NUREG-1777

# Regulatory Effectiveness Assessment of Option B of Appendix J

U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Washington, DC 20555-0001

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# Regulatory Effectiveness Assessment of Option B of Appendix J

Manuscript Completed: November 2002
Date Published: August 2003

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# ABSTRACT

The Nuclear Regulatory Commission's Office of Nuclear Regulatory Research is reviewing selected regulations to determine if they are achieving the desired results. This initiative is part of an evolving program to make NRC activities and decisions more effective, efficient, and realistic. The goal of this assessment is to determine whether the revised, performance-based, risk-informed, voluntary Option B of 10 CFR 50, Appendix J, Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors, was effective, and, if not, to make appropriate recommendations.

The effectiveness of Option B was determined by comparing regulatory expectations to outcomes. The assessment concluded that risk-informing Appendix J has been effective. The revised Appendix J has been at least partially adopted by all currently operating nuclear power plants. Its adoption has resulted in cost saving and burden reduction to licensees, while maintaining safety. Note that this conclusion regarding maintenance of safety is based on probabilistic risk assessment insights and the very limited failure data available since the adoption of Option B by licensees. Occupational radiation exposure to workers has been reduced by adoption of the revised Appendix J. However, with the reduced frequency of Type A tests under Option B, it is likely that a degraded containment will not be identified as quickly as under the original Appendix J. Required licensee inspections of containment structural members limit the potential for significant degradation to remain undetected for lengthy periods of time.

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# EXECUTIVE SUMMARY

As part of the Nuclear Regulatory Commission program to address regulatory effectiveness, the Office of Nuclear Regulatory Research (RES) is reviewing selected regulations to determine if they are achieving the desired results. SECY-97-180, "Response to Staff Requirements Memorandum of May 28, 1997, Concerning Briefing on IPE Insight Report," August 6, 1997, describes a plan for the RES staff to assess the effectiveness of several major safety issue resolution efforts or regulations.

Reactor containments constitute one of the principal lines of defense in the defense-in-depth design philosophy embodied in the current generation of light water power reactors. Several mechanisms can cause releases to the environment. These include gross failure of containment due to the pressure forces resulting from an accident, containment base-mat melt-through, failure of containment isolation systems, interfacing system loss-of-coolant accidents, steam generator tube ruptures, and releases as a result of containment leakage.

The original Appendix J to Title 10 of the *Code of Federal Regulations* Part 50 (10 CFR 50), Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors, specifies leakage testing requirements including the types of tests to be performed, testing frequencies, acceptance criteria, and reporting requirements. Appendix J test frequencies were based on conservative, engineering judgment. The maximum allowable leakage rate is calculated in accordance with 10 CFR 100, Reactor Site Criteria, and is defined in each facility's Technical Specifications. Typical values are 0.1 percent of containment air mass per day for pressurized water reactors and 1.0 percent of containment air mass per day for boiling-water reactors. Appendix J became effective on March 16, 1973.

In September 1995, NRC issued the revised Appendix J. NRC allowed increasing the intervals of tests based on the performance history of the containment, penetrations, and valves. Guidance for implementation of Option B was issued as Regulatory Guide 1.163, "Performance Based Containment Leak-Test Program." In Regulatory Guide 1.163, NRC stated the regulatory position limiting extension of main steam and feedwater isolation valves in boiling-water reactors, and containment vent and purge valves to 30 months based on operating experience and their importance. Option B was voluntary for licensees.

The goal of this assessment was to determine whether Option B of Appendix J was effective in achieving its desired results. The expectations were established from objectives stated when the rule was issued. In general, Appendix J was to be made less prescriptive and more performance oriented with appropriate regulatory guidance or endorsement of industry guidelines. Adoption of Option B was voluntary. For this evaluation, effectiveness was evaluated by assessing the extent to which the benefits of the rule have been achieved, and the rule's impact on safety. Essentially, regulatory expectations and outcomes were compared. The results were obtained from reviews of documents and operating experience. This evaluation considered four main expected outcomes from Option B: (1) opportunity for reduction in occupational radiation exposure from leak rate testing; (2) only a marginal risk increase; (3) opportunity for reduced testing burden resulting in more efficient use of utility resources; and (4) opportunity for licensee cost savings.

