for ultrasonic examination of the repaired volume is required using representative samples which contain construction type flaws.

ASME Code Case N-638-7 does not address the reasons for imposing this condition; therefore, RG 1.147, Revision 19, will retain this condition. The NRC does not expect industry to incur incremental implementation costs associated with this identical condition.

5.3.6 Alternative Requirements for Inner Radius Examinations of Class 1 Reactor Vessel Nozzles, Section XI

The NRC is imposing one condition for ASME Code Case N-648-2, which is related to preservice inspections. ASME Code Case N-648-2 shall not be used to eliminate the preservice or inservice volumetric examination of plants with a combined license under 10 CFR Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants," or a plant that received its operating license after October 22, 2015.

The NRC's position on ASME Code Case N-648-2 is that the required preservice volumetric examinations should be performed on all vessel nozzles for comparison with later volumetric examinations if indications are found. Eliminating the volumetric preservice or inservice examination is based on the good operating experience of the existing fleet, which has not found any inner radius cracking in the nozzles within the scope of the Code Case. At this time, the new reactor designs have no inspection history or operating experience available to support eliminating the periodic volumetric examination of the nozzles in question. The use of ASME Code Case N-648-2 would not eliminate preservice examinations for the existing fleet because all plants have already completed a preservice examination.

A condition on ASME Code Case N-648-1 already prohibits preservice examinations. The NRC does not expect industry to incur incremental implementation costs associated with this condition; however, the agency does expect industry to incur incremental operation costs for this condition, as discussed in Section 5.4.6.

5.3.7 Qualification Requirements for Dissimilar Metal Piping Welds

ASME Code Case N-695-1 provides alternative rules for ultrasonic inspections of dissimilar metal welds (DMWs) from the inner and outer surfaces. ASME developed Code Case N-695 in ASME BPV Code, Section XI, editions before 2007 to allow for inspections from the inner surface. However, no inspection vendor was able to meet the depth-sizing requirements of the 0.125-inch root mean square (RMS) error. The NRC has granted relief to several licensees to allow the use of alternate depth-sizing requirements. The NRC reviewed the depth-sizing results at EPRI's Performance Demonstration Initiative for procedures that can achieve an RMS error over 0.125 inch but less than 0.25 inch. The review found that the inspectors tend to oversize small flaws and undersize deep flaws. The flaws sized by the inspectors as 50-percent though-wall or less were accurately or conservatively measured. However, in some instances, very large flaws were measured as significantly smaller than the true state, but such flaws were not measured as less than 50-percent through-wall.

ASME Code Case N-695-1 changes the depth-sizing requirements for inner-surface examinations of test blocks of 2.1 inches or greater in thickness to 0.25 inch. This change is in line with the granted relief requests and with the NRC's review of the Performance Demonstration Institute test results.

The depth-sizing capabilities of the inspections do not provide sufficient confidence in the ability of an inspector qualified using a 0.25-inch RMS error to accurately measure the depth of deep flaws. The NRC is imposing a condition on ASME Code Case N-695-1 stating that any surface-connected flaw sized over 50-percent through-wall should be considered to be of indeterminate size.

The NRC approves ASME Code Case N-695-1 with the following condition:

> Inspectors qualified using the 0.25 root mean square error for measuring the depths of flaws using N-695-1 are not qualified to depth-size inner diameter (ID) surface breaking flaws greater than 50% through-wall in dissimilar metal welds 2.1 inches or greater in thickness. When an inspector qualified using N-695-1 measures a flaw as greater than 50% through-wall in a dissimilar metal weld from the inner diameter, the flaw shall be considered to have an indeterminate depth.

The NRC does not expect industry to incur incremental implementation costs for this condition; however, the agency does expect industry to incur incremental operation costs as a result of relief requests, as discussed in Section 5.4.7.

5.3.8 Qualification Requirements for Mandatory Appendix VIII Piping Examination Conducted from the Inside Surface

ASME Code Case N-696-1 provides alternative rules for ultrasonic inspections of Supplement 2, 3, and 10 welds from the inner and outer surfaces. The justifications for ASME Code Case N-696-1 are the same as those for ASME Code Case N-695-1 described above, while the condition varies in the specification of the weld metals:

> Examiners qualified using the 0.25 RMS error for measuring the depths of flaws using N-696-1 in dissimilar metal or austenitic welds are not qualified to depth-size inner diameter (ID) surface breaking flaws greater than 50 percent through-wall in dissimilar metal or austenitic weld metal welds 2.1 inches or greater in thickness. When an Examiner qualified using N-696-1 measures a flaw as greater than 50 percent through-wall in a dissimilar metal or austenitic weld from the ID, the flaw shall be considered to have an indeterminate depth.

The NRC does not expect industry to incur incremental implementation costs for this condition; however, the agency does expect industry to incur incremental operation costs as a result of relief requests, as discussed in Section 5.4.8.

5.3.9 Alternative Requirements for Boiling-Water Reactor Nozzle Inner Radius and Nozzle-to-Shell Welds, Section XI, Division 1

The NRC previously accepted with conditions ASME Code Case N-702 in RG 1.147, Revision 18. For RG 1.147, Revision 19, the NRC is imposing revisions to the conditions on ASME Code Case N-702. The original conditions in RG 1.147, Revision 17, were consistent with the established review procedure for all applicants before August 2014 for the original 40-year operating period. The conditions were required to ensure that the probability of vessel nozzle failure meets the NRC's safety goal. During the 40-year operating period, past reviews by the NRC have indicated that all licensees evaluated the condition adequately and that future NRC reviews are not necessary. Applications are prohibited for the extended operation period to enable licensees to submit relief requests based on Appendix A, "BWR Nozzle Radii and

Nozzle-to-Vessel Welds Demonstration of Compliance with the Technical Information Requirements of the License Renewal Rule (10 CFR 54.21)," to Boiling-Water Reactor Vessel Internals Project (BWRVIP)-241, "BWR Vessel and Internals Project Probabilistic Fracture Mechanics Evaluation for the Nozzle-to-Vessel Shell Welds and Nozzle Blend Radii," dated April 19, 2013, which the agency approved on April 26, 2017, or to submit plant-specific probabilistic fracture mechanics analyses. Therefore, the NRC is revising the condition in RG 1.147, Revision 17, to reflect the changes stated in this paragraph.

Consistent with the safety evaluations for all prior ASME Code Case N-702 applicants, the NRC has added a condition on visual examination to reaffirm that it is not relaxing the licensees' practice of conducting visual testing 1 (VT-1) on nozzle inner radii.

The revised conditions on ASME Code Case N-702 state the following:

> The applicability of Code Case N-702 for the first 40 years of operation must be demonstrated by satisfying the criteria in Section 5.0 of NRC Safety Evaluation regarding BWRVIP-108 dated December 18, 2007 (ADAMS Accession No. ML073600374) or Section 5.0 of NRC Safety Evaluation regarding BWRVIP-241 dated April 19, 2013 (ADAMS Accession No. ML13071A240).
>
> The use of Code Case N-702 in the period of extended operation is not approved.

The NRC does not expect industry to incur incremental implementation costs as a result of these conditions, which are consistent with the approach that licensees used before the existence of the ASME Code Case.

5.3.10 Evaluation Criteria for Temporary Acceptance of Degradation in Moderate-Energy Class 2 or 3 Vessels and Tanks

The NRC previously accepted ASME Code Case N-705 in RG 1.147, Revision 16, issued October 2010, without conditions, and the revised Code Case in Supplement 11 only contains editorial changes. However, the NRC has identified an area of concern. The Code Case is applicable to the temporary acceptance of degradation, which could be a through wall leak, and would permit a vessel or tank to leak coolant for 26 months without repair or replacement. Paragraph 1(d) of Code Case N-705 states that the evaluation period is the operational time for which the temporary acceptance criteria are satisfied (i.e., evaluation period $\leq t_{allow}$) but not greater than 26 months from the initial discovery of the condition. The NRC finds that flaws which are not through-wall that have been evaluated in accordance with the code case should be allowed to remain in service the entire length of the period evaluated by the code case (i.e. up to 26 months). The evaluation methods of the code case reasonably assure the structural integrity of the component will not be impacted during the period of the evaluation. However, the NRC finds that through-wall flaws accepted in accordance with the code case should be subject to repair/replacement at the next refueling outage. Therefore, the NRC imposes the following condition on ASME Code Case N-705:

> The ASME Code repair or replacement activity temporarily deferred under the provisions of this Code Case shall be performed no later than the next scheduled refueling outage for through-wall flaws.

The NRC does not expect industry to incur incremental costs associated with this condition.

5.3.11 Alternative Examination Coverage Requirements for Examination Category B-F, B-J, C-F-1, C-F-2, and R-A Piping Welds

The NRC first listed ASME Code Case N-711 as unacceptable for use in RG 1.193, "ASME Code Cases Not Approved for Use," Revision 3, issued October 2010 (NRC 2010). ASME created ASME Code Case N-711-1 to incorporate several NRC conditions for the use of ASME Code Case N-711. This Code Case provides requirements for determining an alternative required examination volume. This alternative volume is defined as the volume of primary interest based on the postulated degradation mechanism in a particular piping weld.

The NRC finds ASME Code Case N-711-1 acceptable with the following condition:

> Code Case N-711-1 shall not be used to redefine the required examination volume for preservice examinations or when the postulated degradation mechanism for piping welds is PWSCC, or crevice corrosion degradation mechanisms.

There is no degradation method during preservice; therefore, the ASME Code Case would not apply. For primary water stress-corrosion cracking (PWSCC), the NRC finds that the examination volume must meet the requirements of ASME Code Case N-770-1 with the conditions in 10 CFR 50.55a(g)(6)(ii)(F). For IGSCC and crevice corrosion, the Code Case does not define a volume of primary interest; therefore, it cannot be used for these degradation mechanisms. The Code Case requires selection of an alternative inspection location within the same risk region or category if it will improve the examination coverage of the volume of primary interest. Further, the Code Case refers to the owner's program for IGSCC.

The licensee's 90-day postoutage report of activities must identify the use of the ASME Code Case and the examination category, weld number, weld description, and percent coverage and a description of limitation. The NRC determined that the Code Case provides a suitable process for determining the appropriate volume of primary interest based on the degradation mechanism postulated by the degradation mechanism analysis except as noted in the final condition. The NRC does not expect industry to incur incremental implementation costs associated with this condition.

5.3.12 Optimized Structural Dissimilar Metal Weld Overlay for Mitigation of Pressurized-Water Reactor Class 1 Items

The NRC approves ASME Code Case N-754-1 with two conditions. ASME Code Case N-754 concerns the use of optimized structural weld overlays as an alternative to full-structure overlays for mitigation of flaws in large-diameter piping. The first condition on Code Case N-754-1 is the same as the first condition on ASME Code Case N-754 that the NRC first approved in RG 1.147, Revision 18. The condition states the following:

> The conditions imposed on the optimized weld overlay design in NRC safety evaluation for the topical report, "Materials Reliability Program (MRP): Technical Basis for Preemptive Weld Overlays for Alloy 82/182 Butt Welds in PWRs (MRP-169)," Revision 1-A, Electric Power Research Institute (ADAMS Accession Nos. ML101620010 and ML101660468) must be satisfied.

ASME Code Case N-754-1 does not address the reasons for imposing this condition; therefore, RG 1.147, Revision 19, will retain this condition.

The second condition on ASME Code Case N-754-1 is similar to the second condition on ASME Code Case N-754 that the NRC approved in RG 1.147, Revision 18. The second condition states the following:

> The preservice and inservice inspections of the overlaid weld must satisfy 10 CFR 50.55a(g)(6)(ii)(F).

ASME Code Case N-754-1 does not address the reasons for imposing this condition; therefore, RG 1.147, Revision 19, will retain this condition with the following modified language for clarity:

> In lieu of the pre-service and inservice examinations as specified in Section 3(c) of the code case, the optimized weld overlay must be examined in accordance with 10 CFR 50.55a(g)(6)(ii)(F).

The NRC does not expect industry to incur incremental implementation costs associated with these essentially identical and clarifying conditions.

5.3.13 Nickel Alloy Reactor Coolant Inlay and Onlay for Mitigation of Pressurized-Water Reactor Full-Penetration Circumferential Nickel Alloy Dissimilar Metal Welds in Class 1 Items

ASME Code Case N-766-1 contains provisions for repairing nickel-based Alloy 82/182 dissimilar metal butt welds in Class 1 piping using weld inlay and onlay. The Code Case provides adequate requirements for the design, installation, pressure testing, and examinations of the inlay and onlay. The weld inlay and onlay using the Code Case provides reasonable assurance that the structural integrity of the repaired pipe will be maintained. However, certain provisions of the Code Case are inadequate; therefore, the NRC has imposed five conditions.

The first condition on ASME Code Case N-766-1 is new and prohibits the reduction of inspection requirements of this Code Case for inlays or onlays applied to Alloy 82/182 DMWs, which contain an axial indication that has a depth of more than 25 percent of the pipe wall thickness and a length of more than half the axial width of the DMW or a circumferential indication that has a depth of more than 25 percent of the pipe wall thickness and a length of more than 20 percent of the circumference of the pipe. Paragraph 1(c)(1) of the Code Case states the following:

> Indications detected in the examination of 3(b)(1) that exceed the acceptance standards of IWB-3514 shall be corrected in accordance with the defect removal requirements of IWA-4000. Alternatively, indications that do not meet the acceptance standards of IWB-3514 may be accepted by analytical evaluation in accordance with IWB-3600.

The above alternative would allow a flaw with a maximum depth of 75-percent through-wall to remain in service in accordance with ASME BPV Code, Section XI, IWB-3643. Even if the inlay or onlay will isolate the DMW from the reactor coolant to minimize the potential for stress-corrosion cracking, the NRC finds that having a 75-percent flaw in the Alloy 82/182 weld does not provide reasonable assurance of the structural integrity of the pipe. The NRC finds

that the indication in the Alloy 82/182 weld needs to be limited in size to ensure structural integrity of the weld.

