NUREG/CR-4398

Cost Analysis of Revisions to 10 CFR Part 50, Appendix J, Leak Tests for Primary and Secondary Containments of Light-Water-Cooled Nuclear Power Plants

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Prepared for
U.S. Nuclear Regulatory
Commission

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ABSTRACT

This report evaluates the cost implications associated with proposed revisions to 10 CFR Part 50, Appendix J, Leak Tests for Primary and Secondary Containments of Light-Water-Cooled Nuclear Power Plants. The work was sponsored by the NRC's Cost Analysis Group as part of its overall mission to support the development of cost estimates for NRC regulatory impact analyses.

The report examines the differences between the existing and proposed Appendix J and identifies eleven substantive areas where quantifiable impacts will likely result. The analysis indicated that there are four areas of change which tend to dominate all others in terms of cost impacts. The applicable paragraph numbers from Draft E2 of the Appendix J revision and the nature of the change follows: III.A(4) and III.A(6) - Test Pressure and Testing at Reduced Pressure No Longer Allowed; III.A(7)(b)(i) Acceptance Criteria 1.0 L_a Acceptable "As Found" Leakage; III.A(8)(a) Retesting Following Failure of "As Found" Type A Test - Corrective Action Plan, and III.A(8)(b)(ii) Option To Do More Frequent Type B & C Testing Rather Than More Type A Penalty Tests. The best estimate is that the proposed Appendix J would result in <u>cost savings</u> ranging from about $100 million to $160 million, and increase routine occupational exposure on the order of 10,000 person-rem. These estimates capture the total impact to industry and the NRC over the assumed operating life of all existing and planned future power reactors. All dollar impacts projected to occur in future years have been present worthed at discount rates ranging from 5% to 10%.

TABLE OF CONTENTS

Table of Contents - Continued

1.0 EXECUTIVE SUMMARY

The containment of all light-water-cooled reactor power plants must be periodically leak tested. These leak tests help assure that any radioactive materials released into the containment will be suitably contained and that releases to the outside environment will be small. The leak test requirements are specified in 10 CFR 50, Appendix J, "Leak Tests for Primary and Secondary Containments of Light-Water-Cooled Nuclear Power Plants". This appendix identifies the general requirements and acceptance criteria for preoperational and subsequent periodic leak testing.

The Nuclear Regulatory Commission is presently proposing to revise Appendix J. This is being done to update the criteria, clarify questions of interpretation, and reflect the issuance of a national standard addressing the procedures for conducting system leak rate tests and methods of analyzing test data. These changes to Appendix J may result in cost impacts to the utilities with nuclear power plants as well as to other agencies and entities.

An analysis has been performed of the impacts of the proposed general revision to 10 CFR 50, Appendix J. The analysis has quantified the potential impacts in terms of incremental costs and radiation exposure. The results of this analysis are summarized herein.

This effort focused on the differences between the existing Appendix J requirements as defined in the Code of Federal Regulations, 10 CFR Part 50, dated January 1, 1983, and the proposed revision to this appendix. The revision used is Draft E2, dated December, 1984. A careful comparison of the existing and proposed Appendix J was made in order to identify significant differences. The effort then concentrated on quantifying the impacts of the changed leak rate testing requirements. Investigators addressed impacts to nuclear power utilities and the NRC. No other parties or entities were identified which

would be impacted significantly. Thus, this report presents the impacts as they relate to the NRC and affected utilities.

The results of this effort are summarized in Tables 1.1 through 1.4. The impacts of the proposed revision to Appendix J are presented in terms of costs or radiation exposure. The impacts correspond to five attribute categories. These categories are as follows:

Occupational Exposure (Routine)
Industry Implementation
Industry Operation
NRC Implementation
NRC Operation

The sign convention used in presenting quantitative results is that adopted in NUREG/CR-3568," A Handbook for Value-Impact Assessment" (Ref. 1). Favorable consequences are positive; adverse consequences are negative. Thus increased costs or increased radiation exposure resulting from Appendix J revisions are indicated by a negative (-) sign since these represent adverse consequences.

1.1 SUMMARY OF OVERALL IMPACTS

Tables 1.1 and 1.2 present the overall results of this evaluation. Table 1.1 is based on a 5% discount rate for cost impacts incurred in future years, whereas Table 1.2 is based on a 10% discount rate. The occupational radiation exposure estimates are not subject to discounting. Both cost impacts and radiation exposure changes due to the revisions to Appendix J are shown. The tables give best estimates and high and low values for each category. The values tabulated include both near term effects and effects which will be felt over the remaining life of all water-cooled nuclear power plants in this country. They include cost impacts from plants currently in operation and those presently under construction.

Impacts to industry are made up of contributions from replacement energy costs, manpower requirements and occupational radiation exposure. Occupational exposures are expected to

TABLE 1.1 Summary of Impacts Due to Proposed Revision of 10 CFR 50, Appendix J - 5% Discount Rate

ATTRIBUTE	Dose Reduction (person-rem) Best Estimate	High Estimate	Low Estimate	Evaluation (10^6 $) Best Estimate	High Estimate	Low Estimate
Occupational Exposure (Routine)	(-)9885	(-)18297	(-)1472			
Industry Implementation				(-) 3.5	(-) 1.4	(-) 5.5
Industry Operation				172.8	305.3	40.2
NRC Implementation				(-) 3.2	(-) 3.0	(-) 3.4
NRC Operation				(-) 1.2	(-) 1.1	(-) 2.5
Net Impact	(-)9885	(-)18297	(-)1472	164.3	299.8	28.8

TABLE 1.2 Summary of Impacts Due to Proposed Revision of 10 CFR 50, Appendix J - 10% Discount Rate

ATTRIBUTE	Dose Reduction (person-rem) Best Estimate	High Estimate	Low Estimate	Evaluation (10^6 $) Best Estimate	High Estimate	Low Estimate
Occupational Exposure (Routine)	(-)9885	(-)18297	(-) 1472			
Industry Implementation				(-) 3.5	(-) 1.4	(-) 5.5
Industry Operation				106.4	188.1	24.7
NRC Implementation				(-) 3.2	(-) 3.0	(-) 3.4
NRC Operation				(-) 1.2	(-) 0.7	(-) 1.7
Net Impact	(-)9885	(-)18297	(-)1472	98.5	183.7	14.1

NOTE: (-) denotes increased costs or increased radiation exposures

increase under the proposed revisions to Appendix J. Manpower requirements change somewhat, but not dramatically. By far, the largest cost impact is the reduction in replacement energy costs due to expected reductions in plant outage times. For example, based on the 5% discount rate, the cost savings due to reduced replacement energy costs ranges from about $\$50 \times 10^6$ to about $\$270 \times 10^6$. This represents the dominant share of the cost impacts.

Tables 1.1 through 1.4 present ranges of values. To calculate total effects the various parameters such as manhours per cycle, number of cycles, number of plants affected, etc., were added or multiplied as appropriate. In carrying this out, the end points of each range were used rather than trying to define a mean and standard deviation from a limited data base. This resulted in new ranges defined by propagation of the extremes. This approach tends to put forth ever broadening ranges. In addition, the sums shown in Tables 1.1 through 1.4 were arrived by adding the smallest positive value to the largest negative value in a given impact area to arrive at the low estimates. Similarly, the largest positive value in a range was added to the smallest negative to determine the high estimate.

The differences in costs between Tables 1.1 and 1.2 indicate that many of the costs incurred are future costs whose present worth is affected by the prevailing discount rate. At the higher discount rate, the net costs are fairly small when considered on an industry-wide basis. At the 5% discount rate, however, the cost savings are potentially quite significant since their present worth may approach $\$300 \times 10^6$.

The results displayed in Tables 1.1 and 1.2 indicate that the Appendix J revisions are expected to yield cost savings ranging from slightly more than $\$14 \times 10^6$ to about $\$300 \times 10^6$. Industry is the beneficiary of these savings. NRC costs associated with Appendix J revisions are expected to rise somewhat relative to costs under the existing Appendix J rules.

The changes to Appendix J are estimated to result in higher occupational radiation exposures than are presently experi-

enced. The values shown in the tables represent incremental exposures incurred over the remaining lifetime of all commercial water-cooled nuclear power plants in the United States as a result of changes in the containment leak testing requirements. Unlike dollar costs, future occupational radiation exposures are not discounted. As with cost impacts, this includes plants currently in operation and those presently under construction.

The incremental exposures shown in Tables 1.1 and 1.2 represent industry average increases of about 3.0 man-rem per year of operation per plant. The high estimate is 5.6 man-rem per plant per year, and the low goes down to 0.5 man-rem incremental exposure.

1.2 IMPACTS OF SPECIFIC CHANGES TO APPENDIX J

Tables 1.3 and 1.4 show cost and exposure impacts as they relate to the major individual changes to Appendix J. The analysis of the revisions to Appendix J indicated that eleven (11) areas of change had quantifiable impacts. Several other areas of change were also identified and studied, but these were judged to have negligible impacts and are not included in Tables 1.3 and 1.4. As with Tables 1.1 and 1.2, impacts are couched in terms of Occupational Exposure (Routine), Industry Implementation, Industry Operation, NRC Implementation, and NRC Operation. Similarly, the values shown with a negative (-) sign represent either increased radiation exposure or increased costs relative to containment leak testing under the existing Appendix J rules.

The analysis indicated that there are four areas of change which tend to dominate all others in terms of cost impact magnitude. The applicable paragraph numbers (from Draft E2 of the proposed general revision to Appendix J) and the nature of the change are as follows:

III.A(4) & III.A(6)	Test Pressure Testing at Reduced Pressure No Longer Allowed
III.A(7)(b)(i)	Acceptance Criteria 1.0 L_a Acceptable "As Found" Leakage

Table 1.3. Impacts Due to Appendix J - 5% Discount Rate

Paragraph (Draft E2)	Area of Change	Radiation Dose Impacts: Occupational Exposure (Routine), man-rem	Cost Impacts: Industry Impl. $10^6$$	Industry Oper. $10^6$$	NRC Impl. $10^6$$	NRC Oper. $10^6$$
	Type A Testing					
III.A(4) & III.A(6)	Test Pressure Testing at Reduced Pressure No Longer Allowed			(-) 12.8 to (-) 22.8		
III.A(7)(b)(i)	Acceptance Criteria 1.0La Acceptable "As Found" Leakage	5 to 39		4.6 to 73.2		
III.A(8)(a)	Retesting Retesting Following Failure of "As Found" Type A Test - Corrective Action Plan	(-)1411 to (-)9220		(-) 2.5 to (-) 19.0		(-) 1.0 to (-) 2.2
III.A(8)(b)(ii)	Retesting Option to Do More Frequent Type B & C Testing Rather Than More Type A Penalty Tests	(-) 353 to (-)5408		80.5 to 244.3		
	TYPE B TESTING					
III.B(1)(b)	Frequency of Testing of Penetrations With Continuous Leak Monitoring Must Be Specified in Technical Specifications		(-) 0.4 to (-) 0.7		(-) 0.5 (-) 0.7	
III.B(3)(a)	Air Locks. Periodic Tests: Flexibility to Postpone Testing at Pa if Air Lock Has Not Been Opened	135 to 447		0.8 to 2.9		(-) 0.1 (-) 0.3
III.B(3)(b)	Intermediate Tests: Flexibility to Test Seals or to Test at Pressures Other Than Pa Following Intermediate Openings of Air Locks		0.5 to 0.8		0.9	

Table 1.3. (Continued)

Paragraph (Draft E2)	Area of Change	Radiation Dose Impacts: Occupational Exposure (Routine), man-rem	Cost Impacts: Industry Impl. 10^6 $	Industry Oper. 10^6 $	NRC Impl. 10^6 $	NRC Oper. 10^6 $
III.B(4)(a)	Type B Test Acceptance Criteria - Requirement to Determine "As Found" Data	0 to (-)601		0 to (-) 0.7		
III.B(4)(c)	Type B Test Acceptance Criteria - Retest Following Repairs and Implied Corrective Action Plan	(-)194 to (-)3208		(-) .5 to (-) 4.0		
	TYPE C TESTING					
III.C(3)(c)	Acceptance Criteria Hydraulically Tested Valves Must Have Leak Limits Specified in Technical Specifications		(-) 1.0 to (-) 4.2		(-) 0.5 (-) 0.7	
	TEST METHODS, PROCEDURES, AND ANALYSES					
V.A	Testing Details and Methods Must Be Defined in Technical Specifications		(-) 0.8 to (-) 1.1		(-) 1.1	
SUMMATION	MEAN	(-)9885	(-) 3.5	172.8	(-) 3.2	(-) 1.8
	RANGE	(-)1972 to (-)18297	(-) 1.4 to (-) 5.5	40.2 to 305.3	(-) 3.0 to (-) 3.4	(-) 1.1 to (-) 2.5

NOTE: (-) means increased costs or increased exposure

Table 1.4. Impacts Due to Appendix J - 10% Discount Rate

Paragraph (Draft B2)	Area of Change	Radiation Dose Impacts: Occupational Exposure (Routine), man-rem	Cost Impacts: Industry Impl, 10^6 $	Cost Impacts: Industry Oper, 10^6 $	Cost Impacts: NRC Impl, 10^6 $	Cost Impacts: NRC Oper, 10^6 $
	Type A Testing					
III.A(4) & III.A(6)	Test Pressure Testing at Reduced Pressure Longer Allowed			(-) 7.9 to (-) 14.0		
III.A(7)(b)(i)	Acceptance Criteria 1.0La Acceptable "As Found" Leakage	5 to 39		2.8 to 45.1		
III.A(8)(a)	Retesting Retesting Following Failure of "As Found" Type A Test - Corrective Action Plan	(-)1411 to (-)9220		(-) 1.5 to (-) 11.7		(-) 0.6 (-) 1.4
III.A(8)(b)(ii)	Retesting Option to Do More Frequent Type B & C Testing Rather Than More Type A Penalty Tests	(-) 353 to (-)5408		49.6 to 150.4		
	TYPE B TESTING					
III.B(1)(b)	Frequency of Testing of Penetrations With Continuous Leak Monitoring Must Be Specified in Technical Specifications		(-) 0.4 to (-) 0.7		(-) 0.5 to (-) 0.7	
III.B(3)(a)	Air Locks. Periodic Tests: Flexibility to Postpone Testing at Pa if Air Lock Has Not Been Opened	135 to 447		0.5 to 1.9		(-) 0.1 to (-) 0.3
III.B(3)(b)	Intermediate Tests: Flexibility to Test Seals or to Test at Pressures Other Than Pa Following Intermediate Openings of Air Locks		0.5 to 0.8		0.9	

Table 1.4. (Continued)

