CALCULATION TITLE PAGE

Total Number of Pages: 22

MP-2 Fuel Handling Accident in Containment

TITLE

M2FHAIC-02701R2	1	N/A
CALCULATION No.	Revision No.	System Name

N/A	N/A	N/A	N/A
VENDOR CALCULATION No.	Structure	System Number	Component

NUCLEAR INDICATOR:	Safety Evaluation or Screen Attached	Calc. Supports DCR/MMOD?	Calc. Supports Other Process?
☒CAT1 ☐RWQA ☐SBOQA ☐FPQA ☐ATWSQA ☐NON-QA	☐YES ☒NO	☐YES ☒NO	☒YES ☐NO

C #1

INCORPORATES:

CCN NO: N/A AGAINST REV. N/A

N/A (DCR/MMOD No.)

FARCR 99-MP2-81 PTSCR 2-13-99 (Reference)

Executive Summary

The purpose of this calculation is to reanalyze the radiological consequences of a Fuel Handling Accident (FHA) in the containment at Millstone Unit 2 for 150 hour decayed fuel. Other changes include the assumption of 1 fuel assembly damaged versus 14 pins and allowing the personnel hatch to reamin open as long as it can be closed within 10 minutes and the purge exhaust flow rate is greater than the purge supply. The results below for the EAB and LPZ show that the thyroid and whole body doses calculated are all less than 25% of the 10CFR100 limits. The results below for the control room show that the thyroid, whole body and beta skin doses are less than the limits of GDC19.

	FHAIC DOSE (rem)		
	Thyroid	Whole Body	Beta Skin
EAB	1.769E+01	6.137E-02	N/A
LPZ	2.308E+00	8.049E-03	N/A
Control Room	1.230E+01	1.91E-02	6.44E-01

Calculation results are conditional upon 1) fuel is decayed at least 150 hours, 2) containment purge is in operation and 3) the personnel hatch doors must be operable and one door can be closed within 10 minutes of a FHA, 4) the purge system is balanced such that exhaust flow rate is greater than the supply.

Approvals (Print & Sign Name)			
Preparer: James L. Wheeler		Date:	9/23/99
Interdiscipline Reviewer:	Discipline:	Date:	
Interdiscipline Reviewer :	Discipline:	Date:	
Independent Reviewer: Stuart Torf		Date:	9/23/99
Supervisor: William Eakin		Date:	9/23/99

Installation Verification

☐ Calculation represents the installed configuration and approved licensing condition (Calculation of Record)

☐ N/A does not affect plant configuration (e.g., study, hypothetical analysis, etc.)

Preparer/Designer Engineer: (Print and Sign) Date:

CH 10

CH #9

~~MP2 ENG Initial:~~

QRB Date: 9/27/99

CALCULATION TITLE PAGE

Total Number of Pages: 21

MP-2 Fuel Handling Accident in Containment

TITLE

M2FHAIC-02701R2	0	N/A
CALCULATION #	REVISION No.	SYSTEM NAME
N/A	N/A	N/A
VENDOR CALCULATION NUMBER	Structure	System Number

NUCLEAR INDICATOR:	Calc. Supports DCR/MMOD?	Calc. Supports Ind. Analysis?	N/A
☒CAT1 ☐RWQA ☐SBOQA	☐YES ☒NO	☐YES ☒NO	Component
☐FPQA ☐ATWSQA ☐NON-QA			

N/A	N/A
DCR/MMOD No.	Reference

INCORPORATES:

CCN NO:	AGAINST REV.
N/A	N/A

Executive Summary

The purpose of this calculation is to analyze the radiological consequences of a Fuel Handling Accident (FHA) in the containment at Millstone Unit 2. The results below for the EAB and LPZ show that the thyroid and whole body doses calculated are all less than the Standard Review Plan 15.7.4 limits of 75 rem and 6 rem, respectively. The results below for the control room show that the thyroid, whole body and beta skin doses are less than the SRP 6.4 criteria of 30 rem, 5 rem and 30 rem respectfully.

	FHAIC DOSE (rem)		
	Thyroid	Whole Body	Beta Skin
EAB	4.815E+00	1.935E-02	N/A
LPZ	6.315E-01	2.538E-03	N/A
Control Room	3.58E+00	6.12E-03	1.95E-01

REC'D 9-30-98
ON HOLD —
CDS 10/15/98
CDS QC 10-16-98
NRP √ MC

Approvals (Print & Sign Name)		
Preparer::James L. Wheeler		Date:9/24/98
Interdiscipline Reviewer:	Discipline:	Date:
Interdiscipline Reviewer:	Discipline:	Date:
Independent Reviewer:Stuart Torf		Date: 9/24/98
Supervisor: William Eakin		Date: 9/28/98

Installation Verification

☒ Calculation accurately reflects plant configuration, OR

☐ N/A does not affect plant configuration)

Preparer/Designer Engineer: James L. Wheeler Date: 9/28/98

C #4

DCM FORM 5-1A
Rev. 6

PassPort DATABASE INPUTs

Calculation Number: M2FHAIC-02701R2 Revision: 1

Vendor Calculation Number/Other: N/A Revision: N/A

CCN # N/A QA ☒ Yes ☐ No Calc Voided: ☐ Yes ☒ No

Superseded By: N/A Supersedes Calc: N/A

Discipline (Up to 10) Z

Unit	Project Reference (EWA, DCR or MMOD)	Component Id	Computer Code	Rev. No./ Level No.
MP2	N/A	RM-9799A	TACTIII	83.0
		RM-9799B	CRADLE	2/1

PMMS CODES*

Structure	System	Component	Reference Calculation	Rev No.	CCN
N/A	N/A	N/A	NUC-181	0	N/A
			070771300.WM(B)-03	0	N/A
			XX-XXX-37RA	2	N/A
			3D00-5	0	N/A
			07077.13-WM(B)-02	0	N/A
			UR(B)-453	0	N/A

*The codes required must be alpha codes designed for structure, system and component.
*Use a separate line to post information to be entered (one document per line).

