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Engineering Physics Division

IMPACT OF CONTAINMENT BUILDING LEAKAGE ON LWR ACCIDENT RISK

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We gratefully thank G. F. Flanagan and J. V. Pace, III for their review of this document. Also, we thank J. K. Ingersoll for typing and producing the final manuscript.

ABSTRACT

The consequences, or risks, from LWR accidents were evaluated as a function of containment building leakage rates. The analysis used the set of generic source terms and frequencies of occurrence, developed as representative of the range of postulated types of accidents currently applied in reactor safety research. The variable, M_{sp}, termed the accident spectrum weighted impact fraction rate from containment building leakage was computed. Explicity, M_{sp} was formulated as the sum of fractional increases in consequences, due to the building leakage, for each type of accident weighted by its frequency of occurrence. The base case common to similar types of analyses was applied. The computed result was $M_{sp} \leq 1.5 \cdot 10^{-3}$ fractional increase in the accident spectrum risk per %/day containment building leakage rate.

LIST OF TABLES

1. INTRODUCTION AND OBJECTIVE

The consequences from LWR accidents were evaluated as a function of containment building leakage rate. The available data and methodology currently applied in assessments of nuclear reactor accident consequences were used as a basis for this evaluation.

1.1. Containment Building Leakage Rates

The main issue addressed here is the overall impact of variations in the containment building leakage rate on the risk from a postulated spectrum of types of hypothetical LWR accidents.

There are two main functions of the reactor containment building and associated safety systems:

1. To maintain shell integrity to avoid a release through a severe breach in the shell or a base mat meltthrough.

2. To establish appropriate isolation to limit radionuclide transport to the environment.

The second function is considered here. While it is obviously desirable to establish the complete isolation of a release into the containment building, on a practical basis there are sources of small leaks that are difficult to completely eliminate.

During normal operations of a nuclear reactor there can be transport of radionuclides, at least in minute quantities, into the containment building. Those nuclides either are trapped or become the small effluence from reactors. It is beyond the scope of this study to determine the effect of leakage rates upon assessments of normal operations.

1.2. Objective

1.2.1. Quantifying the Weighted Impact on LWR Accidents

The main purpose of this analysis is to quantitatively describe, as a function of containment building leakage rate, the weighted increase in the spectrum of consequences from the set of postulated types of accidents that have been established for consideration in reactor safety research.

1.2.2. Specified Method of Producing Objective

It was specified that this analysis be as consistent as possible with the assumptions[1] and methodology[2] used in the most recent research on reactor safety.

1.2.2.1. Generic Source Terms and "Accident Spectrum"

Reactor safety research,[3] sponsored by the U. S. Nuclear Regulatory Commission, has produced a technical bases for estimating radionuclide behavior during hypothetical LWR accidents. These evaluations have led to the development[1] of five generic source terms to be associated with the five generic groups of reactor accidents, sometimes termed the "accident spectrum". Also, associated with this accident spectrum, are[1] representative frequencies of occurrence together with parameters required in computing the consequences resulting from the corresponding source terms.

1.2.2.2. Applying Consequences in Guide for Siting Criteria

The evaluation of probable consequences of LWR accidents from the guide for reactor siting criteria[2] were used, when applicable, in this study. The same base case, as the "worst case," was applied.

1.2.2.3. Additional Analyses with CRAC2 Code

Consistency with recent research on reactor safety was maintained by using the CRAC2 code[4,5] for the additional calculations required, since it was applied in the siting criteria study. It is a modified version of the CRAC code, which was originally developed for use in the Reactor Safety Study, (WASH-1400).[6]

1.2.2.4. Weighted Impact on LWR Accident Risk

The consequences of each type of accident group and source term were analyzed separately as a function of containment building leakage rate. Thus, the magnitude of the risk from each accident group can be compared on a relative basis with that of the base case.

1.2.3. Impact Based on Person-Dose or Latent Cancer Effect

Not all of the given source terms were severe enough to produce early fatalities or early injuries. Also, due to characteristics of CRAC2, it was necessary to compute a series of small puff releases to represent the effect of a continuous leakage rate. Then, consequences from small puffs were added to that attributable to the severe release (e.g., that from eventual containment failure). It would be incorrect to add early fatalities or early injuries from separate cases, because they are not proportional to total person-dose. However, person-dose values (man-rems) from separate cases are additive, provided that the time history of the assumed evacuation scheme is properly maintained. The ratio of computed latent cancer fatalities to total person-dose is approximately a constant. Thus, the final impact of leakage rates are based upon risk in terms of either total person-dose or mean latent cancer fatalities.

1.2.4. Assessment Using Weighted Impact Fraction Rate

The results of the study are summarized by a single value defined as the weighted impact fraction rate from containment building leakage rates. The effect of the frequencies of occurrence of accidents leading to the set of

generic source terms is directly used in deriving the weighted impact fraction rate. Although there are significant uncertainties associated with both the consequences and frequencies of the postulated types of accidents, the weighted impact fraction rate provides a quantitative description of the realistic impact of containment building leakage rates on the risk resulting from the accident spectrum.

2. SOURCE TERM DATA AND PREVIOUS CONSEQUENCE RESULTS

The NRC generic source terms used in this study have been identified by SST1, SST2, SST2, SST4 and SST5. A brief description[2] of the accident spectrum associated with these source terms, reduced from the more detailed description,[1] is presented in Table 2.1. The fraction of the core inventory released for the set of seven groups of nuclides is shown, for each source term,[1,2] in Table 2.2. The postulated release times, containment building leakage rates and the time periods that the containment pressure exceeds ambient[1] are listed in Table 2.3. Although the frequencies of occurrence for the generic source terms have large variations for specific reactor designs, representative frequencies of occurrence have been estimated[1] for use in safety studies. These representative frequencies of occurrence and the computed consequences of mean latent cancer fatalities,[2] relative to that of the base case, are shown in Table 2.4. The calculations were performed at Sandia National Laboratories, using the CRAC2 code. The basic assumptions for the cases were: a standard 1120 MWe PWR, New York City meteorology, the Indian Point wind rose and population, and an assumed evacuation scheme.

3. METHODOLOGY

The objective of the analysis is to quantitatively determine the effects that containment building leakage rates have upon the consequences of the postulated accident spectrum. Thus, the method involves comparisons or

Table 2.1. Brief Descriptions[a] Characterizing the Accident Groups Within the NRC "Accident Spectrum"

Accident Group	Description
1	Severe core damage. Essentially involves loss of all installed safety features. Severe direct breach of containment.
2	Severe core damage. Containment fails to isolate. Fission product release mitigation system (e.g., sprays, suppression pool, fan coolers) operate to reduce release.
3	Severe core damage. Containment fails by base mat meltthrough. All other release mitigation systems function as designed.
4	Modest core damage. Containment systems operate in a degraded mode.
5	Limited core damage. No failures of engineered safety features beyond those postulated by the various design basis accidents. The most severe accident in this group assumes that the containment functions as designed following a substantial core melt.

