March 3, 2003

MEMORANDUM TO: Hossein Hamzehee, Acting Chief
Probabilistic Risk Analysis Branch
Division of Risk Analysis & Applications

FROM: Jit Singh /RA/
Probabilistic Risk Analysis Branch
Division of Risk Analysis & Applications

W. Brad Hardin /RA/
Probabilistic Risk Analysis Branch
Division of Risk Analysis & Applications

SUBJECT: NOTICE OF PUBLIC MEETING WITH INTERESTED STAKEHOLDERS FOR DISCUSSION REGARDING THE DRAFT REVISED REGULATORY GUIDE 1.178, "AN APPROACH FOR PLANT SPECIFIC RISK-INFORMED DECISIONMAKING FOR INSERVICE INSPECTION OF PIPING, AND STANDARD REVIEW PLAN CHAPTER 3.9.8"

DATE AND TIME: Thursday, March 13, 2003
9:00 a.m. - 4:30 p.m.

LOCATION: USNRC Two White Flint Bldg, Auditorium

PURPOSE: To provide for interaction between the NRC and stakeholders on the staff's draft revisions to Regulatory Guide 1.178, "An Approach for Plant Specific Risk-Informed decisionmaking for Inservice Inspection of Piping," and the associated Standard Review Plan Chapter 3.9.8. Attachment 1 is the agenda for the meeting.

Persons other than NRC staff and NRC contractors interested in making a presentation at the meeting should notify Jit Singh, (301) 415-6243, email: axs3@nrc.gov, ; or Brad Hardin, (301) 415-6561, email: wbh@nrc.gov; Office of Nuclear Regulatory Research, MS: T-10E50, U.S. Nuclear Regulatory Commission, Washington, D.C. 20555-0001,

Attachment: Preliminary Agenda

cc: See next page

*Meetings between the NRC technical staff and applicants or licensees are open for interested members of the public, petitioners, interveners, or other parties to attend as observers pursuant to "Commission Policy Statement on Staff Meeting Open to the Public," 65 Federal Register 56964, 9/20/2000. Members of the public who wish to attend should contact Jit Singh or Brad Hardin at the above addresses.

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Attachment 1

DRAFT REVISED REGULATORY GUIDE

"AN APPROACH FOR PLANT SPECIFIC RISK-INFORMED DECISIONMAKING FOR INSERVICE INSPECTION OF PIPING"
AND STANDARD REVIEW PLAN 3.9.8

PUBLIC MEETING

March 13, 2003

Nuclear Regulatory Commission Two White Flint Auditorium

PRELIMINARY AGENDA

9:00 am - 9:20	Introduction/Opening Remarks, Meeting Objectives	(Scott Newberry & Mike Mayfield)
9:20 - 10:30	Final Agenda, Background/History of Risk-Informed ISI Activities	(Syed Ali)
10:30 - 10:10:45	BREAK	
10:45 - 11:30	Revisions to RG 1.178	(Syed Ali)
11:30 - 1:00 pm	LUNCH	
1:00 pm - 1:30	Revisions to SRP Chapter 3.9.8	(Steve Dinsmore & Andrea Keim)
1:30 - 2:30	Industry Presentations	
2:30 - 2:45	BREAK	
2:45 - 4:00	Open Discussion	
4:00 - 4:30	Summary	
	Adjourn	

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REGULATORY RESEARCH

REGULATORY GUIDE

DRAFT

REGULATORY GUIDE 1.178
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 (Ref. 1) 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 (Ref. 2). This regulatory guide, which addresses inservice inspection of piping (ISI), with its companion Standard Review Plan, Section 3.9.8 of NUREG-0800 (Ref. 3), and other regulatory documents (Refs. 4-10), 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 (Ref. 4). The regulatory guide issued for trial use did not establish any final staff positions, and could be revised in response to experience with its use. As such, the trial regulatory guide did not establish a staff position for purposes of the Backfit Rule, 10 CFR 50.109, and any changes to the regulatory guide prior to staff adoption in final form will not be considered to be backfits as defined in 10 CFR 50.109(a)(1). This will ensure that the lessons learned from regulatory review of the pilot plants are 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.

In December 1998, and October 1999, the staff approved two methods describing how risk-informed ISI programs can be developed and implemented. One methodology (Ref. 11) was developed by the Electric Power Research Institute (EPRI). The other methodology (Ref. 12) was developed by the Westinghouse Owners Group (WOG). The draft regulatory guide for trial use was used to support the review and approval of the two industry developed methodologies. Based on the experience developed during the review and approval of the industry methodologies and the review and approval of numerous plant specific relief requests, the staff in now issuing this updated final version of this regulatory guide.

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 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 in support of proposed changes to a plant's design, operations, and other activities that require NRC approval. 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 (Ref. 1). 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 shall 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 November 27, 1995, 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 2000 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 (ASME) Boiler and Pressure Vessel Code (BPVC) (Ref. 14) 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 (Ref. 4). 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 (Ref. 4), this regulatory guide focuses on the use of PRA in support of a risk-informed 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 risk-informed ISI programs would amend their final safety analysis report (FSAR, Sections 5.3.4 and 6.6) accordingly. A Standard Review Plan (SRP) (Ref. 3) has been prepared for use by the NRC staff in reviewing RI-ISI applications.

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 (Ref. 4). 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 an uniquely identified sub-set 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

  1. 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.

  2. Non-safety-related structures, systems or components:

     1. 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 (Ref. 4).

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. 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

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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 included those system components or portions of systems important to safety that are designed to provide cooling water and auxiliary feedwater for the front-line systems.

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 (Ref. 4). 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. Regulatory Guide 1.174 describes a general approach to risk-informed regulatory decisionmaking and discusses specific topics common to all risk-informed regulatory applications. Topics addressed include:

- PRA quality - data, assumptions, methods, peer review,
- 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,
- Risk metrics - core damage frequency, large early release frequency and 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 document 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 collection of information unless it displays a currently valid OMB control number.

Abbreviations and Definitions

ASME American Society of Mechanical Engineers

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

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 Spec	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 (Ref. 4). 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 core damage frequency 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. 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 (Ref. 4). 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 core damage frequency 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

    - Criterion I, "Overall Requirements"

  - Criterion II, "Protection of Multiple Fission Product Barriers"
  - Criterion III, "Protection and Reactivity Control Systems"
  - Criterion IV, "Fluid Systems," etc

- ASME Boiler and Pressure Vessel Code, Section XI (10 CFR Part 50.55a)
- Regulatory Guide 1.84 (Ref. 15)
- Regulatory Guide 1.85 (Ref. 16)
- Regulatory Guide 1.147 (Ref. 17)
- Appendix B to 10 CFR Part 50.

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 (Ref. 4), 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, Reference 4, 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, no segments in the hot and cold legs of the primary system piping as 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 (Ref. 18, 19).

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 (Ref. 4), "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 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.

The general methodology for using PRA in regulatory applications is discussed in Regulatory Guide 1.174. The PRA can be used to categorize the piping segments into safety significant and non safety significant classification (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 (Ref. 4).

If a licensee elects to use PRA to enhance or modify its 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 will also apply to the PRA. In this context, therefore, a licensee would be expected to control PRA activity in a manner commensurate with its impact on the facility's design and licensing basis and in accordance with all applicable regulations and its QA program description. An independent peer review can be an important element in ensuring this quality. 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 report 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 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 requantification should explicitly address truncation errors, since cut set or truncated sequences may not fully capture the impact of multiple failure events. This yields conditional CDF (CCDF) and conditional LERF (CLERF) estimates when the segment failure would trip the plant, and conditional core damage probabilities (CCDP) and conditional large early release probabilities (CLERP) when the segment failure would not trip the plant.

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

Once 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 (Refs. 4 and 8), may be performed. Alternatively, if a CCDF, CLERF, CCDP, or 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, higher safety significant segments will receive more inspections and more demanding inspections than non 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 neutrality. 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, when feasible, 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 the estimated change in risk is a realistic or a bounding estimate. Realistic estimates should include an evaluation of the uncertainty in the estimate.