Reference Drawing	Sheet	Rev. No.
25203-26028	5	22
25203-29644	N/A	2

Comments:
N/A

SUBJECT	MP-2 Fuel Handling Accident in Containment Rev. 1	BY	JLW	DATE	10/10/98
		CHKED		DATE	
		CALC #	M2FHAIC	02701R2	
		SHEET	3		

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SUBJECT	MP-2 Fuel Handling Accident in Containment Rev. 1	BY	JLW	DATE	10/10/98
		CHKED		DATE	
		CALC #	M2FHAIC	02701R2	
		SHEET	4		

I. Purpose/Objective:

The purpose of this calculation is to reanalyze the radiological consequences of a Fuel Handling Accident (FHAIC) in the containment at Millstone Unit 2 for the purpose of supporting Technical Specification changes.
This calculation addresses issues identified in CRs M2-98-0967, M2-98-2112 and M2-99-0414.

II. Summary of Results

The results in Table II-1 for the EAB and LPZ show that the thyroid and whole body doses calculated are all less than 25% of the 10CFR100 limits. The results in Table II-1 for the control room show that the thyroid, whole body and beta skin doses are less than the limits of GDC19.

Table II-1

FHAIC DOSE (rem)

	Thyroid	Whole Body	Beta Skin
EAB	1.76E+01	6.137E-02	N/A
LPZ	2.308E+00	8.049E-03	N/A
Control Room	1.23E+01	1.91E-02	6.44E-01

III. References

1) Standard Review Plan 15.7.4, "Radiological Consequences of Fuel Handling Accidents", Rev. 1, July 1981.

2) MP2 Facility Operating License, Docket No 50-336, Amendment 213, July 13, 1999

3) Regulatory Guide 1.25, Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors, Rev. 0, March 1972.

4) TACT III, Atmospheric Transport Code System, Oak Ridge National Laboratory, CCC-447, version 83.0.

5) Report of Committee II on Permissible Dose for Internal Radiation, ICRP Publication 2, Permagon Press, New York, 1959.

6) Annals of the ICRP, Limits for Intakes of Radionuclides by Workers, ICRP30 Supplement to Part 1, Volume 3, No. 1-4, Permagon Press, New York, First Edition, 1980.

7) Intentionally blank

8) DiNunno, J.J. et. al., Calculation of Distance Factors for Power and Test Reactor Sites, TID-14844, U. S. Atomic Energy Commission, March 23, 1962.

9) Millstone Nuclear Power Station Unit 2 Technical Specifications, through Amendment 236, Change 250

10) "MP-2 Design Basis Loss of Coolant Accident - Radiation Source Term", DES Calculation NUC-181, Rev. 0, June 1998.

11) Intentionally blank

12) Siemens Document No. EMF-93-216(P), Millstone Unit 2 Mechanical Design Report for Reload Batch R (MIB-4)

13) "Normalized Concentrations (X/Q) at the EAB and LPZ for Gaseous Releases from the Unit 1 Stack and the Unit 2 Containment, Stack, PORV's/ADV's and MSLB", SWEC Calculation 07077.13.WM(B)-03, Rev. 0, July 1998

14) P&ID 25203-26028, Sheet 5 of 5, Rev. 22

15) Intentionally blank

16) "Assessment of the Use of Extended Burnup Fuel in Light Water Power Reactors", NUREG/CR-5009, 1988

17) "Auxiliary Building Elevator Shaft 'Smoke Hole' Flow Determination", Millstone Nuclear Power Station Special Procedure SPROC 95-2-11, Rev. 0. Test Performed 2/8/96.

18) Code of Federal Regulations, 10CFR Part 100 - Reactor Site Criteria.

19) Intentionally blank

20) NRC Standard Review Plan 6.4, Rev. 2, "Control Room Habitability System", NUREG-0800, July 1981.

21) ERC 25203-ER-98-0050, Rev. 2, "Control Room Filtration System Design Basis Parameters for Inputs to Revise Millstone Unit 2 Control Room Post-Accident Radiological Habitability Analyses", June, 1998.

22) CRADLE - Control Room Accident Dose Level Evaluations, QA Category 1 Calculation #XX-XXX-37 RA, Rev. 2, Donald Miller Nov. 22, 1982.

23) Bechtel Calc. 3D00-5, Containment Heat Sinks, dated 6/04/74

24) Normalized X/Qs at the Unit 2 & 3 Control Room and TSC for Releases from Unit 2, Calculation No. 07077.13-WM(B)-02, Rev. 0, July, 1998

25) "MP-2 Control Room Operator Doses Following a MP-3 LOCA Assuming Duct Leakage and Damper Bypass", UR(B)-453, Rev. 0, CCN 1, Sept. 11, 1998

26) Intentionally blank

27) NUSCo Drawing Number 25203-29644, Rev. 2

28) Engineering Evaluation M2-EV-98-0186, "Evaluate Containment Atmosphere Mixing During Purge Activities", Rev. 1, Oct. 12, 1998

29) NNECo letter to Director of Nuclear Reactor Regulation, "Millstone Nuclear Power Station, Unit No. 2 Evaluation of Postulated Fuel Handling Accident Inside Containment", Docket No. 50-336, March 21, 1977.