[a]Descriptions quoted from guide on siting criteria.

Table 2.2. Core Inventory Release Fractions of NRC Set of Generic Source Terms

No.	Nuclides/Source Term	SST1	SST2	SST3	SST4	SST5
1	Xe-Kr Group	1.	9×10^{-1}	6×10^{-3}	3×10^{-6}	3×10^{-7}
2	(not used)					
3	I Group	0.45	3×10^{-3}	2×10^{-4}	1×10^{-7}	1×10^{-8}
4	Cs-Rb Group	0.67	9×10^{-3}	1×10^{-5}	6×10^{-7}	6×10^{-8}
5	Te-Sb Group	0.64	3×10^{-2}	2×10^{-5}	1×10^{-9}	1×10^{-10}
6	Ba-Sr Group	0.07	1×10^{-3}	1×10^{-6}	1×10^{-11}	1×10^{-12}
7	Ru Group	0.05	2×10^{-3}	2×10^{-6}	0	0
8	La Group	0.009	3×10^{-4}	1×10^{-6}	0	0

Table 2.3. Release Times and Containment Leakage Durations

Source Term	Shell Failure	Release Time, hours	Leakage Rate	Leakage Duration, hours
SST1	Yes	1.5	–	1.5
SST2	Yes	3.0	–	3.0
SST3	Yes	10.0	1.0 %/day	10.0
SST4	No	0.5	1.0 %/day	0.5
SST5	No	0.5	0.1 %/day	0.5

Table 2.4. Accident Frequencies of Occurrence and Consequences

Accident Group	Source Term	Frequencies of Occurrence, ϕ (per reactor year)	Relative Consequence (Basis: Mean Latent Cancer Fatalities)
1	SST1	1×10^{-5}	1
2	SST2	2×10^{-5}	7×10^{-2}
3	SST3	1×10^{-4} sum (groups 3–5)	2×10^{-4}
4	SST4		4×10^{-6}
5	SST5		4×10^{-7}

ratios of consequences, which are consistently derived. Previous evaluations are incorporated, when the required data have already been computed. Also, when making any required new assumptions, a definite effort was made to use conservative estimates.

3.1. Base Case

Essentially, the same base case applied in the guide for reactor siting criteria[2] was also used in this analysis. The total weighted consequence of the assumed accident spectrum is the sum of the products of consequence and corresponding probability of occurrence for each of the generic source terms. However, the total weighted consequence is not significantly higher than the weighted consequence of the SST1 source term of the base case. Thus, the conservative comparison, or ratio, of each computed source term consequence to that of the base case was applied.

A requirement of CRAC2 is that consequences in terms of person-dose may be computed for only a single evacuation scheme. All cases in this analysis used the second of the three evacuation schemes applied in the summary evacuation in the guide on siting criteria. Its parameters were in the intermediate range of the the three schemes.

3.2. Impact of Leakage Rates on Accident Risk

A direct evaluation of the impact of containment building leakage rates is described in the section. The method directly compares the risk attributed to "containment building leakage rates" for a given source term with the risk computed for the "base case". The meaning, used here, for the term "risk" is "the product of the consequence of a type of reactor accident and its frequency of occurrence." Also, "consequence" is quantitatively defined as the total man-rems or mean latent cancer fatalities computed for the source term derived for a type of accident.

If f represents the fractional consequence of a given type of accident, and

c and C equal the consequence of the given accident and that of the base case, respectively:

$$f = c \; / \; C \quad . \tag{1}$$

Consider the containment building leakage rate to be L %/day. Then, in general, the variable source term S(L) produces c(L) and the increased consequence is c(L) − c(0). If g(L) represents the fractional increase in consequence due to L,

$$g(L) = \frac{c(L) - c(0)}{C} \quad . \tag{2}$$

Now, consider the effect of generalizing the NRC generic source terms, in section 1.2.2, to explicity account for variations in L. Note that the SST3, SST4 and SST5 source terms already contain a specified L, from the conditions assumed in the associated types of accidents. Therefore, in these three cases, S(L) - S(0), c(L) − c(0) and g(L) are proportional to L. Also, cases computed to simulate c(L) for the SST1 source term proved that g(L) was proportional to L. Thus, defining R as the fractional increased consequence rate per % containment building leakage rate,

$$\frac{dg(L)}{dL} = R = \text{constant} \quad . \tag{3}$$

or, with L = 1, R becomes,

$$R = \frac{c(1) - c(0)}{C} \quad . \tag{4}$$

Now, represent the frequency of occurrence of a given type of accident by ϕ, with ϕ_1 denoting that of the base case. Then, the weighted impact

fraction rate of the given accident, M, may be described by,

$$M = R\phi / \phi_1 \ , \tag{5}$$

where M is produced in units of impact fraction per % containment building leakage rate.

The NRC generic source terms were derived from consideration of irradiated fuel released, first, to the containment building and, then, the transport of the radionuclides by different means out of the building. Thus, a single impact fraction rate M would represent both SST4 and SST5, which pertain to different containment building leakage rates for the same fuel release category.

Equation (5) can be used for any source term. Thus, it may be applied to the complete NRC generic accident spectrum:

$$M_{sp} = \sum_{i=1}^{4} R_i \phi_i / \phi_1 \ . \tag{6}$$

where,

M_{sp} = weighted impact fraction rate of accident spectrum;
R_i = fractional increased consequence rate of source term i;
ϕ_i = frequency of occurrence of accident type i.

Data representing ϕ_i have been established, as listed in Table 2.4. Where R_i data for source terms $S_i(L)$ are not already available, methods of computing $c_i(1)$ and $c_i(0)$ are given in the next section.

In place of converting to a rate, the fractional increase in consequences g(L) may be weighted directly to compute the weighted impact fraction of the accident spectrum, represented by $h_{sp}(L)$:

$$h_{sp}(L) = \sum_{i=1}^{4} g_i(L)\phi_i / \phi_1 \quad . \qquad (7)$$

3.3. Evaluations of Comparative Consequences

The methods used in determining R_i, the fractional increased consequence rate for $S_i(L)$, are presented in the next two subsections.

3.3.1. Impact Fraction Rates of First Two Source Terms

The breach in the containment building, which produces the SST1 source term and $S_1(L)$, has an associated release time of 1.5 hours. The evaluation of R_1 requires computing the effect of leakage rates during the 1.5 hour period prior to the large release. The consequences were computed by CRAC2 for the fraction of the gaseous nuclides, assumed to be all nuclides in groups 1 and 3, in the SST1 source term that would be released during 0.5 hour intervals for various leakage rates. Three cases were run for release times of 10, 40 and 70 minutes. A fourth case, using the part of the SST1 source term that had leaked was calculated for the breach at 1.5 hours. The timing of the breach was assumed not to be effected by the containment building leakage rate. All cases considered the warning time in the evacuation scheme to be 10 minutes, so that each value of c in terms of total man-rems for the first three cases could be added and that of the last case subtracted to produce $c_1(L) - c_1(0)$. The same evacuation scheme was applied in the base case, in which C and $c_1(0)$ (since, $C = c_1(0)$) were computed. Then, applying the computed $c_1(L) - c_1(0)$ and C, Equations (2) and (4) were used to evaluate $g_1(L)$ and R_1, respectively.

