

Attachment 2

Fuel Handling Accident Dose Analysis

PROC./WORK PLAN NO. 5010.015	PROCEDURE/WORK PLAN TITLE: ENGINEERING CALCULATIONS	CHANGE:	001-02-1
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**ARKANSAS NUCLEAR ONE
CALCULATION COVER SHEET**

Calc. No.: 95-E-0031-01	Rev. No.: 2(2)
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Calc. Title: Fuel Handling Accident Dose Analysis

Unit: 2	Category: Q
System(s): RB,FB	
Calc. Type: NS	

Components: NA		
Comp Tag	Suffix	Comp Code

Topics:	
Plt Area:	Bldg. 2RB,2FB Elev. N/A
	Room N/A Wall
	Coordinates: N/A
Config. Checklist (per 5010.004) completed? (Y or N)	Y
Document Comment/Resolution Form completed? (Y or N)	Y

Abstract (Included Purpose/Results):
 This Calculation: Determines the offsite and Control Room dose consequences of a fuel handling accident occurring in either the containment or the spent fuel handling area. The results establish the minimum time delay for fuel movement. Revision 2 of this calculation revises the previous results for steam generator replacement and power uprate. Revision 2(1) incorporates the use of a new Control Room χ/Q (0-8 hour) value in the calculation and gives the skin dose in terms of "total" skin dose. Revision 2(2) incorporates the use of a new Control Room χ/Q (0-8 hour) value in the calculation and updated fuel source terms.

Pages Revised and/or Added: Rev. 2(2) changes marked w/ revision bars.

Purpose of Revision:
 The purpose of revision 2 is to reevaluate the fuel handling accident with a power level of 3087 Mwt for the Unit 2 power uprate and to include the updated Control Room χ/Q . Revision 2(1) incorporates the use of a new Control Room χ/Q (0-8 hour) value in the calculation and gives the skin dose in terms of "total" skin dose. Revision 2(2) incorporates the use of a new Control Room χ/Q (0-2 hour) value in the calculation.

Initiating Documents
ER 980528 E202, "Revise ANO2 Dose Calculations to Support Power Uprate".

Resulting Document(s)
SAR Section 15.1.23

Key Design Input Documents
Calculation 98-E-0029-01, Rev. 0
Calculation 95-E-0030-10, Rev. 0(2)
Engineering Report 98-R-2005-01

Verification Method: Design Review X Alternate Calculation _____ Qualification Testing _____
 Amends Calc(s): N/A
 Supersedes Calc(s): N/A
 Computer Software Used: TRANSACT

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Check if Additional Revisions: _____

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1 PURPOSE

The purpose of this calculation is to evaluate the offsite (Exclusion Area Boundary, EAB) and control room dose consequences of a fuel handling accident (FHA). This accident is postulated to occur either in the containment or in the spent fuel pool area. This calculation consolidates design basis data and addresses issues that were not addressed in previous evaluations of the fuel handling accident. These include:

- proposed relaxation of containment integrity requirements during fuel handling
- proposed relaxation of spent fuel building integrity requirements during fuel handling
- use of ICRP 30 Dose Conversion Factors
- use of power uprate (3087 Mwt) source terms obtained from the ORIGEN-II code
- updated Control Room χ/Q values (Calculation 95-E-0030-10, Revision 0(2)).

The following cases are analyzed:

- Case 1: This case evaluates the limiting fuel handling event for informational purposes: 1) Failure of an entire assembly (236 rods) in the fuel building with equipment hatch open, or 2) Failure of an entire assembly in the containment with the containment personnel or equipment hatch open. Analysis will be based on typical licensing basis assumptions for EAB and Control Room dose consequences. Offsite (EAB) and onsite doses will be calculated based on a puff release and Regulatory Guide 1.25 assumptions, the results are applicable to a fuel handling accident either inside the spent fuel building or the containment. Since the Technical Specifications restrict fuel handling operations until 100 hours after shutdown, a decay time of 100 hours is assumed.
- Case 2: Failure of an entire assembly (236 rods, 100 hours decay) in the containment or fuel building with credit for fuel pool ventilation and filtration system or containment purge filtration system. Calculation assumes that the equipment hatch is closed in the spent fuel building or the containment personnel airlock and equipment hatch are closed. Analysis will be based on typical licensing basis assumptions for EAB and Control Room dose consequences.
- Case 3: FHA in the fuel building with credit for the fuel pool ventilation and filtration system. Offsite and onsite doses will be calculated for failure of 60 fuel rods and a decay time 100 hrs.
- Case 4 FHA in the fuel building without credit for the fuel pool ventilation and filtration system. Offsite and onsite doses will be calculated for failure of 60 fuel rods and a decay time 100 hrs. Case 4 evaluates the ANO Unit 2 design basis fuel handling accident.

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2 Cycle dependent Parameters

Some of the parameters utilized in this calculation are based on the current fuel type and cycle exposure. Consequently, this calculation should be reviewed for adequacy each cycle. The following table lists the calculation parameters that are cycle-dependent along with the bounding values used in the analysis.

Calculation Parameter	Rationale
Rod internal pressure <1200 psig	Required by Regulatory Guide 1.25 (Position 1.b)
Core radial power peaking factor ≥ 1.65	ANO-2 Technical Specification, Section 3/4 9.1. Core radial power peaking factor ≥ 1.65 required by Regulatory Guide 1.25 (Position 1.e)
Peak linear power density ≤ 20.5 kW/ft	Peak linear power density ≤ 20.5 kW/ft required by Regulatory Guide 1.25 (Position 1)
Maximum fuel centerline temperature <4500°F	Required by Regulatory Guide 1.25 (Position 1)
Fuel batch average burnup for peak assembly $\leq 65,000$ MWD/MTU. [maximum isotopic inventory for 4 w/o or 5 w/o enrichment used]	Used in development of radionuclide source terms with the ORIGEN-II code. [Note: Fuel batch average burnup for peak assembly $\leq 25,000$ MWD/ton is required by Regulatory Guide 1.25 (Position 1)]
Maximum number of fuel rods damaged during a fuel handling accident = 236	Assumed value based on failure of all rods within a single assembly
Reactor and spent fuel pool water level sufficient to ensure 23 feet water coverage above any damaged fuel	Used in the basis for a decontamination factor of 100 for iodine per Regulatory Guide 1.25 (Position 1.c)
χ/Q at exclusion area boundary (0-2 hrs) $\leq 6.5 \times 10^{-4}$ sec/m ³	Used in calculating the dose consequences of fuel failures
Spent Fuel Building and containment exhaust filter removal efficiency for iodine = 90% for inorganic and 70% for organic	Removal efficiency for iodine per Regulatory Guide 1.25 (Position 1.j). Based on 2-inch charcoal bed depth.

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3 RESULTS

Standard Review Plan (SRP) 15.7.4 requires that the dose consequences of a FHA must be well within the limits given in 10CFR100. "Well within" is further defined in this SRP as 25% of the limits of 10CFR100. This results in an offsite dose limit of 6 rem to the whole body and 75 rem to the thyroid for the duration of the accident.

Case 1

The results for the limiting FHA: 1) FHA (236 rods, 100 hrs. decay) in the fuel building with equipment hatch open, or 2) FHA (236 rods, 100 hrs. decay) in the containment with the containment personnel or equipment hatch open are given below. Case 1 was evaluated for informational purposes. It is an event that is beyond the design basis and is not expected to meet dose limits given above.

Table 1.
CASE 1 - ANO UNIT 2 FHA
FHA with 100 hour delay and no ESF filtration

Dose Category	EAB (2hr) Rem	Control Room Rem
<i>Whole Body</i>	<i>3.928E-01</i>	<i>1.278E-02</i>
<i>Skin¹</i>	<i>1.475E+00</i>	<i>9.921E-01</i>
<i>Thyroid</i>	<i>2.081E+02</i>	<i>2.645E+00</i>

Case 2

This case evaluates a FHA (236 rods, 100 hours decay) in the containment or fuel building with credit for filtration. The results for Case 2 are given in Table 2

Table 2.
CASE 2 - ANO UNIT 2 FHA
FHA with filtration, 100 hour decay

Dose Category	EAB (2hr) Rem	Control Room Rem
<i>Whole Body</i>	<i>3.377E-01</i>	<i>9.329E-03</i>
<i>Skin¹</i>	<i>1.316E+00</i>	<i>7.247E-01</i>
<i>Thyroid</i>	<i>2.904E+01</i>	<i>3.481E-01</i>

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Case 3

The results for the 60-rod failure FHA in the fuel building with credit for the fuel pool ventilation and filtration system are given below.

**Table 3.
CASE 3 - ANO UNIT 2 FHA – 60 Rod Failure
FHA with filtration, 100 hour decay**

Dose Category	EAB (2 hr.) Rem	Control Room Rem
<i>Whole Body</i>	<i>8.586E-02</i>	<i>2.372E-03</i>
<i>Skin¹</i>	<i>3.345E-01</i>	<i>1.842E-01</i>
<i>Thyroid</i>	<i>7.381E+00</i>	<i>8.848E-02</i>

Case 4

The onsite and offsite doses for a 60-rod failure FHA in the fuel building without credit for the fuel pool ventilation and filtration system are given below. Case 4 results constitute the ANO Unit 2 design basis fuel handling accident.

**Table 4.
CASE 4 - ANO UNIT 2 FHA – 60 Rod Failure
FHA without filtration, 100 hour decay**

Dose Category	EAB (2 hr.) Rem	Control Room Rem
<i>Whole Body</i>	<i>9.985E-02</i>	<i>3.245E-03</i>
<i>Skin¹</i>	<i>3.750E-01</i>	<i>2.519E-01</i>
<i>Thyroid</i>	<i>5.289E+01</i>	<i>6.722E-01</i>

1 The "total" skin dose is reported, that is, the skin dose resulting from gamma radiation plus that resulting from beta radiation.

For the design basis FHA in which 60 rods are damaged, the EAB doses are within the regulatory limits without credit for filtration. For a case in which fewer rods are damaged, the resultant onsite and offsite doses are a direct ratio of the above results. For 16 failed rods with ESF filtration, the EAB Thyroid dose would be:

$$\text{EAB Dose} = \frac{16}{60} * 52.89 \text{ rem} = 14.1 \text{ rem}$$

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4 REFERENCES

1. 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 23, 1972.
2. NUREG-0800 (Standard Review Plan), Section 15.7.4, "Radiological Consequences of Fuel Handling Accidents", Revision 1, July 1981.
3. 10CFR 100.11, "Determination of Exclusion Area, Low Population Zone, and Population Center Distance", last amendment date - June 24, 1975.
4. Annals of the ICRP, ICRP 30 supplement to Part 1, July 1978.
5. Regulatory Guide 1.13, "Spent Fuel Storage Facility Design Basis", Revision 1, December 1975.
6. 10CFR, Part 50, Appendix A, Criterion 60, "Control of Releases to the Environment", January 1, 1987.
7. 10CFR, Part 50, Appendix A, Criterion 61, "Fuel Storage and Handling and Radioactivity Control", January 1, 1987.
8. NUREG-800, Standard Review Plan 2.3.4, "Short Term Dispersion Estimates for Accidental Atmospheric Releases", revision 1, July 1981.
9. NUREG/CR-5106, *User's Guide for the TACT5 Computer Code*, Appendix e, June 1988.
10. AP&L Memorandum entitled "Fuel Handling Accident (FHA) Re-analysis, NO-94-360, dated August 22, 1984, from Tony Mansell to A. B. McGregor.
11. NUREG/CR-5009, *Assessment of the Use of Extended Burnup Fuel in Light Water Reactors*, February 1988.
12. *Chart of the Nuclides*, Knolles Atomic Power Laboratory, Tenth Edition, Norman E. Holden and F. William Walker
13. *Table of Isotopes*, C. M. Lederer, J. M. Hollander, and I. Perlman, 6th Edition, John Wiley and Sons, New York, 1967
14. Regulatory Guide 1.52, "Design, Testing and Maintenance Criteria for Post Accident Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants", Rev. 2, 1978
15. Regulatory Guide 1.109, "Calculation of Annual doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance With 1 CFR 50, Appendix I", Revision 1, 1977
16. ANO Calculation No. 91-E-0017-01
17. ANO Unit-2, Technical Specifications
18. Procedure 1104.034, Rev. 20, Control Room Air Conditioning, 9/18/92
19. Procedure 2104.034, Rev. 14, Control Room Air Conditioning and Ventilation, 7/11/91
20. Procedure 2104.007, Rev. 12, Control Room Emergency Air Conditioning and Ventilation, 9/18/92

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21. Procedure 5120.421, Rev. 0, "Inplace Leak Testing of Ventilation Systems Containing HEPA and Carbon Filters".
23. Report No. 92-R-2018-01, Justification for a Mixed Containment, 7/31/92
24. Calc. A-22, RB Net Free Volume, Rev. 1, 5/2/75
25. MCS-88-0717, AP&L letter to Bill Watson, from Bill Eaton, Subject: Revised Control Room LOCA Doses, 10/6/88
26. ANO2 SAR Table 15.1.23-1 and 15.1.23-2, Amendment No. 12
27. Standard Review Plan 6.4, "Control Room Habitability System", Rev. 2, July 1981
28. Calculation No. J-20, "Site Boundary Dose For Revised Fuel Handling Accident".
29. Calc. A-28, "RBSS Sprayed Volume", Rev. 0, 7/22/77
30. Calc. J-27, "Fuel Handling Accident", Rev. 0, 4/12/79 (Mech/Nuclear Calc. 111)
31. ANO2 SAR Section 15.1.23, Amendment No. 12
32. Murphy and Campe, "Nuclear Power Plant Control Room Ventilation System Design for Meeting General Design Criterion 19", August 1974
33. TRANSACT Computer Code, CDP 93-C-0003-01, Rev. 1
34. Calculation No. 98-E-0029-01, "ANO-2 Power Uprate Source Terms for LOCA, Non-LOCA, and FHA".
35. ANO Calculation No. 88E-1030-01
36. ANO Unit 2 FSAR, Amendment 12, Table 1.3-1
37. Interoffice Memorandum, CEO-95/00095, dated 3/21/95, from D. L. Smith to J. W. Cotton, "Maximum Cold Internal Pressure of a PWR Fuel Rod"
38. Calculation 95-E-0030-10, Rev. 0(2), "Control Room Atmospheric Dispersion Factors for Non-LOCA Accidents at ANO Units 1 & 2, August 23, 1999.
39. Engineering Report 98-R-2005-01, Rev. 5, "ANO-2 Cycle 15/16 Safety Analysis Groundrules".
40. ANO-2 Technical Specification, Section 3/4 9.1.

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5 CURRENT LICENSING BASIS

The current licensing basis for a FHA is given in Revision 33 to the ANO-2 FSAR. FSAR Section 15.1.23 provides a discussion of the FHA, methods of analysis and analytical results. The primary assumptions used in this analysis were obtained from Regulatory Guide 1.25. The FHA analyses considered two basic cases: (1) A postulated fuel drop which results in the damage to 60 fuel rods [four rows], and (2) A postulated fuel drop which results in the damage to 16 fuel rods [failure of outer row]. An additional case was evaluated to demonstrate compliance with the requirements of Regulatory Guide 1.13. This case assumed the failure of 236 rods (failure of all rods in an assembly).