30) Engineering Evaluation M2-EV-98-0188, "Evaluate Response of Containment Process Radiation Monitors During Fuel Handling Accident", Rev. 0, Sept. 23, 1998

IV. Assumptions

The assumptions used in this calculation are listed in Table IV-1.

Table IV-1

FHA Assumptions

ASSUMPTIONS	BASIS
1) Power Level = 2754 MW	Ref. 2
2) Core Inventory	Ref. 10
3) Core Release Fractions: 12% iodines 10% noble gas 30% Kr-85	Ref. 16 and conservative assumption for iodines
4) Iodine Chemical Form: 75% elemental 25% organic	Ref. 3
5) Offsite Breathing Rate (m^3 / sec) : >24 hrs = 3.47E-4	Ref. 3
6) Decontamination Factor: iodines: 100 noble gasses: 1	Ref 3
7) Release Point: MP-2 Vent	Ref. 14
8) Time after shutdown for fuel transfer using purge: 150 hours	New assumption to support TSCR
9) Peaking Factor: 1.83	Ref. 12
10) Release is secured in 10 minutes	Ref. 28, 30
11) Fuel Damage: 1 assembly	Ref. 3
12) X/Q (sec / m^3): Ground: EAB (0-2) hr = 3.66E-4 LPZ (0-4) hr = 4.80E-5	Ref. 13
Control Room (0-8) hr = 2.92E-3	Ref. 24
13) Purge Flow Rate: 32,000 cfm	Ref. 27
14) Dose Conversion Factors	Ref. 6
15) Recirc Rate Thru Filtration System: 2,250 cfm	Ref. 21
16) Time at Which Recirc Starts Thru Filtration Units: 10 min.	Ref. 21
17) Unfiltered Inleakage Rate: 130 cfm	Ref. 21
18) Control Room Charcoal Efficiency: 90%	Ref. 21
19) Intake Flowrate Prior to Control Room Isolation: 800 cfm	Ref. 21
20) Control Room Isolates Within 10 Seconds	Ref. 21 & Conserv. Assump.
21) Control Room Volume: 35,650 ft3	Ref. 21

V. Method:

This reanalysis of the MP2 FHA inside containment dose calculation uses the assumptions as listed herein. The reason that this accident is being reanalyzed is to support Technical Specification and procedure changes on the following:

1) Technical Specification change so as to allow containment purge in operation when moving fuel if:
   a) The fuel is decayed greater than 150 hours
   b) Both containment auxiliary recirculation fans are operable and operating
   c) The containment particulate and gaseous radiation monitors are operable

2) Technical Specification change so as to allow the personnel hatch to be open when moving fuel that has been decayed greater than 150 hours as long as the following 2 conditions are met:
   a) The personnel hatch is capable of being closed within 10 minutes following a FHA
   b) The purge system is balanced such that the exhaust flow rate is greater than the supply

The TACT III (version 83.0) (Ref. 4) computer code was used in this analysis. TACT III (ver. 83) was validated per NEO 2.24/QS-3 and was last benchmarked on July, 1998. TACT III "simulates the movement of radioactivity released from a reactor core as it migrates through user-defined regions (nodes) of the containment, is immobilized by filters and sprays, and leaks to the outside environment... Outputs are shown for the end of each time interval and include the level of radioactivity in each node of the containment and in the environment, broken down as iodines, noble gases, and solids...; and the radiation dose to reference individuals at the exclusion radius, the boundary of the low population zone, and in the control room.."

The CRADLE (version 2) (Ref. 22) computer code was used for the control room exposure calculations in this analysis. CRADLE was validated per NEO 2.24/QS-3 and was last benchmarked on July 1998. CRADLE calculates the activity which enters the control room after an accident. The effects of filtration, buildup, decay and plateout are taken into account in the transport of activity from the core into containment to the environment and eventually to the control room. From the activity in the control room, CRADLE calculates the resulting thyroid, whole body and beta doses to the control room operators.

The thyroid dose conversion factors (DCF)s currently used in the TACTIII and CRADLE codes date back to Reg Guide 1.109, Rev. 1, (Ref. 5). ICRP 30 adult thyroid DCF's will be used in this analysis because they are more up-to-date and realistic. Table VI-5 lists both the Reg Guide 1.109 and ICRP 30 thyroid dose conversion factors and Reg Guide 1.109-to-ICRP30 conversion ratios for each iodine isotope. In Tables VI-7 and VI-10 the TACTIII and CRADLE thyroid dose for each isotope is converted to ICRP 30 dose using the ratios as listed in Table VI-5.

Although reference 16 states that 10% of the iodines are available for release (except I-131 which is 12%), 12% will be used for all iodines for simplicity.

VI. Analysis

A. Release Activity

Rather than use the inventories in TACT III based on TID 14844, the source core activity was taken from Reference 10. The equation for calculating the core release fraction is:

$$Fc = (Fd/N) * P * (1/DF) * Fg$$

where:

- Fc = isotopic release fraction of core
- Fd = number of fuel assemblies damaged due to FHA, 1
- N = number of fuel assemblies in core, 217 (Ref. 9)
- P = peaking factor, 1.83
- DF = decontamination factor, 100 for iodines, 1 for noble gasses
- Fg = fraction of fuel in the gap, 12% iodines, 10% noble gasses

Therefore:

Fc(iodines) = 1.012E-05
Fc(noble gas) = 8.433E-04

Table VI-1 lists full core activity according to reference 10 multiplied by the above release fractions.