The fractional increased consequence rate R_2 for the generalized SST2 source term, $S_2(L)$, is certain to be no greater than twice that of $S_1(L)$, since its release time is 3 hours or twice that of SST1. Or,

$$R_2 \leq 2R_1 \quad . \tag{8}$$

The impact fraction rates for the first two source terms can be computed from Equation (5), using the evaluations of R_1, R_2 and frequencies of occurrence in Table 2.4.

While nuclides in the particulate or liquid form could leak to a certain degree as aerosols, they were not included in the leakage part of the SST1 and SST2 source terms because: they were included in the SST3 source term, which has a much greater impact (due to a longer leakage time and a higher frequency); they would tend to plug leaks and probably reduce the consequences; and, it is beyond the scope of this study to evaluate the source terms for these types of nuclides.

3.3.2. Other Impact Fraction Rates from Previous Data

The $S_4(1)$ and SST4 source terms are identical, since the only radionuclide transport to the environment for the accident group is due to the 1 %/day leakage rate of the containment building. There is no $S_4(0)$ term in Equation (4) in this case. Then, R_4 equals the relative consequence fraction that was previously[2] computed for SST4, as listed in Table 2.4.

The SST3 source term contains two parts: $S_3(1)$, that from a 1 %/day containment building leakage rate for a 10 hour period, and that resulting from meltthrough of the base mat. The breakdown into these two components was not explicity listed in the reports[1,2,3,6,7,8] researched on the development of source terms. Since the impact fraction rate R_3 is very low, a conservative upper bound was computed for R_3 and M_3. In core melt type of accidents, 100 % of the noble gases (Xe and Kr of nuclide group 1) are considered available for leakage from the reactor containment (as specified in section 8.1 of the report[3] on the technical bases for developing source terms). Using the 1 %/day leakage specified to be the rate at which the noble gases are leaked and the 10 hour period of leakage (as specified for SST3), the noble gas "group 1" fractional source $S_{3,1}(1)$ can be computed. Then, if R_3' is the total fractional consequence rate for the

total SST3 source term and $SST3_1$ is the part of SST3 from only "group 1" nuclides, the upper bound of R_3 can be established:

$$R_3 \leq \frac{S_{3,1}(1) R_3'}{SST3_1} \quad . \tag{9}$$

Note that $SST3_1$ is given in Table 2.2 for the Xe-Kr group for SST3 and the computed R_3' is the the relative consequence listed in Table 2.4. Also, from the above description of $S_{3,1}(1)$,

$$S_{3,1}(1) < (10\ h/24\ h)\ (1\ \%/100\ \%) \quad . \tag{10}$$

Thus, the upper bound of R_3 can be evaluated from Equation (9).

There are several reasons why the use of Equations (9) and (10) are conservative:

1. Equation (9) produces the same fractional consequences for all nuclide groups as that of group 1.

2. During the 10 hours in which the containment building is above ambient, its pressure may be reduced from the value of the design pressure assumed in a 1 %/day specification.

3. Leaks would tend to plug, due to particulates in the aerosols, reducing the leakage time to less than the 10 hours.

There are good reasons, also, for using Equations (9) and (10) in the above method:

1. The representative frequencies of occurrence would tend to have uncertainties which would exceed the conservative error in R_3.

2. The final weighted impact fraction computed by this method is very small, even though it could be considered to be an upper limit.

3. These results can be easily modified, should more precise data become available.

4. RESULTS

The details of the methodology in deriving the results are presented in section 3. Also, available data required in the analyses are given in Tables 2.1 - 2.4. The main objective of the results is the evaluation of M_{sp}, the weighted impact fraction rate of the postulated accident spectrum.

The consequence computed by CRAC2 for the base case (SST1 source term) was 9.99×10^7 man-rems. The increase in consequence $c_1(L) - c_1(0)$, determined by generalizing SST1 to include L % containment building leakage rates, were computed from CRAC2 results as described in section 3.3.1. Both $c_1(L) - c_1(0)$ and $g_1(L)$, the fractional increase in consequences, are listed as a function of L in Table 4.1. It is seen that $g_1(L)$ is directly proportional to L.

The results of computing the fractional increased consequence rate R_i and the weighted impact fraction rate M_i, following the method given in section 3, are tabulated in Table 4.2. Finally, using M_i and the frequencies of occurrence ϕ_i, from Table 2.4, M_{sp} was evaluated as shown. Thus, the conservative calculation of the accident spectrum weighted impact fraction rate, for the reactor size, meterology, wind rose and population of the base case, was 1.5×10^{-3} per %/day leakage from a containment building.

The accident spectrum weighted impact fraction $h_{sp}(L)$ (from Equation(7))

Table 4.1. Increase in Worst Case Accident Consequences Caused by Containment Building Leakage Rates

Leakage Rate, L %/day	Increase in Consequences $c_1(L)-c_1(0)$, man-rems	Fractional Increase $g_1(L)$
0 (Base Case)	0.0	0.0
1	4.4×10^2	4.4×10^{-6}
10	4.4×10^3	4.4×10^{-5}
100	4.4×10^4	4.4×10^{-4}
1,000	4.4×10^5	4.4×10^{-3}
1,600 (all, in 1.5 hr)	7.0×10^5	7.0×10^{-3}

Table 4.2. Individual and "Accident Spectrum" Weighted Impact Fraction Rates

Accident Group or Type	Source Term	Fractional Increase in Consequence Rate (Units in fraction per %/day leakage)	Weighted Impact Fraction Rate (Units in fraction per %/day leakage)
1	$S_1(L)$	4.4×10^{-6}	4.4×10^{-6}
2	$S_2(L)$	8.8×10^{-6}	1.7×10^{-5}
3	$S_3(L)$	1.4×10^{-4} }	1.4×10^{-3} (groups 3 and 4)
4	$S_4(L)$	4.0×10^{-6} }	
Total Spectrum, M_{sp}			1.5×10^{-3}

was plotted as a function of L, as shown in Fig. 4.1.

5. CONCLUSIONS

The computed weighted impact fraction rate of 1.5×10^{-3} per %/day leakage is very small. Its main component is due to the containment leakage source term that is part of the generalized SST3 source term. This source term was associated with the case which assumed a base mat meltthrough during a core melt type of accident. When weighting the consequence from this leakage with its frequency, the computed risk is small compared with the risk of a severe release due to a breach in the containment building.

