Attachment 2 to 2.04.003

Entergy Nuclear Operations, Inc.
Pilgrim Nuclear Power Plant
Proposed Amendment to the Technical Specifications

Entergy Calculation No. PNPS-1-ERHS-XXII.A-2, "Radiological Consequences of a Design Basis Fuel Handling Accident using the Alternate Source Term", Rev. 1 (48 pages). (Computer run pages are not included)

CALCULATION COVER PAGE

RType B4.65

☐ IP-2	☐ IP-3	☐ JAF	☒ PNPS	☐ VY

Calculation No. PNPS-1-ERHS-XXII.A-2	This revision incorporates the following MERLIN DRNs or Minor Calc Changes:	Sheet 1 of 181
Title: Radiological Consequences of a Design Basis Fuel Handling Accident Using the Alternative Source Term		☒ QR ☐ NQR
Discipline: Systems and Safety Analysis		Design Basis Calculation? ☒ Yes ☐ No

This calculation supercedes/voids calculation: ERHS-XXII.A-2. Revision 0

Modification No./Task No/ER No: N/A

☐ No software used

☐ Software used and filed separately (Include Computer Run Summary Sheet). If "YES", Code: __

☒ Software used and filed with this calculation. If "YES", Code: RADTRAD

System No./Name: N/A

Component No./Name: N/A

(Attached additional pages if necessary)

Print / Sign

REV #	STATUS (Prel. Pend, A, V, S)	PREPARER	REVIEWER/DESIGN VERIFIER	OTHER REVIEWER/ DESIGN VERIFIER	APPROVER	DATE
1	Pend.	P. Compagnone P. Compagnone	P. T. Karatzas P.T. Karatzas		S. Wollman S Wollman	4/6/03

RECORD OF REVISIONS

Calculation No. PNPS-ERHS-XXII.A-2

Revision No.	Description of Change	Reason For Change
1	Full revision	Revised to reflect revisions in referenced design documents

Subject: Radiological Consequences of a Design Basis Fuel Handling Accident Using the AST

CALCULATION SUMMARY PAGES

Page 1 of 2
Calculation No. PNPS-1-ERHS-XXII.A-2
Revision No. 1

CALCULATION OBJECTIVE:

To determine the potential radiological consequences offsite and to Control Room personnel following a design basis fuel handling accident for various plant configurations using the alternative source term.

CONCLUSIONS:

With the SGTS in operation fuel may be moved 24 hours after reactor shutdown. Without SGTS in operation, fuel may be moved 48 hours after shutown. In either case CRHEAFS is not required to be in operation.

The potential dose consequences of a FHA are as follows:

		Operation		Dose (Rem)			
Case	Fuel Decay	SGTS	CRHEAFS	CR (RB vent*)	CR (RB trucklock*)	EAB	LPZ
1	24 hrs	YES	YES	2.2E-05	2.2E-05	3.9E-01	1.3E-02
2	24 hrs	YES	NO	2.6E-05	2.6E-05	3.9E-01	1.3E-02
3a	24 hrs	NO	YES	2.7	1.5	6.5	6.5E-02
3b	48 hrs	NO	YES	2.4	1.3	4.9	4.9E-02
3c	72 hrs	NO	YES	2.1	1.1	4.2	4.2E-02
4a	24 hrs	NO	NO	3.3	1.8	6.5	6.5E-02
4b	48 hrs	NO	NO	2.9	1.5	4.9	4.9E-02
4c	72 hrs	NO	NO	2.5	1.4	4.2	4.2E-02
4d	96 hrs	NO	NO	2.3	1.2	3.8	3.7E-02
4e	120 hrs	NO	NO	2.1	1.1	3.4	3.4E-02
Regulatory limit				5	5	6.3	6.3

* For Cases 3 and 4, only.

ASSUMPTIONS:

- The FHA scenario is as detailed in RG 1.183.
- GE14 fuel assemblies are involved in the FHA.
- A conservative radial peaking factor of 2.1 is applied to all damaged fuel assemblies.
- Inflow into the Control Room during normal ventilation operation is 500 cfm.
- Inleakage into the Control Room during CRHEAFS operation is 500 cfm.

Subject: Radiological Consequences of a Design Basis Fuel Handling Accident Using the AST

CALCULATION SUMMARY PAGES (CONTINUED)

DESIGN INPUT DOCUMENTS:

Regulatory Guide 1.183	Dept. Doc. OSD 00-088
Technical Specifications: 1.0, 3.7.A/B	Calculation PNPS-1-ERHS-I.G-7, Rev. 0
Calculation PNPS-1-ERHS-X.G4-127, Rev. 0	Calculation PNPS-1-ERHS-XI.L-28, Rev. 0
Calculation PNPS-1-ERHS-II.A-1, Rev. 1	Calculation PNPS-1-ERHS-II.A-2, Rev. 1
Calculation PNPS-1-ERHS-II.B-4, Rev. 1	Drawing M23
Procedure 2.2.46	Calculation C15.0.3411
PNPS Memorandum C15-SMP-001	

AFFECTED DOCUMENTS:

N/A

METHODOLOGY:

The computer program RADTRAD was used to calculate the TEDE at the EAB and LPZ and to CR personnel assuming a design basis fuel handling accident in accordance with RG 1.183 Appendix B. Various configurations of the SGTS and CRHEAFS were considered.

Subject: Radiological Consequences of a Design Basis Fuel Handling Accident Using the AST

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Page	Revision
1 to 181	1
Attachment 1 (A1-1 – A1-2)	1
Attachment 2 (A2-1)	1
Attachment 3 (A3-1 – A3-6)	1
Attachment 4 (A4-1)	1

1.0 BACKGROUND

GE14 (10x10) fuel assemblies were loaded into the Pilgrim Nuclear Power Station (PNPS) reactor core during Reload 13 [1][1]. It is anticipated that all future reloads will use GE14 fuel assemblies, as well. The radiological consequences of a fuel handling accident (FHA) involving GE14 fuel assemblies, using the guidance of Regulatory Guide 1.25 [2] were evaluated in calculation PNPS-1-ERHS-XIII.Y-64, "Design Basis Fuel Handling Accident For RFO #13 (GE14, 10x10) Fuel" [3].

The worst-case activity release for a FHA results from the accidental dropping of a fuel assembly onto the reactor core during fuel movement [18A, 18B]. A fuel assembly dropped in the spent fuel pool would result in fewer fuel rods damaged due to a significantly smaller drop height [8]. This analysis evaluates the potential radiological consequences for a FHA involving GE14 fuel in the PNPS core and applying the alternative source term (AST) in accordance with the guidance provided in Regulatory Guide 1.183, "Alternative Radiological Source Terms For Evaluating Design Basis Accidents at Nuclear Power Plants" [4].

2.0 PURPOSE

The purpose of this calculation is to estimate the radiological consequences to the public offsite, at the exclusion area boundary and the low population zone, and to personnel in the Control Room in the event of a design basis fuel handling accident at Pilgrim Nuclear Power Station using the alternative source term in accordance with RG 1.183 and for various plant configurations.

[1] References are indicated in brackets [ ].

3.0 METHOD OF SOLUTION

The evaluation of the radiological consequences due to a design basis fuel handling accident (FHA) involving GE14 fuel assemblies in the PNPS reactor core and the alternative source term (AST) is based on Regulatory Guide 1.183 [4] assumptions and PNPS specific input. The number of damaged fuel rods was used to determine the fraction of the total core activity that is available for release to the environment. All the damaged fuel assemblies are assumed to leak the inventory specified in RG 1.183 to the coolant. The assumptions of RG 1.183, Appendix B are employed to determine the fraction of the released activity that eventually is available for release to the environment. The computer program RADTRAD [5] was used to calculate the doses at the exclusion area boundary (EAB), at the low population zone (LPZ), and in the control room (CR), based on the activity available for release to the environment and PNPS-specific atmospheric dispersion coefficients. Dose consequences are evaluated with and without the availability of the standby gas treatment system (SGTS) filters and the with and without the availability of the control room high efficiency air filtration system. For scenarios without SGTS available, release to the environment from the reactor building refuel floor is assumed to occur via the normal ventilation system out the reactor building vent or directly out of the reactor building trucklock.