In CRADLE the option does not exist to input a plant specific source term. Therefore the above release fractions will be input into CRADLE. Tables VI-8 through VI-10 adjusts the doses based on a ratio between the CRADLE source term and the MP-2 specific source term.

The CRADLE release must also be corrected for the 20% additional Kr-85. Therefore the Kr-85 source term resulting from 10% release will be multiplied by 3 for that correction.

Table VI-1

Instantaneous Release Activity

Radionuclide	Inventory	One Assembly Release Fraction	One Assembly Release Inventory
I-129	4.137E+00	1.01E-05	4.178E-05
I-131	7.719E+07	1.01E-05	7.796E+02
I-132	1.105E+08	1.01E-05	1.116E+03
I-133	1.504E+08	1.01E-05	1.519E+03
I-134	1.666E+08	1.01E-05	1.683E+03
I-135	1.407E+08	1.01E-05	1.421E+03
I-130	5.101E+06	1.01E-05	5.152E+01
Kr-83m	1.080E+07	8.43E-04	9.104E+03
Kr-85m	2.451E+07	8.43E-04	2.066E+04
Kr-85	1.194E+06	8.43E-04	3.024E+03
Kr-87	4.860E+07	8.43E-04	4.097E+04
Kr-88	6.865E+07	8.43E-04	5.787E+04
Kr-89	8.593E+07	8.43E-04	7.244E+04
Xe-131m	8.615E+05	8.43E-04	7.262E+02
Xe-133m	4.808E+06	8.43E-04	4.053E+03
Xe-133	1.569E+08	8.43E-04	1.323E+05
Xe-135m	3.104E+07	8.43E-04	2.617E+04
Xe-135	5.658E+07	8.43E-04	4.770E+04
Xe-137	1.316E+08	8.43E-04	1.109E+05
Xe-138	1.316E+08	8.43E-04	1.109E+05

Note: Kr-85 release inventory represents 30% release

Reference 28 supports the assumption that the release from the FHA is mixed within 50% of containment. For input into CRADLE a removal rate (per hour) must be calculated. Using 32,000 cfm over 50% of the containment volume, results in a removal rate of 2/hr. For input into TACTIII, the removal rate of 2/hr is converted to %/day by:

2/hr x 24 hrs/day x 100 = 4.80E+03 %/day

According to reference 30, and supported by reference 28, the release from containment is secured within 10 minutes after the FHA. The time of 10 minutes for the containment airborne radiation monitors to detect the FHA and shut the purge valves will be used for conservatism. The equation below supports that the containment particulate and gaseous radiation monitors trip the purge valves once they detect the release.

1.077E4 Ci Xe-133 (from Table VI-1) decayed for 72 hrs = 7245 Ci
7245 Ci Xe-133 / 950,000 ft3 (50% containment volume mixture) = 0.269 uCi/cc
0.269 uCi/cc / 3.5E-8 uCi/cc per cpm (ref. 32) = 7.7E6 cpm

The alarm setpoint is 9E4 cpm (ref. 9) therefore the rad monitor will respond to the release and shut the purge valves.

B. Control Room

The control room is isolated within 10 seconds after a FHA. The methodology of Reference 25 will be used to calculate the MP2 control building inlet monitor response time to ensure the 10 second assumption is valid.

Duration of release: 10 sec

Conc. to DR Factor: 9.0E-3 uCi/cc / mr/hr Xe-133 EQ (ref. 21)

X/Q: 2.92E-3 sec/m3

Xe-133 EQ Conc.: product sum of activity released over 10 sec times the ave. gamma energy per isotope times the dispersion factor divided by the ave. gamma energy of Xe-133 (information from Table VI-2 below)

Xe-133 EQ Conc.: 1.47E+01 Ci-Mev/dis / 4.52E-2 Mev/dis / 10 sec * 2.92E-3 sec/m3
9.496E-02 uCi/cc (ave conc over 10 sec release)

Dose Rate (Cs): 1 mr/hr set point (ref. 21)

Dose Rate (Cf): Xe-133 EQ Conc. / conc. to dose conversion factor
1.055E+01 mr/hr

RC: 0.0033 (ref. 21)

Response Time: Cs/Cf = 1 - exp(-T/RC)

Response Time: 3.3E-4 sec

The radiation monitor response time is not significant, therefore assuming an isolation time of 10 seconds is conservative

Table VI-2

MP2 Control Room Monitor Response

	Activity (Ci)		
	Released	Ave Eng	
	During 10 sec.	(MeV/dis)	Product
Kr-83m	0.00E+00	2.56E-03	0.00E+00
Kr-85	1.59E+01	2.23E-03	3.55E-02
Kr-85m	8.00E-09	1.58E-01	1.26E-09
Kr-87	0.00E+00	7.83E-01	0.00E+00
Kr-88	0.00E+00	1.94E+00	0.00E+00
Kr-89	0.00E+00	1.68E+00	0.00E+00
Xe-131m	2.40E+00	2.01E-02	4.82E-02
Xe-133m	2.70E+00	4.15E-02	1.12E-01
Xe-133	3.20E+02	4.52E-02	1.45E+01
Xe-135m	0.00E+00	4.31E-01	0.00E+00
Xe-135	8.00E-03	2.47E-01	1.97E-03
Xe-137	0.00E+00	1.70E-01	0.00E+00
Xe-138	0.00E+00	1.10E+00	0.00E+00
Total	3.30E+02		1.47E+01

