ATTACHMENT 2

Consumers Power Company
Palisades Plant
Docket 50-255

BENCH-MARKING OF THE MHACALC CODE

EA-PAH-91-05

April 29, 1992

Consumers Power
POWERING MICHIGAN'S PROGRESS

PALISADES NUCLEAR PLANT
ENGINEERING ANALYSIS WORK SHEET

EA-PAH-91-05
Sheet 1 of 50

Title BENCHMARKING OF THE MHACALC CODE

INITIATION AND REVIEW

Rev #	Description	Initiated		Initiator	Review Method Check (√)			Technically Reviewed		Reviewer
		By	Date	Appd By	Alt Calc	Det Rvw	Qual Test	By	Date	Appd By
0	Original Issue		3/3/92		X	X		DDWinter	4 March 92	

PURPOSE:

The objective of this Engineering Analysis is to demonstrate the calculational methodology used to write the MHACALC FORTRAN code and to verify the accuracy of the output from the code through the use of test cases and alternate calculations.

PROCEDURE UTILIZED:

The guidance of Regulatory Guide 1.4, Rev. 2, the Standard Review Plan, Section 6.5.2, Rev. 2, and differential equations to model radionuclide transport in and out of the containment building.

SUMMARY OF RESULTS:

The MHACALC code was written to calculate the time dependent activity of iodine and noble gas in the containment atmosphere and sump following a LOCA. The code also determines the resultant offsite radiation exposure doses, and the time dependent radionuclide release rates for use in control room habitability calculations. Through the use of several test cases and alternate calculations, the code was verified to perform all of the desired functions accurately. The MHACALC code is therefore functionally correct to perform radiological consequence analyses of a LOCA at Palisades in accordance with the Regulatory Guide and Standard Review Plan guidance.

SPECIAL MEDIA ATTACHED (DRAWINGS, MICROFICHE, ETC)

____ NO __X__ YES - List of Attachments included

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BENCHMARKING OF THE MHACALC CODE

1.0 OBJECTIVE

The objective of this Engineering Analysis is to demonstrate the calculational methodology used to write the MHACALC Fortran code and to verify the accuracy of the output from the code through the use of test cases and hand calculations.

2.0 REFERENCES

2.1 Regulatory Guide 1.4, "Assumptions Used For Evaluating The Potential Radiological Consequences of a Loss of Coolant Accident For Pressurized Water Reactors." Rev. 2, June 1974.

2.2 Letter from A. Schwencer (NRC) to D. Bixel (CPCo). Subject: Transmittal of Amendment No. 31 and Safety Evaluation. November 1, 1977. Cart./Frame: 2511/1751.

2.3 EA-P-LOCA-870424, "Calculation of The Offsite Thyroid and Wholebody Doses Due to The Palisades MHA." May 1987. Cart/Frame: 3644/932

2.4 NUREG-0800, USNRC Standard Review Plan. Section 15.6.5 Appendix A, Rev. 1 - July 1981. Section 15.6.5 Appendix B, Rev. 1 - July 1981. Section 6.2.4, Rev. 2 - July 1981. Section 6.5.2, Rev. 2 - December 1988.

2.5 Palisades Plant Technical Specifications.

2.6 EA-P-LOCA-881024, "Calculation of Offsite Doses Due to The Palisades MHA Including The Effect of The CWRT Vent." October 1988.

2.7 Palisades Plant Final Safety Analysis Report.

2.8 Letter from D. P. Hoffman (CPCo.) to D. L. Ziemann (NRC). March 9, 1978. Cart./Frame: 0575/1561.

2.9 Letter from D. L. Ziemann (NRC) to D. P. Hoffman (CPCo.). Subject: Amendment No. 40. April 12, 1978.

2.10 E-PAL-90-035, "RT-88A Test Failure", Palisades Event Report. September 25, 1990.

2.11 Code of Federal Regulations, Title 10, Part 20, "Standards for Protection Against Radiation," May 1991. Title 10, Part 100, "Reactor Site Criteria," January 1 1990.

2.12 ICRP Publication 30, "Limits for Intakes of Radionuclides by Workers," Pergamon Press, July 1978.

2.13 NEDO-24782, "BWR Owner's Group NUREG-0578 Implementation: Analysis and Positions for Plant Unique Submittals," General Electric Co. 1984.

2.14 NUREG/CR-1413, "A Radionuclide Decay Data Base - Index and Summary Table," Oak Ridge National Laboratory. May 1980.

2.15 RETRAN-02 Computer Code Manual, Volume 3, Rev. 4. November 1988.

2.16 Internal Correspondence WLR92-001, from WLRoberts to PMDonnelly. Subject: "Palisades Plant - Meeting With the NRC on CRHAB, Iodine Removal and SIRW Tank Dose Issues," January 22, 1992.

2.17 Palisades Plant Drawing M-116 Rev 13, "Heating & Ventilation Auxiliary & Containment Plan at Elevation 590'-0"."

2.18 Palisades Plant Drawing M-118 Rev 18, "Heating & Ventilation Auxiliary & Containment Plan at El 607'-6" & 611'-0"."

2.19 Palisades Plant Drawing M-120 Rev 10, "Heating & Ventilation Auxiliary & Containment Building Plan Elevation 625'-0"."

2.20 Palisades Plant Drawing M-122 Rev 4, "Heating & Ventilation Reactor Containment Building Recirculation Risers."

2.21 Palisades Plant Drawing M-123 Rev 4, "Heating & Ventiltation Reactor Containment Building Coolers - Unit V-3 & Unit V-4."

2.22 FD-M-25 Rev C, "Palisades Plant Consumers Power Company Unit 1 Functional Description Containment Air Cooling System," Bechtel Company, September 1968. Located in DCC in the functional description books.

2.23 EMF-91-177, "Palisades Large Break LOCA/ECCS Analysis With Increased Radial Peaking and Reduced ECCS Flow," Siemens Nuclear Power Corporation, October 1991.

2.24 NUREG/CR-5106, "User's Guide for the TACT5 Computer Code," June 1988.

2.25 NUREG/CR-5732, "Iodine Chemical Forms in LWR Severe Accidents," Oak Ridge National Laboratory, July 1991.

2.26 EA-PAH-91-06, "Iodine Removal Coefficients for Containment Sprays Based on Standard Review Plan 6.5.2, Revision 2," December 1991. Cart/Frame: F005/2454.

2.27 EA-GCP-91-04, "Maximum and Minimum Containment Sump Volume and Boron Concentration Following a Large Break LOCA," November 1991.

2.28 "CRC Handbook of Chemistry and Physics," 55th edition. CRC Press 1974.

2.29 EA-A-NL-92-012-01, "Benchmarking of the CONDOSE Code for Control Room Habitability Calculations," March 1991.

2.30 Letter from E.C. Beahm (Martin Marietta Energy Systems, Inc.) to Jay Y. Lee (USNRC) dated February 5, 1992. (Attached)

3.0 BACKGROUND

To analyze the radiological consequences of a loss of coolant accident (LOCA), or the maximum hypothetical accident (MHA) as it is sometimes called, numerous calculations must be performed to model the time dependent concentration of radionuclides in the containment atmosphere and the subsequent release of those radionuclides to the environment. The calculations must take into account a vast assortment of parameters, most of which are time dependent. Performing an analysis of the MHA over a large time period, such as 30 days as is necessary, is a long and tedious task for hand calculations if performed accurately. For this reason, the MHACALC code was written. The MHACALC code ("the code") calculates the time dependent activity of iodine and noble gas in the containment atmosphere and sump, and determines the resultant offsite radiation exposure doses by modeling the release paths from containment, for a LOCA type accident. The code also calculates the radionuclide release rates following the accident for use in control room habitability evaluations using the CONDOSE code [Ref. 2.29].

The code can model the release of radionuclides to the environment from containment atmosphere leakage and leakage of engineered safety features (ESF) components such as valve stems, pump seals, etc. The ability to model the release of radionuclides from the Safety Injection and Refueling Water (SIRW) Tank due to valve seat leakage during recirculation was also incorporated into the code after the discovery of a potential leak path to the SIRW Tank, which is vented to the atmosphere. This leak path to the SIRW Tank is documented in Reference 2.10.

4.0 ANALYSIS INPUT

4.1 The total airflow through each containment air cooler during MHA conditions, 37,500 ft^3/min, is from Reference 2.7 [Table 6-8 Rev. 12].

4.2 The free air volume in containment, 1.64E+06 ft^3, is from Reference 2.7 [section 5.8.2, Rev. 12].

4.3 The air volume in containment covered by sprays, 1.48E+06 ft^3, which corresponds to 90% of the free air volume is from Reference 2.2.

4.4 The methods for calculating radiation exposure doses to individuals are from ICRP-30 [Ref. 2.12], which contains the most current methods accepted by the NRC as adopted for the newest revision to 10 CFR 20 [Ref. 2.11].

4.5 As long as the pH of the sump is controlled above 7.0, the fraction of iodine reaching the SIRW Tank that will be in volatile form and can evolve out of solution is 3.0E-04 from Reference 2.25 [pg. 26] and Reference 2.30.

5.0 ASSUMPTIONS

5.1 The interaction between the containment atmosphere iodine activity and sump solution activity due to iodine removal by sprays does not need to be accounted for when using Regulatory Guide 1.4 source terms. The results of the NRC's calculations in Reference 2.2 were duplicated in Reference 2.3 [pg. 41] without considering the interaction. This assumption was also recently verified during informal discussions with the NRC [Ref. 2.16].

5.2 The containment atmosphere can be modeled as a single, well-mixed space if at least 90 % of the containment is covered by sprays and a ventilation system is available for adequate mixing of unsprayed compartments [Ref. 2.4, section 6.5.2].

5.3 The containment vent path through a clean waste receiver tank with the rupture disc removed does not need to be included as a release path for LOCA doses. Reference 2.4, SRP 15.6.5 Appendix A states that this path need not be considered if the position of SRP 6.2.4 is met. Since Technical Specifications require this path to be isolated within 25 seconds [Ref. 2.5, Table 3.6.1] and the earliest predicted hot rod burst occurs at 46 seconds for a double ended cold leg guillotine break [Ref. 2.23, Table 2.1], it is assumed that the position of SRP 6.2.4 is met. Also, the calculated dose contribution at the site boundary for this path is 0.02 rem [Ref 2.6].

5.4 The containment leak rate decreases to 50 % of its initial value 24 hours after a LOCA [Ref. 2.1].

5.5 The removal rate of particulate iodine only changes when the total particulate iodine activity decreases by a factor of 50 from the initial activity [Ref. 2.4, section 6.5.2], or when sprays stop.

5.6 The removal rate of elemental iodine ends (becomes 0.0) when the ratio of the initial elemental iodine activity to that at some time after sprays begin equals the decontamination factor for elemental iodine [Ref. 2.4, section 6.5.2] (assuming the condition is met before sprays stop.)

5.7 No credit can be taken for spray removal of organic iodine [Ref. 2.4, section 6.5.2].

5.8 The leak rate from ESF components, taken as the Technical Specification maximum, is multiplied by a factor of 2 for the duration of recirculation after a LOCA [Ref. 2.4, section 15.6.5 App. B].

5.9 The release of radionuclides ends after 30 days.

5.10 Daughter products are not considered during the radioactive decay of the radionuclides of concern in containment. Daughter product ingrowth capability was also removed from the NRC's TACT5 computer code since it is generally not considered in design basis accident analysis [Ref. 2.24].

5.11 Radionuclides leaking into the SIRW tank from recirculation line valve seat-leakage become homogeneously mixed with the volume of water in the SIRW tank, accompanied by instantaneous equilibrium partitioning of the volatile iodine in the SIRW tank liquid and air volumes. This assumption is conservative since it would take a considerable amount of time for the iodine to mix homogeneously and for the volatile iodine to come to equilibrium with the SIRW tank air volume.

5.12 Since the SIRW tank is aluminum, some heat transfer would occur with the environment, the density of the air in the tank is assumed to remain relatively constant as sump water enters the tank. Density changes could also occur from day to night and vice versa, but would result in some periods forcing air from the tank and some drawing air into the tank. There could also be some diffusion in and out of the vent. To account for this, a user defined multiplication factor is specified for the rate at which the iodine exits the tank.

5.13 During the period of time that the sump water is above 212°F, the valve seat-leakage that flashes will condense before reaching the SIRW tank air volume. The leakage will travel through approximately 60 feet of 6 inch piping filled with water into the SIRW tank containing more than 20000 gallons of water after RAS, all of which will be near ambient temperatures. This is designed for use with very small leakages on the order of a few tenths of a gallon per minute.

5.14 The volume of air displaced from the SIRW tank to the environment equals the volume of water that enters the tank. With the vent protruding from the top of the tank being upside down "U"-shaped, air flow into or out of the tank at steady state conditions would be very low. The iodine, homogeneously mixed in the air, exits the tank at the rate at which air exits times a user defined multiplier to account for any diffusion and add conservatism.

5.15 The containment sump water volume decreases with time due to the leakage out of containment, but is conservatively assumed not to increase due condensation of steam in containment.

5.16 For releases from the SIRW tank, the method of Reference 2.25 [pg. 29, Eqn 25] can be used to calculate the partition factor for the volatile iodine in the tank [Ref. 2.30].

6.0 METHODOLOGY

To model containment and the radionuclide release paths from containment, two separate regions are considered: the containment atmosphere and the containment sump. Since no regulatory guidance has been given as to whether or not the interaction between the containment atmosphere and containment sump should be modeled when using Regulatory Guide 1.4 [Ref. 2.1] source terms, References 2.2 and 2.3 are evaluated. In Reference 2.2 [pgs. 25-28] the NRC listed the assumptions, input, and results of their staff's calculations of the doses from a LOCA at Palisades. In Reference 2.3 [pgs. 31-41], the methodology used by the NRC staff was determined by duplicating the NRC staff's results. Excellent agreement with the NRC staff's results were obtained without modeling an interaction between the containment atmosphere and the containment sump [Ref. 2.3, pg. 41]. Also, following the Standard Review Plan 15.6.5 Appendices A & B [Ref. 2.4], the containment atmosphere leakage and the ESF leakage contributions to doses are evaluated separately and then summed to yield the total doses from the incident. Therefore, it is inferred that the regulatory guidance on the source term for the containment sump water conservatively includes the contribution of iodine washed from containment atmosphere by sprays. The containment is thus modeled as two non-interactive regions, the containment atmosphere and the containment sump, each with separate radionuclide release paths to the environment. This was also verified during informal discussions with the NRC [Ref. 2.16].

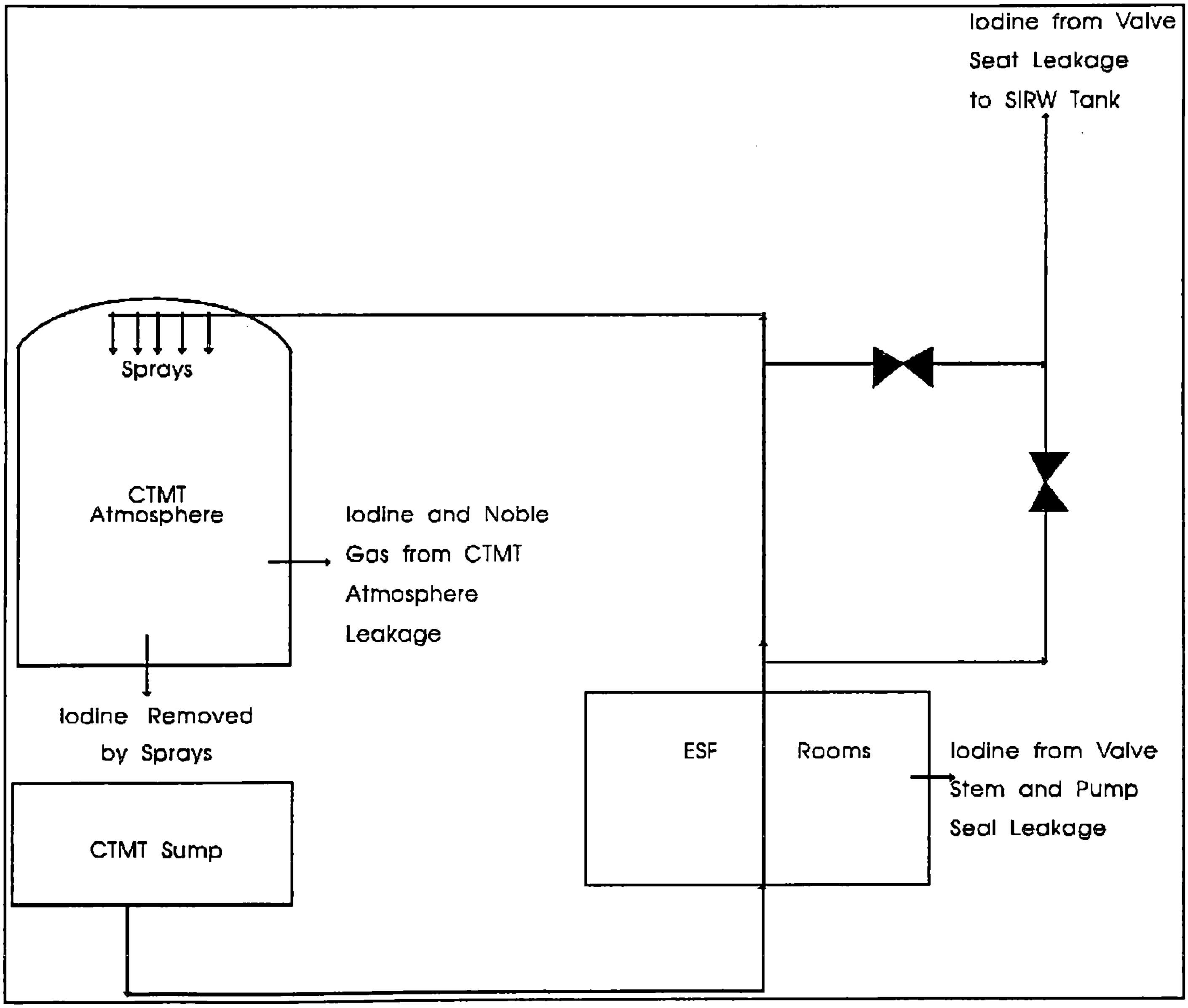
The containment atmosphere in this model is assumed to be a single, well-mixed space, as opposed to modeling a sprayed region and unsprayed region as was done in Reference 2.3. This assumption takes credit for the methodology of revision 2 to section 6.5.2 of the Standard Review Plan (SRP) [Ref. 2.4]. According to SRP 6.5.2, a single, well-mixed space can be assumed if the containment sprays cover at least 90 % of the containment building space and a ventilation system is available for mixing unsprayed spaces in containment [Ref. 2.4, 6.5.2-III.1.c].

The significant unsprayed compartments are the containment dome and most parts of the 590' elevation in containment. After a LOCA, the containment air coolers would be operating. VHX-1, 2, & 3 operate off of emergency diesel generator (EDG) 1-2, and VHX-4 operates off of EDG 1-1. For worst case fan operation with EDG 1-2 lost, VHX-4 would still be operating off of EDG 1-1. Service water is not available to VHX-4, but the fan motor will still be sequenced on. Therefore, even with loss of one EDG, at least one containment air cooler will be circulating 37,500 cfm [Ref. 2.7, Table 6-8] of air in containment. For mixing of the containment dome, VHX-3 & 4 tie into a common 10" riser that draws air from the containment dome. This 10" riser can be seen on References 2.17, 2.18, & 2.19. For mixing of the 590' elevation, all of the air coolers have a hinged plate at the bottom of the ducts that draw from the steam generator compartments. The hinged plates are designed to shear their rivets and open in case of gas expansion caused by a pipe break within the steam generator compartments [Ref. 2.22, pg. 3 & Ref. 2.21] to protect the coolers and fans from internal pressures greater than design. This should occur for a large break LOCA, causing the coolers to draw air from the 590' elevation. As can be seen on Reference 2.20, the discharge from the coolers is at the 625' and 668' elevations which are regions that should be covered by sprays. Therefore, between the coolers and the natural convection forces that would be occurring, adequate mixing should occur during a large break LOCA.

For the spray coverage of containment, 1.48E+06 ft^3 has been used in all previous MHA analyses for Palisades [Refs. 2.3 & 2.6], which corresponds to 90% of the containment net free volume. The basis for this volume could not be found. However, the 90% spray coverage value has been used in MHA calculations submitted to the NRC for review [Ref. 2.8] and has also been used in safety evaluation calculations by the NRC staff for amendments to the Palisades operating license [Refs. 2.2 & 2.9]. It is inferred from those analyses and calculations that 90% spray coverage of the containment air volume has been accepted as appropriate for Palisades since both CPCo and NRC staff used that value.

A basic illustration of the containment model used is shown in Figure 1.

FIGURE 1
CONTAINMENT RELEASE PATH MODEL



6.1 RELEASES FROM CONTAINMENT ATMOSPHERE

The containment atmosphere will contain noble gas and airborne iodine following an accident in which fuel failures occur. The radionuclides of main concern that will be present in the containment atmosphere are the following: Kr-83m, Kr-85m, Kr-85, Kr-87, Kr-88, Kr-89, Xe-131m, Xe-133m, Xe-133, Xe-135m, Xe-135, Xe-137, Xe-138, I-131, I-132, I-133, I-134, and I-135. For iodine in the containment atmosphere, several removal mechanisms will exist: radioactive decay, removal by containment sprays and surface plateout, and leakage of the containment atmosphere to the environment at the design leak rate. For noble gas in the containment atmosphere, however, only radioactive decay and leakage of the containment atmosphere to the environment at the design leak rate will occur.

The normal containment venting path, through a clean waste receiver tank (CWRT) with the rupture disc removed, is not considered for a release path in the model for the code. SRP Section 15.6.5 [Ref. 2.4, 15.6.5-III.4] states that the containment vent release path should be considered an additional contributor to the LOCA doses if the position of SRP Section 6.2.4 is not met [Ref. 2.4]. Reference 2.23 predicted hot rod burst to occur at 46 seconds for a double ended guillotine cold leg break. Technical Specifications require all containment penetrations, including the CWRT vent, to be automatically isolated within 25 seconds [Ref. 2.5, TS 3.6], which is before fuel melting would begin during a LOCA and is within the guidelines of SRP Section 6.2.4. Therefore, it is not necessary to include the containment vent contribution to the calculated doses from a LOCA at Palisades. The dose contribution from the vent path prior to isolation would also be extremely small if it were to be included, ~0.02 rem thyroid at the site boundary [Ref. 2.6, pg. 15].

6.1.1 NOBLE GAS

The initial noble gas activity in the containment is calculated by multiplying noble gas source term values (in Ci/MW_t) by the rated thermal power of the reactor core and the fraction of the noble gas activity in the core that is released to the containment atmosphere. This initial activity for each noble gas isotope is illustrated in Equation (1).

$$N_{CAi}(0) = P S_i f_{CAi} \tag{1}$$

where
N_{CA} = the initial noble gas activity in the containment atmosphere, Ci
P = the rated thermal power of the reactor core, MW_t
S = the activity source term of each isotope, Ci/MW_t
f_{CA} = fraction of the noble gas activity in the core that is released to the containment atmosphere
and subscript "i" denotes the individual isotopes in this and all following equations.

Considering radioactive decay and leakage from containment as the only removal mechanisms for noble gas in the containment atmosphere, the rate of change of the noble gas activity in the containment atmosphere with time can be represented by the following equation for each noble gas isotope:

$$\frac{d}{dt}N_{CAi}(t) = -[\lambda_i + \lambda_L]\,N_{CAi}(t) \qquad (2)$$

where N_{CA} = noble gas activity in containment at time "t"
λ = radioactive decay constant, min^{-1}
λ_L = leak rate from the containment atmosphere, min^{-1}
(same as the containment leak rate converted from %/day)

This is very similar to the basic representation of radioactive decay except that another 'decay' term has been added to account for leakage from containment. It should be noted, however, that λ_L is not constant, but can be treated as a constant over a given time interval since its value only changes at certain points in time. When using Regulatory Guide assumptions for LOCA analysis, the containment leak rate, or λ_L, only changes after 24 hours at which time it becomes 50% of the containment design leak rate [Ref. 2.1]. The MHACALC code ("the code") is programmed to automatically decrease the value of λ_L by 50% after 24 hours. Treating λ_L as a constant, Equation (2) can be integrated to result in the following equation, representing the noble gas activity at any point in time of a given time interval:

$$N_{CAi}(t) = N_{CAi}(t_0)\,e^{-(\lambda_i+\lambda_L)t} \qquad (3)$$

where $N_{CA}(t)$ = activity in containment at time "t" into the time interval, Ci
$N_{CA}(t_0)$ = activity in containment at the beginning of the time interval, Ci
λ and λ_L are the same as described above.

The release rate of each noble gas isotope from the containment atmosphere at a given time is just the activity in the containment atmosphere multiplied by the leak rate from the containment atmosphere as shown below.

$$\dot{q}_{CAi}(t) = \lambda_L N_{CAi}(t_0)\,e^{-(\lambda_i+\lambda_L)t} \qquad (4)$$

where $\dot{q}_{CA}$ = noble gas release rate to the environment from the containment atmosphere at time "t", Ci/min

Integrating the release rate over a given time interval then results in the total noble gas activity released from the containment atmosphere during the time interval, as shown in Equation (5).

$$Q_{CAi}(t) = \frac{\lambda_L N_{CAi}(t_0)}{\lambda_i + \lambda_L}\,[1 - e^{-(\lambda_i+\lambda_L)\Delta t}] \qquad (5)$$

where Q_{CA} = noble gas activity released to the environment from the containment atmosphere during the time interval, Ci
Δt = the time span from t_0 to t, min

6.1.2 IODINE

The equations to represent the iodine activity in the containment atmosphere are slightly more complicated than those for noble gas. There are three iodine removal processes taking place, and three chemical species that react differently to the containment sprays. Following the guidance of Reference 2.1, the three chemical species of iodine that would be present after an accident in which fuel damage occurs are elemental, particulate, and organic. The initial activity in the containment atmosphere of each chemical species of each iodine isotope is calculated using the following equation:

$$N^k_{CAi}(0) = PS_i\, f_{CAi}\, f^k_{CF} \tag{6}$$

where N_{CA} = the initial iodine activity in the containment atmosphere, Ci
P = the rated thermal power of the reactor core, MW_t
S = the activity source term of each isotope, Ci/MW_t
f_{CA} = fraction of the iodine activity in the core that is released to the containment atmosphere
f_{CF} = the fraction of the iodine released in each chemical species.
superscript "k" denotes iodine chemical species.

The time dependent rate of change of iodine activity in the containment atmosphere can be represented by the following equation for each chemical species of each iodine isotope:

$$\frac{d}{dt}N^k_{CAi}(t) = -(\lambda_i+\lambda_L+\lambda^k_S)\,N^k_{CAi}(t) \tag{7}$$

where λ_S = spray removal coefficient for each iodine chemical species, min^{-1}
all other variables are the same as defined in the previous section, but are representing iodine isotopes instead of noble gas isotopes.