4.0 ASSUMPTIONS

1. The FHA scenario is as detailed in RG 1.183 Appendix B.
2. GE14 fuel assemblies are involved in the fuel handling accident [1].
3. A conservative value of 2.1 for radial peaking factor is applied to all damaged fuel rods [1].
4. For purposes of the radiological evaluation, additional inflow into the Control Room during normal ventilation equals 500 cfm, approximately equal to the intake flow rate into the Control Room. In reality, such a high inflow would not be acceptable for heating and air conditioning purposes.
5. During CRHEAFS operation the unfiltered inleakage is less than or equal to 500 cfm.

Subject: Radiological Consequences of a Design Basis Fuel Handling Accident Using the AST

5.0 INPUT AND DESIGN CRITERIA

The dose consequences due to a postulated design basis fuel handling accident (FHA) are based on the following data. The specific computer program parameter input values for receptor locations are listed in the subsequent sections.

5.1 Release Activity

In the event of a fuel handling accident it is assumed that a number of fuel rods are damaged and radioactivity is released from the damaged rods. The number of rods assumed damaged and the consequent activity available for release is as given in Ref. 1 and RG 1.183.

1. Reactor power level = 2038 MWt.
   This accounts for the reactor current licensed power level of 2028 MWt [6A] plus a measurement uncertainty of 0.5%. This is consistent with core inventory as determined in Reference 7.
2. FHA AST nuclide activities at 2038 MWt [7, Table 7-4]

Nuclide	Core Activity (Ci/MWt)		Nuclide	Core Activity (Ci/MWt)		Nuclide	Core Activity (Ci/MWt)
Kr-85	3.14E+02		I-131	2.63E+04		Xe-133	5.52E+04
Kr-85m	7.94E+03		I-132	3.81E+04		Xe-135	2.50E+04
Kr-87	1.55E+04		I-133	5.51E+04			
Kr-88	2.19E+04		I-134	6.07E+04		Cs-134	3.06E+03
			I-135	5.14E+04		Cs-136	1.31E+03
Rb-86	3.56E+01					Cs-136	3.14E+03

3. Number of GE 14 fuel rods damaged = 151 [1]
4. Total number of fuel rods in core = 45512 [1]
5. Radial peaking factor = 2.1 [1]
   This factor is conservatively applied to all damaged fuel rods.
6. Delay time before fuel movement – assumed.

5.0 INPUT AND DESIGN CRITERIA (Continued)

5.1 Release Activity (Continued)

7. Fraction of fission product inventory in gap that is released to coolant [4, Table 3]

Group	Fraction
I-131	0.08
Kr-85	0.10
Other Noble Gases	0.05
Other Iodines	0.05
Alkali metals (Cs, Rb)	0.12

Note: the maximum burnup at the end of Cycle 15 is predicted to be 51.7 GWD/MTU [19]. Therefore, the condition of Footnote 11 of RG 1.183 [4, page 1.183-14] is met and the fractions given in RG 1.183, Table 3 apply.

8. Iodine species fractions released to pool [4, Appendix B]:
   - Aerosol = 95%
   - Elemental = 4.85%
   - Organic = 0.15%
9. Depth of water above fuel in refuel cavity ≥ 23 ft [8].

   Core is approximately at elevation 70 ft. Water level during refueling is at elevation 116 ft. (See §1.0).
10. Effective iodine decontamination factor = 200 [4, Appendix B]
11. Noble gas decontamination factor = 1.0 [4, Appendix B]
12. Particulate decontamination factor = infinite [4, Appendix B]
13. Release to environment occurs over a 2-hr time period [4, Appendix B]
14. Iodine species fractions above water [4, Appendix B]
    - Elemental = 57%
    - Organic = 43%

5.0 INPUT AND DESIGN CRITERIA (Continued)

5.2 Dose Analyses

1. Refuel floor air volume = 7.0×10^5 ft^3 [9, page 14]
2. Standby gas treatment system (SGTS) iodine filter efficiency = 99% [6B] [17]
3. Normal operation control room ventilation envelope comprises the Control Room (CR), the cable spreading room, computer room, storage room and corridor. Not including the CR, the net volume of the envelope = 28,620 ft^3 [10, page 63].
4. Control Room net volume = 34,280 ft^3 [20].
5. Total normal operation control room ventilation envelope net volume = (28,620 ft^3 + 34,280 ft^3) = 62,900 ft^3 [from #3 and #4, above).
6. Control Room normal ventilation inflow/exhaust rate = 1100 cfm
   a. Normal operation intake/exhaust rate (for ventilation envelope) = 1090 cfm [10, page 60-63] This includes a normal ventilation intake of 1000 cfm and 90 cfm inflow, due to access/egress through doorways in the total envelope, to the total volume of 62,900 ft^3. The portion going to the CR volume of 34,280 ft^3 = [(34,280 ft^3/62,900 ft^3)(1090 cfm)] ≅ 600 cfm.
   b. Assumed additional inflow from surrounding ventilation zones = 500 cfm [§4.0, #5]
   c. Therefore, the total inflow to the CR = 600 cfm + 500 cfm = 1100 cfm.
   d. Intake iodine filter efficiency = 0 (no iodine filters)
7. Control room filtered intake – 0.5 hr [11, page 11] – 720 hrs (post-accident):
   - Filtered intake rate = 1100 cfm [6C][11, page 12]
   - Intake iodine filter efficiency = 95% [6C]
8. Unfiltered inflow to CR (0.5 hr – 720 hrs, post-accident):
   - Unfiltered inleakage = 10 cfm (doorway) [12]
   - Unfiltered inleakage = 500 cfm (other locations) [§4.0, #5]
9. Control Room occupancy factors [4, pg 1.183-18]:

Time	Occupancy Factor
0 – 24 hrs	1.0
1 - 4 days	0.6
4 – 30 days	0.4

5.0 INPUT AND DESIGN CRITERIA (Continued)

5.2 Dose Analyses (Continued)

10. Breathing rates:[4, pg 1.183-16]:

Time *	Breathing Rate
0 – 8 hrs	3.5×10^{-4} m^3/s (0 – 720 hrs for CR)
8 - 24 hrs	1.8×10^{-4} m^3/s
24 – 720 hrs	2.3×10^{-4} m^3/s

11. Atmospheric dispersion factors (χ/Q):

		Ground-level - Reactor Building		Elevated (Main Stack)
		Vent	Trucklock	
	Time Interval (hrs) *	χ/Q (s/m^3)	χ/Q (s/m^3)	χ/Q (s/m^3)
EAB [13]	fumigation (0 –2)			5.85E-04
	0 - 2	2.61E-03		
LPZ [13]	Fumigation (0 – 4)			1.91E-05
	0 – 8	2.58E-05		
CR [14]	0 – 2	1.85E-03	9.87E-04	7.32E-07

12. Regulatory dose limits:

	TEDE	Ref.
CR	5 rem	[15]
EAB	6.3 rem	[4, Table 6]
LPZ	6.3 rem	[4, Table 6]

* Time intervals are relative to time post-accident.

6.0 REFERENCES

1. Office Memorandum Dept. Doc. OSD 00-088, "Design Criteria Input Request for Cycle 14 Reload Core Design Change, PDC 01-03," from S. Paranjape - Attachment 1 (2 pages).
2. USNRC Regulatory Guide 1.25 {Safety Guide 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," March 12, 1972.
3. Calculation PNPS-1-ERHS-XIII.Y-64, Revision 0, "Design Basis Fuel HandlingAccident For RFO #13 (GE14, 10x10) Fuel"
4. USNRC Regulatory Guide 1.183, "Alternative Radiological Source Terms For Evaluating Design Basis Accidents at Nuclear Power Plants," July 2000.
5. S&SACP35, "RADTRAD Qualification Conformance Matrix," Revision 0. Software Catalog #01812.
6. PNPS Technical Specifications
   A. Amendment 201, "1.0 Definitions – Design Power."
   B. 3.7.B.1 "SGTS"
   C. 3.7.B.2 "CHREAFS"
7. Calculation PNPS-1-ERHS-XXI.A-1, "PNPS AST Nuclide Inventory," Revision 0.
8. Drawing M23, Equipment Location Sections DD &LL, Rev. E8.
9. Calculation PNPS-1-ERHS-X.G4-127, "Environmental Qualification Airborne Radiation Levels in the Reactor Building Secondary Containment," Revision 0.
10. Calculation PNPS-1-ERHS-XI.L-28, Revision 0, "CR Habitability Radiological Reassessment for a DBA LOCA."
11. Procedure 2.2.46, "Control Room Cable Spreading Room, and Computer Room Heating, Ventilation, and Air Conditioning System," Revision 38.
12. USNRC, NUREG-0800, Standard Review Plan 6.4, "Control Room Habitability System," Rev. 2, July 1981