Paragraph (Draft E2)	Area of Change	Radiation Dose Impacts: Occupational Exposure (Routine), man-rem	Cost Impacts: Industry Impl. 10^6 $	Cost Impacts: Industry Oper. 10^6 $	Cost Impacts: NRC Impl. 10^6 $	Cost Impacts: NRC Oper. 10^6 $
III.B(4)(a)	Type B Test Acceptance Criteria - Requirement to Determine "As Found" Data	0 to (-) 601		0 to (-) 0.4		
III.B(4) (c)	Type B Test Acceptance Criteria - Retest Following Repairs and Implied Corrective Action Plan	(-) 194 to (-)3208		(-) .3 to (-) 2.5		
	TYPE C TESTING					
III.C(3)(c)	Acceptance Criteria Hydraulically Tested Valves Must Have Leak Limits Specified in Technical Specifications		(-) 1.0 to (-) 4.2		(-) 0.5 (-) 0.7	
	TEST METHODS, PROCEDURES, AND ANALYSES					
V.A	Testing Details and Methods Must Be Defined in Technical Specifications		(-) 0.8 to (-) 1.1		(-) 1.1	
SUMMATION	MEAN	(-)9885	(-) 3.5	106.4	(-) 3.2	(-) 1.2
	RANGE	(-) 1472 to (-)18297	(-) 1.4 to (-) 5.5	24.7 to 188.1	(-) 3.0 to (-) 3.4	(-) 0.7 to (-) 1.7

NOTE: (-) means increased costs or increased exposure

III.A(8)(a)	Retesting Retesting Following Failure of "As Found" Type A Test - Corrective Action Plan
III.A(8)(b)(ii)	Retesting Option to Do More Frequent Type B & C Testing Rather Than More Type A Penalty Tests

Paragraph III.A(4) of the proposed revision requires that the containment integrated leak rate tests (CILRT) be performed at pressures not less than P_a, the design basis accident pressure. The current Appendix J allows testing at reduced pressures P_t ($P_t \geq P_a/2$). About 40% of the existing plants perform their CILRTs at reduced pressures. This would no longer be allowed under the proposed revision. Test costs for these plants increase because of the longer pressurization and depressurization times required for tests at P_a as compared to those at P_t. These longer times translate into incremental plant downtime, which is very expensive. Thus testing costs increase.

The proposed revision to Appendix J states that the "as found" allowable leakage determined from a CILRT must be less than or equal to 1.0 L_a (paragraph III.A(7)(b)(i)). The existing rule states that this allowable leakage must not be greater than 0.75 L_a. Thus, the proposed rule represents a slight relaxation in the allowable leakage limits. It reduces slightly the likelihood that plants will fail their Type A CILRT. This also reduces the likelihood that plants will fail two consecutive Type A tests, and thus they will be more likely to avoid the penalty test situation brought about by two consecutive failures. The cost savings associated with this Appendix J change results from a reduced number of Type A penalty tests and their associated plant downtime costs.

The provisions of paragraph III.A(8)(a) in the revised Appendix J state that a Corrective Action Plan (CAP) must be developed and implemented whenever a plant fails a Type A test. The failure rate for such tests is estimated to be on the order of 0.4 to 0.5 presently. Thus a large number of plants will likely have to develop and implement CAPs to better ensure the integrity of their containment systems. The CAPs generally require increased surveillance and maintenance of containment penetrations. The increased costs and radiation exposures result from these increased activities.

Paragraph III.A(8)(b)(ii) had the largest identified cost impact of any of the revisions to Appendix J. It gives utilities the option to do more frequent local leak rate tests (Type B and C tests) in lieu of more frequent penalty Type A tests if the previous Type A test failures were due to leakage through Type B and C penetrations (valves, air locks, electrical penetrations, etc.). Past experience indicates that Type B and C penetration leakage is the dominant cause of Type A test failures. Costs are potentially reduced by this change to Appendix J because the additional Type B and C tests are less expensive than the Type A tests. The Type A tests require on the order of 3 to 5 days of incremental plant downtime. The Type B and C tests do not require this type of downtime, and thus involve significantly reduced costs compared to the Type A tests. The more frequent testing of individual containment penetrations does require additional time inside containment for test crews. This local testing involves substantially higher occupational exposures than does the integrated leak rate testing.

2.0 INTRODUCTION

The containments of all light-water-cooled reactor power plants must be periodically leak tested. The primary and secondary containments must meet the leak test requirements set forth in 10 CFR 50, Appendix J. Otherwise, the plant operating license will be suspended or withheld. The tests ensure that leakage through the primary and secondary containment or systems and components penetrating these containments does not exceed allowable leakage rates specified in the technical specifications. The tests also assure that inservice inspection of penetrations and isolation valves is performed so that proper maintenance and repairs are made during their service life. Appendix J identifies the general requirements and acceptance criteria for preoperational and subsequent periodic leak testing.

The Nuclear Regulatory Commission is presently proposing to revise Appendix J to update its criteria, clarify questions of interpretation, and to reflect the issuance of a national standard addressing the procedures for conducting system leak rate tests and methods of analyzing test data. These changes to Appendix J may result in cost impacts to the utilities with nuclear power plants as well as to other agencies and entities. The impacts may be positive or negative, depending on the nature of the revision being considered.

2.1 OBJECTIVES

The U.S. Nuclear Regulatory Commission (NRC) authorized Science and Engineering Associates, Inc. (SEA) and its subcontractors, S. Cohen and Associates, Inc. (SC&A) and Mathtech, Inc. to perform a cost analysis of the impacts of the general revision to 10 CFR 50, Appendix J, Leak Tests for Primary and Secondary Containments of Light-Water-Cooled Nuclear Power Plants. The results of this analysis are presented in this report. The major changes to Appendix J as proposed in the general revision, are noted herein. The impacts of each of these changes are also defined. These impacts are couched primarily in

terms of incremental costs. Also, incremental radiation exposure data is presented where this could be assessed.

In the conduct of this effort, investigators have focused on the differences between the existing Appendix J requirements as defined in the Code of Federal Regulations, 10 CFR Part 50, dated January 1, 1983, and the proposed revision to this appendix. The revision used is Draft E2, dated December, 1984. A careful comparison of the existing and proposed Appendix J was made in order to identify significant differences. The effort then concentrated on quantifying the impacts of the changed leak rate testing requirements. Investigators addressed impacts to nuclear power utilities and the NRC. No other parties or entities were identified which would be impacted significantly. Thus, this report presents the impacts as they relate to the NRC and effected utilities.

2.2 REPORT ORGANIZATION

This report is organized as follows. An overall summary of the impacts of proposed changes in containment leak testing requirements is presented in the Executive Summary, Section 1.0. That section presents the impacts in terms of "major attributes". Section 3.0 briefly discusses the technical approach used in the conduct of this assessment. It also reviews the data base used in the effort.

Section 4.0 presents the changes to Appendix J which were deemed to have potentially significant impacts. It indicates the changes of primary interest to this study. Section 5.0 discusses the impacts of Appendix J revisions. Each of the significant changes to Appendix J are presented separately. Impacts of these individual changes are quantified wherever possible. The quantification is primarily in terms of incremental plant downtime, labor costs, and occupational radiation exposure. The Section 5.0 discussions present the basis, assumptions, and methodology used in carrying out the quantification.

The cost estimating basis used in the evaluations is given in Section 6.0 All assumptions are noted, as well as the

methodology for the quantification of impacts for both existing and planned nuclear plants.

This study was conducted on a rather short time schedule and with limited resources. Thus, the study could not be exhaustive in terms of surveying and utilizing all of the available data sources which could potentially bear on the results. The limitations of the effort, therefore, contribute to the uncertainties of the results. These and other contributors to uncertainties are discussed in Section 7.0.

The Appendix supplements the information presented in the text. It presents the basis used in estimating incremental worker radiation exposures due to the implementation of the revised Appendix J.

3.0 TECHNICAL APPROACH

3.1 PLAN

SEA and its subcontractors identified a number of steps which were necessary in order to accomplish the stated objectives of this task. In the broadest sense, this effort required a detailed and careful comparison of the old and the new Appendix J in order to clearly understand the changes proposed. These changes then had to be translated into cost impacts on nuclear plant utilities and other affected entities.

The specific steps followed in the conduct of this effort were as follows:

a. Gather pertinent background materials,

b. Perform a detailed evaluation of Appendix J changes,

c. Evaluate the impacts due to Appendix J revisions,

d. Evaluate costs impacts, and

e. Document the results.

3.2 DATA BASE AND BACKGROUND INFORMATION

Information and data needed to perform this cost analysis were obtained from a number of sources. Documents describing the proposed revisions to Appendix J, a quantitative assessment of the potential impacts of the proposed changes, and other pertinent background information were received from the NRC at the onset of this effort. This documentation was extremely helpful in focusing attention on the areas of major change between the proposed and existing versions of Appendix J.

Much valuable information was obtained from NRC regional inspectors and from other NRC personnel who have direct experience in nuclear plant containment leak rate testing. These personnel also are very familiar with the test reports submitted by utilities and with exemption requests pertaining to containment leak rate testing. Their contributions to this effort have been extremely valuable.

Another important source of information used in this effort was the nuclear plant utilities. Investigators contacted about a dozen utilities regarding their experiences in containment leak rate testing. Their input was especially valuable in assessing the costs associated with the various tests and in estimating worker radiation exposure incurred as part of the testing effort.

Finally, a major source of information related to leak testing of containments of light-water-reactor plants has been the NRC's Public Document Room. Using the NRC's computerized search capabilities, investigators obtained listings of more than five hundred bibliographic citations. A review of the citations revealed that the available documentation includes:

- reports from the utilities to the NRC summarizing containment integrated (Type A) and local (Type B & C) leak rate tests;
- reports from the utilities to the NRC summarizing test procedures and results for specific types of valves;
- requests by utilities for exemptions from specific interval, frequency, or testing requirements of Appendix J, and the NRC's Safety Evaluation Reviews and decisions on such requests;
- internal NRC documents and memoranda relating to the proposed revisions of Appendix J; and
- miscellaneous reports and correspondence.

Investigators have reviewed examples of each type of document to determine the kinds of information each contains, focusing specifically on identifying information from actual utility experience on outage times, manpower requirements, radiation exposures, and difficulties encountered in performing the required tests.

The Containment Integrated (Type A) and Local (Type B & C) Leak Rate Test reports typically include a chronology of the Type A test, schematics of the test instrumentation used in the Type A test, tables of the data recorded during the Type A test, a discussion of the results and the error analysis methods used, and summary tables of the results of Type B & C tests performed

since the previous Type A test. Total time needed to accomplish the Type A tests is usually included in the chronology (or can be inferred), but no data are given on the time required to perform the local (Type B & C) leak rate tests. The Type B & C summaries do (to a greater or lesser degree of clarity) identify the specific valves, and other penetrations that need to be tested. Some of these also identify penetration leaktightness requirements. A few of these reports give the "as found" condition; most do not give this type of information. None of the reports reviewed included information on radiation doses. A few of the reports included information on the number of persons needed to perform a Type A test.

The reports from the utilities to the NRC summarizing test procedures and results for specific types of valves include schematics of the valve(s) to be tested, schematics of the testing equipment, and a discussion of the testing procedures.

Utility requests for exemptions and NRC responses fall into three general groups: exemptions to the testing interval requirements; exemptions to the frequency requirements; and exemptions for specific components from the testing requirements. Requests for exemptions to the interval requirements generally contain the utilities' rationale for seeking such an exemption and typically summarize the components that will exceed the Appendix J interval requirements and the leak rate history of those components. Included in the exemption requests surveyed was one which cited data on worker radiation exposures associated with leak testing a series of valves, penetrations, and components subjected to Type B & C tests. The exposure data given is based on performing the tests while the reactor is in cold shutdown. The inclusion of this type of information was atypical.

Several of the exemption requests surveyed were useful in that they reinforce the need for many of the proposed changes to Appendix J which should improve compliance with the requirements and reduce the need for exemption requests from the utilities.

The third general type of exemption request involves relief from specific requirements for specific valves or penetrations. Generally, the information contained in these requests concerns the specific testing procedure and/or valve configuration. At least one such request included a discussion of the radiation exposure and time required to perform a specific test.

Overall, data on manpower requirements, outage times, radiation exposures, and specific difficulties encountered in performing the containment integrated and local leak rate tests are sparse. The reports submitted by the utilities summarizing the results of such tests provide a clear picture of what the tests involve, but are notably lacking in the specifics needed to assess impacts associated with Appendix J changes. Exemption requests contain a smattering of such data, but the inclusion of pertinent data appears to be the exception rather than the rule.

In addition to the information available from the NRC Public Document Room, other reports and documentation were reviewed. These include technical specifications for a number of nuclear plants as well as Standard Technical Specifications issued by nuclear plant vendors.

4.0 EVALUATION OF CHANGES TO APPENDIX J

Each of the proposed changes to Appendix J was studied. In this effort the materials supplied by the NRC at the onset of the task were extremely helpful. The following items were especially useful:

1. Proposed 10 CFR Part 50, Appendix J, Draft E2
2. Comparative Draft of present Appendix J vs proposed Appendix J, Draft D5
3. Changes to 10 CFR 50 Appendix J, based on Draft D5
4. Types of changes and Ratchet Status 10 CFR 50 Appendix J, based on Draft D5
5. Memorandum, F. Maura to R. Spessard, "Summary of October 3-5 Meeting on Containment Integrated Leak Rate Testing and Proposed Revisions to Appendix J."
6. CRGR Review Material (Relative to Appendix J proposed revisions).

Based on these and other materials, as well as input from NRC staff members and on our own assessments and judgements, the SEA team completed a screening of the changes to Appendix J. This screening yielded a list of the particular Appendix J changes deemed likely to have significant cost impacts. Table 4.1 shows the candidate changes which were selected for further investigation. The list is not intended to be a comprehensive itemization of changes between the proposed revision to Appendix J and the existing Appendix J. Rather, as noted previously the focus is on those revisions or changes which have the potential for significantly impacting costs to the NRC and to nuclear power utilities. Note that impacts can be positive as well as negative, i.e., cost savings or reductions associated with containment leak testing may accrue as well as cost increases.

Table 4.1 lists the proposed changes to Appendix J in order according to paragraph number. The paragraph number is noted and a brief description of the topic of the change is

given. The paragraph number refers to Draft E2 of proposed 10 CFR Part 50, Appendix J.

The investigations of each Appendix J change revealed that, indeed, most of the revisions would have a cost impact. In some cases, however, the evaluations indicated that the impact is likely to be insignificant. For these cases the impacts were not quantified. Table 4.1 indicates which changes were quantified in terms of their cost impacts and which were not.