This is very similar to Equation (2) with the exception that another term has been added to account for the removal of iodine from the containment atmosphere by containment sprays, and that each iodine isotope has three chemical species As with λ_L, λ_S for each chemical species can be assumed to be constant over a given time interval since its value only changes at certain points in time, as will be discussed later in this section. The activity of each chemical species of each iodine isotope in the containment atmosphere at any given point in time of a time interval can be found by integrating Equation (7) to result in the following:

$$N^k_{CAi}(t) = N^k_{CAi}(t_0)\, e^{-(\lambda_i+\lambda_L+\lambda^k_S)\,t} \tag{8}$$

where $N_{CA}(t)$ = activity in containment atmosphere at time "t" into the time interval, Ci
$N_{CA}(t_0)$ = activity in containment atmosphere at beginning of time interval, Ci

The total activity of each iodine isotope in the containment atmosphere is just the sum of the activities of each chemical species of the isotope as shown below.

$$N_{CAi}(t) = \sum_{k=1}^{3} N_{CAi}^{k}(t_0)\, e^{-(\lambda_i+\lambda_L+\lambda_S^k)t} \tag{9}$$

The release rate from the containment atmosphere of each iodine isotope at a given time, as shown in Equation (10), is just the activity in the containment atmosphere multiplied by the containment leak rate.

$$\dot{q}_{CAi}(t) = \sum_{k=1}^{3} \lambda_L N_{CAi}^{k}(t_0)\, e^{-(\lambda_i+\lambda_L+\lambda_S^k)t} \tag{10}$$

where $\dot{q}_{CA}$ = iodine release rate to the environment from the containment atmosphere at time "t", Ci/min

Being similar to the equations for noble gas release, integrating the iodine release rate over a given time interval results in the total iodine activity released from the containment atmosphere during the time interval, as illustrated in Equation (11).

$$Q_{CAi}(t) = \sum_{k=1}^{3} \frac{\lambda_L N_{CAi}^{k}(t_0)}{\lambda_i+\lambda_L+\lambda_S^k}\,[1 - e^{-(\lambda_i+\lambda_L+\lambda_S^k)\Delta t}] \tag{11}$$

where Q_{CA} = iodine activity released to the environment from the containment atmosphere during the time interval, Ci
Δt = the time span from t_0 to t, min

After the containment atmosphere iodine activity and the iodine activity released to the environment during a time interval have been calculated, several conditions for iodine must be checked before performing the calculations for the next time interval. As was mentioned previously, the value of λ_S changes at certain points in time. The code is written so that the value of λ_S for elemental iodine can change at time points given in the input to the code. The code also determines when the maximum elemental iodine decontamination factor, which is specified in the input to the code, is reached. From Reference 2.4 [section 6.5.2], the decontamination factor is defined:

> "as the maximum iodine concentration in the containment atmosphere divided by the concentration of iodine in the containment atmosphere at some time after decontamination."

Relative to elemental iodine, this can be interpreted as the ratio of the initial elemental iodine activity in the containment atmosphere to the activity of elemental iodine in the containment atmosphere at some time after sprays begin. Letting the superscript "k" = 1 denote elemental iodine, the following condition is tested for:

$$\frac{\sum_{i=1}^{5} N_{CAi}^{1}(0)}{\sum_{i=1}^{5} N_{CAi}^{1}(t)} \geq DF_{\max} \tag{12}$$

where $DF_{\max}$ = maximum elemental iodine decontamination factor
all variables have been previously defined, remembering that the subscript "i" represents the iodine isotopes.

When the condition in Equation (12) is met for the value of $DF_{\max}$ specified in the input to the code, λ_s^1 is set equal to zero for the remainder of the incident. However, if the sump solution pH falls below 7.0, elemental iodine must be assumed to evolve back into the containment atmosphere. To account for this, λ_s^1 can be decreased by an appropriate amount if the condition in Equation (12) has not been met yet. If λ_s^1 has been set to zero, a negative value would account for re-evolution. The code is written so that it will not set λ_s^1 equal to zero if it is a negative number.

For particulate iodine, the superscript "k" = 2 denoting particulate, the ability to change the value of λ_s^2 at specified points in time was not included in the code since particulate removal is a mechanical process and not dependent on spray additives or pH. However, the code does change the value of λ_s^2 to a second value given in the input to the code when the activity of particulate iodine in the containment atmosphere has been depleted by a factor of 50, in accordance with Reference 2.4 [section 6.5.2]. Being similar to the test for elemental iodine, the following condition is tested for:

$$\frac{\sum_{i=1}^{5} N_{CAi}^{2}(0)}{\sum_{i=1}^{5} N_{CAi}^{2}(t)} \geq 50.0 \tag{13}$$

When the condition in Equation (13) is met, the code changes the value of λ_s^2.

The code is also set up for a time to be specified in the input deck for when containment sprays stop. When that time is reached, if a time is specified, the code sets λ_s for elemental and particulate iodine equal to 0.0 (except when λ_s^1 has a negative value to account for iodine re-evolution from the sump.) In accordance with the Standard Review Plan, no spray removal for organic iodine can be accredited [Ref. 2.4, section 6.5.2], and λ_s^3 for organic iodine is always set equal to 0.

6.2 RELEASES FROM CONTAINMENT SUMP

The sump solution is assumed to contain iodine but is not assumed to contain any noble gas, since all of the noble gas would evolve out of the solution into the containment atmosphere. The initial activity of each iodine isotope in the sump solution is represented by the following:

$$N_{si}(0) = P S_i f_s \tag{14}$$

where N_s = initial iodine activity in the containment sump, Ci
P = the rated thermal power of the reactor core, MW_t
S = the activity source term of each isotope, Ci/MW_t
f_s = the fraction of the iodine activity in the core that is released to the sump.

As mentioned previously, because of the high fraction of iodine that Reference 2.1 gives as being released to the containment sump (50% of the core's iodine), the iodine activity in the sump is treated as being independent of the iodine activity removed from the containment atmosphere by sprays and plateout. Therefore, the only removal mechanisms for iodine from the containment sump solution are radioactive decay and leakage outside of containment when recirculating the sump water. However, with the current plant configuration at Palisades, two paths for leakage outside of containment must be considered once recirculation of the sump water begins. Engineered Safety Features (ESF) leakage of sump water into the east and west safeguards rooms, through components such as valve stems and pump seals, is one out-of-containment release path that must be considered [Ref. 2.4, 15.6.5 App. B]. The other out-of-containment release path to consider is valve seat-leakage through recirculation lines leading to the SIRW tank [Ref. 2.10], or to any other area outside containment that could ultimately vent to the environment. Considering these removal mechanisms for iodine from the containment sump solution, the time dependent rate of change of iodine activity in the containment sump solution can be represented by Equation (15) for each iodine isotope. Account is also taken for the sump water volume decreasing with time as leakage outside of containment occurs. It is conservatively assumed that condensation of steam in the containment atmosphere does not affect the sump water volume.

$$\begin{aligned}\frac{d}{dt} N_{si}(t) &= -\left(\lambda_i + \frac{LR_{ESF} + LR_{SRW}}{V_s(t)}\right) N_{si}(t) \\ &= -\left(\lambda_i + \frac{LR_{ESF} + LR_{SRW}}{V_s(0) - (LR_{ESF} + LR_{SRW})\, t}\right) N_{si}(t)\end{aligned} \tag{15}$$

where LR_{ESF} = leak rate of sump water through ESF components, ft^3/min
LR_{SRW} = leak rate of sump water (from valve seat-leakage) to any area
outside containment that can vent to the atmosphere, ft^3/min
V_s = sump water volume, ft^3

As can be seen in this equation, the chemical species of the iodine in the sump water is not important since there are no different removal mechanisms for the different chemical species as there was for iodine in the containment atmosphere with sprays operating. It should be noted that the code multiplies the ESF leak rate, LR_{ESF}, specified in the input to the code, by a factor of 2 to remain consistent with the requirements of Reference 2.4 [section 15.6.5, App. B]. The code, however, does not multiply the input value for LR_{SRW} by a factor of 2 since it is questionable whether leakage of that sort would fall under the same requirements, and additional conservatism is provided for the SIRW tank release as will be discussed later. To increase its capabilities, the code was written so that up to four values for ESF and SRW leak rates could be specified in the input, along with times at which the values change. However, all values of LR_{ESF} will be multiplied by the factor of 2 mentioned above.

Now, Equation (15) must be integrated to obtain the activity of each iodine isotope in the containment sump solution at any point in time of a given time interval.

$$\int_0^t \frac{dN_{si}(t)}{N_{si}(t)}dt = -\int_0^t \left(\lambda_i + \frac{LR_{ESF}+LR_{SRW}}{V_s(0) - (LR_{ESF}+LR_{SRW})\,t}\right)dt$$

$$\ln\left(\frac{N_{si}(t)}{N_{si}(0)}\right) \rightarrow N_{si}(t) = N_{si}(0)\, e^{\left[-\int_0^t \left(\lambda_i + \frac{LR_{ESF}+LR_{SRW}}{V_s(0) - (LR_{ESF}+LR_{SRW})\,t}\right)dt\right]}$$

By letting a = $V_s(0)$ and b = $LR_{ESF} + LR_{SRW}$, the second term in the exponential can be expressed in a form similar to that of Reference 2.28 [pg. A-113, #27], which shows:

$$\int \frac{dx}{a+bx} = \frac{1}{b}\ln(a+bx)$$

or for this case:

$$\int_0^t \frac{b\,dt}{a-bt} = b\left(-\frac{1}{b}\right)\ln(a-bt)\Big|_0^t = \ln\left(\frac{a-bt}{a}\right)$$

Using this, the integration of Equation (15) can be completed to result in the following expression:

$$\begin{aligned} N_{si}(t) &= N_{si}(t_0)\, e^{\left[-\lambda_i t + \ln\left(\frac{V_s(t_0) - (LR_{ESF}+LR_{SRW})\,\Delta t}{V_s(t_0)}\right)\right]} \\ &= N_{si}(t_0)\left[\frac{V_s(t_0) - (LR_{ESF}+LR_{SRW})\,\Delta t}{V_s(t_0)}\right] e^{-\lambda_i \Delta t} \end{aligned} \tag{16}$$

where
$N_s(t)$ = activity in containment sump water at time "t" into the time interval, Ci
$N_s(t_0)$ = activity in containment sump water at beginning of the time interval, Ci
$V_s(t_0)$ = sump water volume at beginning of time interval, ft^3
Δt = the time span from t_0 to t, min.

The release of iodine from the sump water to the environment must be considered separately for the two possible release paths.

6.2.1 RELEASES FROM SAFEGAURDS ROOMS

The ESF leakage into the safeguards rooms is to account for expected leakage from valve stems, pump seals, and from failure of an ESF passive component, such as a pump seal [Ref. 2.4, SRP 15.6.5, App.

B]. For the ESF leakage, the release rate of iodine to the environment at a given time is equal to the iodine concentration in the sump water multiplied by the ESF leak rate, and divided by a partition factor and any applicable retention or decontamination factor. The partition factor accounts for the fact that only a percentage of the iodine will evolve out of the solution into the ESF room atmosphere. The retention factor accounts for the retention of iodine released in the safeguards rooms due to the automatic isolation of the ventilation in the rooms. Credit for a retention factor can be taken because with the ventilation isolated, little air flow out of the rooms should exist, which allows iodine to plate-out on walls and surfaces. After taking credit for the partition and retention factors, the iodine is assumed to be instantaneously released to the environment with no hold up time for traveling through the Auxiliary building. Equation (17) is used to represent the release rate of each iodine isotope from the ESF rooms at any given time.

$$\dot{q}_{ESFi}(t) = \frac{LR_{ESF}}{DF_{ESF}\,PF_{ESF}}\,\frac{N_{Si}(t)}{V_S(t)}\,e^{-\lambda_i t} = \frac{LR_{ESF}}{DF_{ESF}\,PF_{ESF}}\,\frac{N_{Si}(t_0)}{V_S(t_0)}\,e^{-\lambda_i t} \qquad \textbf{(17)}$$

where $\dot{q}_{ESF}$ = iodine release rate to the environment from ESF leakage at time "t", Ci/min

DF_{ESF} = iodine retention factor for the safeguards rooms due to the automatic isolation of the ventilation

PF_{ESF} = partition factor for iodine in the sump water released to the safeguards rooms

Integrating Equation (17) over a given time interval results in the total activity of each iodine isotope released to the environment from ESF leakage during the time interval. Using Reference 2.28 [pg. A-111, #12], integration of Equation (17) results in the following:

$$Q_{ESFi}(t) = \int_{t_0}^{t} \dot{q}_{ESFi}(t)\,dt = \left[\frac{LR_{ESF}\ N_{Si}(t_0)}{DF_{ESF}\ PF_{ESF}\ V_S(t_0)\ \lambda_i}\right]\left[1-e^{-\lambda_i \Delta t}\right] \qquad \textbf{(18)}$$

where Q_{ESF} = iodine activity released to the environment from ESF leakage during the time interval, Ci

Δt = the time span from t_0 to t, min.

6.2.2 RELEASES FROM SIRW TANK

Leakage of sump water into the SIRW tank is to account for possible seat-leakage of valves in the recirculation lines leading to the SIRW tank, or to any other area outside of containment that is vented to the environment. This potential leak path has not been previously analyzed and the valves in the recirculation lines to the SIRW tank are not currently seat-leak tested (see E-PAL-91-035). The allowable leakage for these valves is expected to be low, less than one gallon per minute. For the seat-leakage of valves isolating the SIRW tank from sump water, it is assumed that as iodine leaks through the valves, homogeneous mixture and equilibrium partitioning occur instantaneously in the SIRW tank and the line leading to the tank. This is a conservative assumption since it would take some amount of time for the iodine to mix in the water of the tank and line leading to it, and for equilibrium partitioning of the volatile iodine to occur. The rate at which iodine enters the line leading to the SIRW tank is just the iodine concentration of the sump water multiplied by the total leak rate through the valves. The following equation can be used to represent this leak rate for each iodine isotope:

$$\dot{q}_{VLVi}(t) = LR_{SRW}\frac{N_{Si}(t)}{V_S(t)} = \frac{LR_{SRW}\, N_{Si}(t_0)}{V_S(t_0)}\, e^{-\lambda_i t} \tag{19}$$

where $\dot{q}_{VLV}$ = iodine leak rate through recirculation line valves at time "t", Ci/min.

Integrating Equation (19) over a given time interval, as was done to obtain Equation (18), results in a representation of the total activity of each iodine isotope that entered the SIRW tank during the time interval, as shown below.

$$Q_{VLVi}(t) = \int_{t_0}^{t}\dot{q}_{VLVi}(t)\, dt = \left[\frac{LR_{SRW}\, N_{Si}(t_0)}{V_S(t_0)\,\lambda_i}\right]\left[1 - e^{-\lambda_i \Delta t}\right] \tag{20}$$

where Q_{VLV} = iodine activity that entered the SIRW tank from valve seat-leakage during the time interval, Ci
Δt = the time span from t_0 to t, min

To represent the total activity in the SIRW tank at any point during a time interval, the iodine activity in the tank at the beginning of the time interval and the iodine activity released to the environment from the tank during the time interval need to be considered. If radioactive decay in the SIRW tank is accounted for, a term to decay the activity in the tank at the beginning of the time interval should be included. For conservatism when calculating the iodine activity in the SIRW tank, the iodine released to the environment during a time interval will not be subtracted from the tank activity until the next time interval. The following equation can be used to represent this:

$$\begin{aligned} A_{SRWi}(t) &= \left[A_{SRWi}(t_0) - Q_{SRWi}(t_0)\right]e^{-\lambda_i \Delta t} + Q_{VLVi}(t) \\ &= \left[A_{SRWi}(t_0) - Q_{SRWi}(t_0)\right]e^{-\lambda_i \Delta t} + \frac{LR_{SRW}\, N_{Si}(t_0)}{V_S(t_0)\,\lambda_i}\left[1 - e^{-\lambda_i \Delta t}\right] \end{aligned} \tag{21}$$

where A_{SRW} = the total iodine activity in the SIRW tank at time "t", Ci
$A_{SRW}(t_0)$ = the total iodine activity in the SIRW tank at "t_0", Ci
$Q_{SRW}(t_0)$ = the iodine activity released through the the SIRW tank vent during the previous time interval, Ci
Δt = the time span from t_0 to t, min.

When the leakage to the SIRW tank begins, Q_{SRW} = 0 assuming the iodine initially in the SIRW tank is negligible. To solve Equation (21) after the leakage begins, the activity released through the vent to the environment during each time interval is needed. Since the SIRW tank vent is a small, upside down "U"-shaped pipe off the top of the tank, no significant airflow should normally exist in or out of the tank if it remains at a constant water volume. Changes in density could cause air flow out of the tank if the tank heats up as the sun shines on it, but along the same philosophy, air would flow into the tank as it cooled down at night. At very small leak rates, as are expected, the sump water entering the SIRW tank would not be expected to significantly heat up the air of the tank either. Therefore, the activity released through the vent can be characterized by the concentration of iodine in the SIRW tank air volume multiplied by the volume of air displaced from the tank as the water level in the tank increases. However, a multiplication factor will be used to account for diffusion out of the tank or to add conservatism if desired. This multiplication factor can be specified to be any value and will be used as an input to the code. The volume of air displaced from the tank is the same as the volume of sump water that has entered the tank through the recirculation line valves. Since the iodine activity in the SIRW tank is increasing with time, the iodine activity released from the tank to the environment during a time interval is conservatively based on the air concentration in the tank at the end of that time interval. This shown is in the following equation.

$$Q_{SRWi}(t) = C_{airi}(t)\; LR_{SRW} k_D \Delta t \tag{22}$$

where Q_{SRW} = the iodine activity released from the SIRW tank during the interval t_0 to t, Ci

C_{air} = the iodine concentration in the SIRW tank air volume at time "t", Ci/ft^3

k_D = multiplication factor for the rate at which iodine exits the SIRW tank to account for diffusion through the vent or for added conservatism

Δt = the time span from t_0 to t, min.

Now a correlation between the total iodine activity in the SIRW tank and the iodine activity in the air volume of the SIRW tank is needed. First, it must be understood that only volatile forms of iodine, such as I_2 and CH_3I, will evolve out of the liquid [Ref. 2.25, pg. 30]. Equation (21) can also be used to represent the activity of the volatile iodine in the SIRW tank if the total activity, A_{SRW}, is replaced with the volatile iodine activity, A_{I2}, and the total iodine activity entering the tank is multiplied by the fraction that is volatile, $Q_{VLV} \bullet f_{I2}$; where f_{I2} is the fraction of the iodine in the sump that is in a volatile form. The equilibrium iodine partition coefficient is then used to account for the fraction of the volatile iodine that evolves out of the solution. The equilibrium partition coefficient for a single volatile species of iodine is defined as the ratio of the concentration of that volatile species in the liquid to the concentration of that volatile species in the air at equilibrium [Ref. 2.25, pg. 6]. The volatile form of iodine reaching the SIRW tank and partitioning out of solution would be I_2 [Ref. 2.30] since the pH of the sump solution is controlled above a value of 7.0. Therefore, the concentration of I_2 in the air can be represented by the concentration of I_2 in the liquid divided by the appropriate partition coefficient for the temperature of the water in the SIRW tank. The non-volatile iodine in the SIRW tank will simply remain in solution. Representing the concentrations as activity divided by the volume, the following equation can be used.

$$\frac{A_{airi}(t)}{V_{air}(t)} = \frac{A_{liqi}(t)}{PF_{SRW}\, V_{liq}(t)} \tag{23}$$

where A_{air} = the I_2 activity in the SIRW tank air volume, Ci
A_{liq} = the I_2 activity in the SIRW tank liquid volume, Ci
V_{air} = the SIRW tank air volume, ft^3
V_{liq} = the SIRW tank liquid volume, ft^3
PF_{SRW} = the I_2 partition coefficient in the SIRW tank

The total I_2 activity for each isotope in the tank at any point in time is just the activity in the air plus the activity in the water. The I_2 activity in the SIRW tank liquid volume in Equation (23) can be solved for and substituted into an equation for the total I_2 activity as shown below.

$$A_{I2i}(t) = A_{airi}(t) + \frac{A_{airi}(t)\ PF_{SRW}\, V_{liq}(t)}{V_{air}(t)} \tag{24}$$

where A_{I2} = the total I_2 activity in the SIRW tank, air plus liquid, volume, Ci

Solving Equation (24) for the activity in the SIRW tank air volume and dividing by the SIRW tank air volume yields the iodine concentration in the SIRW tank air volume, all of which will be I_2, as shown below.

$$C_{airi}(t) = \frac{A_{I2i}(t)}{V_{air}(t) + PF_{SRW}\, V_{liq}(t)} \tag{25}$$

where $V_{air}(t)$ can be represented by V_{tank} - $V_{liq}(t)$.

6.3 TOTAL RELEASE AND DOSES

For noble gas, the total activity released over each time interval is just that released from the containment atmosphere, or Q_{CA} shown previously in Equation (5). For iodine, however, the total activity released during each time interval is the sum of that from the containment atmosphere, ESF components, and recirculation line valves as shown previously in Equations (11), (18), & (22) for Q_{CA}, Q_{ESF}, and Q_{SRW} respectively. The code also calculates the release rates of each noble gas and iodine isotope, and creates two output files for direct use as release rate input decks in the CONDOSE code for control room habitability calculations [Ref. 2.29]. However, the release rate equations that were derived previously in this analysis are not used to calculate the release rates written to the output files. The reason for not using the release rate equations given previously is that the release rate changes at almost every instant in time with those equations. Instead, the code adds up the release of each radionuclide during a time interval of interest for control room habitability calculations (time intervals are specified in the input to the code) and divides by the time span of the interval. This results in an "averaged", or uniform release rate over each time interval of interest by simply using the total release during that interval. Different release rates are calculated for the two output files for use in control room habitability calculations due to different assumed locations for the releases. The containment atmosphere leakage of iodine and noble gas and the ESF leakage of iodine are all assumed to be released from the location of the stack, with the release rates being calculated and written to one output file. The valve seat-leakage to the SIRW tank releases from a completely different location, being directly above the control room. Therefore, the release rates of iodine from the SIRW tank are calculated separately and written to a separate output file.

Offsite doses must be calculated at the site boundary (SB) for the first 2 hours after the accident, and at the low population zone distance (LPZ) for the duration of the release [Ref. 2.11]. Thyroid and whole body doses are calculated at each. Since the distance between the two assumed release locations is much smaller than the the distance to either offsite location, no differences for offsite atmospheric dispersion factors are accounted for due to the difference between the two release locations.

For calculating the offsite dose, the methods and dose conversion factors of ICRP-30 [Ref. 2.12] are used. This is the same methodology as used in the most recent revision to 10 CFR 20 [Ref. 2.11]. Submersion doses are calculated for exposure to clouds of noble gas, and inhalation doses are calculated for inhalation of iodine. The dose calculated to each individual organ or tissue from inhalation or ingestion of a radionuclide is called the committed dose equivalent (CDE) using this methodology. If the CDE to each organ that receives a dose is multiplied by an appropriate weighting factor for the particular organ, and the product of the weighting factors and the CDEs are summed, the committed effective dose equivalent (CEDE) to the whole body is obtained. The CEDE relates the dose to organs from intake of a radionuclide to the stochastic effects if the whole body were irradiated uniformly. The dose calculated to each organ or tissue from external exposure from submersion in a cloud of noble gas is called the deep-dose equivalent. The deep-dose equivalent to each organ or tissue can also be multiplied by an appropriate weighting for each organ and summed to yield the total whole body dose from external radiation. The total effective dose equivalent (TEDE) to the whole body is then the sum of the CEDE and the total whole body dose from external radiation.

For the analysis of offsite doses after design basis accident, the dose to the thyroid and that to the whole body are the doses of main concern since the 10 CFR 100 [Ref. 2.11] limits are specified for those. For inhalation of iodine, the CDE to the thyroid and the CEDE are calculated by the code separately for each of the three release paths and for total release. For external exposure to noble gas, the deep-dose equivalent to the thyroid and the dose to the whole body are calculated by the code for containment atmosphere leakage only since no noble gas is assumed present in the sump. The whole body dose from exposure to noble gas and the CEDE from inhalation of iodine are then summed to yield the TEDE.

The intake of each iodine isotope during a time interval is found by multiplying the appropriate breathing rate by the atmospheric dispersion factor and the activity of each isotope released during the time interval, which can be gathered from the units of each. The CDE to the thyroid from the intake is then found by multiplying the amount of each isotope inhaled by the committed dose equivalent per unit intake (dose conversion factor) for each isotope, as can be seen in Reference 2.12 [Part 1, pg. 8]. This is shown in the following equation:

$$H_{Thy,50} = DCF_{inh} \, BR \, \frac{\chi}{Q} \, Q \qquad (26)$$

where

$H_{Thy,50}$ = committed dose equivalent to the thyroid from inhalation of each iodine isotope during the time interval, Rem
DCF_{inh} = thyroid inhalation dose conversion factor for each iodine isotope, or committed dose equivalent per unit intake, Rem/Ci-inhaled
BR = appropriate breathing rate for the time interval of interest, m^3/sec
χ/Q = atmospheric dispersion factor, for SB or LPZ, for the time interval, sec/m^3
Q = activity of each iodine isotope released during the time interval for each release path, Ci.

The CDE to the thyroid from each iodine isotope and each time interval is then added to yield the total CDE to the thyroid from each iodine release path. That from each release path is then added to give the total CDE to the thyroid from the event. For calculation of the CEDE from the inhalation of iodine, Equation (26) is still used, but the dose conversion factor that is used in the equation is different. The dose conversion factor from ICRP-30 for calculating the CEDE from each iodine isotope is the sum of weighted dose conversion factors for every organ listed for the iodine isotope. The weighted dose conversion factor for each organ is simply the dose conversion factor multiplied by the weighting factor appropriate for each organ. Summing the weighted dose conversion factors makes calculating the CEDE quite easy. The alternate method for calculating the CEDE is to calculate the dose received by every organ that receives a dose from each isotope, then multiply the dose to each of the organs by the appropriate weighting factor, and sum the results. These calculations are performed separately for the SB and LPZ, using the appropriate atmospheric dispersion factors, keeping in mind that the SB dose is only calculated for the first two hours of the event.

The dose to the whole body from external exposure received during a time interval can be found by multiplying the activity released by the atmospheric dispersion factor and the dose rate conversion factor. This is similar to the formulas shown in Reference 2.1, except that the disintegration energy and units conversion are lumped into one parameter for the ICRP-30 methodology. This equation for dose to the whole body from external exposure is shown below.

$$H_{WB} = DCF_{sub} \frac{\chi}{Q} Q \qquad (27)$$

where

H_{WB} = deep-dose equivalent to the whole body from exposure to each noble gas isotope during the time interval, Rem
DCF_{sub} = whole body dose rate conversion factor for submersion in a cloud, or dose equivalent rate from exposure to a unit concentration, of each noble gas isotope, (rem/sec)/(Ci/m^3)
χ/Q = atmospheric dispersion factor as defined for Equation (26)
Q = represents the total activity of each noble gas isotope released during the time interval, Ci

This equation is also used for the deep-dose equivalent to the thyroid from noble gas, just with dose rate conversion factors for the thyroid as opposed to whole body equivalent. As was mentioned above for calculating the CEDE from inhalation, the dose rate conversion factor for the dose to the whole body from external exposure to each noble gas isotope should be the sum of the weighted dose rate conversion factors for every organ listed in ICRP-30 for the isotope. The total dose to the whole body from external exposure is calculated by summing the dose received from each radionuclide and each time interval. As is done for the CDE to the thyroid, the dose to the whole body is calculated separately for the SB and LPZ using the appropriate atmospheric dispersion factors. The TEDE is then calculated by summing the CEDE received from the total iodine release and the dose to the whole body received from the noble gas release.

The breathing rates and atmospheric dispersion factors are treated in accordance with Reference 2.1. Three breathing rates are to specified in the input to the code: 0 to 8 hour value, 8 to 24 hour value, and a value for 24 hours to the end of the event. Four LPZ atmospheric dispersion factors are specified in the input to the code: 0 to 8 hour value, 8 to 24 hour value, 1 to 4 day value, and 4 to 30 day value. The code automatically uses the appropriate values for each time interval, provided that they are specified correctly in the input deck. The SB atmospheric dispersion factor has only one value since SB doses are only calculated for 0 to 2 hours.