6.0. REFERENCES (Continued)

13. Calculation
    A. PNPS-1-ERHS-II.A-1, "Accident χ/Q's for Main Stack and Turbine Building Releases," Revision 1.
    B. PNPS-1-ERHS-II.A-2, "Accident χ/Q's for Reactor Building and Yard Area Releases," Revision 1.
14. Calculation PNPS-1-ERHS-II.B-4, Revision 1, "Control Room and Technical Support Center Accident χ/Q's Using ARCON96."
15. Code of Federal Regulations Title 10 Part 50.67 (10CFR50.67).
16. NUREG/CR-6604, "RADTRAD: A Simplified Model For RADionuclide Transport and Removal And Dose Estimation," December 1997.
17. Calculation S&SA 154, "SGTS Train Efficiency For Radioiodine Removal by Dual Bank Carbon Adsorbers," Revision 0.
18. PNPS Final Safety Analysis Report:
    A. Section 14.5.5, "Fuel Handling Accident", Rev 22, October 1999
    B. Appendix R, Section R.3.4, "Refueling Accident", Revision 6, July 1986
    C. Section 7.18, "Reactor Building Isolation and Control System", Revision 10, July 1989
19. Memorandum from S. Paranjape to P. Compagnone, August 12, 2003 - Attachment 2 (1 page).
20. Calculation C15.0.3411, "Control Room Volume," Revision 0.
21. PNPS Memorandum, C15-SMP-001, dated 4/01/04, from S.M. Paranjape to Phil Karatzas, "Fuel Handling Accident Calculation ERHS-XXII.A-2, Question on Cycle 13 Data Versus Current Cycle 15 Fuel Configuration".

Subject: Radiological Consequences of a Design Basis Fuel Handling Accident Using the AST

7.0 CALCULATION/ANALYSIS

The potential radiological consequences of a postulated fuel handling accident are evaluated for various plant configurations to determine acceptable plant configurations during fuel movement. The data and assumptions listed in Section 5.0 are used with the computer program RADTRAD to calculate the doses in the Control Room (CR) and offsite, at the EAB and LPZ, as a result of the postulated releases to the environment.

7.1 FHA Activity Release

The design basis fuel handling accident, as described in Regulatory Guide 1.183 "Alternative Radiological Source Terms For Evaluating Design Basis Accidents at Nuclear Power Reactors," [4] is modeled as an essentially instantaneous release of the radioactivity from the damaged fuel to the coolant and then to the refuel floor. Release from the refuel floor to the environment occurs at a rate such that essentially all the available radioactivity is released to the environment in 2 hours

The activity available for release from the refuel floor is determined as follows.

1. Reactor power = 2038 MWt [§5.1 #1]
2. Nuclide specific activities (Ci/MWt) – [§5.1, #2].
3. Fraction of iodine activity released to coolant = 0.05 [§5.1, #7]
4. I-131 specific activity adjusted to correspond to 0.05 release = 4.21E+04 Ci/MWt
   * Fraction of iodine activity in coolant = 0.05
   * Fraction of I-131 activity in coolant = 0.08 [§5.1, #7]
   * I-131 specific activity is adjusted by a factor of (0.08)/(0.05) = 1.6.

     Core A_{I131} = 2.63E+04 Ci/MWt [item #2, above]
     Adjusted A_{I131} = 2.63E+04 Ci/MWt (1.6) = 4.21E+04 Ci/MWt

Subject: Radiological Consequences of a Design Basis Fuel Handling Accident Using the AST

7.0 CALCULATION/ANALYSIS (Continued)

7.1 FHA Activity Release (Continued)

5. Fraction of NG activity released to pool = 0.05 [§5.1, #7]
6. Kr-85 specific activity adjusted to correspond to 0.05 release = 6.28E+02 Ci/MWt
   * Fraction of noble gas activity in coolant = 0.05
   * Fraction of Kr-85 activity in coolant = 0.10 [§5.1, #7]
   * Kr-85 specific activity is adjusted by a factor of (0.10)/(0.05) = 2.0

     Core A_{Kr85} = 3.14E+02 Ci/MWt [item #2, above]
     Adjusted A_{Kr85} = 3.14E+02 Ci/MWt (2.0) = 6.28E+02 Ci/MWt
7. FHA effective power (P_{FHA}) = 14.2 MWt

   This is the effective power generated by the damaged fuel rods at a radial peaking factor of 2.1.
   * Power = 2038 MWt [§5.1, #1]
   * Number of damaged fuel rods = 151 [§5.1, #3]
   * Total number of fuel rods = 45512 [§5.1, #4]
   * Radial peaking factor = 2.1 [§5.1, #5]

$$P_{CRDA} = \frac{(2038 MWt)(151)(2.1)}{45512} = 14.2\ MWt$$

7.0 CALCULATION/ANALYSIS (Continued)

7.2 Activity Release From Refuel Floor

1. Fraction of iodine inventory available for release from the refuel floor (F_I) = 2.5E-04
   * Fraction of iodine activity in pool = 0.05 [§5.1, #7]; fraction of 0.08 for I-131 accounted for by adjusted I-131 specific activity [§7.1, #4]
   * Pool effective iodine decontamination factor = 200 [§5.1, #10]

   $$\therefore F_I = (0.05)/(200) = 0.00025$$

2. Fraction of noble gas activity available for release from the refuel floor (F_{NG}) = 5.0E-02
   * Fraction of noble gas activity in pool = 0.05 [§5.1, #7], fraction of 2.0 for Kr-85 accounted for by adjusted Kr-85 specific activity [§7.1, #6]
   * Pool effective noble gas decontamination factor = 1.0 [§5.1, #11]

   $$\therefore F_{NG} = (0.05)/(1.0) = 0.05$$

3. Fraction of alkali metal activity available for release from refuel floor (F_P) = 0
   Particulates are retained in the pool [§5.1, #12].
4. Activity release rate from the refuel floor = 6.908/hr = 80600 cfm
   The activity released to the refuel floor must be released to the environment in a two-hour time period [§5.1, #13]. The activity remaining in the building at any time, as accounted for by the computer program RADTRAD follows an exponential decay curve. In order to release essentially all the activity in a 2-hr time period, the activity release rate for use with RADTRAD is determined as follows. Assume that at the end of the 2-hr time period only 10^{-6} of the initial activity at t = 0 hr, A_0, remains.

7.0 CALCULATION/ANALYSIS (Continued)

7.2 Activity Release From Refuel Floor (Continued)

$$10^{-6} A_0 = A_0 e^{-\lambda t}$$
$$10^{-6} = e^{-\lambda t}$$
$$\ln 10^{-6} = -\lambda(2hr)$$
$$6.908/hr = \lambda$$

This release rate corresponds to a volumetric release rate (RR) of 80600 cfm.

$$RR = \frac{(700000\,\text{ft}^3)(6.908/\text{hr})}{60\,\text{min}/\text{hr}} = 80600\,\text{cfm}$$

7.3 Case 1: FHA Dose Consequences With SGTS and With CRHEAFS

7.3.1 Case 1 Release Scenario

For this scenario, activity is released to the environment through the standby gas treatment system (SGTS) filters and out the main stack. As indicated in Reference 18C, in the event of a fuel handling accident, isolation of the Reactor Building occurs before any radioactivity can be released directly from the Reactor Building to the environment [18C]. The control room high efficiency air filtration system (CRHEAFS) is in operation within 30 minutes of accident initiation. For this case it is assumed that fuel is moved 24 hours after reactor shut down. Additional delay in fuel movement provides additional decay time and, thus, lower doses. The activity release scenario is shown on the following sketch. The plant scenario file used with the computer program RADTRAD is detailed in the following sections.