The second condition on ASME Code Case N-766-1 is new and modifies the Code Case to require that piping with any thickness of inlay or onlay must be evaluated for weld shrinkage, pipe system flexibility, and additional weight of the inlay or onlay. Paragraph 2(e) of the Code Case states the following:

> If the inlay or onlay deposited in accordance with this Case is thicker than 1/8t, where t is the original nominal DMW thickness, the effects of any change in applied loads, as a result of weld shrinkage from the entire inlay or onlay, on other items in the piping system (e.g., support loads and clearances, nozzle loads, and changes in system flexibility and weight due to the inlay or onlay) shall be evaluated. Existing flaws previously accepted by analytical evaluation shall be evaluated in accordance with IWB-3640.

The NRC finds that a pipe with any thickness of inlay or onlay must be evaluated for weld shrinkage, pipe system flexibility, and the additional weight of the inlay or onlay. This clarifies the expected welding process; it is not a new requirement.

The third condition on ASME Code Case N-766-1 is new. The third condition sets reexamination requirements for inlay or onlay when applied to Alloy 82/182 DMWs with any indication that it exceeds the acceptance standards of ASME BPV Code, Section XI, IWB-3514 and is accepted for continued service in accordance with IWB-3132.3 or IWB-3142.4. This condition states that the subject weld must be inspected in three successive examinations after the installation of the inlay or onlay. The NRC has concerns about the Code Case permitting indications exceeding IWB-3514 to remain in service after inlay or onlay installation based on the analytical evaluation of IWB-3600. IWB-2420 requires three successive examinations for indications that are permitted to remain in service per IWB-3600. The Code Case does not discuss the three successive examinations. If an inlay or onlay is applied to an Alloy 82/182 DMW that contains an indication that exceeds the acceptance standards of IWB-3514 and is accepted for continued service in accordance with IWB-3132.3 or IWB-3142.4, the subject weld must be inspected in three successive examinations after inlay or onlay installation. The NRC is imposing this condition to ensure performance of the three successive examinations.

The fourth condition on ASME Code Case N-766-1 is new and prohibits an inlay or onlay from remaining in service when eddy current testing during acceptance examinations discovers a detectable subsurface indication. Operational experience has shown that subsurface flaws on Alloy 52 welds for upper heads may be very near the surface. However, these flaws are undetectable by liquid dye penetrant because there are no surface-breaking aspects during initial construction. Nevertheless, in multiple cases, after a plant goes through one or two cycles of operation, these defects become exposed to the primary coolant. The exposure of these subsurface defects to primary coolant challenges the effectiveness of the Alloy 52 weld mitigation of only 3 millimeters in total thickness. In the upper head scenario, these welds are inspected during each outage. To allow the extension of the inspection frequency to that defined by 10 CFR 50.55a(g)(6)(ii)(F), the NRC found that all subsurface indications detectable by eddy current examination should be removed from the Alloy 52 weld layer. This clarifies the expected welding process; it is not a new requirement in that sense.

The fifth condition on ASME Code Case N-766-1 is new and requires the flaw analysis of Paragraph 2(d) of the Code Case to consider PWSCC growth in the circumferential and axial

directions in accordance with IWB-3640. The postulated flaw evaluation in the Code Case requires only a fatigue analysis. Conservative generic analysis by the NRC has raised the concern that a PWSCC could potentially grow through the inner Alloy 52 weld layer and into the highly susceptible Alloy 82/182 weld material to a depth of 75-percent through-wall within the period of reexamination frequency required by 10 CFR 50.55a(g)(6)(ii)(F). Therefore, users of this Code Case will verify, for each weld, that a PWSCC will not reach a depth of 75-percent through-wall within the required reinspection interval. This clarifies the expectations of Paragraph 2(d) of the Code Case and has no additional burden.

The NRC does not expect industry to incur incremental implementation costs as a result of these conditions. However, the first condition does result in incremental operation costs to industry, as discussed in Section 5.4.13.

5.3.14 Ultrasonic Examination of Cast Austenitic Piping Welds from the Outside Surface, Section XI, Division 1

ASME Code Case N-824 is a new Code Case for the examination of cast austenitic piping welds from the outside surface. Using NUREG/CR-6933, "Assessment of Crack Detection in Heavy-Walled Cast Stainless Steel Piping Welds Using Advanced Low-Frequency Ultrasonic Methods," issued March 2007 (NRC 2007), and NUREG/CR-7122, "An Evaluation of Ultrasonic Phased Array Testing for Cast Austenitic Stainless Steel Pressurizer Surge Line Piping Welds," issued March 2012 (NRC 2012), the NRC has determined that inspections of cast austenitic stainless steel (CASS) materials are very challenging and that sufficient technical basis exists to add conditions to the Code Case to bring it into agreement with NUREG/CR-6933 and NUREG/CR-7122. These reports also show that CASS materials produce high levels of coherent noise. The noise signals can be confusing and mask flaw indications.
The use of dual-element, phased-array search units showed the most promise in obtaining meaningful responses from flaws. For this reason, the NRC has added a condition to require the use of dual, transmit-receive, refracted longitudinal wave, multielement phased-array search units when using ASME Code Case N-824 for the examination of CASS components.

NUREG/CR-6933 and NUREG/CR-7122 describe the optimum inspection frequencies for examining CASS components of various thicknesses. For this reason, the NRC is proposing to add a condition to require that ultrasonic examinations performed to implement ASME Code Case N-824 on piping greater than 1.6 inches thick use a phased-array search unit with a center frequency of 500 kHz with a tolerance of ±20 percent.

NUREG/CR-6933 shows that the grain structure of CASS can reduce the effectiveness of some inspection angles (i.e., angles including, but not limited to, 30 to 55 degrees with a maximum increment of 5 degrees). Because the NRC is requiring the use of a phased-array search unit, the NRC finds that the use of the phased-array search unit must be limited so that the unit is used at inspection angles that would provide acceptable results. For this reason, the NRC is adding a condition to require that ultrasonic examinations, which are performed to implement ASME Code Case N-824, use a phased-array search unit that produces angles including, but not limited to, 30 to 55 degrees with a maximum increment of 5 degrees.

Therefore, the NRC finds ASME Code Case N-824 acceptable with the following conditions:

> Instead of paragraph 1(c)(1)(–c)(–2), licensees shall use a phased-array search unit with a center frequency of 500 kHz with a tolerance of ± 20 percent.

Instead of paragraph 1(c)(1)(–d), the phased-array search unit must produce angles including, but not limited to, 30 to 55 degrees with a maximum increment of 5 degrees.

The NRC approved these conditions under 10 CFR 50.55a in a previous ASME Code edition final rule (NRC 2017e).

Because these conditions were previously approved and the final regulatory analysis estimated the costs at that time (NRC 2017e), the NRC does not expect industry to incur incremental implementation costs as a result of the conditions.

5.3.15 Austenitic Stainless Steel Cladding and Nickel-Base Cladding Using an Ambient Temperature Machine Gas Tungsten Arc Welding Temper Bead Technique

ASME Code Case N-829 is a new Code Case for the use of an automatic or machine gas tungsten arc welding temper bead technique to repair stainless steel cladding and nickel-base cladding without the specified preheat or postweld heat treatment described in ASME BPV Code, Section XI, IWA-4411.

The NRC finds the ASME Code Case acceptable on the condition that the provisions of ASME Code Case N-829, Paragraph 3(e)(2) or 3(e)(3), may be used only when it is impractical to use the direct interpass temperature measurement methods described in ASME Code Case N-829, Paragraph 3(e)(1) (e.g., in weldment areas that are inaccessible (i.e., internal bore welding) or in areas with extenuating radiological conditions). The NRC has determined that interpass temperature measurement is critical to obtaining acceptable corrosion resistance or notch toughness, or both, in a weld. Alternate methods, such as the calculation method described in ASME Code Case N-829, Section 3(e)(2), or the weld coupon test method described in ASME Code Case N-829, Section 3(e)(3), shall only be allowed in areas that are totally inaccessible to temperature measurement devices or in areas with extenuating radiological conditions.

The NRC estimates that the temperature measurement techniques of the ASME Code Case do not differ significantly in cost; therefore, the NRC does not expect industry to incur incremental implementation costs as a result of this condition.

5.3.16 Direct Use of the Master Fracture Toughness Curve for Pressure-Retaining Materials of Class 1 Vessels

The 2013 edition of the ASME Code introduced ASME Code Case N-830. This Code Case outlines the use of a material-specific master curve as an alternative fracture toughness curve for crack initiation, K_{IC}, in ASME BPV Code, Section XI, Division 1, Appendices A and G, for Class 1 pressure-retaining materials other than bolting.

The NRC finds ASME Code Case N-830 acceptable with one condition to prohibit the use of the provision in Paragraph (f) of the Code Case, which allows the use of an alternative to limiting the lower shelf of the 95-percent lower tolerance bound master curve toughness, $K_{JC\text{-}lower\ 95\%}$, to a value consistent with the current K_{IC} curve. ASME Code Case N-830 contains provisions for using the $K_{JC\text{-}lower\ 95\%}$ curve and the master curve-based reference temperature T_o as an alternative to the K_{IC} curve and the nil-ductility transition reference temperature (RT_{NDT}) in Appendices A and G of the ASME BPV Code, Section XI. The reference temperature T_o is determined in accordance with American Society for Testing and Materials International (ASTM) Standard E1921, "Standard Test Method for Determination of Reference Temperature, T_o, for

Ferritic Steels in the Transition Range," from direct fracture toughness testing data. The RT_{NDT} is determined in accordance with ASME BPV Code, Section III, NB-2330, "Test Requirements and Acceptance Standards," from indirect Charpy V-notch testing data, and RG 1.99, "Radiation Embrittlement of Reactor Vessel Materials," Revision 2, issued May 1988 (NRC 1988). Considering the entire test data at a wide range of $T\text{-}RT_{NDT}$ (-400 degrees Fahrenheit (F) to 100 degrees F), the NRC found that the current K_{IC} curve also represents approximately a 95-percent lower tolerance bound for the data. Therefore, using the $K_{JC\text{-}lower\ 95\%}$ curve based on the master curve is acceptable. However, because Paragraph (f) provides a significant deviation from the $K_{JC\text{-}lower\ 95\%}$ curve for $(T\text{-}T_o)$ below -115 degrees F in a nonconservative manner without justification, the NRC determined that Paragraph (f) of ASME Code Case N-830 must not be applied.

The NRC does not expect industry to incur incremental implementation costs as a result of this condition, which clarifies that the analysis will use a single curve.

5.3.17 Ultrasonic Examination in Lieu of Radiography for Welds in Ferritic Pipe

ASME Code Case N-831 is a new Code Case that provides an alternative to radiographic testing when it is required by the construction code for ASME BPV Code, Section Xl repair and replacement activities. This Code Case describes the requirements for inspecting ferritic welds for fabrication flaws using ultrasonic testing as an alternative to the current requirements to use radiography. The Code Case describes the scanning methods, recordkeeping, and performance demonstration qualification requirements for the ultrasonic procedures, equipment, and personnel.

The NRC finds ASME Code Case N-831 acceptable with the condition that it is prohibited for use in new reactor construction. History has shown that the combined use of radiographic testing for weld fabrication examinations followed by the use of ultrasonic testing for preservice inspections and ISIs ensures that workmanship is maintained (with radiographic testing) while potentially critical planar fabrication flaws are not put into service (with ultrasonic testing). Until studies are completed that demonstrate the ability of ultrasonic testing to replace radiographic testing (repair and replacement activities), the NRC will not generally allow the substitution of ultrasonic testing for radiographic testing in weld fabrication examinations. In addition, ultrasonic examinations are not equivalent to radiographic examinations because they use different physical mechanisms to detect and characterize discontinuities. These differences in physical mechanisms result in several key differences in sensitivity and discrimination capability. Because of these differences and the inherent strengths of each of the methods, the two methods are not considered to be interchangeable but instead are complementary. Therefore, the NRC determined that this ASME Code Case is not acceptable for use on new reactor construction.

This condition will require new reactors under construction to use radiography. The NRC estimates that industry will not incur incremental implementation costs for using radiation as compared to existing methods because the time required to set up and perform radiography examinations is approximately equal to the time required to use existing methods. Additionally, new reactors under construction would not incur any incremental costs to shut down or extend an outage to perform the radiography.

5.3.18 Flaw Tolerance Evaluation of Cast Austenitic Stainless Steel Piping, Section XI, Division 1

The NRC approves ASME Code Case N-838 with the following condition:

> Code Case N-838 shall not be used to evaluate flaws in CASS piping where the delta ferrite content exceeds 25 percent.

ASME Code Case N-838 contains provisions for performing a postulated flaw tolerance evaluation of ASME Class 1 and 2 CASS piping with delta ferrite exceeding 20 percent. The Code Case recommends a target flaw size for the qualification of nondestructive examination methods along with an approach that may be used to justify a larger target flaw size, if needed. The Code Case is intended for the flaw tolerance evaluation of postulated flaws in CASS base metal adjacent to welds, in conjunction with license renewal commitments. The NRC notes that the Code Case is limited in application and provides restrictions so that it will not be misused. For example, the Code Case applies to portions of Class 1 and 2 piping made of SA-351 statically or centrifugally cast Grades CF3, CF3A, CF3M, CF8, CF8A, and CF8M base metal with delta ferrite exceeding 20 percent and niobium or columbium content not greater than 0.2 weight percent. This Code Case is limited in application to the thermally aged CASS material types mentioned above with normal operating temperatures between 500 degrees F and 662 degrees F. The Code Case does not apply to the evaluation of detected flaws. Section 3 of the Code Case provides specific analytical evaluation procedures for the pipe mean radius-to-thickness (R/t) ratio greater and less than 10. Tables 1 through 4 of the Code Case provide the maximum tolerable flaw depth-to-thickness ratios for circumference and axial flaws.