6.4 DOSE EQUIVALENT IODINE 131

The code has also been programmed with the ability to create an output deck that can be used directly as an input deck to the RETRAN code PLOTER module for creating and printing plots of the iodine acitivty in the containment atmosphere versus time. However, with five iodine isotopes and three chemical species for each isotope, a large number of plots would have to be made. Therefore, the dose equivalent iodine 131 activity is used. Dose equivalent iodine 131 (DE I-131) activity can be defined as the activity of I-131 that would result in the same dose to the thyroid as the collective doses from the individual iodine isotopes present. This can be represented by the following equation:

$$N_{DE\ I131} = N_{I131} + \frac{DCF_{I132}}{DCF_{I131}} N_{I132} + \frac{DCF_{I133}}{DCF_{I131}} N_{I133} + \frac{DCF_{I134}}{DCF_{I131}} N_{I134} + \frac{DCF_{I135}}{DCF_{I131}} N_{I135} \qquad (28)$$

where

$N_{DE\,I131}$ = dose equivalent I-131 activity, Ci
N = activity of each iodine isotope, Ci
DCF = thyroid inhalation dose conversion factor for each iodine isotope, Rem/Ci-inhaled.

The code calculates the DE I-131 activity for elemental iodine, particulate iodine, organic iodine, and the total. The code writes DE I-131 activities to an output deck at the first two time steps. After the first two time steps, the code compares the DE-131 activities for each of the types to the activity at the last time step that it wrote to the output deck. Whenever the activity changes by + or - 3% the code writes to the output deck the activity at that time step and at the immediately previous time step if it has not been written already. The reason for writing the activity at the immediately previous time step is to avoid a misrepresenting plot if there is a drastic change in activity over any one time interval.

The code also writes to the output deck all of the other information required to use it directly as the input deck to the RETRAN code PLOTER module without having to make any changes. This is discussed in more detail later in this analysis.

7.0 INPUT DECK DESCRIPTION

The input deck is described line by line below. For each parameter of the input deck, the variable name used in the code, the Fortran format for the read statement, and a description of the limitations for the parameter is given. Recommended values are also given for each parameter, with references if appropriate. Examples of the input decks for the test cases can be seen on the attached microfiche.

line 1
TITLE
[A80]

TITLE is just a description of the input deck or the case to be executed, and will be printed at the top of the output deck.

line 2
DEBUG
[I4]

DEBUG is the input for the debug option. A value of 0 will cause the code to write almost every variable at every point in time to the output deck. This will generate thousands of lines of output, and the code will not finish execution if the execution is for a large number of time steps. Any value greater than 0 for the debug option will result in normal execution of the code.

line 3
DURATION
[I10]

DURATION is the number of time steps that program execution is to occur for. The code counts by one minute time steps, so DURATION is the amount of time, in minutes, that the calculations are to be performed for. A normal execution for a LOCA or the MHA is for 30 days, or 43200 minutes. Generally, this value will be 43200 unless using the debug option set to 0. If the debug option is used, set to 0, a value of 300 or less is recommended for DURATION, as execution will be terminated before complete if a much larger value is used.

line 4
POWER, CONTLR, VSUMP
[F10.1, F10.2, F10.1]

POWER is the thermal power of the reactor in units of MW_t. Generally, for accident analyses, a 2% power uncertainty is assumed so that 102% of the rated thermal power of the reactor is used. Since 2530 MW_t is the rated thermal power of Palisades, 2580.6 should normally be used for MHA analyses.

CONTLR is the containment leak rate in units of %/day. The design leak rate at Palisades is 0.1%/day [Ref. 2.7, section 5.8] which should generally be used for all applications.

VSUMP is the volume of sump water in the containment to be recirculated, in units of ft^3. Using a minimum value is conservative since it would increase the concentration of iodine in the solution. This value can be obtained for current plant conditions from Reference 2.27. The minimum value after recirculation begins is normally appropriate.

line 5
FNG, FIA, FIS
[3F10.1]

FNG is the fraction of the core's noble gas inventory that is released to the containment atmosphere, in %. For MHA calculations, this value should always be 100.0% following the guidance of References 2.1 and 2.4.

FIA is the fraction of the core's iodine inventory that is released to the containment atmosphere, in %. This value should always be 25.0% when performing MHA calculations in accordance with References 2.1 and 2.4.

FIS is the fraction of the core's iodine inventory that is released to the containment sump and mixed in the containment sump solution, in %. This value should always be 50.0% when performing MHA calculations in accordance with Reference 2.4.

line 6
FCF(1), FCF(2), FCF(3)
[3F10.1]

FCF is the fraction of the iodine released to the containment atmosphere that is in each chemical form. FCF(1) is the fraction of the iodine in the containment atmosphere in elemental form, in %. This value is 91.0% following the guidance of References 2.1 and 2.4.

FCF(2) is the fraction of the iodine in the containment atmosphere in particulate form, in %. This value is 5.0% following the guidance of References 2.1 and 2.4.

FCF(3) is the fraction of the iodine in the containment atmosphere in organic form, in %. This value is 4% following the guidance of References 2.1 and 2.4.

line 7
DFESF, PFESF, PFSRW, KSUBD, VTANK, VSRWLIQ, FI2
[6F10.1,E10.2]

DFESF is the iodine decontamination factor, or retention factor, for any ESF leakage, accredited due to automatic isolation of the ventilation in the safeguards rooms and the subsequent plate-out of iodine. For MHA calculations, the NRC has given Palisades credit for a value of 2.0 for this factor [Ref. 2.2, pg. 26]. If no retention factor is to be conservatively used for ESF leakage (assuming all of the iodine released from the solution exits the rooms), a value of 1.0 should be specified.

PFESF is the iodine partition factor for ESF leakage. This is used to account for the fact that only part of the iodine will evolve out of solution. For MHA calculations, Reference 2.4 [section 15.6.5] directs the use of a value of 10.0 if the water temperature of the leakage is below 212°F. If the water temperature of the leakage is above 212°F, Reference 2.4 directs the use of whichever is greater, the factor of 10.0 or a factor accounting for the fraction flashing to steam, from which the factor of 10 would probably be more limiting. However, Reference 2.4 [15.6.5] also states that other values can be justified based on actual sump pH. Since the ESF leakage is sump water, the same partition coefficient factor used in containment is appropriate, and should be much larger than 10. The flashing fraction may turn out to be more limiting when compared to the containment sump partition factor. If no ESF leakage partition factor is used (conservatively assuming all of the iodine evolves out of solution), a value of 1.0 should be specified.

PFSRW is the equilibrium partition factor for the volatile forms of iodine for leakage through the recirculation lines to the SIRW tank. Reference 2.25 can be consulted for determination of partition coefficients. For the volatile I_2, Reference 2.25 and Reference 2.30 describe methods for calculating the partition coefficient. Any other decontamination factor that may become applicable for recirculation line leakage can be used in conjunction with the partition factor by multiplying the partition factor and the decontamination factor together. If no partition or decontamination factor is to be used for the recirculation line leakage, or if that leak path is not applicable, a value of 1.0 should be specified.

KSUBD is a user defined multiplication factor to enhance the rate at which iodine exits the SIRW Tank. The code has been written such that the iodine exits the tank at the rate which air is being displaced. The rate at which iodine is exiting the tank will be multiplied by this factor. It can be used to add conservatism or to acount for any diffusion out of the SIRW Tank vent that would occur. From infromal telephone discussions with the NRC, a factor of 2 as is specified by the Standard Review Plan for ESF leakage would conservatively encompass uncertainty in diffusion out of the SIRW tank vent. If no factor to account for additional release from the tank is to be used, a value of 1.0 should be specified.

VTANK is the entire volume of the SIRW tank, in ft^3. This value includes air space, and not just usable water volume. This value will be used for calculating the air volume in the tank, which is needed to determine the iodine concentration, as a function of time after leakage of sump water into the tank begins. The total air volume in the tank can easily be calculated from the dimensions of the tank. Even if SIRW tank leakage is not going to be accounted for, a dummy value greater than 1.0 needs to be specified.

VSRWLIQ is the volume of water present in the SIRW tank when RAS (recirculation actuation signal) is generated, in ft^3. When the tank is isolated after RAS, approximately 20000 gallons of water should be left [Ref. 2.5, TS 2.16]. The actual value in the SIRW tank and the lines leading to it should be calculated. Even if SIRW tank leakage is not going to be accounted for, a dummy value greater than 1.0 and less than VTANK needs to be specified.

FI2 is the fraction of the total iodine activity entering the SIRW tank that is in a volatile form. If all of the iodine entering the SIRW tank is conservatively assumed to be in a volatile form, a value of 1.00E+00 should be specified. If the sump water is controlled at a pH $\geq$ 7 and the SIRW tank pH is around 5, the predominant volatile form will be I_2 and a value of 3.00E-04 is appropriate [Ref. 2.25, pg. 26 & Ref. 2.30]. The value of 3.00E-04 is more of a bounding value, and a more conservative value should be considered if very high leak rates into the SIRW tank or very high dose rates in the SIRW tank are expected. Specifying a value of 0.00E+00 will prevent any iodine release from the SIRW tank from being accounted for.

line 8
BREATH(1), BREATH(2), BREATH(3)
[3E10.2]

BREATH is the breathing rate to be used in the thyroid dose calculations during each time interval. BREATH(1) is the 0 to 8 hour breathing rate, in units of m^3/sec. Following the guidance of Reference 2.1, this value should always be 3.47E-04 m^3/sec.

BREATH(2) is the 8 to 24 hour breathing rate, in units of m^3/sec. Following the guidance of Reference 2.1, this value should always be 1.75E-04 m^3/sec.

BREATH(3) is the breathing rate from 1 day throughout the duration of the incident, in units of m^3/sec. Following the guidance of Reference 2.1, this value should always be 2.32E-04 m^3/sec.

line 9
CHIQSB
[E10.2]

CHIQSB is the 0 to 2 hour site boundary atmospheric dispersion factor, in units of sec/m^3. This should be the maximum value for 0 to 2 hours at the site boundary listed in Reference 2.7 [Table 2-17].

line 10
LPZCHI(1), LPZCHI(2), LPZCHI(3), LPZCHI(4)
[4E10.2]

LPZCHI is the low population zone atmospheric (LPZ) dispersion factor to be used for the thyroid and whole body dose calculations during each time interval.
LPZCHI(1) is the 0 to 8 hour LPZ atmospheric dispersion factor, in units of sec/m^3. This should be the maximum value for 0 to 8 hours at the LPZ listed in Reference 2.7 [Table 2-18].

LPZCHI(2) is the 8 to 24 hour LPZ atmospheric dispersion factor, in units of sec/m^3. This should be the maximum value for 8 to 24 hours at the LPZ listed in Reference 2.7 [Table 2-18].

LPZCHI(3) is the 1 to 4 day LPZ atmospheric dispersion factor, in units of sec/m^3. This should be the maximum value for 1 to 4 days at the LPZ listed in Reference 2.7 [Table 2-18].

LPZCHI(4) is the 4 to 30 day LPZ atmospheric dispersion factor, in units of sec/m^3. This should be the maximum value for 4 to 30 days at the LPZ listed in Reference 2.7 [Table 2-18].

line 11
SPRAPR(1), SPRAPR(2)
[F10.2, F10.3]

SPRAPR is the spray removal coefficient for particulate iodine.
SPRAPR(1) is the spray removal coefficient for particulate iodine when containment sprays begin, in units of hr^{-1}. This coefficient should be calculated in accordance with Reference 2.4 [section 6.5.2] and is dependent upon the fall height of the spray drops, the containment net free volume, the spray flow rate, and the diameter of the spray drops. Reference 2.26 is the most recent calculation of all spray removal coefficients, and is in accordance with Reference 2.4 [section 6.5.2].

SPRAPR(2) is the spray removal coefficient for particulate iodine after 98% of the particulate iodine has been removed from the containment atmosphere (depleted by a factor of 50), in units of hr^{-1}, following the methodology of Reference 2.4 [section 6.5.2]. Its value should be the value used for SPRAPR(1) reduced by a factor of 10 following Reference 2.4.

lines 12 - 16
TEL(k), SPRAEL(k)
[I10, F10.3]

TEL(k) are five times from the initiation of the event, in minutes, at which the elemental iodine removal by sprays starts and changes. TEL(1) should be the time at which full sprays are achieved in containment, generally around 1 minute. Following the methodology of Reference 2.4 [section 6.5.2], the removal coefficient for elemental iodine should not change from the time full sprays are achieved until the maximum elemental iodine decontamination factor (discussed in Section 6.1.2) is reached.

However, if the pH of the sump water is predicted to fall below 7.0 and iodine re-evolution must be accounted for, the times at which the pH falls below 7.0 can be specified in conjunction with an adjusted value for the spray removal coefficient. If only one spray removal coefficient is used and iodine re-evolution will not occur, TEL(1) on line 12 should be the time at which full sprays are achieved and a value of 0 should be specified for TEL(2), TEL(3), TEL(4), and TEL(5) on lines 13 - 16 respectively. All values should be specified as whole numbers and chosen conservatively if the actual value is not a whole number (i.e. if full spray is achieved at 1.5 min., use 2 min.)

SPRAEL(k) are five spray removal coefficients for elemental iodine, in units of hr^{-1}, starting at each of the corresponding times of TEL(k). This coefficient should be calculated in accordance with Reference 2.4, which has been done in Reference 2.26. Generally, only one value should be used, SPRAEL(1), when using the guidelines of Reference 2.4 [section 6.5.2] and maintaining the sump solution pH above 7.0. Should the pH of the sump water be predicted to fall below 7.0, the re-evolution of elemental must be accounted for in one of two ways. If spray removal is still occuring while the pH is below 7.0, the removal coefficient can be decreased by an appropriate amount. However, if the pH is below 7.0 after spray removal has stopped, a negative value for the removal coefficient can be used to account for the re-evolution. Since there is no standard methodology for determining iodine re-evolution rates, the appropriate values would have to be determined at such time that they were used. These values can be specified with the corresponding times at which it occurs. A value of 0.0 should usually be specified for SPRAEL(2), SPRAEL(3), SPRAEL(4), and SPRAEL(5) on lines 13 - 16 respectively, if they are not going to be used. The value of SPRAEL(k) will automatically be set equal to 0.0 when the maximum elemental decontamination factor is reached, as discussed in Section 6.1.2 of this analysis, unless the value of SPRAEL(k) is negative to account for re-evolution.

line 17
DFMAX, STOPSPRA
[F10.2, I10]

DFMAX is the maximum elemental iodine decontamination factor. This factor determines the time at which containment sprays are no longer effective for removing elemental iodine. When the maximum elemental iodine decontamination factor is reached, the code will set the spray removal coefficient for elemental iodine equal to 0.0 for the remainder of the event, unless the removal coefficient is negative to account for iodine re-evolution. This occurs regardless of the times and values specified in lines 13 - 16 of the input deck. The value of this factor should also be calculated in accordance with the guidelines of Reference 2.4 [section 6.5.2].

STOPSPRA is the time at which operators are assumed to terminate the containment spray, in minutes. When this time is reached, all spray removal of iodine is set equal to 0.0, except for that of elemental iodine when it has a negative value to account for iodine re-evolution. This value should be specified as 0 if a spray stop time is not going to specified. Generally, the condition for DFMAX is reached before 24 hours so a time for stopping the sprays only ends particulate iodine removal. The value must be specified as a whole number and chosen conservatively if the actual value is not a whole number (i.e. if sprays stop at 1440.5 min., use 1440 min.)

lines 18 - 21
TESF(k), LRESF(k), TSIRW(k), LRSRW(k)
[I10,F10.1,I10,F12.3]

TESF(k) are four times from initiation of the event, in minutes, that the ESF leak rate starts, changes, and/or stops. The first value will be the time at which recirculation of sump water begins and can be any value including 0, but should normally be the minimum time to RAS of 19 minutes assuming that time 0 is the beginning of the accident. For MHA calculations in accordance with Reference 2.4 [section 15.6.5], only one value, TESF(1) on line 18, should be specified since the Technical Specification maximum leakage is to be assumed to start at recirculation and continue for the remainder of the event. If the ESF leak rate is not assumed to change throughout the event, the values of TESF(2), TESF(3), and TESF(4) on lines 19 - 21, respectively, should be specified as 0. All values must be specified as whole numbers and should be chosen conservatively if the actual value is not a whole number (i.e. if leakage starts at 19.5 min., use 19 min.)

LRESF(k) are four possible ESF component leak rates, in units of gpm. Normally, only one value will be used, LRESF(1) on line 18, which should be equal to the Technical Specification limit of 0.2 gpm [Ref. 2.5, TS 4.5]. More than one leak rate can be specified to correspond with the times of TESF(k) if the leak rate is assumed to change for some reason. If only one ESF leak rate is being used, LRESF(2), LRESF(3), and LRESF(4) on lines 19 - 21, respectively should be specified as 0.0. It should be noted that the code automatically multiplies the value of LRESF(k) by a factor of 2 in accordance with Reference 2.4 [section 15.6.5]. The code also automatically changes the units to ft^3/min to be consistent with all volumes used for calculations.

TSIRW(k) are four times from initiation of the event, in minutes, that the recirculation line leak rate starts, changes, and/or stops. This was added to encompass the recirculation line valve seat-leakage and may not be applicable depending on any future plant modifications to mitigate this leakage. If this leakage is not applicable, values of 0 should be specified for TSIRW(k) on lines 18 - 21. Values of 0 should also be specified for the remainder of the times if less that four times will be used. Note though, that a value of 0 can be specified to start the leakage if a corresponding value of LRSRW(k) is specified. All values must be specified as whole numbers and should be chosen conservatively if the actual value is not a whole number (i.e. if leakage starts at 19.5 min., use 19 min.)

LRSRW(k) are four possible recirculation line leak rates, in units of gpm. The leak rate can be specified to change at the times corresponding to values of TSIRW(k), or 0.0 can be specified if the leak rate is not applicable. Values of 0.0 should also be specified for all leak rates corresponding to a TSIRW(k) value of 0. The code does not multiply this leak rate by a factor of 2, as LRESF(k) is, since the Standard Review Plan does not specifically address this type of leakage. This value is also automatically changed to units of ft^3/min by the code.

lines 22 - 39
SOURCE(i), LAMBDA(i), DCF(thyroid,i), DCF(whole body,i)
[4F10.1]

SOURCE(i) is the source term for each radionuclide, in units of Ci/MW_t. The order in which the radionuclides occur is shown below. These values have generally been taken from Reference 2.13 for all accident analyses at Palisades, due to the unavailability of plant specific calculations.

LAMBDA(i) is the radioactive decay constant for each radionuclide, in units of min^{-1}. These values can be obtained from Reference 2.14.

DCF(thyroid,i) is the thyroid committed dose equivalent dose conversion factor for inhalation of iodine and the thyroid deep-dose rate conversion factor for submersion in a cloud of noble gas. The units for the input deck Rem/Ci-inhaled for iodine isotopes and (Rem/sec)/(Ci/m^3) for noble gas isotopes. These values must be obtained from Reference 2.12 for the thyroid organ, noting that the units must be converted for use in the input deck. These values are for the noble gas isotopes on lines 22 - 34, and for iodine isotopes on lines 35 through 39.

DCF(whole body,i) is the committed effective dose equivalent dose conversion factor for inhalation of iodine and the whole body equivalent dose rate conversion factor for submersion in a cloud of noble gas. The units must be the same as for the thyroid dose and dose rate conversion factors. These values are not simply listed in Reference 2.12. These values for each radionuclide must be obtained from Reference 2.12 by summing the weighted dose (or dose rate) conversion factors for every organ that receives dose from the radionuclide. The units listed in Reference 2.12 must also be converted for use in the input deck.

It should be noted that Kr-89 and Xe-137 do not have dose conversion factors in ICRP30, and therefore do not result in a dose. These two nuclides were originally included in the code for using now outdated dose calculation methods and were not removed when the code was written to use ICRP30 methodology. The dose conversion factors for this two nuclides should be simply specified as 0.000E-00. The order of the radionuclides for lines 22 through 39 are as follows:

line 22 - Kr-83m
line 23 - Kr-85m
line 24 - Kr-85
line 25 - Kr-87
line 26 - Kr-88
line 27 - Kr-89
line 28 - Xe-131m
line 29 - Xe-133m
line 30 - Xe-133
line 31 - Xe-135m
line 32 - Xe-135
line 33 - Xe-137
line 34 - Xe-138
line 35 - I-131
line 36 - I-132
line 37 - I-133
line 38 - I-134
line 39 - I-135

line 40
INTRVALS
[I10]

INTRVALS is the number of time intervals that radionuclide release rates are to be calculated for and written to output files for use in the CONDOSE code for control room habitability calculations. This can be any value up to 100, but need not be that many. Since the code calculates the radionuclide release rates by adding the total activity of each radionuclide released during a time period and dividing by the length of the time period, the time intervals should be chosen to correspond with most of the points in time that the release rates will change by any large amount. Consideration should also be given to times at which the control room HVAC system flow rates or other parameters change. This will provide the smallest amount of error for control room habitability calculations in situations where the release rate suddenly changes from very high to very low or vice versa. Times at which the release rates change by very much would be times such as: when spray removal of iodine begins or changes, when ESF or SIRW tank leakage begins or changes, when atmospheric dispersion factors change, and etc. Times should also be specified when important parameters for control room habitability calculations change, such as: when control room HVAC system flow rates or filter efficiencies change, when breathing rates change, when control room occupancy factors change, and etc. Reference 2.29 should be consulted for more detail on the control room parameters. A value of 0 should be specified if no release rates are needed for control room habitability calculations.

line 41 - ?
T2(1) .... T2(8)
[8F10.2]
T2(9) .... T2(16)
[8F10.2]
etc.

T2(k) are the beginning and ending times, in minutes, for each of the time intervals for which the radionuclide release rates are to be calculated and written to output decks. The output decks are for direct use as input decks of the CONDOSE code for control room habitability calculations. The times are specified with 8 values per line, and the total number of values listed should be 1 + INTRVALS specified in line 40. If 0 is specified in line 40, no times are to be specified for T2(k) and NPRINT should be specified on line 41. Also, none of the times specified should exceed the value of DURATION specified in line 3. The first time should always be 0.00 and the last time interval should always be 43200.00. These values do not need to be specified as whole numbers.

next line
NPRINT
[I10]

NPRINT is the number of points in time, other than time zero, that the activity of each radionuclide in the containment atmosphere, sump, and SIRW tank are to be printed in the output listing from the code. Any number from 0 to 30 points in time can be specified, remembering that time zero is automatically printed. If a value greater than 30 is specified, execution of the code will terminate and an error message will be given in the output.

last lines
TPRINT(NPRINT)
[8I10]

TPRINT(NPRINT) are up to 30 times, in minutes, at which the activity of each radionuclide in the containment atmosphere, sump, and SIRW tank are to be printed to the output deck. Eight values are specified per line, and the code will only read the number of values specified NPRINT. Zero should not be specified as the first time, since the code automatically prints the time zero activities. Also, none of the times specified here can be greater than time specified as the DURATION in line 3. If a value greater than the DURATION specified in line three is given, execution of the code will terminate and an error message will be given in the output. All values must be specified as whole numbers.

8.0 MHACALC EXECUTION

The MHACALC code is located in VM8. The code was compiled in double precision using the AUTODBL(12220) specification. There are two exec files for execution of the code, MHA EXEC and MHAB EXEC, both in the same location as the code. The MHA EXEC creates a VMBATCH SUBMIT to execute the code as a batch job, and the MHAB EXEC executes the MHACALC code. A listing of the MHACALC code, MHA EXEC and, MHAB EXEC are provided on the attached microfiche. To execute the code, type *MHA* and hit enter. The filename of the input deck is then requested in the format: *Filename Filetype Minidisk-Number*. An example of the proper format will be given on the screen. At this point, *CANCEL* can be entered to abort execution of the code. The next prompt requests all VMBATCH options. Hitting the enter key will continue execution of the code.

When execution of the code is finished, four output decks will be returned. One output deck will have the same filename as the input deck, but the filetype will be LISTING. This will be the results of the
o
x^G{nother output deck will have the filename and filetype - STACKRR DATA. This file contains the radionuclide release rates from the containment atmosphere and ESF leakage for the time intervals specified in the input deck, and can be used as an input deck to the CONDOSE code for control room habitability calculations. The third file will have the filename and filetype - SIRWRR DATA, and will contain the radionuclide release rates from the SIRW tank for the same time intervals as the STACKRR DATA deck, also for use in the CONDOSE code. The last output deck will have the filename and filetype - RPLOT DATA. This file is setup in the format required for the RETRAN code PLOTER module, and contains all of the data needed to plot the dose equivalent iodine 131 activity in containment versus time. These output files are discussed in the following section.

9.0 OUTPUT DESCRIPTIONS

As mentioned above, four output files are produced from execution of the code. One output deck will contain the offsite doses and related information. Two will contain the radionuclide release rates, one for containment and ESF leakage and one for SIRW tank releases, during the time intervals specified in the input deck. The other will contain all of the data needed to plot the dose equivalent iodine 131 activity in containment versus time using the RETRAN code PLOTER module.

9.1 OFFSITE DOSES FILE

The name of this file will be the same as the input deck used, with the filetype being - LISTING. This file will vary in length, from 4 to 18 pages, depending upon the input specification of how many points in time to print the activity in containment. If zero time points are specified to print out the activity in containment, the minimum length of this file will be 4 pages. The first page will always be an echo of the input deck, to ensure the accuracy of the information read by the code. The first li x^G{ page will contain the title specified on the first line of the input deck. After the title, the second page of the output will contain the initial activities of all of the radionuclides in the containment atmosphere and the containment sump, listed in units of Curies. After the initial activities, the activities in the containment atmosphere, containment sump, and the SIRW tank at each of the times specified in the input deck will be listed, if additional times to print the activities are listed.

The second to last page of this output deck will contain the total activity of each radionuclude released from each path, in units of Curies. After the total activity released, the Committed Dose Equivalent (CDE) to the thyroid, the deep-dose equivalent to the thyroid, and the total of the two will be listed for each release path and the total, at the site boundary (SB). Then the Committed Effective Dose Equivalent (CEDE), the external whole body dose and the Total Effective Dose Equivalent (TEDE) will be listed for each release path and the total, at the site boundary. Below this, the same will be repeated, except all of the doses will be for the low population zone (LPZ) distance. Care should be taken when chosing dose values from this page. For whole body dose, if only the external dose to the whole body dose is desired, then the values listed for whole body dose should be used. If the contribution from internal dose is desired for inclusion in the whole body dose, the TEDE or total effective dose equivalent value should be used. The last line on this page will be the time specified in the input deck for sprays to stop or the time at which the maximum elemental iodine decontamination factor was reached, whichever is reached first.

The last page of this file is just the program execution summary. Examples of this output deck can be seen on the attached microfiche.

9.2 RELEASE RATE FILES

The filename and filetype of these two files will be STACKRR DATA. If more than one execution of the MHACALC code will be made, the name of these files will have to be changed each time. These files will vary in length depending upon how many time intervals were specified for release rates, and will contain the release rate of each of the radionuclides of main concern for each of the time intervals specified in the input deck. The STACKRR DATA deck contains the radionuclide release rates from the containment and from ESF leakage, which are assumed to be released from the location of the stack, not accounting for stack height (not assumed an elevated release). The SIRWRR DATA deck contains the radionuclide release rates from the SIRW tank. The release rates are calculated as uniform release rates over each time interval by dividing the activity released from the respective release paths during each time interval by the time span of each time interval. The release rates are given in units of μCi/hr, and the files are created for direct use in the CONDOSE code for control room habitability calculations. Separate files are created for the stack release rates and the SIRW tank release rates because the atmospheric dispersion relative to the control room intakes will be different for the two assumed release locations.