The assessment concluded that risk-informing Appendix J has been effective. The revised Appendix J has been at least partially adopted by all currently operating nuclear power plants.[1] Its adoption has resulted in cost savings and burden reduction to licensees, while maintaining safety. Note that this conclusion regarding maintenance of safety is based on probabilistic risk assessment insights and the very limited failure data available since the adoption of Option B by licensees. Occupational radiation exposure to workers has been reduced by adoption of the revised Appendix J. However, with the reduced frequency of Type A tests under Option B, it is likely that a degraded containment will not be identified as quickly as under the original Appendix J. Required licensee inspections of containment structural members limit the potential for significant degradation to remain undetected for lengthy periods of time.

[1]Partial adoption as used in this report means that not all portions of this voluntary rule were adopted by all licensees. The vast majority of plants have adopted all portions.

# FOREWORD

This report evaluates the effectiveness of the voluntary, Option B of Appendix J to Title 10 of the *Code of Federal Regulations* Part 50, “Primary Reactor Containment Leakage Testing for Water-Cooled Reactors.” NRC issued the revised, risk-informed, Appendix J in September, 1995. NRC allowed increasing the intervals of tests based on the performance history of the containment, penetrations, and valves. The effectiveness of Option B is assessed by comparing regulatory expectations to outcomes in the areas of opportunities for occupational radiation exposure reduction, risk impact, testing burden reduction, and licensee cost savings. The report concludes that risk-informing Appendix J has been effective. The revised Appendix J has been at least partially adopted by all currently operating nuclear power plants. Its adoption has resulted in cost savings and burden reduction to licensees, while maintaining safety. Occupational radiation exposure to workers has been reduced by the adoption of the revised Appendix J. However, with the reduced frequency of Type A tests under Option B, it is likely that a degraded containment will not be identified as quickly as under the original Appendix J. Required licensee inspections of containment structural members limit the potential for significant degradation to remain undetected for lengthy periods of time.

This report is consistent with the NRC strategic performance goals of maintaining safety; increasing public confidence; and making NRC activities more effective, efficient, and realistic as follows:

**Maintaining safety** — The study report confirms that safety was maintained with the implementation of Option B. The reduction in occupational radiation exposure resulting from Option B directly contributes to the safety of nuclear workers. If the study had found that safety had not been maintained, appropriate recommendations would have been made.

**Public confidence** — Public confidence should be improved by confirming that implementation of Option B resulted in maintaining safety while burden and costs to licensees (ultimately, societal costs) and occupational radiation exposure were reduced.

**Making NRC activities more effective, efficient, and realistic** — The report compares the regulatory expectations to outcomes to assess the effectiveness of this regulation in achieving its goals and identify areas needing attention, if any. In this case, issuing a voluntary, risk-informed regulation was successful.

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# ABBREVIATIONS

| | |
|---|---|
| BWR | boiling-water reactor |
| CFR | *Code of Federal Regulations* |
| EPRI | Electric Power Research Institute |
| ILRT | integrated leak rate test |
| INEEL | Idaho National Engineering and Environmental Laboratory |
| LLRT | local leak rate test |
| NRC | Nuclear Regulatory Commission, U.S. |
| PRA | probabilistic risk assessment |
| PWR | pressurized-water reactor |
| RES | Nuclear Regulatory Research, Office of (NRC) |

# 1 INTRODUCTION

As part of the Nuclear Regulatory Commission program to address regulatory effectiveness, the Office of Nuclear Regulatory Research (RES) is reviewing selected regulations to determine if they are achieving the desired results. SECY-97-180, “Response to Staff Requirements Memorandum of May 28, 1997, Concerning Briefing on IPE Insight Report,” August 6, 1997 (Ref. 1), describes a plan for the RES staff to assess the effectiveness of several major safety issue resolution efforts or regulations.