6 ASSUMPTIONS AND DATA

6.1 General Regulatory Requirements

Reference 2 gives the acceptance criteria related to the radiological consequences of a fuel handling accident:

1. The calculated whole-body and thyroid doses at the exclusion area and low population zone boundaries are to be "well within" the guidelines of 10CFR100.11 (Reference 3: 300 Rem to the thyroid, 25 Rem to the whole body). Reference 2 states that "well within" means $\leq 25\%$ of the 10CFR100.11 limits. This is given as 75 Rem to the thyroid and 6 Rem¹ to the whole-body.
2. The calculated dose shall incorporate the appropriate conservative assumptions stated in Regulatory Guide 1.25 (Reference 1) with the exception of the atmospheric dispersion factors (i.e., χ/Q values) which should be determined in accordance with Standard Review Plan 2.3.4 (Reference 8).

A discussion of the Regulatory Guide 1.25 assumptions is provided in Sections 6.2 through 6.5. A discussion of the application of Standard Review Plan 2.3.4 methodology is given in Section 6.6.

The acceptance criteria for a fuel handling accident with regard to control room doses is given in 10CFR50, Appendix A, General Design Criterion (GDC) 19. The regulatory guidance given in GDC 19 states that adequate radiation protection shall be provided to permit access and occupancy of the control room under accident conditions without personnel receiving radiation exposures to any part of the body in excess of 5 rem whole body, or its equivalent to any part of the body, for the duration of the accident.

¹Actually, 25% of 25 Rem is 6.25 Rem. However, since Reference 2 defines 25% of 25 Rem as 6 Rem, this analysis will use 6 Rem as the limit.

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Standard Review Plan 6.4 (Reference 27) further defines the control room dose limit as 5 rem whole body and 30 rem thyroid or skin dose.

6.2 Regulatory Guide 1.25: Overview

The basic assumptions given in Regulatory Guide 1.25 are related to the following:

1. The manner of calculating the quantity of activity (both iodines and noble gases) released to the containment, spent fuel building, or the environment. Guidance is provided on calculating the following:
 - the fission product inventory within the fuel pellets
 - the fraction of the fuel pellet fission product inventory which is released from the fuel pellets to the pellet/cladding gap and consequently available for release to the pool water following cladding failure
 - the pool decontamination factors for the fission products
 - the iodine removal efficiencies for plant adsorbers/filters

Additional details of these assumptions are given in Section 6.3.

2. The manner of calculating the thyroid dose based on the curies of iodine released into the environment. Details of these calculations are given in Section 6.4.
3. The manner of calculating the whole-body dose based on the curies of noble gas released into the environment. Details of these calculations are given in Section 6.5.

6.3 Regulatory Guide 1.25: Activity Releases

The major guidance and assumptions related to the quantity of activity released are as follows:

1. *Requirement:* The accident occurs at the earliest time that fuel handling can begin as allowed by the Technical Specifications. Radioactive decay of the fission product inventory during the interval between shutdown and the commencement of fuel handling is taken into consideration.

Response: Based on the current revision of Technical Specification 3.9.3.a, the minimum subcritical time before fuel movement is 100 hours.

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2. *Requirement:* The maximum fuel rod pressurization (after the above decay time) is 1200 psig.

Response: FSAR Section 15.1.23.2.2 states that the maximum fuel rod pressure 100 hours after a refueling shutdown will be less than 1,200 psig. This statement is supported by the Fuel Handling Accident Re-analysis given in memorandum NO-84-360 (Reference 10). This re-analysis was performed to determine if the dose consequences of a fuel handling accident were increased for fuel assemblies with an average burnup of 60,000 MWD/MTU rather than the 25,000 MWD/MTU burnup given in Regulatory Guide 1.25. This evaluation concluded that the maximum fuel rod pressure would be 1,192 psig with an average burnup of 60,000 MWD/MTU. Conservatism in the calculation methodology are given in the referenced memo. Reference 37 states that the maximum fuel rod pressure during refueling will be less than 1,200 psig if the hot internal pressure is less than the reactor operating pressure. Fuel rod pressure during refueling for CY-16 (power uprate) fuel would also be less than 1200 psig based on a burnup of 65,000 MWD/MTU.

3. *Requirement:* The minimum water depth between the top of the damaged fuel rods and the fuel pool surface is 23 feet.

Response: This water level is required to allow the use of an overall decontamination factor for iodine of 100 (i.e., 1% of the iodine released to the pool will escape from the pool and 99% will be retained in the pool). The pool decontamination factor for noble gases is 1 (i.e., no noble gases retained in the pool water). The minimum depth of water above the potentially damaged fuel rods is as follows:

Containment	23 ft	Technical Specification 3.9.9
Fuel Pool	23 ft	Technical Specification 3.9.10

Consequently the use of a water coverage of 23 feet is conservative relative to the actual water coverage. Therefore, the iodine decontamination factor given in the Regulatory Guide is also conservative.

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4. *Requirement:* All of the gap activity in the damaged rods is released and consists of 10% of the total noble gas other than Kr-85, 30% of the Kr-85, and 10% of the total radioactive iodine in the rods at the time of the accident. For the purpose of sizing filters for the fuel handling accident addressed in this guide, 30% of the I-127 and I-129 inventory is assumed to be released from the damaged fuel.

Response: NUREG/CR-5009 (Reference 11) discusses the variations in plenum inventories for extended burnup fuel. Table 3.6 of Reference 11 indicates that the I-131 inventory is 20% higher than in Regulatory Guide 1.25 for rod burnups of 60 GWD/MTU. Therefore the gap activity for iodine is assumed to be 12%. The use of 30% of the I-127 and I-129 inventory is not used since this is specified in Regulatory Guide 1.25 only for filter sizing.

Noble Gas Release (except Kr-85)	10%
Kr-85 Release	30%
Radioactive Iodine Release	12%

5. *Requirement:* The values used for individual fission product inventories are calculated assuming full power operation at the end of core life immediately proceeding shutdown and such calculation should include an appropriate radial peaking factor. The minimum acceptable radial peaking factor is 1.65 for PWR's.

Response: This analysis uses the source terms developed by use of the ORIGEN-II code [34]. Uprate (CY-16) power at ANO Unit 2 is 3026 Mwt [39]. The FHA source terms are based on 102% of rated (i.e., 3087 Mwt) and a radial peaking factor of 1.70. The radial peaking factor is consistent with Regulatory Guide 1.25, which specifies a minimum radial peaking factor of 1.65.

6. *Requirement:* The fission products which are assumed to be released to the containment/auxiliary building atmosphere are assumed to escape into the environment within two hours.

Response: All releases of fission products to the environment are assumed to occur over a two hour time period. Also, this calculation conservatively assumes that there is no decay of the fission products during residency in the containment or auxiliary building. Two-hour χ/Q factors are used to calculate the offsite doses.

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7. *Requirement:* If it can be shown that the building atmosphere is exhausted through adsorbers designed to remove iodine, the removal efficiency is 90% for inorganic iodine and 70% for organic species. [This is based on a 2-inch charcoal bed depth with 1/4-second residence time.]

Response: Iodine filter efficiencies of 90% for inorganic iodine and 70% for organic species are used in this calculation. This assumption is conservative since the ANO Technical Specifications (3.9.4 and 3.9.11) require filter efficiencies of ≥ 99.95 when tested in-place with a halogenated hydrocarbon refrigerant test gas. The Technical Specifications also require testing on an 18 month interval and these tests are performed in accordance with the criterion of Regulatory Guide 1.52 (Reference 14) for activated charcoal beds of 2 inches or more.

This calculation will use the following iodine filter removal efficiencies:

Inorganic	90%
Organic	70%

8. *Requirement:* The iodine gap inventory is composed of inorganic species (99.75%) and organic species (0.25%).

Response: The analysis will use these assumptions:

Inorganic Iodine	99.75%
Organic Iodine	0.25%

9. *Requirement:* The pool decontamination factors for the inorganic and organic species are 133 and 1, respectively, giving an overall effective decontamination factor of 100 (i.e., the pool water retains 99% of the total iodine released from the damaged rods). This difference in decontamination factors for inorganic and organic iodine species results in the iodine above the fuel pool being composed of 75% inorganic and 25% organic species.

Response: The analysis will use these assumptions:

Inorganic Iodine DF	133
Organic Iodine DF	1

10. *Requirement:* The retention of noble gases in the pool is negligible (i.e., decontamination factor of 1).

Response: The analysis will use this assumption. [Noble Gas Pool DF = 1]

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11. **Requirement:** The effluent from the filter system passes directly to the emergency exhaust system without mixing (credit for mixing will be allowed in some cases: the amount of credit will be evaluated on an individual case basis) in the surrounding building atmosphere and is then released (as an elevated plume for those facilities with stacks). Credit for an elevated release will be given only if the point of release is (a) more than two and one-half times the height of any structure close enough to affect the dispersion of the plume or (2) located far enough from any structure which could affect the dispersion of the plume.

Response: Credit for mixing in the containment and spent fuel building atmosphere is taken for the FHA inside the containment (Case 3). This case was performed to determine the effect of mixing on the offsite and control room doses. For all other cases evaluated, credit for mixing is not taken. Releases are assumed to be ground level releases.

The guidance provided in Regulatory Guide 1.25 states that the above assumptions are only applicable if the following three conditions are met. These conditions are primarily related to the fraction of fission products that are released to the fuel/cladding gap. If any condition is not met, the impact of this on the above assumptions will need assessment. As shown below, all conditions are met for ANO Unit 2 or suitable adjustments in the release fractions are provided.

1. **Requirement:** The peak linear heat generation rate (LHGR) is not to exceed 20.5 kW/ft.

Response: The ANO Unit 2 Technical Specifications 2.1.1.2 limits the LHGR to 21.0 kW/ft. This value represents the maximum overpower (accident) thermal output. During normal operations, the maximum thermal output, which is appropriate for a fuel handling accident, is 12.7 kW/ft (Reference 36). Even this value would only be reached for low burnup fuel. For the CY-16 (power uprate) fuel, the target linear heat rate limit of the hot rod at hot full power is 13.7 kW/ft. Therefore, fuel centerline melting is not a concern and the assumptions of Regulatory Guide 1.25 are applicable.

2. **Requirement:** The maximum fuel centerline temperature is to be less than 4500°F.

Response: The peak centerline temperature is 2000°F (Reference 10, page 4) for a fuel burnup of 60 GWD/MTU. Reference 36 gives a maximum fuel centerline temperature of 3420°F at 100% power. For CY-16, the fuel maximum centerline temperature should be bounded by the Regulatory

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Guide condition of 4500°F. Therefore, the Regulatory Guide assumptions related to fission products that are released to the fuel/cladding gap are valid for this calculation.

3. *Requirement:* The average burnup of the peak bundle is less than 25,000 MWd/t.

Response: The average burnup of the peak bundle is assumed to be 65 MWd/MTU for the CY-16 (power uprate) fuel. Higher fuel burnup has been shown to have no effect on the internal fuel rod pressure up to a burnup of 60 MWd/MTU (Reference 10). However, there may be an increase in fuel rod gap inventory for high burnup fuel.

NUREG/CR-5009 (Reference 11) discusses the variations in plenum inventories for extended burnup fuel. Table 3.6 of Reference 11 indicates that the I-131 inventory is 20% higher than in Regulatory Guide 1.25 for rod burnups of 60 GWd/t. For rod burnups of 33 GWd/t, the NUREG predicts an I-131 release fraction of 0.04 which is well below the Regulatory Guide 1.25 guidance. A linear interpolation between the values reported in the NUREG, indicates that the release fractions given in Regulatory Guide 1.25 are applicable to peak rod burnups of up to 53.25 MWd/MTU. Since the peak rod burnup is assumed to be 65 MWd/MTU (65 GWd/t), a release fraction of 0.135 will be used (see calculation below).

NUREG /CR-5009 iodine release fractions as a function of burnup. [See Table 3.6, page 3-12, of NUREG /CR-5009]

i:=0..1

Release _i :=	Burnup _i :=
0.04	33
0.12	60

For the RG 1.25 iodine release fraction of 0.1, the corresponding burnup is:

$$\text{linerp}(\text{Release}, \text{Burnup}, 0.1) = 53.25$$

The iodine release fraction for a burnup of 65 Gwd/t (rod average) is:

$$\text{linerp}(\text{Burnup}, \text{Release}, 65) = 0.135$$

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6.4 Regulatory Guide 1.25: Thyroid Dose Calculations

The methodology given in Regulatory Guide 1.25 for determining the thyroid dose is to calculate the dose for each individual iodine isotope using the formula given below. The total thyroid dose is obtained by summing the dose due to the individual isotopes.

The Thyroid dose is given by:

$$D_{thy} = \sum_i D_{thy,i} = \frac{F_g * I_i * F * P}{DF_{p,i} * DF_{f,i}} * B * R_i * \frac{\lambda}{Q}$$

Or,

$$D_{thy,i} = \text{Curies Released to the environment} * B * R_i * \frac{\lambda}{Q}$$

Where :

$D_{thy,i}$ = Thyroid dose for isotope i

F_g = Fraction of fuel rod inventory in the fuel rod void space (0.1 per RG 1.25)

I_i = Core iodine inventory, of isotope i, at time of accident (curies)

F = Fraction of core damaged so as to release void space iodine

P = fission product peaking factor

B = Breathing rate ($3.47 \times 10^{-4} \text{ m}^3/\text{sec}$)

R_i = Dose conversion factor for isotope i (rads/Ci)

$\frac{\lambda}{Q}$ = atmospheric diffusion factor at receptor location (sec/m^3)

$DF_{p,i}$ = effective iodine decontamination factor for pool water for isotope i

$DF_{f,i}$ = effective iodine decontamination factor for filters for isotope i

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The site boundary thyroid dose is given by:

$$D_{thy,i} = \frac{\chi}{Q} R_i * BR * DCF_i$$

Where :

$D_{thy,i}$ = Thyroid dose for isotope i (rem)

$\frac{\chi}{Q}$ = atmospheric diffusion factor at receptor location (sec/m³)

R_i = Activity of radionuclide i released from pool (Ci)

BR = Breathing rate (3.47x10⁻⁴ m³/sec)

DCF_i = Dose conversion factor for isotope i (rem/Ci)

$$D_{thy,i} = 6.5 * 10^{-4} \frac{\text{sec}}{\text{m}^3} * R_i (\text{Ci}) * 3.47 * 10^{-4} \frac{\text{m}^3}{\text{sec}} * DCF_i \left(\frac{\text{rem}}{\text{Ci}} \right)$$

The control room thyroid dose is determined as follows:

$$D_{CR,thy,i} = A_{CR,i} * BR * DCF_i$$

Where :

$D_{CR,thy,i}$ = Thyroid dose for isotope i (rem)

$A_{CR,i}$ = Activity of isotope i in control room (Ci)

BR = Breathing rate (3.47x10⁻⁴ m³/sec)

DCF_i = Dose conversion factor for isotope i (rem/Ci)

The concentration of isotope i at the control room intake is given by :

$$A_{intake,i} = \frac{\chi}{Q} * R_i$$

Where :

$\frac{\chi}{Q}$ = control room atmospheric diffusion factor

R_i = release rate of radionuclide i from pool

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The revised FHA analysis will use the dose conversion factors given in the TACT5 User's Guide (Reference 9). These dose conversion factors are consistent with ICRP 30 and the dose conversion factors used in the maximum hypothetical accident (Reference 16). The Thyroid dose conversion factors used are as follows:

TACT5 Thyroid Dose Conversion Factors

Isotope	Dose Conversion Factors - Rem/Ci Inhaled
	TACT5
I-130	7.40e+04 ²
I-131	1.10e+06
I-132	6.30e+03
I-133	1.80e+05
I-134	1.10e+03
I-135	3.10e+04

²The dose conversion factor for I-130 is not given in Reference 9. This factor is taken from Reference 4 with the following conversion:

$$2 * 10^{-8} \frac{\text{Sievert}}{\text{Bq}} * \frac{100 \text{ Rem}}{\text{Sievert}} * \frac{1 \text{ Bq}}{2.703 * 10^{-11} \text{ Ci}} = 7.40 * 10^4 \frac{\text{Rem}}{\text{Ci}}$$

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6.5 Regulatory Guide 1.25: Whole Body Dose Calculation

The methodology given in Regulatory Guide 1.25 for determining the whole-body dose is to calculate the dose for each individual isotope using the formula given below. The total whole-body dose is obtained by summing the dose due to the individual isotopes.

