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AN APPROACH FOR PLANT-SPECIFIC RISK-INFORMED DECISIONMAKING FOR INSERVICE INSPECTION OF PIPING

A. INTRODUCTION

During the last several years, both the U.S. Nuclear Regulatory Commission (NRC) and the nuclear industry have recognized that probabilistic risk assessment (PRA) has evolved to be more useful in supplementing traditional engineering approaches in reactor regulation. After the publication of its Policy Statement on the use of PRA in nuclear regulatory activities, the Commission directed the NRC staff to develop a regulatory framework that incorporated risk insights. That framework was articulated in a November 27, 1995, paper to the Commission (SECY-95-280). This regulatory guide, which addresses inservice inspection (ISI) of piping, with its companion Standard Review Plan, Section 3.9.8 of NUREG-0800 (SRP Chapter 3.9.8), and other regulatory documents (Regulatory Guides 1.174, 1.175, 1.176, and 1.177; SRP Chapters 3.9.7, 16.1, and 19), implement, in part, the Commission's Policy Statement and the staff's framework for incorporating risk insights into the regulation of nuclear power plants.

In September 1998, the Commission published a version of this regulatory guide for trial use. As stated therein, that regulatory guide issued for trial use did not establish any final staff positions for purposes of the Backfit Rule, 10 CFR 50.109, and any changes to the regulatory guide prior to staff adoption in final form would not be considered to be backfits as defined in 10 CFR 50.109(a)(1). This was intended to ensure that the lessons learned from the subsequent regulatory review of industry methodologies and the pilot plant applications could be adequately addressed in this document and that the guidance is sufficient to enhance regulatory stability in the review, approval, and implementation of proposed RI-ISI programs.

The NRC staff has approved two methods describing how risk-informed ISI programs can be developed and implemented. One methodology (EPRI TR-112657) was developed by the Electric Power Research Institute (EPRI). The other methodology (WCAP-14572) was developed by the Westinghouse Owners Group (WOG). Regulatory Guide 1.178 (for trial use) was used to support the review and approval of the two industry-developed methodologies. Based on the experience during the review and approval of the industry methodologies and the review and approval of numerous plant-specific relief requests for inservice inspection programs, the NRC staff is now issuing this updated version of this regulatory guide.

While there has been a substantial effort to provide an opportunity for stakeholders in this methodology to intereact with the staff in the development of this guide's revisions, the revised guide was not issued in draft form in the manner that has normally been used for regulatory guides. Rather, a more limited stakeholder's review was utilized, including a public meeting noticed on the NRC web site. Prior to the public meeting, the draft of this guide was placed in ADAMS with a public notice identifying the ADAMS accession number. This approach was considered adequate since the revisions are generally editorial in nature and intended to either update certain information or to clarify language without substantial changes to the methodology itself. In addition, since this guide was first issued in 1998, it has been successfully used by the industry and staff in processing numerous requests by licensees to make risk-informed changes to inservice inspection programs.

Until the risk-informed inservice inspection (RI-ISI) process is approved for generic use, the NRC staff anticipates that licensees will request changes to their ISI programs by requesting NRC approval of alternative inspection programs that meet the criteria of 10 CFR 50.55a(a)(3)(i) in Section 50.55a, "Codes and Standards," of 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities," providing an acceptable level of quality and safety. As always, licensees should identify how the chosen approach, methods, data, and criteria are appropriate for the decisions they need to make.

This guide's principal focus is on the use of PRA findings and risk insights for decisions on changes proposed to plants' inservice inspection programs for piping. Such changes include (but are not limited to) license amendments under 10 CFR 50.90, requests for the use of alternatives under 10 CFR 50.55a, and exemptions under 10 CFR 50.12. This regulatory guide describes methods acceptable to the NRC staff for integrating insights from PRA techniques with traditional engineering analyses into ISI programs for piping.

Background

During recent years, both the NRC and the nuclear industry have recognized that PRA has evolved to the point that it can be used increasingly as a tool in regulatory decisionmaking. In August 1995, the NRC adopted a Policy Statement regarding the expanded use of PRA. In part, the Policy Statement states that:

- The use of PRA technology should be increased in all regulatory matters to the extent supported by the state of the art in PRA methods and data and in a manner that complements the deterministic approach and supports the NRC's traditional philosophy of defense in depth.

- PRA and associated analyses (e.g., sensitivity studies, uncertainty analyses, and importance measures) should be used in regulatory matters, where practical within the bounds of the state of-the-art, to reduce unnecessary conservatism associated with current regulatory requirements, regulatory guides, license commitments, and staff practices. Where appropriate, PRA should be used to support the proposal of additional regulatory requirements in accordance with 10 CFR 50.109 (Backfit Rule). Appropriate procedures for including PRA in the process for changing regulatory requirements should be developed and followed. It is, of course, understood that the intent of this policy is that existing rules and regulations be complied with unless these rules and regulations are revised.

- PRA evaluations in support of regulatory decisions should be as realistic as practicable and appropriate supporting data should be publicly available for review.

- The Commission's safety goals for nuclear power plants and subsidiary numerical objectives are to be used with appropriate consideration of uncertainties in making regulatory judgments on the need for proposing and backfitting new generic requirements on nuclear power plant licensees.

In its approval of the Policy Statement, the Commission articulated its expectation that implementation of the Policy Statement will improve the regulatory process in three areas: foremost, through safety decisionmaking enhanced by the use of PRA insights, through more efficient use of agency resources, and through a reduction in unnecessary burdens on licensees.

In parallel with the publication of the Policy Statement, the staff developed a regulatory framework that incorporates risk insights. That framework was articulated in a paper (SECY-95-280) to the Commission. This regulatory guide, which addresses ISI programs of piping at nuclear power plants, is part of the implementation of the Commission's Policy Statement and the staff's framework for incorporating risk insights into the regulation of nuclear power plants.

While the conventional regulatory framework, based on traditional engineering criteria, continues to serve its purpose in ensuring the protection of public health and safety, the current information base contains insights gained from over 2500 reactor-years of plant operating experience and extensive research in the areas of material sciences, aging phenomena, and inspection techniques. This information, combined with modern risk assessment techniques and associated data, can be used to develop a more effective approach to ISI programs for piping.

The current ISI requirements for piping components are found in 10 CFR 50.55a and the General Design Criteria listed in Appendix A to 10 CFR Part 50. These requirements are throughout the General Design Criteria, such as in Criterion I, "Overall Requirements"; Criterion II, "Protection by

Multiple Fission Product Barriers"; Criterion III, "Protection and Reactivity Control Systems"; and Criterion IV, "Fluid Systems."

Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME B&PVC) is referenced by 10 CFR 50.55a, which addresses the codes and standards for design, fabrication, testing, and inspection of piping systems. The objective of the ISI program is to identify service-induced degradation that might lead to pipe leaks and ruptures, thereby meeting, in part, the requirements set in the General Design Criteria and 10 CFR 50.55a. ISI programs are intended to address all piping locations that are subject to degradation. Incorporating risk insights into the programs can focus inspections on the more important locations and reduce personnel exposure, while at the same time maintaining or improving public health and safety. The justification for any reduction in the number of inspections should address the issue that an increase in leakage frequency or a loss of defense in depth should not result from decreases in the numbers of inspections.

When categorizing piping segments in terms of their contribution to risk, it is the responsibility of a licensee to ensure that the categorization of piping segments and the resulting inspection programs are consistent with the key principles and risk guidelines (e.g., core damage frequency (CDF) and large early release frequency (LERF)) addressed in Regulatory Guide 1.174. This regulatory guide augments the guidance presented in Regulatory Guide 1.174 by providing guidance specific to incorporating risk insights to inservice inspection programs of piping.