The quantification analysis and results are discussed in Section 5.0.

Table 4.1. Changes to Appendix J Perceived to Have Potentially Significant Cost Impacts

Paragraph No. (Draft E2)	Area of Change	Impacts Quantified
	Type A Testing	
III.A(1)	Preoperational Test (Type B & C Testing Required Prior to Type A Test)	No
III.A(3)	Test Frequency	No
III.A(4) & III.A(6)	Test Pressure Testing at Reduced Pressure No Longer Allowed	Yes
III.A(7)(b)(i)	Acceptance Criteria Determination of "As Found" Type A Leakage, and	Yes
	1.0La Acceptable "As Found" Leakage	Yes
III.A(8)(a)	Retesting Retesting Following Failure of "As Found" Type A Test - Corrective Action Plan	Yes Yes
III.A(8)(b)(ii)	Retesting Option to Do More Frequent Type B & C Testing Rather Than More Type A Penalty Tests	Yes
	TYPE B TESTING	
III.B(1)(b)	Frequency of Testing of Penetrations With Continuous Leak Monitoring Must Be Specified in Technical Specifications	Yes
III.B(3)(a)	Air Locks. Periodic Tests: Flexibility to Postpone Testing at Pa if Air Lock Has Not Been Opened	Yes
III.B(3)(b)	Intermediate Tests: Flexibility to Test Seals or to Test at Pressures Other Than Pa Following Intermediate Openings of Air Locks	Yes

Table 4.1. (Continued)

Paragraph No. (Draft E2)	Area of Change	Impacts Quantified
III.B(4)(a)	Type B Test Acceptance Criteria - Inclusion of Maximum Pathway Leakage and Continuously Monitored Leak Test Results, and	No
	Requirement to Determine "As Found" Data	Yes
III.B(4)(c)	Type B Test Acceptance Criteria - Retest Following Repairs and Implied Corrective Action Plan	Yes
	TYPE C TESTING	
III.C(3)(c)	Acceptance Criteria Hydraulically Tested Valves Must Have Leak Limits Specified in Technical Specifications	Yes
	SPECIAL LEAK TEST REQUIREMENTS	
IV.A	Retesting Following Containment Modification or Maintenance	No
	TEST METHODS, PROCEDURES, AND ANALYSES	
V.A	Testing Details and Methods Must Be Defined in Technical Specifications	Yes
V.B	Sequence of Periodic Type A, B and C Tests - Determination of "As Found" Conditions	No

5.0 IMPACTS OF APPENDIX J REVISIONS

Each of the Appendix J changes identified in Section 4.0 has been studied and assessed for its potential cost impacts. The results of this effort are discussed below. Section 5.1 presents those aspects of the Appendix J changes which were determined to have quantifiable impacts. In each case the nature of the impact is discussed as well as the quantified results. The basis and assumptions used in arriving at the estimated impacts are also presented.

Section 5.2 discusses the aspects of the Appendix J revisions which were assessed as having a small or non-quantifiable impact.

5.1 APPENDIX J CHANGES WITH QUANTIFIABLE IMPACTS

The following material discusses specific Appendix J changes and the estimated impacts. For each change discussed, the following format is used:

a) The subject proposed 10 CFR 50, Appendix J, paragraph or item is quoted,

b) the change relative to the existing Appendix J is noted, and

c) the nature and extent of the impacts is discussed, along with the basis, assumptions, etc.

The quantified impacts are couched in terms of major "attributes" (Reference 1). The various attribute categories recommended for use in value-impact assessments are listed below. Not all of these attributes are pertinent to this assessment. Those which are pertinent, i.e., those for which quantifiable impacts were established, are indicated with an asterisk (*).

Public Health
Occupational Exposure (Accidental)
*Occupational Exposure (Routine)
Offsite Property
Onsite Property
Regulatory Efficiency

Improvements in Knowledge
*Industry Implementation
*Industry Operation
NRC Development
*NRC Implementation
*NRC Operation

Note that attributes such as Public Health, Occupational Exposure (Accidental), Offsite Property, and Onsite Property could potentially be impacted by the Appendix J changes. This could be the case, for example, if the changes resulted in a higher integrity for reactor containment systems, and thus these systems were more likely to contain radioactive releases during accident situations. These changes constitute the typical values or benefits of NRC regulatory analyses and as such as not within the scope of this cost evaluation.

The following discussions present the assessment of the impacts for each substantive change in the proposed Appendix J revision as compared to the existing leak testing requirements. They are given in order according to their paragraph numbering as found in Draft E2 of the proposed Appendix J revision.

In the following discussions, ranges of values are presented. In order to calculate total effects the various parameters such as manhours per cycle, number of cycles, number of plants affected, etc., are added or multiplied as appropriate. In carrying this out, the end points of each range were used rather than trying to define a mean and standard deviation from a limited data base. This resulted in new ranges defined by propagation of the extremes. This approach tends to put forth ever broadening ranges.

5.1.1 Type A Test Pressure

5.1.1.1 Proposed Appendix J Requirement

III.A(4) Test Pressure. Type A test pressure must be equal to or greater than P_{ac} to start, but must not exceed the containment design pressure and must not be permitted to fall more than 1 psi below P_{ac} for the duration of the test,

not including the verification test. The test pressure is to be established relative to the external pressure of the containment. This may be either atmospheric or the pressure of a secondary containment.

III.A(6) Verification Test. A leakage rate verification test must be performed after a Type A test that meets the leakage rate criteria in III.A.(7)(b)(ii). The results of the Type A test are acceptable if the difference between the containment leakage rates calculated from the Type A test (L_{am}) and the verification test is less than $\pm 0.25\ L_a$.

5.1.1.2 Changes Relative to Existing Appendix J

The changes to Appendix J require that all containment integrated leak rate tests be conducted at full design basis accident pressure P_a. The existing Appendix J allows tests to be done using either P_a or a reduced pressure P_t ($P_t \geq P_a/2$). Reduced pressure test results must be extrapolated to obtain the expected leak rate at full pressure. Currently most utilities use the full pressure test, due to accuracy problems with the half pressure test. However, a significant number of utilities do currently use reduced pressure tests.

5.1.1.3 Quantification of Impacts

To quantify the impact of the Appendix J changes concerning containment integrated leak rate test (CILRT) pressure it was necessary to estimate the average number of plants which are currently using reduced pressure testing. The following table indicates the percentage of the plants, in each region listed, that continue to use reduced pressure CILRTs. These percentages were obtained from the appropriate NRC regional representatives as presented at the meeting to discuss Appendix J changes, Washington, DC, February 20, 1985.

NRC Region	Number of of Currently Operating Units	Percentage of Plants Using Reduced Pressure Testing	Approx. Number of Plants Using Reduced Pressure Testing
I	23	23%	5
II	27	60%	16
III	21	40%	8
IV	4*	41% (assumed)	2
V	6**	41% (assumed)	2

No information was available for Regions IV or V, therefore, an average of Regions I, II, and III, which is 41%, was used. Based on this value it can be estimated that 2 plants* in Region IV and 2 in Region V are currently using reduced pressure testing. The total for Regions I through V is approximately 33 plants which would be affected by the Appendix J changes.

The number of anticipated CILRTs over the lifetime of these 33 plants can be determined from the average remaining lifetime and the test frequency. The average remaining lifetime for all currently operating plants in the U.S. is taken to be 26 years. This value was obtained from Reference 1. The test required frequency is given in Appendix J.

A second CILRT must be conducted 3 years after the preoperational test and then approximately every 4 years thereafter. Since most of the currently operating plants have been on-line for more than 3 years, the test frequency is taken to be one test every 4 years. In the current assessment it was assumed

* Fort St. Vrain is not counted as part of this estimate.
**Hanford N-Reactor is not counted as part of this estimate.

that some fraction of the plants coming on line in the future would also opt for testing at reduced pressure. Eleven (11) future plants were put in this category, so that the total number of affected plants becomes 44. Therefore, the total number of CILRTs for both existing plants and new plants impacted by the Appendix J change is calculated as follows:

$$33 \text{ plants} \times \frac{26 \text{ years}}{\text{plant}} \times \frac{1 \text{ test}}{4 \text{ years}} + 11 \times \frac{30 \text{ years}}{\text{plant}} \times \frac{1 \text{ test}}{4 \text{ years}} = 297 \text{ tests}$$

The greatest impact on those plants affected by the Appendix J changes will be the increased downtime during longer pump-up and depressurization periods. Through personal communications with staff of organizations which specialize in containment leak testing, these specialists estir ted the time increment for pump-up to be 3-4 hours and another 3-4 hours for depressurization time. These numbers are within the range of values given by "CRGR Review Material" which estimates the additional pump-up time to be 3-10 hours. Assuming the utilities will make an effort to minimize down time, the lower values of 3-4 hours will be used to further quantify the industry-wide impact of the changes.

The increased pump-up and depressurization times of 3-4 hours implies a total of 6-8 hours incremental plant down time per CILRT. The plant must be in a cold shutdown condition when the CILRT is performed. No other operations can take place within the primary containment during the test period. Therefore, the time required to perform the CILRT is taken to be critical-path time that extends the plant outage. The present worth of tests to be performed in the future must take the time distribution of these tests into account.

Another impact, though much smaller, is the increased man-hours during the incremental test time. During the incremental pump-up time (3-4 hours) the following personnel are present and should be considered in calculating the increased costs (Reference 2):

Test Coordinator
Shift Coordinator (1 per shift)

Data Engineer (1 per shift)
Data Taker (1 per shift)
Computer Operator (1 per shift)
Support Engineer (1 per shift)

Similarly, during the incremental depressurization time (3-4 hours) the following personnel are required:

Test Coordinator
Shift Coordinator (1 per shift)
Support Engineer (1 per shift)

This assessment of impacts due to requiring CILRTs to be performed at P_a rather than at reduced pressure assumes that utilities currently using reduced pressure tests would normally continue to do so. It is also assumed that containment modifications would not be needed to perform tests at P_a rather than at P_t. Note that all containments are required to perform a structural integrity test at P_a or higher prior to initial plant startup.

The impacts discussed here are in the attribute category of <u>Industry Operation</u>. The impacts are negative, i.e., they represent cost increases for the nuclear industry.

In summary, the cost impact associated with requiring integrated leak rate tests to be performed at P_a is as follows. Two cost ranges are shown corresponding to 5% and 10% discount rates.

Attribute	Impacts, (1000 $)	
Industry Operation	(-)12,799 to (-)22,791	5% discount rate
	(-)7,884 to (-)14,040	10% discount rate

These figures indicate that the potential cost impact is fairly large. It is large because this revision to the test requirement will necessitate additional plant downtime. Downtime costs are estimated to be in the range of $13,500 to $19,000 per hour (see Section 6.2). The incremental outage time of 6 to 8 hours for performing the CILRT at P_a instead of at reduced pressure,

therefore, will increase the costs by $81,000 to $152,000 for each such test.

5.1.2 Type A Test Acceptance Criteria

5.1.2.1 Proposed Appendix J Requirement

III.A(7)(b) Acceptance Criteria. For each periodic Type A test, the 95% upper confidence limit for the leakage rate shall not exceed:

(i) L_a, for the "as found" condition,

(ii) 0.75 L_a, for the "as left" condition.

5.1.2.2 Changes Relative to Existing Appendix J

The 95% UCL and the limit on the "as found" are both new requirements. The "as found" requirement is a clarification of the NRC position as stated in the existing Appendix J that the Type A test determine the "as is" condition of the containment. In addition the proposed requirement is that the "as found" containment leakage be less than or equal to 1.0 L_a, whereas the existing Appendix J sets a limit of 0.75 L_a for both the "as is" and "as left" condition.

5.1.2.3 Quantification of Impacts

5.1.2.3.1 Effect of 95% UCL Basis. Calculation and reporting of the 95% UCL will have a very small impact on the data reduction effort. As a matter of good practice, confidence intervals should be routinely calculated during the statistical analysis of the leak rate data. This should provide a measure of slight conservatism as well as added confidence in the final leak rate calculation. Failures of Type A test due to the addition of the 95% UCL would be expected only for containments that are marginal to begin with.

From our survey of ILRT reports and from other sources, it appears that the reporting of confidence limits, either upper and lower limits or just the UCL, is very much the current prac-

tice in industry. Thus the 95% UCL requirement will have little or no impact. Note that the new ANSI standard (Reference 3) requires the use of the one sided 95% UCL, and BN-TOP-1 (Reference 4) and EPRI NP-3400 (Reference 5) both use the 95% UCL in their criteria for determining shortened Type A test durations.

5.1.2.3.2 Requirement to Determine "As Found" Condition. The requirement for the "as found" condition is necessary to insure that the containment has not become degraded between Type A tests to the point of exceeding the maximum allowable leak rate. This requirement is not new since the existing Appendix J calls for a determination of the "as is" condition of containment. However, the proposed revision removes ambiguities regarding the determination of the "as found" or "as is" condition. It removes the potential for abuses whereby, for example, maintenance on containment penetrations could be performed just prior to the ILRT, and thus defeating the intent of determining a true "as found" condition.

The CILRT tests surveyed indicated that reporting of the "as found" condition for the Type A test does not appear to be presently done. The NRC has been requesting that the utilities supply sufficient data from the Type B and C tests results to derive an "as found" condition for the containment. However, because of ambiguities in the current regulation this requirement or request has not been enforced in all NRC regions.

The requirement for reporting the "as found" condition for the Type A test will remove the present ambiguity and make the reporting of the "as found" mandatory. This will be a benefit to the NRC. At the present time it is not possible to quantify this benefit. The utilities will see some negative impact from this requirement. There will be some increase in time needed for reporting and analysis of the Type B and C testing done in conjunction with the Type A test, so that the "as found" condition of the containment can be determined. This should be small compared to the total cost of the Type A test. Because of the interrelationship of this requirement and others

to be discussed in the following sections, a quantification of the impact of this requirement will not be done in this section. Thus, there is no incremental impact here that is not covered by other discussions included elsewhere.

5.1.2.3.3 1.0 L_a for the "As Found" Conditions. This change in Appendix J represents a small but meaningful relaxation in the as found containment condition. The present requirement specifies that leakage not exceed 0.75 L_a, whereas the proposed change allows a higher leakage limit of 1.0 L_a. However, the 1.0 L_a requirement is consistent with the accident analysis evaluation for each plant which sets the allowable leakage limit at L_a in the first place.

