NRC Research and Technical Assistance Report

INTERIM REPORT

6-5-79

Accession No. ____________

____

Contract Program or Project Title:

Subject of this Document: "Inhalation Dosage Determination Resulting from BST Failure and from Release Directly to the LOFT Containment Following L2-3 Blowdown"

Type of Document:

Author(s): R. S. Schofield

Date of Document: January 1979

Responsible NRC Individual and NRC Office or Division: G. D. McPherson

This document was prepared primarily for preliminary or internal use. It has not received full review and approval. Since there may be substantive changes, this document should not be considered final.

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Prepared for
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

NRC Fin #A6048

INTERIM REPORT

NRC Research and Technical Assistance Report

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EG&G Idaho

FORM EG&G 954
(Rev. 9-76)

INTEROFFICE CORRESPONDENCE

NO. R-4291

date FEB 0 2 1979

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LOFT TECHNICAL REPORT LTR 10-51
JANUARY 16, 1979
P394

INHALATION DOSAGE DETERMINATION RESULTING FROM BST FAILURE AND FROM RELEASE DIRECTLY TO THE LOFT CONTAINMENT FOLLOWING L2-3 BLOWDOWN

R. S. Schofield

EG&G Idaho, Inc.
IDAHO NATIONAL ENGINEERING LABORATORY
DEPARTMENT OF ENERGY
IDAHO OPERATIONS OFFICE UNDER CONTRACT EY-76-C-07-1570

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EG&G Idaho, Inc.

FORM EG&G-229
(Rev. 12-78)

LOFT TECHNICAL REPORT
LOFT PROGRAM

TITLE: INHALATION DOSAGE DETERMINATION RESULTING FROM BST FAILURE AND FROM RELEASE DIRECTLY TO THE LOFT CONTAINMENT FOLLOWING L2-3 BLOWDOWN	REPORT NO.: LTR 10-51
AUTHOR: R. S. Schofield	GWA NO.: 52191-100-300
PERFORMING ORGANIZATION: Safety Division	
LOFT APPROVAL: SA&TSS Supvr. / PTCSB Mgr. / RSB Mgr. / RSB Mgr.	DATE: January 16, 1979

This LTR presents results obtained from analyses to scope potential radiological dosages following L2-3 blowdown. Two events were considered by these analyses:

(1) inhalation dose at the site boundary assuming Blowdown Suppression Tank header failure and (2) inhalation dose at the one-mile fence following Blowdown Suppression Tank integrity failure. Both events were evaluated using the following assumptions:

1. Releases were examined for L2-3 operating times of 20, 40, 100, and 1,000 hours at 37.2 MW.
2. Of the core's fuel rods, 20% were perforated during blowdown releasing 11% of the core iodine fission inventory (FPI).
    a. The entire 11% iodine inventory was exhausted to the PCS.
3. The leak rate from containment was considered to be a function of the CV pressure and temperature, as described in LOFT FSAR Volume 1, Chapter 6, Appendix 6-E, and Volume 2, Chapter 13, Appendix 13-A.
4. Class F (2 meters per second windspeed) meteorological conditions were used to determine isotopic air concentrations at the location of inhalation.
5. Breathing rates were 1.25 m^3/hr for inhalation times of one hour and eight hours at the one-mile exclusion fence and at the 10^4 m site boundary.
6. Doses were calculated for an adult thyroid (i.e., 20 gm mass).

A. Analysis 1

Analysis 1 was performed to indicate the maximum radiological exposure which could specifically result from the L2-3 test. Blowdown was directed to the containment due to BST header failure. The probability of this event (extremely unlikely) during a LOCE requires the consequence of the event to meet Damage Criteria D (7.2R) inhalation dose at the site boundary (10^4 meters). This event does not exceed Damage Criteria D.

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B. Analysis 2

Analysis 2 was performed to evaluate the radiological exposure which could specifically result from the L2-3 test assuming BST integrity failure at the time of blowdown. The consequences of this event are less than Damage Criteria C-1 (ERDAM 0524 limit at the one mile fence); namely 1.5 Rem.

NOTE: 1. The pressure time history of this transient indicates no driving pressure inside the containment after 8 hours.