Purpose of the Guide

Consistent with Regulatory Guide 1.174, this regulatory guide focuses on the use of PRA in support of a RI-ISI program. This guide provides guidance on acceptable approaches to meeting the existing Section XI requirements for the scope and frequency of inspection of ISI programs. Its use by licensees is voluntary. Its principal focus is the use of PRA findings and risk insights for decisions on changes proposed to a plant's inspection program for piping. The current ISI programs are performed in compliance with the requirements of 10 CFR 50.55a and with Section XI of the ASME Boiler and Pressure Vessel Code, which are part of the plant's licensing basis. This approach provides an acceptable level of quality and safety (per 10 CFR 50.55a(a)(3)(i)) by incorporating insights from probabilistic risk and traditional analysis calculations, supplemented with operating reactor data. Licensees who propose to apply RI-ISI programs would amend their final safety analysis report (FSAR, Sections 5.3.4 and 6.6) accordingly. A Standard Review Plan (SRP Chapter 3.9.8) has been prepared for use by the NRC staff in reviewing RI-ISI applications.

Additional augmented inspection programs to address generic piping degradation problems have been recommended by the NRC to preclude piping failure and implemented by the industry. Notable examples of augmented programs for piping inspections include the following topics:

- intergranular stress corrosion cracking (IGSCC) of stainless steel piping in boiling water reactors (BWRs) (Generic Letter 88-01),
- thermal fatigue (NRC Bulletins 88-08 and 88-11, NRC Information Notice 93-20),

- stress corrosion cracking in pressurized water reactors (PWRs) (IE Bulletin 79-17),
- Service Water Integrity Program (NRC Generic Letter 89-13),
- flow accelerated corrosion (FAC) in the balance of plant for both PWRs and BWRs (NRC Generic Letter 89-08).

Augmented programs have generally been developed to address observed degradation and the inspections tend to be targeted at locations where the most severe effects are expected. Selected augmented programs, or parts of the programs, may be incorporated into a RI-ISI program provided that the licensee identifies and the staff approves the specific programs and program changes.

This document addresses risked-informed methods to develop, monitor, and update more efficient ISI programs for piping at a nuclear power facility. This guidance does not preclude other approaches for incorporating risk insights into the ISI programs. Licensees may propose other approaches for NRC consideration. It is intended that the methods presented in this guide be regarded as examples of acceptable practices; licensees should have some flexibility in satisfying the regulations on the basis of their accumulated plant experience and knowledge. This document addresses risk-informed approaches that are consistent with the basic elements identified in Regulatory Guide 1.174. In addition, this document provides guidance on the following for the purposes of RI-ISI.

- Estimating the probability of a leak, a leak that prevents the system from performing its function (disabling leak), and a rupture for piping segments,

- Identifying the structural elements for which ISI can be modified (reduced or increased), based on factors such as risk insights, defense in depth, reduction of unnecessary radiation exposure to personnel,

- Determining the risk impact of changes to ISI programs,

- Capturing deterministic considerations in the revised ISI program, and

- Developing an inspection program that monitors the performance of the piping elements for consistency with the conclusions from the risk assessment.

Until the RI-ISI process is approved for generic use, the staff anticipates that licensees will request changes to their ISI programs by requesting NRC approval of a proposed inspection program that meets the criteria of 10 CFR 50.55a(a)(3)(i), providing an acceptable level of quality and safety. The licensee's RI-ISI program will be enforceable under 10 CFR 50.55a.

Scope of the RI-ISI Program

This regulatory guide only addresses changes to the ISI programs for inspection of piping. To adequately reflect the risk implications of piping failure, both partial and full-scope RI-ISI programs are acceptable to the NRC staff.

Partial Scope: A licensee may elect to limit its RI-ISI program to a subset of piping classes, for example, ASME Class-1 piping only, including piping exempt from the current requirements. Partial scope applications should include the full population of piping within the selected subset of piping such as ASME Class and/or plant systems.

Full Scope: A full scope RI-ISI includes:

- All Class 1, 2, and 3[1] piping within the current ASME Section XI programs, and

- All piping whose failure would compromise:

    S Safety-related structures, systems, or components that are relied upon to remain functional during and following design basis events to ensure the integrity of the reactor coolant pressure boundary, the capability to shut down the reactor and maintain it in a safe shutdown condition, or the capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to 10 CFR Part 100 guidelines.

    S Non-safety-related structures, systems, or components:

    - That are relied upon to mitigate accidents or transients or are used in plant emergency operating procedures; or

    - Whose failure could prevent safety-related structures, systems, or components from fulfilling their safety-related function; or

    - Whose failure could cause a reactor scram or actuation of a safety-related system.

For both the partial and full scope evaluations, the licensee is to demonstrate compliance with the acceptance guidelines and key principles of Regulatory Guide 1.174.

The inspection locations of concern include all weld and base metal locations at which degradation may occur, although pipe welds are the usual point of interest in the inspection program. Within this regulatory guide, references to "welds" are intended in a broad sense to address inspections of critical structural locations in general, including the base metal as well as weld metal. Inspections will often focus on welds because detailed evaluations will often identify welds as the locations most likely to experience degradation. Welds are most likely to have fabrication defects, welds are often at locations of high stress, and certain degradation mechanisms (stress corrosion cracking) usually occur at welds.

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[1] Generally, ASME Code Class 1 includes all reactor pressure boundary components. ASME Code Class 2 generally includes systems or portions of systems important to safety that are designed for post-accident containment and removal of heat and fission products. ASME Code Class 3 generally includes the system components or portions of systems important to safety that are designed to provide cooling water and auxiliary feedwater for the front-line systems.

Nevertheless, there are other degradation mechanisms such as flow-assisted-corrosion (e.g., erosion-corrosion) and thermal fatigue that occur independent of welds.

Licensees implementing the risk-informed process may identify piping segments categorized as safety significant that are not currently subject to the traditional Code requirements (e.g., outside the Code boundaries, including Code exempt piping) or are not being inspected to a level that is commensurate with their risk significance. In this context, safety significant refers to a piping segment that has a relatively high contribution to risk. PRA systematically takes credit for systems with non-Code or exempt piping that provide support, act as alternatives, and act as backups to those systems with piping that are within the scope of the current Section XI of the Code. The RI-ISI program should result in inspections of safety significant piping.

Organization and Content

This regulatory guide is structured to follow the general four-element process for risk-informed applications discussed in Regulatory Guide 1.174. The Discussion section summarizes the four-element process developed by the staff to evaluate proposed changes related to the development of a RI-ISI program. Regulatory Position 1 discusses an acceptable approach for defining the proposed changes to an ISI program. Regulatory Position 2 addresses, in general, the traditional and probabilistic engineering evaluations performed to support RI-ISI programs and presents the risk acceptance goals for determining the acceptability of the proposed change. Regulatory Position 3 presents one acceptable approach for implementing and monitoring corrective actions for RI-ISI programs. The documentation the NRC will need to render its safety decision is discussed in Regulatory Position 4.

Relationship to Other Guidance Documents

As stated above, this regulatory guide discusses acceptable approaches to incorporate risk insights into an ISI program and directs the reader to Regulatory Guide 1.174 and SRP Chapters 19 and 3.9.8 for additional guidance, as appropriate. Further guidance is being developed in Draft Regulatory Guide DG-1122 and Draft SRP Chapter 19.1. Regulatory Guide 1.174 describes a general approach to risk-informed regulatory decisionmaking and discusses specific topics common to all risk-informed regulatory applications. Draft Regulatory Guide DG-1122, when finalized, will provide guidance on determining the quality of the PRA, *in toto* or for those parts that are used to support an application and are sufficient to provide confidence in the results such that they can be used in regulatory decisionmaking for light-water reactors. Topics addressed in these documents include:

- PRA quality - characteristics and attributes for technical elements of a PRA,

- PRA scope - internal and external event initiators, at-power and shutdown modes of operation, consideration of requirements for Level 1, 2, and 3[2] analyses,

[2] Level 1 - accident sequence analysis, Level 2 - accident progression and source term analysis, and Level 3 - offsite consequence analysis.