The Whole-body dose is given by:

$$\beta \text{ Whole Body Dose (rad)} = 0.23 * \bar{E}_\beta * \chi$$

$$\gamma \text{ Whole Body Dose (rad)} = 0.25 * \bar{E}_\gamma * \chi$$

Where :

\bar{E}_β = Average β energy per disintegration (Mev/dis)

\bar{E}_γ = Average γ energy per disintegration (Mev/dis)

χ = Concentration time integral (curies * sec/ m³)

$$= \text{curies of Activity} * \frac{\chi}{Q}$$

$\frac{\chi}{Q}$ = atmospheric diffusion factor at receptor location (sec/ m³)

The whole-body dose at the exclusion area boundary can be found by use of the following formula:

$$Dose (Rem) = \frac{\chi}{Q} * (Dose Factors) * (Curies Released)$$

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The control room whole-body dose can be found by use of the following formulas:

$$Dose_{CR-WB} (Rem) = \left(\frac{DCF_{Gamma}}{GF} \right) * A_{CR} * \frac{Occ}{V_{CR}} * \delta t$$

$$Where : GF = \frac{1173}{V^{0.338}} = \frac{1173}{(40,000)^{0.338}} = 32.643877 \text{ See ref.32}$$

Occ = Control Room Occupancy

V_{CR} = Volume of Control Room

A_{CR} = Average Activity in Control Room

$$Dose_{CR-Skin} (Rem) = \left(\frac{DCF_{Gamma}}{GF} + DCF_{Beta} \right) * A_{CR} * \frac{Occ}{V_{CR}} * \delta t$$

$$Dose_{EAB-WB} (Rem) = \frac{\chi}{Q} * (DCF_{Gamma}) * (Curies Released)$$

$$Dose_{EAB-Skin} (Rem) = \frac{\chi}{Q} * (DCF_{Beta}) * (Curies Released)$$

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The original ANO Fuel Handling Accident dose analysis used dose conversion factors obtained from Regulatory Guide 1.109 (Reference 15). The revised analysis will use the dose conversion factors given in the Tact5 User's Manual (Reference 9). This is consistent with ICRP 30 and the dose conversion factors used in the maximum hypothetical accident (Reference 16).

The ICRP 30 whole body gamma and beta dose conversion factors from TACT5 are as follows:

TACT5 (ICRP 30) Dose Conversion Factors

Isotope	Dose Conversion Factors		
	Whole Body Gamma Rem-m ³ /Ci-sec	Skin Beta Rem-m ³ /Ci-sec	Skin Gamma Rem-m ³ /Ci-sec
Kr-83m	1.27e-05	0.00e+00	1.36e-04
Kr-85m	2.31e-02	4.97e-02	3.20e-02
Kr-85	3.31e-04	4.84e-02	4.75e-04
Kr-87	1.33e-01	3.36e-01	1.85e-01
Kr-88	3.38e-01	7.76e-02	4.69e-01
Kr-89	3.03e-01	3.47e-01	4.21e-01
Xe-131m	1.25e-03	1.33e-02	2.71e-03
Xe-133m	4.29e-03	2.96e-02	7.00e-03
Xe-133	4.96e-03	9.67e-03	7.89e-03
Xe-135m	6.37e-02	2.14e-02	9.16e-02
Xe-135	3.59e-02	6.32e-02	5.07e-02
Xe-137	2.83e-02	4.59e-01	4.02e-02
Xe-138	1.87e-01	1.47e-01	2.61e-01
I-130			
I-131	5.59e-02	3.07e-02	7.95e-02
I-132	3.55e-01	1.10e-01	5.07e-01
I-133	9.11e-02	8.90e-02	1.31e-01
I-134	4.11e-01	1.42e-01	5.86e-01
I-135	2.49e-01	7.86e-02	3.52e-01

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6.6 Atmospheric Dispersion Factors

Standard Review Plan 2.3.4 (Reference 8) states that the atmospheric dispersion factor (i.e., χ/Q) can be determined on a probabilistic basis using the χ/Q value which will not be exceeded 95% of the time. Since the fuel handling accident assumes the release of all fission products to the environment over a two hour period, the two hour χ/Q values are used in this analysis. The two hour χ/Q values are as follows:

Control Room (0-2 hr)	$1.20 \times 10^{-3} \text{ sec/m}^3$	[Reference 38]
Exclusion Area Boundary, EAB, (0-2 hr)	$6.5 \times 10^{-4} \text{ sec/m}^3$	(Unit 2 FSAR, Table 15.1.0-5)

Since the offsite dose limits of 75 Rem thyroid and 6 Rem whole-body are to be applied to both the exclusion area boundary and the low population zone, the offsite dose consequences of a fuel handling accident are most limiting at the exclusion area boundary due to the higher χ/Q value. On this basis, this calculation will consider only the dose consequences for the control room and the EAB.

6.7 Data

In the event that radioactivity is detected in the Unit 1 control room and/or the Unit 2 control room normal ventilation intake (Ref. 4), both Unit 1 and Unit 2 emergency ventilation systems are initiated. One of the two systems is subsequently shutdown as one is sufficient to maintain habitability. Although both systems meet the design intent for control room habitability, the Unit 1 ventilation system is limiting since it has a 2 inch recirculation charcoal bed compared to a 4 inch bed on the Unit 2 system. Therefore, in the control room analysis, the Unit 1 system was assumed to be operating and per the guidelines of Regulatory Guide 1.52 a 95% recirculation filter efficiency was used. Control room doses resulting from the FHA assumes that the control room recirculation charcoal absorber filter efficiency is 95% based on the limiting unit, Unit 1, which has a 2 inch charcoal absorber.

The data used in the evaluation of control room doses is given below:

Parameter	Input	Reference
Control Room Volume	$4.00 \times 10^4 \text{ ft}^3$	88E-0130-01
CR unfiltered inleakage	10 cfm	Regulatory Guide 1.78
CR filtered inleakage	333 cfm	2104.007
CR out leakage	343 cfm [333 + 10 cfm]	N/A
CR recirculation	1667 cfm	2104.007
CR occupancy factor		
0-24 hrs.	1.0	Murphy and Campe (Ref. 32)
Breathing Rate (CR)	3.47×10^4	

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Control Room χ/Q			
0-2 hrs.	1.20×10^{-3}		Reference 38
CR filter efficiency			
recirc (2" filter)	95%		Regulatory Guide 1.52
intake (2-2" filters)	99%		Regulatory Guide 1.52

Additional FHA Input Data

<u>Parameter</u>	<u>Input</u>	<u>Reference</u>
Dose evaluation points	EAB and Control Room	N/A
Power level	3087 MWt	
Fuel Release Fraction		
Noble Gases (except Kr-85)	10%	Regulatory Guide 1.25
Kr-85	30%	Regulatory Guide 1.25
Halogens	13.5%	NUREG/CR 5009
Plate out	0%	not considered
Iodine Form		
Inorganic	99.75%	Regulatory Guide 1.25
Organic	0.25% "	Regulatory Guide 1.25
Offsite χ/Q		
EAB 0-2 hrs.	6.5×10^{-4}	FSAR Table 15.1.0-5
Breathing Rate (offsite)		Regulatory Guide 1.4
0-8 hrs.	3.47×10^{-4}	
Pool Decontamination Factors		
Inorganic Iodine	133	Regulatory Guide 1.25
Organic Iodine	1	Regulatory Guide 1.25
Fuel Handling Building (or Containment) filter iodine removal efficiencies (2 inch charcoal)		
Inorganic	90 %	(Regulatory Guide 1.25)
Organic	70 %	

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7 CALCULATIONS

The fraction of activity remaining as a function of time after shutdown (relative to activity at shutdown) is shown below. As seen, the only significant isotopes remaining at the minimum time after shutdown (100 hrs) at which fuel movement could occur are I-131, I-133, Kr-85, Xe-131m, Xe-133m, and Xe-133.

Table 5.

Isotope	Half-life ³	Decay Constant (hr ⁻¹)	Days After Shutdown			
			3	6	9	12
I-130	12.4 hr	5.5899e-02	1.79e-02	3.19e-04	5.70e-06	1.02e-07
<i>I-131</i>	<i>8.065 d</i>	<i>3.5810e-03</i>	<i>7.73e-01</i>	<i>5.97e-01</i>	<i>4.61e-01</i>	<i>3.57e-01</i>
I-132	2.284 hr	3.0348e-01	3.24e-10	1.05e-19	3.40e-29	1.10e-38
<i>I-133</i>	<i>20.8 hr</i>	<i>3.3324e-02</i>	<i>9.08e-02</i>	<i>8.24e-03</i>	<i>7.48e-04</i>	<i>6.79e-05</i>
I-134	52.3 m	7.9520e-01	1.36e-25	1.86e-50	2.54e-75	3.46e-100
I-135	6.7 hr	1.0345e-01	5.82e-04	3.39e-07	1.97e-10	1.15e-13
Kr-83m	1.86 hr	3.7266e-01	2.22e-12	4.95e-24	1.10e-35	2.45e-47
Kr-85m	4.4 hr	1.5753e-01	1.19e-05	1.41e-10	1.67e-15	1.98e-20
<i>Kr-85</i>	<i>10.74 yr</i>	<i>7.3674e-06</i>	<i>9.99e-01</i>	<i>9.99e-01</i>	<i>9.98e-01</i>	<i>9.98e-01</i>
Kr-87	76 m	5.4722e-01	7.74e-18	5.99e-35	4.64e-52	3.59e-69
Kr-88	2.79 hr	2.4844e-01	1.70e-08	2.90e-16	4.95e-24	8.43e-32
Kr-89	3.18 m	1.3078e+01	0.00e+00	0.00e+00	0.00e+00	0.00e+00
<i>Xe-131m</i>	<i>11.96 d</i>	<i>2.4148e-03</i>	<i>8.40e-01</i>	<i>7.06e-01</i>	<i>5.94e-01</i>	<i>4.99e-01</i>
<i>Xe-133m</i>	<i>2.26 d</i>	<i>1.2779e-02</i>	<i>3.98e-01</i>	<i>1.59e-01</i>	<i>6.33e-02</i>	<i>2.52e-02</i>
<i>Xe-133</i>	<i>5.27 d</i>	<i>5.4803e-03</i>	<i>6.74e-01</i>	<i>4.54e-01</i>	<i>3.06e-01</i>	<i>2.06e-01</i>
Xe-135m	15.7 m	2.6490e+00	1.48e-83	2.18e-166	3.21e-249	0.00e+00
Xe-135	9.16 hr	7.5671e-02	4.30e-03	1.85e-05	7.97e-08	3.43e-10
Xe-137	3.82 m	1.0887e+01	0.00e+00	0.00e+00	0.00e+00	0.00e+00
Xe-138	14.2 m	2.9288e+00	2.62e-92	6.89e-184	1.81e-275	0.00e+00

As shown above, the only significant isotopes that need to be considered at 100 hrs after shutdown are I-131, I-133, Kr-85, Xe-131m, Xe-133m, and Xe-133.

³Data from "Chart of the Nuclides", Tenth Edition, (Reference 12)

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REV.	DATE	BY	CHK'D			

7.1 Calculation Procedure

The fuel gap activity has been determined for the CY-16 fuel [Ref. 34]. From this data, the activity released to the environment is determined based on the isotopic form in the fuel, the isotopic pool decontamination factors and building filter efficiencies as applicable. The offsite and control room doses are calculated using the TRANSACT computer code. TRANSACT (Reference 9 and 33) is a Fortran computer code designed to model the transport of radionuclides through various compartments, the release to the environment, and the resulting onsite and offsite doses.

7.2 Radionuclide Source Terms

Fuel Gap activity is determined as follows:

$$A_{\text{gap},i} = A_{\text{fuel},i} * 13.5\% \text{ For Iodines}$$

$$A_{\text{gap},i} = A_{\text{fuel},i} * 10\% \text{ For Noble Gases except Kr 85}$$

$$A_{\text{gap},i} = A_{\text{fuel},i} * 30\% \text{ For Kr 85}$$

Since the Technical Specifications restrict fuel handling operations until 100 hours after shutdown, the only significant isotopes which will be considered are Kr-85, I-131, I-133, Xe-131m, Xe-133m and Xe-133.

Table 6.
Fuel Gap Activity at 100 hours Delay

Isotope	Fuel Activity ⁶ at t=100 hr (Ci)	Gap Activity at 100 hrs (Ci)
Kr-85	1.076E+04	3.228E+03
Xe-131m	9.543E+03	9.543E+02
Xe-133m	2.121E+04	2.121E+03
Xe-133	1.088E+06	1.088E+05
I-131	6.117E+05	8.258E+04
I-133	5.856E+04	7.906E+03

⁶Reference 34

2(2)	9/21/2000	MAM	JGM	 Energy Operations ARKANSAS NUCLEAR ONE	CALCULATION NUMBER	
2(1)	1/17/00	JGM	MAM		95-E-0031-01	
2	5/06/99	MAM	KLA		PAGE NUMBER	Page <u>24</u> of <u>27</u>
1	11/10/95	MAM	JWC			
0	2/28/95	MAM	JWC			
REV.	DATE	BY	CHK'D			

The gap activity for 60 failed fuel rods is obtained as a ratio of the gap activity for 236 rods.

$$\text{Gap activity (60 rods)} = \text{Gap Activity (236 rods)} * \frac{60}{236}$$

Table 7.
Fuel Gap Activity
60 Rods, 100 hour Delay

Isotope	Fuel Activity ⁶ at t=100 hr for 236 rods (Ci)	Gap Activity at 100 hrs for 236 rods (Ci)	Gap Activity at 100 hrs for 60 rods (Ci)
Kr-85	1.076E+04	3.228E+03	8.207E+02
Xe-131m	9.543E+03	9.543E+02	2.426E+02
Xe-133m	2.121E+04	2.121E+03	5.392E+02
Xe-133	1.088E+06	1.088E+05	2.766E+04
I-131	6.117E+05	8.258E+04	2.099E+04
I-133	5.856E+04	7.906E+03	2.010E+03

Releases from the pool are given by:

$$R_{pool,i} = \frac{A_{gap,i} D_{gap,i}}{DF_{pool,i}}$$

Where:

$R_{pool,i}$ = Activity of isotope i released from pool (Ci)

$A_{gap,i}$ = Activity of isotope i in gap (Ci)

$D_{gap,i}$ = Distribution of isotope i (or isotopic form) in gap

2(2)	9/21/2000	MAM	JGM	 Entergy Operations ARKANSAS NUCLEAR ONE	CALCULATION NUMBER	
2(1)	1/17/00	JGM	MAM		95-E-0031-01	
2	5/06/99	MAM	KLA		PAGE NUMBER	Page <u>25</u> of <u>27</u>
1	11/10/95	MAM	JWC			
0	2/28/95	MAM	JWC			
REV.	DATE	BY	CHK'D			

The activity released from the pool is used as input to the TRANSACT Computer code. This activity is determined as follows:

$$A(\text{released}) = \frac{\text{Gap Activity}}{\text{Pool DF}} * \text{Species Fraction}$$

For TRANSACT input, the inorganic I₁₃₁ and I₁₃₃ activity released is :

$$A_{\text{inorganic}}(\text{released}) = \frac{\text{Gap Activity of Iodine}}{133} * 0.9975 = \text{Gap Activity of Iodine} * 7.5 * 10^{-3}$$

Where the inorganic species fraction is 0.9975

For organic Iodines, the TRANSACT input iodine species fraction is determined as follows :

$$A_{\text{organic}}(\text{released}) = \frac{\text{Gap Activity of Iodine}}{\text{Pool DF}} * 0.0025 = \frac{\text{Gap Activity of Iodine}}{1} * 0.0025 = \text{Gap Activity of Iodine} * 0.0025$$

Where the organic species fraction is 0.0025

For noble gases, all activity in the fuel-cladding gap is released from the pool.