The format of the release rates in these output decks is such that for each time interval there are three lines of release rates for the radionuclides. Therefore, every fourth line of the files starts the release rates for a different time interval. The radionuclides in each time interval are in the following order:

time interval 1
line 1 - [Kr-83m] [Kr-85m] [Kr-85] [Kr-87] [Kr-88] [Kr-89]
line 2 - [Xe-131m] [Xe-133m] [Xe-133] [Xe-135m] [Xe-135] [Xe-137]
line 3 - [Xe-138] [I-131] [I-132] [I-133] [I-134] [I-135]
time interval 2
line 4 - [Kr-83m] [Kr-85m] [Kr-85] [Kr-87] [Kr-88] [Kr-89]
line 5 - [Xe-131m] [Xe-133m] [Xe-133] [Xe-135m] [Xe-135] [Xe-137]
line 6 - [Xe-138] [I-131] [I-132] [I-133] [I-134] [I-135]
etc.

The release rates are listed as such for each of the specified time intervals. The SIRW DATA deck will contain all zeros for the release rates of noble gas isotopes since no noble gas is assumed to be present in the sump solution. The release rates of all radionuclides in that input deck will be zeros until the time at which leakage starts is reached. An example of these output decks can be seen on the attached microfiche as the third and fourth documents under the heading CASE1.

9.3 PLOTTING DATA FILE

The filename and filetype of this file will be RPLOT DATA. If more than one execution of the MHACALC code will be made, the name of this file must also be changed each time. This file will be constructed in the format required for execution in the RETRAN code PLOTER module. When the RETRAN code PLOTER module is executed using this file as the input deck, two figures will be printed. The first figure will contain three plots of dose equivalent iodine 131 activity in containment versus time; one plot for each chemical species of iodine. The second figure will contain one plot of the dose equivalent iodine 131 activity in containment versus time, with the plot being the sum of the three chemical species, or the total iodine activity. The plots of the three chemical species will be for the first 400 minutes to present a clear comparison of the effect of spray removal on the different chemical species of iodine. The plot of the total dose equivalent iodine 131 activity will be for the first 1440 minutes, or 24 hours, after which only radioactive decay will most likely be affecting the activity. The plots of the three chemical species can also be performed for 24 hours with a minor change to this data file, as will be discussed later. Notice should also be given to the scale of each axis of the figures. Since one figure is for the comparison of the effect of sprays on the different chemical species and one is for understanding of the overall effect, different scales were used for each axis of each figure.

The length of this file will vary, depending on the number of data points to be plotted. Two data points for each of the chemical species of iodine, and for the total, will be listed for each time that the activity changed by + or - 3%, up to 24 hours. The number of data points given for each plot will be specified after the input card number for the plot data, then each line following will contain one time with a corresponding data point. A comment line will be given before each set of data points, specifying which plot the data points represent.

A description of the data cards in this deck is listed below. These data cards are described by card number, using data variable names consistent with the RETRAN-02 manual [Ref. 2.15].

Problem Control and Description Card.

```
010001   LDMP  NDSET  NFRAME  NPLOTC  NPLOTD  NPEDIT  NPTABL
     LDMP = -3 = given by Reference 2.15
     NDSET = 0 = number of tape data sets from which data is to be plotted
     NFRAME = 2 = number of frames requested
     NPLOTC = 4 = number of plot curve requests
     NPLOTD = 0 = number of combination plot curve requests
     NPEDIT = 0 = option flag for tabular edits of curve data
     NPTABL = 4 = number of tabular input data sets
```

Plot Data Table Cards

```
12XX00   NDATA  TDATA(1)   TDATA(2)
     XX = data table number 01, 02, 03, or 04
     NDATA = number of data points
     TDATA(1) = independent variable
     TDATA(2) = dependent variable
```

Independent Axis Specification Data Cards

```
02XX01   XVAR  XREG  XLINOG  XLENG  XMIN  XMAX  XLABL
     XX = frame number 01 or 02
     XVAR = dummy variable = 'ABCD' for frame 01 = 'EFGH' for frame 02
     XREG = dummy value = 0
     XLINOG = linear or logarithmic request flag = 'LIN' for frame 01 = 'LOG' for frame 02
     XLENG = length of independent axis, inches = 8.0
     XMIN = minimum value of independent axis = 0.0 for frame 01 = 1.0 for frame 02
     XMAX = maximum value of independent axis = 400.0 for frame 01 = 1440.0 for frame 02
     XLABL = independent axis label = 'TIME (MINUTES)'
```

Dependent Axis Specification Data Cards

```
03XXY0   YLINOG  YLENG  YMIN  YMAX  YLABL
     XX = frame number 01 or 02
     Y = dependent axis number for frame XX = 1, 2, or 3 for frame 01 = 1 for frame 02
```

```
     YLINOG = linear or logarithmic request flag = 'LOG' for frame 01 axes 1, 2, and 3
            = 'LIN' for frame 02
     YLENG = length of dependent axis, inches = 5.0
     YMIN = minimum value of dependent axis = 1.E+03 for frame 01 axes 1, 2, and 3
          = 0. for frame 02
     YMAX = maximum value of dependent axis = 3.E+07 for frame 01 axes 1, 2, and 3
          = 30.0 for frame 02
     YLABL = dependent axis label = 'ELEMENTAL (CURIES)' for frame 01 axis 1
          = 'PARTICULATE (CURIES)' for frame 01 axis 2
          = 'ORGANIC (CURIES)' for frame 01 axis 3
          = 'TOTAL DE I-131 (MEGA-CURIES)' for frame 02
```

Plot Curve Request Data Cards

```
4XXYOS   YVARC  IYREGC  IDSETC  YSCTRN  YSCMAG  * comment
     XX = frame number 01 or 02
     Y = dependent axis number for frame XX = 1, 2, or 3 for frame 01 = 1 for frame 02
     S = sequence number for plot on frame XX = 1, 2, or 3 for frame 01 = 1 for frame 02
     YVARC = dummy variable = 'TABL'
     IYREGC = dummy value = 0
     IDSETC = data table number from which variable is retrieved, -XX from card 12XX00
            = -1 for frame 01 plot 1 = -2 for frame 01 plot 2 = -3 for frame 01 plot 3
            = -4 for frame 02 plot 1
```

These specifications can be changed prior to executing the RETRAN code PLOTER module, if so desired. If the time for the three plots of the chemical species is to be extended further than 400 minutes, card number 020101 parameter XMAX can be changed. If a different title is desired for the two figures, the second to last line should be changed. If any other information is to be changed, the RETRAN manual [Ref. 2.15] should be consulted.

To execute the RETRAN code PLOTER module, type the name *RETRAN* and hit enter. A menu will appear giving choices of which routine to execute. To chose the plotting routine, type: *Filename Filetype Minidisk-Number PD*. The filename, filetype, and minidisk-number should be name of the file containing the plotting data (RPLOT DATA 191 is the name given by the code), followed by the letters PD. When execution is complete, the figures will automatically be printed on the Reactor Engineering HP laser printer.

Examples of this output deck can be seen on the attached microfiche.

10.0 TEST CASES AND VERIFICATION

To verify the accuracy of the calculations performed by the code, three test cases were executed. These test cases were then verified by alternate calculations or knowledge of the behavior expected. Test case 1 was used to verify the accuracy of all calculations performed by the code, and the input deck was therefore set up to make use of all of the calculations performed by the code. Test case 2 was used to ensure that the spray stop time (STOPSPRA in the input deck) performs the desired function of terminating all spray removal of iodine. Test case 3 was used to ensure that a negative spray removal coefficient would adequately model iodine re-evolution from the sump solution if the pH of the solution is predicted to fall below 7. The name of the input deck used for each of the three test cases is listed below.

Case 1 - C1MCALC DATA
Case 2 - C2MCALC DATA
Case 3 - C3MCALC DATA

10.1 TEST CASE 1

Test case 1 was created to verify all of the calculations that the code performs. The input deck for this test case, as mentioned above is C1MCALC DATA. This input deck is listed on the attached microfiche. The parameters in this input deck are described line by line, below. Most of the parameters used are taken from Reference 2.6.

line 1: `CASE 1: BENCHMARK RUN OF MHACALC CODE`
This is just the title given to this case.

line 2: `1`
This line specifies that the debug option is not to be used since a value greater than 0 is specified.

line 3: `43200`
This line specifies that the calculations are to be performed for 43200 minutes, or 30 days.

line 4: `2530.0 0.10 40304.5`
This line specifies the rated thermal power of the core, 2530 MW_t as used in Reference 2.6 [pg. 34]. The next value is the containment leak rate, 0.1 %/day, which converts to 6.944E-07 min^{-1} as used in Reference 2.6 [pg. 37 (LAML1 and LAML2 values)]. The third value on this line is the volume of the sump, 40304.5 ft^3, corresponding to 3.015E+05 gallons as used for the recirculation volume in Reference 2.6 [pg. 37].

line 5: `100.0 25.0 50.0`
This line specifies the fraction of the core's noble gas inventory released to the containment atmosphere as 100%, the fraction of the core's iodine inventory released to the containment atmosphere as 25%, and the fraction of the core's iodine inventory released to the containment sump as 50%. These values are the same as those used in Reference 2.6 [pg. 33].

line 6: `95.5 2.5 2.0`
This line specifies the elemental fraction of iodine as 95.5%, the particulate fraction as 2.5%, and the organic fraction as 2.0% as used in Reference 2.6 [pg. 37].

line 7: `2.0 10.0 1.0 2.0 38767.2 3739.3 3.00E-01`

The first value on this line is the iodine decontamination, or retention factor for ESF leakage, 2 as used in Reference 2.6 [pg. 33]. The second value on this line is the iodine partition factor for ESF leakage, 10 as used in Reference 2.6 [pg. 37]. The third value on this line is the partition factor for recirculation line valve leakage and was arbitrarily chosen as 1.0. The fourth value on this line is the multiplication factor for the rate at which iodine exits the SIRW tank, and was arbitrarily chosen as 2.0. The fifth value on this line represents the total volume of the SIRW tank and was arbitrarily chosen as 38767.2 ft^3. The sixth value on this line is the volume of water present in the SIRW tank at RAS, and was arbitrarily chosen as 3739.3 ft^3. The last value on this line is the fraction of the iodine entering the SIRW tank in a volatile form and was arbitrarily chosen as 3.00E-01.

line 8: 3.47E-04 1.75E-04 2.32E-04
This line specifies the 0 to 8 hour breathing rate as 3.47E-04 m^3/sec, the 8 to 24 hour breathing rate as 1.75E-04 m^3/sec, and the breathing rate from 1 to 30 days as 2.32E-04 m^3/sec. These values are as used in Reference 2.6 [pg. 33].

line 9: 1.55E-04
This line specifies the 0 to 2 hour site boundary atmospheric dispersion factor as 1.55E-04 sec/m^3 as used in Reference 2.6 [pg 33].

line 10: 1.09E-05 6.94E-06 2.58E-06 6.25E-07
This line specifies the 0 to 8 hour LPZ atmospheric dispersion factor as 1.09E-05 sec/m^3, the 8 to 24 hour LPZ atmospheric dispersion factor as 6.94E-06 sec/m^3, the 1 to 4 day LPZ atmospheric dispersion factor as 2.58E-06 sec/m^3, and the 4 to 30 day LPZ atmpspheric dispersion factor as 6.25E-07 sec/m^3 as used in Reference 2.6 [pg. 33].

line 11: 1.00 0.00
The first value on this line is the spray removal coefficient for particulate iodine when the containment sprays begin, 1.0 hr^{-1}, which coverts to 1.667E-02 min^{-1} as used in Reference 2.6 [pg. 34]. The second value on this line is the spray removal coefficient for particulate iodine after 98% of the particulate iodine has been removed from the containment atmosphere, and was chosen as 0.0 since Reference 2.6 ended particulate iodine removal at the same time as elemental iodine removal.

line 12: 1 0.420
line 13: 5 10.000
line 14: 19 0.000
line 15: 720 0.420
line 16: 0 0.000

The first value on line 12 is the time at which full sprays are achieved, 1 minute [Ref. 2.6, pg. 35], and the second value is the spray removal coefficient for elemental iodine when full sprays start, 0.42 hr^{-1}, which converts to 7.0E-3 min^{-1} as used in Reference 2.6 [pg. 34]. Line 13 specifies the first time at which the spray removal coefficient for elemental iodine changes, 5 minutes, and the value the coefficient changes to 10.0 hr^{-1}, which converts to 1.667E-01 min^{-1} as used in Reference 2.6 [pg. 34-35]. Lines 14 and 15 specify two more times at which the spray removal coefficient for elemental iodine change and the values the coefficient changes to, as used in Reference 2.6 [pg. 34-35]. Line 16 simply contains zeros so as to not change the spray removal rate again.

line 17: 25.57 0

The first value on this line specifies the maximum elemental iodine decontamination factor as 25.57 as used in Reference 2.6 [pg. 23]. The second value on this line is the time at which containment sprays, and all spray removal of iodine is terminated and is chosen as 0 to allow the maximum elemental iodine decontamination factor terminate the spray removal of elemental iodine.

line 18:	19	0.2	19	1.0
line 19:	0	0.0	1440	0.0
line 20:	0	0.0	0	0.0
line 21:	0	0.0	0	0.0

The first value on line 18 specifies the time at which ESF leakage starts, 19 minutes, and the second value specifies the ESF leak rate when the leakage starts, 0.2 gpm, as used in Reference 2.6 [pg. 33]. The third and fourth values on line 17 specify the time at which recircultion line valve leakage begins and the leak rate when the leakage begins, arbitrarily chosen as 19 minutes and 1 gpm respectively. On line 19, the first and second values are specified as 0 to indicate that the ESF leak rate does not change, but the third and fourth values are arbitrarily specified as 1440 minutes and 0.0 gpm to indicate that the recirculation line leakage stops. All values in lines 20 and 21 are specified as 0 to indicate that the ESF and recirculation line leak rates do not change again for the duration of the calculations.

line 22:	2.998E+03	6.211E-03	0.000E-00	3.649E-06
line 23:	6.498E+03	2.579E-03	1.233E-03	1.269E-03
line 24:	2.999E+02	1.230E-07	0.000E-00	2.314E-05
line 25:	1.155E+04	9.120E-03	5.550E-03	5.684E-03
line 26:	1.690E+04	4.068E-03	1.439E-02	1.402E-02
line 27:	1.993E+04	2.201E-01	0.000E-00	0.000E-00
line 28:	1.760E+02	4.038E-05	0.000E-00	1.915E-04
line 29:	1.954E+03	2.198E-04	0.000E-00	3.823E-04
line 30:	5.648E+04	9.169E-05	4.317E-04	3.361E-04
line 31:	1.698E+04	4.530E-02	0.000E-00	3.618E-03
line 32:	9.781E+03	1.271E-03	0.000E-00	7.914E-03
line 33:	4.705E+04	1.800E-01	0.000E-00	0.000E-00
line 34:	4.433E+04	4.881E-02	7.811E-03	7.801E-03
line 35:	2.938E+04	5.986E-05	1.073E+06	3.256E+04
line 36:	4.160E+04	5.045E-03	6.290E+03	3.367E+02
line 37:	4.808E+04	5.554E-04	1.813E+05	5.550E+03
line 38:	6.218E+04	1.318E-02	1.073E+03	1.106E+02
line 39:	4.922E+04	1.754E-03	3.145E+04	1.121E+03

On each line is listed the source term, the radioactive decay constant, the thyroid dose (or dose rate for noble gas) conversion factor, and the sum of the weighted dose (or dose rate) conversion factors for each of the 18 radionuclides of main concern. The order of the radionuclides was given in section 7.0 of this analysis. The source term and radioactive decay constant values are the same as those used in Reference 2.6 [pgs. 34 & 42]. The dose and dose rate conversion factors are from Reference 2.12, converted to conventional units.

line 40: 24
On line 40 is the number of time intervals for which radionuclide release rates are to be calculated.

line 41:	0.00	1.00	2.28	5.00	19.00	30.00	45.00	60.00
line 42:	75.00	90.00	105.00	120.00	135.00	150.00	165.00	180.00
line 43:	195.00	210.00	240.00	480.00	720.00	1440.00	1800.00	5760.00
line 44:	43200.00							

On each of these lines are the arbitrarily chosen start and stop times (minutes) for the 24 time intervals for which the radionuclide release rates are to be calculated and written to an output deck.

line 45: 24
This line specifies the arbitrarily chosen number of points in time that the activity of each radionuclide in containment is to be written to the output deck.

line 46:	2	3	5	19	30	45	60	75
line 47:	90	105	120	135	150	165	180	195
line 48:	210	240	480	720	1440	1800	5760	43200

On these three lines are the arbitrarily chosen points in time at which the activity of each radionuclide in containment is to be written to the output deck.

The four output decks from the execution of MHACALC with the C1MCALC DATA input deck are listed on the attached microfiche. The names of the release rate output files and the plotting data file were changed to C1STACKR DATA, C1SIRWR DATA, and C1MPLOT DATA to indicate case 1. Attachment 1 contains all of the hand calculations to verify these three output decks. Pages 1 through 37 of Attachment 1 contain the calculations to verify C1MCALC LISTING, C1STACKR DATA, and C1SIRWR DATA, and pages 38 through 51 contain the calculations to verify C1MPLOT DATA.

To verify the output, the activity of each of the radionuclides in the containment atmosphere and the release rate of each of the radionuclides must be caluclated for each of the time intervals and times listed in lines 41 through 44 and 46 through 48 of the input deck. First the initial acitivity of each radionuclide in the containment atmosphere and containment sump is calculated using Equations (1), (6), & (14) for the noble gas and iodine isotopes, where P corresponds to POWER in the input deck, S corresponds to SOURCE in the input deck, f_{CA} corresponds to FNG/100 for noble gas and FIA/100 for iodine in the input deck, and f_S corresponds to FIS/100 in the input deck. Also f_{CF} corresponds to FCF/100 in the input deck, and the total iodine activity for each isotope is just the sum of the activity of each of the three chemical forms. The results of these calculations, shown on page 1 of Attachment 1, were compared to the initial containment activities given in C1MCALC LISTING showing excellent agreement.

The activity of each radionuclide released from 0 to 1 minutes is then calculated from the initial containment activity using Equation (5) for each noble gas isotope and Equation (11) for each iodine isotope. In these equations, λ_L corresponds to CONTLR in the input deck converted to min^{-1}, λ_I corresponds to LAMBDA in the input deck, λ_S corresponds to SPRAPR in the input deck for particulate iodine converted to min^{-1}, SPRAEL in the input deck for elemental iodine converted to min^{-1}, and λ_S always = 0.0 for organic iodine. Since full sprays are not achieved until 1 minute, from line 12 of the input deck, all values of λ_S = 0.0 during first time interval. The release rate from 0 to 1 minutes is then just the activity released divided by the duration of the interval, converted to units of μCi/hr. The results of these calculations, shown on page 2 of Attachment 1, were compared to the release rates for the first time interval given in C1STACKR DATA, showing excellent agreement also.

The activity of each radionuclide in containment at 1 minute is then calculated using Equation (3) for noble gas in the containment atmosphere, Equation (8) for iodine in the containment atmosphere, and Equation (16) for iodine in the containment sump. Equation (9) is then used to calculate the total activity of each iodine isotope. In Equation (16), LR_{ESF} corresponds to LRESF in the input deck and LR_{SRW} corresponds to LRSRW in the input deck, both converted to ft^3/min. As given on line 18 of the input deck, however, LRESF and LRSRW do not begin until 19 minutes and are zero before that time. V_S corresponds to VSUMP in the input deck, but decreases after ESF and SRW leakage start. After 1 minute, spray removal of iodine in the containment atmosphere starts as is indicated on line 12 of the input deck. The value of λ_S for particulate iodine is specified on line 11 of the input deck, 1.0 hr^{-1}, which must be converted to min^{-1}. The value of λ_S for elemental iodine is specified on line 12 of the input deck, 0.42 hr^{-1} which must also be converted to min^{-1}. The value of λ_S for organic iodine will always be zero. Using Equations (3), (8), & (16), the activity of each radionuclide in containment was calculated at 2 minutes, again showing excellent agreement will the values given in C1MCALC LISTING. The activity released from 1 to 2 minutes was then calculated. However, the next interval for release rates is 1 to 2.28 minutes, so the calculations are repeated for the activity at 3 minutes and the activity released from 2 to 3 minutes. The release rate from 1 to 2.28 minutes was then calculated using the equation shown on page 6 of Attachment 1. Again very good agreement was shown with the values given in C1MCALC LISTING and C1STACKR DATA, with some very small differences due to rounding error since the code keeps track of more significant digits than was carried by my calculator.

These calculations were continued for each of the times and time intervals that the containment atmosphere activity and the release rates were specified to be written in the output decks. It is noted that at 5 minutes, λ_S for elemental iodine changes to 10.0 hr^{-1}, which converts to 0.167 min^{-1}, as specified on line 13 of the input deck. At 19 minutes, as specified on line 14 of the input deck, λ_S for elemental iodine changes to 0.0. Also at 19 minutes, as specified on line 18 of the input deck, LRESF and LRSRW take on values. As discussed in section 6.2 of this analysis, the value of LRESF is multiplied by a factor of 2 by the code resulting in LR_{ESF} = (0.2)(2)(0.13368) = 0.053472 ft^3/min. The value of LR_{SRW} becomes (1.0)(0.13368) = 0.13368 ft^3/min.

Comparing the calculated contaiment activity of each radionuclide to that given in C1MCALC LISTING for 19 minutes, the roundoff error in the hand calculations for the iodine activity was starting to become more significant. The roundoff error was becoming more significant since the activity of each chemical species of each iodine isotope is calculated using exponential terms and the roundoff error keeps increasing from using the results of each of the previous hand calculations. Therefore, the debug option of the code was executed using the C1MCALC DATA input deck with DEBUG on line 2 specified as 0. The debug option was used so that the activity of each chemical species of each iodine isotope that the code calculated could be used. Since the debug option produces hundreds of pages of output, the page with the iodine activity at 19 minutes is given in Attachment 1 on page 8A. The values for the iodine activity of each chemical species shown on page 8A of Attachment 1 were then used for the calculations of the activities at 30 minutes.

Since the values of LR_{ESF} and LR_{SRW} are non-zero after 19 minutes, the release of radionuclides from these paths must be included in the calculations after 19 minutes. The activity of each radionuclide released from ESF leakage is calculated using Equation (18), where DF_{ESF} and PF_{ESF} correspond to DFESF and PFESF on line 7 of the input deck. The total activity of each iodine isotope in the SIRW tank from recirculation line valve seat-leakage is calculated using Equation (21), with the intial SIRW tank activity and release being 0.0. The activity of the volatile fraction of each iodine isotope in the SIRW tank is calculated using Equation (21) again, but multiplying the second part of the equation by the fraction of the total iodine in the sump water that is volatile, or FI2 from line 7 of the input deck. The concentration of each iodine isotope in the SIRW tank air volume is then calculated using Equation (25), where PF_{SRW} corresponds to PFSRW, V_{LIQ} initially corresponds to VSRWLIQ, and V_{AIR} initially corresponds to VTANK minus V_{LIQ}, all on line 7 of the input deck. The activity released from the SIRW tank is then calculated using Equation (22), where k_D corresponds to KSUBD on line 7 of the input deck. It should be noted that as all other calculations can be performed as one calculation of a large time interval, calculations of the sump and SIRW tank activities, and the ESF and SIRW tank releases must be calculated over 1 minute increments to avoid large error. This is due to the interdependence of the equations on the values at the previous time step. A simple basic program was written to perform the ESF and SIRW tank release calculations over any given time interval to verify the values calculated by the code. A listing of this basic program and a calculation over a 1 minute time step to verify it are listed in Attachment 2.

The calculated values continued to show very good agreement with the values given in C1MCALC LISTING, C1STACKR DATA, and C1SIRWR DATA until 210 minutes, at which time the iodine activities were somewhat off. Since λ_S for elemental iodine was set equal to 0.0 after 19 minutes and λ_S for organic iodine never changes from 0, spray removal of particulate iodine must have changed between 195 and 210 minutes. From section 6.1.2 of this analysis, the value of λ_S for particulate iodine changes when the condition in Equation (13) is met. The value that λ_S for particulate iodine changes to is the second value given on line 11 of the input deck, 0.0 in C1MCALC DATA. As can be seen on page 21 of Attachment 1, the condition of Equation (13) was met between 195 and 210 minutes. To find the correct values of the particulate activity of each iodine isotope, the output of the debug option execution that was mentioned previously was used. The page from the debug option output that contains the iodine activity at 210 minutes is given in Attachment 1 on page 21A. The values for particulate iodine activity on page 21A were then used to calculate the activity at 240 minutes, resulting in values that agreed with that in C1MCALC LISTING, C1STACKR DATA, and C1SIRWR DATA.

After 720 minutes, as is given on line 15 of the input deck, the value of λ_S for elemental iodine should change from 0.0 to 0.42 hr^{-1}. However, checking the condition of Equation (12), the value of DF_{max} given on line 16 of the input deck the condition has be exceeded prior to 720 minutes. This is shown on page 24 of Attachment 1. This is also verified by the last line of the output deck C1MCALC LISTING which gives the time at which DF_{max} was reached as 421 minutes. As is discussed in section 6.1.2 of this analysis, after that condition has been met, λ_S for elemental iodine is set equal to zero for the remainder of the incident.

After 1440 minutes (24 hours), two parameters change. The code automatically decreases λ_L by a factor of 2, as discussed in section 6.1.1 of this analysis. The value of λ_L then becomes 3.472E-07 min^{-1}. Also at 1440 minutes, as is given on line 19 of the input deck, the value of LR_{SRW} changes to 0.0. This ends the recirculation line valve leakage, and no additional activity is released through the SIRW tank. The release rates of all radionuclides are 0.0 for each time interval in the C1SIRWR DATA file after 1440 minutes. The calculations continued to be in very good agreement with the values given in C1MCALC LISTING and C1STACKR DATA for the containment activity and the release rates out to the last time point, 43200 minutes. This concludes that the code properly calculates the time dependant depletion of the radionuclides and the release rates of the radionuclides from the two assumed release locations. However, the activity of the radionuclides released and the resultant offsite doses must now be verified.

The activity released from each release path for each iodine isotope is totaled on pages 29 and 30 and that of noble gas on page 31 of Attachment 1, showing the total during time intervals at which dose calculation parameters change (breathing rate and atmospheric dispersion factors change at certain points in time) and a cummulative total released over the 43200 minutes. The cummulative totals for each isotope and release path shown on page 32 of Attachment 1 are also in good agreement with the values given in C1MCALC LISTING. The iodine activity released from the containment atmosphere was calculated to be slightly higher than that listed in the output, but is attributed to roundoff differences and the spray removal coefficients changing between the time intervals for which hand calculations were performed.

The doses are calculated for 0 to 2 hours at the site boundary (SB) and for 0 to 30 days at the low population zone (LPZ). Inhalation committed dose equivalent (CDE) to thyroid and committed effective dose equivalent (CEDE) to the whole body from each of the iodine isotopes is calculated using Equation (26) where DCF_{inh} corresponds to DCF on lines 35 through 39 of the input deck, BR corresponds to BREATH on line 8, and χ/Q corresponds to CHIQSB or LPZCHI on lines 9 and 10 of the input deck. The external dose from each of the noble gas isotopes is calculated using Equation (27) where DCF_{sub} corresponds to DCF on lines 22 through 34 of the input deck. Doses at the site boundary are calculated using CHIQSB from line 9 of the input deck and the first value of BREATH on line 8. Doses at the low population zone must be calculated in intervals. The first interval is 0 to 8 hours using the first value of BREATH on line 8 and the first value of LPZCHI on line 10 of the input deck. The second interval is 8 to 24 hours using the second value of BREATH on line 8 and the second value of LPZCHI on line 10. The third interval is 1 to 4 days using the third value of BREATH on line 8 and the third value of LPZCHI on line 10. The last time interval is 4 to 30 days using the third value of BREATH on line 8 and the fourth value of LPZCHI on line 10.