The work described in this report is an assessment of the performance-based, risk-informed, voluntary option B of Title 10 *Code of Federal Regulations* Part 50 (10 CFR 50), Appendix J, “Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors.” The final rule for revision of Appendix J was published on September 26, 1995, in the Federal Register (60FR49495). Much of this study is based on work performed by NRC contractors at the Idaho National Engineering and Environmental Laboratory (INEEL).

# 2 BACKGROUND

## 2.1 General Background

Reactor containments constitute one of the principal lines of defense in the defense-in-depth design philosophy embodied in the current generation of light water power reactors. Several mechanisms can cause releases to the environment. These include gross failure of containment due to the pressure forces resulting from an accident, containment base-mat melt-through, failure of containment isolation systems, interfacing system loss-of-coolant accidents, steam generator tube ruptures, and releases as a result of containment leakage.

## 2.2 Original Appendix J Requirements

10 CFR 50, Appendix A, General Design Criteria for Nuclear Power Plants, Criterion 16, mandates that the primary containment provide an essentially leak-tight barrier to protect against uncontrolled release of radioactivity to the environment following postulated accidents. Appendix J to 10 CFR 50, “Primary Reactor Containment Leakage Testing for Water-Cooled Power Reactors,” specifies leakage testing requirements including the types of tests to be performed, testing frequencies, acceptance criteria, and reporting requirements. Appendix J test frequencies were based on conservative, engineering judgment. The maximum allowable leakage rate is calculated in accordance with 10 CFR 100, “Reactor Site Criteria,” and is defined in each facility’s Technical Specifications. Typical values are 0.1 percent of containment air mass per day for pressurized-water reactors (PWRs) and 1.0 percent of containment air mass per day for boiling-water reactors (BWRs). Appendix J became effective on March 16, 1973.

Three types of containment leakage tests are required by the original Appendix J: (1) Type A, integrated (or overall) leakage rate tests (ILRTs), (2) Type B, leakage tests of penetration seals, gaskets, and expansion bellows, and (3) Type C, leakage tests of isolation valves of pipes penetrating containment. Type B and C tests are often called local leak rate tests (LLRTs).

Type A tests are required to be performed three times every 10 years. The Type A test itself usually does not last longer than 24 hours, however, other activities associated with the test (visual inspection, instrument setup, system lineups, pressurization, pressure stabilization, verification, and depressurization) require several days and significant personnel resources. ILRTs significantly impact plant outages because maintenance and refueling activities are restricted and no activities are allowed inside containment during the tests. ILRTs are usually a critical path activity.

Type B and C tests (LLRTs) are required on all penetrations at least once every 2 years, except for airlocks which are tested more frequently. LLRTs are required to determine the "as found" condition of penetrations and isolation valves and another test must be performed following maintenance or repairs. Although labor intensive, LLRTs are usually not critical path. Each LLRT takes about 1 to 8 hours to perform. The number of penetrations and containment isolation valves varies, but the typical PWR has about 90 containment penetrations while the typical BWR has about 175 penetrations (Ref. 2). The weighted average of all U.S. BWRs and PWRs is 110 penetrations per plant (Reference 2).

## 2.3 Impetus for Option B

NRC initiated a program in 1984 to identify regulatory requirements with marginal importance to safety (49FR39066). The goal was the elimination or modification of requirements where burdens on licensees were not commensurate with the requirement's safety significance. Under this program, licensees were surveyed and Appendix J requirements were identified as imposing significant burdens while having only marginal importance to risk (Ref. 3). An NRC staff survey also identified Appendix J as a candidate for modification.

Another impetus for changing Appendix J was the results from probabilistic risk assessments (PRAs) and other studies. PRAs provided a broad technical basis for the revision of the original Appendix J requirements. PRAs, beginning with WASH-1400, "Reactor Safety Study," 1975 (Ref. 4), have consistently shown that containment leakage is a relatively minor contributor to overall plant risk.