7.3 FHA inside Containment or Spent Fuel Building Without Filtration (Case 1)

This case evaluates the consequences of the limiting fuel handling accident; failure of an assembly (236 rods, 100 hrs. decay) in either the fuel handling building or the containment without building integrity. A puff (2 hour) release is assumed with equipment hatch open in the spent fuel building or the containment equipment hatch open. This analysis will be based on typical licensing basis assumptions for EAB and Control Room dose consequences. Since this case is based on a puff release and typical regulatory guide assumptions, the results are applicable to a fuel handling accident either inside the spent fuel building or the containment. Input and output files for this case are given in Attachment 1.

7.4 FHA inside Containment or Spent Fuel Building With Filtration (Case 2)

This case evaluates the release of radioisotopes following a fuel handling accident with the equipment hatch open. This is the same basic scenario as Case 1 except that credit for fuel pool ventilation and filtration system or the containment purge system, is utilized. The radioisotopes released from the fuel gap of the damaged fuel pass through the pool water and are then released at the pool surface. At this point, the pool sweep system directs the airflow, and the radioisotopes released from the pool, to the fuel handling area ventilation system. This system is designed to remove radioiodine from the airflow to minimize the offsite dose consequences of a fuel handling accident. The fuel handling area ventilation system is designed to meet the requirements of Regulatory Guide 1.52. An iodine decontamination efficiency of 90% for elemental iodine and 70% is assumed based on the guidance in Regulatory Guide 1.25.

In the spent fuel building, the pool sweep system filters any activity released from the damaged fuel as it evolves from the pool. The fuel handling area ventilation system is required to be OPERATIONAL

2(2)	9/21/2000	MAM	JGM	 Entergy Operations ARKANSAS NUCLEAR ONE	CALCULATION NUMBER	
2(1)	1/17/00	JGM	MAM		95-E-0031-01	
2	5/06/99	MAM	KLA		PAGE NUMBER	Page <u>26</u> of <u>27</u>
1	11/10/95	MAM	JWC			
0	2/28/95	MAM	JWC			
REV.	DATE	BY	CHK'D			

whenever irradiated fuel is being moved in the storage pool and during crane operation with loads over the storage pool (Reference Technical specification 3.9.11). Activity removed by the pool sweep system is directed to the filtration system before it enters the atmosphere.

Inclusion of credit for the filtration system only affects the EAB and Control Room thyroid doses since the filters are ineffective in removal of noble gases. Due to the design and operation of the pool sweep system, no credit for mixing within the fuel handling building is considered. Input and output files for this case are given in Attachment 2.

7.5 FHA With 60 Rods Failed With Filtration (Case 3)

This case evaluates the offsite and onsite dose consequences of a fuel handling accident in which 60 fuel rods are damaged. The ANO Unit 2 Upper Level Document, ULD-2-TOP-02, Revision 0 (Reference 25) states that the number of fuel rods damaged during a fuel handling accident is 60 (4 layers of fuel rods) of the 236 rods in an assembly. The number of rods damaged is also given in FSAR Section 15.1.23 (Amendment 12).

The FHA is assumed to occur in the fuel handling building or the containment after 100 hours decay. Due to the design and operation of the pool sweep system, no credit for mixing within the fuel handling building is considered. Since the charcoal adsorber iodine removal efficiency for the fuel handling building and containment building filters are the same, a FHA in the fuel building will be limiting relative to release rate (no holdup due to mixing) and will be evaluated here. In the spent fuel building, the pool sweep system filters any activity released from the damaged fuel as it evolves from the pool. The fuel handling area ventilation system is required to be OPERATIONAL whenever irradiated fuel is being moved in the storage pool and during crane operation with loads over the storage pool (Reference Technical Specification 3.9.11). Activity removed by the pool sweep system is directed to the filtration system before it enters the atmosphere.

The activity released from the pool at 100 hrs for 60 failed fuel rods used as input for the TRANSACT computer code. Input and output files for this case are given in Attachment 3.

7.6 FHA With 60 Rods Failed Without Filtration (Case 4)

This case evaluates the offsite and onsite dose consequences of a fuel handling accident in which 60 fuel rods are damaged. The input for this case is the same as for case 3 except that credit for the fuel building ventilation system is not taken. The activity released from the pool escapes directly into the environment without filtration. Input and output files for this case are given in Attachment 4.

The input data file used for all cases is given in Attachment 5.

2(2)	9/21/2000	MAM	JGM	 Entergy Operations ARKANSAS NUCLEAR ONE	CALCULATION NUMBER	
2(1)	1/17/00	JGM	MAM		95-E-0031-01	
2	5/06/99	MAM	KLA		PAGE NUMBER	Page <u>27</u> of <u>27</u>
1	11/10/95	MAM	JWC			
0	2/28/95	MAM	JWC			
REV.	DATE	BY	CHK'D			

ATTACHMENT 1

CASE 1 Input and Output Files

Input File: Casel.in

```

'a:FHADdata
'a:LTAPE ', 'a:MTAPE ', 'a:NTAPE '
'ANO UNIT 2 FHA Dose, 100 hour decay; input file: Casel.in   output file: Casel.out'
'236 rods failed, no ESF filtration
'
0, 0, 0, 1, 0
1, 3
'POOL'
21
0.000E+00, 0.000E+00
0.000E+00, 0.000E+00
0.000E+00, 0.000E+00
7.500E-03, 2.500E-03, 0.000E+00
1.000E+00, 0.000E+00, 0.000E+00
1.000E+01, 4.000E+04
'TIME INTERVAL ', 0,0,0,0,2, 0.000E+00, 2.800E-04
'INITIAL FRACTION', 0,0,0,0,1, 1.000E+00
'INITIAL CURIES ', 0,0,1,0,1, 3.228E+03
'INITIAL CURIES ', 0,0,2,0,1, 9.543E+02
'INITIAL CURIES ', 0,0,3,0,1, 2.121E+03
'INITIAL CURIES ', 0,0,4,0,1, 1.088E+05
'INITIAL CURIES ', 0,0,5,0,1, 8.258E+04
'INITIAL CURIES ', 0,0,6,0,1, 7.906E+03

'TIME INTERVAL ', 0,0,0,0,2, 2.800E-04, 0.100E+00
'CR FILTER EFF ', 1,1,0,0,2, 0.950E+02, 0.990E+02
'CR FILTER EFF ', 1,2,0,0,2, 0.950E+02, 0.990E+02
'CR FILTER EFF ', 1,3,0,0,2, 0.950E+02, 0.990E+02
'TRANSFER CFM ', 0,0,0,1,2, 1.000E+06, 0.000E+00
'CONTROL ROOM ', 0,0,0,0,5, 1.000E+01, 3.330E+02, 3.430E+02, 1.667E+03, 1.000E+00
'DOSE PARAMS ', 0,0,0,0,7, 6.500E-04, 3.470E-04, 0.000E+00, 3.470E-04, 1.200E-03,
3.470E-04, 0.000E+00

'TIME INTERVAL ', 0,0,0,0,2, 0.100E+00, 0.200E+00
'TIME INTERVAL ', 0,0,0,0,2, 0.200E+00, 0.300E+00
'TIME INTERVAL ', 0,0,0,0,2, 0.300E+00, 0.400E+00
'TIME INTERVAL ', 0,0,0,0,2, 0.400E+00, 0.500E+00
'TIME INTERVAL ', 0,0,0,0,2, 0.500E+00, 0.600E+00
'TIME INTERVAL ', 0,0,0,0,2, 0.600E+00, 0.700E+00
'TIME INTERVAL ', 0,0,0,0,2, 0.700E+00, 0.800E+00
'TIME INTERVAL ', 0,0,0,0,2, 0.800E+00, 0.900E+00
'TIME INTERVAL ', 0,0,0,0,2, 0.900E+00, 1.000E+00
'TIME INTERVAL ', 0,0,0,0,2, 1.000E+00, 1.100E+00
'TIME INTERVAL ', 0,0,0,0,2, 1.100E+00, 1.200E+00
'TIME INTERVAL ', 0,0,0,0,2, 1.200E+00, 1.300E+00
'TIME INTERVAL ', 0,0,0,0,2, 1.300E+00, 1.400E+00
'TIME INTERVAL ', 0,0,0,0,2, 1.400E+00, 1.500E+00
'TIME INTERVAL ', 0,0,0,0,2, 1.500E+00, 1.600E+00
'TIME INTERVAL ', 0,0,0,0,2, 1.600E+00, 1.700E+00
'TIME INTERVAL ', 0,0,0,0,2, 1.700E+00, 1.800E+00
'TIME INTERVAL ', 0,0,0,0,2, 1.800E+00, 1.900E+00
'TIME INTERVAL ', 0,0,0,0,2, 1.900E+00, 2.000E+00

'END ', 0,0,0,0,0, 0.000E+00, 0.000E+00

```

Output File: Casel.out

1 TRANSACT Version 1.0, Revision 2
 Based on TACT V - SEP 87 PC VERSION

REVISED TO REVISION 2 December 1996
 BY OMEGA TECHNICAL SERVICES, INC.

REVISED TO REVISION 1 FEBRUARY 1995
 BY OMEGA TECHNICAL SERVICES, INC.

MODIFIED FALL 1992 FOR GGNS
 BY OMEGA TECHNICAL SERVICES, INC.

NUCLEAR REGULATORY COMMISSION
 ACCIDENT EVALUATION BRANCH
 DATE 9/19/2000 TIME 15:18:31

MODEL SUMMARY FOR CASE 1

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Casel.in output file: Casel.
 236 rods failed, no ESF filtration

1 TIME INDEPENDENT INPUT
 CASE NUMBER 1

NODES NSTEP
 1 21

OUTPUT CONTROL PARAMETER
 I 1 2 3 4 5
 IPRINT(I) 0 0 0 1 0

NUMBER OF DOSE EVALUATION POINTS - 3

POWER (MWT) REACTOR SHUTDOWN TIME (HRS)
 0.000E+00 0.000E+00

FRACTION OF ACTIVITY RELEASED FROM CORE TO CONTAINMENT BY ISOTOPIC GROUP

HALOGENS	NOBLES
0.000E+00	0.000E+00

PLATEOUT FACTOR FOR ACTIVITY RELEASED FROM
 CORE TO CONTAINMENT BY ISOTOPIC GROUP

HALOGENS	NOBLES
0.000E+00	0.000E+00

FRACTION OF CORE INVENTORY AIRBORNE IN THE CONTAINMENT BY ISOTOPIC GROUP

HALOGENS	NOBLES
0.000E+00	0.000E+00

ISOTOPIC SPLIT BY GROUP

	ELEM.	ORG.	PART.
HALOGENS	7.500E-03	2.500E-03	0.000E+00
NOBLES	1.000E+00	0.000E+00	0.000E+00

VOLUME OF NODES (CU FT)

POOL
 1.000E+01

CONTROL ROOM VOLUME (CU FT)

4.000E+04

DATA FROM NUCLIDE FILE a:FHAdata

ISOTOPE NAME	SOURCE SPLIT	(CI/MWT)	DECAY CONSTANT (1/HR)	DOSE CONVERSION FACTORS			
				WHOLEBDY	SKIN-B	THYROID	SKIN-G
SKIN-T							
KR 85	ELEM.	4.1020000E+02	7.3512000E-06	3.310E-04	4.840E-02	0.000E+00	4.750E-04
0.000E+00							
XE 131M	ELEM.	2.5950000E+02	2.4048000E-03	1.250E-03	1.330E-02	0.000E+00	2.710E-03
0.000E+00							
XE 133M	ELEM.	1.3840000E+03	1.2564000E-02	4.290E-03	2.960E-02	0.000E+00	7.000E-03
0.000E+00							
XE 133	ELEM.	5.6220000E+04	5.4792000E-03	4.960E-03	9.670E-03	0.000E+00	7.890E-03
0.000E+00							
I 131	ELEM.	1.8810000E+02	3.5870390E-03	5.590E-02	3.070E-02	1.100E+06	7.950E-02
0.000E+00							
I 131	ORG.	6.2700000E+01	3.5870390E-03	5.590E-02	3.070E-02	1.100E+06	7.950E-02
0.000E+00							
I 133	ELEM.	4.2165000E+02	3.3188400E-02	9.110E-02	8.900E-02	1.800E+05	1.310E-01
0.000E+00							
I 133	ORG.	1.4055000E+02	3.3188400E-02	9.110E-02	8.900E-02	1.800E+05	1.310E-01
0.000E+00							

TIME DEPENDENT INPUT
 CASE NUMBER 1

TIME INTERVAL	0	0	0	0	2	0.00000E+00	2.80000E-04
INITIAL FRACTION	0	0	0	0	1	1.00000E+00	
INITIAL CURIES	0	0	1	0	1	3.22800E+03	
INITIAL CURIES	0	0	2	0	1	9.54300E+02	
INITIAL CURIES	0	0	3	0	1	2.12100E+03	
INITIAL CURIES	0	0	4	0	1	1.08800E+05	
INITIAL CURIES	0	0	5	0	1	8.25800E+04	
INITIAL CURIES	0	0	6	0	1	7.90600E+03	
TIME INTERVAL	0	0	0	0	2	2.80000E-04	1.00000E-01
CR FILTER EFF	1	1	0	0	2	9.50000E+01	9.90000E+01
CR FILTER EFF	1	2	0	0	2	9.50000E+01	9.90000E+01
CR FILTER EFF	1	3	0	0	2	9.50000E+01	9.90000E+01
TRANSFER CFM	0	0	0	1	2	1.00000E+06	0.00000E+00
CONTROL ROOM	0	0	0	0	5	1.00000E+01	3.33000E+02
3.43000E+02	1.66700E+03	1.00000E+00					
DOSE PARAMS	0	0	0	0	7	6.50000E-04	3.47000E-04
0.00000E+00	3.47000E-04	1.20000E-03				3.47000E-04	0.00000E+00
TIME INTERVAL	0	0	0	0	2	1.00000E-01	2.00000E-01
TIME INTERVAL	0	0	0	0	2	2.00000E-01	3.00000E-01
TIME INTERVAL	0	0	0	0	2	3.00000E-01	4.00000E-01
TIME INTERVAL	0	0	0	0	2	4.00000E-01	5.00000E-01
TIME INTERVAL	0	0	0	0	2	5.00000E-01	6.00000E-01
TIME INTERVAL	0	0	0	0	2	6.00000E-01	7.00000E-01
TIME INTERVAL	0	0	0	0	2	7.00000E-01	8.00000E-01
TIME INTERVAL	0	0	0	0	2	8.00000E-01	9.00000E-01
TIME INTERVAL	0	0	0	0	2	9.00000E-01	1.00000E+00
TIME INTERVAL	0	0	0	0	2	1.00000E+00	1.10000E+00
TIME INTERVAL	0	0	0	0	2	1.10000E+00	1.20000E+00
TIME INTERVAL	0	0	0	0	2	1.20000E+00	1.30000E+00
TIME INTERVAL	0	0	0	0	2	1.30000E+00	1.40000E+00
TIME INTERVAL	0	0	0	0	2	1.40000E+00	1.50000E+00
TIME INTERVAL	0	0	0	0	2	1.50000E+00	1.60000E+00
TIME INTERVAL	0	0	0	0	2	1.60000E+00	1.70000E+00
TIME INTERVAL	0	0	0	0	2	1.70000E+00	1.80000E+00
TIME INTERVAL	0	0	0	0	2	1.80000E+00	1.90000E+00
TIME INTERVAL	0	0	0	0	2	1.90000E+00	2.00000E+00

