FEASIBILITY OF PREDICTING CONTAINMENT LEAK RATE

Charles K. Bayne

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

FEASIBILITY OF PREDICTING CONTAINMENT LEAK RATE

Charles K. Bayne, Computer Sciences Division

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:

LEAKAGE = AIR LOCK + COMPONENTS + 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

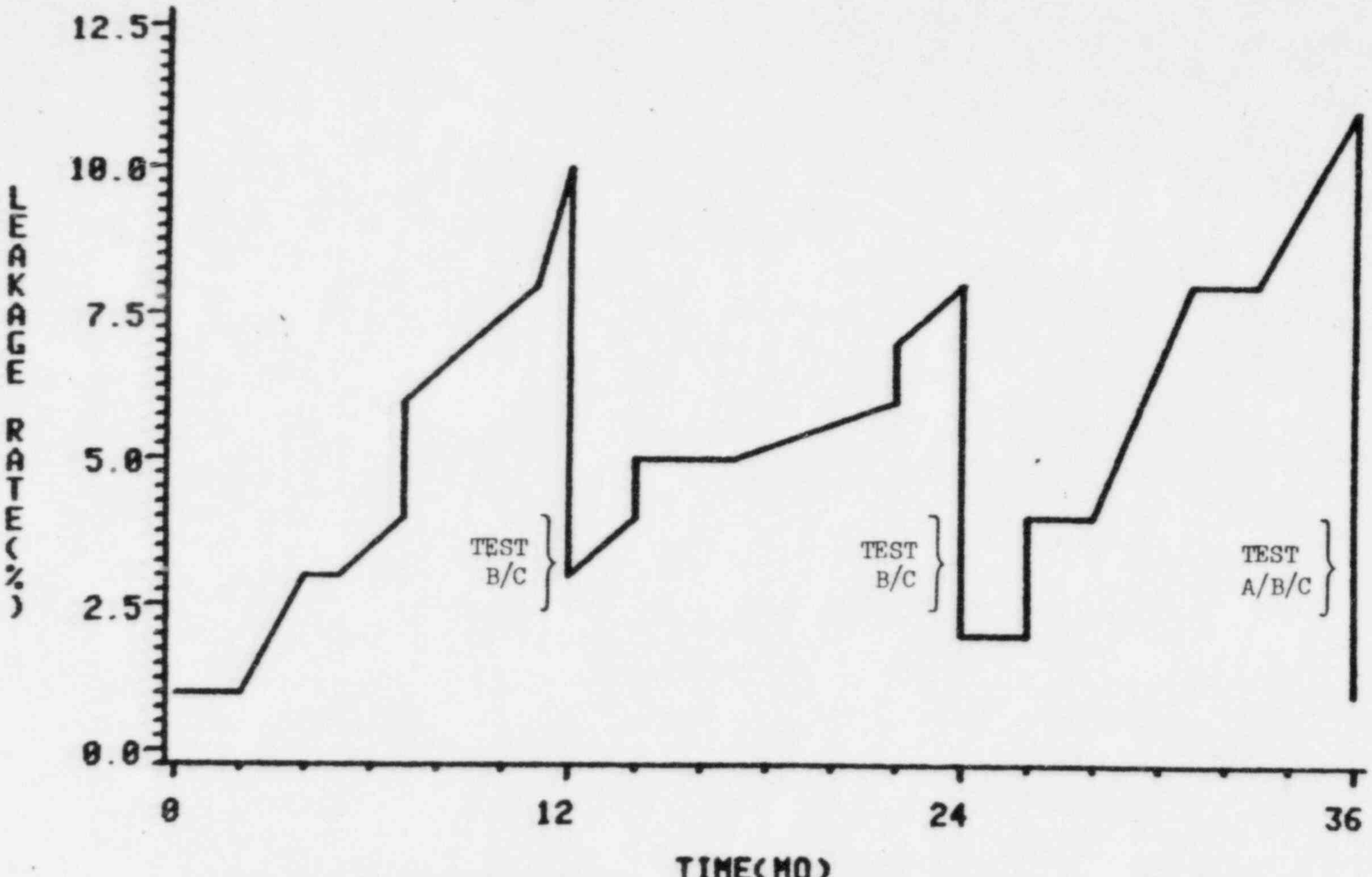

FIG 1. SCHEMATIC FOR CONTAINMENT BUILDING LEAKAGE

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.