This change to Appendix J will be a benefit to plants with ILRT results which fall between 0.75 and 1.0 L_a for their as found leakage rate. Thus plants have a slightly greater chance of passing a Type A test with the proposed criterion as compared to the existing Appendix J limit. This becomes meaningful when one considers the consequence of failing two consecutive Type A tests. The plant or utility failing two such consecutive tests must go to an accelerated testing schedule. Additional Type A tests (penalty tests) are costly, primarily because of the attendant incremental plant downtime.

The impacts of the 1.0 L_a vs. 0.75 L_a leakage criteria can be estimated by considering the frequency with which Type A tests yield integrated leakage rates which fall between 0.75 and 1.0 L_a Of the 30 or so CILRT reports surveyed, none showed containment leak rates in this range. Some came very close, however. NRC regional inspectors were contacted concerning test results for reactors in their regions. For Region III it was estimated that on the order of 3 or 4 tests had initial results which would have fallen in this range of 0.75 to 1.0 L_a. Under the existing requirement, of course, these plants would have failed this particular Type A test. In Region III there are 23 operating plants. They are assumed to have an average age (operating years) of 9 years. Thus there should have been about

62 tests for these 23 plants, assuming an average Type A test interval per plant of 3-1/3 years. On this basis, the probability of a Type A test result falling between 0.75 and 1.0 L_a is estimated to be approximately 4/62, or about 6.5%.

Region II inspectors estimated that Type A tests falling between 0.75 and 1.0 L_a had occurred only once. The operating plants in Region II should have had a total of about 78 Type A tests. Thus the frequency of tests with leak rates falling between 0.75 and 1.0 L_a in Region II is estimated to be 1/78 or about 1%. Considering the approximate nature of these data, the overall likelihood of Type A tests falling into this range of leakage rates is taken to be from 0.01 to 0.1. Note that these are tests which would fail the Type A test under the existing requirements but which would pass under the proposed revision to Appendix J.

The main benefit to industry, as noted previously, are the cases where failure of two consecutive Type A tests can now be avoided. The likelihood of two such consecutive failures is reduced slightly with the proposed change in Appendix J.

The survey of test reports and discussions with NRC Regional Inspectors indicates that the likelihood of Type A test failures under the existing rule is in the range of 0.4 to 0.5. With the proposed changes the likelihood of failing a given Type A test would be reduced somewhat so that the likelihood range becomes 0.3 to 0.39 on the low end and 0.4 to 0.49 on the high end. The overall range, therefore, is 0.3 to 0.49.

The assumption can be made that the likelihood of failing a given ILRT is independent of the results of the previous test, i.e., the tests are basically independent. Therefore, the likelihood of a given plant failing two consecutive Type A tests is the square of the independent failure probabilities.

	Likelihood of Failing Two Consecutive Type A Tests
Existing Appendix J	0.4 x 0.4 = 0.16 to 0.5 x 0.5 = 0.25 Range is 0.16 to 0.25
Proposed Appendix J	0.3 x 0.3 = 0.09 to 0.49 x 0.49 = 0.24 Range is 0.09 to 0.24

These likelihoods of failing two Type A tests in a row can now be applied separately to two plant categories; units currently in operation, which are assumed to have an average remaining lifetime of 26 years, and new plants which are starting up in 1985 and beyond. These new plants are assumed to have a plant lifetime of 30 years. There are 90 plants in the currently operational or "existing plant" category (plants licensed to operate at full power or licensed for lower power testing), and 30 in the new plant category. The new plant category excludes those which are planned and for which construction may have started, but whose startup date has been indefinitely delayed.

Applying the foregoing probability ranges to the total plant populations, the number of Type A penalty test situations (i.e., a plant failing two consecutive Type A tests) for a given 4 year Type A test cycle is estimated to be in the range noted below.

	Probable number of plants requiring Type A penalty tests, per 4 yr. cycle	
	Existing App. J	Revised App. J
Existing Plants	14.4 to 22.4	8.1 to 21.6
New Plants	4.8 to 7.5	2.7 to 7.2

This is a change in the number of penalty test situations due to the change in the Appendix J "as found" allowable leakage limits. The reduction in the number of penalty tests for each plant category is as follows:

Savings (Reduction in Penalty Tests)

Existing Plants	0.8 to 6.3 tests per 4 yr. cycle
New Plants	0.3 to 2.1 tests per 4 yr. cycle

Based on the remaining plant lifetime, existing plants have 5.5 Type A test cycles remaining, whereas the new plants have 6.5 cycles remaining. A Type A test cycle for a given plant is nominally taken to be 4 years, the upper bound allowed by the Appendix J rules.

The attributes affected by this proposed revision to Appendix J are Occupational Exposure (Routine) and Industry Operation. The net impacts are summarized below. The cost impact takes into account the present worth of future events. The costs include manpower, equipment, and replacement energy effects.

Attributes	Impact
Occupational Exposure (Routine), man-rem	5 to 39
Industry Operation, $10^3$$	4605 to 73189 (5% rate) 2825 to 45055 (10% rate)

These figures indicate that the cost impact of the 1.0 L_a "as found" criterion as compared to the 0.75 L_a existing requirement can be quite large. Integrated containment leak rate tests (Type A tests) are quite expensive, primarily because the plant must be off-line in cold shutdown for these tests, which require 3 to 5 days to complete. The nominal cost of performing a Type A test is estimated to be in the range of $\$1.2 \times 10^6$ to $\$2.5 \times 10^6$. The main contributor to costs is the cost of replacement power. (See Section 6.0)

The figures above also show modest reductions in worker radiation exposure due to this proposed revision to Appendix J. Utility data indicates that an average of about 0.8 man-rem of exposure is accumulated in the conduct of a typical type A test. Personnel must enter containment to perform visual checks, to install test instrumentation and to align certain

systems. The exposure accumulates as a result of this in-containment time. To calculate the overall exposure increase or decrease associated with the 1.0 L_a vs 0.75 L_a allowable leakage requirement the average exposure per type A test (0.8 man-rem) is multiplied by the number of type A tests involved over the remaining plant lifetimes. The low-end estimate for the reduction in worker radiation exposure, therefore, is 0.8 plants per 4 year test cycle x 5.5 cycles remaining plus, for new plants, 0.3 plants x 6.5 cycles remaining for the total minimum number of type A tests avoided. This is then multiplied by 0.8 man-rem per type A test. The range is calculated as follows:

low-end: (0.8 x 5.5 + 0.3 x 6.5) x 0.8 = 5.08
high-end: (6.3 x 5.5 + 2.1 x 6.5) x 0.8 = 38.6

Rounding off to the nearest man-rem gives a range of 5 to 39 man-rem savings.

The basis for the estimate of 0.8 man-rem of exposure per type A test is discussed in the Appendix.

5.1.3 Retesting Following Failure of "As Found" Type A Test

5.1.3.1 Proposed Appendix J Requirement

III.A(8)(a) Retesting. If for any periodic Type A test the "as found" leakage rate fails to meet the acceptance criteria of 1.0 L_a, a Corrective Action Plan that focuses attention on the cause of the problem is to be developed by the licensee, implemented, and then submitted together with the Containment Leak Test Report, as required by Section VI of this Appendix. The test schedule applicable to subsequent Type A tests (III.A(3)) will be reviewed and approved by the NRC staff. An "as left" Type A test that meets the acceptance criterion of 0.75 L_a is required prior to plant startup.

5.1.3.2 Changes Relative to Existing Appendix J

Retesting following the failure of Type A test is required by the existing Appendix J. The acceptance of 1.0 L_a for the "as found" Type A test is a change relative to the existing Appendix J. This change has been discussed in Section 5.1.2. The requirement for a Corrective Action Plan already exists in the current Appendix J, although untitled. The above requirement emphasizes the development of a Corrective Action Plan and reporting of it along with the Containment Leak Test Report. Additional effort will also be required on NRC's part to review and approve the CAP's submitted.

5.1.3.3 Quantification of Impacts

Presently the Corrective Action Plan is not submitted with the ILRT report. Repairs to containment penetrations, usually included in the reporting of Type B and C tests, are noted, but there is presently no indication from our survey of ILRT reports of formal development and implementation of Corrective Action Plans.

From Section 5.1.2, the likelihood of failing a given Type A test (under th proposed Appendix J) ranges from 0.3 to 0.49. The population of existing plants is 90 and the population of new plants is 30. Assuming an average cycle of 4 years for Type A tests, the estimated range of plants needing to submit a Corrective Action Plan is noted below.

	Probable number of plants failing an "as found" Type A test, per 4 year cycle
Existing Plants	27 to 44
New Plants	9 to 15

Estimates of the time needed for development of a corrective action plan range from 4 manweeks to 12 manweeks per plant failing the "as found" Type A test. These estimates are based on efforts such as those required to analyze test data, review previous repair and failure histories, and plan a program

to reduce failures while minimizing worker radiation exposure and plant downtime. The range of time needed per year for development of Corrective Action Plans is calculated by multiplying the number of plants times the probability of failing times the number of manhours needed to develop the CAP divided by the number of years in a typical Type A cycle. The ranges are noted below.

	Probable number of hours needed to develop Corrective Action Plans, per year, industry wide
Existing Plants	1080 to 5280
New Plants	360 to 1764

Implementation of the Corrective Action Plan will typically involve more frequent servicing and inspection of penetrations, especially those that have been identified as giving problems. Our survey of ILRT and LLRT reports has shown an average number of containment penetrations of approximately 96, with an average of approximately 11 penetrations needing repairs per year. It is unlikely that the CAP would involve repair and maintenance to all containment penetrations, but rather would focus on those types that are the most troublesome. Estimates of the number of penetrations involved in the CAP range from 1 to 4 times the number needing repairs per year (11 to 44). The average maintenance time per penetration, based on utility outage planning information, is approximately 4 hours. This assumes 1 mechanic and 1 supervisor per repair for this period. In addition, the services of a health physicist are assumed to be needed an additional 20% of the time. The range of maintenance times is noted below.

	Net maintenance time (manhours) for implementation of CAP, per year, industry wide
Existing Plants	2614 to 17075
New Plants	871 to 5692

The information obtained from utilities indicates that the radiation field associated with the testing of Type B and C penetrations is on the order of 15 mr/hr (see Appendix.) Using this dose rate, the total exposure impact of implementing Corrective Action Plans is estimated as follows:

low-end: (2614 hrs/yr x 26 yrs + 871 x 30) x 0.015 hr = 1411 man-rem
high-end: (17075 x 26 + 5692 x 30) x 0.015 = 9220 man-rem

These are increases in the occupational radiation exposure so the exposure impact range becomes (-) 1411 to (-)9220 man-rem.

The existing Appendix J specifies that the NRC must review and approve the testing schedules subsequent to the failure of a Type A test. However, the proposed requirement to submit corrective action plans following such failures will require additional NRC effort to review and approve these CAP's. The estimates are that this effort will be in the range of 2 to 3 man-weeks of technical staff review per CAP. Each CAP will also require a similar effort by NRC management and legal staff personnel. Thus the incremental NRC effort is estimated to be as follows:

		Probably number of NRC Staff hours to review and <u>approve CAP's per year</u>
Existing Plants	Technical Staff	600 to 1323
	Mgmt & Legal	600 to 1323
New Plants	Technical Staff	200 to 441
	Mgmt & Legal	200 to 441

The impacts discussed here are in the attribute category of Occupational Exposure (Routine), Industry Operation and NRC Operation. These impacts are summarized below. The negative sign (-) means <u>increases</u> in exposure and costs.

Attribute	Impact
Occupational Exposure (Routine), man-rem	(-)1411 to (-)9220
Industry Operation, 10^3\$	(-)2494 to (-)18987 (5% rate) (-)1535 to (-)11689 (10% rate)
NRC Operation, 10^3\$	(-)1048 to (-) 2246 (5% rate) (-) 645 to (-) 1383 (10% rate)

5.1.4 Retesting Following Failure of Two Consecutive "As Found" Type A Tests

5.1.4.1 Proposed Appendix J Requirement

III.A(8)(b)(ii) Retesting. Investigation as to the cause and nature of the Type A test failure might indicate that an alternative leakage test program, such as more frequent Type B or Type C testing, may be more appropriate than the performance of two consecutive successful Type A leakage tests. The licensee may then submit a Corrective Action Plan and an alternate leakage test program proposal for NRC staff review. If this submittal is approved by the NRC staff, the licensee may implement the corrective action and alternate leakage test program in lieu of one or both of the Type A leakage tests required by Section III.A(8)(b)(i).

5.1.4.2 Changes Relative to Existing Appendix J

The proposed Appendix J provides an alternative to Type A penalty tests by allowing Type B or C penalty tests and the submittal of a Corrective Action Plan.

5.1.4.3 Quantification of Impacts

This should be a very substantial and welcome change to the utilities. It appears that the majority of failures of Type A tests are due to Type B and C items, e.g. only two failures due to holes being drilled in the containment liners have been noted in the ILRT reports. It would appear that increased testing of Type B and C items would be a much more effective way to insure compliance with the Appendix J acceptance criteria. This change

would eliminate the need for a utility to apply for an exemption of increased Type A tests due to failures of Type B or C items.

This should be a benefit to the industry. The cost of increased Type B and C testing would have to be balanced against the cost of increased Type A testing. The cost of preparing the Corrective Action Plan should balance out against the preparation of an exemption request, which would basically be a Corrective Action Plan. Also paragraph III.A(8)(a) requires the development and implementation of a Corrective Action Plan. Since this was discussed in Section 5.1.3, it will not be discussed in this section. The cost for increased Type B and C testing was previously discussed in Section 5.1.3, however, in this section we are dealing with the case where the Corrective Action Plan for the previous Type A "as found" failure was not adequate. This would indicate the Corrective Action Plan for the second Type A "as found" failure would have to be more comprehensive than the first plan.

Since a CAP must be prepared each time a Type A test failure occurs, the costs of preparing the CAP are covered in Section 5.1.3 (paragrah III.A.(8) (a)). The cost of preparing a more comprehensive CAP to address the case of two consecutive Type A test failures should be about the same, or only marginally larger, than the costs associated with the CAP needed when a single Type A test failure occurs. Therefore, costs of preparing this CAP are covered by the costs noted in Section 5.1.3. Similarly, the NRC effort needed to review this CAP is covered by the costs presented in Section 5.1.3.

A more comprehensive Corrective Action Plan could include more frequent Type B and C testing or inclusion of more containment penetrations in the penalty Type B and C testing program. For the option of more frequent Type B and C testing, it is assumed that the utility would reduce the time between Type B and C testing by one half. The range of containment penetration tests per year for this option, using the data of Section 5.1.3, is 22 to 88. Note that the number of penetrations involved in a CAP developed in response to a single Type A test

failure was from 11 to 44. If two consecutive failures occur, the assumption is made here that the number of penetrations requiring attention would at least double since the previous CAP was not effective in producing a successful Type A test. The option of penalty testing more Type B and C items could include penalty testing of all containment penetrations. The upper bound for this option is taken to be the average number of containment penetrations (96). The range for number of penalty Type B and C tests per year is, therefore, 22 to 96. Using the probabilities for failing a Type A test, the reactor populations, time to complete the Type B and C tests, and other pertinent data from the preceeding sections, the total manhours per year for penalty Type B and C tests in place of the Type A penalty test are noted below.