SUMMARY OF OFF-SITE DOSES

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Casel.in output file: Casel.
 CALCULATION FOR WHOLEBODY DOSE (REMS)
 SINGLE NODE CONTAINMENT WITH NO ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
8.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
9.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.100E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.200E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.300E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.400E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.500E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.600E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.700E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.800E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.900E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	TOTAL	0.000E+00	TOTAL	0.000E+00	TOTAL	0.000E+00

CALCULATION FOR WHOLEBODY DOSE (REMS)

MULTI NODE CONTAINMENT WITH ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	3.928E-01	3.928E-01	0.000E+00	0.000E+00	5.125E-04	5.125E-04
1.000E-01	2.355E-33	3.928E-01	0.000E+00	0.000E+00	9.926E-04	1.505E-03
2.000E-01	2.354E-33	3.928E-01	0.000E+00	0.000E+00	9.417E-04	2.447E-03
3.000E-01	2.352E-33	3.928E-01	0.000E+00	0.000E+00	8.935E-04	3.340E-03
4.000E-01	2.351E-33	3.928E-01	0.000E+00	0.000E+00	8.479E-04	4.188E-03
5.000E-01	2.350E-33	3.928E-01	0.000E+00	0.000E+00	8.047E-04	4.993E-03
6.000E-01	2.348E-33	3.928E-01	0.000E+00	0.000E+00	7.637E-04	5.757E-03
7.000E-01	2.347E-33	3.928E-01	0.000E+00	0.000E+00	7.249E-04	6.481E-03
8.000E-01	2.346E-33	3.928E-01	0.000E+00	0.000E+00	6.880E-04	7.169E-03
9.000E-01	2.344E-33	3.928E-01	0.000E+00	0.000E+00	6.531E-04	7.823E-03
1.000E+00	2.343E-33	3.928E-01	0.000E+00	0.000E+00	6.199E-04	8.442E-03
1.100E+00	2.342E-33	3.928E-01	0.000E+00	0.000E+00	5.885E-04	9.031E-03
1.200E+00	2.340E-33	3.928E-01	0.000E+00	0.000E+00	5.586E-04	9.589E-03
1.300E+00	2.339E-33	3.928E-01	0.000E+00	0.000E+00	5.303E-04	1.012E-02
1.400E+00	2.337E-33	3.928E-01	0.000E+00	0.000E+00	5.034E-04	1.062E-02
1.500E+00	2.336E-33	3.928E-01	0.000E+00	0.000E+00	4.779E-04	1.110E-02
1.600E+00	2.335E-33	3.928E-01	0.000E+00	0.000E+00	4.536E-04	1.155E-02
1.700E+00	2.333E-33	3.928E-01	0.000E+00	0.000E+00	4.306E-04	1.199E-02
1.800E+00	2.332E-33	3.928E-01	0.000E+00	0.000E+00	4.088E-04	1.239E-02
1.900E+00	2.331E-33	3.928E-01	0.000E+00	0.000E+00	3.881E-04	1.278E-02
	TOTAL	3.928E-01	TOTAL	0.000E+00	TOTAL	1.278E-02

SUMMARY OF OFF-SITE DOSES

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Casel.in output file: Casel.
 CALCULATION FOR SKIN-B DOSE (REMS)
 SINGLE NODE CONTAINMENT WITH NO ESF

1.100E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.200E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.300E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.400E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.500E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.600E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.700E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.800E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.900E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	TOTAL	0.000E+00	TOTAL	0.000E+00	TOTAL	0.000E+00

CALCULATION FOR SKIN-T DOSE (REMS)

MULTI NODE CONTAINMENT WITH ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	1.475E+00	1.475E+00	0.000E+00	0.000E+00	3.970E-02	3.970E-02
1.000E-01	8.844E-33	1.475E+00	0.000E+00	0.000E+00	7.691E-02	1.166E-01
2.000E-01	3.839E-33	1.475E+00	0.000E+00	0.000E+00	7.300E-02	1.396E-01
3.000E-01	8.835E-33	1.475E+00	0.000E+00	0.000E+00	6.930E-02	2.589E-01
4.000E-01	3.830E-33	1.475E+00	0.000E+00	0.000E+00	6.573E-02	3.247E-01
5.000E-01	8.825E-33	1.475E+00	0.000E+00	0.000E+00	6.244E-02	3.871E-01
6.000E-01	3.820E-33	1.475E+00	0.000E+00	0.000E+00	5.925E-02	4.464E-01
7.000E-01	8.815E-33	1.475E+00	0.000E+00	0.000E+00	5.627E-02	5.027E-01
8.000E-01	3.810E-33	1.475E+00	0.000E+00	0.000E+00	5.342E-02	5.561E-01
9.000E-01	8.806E-33	1.475E+00	0.000E+00	0.000E+00	5.072E-02	6.068E-01
1.000E+00	8.801E-33	1.475E+00	0.000E+00	0.000E+00	4.815E-02	6.550E-01
1.100E+00	3.796E-33	1.475E+00	0.000E+00	0.000E+00	4.571E-02	7.007E-01
1.200E+00	8.791E-33	1.475E+00	0.000E+00	0.000E+00	4.339E-02	7.441E-01
1.300E+00	3.787E-33	1.475E+00	0.000E+00	0.000E+00	4.119E-02	7.853E-01
1.400E+00	8.782E-33	1.475E+00	0.000E+00	0.000E+00	3.911E-02	8.244E-01
1.500E+00	3.777E-33	1.475E+00	0.000E+00	0.000E+00	3.713E-02	8.615E-01
1.600E+00	8.772E-33	1.475E+00	0.000E+00	0.000E+00	3.525E-02	8.967E-01
1.700E+00	3.767E-33	1.475E+00	0.000E+00	0.000E+00	3.346E-02	9.302E-01
1.800E+00	8.763E-33	1.475E+00	0.000E+00	0.000E+00	3.177E-02	9.620E-01
1.900E+00	3.758E-33	1.475E+00	0.000E+00	0.000E+00	3.016E-02	9.921E-01
	TOTAL	1.475E+00	TOTAL	0.000E+00	TOTAL	9.921E-01

1 NO MORE CASES

END OF EXECUTION

ATTACHMENT 2

CASE 2 Input and output Files

Input File: Case2.in

```
'a:FHAdata
'a:LTAPE ', 'a:MTAPE ', 'a:NTAPE '
'ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case2.in   output file: Case2.out'
'236 rods failed, with ESF filtration
,
0, 0, 0, 1, 0
  1, 3
'POOL'
,
0.000E+00, 0.000E+00
0.000E+00, 0.000E+00
0.000E+00, 0.000E+00
7.500E-03, 2.500E-03, 0.000E+00
1.000E+00, 0.000E+00, 0.000E+00
1.78E+06, 4.000E+04
'TIME INTERVAL ', '0,0,0,0,2, 0.000E+00, 2.800E-04
'INITIAL FRACTION', '0,0,0,0,1, 1.000E+00
'INITIAL CURIES ', '0,0,1,0,1, 3.228E+03
'INITIAL CURIES ', '0,0,2,0,1, 9.543E+02
'INITIAL CURIES ', '0,0,3,0,1, 2.121E+03
'INITIAL CURIES ', '0,0,4,0,1, 1.088E+05
'INITIAL CURIES ', '0,0,5,0,1, 8.258E+04
'INITIAL CURIES ', '0,0,6,0,1, 7.906E+03

'TIME INTERVAL ', '0,0,0,0,2, 2.800E-04, 0.100E+00
'CR FILTER EFF ', '1,1,0,0,2, 0.950E+02 0.990E+02
'CR FILTER EFF ', '1,2,0,0,2, 0.950E+02 0.990E+02
'CR FILTER EFF ', '1,3,0,0,2, 0.950E+02, 0.990E+02
'FILTER EFF ', '1,1,0,1,1, 9.000E+01
'FILTER EFF ', '1,2,0,1,1, 7.000E+01
'FILTER EFF ', '1,3,0,1,1, 0.000E+00
'TRANSFER CFM ', '0,0,0,1,2, 4.000E+04, 0.000E+00
'CONTROL ROOM ', '0,0,0,0,5, 1.000E+01, 3.330E+02, 3.430E+02, 1.667E+03, 1.000E+00
'DOSE PARAMS ', '0,0,0,0,7, 6.500E-04, 3.470E-04, 0.000E+00, 3.470E-04, 1.200E-05, 3.470E-04, 0.000E+00

'TIME INTERVAL ', '0,0,0,0,2, 0.100E+00, 0.200E+00
'TIME INTERVAL ', '0,0,0,0,2, 0.200E+00, 0.300E+00
'TIME INTERVAL ', '0,0,0,0,2, 0.300E+00, 0.400E+00
'TIME INTERVAL ', '0,0,0,0,2, 0.400E+00, 0.500E+00
'TIME INTERVAL ', '0,0,0,0,2, 0.500E+00, 0.600E+00
'TIME INTERVAL ', '0,0,0,0,2, 0.600E+00, 0.700E+00
'TIME INTERVAL ', '0,0,0,0,2, 0.700E+00, 0.800E+00
'TIME INTERVAL ', '0,0,0,0,2, 0.800E+00, 0.900E+00
'TIME INTERVAL ', '0,0,0,0,2, 0.900E+00, 1.000E+00
'TIME INTERVAL ', '0,0,0,0,2, 1.000E+00, 1.100E+00
'TIME INTERVAL ', '0,0,0,0,2, 1.100E+00, 1.200E+00
'TIME INTERVAL ', '0,0,0,0,2, 1.200E+00, 1.300E+00
'TIME INTERVAL ', '0,0,0,0,2, 1.300E+00, 1.400E+00
'TIME INTERVAL ', '0,0,0,0,2, 1.400E+00, 1.500E+00
'TIME INTERVAL ', '0,0,0,0,2, 1.500E+00, 1.600E+00
'TIME INTERVAL ', '0,0,0,0,2, 1.600E+00, 1.700E+00
'TIME INTERVAL ', '0,0,0,0,2, 1.700E+00, 1.800E+00
'TIME INTERVAL ', '0,0,0,0,2, 1.800E+00, 1.900E+00
'TIME INTERVAL ', '0,0,0,0,2, 1.900E+00, 2.000E+00

'END ', '0,0,0,0,0, 0.000E+00, 0.000E+00
```

Output File: Case2.out

1 TRANSACT Version 1.0, Revision 2
 Based on TACT V - SEP 87 PC VERSION

REVISED TO REVISION 2 December 1996
BY OMEGA TECHNICAL SERVICES, INC.

REVISED TO REVISION 1 FEBRUARY 1995
BY OMEGA TECHNICAL SERVICES, INC.

MODIFIED FALL 1992 FOR GGNS
BY OMEGA TECHNICAL SERVICES, INC.

NUCLEAR REGULATORY COMMISSION
ACCIDENT EVALUATION BRANCH
DATE 9/19/2000 TIME 16:42:59

MODEL SUMMARY FOR CASE 1

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case2.in output file: Case2.
236 rods failed, with ESF filtration

1 TIME INDEPENDENT INPUT
 CASE NUMBER 1

 NODES NSTEP
 1 21

 OUTPUT CONTROL PARAMETER
 I 1 2 3 4 5
IPRINT(I) 0 0 0 1 0

NUMBER OF DOSE EVALUATION POINTS - 3

POWER (MWT) REACTOR SHUTDOWN TIME (HRS)
0.000E+00 0.000E+00

FRACTION OF ACTIVITY RELEASED FROM CORE TO CONTAINMENT BY ISOTOPIC GROUP
 HALOGENS NOBLES
 0.000E+00 0.000E+00

 PLATEOUT FACTOR FOR ACTIVITY RELEASED FROM
 CORE TO CONTAINMENT BY ISOTOPIC GROUP
 HALOGENS NOBLES
 0.000E+00 0.000E+00

FRACTION OF CORE INVENTORY AIRBORNE IN THE CONTAINMENT BY ISOTOPIC GROUP
 HALOGENS NOBLES
 0.000E+00 0.000E+00

 ISOTOPIC SPLIT BY GROUP
 ELEM. ORG. PART.
HALOGENS 7.500E-03 2.500E-03 0.000E+00
NOBLES 1.000E+00 0.000E+00 0.000E+00

 VOLUME OF NODES (CU FT)
POOL
1.780E+06

 CONTROL ROOM VOLUME (CU FT)
 4.000E+04

DATA FROM NUCLIDE FILE a:FHAdat

TOTAL 0.000E+00 TOTAL 0.000E+00 TOTAL 0.000E+00

CALCULATION FOR THYROID DOSE (REMS)

MULTI NODE CONTAINMENT WITH ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	3.926E+00	3.926E+00	0.000E+00	0.000E+00	6.579E-03	6.579E-03
1.000E-01	3.440E+00	7.366E+00	0.000E+00	0.000E+00	1.671E-02	2.329E-02
1.000E-01	3.005E+00	1.037E+01	0.000E+00	0.000E+00	2.281E-02	4.609E-02
3.000E-01	2.625E+00	1.300E+01	0.000E+00	0.000E+00	2.607E-02	7.216E-02
4.000E-01	2.293E+00	1.529E+01	0.000E+00	0.000E+00	2.737E-02	9.953E-02
5.000E-01	2.003E+00	1.729E+01	0.000E+00	0.000E+00	2.736E-02	1.269E-01
6.000E-01	1.749E+00	1.904E+01	0.000E+00	0.000E+00	2.647E-02	1.534E-01
7.000E-01	1.526E+00	2.057E+01	0.000E+00	0.000E+00	2.506E-02	1.784E-01
8.000E-01	1.335E+00	2.190E+01	0.000E+00	0.000E+00	2.333E-02	2.018E-01
9.000E-01	1.166E+00	2.307E+01	0.000E+00	0.000E+00	2.147E-02	2.232E-01
1.000E+00	1.018E+00	2.409E+01	0.000E+00	0.000E+00	1.956E-02	2.428E-01
1.100E+00	8.897E-01	2.498E+01	0.000E+00	0.000E+00	1.769E-02	2.605E-01
1.200E+00	7.771E-01	2.575E+01	0.000E+00	0.000E+00	1.591E-02	2.764E-01
1.300E+00	6.788E-01	2.643E+01	0.000E+00	0.000E+00	1.424E-02	2.906E-01
1.400E+00	5.930E-01	2.703E+01	0.000E+00	0.000E+00	1.269E-02	3.033E-01
1.500E+00	5.180E-01	2.754E+01	0.000E+00	0.000E+00	1.128E-02	3.146E-01
1.600E+00	4.524E-01	2.800E+01	0.000E+00	0.000E+00	9.993E-03	3.246E-01
1.700E+00	3.952E-01	2.839E+01	0.000E+00	0.000E+00	8.836E-03	3.334E-01
1.800E+00	3.452E-01	2.874E+01	0.000E+00	0.000E+00	7.799E-03	3.412E-01
1.900E+00	3.016E-01	2.904E+01	0.000E+00	0.000E+00	6.872E-03	3.481E-01
	TOTAL	2.904E+01	TOTAL	0.000E+00	TOTAL	3.481E-01

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SUMMARY OF OFF-SITE DOSES

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case2.in output file: Case2.
 CALCULATION FOR SKIN-G DOSE (REMS)

SINGLE NODE CONTAINMENT WITH NO ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
8.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
9.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.100E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.200E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.300E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.400E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.500E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.600E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.700E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.800E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.900E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	TOTAL	0.000E+00	TOTAL	0.000E+00	TOTAL	0.000E+00

CALCULATION FOR SKIN-G DOSE (REMS)

MULTI NODE CONTAINMENT WITH ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.