While the evaluation of the impact of leakage rates on LWR accident risks is indicated to be relatively small, the release during accident conditions is only one of the considerations relating to containment integrity. Among the other considerations are the effect of the leakage rate upon environmental assessments during normal reactor operations, as well as other potential pathways by which radionuclides may be transported through the containment (e.g., by certain types of coolant system ruptures). In fact, these other considerations may dictate a much tighter design requirement for containment integrity, as opposed to that based solely on the accident spectrum. It appears prudent to contain and trap, to a reasonable degree, even small quantities of radionuclides leaking into the containment during either routine operations or minor releases.

This study has shown that the LWR accident risk is relatively insensitive to the containment building leakage rate. Hence, if the impact on accident risk is the dominant consideration, the strict use of an absolute cut-off for the allowable containment building leakage rate may not be justified on a cost/benefit basis.

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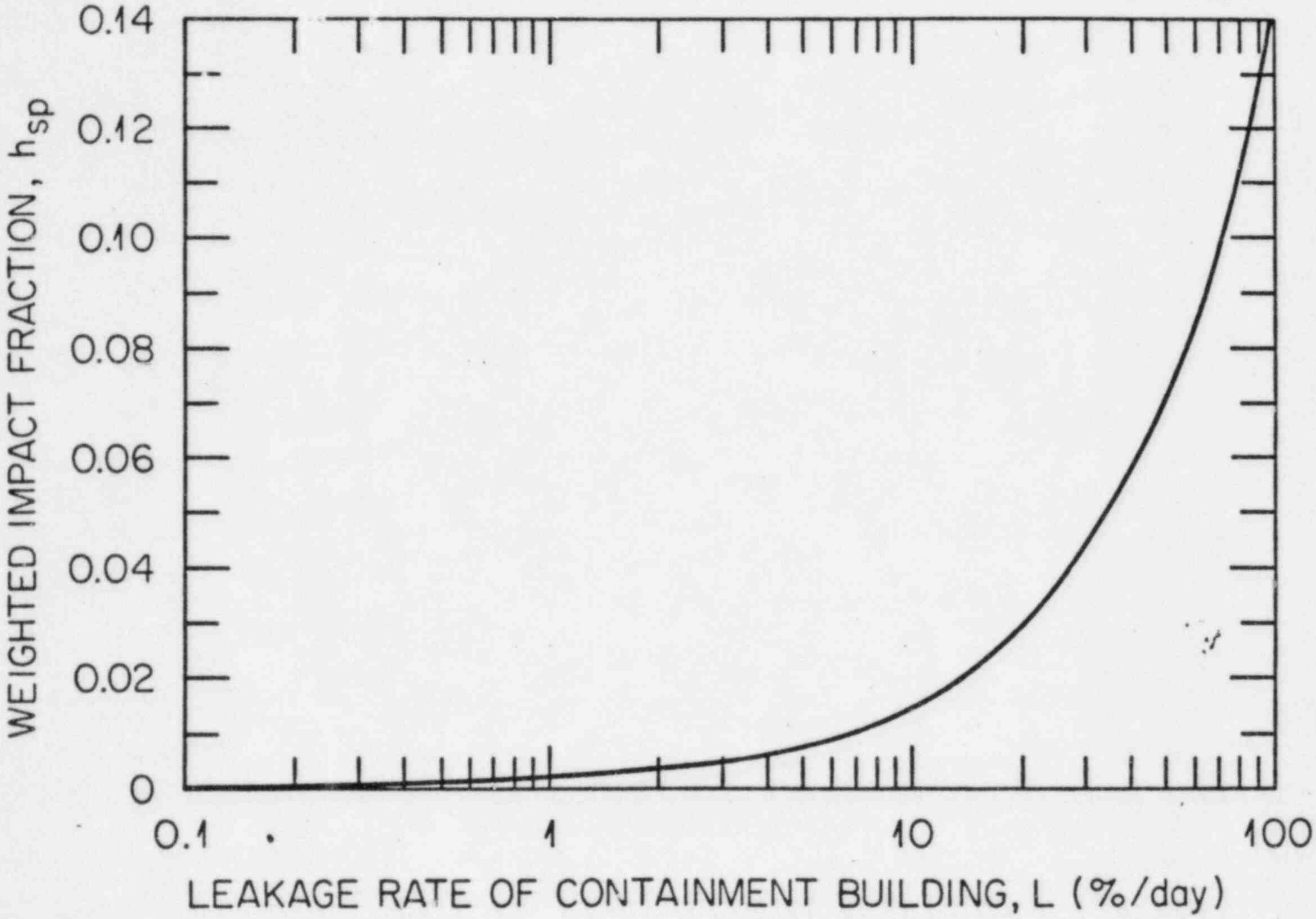

Fig. 4.1. Impact on Accident Spectrum Risk From Variation in Containment Building Leakage Rate.

6. REFERENCES

1. R. M. Blond, et al., "The Development of Severe Reactor Accident Source Terms: 1957-1981," U.S. Nuclear Regulatory Commission, NUREG-0773 (November 1982).

2. D. C. Aldrich, et al., "Technical Guidance For Siting Criteria Development," Sandia National Laboratories, NUREG/CR-2239, SAND81-1549, Preliminary Report (November 1982).

3. M. Silberberg, et al., "Technical Bases for Estimating Fission Product Behavior During LWR Accidents," U.S. Nuclear Regulatory Commission, NUREG-0772 (June 1981).

4. L. T. Ritchie, J. D. Johnson, and R. M. Blond, "Calculations of Reactor Accident Consequences, Version 2 - CRAC2 - Computer Code Input Data Description," Sandia National Laboratories, NUREG/CR-2326, SAND81-1994, Preliminary Report (1982).

5. L. T. Ritchie, et al., "CRAC2, Calculation of Reactor Accident Consequences, Version 2, Model Description," Sandia National Laboratories, NUREG/CR-2552, SAND82-0342 (to be published).

6. "Reactor Safety Study," U.S. Nuclear Regulatory Commission, WASH-1400 (NUREG-75/014) (October 1975).

7. W. F. Pasedag, R. M. Blond, and M. W. Jankowski, "Regulatory Impact of Nuclear Reactor Accident Source Term Assumptions," U.S. Nuclear Regulatory Commission, NUREG-0771 (June 1981).

8. W. A. Sebrell, et al., "Proceedings of the Workshop on Containment Integrity, Volume I," Sandia National Laboratories, NUREG/CP-0033, SAND82-1659 (October 1982).

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UNION CARBIDE CORPORATION

NUCLEAR DIVISION

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October 14, 1983

Mr. Gunter Arndt
Mechanical/Structural Engineering Branch
Division of Energy Technology
U. S. Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Gunter:

I am enclosing the draft version of the containment leak rate sensitivity report. I would appreciate any comments you would care to make. In addition, the expenditure numbers you requested are:

March	$ 396
April	15
May	0
June	2578
July	3850
August	6369
September	20560
TOTAL	$33768

As you can see, the majority of the effort was concentrated in September. I expect to spend the other $16,232 during October and November to put together and publish the reports we owe you.