2. These analyses have received independent safety review thru the EG&G Safety Division Ref. DPH-217-78 letter.

2146 257

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LTR 10-51

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INTEROFFICE CORRESPONDENCE

date September 25, 1978

to C. H. Cooper

from R. S. Schofield R. S. Schofield

subject IODINE INHALATION DOSAGE DETERMINATION FROM A MAXIMUM HYPOTHETICAL PRIMARY COOLANT SYSTEM RELEASE ACCIDENT FOLLOWING L2-3 - RSS-10-78

Ref: R. S. Schofield ltr to C. H. Cooper, RSS-8-78, Inhalation Dosage Determination From A Blowdown Suppression Tank (BST) Relief Valve Rupture Following L2-3, July 25, 1978

An analysis has been performed to determine the inhalation dose at the one-mile exclusion fence and at the site boundary as a result of a maximum hypothetical accident (MHA) primary coolant system (PCS) containment vessel release following L2-3. The RSAC-II computer code[1] was used to verify the iodine thyroid dose (considered as the dominant hazard in a containment release[2]) for inhalation times of one hour and eight hours. The following assumptions used in this study should be examined carefully for complete understanding of this analysis and the parameters it is dependent upon.

Assumptions:

1. Releases were examined for L2-3 operating times of 20, 40, 100, and 1,000 hours at 37.2 MW.

2. Of the core's fuel rods, 20% were perforated during blowdown, releasing 11% of the core iodine fission product inventory (FPI).

   a. The entire 11% iodine inventory was exhausted to the PCS.

3. The PCS ruptured immediately following blowdown, releasing all of the iodines to the containment vessel (CV) (i.e., no water filtration of elemental iodine assumed).

   a. L2-3 blowdown was performed in a containment isolation mode, therefore no CV atmospheric clean-up was considered.

   b. No iodine plate-out was considered during the PCS release to containment.

4. The leak rate from containment was considered to be a function of the CV pressure and temperature, as described in LOFT FSAR Volume 1, Chapter 6, Appendix 6-E, and Volume 2, Chapter 13, Appendix 13-A.

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5. Class F (2 metres per second windspeed) meteorological conditions were used to determine isotopic air concentrations at the location of inhalation.

6. Breathing rates were 1.25 m^3/hr for inhalation times of one hour and eight hours at the one-mile exclusion fence and at the 10^4 m site boundary.

7. Doses were calculated for an adult thyroid (i.e., 20 gm mass).

Tables I and II reveal the isotopic and total iodine inhalation dose to the thyroid for the previously-mentioned conditions. Isotopic radioactive decay during transit to the inhalation point was considered in the calculations. It is interesting to observe that, for the operating times specified (20, 40, and 100 hours), the iodine-131 thyroid dose is significantly lower than the dose contribution from iodine-133. Traditionally, the literature[2] states the iodine-131 dose contributes approximately 65% of the total thyroid dose, while iodine-133 contributes approximately 30%. These iodine ratios appear to be valid only after operating times approaching 1,000 hours.

TABLE I

ONE-HOUR INHALATION THYROID DOSES*
FOLLOWING L2-3 MHA PCS RELEASE

	REACTOR OPERATING TIMES (at 37.2 MW)			
	20 Hours	40 Hours	100 Hours	1000 Hours
		One-Mile Exclusion Fence		
^{131}I	7.5 (18%)	12.6 (21%)	26.7 (32%)	85.4 (59%)
^{133}I	26.4 (64%)	37.7 (65%)	48.1 (58%)	49.7 (34%)
Total Iodine Thyroid Dose	41.1	58.7	83.9	145.3
		Site Boundary (10^4 m)		
^{131}I	1.2 (17%)	2.0 (21%)	4.2 (31%)	13.5 (58%)
^{133}I	4.6 (67%)	6.3 (66%)	7.9 (58%)	8.1 (35%)
Total Iodine Thyroid Dose	6.9	9.6	13.6	23.3

* All units in mrem.

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TABLE II

EIGHT-HOUR INHALATION THYROID DOSES*
FOLLOWING L2-3 MHA PCS RELEASE

	REACTOR OPERATING TIMES (at 37.2 MW)			
	20 Hours	40 Hours	100 Hours	1000 Hours
		One-Mile Exclusion Fence		
^{131}I	35.5 (18%)	61.7 (22%)	132.0 (33%)	417.1 (59%)
^{133}I	137.6 (69%)	188.2 (66%)	234.5 (57%)	242.2 (34%)
Total Iodine Thyroid Dose	202.2	285.9	410.5	714.6
		Site Boundary (10^4 m)		
^{131}I	5.7 (19%)	9.9 (23%)	21.0 (33%)	65.7 (59%)
^{133}I	21.8 (69%)	29.4 (66%)	36.5 (56%)	37.6 (33%)
Total Iodine Thyroid Dose	31.6	44.6	64.2	112.1

* All units in mrem.