However, the NRC finds that Paragraph 3(c) of the ASME Code Case is inadequate. Paragraph 3(c) specifies that, for delta ferrite exceeding 25 percent or a pipe mean R/t ratio exceeding 10, the flaw tolerance evaluation shall be performed using representative data to determine the maximum tolerable flaw depths applicable to the CASS base metal and R/t ratio instead of Tables 1 through 4 of the Code Case.

The NRC notes that the open source literature provides insufficient fracture toughness data for CASS that contains more than 25-percent delta ferrite. Therefore, the NRC needs to review flow tolerance evaluations to ensure that the flaw tolerance evaluations are adequately conservative. Therefore, the NRC has imposed a condition to prohibit the use of this ASME Code Case when delta ferrite in CASS piping exceeds 25 percent. The NRC does not expect industry to incur incremental implementation costs as a result of this condition; however, the agency does expect industry to incur operation costs as a result of relief requests, as discussed in Section 5.4.18.

5.3.19 Alternative Pressure Testing Requirements Following Repairs or Replacements for Class 1 Piping between the First and Second Inspection of Isolation Valves, Section XI, Division 1

ASME Code Case N-843 is consistent with alternatives granted by the NRC. The NRC originally voted against this Code Case because of the inclusion of return lines, which could have allowed significantly lower pressures to be used on Class 1 portions of return lines. Therefore, the NRC has imposed the following condition to ensure that the injection lines are tested at the highest pressure of the lines' intended safety function:

> [I]f the portions of the system requiring pressure testing are associated with more than one safety function, the pressure test and visual examination VT-2 shall be performed during a test conducted at the higher of the operating pressures for the respective system safety functions.

This clarifying condition represents good engineering practice and does not impose additional requirements beyond those typical for pressure testing. Therefore, the NRC does not expect industry to incur incremental implementation costs as a result of this condition.

5.3.20 In Situ Visual Testing 3 Examination of Removable Core Support Structures without Removal

ASME Code Case N-849 is a new Code Case introduced in the 2013 Edition of the ASME BPV Code. This Code Case is meant to provide guidelines for allowing the VT-3 inspection requirements of Table IWB-2500-1 for preservice or inservice inspections of the core support structures to be performed without the removal of the core support structure. The NRC finds the Code Case acceptable with two conditions.

The first condition limits the use of ASME Code Case N-849 to plants that are designed with accessible core support structures to allow for in situ inspection. ASME Code Case N-849 allows the performance of VT-3 preservice or inservice visual examinations of removable core support structures in situ using a remote examination system. The Code Case includes a provision that all surfaces accessible for examination when the structure is removed shall be accessible when the structure is in situ except for load bearing and contact surfaces that would be inspected only when the core barrel is removed. Designs for new reactors, such as small modular reactors, may include accessibility of the annulus between the core barrel and the reactor vessel. Unlike newly designed reactors, currently operating plants were not designed to allow in situ VT-3 examinations. There are no industry survey results of the current fleet to provide an evaluation of operating plant inspection findings. Therefore, the applicability of the Code Case to the designs of currently operating plants has not been satisfactorily addressed. Furthermore, this condition is a clarifying condition because it reflects the ASME committee's intent.

The second condition on ASME Code Case N-849 requires that, before initial plant startup, the VT-3 preservice examination must be performed with the core support structure removed, as required by ASME BPV Code, Section XI, IWB-2500-1. The NRC has concerns that a preservice examination would not be performed on the load bearing and contact surfaces even though the surfaces would be accessible before installation of the core support structure. No evidence exists that the in situ examination will achieve the same coverage as the examination with the core support structure removed. This clarifying condition reflects existing ASME Code requirements.

The NRC does not expect industry to incur incremental implementation costs as a result of these clarifying conditions.

5.3.21 Performance-Based Requirements for Extending the Snubber Inservice Visual Examination Interval at Light-Water Reactor Power Plants

The NRC has added the following condition on ASME Code Case OMN-13, which relaxes the applicability of the Code Case in response to public comments from the final rule:

> This Code Case is applicable to the editions and addenda of the OM Code listed in §50.55a(a)(1)(iv). Although Code Case OMN-13 has an applicability statement in its inquiry and reply, the guidance in Code Case OMN-13 is acceptable for application at nuclear power plants with a Code of [R]ecord of any

edition or addenda of the OM Code incorporated by reference in §50.55a as listed in paragraph (a)(1)(iv).

The NRC expects this relaxation to avert ASME Code Case relief requests, as discussed in Section 5.4.

5.3.22 Inservice Test Frequency

The NRC has modified the following condition on ASME Code Case OMN-20 to relax the applicability of the Code Case in response to public comments from the final rule:

> This Code Case is applicable to the editions and addenda of the OM Code listed in §50.55a(a)(1)(iv). Although Code Case OMN-20 has an applicability statement in its inquiry and reply, the guidance in Code Case OMN-20 is acceptable for application at nuclear power plants with a Code of [R]ecord of any edition or addenda of the OM Code incorporated by reference in §50.55a as listed in paragraph (a)(1)(iv).

The NRC expects this relaxation to avert Code Case relief requests, as discussed in Sections 5.4 and 5.7.

5.4 Industry Operation

This attribute accounts for the projected net economic effect of routine and recurring activities required by the alternative for all affected licensees. Under Alternative 2, a nuclear power plant licensee would not need to submit an alternative request under the new 10 CFR 50.55a(z) or a relief request under 10 CFR 50.55a(f) or (g) to receive permission to use a later edition or addendum of the ASME Codes (as an alternative to the ASME Code provisions) that provides a net benefit (i.e., averted cost) to the licensee.

The use of later editions and addenda of the ASME BPV and OM Codes would benefit NRC nuclear power plant licensees and applicants for several reasons. Later editions and addenda may introduce the use of advanced techniques, procedures, and measures. Alternative 2 has the advantage that, on implementation of the final rule, licensees and applicants would be able to voluntarily ask to use a more recent edition or addenda of the ASME BPV and OM Codes under 10 CFR 50.55a(f)(4)(iv) and (g)(4)(iv).[6]

Submission of an alternative request to the NRC is not a trivial matter. Once ASME issues a Code edition, the licensee or applicant must determine the applicability of the edition to its facility and the benefit derived from its use. If the licensee or applicant determines that use of the ASME Code would be beneficial, but the NRC has not approved the ASME Code edition, the licensee or applicant must prepare a request for the use of the ASME Code alternative, and appropriate levels of licensee or applicant management must review and approve the request before submitting it to the NRC. A review of ASME Code alternative requests submitted to the NRC over the last 5 years indicated that these submittals ranged from a few pages to several hundred pages with an average of approximately 32 pages of average technical complexity.

6 The regulations in 10 CFR 50.55a(f)(4) and (g)(4) establish the effective ASME Code edition and addenda that licensees must use in performing IST of pumps and valves and ISI of components (including supports), respectively. Regulatory Issue Summary 2004-12, "Clarification on Use of Later Editions and Addenda to the ASME OM Code and Section XI," dated July 28, 2004 (NRC 2004), clarifies the requirements for IST and ISI programs using later editions and addenda of the ASME OM Code.

Therefore, the NRC estimates that an ASME Code alternative submittal will require an average of 280 hours of effort to develop the technical justification and an additional 100 hours to research, review, approve, process, and submit the document to the NRC for the use of alternatives under 10 CFR 50.55a(z) (for a total of 380 hours per submittal). The NRC assumes that licensees or applicants would decide whether to request the use of an alternative by weighing the cost against the benefit to be derived. In some cases, licensees may decide to forfeit the benefits of using newer ASME Code editions, whether in terms of radiological considerations or burden reduction.

A review of past submittals of ASME Code alternative requests has determined that plant owners submit ASME Code alternative requests that cover multiple units and multiple plant sites. Based on annual ASME Code Case relief request submissions before and after ASME final rules are published, the NRC estimated that, if Alternative 2 is not adopted, operating sites would submit 24 relief requests annually for the Code Cases in the final rule. Under Alternative 2, a nuclear power plant licensee would no longer need to submit the aforementioned ASME Code alternative requests under the new 10 CFR 50.55a(z), which would provide a net benefit (i.e., averted cost) to the licensee. As shown in Table 6, the implementation of Alternative 2 would avert 24 additional ASME Code alternative submittals (and their associated preparation) each year under the new 10 CFR 50.55a(z). The NRC expects the industry operation averted costs for operating nuclear power plants to range from $4.93 million (7-percent NPV) to $5.60 million (3-percent NPV), which will yield a net positive savings for Alternative 2.

Table 6 Industry Operation—Averted Costs for Code Alternative Requests

Year	Activity	Relief Requests per Year	Labor Hours	Weighted Hourly rate	Cost		
					Undiscounted	7% NPV	3% NPV
2020	Code Case relief request preparation and submission	24	380	$115	$1,034,000	$966,000	$1,004,000
2021	Code Case relief request preparation and submission	24	380	$115	$1,034,000	$903,000	$975,000
2022	Code Case relief request preparation and submission	24	380	$115	$1,034,000	$844,000	$946,000
2023	Code Case relief request preparation and submission	24	380	$115	$1,034,000	$789,000	$919,000
2024	Code Case relief request preparation and submission	24	380	$115	$1,034,000	$737,000	$892,000
2025	Code Case relief request preparation and submission	24	380	$115	$1,034,000	$689,000	$866,000
Total:					**$6,204,000**	**$4,928,000**	**$5,602,000**

5.4.1 Additional Materials for Subsection NF, Class 1, 2, 3, and Metal Containment Supports Fabricated by Welding

The NRC does not expect industry to incur incremental operation costs associated with the conditions of this ASME Code Case, which are either identical or substantively identical to existing conditions or administrative in nature.

5.4.2 Underwater Welding, Section XI, Division 1

The NRC does not expect industry to incur incremental operation costs associated with the conditions of this ASME Code Case, which clarify the existing condition.

5.4.3 Evaluation of Pipe Wall Thinning, Section XI

The NRC does not expect industry to incur incremental operation costs associated with the conditions of this ASME Code Case, which are either identical or substantively identical to existing conditions.

5.4.4 Similar and Dissimilar Metal Welding Using an Ambient Temperature Machine Gas Tungsten Arc Welding Temper Bead Technique for Boiling-Water Reactor Control Rod Drive Housing/Stub Tube Repairs

The NRC does not expect industry to incur incremental operation costs associated with the condition of this ASME Code Case, which is identical to the existing condition.

5.4.5 Similar and Dissimilar Metal Welding Using an Ambient Temperature Machine Gas Tungsten Arc Welding Temper Bead Technique

The NRC does not expect industry to incur incremental operation costs associated with the condition of this ASME Code Case, which is identical to the existing condition.

5.4.6 Alternative Requirements for Inner Radius Examinations of Class 1 Reactor Vessel Nozzles, Section XI

This condition prevents the ASME Code Case from allowing new pressurized-water reactors (PWRs) and boiling-water reactors (BWRs) to use VT instead of ultrasonic testing on their first reactor vessel nozzle ISI, which would occur during the lifetime of this ASME Code Case. It takes approximately 16 hours more per nozzle to perform ultrasonic testing than it does to perform VT, and the NRC estimates that this condition would affect two PWRs, but no BWRs. PWRs have approximately 8 nozzles, whereas BWRs have approximately 25 nozzles, and the inspection must cover at least 25 percent, but not more than 50 percent, of the nozzles. As shown in Table 7, this results in costs ranging from ($7,600) at a 7-percent NPV to ($8,900) at a 3-percent NPV. Due to the similar staytimes between VT and UT, and expected radiation exposure rates at new reactors, incremental dose differences were not calculated for this condition.

Table 7 ASME Code Case N-648-2 Reactor Nozzle Ultrasonic Test Inspection

Year	Activity	Number of Affected Entities	Hours per Nozzle	Ratio of Nozzles Inspected	Number of Nozzles	Weighted Hourly rate	Cost		
							Undiscounted	7% NPV	3% NPV
2023	Additional cost of UT instead of VT for Reactor Nozzles at New PWRs	2	16	0.4	8	$115	($10,000)	($7,600)	($8,900)
2023	Additional cost of UT instead of VT for Reactor Nozzles at New BWRs	0	16	0.4	25	$115	$0	$0	$0
						Total:	**($10,000)**	**($7,600)**	**($8,900)**

5.4.7 Qualification Requirements for Dissimilar Metal Piping Welds

The NRC expects that industry will operate in accordance with this condition in most cases based on over 15 years of operating experience in which this condition would not have altered industry actions. For this cost estimate, the NRC has assumed that the condition would affect one licensee over the lifetime of this ASME Code Case. This condition would result in a verbal review of the licensee's maintenance issue, which would take industry approximately 190 hours to perform. As shown in Table 8, the estimated costs range from ($18,000) at a 7-percent NPV to ($20,000) at a 3-percent NPV.

Table 8 ASME Code Case N-695-1 Piping Examination Relief Request

Year	Activity	Number of Affected	Labor Hours	Weighted Hourly rate	Cost		
					Undiscounted	7% NPV	3% NPV
2022	Verbal relief request	1	190	$115	($22,000)	($18,000)	($20,000)
				Total:	**($22,000)**	**($18,000)**	**($20,000)**

5.4.8 Qualification Requirements for Mandatory Appendix VIII, Piping Examination Conducted from the Inside Surface

For this cost estimate, the NRC has assumed that the condition would affect one licensee over the lifetime of this ASME Code Case. This condition would result in a verbal review of the licensee's maintenance issue, which would take industry approximately 190 hours to perform. As shown in Table 9, the estimated costs range from ($18,000) at a 7-percent NPV to ($20,000) at a 3-percent NPV.