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 (Ref. 4), 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 (Ref. 4). 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 reevaluation 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 reevaluation 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 an unacceptable flaws, additional examinations will be performed on those elements with the same root cause or degradation mechanisms as the identified flaw or relevant condition. The number of additional examinations shall 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.

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.

    Examination qualification and methods and personnel 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 requirements specified in approved topical reports may be used instead of the following requirements. 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 (Ref. 4) for more details).

  – 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.

- 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).

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

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

- 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 (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.

• 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 (RAW, 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 or 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.

• 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 (Ref. 4).

• 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).

- 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, and 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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REGULATORY ANALYSIS

A draft regulatory analysis was published with the draft of this guide when it was published for public comment (Task DG-1063, October 1997). No changes were necessary, so a separate regulatory analysis for Regulatory Guide 1.178 has not been prepared. A copy of the draft regulatory analysis is available for inspection or copying for a fee in the NRC's Public Document Room at 2120 L Street NW., Washington, D.C., under Task DG-1063.

UNITED STATES NUCLEAR REGULATORY COMMISSION

STANDARD REVIEW PLAN

OFFICE OF NUCLEAR REACTOR REGULATION

DRAFT

Standard Review Plan
For the Review of Risk-Informed
Inservice Inspection of Piping

SRP Chapter 3.9.8

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Standard Review Plan

For the Review of Risk-Informed Inservice Inspection of Piping

FOREWORD

The U.S. Nuclear Regulatory Commission's (NRC) policy statement on probabilistic risk assessment (PRA) (Ref. 1) encourages greater use of this analysis technique to improve safety decisionmaking and improve regulatory efficiency. The NRC staff's Risk-Informed Regulation Implementation Plan (Ref. 2) describes activities now under way or planned to expand this use. These activities include, for example, providing guidance for NRC inspectors on focusing inspection resources on risk-important equipment.

This Standard Review Plan (SRP) chapter describes review procedures and acceptance guidelines for NRC staff reviews of proposed plant-specific, risk-informed changes to a licensee's inservice inspection (ISI) program for piping. The review procedures contained in this SRP are consistent with the approach for using probabilistic risk assessment in risk-informed decisions on plant-specific changes to the licensing basis described in RG 1.174 (Ref. 3) and acceptable methods for implementing a risk-informed ISI (RI-ISI) program described in RG 1.178 (Ref. 4). Licensees may propose RI-ISI programs consistent with the guidance provided in RG 1.178 (Ref. 4), propose an approach consistent with the methodologies approved by the NRC staff (Ref. 5 and 6) or maintain their ISI program in accordance with the American Society of Mechanical Engineers (ASME) Code as referenced in *10 CFR 50.55a.*

It is the NRC staff's intention to initiate rulemaking as necessary to permit licensees to implement RI-ISI programs, consistent with this SRP chapter, without having to get NRC approval of an alternative to the ASME Code requirements pursuant to *10 CFR 50.55a(a)(3)*. Until the completion of such rulemaking, the staff anticipates reviewing and approving each licensee's RI-ISI program as an alternative to the current Code required ISI program. As such, the licensee's RI-ISI program will be enforceable under *10 CFR 50.55a.*

The current ASME Code inservice inspection requirements, as endorsed in *10 CFR 50.55a*, have been determined to provide reasonable assurance that public health and safety will be maintained. The individual ASME Code committees concerned with inservice inspection continually review these inspection strategies to develop improvements to the existing Code requirements (Ref. 7, 8, 9). Changes to the ASME Code, either as new Code editions or Code Cases, are subject to review and approval by the NRC to ensure that the new inspection requirements maintain an adequate level public health and safety. A risk-informed inservice inspection program, if properly constructed, will also provide an acceptable level of quality and safety by evaluating and possibly improving the inspection effectiveness for the safety significant piping (as identified by the licensee's integrated decision making process) in conjunction with the relaxation of inspection requirements for the remaining piping.

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3.9.8 RISK-INFORMED INSERVICE INSPECTION

REVIEW RESPONSIBILITIES

Primary: Materials and Chemical Engineering Branch (EMCB)
Secondary: Probabilistic Safety Assessment Branch (SPSB)

I. AREAS OF REVIEW

The purpose of this standard review plan is to describe the procedure that the NRC staff will utilize to review risk-informed inservice inspection programs for piping that are different from the current ISI programs at a nuclear power facility. In implementing risk-informed decision making, the licensee must ensure that any proposed change to the ISI program or the regulation meets the following key principles:

1. The proposed change meets the current regulations unless it is explicitly related to the request for alternatives under *10 CFR 50.55a(a)(3)* or a requested exemption or rule change, i.e., a "specific exemption" under 10 CFR 50.12 or a "petition for rulemaking" under 10 CFR 2.802.

2. The proposed change is consistent with the defense-in-depth philosophy.

3. The proposed change maintains sufficient safety margins.

4. When proposed changes result in an increase in core damage frequency or risk, the increases should be small and consistent with the intent of the Commission's Safety Goal Policy Statement (Ref. 10).

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

Each of these principles should be considered in the risk-informed, integrated decisionmaking process. Given these principles of risk-informed decision making, the staff has identified a four-element approach that forms the basis for evaluating proposed changes to a plant's ISI program based on risk-informed methods. This approach is not sequential in nature; rather, it is iterative.

The first element involves the characterization of the proposed change. The licensee should identify those aspects of the plant's licensing bases that may be affected by the proposed change in ISI requirements, including, but not limited to, rules and regulations, final safety analysis report

(FSAR), technical specifications, licensing conditions, and licensing commitments. The licensee should also identify all aspects and elements of the ISI program that it intends to modify in future evaluations without prior NRC approval of the change. Piping systems, segments, and welds that are affected by the change in ISI program should be identified. Plant systems and functions that rely on the affected piping should also be identified. Industry and plant specific information applicable to the piping degradation mechanisms that characterizes the relative effectiveness of past inspections should be documented.

As part of the second element, the licensee should evaluate the proposed change with regard to the principles that the proposed change is consistent with the defense-in-depth philosophy, that sufficient margins are maintained, and that proposed increases in core damage frequency and risk are small and are consistent with the intent of the Commission’s Safety Goal Policy Statement as discussed in RG 1.174 (Ref. 3). This element consists of engineering evaluations, including traditional engineering analyses as well as PRAs. The PRA-based assessment of the proposed change should explicitly consider the affected piping segments and assess the impact on the core damage frequency (CDF) and large early release frequency (LERF) caused by changing the licensee’s current ISI program. The results of the complementary traditional and PRA methods should be used in an integrated decisionmaking process.

The third element involves developing implementation and monitoring programs. The primary goal for this element is to assess the performance of piping under the proposed change by establishing performance-monitoring strategies to confirm the assumptions and analyses that were conducted to justify the change. Inspection scope, intervals, and techniques should be clearly defined. The inspection scope and techniques should address all relevant failure mechanisms that could significantly impact the reliability and integrity of the piping.

The fourth element involves documenting the analyses and submitting the request for NRC review and approval. The submittal is reviewed by NRC in accordance with this standard review plan.

The following areas related to the use of RI-ISI program for piping are reviewed.

I.1 Element 1: Define the Proposed Change to ISI Program

The licensee's RI-ISI submittal is reviewed to verify that the proposed changes to the ISI program have been defined in general terms. Those aspects of the plant's licensing bases that may be affected by the proposed change, including, but not limited to, rules and regulations, FSAR, technical specifications, and licensing conditions are reviewed. In addition, licensing commitments are reviewed. Particular piping systems and welds that are affected by the change in inspection practices are reviewed. Specific revisions to inspection scope, schedules, locations, and techniques are reviewed. The licensee’s program and procedures guiding the evaluations leading to future changes to the ISI program without prior NRC approval are reviewed.

Plant systems and functions that rely on the affected piping are also reviewed. The staff reviews available engineering studies, methods, codes, applicable plant-specific and industry data and operational experience, PRA findings, and research and analysis results relevant to the proposed change. Plant-specific experience with inspection program results is reviewed and characterization relative to the effectiveness of past inspections of the piping and the flaws that have been observed is reviewed.