	Manhours per year for penalty Type B and C tests in place of penalty Type A Test
Existing Plants	1425 to 16596
New Plants	475 to 5532

It must be remembered that those plants were already doing some amount of additional Type B and C testing, since they had failed the previous "as found" Type A test. The number of manhours per year that they are already expending for penalty Type B and C testing must be subtracted from the above in order to obtain the range of extra manhours per year that will be incurred for these penalty tests. The range of the number of plants that would be in this penalty situation under the revised Appendix J rules (per 4 year cycle) is 8.1 to 21.6 for existing plants and 2.7 to 7.2 for new plants. The range of manhours per year that these plants are already expending on additional Type B and C tests is 712 to 6336 for existing plants and 198 to 2112 for new plants. The range of additional manhours per year for

these penalty Type B and C tests because of two consecutive Type A test failures are noted below.

	Total additional manhours per year expended for penalty Type B and C tests in place of Type A penalty test
Existing Plants	713 to 10259
New Plants	277 to 3420

The present Appendix J rules require penalty Type A testing if two consecutive Type A tests fail at a given plant. The proposed revision which allows additional B and C testing in place of the Type A penalty tests can, therefore, significantly reduce plant downtime due to testing. Each Type A test requires about 3 to 5 days to complete. This is almost always critical path time. As noted previously, the nominal cost of performing a Type A test is estimated to be in the range of $\$1.2 \times 10^6$ to $\$2.5 \times 10^6$, including labor, equipment, and replacement energy costs. Replacement energy costs are by far the dominant contributor here. The number of penalty Type A tests which can potentially be avoided due to the proposed Appendix J revisions is 8.1 to 21.6 for existing plants and 2.7 to 7.2 for new plants per 4 year test cycle. The cost reduction to utilities associated with the reduced number of Type A penalty tests, per 4 year cycle, is:

	Utility Savings due to Penalty Type A tests avoided
Existing plants, 10^3\$	9720 to 54000
New Plants, 10^3\$	3240 to 18000

These benefits are exclusive of those due to "as found" allowable leakage of 1.0 L_a vs. 0.75 L_a discussed in Section 5.1.2. These benefits must be reduced by the costs associated with the additional Type B and C testing substituted for Type A penalty tests.

The impacts due to this provision in the revision to Appendix J are given below. These are the incremental changes of substituting additional Type B and C tests in place of penalty

Type A tests. The net effects are dollar savings to utilities due to reduced plant downtime but higher occupational radiation exposure. In evaluating the impact on occupational radiation exposure, an average dose rate of 0.015 rem/hr is assumed for Type B and C tests (See Appendix).

Attribute	Impact
Occupational Exposure (Routine), man-rem	(-)353 to (-)5408
Industry Operation, $10^3$$	80622 to 244277 (5% rate) 49630 to 150374 (10% rate)

This change to Appendix J which allows additional Type B and C tests in place of penalty Type A tests has the largest cost impact of any of the proposed revisions to Appendix J. The impacts are large because, based on experience to date, a large number of plants are in a penalty test situation due to failing two consecutive Type A tests. The provision to substitute more frequent Type B and C tests for the CILRT is quite reasonable since Type B and C penetration leakage is the dominant cause of Type A test failures. The Type B and C tests in place of the Type A penalty test significantly reduces plant downtime due to testing. This saves significantly on the replacement power costs, giving a large beneficial cost impact. On the other hand, the Type B and C tests result in higher occupational radiation exposure than is the case with the Type A tests. The exposures are calculated in a manner analogous to that discussed in Section 5.1.3.

5.1.5 Frequency of Testing of Penetrations with Continuous Leak Monitoring must be Specified in Technical Specifications

5.1.5.1 Proposed Appendix J Requirement

III.B. Type B Test.

(1) Frequency.

(b) For containment penetrations employing a continuous leakage monitoring system which is at a pressure

not less than P_{ac}, leakage readings of sufficient sensitivity to permit comparison with Type B test leak rates shall be taken at intervals specified in the Technical Specifications. Reporting of these readings is part of the Type B reporting of VI.A.

5.1.5.2 Change Relative to Existing Appendix J

Existing Appendix J states that the test interval for these types of penetrations should be every other reactor shutdown for refueling but in no case at intervals greater than 3 years. The proposed Appendix J states that the interval should be as defined in the plant Technical Specifications.

5.1.5.3 Quantification of Impacts

This change may require modifications to plant Tech Specs if the test interval in question is not presently defined there.

A survey of technical specifications from several plants revealed that none included any mention of the testing interval for Type B penetrations with continuous leak monitoring systems. Based on this limited sample, we conclude that all plants having such systems will need to amend their technical specifications. This sample was made up of 60% PWRs and 40% BWRs. The Technical Specification modifications will involve modest manpower requirements but no plant downtime or other cost impacts.

Several utilities were contacted regarding containment penetrations with continuous leak monitoring. Of those contacted, slightly more than half had penetrations of this type, the others had none. Based on this limited sample we estimate that roughly 50 to 70 percent of the plant population would have to amend their Technical Specifications to meet the requirements of the revised Appendix J. Plant personnel indicated that, for those plants that would be affected, amending the technical specifications to include the testing interval would require 2-4 man-weeks for each reactor. The bulk of this effort would

consist of reviews by the various safety review committees which are composed of senior management and technical personnel. An average of one man-week of engineering effort and 3 man-weeks of management and legal effort was assumed for the current assessment.

The requirement to modify plant technical specifications will also affect NRC since the NRC must review and approve all such modifications. The NRC has estimated the costs associated with this review and approval cycle (Reference 6). The NRC has estimated that each technical specification amendment will require about 4 man-weeks of technical staff time and 2 man-weeks of management time. In addition, each technical specification amendment will have associated with it additional costs of about $800 to cover Federal Register notices and other items. This NRC effort is on a per plant basis. Virtually all of these costs will ultimately be passed on to the utilities under the NRC's fee recovery program. The plant population affected by this Appendix J proposed revision is taken to be those which have their technical specifications currently developed. There are about 96 plants in this category. Based on the foregoing estimate of the percentage of the population affected, the number of plant technical specifications requiring modification should be on the order of 48 to 67. This range is used in estimating the overall cost impacts of this change to Appendix J. Note that these are one-time, near-term impacts. Therefore, the discount rate used has no affect on the costs. The impacts are summarized below. They are negative, i.e., cost increases.

Attributes	Impact
Industry Implementation, 10^3\$	(-)417 to (-)741 (5% rate)
NRC Implementation, 10^3\$	(-)534 to (-)745

5.1.6 Air Locks Test Requirements

5.1.6.1 Proposed Appendix J Requirement

III.B Type B Test.

(3) Air Locks.

(a) Initial and periodic tests. Air locks must be tested prior to initial fuel loading and at least once each 6 month interval thereafter at an internal pressure not less than P_{ac}. Alternatively, if there have been no air lock openings since the last successful test at P_{ac}, this interval may be extended up to the next refueling outage or airlock opening (i.e., full pressure test maximum interval of 24 months with reduced pressure tests performed on the air lock or its door seals at 6 month intervals). Opening of the air lock for the purpose of removing test equipment following an air lock test does not require further testing of the air lock.

5.1.6.2 Change Relative to Existing Appendix J

The present requirement in Appendix J is that air locks must be tested at 6-month intervals at an internal pressure not less than P_a. The proposed requirement allows reduced pressure tests rather than tests at P_a at 6-month intervals if the air lock has not been used since the last successful full pressure test. The revision also allows testing of the seals for the 6-month interval tests in lieu of the internal pressure type tests. Thus, the new requirement gives utilities considerable flexibility in air lock testing compared to the present Appendix J.

5.1.6.3 Quantification of Impacts

Nuclear plant utilities have indicated that the existing Appendix J requirement is somewhat difficult to live with and have felt that the requirement to test air locks at P_a at 6-month intervals was not necessary to assure containment integrity. This is evidenced by the numerous exemption requests submit-

ted by utilities requesting relief from this type of frequent testing. The test at P_a wherein the air lock is pressurized between the two doors is difficult to do, primarily because in most containment designs the inner door was not designed to seal against internal pressurization. The direction of pressurization on this door is opposite that expected during accident conditions. According to NRC regional inspectors most plants, even the newer ones, have air lock doors which must be modified or adjusted in order to accomplish the internal pressure test at P_a. In most cases strongbacks are installed on the inner door for such tests. Some plants, especially the older ones, had to be shutdown because the strongbacks had to be applied from inside containment. On some plants this necessitated deinerting the containment. Apparently this is no longer the case. The air locks have been modified so that the necessary modifications can be accomplished from inside the air lock. Thus at most plants the modifications as well as the testing can be performed while the plant is operating.

Thus, the existing Appendix J requires modifications to the air lock inner doors each time the test at P_a is performed. This is required at least every 6 months.

The revised Appendix J would allow utilities to substitute reduced pressure tests or testing of door seals in place of the internal pressurization test at P_a if the air lock has not been used since the last successful test at full pressure. A test at P_a must still be performed at least every 24 months. This change, as a minimum, should eliminate most of the time and effort required to install strongbacks and perform other modifications to the doors since most of the tests can now be performed at reduced pressure or be accomplished by pressurizing only the door seals. The addition of strongbacks would still be required to accomplish the 24-month interval test at P_a.

Most containment designs employ at least two air locks. One is a personnel lock. Presumably this air lock would be used (opened) on a fairly frequent basis, and thus would not benefit from this proposed revision to Appendix J. At least one air lock

in each containment should meet the infrequent use qualification to eliminate the need for testing at P_a every 6 months.

As noted previously, some containment designs have air locks which are designed to allow the P_a tests without the need for modifications or the addition of strongbacks. These plants are relatively few. It is assumed here that 80% of all plants require the use of strongbacks to accomodate the air lock tests at P_a.

The time required to install strongbacks on the inner door of containment air locks is estimated to be 2 to 8 hours. This is based on input from NRC regional inspectors and on evaluations performed for NRC by the Franklin Research Center (Reference 7). The manpower requirements are taken to be the following:

Activity	Manpower Type	Time, Hrs.
Door modifications/strongback application & removal	2 Mechanics	2-8
	1 Health Physicist	1-2
	1 Supervisor	1-2

Under the existing rule these efforts must be repeated twice a year. With the proposed revision to Appendix J they will be required every 24 months (if the air lock has not been opened). Note that these door modification efforts are assumed necessary at 80% of all plants, including those not yet in operation.

The leak testing of the air locks also requires time and effort. Based on the above sources, the testing manpower and time is taken to be the following:

Activity	Manpower Type	Time, Hrs.
Air lock test at P_a	2 Technicians (ea.)	4-16
	1 Health Physicist	2-4
	1 Supervisor	2-4
Air lock test at reduced pressure, or seal tests	2 Technicians (ea.)	2-8
	1 Health Physicist	1-2
	1 Supervisor	1-2

The applicable tests are required by all plants (those operating and those with future startup dates). Under the existing Appendix J requirement the testing at P_a must be performed by each plant every 6 months. The proposed Appendix J would allow three tests at reduced pressure and require one at full pressure for each 24-month interval. The radiation exposure changes due to this proposed revision to Appendix J are calculated in an analagous manner to those discussed in Section 5.1.3. In this case, however, the applicable dose rate used was 5 mr/hr for activities inside the air locks, such as installation of strongbacks, and 1 mr/hr for activities outside of the air locks. It is assumed that the leak testing can be accomplished with personnel outside of the air locks. The dose received for all plants for their remaining plant lifetimes under the existing Appendix J requirements is compared to that expected with the proposed revisions to Appendix J to estimate the exposure savings.

Numerous exemption requests have been submitted by utilities requesting relief from the current Appendix J rules. The revisions to Appendix J would presumably eliminate the need for these exemption requests. Thus, some additional savings are potentially available in that the effort needed to prepare and review these exemption requests would no longer be necessary.

It is roughly estimated that between 5 and 20% of all plants would be submitting exemption requests pertaining to the 6 month P_a testing interval for air locks. This allows for the exemption requests already submitted. On this basis, it is estimated that between 6 and 24 such requests will be eliminated by the proposed change to Appendix J. The following table indicates the utility and NRC efforts associated with this type of exemption request. They are given on a per plant basis. It is further assumed here that an exemption request for relief from this type of air-lock testing would, if granted, stand for the life of the plant. The reduced number of exemption requests result in savings in the attribute categories of Industry and NRC Operation.

Utility effort to prepare exemption request:	Engineer	80-120 hrs.
	Management	40 hrs.

NRC Review and ruling:

1. Initial review	Technical Staff	120 hrs.
	Management & Legal	40 hrs.
2. Final review and position statement	Technical Staff	100 hrs.
	Management & Legal	40 hrs.

The preceding manpower and time requirements translate into the following impacts. These are savings compared to the existing Appendix J.

Attributes	Impact
Occupational Exposure (Routine), man-rem	135 to 447
Industry Operation, 10^3\$	842 to 2924 (5% rate) 533 to 1891 (10% rate)
NRC Operation, 10^3\$	67 to 344 (5 and 10% rates)

5.1.7 Air Lock Test Requirements - Intermediate Tests

5.1.7.1 Proposed Appendix J Requirement

III.B Type B Test.

(3) Air Locks

(b) Intermediate tests. Air locks opened during periods when containment integrity is required by the plant's Technical Specifications must be tested within 3 days after being opened. For air lock doors opened more frequently than once every 3 days, the air lock must be tested at least once every 3 days during the period of frequent openings. Air locks opened during periods when containment integrity is not required by the plant's Technical Specifications need not be tested while containment integrity is not required, but must

be tested prior to returning the reactor to an operating mode requiring containment integrity. For air lock doors having testable seals, testing the seals fulfills the intermediate test requirements of this paragraph. In the event that this intermediate testing cannot be at P_{ac}, the test pressure must be as stated in the Technical Specifications. Whenever maintenance, other than on door seals, has been performed on an air lock, a complete air lock test at a test pressure of not less than P_{ac} is required. Air lock door seal testing or reduced pressure testing must not be substituted for the initial or periodic full pressure test of the entire air lock required in paragraph III.B.(3)(a) of this Section.