The results of the hand calculations for the site boundary doses are shown on page 32 of Attachment 1 for the thyroid dose and on page 33 for the whole body. These calculated values are in good agreement with the values listed in C1MCALC LISTING. The results of the hand calculations for the low population zone doses are shown on pages 34 and 35 of Attachment 1 for the thyroid doses and pages 36 and 37 for the whole body doses. These values are also in good agreement with the values listed in C1MCALC LISTING. The CEDE and thyroid dose from inhalation of iodine released from the containment atmosphere were calculated to be slightly higher than that given in the output, but is expected due to the total calculated releases being slightly higher. The little differences between the other hand calculated values and the values given in the output deck can be attributed to consistent roundoff error throughout the calculations. This concludes that the code properly calculates the radionuclide releases and offsite doses.

The last calculations that need to be verified are the dose equivalent I-131 activities given in the output deck C1MPLOT DATA for use in the RETRAN code PLOTER module. Dose equivalent I-131 activity is calculated using Equation (28). To verify the values in C1MPLOT DATA, at each of the times that the containment atmosphere activity was calculated, the dose equivalent I-131 activity for elemental, particulate, organic, and total iodine have also been calculated as shown in pages 38 through 51 of Attachment 1. At each of the times that the dose equivalent I-131 activities were calculated by hand, the calculated values were compared to the values in C1MPLOT DATA for each of the chemical species and the total. These showed close agreement. However, only 23 time points were calculated by hand, whereas many more time points are given in C1MPLOT DATA. Therefore, an input deck for the RETRAN code PLOTER module was made using the hand calculated dose equivalent I-131 activities at the 23 time points, filename - PLOTCHK DATA. The PLOTCHK DATA input deck is listed on pages 52 through 54 of Attachment 1. The two plots output by the RETRAN code PLOTER module execution using PLOTCHK DATA are shown on pages 55 and 56 of Attachment 1. The containment atmosphere activity plots in Attachment 1 can be compared to the plots on pages 1 and 2 of Attachment 3, created from execution of the RETRAN code PLOTER module using C1MPLOT DATA as the input deck, showing excellent agreement. This concludes that the code calculates the dose equivalent I-131 containment atmosphere activities correctly and writes the RPLOT DATA output deck in the proper format for the RETRAN code PLOTER module.

10.2 TEST CASE 2

Test case 2 was created to verify that if a stop time for containment sprays is used in the input deck to the MHACALC code, that all spray removal of iodine would be terminated setting the values of the spray removal coefficients to 0.0. The input deck for this test case is C2MCALC DATA and is listed on the attached microfiche. This input deck is almost identical to the input deck for test case 1, with the parameters that are different being discussed below.

line 1: `CASE 2: VERIFICATION OF THE SPRAY STOP TIME`
This line is just the title and is changed appropriately for this test case.

line 14: `00.0     0.000`
line 15: `000.0     0.000`
These lines are changed to values of 0.0 so that the elemental iodine spray removal rate specified on line 13 will continue until DF_{max} is reached or a spray stop time is reached, which ever is first.

line 16: `25.57     24.0`
The second value on this line, STOPSPRA, has been changed from 0 to a value of 24 minutes. Changing this value to 24 minutes causes the spray removal of elemental and particulate iodine to be terminated at 24 minutes.

line 40: `00`
The value of INTRVALS has been changed to 00 to prevent the code from creating release rate files since they are not needed for this test case.

line 41: 00
The value of NPRINT was changed to 00 to prevent the containment atmosphere activity from being sent to the output deck at a number of times. The containment atmosphere activity at different points in time is unnecessary since a separate output deck is created for plotting it with the RETRAN code PLOTER module.

The MHACALC code was executed using the C2MCALC DATA input deck. The C2MCALC LISTING output deck is listed on the attached microfiche. No release rate files were created since the value of INTRVALS on line 40 of the input deck was specified as 00. The output deck set up for use in the RETRAN code PLOTER module, however, was necessary and was renamed C2MPLOT DATA. C2MPLOT DATA is also listed on the attached microfiche.

To evaluate the time at which spray removal of iodine ended, the last page of the C2MCALC LISTING output deck can be examined. As can be seen, C2MCALC LISTING gives the time at which the DF_{max} or the spray stop time was reached as 24 minutes. This is the same time as specified in the input deck, but it must be verified that the spray removal of iodine was terminated at that time. The only difference between the spray stop time being reached and the DF_{max} being reached is that when the spray stop time is reached, spray removal of elemental and particulate iodine is terminated. When the DF_{max} is reached, only that for elemental iodine is terminated. The RETRAN code PLOTER module was executed using the C2MPLOT DATA deck, with the resultant plots shown in Attachment 4. As can be seen on page 1 of Attachment 4, the elemental iodine activity and the particulate iodine activity stop decreasing sharply at 24 minutes. This verifies that the spray stop time performs its desired function.

10.3 TEST CASE 3

Test case 3 was created to verify that use of a negative value for the elemental iodine spray removal coefficient could adequately model iodine re-evolution from the sump solution to the containment atmosphere. This situation can occur if the sump solution pH is allowed to fall below 7.0 at any time during a LOCA, or the MHA. The input deck for this test case is C3MCALC DATA and is listed on the attached microfiche. This input deck is very similar to the input deck for test case 2. The parameters that are different are explained below.

line 1: `CASE 4: VERIFICATION OF IODINE RE-EVOLUTION`
This line is just the title and again was changed appropriately for this test case.

line 12: 1.0 10.000
line 13: 19.0 5.000
line 14: 45.0 -1.000
line 15: 150.0 0.000
The second value of line 12 was changed to 10 to give the elemental iodine a large spray removal coefficient so that a rapid decrease in elemental iodine activity can be seen. On line 13, the first time at which the elemental iodine spray removal coefficient changes was arbitrarily chosen as 19 minutes with a spray removal coefficient of 5 hr^{-1} to slow the decrease in the elemental iodine activity before

the value of DF_{max} is reached. On line 14, 45 minutes was arbitrarily chosen as the time at which elemental iodine re-evolution would occur with a negative spray removal coefficient of -1.0 hr^{-1} so that re-evolution does not occur at too rapid of a rate. On line 15, 150 minutes was arbitrarily chosen as the time at which elemental iodine re-evolution would terminate.

line 16: `25.57 1440.0`
The second value on this line was arbitrarily set at 1440 minutes for the spray stop time in case spray removal of particulate iodine continued.

The MHACALC code was executed using the C3MCALC DATA input deck. The C3MCALC LISTING output deck is listed on the attached microfiche. As with case 2, no release rate files were created since they were not needed for this test case. The output deck set up for use in the RETRAN code PLOTER module is necessary, however. This output deck was renamed C3MPLOT DATA and is also listed on the attached microfiche.

To evaluate the re-evolution of elemental iodine, the plots of the iodine activity versus time are used. Therefore, the RETRAN code PLOTER module was executing using the C3MPLOT DATA deck. The resultant plots from this execution are shown in Attachment 5. If page 1 of Attachment 5 is examined, the elemental iodine activity behaves exactly as would be expected considering the values specified on lines 12 through 15 of C3MCALC DATA. The elemental iodine activity decreases very sharply from approximately 1 to 19 minutes. The decrease is then less sharp for just a few minutes before leveling off. The reason for the elemental iodine activity leveling off is that the DF_{max} value is reached at 22 minutes, as can be seen on C3MCALC LISTING, which terminates elemental iodine removal. At 45 minutes, the elemental iodine starts increasing at approximately the same rate as the particulate iodine is decreasing. This is as expected since the particulate iodine removal rate is 1.0 hr^{-1} and the elemental iodine re-evolution rate is 1.0 hr^{-1}, or removal rate of -1.0 hr^{-1}. At 150 minutes the elemental iodine activity levels off again since at that time the removal coefficient is set to 0. The particulate iodine activity levels off at around 200 minutes, which is due to the condition in Equation (13) being met. At that time the particulate iodine removal coefficient changes to the second value specified on line 11, which is 0, in C3MCALC DATA. It is interesting to view the effect that the changing elemental iodine activity has on the total iodine activity shown on page 2 of Attachment 5. For this case, the elemental iodine activity was always greater that that of the other chemical forms and was therefore dominating on the plot of total iodine activity. This case has confirmed that the MHACALC code can also properly model elemental iodine re-evolution into the containment atmosphere if the rate at which re-evolution is to occur can be determined.

11.0 SUMMARY

The MHACALC code was written to calculate the time dependent activity of iodine and noble gas in the containment atmosphere and sump following a LOCA. The containment atmosphere was modeled as a single, well-mixed space. This is accepted by the Standard Review Plan since the containment sprays cover at least 90% of the containment building space and the air coolers are available to circulate the sprayed and unsprayed regions. The containment atmosphere activity and the sump activity are modeled as non-interactive, intended for use with Regulatory Guide and Standard Review Plan activity source terms. Modeling the atmosphere and sump as non-interactive means that the activity removed by containment sprays will not be added to the activity of the sump solution since the sump activity will be assumed high enough to account for the interaction when using regulatory guidance on the activity source terms. Three removal mechanisms are modeled for the iodine in the containment atmosphere: radioactive decay, removal by containment sprays and surface plateout, and leakage of the containment atmosphere to the environment. For noble gas in the containment atmosphere, only radioactive decay and leakage of the containment atmosphere are considered. An output deck is created for direct use in the RETRAN code plotting routine which creates plots of the iodine activity versus time. Plots of the dose equivalent I-131 activity for each chemical species and for the total are created.

The MHACALC code also determines the resultant offsite radiation exposure doses by modeling the possible release paths from containment. The code can model the release of radionuclides to the environment from leakage of the containment atmosphere, leakage of ESF components into the safeguards rooms during recirculation of sump water, and seat-leakage of valves in the recirculation lines to the SIRW tank during recirculation of sump water. The doses are calculated using the methodology and dose conversion factors of ICRP30. Using the ICRP30 methodology, doses are calculated as the committed dose equivalent (CDE) to the thyroid, the deep-dose equivalent to the thyroid, the committed effective dose equivalent (CEDE) to the whole body, external dose to the whole body, and the total effective dose equivalent (TEDE). The CDE to the thyroid is from inhalation of iodine, and the CEDE relates the dose to all organs from inhalation of iodine to a whole body dose. The deep-dose equivalent to the thyroid is contribution from submersion in a cloud of noble gas, and the external dose to the whole body is dose from submersion in a noble gas cloud. The TEDE adds the contribution to the whole body dose from internal organs to that to the whole body externally. The doses were all calculated separately for each release path.

The code also calculates the release rates of the radionuclides of concern for specified time intervals and writes them to two output decks, one containing release rates from containment and ESF leakage and one containing release rates from the SIRW tank, for use in the CONDOSE code which performs control room habitability calculations.

The methodology used to write the MHACALC code was described in full detail and the input deck for the code was explained line by line also giving limitations and suggested values for each parameter. To verify the functions performed by the code, three test cases were executed. The first test case made use of all of the calculations that the code performs and was verfied by alternate calculations for every value sent as output from the code. The second test case was used to verify that by specifying a containment spray stop time in the input deck, the removal of elemental and particulate iodine would be terminated at the desired time. The test case confirmed that the spray stop time function of the code works correctly also. The third test case was to verify that a negative elemental iodine spray removal coefficient specified in the input deck would model re-evolution of elemental iodine, and results verified that the code did so correctly.

12.0 CONCLUSION

All of the calcuclations that the MHACALC code performs have been verified by alternate calculations that show agreement for all values. All of the desired functions that the code will perform have also been verified showing that the code performs the functions correctly. Therefore, the MHACALC code is functionally correct for performing radiological analysis of LOCA's at Palisades in accordance with Regulatory Guide and Standard Review Plan guidance.

LIST OF ATTACHMENTS

1. Test Case 1 Verification of TRYMHA DATA Deck Execution With Hand Calculations, 57 pages.
2. Basic program and verification to perform alternate sump activity release calculations 4 pages.
3. Test Case 1 RETRAN Plots of C1MPLOT DATA Deck, 2 pages.
4. Test Case 2 RETRAN Plots of C2MPLOT DATA Deck, 2 pages.
5. Test Case 3 RETRAN Plots of C3MPLOT DATA Deck, 2 pages.
6. Letter from E.C. Beahm (Martin Maietta Energy Systems, Inc.) to Jay Y. Lee (NRC) dated February 5, 1992, 3 pages.
7. Form 3698 9-89, Palisades Nuclear Plant Engineering Analysis Checklist, 1 page.
8. Procedure No. 9.11 Attachment 5, Technical Review Checklist, 1 page.
9. Form 3110 1-82, NOD Document Review Sheet, 67 pages.
10. Microfiche Titled - EA-PAH-91-05 MHACALC CODE BENCHMARK, 1 fiche.

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PALISADES NUCLEAR PLANT
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HANDCALCS. FOR CASE 1

INITIAL ACTIVITIES IN CONT. ATM.

$N_{CA} = P \cdot S_i \cdot f_{CA}$

$P = 2530$ MWt

$f_{CA} = 1$ Noble Gas
$= .25$ Iodine

SUMP IODINE ACTIVITY

$N_{SI} = P \cdot S_i \cdot f_S$

$f_S = .5$

	S_i	N_{CA} (Ci)	N_{SI} (Ci)
Kr-83m	2.998E+3	7.585E+6	
Kr-85m	6.498E+3	1.644E+7	
Kr-85	2.999E+2	7.587E+5	
Kr-87	1.155E+4	2.922E+7	
Kr-88	1.690E+4	4.276E+7	
Kr-89	1.993E+4	5.042E+7	
Xe-131m	1.760E+2	4.453E+5	
Xe-133m	1.954E+3	4.944E+6	
Xe-133	5.648E+4	1.429E+8	
Xe-135m	1.698E+4	4.296E+7	
Xe-135	9.781E+3	2.475E+7	
Xe-137	4.705E+4	1.190E+8	
Xe-138	4.433E+4	1.122E+8	
I-131	2.938E+4	1.858E+7	3.717E+7
I-132	4.160E+4	2.631E+7	5.262E+7
I-133	4.808E+4	3.041E+7	6.082E+7
I-134	6.218E+4	3.933E+7	7.866E+7
I-135	4.922E+4	3.113E+7	6.226E+7

ACTIVITY RELEASED FROM CONT. ATM.

$Q \to 1$ min

for Noble Gas

$$Q = \frac{\lambda_L N_{CAi}^{(t-1)}}{\lambda_L + \lambda_i}\left(1 - e^{-(\lambda_L + \lambda_i)\Delta t}\right)$$

for Iodine

$$Q_{elem}^{(t)} = \frac{\lambda_L N_{CA\,elem}^{(t-1)}}{\lambda_L + \lambda_i + \lambda_{s\,elem}}\left(1 - e^{-(\lambda_L + \lambda_i + \lambda_{s\,elem})\Delta t}\right)$$

$$Q_{part}^{(t)} = \frac{\lambda_L N_{CA\,part}}{\lambda_L + \lambda_i + \lambda_{s\,part}}\left(1 - e^{-(\lambda_L + \lambda_i + \lambda_{s\,part})\Delta t}\right)$$

$$Q_{org.}^{(t)} = \frac{\lambda_L N_{CA\,org}}{\lambda_L + \lambda_i + \lambda_{s\,org}}\left(1 - e^{-(\lambda_L + \lambda_i + \lambda_{s\,org.})\Delta t}\right)$$

$$Q = Q_{elem} + Q_{part} + Q_{org.}$$

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0 → 1 min

for 0→1 min

$\lambda_L = .1\%/day = 6.944E-7\ min^{-1}$

$\lambda_{s\,elem} = \lambda_{s\,part} = \lambda_{s\,org} = 0$

	$\lambda_i\ (min^{-1})$	Q (ci)	STACK $\dot{q}\ (\frac{\mu Ci}{hr})$
Kr-83m	6.211E-3	5.2507	3.150E+8
Kr-85m	2.579E-3	11.4012	6.841E+8
Kr-85	1.230E-7	0.5268	3.161E+7
Kr-87	9.120E-3	20.1981	1.212E+9
Kr-88	4.068E-3	29.6322 ~~13.2108~~	1.778E+9 ~~7.931E+8~~
Kr-89	2.201E-1	31.4264 ~~750.3821~~	1.886E+9
Xe-131m	4.038E-5	0.3092	1.855E+7
Xe-133m	2.198E-4	3.4327	2.059E+8
Xe-133	9.169E-5	99.2255	5.954E+9
Xe-135m	4.530E-2	29.1658	1.750E+9
Xe-135	1.271E-3	17.1755	1.031E+9
Xe-137	1.800E-1	75.6234	4.537E+9
Xe-138	4.881E-2	76.0408	4.562E+9
I-131	5.986E-5	12.9016	7.741E+8
I-132	5.045E-3	18.2236	1.093E+9
I-133	5.554E-4	21.1108	1.267E+9
I-134	1.318E-2	27.1315	1.628E+9
I-135	1.754E-3	21.5977	1.296E+9

for Noble Gas $N_{CA}(t) = N_{CA}(t-1)\,e^{-(\lambda_{LO}+\lambda_i)\Delta t}$

for Iodine $N_{CA}(t) = N_{CA}(t-1)\left[e^{-(\lambda_L+\lambda_i+\lambda_{s\,elem})\Delta t} + e^{-(\lambda_L+\lambda_i+\lambda_{s\,part})\Delta t} + e^{-(\lambda_L+\lambda_i+\lambda_{s\,org})\Delta t}\right]$

$N_{CA\,elem} = N_{CA\,elem}^{(t-1)}\,e^{-(\lambda_L+\lambda_i+\lambda_{s\,elem})\Delta t}$

$N_{CA\,part} = N_{CA\,part}^{(t-1)}\,e^{-(\lambda_L+\lambda_i+\lambda_{s\,part})\Delta t}$

$N_{CA\,org} = N_{CA\,org}^{(t-1)}\,e^{-(\lambda_L+\lambda_i)\Delta t}$

Reference/Comment

@1min

	N_{CA} (Ci)
Kr-83m	7.538E+6
Kr-85m	1.646E+7
Kr-85	7.587E+5
Kr-87	2.895E+7
Kr-88	4.259E+7
Kr-89	4.046E+7
Xe-131m	4.453E+5
Xe-133m	4.993E+6
Xe-133	1.429E+8
Xe-135m	4.106E+7
Xe-135	2.472E+7 ~~1.188E+8~~
Xe-137	9.94E+7
Xe-138	1.069E+8
I-131	1.858E+7
I-132	2.618E+7
I-133	3.039E+7
I-134	3.882E+7
I-135	3.108E+7

since $\lambda_{sclean} = \lambda_{spart} = \lambda_{sorg} = 0$

$N_{CA} = N_{CA}(t-1)\, e^{-(\lambda_a+\lambda_i)\Delta t}$

@2min

	N_{CA}
Kr-83m	7.491E+6
Kr-85m	1.636E+7
Kr-85	7.587E+5
Kr-87	2.869E+7
Kr-88	4.242E+7
Kr-89	3.249E+7
Xe-131m	4.453E+5
Xe-133m	4.942E+6
Xe-133	1.429E+8
Xe-135m	3.924E+7 ~~4.141E+7~~
Xe-135	2.469E+7 ~~3.924E+7~~
Xe-137	8.303E+7
Xe-138	1.018E+8

$\lambda_{sclean} = .007$

$\lambda_{spart} = .017$

$\lambda_{sorg} = 0.2$

	$N_{CAclean}$	N_{CApart}	N_{CAorg}	N_{CA}	N_{sump}
I-131	1.762E+7	4.566E+5	3.716E+5	1.845E+7	3.717E+9
I-132	2.478E+7	6.402E+5	5.210E+5	2.586E+7	5.208E+7
I-133	2.880E+7	7.465E+5	6.075E+5	3.015E+7	6.075E+7
I-134	3.633E+7	9.417E+5	7.662E+5	3.804E+7	7.661E+7
I-135	2.942E+7	7.626E+5	6.205E+5	3.080E+7	6.204E+7

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	Q (Ci) 1→2 min	Reference/Comment
Kr-83m	5.2182	
Kr-85m	11.3735	
Kr-85	0.5268	
Kr-87	20.0115	
Kr-88	29.5144	
Kr-89	25.2184	
Xe-131m	0.3092	
Xe-133m	3.4320	
Xe-133	99.2255	
Xe-135m	27.8759	
Xe-135	17.1547	
Xe-137	63.1678	
Xe-138	72.4488	
I-131	12.9016	
I-132	18.1336	
I-133	21.0969	
I-134	26.7797	
I-135	21.5630	

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	N_{ca} @ 3min	Q(Ci) 2→3min
Kr-83m	7.445E+6	5.1856
Kr-85m	1.632E+7	11.3897
Kr-85	7.587E+5	0.5268
Kr-87	2.843E+7	19.8318
Kr-88	4.225E+7	29.3966
Kr-89	2.606E+7	20.2383
Xe-131m	4.453E+5	0.3092
Xe-133m	4.942E+6	3.4314
Xe-133	1.429E+8	99.2255
Xe-135m	3.750E+7	26.6403
Xe-135	2.466E+7	17.1338
Xe-137	6.935E+7	52.7648
Xe-138	9.695E+7	68.9924

	$N_{ca\,elem}$	$N_{ca\,part}$	$N_{ca\,org}$	N_{ca}	N_{sump}
I-131	1.750E+7	4.489E+5	3.716E+5	1.832E+7	3.717E+7
I-132	2.440E+7	6.262E+5	5.184E+5	2.555E+7	5.183E+7
I-133	2.858E+7	7.335E+5	6.072E+5	2.992E+7	6.072E+7
I-134	3.560E+7	9.137E+5	7.561E+5	3.727E+7	7.561E+7
I-135	2.916E+7	7.484E+5	6.194E+5	3.053E+7	6.193E+7

	Q 2→3min
I-131	12.8114
I-132	17.9120
I-133	20.9303 ~~[illegible]~~
I-134	26.2417
I-135	21.3688

Form 3650 6-89

ATTACHMENT 1

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$$\dot{q}\underset{\mu Ci/Hr}{(1\rightarrow 2.28\,min)} = \left[Q(1\rightarrow 2\,min) + .28\left(Q(2\rightarrow 3\,min)\right)\right] * 1\times10^{6} * 60/1.28$$

	STACK $\dot{q}\left(\frac{\mu Ci}{Hr}\right)$ 1→2.28 min
Kr-83m	3.127E+8
Kr-85m	6.820E+8
Kr-85	3.161E+7
Kr-87	1.198E+9
Kr-88	1.769E+9
Kr-89	1.448E+9
Xe-131m	1.855E+7
Xe-133m	2.059E+8
Xe-133	5.954E+9
Xe-135m	1.656E+9
Xe-135	1.029E+9
Xe-137	3.654E+9
Xe-138	4.302E+9
I-131	7.729E+8
I-132	1.085E+9
I-133	1.264E+9
I-134	1.599E+9
I-135	1.291E+9

$$\dot{q}(2.28\rightarrow 5\,min) = \left[.72\left(Q(2\rightarrow 3\,min) + Q(3\rightarrow 5\,min)\right)\right] * \frac{6E+7}{2.72}$$

	@5min NCA	$Q(\overset{3}{\cancel{2.28}}\rightarrow 5\,min)$	STACK $\left(\frac{\mu Ci}{Hr}\right)$ $\dot{q}(2.28\rightarrow 5\,min)$
Kr-83m	7.353E+6	10.2757	3.090E+8
Kr-85m	1.624E+7	22.6069	6.789E+8
Kr-85	7.587E+5	1.0537	3.161E+7
Kr-87	2.792E+7	39.1256	1.178E+9
Kr-88	4.191E+7	58.4387	1.756E+9
Kr-89	1.678E+7	29.2770	9.672E+8
Xe-131m	4.453E+5	0.6184	1.855E+7
Xe-133m	4.939E+6	6.8606	2.058E+8
Xe-133	1.429E+8	198.4412	5.953E+89

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ATTACHMENT 2

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	N_{CA} @ 5min	Q(~~2.28~~ 3 →5min)	$\dot{q}$ STACK (2.28→5min)
Xe-135m	3.425E+7	49.7904	1.521E+9
Xe-135	2.460E+7	34.2043	1.827E+9
Xe-137	4.838E+7	80.8827	2.622E+9
Xe-138	8.793E+7	128.2808	3.925E+9

	$N_{CA\,elem}$	$N_{CA\,part}$	$N_{CA\,org}$	N_{CA}	N_{sump}
I-131	1.725E+7	4.338E+5	3.716E+5	1.806E+7	3.717E+7
I-132	2.382E+7	5.996E+5	5.132E+5	2.493E+7	5.131E+7
I-133	2.815E+7	7.082E+5	6.065E+5	2.947E+7	6.065E+7
I-134	3.419E+7	8.602E+5	7.364E+5	3.579E+7	7.364E+7
I-135	2.865E+7	7.209E+5	6.172E+5	2.999E+7	6.171E+7

	Q 3→5min	$\dot{q}$ 2.28→5min STACK ($\mu Ci/Hr$)
I-131	25.0802	7.567E+8
I-132	35.3054	1.063E+9
I-133	41.5298	1.248E+9
I-134	50.1408 ~~51.0843~~	1.528E+9
I-135	42.0238	1.266E+9

After 5min $\lambda_{s\,elem} = 0.167\ min^{-1}$

	N_{CA} @19min	Q 5→19min (Ci)	$\dot{q}$ STACK 5→19min ($\mu Ci/Hr$)
Kr-83m	6.741E+6	68.4629	2.934E+8
Kr-85m	1.566E+7	155.0618	6.646E+8
Kr-85	7.587E+5 ~~3.161E+7~~	7.3758 ~~8.6873~~	3.161E+7
Kr-87	2.457E+7	254.8125	1.092E+9
Kr-88	3.959E+7	396.0455	1.697E+9
Kr-89	7.701E+5	50.5099	2.165E+8
Xe-131m	4.450E+5	4.3278	1.855E+7
Xe-133m	4.924E+6	47.9409	2.055E+8
Xe-133	1.427E+8	1338.3185	5.950E+9
Xe-135m	1.017E+7	246.5674	1.057E+9
Xe-135	2.417E+7	237.0350	1.016E+9
Xe-137	3.893E+6	171.6219	7.355E+8
Xe-138	4.440E+7	619.3052	2.654E+9

Reference/Comment

@ 19 min

	$N_{CA\,elem}$	$N_{CA\,part}$	$N_{CA\,org}$	N_{CA}	N_{sump}
I-131	1.664E+6	3.416E+5	3.713E+5	2.377E+6	3.714E+7
I-132	2.142E+6	4.404E+5	4.782E+5	3.061E+6	4.781E+7
I-133	2.696E+6	5.539E+5	6.018E+5	3.852E+6	6.018E+7
I-134	2.744E+6	5.638E+5	6.123E+05	3.920E+6	6.123E+7
I-135	2.698E+6	5.544E+5	6.022E+5	3.855E+6	6.021E+7

	Q 5-19min (Ci)	STACK $\dot{q}$ 5→19min $\left(\frac{MCi}{Hr}\right)$
I-131	72.1486	3.092E+8
I-132	97.3265	4.171E+8
I-133	117.4659	5.039E+8
I-134	134.5479	5.766E+8
I-135	118.8785	5.095E+8

After 19 min $\lambda_{s\,elem} = 0.0$ $\lambda_{s\,part} = 0.016667\ min^{-1}$

ESF LEAKAGE STARTS $LR_{ESF} = 2(.2gpm)(.13368\frac{ft^3}{gal}) = .05347\frac{ft^3}{min}$

$LR_{SRW} = 1gpm(.13368\frac{ft^3}{gal}) = .13368\frac{ft^3}{min}$

(using values at 19min from Program output since roundoff error was occurring) Debug option output for 19 min. on next page.

