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FEASIBILITY OF PREDICTING CONTAINMENT LEAK RATE

Charles K. Bayne

Computer Sciences Division
Union Carbide Corporation-Nuclear Division
Oak Ridge, Tennessee

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The objective of this study is to evaluate the feasibility of predicting the leakage rate of a containment building from past leakage rate tests. There are three main sources of leakage in the containment building at any fix time:

$$\text{LEAKAGE} = \text{AIR LOCK} + \text{COMPONENTS} + \text{PENETRATIONS}$$

The **AIR LOCK** sources represent personnel air locks, equipment hatches, fuel transfer tubes, etc. The **COMPONENTS** sources are comprised of all those parts represented by valves, gaskets, etc. that would cause leakage during an accident scenario. The component parts would be in the safety injection systems, sample injection systems, vents and drains, etc. The **PENETRATIONS** sources are represented by pipes, electrical conduits, etc., that penetrate the walls of the containment building.

Leakage rate test classified as Type A, B, and C are designed to measure the leakage rate of these three sources. Type C test are leakage rate tests on components. These tests are usually scheduled yearly but are not done on every valve and gasket in the containment building. If the test shows an unreasonable amount of leakage, three actions can be taken: maintenance (i.e., tighten a nut, weld on a patch, etc.), replace the part with the same part, or replace the part with a different part. The repair action should decrease the leakage to an acceptable level and to verify this result an additional test should be run on the repaired part. Type B tests are made on the air locks and if these tests are unacceptable repairs are made. Type A tests are made on the total containment building about every five years. Before the Type A test is performed, Type B and Type C tests are made on the major components and any defective parts are repaired. Therefore, Type A test represents the leakage due to penetrations of pipes, electrical conduits, etc., and any known or unknown component leakage. Type A test can be adjusted for the known component leakage so that the results reflect only the unknown components and the penetrations.

The leakage rate at any one time may be represented by the schematic diagram in Fig. 1. In the figure, the leakage rate is shown to increase due to the failure of components with time. The leakage rate increases until repairs are made on the components upon testing or regular maintenance. The leakage rate would then drop to a lower level and again start to increase with time. The next cycle would not necessarily increase in the same manner as the first cycle because only a fraction of the components are tested and/or repaired and any new items installed may have a different failure rates. After a series of these cycles, Type A test is performed typically preceded by both Type B and Type C tests.

The ability to predict leakage rates at any given time is dependent on having proper data from the three tests. The ideal data set would include the following information:

Type A Tests:

- (1) A long history of leakage rate data.

Type B Tests:

- (1) A record of leakage rates found.
- (2) The action taken after the test.
- (3) Post-repair leakage rates.
- (4) Failure rates of any replacement parts.

Type C Tests:

- (1) A record of leakage rates on each component.
- (2) The action taken after the test.
- (3) Post-repair leakage rates.
- (4) Failure rates of any replacement parts.

The available data on 27 reactors are published in the Containment Leakage Test Reports. These reports contain information on Type B and C test for 25 reactors. The test results cover various number of years on a partial listing of air lock sources and components. Type A tests are reported once for eight reactors, twice for sixteen reactors and three times for three reactors. If we