I.2 Element 2: Engineering Analysis

As part of the second element, the staff will review the licensee's engineering analysis of the proposed changes. The purpose of the review is to determine whether defense-in-depth is maintained, sufficient safety margins are maintained, and that proposed increases in risk, and their cumulative effect, are small and do not cause the NRC Safety Goals to be exceeded. Regulatory Guides (RG) 1.174 (Ref. 3) and RG 1.178 (Ref. 4) provide guidance for the performance of this evaluation.

I.2.1 Traditional Analysis

The engineering analyses are reviewed to determine whether the impact of the proposed ISI changes is consistent with the principles that defense-in-depth and adequate safety margins are maintained.

The primary regulations governing ISI of piping are *10 CFR 50.55a* and Appendix A to *10 CFR* Part 50. The regulations reference other codes and requirements that define the elements of defense-in-depth and safety margins to ensure that structural integrity of piping is maintained. The staff reviews the licensee's assessment of whether the proposed changes meet the regulations.

10 CFR 50.55a references ASME Boiler and Pressure Vessel Code (BPVC) Section XI for the detailed requirements regarding piping ISI. Inspections required by ASME BPVC Section XI are performed on a sample basis with additional inspections, in terms of locations as well as frequency, mandated in response to the detection of flaws. The objective of ISI is to identify conditions, such as flaw indications, that are precursors to leaks and ruptures in pressure boundaries that may impact plant safety. The staff reviews the licensee's bases for the assessment that the proposed change meets the intent of the ASME Code requirements.

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 are to address intergrannular stress corrosion cracking (IGSCC) of stainless steel piping in boiling water reactors (BWR) (NRC Generic Letter 88-01), thermal fatigue (NRC Bulletin 88-08, NRC Bulletins 88-11, NRC Information Notice 93-020), stress corrosion cracking in pressurized water reactors (PWR) (IE Bulletin 79-17), Service Water Integrity Program (NRC Generic Letter 89-13) and flow accelerated corrosion (FAC) in the balance of plant for both PWRs and BWRs (NRC Generic Letter 89-08). The manner in which the augmented inspection programs for piping is addressed is reviewed.

I.2.2 Probabilistic Risk Assessment

The scope, level of detail, and quality required of the PRA is commensurate with the emphasis that is put on the risk insights and on the role the PRA results play in the integrated decision making process. If the justification for the change is based on well founded traditional arguments supported by PRA insights, a limited PRA review may be warranted. However, if the justification for change is based on complex PRA arguments, then the breadth and depth of the PRA review will be substantially greater. Only those parts of the PRA which are used to support the ISI change application need to be reviewed.

I.2.2.1 Scope of Piping Systems

The scope of piping included in the proposed RI-ISI program is reviewed. The current ISI requirements for nuclear power plant piping are specified in *10 CFR 50.55a* which incorporates, by reference, the requirements of ASME BPVC Section XI. The extent to which the RI-ISI program scope incorporates ASME Class 1, 2 and 3 piping systems currently included in ASME BPVC Section XI program and any balance of plant piping is reviewed. The process to select the scope of piping, justification for the scope, and the specific choice of piping selected is reviewed.

I.2.2.2 Piping Segments

The procedure for defining piping segments within the piping systems for the purpose of modeling a run of a pipe in a PRA or to define its ISI requirements is reviewed. The methods by which the failure consequences such as an initiating event, loss of a train, loss of a system, or a combination thereof, is incorporated in the definition of segments are reviewed. In addition to the failure consequences, the procedure and criteria used to identify and document the degradation mechanisms that can be present in piping within the selected systems boundaries is reviewed.

The procedure by which the location of the piping in the plant, and whether inside or outside the containment, is taken into account in defining piping segments is reviewed. The selection of piping segments within the piping system boundaries is an iterative process which may be affected by degradation as well as consequence evaluation which is not completed at the time of initial selection of piping segments within the selected piping systems. The procedure by which degradation mechanisms and consequences of piping segment failures are incorporated in the iterative process is reviewed.

I.2.2.3 Evaluating Pipe Failures with PRA

Pipe ruptures are traditionally modeled as initiators and the failure of individual pipe segments or structural elements are not modeled in PRAs. The manner in which PRA, or the PRA results, is modified so that a more detailed treatment of the potential (or probability) of pipe failures and the influence of such failures on other systems is incorporated in the PRA is reviewed.

I.2.2.4 Piping Failure Potential

Segment failure potential may be a quantitative estimate for each segment, or segments may be categorized into groups based on similar degradation mechanism, environment, and failure modes. There are three failure modes:

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

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 which may require shutdown due to technical specifications or limiting conditions for operation. Unavailability is a combination of failure frequency and exposure time.

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

The approach used for the determination of failure potential of piping segments is reviewed. The manner in which past failure data, expert opinion and probabilistic fracture mechanics is considered in determining the piping failure potential is reviewed. The determination of exposure time appropriate to standby failures is reviewed. It is expected that inspections will be performed in accordance with the schedule of Inspection Program A or Program B as specified in ASME XI. When data analysis is utilized, appropriateness and completeness of data and whether data is taken over time is evaluated.

Probabilistic structural analysis techniques may be used to estimate a numerical frequency or probability of piping segment failure. This method utilizes conventional structural analysis techniques, such as fracture mechanics analysis, in combination with probabilistic methods, such as Monte-Carlo simulation. These techniques are implemented by computer codes to estimate failure probabilities as a function of time. The probabilistic structural analysis methodology for the determination of piping failure probabilities is reviewed to determine the appropriate application of fracture mechanics analysis and Monte-Carlo simulation techniques. Benchmarking of computer codes based on comparison with industry standard codes as well as operating experience is also reviewed. The applicant should demonstrate that the methodology is able to identify significant differences in failure frequencies or probabilities arising from differences in material properties and environmental influences such as the presence of known degradation mechanisms.

Alternatively, expert opinion or categorization based on degradation mechanisms may be used in conjunction with, or in lieu of fracture mechanics analysis to assign each element into a small number of failure potential categories; high, medium, or low for example. In such cases, the process and basis of failure potential determination is reviewed.

For both quantitative estimates and classification into similar groups, the manner in which failure modes, applicable industry experience, piping material, degradation mechanisms, and various other parameters are identified and considered is evaluated. There are numerous uncertainties involved in performing an assessment of segment failure potential. The procedures for addressing these uncertainties when predicting failure potential are reviewed.

I.2.2.5 Consequences of Failure

Direct effects of piping failures include loss of coolant accidents (LOCA) or other flow diversions resulting in an initiator, or a consequential loss of systems because of the inability to deliver sufficient flow because of the failed piping. Indirect effects include consequential failures of additional equipment, including equipment in other systems, because of effects such as pipe whip, jet impingement, flooding, or temperature. The procedure by which direct and indirect effects are characterized and documented is reviewed to verify that appropriate failure mechanisms and dependencies will be evaluated in the risk analysis.

I.2.2.6 Risk Impact of ISI Changes

The methodology used to characterize the change in risk due to the proposed change in the ISI program is reviewed. Part of the basis for the acceptability of any RI-ISI program is a demonstration that established risk measures are not significantly increased by the proposed reduction in the number of inspections for selected piping. To demonstrate this, the process and methodology used to appropriately account for the change in the number of elements inspected, and when feasible, the effects of an enhanced inspection method are reviewed.

I.2.3 Integrated Decisionmaking

Acceptability of the impact of the proposed change in the ISI program is determined based on the review of the adequacy of the licensee's fulfillment of the five key principles as listed in Section I and discussed in detail in RG 1.174 (Ref. 3). The licensee's processes, procedures, and decision criteria to integrate, and to iterate on the integration as necessary, the different elements of the engineering analysis discussed in Sections I.2.1 and I.2.2 and the key principles are reviewed.

The assignment of pipe elements into safety significant categories is an integral part of the risk-informed ISI process. Consequently, the categorization process and all qualitative and quantitative guidelines used to support the categorization are also reviewed.