Table 9 ASME Code Case N-696-1 Piping Examination Relief Request

Year	Activity	Number of Affected	Labor Hours	Weighted Hourly rate	Cost		
					Undiscounted	7% NPV	3% NPV
2022	Verbal relief request	1	190	$115	($22,000)	($18,000)	($20,000)
				Total:	**($22,000)**	**($18,000)**	**($20,000)**

5.4.9 Alternative Requirements for Boiling-Water Reactor Nozzle Inner Radius and Nozzle-to-Shell Welds, Section XI, Division 1

The NRC does not expect industry to incur incremental operation costs associated with the conditions of this ASME Code Case, which are consistent with the approach that licensees used before the Code Case existed.

5.4.10 Evaluation Criteria for Temporary Acceptance of Degradation in Moderate-Energy Class 2 or 3 Vessels and Tanks

The NRC does not expect industry to incur incremental operation costs associated with the conditions of this ASME Code Case, which are consistent with the approach that licensees used before the Code Case existed.

5.4.11 Alternative Examination Coverage Requirements for Examination Category B-F, B-J, C-F-1, C-F-2, and R-A Piping Welds

The NRC does not expect industry to incur incremental operation costs associated with this condition, which clarifies the language used in the ASME Code Case.

5.4.12 Optimized Structural Dissimilar Metal Weld Overlay for Mitigation of Pressurized-Water Reactor Class 1 Items

The NRC does not expect industry to incur incremental operation costs associated with the conditions of this ASME Code Case, which are either identical to existing conditions or which clarify the language used in the Code Case.

5.4.13 Nickel Alloy Reactor Coolant Inlay and Onlay for Mitigation of Pressurized-Water Reactor Full-Penetration Circumferential Nickel Alloy Dissimilar Metal Welds in Class 1 Items

The NRC expects licensees to incur incremental costs when the first condition on ASME Code Case N-766-1 prevents the use of the Code Case on a weld. Licensees would submit relief requests in this circumstance, which the NRC expects to occur about once per year. As shown in Table 10, these relief requests require approximately 380 hours to produce and result in costs ranging from ($209,000) at a 7-percent NPV to ($238,000) at a 3-percent NPV.

Table 10 ASME Code Case N-766-1 Inlay and Onlay Repair Relief Requests

Year	Activity	Number of Affected Entities	Labor Hours	Weighted Hourly rate	Cost		
					Undiscounted	7% NPV	3% NPV
2020	Relief request when condition prevents use of N-766-1	1	380	$115	($44,000)	($41,000)	($43,000)
2021	Relief request when condition prevents use of N-766-1	1	380	$115	($44,000)	($38,000)	($41,000)
2022	Relief request when condition prevents use of N-766-1	1	380	$115	($44,000)	($36,000)	($40,000)
2023	Relief request when condition prevents use of N-766-1	1	380	$115	($44,000)	($34,000)	($39,000)
2024	Relief request when condition prevents use of N-766-1	1	380	$115	($44,000)	($31,000)	($38,000)
2025	Relief request when condition prevents use of N-766-1	1	380	$115	($44,000)	($29,000)	($37,000)
				Total:	**($264,000)**	**($209,000)**	**($238,000)**

5.4.14 Ultrasonic Examination of Cast Austenitic Piping Welds from the Outside Surface, Section XI, Division 1

The NRC does not expect industry to incur incremental operation costs associated with the conditions of this ASME Code Case, which have already been incorporated by reference into 10 CFR 50.55a. The latest final regulatory analysis for the ASME Code editions rulemaking already estimated the costs (NRC 2017e).

5.4.15 Austenitic Stainless Steel Cladding and Nickel-Base Cladding Using an Ambient Temperature Machine Gas Tungsten Arc Welding Temper Bead Technique

The NRC does not expect industry to incur incremental operation costs associated with this condition because the referenced paragraphs do not indicate an appreciable cost difference between the temperature measurement techniques.

5.4.16 Direct Use of the Master Fracture Toughness Curve for Pressure-Retaining Materials of Class 1 Vessels

The NRC does not expect industry to incur incremental operation costs associated with this clarifying condition.

5.4.17 Ultrasonic Examination in Lieu of Radiography for Welds in Ferritic Pipe

The NRC does not expect industry to incur incremental operation costs associated with this condition because new reactors can use radiography instead of this ASME Code Case with no cost impact.

5.4.18 Flaw Tolerance Evaluation of Cast Austenitic Stainless Steel Piping, Section XI, Division 1

The NRC expects licensees to incur incremental costs when the condition on ASME Code Case N-838 prevents the use of the Code Case to evaluate a CASS flaw. Licensees would submit relief requests under this circumstance, which the NRC expects to occur about once per year. As shown in Table 11, these relief requests are estimated to take about 380 hours to produce, resulting in costs ranging from ($209,000) at a 7-percent NPV to ($238,000) at a 3-percent NPV.

Table 11 ASME Code Case N-838 CASS Flaw Tolerance Evaluation Relief Requests

Year	Activity	Number of Affected Entities	Labor Hours	Weighted Hourly rate	Cost		
					Undiscounted	7% NPV	3% NPV
2020	Relief request when condition prevents use of N-838	1	380	$115	($44,000)	($41,000)	($43,000)
2021	Relief request when condition prevents use of N-838	1	380	$115	($44,000)	($38,000)	($41,000)
2022	Relief request when condition prevents use of N-838	1	380	$115	($44,000)	($36,000)	($40,000)
2023	Relief request when condition prevents use of N-838	1	380	$115	($44,000)	($34,000)	($39,000)
2024	Relief request when condition prevents use of N-838	1	380	$115	($44,000)	($31,000)	($38,000)
2025	Relief request when condition prevents use of N-838	1	380	$115	($44,000)	($29,000)	($37,000)
				Total:	**($264,000)**	**($209,000)**	**($238,000)**

5.4.19 Alternative Pressure Testing Requirements Following Repairs or Replacements for Class 1 Piping between the First and Second Inspection of Isolation Valves, Section XI, Division 1

The NRC does not expect industry to incur incremental operation costs associated with this clarifying condition.

5.4.20 In Situ Visual Testing 3 Examination of Removable Core Support Structures without Removal

The NRC does not expect industry to incur incremental operation costs associated with these clarifying conditions.

5.4.21 Performance-Based Requirements for Extending the Snubber Inservice Visual Examination Interval at Light-Water Reactor Power Plants

The NRC expects that this relaxation will avert ASME Code Case relief requests from industry, as shown in Table 6.

5.4.22 Inservice Test Frequency

The NRC expects that this relaxation will avert ASME Code Case relief requests from industry, as shown in Table 6.

5.5 Total Industry Costs

Table 12 shows the total industry costs, separated by implementation and operation costs, for the requirements under Alternative 2. These total industry costs represent averted costs of $4.43 million at a 7-percent NPV and $5.04 million at a 3-percent NPV.

Table 12 Total Industry Costs

Attribute	Total Industry Costs[a]		
	Undiscounted	**7% NPV**	**3% NPV**
Implementation Costs:	$0	$0	$0
Operation Costs:	$5,620,000	$4,470,000	$5,080,000
Total Industry Cost:	**$5,620,000**	**$4,470,000**	**$5,080,000**

[a] Total costs are rounded to three significant figures.

5.6 NRC Implementation

Because the final rule stage concludes the rulemaking process, the NRC will not incur further implementation costs for the rulemaking process.

5.6.1 Additional Materials for Subsection NF, Class 1, 2, 3, and Metal Containment Supports Fabricated by Welding

The NRC does not expect the agency to incur incremental implementation costs associated with the conditions of this ASME Code Case, which are either identical or substantively identical to existing conditions or are administrative in nature.

5.6.2 Underwater Welding, Section XI, Division 1

The NRC does not expect the agency to incur incremental implementation costs associated with the conditions of this ASME Code Case, which are clarifications of the existing condition.

5.6.3 Evaluation of Pipe Wall Thinning, Section XI

The NRC does not expect the agency to incur incremental implementation costs associated with the conditions of this ASME Code Case, which are either identical or substantively identical to existing conditions.

5.6.4 Similar and Dissimilar Metal Welding Using an Ambient Temperature Machine Gas Tungsten Arc Welding Temper Bead Technique for Boiling-Water Reactor Control Rod Drive Housing/Stub Tube Repairs

The NRC does not expect the agency to incur incremental implementation costs associated with the condition of this ASME Code Case, which is identical to the existing condition.

5.6.5 Similar and Dissimilar Metal Welding Using an Ambient Temperature Machine Gas Tungsten Arc Welding Temper Bead Technique

The NRC does not expect the agency to incur incremental NRC implementation costs associated with the condition of this ASME Code Case, which is identical to the existing condition.

5.6.6 Alternative Requirements for Inner Radius Examinations of Class 1 Reactor Vessel Nozzles, Section XI

The NRC does not expect the agency to incur incremental implementation costs for ISIs associated with the condition of this ASME Code Case.

5.6.7 Qualification Requirements for Dissimilar Metal Piping Welds

The NRC does not expect the agency to incur incremental implementation costs associated with the condition of this ASME Code Case because the resulting relief request is an operation cost.

5.6.8 Qualification Requirements for Mandatory Appendix VIII Piping Examination Conducted from the Inside Surface

The NRC does not expect the agency to incur incremental implementation costs associated with the condition of this ASME Code Case because the resulting relief request is an operation cost.

5.6.9 Alternative Requirements for Boiling-Water Reactor Nozzle Inner Radius and Nozzle-to-Shell Welds, ASME BPV Code, Section XI, Division 1

The NRC does not expect the agency to incur incremental implementation costs associated with the conditions of this ASME Code Case, which are consistent with the approach that licensees used before the Code Case existed.

5.6.10 Evaluation Criteria for Temporary Acceptance of Degradation in Moderate-Energy Class 2 or 3 Vessels and Tanks

The NRC does not expect the agency to incur incremental implementation costs from the tank repairs associated with the condition of this ASME Code Case.

5.6.11 Alternative Examination Coverage Requirements for Examination Category B-F, B-J, C-F-1, C-F-2, and R-A Piping Welds

The NRC does not expect the agency to incur incremental implementation costs associated with this condition, which clarifies the language used in the ASME Code Case.

5.6.12 Optimized Structural Dissimilar Metal Weld Overlay for Mitigation of Pressurized-Water Reactor Class 1 Items

The NRC does not expect the agency to incur incremental implementation costs associated with the conditions of this ASME Code Case, which are identical to existing conditions or clarify the language used in the Code Case.

5.6.13 Nickel Alloy Reactor Coolant Inlay and Onlay for Mitigation of Pressurized-Water Reactor Full-Penetration Circumferential Nickel Alloy Dissimilar Metal Welds in Class 1 Items

The NRC does not expect the agency to incur incremental implementation costs associated with the conditions of this ASME Code Case because the resultant relief requests are operation costs.

5.6.14 Ultrasonic Examination of Cast Austenitic Piping Welds from the Outside Surface, Section XI, Division 1

The NRC does not expect the agency to incur incremental implementation costs associated with the conditions of this ASME Code Case, which have already been incorporated by reference into 10 CFR 50.55a. The final regulatory analysis for the latest ASME Code editions rulemaking already estimated the costs (NRC 2017e).

5.6.15 Austenitic Stainless Steel Cladding and Nickel-Base Cladding Using an Ambient Temperature Machine Gas Tungsten Arc Welding Temper Bead Technique

The NRC does not expect the agency to incur incremental implementation costs associated with this condition.

5.6.16 Direct Use of the Master Fracture Toughness Curve for Pressure-Retaining Materials of Class 1 Vessels

The NRC does not expect the agency to incur incremental implementation costs associated with this clarifying condition.

5.6.17 Ultrasonic Examination in Lieu of Radiography for Welds in Ferritic Pipe

The NRC does not expect the agency to incur incremental implementation costs associated with the condition of this ASME Code Case, which causes new reactors to use radiography instead of this Code Case with no cost impact.

5.6.18 Flaw Tolerance Evaluation of Cast Austenitic Stainless Steel Piping, Section XI, Division 1

The NRC does not expect the agency to incur incremental implementation costs associated with the conditions of this ASME Code Case because the resultant relief requests are operation costs.

5.6.19 Alternative Pressure Testing Requirements Following Repairs or Replacements for Class 1 Piping between the First and Second Inspection of Isolation Valves, Section XI, Division 1

The NRC does not expect the agency to incur incremental NRC implementation costs associated with this clarifying condition.

5.6.20 In Situ Visual Testing 3 Examination of Removable Core Support Structures without Removal

The NRC does not expect the agency to incur incremental implementation costs associated with these clarifying conditions.

5.6.21 Performance-Based Requirements for Extending the Snubber Inservice Visual Examination Interval at Light-Water Reactor Power Plants

The NRC expects that this relaxation will avert ASME Code Case relief requests, as discussed in Section 5.4.

5.6.22 Inservice Test Frequency

The NRC expects that this relaxation will avert ASME Code Case relief requests, as discussed in Section 5.4.

5.7 NRC Operation

When the NRC receives an alternative request, the NRC requires additional time to evaluate the acceptability of the alternative request submittal relative to the criteria currently approved by the agency. Alternative 2 would not require the additional seven alternative request submittals per year. By incorporating by reference the ASME Code editions in the *Code of Federal Regulations*, a nuclear power plant licensee could use a more current ASME Code edition or addenda without submitting an alternative request for NRC review.

Section 5.4 states that the NRC expects Alternative 2, the rule alternative, to avert approximately 24 relief requests per year. As shown in Table 13, the NRC estimates that each submittal would require 143 hours of staff time to perform the technical review (including resolving technical issues), document the evaluation, and respond to the licensee's request. The absence of these submittals would result in an NRC-averted cost that ranges from $2.08 million based on a 7-percent NPV to $2.36 million based on a 3-percent NPV. Therefore, this alternative would provide a net benefit (i.e., averted cost).