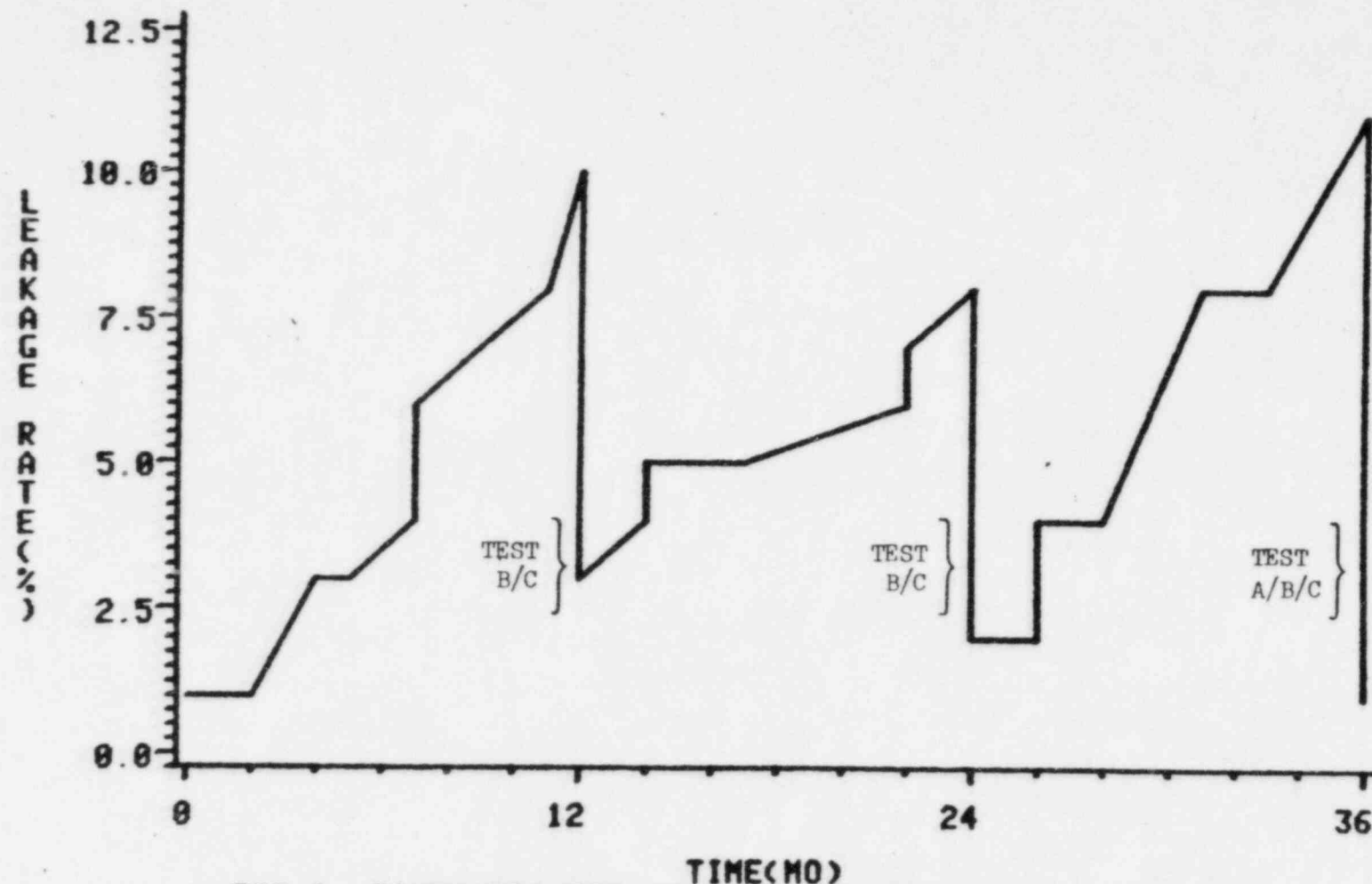


FIG 1. SCHEMATIC FOR CONTAINMENT BUILDING LEAKAGE

assume that the percentage of leakage is about the same for every reactor, these records could give a reasonable estimation of the **PENETRATIONS** sources of leakage. For many cases, this source represents a minor part of the total leakage while the majority of the leakage is due to air lock and component sources.

The data for Type B test can not be used to form a probability model for the **AIR LOCK** sources because in many cases the action taken after a Type B test is not known. If leakage is found, repairs may or may not be made depending on whether the combined test of both Type B and Type C test are within acceptable limits. Subsequent Type B tests may be on either old parts or replacement parts with different failure rates.

The same problems with using Type B test for modeling also occur for Type C test. In addition, only a partial record of the test results on the total components are recorded in any one year. The nature of component failure require different probabilistic models. One model would need to represent the complete and sudden breakdown of a component while another would represent the slow deterioration that occurs over a long period of time. The data available at this time does not seem to be complete enough to support either of these models.

In conclusion, the ability to predict leakage is a desirable goal. However, the manner leakage data is recorded for Types A, B, and C tests is neither sufficient nor appropriate to make a valid estimate of a prediction model.