Risk measures utilized to characterize and differentiate the risk contributions from the individual piping segments are reviewed. The techniques, criteria, and the documentation used to develop and describe the risk measures are reviewed. The criteria for utilizing these risk measures to categorize the safety significance of each pipe segment are reviewed. Consideration of absolute and relative figures of merit is reviewed. Review is focused on the criteria for risk significance determination for ISI at the pipe segment and structural element levels that are used to prioritize inspection locations. The procedure used to perform review of piping segments and piping structural elements to ensure that segments are appropriately ranked is reviewed.

The criteria and procedure used to define the number and location of structural elements within the piping segments that will be subject to ISI is reviewed. The comparison between the ISI program for piping under ASME XI and the requested RI-ISI program is reviewed.

I.3 Element 3: Implementation and Monitoring Programs

The adequacy of the implementation and monitoring plans is reviewed. Inspection strategies are reviewed to ensure that failure mechanisms of concern have been addressed and there is a sufficiently high probability of detecting damage before structural integrity is impacted. The process by which the safety significance of piping segments is taken into account in defining the scope of the inspection program is reviewed. Inspection scope, examination methods, and methods of evaluation of examination results are reviewed with the objective of establishing whether the RI-ISI inspection program provides an acceptable level of quality and safety.

The criteria for selecting areas and volumes of safety significant piping structural elements for inspection are reviewed to ensure that the applicable degradation mechanisms are addressed. The methods by which the degradation mechanisms, postulated failure modes, and configuration of piping structural elements are incorporated in the inspection scope and inspection locations are reviewed. The manner in which significant stress concentration, geometric discontinuities, and generic as well as plant-specific pipe cracking experience is considered in selecting inspection locations is reviewed. Alternate methods to ensure structural integrity in cases where examination methods cannot be applied due to limitations, such as inaccessibility or radiation exposure hazards are reviewed.

In the context of the RI-ISI program, the sampling strategy is defined by the selection of structural elements that are proposed by the licensee for inclusion in the inspection. The reviewer will determine if the criteria for the expansion of the sample size are acceptable and that sequential sampling is based on ISI findings and other evidence of structural degradation.

Inspection methods and acceptance standards utilized in the implementation of the RI-ISI program are reviewed. Inspection methods selected by the licensee should address the degradation mechanisms, pipe sizes, and materials of concern. The manner in which the degradation mechanism is taken into consideration in determining the suitability of examination methods such as visual, surface, and volumetric examination is reviewed. The extent to which the RI-ISI program incorporates inspection intervals, examination methods and acceptance standards currently specified in the ASME BPVC Section XI program is reviewed.

The reliability of any NDE method is dependent on the qualification of the inspection personnel. The RI-ISI program is reviewed to verify that inspection teams will meet industry codes and standards, and use accepted methods and procedures.

Implementation plan for the RI-ISI program is reviewed to ensure that appropriate modifications of the ISI plan are developed if new or unexpected degradation mechanisms occur. The reviewer will ensure that the adequacy of the reliability of the implemented NDE methods is monitored.

II. ACCEPTANCE CRITERIA

The acceptance criteria for the areas of review described in subsection I of this SRP are given below. Other approaches that can be justified to be equivalent to the stated acceptance criteria may be used. The staff accepts the risk-informed development of an inspection plan if the relevant requirements of *10 CFR 50.55a* concerning ISI are complied with. The relevant requirements of *10 CFR 50.55a* are:

1. Proposed alternatives to the ISI requirements of paragraphs of *10 CFR 50.55a*, which requires compliance with ASME XI for ASME Code Class 1, 2, and 3 components, may be used when authorized by the Director of the Office of Nuclear Reactor Regulation.

2. The applicant shall demonstrate that the proposed alternatives would provide an acceptable level of quality and safety.

General guidelines on judging the acceptability of the engineering evaluations and PRA used to support risk informed applications are provided in RG 1.174 (Ref. 3) and SRP Chapter 19.0 (Ref. 11). A summary of acceptance guidelines for engineering evaluations and selected PRA issues specific to ISI is provided in RG 1.178 (Ref. 4).

II.1 Element 1: Define the Proposed Change to ISI Program

The licensee's RI-ISI submittal should have defined the proposed changes to the ISI program in general terms. The licensee should have confirmed that the plant is designed and operated in accordance with the currently approved requirements and that the PRA used in support of their RI-ISI program submittal reflects the actual plant. The licensee should identify those aspects of the plant's licensing bases that may be affected by the proposed change, including, but not limited to, rules and regulations, FSAR, technical specifications, and licensing conditions. In addition, the licensee should identify any changes to commitments. The programs and procedures in place guiding future changes to the ISI program without prior NRC approval should provide for engineering analyses, internal reviews, and degree of traceability consistent with the magnitude of the changes the licensee intends to make.

The particular piping systems, segments, and welds that are affected by the change in the ISI program should be identified. Specific revisions to inspection scope, schedules, locations, and techniques should also be identified. In addition, plant systems and functions that rely on the affected piping should be identified. Industry and plant-specific experience with inspection program results should be obtained and characterization relative to the effectiveness of past inspections of the piping and the flaws that have been observed should be described.

II.2 Element 2: Engineering Analysis

After the proposed changes to the licensee's ISI program have been defined, the licensee should conduct an engineering analysis of the proposed changes using a combination of traditional engineering analysis with supporting insights from a PRA. RGs 1.174 (Ref. 3) and 1.178 (Ref. 4) provide guidance for the performance of this evaluation.

II.2.1 Traditional Analysis

The traditional engineering analyses conducted should assess whether the impact of the proposed ISI changes (individually and cumulatively) is consistent with the principles that defense-in-depth and adequate safety margins are maintained.

10 CFR 50.55a and Appendix A to *10 CFR* Part 50 are the primary regulations governing ISI of piping. The intent of these documents is to maintain the structural integrity of piping in a nuclear power plant. The regulations reference other codes and requirements that define the elements of a defense-in-depth philosophy to ensure structural integrity of piping. For each of the regulations and licensing bases relevant to the ISI of piping, the licensee should ensure that the proposed changes to the ISI program do not deviate from the regulations and licensing bases.

10 CFR 50.55a references ASME BPVC Section XI for the detailed requirements regarding piping ISI for safety significant systems. The objective of the ISI requirements of the ASME Code has been to identify conditions, such as flaw indications, that are precursors to leaks and ruptures in pressure boundaries that may impact plant safety. The licensee should verify that the proposed changes to the ISI program meet or exceed the intent of the ASME BPVC Section XI to identify conditions that are precursors to leaks and ruptures and to provide plans for additional and more frequent inspections in response to detection of flaws and degradation mechanisms.

The nuclear industry has implemented augmented inspection programs to address generic industry wide piping degradation problems such as IGSCC and FAC. The licensee should identify whether the proposed changes in the ISI program affect previous licensee commitments for augmented inspection programs for piping degradation problems such as IGSCC and FAC.

II.2.2 Probabilistic Risk Assessment

The quality of the PRA should be compatible with the safety implications of the ISI change being requested and the degree that the justification of the change request depends on the PRA analysis. Guidance relating the acceptable scope, level of detail, and quality of the PRA analysis based on the anticipated change in risk can be found in RG 1.174 (Ref. 3), Section 2.2.3, "Quality of PRA Analysis," and SRP Chapter 19.0 (Ref. 11), Section III.2.2.4, "Quality of a PRA for Use in Risk-Informed Regulation."

The PRA performed should realistically reflect the actual design, construction, and operational practices and reflect the impact of previous changes made to the approved requirements. All calculations using the PRA model should be performed correctly, and in a manner that is consistent with accepted practices. Limitations and approximations in the PRA and the PRA techniques which can influence the interpretation of the results required to support the ISI application should be clearly described and appropriately addressed. Parameter uncertainty, model uncertainty, and completeness uncertainty should be addressed in accordance with the guidelines of RG 1.174 (Ref. 3).