Sincerely,

Tony Burns

T. J. Burns

TJB:nc

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Tom Burns 624-6101

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1. INTRODUCTION AND OBJECTIVE

The consequences from LWR accidents were evaluated as a function of containment building leakage rate. The available data and methodology currently applied in assessments of nuclear reactor accident consequences were used as a basis for this evaluation.

1.1. Containment Building Leakage Rates

The main issue addressed here is the overall impact of variations in the containment building leakage rate on the risk from a postulated spectrum of types of hypothetical LWR accidents.

There are two main functions of the reactor containment building and associated safety systems:

1. To maintain shell integrity to avoid a release through a severe breach in the shell or a base mat meltthrough.

2. To establish appropriate isolation to limit radionuclide transport to the environment.

The second function is considered here. While it is obviously desirable to establish the complete isolation of a release into the containment building, on a practical basis there are sources of small leaks that are difficult to completely eliminate.

During normal operations of a nuclear reactor there can be transport of radionuclides, at least in minute quantities, into the containment building. Those nuclides either are trapped or become the small effluence from reactors. It is beyond the scope of this study to determine the effect of leakage rates upon assessments of normal operations.

1.2. Objective

1.2.1. Quantifying the Weighted Impact on LWR Accidents

The main purpose of this analysis is to quantitatively describe, as a function of containment building leakage rate, the weighted increase in the spectrum of consequences from the set of postulated types of accidents that have been established for consideration in reactor safety research.

1.2.2. Specified Method of Producing Objective

It was specified that this analysis be as consistent as possible with the assumptions[1] and methodology[2] used in the most recent research on reactor safety.

1.2.2.1. Generic Source Terms and "Accident Spectrum"

Reactor safety research,[3] sponsored by the U. S. Nuclear Regulatory Commission, has produced a technical bases for estimating radionuclide behavior during hypothetical LWR accidents. These evaluations have led to the development[1] of five generic source terms to be associated with the five generic groups of reactor accidents, sometimes termed the "accident spectrum". Also, associated with this accident spectrum, are[1] representative frequencies of occurrence together with parameters required in computing the consequences resulting from the corresponding source terms.

1.2.2.2. Applying Consequences in Guide for Siting Criteria

The evaluation of probable consequences of LWR accidents from the guide for reactor siting criteria[2] were used, when applicable, in this study. The same base case, as the "worst case," was applied.

1.2.2.3. Additional Analyses with CRAC2 Code

Consistency with recent research on reactor safety was maintained by using the CRAC2 code[4,5] for the additional calculations required, since it was applied in the siting criteria study. It is a modified version of the CRAC code, which was originally developed for use in the Reactor Safety Study, (WASH-1400).[6]

1.2.2.4. Weighted Impact on LWR Accident Risk

The consequences of each type of accident group and source term were analyzed separately as a function of containment building leakage rate. Thus, the magnitude of the risk from each accident group can be compared on a relative basis with that of the base case.

1.2.3. Impact Based on Person-Dose or Latent Cancer Effect

Not all of the given source terms were severe enough to produce early fatalities or early injuries. Also, due to characteristics of CRAC2, it was necessary to compute a series of small puff releases to represent the effect of a continuous leakage rate. Then, consequences from small puffs were added to that attributable to the severe release (e.g., that from eventual containment failure). It would be incorrect to add early fatalities or early injuries from separate cases, because they are not proportional to total person-dose. However, person-dose values (man-rems) from separate cases are additive, provided that the time history of the assumed evacuation scheme is properly maintained. The ratio of computed latent cancer fatalities to total person-dose is approximately a constant. Thus, the final impact of leakage rates are based upon risk in terms of either total person-dose or mean latent cancer fatalities.

not assumed

See 12/22/82 mtg memo

1.2.4. Assessment Using Weighted Impact Fraction Rate

The results of the study are summarized by a single value defined as the weighted impact fraction rate from containment building leakage rates. The effect of the frequencies of occurrence of accidents leading to the set of

generic source terms is directly used in deriving the weighted impact fraction rate. Although there are significant uncertainties associated with both the consequences and frequencies of the postulated types of accidents, the weighted impact fraction rate provides a quantitative description of the realistic impact of containment building leakage rates on the risk resulting from the accident spectrum.

2. SOURCE TERM DATA AND PREVIOUS CONSEQUENCE RESULTS

The NRC generic source terms used in this study have been identified by SST1, SST2, SST2, SST4 and SST5. A brief description[2] of the accident spectrum associated with these source terms, reduced from the more detailed description,[1] is presented in Table 2.1. The fraction of the core inventory released for the set of seven groups of nuclides is shown, for each source term,[1,2] in Table 2.2. The postulated release times, containment building leakage rates and the time periods that the containment pressure exceeds ambient[1] are listed in Table 2.3. Although the frequencies of occurrence for the generic source terms have large variations for specific reactor designs, representative frequencies of occurrence have been estimated[1] for use in safety studies. These representative frequencies of occurrence and the computed consequences of mean latent cancer fatalities,[2] relative to that of the base case, are shown in Table 2.4. The calculations were performed at Sandia National Laboratories, using the CRAC2 code. The basic assumptions for the cases were: a standard 1120 MWe PWR, New York City meteorology, the Indian Point wind rose and population, and an assumed evacuation scheme.

3. METHODOLOGY

The objective of the analysis is to quantitatively determine the effects that containment building leakage rates have upon the consequences of the postulated accident spectrum. Thus, the method involves comparisons or

Table 2.1. Brief Descriptions[a] Characterizing the Accident Groups Within the NRC "Accident Spectrum"

Accident Group	Description
1	Severe core damage. Essentially involves loss of all installed safety features. Severe direct breach of containment.
2	Severe core damage. Containment fails to isolate. Fission product release mitigation system (e.g., sprays, suppression pool, fan coolers) operate to reduce release.
3	Severe core damage. Containment fails by base mat meltthrough. All other release mitigation systems function as designed.
4	Modest core damage. Containment systems operate in a degraded mode.
5	Limited core damage. No failures of engineered safety features beyond those postulated by the various design basis accidents. The most severe accident in this group assumes that the containment functions as designed following a substantial core melt.

[a]Descriptions quoted from guide on siting criteria.

Table 2.2. Core Inventory Release Fractions of NRC Set of Generic Source Terms

No.	Nuclides/Source Term	SST1	SST2	SST3	SST4	SST5
1	Xe-Kr Group	1.	9×10^{-1}	6×10^{-3}	3×10^{-6}	3×10^{-7}
2	(not used)					
3	I Group	0.45	3×10^{-3}	2×10^{-4}	1×10^{-7}	1×10^{-8}
4	Cs-Rb Group	0.67	9×10^{-3}	1×10^{-5}	6×10^{-7}	6×10^{-8}
5	Te-Sb Group	0.64	3×10^{-2}	2×10^{-5}	1×10^{-9}	1×10^{-10}
6	Ba-Sr Group	0.07	1×10^{-3}	1×10^{-6}	1×10^{-11}	1×10^{-12}
7	Ru Group	0.05	2×10^{-3}	2×10^{-6}	0	0
8	La Group	0.009	3×10^{-4}	1×10^{-6}	0	0

Table 2.3. Release Times and Containment Leakage Durations

Source Term	Shell Failure	Release Time, hours	Leakage Rate	Leakage Duration, hours
SST1	Yes	1.5	-	1.5
SST2	Yes	3.0	-	3.0
SST3	Yes	10.0	1.0 %/day	10.0
SST4	No	0.5	1.0 %/day	0.5
SST5	No	0.5	0.1 %/day	0.5

logic? ?!