@ 30 min

	N_{CA}	Q 19-30 min	STACK $\dot{q}$ 19-30 min
Kr-83m	6.296E+6	49.7707	2.715E+8
Kr-85m	1.521E+7	117.8608	6.429E+8
Kr-85	7.587E+5	5.7953	3.161E+7
Kr-87	2.222E+7	178.5681	9.740E+8
Kr-88	3.785E+7	295.6622	1.613E+9
Kr-89	6.838E+4	2.2132	1.207E+7
Xe-131m	4.447E+5	3.3976	1.853E+7
Xe-133m	4.911E+6	37.5583	2.049E+8
Xe-133	1.425E+8	1088.6826	5.938E+9
Xe-135m	1.184E+7	109.3038	5.962E+8
Xe-135	2.382E+7	183.259	9.996E+8
Xe-137	5.376E+5	12.9481	7.063E+7
Xe-138	2.594E+7	262.2441	1.430E+9

```
          CELEM = 0.1424E+08  CPART = 0.2521E+07  C[illegible]M = 0.1392E+09  COPART = 0.3644E+07   J =  19 MIN
                                 19 MIN   LAMBS(1)= 0.167  LAMBS(2)= 0.017
          LAMBL =  0.6944E-06  LRESF = 0.0000E+00  LRSRW =  0.0000E+00  VLIQ = 0.3739E+04  J =  19 MIN
                             BR = 0.3470E-03  CHIQ = 0.1090E-04   J =  19 MIN
 elem. -->I-131     NIA(N,1) = 0.1671E+07  NCA(NUC) = 0.1671E+07  J =  19 MIN
 part. -->I-131     NIA(N,2) = 0.3438E+06  NCA(NUC) = 0.2015E+07  J =  19 MIN
 org.  -->I-131     NIA(N,3) = 0.3712E+06  NCA(NUC) = 0.2386E+07  J =  19 MIN
          I-131     NIS(NUC) = 0.3712E+08  QIESF = 0.0000E+00  QISRW = 0.0000E+00   J =  19 MIN
          I-131     ASRW(NUC) = 0.0000E+00  CAIR(NUC) = 0.0000E+00   J =  19 MIN
          I-131      Q(NUC) = 0.1762E+01      J =  19 MIN
 elem. -->I-132     NIA(N,1) = 0.2153E+07  NCA(NUC) = 0.2153E+07  J =  19 MIN
 part. -->I-132     NIA(N,2) = 0.4428E+06  NCA(NUC) = 0.2596E+07  J =  19 MIN
 org.  -->I-132     NIA(N,3) = 0.4781E+06  NCA(NUC) = 0.3074E+07  J =  19 MIN
          I-132     NIS(NUC) = 0.4781E+08  QIESF = 0.0000E+00  QISRW = 0.0000E+00   J =  19 MIN
          I-132     ASRW(NUC) = 0.0000E+00  CAIR(NUC) = 0.0000E+00   J =  19 MIN
          I-132      Q(NUC) = 0.2275E+01      J =  19 MIN
 elem. -->I-133     NIA(N,1) = 0.2710E+07  NCA(NUC) = 0.2710E+07  J =  19 MIN
 part. -->I-133     NIA(N,2) = 0.5573E+06  NCA(NUC) = 0.3267E+07  J =  19 MIN
 org.  -->I-133     NIA(N,3) = 0.6018E+06  NCA(NUC) = 0.3869E+07  J =  19 MIN
          I-133     NIS(NUC) = 0.6018E+08  QIESF = 0.0000E+00  QISRW = 0.0000E+00   J =  19 MIN
          I-133     ASRW(NUC) = 0.0000E+00  CAIR(NUC) = 0.0000E+00   J =  19 MIN
          I-133      Q(NUC) = 0.2857E+01      J =  19 MIN
 elem. -->I-134     NIA(N,1) = 0.2757E+07  NCA(NUC) = 0.2757E+07  J =  19 MIN
 part. -->I-134     NIA(N,2) = 0.5670E+06  NCA(NUC) = 0.3324E+07  J =  19 MIN
 org.  -->I-134     NIA(N,3) = 0.6123E+06  NCA(NUC) = 0.3936E+07  J =  19 MIN
          I-134     NIS(NUC) = 0.6123E+08  QIESF = 0.0000E+00  QISRW = 0.0000E+00   J =  19 MIN
          I-134     ASRW(NUC) = 0.0000E+00  CAIR(NUC) = 0.0000E+00   J =  19 MIN
          I-134      Q(NUC) = 0.2925E+01      J =  19 MIN
 elem. -->I-135     NIA(N,1) = 0.2712E+07  NCA(NUC) = 0.2712E+07  J =  19 MIN
 part. -->I-135     NIA(N,2) = 0.5577E+06  NCA(NUC) = 0.3269E+07  J =  19 MIN
 org.  -->I-135     NIA(N,3) = 0.6022E+06  NCA(NUC) = 0.3871E+07  J =  19 MIN
          I-135     NIS(NUC) = 0.6022E+08  QIESF = 0.0000E+00  QISRW = 0.0000E+00   J =  19 MIN
          I-135     ASRW(NUC) = 0.0000E+00  CAIR(NUC) = 0.0000E+00   J =  19 MIN
          I-135      Q(NUC) = 0.2860E+01      J =  19 MIN
```

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	$N_{CA\,elem}$	$N_{CA\,part}$	$N_{CA\,org}$	$N_{CA\,Total}$	N_{sump}
I-131	1.670E+6	2.860E+5	3.710E+5	2.328E+6	3.709E+7
I-132	2.037E+6	3.487E+5	4.523E+5	2.838E+6	4.523E+7
I-133	2.693E+6	4.611E+5	4.981E+5	3.752E+6	5.981E+7
I-134	2.385E+6	4.883E+5	5.297E+5	3.323E+6	5.296E+7
I-135	2.660E+6	4.554E+5	5.907E+5	3.706E+6	5.907E+7

Reference/Comment

@ 30 min

From Eqn (18): $Q_{ESF}(t) = \dfrac{LR_{ESF} \cdot N_{sump}(t-1)}{DF_{ESF} \cdot PF_{ESF} \cdot V_{sump}(t-1) \cdot \lambda_i} \left[1 - e^{-\lambda_i \Delta t}\right]$

From Eqn (21): $A_{SRW}(t) = \left[A_{SRW}(t-1) - Q_{SRW}(t-1)\right] e^{-\lambda_i \Delta t} + \dfrac{LR_{SRW} \cdot N_{sump}(t-1)}{V_{sump}(t-1) \cdot \lambda_i} \left[1 - e^{-\lambda_i \Delta t}\right]$

$$A_{I_2}(t) = \left[A_{I_2}(t-1) - Q_{SRW}(t-1)\right] e^{-\lambda_i \Delta t} + \frac{f_{I_2} \cdot LR_{ESF} \cdot N_{sump}(t-1)}{V_{sump}(t-1) \cdot \lambda_i} \left[1 - e^{-\lambda_i \Delta t}\right]$$

From Eqn (25): $C_{AIR}(t) = \dfrac{A_{I_2}(t)}{V_{AIR}(t) + PF_{SRW} \cdot V_{LIQ}(t)}$ where $V_{AIR}(t) = V_{TANK} - V_{LIQ}(t)$

From Eqn (22): $Q_{SRW}(t) = C_{AIR}(t) \cdot LR_{SRW} \cdot K_D \cdot \Delta t$

From Input Deck: $DF_{ESF} = 2$, $PF_{ESF} = 10$, $PF_{SRW} = 1$, $K_D = 2$, $f_{I_2} = 0.3$, $V_{TANK} = 38767.2\ ft^3$
$V_{sump}(19\ min) = 40304.5\ ft^3$, $V_{LIQ}(19) = 3739.3\ ft^3$, $V_{AIR}(19) = 38767.2 - 3739.3 = 35027.9\ ft^3$
$A_{SRW}(19) = 0$, $A_{I_2}(19) = 0$, $C_{AIR}(19) = 0$, $Q_{SRW}(19) = 0$

Note: Due to the interdependence of the eqns for SIRW Tank release & activity, hand calcs must be performed over 1 minute time steps to obtain same results as the code.

	A_{SRW} (Ci)	A_{I_2} (Ci)	C_{AIR} (Ci/ft^3)
I-131	1.3531E+3	4.0592E+2	1.0471E-2
I-132	1.6543E+3	4.9628E+2	1.2802E-2
I-133	2.1830E+3	6.5487E+2	1.6892E-2
I-134	1.9452E+3	5.8355E+2	1.5853E-2
I-135	2.1570E+3	6.4709E+2	1.6692E-2

$V_{sump} = 40302.44$
$V_{LIQ} = 3740.771$
$V_{AIR} = 35026.43$

19→30 min

	Q_{CA}	Q_{ESF}	Q_{SIRW}	$\dot{q}_{STACK}$ ($\mu Ci/hr$)	$\dot{q}_{SRW}$ ($\mu Ci/hr$)
I-131	17.9926	27.0702	0.0168	2.458E+8	9.164E+4
I-132	22.5585	33.9359	0.0209	3.082E+8	1.140E+5
I-133	29.0976	43.7810	0.0271	3.975E+8	1.478E+5
I-134	27.7078	41.5909	0.0257	3.78E+8	1.375E+5
I-135	28.9285	43.5213	0.0269	3.952E+8	1.467E+5

$\dot{q}_{STACK} = \dfrac{Q_{CA} + Q_{ESF}}{\Delta t}$

$\dot{q}_{SIRW} = \dfrac{Q_{SIRW}}{\Delta t}$

ATTACHMENT 1

PALISADES NUCLEAR PLANT
ANALYSIS CONTINUATION SHEET

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Reference/Comment

	Nca	Q 30→45 min	$\dot{q}$ 30→45 min
Kr-83m	5.735E+6	62.6067	2.585E+8
Kr-85m	1.464E+7	155.5035	6.220E+8
Kr-85	7.587E+5	7.9026	3.161E+7
Kr-87	1.939E+7	216.4069	8.656E+8
Kr-88	3.560E+7	382.3551	1.529E+9
Kr-89	2.519E+3	0.2078	8.313E+5
Xe-131m	4.449E+5	4.6306	1.852E+7
Xe-133m	4.895E+6	51.0685	2.043E+8
Xe-133	1.423E+8	1483.2518	5.933E+9
Xe-135m	5.596E+6	83.4526	3.338E+8
Xe-135	2.337E+7	245.7577	9.830E+8
Xe-137	3.613E+4	1.9346	7.738E+6
Xe-138	1.247E+7	191.5024	7.660E+8

@45 min

	Nca elem	Nca part.	Nca org.	Nca	Nsump
-131	1.669E+6	2.225E+5	3.787E+5	2.262E+6	3.786E+7
I-132	1.889E+6	2.518E+5	4.193E+5	2.560E+6	4.193E+7
I-133	2.671E+6	3.561E+5	5.931E+5	3.620E+6	5.931E+7
I-134	1.957E+6	2.609E+5	4.347E+5	2.653E+6	4.346E+7
I-135	2.591E+6	3.455E+5	5.754E+5	3.512E+6	5.753E+7

	A_{SRW} (Ci)	A_{I2} (Ci)	C_{AIR} (Ci/ft³)
I-131	3,1956E+3	9.5853E+2	2.4725E-2
I-132	3,6253E+3	1.0875E+3	2.8051E-2
I-133	5,1168E+3	1.5350E+3	3.9594E-2
I-134	3,7729E+3	1.1318E+3	2.9195E-2
I-135	4.966E+3	1.4897E+3	3.8426E-2

$V_{sump} = 40299.63$

$V_{LIQ} = 3742.776$

$V_{AIR} = 35024.42$

30→45min.

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SIRW}$
I-131	23.8840	36.8852	0.0725	2.431E+8	2.9E+5
132	28.3916	43.3434	0.0848	2.869E+8	3.392E+5
-133	38.3701	59.272	0.1164	3.986E+8	4.656E+5
I-134	30.9750	47.8202	0.0928	3.152E+8	3.712E+5
I-135	37.5621	58.01	0.1138	3.823E+8	4.552E+5

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PALISADES NUCLEAR PLANT
ANALYSIS CONTINUATION SHEET

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Reference/Comment: @ 60 min

	Nca	Q 45→60 min	$\dot{q}$ 45→60 min
Kr-83m	5.225E+6	57.0373	2.282E+8
Kr-85m	1.408E+7	149.5776	5.983E+8
Kr-85	7.587E+5	7.9026	3.161E+7
Kr-87	1.690E+7	188.6624	7.547E+8
Kr-88	3.349E+7	359.7210	1.439E+9
Kr-89	9.277E+1	0.0077	3.062E+4
Xe-131m	4.442E+5	4.6285	1.851E+7
Xe-133m	4.879E+6	50.9021	2.836E+8
Xe-133	1.421E+8	1481.17	5.925E+9
Xe-135m	2.835E+6	42.2857	1.691E+8
Xe-135	2.293E+7	241.1149	9.645E+8
Xe-137	2.430E+3	0.1300	5.201E+5
Xe-138	5.996E+6	92.0955	3.684E+8

	Nca elem	Nca part.	Nca org	Nca	Nsump
I-131	1.668E+6	1.731E+5	3.703E+5	2.211E+6	3.702E+7
I-132	1.750E+6	1.818E+5	3.887E+5	2.321E+6	3.887E+7
I-133	2.649E+6	2.750E+5	5.883E+5	3.512E+6	5.881E+7
I-134	1.606E+6	1.668E+5	3.567E+5	2.129E+6	3.566E+7
I-135	2.524E+6	2.620E+5	5.605E+5	3.347E+6	5.603E+7

	A_{SRW}	A_{I2}	C_{AIR}
I-131	5.035E+3	1.511E+3	3.896E-2
I-132	5.3 E+3	1.590E+3	4.101E-2
I-133	8.002E+3	2.4E+3	6.191E-2
I-134	4.882E+3	1.465E3	3.778E-2
I-135	7.628E+3	2.288E+3	5.902E-2

$V_{SUMP} = 40296.82$

$V_{LIQ} = 3744.781$

$V_{AIR} = 35022.42$

45 → 60 min

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SRW}$
I-131	23.2845	36.8521	.1296	2.406E+8	5.184E+5
I-132	25.3844	40.1844	.1409	2.623E+8	5.636E+5
I-133	37.1272	58.7802	.2067	3.836E+8	8.268E+5
I-134	24.7954	39.242	.1370	2.562E+8	5.48E+6
I-135	35.6944	56.5036	.1985	3.688E+8	7.94E+5

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PALISADES NUCLEAR PLANT
ANALYSIS CONTINUATION SHEET

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Rev #

Reference/Comment: @ 75 min

	Nca	Q 60→75 min	$\dot{q}$ 60→75 min
r-83m	4.760E+6	51.9651	2.079E+8
Kr-85m	1.355+7	143.8650	5.754E+8
Kr-85	7.589E+5	7.9026	3.161E+7
Kr-87	1.475E+7	164.6172	6.585E+8
Kr-88	3.152E+7	338.5015	1.354E+9
Kr-89	3.416E+0	0.0002818	1.127E+3
Xe-131m	4.439E+5	4.6254	1.850E+7
Xe-133m	4.863E+6	50.7357	2.029E+8
Xe-133	1.419E+8	1479.0885	5.916E+9
Xe-135m	1.437E+6	21.4301	8.572E+7
Xe-135	2.250E+7	236.5753	9.463E+8
Xe-137	1.632E+2	0.0087	3.495E+4
Xe-138	2.884E+6	44.2900	1.772E+8

	Nca elem	Nca part.	Nca org.	Nca	Nsump
-131	1.666E+6	1.347E+5	3.700E+5	2.171E+6	3.698E+7
I-132	1.622E+6	1.313E+5	3.604E+5	2.114E+6	3.603E+7
I-133	2.627E+6	2.124E+5	5.834E+5	3.423E+6	5.832E+7
I-134	1.318E+6	1.066+5	2.927E+5	1.717E+6	2.926E+7
I-135	2.458E+6	1.987E+5	5.459E+5	3.203E+6	5.457E+7

	A_{SRW}	A_{I_2}	C_{AIR}
I-131	6.871E+3	2.061E+3	5.315E-2
I-132	6.711E+3	2.013E+3	5.193E-2
I-133	1.084E+4	3.251E+3	8.386E-2
I-134	5.472E+3	1.642E+3	4.234E-2
I-135	1.015E+4	3.044E+3	7.851E-2

$V_{sump} = 40294.01$

$V_{LIQ} = 3746.786$

$V_{AIR} = 35020.42$

60 → 75 min.

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SRW}$
I-131	22.8159	36.819	.1866	2.386E+8	7.464E+5
32	23.0707	37.2557	.1885	2.413E+8	7.54E+5
33	36.1038	58.2925	.2954	3.776E+8	1.182E+6
I-134	19.9499	32.2026	.1624	2.086E+8	6.496E+5
I-135	34.0934	55.0364	.2787	3.565E+8	1.115E+6

Reference/Comment
@ 90 min

	N_{CA}	Q 75→90 min	$\dot{q}$ 75→90 min
-83m	4.337E+6	47.3404	1.894E+8
Kr-85m	1.304E+7	138.4410	5.538E+8
Kr-85	7.587E+6	7.9026	3.161E+7
Kr-87	1.286E+7	143.4925	5.740E+8
Kr-88	2.964E+7	318.3935	1.278E+9
Kr-89	1.258E-1	1.038E-5	4.152E+1
Xe-131m	4.436E+5	4.6222	1.849E+7
Xe-133m	4.847E+6	50.5693	2.023E+8
Xe-133	1.417E+8	1477.0068	5.908E+9
Xe-135m	7.284E+5	10.8624	4.345E+7
Xe-135	2.207E+7	232.0357	9.281E+8
Xe-137	1.097E+1	5.873E-4	2.349E+3
Xe-138	1.387E+6	21.2994	8.520E+7

	$N_{CA\,elem}$	$N_{CA\,part.}$	$N_{CA\,org.}$	N_{CA}	N_{sump}
-131	1.664E+6	1.048E+5	3.697E+5	2.139E+6	3.695E+7
I-132	1.504E+6	9.480E+4	3.341E+5	1.933E+6	3.341E+7
I-133	2.605E+6	1.640E+5	5.786E+5	3.348E+6	5.783E+7
I-134	1.082E+6	6.813E+4	2.402E+5	1.390E+6	2.401E+7
I-135	2.394E+6	1.507E+5	5.317E+5	3.077E+6	5.315E+7

	A_{SRW}	A_{I_2}	C_{AIR}
I-131	8.702E+3	2.610E+3	6.733E-2
I-132	7.889E+3	2.366E+3	6.104E-2
I-133	1.363E+4	4.088E+3	1.054E-1
I-134	5.693E+3	1.708E+3	4.405E-2
I-135	1.254E+4	3.759E+3	9.696E-2

$V_{sump} = 40291.29$

$V_{LIQ} = 3748.791$

$V_{AIR} = 35018.41$

75→90 min.

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SRW}$
I-131	22.4382	36.786	.2435	2.369E+8	9.74E+5
-132	21.0539	34.5404	.2283	2.224E+8	9.132E+5
-133	35.2501	57.8088	.3826	3.722E+8	1.53E+6
I-134	16.1177	26.426	.1742	1.702E+8	6.968E+5
I-135	32.6888	53.6072	.3547	3.452E+8	1.419E+6

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ATTACHMENT 2

PALISADES NUCLEAR PLANT
ANALYSIS CONTINUATION SHEET

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Rev #

Reference/Comment: @ 105 min

	N_{CA}	Q 90→105 min	$\dot{q}$ 90→105 min
Kr-83m	3.951E+6	41.1335	1.725E+8
Kr-85m	1.254E+7	133.1281	5.325E+8
Kr-85	7.587E+5	7.9026	3.161E+7
Kr-87	1.122E+7	125.1908	5.008E+8
Kr-88	2.789E+7	299.5991	1.198E+9
Kr-89	4.633E-3	3.823E-7	1.529E+0
Xe-131m	4.433E+5	4.6191	1.848E+7
Xe-133m	4.830E+6	50.3926	2.016E+8
Xe-133	1.415E+8	1474.9250	5.900E+9
Xe-135m	3.693E+5	5.5068	2.203E+7
Xe-135	2.165E+7	277.7025	9.108E+8
Xe-137	7.372E-1	3.948E-5	1.579E+2
Xe-138	6.670E-5	10.2435	4.097E+7

	N_{CA} elem	N_{CA} part.	N_{CA} org.	N_{CA}	N_{sump}
I-131	1.662E+6	8.154E+4	3.694E+5	2.113E+6	3.691E+7
I-132	1.394E+6	6.845E+4	3.097E+5	1.773E+6	3.097E+7
I-133	2.583E+6	1.267E+5	5.738E+5	3.284E+6	5.736E+7
I-134	8.879E+5	4.366E+4	1.971E+5	1.129E+6	1.978E+7
I-135	2.332E+6	1.143E+5	5.179E+5	2.964E+6	5.177E+7

	A_{SRW}	A_{I_2}	C_{AIR}
I-131	1.053E+4	3.159E+3	8.149E-2
I-132	8.859E+3	2.657E+3	6.854E-2
I-133	1.637E+4	4.909E+3	1.266E-1
I-134	5.659E+3	1.697E+3	4.378E-2
I-135	1.478E+4	4.434E+3	1.144E-1

$V_{sump} = 40288.38$

$V_{LIQ} = 3750.797$

$V_{AIR} = 35016.4$

90→105 min.

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SIRW}$
I-131	22.1388	36.7622	.3004	2.356E+8	1.202E+6
I-132	19.2818	32.023	.2613	2.052E+8	1.045E+6
I-133	34.5279	57.3262	.4683	3.674E+8	1.873E+6
I-134	13.0696	21.6856	.1766	1.39E+8	7.064E+5
I-135	31.4480	52.2144	.4264	3.347E+8	1.706E+6

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ATTACHMENT 1

PALISADES NUCLEAR PLANT

ANALYSIS CONTINUATION SHEET

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	N_{CA}	Q 105→120 min	$\dot{q}$ 105→120 min	Reference/Comment
Kr-83m	3.599E+6	39.2945	1.572E+8	@ 120 min
Kr-85m	1.206E+7	128.1218	5.125E+8	
Kr-85	7.587E+6	7.9026	3.161E+7	
Kr-87	9.777E+6	109.1283	4.365E+8	
Kr-88	2.624E+6	281.8151	1.127E+9	
Kr-89	1.706E-4	1.408E-8	5.631E-2	
Xe-131m	4.431E+5	4.6170	1.847E+7	
Xe-133m	4.814E+6	50.2262	2.009E+8	
Xe-133	1.413E+8	1472.8433	5.891E+9	
Xe-135m	1.871E+5	2.7908	1.116E+7	
Xe-135	2.124E+7	223.3692	8.935E+8	
Xe-137	4.953E-2	2.652E-6	1.061E+1	
Xe-138	3.206E+5	4.9246	1.970E+7	

	$N_{CA\,elem}$	$N_{CA\,part.}$	$N_{CA\,org.}$	N_{CA}	N_{sump}
-131	1.660E+6	6.345E+4	3.691E+5	2.093E+6	3.688E+7
I-132	1.292E+6	4.942E+4	2.871E+5	1.629E+6	2.871E+7
I-133	2.562E+6	9.785E+4	5.690E+5	3.228E+6	5.687E+7
I-134	7.286E+5	2.790E+4	1.617E+5	9.183E+5	1.617E+7
I-135	2.271E+6	8.670E+4	5.044E+5	2.863E+6	5.042E+7

	A_{SRW}	A_{I2}	C_{AIR}
I-131	1.236E+4	3.707E+3	9.562E-2
I-132	9.645E+3	2.893E+3	7.462E-2
I-133	1.906E+4	5.718E+3	1.475E-1
I-134	5.454E+3	1.636E+3	4.219E-2
I-135	1.691E+4	5.072E+3	1.308E-1

$V_{sump} = 40285.56$

$V_{LIQ} = 3752.802$

$V_{AIR} = 35014.4$

105 → 120 min

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SIRW}$
I-131	21.9006	36.7292	.357	2.345E+8	1.428E+6
-132	17.6993	29.6891	.2883	1.896E+8	1.153E+6
I-133	33.9075	56.8506	.5526	3.63E+8	2.21E+6
I-134	10.6209	17.7956	.1725	1.137E+8	6.9E+5
I-135	30.3375	50.8586	.4942	3.248E+8	1.977E+6

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@ 135 min

	N_{CA}	$Q_{120 \to 135\ min}$	$\dot{q}_{120 \to 135\ min}$
Kr-83m	3.279E+6	35.7937	1.432E+8
Kr-85m	1.160E+7	123.2176	4.929E+8
Kr-85	7.587E+5	7.9026	3.161E+7
Kr-87	8.530E+6	95.2171	3.809E+8
Kr-88	2.469E+7	265.1427	1.061E+9
Kr-89	6.283E-6	5.184E-10	2.074E-3
Xe-131m	4.428E+5	4.6139	1.846E+7
Xe-133m	4.799E+6	50.0782	2.003E+8
Xe-133	1.411E+8	1470.7615	5.883E+9
Xe-135m	9.489E+4	1.4151	5.660E+6
Xe-135	2.084E+7	219.1391	8.766E+8
Xe-137	3.329E-3	1.782E-7	7.129E-1
Xe-138	1.542E+5	2.3685	9.474E+6

	$N_{CA\ elem}$	$N_{CA\ part.}$	$N_{CA\ org.}$	N_{CA}	N_{sump}
I-131	1.658E+6	4.937E+4	3.688E+5	2.077E+6	3.684E+7
I-132	1.198E+6	3.568E+4	2.662E+5	1.500E+6	2.662E+7
I-133	2.541E+6	7.557E+4	5.643E+5	3.181E+6	5.639E+7
I-134	5.979E+5	1.783E+4	1.327E+5	7.484E+5	1.327E+7
I-135	2.212E+6	6.577E+4	4.913E+5	2.769E+6	4.911E+7

	A_{SRW}	A_{I_2}	C_{AIR}
I-131	1.418E+4	4.253E+3	1.097E-1
I-132	1.027E+4	3.08E+3	7.945E-2
I-133	2.171E+4	6.512E+3	1.68E-1
I-134	5.14E+3	1.542E+3	3.977E-2
I-135	1.892E+4	5.674E+3	1.464E-1

V_{sump} = 40282.75

V_{LIQ} = 3754.807

V_{AIR} = 35012.39

120→135 min

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SIRW}$
I-131	21.7100	36.6963	.4136	2.336E+8	1.654E+6
I-132	16.2802	27.5253	.31	1.752E+8	1.24E+6
[illegible]33	33.3750	56.379	.6354	3.59E+8	2.542E+6
I-134	8.6485	14.6833	.1642	9.301E+7	6.568E+5
I-135	29.3205	49.5379	.5582	3.154E+8	2.233E+6