The programs and procedures regarding the long term maintenance, update, and use of the PRA should be sufficient to ensure that any anticipated changes in the ISI program which do not require NRC notification or approval will always be based on an appropriately generated set of risk insights.

II.2.2.1 Scope of Piping Systems

The piping systems included in the RI-ISI program for the purpose of evaluating the impact of the proposed changes in the ISI program on total plant risk and for the purpose of screening to classify the safety significance of piping systems should be such that any proposed increases in core damage frequency and risk are small and are consistent with the intent of the Commission's Safety Goal Policy Statement.

II.2.2.2 Piping Segments

An acceptable method for modeling a run of a pipe in a PRA or to define its ISI requirements is to divide the pipe run into segments. Portions of piping within the piping systems having the same consequences of failure should be systematically identified. Consequences of failure include an initiating event, loss of a particular train, loss of a system, or a combination thereof. The location of the piping in the plant, and whether inside or outside the containment, should be taken into account in defining piping segments.

Piping sections subjected to the same degradation mechanism should be systematically identified. Most of the degradation mechanisms present in nuclear power plant piping are dependent on a combination of design characteristics, fabrication processes and practices, operating conditions, and service experience. The degradation mechanisms to be considered include, but may not be limited to, vibration fatigue, thermal fatigue, corrosion cracking, primary water stress corrosion cracking (PWSCC), IGSCC, microbiologically induced corrosion (MIC), erosion, cavitation, and FAC.

Piping segments should be defined taking into account potential degradation mechanism and consequence of failure at any point in the segment. Segments with the same consequences but a different degradation mechanism may be combined for consequence characterization, but the development of the inspection program should explicitly address the different degradation mechanisms within such segments. In addition, consideration should be given to identifying distinct segment boundaries at branching points such as flow splits or flow joining points, locations of size changes, isolation valve, motor operated valves (MOV) and air operated valves (AOV) locations. Distinct segment boundaries should be defined if the break potential is expected to be significantly different for various portions of piping.

II.2.2.3 Evaluating Pipe Failures with PRA

The licensee's methodology should systematically utilize risk insights from the PRA and PRA results to characterize the impact of each segment's failure on the plant's risk. The characterization should allow for the determination of the relative safety-significance of the different pipe segments, and should also support the final determination regarding the impact of implementing the program on plant risk.

Generally, three or four primary system LOCA sizes and two steam line rupture locations representing the spectrum of demands on the mitigating systems are modeled in PRAs. An internal events flooding analysis is also included in most PRAs performed in response to Generic Letter 88-20. Much of this analysis will be used as a basis for determining the consequence of pipe failures. The review should focus on the robustness of the above models and methods in the baseline PRA, and appropriate use of this information to investigate the impact of the change in risk due to RI-ISI implementation.

One acceptable approach is to investigate the change in risk due to an ISI program change is based on developing the pipe elements' failure potentials into probabilities, and integrating these probabilities into the existing quantitative PRA framework. The contribution to risk from each piping elements may be ranked and the safety significance of the element determined.

An alternative acceptable approach is based on categorizing each segment's failure potential and the consequences of each segment's failures. These two elements of risk, failure potential and consequences, are then systematically combined to determine the safety significance of each segment.

II.2.2.4 Piping Failure Potential

The determination of the degradation mechanisms present at each weld within all pipe runs included in the scope of the submittal is central to the success of the ISI application. The process used to identify the degradation mechanism at each weld should be well defined, systematic and applied to all welds within the scope. The documentation and engineering evaluations upon which the process is based should be capable of supporting the identification of all applicable degradation mechanisms.

The determination of failure potential of piping segments, either as a quantitative estimate or a categorization into groups, should be based on appropriate design, operational, and inspection parameters in conjunction with the identified degradation mechanisms. The evaluation should include a determination of whether the potential failure of each segment is best characterized as a demand failure while responding to a plant transient or an operational failure which causes a plant transient.

When data analysis is utilized to develop a quantitative estimate, the data should be appropriate and complete. When elicitation of expert opinion is used in conjunction with, or in lieu of probabilistic fracture mechanics or data analysis, a systematic procedure should be developed for conducting such elicitation and a suitable team of experts should be selected and trained. When categorization based on the degradation mechanism is used, the justification for the relationship between the degradation mechanism and the assigned category should be appropriate and complete.

The assessment of piping failure potential should take into account uncertainties. These uncertainties include, but are not limited to, design versus fabrication differences; variation in material properties and strength; effect 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; and capabilities of analytical methods and models to predict realistic results.

The methodology, process, and rationale used to determine the failure potential of piping segments should be reviewed and approved by the plant expert panel as part of its deliberations during the final classification of the safety significance of each segment. This process should be justified, documented, and included in the submittal. When computer codes are used to develop quantitative estimates, the techniques should be verified and validated against established industry codes.

II.2.2.5 Consequences of Failure

The impact on risk due to piping pressure boundary failure should consider both direct and indirect effects. Consideration of direct effects should include failures that cause initiating events, disable single or multiple components, trains or systems, or a combination of these effects. Indirect effects of pressure boundary failures affecting other systems, components and/or piping segments, also referred to as spatial effects such as pipe whip, jet impingement, flooding, or consequential initiation of fire protection systems should also be considered.

The direct and indirect effects of pipe failures should be characterized to incorporate appropriate failure mechanisms and dependencies into the PRA model. The possibility of different leak sizes ranging from minor leaks to full rupture should be considered. In general, the leak size resulting in the most severe consequence should be selected to characterize the consequence for each segment.

An acceptable method of incorporating pipe failures is to classify pipe failures as leaks, disabling leaks, and breaks. Each of these failure modes may be characterized with a different failure probability or potential and a corresponding potential for degrading system performance through direct and/or indirect effects. The time available for operator actions also depends on the break size, and this timing dependence should be recognized and incorporated into the analysis as appropriate.

II.2.2.6 Risk Impact of ISI Changes

The guidelines discussed in RG 1.174 (Ref. 3), Section 2.2.4, “Acceptance Guidelines” are applicable to ISI change requests. General guidance for reviewing the risk impact from changes to the current licensing basis can be found in SRP Chapter 19.0 (Ref. 11), Section III.2.2.5 “Evaluation of Risk Impact.”

The licensee should demonstrate that principle four in RG 1.174 (Ref. 3) and RG 1.178 (Ref. 4) is met. Principle four states that proposed increases in core damage frequency and risk are small and are consistent with the intent of the Commission’s Safety Goal Policy Statement. Increase in risk caused by changes in the ISI program could arise from a decrease in the number of welds inspected, reduced efficiency from simplified weld inspections, or both. Decreases in risk could arise from inspecting welds not currently being inspected in the program, improved weld inspections, or both. The greater the potential risk increase due to the proposed change in the ISI program (e.g., the larger the reduction in the number of welds to be inspected and of replacements of detailed inspections with simplified inspections) the more rigorous and detailed the risk analyses needed.

A direct evaluation of the fulfillment of principle four may be based on:

- risk importance measures or bounding estimates capable of characterizing plant specific pipe element failure potential and consequences categories,

- a systematic process to combine failure potential and consequence to determine pipe element safety-significance,

- pipe segmentation and element inspection selection process which provides for changes in the ISI program based on the safety-significance of the pipe element, and

- a discussion and evaluation of the aggregate risk impact of the set of changes requested in the ISI program including an evaluation of uncertainty indicating that the uncertainties do not invalidate the conclusions.

Alternatively, principle four may be shown to be met by calculating the expected change in CDF and LERF. The expected change can be calculated using the baseline PRA and before change versus after change piping failure potential expressed as failure probabilities. An evaluation of the uncertainty in the results should be performed indicating that the uncertainties do not invalidate the conclusions.

II.2.3 Integrated Decisionmaking

The integrated decisionmaking must address all five key safety principles presented in Section I, "Areas of Review," in this SRP and should address each of the expectations discussed in Section 2, "An Acceptable Approach to Risk-Informed Decisionmaking" of RG 1.174 (Ref. 3). The integrated decision making should also ensure that the proposed ISI program is consistent with the intent of each of the elements related to defense-in-depth and safety margins discussed in 2.2.1.1, "Defense-in-Depth," and 2.2.1.2, "Safety Margins" of RG 1.174 (Ref. 3). The results of the different elements of the engineering analysis discussed in Sections I.2.1 and I.2.2 must be considered in an integrated decisionmaking process.