Table 13 NRC Operation Costs—Reviews of Averted ASME Code Alternative Requests (Operating and New Reactors)

Year	Activity	Number of Actions	Hours	Weighted Hourly rate	Cost		
					Undiscounted	7% NPV	3% NPV
2020	Review Code Case relief request submittal and issue safety evaluation	24	143	$129	$436,000	$407,000	$423,000
2021	Review Code Case relief request submittal and issue safety evaluation	24	143	$129	$436,000	$381,000	$411,000
2022	Review Code Case relief request submittal and issue safety evaluation	24	143	$129	$436,000	$356,000	$399,000
2023	Review Code Case relief request submittal and issue safety evaluation	24	143	$129	$436,000	$333,000	$387,000
2024	Review Code Case relief request submittal and issue safety evaluation	24	143	$129	$436,000	$311,000	$376,000
2025	Review Code Case relief request submittal and issue safety evaluation	24	143	$129	$436,000	$291,000	$365,000
				Total:	**$2,616,000**	**$2,079,000**	**$2,361,000**

The NRC considers its review costs for any ASME Code alternative request submitted to the agency before the effective date of the final rule to be sunk costs; therefore, this regulatory analysis does not further address them.

5.7.1 Additional Materials for Subsection NF, Class 1, 2, 3, and Metal Containment Supports Fabricated by Welding

The NRC does not expect the agency to incur incremental operation costs associated with the conditions of this ASME Code Case, which are either identical or substantively identical to existing conditions or are administrative in nature.

5.7.2 Underwater Welding, Section XI, Division 1

The NRC does not expect the agency to incur incremental operation costs associated with the conditions of this ASME Code Case, which clarify the existing conditions.

5.7.3 Evaluation of Pipe Wall Thinning, Section XI

The NRC does not expect the agency to incur incremental operation costs associated with the conditions of this ASME Code Case, which are either identical or substantively identical to the existing conditions.

5.7.4 Similar and Dissimilar Metal Welding Using an Ambient Temperature Machine Gas Tungsten Arc Welding Temper Bead Technique for Boiling-Water Reactor Control Rod Drive Housing/Stub Tube Repairs

The NRC does not expect the agency to incur incremental operation costs associated with the condition of this ASME Code Case, which is identical to the existing condition.

5.7.5 Similar and Dissimilar Metal Welding Using an Ambient Temperature Machine Gas Tungsten Arc Welding Temper Bead Technique

The NRC does not expect the agency to incur incremental operation costs associated with the condition of this ASME Code Case, which is identical to the existing condition.

5.7.6 Alternative Requirements for Inner Radius Examinations of Class 1 Reactor Vessel Nozzles, Section XI

The NRC does not expect the agency to incur incremental NRC operation costs from the resultant ISIs associated with the condition of this ASME Code Case.

5.7.7 Qualification Requirements for Dissimilar Metal Piping Welds

The NRC expects the agency to incur incremental operation costs associated with the condition of this ASME Code Case because of the resulting relief requests. The NRC would need to approve a relief request submitted by a licensee; this request results in estimated costs ranging from ($20,000) at a 7-percent NPV to ($23,000) at a 3-percent NPV, as shown in Table 14.

Table 14 ASME Code Case N-695-1 Piping Examination Relief Request Review

Year	Activity	Number of Affected	Labor Hours	Weighted Hourly rate	Cost		
					Undiscounted	7% NPV	3% NPV
2022	Verbal relief request	1	190	$129	($25,000)	($20,000)	($23,000)
				Total:	**($25,000)**	**($20,000)**	**($23,000)**

5.7.8 Qualification Requirements for Mandatory Appendix VIII Piping Examination Conducted from the Inside Surface

The NRC expects the agency to incur incremental operation costs associated with the condition of this ASME Code Case because of the resulting relief requests. The NRC would need to approve a relief request submitted by a licensee; this request results in estimated costs ranging from ($20,000) at a 7-percent NPV to ($23,000) at a 3-percent NPV, as shown in Table 15.

Table 15 ASME Code Case N-696-1 Piping Examination Relief Request Review

Year	Activity	Number of Affected	Labor Hours	Weighted Hourly rate	Cost		
					Undiscounted	7% NPV	3% NPV
2022	Verbal relief request	1	190	$129	($25,000)	($20,000)	($23,000)
				Total:	**($25,000)**	**($20,000)**	**($23,000)**

5.7.9 Alternative Requirements for Boiling-Water Reactor Nozzle Inner Radius and Nozzle-to-Shell Welds, Section XI, Division 1

The NRC does not expect the agency to incur incremental operation costs associated with the conditions of this ASME Code Case, which are consistent with the approach that licensees used before the Code Case existed.

5.7.10 Evaluation Criteria for Temporary Acceptance of Degradation in Moderate-Energy Class 2 or 3 Vessels and Tanks

The NRC does not expect the agency to incur incremental operation costs from the tank repairs associated with the condition of this ASME Code Case.

5.7.11 Alternative Examination Coverage Requirements for Examination Category B-F, B-J, C-F-1, C-F-2, and R-A Piping Welds

The NRC does not expect the agency to incur incremental operation costs associated with this condition, which clarifies the language used in the ASME Code Case.

5.7.12 Optimized Structural Dissimilar Metal Weld Overlay for Mitigation of Pressurized-Water Reactor Class 1 Items

The NRC does not expect the agency to incur incremental operation costs associated with the conditions of this ASME Code Case, which are either identical to existing conditions or clarify the language used in the Code Case.

5.7.13 Nickel Alloy Reactor Coolant Inlay and Onlay for Mitigation of Pressurized-Water Reactor Full-Penetration Circumferential Nickel Alloy Dissimilar Metal Welds in Class 1 Items

The NRC expects to incur costs associated with the review of ASME Code Case N-766-1 relief requests submitted by licensees. As shown in Table 16, the NRC estimates receiving one review request per year. This request requires approximately 143 hours per review and results in costs ranging from ($87,000) at a 7-percent NPV to ($97,000) at a 3-percent NPV.

Table 16 ASME Code Case N-766-1 Relief Request Reviews

Year	Activity	Number of Actions	Hours	Weighted Hourly rate	Cost		
					Undiscounted	7% NPV	3% NPV
2020	Review relief request when condition prevents use of N-766-1	1	143	$129	($18,000)	($17,000)	($17,000)
2021	Review relief request when condition prevents use of N-766-1	1	143	$129	($18,000)	($16,000)	($17,000)
2022	Review relief request when condition prevents use of N-766-1	1	143	$129	($18,000)	($15,000)	($16,000)
2023	Review relief request when condition prevents use of N-766-1	1	143	$129	($18,000)	($14,000)	($16,000)
2024	Review relief request when condition prevents use of N-766-1	1	143	$129	($18,000)	($13,000)	($16,000)
2025	Review relief request when condition prevents use of N-766-1	1	143	$129	($18,000)	($12,000)	($15,000)
				Total:	**($108,000)**	**($87,000)**	**($97,000)**

5.7.14 Ultrasonic Examination of Cast Austenitic Piping Welds from the Outside Surface, Section XI, Division 1

The NRC does not expect the agency to incur incremental operation costs associated with the conditions of this ASME Code Case, which have already been incorporated by reference into 10 CFR 50.55a. The final regulatory analysis for the latest ASME Code editions rulemaking already estimated the costs (NRC 2017e).

5.7.15 Austenitic Stainless Steel Cladding and Nickel-Base Cladding Using an Ambient Temperature Machine Gas Tungsten Arc Welding Temper Bead Technique

The NRC does not expect the agency to incur incremental operation costs associated with this condition.

5.7.16 Direct Use of the Master Fracture Toughness Curve for Pressure-Retaining Materials of Class 1 Vessels

The NRC does not expect the agency to incur incremental operation costs associated with this clarifying condition.

5.7.17 Ultrasonic Examination in Lieu of Radiography for Welds in Ferritic Pipe

The NRC does not expect the agency to incur incremental operation costs associated with this condition, which causes new reactors to use radiography instead of this ASME Code Case with no cost impact.

5.7.18 Flaw Tolerance Evaluation of Cast Austenitic Stainless Steel Piping, Section XI, Division 1

The NRC expects to incur costs associated with the review of ASME Code Case N-838 relief requests submitted by licensees. As shown in Table 17, the NRC estimates receiving one review request per year. This request requires approximately 143 hours per review and results in costs ranging from ($87,000) at a 7-percent NPV to ($97,000) at a 3-percent NPV.

Table 17 ASME Code Case N-838 Relief Request Reviews

Year	Activity	Number of Actions	Hours	Weighted Hourly rate	Cost		
					Undiscounted	7% NPV	3% NPV
2020	Review relief request when condition prevents use of N-838	1	143	$129	($18,000)	($17,000)	($17,000)
2021	Review relief request when condition prevents use of N-838	1	143	$129	($18,000)	($16,000)	($17,000)
2022	Review relief request when condition prevents use of N-838	1	143	$129	($18,000)	($15,000)	($16,000)
2023	Review relief request when condition prevents use of N-838	1	143	$129	($18,000)	($14,000)	($16,000)
2024	Review relief request when condition prevents use of N-838	1	143	$129	($18,000)	($13,000)	($16,000)
2025	Review relief request when condition prevents use of N-838	1	143	$129	($18,000)	($12,000)	($15,000)
				Total:	**($108,000)**	**($87,000)**	**($97,000)**

5.7.19 Alternative Pressure Testing Requirements Following Repairs or Replacements for Class 1 Piping between the First and Second Inspection of Isolation Valves, Section XI, Division 1

The NRC does not expect the agency to incur incremental operation costs associated with this clarifying condition.

5.7.20 In Situ Visual Testing 3 Examination of Removable Core Support Structures without Removal

The NRC does not expect the agency to incur incremental operation costs associated with these clarifying conditions.

5.7.21 Performance-Based Requirements for Extending the Snubber Inservice Visual Examination Interval at Light-Water Reactor Power Plants

The NRC expects this relaxation to avert ASME Code Case relief requests from industry, as shown in Table 13.

5.7.22 Inservice Test Frequency

The NRC expects this relaxation to avert ASME Code Case relief requests from industry, as shown in Table 13.

5.8 Total NRC Costs

Table 18 shows the total NRC costs broken down between implementation and operation costs for Alternative 2. These total NRC costs represent averted costs (savings) and are estimated to range from $1.87 million at a 7-percent discount rate to $2.12 million at a 3-percent discount rate.

Table 18 Total NRC Costs

Attribute	NRC Costs		
	Undiscounted	**7% NPV**	**3% NPV**
Total NRC Implementation Cost:	$0	$0	$0
Total NRC Operation Cost:	$2,350,000	$1,870,000	$2,120,000
Total NRC Cost:	$2,350,000	$1,870,000	$2,120,000

5.9 Total Costs

Table 19 shows the total averted costs (benefits/savings) broken down between implementation and operation for the industry and the NRC under Alternative 2. These total averted costs are estimated to range from $6.34 million at a 7-percent discount rate to $7.20 million at a 3-percent discount rate.

Table 19 Total Costs

Attribute	Total Averted Costs (Costs)		
	Undiscounted	**7% NPV**	**3% NPV**
Industry Implementation	$0	$0	$0
Industry Operation	$5,620,000	$4,470,000	$5,080,000
Total Industry Cost	*$5,620,000*	*$4,470,000*	*$5,080,000*
NRC Implementation	$0	$0	$0
NRC Operation	$2,350,000	$1,870,000	$2,120,000
Total NRC Cost	*$2,350,000*	*$1,870,000*	*$2,120,000*
Net	***$7,970,000***	***$6,340,000***	***$7,200,000***

5.10 Improvements in Knowledge

Compared to the regulatory baseline (Alternative 1), Alternative 2 would improve the knowledge of industry and the NRC by allowing them to gain experience with new technology before its incorporation into the ASME Code and by permitting licensees to use advances in ISI and IST.

Developing greater knowledge and common understanding of the ASME Code and eliminating unnecessary work better enables industry and the NRC to produce desired on-the-job results; such results lead to pride in performance and increased job satisfaction.

5.11 Regulatory Efficiency

Compared to the regulatory baseline, Alternative 2 would increase regulatory efficiency because licensees that want to use NRC-approved ASME Code Cases would not need to submit requests for alternatives to the NRC's regulations. This would give licensees flexibility and decrease their uncertainty when modifying or preparing to perform ISI or IST. Further, Alternative 2 is consistent with the provisions of the NTTAA, which encourages Federal regulatory agencies to consider adopting voluntary consensus standards as an alternative to *de novo* agency development of standards affecting an industry. Alternative 2 is also consistent with the NRC's policy of evaluating the latest versions of consensus standards in terms of their suitability for endorsement by regulations and RGs. Finally, Alternative 2 is consistent with the NRC's goal of harmonizing with international standards to improve regulatory efficiency for both the NRC and international standards groups.

5.12 Other Considerations

5.12.1 National Technology Transfer and Advancement Act of 1995

Alternative 2 is consistent with the provisions of the NTTAA and its implementing guidance in OMB Circular A-119, "Federal Participation in the Development and Use of Voluntary Consensus Standards and in Conformity Assessment Activities," dated January 27, 2016 (OMB 2016), which encourage Federal regulatory agencies to consider adopting voluntary consensus standards as an alternative to *de novo* agency development of standards affecting an industry.

5.12.2 Continued NRC Practice of Incorporation by Reference of ASME Code Editions and Addenda into the Code of Federal Regulations

Alternative 2 would continue the NRC's practice of establishing requirements for the design, construction, operation, ISI, and IST of nuclear power plants by approving the use of new ASME BPV and OM Code Cases in 10 CFR 50.55a.

Based on the existing data and information, Alternative 2 is the most effective way to implement the updated ASME Code Cases. The updates would amend 10 CFR 50.55a to incorporate by reference the latest revisions to RGs 1.84, 1.147, and 1.192, which list Code Cases published by ASME and approved by the NRC.