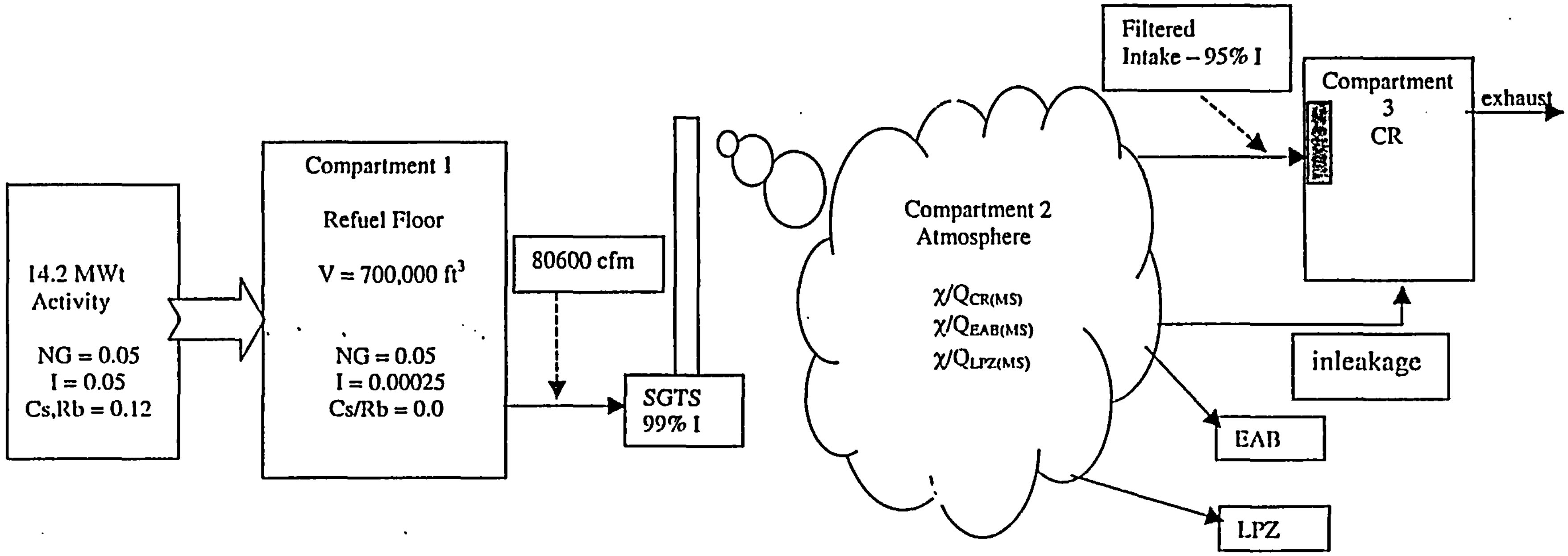
Subject: Radiological Consequences of a Design Basis Fuel Handling Accident Using the AST

7.0 CALCULATION/ANALYSIS (Continued)

7.3 Case 1: FHA Dose Consequences With SGTS and CRHEAFS (Continued)

7.3.1 Case 1 Release Scenario (Continued)

Figure 7-1 FHA Case 1 Scenario: SGTS & CRHEAFS



7.0 CALCULATION/ANALYSIS (Continued)

7.3 Case 1: FHA Dose Consequences With SGTS and CRHEAFS (Continued)

7.3.2 Case 1 Dose Analysis

1. Activity decay time = 24 hrs.

   Any additional decay would result in lower doses.
2. SGTS iodine filter efficiency = 99% [§5.2, #2]
3. Release is at the elevated level from the main stack.
4. Control Room intake/exhaust rate:
   - 0 – 30 minutes = 1100 cfm [§5.2, #6]
   - 0.5 hr - 720 hrs: intake = 1100 cfm, filter efficiency = 95% [§5.2, #7]
5. Unfiltered inleakage into CR (0.5 hr – 720 hrs) = 510 cfm [§5.2, #8]

7.3.3 Case 1 RADTRAD Input Data

The computer program RADTRAD is used to determine the dose consequences offsite at the exclusion area boundary (EAB) and at the low population zone (LPZ) and to the control room (CR) based on the case 1 scenario. The control room high efficiency air filtration system (CRHEAFS) will not be in operation until 30 minutes after accident initiation. For the first 30 minutes post-accident the normal ventilation system, which provides outside air for the CR, the cable spreading room, the computer room, storage room and corridor, will be in operation. The input is described in the following sections. All input times are post-accident.

7.0 CALCULATION/ANALYSIS (Continued)

7.3 Case 1: FHA Dose Consequences With SGTS and CRHEAFS (Continued)

7.3.3 Case 1 RADTRAD Input Data (Continued)

Compartments

1. Refuel floor (3-Other)
   a. Volume = 700,000 ft^3 [§5.2, #1]
   b. Source term fraction = 1.0 (all the activity corresponding to the FHA equivalent power)
   c. Compartment features - none
2. Atmosphere (Environment)
3. Control Room volume = 34,280 ft^3 [§5.2, #4]

Transfer pathways

1. Refuel floor to atmosphere
   a. Transfer mechanism – filter
   b. Flow rate and Filter efficiencies (percent) [§7.2, #4][§7.3.2, #2]

Time (h)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	80600	99	99	99
2.0	0	0.0	0.0	0.0

2. Atmosphere to CR (intake)
   a. Transfer mechanism – filter
   b. Flow rates and Filter efficiencies (percent) [§5.2, #6, #7]

Time (h)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	1100	0.0	0.0	0.0
0.5	1100	95	95	95
720	0.0	0.0	0.0	0.0

7.0 CALCULATION/ANALYSIS (Continued)

7.3 Case 1: FHA Dose Consequences With SGTS and CRHEAFS (Continued)

7.3.3 Case 1 RADTRAD Input Data (Continued)

3. Atmosphere to CR (inleakage)
   a. Transfer mechanism – filter
   b. Flow rate and Filter efficiencies (percent) [§5.2, #8]

Time (h)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	0	0	0	0
0.5	510	0	0	0
720	0	0	0	0

4. Control Room to Atmosphere (exhaust)
   a. Transfer mechanism – filter
   b. Flow rate and Filter efficiencies (percent)

Time (h)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	1100	0	0	0
0.5	1610	0	0	0
720	0	0	0	0

Dose Locations

Location:	EAB	LPZ	Control Room
χ/Q (s/m^3): from MS [§5.2, #11]	0 hr: 5.85E-04 2 hrs: 0.0	0 hr: 1.91E-05 4 hrs: 0.0	0 hr: 7.32E-07 2 hrs: 0.0
Breathing rate (m^3/s) [§5.2, #10]	0 hr: 3.5E-04 8 hrs: 1.8E-04 24 hrs: 2.3E-04 720 hrs: 0.0	0 hr: 3.5E-04 8 hrs: 1.8E-04 24 hrs: 2.3E-04 720 hrs: 0.0	0 hr: 3.5E-04 720 hrs: 0.0
Occupancy [§5.2, #9]			0 hr: 1.0 24 hrs: 0.6 96 hrs: 0.4 720 hrs: 0.0

7.0 CALCULATION/ANALYSIS (Continued)

7.3 Case 1: FHA Dose Consequences With SGTS and CRHEAFS (Continued)

7.3.3 Case 1 RADTRAD Input Data (Continued)

Source Term and Dose Conversion Factors

1. Nuclide inventory – User inventory: file "fha.nif"
   File consists of PNPS specific activities given in §5.1, #2, with the activities for I-131 and Kr-85 adjusted as indicated in §7.1, #4 and #6 in the RADTRAD file format [16, Table 1.4.3.2-3].
2. Plant power = 14.2, corresponding to damaged fuel rods [§7.1, #7]
3. Decay and Daughter Products – decay/daughter products
4. Iodine Chemical Fractions above water [§5.1, # 14]
   Aerosol = 0.0
   Elemental I = 0.57
   Organic I = 0.43
5. Release Fractions and Timing – user "rft" file – "fha.rft"
   Duration of release to refuel floor – essentially instantaneous = 1.0E-04 hr
   Noble gas fraction = 0.5000E-01 [§7.2, #2]
   Iodine fraction = 0.25000E-3 [§7.2, #1]
   Others = 0.0 [§7.2, #3]
   Delay (hours) = 24
6. Dose Conversion Factors – "fgr11&12.inp" (default)

7.3.4 Case 1 RADTRAD Input Files

The above data are used to define the RADTRAD plant scenario file for the fuel handling accident – case 1, "fha1.psf". The scenario file reads the additional files for nuclide inventory, "fha.nif", the release fractions and timing, "fha.rft", and the dose conversion factors, "fgr11&12.inp". A copy of the computer run file is given in Appendix A.