- PRA peer review - approach, process, and documentation,

- Risk metrics - CDF, LERF, importance measures,
- Sensitivity and uncertainty analyses.

To the extent that a licensee elects to use PRA as an element to enhance or modify its implementation of activities affecting the safety-related functions of SSCs subject to the provisions of Appendix B to 10 CFR Part 50, the pertinent requirements of Appendix B are applicable.

The information collections contained in this regulatory guide are covered by the requirements of 10 CFR Part 50, which were approved by the Office of Management and Budget (OMB), approval number 3150-0011. The NRC may not conduct or sponsor, and a person is not required to respond to, a request for information or an information collection requirement unless the requesting document displays a currently valid OMB control number.

Abbreviations and Definitions

ASME	American Society of Mechanical Engineers
BPVC	Boiler and Pressure Vessel Code
CCDF	Conditional core damage frequency
CCF	Common cause failure
CDF	Core damage frequency
CLERF	Conditional large early release frequency
Expert Elicitation	A process used to estimate failure rates or probabilities of piping when data and computer codes are unavailable for the intended purpose.
Expert Panel	Normally refers to plant personnel experienced in operations, maintenance, PRA, ISI programs, and other related activities and disciplines that impact the decision under consideration.
FSAR	Final Safety Analysis Report
IGSCC	Intergranular stress corrosion cracking
Importance Measures	Used in PRA to rank systems or components in terms of risk significance
ISI	Inservice inspection
IST	Inservice testing
LERF	Large early release frequency
NDE	Nondestructive examination
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission
PRA	Probabilistic risk assessment
PSA	Probabilistic safety assessment
RCPB	Reactor coolant pressure boundary
RI-ISI	Risk-informed inservice inspection
Staff	Refers to NRC employees

Sensitivity Studies	Varying parameters to assess impact due to uncertainties
SRP	Standard Review Plan
SRRA	Structural reliability/risk assessment (refers to fracture mechanics analysis)
SSCs	Structures, systems and components
Tech Specs	Technical specifications

B. DISCUSSION

When a licensee elects to incorporate risk insights into its ISI programs, it is anticipated that the licensee will build upon its existing PRA activities. The five key principles involved in the integrated decisionmaking process are described in detail in Regulatory Guide 1.174. In addition, Regulatory Guide 1.174 describes a four-element process for evaluating proposed risk-informed changes.

The key principles and the section of this guide that addresses each of these principles for RI-ISI programs are as follows.

1. The proposed change meets the current regulations unless it is explicitly related to a requested exemption or rule change. (Regulatory Position 2.1.1)

2. The proposed change is consistent with the defense-in-depth philosophy. (Regulatory Position 2.1.2)

3. The proposed change maintains sufficient safety margins. (Regulatory Position 2.1.3)

4. When proposed changes result in an increase in CDF or risk, the increases should be small and consistent with the intent of the Commission's Safety Goal Policy Statement. (Regulatory Position 2.2)

5. The impact of the proposed change should be monitored by using performance measurement strategies. (Regulatory Position 3)

Section 2 of Regulatory Guide 1.174 describes a four-element process for developing risk-informed regulatory changes. These are: define the change, perform an engineering analysis, define the implementation and monitoring program, and submit the proposed change. The order in which the elements are performed may vary or they may occur in parallel, depending on the particular application and the preference of the program developers. The process is highly iterative. Thus, the final description of the proposed change to the ISI program as defined in Element 1 depends on both the analysis performed in Element 2 and the definition of the implementation of the ISI program performed in Element 3. While ISI is, by its nature, an inspection and monitoring program, it should be noted that the monitoring referred to in Element 3 is associated with making sure that the assumptions made about the impact of the changes to the ISI program are not invalidated. For example, if the inspection intervals are based on an allowable margin to failure, the monitoring is performed to make sure that these margins are not eroded. Element 4 involves preparing the documentation to be submitted to the NRC and to be maintained by the licensee for later reference.

C. REGULATORY POSITION

1. ELEMENT 1: DEFINE THE PROPOSED CHANGES TO ISI PROGRAMS

In this first element of the process, the proposed changes to the ISI program are defined. This involves describing the scope of piping that would be incorporated in the overall assessment and how the inspection of this piping would be changed. Also included in this element is identification of supporting information and a proposed plan for the licensee's interactions with the NRC throughout the implementation of the RI-ISI program.

1.1 Description of Proposed Changes

A full description of the proposed changes in the ISI program is to be prepared. This description should include:

- Identification of the plant's current requirements that would be affected by the proposed RI-ISI program. To provide a basis from which to evaluate the proposed changes, the licensee should also confirm that the plant's design and operation is in accordance with its current requirements and that engineering information used to develop the proposed RI-ISI program is also consistent with the current requirements.

- Identification of the elements of the ISI program to be changed.

- Identification of the piping in the plant that is both directly and indirectly involved with the proposed changes. Any piping not presently covered in the plant's ISI program but categorized as safety significant (e.g., through an integrated decisionmaking process using PRA insights) should be identified and appropriately addressed. In addition, the particular systems that are affected by the proposed changes should be identified since this information is an aid in planning the supporting engineering analyses.

- Identification of the information that will be used to support the changes. This could include performance data, traditional engineering analyses, and PRA information.

- A brief statement describing how the proposed changes meet the intent of the Commission's PRA Policy Statement.

1.2 Changes to Approved RI-ISI Programs

This section provides guidance on the need for licensees to report program activities and guidance on formal NRC review of changes made to RI-ISI programs.

The licensee should implement a process for determining when RI-ISI program changes require formal NRC review and approval. Changes made to the NRC-approved RI-ISI program that could affect the process and results that were reviewed and approved by the NRC staff should be evaluated to ensure that the basis for the staff's approval has not been compromised. All changes should be evaluated using the change mechanisms described in the applicable regulations (e.g., 10 CFR 50.55a, 10 CFR 50.59) to determine whether NRC review and approval are required prior to implementation. If there is a question regarding this issue, the licensee should seek NRC review and approval prior to implementation.

2. ELEMENT 2: ENGINEERING ANALYSIS

As part of defining the proposed change to the licensee's ISI program, the licensee should conduct an engineering evaluation of the proposed change, using and integrating a combination of traditional engineering methods and PRA. The major objective of this evaluation is to confirm that the proposed program change will not compromise defense in depth, safety margins, and other key principles described in this guide and in Regulatory Guide 1.174. Regulatory Guide 1.174 provides general guidance for performing this evaluation, which is supplemented by the RI-ISI guidance herein.

The regulatory issues and engineering activities that should be considered for a risk-informed ISI program are summarized here. For simplicity, the discussions are divided into traditional and PRA analyses. Regulatory Position 2.1 addresses the traditional engineering analysis, Regulatory Position 2.2 addresses the PRA-related analysis, and Regulatory Position 2.3 describes the integration of the traditional and PRA analyses. In reality, many facets of the traditional and PRA analyses are iterative.

The engineering evaluations are to:

- Demonstrate that the change is consistent with the defense-in-depth philosophy;

- Demonstrate that the proposed change maintains sufficient safety margins;

- Demonstrate that when proposed changes result in an increase in CDF or risk, the increase is small and consistent with the intent of the Commission's Safety Goal Policy Statement; and

- Support the integrated decisionmaking process.