0.000E+00						
2.800E-04	7.266E-02	7.266E-02	0.000E+00	0.000E+00	1.023E-04	1.023E-04
1.000E-01	6.365E-02	1.363E-01	0.000E+00	0.000E+00	2.582E-04	3.905E-04
2.000E-01	5.559E-02	1.919E-01	0.000E+00	0.000E+00	4.404E-04	8.309E-04
3.000E-01	4.855E-02	2.405E-01	0.000E+00	0.000E+00	5.638E-04	1.395E-03
4.000E-01	4.240E-02	2.829E-01	0.000E+00	0.000E+00	6.624E-04	2.057E-03
5.000E-01	3.703E-02	3.199E-01	0.000E+00	0.000E+00	7.400E-04	2.797E-03
6.000E-01	3.234E-02	3.522E-01	0.000E+00	0.000E+00	7.995E-04	3.597E-03
7.000E-01	2.825E-02	3.805E-01	0.000E+00	0.000E+00	8.438E-04	4.440E-03
8.000E-01	2.467E-02	4.052E-01	0.000E+00	0.000E+00	8.750E-04	5.315E-03
9.000E-01	2.155E-02	4.267E-01	0.000E+00	0.000E+00	8.953E-04	6.211E-03
1.000E+00	1.882E-02	4.455E-01	0.000E+00	0.000E+00	9.064E-04	7.117E-03
1.100E+00	1.644E-02	4.620E-01	0.000E+00	0.000E+00	9.098E-04	8.027E-03
1.200E+00	1.436E-02	4.763E-01	0.000E+00	0.000E+00	9.067E-04	8.934E-03
1.300E+00	1.254E-02	4.889E-01	0.000E+00	0.000E+00	8.984E-04	9.832E-03
1.400E+00	1.095E-02	4.998E-01	0.000E+00	0.000E+00	8.857E-04	1.072E-02
1.500E+00	9.563E-03	5.094E-01	0.000E+00	0.000E+00	8.695E-04	1.159E-02
1.600E+00	8.352E-03	5.177E-01	0.000E+00	0.000E+00	8.505E-04	1.244E-02
1.700E+00	7.295E-03	5.250E-01	0.000E+00	0.000E+00	8.293E-04	1.327E-02
1.800E+00	6.371E-03	5.314E-01	0.000E+00	0.000E+00	8.063E-04	1.407E-02
1.900E+00	5.564E-03	5.369E-01	0.000E+00	0.000E+00	7.822E-04	1.486E-02
	TOTAL	5.369E-01	TOTAL	0.000E+00	TOTAL	1.486E-02

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SUMMARY OF OFF-SITE DOSES

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case2.in output file: Case2.
 CALCULATION FOR SKIN-T DOSE (REMS)
 SINGLE NODE CONTAINMENT WITH NO ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
8.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
9.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.100E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.200E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.300E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.400E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.500E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.600E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.700E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.800E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.900E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	TOTAL	0.000E+00	TOTAL	0.000E+00	TOTAL	0.000E+00

CALCULATION FOR SKIN-T DOSE (REMS)

MULTI NODE CONTAINMENT WITH ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	1.780E-01	1.780E-01	0.000E+00	0.000E+00	4.989E-03	4.989E-03
1.000E-01	1.559E-01	3.340E-01	0.000E+00	0.000E+00	1.405E-02	1.904E-02
1.000E-01	1.362E-01	4.702E-01	0.000E+00	0.000E+00	2.147E-02	4.051E-02
3.000E-01	1.190E-01	5.891E-01	0.000E+00	0.000E+00	2.749E-02	6.800E-02
4.000E-01	1.059E-01	6.930E-01	0.000E+00	0.000E+00	3.230E-02	1.005E-01
5.000E-01	9.074E-02	7.838E-01	0.000E+00	0.000E+00	3.609E-02	1.364E-01
6.000E-01	7.926E-02	8.630E-01	0.000E+00	0.000E+00	3.899E-02	1.754E-01

7.000E-01	6.922E-02	9.522E-01	0.000E+00	0.000E+00	4.115E-02	2.165E-01
8.000E-01	6.046E-02	9.927E-01	0.000E+00	0.000E+00	4.268E-02	2.592E-01
9.000E-01	5.280E-02	1.045E+00	0.000E+00	0.000E+00	4.367E-02	3.029E-01
1.000E+00	4.612E-02	1.092E+00	0.000E+00	0.000E+00	4.422E-02	3.471E-01
1.100E+00	4.028E-02	1.132E+00	0.000E+00	0.000E+00	4.438E-02	3.915E-01
1.200E+00	3.513E-02	1.167E+00	0.000E+00	0.000E+00	4.424E-02	4.357E-01
1.300E+00	3.073E-02	1.198E+00	0.000E+00	0.000E+00	4.383E-02	4.796E-01
1.400E+00	2.684E-02	1.225E+00	0.000E+00	0.000E+00	4.322E-02	5.228E-01
1.500E+00	2.344E-02	1.248E+00	0.000E+00	0.000E+00	4.243E-02	5.652E-01
1.600E+00	2.047E-02	1.269E+00	0.000E+00	0.000E+00	4.150E-02	6.067E-01
1.700E+00	1.788E-02	1.286E+00	0.000E+00	0.000E+00	4.047E-02	6.472E-01
1.800E+00	1.562E-02	1.302E+00	0.000E+00	0.000E+00	3.935E-02	6.865E-01
1.900E+00	1.364E-02	1.316E+00	0.000E+00	0.000E+00	3.817E-02	7.247E-01
	TOTAL	1.316E+00	TOTAL	0.000E+00	TOTAL	7.247E-01

1 NO MORE CASES

END OF EXECUTION

ATTACHMENT 3

CASE 3 Input and output Files

Input File: Case3.in

```

'a:FHADdata
'a:LTAPE ', 'a:MTAPE ', 'a:NTAPE '
'ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case3.in   output file: Case3.out'
'60 rods failed, with ESF filtration
,
0, 0, 0, 1, 0
  1, 3
'POOL'
21
0.000E+00, 0.000E+00
0.000E+00, 0.000E+00
0.000E+00, 0.000E+00
7.500E-03, 2.500E-03, 0.000E+00
1.000E+00, 0.000E+00, 0.000E+00
1.78E+06, 4.000E+04
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.000E+00, 2.800E-04
'INITIAL FRACTION', 0, 0, 0, 0, 1, 1.000E+00
'INITIAL CURIES ', 0, 0, 1, 0, 1, 8.207E+02
'INITIAL CURIES ', 0, 0, 2, 0, 1, 2.426E+02
'INITIAL CURIES ', 0, 0, 3, 0, 1, 5.392E+02
'INITIAL CURIES ', 0, 0, 4, 0, 1, 2.766E+04
'INITIAL CURIES ', 0, 0, 5, 0, 1, 2.099E+04
'INITIAL CURIES ', 0, 0, 6, 0, 1, 2.010E+03

'TIME INTERVAL ', 0, 0, 0, 0, 2, 2.800E-04, 0.100E+00
'CR FILTER EFF ', 1, 1, 0, 0, 2, 0.950E+02 0.990E+02
'CR FILTER EFF ', 1, 2, 0, 0, 2, 0.950E+02 0.990E+02
'CR FILTER EFF ', 1, 3, 0, 0, 2, 0.950E+02, 0.990E+02
'FILTER EFF ', 1, 1, 0, 1, 1, 9.000E+01
'FILTER EFF ', 1, 2, 0, 1, 1, 7.000E+01
'FILTER EFF ', 1, 3, 0, 1, 1, 0.000E+00
'TRANSFER CFM ', 0, 0, 0, 1, 2, 4.000E+04, 0.000E+00
'CONTROL ROOM ', 0, 0, 0, 0, 5, 1.000E+01, 3.330E+02, 3.430E+02, 1.667E+03, 1.000E+00
'DOSE PARAMS ', 0, 0, 0, 0, 7, 6.500E-04, 3.470E-04, 0.000E+00, 3.470E-04, 1.200E-03,
3.470E-04, 0.000E+00

'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.100E+00, 0.2000E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.200E+00, 0.300E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.300E+00, 0.400E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.400E+00, 0.500E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.500E+00, 0.600E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.600E+00, 0.700E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.700E+00, 0.800E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.800E+00, 0.900E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.900E+00, 1.000E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.000E+00, 1.100E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.100E+00, 1.200E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.200E+00, 1.300E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.300E+00, 1.400E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.400E+00, 1.500E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.500E+00, 1.600E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.600E+00, 1.700E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.700E+00, 1.800E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.800E+00, 1.900E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.900E+00, 2.000E+00

'END ', 0, 0, 0, 0, 0, 0.000E+00, 0.000E+00

```

Output File: Case3.out

1 TRANSMACT Version 1.0, Revision 2
Based on TACT V - SEP 87 PC VERSION

REVISED TO REVISION 2 December 1996
BY OMEGA TECHNICAL SERVICES, INC.

REVISED TO REVISION 1 FEBRUARY 1995
BY OMEGA TECHNICAL SERVICES, INC.

MODIFIED FALL 1992 FOR GGNS
BY OMEGA TECHNICAL SERVICES, INC.

NUCLEAR REGULATORY COMMISSION
ACCIDENT EVALUATION BRANCH
DATE 9/19/2000 TIME 16:43:27

MODEL SUMMARY FOR CASE 1

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case3.in output file: Case3.
60 rods failed, with ESF filtration

1 TIME INDEPENDENT INPUT
CASE NUMBER 1

NODES NSTEP
1 21

OUTPUT CONTROL PARAMETER
I 1 2 3 4 5
IPRINT(I) 0 0 0 1 0

NUMBER OF DOSE EVALUATION POINTS - 3

POWER (MWT) REACTOR SHUTDOWN TIME (HRS)
0.000E+00 0.000E+00

FRACTION OF ACTIVITY RELEASED FROM CORE TO CONTAINMENT BY ISOTOPIC GROUP
HALOGENS NOBLES
0.000E+00 0.000E+00

PLATEOUT FACTOR FOR ACTIVITY RELEASED FROM
CORE TO CONTAINMENT BY ISOTOPIC GROUP
HALOGENS NOBLES
0.000E+00 0.000E+00

FRACTION OF CORE INVENTORY AIRBORNE IN THE CONTAINMENT BY ISOTOPIC GROUP
HALOGENS NOBLES
0.000E+00 0.000E+00

ISOTOPIC SPLIT BY GROUP
ELEM. ORG. PART.
HALOGENS 7.500E-03 2.500E-03 0.000E+00
NOBLES 1.000E+00 0.000E+00 0.000E+00

VOLUME OF NODES (CU FT)
POOL
1.780E+06

CONTROL ROOM VOLUME (CU FT)
4.000E+04

DATA FROM NUCLIDE FILE a:FHadata

ISOTOPE NAME	SPLIT	SOURCE (CI/MWT)	DECAY CONSTANT (1/HR)	DOSE CONVERSION FACTORS			
				WHOLEBDY	SKIN-B	THYROID	SKIN-G
SKIN-T							
KR 85	ELEM.	4.1020000E+02	7.3512000E-06	3.310E-04	4.840E-02	0.000E+00	4.750E-04
0.000E+00							
XE 131M	ELEM.	2.5950000E+02	2.4048000E-03	1.250E-03	1.330E-02	0.000E+00	2.710E-03
0.000E+00							
XE 133M	ELEM.	1.3840000E+03	1.2564000E-02	4.290E-03	2.960E-02	0.000E+00	7.000E-03
0.000E+00							
XE 133	ELEM.	5.6220000E+04	5.4792000E-03	4.960E-03	9.670E-03	0.000E+00	7.890E-03
0.000E+00							
I 131	ELEM.	1.8810000E+02	3.5870390E-03	5.590E-02	3.070E-02	1.100E+06	7.950E-02
0.000E+00							
I 131	ORG.	6.2700000E+01	3.5870390E-03	5.590E-02	3.070E-02	1.100E+06	7.950E-02
0.000E+00							
I 133	ELEM.	4.2165000E+02	3.3188400E-02	9.110E-02	8.900E-02	1.800E+05	1.310E-01
0.000E+00							
I 133	ORG.	1.4055000E+02	3.3188400E-02	9.110E-02	8.900E-02	1.800E+05	1.310E-01
0.000E+00							

TIME DEPENDENT INPUT
 CASE NUMBER 1

TIME INTERVAL	0	0	0	0	2	0.00000E+00	2.80000E-04
INITIAL FRACTION	0	0	0	0	1	1.00000E+00	
INITIAL CURIES	0	0	1	0	1	8.20700E+02	
INITIAL CURIES	0	0	2	0	1	2.42600E+02	
INITIAL CURIES	0	0	3	0	1	5.39200E+02	
INITIAL CURIES	0	0	4	0	1	2.76600E+04	
INITIAL CURIES	0	0	5	0	1	2.09900E+04	
INITIAL CURIES	0	0	6	0	1	2.01000E+03	
TIME INTERVAL	0	0	0	0	2	2.80000E-04	1.00000E-01
CR FILTER EFF	1	1	0	0	2	9.50000E+01	9.90000E+01
CR FILTER EFF	1	2	0	0	2	9.50000E+01	9.90000E+01
CR FILTER EFF	1	3	0	0	2	9.50000E+01	9.90000E+01
FILTER EFF	1	1	0	1	1	9.00000E+01	
FILTER EFF	1	2	0	1	1	7.00000E+01	
FILTER EFF	1	3	0	1	1	0.00000E+00	
TRANSFER CFM	0	0	0	1	2	4.00000E+04	0.00000E+00
CONTROL ROOM	0	0	0	0	5	1.00000E+01	3.33000E+02
3.43000E+02	1.66700E+03	1.00000E+00					
DOSE PARAMS	0	0	0	0	7	6.50000E-04	3.47000E-04
0.00000E+00	3.47000E-04	1.20000E-03				3.47000E-04	0.00000E+00
TIME INTERVAL	0	0	0	0	2	1.00000E-01	2.00000E-01
TIME INTERVAL	0	0	0	0	2	2.00000E-01	3.00000E-01
TIME INTERVAL	0	0	0	0	2	3.00000E-01	4.00000E-01
TIME INTERVAL	0	0	0	0	2	4.00000E-01	5.00000E-01
TIME INTERVAL	0	0	0	0	2	5.00000E-01	6.00000E-01
TIME INTERVAL	0	0	0	0	2	6.00000E-01	7.00000E-01
TIME INTERVAL	0	0	0	0	2	7.00000E-01	8.00000E-01
TIME INTERVAL	0	0	0	0	2	8.00000E-01	9.00000E-01
TIME INTERVAL	0	0	0	0	2	9.00000E-01	1.00000E+00
TIME INTERVAL	0	0	0	0	2	1.00000E+00	1.10000E+00
TIME INTERVAL	0	0	0	0	2	1.10000E+00	1.20000E+00
TIME INTERVAL	0	0	0	0	2	1.20000E+00	1.30000E+00
TIME INTERVAL	0	0	0	0	2	1.30000E+00	1.40000E+00
TIME INTERVAL	0	0	0	0	2	1.40000E+00	1.50000E+00
TIME INTERVAL	0	0	0	0	2	1.50000E+00	1.60000E+00
TIME INTERVAL	0	0	0	0	2	1.60000E+00	1.70000E+00
TIME INTERVAL	0	0	0	0	2	1.70000E+00	1.80000E+00
TIME INTERVAL	0	0	0	0	2	1.80000E+00	1.90000E+00
TIME INTERVAL	0	0	0	0	2	1.90000E+00	2.00000E+00

SUMMARY OF OFF-SITE DOSES

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case3.in output file: Case3.