7.0 CALCULATION/ANALYSIS (Continued)

7.3 Case 1: FHA Dose Consequences With SGTS and CRHEAFS (Continued)

7.3.5 FHA Case 1 Dose Consequences

The estimated dose consequences due to FHA activity release with the SGTS and CRHEAFS in operation are:

Table 7-1 FHA Case 1: With SGTS & With CRHEAFS – Dose Consequences

Decay Time (hrs)	Dose Interval	EAB TEDE (rem)	LPZ TEDE (rem)	CR TEDE (rem)
24	0 – 2 hrs	**3.91E-01**		
	0 – 720 hrs		**1.28E-02**	**2.20-05**

7.4 Case 2 - FHA Dose Consequences With SGTS & NO CRHEAFS

7.4.1 Case 2 Release Scenario

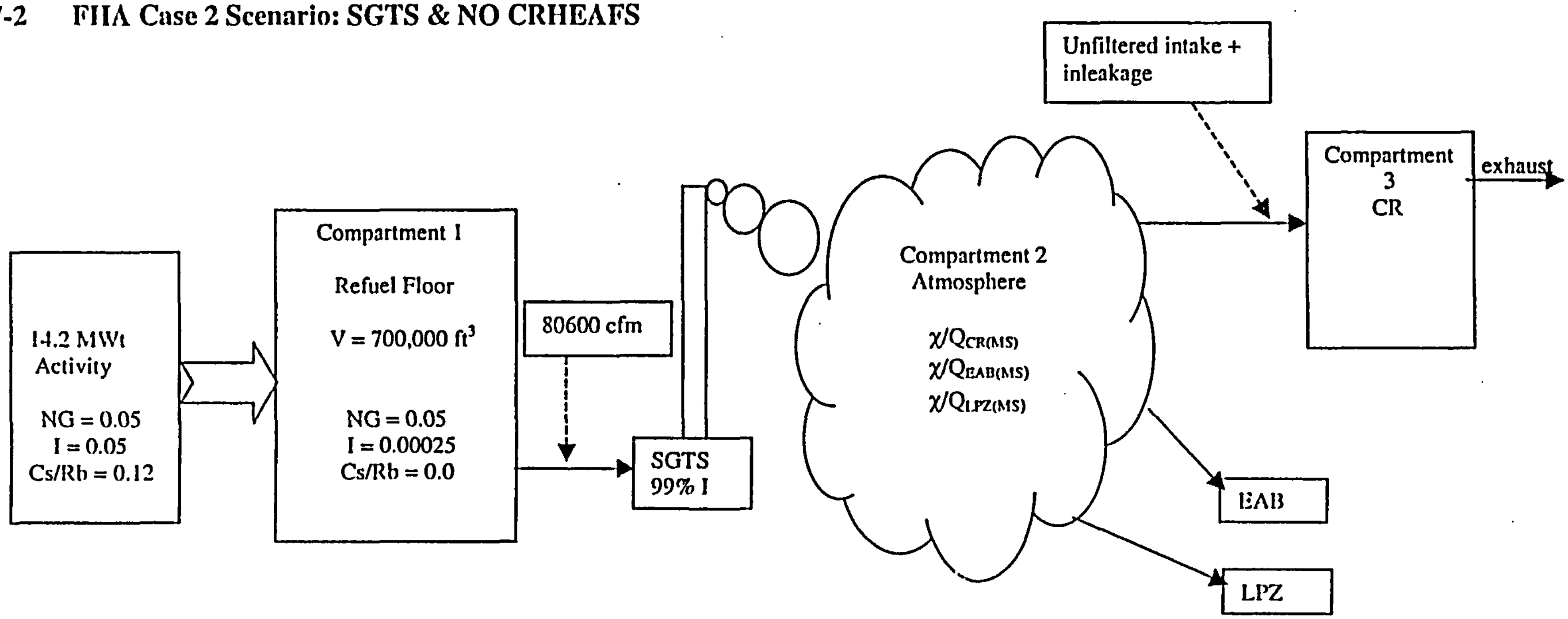
For this scenario, activity is released to the environment through the standby gas treatment system (SGTS) filters and out the main stack. The control room high efficiency air filtration system (CRHEAFS) will not be put into operation during the accident. The normal ventilation system will be in operation throughout the accident. For this case it is assumed that fuel will not be moved for a minimum of 24 hours after reactor shut down. Additional delay in moving the fuel will result in lower doses. The activity release scenario for Case 2 is shown on the following sketch. The plant scenario file used with the computer program RADTRAD is detailed in the following sections.

7.0 CALCULATION/ANALYSIS (Continued)

7.4 Case 2: FHA Dose Consequences With SGTS & NO CRHEAFS (Continued)

7.4.1 Case 2 Release Scenario (Continued)

Figure 7-2 FHA Case 2 Scenario: SGTS & NO CRHEAFS



7.0 CALCULATION/ANALYSIS (Continued)

7.4 Case 2: FHA Dose Consequences With SGTS & NO CRHEAFS (Continued)

7.4.2 Case 2 Dose Analysis

1. Activity decay time = 24 hours.
2. SGTS iodine filter efficiency = 99% [§5.2, #2]
3. Release is elevated from the main stack.
4. Control Room intake/exhaust rate = 1100 cfm [§5.2, #6]

7.4.3 Case 2 RADTRAD Input Data

The computer program RADTRAD is used to determine the dose consequences to the control room (CR) and offsite at the exclusion area boundary (EAB) and at the low population zone (LPZ) based on the case 2 scenario. The input is described in the following sections.

Compartments

1. Refuel floor (3-Other)
   a. Volume = 700,000 ft^3 [§5.2, #1]
   b. Source term fraction = 1.0 (all the activity corresponding to the FHA equivalent power)
   c. Compartment features - none
2. Atmosphere (Environment)
3. Control Room
   Volume = 34,280 ft^3 [§5.2, #4]

7.0 CALCULATION/ANALYSIS (Continued)

7.4 Case 2: FHA Dose Consequences With SGTS & NO CRHEAFS (Continued)

7.4.3 Case 2 RADTRAD Input Data (Continued)

Transfer pathways

1. Refuel floor to atmosphere
   a. Transfer mechanism – filter
   b. Flow rate and filter efficiencies (percent) [§7.2, #4] [§7.4.2, #2]

Time (h)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	80600	99	99	99
2.0	0	0.0	0.0	0.0

2. Atmosphere to CR (intake)
   a. Transfer mechanism – filter
   b. Flow rate and filter efficiencies (percent) [§5.2, #6]

Time (h)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	1100	0.0	0.0	0.0
720	0.0	0.0	0.0	0.0

3. Control Room to Atmosphere (exhaust)
   a. Transfer mechanism – filter
   b. Filter efficiencies (percent)

Time (h)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	1100	0.0	0.0	0.0
720	0.0	0.0	0.0	0.0

7.0 CALCULATION/ANALYSIS (Continued)

7.4 Case 2: FHA Dose Consequences With SGTS & NO CRHEAFS (Continued)

7.4.3 Case 2 RADTRAD Input Data (Continued)

Dose Locations

Location:	EAB	LPZ	Control Room
χ/Q (s/m^3): from MS [§5.2, #11]	0 hr: 5.85E-04 2 hrs: 0.0	0 hr: 1.91E-05 4 hrs: 0.0	0 hr: 7.32E-07 2 hrs: 0.0
Breathing rate (m^3/s [§5.2, #10]	0 hr: 3.5E-04 8 hrs: 1.8E-04 24 hrs: 2.3E-04 720 hrs: 0.0	0 hr: 3.5E-04 8 hrs: 1.8E-04 24 hrs: 2.3E-04 720 hrs: 0.0	0 hr: 3.5E-04 720 hrs: 0.0
Occupancy [§5.2, #9]			0 hr: 1.0 24 hrs: 0.6 96 hrs: 0.4 720 hrs: 0.0

Source Term and Dose Conversion Factors

1. Nuclide inventory – User inventory: file "fha.nif" – see §7.3.3
2. Plant power = 14.2, corresponding to damaged fuel rods [§7.1, #7]
3. Decay and Daughter Products – decay/daughter products
4. Iodine Chemical Fractions above water [§5.1, # 14]
   Aerosol = 0.0
   Elemental I = 0.57
   Organic I = 0.43
5. Release Fractions and Timing – user "rft" file – "fha.rft"
   Duration of release to refuel floor – essentially instantaneous = 1.0E-04 hr
   Noble gas fraction = 0.5000E-01 [§7.2, #2]
   Iodine fraction = 0.25000E-3 [§7.2, #1]
   Others = 0.0 [§7.2, #3]
   Delay (hours) = 24
6. Dose Conversion Factors – "fgr11&12.inp" (default)

7.0 CALCULATION/ANALYSIS (Continued)

7.4 Case 2: FHA Dose Consequences With SGTS & NO CRHEAFS (Continued)

7.4.4 Case 2 RADTRAD Input Files

The above data are used to define the RADTRAD plant scenario files for the fuel handling accident – case 2, "fha2.psf". The scenario file reads the additional files for nuclide inventory, "fha.nif", the release fractions and timing, "fha.rft", and the dose conversion factors, "fgr11&12.inp". A copy of the input for case 2 and corresponding output file is provided in Appendix B.