5.1.7.2 Changes Relative to Existing Appendix J

The current Appendix J requires that air locks opened during periods when containment integrity is not required by the plant's technical specifications be retested at the end of such periods at a test pressure not less than P_a. The proposed revision gives greater flexibility in that it allows testing of seals and/or testing at reduced pressure instead of testing the entire air lock at full pressure P_a.

5.1.7.3 Quantification of Impacts

Personnel in NRC's Containment Systems Branch have stated that the current Appendix J requirements have triggered a high number of exemption requests. In fact the expectation was that <u>all</u> plants would apply for relief from the present rule. This is because the present requirement necessitates a full pressure test at the end of downtime periods if the air lock has been opened during that outage, regardless of the duration of the outage and its timing relative to the previous outage when a similar test was required. The testing is onerous and difficult because, as noted in Section 5.1.6, strongbacks have to be

applied to the inside air lock doors of most containments in order to allow testing at P_a. Then, too, the testing itself at P_a is quite time consuming and does involve some radiation exposure.

NRC personnel have stated that the original intent of the existing requirement was to assure that air locks were tested at the end of extended outages during which the air locks may have been opened several times. The wording of the requirement was left quite general, however, and supposedly covers more types of plant outage situations than was originally intended. Because of this, the exemption requests relative to this Appendix J requirement have generally been granted.

Under the current Appendix J rule the plant operators have essentially two options. They can comply with the rule as stated, or they can apply for an exemption. The latter would appear to be the preferable route because compliance with the rule is difficult, it may require additional plant downtime, and it results in additional radiation exposure to personnel. Since the exemption requests are being granted, it seems reasonable to assume that essentially all plants would choose this option rather than attempting to comply with the existing requirement.

Therefore, the most significant impact of the proposed Appendix J revision is that it essentially eliminates the need for plants to submit exemption requests relative to this aspect of air lock testing. It also eliminates the NRC effort needed to review and rule on these exemption requests. The efforts associated with relatively simple exemption requests such as this is estimated to be as follows:

Utility effort to prepare exemption request:	Engineer	80-120 hrs.
	Management	40 hrs.
NRC Review and ruling:		
1. Initial review	Technical Staff	120 hrs.
	Management & Legal	40 hrs.
2. Final review and position statement	Technical Staff	100 hrs.
	Management & Legal	40 hrs.

3. NRC effort for plants not yet undergoing technical specification review	Technical Staff	40 hrs.

The above are the efforts required for each plant. Per NRC personnel, about 30 exemption requests to this existing Appendix J requirement have been submitted and approved. That leaves a total of about 90 plants which could benefit from the revised Appendix J position. The benefit would be the elimination of the effort needed to prepare, review, and rule on each of these exemption requests.

The exemption requests submitted thus far, and presumably those which would be submitted in the future, have been approved on the basis of substituting more reasonable air lock testing requirements than what is called for in the existing Appendix J rules. The substitute tests are taken to be the equivalent of the tests which are called for in the proposed revision to Appendix J. Thus, the effort required to perform the air lock tests assuming an exemption has been granted to a plant is taken to be the same as the leak testing effort called for by the revisions to Appendix J. Therefore, the only impacts associated with this change in air lock testing requirements is the elimination of the effort associated with the exemption requests. The cost impacts are summarized as follows:

Attributes	Impact
Industry Operation, 10^3\$	504 to 827
NRC Implementation, 10^3\$	930 (5% rate) 926 (10% rate)

These are near term cost savings, and thus the discount rate has essentially no effect.

5.1.8 Type B Test Acceptance Criteria

5.1.8.1 Proposed Appendix J Requirement

III.B(4)(a) Acceptance Criteria. The sum of the "as found" or "as left" total values of Type B and C test results shall not exceed 0.60 L_a, using maximum pathway leakage, and including continuous monitoring leak test results.

5.1.8.2 Change Relative to Existing Appendix J

This is a redefinition of the leakage pathway and the inclusion of continuous monitoring leak test results. It gives the requirement for determination of the "as found" and "as left" condition of the Type B and C test results.

5.1.8.3 Quantification of Impacts

The use of maximum pathway leakage will result in an increased probability of failure of the acceptance criteria for the combined Type B and C tests. The old Appendix J does not stipulate the use of maximum pathway leakage, so that the utilities could be reporting the Type B and C combined tests on the basis of minimum pathway leakage or a combination of minimum and maximum pathway leakage. The effect of using maximum pathway leakage was not quantified. From the summary of the October 3-5 meeting on containment integrated leak rate testing and proposed revisions to Appendix J, from F. Maura to R. L. Spessard, it was agreed that all regions will now use the "maximum pathway" leakage in the computation of Type B and C leakages to compare against the 0.6 L_a requirement. Therefore, the effect of this change should be zero.

The requirement for determining the "as found" and "as left" values for Type B and C testing will result in extra testing of Type B and C items. Note that all plants must routinely do Type B and C tests on all applicable penetrations. For those items that do not need repairs or adjustments, the test represents both the "as found" and "as left" value. It is only

those penetrations which are repaired, modified, replaced, or adjusted which must be tested twice, once before the change to determine the "as found" and once after to determine the "as left" condition. Our survey of ILRT and LLRT reports has determined that on average approximately 11 penetrations per year are being repaired, modified, replaced, or adjusted.

Our survey of ILRT and LLRT reports has shown that between 60% to 80% of the plants are reporting "as found" and "as left" conditions for the Type B and C tests. Assuming that the balance of the existing plants are not performing these tests, but will have to comply with proposed Appendix J, the number of existing plants affected will be between 18 and 36. We further assume that a similar fraction of new plants will also be affected, i.e., between 6 and 12 new plants. Discussions with NRC regional inspectors indicate the time required to accomplish Type B and C tests is roughly 1.0 to 1.5 hours per Type B or C penetration. Assuming one technician and one supervisor per test, the time requirement per Type B and C penetration test is 2.0 to 3.0 manhours.

The upper limit on the additional manhours for Type B and C testing needed to determine the "as found" and "as left" conditions is the number of penetrations repaired times the manhours per Type B and C test times the number of plants not currently determining "as found" and "as left" conditions. The lower limit can be taken as zero, which assumes the plants presently do the tests but not fully report the results. This results in a range of 0 to 1188 manhours per year for existing plants and 0 to 396 manhours per year for new plants.

The requirement for determining the "as found" condition of the Type B and C penetrations will eliminate the practice of repairing penetrations before they are tested. It may be necessary for a utility to develop reasonable upper bounds of leakage rates for penetrations that are leaking at rates beyond the capability or range of their instrumentation. Our survey showed several cases in which the leakage was greater than the instrument capability or in which the penetration could

not be pressurized to the test pressure. The impact of this is presently unquantifiable in terms of whether or not it would result in more failures of Type A, B, or C tests. The net impact of the revisions to Appendix J is to require plants not currently establishing "as found" conditions to do so prior to penetration repairs. The impacts are as follows*:

Attributes	Impacts
Occupational Exposure (Routine), man-rem	0 to (-)601
Industry Operation, $10^3$$	0 to (-)718 (5% rate) 0 to (-)449 (10% rate)

5.1.9 Type B Test Acceptance Criteria - Retest Following Repairs and Implied Corrective Action Plan

5.1.9.1 Proposed Appendix J Requirement

III.B(4) Acceptance Criteria

(c) An air lock, penetration, or set of penetrations, that fails to pass a Type B test must be retested following determination of cause and completion of corrective action. Corrective action to correct the leak and to prevent its future recurrence must be developed and implemented.

5.1.9.2 Change Relative to Existing Appendix J

This is an addition. It does not appear in the existing Appendix J.

5.1.9.3 Quantification of Impact

This provision requires retesting following any corrective action. It also requires action to correct and prevent further recurrence of the problem.

*In evaluating the impact on occupational radiation exposure, the average dose rate for Type B and C leak rate tests is assumed to be 0.015 rem/hr (See Appendix).

It is common sense and good practice to retest after repairs to penetrations. The survey of leak rate test reports shows that most utilities already retest following repairs to containment air locks and other Type B penetrations.

A survey of available nuclear plant ILRT reports and reports on Type B and C tests gave an indication of the numbers and types of penetrations requiring repairs. In all cases the "as left" leakage was reported; thus in all cases retests had been performed after the repairs had been carried out.

The proposed Appendix J requires that a plan to prevent further recurrence of the problem areas be developed and implemented. The study results indicate that this will potentially translate into more frequent inspection and testing of those penetrations giving problems.

The proposed Appendix J change calls for the development of a corrective action plan and its implementation for Type B penetrations if such penetrations fail to pass a Type B test. However, there is no stated allowable leakage criterion for Type B penetrations alone. There is only the 0.60 L_a combined leakage allowance for the sum of the Type B and C penetration leakages. Therefore, for a Type B penetration to fail this criterion its leakage must exceed 0.60 L_a or some other requirement as defined in the plant technical specifications.

Both ILRT reports and Type B and C leakage test reports were surveyed to estimate the frequency for Type B test failures. This survey indicated that the most prominent cause of leakage, and thus of failing leak tightness tests, are the Type C penetrations. Only in about 10 to 20% of the cases were Type B penetrations the primary cause of test failures. This yields a rough estimate for the likelihood of failing a Type B test. This estimate includes Type A test failures caused by leaky Type B penetrations.

Local leak rate tests must be performed at intervals not greater than every 2 years. For the 90 operating plants we would estimate that 10 to 20% could be in a Type B test failure

situation wherein corrective action would have to be defined and implemented to satisfy the requirements of paragraph III.B(4)(c) in the proposed revision to Appendix J. This is between 9 and 18 plants per 2-year local leak rate test cycle for existing plants. On the order of 3 to 6 new plants could also be expected to be in this same situation each 2-year cycle.

A corrective action plan must focus on those penetrations showing excessive leakage. The test reports surveyed indicated that on the order of 11 penetrations per plant required servicing each year in order to reduce leakage. Of these on the order of 1 to 4 were Type B penetrations; the rest were Type C. A minimal CAP would be one which calls for more frequent maintenance and inspection of those penetrations causing problems. A broader CAP would perform this servicing on all penetrations of the type giving problems - in the limit this would include all Type B penetrations. The test reports surveyed indicated that plants typically have about 30 Type B penetrations, of which about 3 are air locks. Thus it is reasonable to assume that a CAP needed because of failed Type B tests would involve from 4 penetrations as a minimum to about 30 penetrations as a maximum.

As noted above Type B tests are normally performed at least once per plant over a refueling cycle. They must be performed at least every 2 years. A corrective action plan presumably would include more frequent testing as well as more frequent servicing. Halving the test and servicing cycle length to one year, therefore, would seem to be a reasonable approach for a CAP. This is assumed here.

Servicing of Type B penetrations (i.e., replacing bellows, replacing seals, cleaning seal surfaces, applying sealant, etc.) is estimated to require from 2 to 5 hours (3.5 hrs. average) per penetration. The penetrations must also be retested following their servicing or repair. As discussed previously the testing is estimated to take 1 to 1.5 hours per penetration.

Engineering effort will be required to develop the corrective action plan itself. Since only Type B penetrations are involved, this development should require less time than that needed for both Type B and C penetrations as was discussed in Section 5.1.3. It is estimated that the corrective action plan for Type B penetrations can be developed with an engineering effort of from 2 to 4 manweeks. The time required would be somewhat dependent on the number of different types of Type B penetrations involved (i.e., air locks, instrumentation penetrations, electrical, etc.). It can also be assumed that this CAP development effort would suffice over at least the two year Type B test cycle, whereas the implementation would be required on an annual basis.

The efforts associated with the corrective action plan called for if Type B test failures are experienced are summarized as follows. These are given on a per plant basis for each plant in this situation.

	Manpower Type	Time, hrs.	Frequency times/yr.
CAP Development	Engineering	80-160	.5
Penetration	Mechanic	14-105	1
Preventative Maintenance	Supervisor	14-105	1
	Health Physicist	3-21	1
Retesting following servicing	Technician	4-45	1
	Supervisor	4-45	1
	Health Physicist	1-9	1

These manpower requirements apply to between 9 and 18 existing plants each year for the next 26 years. It applies to 3 to 6 new plants each year over their 30 year lifetime. This translates into the following industry wide impacts.*

*In evaluating the impact on occupational radiation exposures, an average dose rate of 0.015 rem/hr is assumed for Type B leak rate tests (see Appendix).

Attribute	Impact
Industry Operation, 10^3\$	(-)522 to (-)3958 (5% rate) (-)323 to (-)2490 (10% rate)
Occupational Exposure (Routine), man-rem	(-)194 to (-)3208

The corrective action plan and its implementation called for by paragraph III.B(4)(c) of the proposed revision to Appendix J can be redundant with the requirements of paragraph III.A(8)(a). The latter paragraph calls for a CAP if a Type A test fails. However, since the failure of a Type B test does not necessarily mean the failure of a Type A test, and vice-versa, the overlap is considered to be minimal. In addition the CAP appropriate for a failed Type A test in many cases may not involve Type B penetrations. Thus, the impacts between these two paragraphs need to be considered separately.

5.1.10 Hydraulically Tested Valves Must Have Leak Limits Specified in Technical Specifications

5.1.10.1 Proposed Appendix J Requirement

III.C. Type C Test.

3) Acceptance Criteria

(c) Containment isolation valves that are hydraulically tested, but are not part of a qualified seal system, must also have allowable liquid leakage limits specified in the Technical Specifications.

5.1.10.2 Change Relative to Existing Appendix J.

This change clarifies the requirement to have these leakage limits defined in the Technical Specifications. The existing Appendix J is not clear on this point.

5.1.10.3 Quantification of Impacts.

A number of Tech Specs have been examined as well as vendor Standard Technical Specifications to determine if allowable liquid leakage limits are specified for containment isolation valves. These types of limits were not part of any of the Tech Specs reviewed. However, a few of the leakage test reports studied did specify allowable leakage rates for individual penetrations or for classes of penetrations.

This survey indicates that most plant technical specifications will have to be modified to comply with this change to Appendix J.

Contacts made with utility personnel indicated that not all plants have valves which fall into this category. Based on a limited survey it appears that on the order of 50 to 70% of the existing plants would be affected by this Appendix J revision.

The impact of this change to Appendix J is that plants with hydraulically tested isolation valves must modify their technical specifications to include allowable leakage limits if these limits are not presently specified. We assume that an analysis will be required at each affected plant in order to develop and specify acceptable leakage limits for each of these penetrations. This may be a very modest effort or it may require a fairly complex safety analysis. This effort is perceived to require on the order of 2 to 6 manmonths of engineering effort to develop acceptable leakage limits.