Several PRA documents and other risk information or analyses supporting a voluntary, risk-informed option for Appendix J were reviewed. Some important results which support revision of Appendix J include:

1986 NUREG/CR-4330, "Review of Light Water Reactor Regulatory Requirements" (Reference 3).

Concluded that increasing allowable reactor containment leakage to 10 percent per day would have minimal impact on safety but would provide substantial savings. The effect of containment leakage is small since risk is dominated by accident sequences that result in failure or bypass of containment.

1988 NUREG-1273, "Technical Findings and Regulatory Analysis for Generic Safety Issue II.E.4.3 – Containment Integrity Check" April 1988 (Ref. 5).

Concluded that: (1) the leakages in about one third of reported events were immediately detected and corrected, (i.e., posed minimal threat to containment integrity), (2) about one sixth of reported events involved components in direct containment-to-atmosphere leakage paths, and (3) 99 percent of leakage events were detected by LLRTs.

1990 NUREG-1150, “Severe Accident Risk: An Assessment of Five U.S. Nuclear Power Plants” Vols. 1 and 2, June 1989 and December 1990 (Ref. 6).

Used more advanced PRA techniques. Concluded that the overall levels of risk due to containment leakage are less than previous studies because accident risks are dominated by scenarios where the containment fails or is bypassed. A major finding is that maintaining containment structural integrity post-accident is much more important than containment leak tightness.

1997 NUREG-1560, “Individual Plant Examination Program: Perspectives on Reactor Safety and Plant Performance” December 1997 (Ref. 7).

Contains insights from Individual Plant Examinations, which were performed at all plants using PRA techniques. Risk is dominated by containment failure and bypass following severe accidents. Concludes that containment isolation failures are not important BWR contributors to risk, and that while the probability of isolation failures are relatively large for some PWRs (primarily those with large, dry, and subatmospheric containments), the leak area is usually small such that the failure does not contribute significantly to radionuclide releases.

1994 Electric Power Research Institute (EPRI) TR-104285, “Risk Impact Assessment of Revised Containment Leak Rate Testing Intervals” August 1994 (Ref. 8).

Showed that the risk associated with extension of containment leak rate testing frequencies is insignificant.

1995 NUREG-1493, “Performance Based Containment Leak-Test Program” (Reference 2).

This was a detailed study of the impacts, costs, and risk of the original Appendix J requirements and several alternatives including changing test intervals and allowable leakage rates. Confirmed the insensitivity of population risks to low containment leakage rates following an accident.

Also concluded that: (1) increasing allowable leakage rates by 10 to 100 times results in a marginal risk increase, while reducing costs by about 10 percent; (2) reducing Type A tests to once per 10 years results in imperceptible risk increases, but substantially reduces costs; (3) Type A tests rarely detect significant leakage, the majority of leakage is detected by Type C tests; (4) Type B test frequencies (except airlocks) could be reduced with no risk impact because there are very few Type B failures (except airlocks) and test failures usually involve only small leaks; (5) based on past component performance, Type C test frequencies could be reduced; and (6) reducing Type B and C test frequencies could result in substantial cost savings (up to 58 percent).

## 2.4 Revised Appendix J (Option B)

In September 1995, NRC issued the revised Appendix J (60FR49495). In Option B and its associated guidance documents, NRC allowed increasing the intervals of Type A, B, and C tests based on the performance history of the containment, penetrations, and valves. The maximum test interval for Type A tests was 10 years, but the requirement for three containment visual inspections every 10 years was retained. All Type A tests were to be performed at Pa[2] (rather than extrapolating the leakage from measurements taken at a lower pressure as allowed by the original Appendix J). Type B tests (except for airlocks) would be required at least once every 10 years. The 5 year maximum test interval for containment isolation valves (Type C) was established due to uncertainties about Type C test data. Guidance for implementation of Option B was issued as Regulatory Guide 1.163, “Performance Based Containment Leak-Test Program” September 1995 (Ref. 9). In Regulatory Guide 1.163, NRC stated the regulatory position limiting extension of testing of main steam and feedwater isolation valves in BWRs, and containment vent and purge valves, to 30 months based on operating experience and their importance. Option B was voluntary for licensees.