For ISI application, traditional requirements are outlined in *10 CFR 50.55a* and the General Design Criteria in Appendix A to *10 CFR* Part 50. To be acceptable, the traditional engineering analysis should address all of the relevant regulations and the licensing bases of the plant. Acceptability of impact of the proposed change in the ISI program is based on the adequacy of the traditional engineering analysis, acceptable change in plant risk relative to the criteria, and the adequacy of the proposed implementation and performance monitoring plan. The intent of the ASME BPVC to maintain integrity of reactor coolant system boundary by ISI should be preserved under the RI-ISI program.

An acceptable approach for the risk ranking of piping segments and elements is the use of risk reduction worth (RRW), risk achievement worth (RAW), conditional core damage probability (CCDP), conditional large early release probability (CLERP), or other importance measures. RRW is a measure of the maximum possible reduction in total CDF or LERF due to pressure boundary failures in plant piping systems that can result from making a component perfectly reliable. RAW, CLERP, and CCDP characterize the increase in risk associated with the pressure boundary failure. The risk ranking methodology must be able to systematically identify all safety significant pipe segments within the scope of the RI-ISI program. Guidelines for using risk importance measures to categorize SSCs with respect to safety significance can be found in RG 1.174 (Ref. 3).

The classification of piping segments should be evaluated to determine if any piping segment is inappropriately classified. Considerations should be given to the limitations resulting from the PRA structure, PRA scope, and risk importance measures. Operational insights from previous inspection results, industry data on pipe failures, and Maintenance Rule impacts should also be taken into account. Piping that are subject to ISI under ASME XI requirements but have no segments exceeding the piping segment screening criteria should be further reviewed. Each ASME Class coded system should have some segments inspected for defense-in-depth considerations.

The criteria for determining how many structural elements should be selected for inspection should be based on the safety significance of the segment and the failure potential within that segment. The potential for pipe failure directly drives the need for selecting elements for inspection and the location within a segment to be inspected. The sampling program for the selection of number of elements to be inspected should be fully justified. Guidelines for an acceptable methodology for selection of structural elements for inspection within pipe segments are provided in the RG 1.178 (Ref. 4).

The intent of the ASME BPVC to maintain integrity of the reactor coolant system boundary by ISI should be preserved under the RI-ISI program. Appropriate consideration should be given to implementation and performance monitoring strategies so that piping performance can be assessed under the proposed ISI program change to confirm the assumptions and analyses that were conducted to justify the ISI program change.

II.3 Element 3: Implementation and Monitoring Programs

Careful consideration should be given to implementation and performance-monitoring strategies. The primary goal of this element is to assess piping performance under the proposed RI-ISI program by establishing performance-monitoring strategies to confirm the assumptions and analyses that were conducted to justify the changes in the ISI program. As discussed in RG 1.178 (Ref. 4), performance monitoring encompasses feedback and modification of the RI-ISI program resulting from changes in plant design features, plant procedures, equipment performance, examination results, and individual plant and industry failure information.

Inspection scope and examination methods for the RI-ISI program should provide an acceptable level of quality and safety as stipulated in *10 CFR 50.55a(a)(3)(i)*. Inspection strategies should ensure that failure mechanisms of concern have been addressed and there is a sufficiently high probability of detecting damage before structural integrity is impacted. Safety significance of piping segments should be taken into account in defining the inspection scope for the RI-ISI program.

Degradation mechanisms, postulated failure modes, and configuration of piping structural elements should be incorporated in the definition of the inspection scope and inspection locations. For piping segments that are included in the existing plant FAC or IGSCC (Category B-G) inspection programs, the inspection locations should be the same as in the existing programs. For segments not in these programs, inspection locations should be mainly based on specific degradation mechanism and industry as well as plant-specific cracking experience. Determination of inspection locations for segments with no known degradation mechanism but high failure consequence should be based on sensitized weld locations, stress concentration, geometric discontinuities, and terminal ends. Plant-specific pipe cracking experience should be considered in selecting inspection locations. To be acceptable, alternate examination methods should be specified to ensure structural integrity in cases where examination methods cannot be applied due to limitations, such as inaccessibility or radiation exposure hazards. System pressure tests and visual examination of ASME piping structural elements should continue to be performed regardless of whether the segments contain locations that have been classified as safety significant or non safety significant.

The qualifications of NDE personnel, processes, and equipment should be demonstrated to be in compliance with ASME BPVC Section XI. The acceptance criteria for flaw evaluation should meet the requirements of ASME BPVC Section XI. For inspections outside the scope of Section XI, the acceptance criteria should meet existing regulatory guidance applicable to those programs.

The risk-informed inspection program should specify appropriate inspection intervals consistent with the relevant degradation rate if the data on the degradation mechanism suggests that an inspection interval shorter than that stated in the ASME Section XI is required. In such cases, inspection intervals should be sufficiently short so that degradation too small to be detected during one inspection does not grow to an unacceptable size before the next inspection is performed.

Updates to the RI-ISI program should be performed at least on a 10-year interval basis to coincide with the ISI requirements in ASME Section XI. Significant changes to the PRA model, plant design feature changes, plant procedure changes, and equipment performance changes should be included for review in the RI-ISI program update if needed to support the update. Leakage, flaws, or indications identified during scheduled RI-ISI program NDE examinations and system pressure tests should be evaluated as part of the RI-ISI program update. Periodic updates of RI-ISI programs should include individual plant as well as industry failure information.

Appropriate modifications of the ISI plan should be developed if new or unexpected degradation mechanisms occur. The adequacy of the reliability of the implemented NDE methods should be monitored. The adequacy of NDE performance levels and inspection intervals along with the appropriateness of the selected ISI locations should be considered valid only if the ISI program is successful in detecting degradation before it leads to leakage or rupture of piping.

III. REVIEW PROCEDURES

The staff reviews the licensees proposed RI-ISI program to determine if it appropriately describes the types of changes that the licensee can make without prior NRC approval and the types of changes that require NRC approval before implementation. The reviewer ensures that all changes are evaluated using the change mechanisms described in existing applicable regulations (e.g., *10 CFR 50.55a*, *10 CFR 50.59*, *10 CFR 50*, *Appendix B* for safety-related SSC) to determine if NRC review and approval is required prior to implementation. Licensees may request a variety of ISI programs supported by various levels of analyses and evaluations. In general, the degree of freedom the licensee receives to make future changes to the ISI program without prior NRC approval depends on the level of sophistication of the plant practices and procedures supporting the change to RI-ISI. Some general guidance on determining which future changes are appropriate is given below.

- Changes to segment groupings, inspection intervals, and inspection methods that do not involve a change to the overall RI-ISI approach where the overall RI-ISI approach was reviewed and approved by the NRC do not require specific review and approval prior to implementation provided that the effect of the changes on plant risk increase is insignificant. The overall ISI submittal should specify what types of changes without prior NRC approval are anticipated and describe how such changes will be developed, reviewed by plant personnel, documented, and implemented.

- Segment inspection method changes which involve the implementation of an NRC endorsed ASME Code, NRC-endorsed Code Case, or published NRC guidance approved as part of the RI-ISI program do not require prior NRC approval.

- Inspection method changes that involve deviation from the NRC-endorsed Code requirements require NRC approval prior to implementation.

- Changes to the RI-ISI program that involve programmatic changes (e.g., changes to the categorization criteria or figure of merit used to categorize components, and changes in the Acceptance Guidelines used for the licensee's integrated decision-making process) require NRC approval prior to implementation.

Piping inspection method changes will typically involve the implementation of an applicable ASME Code, Code Case, or other requirements approved by the NRC. Changes to the piping inspection methods for these situations do not require NRC approval. However, inspection method changes that involve deviation from the NRC approved Code requirements require NRC approval prior to implementation.