Once the leakage limits are developed the plant technical specifications must be modified with appropriate approvals from plant management. These technical specification changes must then be submitted to NRC for their review. The overall effort, for each plant affected, is estimated to be as follows.

Effort to Develop Allowable Leakage Limits for Hydraulically Tested Valves and Modify Technical Specifications

	Manpower Type	Time, hrs
Utility		
Develop leakage limits	Engineer	346-1040
Technical specification review	Management & Legal	120
NRC		
Preliminary Evaluation	Technical Staff	60
	Management & Legal	40
Final license amendment	Technical Staff	100
	Management & Legal	40
Federal Register Notice		$800

As noted above this effort would be required for about 50 to 70% of the plants with existing technical specifications. It is a one-time cost for each plant. It is assumed that future plants would not face any incremental costs because of this Appendix J requirement. This is reasonable since it would be a normal part of the development of these future technical specifications.

About 96 plants have existing technical specifications that potentially require modification. Based on 50 to 70 % of this number, it is estimated that 48 to 67 plants might be affected. The cost impacts to the utility industry and the NRC are noted below. No incremental plant downtime or radiation exposure is associated with this aspect of the revised Appendix J. Since there are no future costs, the discount rate has no effect.

Attribute	Impact
Industry Implementation, $10^3$$	(-)1012 to (-)4193
NRC Implementation, $10^3$$	(-) 534 to (-) 745

5.1.11 <u>Testing Details and Methods must be Defined in Technical Specifications</u>

5.1.11.1 Proposed Appendix J Requirement

V. Test Methods, Procedures and Analyses

A. Type A, B and C Test Details. Leak test methods, procedures, and analyses of either steel, concrete or combinations of steel and concrete primary containment and its penetrations and isolation valves for the light-water-cooled power reactors must be referenced or defined in the Technical Specifications.

5.1.11.2 Change Relative to Existing Appendix J

The existing Appendix J references the American National Standard (ANSI N45.4-1972). The proposed revision deletes this reference and simply requires that the plant Technical Specifications include this information.

5.1.11.3 Quantification of Impacts

A survey of several plant technical specifications revealed that some plants reference the 1972 ANSI standard, while others simply state that these tests will be performed in accordance with the requirements of Appendix J. None of the technical specifications we reviewed spelled out detailed test procedures. Because the proposed revisions will require the plants to conduct these tests in accordance with the new ANSI standard, it appears that all plants will have to modify their technical specifications, even those that presently reference the old ANSI standard.

A number of utilities were contacted regarding this proposed change to Appendix J. Personnel from several plants voiced strong concern over the proposed requirements. The proposed wording requires that test methods, procedures, and analyses be included or referenced in the plant technical specifications. The utilities noted that this could have three negative effects. First, each time a test procedure number is

changed, the technical specifications would have to be amended. Several indicated that test procedure numbers change fairly frequently as procedures are added, removed, combined, or split up. Second, they pointed out that this proposed requirement is counter to the NRC move to simplify technical specifications. And third, they felt that they would lose control of their technical specifications, that control would be transferred to the ANSI committee or some other body. In summary, they felt that this requirement will impose a significant adminstrative burden on both them and the NRC with no apparent commensurate benefit.

The foregoing utility arguments are difficult to evaluate on a quantitative basis and they may indicate a lack of understanding of the proposed requirement. It is assumed for the sake of the present analysis that suitable approaches will be found whereby the plant technical specifications will change only once (or at least very infrequently) because of this change to Appendix J.

The effort and costs associated with modifying plant technical specifications is as noted previously in Section 5.1.5. Approximately 4 manweeks of utility effort would be required at each plant. The NRC effort to review and approve or disapprove of the changes would require about 4 manweeks of technical staff time and about 2 manweeks of management and legal review. In addition, costs of about $800 for Federal Register Notices would be required.

These are the costs and efforts associated with each plant technical specification change. There are about 96 plants whose specifications would have to be changed to meet the proposed Appendix J requirement. The overall impacts are as follows:

Attribute	Impact
Industry Implementation, 10^3\$	(-)832 to (-)1059 (5% rate) (-)830 to (-)1056 (10% rate)
NRC Implementation, 10^3\$	(-)1064

5.2 APPENDIX J CHANGES WITH NEGLIGIBLE OR NON-QUANTIFIABLE IMPACTS

The following discussions relate to those changes in the proposed revision of Appendix J which were judged to have very small and/or non-quantifiable impacts. The format is the same as that used in the preceeding section. They are included here because, at least on the surface, they may appear to be significant changes relative to the existing Appendix J rules. For each of these changes the material which follows discusses the basis for the conclusions that the impacts, if any, will be small.

5.2.1 Preoperational Test Requirements

5.2.1.1 Proposed Appendix J Requirement

III.A.1 Preoperational Test. A preoperational Type A test must be conducted on all primary containments and must be preceded by the acceptable completion of:

(a) A visual inspection of the accessible interior and exterior surfaces of the containment system for deterioration which may affect either the containment structural or leak tight integrity,

(b) Type B and Type C tests,

(c) A containment isolation system functional test, and

(d) A structural integrity test.

5.2.1.2 Changes Relative To Existing Appendix J

The proposed Appendix J specifically calls for completion of Type B and C tests and a structural integrity test prior to the preoperational Type A test. This requirement was not explicitly called for in the existing Appendix J.

5.2.1.3 Quantification of Impacts

The structural integrity test is required to satisfy

ASME Code requirements. Therefore, the specification of the completion of this test prior to the Type A test can only effect _when_ the structural integrity test is needed, not _if_ it is needed. It may require rescheduling of the structural integrity test, but the net impact is small.

The requirement for Type B and C testing prior to the preoperational Type A test could potentially impact all plants not yet in operation. This item could impact the preoperational schedule for these plants. Net impact, however, is expected to be small since, with adequate forewarning and adequate planning, the schedule impact, if any, should be small.

5.2.2 Type A Test Frequency

5.2.2.1 Proposed Appendix J Requirement

III.A(3) Test Frequency. The interval between the preoperational and first periodic Type A tests must not exceed three years, and the interval between subsequent periodic Type A tests must not exceed four years, unless a longer interval is specifically approved by the NRC staff. This could result in another preoperational test if the initial fuel loading is delayed such that the three year interval between the first preoperational test and the first periodic test is exceeded. If an additional Type A test is performed under the provisions of Section IV.A. of this Appendix, the Type A test interval may be restarted.

5.2.2.2 Changes Relative to Existing Appendix J

The existing Appendix J test frequency for Type A tests is directly coupled to the 10-year ASME inservice inspection interval for mechanical systems and components. The net effect is to change the maximum periodic retest interval from roughly 3-1/3 years to less than 4 years. The requirement for a Type A test during the 10-year inservice inspection has also been dropped.

5.2.2.3 Quantification of Impact

Based on the present refueling cycle being normally 18 months, the actual Type A test frequency will remain essentially the same. The available data indicates that the utilities conduct Type A tests every 3 to 4 years, with few exceptions. (Ref. 8). Scheduling of a Type A test at times other than when the plant is in a shutdown for refueling or for the 10-year inservice inspection would not be advantageous to the utility. Removal of the explicit requirement for a Type A test during the 10-year inservice inspection could benefit some plants. These plants would have to be on a schedule that allowed them to wait until the next refueling outage following the 10-year inservice inspection. The present data available does not allow quantification of this change. While the proposed Type A test frequency will allow a slightly more flexible schedule for the Type A test, the overall effect will be very small.

5.2.3 Retesting Following Containment Modification or Maintenance

5.2.3.1 Proposed Appendix J Requirement

IV. Special Leak Test Requirements

(a) Containment Modification or Maintenance. Any modification, repair, or replacement of a component which is part of the containment system boundary that may affect containment integrity, must be followed by either a Type A, Type B or Type C test. Any modification, repair, or replacement of a component subject to Type B or Type C testing must also be preceded by a Type B or Type C test. The measured leakage from this test must be included in the report to the Commission, required by Section VI of this Appendix. The acceptance criteria of paragraphs III.A.(7), III.B.(4), or III.C.(3), of this Appendix, as appropriate, must be met.

5.2.3.2 Changes Relative to Existing Appendix J

The revised Appendix J is more specific, not by referring to major repairs as in the existing Appendix J, but by referring to changes that may affect containment integrity. Also, the requirement that repairs to B and C type components be preceded as well as followed by appropriate testing is a clarification.

5.2.3.3 Quantification of Impacts

Additional testing and reporting for repairs, modifications, or replacement of penetrations or other areas of the containment boundary that were previously considered "minor" will now be required.

The evidence to date indicates that most nuclear plant utilities, as a matter of course, retest containment penetrations following any repairs, modifications, or replacement of these items which could affect containment integrity. Therefore, the proposed clarification to retest following such actions will have a small impact, if any. Changes to Type B and C penetrations must be preceded as well as followed by testing to determine the "as found" condition. Therefore, some additional testing will be necessary.

The reporting requirements associated with this proposed change to Appendix J represent an increase relative to the existing Appendix J. This is true since a broader range of repairs, modifications or replacements affecting the containment boundary must now be reported, as well as information pertaining to the "as found" condition.

The effect of this requirement has already been covered in the discussions in Sections 5.1.2, 5.1.3, and 5.1.8. No further quantification of this change is necessary.

5.2.4 Sequence of Periodic Tests

5.2.4.1 Proposed Appendix J Requirement.

V. Test Methods, Procedures and Analyses.

B. Combination of Periodic Type A, B and C Tests. Type B and C tests are considered to be done in conjunction with the periodic Type A test when performed during the refueling outage. The licensee shall perform, record, interpret, and report the tests in such a manner that the containment system leak tight status can be and is determined on both an "as found" basis and an "as left" basis, i.e., what its leak tight status was prior to this periodic Type A test together with the related Type B and C tests, and what its status was following the conclusion of these tests.

5.2.4.2 Changes Relative to Existing Appendix J

This change provides definition of how Type A, B and C tests are to be treated in conjunction with one another. This is lacking in the present Appendix J. The proposed change also clearly specifies that the containment leak tightness must be determined on an "as found" basis as well as "as left." Determination of "as found" is not clearly stated in the present version of Appendix J.

5.2.4.3 Quantification of Impacts

The potential existed for abuses, intentional or not, that could result in finding and fixing all existing leaks just prior to a Type A test, so that a truly leaky containment would not fail its Type A test. The utility would in fact be complying with the letter of the law but not its intent. This should help limit such potential practices in the future.

The impacts of this change have already been discussed in Sections 5.1.2, 5.1.3, and 5.1.8 and no further quantification has been attempted.

6.0 COST ESTIMATE BASIS

Two types of costs are important for the Appendix J analysis: labor and replacement energy. The following sections list the assumptions, sources, and estimating procedures used to compute each type of cost for this task.

6.1 LABOR COST ESTIMATES

6.1.1. General Assumptions

Several general assumptions were made in arriving at the cost estimates:

- Labor costs are incremental with respect to the activities involved. Although utility and NRC personnel would be employed and paid regardless of whether Appendix J was revised or not, the cost of labor is considered to be a true incremental cost. This presumes that utility and NRC personnel would be fully occupied on productive tasks in the absence of Appendix J revision.

- In addition to wages paid, the associated fringe benefit component of labor cost is also considered to be an incremental expense. The time of plant and government management, over and above that directly expensed, is also considered to be incremental. Other overhead and G&A expenses are not considered to be incremental costs.

- Equipment and materials associated with activities defined in this study are considered to be either non-incremental or trivial in terms of cost.

- All non-government personnel associated with Appendix J activities are assumed to be direct utility employees. Although it is possible that contract help would be utilized in certain circumstances by some utilities, potential cost differences are very small.

6.1.2. Wage Rate Determination

The derivation of average hourly base (i.e., excluding fringes and overhead) wages for the different occupations involved is based on data from a variety of published and

unpublished sources. As needed, these wages have been adjusted to 1984 dollars. The main sources used for this task were:

- Bureau of Labor Statistics, U.S. Department of Labor, Industry Wage Survey: Electric and Gas Utilities, February 1978, Bulletin 2040, Washington, D.C., November 1979;
- Bureau of Labor Statistics, U.S. Department of Labor, Industry Wage Survey, Electric and Gas Utilities By None DOL Regions, October 1982, Washington, D.C., April and May, 1983;

BLS survey data for selected utility occupations were used to extract appropriate wage rates. The BLS data are typically preferable due to their national scope and high degree of reliability. For some occupations, however, particularly managerial (e.g., supervisor) and professional (e.g., reactor engineer), wage rates are excluded from the BSL survey. In these cases, information solicited from TVA and other nuclear operators was employed. NRC labor rates were taken at the top of the GS scale for management and legal staff and two grade levels lower for technical staff. Wage rates by labor category are shown in Table 6.1.

It should be recognized that the wage rates used here are based on approximate national averages. As with most industries and firms, the job specifications for a particular utility plant are unique, and salary levels, in turn, differ with these specifications.

6.1.3. Geographic Variation

Labor rates vary with the regional location of the nuclear power plant. These differences may be due to the degree of unionization and urbanization, the local cost of living, and local wage scales. To reflect these differences in the labor cost estimates, geographical adjustment factors were developed. These factors were then used to develop a low and high cost for each labor activity.

Table 6.1

Industry Labor Rates

Labor Category	Wage Rate ($/hr)	Wage Plus Overhead ($/hr)
Management & Legal	38.00	67.00
Test Coordinator	26.00	46.00
Shift Coordinator	26.00	46.00
Data Engineer	26.00	46.00
Support Engineer	26.00	46.00
Mechanic	17.00	30.00
Data Technician	15.00	26.00
Computer Operator	11.00	19.99

NRC Labor Rates

Labor Category	Wage Rate ($/hr)	Wage Plus Overhead ($/hr
Management & Legal	32.00	47.00
Technical Staff	28.00	41.00

BLS wage data for nine DOL Regional Offices were reviewed to determine wage level differences for the same occupation. These differences for selected occupations were then compiled and compared to develop an appropriate range of labor cost variation. A range between ± 12 percent of the base, or 88 and 112 percent, was selected for the geographical adjustment factor in the low and high case.

NRC wage rates were not adjusted for regional variation.

6.1.4 Fringe Benefits

The base wage ranges for the different occupations must be adjusted by an appropriate factor to account for fringe benefits. At a nuclear plant, this factor includes the standard fringe expenses -- compensation insurance, social security, and annual leave -- as well as added costs related to licensing, training, safety, and other activities peculiar to a nuclear operation. These added costs, in turn, typically cause the benefits factor at a nuclear plant to be slightly above that at conventional generating facilities.