Note: The curies of Kr-85 is taken from CRADLE and multiplied by 3 to account for the 30% release

The recirculation flow through the control room filters occurs at 10 minutes after isolation. The control room cleanup rate is calculated using the following equation.

$$CUR = \frac{FR \times Eff}{CRV} \times 60 \text{ min/hr}$$

where, CUR = Clean up rate (/hr)
FR = Flow rate through filters (2250 cfm)
Eff = Control room charcoal efficiency (90%)
CRV = Control Room volume (35,650 ft3)
CUR = 3.408/hr

C. Computer Code Input Data Sets

The input data sets to the TACT III (version 83.0) computer code are given in Table VI-3. The input data set to the CRADLE computer code is given in Table VI-4.

Table VI-3

TACTIII Input Dataset

```
****************************** Top of Data ********************************
MP2 FHAIC, 150 HRS DECAY, 1 ASSEMBLY
1   1 1 21 9   8 98 0 0
2754. 0.0      1.01E-5 2.53E-3 0.0       7.50E-1 2.50E-1 0.0
1   2 0  1.500E+02   150.1667
2   1 1  4.178E-05
2   1 2  7.796E+02
2   1 3  1.116E+03
2   1 4  1.519E+03
2   1 5  1.683E+03
2   1 6  1.421E+03
2   1 8  5.152E+01
2   1 9  9.104E+03
2   1 10 2.066E+04
2   1 11 3.024E+03
2   1 12 4.097E+04
2   1 13 5.787E+04
2   1 14 7.244E+04
2   1 15 7.262E+02
2   1 16 4.053E+03
2   1 17 1.323E+05
2   1 18 2.617E+04
2   1 19 4.770E+04
2   1 20 1.109E+05
2   1 21 1.109E+05
3   1 0  9.500E+05
11  2 1  4.800E+03  0.0
17  6 0  3.660E-04  4.800E-05  3.470E-04  0.0  0.0  0.000E+00
0/
***************************** Bottom of Data ******************************
```

Table VI-4

CRADLE Input Dataset

```
****************************** Top of Data ********************************
 MP-2 CR FROM FHAIC; 1 FUEL ASSEMBLY; 150 HRS DECAY                      1
    2754.  3.565E+4        1.          0          7
       0.0     150.0  150.0028  150.1667     158.0     174.0     246.0
     870.0
  1.012E-5  8.433E-4
       0.0       0.0
       0.0       0.0
       0.0       0.0
       0.0       0.0
       0.0       0.0
       0.0       0.0
      800.      800.      130.      130.      130.      130.      130.
       0.0       0.0       0.0       0.0       0.0       0.0       0.0
      800.      800.      130.      130.      130.      130.      130.
      0.00      0.00      0.00
      0.00      0.00      0.00
      0.00      0.00      0.00
      0.00      0.00      0.00
     3.408     3.408     3.408
     3.408     3.408     3.408
     3.408     3.408     3.408
     3.408     3.408     3.408
       0.0   2.92E-3   2.92E-3       0.0       0.0       0.0       0.0
       0.0       2.0       2.0       0.0       0.0       0.0       0.0
       0.0       0.0       0.0
       0.0       0.0       0.0
       0.0       0.0       0.0
       0.0       0.0       0.0
       0.0       0.0       0.0
       0.0       0.0       0.0
       0.0       0.0       0.0
****************************** Bottom of Data ******************************
```

D. Results of Computer Runs

Whole body dose results for the EAB and LPZ are taken directly from TACT III output and listed in Section 2 of this calculation. TACT III iodine thyroid results will be adjusted using the ICRP 30 thyroid dose conversion factors by utilizing the equation given below.

$D^{ICRP30}_{Thy_i} = D^{TACT}_{Thy_i} * F_i * R_i$ where,

$D^{ICRP30}_{Thy_i}$ = Thyroid dose for isotope i adjusted for ICRP 30 DCF's.

$D^{TACT}_{Thy_i}$ = Total Thyroid dose from TACT III for isotope i

F_i = Fraction of total iodine.

R_i = Ratio of ICRP 30 to TACT III and CRADLE dose conversion factors (see Table VI-5).

The TACT III input data set in Table VI-3 was run on the Wethersfield IBM 3090 mainframe computer. The thyroid doses adjusted for ICRP 30 DCF's in each time interval are listed in Table VI-7 with corresponding data. The summary of both thyroid and whole body dose results appear in Table II-1.

TABLE VI-5

THYROID DOSE CONVERSION FACTORS
(rem/Ci - inhaled)

ISOTOPE	TACT III and CRADLE	ICRP 30 *	DCF RATIO (ICRP 30/TACTIII or CRADLE)
I-129	5.54E+6	5.920E+6	1.068
I-130	1.42E+5	7.400E+4	0.521
I-131	1.49E+6	1.073E+6	0.718
I-132	1.43E+4	6.290E+3	0.440
I-133	2.69E+5	1.813E+5	0.674
I-134	3.73E+3	1.073E+3	0.288
I-135	5.60E+4	3.145E+4	0.562

The results from CRADLE must be adjusted for thyroid dose as described above. The results also must be adjusted for the difference in the source term. Since CRADLE does not have an option to input a plant specific source term, another ratio must be calculated. The ratio will be the total source as calculated in reference 12 to the total source as listed in reference 22 (CRADLE). The doses per time step will be multiplied by this ratio and then summed. The ratios are listed and calculated in Table VI-6 below.