Table 2.4. Accident Frequencies of Occurrence and Consequences

Accident Group	Source Term	Frequencies of Occurrence, ϕ (per reactor year)	Relative Consequence (Basis: Mean Latent Cancer Fatalities)
1	SST1	1×10^{-5}	1
2	SST2	2×10^{-5}	7×10^{-2}
3	SST3	1×10^{-4} sum	2×10^{-4}
4	SST4		4×10^{-6}
5	SST5		4×10^{-7}

?

ratios of consequences, which are consistently derived. Previous evaluations are incorporated, when the required data have already been computed. Also, when making any required new assumptions, a definite effort was made to use conservative estimates.

3.1. Base Case

Essentially, the same base case applied in the guide for reactor siting criteria[2] was also used in this analysis. The total weighted consequence of the assumed accident spectrum is the sum of the products of consequence and corresponding probability of occurrence for each of the generic source terms. However, the total weighted consequence is not significantly higher than the weighted consequence of the SST1 source term of the base case. Thus, the conservative comparison, or ratio, of each computed source term consequence to that of the base case was applied.

A requirement of CRAC2 is that consequences in terms of person-dose may be computed for only a single evacuation scheme. All cases in this analysis used the second of the three evacuation schemes applied in the summary evacuation in the guide on siting criteria. Its parameters were in the intermediate range of the the three schemes.

3.2. Impact of Leakage Rates on Accident Risk

A direct evaluation of the impact of containment building leakage rates is described in the section. The method directly compares the risk attributed to "containment building leakage rates" for a given source term with the risk computed for the "base case". The meaning, used here, for the term "risk" is "the product of the consequence of a type of reactor accident and its frequency of occurrence." Also, "consequence" is quantitatively defined as the total man-rems or mean latent cancer fatalities computed for the source term derived for a type of accident.

If f represents the fractional consequence of a given type of accident, and

c and C equal the consequence of the given accident and that of the base case, respectively:

$$f = c / C \quad . \tag{1}$$

Consider the containment building leakage rate to be L %/day. Then, in general, the variable source term S(L) produces c(L) and the increased consequence is c(L) - c(0). If g(L) represents the fractional increase in consequence due to L,

$$g(L) = \frac{c(L) - c(0)}{C} \quad . \tag{2}$$

Now, consider the effect of generalizing the NRC generic source terms, in section 1.2.2, to explicity account for variations in L. Note that the SST3, SST4 and SST5 source terms already contain a specified L, from the conditions assumed in the associated types of accidents. Therefore, in these three cases, S(L) - S(0), c(L) - c(0) and g(L) are proportional to L. Also, cases computed to simulate c(L) for the SST1 source term proved that g(L) was proportional to L. Thus, defining R as the fractional increased consequence rate per % containment building leakage rate,

$$\frac{dg(L)}{dL} = R = \text{constant} \quad . \tag{3}$$

or, with L = 1, R becomes,

$$R = \frac{c(1) - c(0)}{C} \quad . \tag{4}$$

Now, represent the frequency of occurrence of a given type of accident by ϕ, with ϕ_1 denoting that of the base case. Then, the weighted impact

fraction rate of the given accident, M, may be described by,

$$M = R\phi / \phi_1 \quad . \tag{5}$$

where M is produced in units of impact fraction per % containment building leakage rate.

The NRC generic source terms were derived from consideration of irradiated fuel released, first, to the containment building and, then, the transport of the radionuclides by different means out of the building. Thus, a single impact fraction rate M would represent both SST4 and SST5, which pertain to different containment building leakage rates for the same fuel release category.

Equation (5) can be used for any source term. Thus, it may be applied to the complete NRC generic accident spectrum:

$$M_{sp} = \sum_{i=1}^{4} R_i \phi_i / \phi_1 \quad . \tag{6}$$

where,

M_{sp} = weighted impact fraction rate of accident spectrum;
R_i = fractional increased consequence rate of source term i;
ϕ_i = frequency of occurrence of accident type i.

Data representing ϕ_i have been established, as listed in Table 2.4. Where R_i data for source terms $S_i(L)$ are not already available, methods of computing $c_i(1)$ and c_i (0) are given in the next section.

In place of converting to a rate, the fractional increase in consequences g(L) may be weighted directly to compute the weighted impact fraction of the accident spectrum, represented by $h_{sp}(L)$:

$$h_{sp}(L) = \sum_{i=1}^{4} g_i(L)\phi_i / \phi_1 \quad . \tag{7}$$

3.3. Evaluations of Comparative Consequences

The methods used in determining R_i, the fractional increased consequence rate for $S_i(L)$, are presented in the next two subsections.

3.3.1. Impact Fraction Rates of First Two Source Terms

The breach in the containment building, which produces the SST1 source term and $S_1(L)$, has an associated release time of 1.5 hours. The evaluation of R_1 requires computing the effect of leakage rates during the 1.5 hour period prior to the large release. The consequences were computed by CRAC2 for the fraction of the gaseous nuclides, assumed to be all nuclides in groups 1 and 3, in the SST1 source term that would be released during 0.5 hour intervals for various leakage rates. Three cases were run for release times of 10, 40 and 70 minutes. A fourth case, using the part of the SST1 source term that had leaked was calculated for the breach at 1.5 hours. The timing of the breach was assumed not to be effected by the containment building leakage rate. All cases considered the warning time in the evacuation scheme to be 10 minutes, so that each value of c in terms of total man-rems for the first three cases could be added and that of the last case subtracted to produce $c_1(L) - c_1(0)$. The same evacuation scheme was applied in the base case, in which C and $c_1(0)$ (since, $C = c_1(0)$) were computed. Then, applying the computed $c_1(L) - c_1(0)$ and C, Equations (2) and (4) were used to evaluate $g_1(L)$ and R_1, respectively.

The fractional increased consequence rate R_2 for the generalized SST2 source term, $S_2(L)$, is certain to be no greater than twice that of $S_1(L)$, since its release time is 3 hours or twice that of SST1. Or,

$$R_2 \leq 2R_1 \quad . \qquad (8)$$

The impact fraction rates for the first two source terms can be computed from Equation (5), using the evaluations of R_1, R_2 and frequencies of occurrence in Table 2.4.