The scope and quality of the engineering analyses performed to justify the changes proposed to the ISI programs should be appropriate for the nature and scope of the change. The decision criteria associated with each key principle identified above are presented in the following subsections. Equivalent criteria can be proposed by the licensee if such criteria can be shown to meet the key principles set forth in Section 2 of Regulatory Guide 1.174.

2.1 Traditional Engineering Analysis

This part of the evaluation is based on traditional engineering methods. Areas to be evaluated from this viewpoint include meeting the regulations, defense-in-depth attributes, safety margins, assessment of failure potential of piping segments, and assessment of primary and secondary effects (failures) that result from piping failures.

The engineering analysis for a RI-ISI piping program will achieve the following:

1. Assess compliance with applicable regulations,

2. Perform defense-in-depth evaluation,

3. Perform safety margin evaluation,

4. Define piping segments,

5. Assess failure potential for the piping segment,

6. Assess the consequences (both direct and indirect) of piping segment failure,

7. Categorize the piping segments in terms of safety significance,

8. Develop an inspection program,

9. Assess the impact of changing the ISI program on CDF and LERF, and

10. Demonstrate conformance with the key principles (e.g., maintaining sufficient safety margins, defense in depth consideration, Commission's Safety Goal Policy, etc.).

2.1.1 Assess Compliance with Applicable Regulations

The engineering evaluation should assess whether the proposed changes to the ISI programs would compromise compliance with the regulations. The evaluation should consider the appropriate requirements in the licensing basis and applicable regulatory guidance. Specifically, the evaluation should consider:

- 10 CFR 50.55a
- Appendix A to 10 CFR Part 50
- Appendix B to 10 CFR Part 50
- ASME B&PVC, Section XI (10 CFR Part 50.55a)
- Regulatory Guide 1.84, “Design, Fabrication, and Materials Code Case Acceptability, ASME Section III”

- Regulatory Guide 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1"

In addition, the evaluation should consider whether the proposed changes have affected license commitments. A broad review of the licensing requirements and commitments may be necessary because proposed ISI program changes could affect issues not explicitly stated in the licensee's FSAR or ISI program documentation.

The Director of the Office of Nuclear Regulation is allowed by 10 CFR 50.55a to authorize alternatives to the specific requirements of this regulation provided the proposed alternative will ensure an acceptable level of quality and safety. Thus, alternatives to the acceptable RI-ISI approaches presented in this guide may be proposed by licensees so long as supporting information is provided that demonstrates that the key principles discussed in this guide are maintained.

The licensee should include in its RI-ISI program submittal the necessary exemption requests, technical specification amendment requests (if applicable), and relief requests necessary to implement its RI-ISI program.

NRC-endorsed ASME Code Cases that apply risk-informed ISI programs are consistent with this regulatory guide in that they encourage the use of risk insights in the selection of inspection locations and the use of appropriate and possibly enhanced inspection techniques that are appropriate to the failure mechanisms that contribute most to risk.

2.1.2 Defense-in-Depth Evaluation

As stated in Regulatory Guide 1.174, the engineering analysis should evaluate whether the impact of the proposed change in the ISI program (individually and cumulatively) is consistent with the defense-in-depth philosophy. In this regard, the intent of this key principle is to ensure that the philosophy of defense in depth is maintained, not to prevent changes in the way defense in depth is achieved. The defense-in-depth philosophy has traditionally been applied in reactor design and operation to provide multiple means to accomplish safety functions and prevent the release of radioactive material. It has been and continues to be an effective way to account for uncertainties in equipment and human performance. Where a comprehensive risk analysis can be done, it can be used to help determine the appropriate extent of defense in depth (e.g., balance among core damage prevention, containment failure, and consequence mitigation) to ensure protection of public health and safety. Where a comprehensive risk analysis is not or cannot be done, traditional defense-in-depth consideration should be used or maintained to account for uncertainties. The evaluation should consider the intent of the general design criteria, national standards, and engineering principles such as the single failure criterion. Further, the evaluation should consider the impact of the proposed change on barriers (both preventive and mitigative) to core damage, containment failure or bypass, and the balance among defense-in-depth attributes. The licensee should select the engineering analysis techniques, whether quantitative or qualitative, appropriate to the proposed change (see Regulatory Guide 1.174 for additional guidance).

An important element of defense in depth for RI-ISI is maintaining the reliability of independent barriers to fission product release. Class 1 piping (primary coolant system) is the second boundary between the radioactive fuel and the general public. If a RI-ISI program categorized, for example, all segments in the hot and cold legs of the primary system piping as low safety significant and calculated that, with no inspections, the frequency of leaks would not increase beyond existing performance history of the ASME Code, the staff would continue to require some level of NDE inspection.

2.1.3 Safety Margins

In engineering programs that affect public health and safety, safety margins are applied to the design and operation of a system. These safety margins and accompanying engineering assumptions are intended to account for uncertainties, but in some cases can lead to operational and design constraints that are excessive and costly, or that could detract from safety (e.g., result in unnecessary radiation exposure to plant personnel). Insufficient safety margins may require additional attention. Prior to a request for relaxation of the existing requirements, the licensee must ensure that the uncertainties are adequately addressed. The quantification of uncertainties would likely require supporting sensitivity analyses.

The engineering analyses should address whether the impacts of the changes proposed to the ISI program are consistent with the key principle that adequate safety margins are maintained. The licensee is expected to select the method of engineering analysis appropriate for evaluating whether sufficient safety margins would be maintained if the proposed change were implemented. An acceptable set of guidelines for making that assessment are summarized below. Other equivalent decision criteria could also be found acceptable.

Sufficient safety margins are maintained when:

- Codes and standards (see Regulatory Position 2.1.1) or alternatives approved for use by the NRC are met, and

- Safety analysis acceptance criteria in the licensing basis (e.g., updated FSAR, supporting analyses) are met, or proposed revisions provide sufficient margins to account for analysis and data uncertainty.

2.1.4 Piping Segments

A systematic approach should be applied when analyzing piping systems. One acceptable approach is to divide or separate a piping system into segments; different criteria or definitions can be applied to each piping segment. One acceptable method is to identify segments of piping within the piping systems that have the same consequences of failure. Other methods could subdivide a segment that exhibits a given consequence into segments with similar degradation mechanisms or similar failure potential. The definition of a segment could encompass multiple criteria, as long as a sound engineering and accounting record is maintained and can be applied to an engineering analysis in a consistent and sound process. Consequences of failure may be defined in terms of an initiating event, loss of a particular train, loss of a system, or combinations thereof. The location of the piping in the plant, and whether inside or outside the containment or compartment, should be taken into consideration when defining piping segments.

The definition of a piping segment can vary with the methodology. Defining piping segments can be an iterative process. In general, an analyst may need to modify the description of the piping segments before they are finalized. This guide does not impose any specific definition of a piping segment, but the analysis and the definition of a segment must be consistent and technically sound.

2.1.5 Assess Piping Failure Potential

The engineering analysis includes evaluating the failure potential of a piping segment. Determining the failure potential of piping segments, either with a quantitative estimate or by categorization into groups, should be based on an understanding of degradation mechanisms, operational characteristics, potential dynamic loads, flaw size, flaw distribution, inspection parameters, experience data base, etc. The evaluation should state the appropriate definition of the failure potential (e.g., failure on demand or operating failures associated with the piping, with the basis for the definition) that will be needed to support the PRA or risk assessment. The failure potential used in or in support of the analysis should be appropriate for the specific environmental conditions, degradation mechanisms, and failure modes for each piping location. When data are analyzed to develop a categorization process relating degradation mechanisms to failure potential, the data should be appropriate and publicly available. When an elicitation of expert opinion is used in conjunction with, or in lieu of, probabilistic fracture mechanics analysis or operating data, a systematic process should be developed for conducting such an elicitation. In such cases, a suitable team of experts should be selected and trained (NUREG/CR-5424 and NUREG-1563).