Table VI-6

	Ref. 12 (NUC-181) Full Core Activity	Ref. 24 (CRADLE) Full Core Activity	Ratio
I-131	7.72E+07	6.91E+07	1.1177
I-132	1.11E+08	1.05E+08	1.0544
I-133	1.50E+08	1.55E+08	0.9714
I-134	1.67E+08	1.81E+08	0.9201
I-135	1.41E+08	1.41E+08	1.0013
Kr-83M	1.08E+07	1.14E+07	0.9445
Kr-85	1.19E+06	1.13E+06	1.0569
Kr-85M	2.45E+07	3.57E+07	0.6862
Kr-87	4.86E+07	6.43E+07	0.7558
Kr-88	6.87E+07	8.81E+07	0.7790
Kr-89	8.59E+07	1.10E+08	0.7842
Xe-131M	8.62E+05	7.15E+05	1.2055
Xe-133M	4.81E+06	3.81E+06	1.2614
Xe-133	1.57E+08	1.55E+08	1.0134
Xe-135M	3.10E+07	4.29E+07	0.7239
Xe-135	5.66E+07	1.48E+08	0.3831
Xe-137	1.32E+08	1.41E+08	0.9364
Xe-138	1.32E+08	1.32E+08	1.0007

The CRADLE input data set in Table V1-4 was run on the Wethersfield IBM 3090 mainframe computer. The thyroid doses adjusted for ICRP 30 DCF's in each time interval is listed in Table VI-10 with corresponding data. The thyroid, beta skin and whole body doses adjusted for the source term correction in each time interval, using the ratios developed in Table VI-6, are listed in Tables VI-8 through 10 with corresponding data. The summary of thyroid, beta skin and whole body dose results appear in Table II-1.

TABLE VI-7

FHAIC With 150 Hour Decay and Purge

DCF Ratio						
I-129	I-130	I-131	I-132	I-133	I-134	I-135
1.068	0.521	0.718	0.440	0.674	0.288	0.562

	TACT III Iodine Dose Fraction							Combined
Release Type	I-129	I-130	I-131	I-132	I-133	I-134	I-135	Factor
10 minutes	3.400E-07	2.376E-06	9.958E-01	9.680E-22	4.164E-03	2.207E-54	2.261E-08	7.1779E-01

Combined Factor(t) = Summation of [DCF Ratio(i) x Iodine Dose Fraction(i)] over i for time interval (t), where i=iodine isotope.

		Thyroid Doses (Rem)			
		TACT III		ICRP 30	
Release Type		EAB	LPZ	EAB	LPZ
10 minutes		2.452E+01	3.216E+00	1.760E+01	2.308E+00
				1.760E+01	2.308E+00

ICRP 30 EAB(t), or LPZ(t) = TACT III EAB(t), or LPZ(t), x Combined Factor(t) for time interval (t).

TABLE VI-8

Control Room Dose Adjustments

SOURCE TERM CORRECTION TO BETA DOSE RESULTS

	Source Term Correction	150 - 150.003 hrs	150.003 - 150.167 hrs	150.167 - 158 hrs	158 - 174 hrs	174 - 246 hrs	246 - 870 hs	Integrated Dose rem	Total Corrected Dose (rem)
I-131 ELEM	1.1177	5.01E-07	3.05E-04	8.78E-04	3.92E-16	2.33E-41	0.00E+00	1.18E-03	1.32E-03
I-132 ELEM	1.0544	1.25E-25	7.38E-23	1.93E-22	8.62E-36	4.65E-63	0.00E+00	2.67E-22	2.81E-22
I-133 ELEM	0.9714	3.16E-08	1.91E-05	5.45E-05	1.93E-17	7.14E-43	0.00E+00	7.37E-05	7.16E-05
I-134 ELEM	0.9201	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-135 ELEM	1.0013	5.49E-13	3.31E-10	9.21E-10	1.89E-22	2.28E-48	0.00E+00	1.25E-09	1.25E-09
I-131 ORG.	1.1177	2.20E-08	1.34E-05	3.86E-05	1.72E-17	1.02E-42	0.00E+00	5.20E-05	5.81E-05
I-132 ORG.	1.0544	5.50E-27	3.24E-24	8.48E-24	3.79E-37	2.04E-64	0.00E+00	1.17E-23	1.24E-23
I-133 ORG.	0.9714	1.39E-09	8.40E-07	2.40E-06	8.49E-19	3.14E-44	0.00E+00	3.24E-06	3.15E-06
I-134 ORG.	0.9201	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-135 ORG.	1.0013	2.42E-14	1.45E-11	4.05E-11	8.29E-24	1.00E-49	0.00E+00	5.50E-11	5.51E-11
I-131 PART.	1.1177	2.76E-08	1.68E-05	4.82E-05	2.15E-17	1.28E-42	0.00E+00	6.50E-05	7.27E-05
I-132 PART.	1.0544	6.87E-27	4.05E-24	1.06E-23	4.74E-37	2.56E-64	0.00E+00	1.47E-23	1.55E-23
I-133 PART.	0.9714	1.73E-09	1.05E-06	3.00E-06	1.06E-18	3.93E-44	0.00E+00	4.05E-06	3.93E-06
I-134 PART.	0.9201	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-135 PART.	1.0013	3.02E-14	1.82E-11	5.06E-11	1.04E-23	1.25E-49	0.00E+00	6.88E-11	6.89E-11
KR-85	1.0569	1.24E-06	7.56E-04	2.96E-02	6.31E-03	1.96E-04	2.83E-11	3.69E-02	1.17E-01
KR-85M	0.6862	1.86E-15	1.11E-12	2.88E-11	1.57E-12	3.73E-15	5.69E-27	3.15E-11	2.16E-11
KR-87	0.7558	1.00E-38	5.78E-36	7.76E-35	2.16E-37	1.29E-42	4.07E-66	8.36E-35	6.31E-35
KR-88	0.7790	8.63E-21	5.11E-18	1.09E-16	2.85E-18	1.57E-21	3.40E-36	1.17E-16	9.14E-17
KR-89	0.7842	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE-131M	1.2055	1.95E-07	1.18E-04	4.61E-03	9.61E-04	2.87E-05	3.48E-12	5.71E-03	6.89E-03
XE-133M	1.2614	4.71E-07	2.86E-04	1.08E-02	2.06E-03	5.21E-05	3.04E-12	1.32E-02	1.67E-02
XE-133	1.0134	1.71E-05	1.04E-02	4.01E-01	8.14E-02	2.31E-03	2.25E-10	4.95E-01	5.02E-01
XE-135M	0.7239	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE-135	0.3831	2.54E-09	1.53E-06	4.87E-05	5.33E-06	4.81E-08	2.92E-17	5.56E-05	2.13E-05
XE-137	0.9364	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE-138	1.0007	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
								Total	6.44E-01