7.4.5 FHA Case 2 Dose Consequences

The estimated dose consequences due to FHA activity release after 24-hr decay, with the SGTS in operation and CRHEAFS NOT in operation are:

Table 7-2 FHA Case 2: With SGTS & Without CRHEAFS – Dose Consequences

Decay Time	Dose Interval	EAB TEDE (rem)	LPZ TEDE (rem)	CR TEDE (rem)
24 hours	0 – 2 hrs	**3.91E-01**		
	0 – 720 hrs		**1.28E-02**	**2.62E-05**

7.0 CALCULATION/ANALYSIS (Continued)

7.5 Case 3: FHA Dose Consequences With NO SGTS and With CRHEAFS

7.5.1 Case 3 Release Scenario

For this scenario, it is assumed that the SGTS is not available and activity is released to the environment at ground level from the reactor building (RB) vent or from the RB trucklock. The control room high efficiency air filtration system (CRHEAFS) is in operation within 30 minutes of accident initiation. For this case fuel movement will be considered from 1 to 3 days after the reactor is shut down. The activity release scenario is shown on the following sketch. The plant scenario file used with the computer program RADTRAD is detailed in the following sections. The only difference beween release from the RB vent and release from the RB trucklock is the χ/Q to the control room (CR). Therefore, computer runs are made only for the RB vent case. For the RB trucklock release case, the CR dose will be determined by the ratio of the appropriate χ/Qs.

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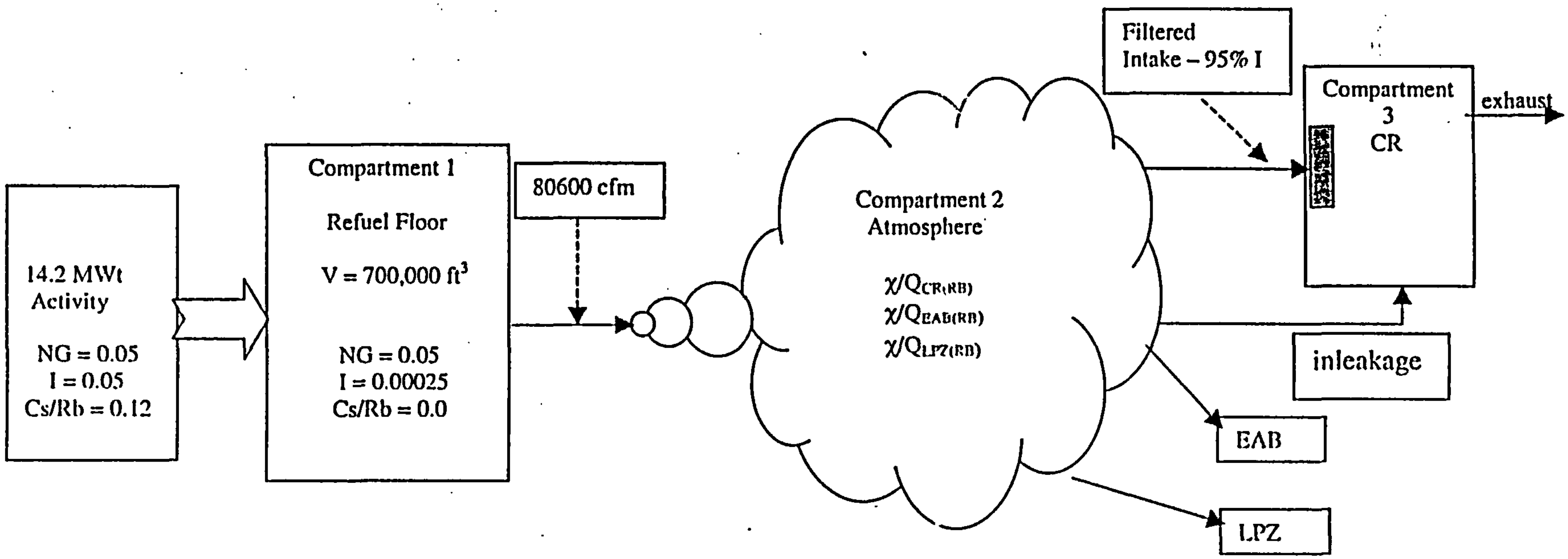
7.0 CALCULATION/ANALYSIS (Continued)

7.5 Case 3: FHA Dose Consequences With NO SGTS and With CRHEAFS (Continued)

7.5.1 Case 3 Release Scenario (Continued)

Figure 7-3 FHA Case 3 Scenario: NO SGTS & CRHEAFS



7.0 CALCULATION/ANALYSIS (Continued)

7.5 Case 3: FHA Dose Consequences With NO SGTS and With CRHEAFS (Continued)

7.5.2 Case 3 Dose Analysis

1. Activity decay time = 24, 48, 72 hrs.
2. Release is at ground level from the reactor building, unfiltered.
3. Control Room intake/exhaust rate
   - 0 – 0.5 hr: intake rate = 1100 cfm [§5.2, #6]; no filters
   - 0.5 hr - 720 hrs: intake rate = 1100 cfm, filter efficiency = 95%[§5.2, #7]
   - 0.5 hr – 720 hrs - unfiltered inleakage = 510 cfm [§5.2, #8]

7.5.3 Case 3 RADTRAD Input Data

The computer program RADTRAD is used to determine the dose consequences to the control room (CR) and offsite at the exclusion area boundary (EAB) and at the low population zone (LPZ) based on the case 1 scenario. The control room high efficiency air filtration system (CRHEAFS) will not be in operation until 30 minutes after accident initiation. For the first 30 minutes post-accident the normal ventilation system, which provides outside air for the CR, the cable spreading room, the computer room, storage room and corridor will be in operation. The input is described in the following sections.

7.0 CALCULATION/ANALYSIS (Continued)

7.5 Case 3: FHA Dose Consequences With NO SGTS and With CRHEAFS (Continued)

7.5.3 Case 3 RADTRAD Input Data (Continued)

Compartments

1. Refuel floor (3-Other)
   a. Volume = 700,000 ft^3 [§5.2, #1]
   b. Source term fraction = 1.0 (all the activity corresponding to the FHA equivalent power)
   c. Compartment features - none
2. Atmosphere (Environment)
3. Control Room
   Volume = 34,280 ft^3 [§5.2, #4]

Transfer pathways

1. Refuel floor to atmosphere
   a. Transfer mechanism – filter
   b. Flow rates and filter efficiencies (percent) [§7.2, #4][§7.5.2, #2]

Time (hr)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	80600	0.0	0.0	0.0
2.0	0	0.0	0.0	0.0

2. Atmosphere to CR - intake
   a. Transfer mechanism – filter
   b. Flow rates and filter efficiencies (percent) [§5.2, #6, #7]

Time (h)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	1100	0	0	0
0.5	1100	95	95	95
720	0	0	0	0

7.0 CALCULATION/ANALYSIS (Continued)

7.5 Case 3: FHA Dose Consequences With NO SGTS and With CRHEAFS (Continued)

7.5.3 Case 3 RADTRAD Input Data (Continued)

3. Atmosphere to CR - inleakage
   a. Transfer mechanism – filter
   b. Flow rates and filter efficiencies (percent) [§5.2, #8]