The ingestion dose to a child's thyroid has been estimated at 400 times the iodine-131 and 20 times the iodine-133 adult inhalation thyroid dose[3]. Table III represents the child thyroid ingestion dose based upon the eight-hour adult inhalation thyroid dose at the site boundary.

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TABLE III

CHILD THYROID INGESTION DOSES* AT THE SITE BOUNDARY
FOLLOWING L2-3 MHA PCS EIGHT-HOUR RELEASE

	REACTOR OPERATING TIMES (at 37.2 MW)			
	20 Hours	40 Hours	100 Hours	1000 Hours
^{131}I** Contribution	2.28	3.95	8.40	26.30
^{133}I** Contribution	0.44	0.59	0.73	0.75
Total Child Thyroid Dose	2.72	4.54	9.13	27.05

* All units in rem.
** ^{131}I inhalation dose x 400; ^{133}I inhalation dose x 20.

The 100-hour and 1,000-hour reactor operating times in Table III exceed maximum hypothetical Class D accident child thyroid dose limits[4] (2 rem/yr) by factors of 1.3 and 3.8.

Since maximum permissible air concentrations and thyroid ingestion dose limits are exceeded, potential emergency actions associated with these conditions would include evacuation of controlled-area personnel and restriction of milk suppliers from local dairy farms[2]. These procedures are not intended to represent the extent of emergency planning accompanying such a release. Further analysis is needed to determine a comprehensive emergency planned response.

Material contained in these calculations falls under the nature of "safety analysis"; therefore, any direct or indirect use of this material in documents for distribution outside the company will require review by the Safety Division.

mab

[1] D. R. Wenzel, Preliminary User's Manual For The Revised Radiological Safety Analysis Coumputer Program (RSAC-II), Allied Chemical Corporation, (June, 1973)

[2] J. R. Beattie, An Assessment Of Environmental Hazard From Fission Product Releases, United Kingdom Atomic Energy Authority, (1963)

[3] G. A. Dinneen, Offsite Thyroid Exposures From Isolation Valve Leakage, LTR-128-2, (November, 1970)

[4] LOFT FSAR, Volume 3, Chapter 15, Section 15.5.1.3.1

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INTEROFFICE CORRESPONDENCE

date November 14, 1978

to C. H. Cooper

from R. S. Schofield *RSSchofield*

subject IODINE INHALATION DOSAGE DETERMINATION FROM A BLOWDOWN SUPPRESSION TANK (BST) FAILURE FOLLOWING L2-3 - RSS-13-78

Ref: (a) R. S. Schofield ltr to C. H. Cooper, RSS-8-78, Inhalation Dosage Determination From A Blowdown Suppression Tank (BST) Relief Valve Rupture Following L2-3, July 25, 1978
(b) R. S. Schofield ltr to C. H. Cooper, RSS-10-78, Iodine Inhalation Dosage Determination From A Maximum Hypothetical Primary Coolant System Release Accident Following L2-3, September 25, 1978

A follow-up analysis to RSS-10-78 has been performed to determine the inhalation dose at the one-mile exclusion fence and at the site boundary as a result of a BST relief valve rupture containment vessel release following L2-3. The RSAC-II computer code[1] was used to verify the iodine thyroid dose (considered as the dominant hazard from a containment release[2]) for inhalation times of one hour and eight hours. The following assumptions used in this study should be examined carefully for complete understanding of this analysis and the parameters it is dependent upon.

Assumptions:

1. Releases were examined for L2-3 operating times of 20, 40, 100, and 1,000 hours at 37.2 MW.

2. Of the core's fuel rods, 20% were perforated during blowdown, releasing 11% of the core iodine fission product inventory (FPI).

   a. The entire 11% iodine inventory was exhausted to the primary coolant system (PCS) and then to the BST at blowdown.

3. The BST relief valve ruptured immediately following blowdown, releasing all of the iodines to the containment vessel (CV) (i.e., no water filtration of elemental iodine is assumed*).

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* Iodine filtration in water has been estimated as high as 90%, but, due to the difficulty in defining a filtration fraction at blowdown, the iodine scrubbing was ignored.

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a. L2-3 blowdown was performed in a containment isolation mode, therefore no CV atmospheric clean-up was considered.

b. Of the iodine released to containment, 50% was assumed to plate out on the mobile test assembly (MTA) and inner surfaces of the CV (USNRC Regulatory Guide 1.4).

4. The leak rate from containment was considered to be a function of the CV pressure and temperature, as described in LOFT FSAR Volume 2, Chapter 13, Appendix 13-A.

a. A conservative maximum CV pressure of 17.0 psia* was assumed to develop following the BST relief valve rupture.