5.12.3 Increased Public Confidence

Alternative 2 incorporates the current ASME Code Cases for the design, construction, operation, ISI, and IST of nuclear power plants by approving the use of later ASME BPV and OM Code Cases in 10 CFR 50.55a. This alternative would allow licensees to use risk-informed, performance-based approaches and the most current methods and technology to design, construct, operate, examine, and test nuclear power plant components while maintaining NRC oversight of these activities and thus increasing public confidence.

5.12.4 Reliable Assessment of Cast Austenitic Stainless Steel Materials

The ability to reliably assess CASS materials is important for life extension and license renewal activities. CASS components continue to cause a level of concern because of the possibility of thermal embrittlement over time and the limitations of current volumetric inspection techniques. Establishing a robust aging management approach for CASS components would improve the knowledge of the material condition of those components exposed to reactor coolant environments and would improve the current state of knowledge, which is constrained by a lack of data, operating experience, and proven nondestructive engineering solutions.

5.13 Uncertainty Analysis

The NRC completed a Monte Carlo sensitivity analysis for this regulatory analysis using the @Risk specialty software program.[7] The Monte Carlo approach answers the question, "What distribution of net benefits results from multiple draws of the probability distribution assigned to key variables?"

5.13.1 Uncertainty Analysis Assumptions

Because this regulatory analysis is based on estimates of values that are sensitive to plant-specific cost drivers and plant dissimilarities, the NRC considered the variables with the greatest uncertainty. To perform this analysis, the NRC used a Monte Carlo simulation analysis using @Risk.

Monte Carlo simulations involve introducing uncertainty into the analysis by replacing the point estimates of the variables used to estimate base-case costs and benefits with probability distributions. By defining input variables as probability distributions instead of point estimates, the influence of uncertainty on the results of the analysis (i.e., the net benefits) can be effectively modeled.

The probability distributions chosen to represent the different variables in the analysis were bounded by the range-referenced input and the staff's professional judgment. Defining the probability distributions for use in a Monte Carlo simulation requires summary statistics to characterize the distributions. These summary statistics include the minimum, most likely, and maximum values of a program evaluation and review technique (PERT) distribution,[8] the minimum and maximum values of a uniform distribution, and the specified integer values of a discrete population. The NRC used the PERT distribution to reflect the relative spread and skewness of the distribution defined by the three estimates.

Table 20 identifies the data elements, the distribution and summary statistics, and the mean value of the distribution that the uncertainty analysis used.

Table 20 Uncertainty Analysis Variables

7 Information about this software is available at http://www.palisade.com.

8 A PERT distribution is a special form of the beta distribution with specified minimum and maximum values. The shape parameter is calculated from the defined *most likely* value. The PERT distribution is similar to a triangular distribution in that it has the same set of three parameters. Technically, it is a special case of a scaled beta (or beta general) distribution. The PERT distribution is generally considered superior to the triangular distribution when the parameters result in a skewed distribution, as the smooth shape of the curve places less emphasis in the direction of skew. Similar to the triangular distribution, the PERT distribution is bounded on both sides and therefore may not be adequate for modeling purposes that need to capture tail or extreme events.

Data Element	Mean Estimate	Distribution	Low Estimate	Best Estimate	High Estimate
ASME Code Case N-695-1 and N-696-1 Piping Examinations					
Verbal relief request (industry)					
Weighted hourly rate for relief request (industry)	$114.73	PERT	$86.85	$116.27	$136.43
Hours to produce relief request	190.0	PERT	50	190	330
Number of relief requests (per ASME Code Case)	1	PERT	1	1	1
Verbal relief request (NRC)					
Weighted hourly rate (NRC)	$129	PERT	$129	$129	$129
Hours to approve relief request	190.0	PERT	50	190	330
Number of relief requests (per Code Case)	1	PERT	1	1	1
ASME Code Case N-766-1 Inlay and Onlay Repair					
Condition that prevents the use of the ASME Code Case in certain situations (industry)					
Weighted hourly rate for relief request (industry)	$114.73	PERT	$86.85	$116.27	$136.43
Hours to produce ASME Code Case N-766-1 relief request	380.0	PERT	100	380	660
Number of ASME Code Case N-766-1 relief requests produced per year	1.0	PERT	0	1	2
Condition that prevents the use of the ASME Code Case in certain situations (NRC)					
Weighted hourly rate (NRC)	$129	PERT	$129	$129	$129
Hours to approve relief request	143.3	PERT	120	140	180
Number of ASME Code Case N-766-1 relief requests approved per year	1.0	PERT	0	1	2
ASME Code Case N-838 Flaw Tolerance Evaluation of CASS					
Condition that prevents the use of the ASME Code Case in certain situations (industry)					
Weighted hourly rate for relief request (industry)	$115	PERT	$86.85	$116.27	$136.43
Hours to produce ASME Code Case N-838 relief request	380	PERT	100	380	660
Number of ASME Code Case N-838 relief requests (total, all reactors)	1.0	PERT	0	1	2
Condition that prevents the use of the ASME Code Case in certain situations (NRC)					
Weighted hourly rate (NRC)	$129	PERT	$129	$129	$129
Hours to approve relief request	143.3	PERT	120	140	180
Number of relief requests per year	1.0	PERT	0	1	2
ASME Code Case N-648-2 nozzle inspection (new reactors only)					
Hourly rate for technical staff	$115	PERT	$86.85	$116.27	$136.43
Hours per nozzle (ultrasonic versus VT)	16.0	PERT	12	16	20

Data Element	Mean Estimate	Distribution	Low Estimate	Best Estimate	High Estimate
Number of nozzles (BWR)	25.0	PERT	22	25	28
Number of nozzles (PWR)	8.0	PERT	6	8	10
Inspection time after reactor placed into service	2.8	PERT	2	3	3
Percentage of nozzles inspected	0.4	PERT	25%	35%	50%
Number of new PWRs	2	PERT	1	2	2
Number of new BWRs	0	PERT	0	0	0
Averted ASME Code Case relief request costs					
Weighted hourly rate for relief request (engineer)	$115	PERT	$86.85	$116.27	$136.43
Relief request preparation and submission (hours)	380.0	PERT	100	380	660
Number of relief requests per year	23.6	PERT	16.5	22.5	35.0
Averted review of an ASME Code alternative request (NRC)					
Hourly rate for NRC	$129	PERT	$129	$129	$129
Hours to review	143.3	PERT	120	140	180
Number of actions (this is a recurring averted cost)	23.6	PERT	16.5	22.5	35.0

5.13.2 Uncertainty Analysis Results

The NRC performed the Monte Carlo simulation by repeatedly recalculating the results 10,000 times. For each iteration, the values identified in Table 20 were chosen randomly from the probability distributions that define the input variables. The values of the output variables were recorded for each iteration, and these values were used to define the resultant probability distribution.

For the analysis shown in each figure below, 10,000 simulations were run in which the key variables were changed to assess the resulting effect on costs and benefits. Figure 1, 2, and 3 display the histograms of the incremental costs and benefits from the regulatory baseline (Alternative 1). The analysis shows that both industry and the NRC would benefit by the issuance of this final rule.

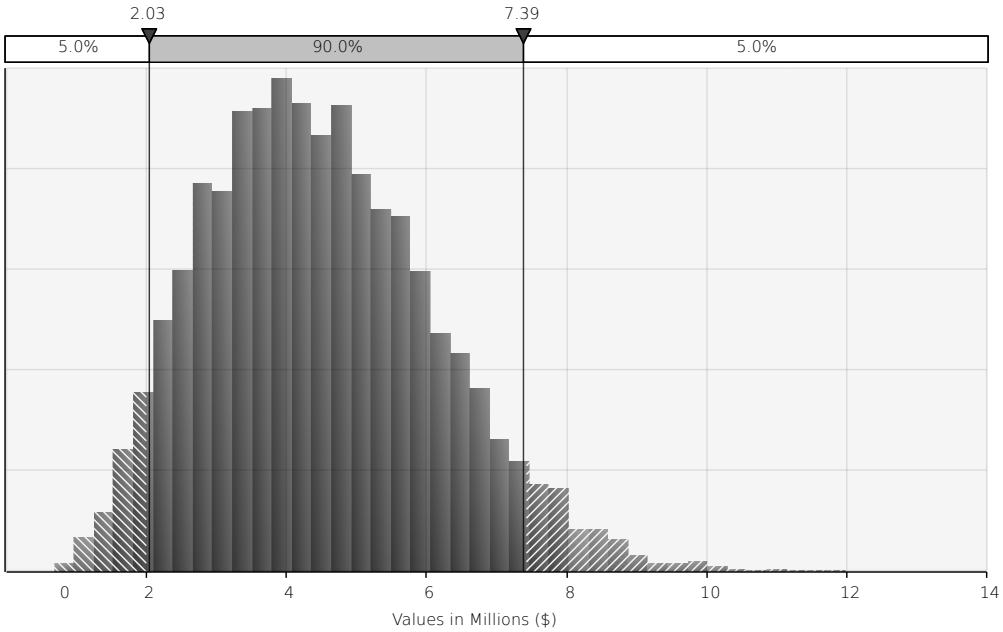

Figure 1 Total Industry Costs (7-Percent NPV) (Alternative 2)

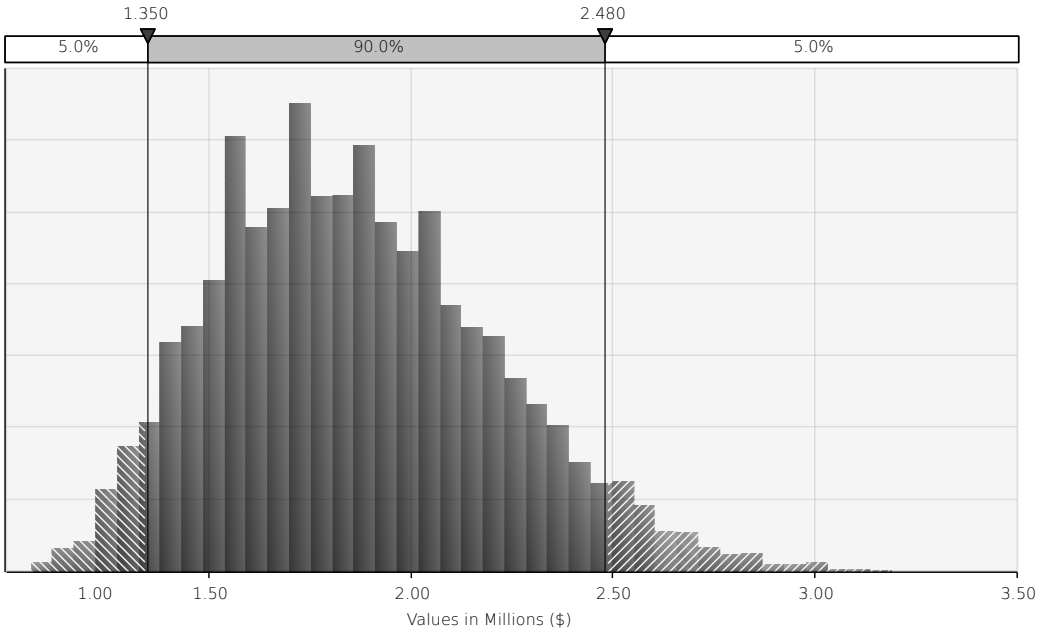

Figure 2 Total NRC Costs (7-Percent NPV) (Alternative 2)

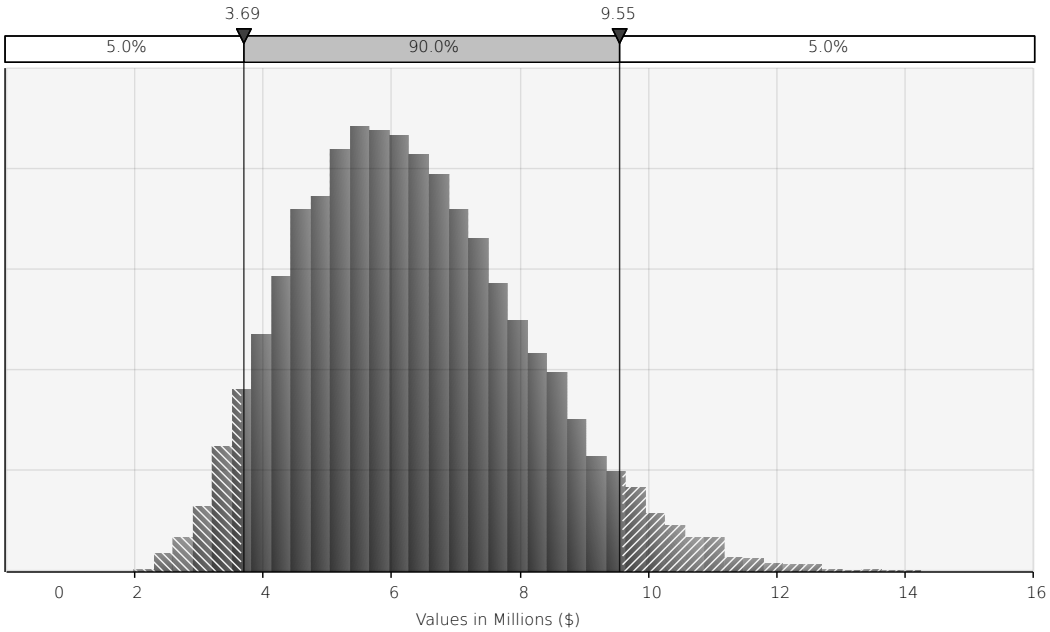

Figure 3 Total Costs (7-Percent NPV) (Alternative 2)

Table 21 presents descriptive statistics for the uncertainty analysis. The 5-percent and 95-percent values (i.e., the bands marked "5.0%" on either side of the "90.0%" confidence interval in Figure 1 and Figure 2) that appear as numerical values on the top of the vertical lines in Figure 1, 2, and 3 are reflected in Table 21 (rounded) as the 0.05 and 0.95 values, respectively.