When implementing probabilistic fracture mechanics computer programs that estimate structural reliability and are used in risk assessment of piping, or other analytic methods for estimating the failure potential of a piping segment, some of the important parameters that need to be assessed in the analysis include the identification of structural mechanics parameters, degradation mechanisms, design limit considerations, operating practices and environment, and the development of a data base or analytic methods for predicting the reliability of piping systems. Design and operational stress or strain limits are assessed. This information is available to the licensee in the design information for the plant. The loading and resulting stresses or strains on the piping are needed as input to the calculations that predict the failure probability of a piping segment. The use of validated computer programs, with appropriate input, is strongly recommended in a quantitative RI-ISI program because it may facilitate the regulatory evaluation of a submittal. The analytic method should be validated with applicable plant and industry piping performance data.

To understand the impact of specific assumptions or models used to characterize the potential for piping failure, appropriate sensitivity or uncertainty studies should be performed. These uncertainties include, but are not limited to, design versus fabrication differences, variations in material properties and strengths, effects of various degradation and aging mechanisms, variation in steady-state and transient loads, availability and accuracy of plant operating history, availability of inspection and maintenance program data, applicability and size of the data base to the specific degradation and piping, and the capabilities of analytic methods and models to predict realistic results. Evaluation of these uncertainties provides insights to the input parameters that affect the failure potential and, therefore, require careful consideration in the analysis.

The methodology, process, and rationale used to determine the likelihood of failure of piping segments should be independently reviewed during the final classification of the risk significance of each segment. Referencing applicable generic topical reports approved by the NRC is one acceptable means to standardize the process. When new computer codes are used to develop quantitative estimates, the techniques should be verified and validated against established industry codes and available data. When data are used to evaluate the likelihood of piping failures, the data should be submitted to the NRC or referenced by an NRC-approved topical report. As stated in Regulatory Guide 1.174, "data, methods, and assessment criteria used to support regulatory decisionmaking must be scrutable and available for public review." It is the responsibility of the licensee to provide the data, methods, and justification to support its estimation of the failure potential of piping segments.

2.1.6 Assess Consequences of Piping Segment Failures

When evaluating the risk from piping failures, the analyst needs to evaluate the potential consequences, or failures, that a piping failure can initiate. This can be accomplished by performing a detailed walkdown of a nuclear power facility's piping network. The consequences of the postulated pipe segment failure include direct and indirect effects of the failure. Direct effects include the loss of a train or system and associated possible diversion of flow or an initiating event such as a loss of coolant accident (LOCA) or both. Indirect effects include the spatial effects of flood, spray, pipe whip, or jet impingement that may affect adjacent SSCs or depletion of water sources and loss of associated systems.

2.2 Probabilistic Risk Assessment

In accordance with the Commission’s Policy Statement on PRA, the risk-informed application process is intended not only to support reduction in the number of inspections, but also to identify areas where increased resources should be allocated to enhance safety. Therefore, an acceptable RI-ISI process should not focus exclusively on areas in which reduced inspection could be justified. This section addresses ISI-specific considerations in the PRA to support relaxation of inspections, enhancement of inspections, and validation of component operability.

ASME has published a PRA standard that addresses a Level 1 and limited Level 2 PRA for full-power operation for internal events (excluding internal fire) (ASME RA-S-2002). Other standards for external events (i.e., seismic, wind and flood), low power and shutdown conditions and internal fires are under development by ANS.

The NRC staff is currently developing a regulatory guide to provide guidance to licensees on determining the technical adequacy of a PRA used in a risk-informed integrated decision making process, and to endorse standards and industry guidance (see Draft Regulatory Guide DG-1122). The NRC staff is continuing to evaluate PRAs submitted in support of specific applications using the guidelines given in Section 2.2.3 and Section 2.5 of Regulatory Guide 1.174 and in SRP Chapter 19 of the Standard Review Plan.

The PRA can be used to categorize the piping segments into safety-significant and low-safety-significant classifications (or more classifications, if a finer graded approach is desired) and to confirm that the change in risk caused by the change in the ISI program is in accordance with the guidance of Regulatory Guide 1.174. The licensee's submittal should discuss measures used to ensure adequate quality, such as a report of a peer review, when performed, that addresses the appropriateness of the PRA model for supporting a risk assessment of the change under consideration. The submittal should address any limitations of the analysis that are expected to impact the conclusion regarding the acceptability of the proposed change. The licensee's resolution of the findings of the peer review, certification, or cross comparison, when performed, should also be submitted. This response could indicate whether the PRA was modified or justify why no change to the PRA was necessary to support decisionmaking for the change under consideration.

2.2.1 Modeling Piping Failures in a PRA

Input from the traditional engineering analysis addressed in Regulatory Position 2.1 includes identification of piping segments from the point of view of the failure potential (degradation mechanisms) and consequences (resulting failure modes and consequential primary and secondary effects). The traditional analysis identifies both the primary and secondary effects that can result from a piping failure. The assessment of the primary and secondary failures identifies the portions of the PRA that are affected by the piping failure.

Each pipe segment failure may have one of three types of impacts on the plant.

1. Initiating event failures are when the failure directly causes a transient and may or may not also fail one or more plant trains or systems.

2. Standby failures are those failures that cause the loss of a train or system but which do not directly cause a transient. Standby failures are characterized by train or system unavailability that may require shutdown because of the technical specifications or limiting conditions for operation.

3. Demand failures are failures accompanying a demand for a train or system and are usually caused by the transient-induced loads on the segment during system startup.

The impact of the pipe segment failure on risk should be evaluated with the PRA. Evaluation may involve a quantitative estimate derived from the PRA, a systematic technique to categorize the consequence of the pipe failure on risk, or some combination of quantification and categorization. If a segment failure were to lead to plant transients and equipment failures that are not at all represented in the PRA (a new and specific initiating event, for example), the evaluation process should be expanded to assess these events.

PRAs normally do not include events that represent failure of individual piping segments nor the structural elements within the segments. A quantitative estimate of the impact of segment failures can be done by modifying the PRA logic to systematically and explicitly include the impact of the individual pipe segment failures. The impact of each segment's failure on risk can also be estimated without modifying the PRA's logic by identifying an initiating event, basic event, or group of events, already modeled in the PRA, whose failures capture the effects of the piping segment's failure (referred to as the surrogate approach). In either case, to assess the impact of a particular segment failure, the analyst sets the appropriate events to a failed state in the PRA and requantifies the PRA or the appropriate parts of the PRA as needed. The analysis should appropriately incorporate segment failures that only cause an initiating event, that only degrade or fail a mitigating system required to respond to an independent initiating event, and that simultaneously cause an initiating event and degrade or fail a mitigating system responding to the initiating event. The requantification should explicitly address truncation errors, since cut set or truncated sequences may not fully capture the impact of multiple failure events.

If a systematic technique is used to categorize the consequence of pipe failures, it should also be based on PRA results. In this case, however, the categories may be represented by ranges of conditional results, and instead of quantifying the impact of each segment failure, the process should provide for determining the range within which each segment's failure would lie. In general, the consequences would range from high, for those segments whose failure would have a high likelihood of leading to core damage or large early release, to low for those segments whose failure would likely not lead to core damage or large early release. The licensee should provide a discussion and justification of the ranges selected. The use of ranges instead of individual results estimates may require fewer calculations, but the categorization process and decision criteria should be justified, well defined, and repeatable.