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	N_{CA}	Q 135→150 min	$\dot{q}$ 135→150 min	Reference/Comment
Kr-83m	2.987E+6	32.6112	1.304E+8	@150 min
Kr-85m	1.117E+6	118.6199	4.745E+8	
Kr-85	7.587E+6	7.9026	3.161E+7	
Kr-87	7.439E+6	83.0387	3.322E+8	
Kr-88	2.323E+7	249.4807	9.979E+8	
Kr-89	2.314E-7	1.909E-11	7.637E-5	
Xe-131m	4.425E+5	4.6108	1.844E+7	
Xe-133m	4.783E+6	49.9038	1.996E+8	
Xe-133	1.409E+8	1468.6797	5.875E+9	
Xe-135m	4.808E+4	0.7171	2.868E+6	
Xe-135	2.045E+7	215.0122	8.600E+8	
Xe-137	2.237E-4	1.198E-8	4.792E-2	
Xe-138	7.415E+4	1.1388	4.555E+6	

	$N_{CA\ elem}$	$N_{CA\ part.}$	$N_{CA\ org.}$	N_{CA}	N_{sump}
I-131	1.656E+6	3.841E+4	3.685E+5	2.063E+6	3.681E+7
I-132	1.111E+6	2.576E+4	2.468E+5	1.383E+6	2.467E+7
I-133	2.520E+6	5.836E+4	5.596E+5	3.138E+6	5.592E+7
I-134	4.906E+5	1.139E+4	1.089E+5	6.109E+5	1.089E+7
I-135	2.155E+6	4.989E+4	4.785E+5	2.683E+6	4.783E+7

	A_{SRW}	A_{I2}	C_{AIR}
I-131	1.6E+4	4.799E+3	1.238E-1
I-132	1.075E+4	3.225E+3	8.318E-2
I-133	2.432E+4	7.293E+3	1.881E-1
I-134	4.763E+3	1.429E+3	3.685E-2
I-135	2.081E+4	6.241E+3	1.61E-1

$V_{sump} = 40279.94$

$V_{LIQ} = 3756.812$

$V_{AIR} = 35010.39$

135→150 min

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SIRW}$
I-131	21.5564	36.6633	.4701	2.329E+8	1.88E+6
I-132	15.0054	25.5192	.327	1.621E+8	1.308E+6
[illegible]33	32.9040	55.9112	.7168	3.553E+8	2.867E+6
I-134	7.0546	11.9837	.1534	7.615E+7	6.136E+5
I-135	28.3888	48.2516	.6185	3.066E+8	2.474E+6

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6059 1502

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Reference/Comment: @165 min

	N_{CA}	Q 150 → 165 min	$\dot{q}$ 150 → 165 min
Kr-83m	2.721E+6	29.7071	1.188E+8
Kr-85m	1.074E+7	114.0273	4.561E+8
Kr-85	7.587E+5	7.9026	3.161E+7
Kr-87	6.488E+6	72.4179	2.897E+8
Kr-88	2.185E+7	234.6720	9.385E+8
Kr-89	8.522E-9	7.032E-13	2.813E-6
Xe-131m	4.422E+5	4.6077	1.843E+7
Xe-133m	4.767E+6	49.7374	1.989E+8
Xe-133	1.407E+8	1466.5980	5.866E+9
Xe-135m	2.437E+4	0.3634	1.454E+6
Xe-135	2.006E+7	210.9885	8.440E+8
Xe-137	1.503E-5	8.050E-10	3.220E-3
Xe-138	3.566E+4	0.5476	2.190E+6

	N_{CA} elem	N_{CA} part.	N_{CA} org.	N_{CA}	N_{sump}
I-131	1.654E+6	2.989E+4	3.682E+5	2.053E+6	3.677E+7
I-132	1.030E+6	1.860E+4	2.288E+5	1.277E+6	2.287E+7
I-133	2.499E+6	4.507E+4	5.550E+5	3.099E+6	5.546E+7
I-134	4.026E+5	7.279E+3	8.936E+4	4.992E+5	8.932E+6
I-135	2.099E+6	3.784E+4	4.661E+5	2.603E+6	4.658E+7

	A_{SRW}	A_{I_2}	C_{AIR}
I-131	1.782E+4	5.343E+3	1.378E-1
I-132	1.111E+4	3.332E+3	8.595E-2
I-133	2.688E+4	8.06E+3	2.079E-1
I-134	4.356E+3	1.307E+3	3.37E-2
I-135	2.259E+4	6.775E+3	1.748E-1

$V_{SUMP} = 40277.13$

$V_{LIQ} = 3758.817$

$V_{AIR} = 35008.38$

150 → 165 min.

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SIRW}$
I-131	21.4315	36.6304	.5265	2.322E+8	2.186E+6
I-132	13.8499	23.6593	.3398	1.5E+8	1.359E+6
I-133	32.4794	55.4474	.7969	3.517E+8	3.188E+6
I-134	5.7615	9.834	.1411	6.238E+7	5.644E+5
I-135	27.5267	46.9986	.6753	2.981E+8	2.701E+6

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F059 1503

PALISADES NUCLEAR PLANT
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Reference/Comment

@180 min

	N_{CA}	Q 165→180 min	$\dot{q}$ 165→180 min
-83m	2.480E+6	27.0716	1.083E+8
Kr-85m	1.033E+7	109.7311	4.389E+8
Kr-85	7.586E+5	7.9015	3.161E+7
Kr-87	5.658E+6	63.1600	2.526E+8
Kr-88	2.056E+7	220.7838	8.831E+8
Kr-89	3.138E-10	2.590E-14	1.036E-7
Xe-131m	4.420E+5	4.6056	1.842E+7
Xe-133m	4.751E+6	49.5711	1.983E+8
Xe-133	1.405E+8	1464.5162	5.858E+9
Xe-135m	1.235E+4	0.1842	7.369E+5
Xe-135	1.968E+7	206.9647	8.279E+8
Xe-137	1.010E-6	5.409E-11	2.163E-4
Xe-138	1.714E+4	0.2633	1.053E+6

	$N_{CA\,elem}$	$N_{CA\,part.}$	$N_{CA\,org.}$	N_{CA}	N_{sump}
-131	1.652E+6	2.326E+4	3.679E+5	2.044E+6	3.674E+7
I-132	9.549E+5	1.343E+4	2.121E+5	1.180E+6	2.121E+7
I-133	2.478E+6	3.481E+4	5.504E+5	3.063E+6	5.499E+7
I-134	3.304E+5	4.652E+3	7.333E+4	4.084E+5	7.330E+6
I-135	2.044E+5	2.870E+4	4.540E+5	2.527E+6	4.537E+7

	A_{SRW}	A_{IZ}	C_{AIR}
I-131	1.963E+4	5.887E+3	1.518E-1
I-132	1.136E+4	3.406E+3	8.787E-2
I-133	2.939E+4	8.814E+3	2.274E-1
I-134	3.942E+3	1.182E+3	3.049E-2
I-135	2.426E+4	7.276E+3	1.877E-1

$V_{SUMP} = 40274.31$

$V_{LIQ} = 3760.823$

$V_{AIR} = 35006.38$

165→180 min.

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SIRW}$
I-131	21.3290	36.5976	.5827	2.317E+8	2.331E+6
-132	12.7931	21.9349	.349	1.389E+8	1.396E+6
-133	32.0919	54.9874	.8755	3.483E+8	3.502E+6
I-134	4.7106	8.07	.1283	5.112E+7	5.132E+5
I-135	26.7139	45.7782	.7288	2.899E+8	2.915E+6

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PALISADES NUCLEAR PLANT
ANALYSIS CONTINUATION SHEET

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	N_{CA}	$Q_{180\to195\ min}$	$\dot{q}_{180\to195\ min}$
Kr-83m	2.259E+6	24.6648	9.866E+7
Kr-85m	9.938E+6	105.5421	4.222E+8
Kr-85	7.586E+5	7.9015	3.161E+7
Kr-87	4.935E+6	55.0898	2.204E+8
Kr-88	1.934E+7	207.7490	8.310E+8
Kr-89	1.156E-11	9.536E-16	3.814E-9
Xe-131m	4.417E+5	4.6025	1.841E+7
Xe-133m	4.735E+6	49.4047	1.976E+8
Xe-133	1.403E+8	1462.4345	5.850E+9
Xe-135m	6.260E+3	0.0934	3.734E+5
Xe-135	1.931E+7	203.0441	8.122E+8
Xe-137	6.788E-8	3.634E-12	1.454E-5
Xe-138	8.247E+3	0.1267	5.066E+5

Reference/Comment

@195 min

	$N_{CA\ elem}$	$N_{CA\ part.}$	$N_{CA\ org.}$	N_{CA}	N_{sump}
I-131	1.651E+6	1.810E+4	3.676E+5	2.036E+6	3.670E+7
I-132	8.853E+5	9.697E+3	1.966E+5	1.092E+6	1.966E+7
I-133	2.457E+6	2.688E+4	5.458E+5	3.030E+6	5.453E+7
I-134	2.711E+5	2.973E+3	6.018E+4	3.343E+5	6.015E+6
I-135	1.991E+6	2.177E+4	4.422E+5	2.455E+6	4.419E+7

	A_{SRV}	A_{EZ}	C_{AIR}
I-131	2.144E+4	6.429E+3	1.658E-1
I-132	1.151E+4	3.452E+3	8.905E-2
I-133	3.186E+4	9.554E+3	2.465E-1
I-134	3.536E+4	1.061E+3	2.735E-2
I-135	2.584E+4	7.747E+3	1.998E-1

$V_{sump} = 40271.5$

$V_{LIQ} = 3762.828$

$V_{AIR} = 35004.37$

180 → 195 min.

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SRW}$
I-131	21.2440	36.5647	.6389	2.312E+8	2.556E+6
I-132	11.8263	20.3363	.3551	1.287E+8	1.42E+6
-133	31.7322	54.5312	.9527	3.451E+8	3.811E+6
I-134	3.8547	6.6224	.1155	4.191E+7	4.62E+5
I-135	25.9409	44.5895	.7789	2.821E+8	3.116E+6

ATTACHMENT 2

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PALISADES NUCLEAR PLANT
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Reference/Comment

@210 min

	Nca	Q 195→210 min	$\dot{q}$ 195→210 min
Kr-83m	2.058E+6	22.4668	8.987E+7
Kr-85m	9.464E+6	101.5677	4.063E+8
Kr-85	7.586E+5	7.9015	3.161E+7
Kr-87	4.304E+6	48.0417	1.922E+8
Kr-88	1.819E+7	195.4215	7.817E+8
Kr-89	~~4.257E-137~~ ≈ 0.0	3.513E-17	1.485E-10
Xe-131m	4.414E+5	4.5993	1.840E+7
Xe-133m	4.720E+6	49.2487	1.970E+8
Xe-133	1.401E+8	1460.3527	5.841E+9
Xe-135m	3.173E+3	0.0473	1.893E+5
Xe-135	1.895E+7	199.2268	7.969E+8
Xe-137	4.563E-9	2.443E-13	9.774E-7
Xe-138	3.965E+3	0.0609	2.436E+5

use values from page 21A since λspart. changed

	Nca elem	Nca part.	Nca org.	Nca	Nsump
-131	1650E+6	1.808E+4	3.673E+5	2.035E+6	3.667E+7
I-132	8.208E+5	8.998E+3	1.823E+5	1.012E+6	1.822E+7
I-133	2.437E+6	2.666E+4	5.413E+5	3.004E+6	5.407E+7
I-134	2.225E+5	2.440E+3	4.938E+4	2.743E+5	4.935E+6
I-135	1.939E+6	2.120E+4	4.307E+5	2.391E+6	4.304E+7

Since λs part. changes to 0.0 somewhere between 195 + 210 min., values for Nca part. are slightly off. Values from DEBUG option output are used for calculations to next time step. DEBUG option on pg 21A

$$\frac{C_{o\,part.}}{C_{part}} = \frac{3.644E+6}{6.082E+4} = 60.4793$$

so $\lambda_s^{part.} = 0.0$ between 195 + 210 min.

	A_{SKV}	A_{IZ}	C_{AIR}
I-131	2.324E+4	6.97E+3	1.798E-1
I-132	1.158E+4	3.473E+3	8.959E-2
I-133	3.429E+4	1.028E+4	2.652E-1
I-134	3.149E+3	9.443E+2	2.436E-2
I-135	2.731E+4	8.189E+3	2.112E-1

V_{sump} = 40268.69
V_{LIQ} = 3764.883
V_{AIR} = 35002.37

195→210 min.

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SIRW}$
I-131	21.1829	36.5319	.6949	2.309E+8	2.779E+6
-132	10.9394	18.8541	.3585	1.192E+8	1.434E+6
-133	31.3938	54.0788	1.0287	3.419E+8	4.115E+6
I-134	3.1559	5.4344	.1032	3.436E+7	4.128E+5
I-135	25.2117	43.4317	.826	2.746E+8	3.304E+6

```
                CELEM = 0.7084E+07  CPART = 0.7134E+05  C[illegible] = 0.1392E+09  COPART = 0.3644E+07   J = 210 MIN
                                      210 MIN   LAMBS(1)= 0.000  LAMBS(2)= 0.000
                LAMBL =  0.6944E-06  LRESF = 0.5347E-01  LRSRW =  0.1337E+00  VLIQ = 0.3765E+04  J = 210 MIN
                                     BR = 0.3470E-03  CHIQ = 0.1090E-04   J = 210 MIN
   elem. ------>I-131      NIA(N,1) = 0.1652E+07  NCA(NUC) = 0.1652E+07  J = 210 MIN
   part. ------>I-131      NIA(N,2) = 0.1664E+05  NCA(NUC) = 0.1669E+07  J = 210 MIN
   org. ------->I-131      NIA(N,3) = 0.3670E+06  NCA(NUC) = 0.2036E+07  J = 210 MIN
                I-131      NIS(NUC) = 0.3667E+08  QIESF = 0.2435E+01  QISRW = 0.4807E-01   J = 210 MIN
                I-131      ASRW(NUC) = 0.2325E+05  CAIR(NUC) = 0.1798E+00   J = 210 MIN
                I-131       Q(NUC) = 0.3897E+01     J = 210 MIN
   elem. ------>I-132      NIA(N,1) = 0.8212E+06  NCA(NUC) = 0.8212E+06  J = 210 MIN
   part. ------>I-132      NIA(N,2) = 0.8270E+04  NCA(NUC) = 0.8295E+06  J = 210 MIN
   org. ------->I-132      NIA(N,3) = 0.1824E+06  NCA(NUC) = 0.1012E+07  J = 210 MIN
                I-132      NIS(NUC) = 0.1823E+08  QIESF = 0.1213E+01  QISRW = 0.2395E-01   J = 210 MIN
                I-132      ASRW(NUC) = 0.1158E+05  CAIR(NUC) = 0.8960E-01   J = 210 MIN
                I-132       Q(NUC) = 0.1942E+01     J = 210 MIN
   elem ------->I-133      NIA(N,1) = 0.2437E+07  NCA(NUC) = 0.2437E+07  J = 210 MIN
   part. ------>I-133      NIA(N,2) = 0.2454E+05  NCA(NUC) = 0.2461E+07  J = 210 MIN
   org. ------->I-133      NIA(N,3) = 0.5412E+06  NCA(NUC) = 0.3002E+07  J = 210 MIN
                I-133      NIS(NUC) = 0.5408E+08  QIESF = 0.3591E+01  QISRW = 0.7091E-01   J = 210 MIN
                I-133      ASRW(NUC) = 0.3429E+05  CAIR(NUC) = 0.2652E+00   J = 210 MIN
                I-133       Q(NUC) = 0.5748E+01     J = 210 MIN
   elem. ------>I-134      NIA(N,1) = 0.2224E+06  NCA(NUC) = 0.2224E+06  J = 210 MIN
   part. ------>I-134      NIA(N,2) = 0.2239E+04  NCA(NUC) = 0.2246E+06  J = 210 MIN
   org. ------->I-134      NIA(N,3) = 0.4939E+05  NCA(NUC) = 0.2740E+06  J = 210 MIN
                I-134      NIS(NUC) = 0.4935E+07  QIESF = 0.3298E+00  QISRW = 0.6513E-02   J = 210 MIN
                I-134      ASRW(NUC) = 0.3149E+04  CAIR(NUC) = 0.2436E-01   J = 210 MIN
                I-134       Q(NUC) = 0.5279E+00     J = 210 MIN
   elem. ------>I-135      NIA(N,1) = 0.1939E+07  NCA(NUC) = 0.1939E+07  J = 210 MIN
   part. ------>I-135      NIA(N,2) = 0.1953E+05  NCA(NUC) = 0.1959E+07  J = 210 MIN
   org. ------->I-135      NIA(N,3) = 0.4307E+06  NCA(NUC) = 0.2390E+07  J = 210 MIN
                I-135      NIS(NUC) = 0.4304E+08  QIESF = 0.2860E+01  QISRW = 0.5648E-01   J = 210 MIN
                I-135      ASRW(NUC) = 0.2731E+05  CAIR(NUC) = 0.2112E+00   J = 210 MIN
                I-135       Q(NUC) = 0.4578E+01     J = 210 MIN
```

Sheet 21A of 56

Consumers Power
POWERING MICHIGAN'S PROGRESS

5059 1507

ATTACHMENT 1
PALISADES NUCLEAR PLANT
ANALYSIS CONTINUATION SHEET

EA - AAH-91-05
Sheet 22 of 56
Rev #

	N_{CA}	Q 210→240 min	$\dot{q}$ 210→240 min	Reference/Comment
Kr-83m	1.708E+6	39.1146	7.823E+7	@240 min
Kr-85m	8.852E+6	191.7228	3.834E+8	
Kr-85	7.586E+5	15.8030	3.161E+7	
Kr-87	3.274E+6	78.4406	1.569E+8	
Kr-88	1.610E+7	356.7205	7.134E+8	
Kr-89	0	0	0	
Xe-131m	4.410E+5	9.1917	1.838E+7	
Xe-133m	4.689E+6	98.0025	1.960E+8	
Xe-133	1.397E+8	2914.5225	5.829E+9	
Xe-135m	8.154E+7	0.0362	7.231E+4	
Xe-135	1.824E+7	387.3309	7.747E+8	
Xe-137	2.061E-11	1.752E-14	3.505E-8	
Xe-138	9.168E+2	0.0434	8.673E+4	

	$N_{CA\,elem}$	$N_{CA\,part.}$	$N_{CA\,org.}$	N_{CA}	N_{sump}
I-131	1.649E+6	1.661E+4	3.663E+5	2.032E+6	3.659E+7
I-132	7.058E+5	7.108E+3	1.568E+5	8.697E+5	1.566E+7
I-133	2.397E+6	2.413E+4	5.322E+5	2.953E+6	5.317E+7
I-134	1.498E+5	1.508E+3	3.326E+4	1.845E+5	3.323E+6
I-135	1.840E+6	1.853E+4	4.086E+5	2.267E+6	4.083E+7

	A_{SRW}	A_{IZ}	C_{AIR}
I-131	2.685E+4	8.849E+3	2.876E-1
I-132	1.152E+4	3.454E+3	8.989E-2
I-133	3.982E+4	1.17E+4	3.018E-1
I-134	2.454E+3	7.357E+2	1.898E-2
I-135	2.998E+4	8.988E+3	2.319E-1

$V_{sump} = 40263.86$

$V_{LIQ} = 3768.843$

$V_{AIR} = 34998.36$

210→240 min.

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SRW}$
I-131	42.3680	72.9655	1.5576	2.307E+8	3.115E+6
I-132	19.5614	33.686	.7178	1.065E+8	1.436E+6
-133	62.0342	106.8153	2.2797	3.377E+8	4.459E+6
I-134	4.7151	8.1192	.1725	2.567E+7	3.45E+5
I-135	48.4851	83.5093	1.7815	2.64E+8	3.563E+6

ATTACHMENT 4

Consumers Power
POWERING MICHIGAN'S PROGRESS

5059 1508

PALISADES NUCLEAR PLANT
ANALYSIS CONTINUATION SHEET

EA - PAH-91-05
Sheet 23 of 56
Rev #

	Nca	Q 240→480 min	$\dot{q}$ 240→480 min	Reference/Comment
Kr-83m	3.846E+5	147.9388	3.698E+7	@ 480 min
Kr-85m	4.766E+6	1099.8540	2.750E+8	
Kr-85	7.585E+5	126.4128	3.160E+7	
Kr-87	3.668E+5	221.3388	5.533E+7	
Kr-88	6.064E+6	1712.8214	4.282E+8	
Kr-89	0	0	0	
Xe-131m	4.366E+5	73.1176	1.828E+7	
Xe-133m	4.447E+6	761.1333	1.903E+8	
Xe-133	1.367E+8	2.304E+4	5.761E+9	
Xe-135m	1.547E-2	0.0125	3.124E+3	
Xe-135	1.344E+7	2619.7227	6.549E+8	
Xe-137	≈0	7.951E-17	1.988E-11	
Xe-138	7.493E-3	0.0130	3.260E+3	

	Nca elem	Nca part.	Nca org.	Nca	Nsump
I-131	1.625E+6	1.637E+4	3.610E+5	2.003E+6	3.604E+7
I-132	2.103E+5	2.118E+3	4.671E+4	2.591E+5	4.661E+6
I-133	2.098E+6	2.112E+4	4.657E+5	2.584E+6	4.649E+7
I-134	6.334E+3	6.376E+1	1.406E+3	7.804E+3	1.404E+5
I-135	1.208E+6	1.216E+4	2.682E+5	1.488E+6	2.677E+7

	ASRW	AIR	CAIR
I-131	5.519E+4	1.654E+4	4.266E-1
I-132	7.158E+3	2.145E+3	5.533E-2
I-133	7.122E+4	2.134E+4	5.585E-1
I-134	2.164E+2	6.485E+1	1.673E-3
I-135	4.104E+4	1.229E+4	3.172E-1

V_{SUMP} = 40218.06

V_{LIQ} = 3800.927

V_{AIR} = 34966.27

240→480 min.

	QCA	QESF	QSRW	$\dot{q}$STACK	$\dot{q}$SRW
I-131	336.1812	579.0316	20.4136	2.288E+8	5.103E+6
I-132	84.0341	144.7271	4.7534	5.719E+7	1.188E+6
I-133	460.7594	793.3732	27.7755	3.135E+8	6.944E+6
I-134	9.3125	16.0333	.4752	6.336E+6	1.188E+5
I-135	308.3581	531.0563	18.2779	2.099E+8	4.569E+6

Reference/Comment

	Nca	Q 480→720 min	$\dot{q}$ 480→720 min
r-83m	8.661E+4	33.3122	8.328E+6
Kr-85m	2.566E+6	592.1718	1.480E+8
Kr-85	7.583E+5	126.3795	3.159E+7
Kr-87	4.109E+4	24.7975	6.199E+6
Kr-88	2.284E+6	645.2529	1.613E+8
Kr-89	0	0	0
Xe-131m	4.323E+5	72.4045	1.810E+7
Xe-133m	4.218E+6	721.8511	1.805E+8
Xe-133	1.337E+8	2.253E+4	5.633E+9
Xe-135m	2.936E-7	2.371E-7	5.928E-2
Xe-135	9.905E+6	1930.3220	4.826E+8
Xe-137	0	0	0
Xe-138	6.125E-8	1.066E-7	2.665E-2

@ 720 min

	Nca elem	Nca part.	Nca org.	Nca	Nsump
-131	1.602E+6	1.613E+4	3.558E+5	1.973E+6	3.54 E+7
I-132	6.265E+4	6.310E+2	1.392 E+4	7.720E+4	1.38 E+6
I-133	1.836E+6	1.848E+4	4.075E+5	2.262E+6	4.064E+7
I-134	2.678E+2	2.696E+0	5.945E+1	3.380E+2	5.93 E+3
I-135	7.928E+5	7.981E+3	1.760E+5	9.768E+5	1.755E+7

from input deck, $\lambda_{s\,elem} = 0.007$ after 720 min.

However, $\frac{C_{o\,elem}}{C_{elem}} = 32.42$ @ 720 min.

$32.42 > DF_{max} = 25.57$ from input deck.

Therefore, $\lambda_{s\,elem} = 0.0$ after 720 min.

	A_{SRW}	A_{IZ}	C_{AIR}
I-131	8.27E+4	2.477E+4	6.389E-1
I-132	3.242E+3	9.71E+2	2.505E-2
I-133	9.476E+4	2.838E+4	7.32E-1
I-134	1.391E+1	4.167E+0	1.075E-4
I-135	4.095E+4	1.226E+4	3.164E-1

$V_{sump} = 40173.06$

$V_{LIQ} = 3833.01$

$V_{AIR} = 34934.19$

480→720 min.

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SRW}$
I-131	331.2938	570.7736	34.2484	2.255E+8	8.562E+6
-132	25.0378	43.1228	2.4837	1.704E+7	6.209E+5
-133	403.2668	694.3661	41.4943	2.744E+8	1.037E+7
I-134	0.3937	.6781	.0369	2.679E+5	9.225E+3
I-135	202.4356	348.5948	20.6257	1.378E+8	5.156E+6

	N_{CA}	Q 720→1440 min	$\dot{q}$ 720→1440 min	Reference/Comment
Kr-83m	9.892E+2	9.5726	7.977E+5	@1440 min
Kr-85m	4.006E+5	583.0427	4.859E+7	
Kr-85	7.579E+5	379.0142	3.158E+7	
Kr-87	5.778E+1	3.1240	2.603E+5	
Kr-88	1.220E+5	368.9822	3.075E+7	
Kr-89	0	0	0	
Xe-131m	4.197E+5	212.9715	1.775E+7	
Xe-133m	3.599E+6	1949.4853	1.625E+8	
Xe-133	1.251E+8	6.467E+4	5.389E+9	
Xe-135m	≃0	4.502E-12	3.752E-7	
Xe-135	3.965E+6	3243.6827	2.703E+8	
Xe-137	0	0	0	
Xe-138	≃0	8.714E-13	7.261E-8	

	N_{CA} elem	N_{CA} part.	N_{CA} org.	N_{CA}	N_{sump}
I-131	1.534E+6	1.544E+4	3.406E+5	1.890E+6	3.387E+7
I-132	1.656E+3	1.668E+1	3.680E+7	2.041E+3	3.658E+4
I-133	1.230E6	1.236E+4	2.730E+5	1.516E+6	2.715E+7
I-134	2.024E-2	2.038E-4	4.494E-3	2.494E-2	4.470E-1
I-135	2.241E+5	2.256E+3	4.975E+4	2.761E+5	4.948E+6

	A_{SRW}	A_{IZ}	C_{AIR}
I-131	1.605E+5	4.797E+4	1.237E+0
I-132	1.737E+2	5.194E+1	1.34E-3
I-133	1.287E+5	3.847E+4	9.923E-1
I-134	2.132E-3	6.373E-4	1.644E-8
I-135	2.346E+4	7.014E+3	1.809E-1

V_{sump} = 40038.06

V_{LIQ} = 3929.259

V_{AIR} = 34837.94

720 → 1440 min.