ORNL

6/28/84

Addendum (Flanagan)

FY 84

<u>Sept '83</u>		<u>Oct</u>	<u>Nov</u>	<u>Dec</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>June</u>
Spent 33,768	Monthly	1,787	100	70	2,887	61	2924	16 ⁴	306	0
bal. <u>16,232</u>	Cum.	1,787	1,887	1,957	4,844	4,905	7,829	7,9 ⁹³ 87	8,2 ⁹ 95	8,299
Total 50,000	Bal.	14,445	14,345	14,275	11,388	11,327	8,403	8,2 ³⁹ 43	7,9 ³ 37	7,933

July 1, 1984 : Addendum closed. Balance transferred to Base Contract (7,933)

Base Contract (Naus)

<u>Sept '83</u>		<u>Oct</u>	<u>Nov</u>	<u>Dec</u>	<u>Jan</u>	<u>Feb</u>	<u>Mar</u>	<u>Apr</u>	<u>May</u>	<u>June</u>
Spent 112	Monthly	9	13	3	0	3	2	2		
Cum 112		121	134	137	137	140	142	144		
Balance						10	8	6		

	<u>July 84</u>	<u>Aug</u>	<u>Sept.</u>
Spent	-		

Cumulative
 (transfer) + 7,933
 Balance

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ORNL CONTAINMENT LEAK TEST SENSITIVITY STUDY

Work begun: May 1983
Completion: September 1983
Cost: \$50,000

OBJECTIVES:

- * Identify changes to risk contribution by the containment system as the leak rate changes, using simplified assumptions.
- * Develop initial method for comparing test and operational data to estimate actual leakage probabilities at times between tests.
- * Provide opinion on improved method(s) for reporting containment leakage values that would be applicable to all containment types.

RES/DRA Contact (& "client"): R. Blond

NRC Technical Monitor: G. Arndt

5/13/83
Fr. et
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VALUE OF APPENDIX J IN LIGHT OF RISK STUDIES

/ RES:DRA (Bernaro)

- * Overly conservative leak test regulations.
- * 0.1%/day talking rule-of-thumb leakage limit could probably be raised 1 or 2 orders of magnitude (actual limits are plant-specific, and some are 0.5%/day).
- * ORNL sensitivity study will provide some insight.

NRR:CSB

- * Industry well able, and used to, conduct tests within 0.1%/day limit.
- * Radiological risk estimates, although significant, are not sole basis for establishing leak test criteria.
- * Other ^{bases} ~~criteria~~:
 - Public perceptions and demands/expectations;
 - Need to monitor rate of leaktightness deterioration in addition to absolute values of leakage at time of tests;
 - Keep the complex containment system boundary generally as tight as possible, to offset unpredictable accidental breaches of the system boundary.
- * Prefers philosophical approach similar to ALARA concept, considers 0.1% to be within the current desirable test limits, and opposes relaxation solely on grounds of radiological risk assessment studies.

LABORATORY DIVISION/ACCOUNT SEQUENCE			FISCAL YEAR - 1984 PAGE 1			DIVISION - PHYSICS		
ACCOUNT - DESCRIPTION			ACTIVITY NO.			DIV CODE REPORT NO. & THE EXP.		
1984 CONTAIN LEAK TEST SEN			10489			12 3007A-2 60007		
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ORNL Containment Leak Rate Sensitivity Study

DISTRIBUTION LIST

		<u>Draft #1</u>	<u>Final #1</u>	<u>#2</u> ^{Boiler} _{paper}
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George Flanagan

Thomas Burns / ~~Robert Childs~~

Bldg. 6025

Oak Ridge National Laboratory

P.O. Box X

Oak Ridge, TN 37830

(FTS) 624-6155 Flanagan

624-6101 Burns

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FY 1983 PROGRAM BRIEF
DIVISION: DET

TITLE: CONTAINMENT LEAK TEST SENSITIVITY STUDY

FIN NO.: B0489
CONTRACTOR: ORNL
SITE: OAK RIDGE
STATE: TN

NRC TECHNICAL MONITOR: E. G. ARNDT

PRINCIPAL INVESTIGATOR: G. FLANNIGAN

BUDGET ACTIVITY:

FY 83 OBLIG: \$50K

FY 1983 WORK PERIOD: 11/1/82 - 2/1/83

OBJECTIVE:

DETERMINE WHETHER CURRENTLY SPECIFIED CONTAINMENT ALLOWABLE LEAK RATES SHOULD BE REVISED, AND, IF SO, HOW MUCH AND ON WHAT BASIS.