2.2.1.1 Dependencies and Common Cause Failures

The effects of dependencies and common cause failures (CCFs) for ISI components need to be considered carefully because of the significance they can have on CDF. Generally, data are insufficient to produce plant-specific estimates based solely on plant-specific data. For CCFs, data from generic sources may be required.

2.2.1.2 Human Reliability Analyses To Isolate Piping Breaks

For ISI-specific analyses, the human reliability analysis methodology used in the PRA must account for the impact that the piping segment break would have on the operator's ability to respond to the event. In addition, the reliability of the inspection program (including both operator and equipment qualification), which factors into the probability of detection, should also be addressed.

2.2.2 Use of PRA for Categorizing Piping Segments

When the impact of each segment's failure on plant risk metrics has been determined, the safety significance of the segments is developed. The method of categorizing a piping segment can vary. For example, if the pipe failure event frequency or probability is estimated and the events are incorporated into the PRA logic model, importance measure calculations and the determination of safety significance, as discussed in Regulatory Guide 1.174 and SRP Chapter 19, may be performed. Alternatively, if a conditional core damage frequency (CCDF), conditional large early release frequency (CLERF), conditional core damage probability (CCDP), or conditional large early release probability (CLERP) (depending on the impact the segment failure has on the plant) is estimated for each segment from the PRA, a CDF and LERF caused only by pipe failures may be developed by combining the conditional consequences and segment failure probabilities or frequencies external to the PRA logic model. Importance measures can also be developed using these results and these measures compared to appropriate threshold criteria to support the determination of the safety significance of each segment. The calculations used in such a process should yield well-defined estimates of CDF, LERF, and importance measures. The licensee should provide a discussion of and justification for the threshold criteria used.

As discussed in Regulatory Position 2.2.1, the consequence of segment failures may be represented by categories of consequences instead of quantitative estimates for each segment. In this case, the potential for pipe failure as discussed in Regulatory Position 2.1.5 would also be developed as categories ranging from high to low depending on the degradation mechanisms present and the corresponding likelihood that the segment will fail. These consequence and failure likelihood categories should be systematically combined to develop categories of safety significance. The licensee should provide a discussion and justification relating the consequence and failure likelihood categories to the safety-significant category assigned to each combination.

The safety-significance category of the pipe segment will help determine the level of inspection effort devoted to the segment. In general, safety-significant segments will receive more inspections and more demanding inspections than low safety-significant segments. In any integrated categorization process, the principles in Regulatory Guide 1.174 need to be addressed. Irrespective of the method used in the analysis, the licensee needs to justify the final categorization process as being robust and reasonable with respect to the analysis uncertainties.

2.2.3 Demonstrate Change in Risk Resulting from Change in ISI Program

Any change in the ISI program has an associated risk impact. Evaluation of the change in risk may be a detailed calculation or it may be a bounding estimate supported by sensitivity studies as appropriate. The change may be a risk increase, a risk decrease, or risk neutral. The change is evaluated and compared with the guidelines presented in Regulatory Guide 1.174. The staff expects that a RI-ISI program would lead to both risk reduction and reduction in radiation exposure to plant personnel.

The change in risk estimate should appropriately account for the change in the number of elements inspected and the effects of enhanced inspection. The methods used to determine the piping failure potential, the piping failure consequence, and the impact of the change in the number of inspections should together provide confidence that any increase in CDF or risk is small and acceptable in accordance with Regulatory Guide 1.174 guidelines and consistent with the intent of the Commission's Safety Goal Policy Statement.

2.3 Integrated Decisionmaking

Regulatory Positions 2.1 and 2.2 address the elements of traditional analysis and PRA analysis of a RI-ISI program. These elements are part of an integrated decisionmaking process that assesses the acceptability of the program. The key principles of Regulatory Guide 1.174 are systematically addressed. Technical and operations personnel at the plant review the information and render a finding of the safety-significance category for each piping segment under review. Detailed guidelines for the categorization of piping segments should be developed and discussed with the group responsible for the determination (typically performed by the plant's expert panel).

The method for selecting the number of piping elements to be inspected should be justified.

3. ELEMENT 3: IMPLEMENTATION, PERFORMANCE MONITORING, AND CORRECTIVE ACTION STRATEGIES

Integrating the information obtained from Elements 1 and 2 of the RI-ISI process (as described in Regulatory Positions 1 and 2 of this guide), the licensee develops proposed RI-ISI implementation, performance monitoring, and corrective action strategies. The RI-ISI program should identify piping segments whose inspection strategy (i.e., frequency, number of inspections, methods, or all three) should be increased as well as piping segments whose inspection strategies might be relaxed. The number of required inspections should be a product of the systematic application of the risk-informed process. The program should be self-correcting as experience dictates. The program should contain performance measures used to confirm the safety insights gained from the risk analyses.

3.1 Program Implementation

A licensee should have in place a schedule for inspecting all segments categorized as safety significant in its RI-ISI program. This schedule should include inspection strategies and inspection frequencies, inspection methods, the sampling program (the number of elements/areas to be inspected, the acceptance criteria, etc.) for the safety-significant piping that is within the scope of the ISI program, including piping segments identified as safety significant that are not currently in the ISI program.

The analysis for a RI-ISI program will, in most cases, confirm the appropriateness of the inspection interval and scope requirements of the ASME Boiler and Pressure Vessel Code (B&PVC) Section XI Edition and Addenda committed to by a licensee in accordance with 10 CFR 50.55a. The requirements for these intervals are contained in Section XI of the B&PVC. However, should active degradation mechanisms surface, the inspection interval would be modified as appropriate. Updates to the RI-ISI program should be performed at least periodically to coincide with the inspection program requirements contained in Section XI under Inspection Program B. The RI-ISI program should be evaluated periodically as new information becomes available that could impact the ISI program. For example, if changes to the PRA impact the decisions made for the RI-ISI program, if plant design and operations change such that they impact the RI-ISI program, if inspection results identify unexpected flaws, or if replacement activities impact the failure potential of piping, the effects of the new information should be assessed. The periodic evaluation may result in updates to the RI-ISI program that are more restrictive than required by Section XI. As plant design feature changes are implemented, changes to the input associated with the RI-ISI program segment definition and element selections should be reviewed and modified as needed. Changes to piping performance, the plant procedures that can affect system operating parameters, piping inspection, component and valve lineups, equipment operating modes, or the ability of the plant personnel to perform actions associated with accident mitigation should be reviewed in any RI-ISI program update. Leakage and flaws identified during scheduled inspections should be evaluated as part of the RI-ISI update.

Piping segments categorized as safety significant that are not in the licensee's current ISI program should (wherever appropriate and practical) be inspected in accordance with applicable ASME Code Cases (or revised ASME Code), including compliance with all administrative requirements. Where ASME Section XI inspection is not practical or appropriate, or does not conform to the key principles identified in this document, alternative inspection intervals, scope, and methods should be developed by the licensee to ensure piping integrity and to detect piping degradation. A summary of the piping segments and their proposed inspection intervals and scope should be provided to the NRC prior to implementation of the RI-ISI program at the plant.

For piping segments categorized as safety significant that were the subject of a previous NRC-approved relief request or were exempt under existing Section XI criteria, the licensee should assess the appropriateness of the relief or exemption in light of the risk significance of the piping segment.

3.2 Performance Monitoring

3.2.1 Periodic Updates

The RI-ISI program should be updated at least on the basis of periods that coincide with the inspection program requirements contained in Section XI under Inspection Program B. These updates should be performed more frequently if dictated by any plant procedures to update the PRA (which may be more restrictive than a Section XI period type update) or as new degradation mechanisms are identified.