While nuclides in the particulate or liquid form could leak to a certain degree as aerosols, they were not included in the leakage part of the SST1 and SST2 source terms because: they were included in the SST3 source term, which has a much greater impact (due to a longer leakage time and a higher frequency); they would tend to plug leaks and probably reduce the consequences; and, it is beyond the scope of this study to evaluate the source terms for these types of nuclides.

3.3.2. Other Impact Fraction Rates from Previous Data

The $S_4(1)$ and SST4 source terms are identical, since the only radionuclide transport to the environment for the accident group is due to the 1 %/day leakage rate of the containment building. There is no $S_4(0)$ term in Equation (4) in this case. Then, R_4 equals the relative consequence fraction that was previously[2] computed for SST4, as listed in Table 2.4.

The SST3 source term contains two parts: $S_3(1)$, that from a 1 %/day containment building leakage rate for a 10 hour period, and that resulting from meltthrough of the base mat. The breakdown into these two components was not explicity listed in the reports[1,2,3,6,7,8] researched on the development of source terms. Since the impact fraction rate R_3 is very low, a conservative upper bound was computed for R_3 and M_3. In core melt type of accidents, 100 % of the noble gases (Xe and Kr of nuclide group 1) are considered available for leakage from the reactor containment (as specified in section 8.1 of the report[3] on the technical bases for developing source terms). Using the 1 %/day leakage specified to be the rate at which the noble gases are leaked and the 10 hour period of leakage (as specified for SST3), the noble gas "group 1" fractional source $S_{3,1}(1)$ can be computed. Then, if R_3' is the total fractional consequence rate for the

total SST3 source term and $SST3_1$ is the part of SST3 from only "group 1" nuclides, the upper bound of R_3 can be established:

$$R_3 \leq \frac{S_{3,1}(1) R_3'}{SST3_1} \quad . \tag{9}$$

Note that $SST3_1$ is given in Table 2.2 for the Xe-Kr group for SST3 and the computed R_3' is the the relative consequence listed in Table 2.4. Also, from the above description of $S_{3,1}(1)$,

$$S_{3,1}(1) < (10\ h/24\ h)\ (1\ \%/100\ \%) \quad . \tag{10}$$

Thus, the upper bound of R_3 can be evaluated from Equation (9).

There are several reasons why the use of Equations (9) and (10) are conservative:

1. Equation (9) produces the same fractional consequences for all nuclide groups as that of group 1.

2. During the 10 hours in which the containment building is above ambient, its pressure may be reduced from the value of the design pressure assumed in a 1 %/day specification.

3. Leaks would tend to plug, due to particulates in the aerosols, reducing the leakage time to less than the 10 hours.

There are good reasons, also, for using Equations (9) and (10) in the above method:

1. The representative frequencies of occurrence would tend to have uncertainties which would exceed the conservative error in R_3.

2. The final weighted impact fraction computed by this method is very small, even though it could be considered to be an upper limit.

3. These results can be easily modified, should more precise data become available.

4. RESULTS

The details of the methodology in deriving the results are presented in section 3. Also, available data required in the analyses are given in Tables 2.1 - 2.4. The main objective of the results is the evaluation of M_{sp}, the weighted impact fraction rate of the postulated accident spectrum.

The consequence computed by CRAC2 for the base case (SST1 source term) was 9.99×10^7 man-rems. The increase in consequence $c_1(L) - c_1(0)$, determined by generalizing SST1 to include L % containment building leakage rates, were computed from CRAC2 results as described in section 3.3.1. Both $c_1(L) - c_1(0)$ and $g_1(L)$, the fractional increase in consequences, are listed as a function of L in Table 4.1. It is seen that $g_1(L)$ is directly proportional to L.

The results of computing the fractional increased consequence rate R_i and the weighted impact fraction rate M_i, following the method given in section 3, are tabulated in Table 4.2. Finally, using M_i and the frequencies of occurrence ϕ_i, from Table 2.4, M_{sp} was evaluated as shown. Thus, the conservative calculation of the accident spectrum weighted impact fraction rate, for the reactor size, meterology, wind rose and population of the base case, was 1.5×10^{-3} per %/day leakage from a containment building.

The accident spectrum weighted impact fraction $h_{sp}(L)$ (from Equation(7))

Table 4.1. Increase in Worst Case Accident Consequences Caused by Containment Building Leakage Rates

Leakage Rate, L %/day	Increase in Consequences $c_1(L)-c_1(0)$, man-rems	Fractional Increase $g_1(L)$
0 (Base Case)	0.0	0.0
1	4.4×10^{2}	4.4×10^{-6}
10	4.4×10^{3}	4.4×10^{-5}
100	4.4×10^{4}	4.4×10^{-4}
1,000	4.4×10^{5}	4.4×10^{-3}
1,600 (all, in 1.5 hr)	7.0×10^{5}	7.0×10^{-3}

Table 4.2. Individual and "Accident Spectrum" Weighted Impact Fraction Rates

		(Units in fraction per %/day leakage)	
Accident Group or Type	Source Term	Fractional Increase in Consequence Rate	Weighted Impact Fraction Rate
1	$S_1(L)$	4.4×10^{-6}	4.4×10^{-6}
2	$S_2(L)$	8.8×10^{-6}	1.7×10^{-5}
3	$S_3(L)$	1.4×10^{-4}	1.4×10^{-3} (groups 3 and 4)
4	$S_4(L)$	4.0×10^{-6}	
Total Spectrum, M_{sp}			1.5×10^{-3}

was plotted as a function of L, as shown in Fig. 4.1.

5. CONCLUSIONS

The computed weighted impact fraction rate of 1.5×10^{-3} per %/day leakage is very small. Its main component is due to the containment leakage source term that is part of the generalized SST3 source term. This source term was associated with the case which assumed a base mat meltthrough during a core melt type of accident. When weighting the consequence from this leakage with its frequency, the computed risk is small compared with the risk of a severe release due to a breach in the containment building.

While the evaluation of the impact of leakage rates on LWR accident risks is indicated to be relatively small, the release during accident conditions is only one of the considerations relating to containment integrity. Among the other considerations are the effect of the leakage rate upon environmental assessments during normal reactor operations, as well as other potential pathways by which radionuclides may be transported through the containment (e.g., by certain types of coolant system ruptures). In fact, these other considerations may dictate a much tighter design requirement for containment integrity, as opposed to that based solely on the accident spectrum. It appears prudent to contain and trap, to a reasonable degree, even small quantities of radionuclides leaking into the containment during either routine operations or minor releases.

This study has shown that the LWR accident risk is relatively insensitive to the containment building leakage rate. Hence, if the impact on accident risk is the dominant consideration, the strict use of an absolute cut-off for the allowable containment building leakage rate may not be justified on a cost/benefit basis.