NRC decided to defer consideration of changes in allowable leakage rates to a second phase of rulemaking. On-line monitoring of containment integrity could not be justified solely on risk considerations and so was not proposed as a requirement. Containment visual inspection requirements of Appendix J were retained, despite industry assertions that such inspections were adequately addressed by ASME Section XI Subsections IWE and IWL, because rulemaking to incorporate these subsections into the regulations had not been finalized.

Twenty-six letters were received during the comment phase of rulemaking for Option B. Those who supported the rule comprised the vast majority of the commenters (22), and included the Nuclear Energy Institute, which represents the nuclear utility licensees, 18 individual nuclear power plant license respondents, a Spanish regulatory authority and 2 private citizens. Two private citizens and two organizations opposed the proposed rule. NRC did not make any substantive changes to the proposed rule based on the comments received because the comments did not contain new information that had not already been addressed in a public forum.

## 2.5 Expected Results from the Revised Appendix J

NRC had four main expected results from Option B (60FR49495): (1) opportunity for reduced occupational radiation exposure, (2) only a marginal risk increase, (3) opportunity for reduced testing burden, and (4) opportunity for cost savings.

# 3 REGULATORY ASSESSMENT

For this assessment of the regulatory effectiveness of Option B, the following were reviewed and evaluated: (1) history and purpose of Appendix J, (2) PRA documents and other risk information or analyses supporting a voluntary risk-informed option for Appendix J (see

[2] Pa is the calculated peak containment internal pressure related to the design basis accident.

Section 2.3), (3) history and expectations for Option B, (4) operating experience and reliability data for containment valves and penetrations, and (5) data regarding voluntary adoption of Option B (i.e., which plants adopted Option B and when it was adopted).

## 3.1 Impact on Testing Burden and Cost of Testing

A significant decrease in testing burden and cost were expected for those licensees which adopted the revised Appendix J. Costs of Type A tests (ILRTs) were estimated (Reference 2). The total cost for an ILRT was estimated to be about $1.89 million per test, and included equipment cost rentals, labor costs, and replacement power costs. Replacement power costs are included because ILRTs are critical path and usually take from 3 to 5 days. With the revised Appendix J, ILRTs are conducted at a periodic interval based on the performance of the overall containment system. Costs were estimated to decrease by about 67 percent for changing from three ILRTs every 10 years to one ILRT every 10 years.

Costs of LLRTs were also estimated (Reference 2). The costs for a full battery of Type B and C tests for a typical light water reactor was estimated to be about $165,000, and included LLRT crew labor and support from plant staff. To illustrate the potential costs savings with the revised Appendix J, calculations were done which showed that the cost of LLRTs could be reduced by 58 percent. Elimination of Type B electrical penetrations from the previous 2-year frequency was estimated to eliminate $25,000 of LLRT costs, and elimination of half of the Type C tests was estimated to reduce LLRT costs by an additional $70,000, for a total savings of $95,000 or 58 percent of the costs for a typical complete battery of Type B/C tests. Actual savings are, of course, dependent on the actual performance histories of the components.

Burden reduction and cost savings to licensees have resulted from the adoption of the revised Appendix J. All licensees have at least partially adopted the revised Appendix J, mainly in 1996 and 1997. U.S. reactors broke the 80 percent capacity factor average for the first time in 1999, and achieved capacity factors of 87 percent and 88 percent in 2000 and 2001, respectively (Ref. 10). An important factor in this improvement was licensee success in limiting the length of refueling outages. Refueling outages may be shortened when the amount of containment leak rate testing is reduced by the adoption of the revised Appendix J. It was impractical for this assessment to determine precisely the timing and the extent which testing and costs have been reduced. As part of its contract, INEEL reviewed containment isolation valve leakage events as reported in the NRC's Sequence Coding and Search System and the Institute of Nuclear Power Operations' Nuclear Plant Reliability Data System and Equipment Performance and Information Exchange databases. INEEL determined that testing may be deferred on the majority of valves and that ILRTs would rarely be required more than once every 10 years. All licensees have at least adopted portions of the voluntary, revised Appendix J, demonstrating that the burden reduction and cost savings opportunities are real, and are being realized by many licensees.