Note: To correct for the 30% release of Kr-85 from the 10% used in CRADLE:
Total Corrected Dose (Kr-85) = Integrated Dose x Source Term

SUBJECT	MP-2 Fuel Handling	BY	JLW	DATE	10/10/98
	Accident in Containment	CHKED		DATE	
	Rev. 1	CALC #	M2FHAIC	02701R2	
		SHEET	19		

TABLE VI-9

Control Room Dose Adjustments

SOURCE TERM CORRECTION TO WHOLE BODY DOSE RESULTS

	Source Term Correction	150 - 150.003 hrs	150.003 - 150.167 hrs	150.167 - 158 hrs	158 - 174 hrs	174 - 246 hrs	246 - 870 hs	Integrated Dose rem	Total Corrected Dose (rem)
I-131 ELEM	1.1177	1.11E-06	6.76E-04	1.95E-03	8.69E-16	5.16E-41	0.00E+00	2.63E-03	2.93E-03
I-132 ELEM	1.0544	6.24E-25	3.68E-22	9.63E-22	4.30E-35	2.32E-62	0.00E+00	1.33E-21	1.40E-21
I-133 ELEM	0.9714	3.38E-08	2.05E-05	5.85E-05	2.07E-17	7.66E-43	0.00E+00	7.90E-05	7.67E-05
I-134 ELEM	0.9201	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-135 ELEM	1.0013	2.99E-12	1.80E-09	5.00E-09	1.03E-21	1.24E-47	0.00E+00	6.80E-09	6.81E-09
I-131 ORG.	1.1177	4.89E-08	2.97E-05	8.56E-05	3.82E-17	2.27E-42	0.00E+00	1.15E-04	1.29E-04
I-132 ORG.	1.0544	2.74E-26	1.62E-23	4.23E-23	1.89E-36	1.02E-63	0.00E+00	5.85E-23	6.17E-23
I-133 ORG.	0.9714	1.49E-09	9.01E-07	2.57E-06	9.10E-19	3.37E-44	0.00E+00	3.47E-06	3.37E-06
I-134 ORG.	0.9201	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-135 ORG.	1.0013	1.31E-13	7.90E-11	2.20E-10	4.51E-23	5.45E-49	0.00E+00	2.99E-10	2.99E-10
I-131 PART.	1.1177	6.11E-08	3.72E-05	1.07E-04	4.78E-17	2.84E-42	0.00E+00	1.44E-04	1.61E-04
I-132 PART.	1.0544	3.43E-26	2.02E-23	5.29E-23	2.36E-36	1.28E-63	0.00E+00	7.32E-23	7.71E-23
I-133 PART.	0.9714	1.86E-09	1.13E-06	3.21E-06	1.14E-18	4.21E-44	0.00E+00	4.34E-06	4.22E-06
I-134 PART.	0.9201	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-135 PART.	1.0013	1.64E-13	9.87E-11	2.75E-10	5.63E-23	6.82E-49	0.00E+00	3.74E-10	3.74E-10
KR-83M	0.9445	3.78E-31	2.21E-28	3.85E-27	4.06E-29	3.64E-33	2.24E-51	4.11E-27	3.88E-27
KR-85	1.0569	1.61E-08	9.78E-06	3.83E-04	8.17E-05	2.54E-06	3.66E-13	4.77E-04	1.51E-03
KR-85M	0.6862	1.59E-15	9.51E-13	2.47E-11	1.35E-12	3.19E-15	4.87E-27	2.70E-11	1.85E-11
KR-87	0.7558	7.59E-39	4.37E-36	5.87E-35	1.63E-37	9.77E-43	3.08E-66	6.32E-35	4.78E-35
KR-88	0.7790	6.25E-20	3.70E-17	7.92E-16	2.06E-17	1.14E-20	2.46E-35	8.50E-16	6.62E-16
KR-89	0.7842	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE-131M	1.2055	6.49E-08	3.94E-05	1.54E-03	3.20E-04	9.57E-06	1.16E-12	1.90E-03	2.30E-03
XE-133M	1.2614	1.58E-07	9.57E-05	3.62E-03	6.88E-04	1.74E-05	1.02E-12	4.42E-03	5.57E-03
XE-133	1.0134	2.00E-05	1.22E-02	4.70E-01	9.53E-02	2.71E-03	2.63E-10	5.80E-01	5.88E-01
XE-135M	0.7239	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE-135	0.3831	2.66E-09	1.61E-06	5.11E-05	5.58E-06	5.04E-08	3.06E-17	5.83E-05	2.23E-05
XE-137	0.9364	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
XE-138	1.0007	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
							Whole Body Dose:	5.90E-01	6.00E-01
					Total Finite Cloud Whole Body Dose:			1.88E-02	1.91E-02