For each area of review, the following review procedure is followed to ensure consistency in review so as to satisfy the requirements of acceptance criteria stated in subsection II.

III.1 Element 1: Define the Proposed Change to ISI Program

The staff reviewer verifies that the licensee's RI-ISI submittal defines the proposed changes to the ISI program in general terms. The reviewer ensures that the licensee has confirmed that the plant is designed and operated in accordance with the approved requirements and that the PRA used in support of their RI-ISI program submittal reflects the actual plant. The reviewer verifies that the licensee has identified regulations and licensing commitments that impact the current ISI requirements. This includes, but is not limited to, rules and regulations, FSAR, technical specifications, licensing conditions, and licensing commitments. The reviewer also verifies that the piping systems, segments, and welds that are affected by the change in ISI program are identified. In addition, description of the proposed change is reviewed to verify that plant systems and functions that rely on the affected piping have been identified. The characterization of the proposed change in the ISI program is reviewed to verify that the industry and plant specific information relevant to the piping degradation mechanisms has been considered. The description of the proposed change is also reviewed to verify that information that characterizes the relative effectiveness of past inspections and the types of flaws that have been identified has been considered. In addition, the reviewer verifies that specific revisions to existing inspection schedules, locations, and techniques have been described.

III.2 Element 2: Engineering Analysis

In the second element, the staff reviewer verifies that the licensee's engineering analysis of the proposed changes uses a combination of traditional engineering analysis with supporting insights from a PRA. To be acceptable, the licensee should have verified that defense-in-depth is maintained, sufficient safety margins are maintained, and that proposed increases in risk, and their cumulative effect, are small and do not cause the NRC Safety Goals to be exceeded. RGs 1.174 (Ref. 3) and 1.178 (Ref. 4) provide guidance for the performance of this evaluation.

III.2.1 Traditional Analysis

The engineering analyses are reviewed to ensure that the impact of the proposed ISI changes is consistent with the principles that defense-in-depth and adequate safety margins are maintained in accordance with the acceptance criteria in subsection II.2.1.

The reviewer verifies that the proposed changes to the ISI program meet or exceed the intent of the ASME BPVC Section XI to identify conditions that are precursors to leaks and ruptures and that the ISI program provides plans for additional and more frequent inspections in response to detection of flaws and degradation mechanisms. The reviewer ensures that the licensee has demonstrated that there is no impact of the proposed changes in the ISI program on the augmented inspection programs for IGSCC (Category B-G) and FAC.

III.2.2 Probabilistic Risk Assessment

The PRA performed is reviewed in accordance with the acceptance criteria in subsection II.2.2 to confirm that it realistically reflects the actual design, construction, and operational practices and reflects the impact of previous changes made to the approved requirements. The reviewer should identify those parts of the PRA model which support the change application. All previous staff and utility reviews (such as the IPE and IPEEE staff evaluation reports, the maintenance rule inspection report, industry peer or certification reviews) should be obtained. The reviewer should ensure that any prior review findings which may influence those parts of the PRA model or results supporting the ISI change request have been adequately addressed. If necessary to support the change request, a focused scope or a more detailed PRA review should be undertaken. The assessed change in risk due to ISI implementation should be evaluated in accordance with the guidelines in Section 2.2.2 of RG 1.174 (Ref. 3). General guidance for focused scope and more detailed PRA quality reviews is presented in SRP Chapter 19.0 (Ref. 11).

III.2.2.1 Scope of Piping Systems

Scope of piping systems included in the RI-ISI program is reviewed in accordance with the acceptance criteria in subsection II.2.2.1.

III.2.2.2 Piping Segments

Criteria and procedures used to establish piping segments within the piping systems are reviewed to determine whether consequences of failure, degradation mechanisms, and segment boundaries are properly considered for defining piping segments in accordance with the acceptance criteria given in subsection II.2.2.3 of this SRP section.

III.2.2.3 Evaluating Pipe Failures with PRA

Acceptable approaches for evaluating pipe failures with PRA are provided in subsection II.2.2.3. The approach used is reviewed to verify whether the sequence of events from new initiators is appropriately developed if piping segment failure introduce new initiating events. If the pipe segment failure yields the same consequences as some other initiator already included in the PRA, the reviewer verifies that the risk from the original initiating event is appropriately represented in the ISI analysis.

If pipe failures are characterized by a set of PRA basic events used as surrogates representing the equivalent impact of the pipe failure, the basic events are reviewed to insure that the surrogate is an adequate representation of the pipe segment failure, and that the resulting risk insights are reflected in the ISI analysis. If surrogate basic events cannot be found, the analysis used to characterize the new failure events using the PRA models or results and extract representative risk insights is reviewed.

III.2.2.4 Piping Failure Potential

The processes and documentation used to identify the degradation mechanisms is reviewed to verify that they are sufficient and were systematically applied. The identified degradation mechanisms are reviewed to determine that the results are an appropriate characterization and were developed at a level of detail consistent with the use of the information to support the change request. These detailed results are also compared to the reported inspection locations to determine the relationship between the inspection location, strategies, and degradation mechanisms. The procedures used to determine the failure potential of piping segments are reviewed in accordance with the acceptance criteria in subsection II.2.2.4 to verify that the appropriate failure frequency, demand failure, or unavailability mode was used to characterize the impact of failure, and that the determination of the quantitative estimate or group classification is appropriate to the failure mode. The licensee's treatment of uncertainties in failure potential determination and all conclusions are reviewed. The incorporation of the findings of the uncertainty analyses into the final decision making process is reviewed.

When a computer code is used to develop a quantitative estimate, verification and validation of the computer code that implements the probabilistic fracture mechanics techniques is reviewed. When expert elicitation is used, the selection and training of the experts and the elicitation process is reviewed. When the failure potential is determined by classifying the failures into groups, the applicability of the classification scheme is reviewed.

III.2.2.5 Consequences of Failure

The reviewer verifies that the licensee has considered both direct and indirect effects of each segment failure. The guidelines for determining the direct and, in particular, the indirect effects of pipe failure on plant equipment should be reviewed. The reviewer should verify that these guidelines have been consistently applied and that the results of the analysis are well documented. Guidelines for evaluating the consequence of different leak sizes and selecting the most severe consequence should also be reviewed if applicable.

III.2.2.6 Risk Impact of ISI Changes

The risk impact of the proposed change in the ISI program is reviewed for compliance with the acceptance criteria in subsection II.2.2 of this SRP section. The licensee's risk assessment is reviewed to verify that any proposed increases in core damage frequency and risk are small and are consistent with the intent of the Commission's Safety Goal Policy Statement. Selection of piping segments is reviewed to ensure that assumption guiding the spatial effects of pipe failures are applied consistently. It should reflect the current plant ISI program, and risk insights developed should arise from comparing the baseline with the proposed RI-ISI program implementation plant risk. Risk insights are reviewed to ensure that they appropriately account for the change in the number of elements inspected, and when feasible, the effects of an enhanced inspection method. The emphasis put on the risk insights and on the PRA results in the decisionmaking process is determined. The PRA is reviewed to verify that the scope, level of detail, and the quality of the PRA is commensurate with the role the risk and the change in risk results play in determining the acceptability of the requested ISI program.

III.2.3 Integrated Decisionmaking

Acceptance criteria for integrated decisionmaking process is given in subsection II.2.3. The process by which the traditional engineering analysis addresses the relevant regulations and the currently approved requirements of the plant is reviewed to confirm that the regulation is met and the intent of the ASME BPVC to maintain integrity of reactor coolant system boundary by ISI is preserved under the RI-ISI program. The documentation providing input to the integrated decision making process is reviewed to ensure that all applicable risk insights, key principles, and supporting elements were addressed and communicated to the final decision making panel. The documentation of the panel deliberations, recommendations, and finding should be reviewed to ensure that all relevant risk informed insights were incorporated into the final program description. After the RI-ISI program is approved and initiated, plant performance should be supported by inspection and analysis and maintained by programmatic activities goals by comparison against specific performance goals.