## 3.2 Risk Impact

Several PRA documents that supported or provided the bases for revising Appendix J were reviewed (see section 2.3). This review found that:

> Containment leakage is a small contributor to overall accident risk. At the lower end of changes in leakage rates, any uncertainties associated with the calculated leakage

contribution are minuscule in comparison with other uncertainties, (e.g., prediction of containment failure mode probabilities and magnitudes of fission product source terms.) The NUREG-1150 results for PWRs predict significant probabilities of no containment failure even in the event of core melt accidents. With the containments predicted to remain intact, at the upper end of the leakage-rate ranges considered. i.e., 200–400 percent containment volume per day, containment leakage could lead to several-fold increases in the predicted risk. The expected fission product source terms associated with the large leakage-rate cases, considering all possible unit damage states and accident progression bins, were substantially lower than those resulting from containment failure or bypass. Thus, the uncertainties associated with assessing the leakage contribution at the upper ends of the ranges considered would be lower than those associated with other containment failure modes. (NUREG-1493, page 9-1)

Type B and C testing can detect a very large fraction of containment leaks. Only a small fraction (a few percent) of leaks can only be detected by integrated containment leakage tests. An assessment of the risk significance of the leaks only detectable by ILRT was not provided. (NUREG-1273, pg. 6)

Experience from leakage rate testing indicates that frequent Type B testing of electrical penetrations is of limited usefulness. There have been very few Type B failures (except airlocks) and the leakage rates associated with these failures are typically small. (NUREG-1493, pg. 10-3)

In NUREG-1150 (Reference 6), the calculated individual latent cancer fatality risk is below the NRC's safety goal, for containment leakage up to 100 percent per day.

EPRI TR-104285, "Risk Impact Assessment of Revised Containment Leak Rate Testing Intervals" (Reference 8), demonstrated that a small (less than 1 percent), but insignificant, risk increase was associated with the containment leak rate testing frequency reduction of Option B.

Trending of valve failures reported in Nuclear Plant Reliability Data System, Equipment Performance and Information Exchange, and licensee event reports showed generally improving performance (fewer failures per year). The limited data available since the adoption of the revised Appendix J, when taken in conjunction with the larger database considered as part of the revision to Appendix J, does not show a statistically significant change in the trend of the number of failures per year. Since the performance of valves has not significantly changed, the failure rates assumed in support of the revision to Appendix J were appropriate, and may be conservative. Therefore, at most, only the expected marginal increase in risk has resulted from adoption of the revised Appendix J. The effectiveness of the original Appendix J was not assessed for this study. Because of the continued reduction in transient initiators, any risk increase from adoption of the revised Appendix J is likely to be even less than was expected when Option B was offered to licensees.

With the reduced frequency of Type A tests under Option B, it is likely that a degraded containment will not be identified as quickly as under the original Appendix J. However, required licensee inspections of containment structural members limit the potential for significant degradation to remain undetected for lengthy periods of time. Because Option B is performance-based, testing failures will result in adjustments to the testing frequencies.