Table 21 Descriptive Statistics for Uncertainty Results (7-Percent NPV)

Uncertainty Result	Incremental Cost-Benefit (2019 million dollars)					
	Minimum	Mean	Standard Deviation	Maximum	0.05	0.95
Total Industry Cost	$0.68	$4.47	$1.64	$12.0	$2.03	$7.36
Total NRC Cost	$1.06	$1.86	$0.34	$3.19	$1.35	$2.48
Total Cost	$1.98	$6.33	$1.80	$14.3	$3.69	$9.55

An examination of the range of the resulting output distribution in Table 21 enables the NRC to more confidently discuss the potential incremental costs and benefits of the final rule. This table displays the key statistical results, including the 90-percent confidence interval in which the net benefits would fall between the 5-percent and 95-percent values.

Figure 4 shows a tornado diagram that identifies the key variables whose uncertainty drives the largest impact on total costs (and averted costs) for this final rule. This figure ranks the variables based on their contribution to cost uncertainty. Three key variables—the number of hours required for ASME Code Case relief request preparation and submission, the number of relief requests per year, and the weighted hourly rate to generate relief requests—account for the most uncertainty in the costs. The remaining key variables show diminishing variation.

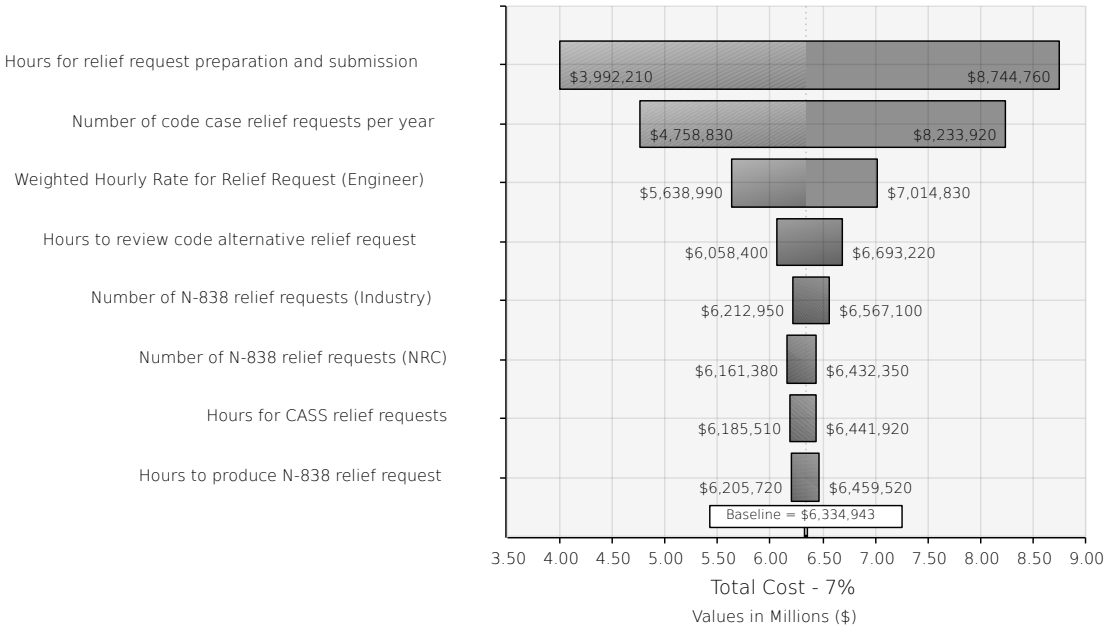

Figure 4 The Top Eight Variables for which Uncertainty Drives the Largest Impact on Total Costs (7-Percent NPV) (Alternative 2)

5.13.3 Summary of Uncertainty Analysis

The simulation analysis shows that the estimated mean benefit (i.e., positive averted costs or savings) for this final rule is $6.33 million with a 90-percent confidence interval that the benefit is between $3.69 million and $9.55 million at a 7-percent discount rate and with a greater than 99-percent chance that the final rule is cost beneficial. The NRC can reasonably infer from the uncertainty analysis that proceeding with the final rule represents an efficient use of resources and averted costs for the NRC and industry. The rule is deemed cost beneficial to both industry and the NRC when they are considered separately.

5.14 Disaggregation

To comply with the guidance in NUREG/BR-0058, Section 4.3.2, on criteria for the treatment of individual requirements, the NRC performed a screening review to determine whether any of the individual requirements (or set of integrated requirements) of the final rule would be unnecessary to achieve the objectives of the rulemaking. The NRC determined that the objectives of the rulemaking are to incorporate RGs by reference and to make conforming changes. Furthermore, the NRC concludes that each of the final rule's requirements would be necessary to achieve one or more objectives of the rulemaking. Table 22 provides the results of this review.

Table 22 Disaggregation

Regulatory Goals for Final Rule	Approve Use of the New ASME Code Cases in Each RG	Make Incorporation by Reference Conforming Changes
10 CFR 50.55a(a)(3)(i), RG 1.84, Revision 38	X	X

5.15 Summary

This regulatory analysis identifies both quantifiable and nonquantifiable costs and benefits that would result from incorporating NRC-approved ASME Code Cases by reference into the *Code of Federal Regulations*. Although quantifiable costs and benefits appear to be more tangible, decisionmakers should also consider costs and benefits that cannot be quantified. Such benefits or costs can be as important as, or even more important than, benefits or costs that can be quantified and monetized.

5.15.1 Quantified Net Benefit

As shown in Table 19 above, the estimated quantified incremental averted costs for Alternative 2, as compared to the regulatory baseline (Alternative 1) over the 6 years the ASME Code Cases will be effective, range from approximately $6.30 million (7-percent discount rate) to $7.16 million (3-percent discount rate). Table 19 shows that Alternative 2 would also be cost beneficial for the NRC and the industry when they are considered separately.

5.15.2 Nonquantified Benefits

In addition to the quantified costs discussed in this regulatory analysis, the attributes of public health (accident), improvements in knowledge, regulatory efficiency, and other considerations would produce a number of nonquantified costs and benefits for the industry and the NRC. The sections below summarize these benefits.

5.15.2.1 Advances in Inservice Inspection and Inservice Testing

Advances in ISI and IST may incrementally decrease the likelihood of a radiological accident, the likelihood of postaccident plant worker exposure, and the level of plant worker radiological exposures during routine inspections or testing. The NRC's approval of later editions and addenda of the ASME BPV and OM Codes and the associated Code Cases may contribute to plant safety by providing alternative examination methods that may result in the earlier identification of material degradation that, if undetected, could result in further degradation and lead to a plant transient. These alternative methods may increase the assurance of plant safety system readiness and may prevent, through inspection and testing, the introduction of a new failure mode or common-cause failure mode not previously evaluated.

5.15.2.2 Reduction in Public Health Radiation Exposures and Offsite Property

The industry's practice of adopting the ASME Code Cases that are incorporated by reference into the regulations may incrementally reduce the likelihood of a radiological accident in a positive, but not easily quantifiable, manner. Pursuing Alternative 2 would continue to meet the NRC's goal of maintaining safety by continuing to provide the agency's approval of later editions and addenda of the ASME Codes and the associated Code Cases to permit licensees to use advances in ISI and IST, provide alternative examinations for older plants, respond promptly to user needs, and provide a limited and clearly focused alternative to specific ASME Code provisions. Improvements in ISI and IST may also result in the earlier identification of material degradation that, if undetected, could lead to further degradation that eventually causes a plant transient. For this reason, Alternative 2 would maintain the same level of safety or possibly an incremental improvement in safety, which may result in an incremental decrease in public health

radiation exposures and in offsite property radiological contamination as compared to the regulatory baseline.

5.15.2.3 Reduction in Worker Radiation Exposures

The NRC's approval of later editions and addenda of the ASME BPV and OM Codes and associated Code Cases may reduce occupational radiation exposures in a positive, but not easily quantifiable, manner. For example, the advances in ISI and IST may result in an incremental decrease in the likelihood of an accident resulting in worker exposure as compared to the regulatory baseline.

5.15.2.4 Improvements in Inservice Inspection and Inservice Testing Knowledge

The NRC's approval of later editions and addenda of the ASME BPV and OM Codes and the associated Code Cases would improve knowledge by enhancing the ability of the industry and the NRC to gain experience with new technology before its incorporation into the ASME Codes and by permitting licensees to use advances in ISI and IST. Improved ISI and IST may result in the earlier identification of material degradation that, if undetected, could lead to further degradation that eventually causes a plant transient.

5.15.2.5 Consistency with the National Technology Transfer and Advancement Act of 1995 and Its Implementing Guidance

Alternative 2 is consistent with the provisions of the NTTAA and its implementing guidance in OMB Circular A-119, which encourage Federal regulatory agencies to consider adopting voluntary consensus standards as an alternative to *de novo* agency development of standards affecting an industry.

5.15.2.6 Continued NRC Practice of Incorporation by Reference of ASME Code Editions and Addenda into the Code of Federal Regulations

Alternative 2 would continue the NRC's practice of establishing requirements for the design, construction, operation, ISI, and IST of nuclear power plants by approving the use of later editions and addenda of the ASME BPV and OM Codes in 10 CFR 50.55a.

5.15.2.7 Increased Public Confidence

Alternative 2 would incorporate the current ASME Code edition, addenda, and Code Cases for the design, construction, operation, ISI, and IST of nuclear power plants by approving the use of editions and addenda of the ASME BPV and OM Codes in 10 CFR 50.55a. This alternative would allow licensees to use risk-informed, performance-based approaches and the most current methods and technology to design, construct, operate, examine, and test nuclear power plant components while maintaining NRC oversight of these activities.

The timely incorporation by reference of current addenda and editions of the ASME BPV and OM Codes into the *Code of Federal Regulations* and the review and approval of associated Code Cases would help the NRC remain an effective industry regulator. This role would be undermined if outdated material remains incorporated by reference in the *Code of Federal Regulations*.

5.15.2.8 Increased Cast Austenitic Stainless Steel Material Component Reliability

The ability to reliably assess CASS materials is important for life extension and license renewal activities. CASS components continue to cause a level of concern because of the possibility of thermal embrittlement over time and the limitations of current volumetric inspection techniques. Establishing a robust aging management approach for CASS components would increase knowledge of the material condition of those components exposed to reactor coolant environments over the current state of knowledge, which is constrained by a lack of data, operating experience, and proven nondestructive engineering solutions.

5.15.3 Nonquantified Costs

The NRC believes that incorporating by reference the most recent ASME BPV and OM Code editions and addenda and the associated NRC-approved Code Cases into the *Code of Federal Regulations* would decrease industry and NRC operation costs. If the NRC has underestimated the number or the complexity of these eliminated submittals, the averted costs would increase proportionally and thereby cause the quantified net cost of Alternative 2 to decrease toward a more net-beneficial determination.

5.16 Safety Goal Evaluation

The final rule alternative would allow licensees and applicants to apply the most recent NRC-approved ASME BPV and OM Code Cases, sometimes with NRC-specified conditions. The NRC's safety goal evaluation only applies to regulatory initiatives that the agency considers to be generic safety enhancement backfits subject to the substantial additional protection standard in 10 CFR 50.109(a)(3). The NRC does not regard the incorporation by reference of NRC-approved ASME Code Cases to be backfitting or to represent an inconsistency with any issue finality provisions in 10 CFR Part 52. The *Federal Register* notice of final rulemaking states the basis for this determination.

5.16.1 Section A: Incorporation by Reference of Later Editions and Addenda of ASME BPV Code, Section III, Division 1

Incorporation by reference of the Code Cases of ASME BPV Code, Section III, Division 1, is prospective in nature. Incorporation by reference of the Code Cases would not affect a plant that has received a construction permit, an operating license, or a combined license, nor would it affect a design that has been approved, because the Code Cases to be used in constructing a plant are, by rule, determined based on the date of the construction permit or the combined license and, therefore, are not changed except voluntarily by the licensee with the approval of the NRC. Thus, incorporation by reference of later Code Cases of ASME BPV Code, Section III, Division 1, would not constitute a "backfitting" as defined in 10 CFR 50.109(a)(1).

5.16.2 Section B: Incorporation by Reference of Later Editions and Addenda of Section XI, Division 1, of the ASME BPV Code, and OM Codes

Incorporation by reference of later Code Cases of Section XI, Division 1, of the ASME BPV Code, and of the ASME OM Code would affect the ISI and IST programs of operating reactors. However, 10 CFR 50.109, "Backfitting" (the Backfit Rule), generally does not apply to the incorporation by reference of later ASME Code Cases of Section XI, Division 1, of the ASME BPV Code and the ASME OM Code for the following reasons:

- The NRC's longstanding policy has been to incorporate later versions of the ASME Codes into its regulations; therefore, licensees know that, when they receive their operating licenses, such updating is part of the regulatory process, as reflected in 10 CFR 50.55a. Under 10 CFR 50.55a, the NRC requires licensees to revise their ISI and IST programs every 120 months to the latest edition and addenda of Section XI, Division 1, of the ASME BPV Code and the ASME OM Code incorporated by reference into 10 CFR 50.55a and that are in effect 12 months before the start of a new 120-month ISI and IST interval. Therefore, when the NRC endorses a later version of an ASME Code, it is implementing this longstanding policy.

- The ASME BPV and OM Codes are national consensus standards, developed by participants with broad and varied interests, in which all interested parties, including the staff and nuclear plant personnel, participate. This consideration is consistent with both the intent and spirit of the Backfit Rule (i.e., the NRC provides for the protection of public health and safety but does not unilaterally impose undue burden on applicants or licensees).

5.16.3 Other Circumstances under Which the NRC Does Not Apply the Backfit Rule to the Endorsement of a Later Code

The NRC does not apply the Backfit Rule to the endorsement of a later code under the following other circumstances:

- When the NRC takes exception to a later ASME BPV or OM Code provision and merely retains the current existing requirement, prohibits the use of the later ASME Code provision, or limits the use of the later ASME Code provision, the Backfit Rule would not apply because the NRC is not imposing new requirements. However, the NRC provides the technical or policy bases, or both, for taking exceptions to the ASME Code in the Statement of Considerations for the rule.