Acceptability of selection of locations to be inspected is reviewed for compliance with the acceptance criteria in subsection II.2.3 of this SRP. Risk measures used are reviewed to determine that appropriate thresholds are used to rank the safety significance of the piping segments. The risk ranking process is reviewed to ensure that it is capable of systematically identifying all safety significant pipe segments, including those that are not included under ASME Section XI as appropriate.

The procedure used to further review piping segments and piping structural elements that may be inappropriately identified as non safety significant is reviewed to verify that the PRA limitations, operational insights, industry pipe failure data, and Maintenance Rule insights are taken into consideration. In addition, the procedure used to determine the ISI program for piping that are subject to ISI under ASME XI requirements but have no segments or piping structural elements exceeding the screening criteria is reviewed to ensure that it is in accordance with the acceptance criteria of subsection II.2.3 of this SRP.

III.3 Element 3: Implementation and Monitoring Programs

The reviewer verifies that the inspection strategies address failure mechanisms of concern and there is a sufficiently high probability of detecting damage before structural integrity is compromised. The reviewer verifies that the degradation mechanisms, postulated failure modes, and configuration of piping structural elements are incorporated in the definition of the inspection scope and inspection locations. Selected inspection locations are reviewed to confirm that stress concentration, geometric discontinuities, and terminal ends are considered in establishing the inspection locations. In addition, the reviewer verifies that plant-specific pipe cracking experience has been considered in selecting inspection locations. The reviewer also determines if alternate examination methods are specified to ensure structural integrity in cases where examination methods cannot be applied due to limitations, such as inaccessibility or radiation exposure hazard. The RI-ISI program is reviewed to ensure that system pressure tests and visual examination of piping structural elements is to be performed on all Class 1, 2, and 3 systems in accordance with ASME BPVC Section XI Program regardless of whether the segments contain locations that have been classified as safety significant or non safety significant.

Sample selection process is examined to verify that expansion of the sample size is in accordance with the acceptance criteria of subsection II.2.1 of this SRP. Inspection methods selected by the licensee are examined to verify that they address the degradation mechanisms, pipe sizes, and materials of concern. The RI-ISI inspection program is reviewed to confirm that appropriate examination methods and intervals are used and acceptance standards meet the requirements of ASME BPVC Section XI or existing regulatory guidance applicable to the piping system.

IV ELEMENT 4: DOCUMENTATION

The reviewer will review the licensee's submittal to ensure that it contains the documentation necessary to conduct the review described in this SRP (i.e., the documentation described in RG 1.178). The RI-ISI program and its updates should be maintained on site and available for NRC inspection consistent with the requirements of *10 CFR 50*, Appendix B.

V EVALUATION FINDINGS

The reviewer verifies that sufficient information has been provided and that the evaluation is sufficiently complete and adequate to support conclusions of the following type, to be included in the staff's safety evaluation report.

The staff concludes that the licensee's proposed RI-ISI program, as described in its submittal, will provide an acceptable level of quality and safety pursuant to 10 CFR 50.55a(a)(3)(i) with regard to the number of inspections, locations of inspections, and methods of inspections. This conclusion is based on the following findings.

The staff finds that the results of the different elements of the engineering analysis are considered in an integrated decisionmaking process. The impact of the proposed change in the ISI program is founded on the adequacy of the engineering analysis and acceptable change in plant risk in accordance with RG 1.174 and 1.178 guidelines.

The licensee's methodology also considers implementation and performance monitoring strategies. Inspection strategies ensure that failure mechanisms of concern have been addressed and there is adequate assurance of detecting damage before structural integrity is affected. The risk significance of piping segments is taken into account in defining the inspection scope for the RI-ISI program.

System pressure tests and visual examination of piping structural elements will continue to be performed on all Class 1, 2, and 3 systems in accordance with the ASME Code Section XI program. The RI-ISI program applies the same performance measurement strategies as existing ASME Code requirements and, in addition, increases the inspection volumes at weld locations that are exposed to thermal fatigue.

The licensee's methodology provides for conducting an engineering analysis of the proposed changes using a combination of engineering analysis with supporting insights from a PRA. Defense-in-depth and quality are not degraded in that the methodology provides reasonable confidence that any reduction in existing inspections will not lead to degraded piping performance when compared to existing performance levels. Inspections are focused on locations with active degradation mechanisms as well as selected locations that monitor the performance of system piping.

The staff's review of the licensee's proposed RI-ISI program concludes that the program is an acceptable alternative to the current ISI program for Class 1 and Class 2 piping welds, which is based on ASME Code, Section XI, requirements for Class 1 and Class 2 welds. Therefore, the licensee's request for relief is authorized pursuant to 10 CFR 50.55a(a)(3)(i) on the basis that the request provides an acceptable level of quality and safety.

This safety evaluation authorizes application of the proposed RI-ISI program during the second ten-year ISI interval for licensee's Unit 1 and Unit 2.

VI IMPLEMENTATION

The following is intended to provide guidance to applicants and licensees regarding the NRC staff's plans for using this SRP section.

Except in those cases in which the applicant or licensee proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used by the staff in its evaluation of conformance with Commission regulations.

VII. REFERENCES

5. USNRC, "Use of Probabilistic Risk Assessment Methods in Nuclear Activities: Final Policy Statement," *Federal Register,* Vol. 60, p. 42622 (60 FR 42622), August 16, 1995.

6. USNRC, "Risk-Informed Regulation Implementation Plan," SECY-00-0213, October 16, 2000; updated December 5, 2001 (SECY-01-0218)[3]

7. Regulatory Guide RG 1.174, "An Approach for Using Probabilistic Risk Assessment In Risk-Informed Decisions On Plant-Specific Changes to the Licensing Basis," July 1998.[4] ????????

8. Regulatory Guide 1.178, "An Approach for Plant-Specific, Risk-Informed Decisionmaking: Inservice Inspection of Piping," August 2003. ????????

9. Westinghouse Owners Group Topical Report WCAP-14572, Revision 1-NP-A, "Application of Risk-Informed Methods to Piping Inservice Inspection," February 1999.

10. EPRI Report TR-112657, Revision B-A, "Risk-Informed Inservice Inspection Evaluation Procedure," December 1999.

11. ASME Code Case N-560-2, "Alternate Examination Requirements for Class 1, Category B-J Piping Welds, Section XI, Division 1," March 28, 2000.

12. ASME Code Case N-577-1, "Risk-Informed Requirements for Class 1, 2, and 3 Piping, Method A, Section XI, Division 1," March 28, 2000.

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[3] USNRC SECY papers are available electronically on the NRC's web page at <www.nrc.gov> under Commission's Activities.

[4] Single copies of regulatory guides, both active and draft, and draft NUREG documents may be obtained free of charge by writing the Reproduction and Distribution Services Section, OCIO, USNRC, Washington, DC 20555-0001, or by fax to (301)415-2289, or by email to <DISTRIBUTION@NRC.GOV>. Active guides may also be purchased from the National Technical Information Service on a standing order basis. Details on this service may be obtained by writing NTIS, 5285 Port Royal Road, Springfield, VA 22161; telephone (703)487-4650; online <http://www.ntis.gov/ordernow>. Copies of active and draft guides are available for inspection or copying for a fee from the NRC Public Document Room at 11555 Rockville Pike, Rockville, MD; the PDR's mailing address is USNRC PDR, Washington, DC 20555; telephone (301)4154737 or (800)397-4209; fax (301)415-3548; email <PDR@NRC.GOV>.

13. ASME Code Case N-578-1, “Risk-Informed Requirements for Class 1, 2, and 3 Piping, Method B, Section XI, Division 1,” March 28, 2000.

14. USNRC, “Safety Goals for the Operations of Nuclear Power Plants; Policy Statement,” *Federal Register*, Vol. 51, p. 30028 (51 FR 30028), August 4, 1986.

15. USNRC, “Use of Probabilistic Risk Assessment in Plant-Specific, Risk-Informed Decisionmaking: General Guidance,” Draft Revision 1 of Chapter 19.0 of the Standard Review Plan, NUREG-0800, June 2001.