3.2.2 Changes to Plant Design Features

As changes to plant design are implemented, changes to the inputs associated with RI-ISI program segment definition and element selections may occur. It is important to address these changes to the inputs used in any assessment that may affect resultant pipe failure potentials used to support the RI-ISI segment definition and element selection. Some examples of these inputs would include:

- Operating characteristics (e.g., changes in water chemistry control)
- Material and configuration changes
- Welding techniques and procedures
- Construction and preservice examination results
- Stress data (operating modes, pressure, and temperature changes)

In addition, plant design changes could result in significant changes to a plant's CDF or LERF, which in turn could result in a change in consequence of failure for system piping segments.

3.2.3 Changes to Plant Procedures

Changes to plant procedures that affect ISI, such as system operating parameters, test intervals, or the ability of plant operations personnel to perform actions associated with accident mitigation, should be included for review in any RI-ISI program update. Additionally, changes in those procedures that affect component inspection intervals, valve lineups, or operational modes of equipment should also be assessed for their impact on changes in postulated failure mechanism initiation or CDF/LERF contribution.

3.2.4 Equipment Performance Changes

Equipment performance changes should be reviewed with system engineers and maintenance personnel to ensure that changes in performance parameters such as valve leakage, increased pump testing, or identification of vibration problems is included in the periodic evaluation of the RI-ISI program update. Specific attention should be paid to these conditions if they were not previously assessed in the qualitative inputs to the element selections of the RI-ISI program.

3.2.5 Examination Results

When scheduled RI-ISI program NDE examinations, pressure tests, and corresponding VT-2 visual examinations for leakage have been completed, and if unacceptable flaws, evidence of service related degradation, or indications of leakage have been identified, the existence of these conditions should be evaluated. This update of the RI-ISI program should follow the applicable elements of Appendix B to 10 CFR Part 50 to determine the adequacy of the scope of the inspection program.

3.2.6 Information on Individual Plant and Industry Failures

Review of individual plant maintenance activities associated with repairs or replacements, including identified flaw evaluations, is an important part of any periodic update, regardless of whether the activity is the result of a RI-ISI program examination. Evaluating this information as it relates to a licensee's plant provides failure information and trending information that may have a profound effect on the element locations currently being examined under a RI-ISI program. Industry failure data is just as important to the overall program as the owner's information. During the periodic update, industry data bases (including available international data bases) should be reviewed for applicability to the owner's plant.

3.3 Corrective Action Programs

Each licensee of a nuclear power plant is responsible for having a corrective action program, consistent with Regulatory Guide 1.174. Measures are to be established to ensure that conditions adverse to quality, such as failures, malfunctions, deficiencies, deviations, defective material and equipment, and nonconformances, are promptly identified and corrected. In the case of significant conditions adverse to quality, the measures must ensure that the cause of the condition is determined and corrective action is taken to preclude repetition. The identification of the significant condition adverse to quality, the cause of the condition, and the corrective action are to be documented and reported to appropriate levels of management.

For Code piping categorized as safety significant, this corrective action program should be consistent with applicable Section XI provisions. For non-Code and Code-exempt piping categorized as safety significant, appropriate Section XI provisions should also be used, or the licensee should submit an alternative program based on the risk significance of the piping.

3.4 Acceptance Guidelines

These acceptance guidelines are for the implementation, monitoring, and corrective action programs for the accepted RI-ISI program plan.

1. The evaluation of the implementation program will be based on the attributes presented in Regulatory Positions 3.1 through 3.3 of this Regulatory Guide 1.178.

2. The corrective action program should provide reasonable assurance that a nonconforming component will be brought back into conformance in a timely fashion. The corrective actions required in ASME Section XI should continue to be followed.

3. Evaluations within the corrective action program may also include:

   - Ensuring that the root cause of the condition is determined and that corrective actions are taken to preclude repetition. The identification of the significant condition adverse to quality, the cause of the condition, and the corrective action are to be documented and reported to appropriate levels of management.

   - Determining the impact of the failure or nonconformance on system or train operability since the previous inspection.

- Assessing the applicability of the failure or nonconforming condition to other components in the RI-ISI program.

- Correcting other susceptible RI-ISI components as necessary.

- Incorporating the lessons in the plant data base and computer models, if appropriate.

- Assessing the validity of the failure rate and unavailability assumptions that can result from piping failures used in the PRA or in support of the PRA, and

- Considering the effectiveness of the component's inspection strategy in detecting the failure or nonconforming condition. The inspection interval would be reduced or the inspection methods adjusted, as appropriate, when the component (or group of components) experiences repeated failures or nonconforming conditions.

4. The corrective action evaluation should be provided to the licensee's PRA and RI-ISI groups so that any necessary model changes and regrouping are done, as appropriate.

5. The RI-ISI program documents should be revised to document any RI-ISI program changes resulting from the corrective actions taken.

6. A program is in place that monitors industry findings.

7. Piping is subject to examination. The examination requirements include all piping evaluated by the risk-informed process and categorized as safety significant.

8. The inspection program is to be completed during each ten-year inspection interval with the following exceptions.

   8.1 If, during the interval, a re-evaluation using the RI-ISI process is conducted and scheduled items are no longer required to be examined, these items may be eliminated.

   8.2 If, during the interval, a re-evaluation using the RI-ISI process is conducted and items must be added to the examination program, those items will be added.

9. If additional examinations are needed following the identification of unacceptable flaws, additional examinations will be performed on the elements with the same root cause or degradation mechanisms as the identified flaw or relevant condition. The number of additional examinations should be equivalent to the number of elements required to be inspected during the current

outage. If unacceptable flaws or relevant conditions are again found similar to the initial problem, the remaining elements identified as susceptible will be examined. All additional examinations should be performed during the current outage.

10. Examination and Pressure Test Requirements. Pressure testing and VT-2 visual examinations are to be performed on Class 1, 2, and 3 piping systems in accordance with Section XI, as specified in the licensee's ISI program. The pressure testing and VT-2 examinations are also to be performed on non-Code safety-significant piping. The non-Code safety-significant piping will be treated as ASME Code Class piping for the purposes of examination and pressure testing.

    Examination methods, equipment qualification, personnel qualification, and procedure qualification are to be in accordance with the edition and addenda endorsed by the NRC through 10 CFR 50.55a, "Codes and Standards."

11. Acceptance standards for identified flaws and repair or replacement activities are to be performed in accordance with the B&PVC Section XI requirements.

12. Records and reports should be prepared and maintained in accordance with the B&PVC Section XI Edition and Addenda as specified in the licensee's ISI program.

4. ELEMENT 4: DOCUMENTATION

The recommended contents for a plant-specific risk-informed ISI submittal are presented here. This guidance will help ensure the completeness of the information provided and aid in minimizing the time needed for the review process.

4.1 Documentation that Should Be Included in a Licensee's RI-ISI Submittal

References to NRC-approved generic topical reports that address the methodology and issues requested in a submittal are acceptable. Documentation guidelines specified in approved topical reports may be used instead of the following guidelines when the methodology from an approved topical report is used. Since topical reports could cover more issues than applied by a licensee or the licensee may elect to deviate from the full body of issues addressed in the topical report, such distinctions should be clearly stated.

The following items should be included in the application to implement a RI-ISI program.

- A request to implement a RI-ISI program as an authorized alternative to the current NRC endorsed ASME Code pursuant to 10 CFR 50.55a(a)(3)(i). The licensee should also provide a description of how the proposed change impacts any commitments made to the NRC.

- Discussions on each of the following five key principles of risk-informed regulations (see Section 2 of Regulatory Guide 1.174 for more details).

1. The proposed change meets the current regulations unless it is explicitly related to an alternative requested under 10 CFR 50.55a(a)(3)(i), a requested exemption, or a rule change.