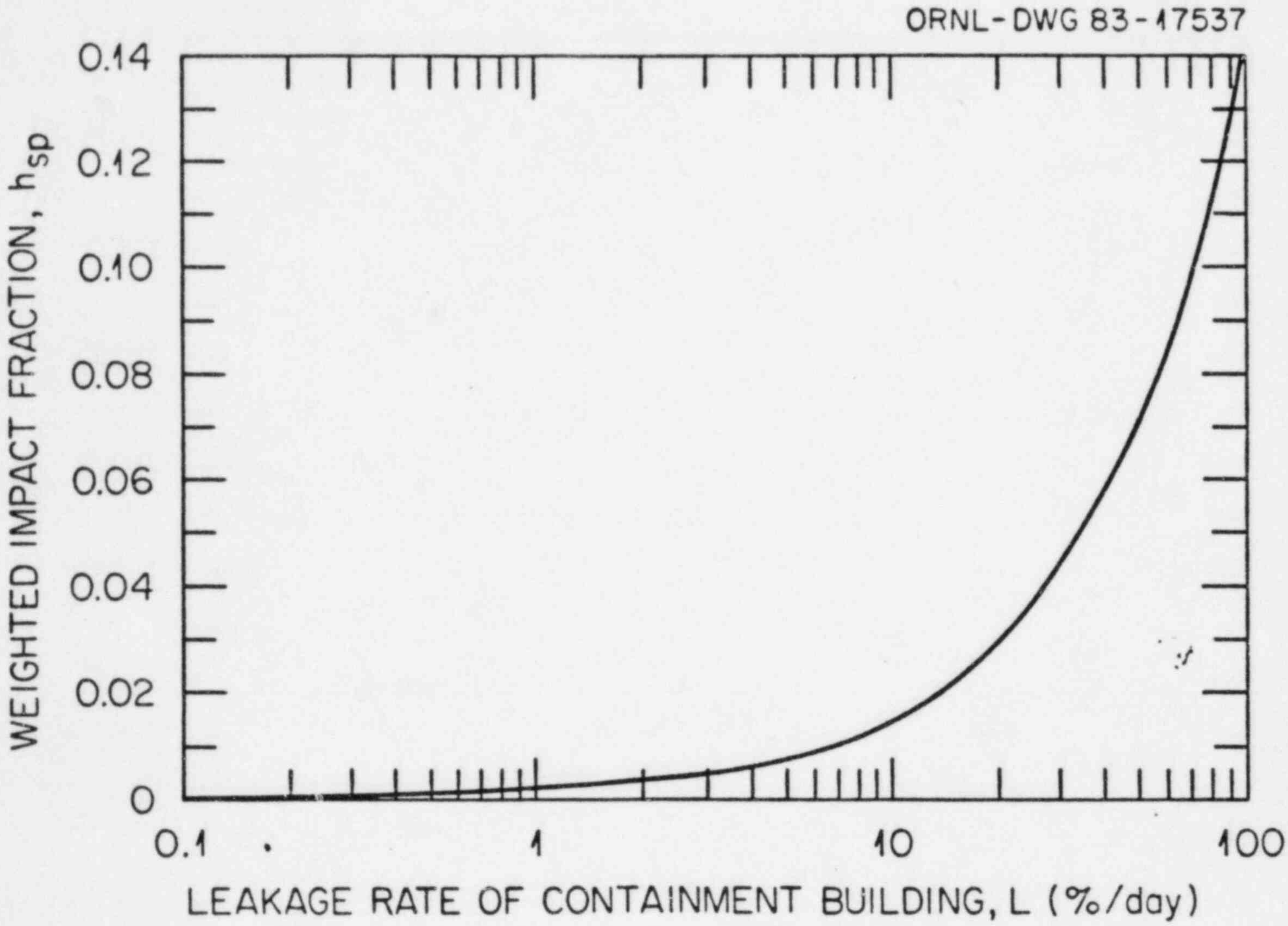

Fig. 4.1. Impact on Accident Spectrum Risk From Variation in Containment Building Leakage Rate.

6. REFERENCES

1. R. M. Blond, et al., "The Development of Severe Reactor Accident Source Terms: 1957-1981," U.S. Nuclear Regulatory Commission, NUREG-0773 (November 1982).

2. D. C. Aldrich, et al., "Technical Guidance For Siting Criteria Development," Sandia National Laboratories, NUREG/CR-2239, SAND81-1549, Preliminary Report (November 1982).

3. M. Silberberg, et al., "Technical Bases for Estimating Fission Product Behavior During LWR Accidents," U.S. Nuclear Regulatory Commission, NUREG-0772 (June 1981).

4. L. T. Ritchie, J. D. Johnson, and R. M. Blond, "Calculations of Reactor Accident Consequences, Version 2 - CRAC2 - Computer Code Input Data Description," Sandia National Laboratories, NUREG/CR-2326, SAND81-1994, Preliminary Report (1982).

5. L. T. Ritchie, et al., "CRAC2, Calculation of Reactor Accident Consequences, Version 2, Model Description," Sandia National Laboratories, NUREG/CR-2552, SAND82-0342 (to be published).

6. "Reactor Safety Study," U.S. Nuclear Regulatory Commission, WASH-1400 (NUREG-75/014) (October 1975).

7. W. F. Pasedag, R. M. Blond, and M. W. Jankowski, "Regulatory Impact of Nuclear Reactor Accident Source Term Assumptions," U.S. Nuclear Regulatory Commission, NUREG-0771 (June 1981).

8. W. A. Sebrell, et al., "Proceedings of the Workshop on Containment Integrity, Volume I," Sandia National Laboratories, NUREG/CP-0033, SAND82-1659 (October 1982).

I. Burns 624-6101

costs (will send monthly $ costs)

Carryover
20-25K

10/3/83

Drafts — Finish by end of Oct '83
reports

1. Sensitivity Analysis
(will send rough draft copy)

2. leak rate predict. method.

3. Criteria Assement
Gross
Monitoring
$0.25 L_a$ margin
Single leak rate criteria

File Note: Arndt call to Tom Burns, ORNL 12/13/83

Re: Status of ORNL reports on 30489 Addendum, "Containment Leak Rate Sensitivity Study"

T.B. Staff member working on report(s) is recovering from a heart attack. T.B. will let me know as soon as a reschedule is set.

Arndt Evacuation not to be a study variable.

T.B. Only one standard evacuation was used since ~~this~~ evacuation was already built into the CRAC2 Code. Therefore evacuation, even though included contrary to 12/82 memo, should not be a variable in the study.

Arndt Frequency of occurrence of accident and weighted fraction are not readily understandable, nor apparently justifiable.

T.B. The draft report will be clarified to make interpretation easier, and justify the frequency-weighted approach.

Arndt DRA still has not provided comment(s) on the draft report. Any received will be relayed to T.B.

FOIA-85-143

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ORNL Leak Rate Sensitivity Study

File Note: Foncon G Arndt to T. Burns 1/10/84
on Status of Reports.

Report #1 : Final report out by end of January

Report #2 : " " " 2 weeks later (mid-Feb)

Draft of Report #2 to be sent to G Arndt.

FOIA-85-143

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(17)