CALCULATION FOR WHOLEBODY DOSE (REMS)
 SINGLE NODE CONTAINMENT WITH NO ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
8.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
9.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.100E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.200E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.300E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.400E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.500E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.600E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.700E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.800E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.900E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	TOTAL	0.000E+00	TOTAL	0.000E+00	TOTAL	0.000E+00

CALCULATION FOR WHOLEBODY DOSE (REMS)
 MULTI NODE CONTAINMENT WITH ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	1.162E-02	1.162E-02	0.000E+00	0.000E+00	1.634E-05	1.634E-05
1.000E-01	1.018E-02	2.180E-02	0.000E+00	0.000E+00	4.601E-05	6.235E-05
2.000E-01	8.889E-03	3.068E-02	0.000E+00	0.000E+00	7.031E-05	1.327E-04
3.000E-01	7.763E-03	3.845E-02	0.000E+00	0.000E+00	9.001E-05	2.227E-04
4.000E-01	6.780E-03	4.523E-02	0.000E+00	0.000E+00	1.058E-04	3.284E-04
5.000E-01	5.922E-03	5.115E-02	0.000E+00	0.000E+00	1.191E-04	4.466E-04
6.000E-01	5.172E-03	5.632E-02	0.000E+00	0.000E+00	1.277E-04	5.742E-04
7.000E-01	4.517E-03	6.084E-02	0.000E+00	0.000E+00	1.347E-04	7.090E-04
8.000E-01	3.945E-03	6.478E-02	0.000E+00	0.000E+00	1.397E-04	8.487E-04
9.000E-01	3.445E-03	6.823E-02	0.000E+00	0.000E+00	1.429E-04	9.916E-04
1.000E+00	3.009E-03	7.124E-02	0.000E+00	0.000E+00	1.447E-04	1.136E-03
1.100E+00	2.628E-03	7.387E-02	0.000E+00	0.000E+00	1.453E-04	1.282E-03
1.200E+00	2.295E-03	7.616E-02	0.000E+00	0.000E+00	1.448E-04	1.426E-03
1.300E+00	2.005E-03	7.817E-02	0.000E+00	0.000E+00	1.434E-04	1.570E-03
1.400E+00	1.751E-03	7.992E-02	0.000E+00	0.000E+00	1.414E-04	1.711E-03
1.500E+00	1.529E-03	8.145E-02	0.000E+00	0.000E+00	1.388E-04	1.850E-03
1.600E+00	1.336E-03	8.278E-02	0.000E+00	0.000E+00	1.358E-04	1.986E-03
1.700E+00	1.166E-03	8.395E-02	0.000E+00	0.000E+00	1.324E-04	2.118E-03
1.800E+00	1.019E-03	8.497E-02	0.000E+00	0.000E+00	1.287E-04	2.247E-03
1.900E+00	8.897E-04	8.586E-02	0.000E+00	0.000E+00	1.249E-04	2.372E-03
	TOTAL	8.586E-02	TOTAL	0.000E+00	TOTAL	2.372E-03

SUMMARY OF OFF-SITE DOSES

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case3.in output file: Case3.

CALCULATION FOR SKIN-B DOSE (REMS)
 SINGLE NODE CONTAINMENT WITH NO ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
8.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
9.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.100E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.200E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.300E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.400E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.500E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.600E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.700E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.800E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.900E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	TOTAL	0.000E+00	TOTAL	0.000E+00	TOTAL	0.000E+00

CALCULATION FOR SKIN-B DOSE (REMS)
 MULTI NODE CONTAINMENT WITH ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	2.678E-02	2.678E-02	0.000E+00	0.000E+00	1.242E-03	1.242E-03
1.000E-01	2.346E-02	5.025E-02	0.000E+00	0.000E+00	3.498E-03	4.741E-03
2.000E-01	2.049E-02	7.074E-02	0.000E+00	0.000E+00	5.347E-03	1.009E-02
3.000E-01	1.790E-02	8.864E-02	0.000E+00	0.000E+00	6.845E-03	1.693E-02
4.000E-01	1.563E-02	1.043E-01	0.000E+00	0.000E+00	8.044E-03	2.498E-02
5.000E-01	1.365E-02	1.179E-01	0.000E+00	0.000E+00	9.986E-03	3.396E-02
6.000E-01	1.193E-02	1.299E-01	0.000E+00	0.000E+00	9.710E-03	4.367E-02
7.000E-01	1.042E-02	1.403E-01	0.000E+00	0.000E+00	1.025E-02	5.392E-02
8.000E-01	9.098E-03	1.494E-01	0.000E+00	0.000E+00	1.063E-02	6.455E-02
9.000E-01	7.946E-03	1.573E-01	0.000E+00	0.000E+00	1.088E-02	7.542E-02
1.000E+00	6.940E-03	1.643E-01	0.000E+00	0.000E+00	1.101E-02	8.643E-02
1.100E+00	6.062E-03	1.703E-01	0.000E+00	0.000E+00	1.105E-02	9.749E-02
1.200E+00	5.294E-03	1.756E-01	0.000E+00	0.000E+00	1.102E-02	1.085E-01
1.300E+00	4.624E-03	1.802E-01	0.000E+00	0.000E+00	1.091E-02	1.194E-01
1.400E+00	4.039E-03	1.843E-01	0.000E+00	0.000E+00	1.076E-02	1.302E-01
1.500E+00	3.528E-03	1.878E-01	0.000E+00	0.000E+00	1.057E-02	1.407E-01
1.600E+00	3.081E-03	1.909E-01	0.000E+00	0.000E+00	1.035E-02	1.511E-01
1.700E+00	2.691E-03	1.936E-01	0.000E+00	0.000E+00	1.008E-02	1.612E-01
1.800E+00	2.350E-03	1.959E-01	0.000E+00	0.000E+00	9.799E-03	1.710E-01
1.900E+00	2.053E-03	1.980E-01	0.000E+00	0.000E+00	9.506E-03	1.805E-01
	TOTAL	1.980E-01	TOTAL	0.000E+00	TOTAL	1.805E-01

SUMMARY OF OFF-SITE DOSES

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case3.in output file: Case3.

CALCULATION FOR THYROID DOSE (REMS)
 SINGLE NODE CONTAINMENT WITH NO ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.

9.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.100E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.200E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.300E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.400E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.500E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.600E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.700E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.800E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.900E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	TOTAL	0.000E+00	TOTAL	0.000E+00	TOTAL	0.000E+00

CALCULATION FOR SKIN-T DOSE (REMS)
 MULTI NODE CONTAINMENT WITH ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	4.526E-02	4.526E-02	0.000E+00	0.000E+00	1.263E-03	1.263E-03
1.000E-01	3.965E-02	8.490E-02	0.000E+00	0.000E+00	3.572E-03	4.840E-03
2.000E-01	3.463E-02	1.195E-01	0.000E+00	0.000E+00	5.459E-03	1.030E-02
3.000E-01	3.024E-02	1.498E-01	0.000E+00	0.000E+00	6.989E-03	1.729E-02
4.000E-01	2.641E-02	1.762E-01	0.000E+00	0.000E+00	8.212E-03	2.550E-02
5.000E-01	2.307E-02	1.993E-01	0.000E+00	0.000E+00	9.174E-03	3.467E-02
6.000E-01	2.015E-02	2.194E-01	0.000E+00	0.000E+00	9.913E-03	4.459E-02
7.000E-01	1.760E-02	2.370E-01	0.000E+00	0.000E+00	1.046E-02	5.505E-02
8.000E-01	1.537E-02	2.524E-01	0.000E+00	0.000E+00	1.085E-02	6.590E-02
9.000E-01	1.342E-02	2.658E-01	0.000E+00	0.000E+00	1.110E-02	7.700E-02
1.000E+00	1.172E-02	2.775E-01	0.000E+00	0.000E+00	1.124E-02	8.824E-02
1.100E+00	1.024E-02	2.873E-01	0.000E+00	0.000E+00	1.123E-02	9.953E-02
1.200E+00	8.944E-03	2.967E-01	0.000E+00	0.000E+00	1.125E-02	1.108E-01
1.300E+00	7.812E-03	3.045E-01	0.000E+00	0.000E+00	1.114E-02	1.219E-01
1.400E+00	6.823E-03	3.113E-01	0.000E+00	0.000E+00	1.099E-02	1.329E-01
1.500E+00	5.959E-03	3.173E-01	0.000E+00	0.000E+00	1.079E-02	1.437E-01
1.600E+00	5.204E-03	3.225E-01	0.000E+00	0.000E+00	1.055E-02	1.542E-01
1.700E+00	4.546E-03	3.270E-01	0.000E+00	0.000E+00	1.029E-02	1.645E-01
1.800E+00	3.970E-03	3.310E-01	0.000E+00	0.000E+00	1.000E-02	1.745E-01
1.900E+00	3.467E-03	3.345E-01	0.000E+00	0.000E+00	9.705E-03	1.842E-01
	TOTAL	3.345E-01	TOTAL	0.000E+00	TOTAL	1.342E-01

1 NO MORE CASES

END OF EXECUTION

ATTACHMENT 4

CASE 4 Input and output Files

Input File: Case4.in

```

'a:FHADdata
'a:LTAPE ', 'a:MTAPE ', 'a:NTAPE '
'ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case4.in   output file: Case4.out'
'60 rods failed, no ESF filtration
'
0, 0, 0, 1, 0
1, 3
'POOL'
21
0.000E+00, 0.000E+00
0.000E+00, 0.000E+00
0.000E+00, 0.000E+00
7.500E-03, 2.500E-03, 0.000E+00
1.000E+00, 0.000E+00, 0.000E+00
1.78E+06, 4.000E+04
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.000E+00, 2.800E-04
'INITIAL FRACTION', 0, 0, 0, 0, 1, 1.000E+00
'INITIAL CURIES ', 0, 0, 1, 0, 1, 8.207E+02
'INITIAL CURIES ', 0, 0, 2, 0, 1, 2.426E+02
'INITIAL CURIES ', 0, 0, 3, 0, 1, 5.392E+02
'INITIAL CURIES ', 0, 0, 4, 0, 1, 2.766E+04
'INITIAL CURIES ', 0, 0, 5, 0, 1, 2.099E+04
'INITIAL CURIES ', 0, 0, 6, 0, 1, 2.010E+03

'TIME INTERVAL ', 0, 0, 0, 0, 2, 2.800E-04, 0.100E+00
'CR FILTER EFF ', 1, 1, 0, 0, 2, 0.950E+02 0.990E+02
'CR FILTER EFF ', 1, 2, 0, 0, 2, 0.950E+02 0.990E+02
'CR FILTER EFF ', 1, 3, 0, 0, 2, 0.950E+02, 0.990E+02
'FILTER EFF ', 1, 1, 0, 1, 1, 0.000E+00
'FILTER EFF ', 1, 2, 0, 1, 1, 0.000E+00
'FILTER EFF ', 1, 3, 0, 1, 1, 0.000E+00
'TRANSFER CFM ', 0, 0, 0, 1, 2, 1.000E+06, 0.000E+00
'CONTROL ROOM ', 0, 0, 0, 0, 5, 1.000E+01, 3.330E+02, 3.430E+02, 1.667E+03, 1.000E+00
'DOSE PARAMS ', 0, 0, 0, 0, 7, 6.500E-04, 3.470E-04, 0.000E+00, 3.470E-04, 1.200E-03,
3.470E-04, 0.000E+00

'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.100E+00, 0.2000E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.200E+00, 0.300E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.300E+00, 0.400E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.400E+00, 0.500E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.500E+00, 0.600E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.600E+00, 0.700E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.700E+00, 0.800E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.800E+00, 0.900E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 0.900E+00, 1.000E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.000E+00, 1.100E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.100E+00, 1.200E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.200E+00, 1.300E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.300E+00, 1.400E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.400E+00, 1.500E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.500E+00, 1.600E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.600E+00, 1.700E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.700E+00, 1.800E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.800E+00, 1.900E+00
'TIME INTERVAL ', 0, 0, 0, 0, 2, 1.900E+00, 2.000E+00

'END ', 0, 0, 0, 0, 0, 0.000E+00, 0.000E+00

```

Output File: Case4.out

1

TRANSACT Version 1.0, Revision 2
Based on TACT V - SEP 87 PC VERSION

REVISED TO REVISION 2 December 1996
BY OMEGA TECHNICAL SERVICES, INC.

REVISED TO REVISION 1 FEBRUARY 1995
BY OMEGA TECHNICAL SERVICES, INC.

MODIFIED FALL 1992 FOR GGNS
BY OMEGA TECHNICAL SERVICES, INC.