2. The proposed change is consistent with the defense-in-depth philosophy (see detailed discussions in Section 2.2.1.1 of Regulatory Guide 1.174).

3. The proposed change maintains sufficient safety margins (see detailed discussions in Section 2.2.1.2 in Regulatory Guide 1.174).

4. When proposed changes result in an increase in CDF and/or risk, the increases should be small and consistent with the guidance in Regulatory Guide 1.174.

5. The impact of the proposed change should be monitored using performance measurement strategies.

- Identification of the aspects of the plant's current requirements that would be affected by the proposed RI-ISI program. This identification should include all commitments and augmented programs (for example, the IGSCC inspections and other commitments arising from generic letters affecting piping integrity) that the licensee intends to change or terminate as part of the RI-ISI program. The application of the RI-ISI methodology to incorporate and change the augmented program should be justified.

- Identification of the specific revisions to existing inspection schedules, locations, and methods that would result from implementation of the proposed program.

- Plant procedures or documentation containing the guidelines for all phases of evaluating and implementing a change in the ISI program based on probabilistic and traditional insights. These should include a description of the integrated decisionmaking process and criteria used for categorizing the safety significance of piping segments, a description of how the integrated decisionmaking was performed, a description and justification of the number of elements to be inspected in a piping segment, the qualifications of the individuals making the decisions, and the guidelines for making those decisions.

- The results of the licensee's ISI-specific analyses used to support the program change with enough detail to be clearly understandable to the reviewers of the program. These results should include the following information.

  - A list of the piping systems reviewed.

  - A list of each segment, including the number of welds, weld type, and properties of the welding material and base metal, the failure potential, CDF, CCDF/CCDP, LERF, CLERF, importance measure results (risk achievement worth (RAW), Fussel-Vesely (F-V), etc.) and justification of the associated threshold values, degradation mechanism, test and inspection intervals used in or in support of the PRA, etc. Results from other methods used to develop the consequences and categorization of each segment (or weld) should be documented in a similar level of detail.

- The degradation mechanisms for each segment (if segments contain welds exposed to different degradation mechanism, for each weld) used to develop the failure potential of each segment. For the selected limiting locations, provide examples of the failure mode, failure potential, failure mechanism, weld type, weld location, and properties of the welding material and base metal.

- A detailed description and justification for the number of elements to be inspected.

- Equipment assumed to fail as a direct or indirect consequence of each segment's failure (if segments contain welds with different failure consequences, for each weld).

- A description of how the impact of the change between the current Section XI and the proposed RI-ISI programs is evaluated or bounded, and how this impact compares with the risk guidelines in Section 2.2.2.2 of Regulatory Guide 1.174.

• The means by which failure probabilities, frequencies, or potential were determined.

• A description of the PRA used for the categorization process and for the determination of risk impact, in terms of the process to ensure quality, scope, and level of detail, and how limitations in quality, scope, and level of detail are compensated for in the integrated decisionmaking process supporting the ISI submittal. At a minimum, the submittal should include the following information.

  - The CDF and LERF estimates and the version, calculation, or other reference number that identifies which version of the PRA was used.

  - A description of the process used to up-date the PRA to ensure that the PRA analyses adequately represent the current design, construction, operational practices, and operational experience of the plant and its operator.

- A description of the staff and industry reviews performed on the PRA.[3] Limitations, weakness, or improvements identified by the reviewers that could change the results of the PRA should be discussed. The resolution of the reviewer comments, or an explanation of the insensitivity of the analysis used to support the submittal to the comment, should be provided.

- If the submittal includes modified inspection intervals, the methodology and results of the analysis should be submitted.

- A description of the implementation, performance monitoring, and corrective action strategies and programs in sufficient detail for the staff to understand the new ISI program and its implications.

- Applicable documentation discussed under the cumulative risk documentation for submittal in Section 1.3 of Regulatory Guide 1.174.

- Reference to NRC-approved topical reports on implementing a RI-ISI and supporting documents. Variations from the topical reports and supporting documents should be clearly identified.

4.2 Documentation that Should Be Available Onsite for Inspection

The licensee should maintain at its facility the technical and administrative records used in support of its submittal or should be able to generate the information on request. This information should be available for NRC review and audit. If changes are planned to the ISI program based on internal procedures and without prior NRC approval, the following information should also be placed in the plant's document control system so that the analyses for any given change can be identified and reviewed. The record should include, but not be limited to, the following information:

- All the documentation discussed in 4.1. Although the documentation requirements in a submittal may be reduced when referring to NRC-approved topical reports, all the documentation included under 4.1 should be available for onsite inspection.

- Plant and applicable industry data used in support of the RI-ISI program. All analyses and assumptions used in support of the RI-ISI program and communications with outside organizations supporting the RI-ISI program (e.g., use of peer and independent reviews, use of expert contractors).

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[3] In April 2000, the Nuclear Energy Institute submitted a process (Letter to S.J. Collins, NRC) for peer review of licensee PRAs. It was submitted for staff review in the context of its use in categorizing SSCs with respect to special treatment requirements (i.e., supporting NRC's risk-informed proposed rulemaking to add new section 10 CFR 50.69, "Risk-Informed Categorization and Treatment of Structures, Systems, and Components""Option 2" work (SECY-02-0176)). This process, when endorsed by the NRC, may also be of use in making licensing basis changes (as well as other regulatory activities not addressed here); if so, future revisions of this regulatory guide may endorse this certification process for this purpose.

- Detailed procedures and analyses performed by an expert panel, or other technical groups, if relied upon for the RI-ISI program, including a record of deliberations, recommendations, and findings.

- Documentation of the plant's baseline PRA used to support the ISI submittal should be of sufficient detail to allow an independent reviewer to ascertain whether the PRA reflects the current plant configuration and operational practices commensurate with the role the PRA results play in the integrated decisionmaking process. In addition to documentation on the PRA itself, analyses performed in support of the ISI submittal should be documented in a manner consistent with the baseline documentation. Such analyses may include:

  - The process used to identify initiating events developed in support of the RI-ISI submittal and the results from the process.

  - Any event and fault trees developed during the RI-ISI submittal preparation.

  - Documentation of the methods and techniques used to identify and quantify the impact of pipe failures using the PRA, or in support of the PRA, if different from those used during the development of the baseline PRA.

  - The techniques used to identify and quantify human actions.

  - The data used in any uncertainty calculations or sensitivity calculations, consistent with the guidance provided in Regulatory Guide 1.174.

  - How uncertainty was accounted for in the segment categorization, as well as the sensitivity studies performed to ensure the robustness of the categorization.

- Detailed results of the inspection program corresponding to the ISI inspection records described in the implementation, performance monitoring, and corrective action program accompanying the RI-ISI submittal.

- For each piping segment, information on weld type, weld location, and properties of welding material and base metal.

- For each piping segment, information regarding the process and assumptions used to develop failure mode and failure potential (frequency/probability), in addition to the identification of the failure mechanism.

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[7] Electronic copies are available at <WWW.NRC.GOV> in the Document Collections under Commission papers. Copies are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike (first floor), Rockville, MD; the PDR’s mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or 1-(800)397-4209; fax (301)415-3548; e-mail <PDR@NRC.GOV>.

REGULATORY ANALYSIS

A separate regulatory analysis was not prepared for this regulatory guide. The regulatory analysis prepared for Draft Regulatory Guide DG-1063, October 1997, provides the regulatory basis for this regulatory guide as well. DG-1063 was issued for public comment as the draft of this regulatory guide. A copy of the regulatory analysis is available for inspection and copying for a fee at the U.S. Nuclear Regulatory Commission Public Document Room, 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301)415-4737 or 1-(800)397-4209; fax (301)415-3548; e-mail <PDR@NRC.GOV>.