0

ORNL 6/28/84

Addendum (Flanagan)

FY 84

Sept '83		Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
spent 33,768	Monthly	1,787	100	70	2,887	61	2924	~~160~~ 164	306	0
bal. 16,232	Cum.	1,787	1,887	1,957	4,844	4,905	7,829	~~7,984~~ 7,993	~~8,295~~ 8,299	8299
Total 50,000	Bal.	14,445	14,345	14,275	11,388	11,327	8,403	~~8,243~~ 8,239	~~7,937~~ 7,933	7933

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

Base Contract (Naus)

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

		July 84	Aug	Sept.
Spent		-		
Cumulative		-		
Balance	(transfer) +	7,933		

FOIA-85-143

77

23

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 <u>all</u> containment types.

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

NRC Technical Monitor: G. Arndt

5/13/83
Att
O

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 ~~criteria~~ bases:

  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.

OAK RIDGE NATIONAL LABORATORY — OPERATING COST REPORT

FISCAL YEAR- 1984 PAGE 73 DIVISION:

COST CENTER/ACCOUNT-DESCRIPTION: NRC B0489 CONTAIN LEAK TST LEM

ACTIVITY NO.: 413186130 189 NO.: B0489

(1) ACTIVITY/(2) 189 DESCRIPTION:
1. NCR B0489 LEAK RATE
2. LEAK RATE - CONTAINMENT

OPERATING COST REPORT		JANUARY $	MY	FEBRUARY $	MY	MARCH $	MY	FY TO DATE $	MY'S	OBLIGATIONS $	MY'S	COST PLUS OBLIGATIONS $	MY'S	COST PLAN $	$
HOURLY LABOR	65														
WEEKLY LABOR	65					141		157							
MONTHLY LABOR	66														
TOTAL DIVISION LABOR						141		157							
LOANEE-IN LABOR	70														
LOANEE-OUT LABOR (-)	70														
NET LABOR						141		157							
PLANS & BENEFITS						44		48							
DIVISION ADMINISTRATION						27		49							
INTRA-COST CENTERS		2079	.2			1871	.2	3950							
INTRA-DIV. COST CTRS.															
INTER-DIV. COST CTRS.															
TOTAL FROM CC ACCTS.		2079	.2			1871	.2	3960							
SHOPS & MAINTENANCE	58														
CONSULTANTS	61														
TRAVEL	62														
R&D SUBCONT. - NON-EXMT.	63														
MAJOR MTL. - NON-EXEMPT	64														
SUPPLIES & OTHER MISC.	65														
MAJOR MATERIAL - EXEMPT	66														
R&D SUBCONTR. - EXEMPT	67														
MISC CHGS & CMR EXEMPT	72					29		1583							
COMPUTER & PROGRAMMING	73	121		47		104		192							
TECHNICAL INFORMATION	75														
TOTAL MATERIALS		121		47		133		1775							
P&E SHOPS & MAINT.	54														
I&C MAINT. & ENGR.	54														
QUALITY ASSUR. & INSP.	54														
Y-12 SHOPS & MAINT.	54														
ORGDP SUPPORT SERVICES	54														
ORGDP ENGINEERING	56														
TOTAL CRAFTS & ENGR.															
MAT'L. & OTR. CHGS-Y-12															
" " " " -ORGDP															
" " " " -OTHER															
APPLIED HEALTH PHYSICS															
HOT CELLS - SERVICES															
REACTORS - SERVICES															
RADIOACT. WASTE DISPOSAL															
ELEC. PUR. POWER - EXEMPT															
OTHER															
SPECIAL DISTR. - EXEMPT															
DISTR. IN - INTRA-DIV.															
DISTR. IN - OTHER DIV.															
TOTAL O. & R COSTS															
TOTAL GROSS COSTS		2200	.2	47		2215	.3	5959							
DISTRIBUTION OUT (-)															
GENERAL & ADM. (G&A)		304	13.0	6	12.0	326	14.0	637							
GEN. PLANT SERV. (GPS)		383	17.0	8	17.0	383	17.0	1033							
TOTAL G&A & GPS		687		14		709		1870							
OPERATING COSTS		2887		61		2924		7829						10232	
FINANCIAL PLAN															
PLAN TO DATE															
MONTHLY RUN. RATE															
QUANTITY AND RATE															
G&A + GPS BASE		2200		47		2215									