NUCLEAR REGULATORY COMMISSION
ACCIDENT EVALUATION BRANCH
DATE 9/19/2000 TIME 16:43:49

MODEL SUMMARY FOR CASE 1

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case4.in output file: Case4.
60 rods failed, no ESF filtration

1 TIME INDEPENDENT INPUT
CASE NUMBER 1

NODES NSTEP
1 21

OUTPUT CONTROL PARAMETER
I 1 2 3 4 5
IPRINT(I) 0 0 0 1 0

NUMBER OF DOSE EVALUATION POINTS - 3

POWER (MWT) REACTOR SHUTDOWN TIME (HRS)
0.000E+00 0.000E+00

FRACTION OF ACTIVITY RELEASED FROM CORE TO CONTAINMENT BY ISOTOPIC GROUP
HALOGENS NOBLES
0.000E+00 0.000E+00

PLATEOUT FACTOR FOR ACTIVITY RELEASED FROM
CORE TO CONTAINMENT BY ISOTOPIC GROUP
HALOGENS NOBLES
0.000E+00 0.000E+00

FRACTION OF CORE INVENTORY AIRBORNE IN THE CONTAINMENT BY ISOTOPIC GROUP
HALOGENS NOBLES
0.000E+00 0.000E+00

ISOTOPIC SPLIT BY GROUP
ELEM. ORG. PART.
HALOGENS 7.500E-03 2.500E-03 0.000E+00
NOBLES 1.000E+00 0.000E+00 0.000E+00

VOLUME OF NODES (CU FT)
POOL
1.780E+06

CONTROL ROOM VOLUME (CU FT)

4.000E+04

DATA FROM NUCLIDE FILE a:FHAdata

ISOTOPE NAME	SPLIT	SOURCE (CI/MWT)	DECAY CONSTANT (1/HR)	DOSE CONVERSION FACTORS			
				WHOLEBDY	SKIN-B	THYROID	SKIN-G
SKIN-T							
KR 85	ELEM.	4.1020000E+02	7.3512000E-06	3.310E-04	4.840E-02	0.000E+00	4.750E-04
0.000E+00							
XE 131M	ELEM.	2.5950000E+02	2.4048000E-03	1.250E-03	1.330E-02	0.000E+00	2.710E-03
0.000E+00							
XE 133M	ELEM.	1.3840000E+03	1.2564000E-02	4.290E-03	2.960E-02	0.000E+00	7.000E-03
0.000E+00							
XE 133	ELEM.	5.6220000E+04	5.4792000E-03	4.960E-03	9.670E-03	0.000E+00	7.890E-03
0.000E+00							
I 131	ELEM.	1.8810000E+02	3.5870390E-03	5.590E-02	3.070E-02	1.100E+06	7.950E-02
0.000E+00							
I 131	ORG.	6.2700000E+01	3.5870390E-03	5.590E-02	3.070E-02	1.100E+06	7.950E-02
0.000E+00							
I 133	ELEM.	4.2165000E+02	3.3188400E-02	9.110E-02	8.900E-02	1.800E+05	1.310E-01
0.000E+00							
I 133	ORG.	1.4055000E+02	3.3188400E-02	9.110E-02	8.900E-02	1.800E+05	1.310E-01
0.000E+00							

TIME DEPENDENT INPUT

CASE NUMBER 1

TIME INTERVAL	0	0	0	0	2	0.00000E+00	2.80000E-04
INITIAL FRACTION	0	0	0	0	1	1.00000E+00	
INITIAL CURIES	0	0	1	0	1	8.20700E+02	
INITIAL CURIES	0	0	2	0	1	2.42600E+02	
INITIAL CURIES	0	0	3	0	1	5.39200E+02	
INITIAL CURIES	0	0	4	0	1	2.76600E+04	
INITIAL CURIES	0	0	5	0	1	2.09900E+04	
INITIAL CURIES	0	0	6	0	1	2.01000E+03	
TIME INTERVAL	0	0	0	0	2	2.80000E-04	1.00000E-01
CR FILTER EFF	1	1	0	0	2	9.50000E+01	9.90000E+01
CR FILTER EFF	1	2	0	0	2	9.50000E+01	9.90000E+01
CR FILTER EFF	1	3	0	0	2	9.50000E+01	9.90000E+01
FILTER EFF	1	1	0	1	1	0.00000E+00	
FILTER EFF	1	2	0	1	1	0.00000E+00	
FILTER EFF	1	3	0	1	1	0.00000E+00	
TRANSFER CFM	0	0	0	1	2	1.00000E+06	0.00000E+00
CONTROL ROOM	0	0	0	0	5	1.00000E+01	3.33000E+02
3.43000E+02	1.66700E+03	1.00000E+00					
DOSE PARAMS	0	0	0	0	7	6.50000E-04	3.47000E-04
0.00000E+00	3.47000E-04	1.20000E-03	3.47000E-04	0.00000E+00			
TIME INTERVAL	0	0	0	0	2	1.00000E-01	2.00000E-01
TIME INTERVAL	0	0	0	0	2	2.00000E-01	3.00000E-01
TIME INTERVAL	0	0	0	0	2	3.00000E-01	4.00000E-01
TIME INTERVAL	0	0	0	0	2	4.00000E-01	5.00000E-01
TIME INTERVAL	0	0	0	0	2	5.00000E-01	6.00000E-01
TIME INTERVAL	0	0	0	0	2	6.00000E-01	7.00000E-01
TIME INTERVAL	0	0	0	0	2	7.00000E-01	8.00000E-01
TIME INTERVAL	0	0	0	0	2	8.00000E-01	9.00000E-01
TIME INTERVAL	0	0	0	0	2	9.00000E-01	1.00000E+00
TIME INTERVAL	0	0	0	0	2	1.00000E+00	1.10000E+00
TIME INTERVAL	0	0	0	0	2	1.10000E+00	1.20000E+00
TIME INTERVAL	0	0	0	0	2	1.20000E+00	1.30000E+00
TIME INTERVAL	0	0	0	0	2	1.30000E+00	1.40000E+00
TIME INTERVAL	0	0	0	0	2	1.40000E+00	1.50000E+00
TIME INTERVAL	0	0	0	0	2	1.50000E+00	1.60000E+00
TIME INTERVAL	0	0	0	0	2	1.60000E+00	1.70000E+00
TIME INTERVAL	0	0	0	0	2	1.70000E+00	1.80000E+00
TIME INTERVAL	0	0	0	0	2	1.80000E+00	1.90000E+00
TIME INTERVAL	0	0	0	0	2	1.90000E+00	2.00000E+00

SUMMARY OF OFF-SITE DOSES

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case4.in output file: Case4.

CALCULATION FOR WHOLEBDY DOSE (REMS)
 SINGLE NODE CONTAINMENT WITH NO ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
8.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
9.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.100E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.200E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.300E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.400E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.500E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.600E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.700E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.800E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.900E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	TOTAL	0.000E+00	TOTAL	0.000E+00	TOTAL	0.000E+00

CALCULATION FOR WHOLEBDY DOSE (REMS)

MULTI NODE CONTAINMENT WITH ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	9.639E-02	9.639E-02	0.000E+00	0.000E+00	1.258E-04	1.258E-04
1.000E-01	3.343E-03	9.973E-02	0.000E+00	0.000E+00	2.479E-04	3.737E-04
2.000E-01	1.148E-04	9.985E-02	0.000E+00	0.000E+00	2.397E-04	6.133E-04
3.000E-01	3.945E-06	9.985E-02	0.000E+00	0.000E+00	2.276E-04	8.409E-04
4.000E-01	1.354E-07	9.985E-02	0.000E+00	0.000E+00	2.159E-04	1.057E-03
5.000E-01	4.650E-09	9.985E-02	0.000E+00	0.000E+00	2.049E-04	1.262E-03
6.000E-01	1.597E-10	9.985E-02	0.000E+00	0.000E+00	1.945E-04	1.456E-03
7.000E-01	5.484E-12	9.985E-02	0.000E+00	0.000E+00	1.846E-04	1.641E-03
8.000E-01	1.884E-13	9.985E-02	0.000E+00	0.000E+00	1.752E-04	1.816E-03
9.000E-01	6.469E-15	9.985E-02	0.000E+00	0.000E+00	1.663E-04	1.982E-03
1.000E+00	2.221E-16	9.985E-02	0.000E+00	0.000E+00	1.579E-04	2.140E-03
1.100E+00	7.629E-18	9.985E-02	0.000E+00	0.000E+00	1.499E-04	2.290E-03
1.200E+00	2.620E-19	9.985E-02	0.000E+00	0.000E+00	1.423E-04	2.432E-03
1.300E+00	8.998E-21	9.985E-02	0.000E+00	0.000E+00	1.350E-04	2.567E-03
1.400E+00	3.090E-22	9.985E-02	0.000E+00	0.000E+00	1.282E-04	2.696E-03
1.500E+00	1.061E-23	9.985E-02	0.000E+00	0.000E+00	1.217E-04	2.817E-03
1.600E+00	3.645E-25	9.985E-02	0.000E+00	0.000E+00	1.155E-04	2.933E-03
1.700E+00	1.252E-26	9.985E-02	0.000E+00	0.000E+00	1.097E-04	3.043E-03
1.800E+00	4.299E-28	9.985E-02	0.000E+00	0.000E+00	1.041E-04	3.147E-03
1.900E+00	1.476E-29	9.985E-02	0.000E+00	0.000E+00	9.883E-05	3.245E-03
	TOTAL	9.985E-02	TOTAL	0.000E+00	TOTAL	3.245E-03

SUMMARY OF OFF-SITE DOSES

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case4.in output file: Case4.

CALCULATION FOR SKIN-B DOSE (REMS)
 SINGLE NODE CONTAINMENT WITH NO ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
3.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
4.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
5.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
6.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
7.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
8.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
9.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.100E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.200E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.300E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.400E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.500E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.600E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.700E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.800E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.900E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	TOTAL	0.000E+00	TOTAL	0.000E+00	TOTAL	0.000E+00

CALCULATION FOR SKIN-B DOSE (REMS)
 MULTI NODE CONTAINMENT WITH ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	2.099E-01	2.099E-01	0.000E+00	0.000E+00	9.541E-03	9.541E-03
1.000E-01	7.281E-03	2.172E-01	0.000E+00	0.000E+00	1.882E-02	2.836E-02
2.000E-01	2.500E-04	2.175E-01	0.000E+00	0.000E+00	1.820E-02	4.655E-02
3.000E-01	8.588E-06	2.175E-01	0.000E+00	0.000E+00	1.729E-02	6.384E-02
4.000E-01	2.949E-07	2.175E-01	0.000E+00	0.000E+00	1.641E-02	8.025E-02
5.000E-01	1.013E-08	2.175E-01	0.000E+00	0.000E+00	1.558E-02	9.583E-02
6.000E-01	3.479E-10	2.175E-01	0.000E+00	0.000E+00	1.479E-02	1.108E-01
7.000E-01	1.195E-11	2.175E-01	0.000E+00	0.000E+00	1.404E-02	1.247E-01
8.000E-01	4.104E-13	2.175E-01	0.000E+00	0.000E+00	1.333E-02	1.380E-01
9.000E-01	1.409E-14	2.175E-01	0.000E+00	0.000E+00	1.265E-02	1.506E-01
1.000E+00	4.841E-16	2.175E-01	0.000E+00	0.000E+00	1.201E-02	1.628E-01
1.100E+00	1.662E-17	2.175E-01	0.000E+00	0.000E+00	1.140E-02	1.740E-01
1.200E+00	5.710E-19	2.175E-01	0.000E+00	0.000E+00	1.082E-02	1.849E-01
1.300E+00	1.961E-20	2.175E-01	0.000E+00	0.000E+00	1.023E-02	1.951E-01
1.400E+00	6.735E-22	2.175E-01	0.000E+00	0.000E+00	9.756E-03	2.049E-01
1.500E+00	2.313E-23	2.175E-01	0.000E+00	0.000E+00	9.262E-03	2.142E-01
1.600E+00	7.944E-25	2.175E-01	0.000E+00	0.000E+00	8.793E-03	2.230E-01
1.700E+00	2.728E-26	2.175E-01	0.000E+00	0.000E+00	8.347E-03	2.313E-01
1.800E+00	9.371E-28	2.175E-01	0.000E+00	0.000E+00	7.925E-03	2.392E-01
1.900E+00	3.218E-29	2.175E-01	0.000E+00	0.000E+00	7.523E-03	2.467E-01
	TOTAL	2.175E-01	TOTAL	0.000E+00	TOTAL	2.467E-01

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SUMMARY OF OFF-SITE DOSES

ANO UNIT 2 FHA Dose, 100 hour decay; input file: Case4.in output file: Case4.

CALCULATION FOR THYROID DOSE (REMS)
 SINGLE NODE CONTAINMENT WITH NO ESF

START TIME	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH	ACCUM.	EACH	ACCUM.	EACH	ACCUM.

8.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
9.000E-01	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.100E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.200E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.300E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.400E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.500E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.600E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.700E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.800E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
1.900E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	TOTAL	0.000E+00	TOTAL	0.000E+00	TOTAL	0.000E+00

CALCULATION FOR SKIN-T DOSE (REMS)

MULTI NODE CONTAINMENT WITH ESF

START TIME (HRS)	EXCLUSION RADIUS		LOW POPULATION ZONE		CONTROL ROOM	
	EACH STEP	ACCUM.	EACH STEP	ACCUM.	EACH STEP	ACCUM.
0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
2.800E-04	3.620E-01	3.620E-01	0.000E+00	0.000E+00	9.741E-03	9.741E-03
1.000E-01	1.255E-02	3.745E-01	0.000E+00	0.000E+00	1.921E-02	2.895E-02
2.000E-01	4.312E-04	3.750E-01	0.000E+00	0.000E+00	1.858E-02	4.753E-02
3.000E-01	1.481E-05	3.750E-01	0.000E+00	0.000E+00	1.765E-02	6.518E-02
4.000E-01	5.085E-07	3.750E-01	0.000E+00	0.000E+00	1.675E-02	8.193E-02
5.000E-01	1.747E-08	3.750E-01	0.000E+00	0.000E+00	1.590E-02	9.783E-02
6.000E-01	5.998E-10	3.750E-01	0.000E+00	0.000E+00	1.510E-02	1.129E-01
7.000E-01	2.069E-11	3.750E-01	0.000E+00	0.000E+00	1.433E-02	1.273E-01
8.000E-01	7.075E-13	3.750E-01	0.000E+00	0.000E+00	1.361E-02	1.409E-01
9.000E-01	2.430E-14	3.750E-01	0.000E+00	0.000E+00	1.292E-02	1.538E-01
1.000E+00	8.345E-16	3.750E-01	0.000E+00	0.000E+00	1.226E-02	1.660E-01
1.100E+00	2.866E-17	3.750E-01	0.000E+00	0.000E+00	1.164E-02	1.777E-01
1.200E+00	9.843E-19	3.750E-01	0.000E+00	0.000E+00	1.105E-02	1.887E-01
1.300E+00	3.380E-20	3.750E-01	0.000E+00	0.000E+00	1.049E-02	1.992E-01
1.400E+00	1.161E-21	3.750E-01	0.000E+00	0.000E+00	9.960E-03	2.092E-01
1.500E+00	3.987E-23	3.750E-01	0.000E+00	0.000E+00	9.456E-03	2.186E-01
1.600E+00	1.369E-24	3.750E-01	0.000E+00	0.000E+00	8.977E-03	2.276E-01
1.700E+00	4.703E-26	3.750E-01	0.000E+00	0.000E+00	8.522E-03	2.361E-01
1.800E+00	1.615E-27	3.750E-01	0.000E+00	0.000E+00	8.091E-03	2.442E-01
1.900E+00	5.547E-29	3.750E-01	0.000E+00	0.000E+00	7.681E-03	2.519E-01
	TOTAL	3.750E-01	TOTAL	0.000E+00	TOTAL	2.519E-01

1 NO MORE CASES

END OF EXECUTION

ATTACHMENT 5

Input Data File

Data File: FHAdata

2	5	3	0	0	1	0	0
WHOLEBDY	SKIN-B	THYROID	SKIN-G	SKIN-T			
HALOGENS NOBLES							
ELEM.	ORG.	PART.					
KR	85						
2.042000E-09	4.102000E+02						
3.310000E-04	4.840000E-02	0.000000E+00	4.750000E-04				
0.0	0.0	0.0	0.0				
0.0	0.0	0.0	0.0				
1	2	0	0	0	0	0	
XE 131M							
6.680000E-07	2.595000E+02						
1.250000E-03	1.330000E-02	0.000000E+00	2.710000E-03				
0.0	0.0	0.0	0.0				
0.0	0.0	0.0	0.0				
2	2	0	0	0	0	0	
XE 133M							
3.490000E-06	1.384000E+03						
4.290000E-03	2.960000E-02	0.000000E+00	7.000000E-03				
0.0	0.0	0.0	0.0				
0.0	0.0	0.0	0.0				
3	2	0	0	0	0	0	
XE 133							
1.522000E-06	5.622000E+04						
4.960000E-03	9.670000E-03	0.000000E+00	7.890000E-03				
0.0	0.0	0.0	0.0				
0.0	0.0	0.0	0.0				
4	2	0	0	0	0	0	
I 131							
9.963996E-07	2.508000E+04						
5.590000E-02	3.070000E-02	1.100000E+06	7.950000E-02				
0.0	0.0	0.0	0.0				
0.0	0.0	0.0	0.0				
5	1	0	0	0	0	0	
I 133							
9.219000E-06	5.622000E+04						
9.110000E-02	8.900000E-02	1.800000E+05	1.310000E-01				
0.0	0.0	0.0	0.0				
0.0	0.0	0.0	0.0				
6	1	0	0	0	0	0	