5. Class F (2 metres per second windspeed) meteorological conditions were used to determine isotopic air concentrations at the location of inhalation.

6. Breathing rates were 1.25 m^3/hr for inhalation times of one hour and eight hours at the one-mile exclusion fence and at the 10^4 m site boundary.

7. Doses were calculated for an adult thyroid (i.e., 20 gm mass).

Tables I and II reveal the isotopic and total iodine inhalation dose to the thyroid for the previously-mentioned conditions. Isotopic radioactive decay during transit to the inhalation point was considered in the calculations.

It is interesting to observe that, for the operating times specified (20, 40, and 100 hours), the iodine-131 thyroid dose is significantly lower than the dose contribution from iodine-133. Traditionally, the literature[2] states the iodine-131 dose contributes approximately 65% of the total thyroid dose, while iodine-133 contributes approximately 30%. These iodine ratios appear to be valid only after operating times approaching 1,000 hours.

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* Conservative estimation as specified by C. H. Cooper, LOFT Protection & Control Systems.

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TABLE I

ONE-HOUR INHALATION THYROID DOSES* FOLLOWING
L2-3 BST RELIEF VALVE RUPTURE

* All units in mrem.

	REACTOR OPERATING TIMES (at 37.2 MW)			
	20 Hours	40 Hours	100 Hours	1000 Hours
	One-Mile Exclusion Fence			
^{131}I	3.4	5.2	10.2	30.7
^{133}I	11.3	15.2	18.[illegible]	19.4
Total Iodine Thyroid Dose	17.6	23.9	33	54.6
	Site Boundary (10^4 m)			
^{131}I	0.6	0.9	1.6	4.9
^{133}I	2.1	2.7	3.3	3.4
Total Iodine Thyroid Dose	3.1	4.1	5.6	9.1

TABLE II

EIGHT-HOUR INHALATION THYROID DOSES* FOLLOWING
L2-3 BST RELIEF VALVE RUPTURE

* All units in mrem.

	REACTOR OPERATING TIMES (at 37.2 MW)			
	20 Hours	40 Hours	100 Hours	1000 Hours
	One-Mile Exclusion Fence			
^{131}I	16.4	26.3	52.1	130.6
^{133}I	65.3	83.5	100.0	102.6
Total Iodine Thyroid Dose	94.4	126.1	174.0	286.7
	Site Boundary (10^4 m)			
^{131}I	2.7	4.3	8.4	24.4
^{133}I	10.7	13.3	15.8	16.2
Total Iodine Thyroid Dose	15.1	20.0	27.7	45.6

The inhalation doses in Tables I and II comply with the radiological consequence levels as specified by LOFT Technical Specification 3.13, "Damage Criteria."

The ingestion dose to a child's thyroid has been estimated at 400 times the iodine-131, and 20 times the iodine-133, adult inhalation thyroid dose[3]. Table III represents the child thyroid ingestion dose based upon the eight-hour adult inhalation thyroid dose at the site boundary.

TABLE III

CHILD THYROID INGESTION DOSES* AT THE SITE BOUNDARY FOLLOWING
L2-3 BST RELIEF VALVE RUPTURE EIGHT-HOUR RELEASE

	REACTOR OPERATING TIMES (at 37.2 MW)			
	20 Hours	40 Hours	100 Hours	1000 Hours
^{131}I** Contribution	1.08	1.72	3.35	7.76
^{133}I** Contribution	0.21	0.27	0.32	0.32
Total Child Thyroid Dose	1.29	1.99	3.67	10.08

* All units in rem.
** ^{131}I adult inhalation dose x 400; ^{133}I adult inhalation dose x 20.

The 40-, 100-, and 1,000-hour reactor operating times in Table III exceed the ERDAM 0524 thyroid yearly dose commitment of 1.5 rem. However, due to the conservative nature of Assumptions 3 and 4a of this analysis, it is not likely the ingested dose rates would yield a thyroid dose in excess of the 1.5 rem limit.

Material contained in these calculations falls under the nature of "safety analysis"; therefore, any direct or indirect use of this material in documents for distribution outside the company will require review by the Safety Division.

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C. H. Cooper
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November 14, 1978
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[1] D. R. Wenzel, Preliminary User's Manual For The Revised Radiological Safety Analysis Computer Program (RSAC-II), Allied Chemical Corporation, (June, 1973)

[2] J. R. Beattie, An Assessment Of Environmental Hazard From Fission Product Releases, United Kingdom Atomic Energy Authority, (1963)

[3] G. A. Dinneen, Offsite Thyroid Exposures From Isolation Valve Leakage, LTR-128-2, (November, 1970)

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