- When an NRC exception relaxes an existing ASME BPV or OM Code provision but does not prohibit a licensee from using the existing code provision, the Backfit Rule would not apply.

5.16.4 Safety Goal Evaluation Result

Based on the reasons described, a safety goal evaluation is not appropriate for this regulatory analysis.

5.17 Results for the Committee to Review Generic Requirements

This section addresses regulatory analysis information requirements for rulemaking actions or staff positions subject to review by the Committee to Review Generic Requirements (CRGR). This regulatory analysis or the *Federal Register* notice for the final rule presents all information required by the CRGR charter (NRC 2018b). Table 23 provides a cross-reference between the relevant information and its location in this document or the *Federal Register* notice.

Table 23 Specific CRGR Information Requirements for Regulatory Analysis

CRGR Charter Citation (NRC 2018b)[a]	Information Item To Be Included in a Regulatory Analysis Prepared for CRGR Review	Where the Information Item Is Discussed
Appendix B, (i)	The new or revised generic requirement or staff position as it is proposed to be sent out to licensees or issued for public comment	Final rule text in *Federal Register* notice for the final rule
Appendix B, (ii)	Documents supporting the requirements or staff positions	*Federal Register* notice for the final rule
Appendix B, (iii)	The sponsoring office's position on each requirement or staff position as to whether the change would modify, implement, or relax or reduce existing requirements or staff positions	Regulatory Analysis, Section 5, and Backfitting and Issue Finality, Section XIII, *Federal Register* notice for the final rule
Appendix B, (iv)	The method of implementation	Regulatory Analysis, Section 7
Appendix B, (vi)	Identification of the category of power reactors, new reactors, or nuclear materials facilities or activities to which the generic requirement or staff position applies	Regulatory Analysis, Section 4.2.2
Appendix B, (vii)–(viii)	The items required by 10 CFR 50.109(c) and the required rationale by 10 CFR 50.109(a)(3) if the action involves a power reactor backfit and if the exceptions in 10 CFR 50.109(a)(4) do not apply	Backfitting and Issue Finality, Section XIII, *Federal Register* notice for the final rule
Section III	For generic relaxations or decreases in current requirements or staff positions, a determination and associated rationale that (1) public health and safety and the common defense and security would be adequately protected if the relaxations were implemented and (2) the cost savings attributed to each action would be significant enough to justify the action	*Federal Register* notice for the final rule
Appendix B, (xi)	An assessment of how the action relates to the Commission's Safety Goal Policy Statement (NRC 1986)	Regulatory Analysis, Section 5.16

[a] The CRGR Charter cites these portions of the CRGR Procedures and Internal Administrative Process.

6. Decision Rationale

Table 24 provides the quantified and qualified costs and benefits for Alternative 2. The quantitative analysis used best-estimate values.

Table 24 Summary of Totals

Net Monetary Savings or (Costs) Total Present Value	Nonquantified Benefits or (Costs)
Alternative 1: No Action $0	None
Alternative 2: Incorporate by reference RG 1.84, Revision 38; RG 1.147, Revision 19; and RG 1.192, Revision 3 Industry: (all provisions) $4.47 million using a 7% discount rate $5.08 million using a 3% discount rate NRC: (all provisions) $1.87 million using a 7% discount rate $2.12 million using a 3% discount rate Net Benefit (Cost): (all provisions) $6.34 million using a 7% discount rate $7.20 million using a 3% discount rate	Benefits: • **Advances in ISI and IST:** This may incrementally decrease the likelihood of a radiological accident, the likelihood of postaccident plant worker exposure, and the level of plant worker radiological exposures during routine inspections or testing. • **Public Health (Accident):** This may incrementally reduce the likelihood of a radiological accident in a positive, but not easily quantifiable, manner. Pursuing Alternative 2 would continue to meet the NRC's goal of maintaining safety by continuing to provide the agency's approval of the use of later editions and addenda of the ASME BPV and OM Codes and applicable Code Cases to permit licensees to use advances in ISI and IST, provide alternative examinations for older plants, respond expeditiously to user needs, and provide a limited and clearly focused alternative to specific ASME Code provisions. Improvements in ISI and IST may also result in the earlier identification of material degradation that, if undetected, could lead to further degradation that eventually causes a plant transient. For this reason, Alternative 2 would maintain the same level of safety or possibly an incremental improvement in safety when compared to the regulatory baseline, which may result in an incremental decrease in public health radiation exposures. • **Occupational Health (Accident and Routine):** The use of later editions and addenda of the ASME BPV and OM Codes and applicable Code Cases may reduce postaccident occupational radiation exposures in a positive, but not easily quantifiable, manner. The advances in ISI and IST may result in an incremental decrease in the likelihood of an accident resulting in worker exposure as compared to the regulatory baseline. • **Improvements in Knowledge:** The staff would gain experience with new technology and ISI and IST advances. On-the-job learning would increase worker satisfaction. Eliminating unnecessary work would better enable the staff

Net Monetary Savings or (Costs) Total Present Value	Nonquantified Benefits or (Costs)
	to produce desired on-the-job results; such results lead to pride in performance and increased job satisfaction. • **Consistent with the NTTAA and Implementing Guidance:** Alternative 2 is consistent with the provisions of the NTTAA and implementing guidance in OMB Circular A-119, which encourage Federal regulatory agencies to consider adopting voluntary consensus standards as an alternative to *de novo* agency development of standards affecting an industry. Furthermore, the ASME Code consensus process is an important part of the regulatory framework. Costs: • **Nonquantified Costs:** If the NRC has underestimated the number or the complexity of these eliminated submittals, the averted costs would increase proportionally, causing the quantified net costs of Alternative 2 to decrease.

The industry and the NRC would benefit from the final rulemaking, Alternative 2, because of the averted costs of licensees not needing to submit and the NRC not needing to review and approve ASME Code Case relief requests on a plant-specific basis under the new 10 CFR 50.55a(z). As shown in Table 24, Alternative 2, as compared to the regulatory baseline, would result in a net benefit (averted cost) to industry that ranges from $4.47 million (7-percent NPV) to $5.08 million (3-percent NPV). The NRC's net benefit would range from $1.87 million (7-percent NPV) to $2.12 million (3-percent NPV). Thus, the total quantitative net averted costs of the final rule would range from $6.34 million (7-percent NPV) to $7.20 million (3-percent NPV).

Alternative 2 would also have the qualitative benefit of meeting the NRC's goal of ensuring the protection of public health and safety and the environment through the agency's approval of the use of later ASME BPV and OM Code Cases. It would also allow for the use of the most current methods and technology. This alternative would also support the NRC's goal of maintaining an open regulatory process because the agency's approval of ASME Code Cases would demonstrate its commitment to participating in the national consensus standards process and would maintain its role as an effective regulator.

The NRC has had a decades-long practice of approving or mandating, or both, the use of certain ASME Code Cases in 10 CFR 50.55a through the rulemaking process of "incorporation by reference." Retaining the practice of approving or mandating the ASME Codes would continue the regulatory stability and predictability provided by the current practice. Retaining the practice would also ensure consistency across the industry and assure the industry and the public that the NRC will continue to support the use of the most updated and technically sound techniques developed by ASME to provide adequate protection to the public. In this regard, these ASME Codes are voluntary consensus standards developed by participants with broad and varied interests, and they have already undergone extensive external review before the

NRC evaluates them. Finally, the NRC's use of the ASME Codes is consistent with the NTTAA, which directs Federal agencies to adopt voluntary consensus standards instead of developing "Government-unique" standards (i.e., those developed by Federal agencies) unless such standards are inconsistent with the applicable law or are otherwise impractical.

Based solely on quantified costs and benefits, this regulatory analysis shows that the final rule is justified because the total quantified benefits of the final rule would exceed the costs of the action for all discount rates up to 7 percent. Certainly, if the qualitative benefits, including the safety, regulatory efficiency, and other nonquantified benefits, are considered together with the quantified benefits, the benefits would outweigh the identified quantitative and qualitative impacts.

Considering nonquantified costs and benefits, this regulatory analysis shows that the final rule is justified because the number and significance of the nonquantified benefits outweigh the nonquantified costs. The uncertainty analysis shows a net benefit (averted cost) for all simulations with a range of averted cost from $1.98 million to $14.3 million (at a 7-percent NPV).

Therefore, integrating both quantified and nonquantified costs and benefits, the benefits of the final rule outweigh the identified quantitative and qualitative impacts attributable to the final rule.

7. Implementation Schedule

The final rule will become effective 30 days after its publication in the *Federal Register*.

8. References

Code of Federal Regulations (CFR), "Domestic Licensing of Production and Utilization Facilities," Part 50, Chapter 1, Title 10, "Energy."

CFR, "Licenses, Certifications, and Approvals for Nuclear Power Plants," Part 52, Chapter 1, Title 10, "Energy."

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National Technology Transfer and Advancement Act of 1995, Public Law 104-113. Available at http://www.gpo.gov/fdsys/pkg/PLAW-104publ113/pdf/PLAW-104publ113.pdf.

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NRC, RG 1.193, "ASME Code Cases Not Approved for Use," Revision 3, October 2010 (ADAMS Accession No. ML101800540).

NRC, NUREG/CR-7122, "An Evaluation of Ultrasonic Phased Array Testing for Cast Austenitic Stainless Steel Pressurizer Surge Line Piping Welds," March 2012 (ADAMS Accession No. ML12087A004).

NRC, RG 1.84, "Design, Fabrication, and Materials Code Case Acceptability, ASME Section III," Revision 37, March 2017a (ADAMS Accession No. ML16321A335).

NRC, RG 1.192, "Operation and Maintenance Code Case Acceptability, ASME OM Code," Revision 2, March 2017b (ADAMS Accession No. ML16321A337).

NRC, RG 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1," Revision 18, March 2017c (ADAMS Accession No. ML16321A336).

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APPENDIX A

MAJOR ASSUMPTIONS AND INPUT DATA

Table A-1 summarizes the major assumptions and input data used in the regulatory analysis, including the key analysis dates, number of entities, number of sites, applicability of the final rule, and labor rates.

Table A-1 Major Assumptions and Input Data

Data Element	Best Estimate	Unit	Source or Basis of Estimate
Key Analysis Dates			
Final rule effective date	2019	year	NRC input
Analysis base year	2019	year	NRC input
Number of Entities			
Number of operating reactor units in 2020	93	units	Calculation. Based on Appendix A to NUREG-1350, "2018-2019 Information Digest," Volume 30, issued August 2018 (NRC 2018c).
Number of forecasted operating reactor units in 2025	88	units	Assumption. Based on NUREG-1350, Appendix A, (NRC 2018c). The Pilgrim Nuclear Power Station and the Three Mile Island Nuclear Station, Unit 1, closed in 2019. The NRC assumes that Davis-Besse Nuclear Power Station, Unit 1, will close in 2020 based on FirstEnergy Nuclear Operating Company's announcement (http://www.firstenergycorp.com) and that Duane Arnold Energy Center will close in 2020 based on NextEra Energy Resources' announcement (https://www.nexteraenergyresources.com). The NRC assumes that Perry Nuclear power Plant, Unit 1, and Beaver Valley Power Station, Units 1 and 2, will shut down in 2021, based on FirstEnergy Nuclear Operating Company's announcement (http://www.firstenergycorp.com). The NRC assumes that Indian Point Nuclear Generating Station (Indian Point), Unit 2, will shut down in 2020; Indian Point, Unit 3, will shut down in

Data Element	Best Estimate	Unit	Source or Basis of Estimate
			2021; and Palisades Nuclear Plant will shut down in 2022, based on Entergy Nuclear Operations, Inc.'s, announcement (http://www.entergy.com). The NRC assumes Diablo Canyon Power Plant, Units 1 and 2, will shut down in 2024 and 2025, respectively, based on Pacific Gas & Electric Company's announcement (http://www.pge.com).
Number of Sites			
Number of sites with operating reactors in 2020	57	sites	Calculation: [total number of sites with operating reactors] + [sites with construction completed in 2019 and 2020] - [sites with units closed in 2019] Information on operating reactor sites was obtained from the NRC's Web site, "Operating Nuclear Power Reactors (by Location or Name)," at http://www.nrc.gov/info-finder/reactor/ (last accessed on April 2, 2019) (data current as of December 31, 2018).
Number of sites forecasted with operating reactors in 2025	53	sites	Calculation: [total number of sites with operating reactors in 2020] + [sites with construction completed in years 2021 through 2025] - [sites with units closed in years 2020 through 2025]. Information on operating reactor sites was obtained from the NRC's Web site at http://www.nrc.gov/info-finder/reactor/ (last accessed on April 2, 2019) (data current as of December 31, 2018).
Final Rule Applicability Period (Years)			
Final rule applicability term	6	years	Code Cases last 3 years and are typically renewed once, for a total of 6 years.
Labor Rates			
Industry engineer or plant supervisor	$130	Dollars per hour	The labor rates used are from the Bureau of Labor Statistics (BLS) Employer Costs for National Compensation Survey dataset (2018 values). These hourly rates were inflated to 2019 dollars using values of the Consumer Price Index for All Urban
Managers	$109	Dollars per hour	
Technical staff	$100	Dollars per hour	

Data Element	Best Estimate	Unit	Source or Basis of Estimate
Administrative staff	$52	Dollars per hour	Consumers. A multiplier of 2.4, which includes fringe and indirect management cost, was then applied and resulted in the NRC, Rulemaker@nrc.gov, "NRC Labor Rates for Use in Regulatory Analyses," 2018.
Licensing staff	$117	Dollars per hour	
Industry plant technician	$94	Dollars per hour	
NRC engineer	$129	Dollars per hour	

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