## 3.3 Impact on Occupational Radiation Exposure

A significant reduction in occupational radiation exposure was expected for those licensees which adopted the revised Appendix J. Staff estimated that at an ILRT frequency of one test every 10 years, industry-wide occupational exposure would be reduced by 0.087 person-sievert (8.7 person-rem) per year (Reference 2). Changing the Type B and C testing frequency to once every 5 years was estimated to reduce industry-wide occupational radiation exposure by about 0.72 person sievert (72 person-rem) per year. Therefore, the total expected reduction in occupational radiation exposure was 0.807 person sievert (80.7 person-rem) per year.
As previously noted, all currently operating U.S. nuclear power plants have at least adopted portions of the revised Appendix J, mainly in 1996 or 1997. Performance Indicator data reported by licensees and available on the NRC's public website, show that industry-wide collective radiation exposure decreased from 202 Rem per plant in Fiscal Year 1995 to 122 Rem in Fiscal Year 2001, with the largest decrease coming in Fiscal Year 1998 (140 Rem down from 176 Rem). Although these reductions cannot be attributed solely to the adoption of the revised Appendix J, occupational exposure is directly related to the number of tests performed. The biggest reduction coincides with the time period immediately following adoption of the revised Appendix J by most plants, and the magnitude of the decrease in occupational radiation exposure corresponds with the expectations for the revised Appendix J. Therefore, the revised Appendix J was successful in providing the opportunity to reduce occupational radiation exposure.

## 3.4 Summary of Appendix J Revision Expectations and Outcomes

| Summary of Appendix J Revision Expectations and Outcomes | | | |
|---|---|---|---|
| **Area** | **Expected Result** | **Actual Outcomes** | **Observations** |
| Cost Savings | Opportunity for cost savings (for licensees) | Analysis of reported valve failures indicate that testing may be deferred on the majority of valves and that ILRTs would rarely be required more than once every 10 years. | Expectations Met* |
| Less Prescriptive Regulation | Opportunity to reduce current testing burden; more efficient use of utility resources. See also cost savings. | 100% of licensees have, at least partially, voluntarily adopted. See also cost savings. | Expectations Met |
| Risk Impact | Marginal Increase | All studies indicate that the risk impact to the public is not significant | Expectations Met |
| Occupational Exposure | Opportunity to reduce occupational radiation exposure | Occupational radiation exposure is directly related to the number of tests performed. The number of tests performed is reduced. | Expectations Met* |

*although unquantified, the revision has been at least partially adopted by all licensees and has allowed licensees to reduce testing costs and occupational exposure, thus expectations are met.

# 4 CONCLUSION

Risk-informing Appendix J has been effective. The revised Appendix J has been at least partially adopted by all currently operating nuclear power plants. Its adoption has resulted in cost saving, burden reduction, and reduced occupational radiation exposure while having an insignificant impact on risk, and demonstrates the potential for further successes in risk-informing regulations.

# 5 REFERENCES


1. U.S. Nuclear Regulatory Commission, "Response to Staff Requirements Memorandum of May 28, 1997, Concerning Briefing on IPE Insight Report," SECY-97-180, August 6, 1997.

2. U.S. Nuclear Regulatory Commission, "Performance-Based Containment Leak-Test Program," NUREG-1493, September 1995.

3. U.S. Nuclear Regulatory Commission, "Review of Light Water Reactor Regulatory Requirements," NUREG/CR-4330, PNL-5809, Vols. 1 and 2, April 1986 and June 1986.

4. U.S. Nuclear Regulatory Commission, "Reactor Safety Study," WASH-1400, NUREG/75/014, 1975.

5. U.S. Nuclear Regulatory Commission, "Technical Findings and Regulatory Analysis for Generic Safety Issue II.E.4.3 – Containment Integrity Check," NUREG-1273, April 1988.

6. U.S. Nuclear Regulatory Commission, "Severe Accident Risks: An Assessment for Five U.S. Nuclear Power Plants, Final Summary Report," NUREG-1150, Vols. 1 and 2, June 1989 and December 1990.

7. U.S. Nuclear Regulatory Commission, "Individual Plant Examination Program: Perspectives on Reactor Safety and Plant Performance," NUREG-1560, Vol. 1, December 1997.

8. Electric Power Research Institute, "Risk Impact Assessment of Revised Containment Leak Rate Testing Intervals," EPRI TR-104285, August 1994.

9. U.S. Nuclear Regulatory Commission, "Performance Based Containment Leak Test Program," Regulatory Guide 1.163, September 1995.

10. Nucleonics Week, "U.S. Nuclear Record Sustained as 2001 Output Nears 800-Million MWH," February 14, 2002.