For this analysis, the benefits factor for utility employees was selected to be 1.70. This factor was based mainly on information presented in:

> Myers, M. L.., Fuller, L. C., and Bowers, H. I., Nonfuel Operations and Maintenance Costs for Large Steam-Electric Power Plants-1982, Oak Ridge National Laboratory, Oak Ridge, Tennessee, Publications Nos. NUREG/CR-2844 and ORNL/TM-8324, September 1982.

Fringe benefits for the Nuclear Regulatory Commission were assumed to be 40 percent.

6.1.5. Management Factor

The activities represented by direct labor costs include first level supervisory personnel. In addition, containment tests are critical activities that command the attention of top-level plant management. (Although corporate attention is also involved, this analysis is confined to on-site personnel only). Using LWR staff requirements as detailed in

DOE's Energy Economic Data Base (DOE/NE-0051, 1983) it was determined that the time for top administrators (plant manager, assistant plant manager, operations superintendent, and maintenance superintendent) would amount to approximately five percent of the base wage bill. Salaries for these administrative positions were based on TVA experience, adjusted for benefits and to 1984 dollars. The same factor was assumed to apply to NRC labor.

6.2 REPLACEMENT ENERGY COSTS

6.2.1 General Methodology

Replacement energy costs were derived from a recent study sponsored by the Cost Analysis Group of the U.S. Nuclear Regulatory Commission. These study results are reported in:

> U.S. NRC, Replacement Energy Costs for Nuclear Electricity Generating Units in the United States. NUREG/CR-4012, October, 1984.

This report, prepared by Argonne National Laboratory, estimates seasonal replacement energy costs for potential short-term shutdowns of 108 nuclear electricity-operating units. Cost estimates are derived from probabilistic production cost simulations of pooled utility system operations.

In deriving relevant replacement energy costs to be applied specifically to this task, several overall assumptions were made:

- o outages are equally likely in any season;
- o daily cost is equally applicable to any hour of the day; and
- o current costs in real terms would be maintained over the life of the plant.

6.2.2. Specific Methodology

One problem specific to the Appendix J analysis is that replacement energy costs must reflect the geographical distribution of two subgroups of nuclear plants. One subgroup is that currently using half-pressure Type A tests; the other is that

using full-pressure tests. In order to calculate the distributed replacement energy costs (based on NUREG/CR-4012), the nine regions of the North American Electrical Reliability Council (NERC) must first be mapped into the five NRC regions. NRC Regions are defined in terms of NERC Regions as follows:

NRC	NERC
Region I	= NPCC + MAAC
Region II	= SERC
Region III	= ECAR + MAIN + MAPP - (Cooper + Ft. Calhoun)
Region IV	= ERCOT + SPP + (Cooper + Ft. Calhoun)
Region V	= WSCC - Ft. St. Vrain

Next, NRC Regional replacement costs are averaged by season, with a range established by the high and low cost seasons. Plants not operational in 1985 are not included. Finally, taking the following distribution of high- and low-pressure test plants, a weighted replacement energy cost range is established.

	Number of Plants	
	Low Pressure Tests	High Pressure Tests
Region I	5	19
Region II	17	12
Region III	9	15
Region IV	0	9
Region V	3	8
	34	63

The resulting national average replacement energy costs are:

Plants using Type A low pressure tests: \$13,500 to \$18,040/hr
Plants using Type A high pressure tests: \$14,833 to \$18,971/hr

6.3 VARIATIONS IN TIMING

Revisions in Appendix J lead to changes in costs incurred (or saved) in the future as well as in the present. In the case of future costs recurring at given frequencies, present values are calculated in conventional fashion using discount rates of both five and ten percent.

These calculations are somewhat complicated in the case of plants not yet in operation. In these cases, present values are first determined in the year of first operation and then further discounted to the present. Thus, even for one-time costs, variations in interest rates will produce slight differences in present values. Also, for future reactors, the same percentage is assumed to use low-pressure Type A tests as the current population of reactors.

The summary tables presented in Section 1.0 show results at both levels of discount. Note that 26 years of remaining life are assumed for existing reactors and 30 years for new reactors.

6.4 OTHER INFORMATION

In instances when Type A retests are avoided, detailed estimates of labor, equipment, etc., savings have not been made. Using industry estimates collected by G. Arndt of the NRC, a representative cost of $200,000 per test was selected (not including replacement energy). Also, costs for Federal Register Notices supplied by S. Feld of the NRC are applied, although the values are virtually insignificant.

Maximum and minimum values shown are true extreme values. For instance, maximum downtime hours are always combined with maximum applicable replacement energy costs, etc. The likely distribution of costs is actually clustered much more closely to the mean of the range.

7.0 UNCERTAINTIES AND LIMITATIONS

There are many factors that influence the uncertainties associated with this cost analysis. Some of these factors are the amount of data gathered and reviewed, assumptions made, predictions made about future practices based on past performances, variations in utility practices, and limitations in manpower and time.

There is a vast amount of data which could potentially be useful. In the NRC Public Document Room alone some 600 to 1000 potentially useful documents exist. The schedule and manpower available for the conduct of this effort dictated that only a fraction of this available data could be obtained, reviewed, and factored into the results obtained. Our review of Containment Leak Rate Test and Local Leak Rate Test reports showed that the desired information was often rather sparse. In order to supplement this data, discussions with NRC regional inspectors and various utilities were conducted. Time and manpower constraints limited the number of discussions held. In spite of these limitation, investigators feel that the information obtained is representative of the current situations relative to containment leak rate testing, and that it provides a meaningful base for estimating impacts due to proposed revisions to Appendix J.

A second factor that impacts the uncertainties is the extrapolation of past trends and practices to future trends and practices. Utility practices can change due to changes in management philosophy, regulations, technology, etc. The prediction of the number of future test failures will be impacted by implementation of changes called for in the revised Appendix J. For example, the Corrective Action Plans called for may significantly reduce the number of test failures. However, the extent of the reduction in test failures could not be quantified for these types of potential effects. For aspects such as this, therefore, past trends were assumed to be reasonable predictions of future events.

Variations in practices and responses from one utility to another will impact the uncertainties. An example of this would be in the expanse and scope of Corrective Action Plans. One utility might opt for increased testing of all B&C type penetrations while another might only concentrate on those penetrations giving repeated problems. Whether or not a utility would opt for the increased B and C testing in place of one or more penalty Type A tests is another variation. In our discussions with various utilities, all indicated that they would rather do the increased B and C testing, although it is felt that they would need to do a cost comparision between the options before making a firm decision.

Where firm data was not available, some assumptions had to made. One of these assumptions is in the number of manhours involved in the development of a Corrective Action Plan. We based our assumption on what we felt it might take a firm such as ours to carefully analyze previous test data, review previous repair and failure histories, plan a program to achieve the desired goals with minimum cost and exposure, meshing of the tests and repairs with other plant schedules to minimize downtime, obtaining management approval, etc. The uncertainty associated with this is whether the utilities would be more or less effective in this effort.

Another assumption that was made concerns plant downtime to perform penalty B & C tests. The B & C tests are normally performed during refueling outages. For the penalty B & C tests performed at times other than refueling outages, we have assumed no added downtime penalty. It is assumed that the utility as part of the Corrective Action Plan would increase the test and repair crew size to accomplish these tests in as short a time as possible rather than incur a lengthy plant shutdown for this purpose. We have also assumed that these tests can be performed when the plant is down for other reasons.

Because of insufficient resources and time, no effort was made to differentiate the impacts between BWR's and PWR's. It is believed that this type of information would not be significant in relation to the net impact of the revised Appendix J.

REFERENCES

1. Heaberlin, S.W., et. al., A Handbook for Value-Impact Assessment. NUREG/CR-3568, Pacific Northwest Laboratory, Richland, WA, 1983.

2. Duke Power Co., Oconee Nuclear Station, Unit 2, Reactor Containment Building Integrated Leak Rate Test, Docket #50-270-8008260482, 1980.

3. ANSI/ANS-56.8-1981, Containment System Leakage Testing Requirements, American Nuclear Society, LaGrange Park, IL, 1981.

4. Cranston, G.V., Testing Criterion for Integrated Leak Rate Testing of Primary Containment Structures for Nuclear Power Plants, BN-TOP-1, Bechtel Corporation, San Francisco, CA, 1972.

5. Rowley, C.W.; Renton, T.E.; and Martin, J.K.; Criteria for Determining the Duration of Integrated Leakage Rate Tests of Reactor Containments, EPRI NP-3400, Quadrex Corporation, Tulsa, OK, 1983.

6. Personal Communication, Letter from S. Feld to F. Sciacca, dated February 22, 1985.

7. DelGaizo, T.J., Containment Leakage Rate Testing, Technical Evaluation Report, Tennessee Valley Authority, Browns Ferry Nuclear Plants 1, 2, and 3, Docket #50,259-260-296, Franklin Research Center, Philadelphia, PA, 1981.

8. Dougan, J.R., Evaluation of Containment Leak Rate Testing Criteria, NUREG/CR-3549, Oak Ridge National Laboratories, Oak Ridge, TN, 1984.

APPENDIX

OCCUPATIONAL RADIATION EXPOSURE FROM LOCAL (TYPE B AND C) AND INTEGRATED (TYPE A) LEAK RATE TESTS

OCCUPATIONAL RADIATION EXPOSURES FROM LOCAL (TYPE B & C) AND INTEGRATED (TYPE A) LEAK RATE TESTS

More than 20 Containment Integrated Leak Rate Test (CILRT) reports submitted to the Nuclear Regulatory Commission by the utilities were reviewed for information on the manpower used and the occupational radiation exposures received in conducting both local (Type B & C) and integrated (Type A) leak rate tests. However, while the CILRT reports do contain information on the performance and results of both types of tests, they do not include data on either manpower or exposures. Accordingly, requests were made of 11 utilities to provide information on manpower used and exposures received in conducting these tests. Four of the utilities were unable to provide data within the time period available. Of the seven utilities that did provide data, three were able to provide information on manpower, and six were able to provide exposure data.

From the three utilities that were able to provide manpower data, it appears that local leak rate testing (Type B & C) can be accomplished in the course of a refueling outage (typically six to ten weeks) by a three to five man crew consisting of two to four technicians and a supervisor. Integrated (Type A) tests require 10 to 20 persons two to three days to set up, and a crew of three to five technicians and a supervisor per shift to conduct. The information received is not sufficient to determine if there are any differences between the manpower requirements at BWRs and PWRs.

The six utilities that could provide exposure data gave the following data for 10 of their units:

Reactor Type	Approx. Power Level (MWe)	Year of Initial Operation	Occupational Exposures (Man-Rem) Type B & C	Type A
W PWR	500	1974	0.7-1.3	ND
GE BWR	500	1972	5-8	2-3
W PWR	800	1977	2.7	0.1
W PWR	800	1981	3.3	0.1
W PWR	700	1972	2.3	0.4
W PWR	700	1973	4.0	0.6
GE BWR	800	1972	6.5	1-2
GE BWR	800	1972	7.0	1-2
W PWR	800	1975	10-12.5	<1
W PWR	800	1977	10-12.5	<1

The exposure data provided for the local leak rate (Type B & C) tests for the first eight units include only exposures received in conducting the initial tests and any required retests. The data provided for the last two units include exposures incurred in making all necessary repairs. Since the number of valves and penetrations requiring repairs is highly plant-specific, depending upon plant age, equipment supplier, and general housekeeping practice at the utility, these data should be thought of only as illustrative and extrapolations made only with caution.

The data for the integrated (Type A) tests include setup of the instrumentation, walkdown of containment, manipulation and verification of valve positions, and the conduct of the tests themselves.

We have averaged the occupational exposure data obtained to derive generic leak test exposures for use in evaluating the impact of the Appendix J changes. Using all of

the BWR data, we obtain an average exposure for Type B & C leak tests in BWRs of approximately 7 man-rem. The derived average exposure for Type B & C leak tests in PWRs (neglecting the data for the last two units in the Table for reasons described earlier) is approximately 3 man-rem. A weighted average for all LWRs, assuming one-third BWRs and two-thirds PWRs, is roughly 4 man-rem.

The average radiation field for Type B & C leak testing can also be derived by making some assumptions about manpower used in conducting the tests. We assume approximately 100 penetrations (including valves) at each plant, roughly 1 1/4 hours of time for testing each penetration, and two maintenance personnel plus aproximately 20% of an H.P. technician in conducting the tests. This results in approximately 275 man-hours in the radiation field for the conduct of the Type B & C tests at a generic LWR, and an average field of roughly 15 mr/hr.

Similarly, average exposures for Type A leak tests were obtained. The average exposure for Type A leak tests in BWRs is approximately 1.8 man-rem. For PWRs, the average exposure is roughly 0.3 man-rem. Therefore, for a generic LWR, the average exposure for conducting a Type A leak test is roughly 0.8 man-rem.

We also solicited exposure data for air lock leak rate tests, which indicated radiation fields inside the air locks of four plants ranging from 1 mr/hr to 40 mr/hr. The highest level was for a BWR which performs leak rate tests on the ascension to power, a practice which does not appear to be prevalent. For plants which are shutdown during the air lock leak rate tests, the range of exposure rates is 1 to 10 mr/hr. For generic exposure rate estimates, we would propose to use a value of 5 mr/hr inside the air lock. Dose rates outside of the air lock range from insignificant to 10 mr/hr. The high value is for the plant which performs leak rate tests on the ascension to power. For generic exposure rate estimates, we would propose to use a value of 1 mr/hr outside the air lock.

Manpower estimates for air lock leak rate tests range from 1 man-hour to 6 man-hours. The high value is for a PWR in which strong backs are installed, a practice which is apparently rare at PWRs.

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13. ABSTRACT (200 words or less)

This report addresses the differences between the existing and proposed Appendix J and identifies eleven substantive areas where quantifiable impacts will likely result. The analysis indicated that there are four areas of change which tend to dominate all others in terms of cost impacts. The applicable paragraph numbers from Draft E2 of the Appendix J revision and the nature of the change follows: III.A(4) & III.A(6) - Test Pressure & Testing at Reduced Pressure No Longer Allowed; III.A(7)(b)(i) Acceptance Criteria 1.0 La Acceptable "As Found" Leakage; III.A(8)(a) Retesting Following Failure of "As Found" Type A Test - Corrective Action Plan, and III.A(8)(b)(ii) Option to Do More Frequent Type B & C Testing Rather Than More Type A Penalty Tests. The best estimate is that the proposed Appendix J would result in cost savings ranging from about \$100 million to \$160 million, and increase routine occupational exposure on the order of 10,000 person-rem. These estimates capture the total impact to industry and the NRC over the assumed operating life of all existing and planned future power reactors. All dollar impacts projected to occur in future years have been present worthed at discount rates ranging from 5% to 10%.

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