Note: To correct for the 30% release of Kr-85 from the 10% used in CRADLE:
Total Corrected Dose (Kr-85) = Integrated Dose x Source Term

Total Corrected Dose (Finite Cloud) = Finite Cloud Integrated Dose x Total Corrected Dose Whole Body / Whole Body Integrated Dose

TABLE VI-10

Control Room Dose Adjustments
SOURCE TERM CORRECTION TO THYROID DOSE RESULTS

	Source Term Correction	150 - 150.003 hrs	150.003 - 150.167 hrs	150.167 - 158 hrs	158 - 174 hrs	Integrated Dose rem	R.G. 1.109 to ICRP 30 DCF Corr.	Inventory Adjust	Corrected Dose (rem)
I-131 ELEM	1.1177	5.90E-03	3.59E+00	1.03E+01	4.61E-12	1.39E+01	7.18E-01	8.24E-01	9.21E+00
I-132 ELEM	1.0544	6.22E-24	3.67E-21	9.59E-21	4.29E-34	1.33E-20	4.40E-01	8.24E-01	5.07E-21
I-133 ELEM	0.9714	2.85E-05	1.72E-02	4.92E-02	1.74E-14	6.64E-02	6.74E-01	8.24E-01	3.58E-02
I-134 ELEM	0.9201	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E-01	8.24E-01	0.00E+00
I-135 ELEM	1.0013	1.51E-10	9.07E-08	2.53E-07	5.17E-20	3.43E-07	5.62E-01	8.24E-01	1.59E-07
I-131 ORG.	1.1177	2.59E-04	1.58E-01	4.54E-01	2.03E-13	6.12E-01	7.18E-01	6.25E+00	3.07E+00
I-132 ORG.	1.0544	2.73E-25	1.61E-22	4.22E-22	1.88E-35	5.83E-22	4.40E-01	6.25E+00	1.69E-21
I-133 ORG.	0.9714	1.25E-06	7.58E-04	2.16E-03	7.65E-16	2.92E-03	6.74E-01	6.25E+00	1.19E-02
I-134 ORG.	0.9201	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E-01	6.25E+00	0.00E+00
I-135 ORG.	1.0013	6.62E-12	3.99E-09	1.11E-08	2.27E-21	1.51E-08	5.62E-01	6.25E+00	5.31E-08
I-131 PART.	1.1177	3.24E-04	1.97E-01	5.68E-01	2.53E-13	7.65E-01	7.18E-01	0.00E+00	0.00E+00
I-132 PART.	1.0544	3.42E-25	2.02E-22	5.27E-22	2.36E-35	7.29E-22	4.40E-01	0.00E+00	0.00E+00
I-133 PART.	0.9714	1.56E-06	9.47E-04	2.70E-03	9.57E-16	3.65E-03	6.74E-01	0.00E+00	0.00E+00
I-134 PART.	0.9201	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E-01	0.00E+00	0.00E+00
I-135 PART.	1.0013	8.28E-12	4.98E-09	1.39E-08	2.84E-21	1.89E-08	5.62E-01	0.00E+00	0.00E+00
								Total:	1.23E+01

Note: CRADLE is based on an iodine mixture of 91% elemental, 4% organic and 5% particulate. These must be adjusted for the Reg. Guide 1.25 requirement of 75% elemental and 25% organic. Therefore the inventory adjustment is:

Elemental = 75% / 91% = 0.824
Organic = 25% / 4% = 6.25
Particulate = 0% / 5% = 0

Calculation Review Comment and Resolution Form

(Sheet 1 of 1)

Calculation Number: M2FHAIC-02701R2 Revision: 1 CCN N/A

Calculation Title: MP-2 Fuel Handling Accident in Containment

Calc. Originator: James L. Wheeler Reviewer (PRINT): Stuart Torf

This form is intended to document significant comments and their resolutions. Typographical errors and other editorial recommendations may be marked up in the calculation text and presented to the originator

Review Type ☞ ☐ **Interdiscipline** ☒ **Independent**

Reviewer (SIGN) Stuart Torf Date: 8/30/99

(signature signifies all comments have been resolved to your satisfaction)

Item	Page/Section	Comments	Response
1	4 / III	For reference 2, state the amendment number	complete
2	5 / III	Delete reference 7. Not used	Done
3	5 / III	for reference 9, state the amendment number	complete
4	5 / III	for reference 14, state the revision number	complete
5	5 / III	for reference 25, state the CCN number	complete
6	5 / III	for reference 27, state the revision number	complete
7	5 / III	reference 28 has the wrong revision number	changed to reference 1
8	9 / VI	state the reference for the number of fuel assemblies in the core	Added
9	11 / B	State the reference for the RC factor	Added
10	11 / B	Add the sentence stating a conclusion of the rad monitor response time	Added
11	13 / C	In Table VI-3, where did the release rate of 4800 cfm come from?	This was an error as far as the units. The units are % / day