EVALUATE THE DESIRABILITY AND PRACTICALITY OF ESTABLISHING, EXPLICITLY IN APPENDIX J, A SINGLE LEAKAGE LIMITING CRITERION FOR ALL CONTAINMENT TYPES.

SCOPE:

DRAFT NUREG-0773, "REACTOR ACCIDENT SOURCE TERMS: DESIGN AND SITING PERSPECTIVES," DATED MARCH 1982, PRESENTS CURRENT INFORMATION ON REACTOR ACCIDENTS THAT HAVE BEEN ANALYZED FOR VARIOUS REACTOR DESIGNS, AND DEVELOPS A SET OF RADIOACTIVE RELEASES (SOURCE TERMS) IN CATEGORIES 1 THROUGH 5 WHICH REPRESENT THE SPECTRUM OF ACCIDENTS.

USING RELEASE FRACTIONS TO THE CONTAINMENT WHICH CORRESPONDS TO THESE SOURCE TERMS IN CATEGORIES 1 THROUGH 5:

- A. PERFORM A SENSITIVITY ANALYSIS (INCLUDE ALSO TEST COSTS VS CONFIDENCE LEVEL) IN WHICH THE CONTAINMENT DESIGN LEAK RATE IS ASSUMED TO BE 0.1%, 0.5%, 1.0%, 5.0%, 10%, 25%, 50%, and 100% (WT.%/DAY).
- B. DETERMINE THE OFFSITE RISK IN TERMS OF DOSE TO THE PUBLIC FROM EACH OF THESE POTENTIAL CONTAINMENT SOURCE TERMS,
- C. COMPARE RISK REDUCTION OF A SIMPLE GROSS CONTAINMENT INTEGRITY CHECK WITH THESE APPENDIX J LEAK RATE TESTS, AND
- D. EVALUATE THE DESIRABILITY AND PRACTICALITY OF ESTABLISHING, EXPLICITLY IN APPENDIX J, A SINGLE LEAKAGE LIMITING CRITERION FOR CONTAINMENT SYSTEMS THAT WOULD APPLY EQUALLY WELL TO:
 - a) LARGE, DRY PWR CONTAINMENTS,
 - b) TYPE I, II, AND III BWR CONTAINMENTS,
 - c) ICE CONDENSER CONTAINMENTS, AND
 - d) NEGATIVE PRESSURE CONTAINMENTS.

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THIS ANALYSIS WILL PROVIDE A BASIS FOR JUDGING WHETHER THE PRESENT APPENDIX J CONTAINMENT INTEGRATED LEAK RATE TEST CRITERIA ARE REALISTIC IN TERMS OF THEIR EFFECT ON PUBLIC RISK AND OPERATIONAL COSTS, AND SHOULD INCLUDE THE FOLLOWING:

- 1) WHETHER THERE IS A CORRELATION BETWEEN LEAKAGE TEST VALUES/TEST INTERVALS AND ESTIMATED ACTUAL LEAKAGE DURING INTERVALS BETWEEN TESTS (BASED ON LERS, AS-FOUND TESTS, ETC.).
- 2) REVIEW THE CURRENT 0.25L_A SAFETY MARGIN TO SEE WHETHER IT PROVIDES REASONABLE ASSURANCE THAT ACTUAL LEAKAGE DOES NOT EXCEED DESIGN VALUE.

OTHER REFERENCES

- NUREG - 0771, (FOR COMMENT) REGULATORY IMPACT OF NUCLEAR REACTOR ACCIDENT SOURCE TERM ASSUMPTIONS, JUNE 1981.
- NUREG - 0772, TECHNICAL BASIS FOR ESTIMATING FISSION PRODUCT BEHAVIOR DURING LWR ACCIDENTS, JUNE 1981.
- NUREG/CR - 2239 (DRAFT), TECHNICAL GUIDANCE FOR SITING CRITERIA DEVELOPMENT (2.3). DESCRIBES, IN PART, ACCIDENT SOURCE TERMS, RELEASE CHARACTERISTICS, AND UNCERTAINTIES IN SOURCE TERM MAGNITUDES.