Time (h)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	0	0	0	0
0.5	510	0	0	0
720	0	0	0	0

4. Control Room to Atmosphere - exhaust
   a. Transfer mechanism – filter
   b. Flow rates and filter efficiencies (percent)

Time (h)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	1100	0	0	0
0.5	1610	0	0	0
720	0	0	0	0

Dose Locations

Location:	EAB	LPZ	Control Room
χ/Q (s/m^3): from RB vent [§5.2, #11]	0 hr: 2.61E-03 2 hrs: 0.0	0 hr: 2.58E-05 8 hrs: 0.0	0 hr: 1.85E-03 2 hrs: 0.0
Breathing rate (m^3/s) [§5.2, #10]	0 hr: 3.5E-04 8 hrs: 1.8E-04 24 hrs: 2.3E-04 720 hrs: 0.0	0 hr: 3.5E-04 8 hrs: 1.8E-04 24 hrs: 2.3E-04 720 hrs: 0.0	0 hr: 3.5E-04 720 hrs: 0.0
Occupancy [§5.2, #9]			0 hr: 1.0 24 hrs: 0.6 96 hrs: 0.4 720 hrs: 0.0

7.0 CALCULATION/ANALYSIS (Continued)

7.5 Case 3: FHA Dose Consequences With NO SGTS and With CRHEAFS (Continued)

7.5.3 Case 3 RADTRAD Input Data (Continued)

Source Term and Dose Conversion Factors

1. Nuclide inventory – User inventory: file "fha.nif" – see §7.3.3
2. Plant power = 14.2, corresponding to damaged fuel rods [§7.1, #7]
3. Decay and Daughter Products – decay/daughter products
4. Iodine Chemical Fractions above water [§5.1, # 14]
   Aerosol = 0.0
   Elemental I = 0.57
   Organic I = 0.43
5. Release Fractions and Timing – user "rft" file – "fha.rft"
   Duration of release to refuel floor – essentially instantaneous = 1.0E-04 hr
   Noble gas fraction = 0.5000E-01 [§7.2, #2]
   Iodine fraction = 0.2500E-3 [§7.2, #1]
   Others = 0.0 [§7.2, #3]
   Delay (hours) = 24, 48, 72
6. Dose Conversion Factors – "fgr11&12.inp" (default)

7.5.4 Case 3 RADTRAD Input Files

The above data are used to define the RADTRAD plant scenario files for the fuel handling accident – case3, "fha3a.psf", "fha3b.psf", and "fha3c.psf". The scenario file reads the additional files for nuclide inventory, "fha.nif", the release fractions and timing, "fha.rft", and the dose conversion factors, "fgr11&12.inp". Copies of the files for case 3 are given in Appendix C1 - Appendix C3.

7.0 CALCULATION/ANALYSIS (Continued)

7.5 Case 3: FHA Dose Consequences With NO SGTS and With CRHEAFS (Continued)

7.5.5 FHA Case 3 Dose Consequences

The estimated dose consequences due to FHA activity release without the SGTS and with CRHEAFS in operation are given below. The CR TEDE values from Appendix C are for release from the RB vent. The corresponding values for release from the RB trucklock are obtain by multiplying the run value by

$$\frac{\text{RB trucklock to CR } \chi/Q}{\text{RB vent to CR } \chi/Q} = \frac{9.87 \times 10^{-4}\ s/m^3}{1.85 \times 10^{-3}\ s/m^3} = 0.534$$

Table 7-3 FHA Case 3: Without SGTS & With CRHEAFS – Dose Consequences

Decay Time	Dose Interval	EAB TEDE (rem)	LPZ TEDE (rem)	CR TEDE (rem)	
				RB vent	RB trucklock
24 hours	0 – 2 hrs	6.54			
	0 – 720 hrs		6.46E-02	2.72	1.45
48 hours	0 – 2 hrs	4.93			
	0 – 720 hrs		4.87E-02	2.35	1.25
72 hours	0 – 2 hrs	4.23			
	0 - 720 hrs		4.18E-02	2.10	1.12

7.0 CALCULATION/ANALYSIS (Continued)

7.6 Case 4: FHA Dose Consequences With NO SGTS and NO CRHEAFS

7.6.1 Case 4 Release Scenario

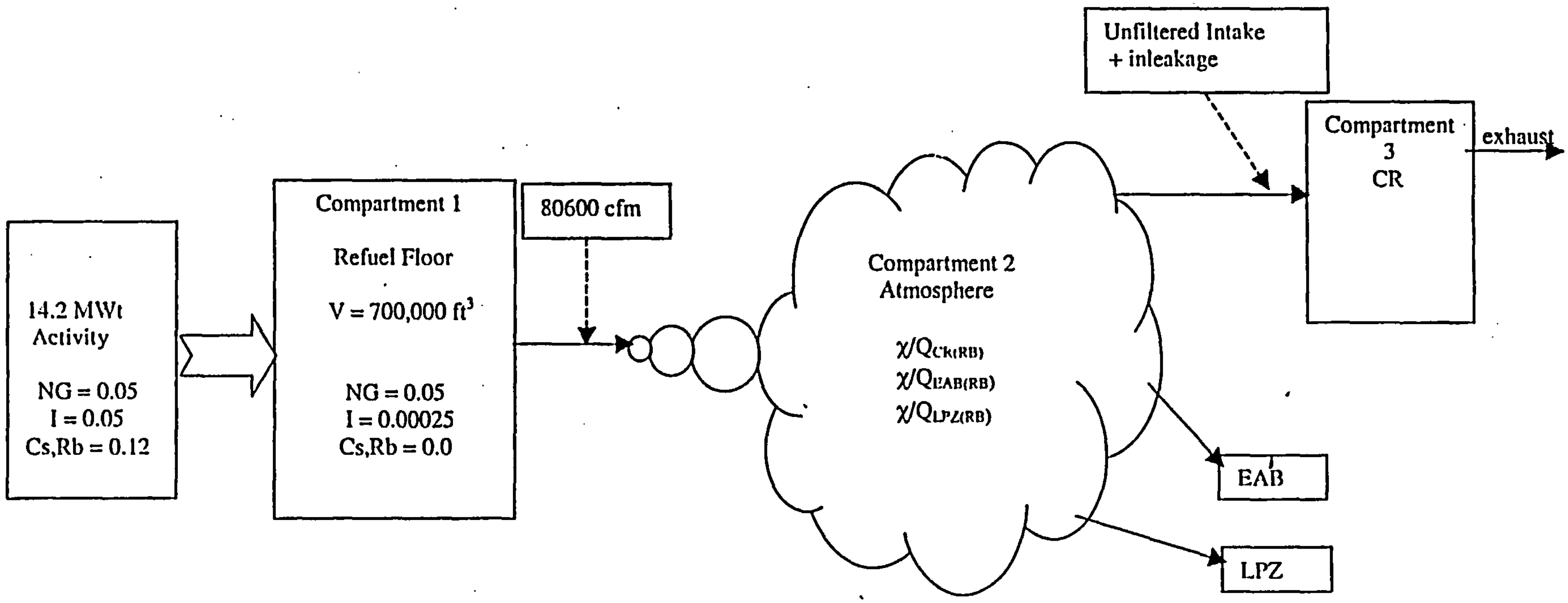
For this scenario, it is assumed that neither the SGTS nor the CRHEAFS is available. Activity is released to the environment directly from the reactor-building vent or from the RB trucklock, at ground level. Fuel movement from 1 day to 5 days after reactor shut down will be considered. The activity release scenario is shown on the following sketch. The plant scenario file used with the computer program RADTRAD is detailed in the following sections. The only difference between release from the RB trucklock and release from the RB vent is the χ/Q to the Control Room. Therefore, computer runs are made only for the RB vent case. For the RB trucklock release case, the CR dose is determined from the RB vent release case by the ratio of the appropriate χ/Qs.