From C.E. Flanagan
5/7/84

LABORATORY DIVISION/ACCOUNT SEQUENCE FISCAL YEAR- 1984 PAGE DIVISION: ENGINEERING PHYSICS

ACCOUNT-DESCRIPTION	ACTIVITY NO.	189 NO.	(1) ACTIVITY/(2) 189 DESCRIPTION	DIV. CODE	REPORT NO.	% THIS EXP.	COST ACCOUNT
B0489 CONTAIN LEAK TST SEN	413155139	B0489	1. NCR B0489 LEAK RATE 2. LEAK RATE - CONTAINMENT	12	3057A-2	66.67	3418-6089

REPORT		MONTH: MARCH $	MM	MONTH: APRIL $	MM	MONTH: MAY $	MM	FY TO DATE $	MY'S	OBLIGATIONS $	MY'S	COST PLUS OBLIGATIONS $	MY'S	COST PLAN $	$
[illegible]	63														
[illegible]	65	141						157							
[illegible]	66	141						157							
[illegible]	70														
[illegible]	70														
[illegible]		141						157							
[illegible]		41						48							
[illegible]		22						29							
[illegible]		1871	.2					3950							
[illegible]		1871	.2					3950							
[illegible]	73	67													
[illegible]	73	104		22		69		1634							
[illegible]		173		99		200		491							
[illegible]				121		229		2125							
[illegible]		2215	.3	121		229		6309							
[illegible]		326	14.0	19	15.0	33	14.0	884							
[illegible]		303	17.0	24	19.0	44	19.0	1101							
[illegible]		749		43		77		1990							
[illegible]		[illegible]		164		306		8299							
[illegible]														16232	
[illegible]		2215		121		229									

Effective July 1, 1984
(1) zero costs
(2) Closed
Tom Burns

$7933

Call Tom Burns 4435-0974

FY84 Costs

FY83 to FY84 Carryover

Balance = 16,232 - 8,299 = $7933

undated

0

ORNL Containment Leak Rate Sensitivity Study

DISTRIBUTION LIST

		Draft #1	Final #1	#2 (r + [illegible] pages)
G. Arndt	MSEB, DET, RES	✓	✓	✓
J. Burns	" " "	3/29/84	✓	✓
J. Richardson	" " "		✓	✓
R. Bernero	DRA, RES		✓	✓
J. Murphy	" "			
G. Burdick	RRB, DRA, RES	3/29/84		✓
P. Niyogi	" " "	3/29/84		✓
J. Glynn	" " "		✓	✓
J. Mitchell	AEB, DSI, NRR	3/29/84		✓
W. Pasedag	" " "			
Z. Rosztoczy	RSCB "			
W. Minners	SPEB "			
24958 W. Milstead	" "			
W. Butler	CSB "			
J. Shapaker	" "	3/29/84		✓
J. Huang	" "	3/29/84		✓
J. Pulsipher	" "			
D. Lurie	RM ADM	3/29/84		✓
D. Kirkpatrick	IE	3/29/84		✓
24507 R. Woodruff	IE (MSIVs)			

FOIA-85-143

78

Undated

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

FOIA-85-143

79

0

updated

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.

FOIA-85-143

80

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:

3

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.