7.0 CALCULATION/ANALYSIS (Continued)

7.6 Case 4: FHA Dose Consequences With NO SGTS and NO CRHEAFS (Continued)

7.6.1 Case 4 Release Scenario (Continued)

Figure 7-4 FHA Case 4 Scenario: NO SGTS & NO CRHEAFS



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7.0 CALCULATION/ANALYSIS (Continued)

7.6 Case 4: FHA Dose Consequences With NO SGTS and NO CRHEAFS (Continued)

7.6.2 Case 4 Dose Analysis

1. Activity decay time = 24, 48, 72, 96, 120 hrs.
2. Release is unfiltered at ground level from the reactor building.
3. Control Room intake/exhaust rate = 1100 cfm [§5.2, #6]:

7.6.3 Case 4 RADTRAD Input Data

The computer program RADTRAD is used to determine the dose consequences to the control room (CR) and offsite at the exclusion area boundary (EAB) and at the low population zone (LPZ) based on the case 4 scenario. The normal ventilation system, which provides unfiltered outside air for the CR, the cable spreading room, the computer room, storage room, and corridor, will be in operation for the entire 30-day period. The input is described in the following sections.

Compartments

1. Refuel floor (3-Other)
   a. Volume = 700,000 ft^3 [§5.2, #1]
   b. Source term fraction = 1.0 (all the activity corresponding to the FHA equivalent power)
   c. Compartment features - none
2. Atmosphere (Environment)
3. Control Room = 34,280 ft^3 [§5.2, #4]

7.0 CALCULATION/ANALYSIS (Continued)

7.6 Case 4: FHA Dose Consequences With NO SGTS and NO CRHEAFS (Continued)

7.6.3 Case 4 RADTRAD Input Data (Continued)

Transfer pathways

1. Refuel floor to atmosphere
   a. Transfer mechanism – filter
   b. Flow rates and filter efficiencies (percent) [§7.2, #4][§7.6.2, #2]

Time (h)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	80600	0.0	0.0	0.0
2.0	0	0.0	0.0	0.0

2. Atmosphere to CR - intake
   a. Transfer mechanism – filter
   b. Flow rates and filter efficiencies (percent) [§7.6.2, #3]

Time (h)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	1100	0.0	0.0	0.0
720	0.0	0.0	0.0	0.0

3. Control Room to Atmosphere - exhaust
   a. Transfer mechanism – filter
   b. Flow rates and filter efficiencies (percent)

Time (h)	Flow Rate (cfm)	Aerosol	Elemental I	Organic I
0.0	1100	0.0	0.0	0.0
720	0.0	0.0	0.0	0.0

7.0 CALCULATION/ANALYSIS (Continued)

7.6 Case 4: FHA Dose Consequences With NO SGTS and NO CRHEAFS (Continued)

7.6.3 Case 4 RADTRAD Input Data (Continued)

Dose Locations

Location:	EAB	LPZ	Control Room
χ/Q (s/m^3): from RB vent [§5.2, #11]	0 hr: 2.61E-03 2 hrs: 0.0	0 hr: 2.58E-05 8 hrs: 0.0	0 hr: 1.85E-03 2 hrs: 0.0
Breathing rate (m^3/s) [§5.2, #10]	0 hr: 3.5E-04 8 hrs: 1.8E-04 24 hrs: 2.3E-04 720 hrs: 0.0	0 hr: 3.5E-04 8 hrs: 1.8E-04 24 hrs: 2.3E-04 720 hrs: 0.0	0 hr: 3.5E-04 720 hrs: 0.0
Occupancy [§5.2, #9]			0 hr: 1.0 24 hrs: 0.6 96 hrs: 0.4 720 hrs: 0.0

Source Term and Dose Conversion Factors

1. Nuclide inventory – User inventory: file "fha.nif" – [§7.3.3]
2. Plant power = 14.2, corresponding to damaged fuel rods [§7.1, #7]
3. Decay and Daughter Products – decay/daughter products
4. Iodine Chemical Fractions above water [§5.1, # 14]
   Aerosol = 0.0
   Elemental I = 0.57
   Organic I = 0.43
5. Release Fractions and Timing – user "rft" file – "fha.rft"
   Duration of release to refuel floor – essentially instantaneous = 1.0E-04 hr
   Noble gas fraction = 0.5000E-01 [§7.2, #2]
   Iodine fraction = 0.2500E-3 [§7.2, #1]
   Others = 0.0 [§7.2, #3]
   Delay (hours) = 24, 48, 72, 96, 120
6. Dose Conversion Factors – "fgr11&12.inp" (default)

7.0 CALCULATION/ANALYSIS (Continued)

7.6 Case 4: FHA Dose Consequences With NO SGTS and NO CRHEAFS (Continued)

7.6.4 Case 4 RADTRAD Input Files

The above data are used to define the RADTRAD plant scenario files for the fuel handling accident – case 4, "fha4a.psf" through "fha4e.psf". The scenario file reads the additional files for nuclide inventory, "fha.nif", the release fractions and timing, "fha.rft", and the dose conversion factors, "fgr11&12.inp". Copies of the computer files for case 4 are given in Appendix D1 - D5.

7.6.5 FHA Case 4 Dose Consequences

The estimated dose consequences due to FHA activity release with NO SGTS and NO CRHEAFS in operation are given below. The CR TEDE values from Appendix D are for release from the RB vent. The corresponding values for release from the RB trucklock are obtain by multiplying the run value by 0.534 [§7.5.5]

Table 7-4 FHA Case 4: Without SGTS & Without CRHEAFS – Dose Consequences

Decay Time *	Dose Interval **	EAB TEDE (rem)	LPZ TEDE (rem)	CR TEDE (rem)	
				RB vent	RB Trucklock
24 hours	0 – 2 hrs	6.54			
	0 – 720 hrs		6.46E-02	3.29	1.76
48 hours	0 – 2 hrs	4.93			
	0 – 720 hrs		4.87E-02	2.85	1.52
72 hours	0 – 2 hrs	4.23			
	0 – 720 hrs		4.18E-02	2.54	1.36
96 hours	0 – 2 hrs	3.78			
	0 – 720 hrs		3.73E-02	2.30	1.23
120 hours	0 – 2 hrs	3.42			
	0 – 720 hrs		3.38E-02	2.10	1.12

* Times are relative to the time after reactor shutdown when fuel movement commences.
** Intervals are post-accident

8.0 RESULTS

The radiological consequences of the fuel handling accident (FHA) assuming GE14 10 x 10 fuel assemblies are summarized below for the four combinations of the SGTS and CRHEAFS:

Case 1: SGTS is in operation, CRHEAFS is in operation
Case 2: SGTS is in operation, CRHEAFS ***is not*** in operation
Case 3: SGTS ***is not*** in operation, CRHEAFS is in operation,
Case 4: SGTS ***is not*** in operation, CRHEAFS ***is not*** in operation

The FHA total effective dose equivalents for each case are given below.

Table 8-1 Fuel Handling Accident TEDE

		Operation		**Dose (rem)**			
Release Point						**RB Vent ***	**RB trucklock***
Case	**Decay**	**SGTS**	**CRHEAFS**	**EAB**	**LPZ**	**CR**	**CR**
1	24 hrs	YES	YES	3.9E-01	1.3E-02	2.2E-05	2.2E-05
2	24 hrs	YES	NO	3.9E-01	1.3E-02	2.6E-05	2.6E-05
3a	24 hrs	NO	YES	6.5	6.5E-02	2.7	1.5
3b	48 hrs	NO	YES	4.9	4.9E-02	2.4	1.3
3c	72 hrs	NO	YES	4.2	4.2E-02	2.1	1.1
4a	24 hrs	NO	NO	6.5	6.5E-02	3.3	1.8
4b	48 hrs	NO	NO	4.9	4.9E-02	2.9	1.5
4c	72 hrs	NO	NO	4.2	4.2E-02	2.5	1.4
4d	96 hrs	NO	NO	3.8	3.7E-02	2.3	1.2
4e	120 hrs	NO	NO	3.4	3.4E-02	2.1	1.1
			Regulatory Limit	*6.3*	*6.3*	*5*	*5*

* For Cases 3 and 4, only.

8.0 RESULTS (CONTINUED)

It is seen in Table 8-1 that the estimated radiological consequences due to a design basis fuel handling accident at PNPS are below the regulatory limits in all cases if fuel is moved after 48 hours post-reactor shutdown, i. e., if fuel is moved 48 hours after reactor shutdown, neither SGTS nor CRHEAFS is required to be in operation. If SGTS is in operation, fuel movement is acceptable 24 hours after reactor shutdown with or without CRHEAFS in operation (case 1 and case 2). Without SGTS in operation, fuel movement prior to 48 hours after reactor shutdown is not acceptable (case 3a and case 4a).

APPENDICES – RADTRAD Computer Program Files

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