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SRW}$
I-131	965.6971	1663.9427	181.5833	2.191E+8	1.513E+7
I-132	10.3437	17.818	1.6173	2.347E+6	1.348E+5
I-133	931.9334	1605.094	171.6431	2.114E+8	1.43E+7
I-134	0.0174	.0299	.0024	3.942E+3	2. E+2
I-135	277.2734	477.6242	48.6274	6.291E+7	4.052 E+6

Reference/Comment

@ ~~1440~~ 1800 min

	N_{CA}	$Q_{1440 \to 1800}$ min	$\dot{q}_{1440 \to 1800}$ min
Kr-83m	1.057E+2	0.0494	8.230E+3
Kr-85m	1.582E+5	32.6093	5.435E+6
Kr-85	7.578E+5	94.7234	1.579E+7
Kr-87	2.167E+0	2.117E-3	3.529E+2
Kr-88	2.820E+4	8.0848	1.339E+6
Kr-89	0	0	0
Xe-131m	4.136E+5	52.0764	8.679E+6
Xe-133m	3.825E+6	432.4821	7.208E+7
Xe-133	1.210E+8	1.538E+4	2.563E+9
Xe-135m	0	0	0
Xe-135	2.509E+6	397.6714	6.628E+7
Xe-137	0	0	0
Xe-138	0	0	0

after 1440 min $\lambda_L = \frac{1}{2}(.1\%/day) = 3.472E-7$

also $LR_{sew} = 0.0$ from input deck

	$N_{CA\,elem}$	$N_{CA\,part}$	$N_{CA\,org}$	N_{CA}	N_{sump}	A_{SRW}
I-131	1.501E+6	1.511E+4	3.333E+5	1.850E+6	3.313E+7	1.571E+5
I-132	2.693E+2	2.713E+0	5.985E+1	3.319E+2	5.947E+3	2.825E+1
I-133	1.007E+6	1.019E+4	2.235E+5	1.241E+6	2.223E+7	1.854E+5
I-134	1.760E-4	1.772E-6	3.908E-5	2.169E-4	3.886E-3	1.854E-5
I-135	1.192E+5	1.200E+3	2.646E+4	1.468E+5	2.638E+6	1.248E+4

1440 → 1800 min.

	Q_{CA}	Q_{ESF}	Q_{SRW}	$\dot{q}_{STACK}$	$\dot{q}_{SIRW}$
I-131	233.6981	805.3001	0	1.732E+8	0
I-132	0.1176	.4054	0	8.717E+4	0
I-133	171.6657	591.5917	0	1.272E+8	0
I-134	6.512E-7	0.0	0	~0	0
I-135	25.5864	88.1934	0	1.896E+7	0

Reference/Comment

@ 5760 min

	NCA	Q1800→5760min	$\dot{q}$1800→5760min
Kr-83m	2.197E-9	5.908E-3	8.952E+1
Kr-85m	5.797E+0	21.2942	3.226E+5
Kr-85	7.563E+5	1040.8015	1.577E+8
Kr-87	≈0	8.249E-5	1.250E+0
Kr-88	2.842E-3	2.4075	3.648E+4
Kr-89	0	0	0
Xe-131m	3.520E+5	525.1756	7.957E+6
Xe-133m	1.391E+6	3050.9001	4.623E+7
Xe-133	8.40E+7	1.394E+5	2.112E+9
Xe-135m	0	0	0
Xe-135	1.633E+4	680.7381	1.031E+7
Xe-137	0	0	0
Xe-138	0	0	0

	NCA elem	NCA part	NCA org	NCA	Nsump	Asew
I-131	1.183E+6	1.190E+4	2.626E+5	1.457E+6	2.688E+7	1.239E+5
I-132	5.665E-7	5.707E-9	1.259E-7	6.981E-7	1.246E-5	5.951E-8
I-133	1.115E+5	1.123E+3	2.476E+4	1.374E+5	2.451E+6	1.168E+4
I-134	≈0	≈0	≈0	≈0	≈0	0
I-135	1.146E+2	1.154E+0	2.544E+1	1.412E+2	2.518E+3	1.201E+1

1800 →5760 min.

	QCA	QESF	$\dot{q}$ STACK
I-131	2262.3714	7802.023	1.525E+8
I-132	0.0228	.0787	1.538E+3
I-133	689.2665	2376.341	4.645E+7
I-134	5.712E-9	0	~0
I-135	29.0369	100.0835	1.956E+6

Reference/Comment

@ 43200 min

	N_{CA}	$Q_{5760 \rightarrow 43200\ min}$	$\dot{q}_{5760 \rightarrow 43200\ min}$
Kr-83m	≈0	1.228E-13	1.968E-10
Kr-85m	≈0	7.806E-4 ~~1.251~~	1.251E+0
Kr-85	7.431E+5	9745.2401	1.562E+7
Kr-87	0	0	0
Kr-88	≈0	2.425E-7	3.887E-4
Kr-89	0	0	0
Xe-131m	7.662E+4	2347.6535	3.762E+6
Xe-133m	3.660E+2	2191.6288	3.512E+6
Xe-133	2.680E+6	3.870E+5	4.920E+8
Xe-135m	0	0	0
Xe-135	≈0	4.4597	7.147E+3
Xe-137	0	0	0
Xe-138	0	0	0

	$N_{CA\ elem}$	$N_{CA\ part}$	$N_{CA\ org}$	N_{CA}	N_{sump}	A_{SLW}
I-131	1.242E+5	1.249E+3	2.756E+4	1.530E+5	2.622E+6	1.318E+4
I-132	≈0	≈0	≈0	≈0	≈0	0
I-133	1.025E-4 ~~1.263E-4~~	1.033E-6	2.276E-5	1.263E-4	2.161 E-3	1.087E-5
I-134	0	0	0	0	0	0
I-135	≈0	≈0	≈0	≈0	≈0	0

5760 → 43200 min.

	Q_{CA}	Q_{EST}	$\dot{q}_{STACK}$
I-131	7522.8319	26065.73	5.383E+7
I-132	4.804E-11	0	~0
I-133	85.8230	296.25	6.123E+5
I-134	0	0	0
I-135	0.0279	.0964	1.992E+2

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Consumers Power
POWERING MICHIGAN'S PROGRESS

PALISADES NUCLEAR PLANT
ANALYSIS CONTINUATION SHEET

EA - PAH-91-05

Sheet 29 **Rev #**

Reference/Comment

Total Iodine Released From Each Path (Ci)

	0→120 min	120→480 min	480→1440 min
CTMT. ATM.			
I-131	290.298	507.003	1296.9909
I-132	344.3414	184.2898	35.3855
I-133	466.5179	716.7699	1335.2002
I-134	408.0779	47.2134	0.411
I-135	456.1845	519.9457	479.709
ESF LEAKAGE			
I-131	247.9039	871.6813	2234.7163
I-132	250.9719	316.2422	60.9408
I-133	392.1113	1231.5235	2299.4601
I-134	226.7629	80.7003	0.708
I-135	369.7515	893.1531	826.219
SIRW LEAKAGE			
I-131	1.3064	25.2979	215.8317
I-132	1.213	7.5106	4.101
I-133	2.0491	35.0612	213.1374
I-134	0.9487	1.4534	0.0393
I-135	1.8932	24.2451	69.2531

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Consumers Power
POWERING MICHIGAN'S PROGRESS

PALISADES NUCLEAR PLANT
ANALYSIS CONTINUATION SHEET

EA - PAH-91-05

Sheet 30 Rev #

Reference/Comment

Total Iodine Released From Each Path (ci)

	1440→5760min	5760→43200min	Total (Ci)
CTMT. ATM.			
I-131	2946.0695	7522.8319	12113.193
I-132	0.1404	~0	564.1571
I-133	860.9322	85.823	3465.2432
I-134	~0	0	455.7023
I-135	54.6233	0.0279	1510.4904
ESF LEAKAGE			
I-131	8607.3231	26865.73	38027.355
I-132	0.4841	0	628.639
I-133	2967.9327	296.25	7187.2776
I-134	~0	0	308.1712
I-135	188.2769	0.0964	2277.4969
SIRW LEAKAGE			
I-131	0	0	242.436
I-132	0	0	12.8246
I-133	0	0	250.2477
I-134	0	0	2.4334
I-135	0	0	95.3914

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Reference/Comment

Total Noble Gas Released From CTMT. ATM.

	0→120 min	120→480 min	480→1440 min
Kr-83m	445.5413	359.3686	42.8848
Kr-85m	1178.2779	1964.2775	1175.2145
Kr-85	63.2208	189.6281	505.3937
Kr-87	1480.0457	716.7446	27.9215
Kr-88	2819.0749	3442.8426	1014.2351
Kr-89	159.099	~0	0
Xe-131m	37.0142	109.9491	285.376
Xe-133m	406.5503	1157.0176	2671.8364
Xe-133	11791.404	34747.865	87200.0
Xe-135m	655.672	2.8692	~0
Xe-135	1912.5176	4261.429	5174.0047
Xe-137	459.0826	~0	0
Xe-138	1591.6855	4.5622	~0

	1440→5760 min	5760→43200 min	Total (Ci)
Kr-83m	0.0553	~0	847.85
Kr-85m	53.9835	0.0008	4371.6742
Kr-85	1135.5249	9745.2401	11639.008
Kr-87	0.0022	0	2224.714
Kr-88	10.4123	~0	7286.5649
Kr-89	0	0	159.099
Xe-131m	577.252	2347.6535	3357.2448
Xe-133m	3483.3422	2191.6288	9910.4693
Xe-133	154780.0	307000.0	5955193
Xe-135m	0	0	658.5412
Xe-135	1078.4095	4.4597	12430.821
Xe-137	0	0	459.0826
Xe-138	0	0	1596.2477

Reference/Comment

Doses From Each Release Path For SB + LPZ

For Submersion Dose (Noble Gas Only):

$D = DCF_{SUB} \cdot X/Q \cdot Q$ Eqn.(27)

For Inhalation Dose (Iodine Only):

$D = DCF_{INH} \cdot BR \cdot X/Q \cdot Q$ Eqn. (26)

DCF_{SUB}, DCF_{INH}, BR, + X/Q values are from the input deck

0→2 Hour Site Boundary Thyroid Dose (Rem)

Submersion:	CTMT	ESF	SIRW	Total
Kr-83m	0	0	0	0
Kr-85m	0.000225	0	0	0.000225
Kr-85	0	0	0	0
Kr-87	0.00127	0	0	0.00127
Kr-88	0.00629	0	0	0.00629
Kr-89	0	0	0	0
Xe-131m	0	0	0	0
Xe-133m	0	0	0	0
Xe-133	0.000789	0	0	0.000789
Xe-135m	0	0	0	0
Xe-135	0	0	0	0
Xe-137	0	0	0	0
Xe-138	0.001927	0	0	0.001927
	Σ = 0.011			Σ = 0.011
Inhalation:				
I-131	16.7535	14.3069	0.0754	31.1358
I-132	0.1165	0.0849	0.0004	0.2018
I-133	4.5491	3.8235	0.0199	8.3925
I-134	0.0235	0.0131	0.0001	0.0367
I-135	0.7716	0.6254	0.0032	1.4002
	Σ = 22.2142	18.8538	0.099	41.167

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Reference/Comment

0 → 2 Hour Site Boundary Whole Body (Submersion) + CEDE (Inhalation)

Submersion	CTMT	ESF	SIRW	Total
Kr-83m	~0			0
Kr-85m	0.00023			0.00023
Kr-85	~0			0
Kr-87	0.0013			0.0013
Kr-88	0.00613			0.00613
Kr-89	0			0
Xe-131m	~0			0
Xe-133m	0.00002			0.00002
Xe-133	0.00061			0.00061
Xe-135m	0.00037			0.00037
Xe-135	0.00235			0.00235
Xe-137	0			0
Xe-138	0.00193			0.00193
	Σ = 0.0129			0.0129

Inhalation				
I-131	0.50838	0.43414	0.00229	0.94481
I-132	0.00624	0.00455	0.00002	0.01081
I-133	0.13926	0.11705	0.00061	0.25692
I-134	0.00243	0.00135	~0	0.00379
I-135	0.0275	0.02229	0.00011	0.04990
Σ =	0.6838	0.5794	0.003	1.2662

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Reference/Comment

30 Day LPZ Thyroid Dose (Rem)

CTMT. ATM			
Submersion	0→480 min	480→1440 min	1440→5760 min
Kr-83m	0	0	0
Kr-85m	0.00004	0.00001	~0
Kr-85	0	0	0
Kr-87	0.00013	~0	~0
Kr-88	0.00098	0.0001	~0
Kr-89	0	0	0
Xe-131m	0	0	0
Xe-133m	0	0	0
Xe-133	0.00032	0.00026	0.00017
Xe-135m	0	0	0
Xe-135	0	0	0
Xe-137	0	0	0
Xe-138	0.00014	0	0
$\Sigma =$	0.00151	0.00037	0.00017
Inhalation			
I-131	3.23577	1.69018	1.89213
I-132	0.01258	0.00027	~0
I-133	0.81142	0.29399	0.09343
I-134	0.00185	~0	0
I-135	0.11611	0.0183	0.00103
$\Sigma =$	4.1777	2.0027	1.9866
ESF LEAKAGE			
I-131	4.54373	2.91219	5.5281
I-132	0.01349	0.00047	~0
I-133	1.11338	0.50632	0.32208
I-134	0.00125	~0	0
I-135	0.15023	0.03156	0.00354
$\Sigma =$	5.8221	3.4505	5.85372
SIRW LEAKAGE			
I-131	0.10797	0.28126	0
I-132	0.00021	0.00003	0
I-133	0.02545	0.04693	0
I-134	0.00001	~0	0
I-135	0.00311	0.00265	0
$\Sigma =$	0.13675	0.3309	0

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Reference/Comment

30 Day LPZ Thyroid Dose (Rem)

CTMT. ATM.

Submersion	5760→43200min	Total (Rem)
Kr-83m	0	0
Kr-85m	~0	0.00005
Kr-85	0	0
Kr-87	0	0.00013
Kr-88	0	0.00108
Kr-89	0	0
Xe-131m	0	0
Xe-133m	0	0
Xe-133	0.00008	0.00073
Xe-135m	0	0
Xe-135	0	0
Xe-137	0	0
Xe-138	0	0.00014
Σ =	0.00008	0.0021
Inhalation		
I-131	1.17044	7.98852
I-132	0	0.01285
I-133	0.00226	1.2011
I-134	0	0.00185
I-135	~0	0.13544
Σ =	1.1727	9.3398
ESF LEAKAGE		
I-131	4.05544	17.03946
I-132	0	0.01396
I-133	0.00779	1.94957
I-134	0	0.00125
I-135	~0	0.18533
Σ =	4.06323	19.1896
SIRW LEAKAGE		
I-131	0	0.38923
I-132	0	0.00024
I-133	0	0.07238
-134	0	0.00001
I-135	0	0.000576
Σ =	0	0.4676

30 Day LPZ Whole Body Dose (submersion) + CEDE (inhalation)

Reference/Comment

CTMT. ATM.

Submersion	0→480 min	480→1440 min	1440→5760 min
Kr-83m	~0	~0	~0
Kr-85m	0.00004	0.00001	~0
Kr-85	~0	~0	~0
Kr-87	0.00014	~0	~0
Kr-88	0.00096	0.0001	~0
Kr-89	0	0	0
Xe-131m	~0	~0	~0
Xe-133m	0.00001	0.00001	~0
Xe-133	0.00017	0.0002	~0
Xe-135m	0.00003	0	0
Xe-135	0.00053	0.00028	0.00002
Xe-137	0	0	0
Xe-138	0.00014	0	0
Σ =	0.00202	0.0006	0.00002
Inhalation			
I-131	0.09819	0.05129	0.05742
I-132	0.00067	0.00001	~0
I-133	0.02484	0.009	0.00286
I-134	0.00019	~0	0
I-135	0.00414	0.00653	0.00004
Σ =	0.12803	0.06683	0.06032
ESF LEAKAGE			
I-131	0.13788	0.08837	0.16775
I-132	0.00072	0.00002	~0
I-133	0.03408	0.0155	0.00986
I-134	0.00013	~0	0
I-135	0.00536	0.00112	0.00013
Σ =	0.17817	0.10501	0.17774
SIRW LEAKAGE			
I-131	0.00328	0.00853	0
I-132	0.00001	~0	0
I-133	0.00078	0.00144	0
I-134	~0	~0	0
I-135	0.00011	0.00009	0
Σ =	0.00418	0.01006	0

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30 Day LPZ Whole Body Dose (Submersion) + CEDE (Inhalation)

CTMT. ATM.

Submersion	5760→43200 min	Total (Rem)	Reference/Comment
Kr-83m	0	0	
Kr-85m	~0	0.00005	
Kr-85	~0	0	
Kr-87	0	0.00014	
Kr-88	0	0.00106	
Kr-89	0	0	
Xe-131m	~0	0	
Xe-133m	~0	0.00002	
Xe-133	0.00007	0.00044	
Xe-135m	0	0.00003	
Xe-135	~0	0.00083	
Xe-137	0	0	
Xe-138	0	0.00014	
Σ =	0.00007	0.0027	
Inhalation			
I-131	0.03552	0.24242	
I-132	0	0.00068	
I-133	0.00007	0.03677	
I-134	0	0.00019	
I-135	~0	0.01071	
Σ =	0.03559	0.2908	
ESF LEAKAGE			
I-131	0.12306	0.51706	
I-132	0	0.00074	
I-133	0.00024	0.05968	
I-134	0	0.00013	
I-135	~0	0.00661	
Σ =	0.1233	0.5842	
SIRW LEAKAGE			
I-131	0	0.01181	
I-132	0	0.00001	
I-133	0	0.00222	
I-134	0	0	
I-135	0	0.0002	
Σ =	0	0.014	

ATTACHMENT 1

	Reference/Comment

HAND CALCS. FOR C1MPLOT DATA DECK FOR RETRAN PLOTS

To calculate dose equivalent I-131 activity:

$$N_{DEI131} = \frac{DCF_{I132}}{DCF_{I131}} N_{I132} + \frac{DCF_{I133}}{DCF_{I131}} N_{I133} + \frac{DCF_{I134}}{DCF_{I131}} N_{I134} + \frac{DCF_{I135}}{DCF_{I131}} N_{I135}$$ Eqn. (28)

where DCF_I is the Thyroid inhalation dose conversion factor.

From the Input Deck:

$$\frac{DCF_{I132}}{DCF_{I131}} = \frac{6.290E+3}{1.073E+6} = 5.8621E-3$$

$$\frac{DCF_{I133}}{DCF_{I131}} = \frac{1.813E+5}{1.073E+6} = 1.6897E-1$$

$$\frac{DCF_{I134}}{DCF_{I131}} = \frac{1.073E+3}{1.073E+6} = 1.0E-3$$

$$\frac{DCF_{I135}}{DCF_{I131}} = \frac{3.145E+4}{1.073E+6} = 2.9310E-2$$

Initial activity of elemental, particulate, and organic forms of iodine are equal to total initial activity multiplied by the fractions for each chemical form.

Fractions are from the Input Deck. Activity values from page 1, this Attachment.

$T = 0$ min

<u>Elemental</u>

$N^E_{I131} = .955(1.858E+7) = 1.7744E+7$

$N^E_{I132} = .955(2.631E+7) = 2.5126E+7$

$N^E_{I133} = .955(3.041E+7) = 2.9042E+7$

$N^E_{I134} = .955(3.933E+7) = 3.7560E+7$

$N^E_{I135} = .955(3.113E+7) = 2.9729E+7$

$$N^E_{DEI31} = (1.7744E+7) + (5.8621E-3)(2.5126E+7) + (1.6897E-1)(2.9042E+7)$$
$$+ (1.0E-3)(3.7560E+7) + (2.931E-2)(2.9729E+7)$$
$$= 2.3700E+7$$

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Reference/Comment

T=0 min

particulate

$N^P_{I131} = .025(1.858E+7) = 4.645E+5$

$N^P_{I132} = .025(2.631E+7) = 6.5775E+5$

$N^P_{I133} = .025(3.041E+7) = 7.6025E+5$

$N^P_{I134} = .025(3.933E+7) = 9.8325E+5$

$N^P_{I135} = .025(3.113E+7) = 7.7825E+5$

$N^P_{DE131} = 6.206E+5$

organic

$N^O_{131} = 0.02(1.858E+7) = 3.716E+5$

$N^O_{132} = 0.02(2.631E+7) = 5.262E+5$

$N^O_{133} = 0.02(3.041E+7) = 6.082E+5$

$N^O_{134} = 0.02(3.933E+7) = 7.866E+5$

$N^O_{135} = 0.02(3.113E+7) = 6.226E+5$

$N^O_{DE131} = 4.965E+5$

Total Dose Equivalent = $N_{DE131} = 2.370E+7 + 6.206E+5 + 4.965E+5 = 2.482E+7$

T=1 min Activity values from page 3 of this Attachment.

elemental

$N^E_{131} = .955(1.858E+7) = 1.7744E+7$

$N^E_{132} = .955(2.618E+7) = 2.5002E+7$

$N^E_{133} = .955(3.039E+7) = 2.9022E+7$

$N^E_{134} = .955(3.882E+7) = 3.7073E+7$

$N^E_{135} = .955(3.108E+7) = 2.9681E+7$

$N^E_{DE131} = 2.370E+7$

Reference/Comment

T=1 min

particulate

$N^{p}_{131} = .025(1.858E+7) = 4.645E+5$

$N^{p}_{132} = .025(2.618E+7) = 6.545E+5$

$N^{p}_{133} = .025(3.039E+7) = 7.5975E+5$

$N^{p}_{134} = .025(3.882E+7) = 9.705E+5$

$N^{p}_{135} = .025(3.108E+7) = 7.770E+5$

$N^{p}_{DE131} = 6.205E+5$

organic

$N^{o}_{131} = .02(1.858E+7) = 3.716E+5$

$N^{o}_{132} = .02(2.618E+7) = 5.236E+5$

$N^{o}_{133} = .02(3.039E+7) = 6.078E+5$

$N^{o}_{134} = .02(3.882E+7) = 7.764E+5$

$N^{o}_{135} = .02(3.108E+7) = 6.216E+5$

$N^{o}_{DE131} = 4.964E+5$

$N_{DE131} = 2.37E+7 + 6.205E+5 + 4.964E+5 = 2.482E+7$

After 1min. Activity of each chemical specie for each isotope can be taken directly from values calculated previously.
Nca elem, Nca part., Nca org

Now the equation for Dose Equivalent is the only calculation to be performed for each chemical specie.

Reference/Comment

T=2 min values from page 3 of this Attachment

elemental	particulate	organic
$N^E_{131} = 1.762E+7$	$N^P_{131} = 4.566E+5$	$N^O_{131} = 3.716E+5$
$N^E_{132} = 2.470E+7$	$N^P_{132} = 6.402E+5$	$N^O_{132} = 5.210E+5$
$N^E_{133} = 2.880E+7$	$N^P_{133} = 7.465E+5$	$N^O_{133} = 6.075E+5$
$N^E_{134} = 3.633E+7$	$N^P_{134} = 9.417E+5$	$N^O_{134} = 7.662E+5$
$N^E_{135} = 2.942E+7$	$N^P_{135} = 7.626E+5$	$N^O_{135} = 6.285E+5$
$N^E_{DE131} = 2.353E+7$	$N^P_{DE131} = 6.098E+5$	$N^O_{DE131} = 4.963E+5$

$N_{DE131} = 2.353E+7 + 6.098E+5 + 4.963E+5 = 2.464E+7$

T=3 min

from page 3

elemental	particulate	organic
$N^E_{131} = 1.750E+7$	$N^P_{131} = 4.489E+5$	$N^O_{131} = 3.716E+5$
$N^E_{132} = 2.440E+7$	$N^P_{132} = 6.262E+5$	$N^O_{132} = 5.184E+5$
$N^E_{133} = 2.858E+7$	$N^P_{133} = 7.335E+5$	$N^O_{133} = 6.072E+5$
$N^E_{134} = 3.560E+7$	$N^P_{134} = 9.137E+5$	$N^O_{134} = 7.561E+5$
$N^E_{135} = 2.916E+7$	$N^P_{135} = 7.484E+5$	$N^O_{138} = 6.194E+5$
$N^E_{DE131} = 2.336E+7$	$N^P_{DE131} = 5.994E+5$	$N^O_{DE131} = 4.962E+5$

$N_{DE131} = 2.336E+7 + 5.994E+5 + 4.962E+5 = 2.446E+7$

Reference/Comment

T = 5 min from page 7 of this Attachment.

elemental	particulate	organic
$N^E_{131} = 1.725E+7$	$N^P_{131} = 4.338E+5$	$N^O_{131} = 3.716E+5$
$N^E_{132} = 2.382E+7$	$N^P_{132} = 5.996E+5$	$N^O_{132} = 5.132E+5$
$N^E_{133} = 2.815E+7$	$N^P_{133} = 7.082E+5$	$N^O_{133} = 6.065E+5$
$N^E_{134} = 3.419E+7$	$N^P_{134} = 8.602E+5$	$N^O_{134} = 7.364E+5$
$N^E_{135} = 2.865E+7$	$N^P_{135} = 7.209E+5$	$N^O_{135} = 6.172E+5$
$N^E_{DE131} = 2.302E+7$	$N^P_{DE131} = 5.79E+5$	$N^O_{DE131} = 4.959E+5$

$$N_{DE131} = 2.302E+7 + 5.79E+5 + 4.959E+5 = 2.41E+7$$

T = 19 min

elemental	particulate	organic
$N^E_{131} = 1.671E+6$	$N^P_{131} = 3.438E+5$	$N^O_{131} = 3.712E+5$
$N^E_{132} = 2.153E+6$	$N^P_{132} = 4.428E+5$	$N^O_{132} = 4.781E+5$
$N^E_{133} = 2.710E+6$	$N^P_{133} = 5.573E+5$	$N^O_{133} = 6.018E+5$
$N^E_{134} = 2.757E+6$	$N^P_{134} = 5.670E+5$	$N^O_{134} = 6.123E+5$
$N^E_{135} = 2.712E+6$	$N^P_{135} = 5.577E+5$	$N^O_{135} = 6.022E+5$
$N^E_{DE131} = 2.224E+6$	$N^P_{DE131} = 4.575E+5$	$N^O_{DE131} = 4.94E+5$

$$N_{DE131} = 2.224E+6 + 4.575E+5 + 4.94E+5 = 3.176E+6$$

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T = 30 min

elemental

$N^{E}_{131} = 1.670E+6$

$N^{E}_{132} = 2.037E+6$

$N^{E}_{133} = 2.693E+6$

$N^{E}_{134} = 2.385E+6$

$N^{E}_{135} = 2.660E+6$

$N^{E}_{DE131} = .2.217E+6$

particulate

$N^{P}_{131} = 2.860E+5$

$N^{P}_{132} = 3.487E+5$

$N^{P}_{133} = 4.611E+5$

$N^{P}_{134} = 4.083E+5$

$N^{P}_{135} = 4.554E+5$

$N^{P}_{DE131} = 3.797E+5$

organic

$N^{O}_{131} = 3.718E+5$

$N^{O}_{132} = 4.523E+5$

$N^{O}_{133} = 5.981E+5$

$N^{O}_{134} = 5.297E+5$

$N^{O}_{135} = 5.907E+5$

$N^{O}_{DE131} = .4.926E+5$

$N_{DE131} = 2.217E+6 + 3.797E+5 + 4.926E+5 = 3.089E+6$

T = 45 min

elemental

$N^{E}_{131} = 1.669E+6$

$N^{E}_{132} = 1.889E+6$

$N^{E}_{133} = 2.671E+6$

$N^{E}_{134} = 1.957E+6$

$N^{E}_{135} = 2.591E+6$

$N^{E}_{DE131} = 2.209E+6$

particulate

$N^{P}_{131} = 2.225E+6$

$N^{P}_{132} = 2.518E+5$

$N^{P}_{133} = 3.561E+5$

$N^{P}_{134} = 2.609E+5$

$N^{P}_{135} = 3.455E+5$

$N^{P}_{DE131} = 2.945E+5$

organic

$N^{O}_{131} = 3.707E+5$

$N^{O}_{132} = 4.193E+5$

$N^{O}_{133} = 5.931E+5$

$N^{O}_{134} = 4.347E+5$

$N^{O}_{135} = 5.754E+5$

$N^{O}_{DE131} = 4.907E+5$

$N_{DE131} = 2.209E+6 + 2.945E+5 + 4.907E+5 = 2.994E+6$

Reference/Comment

$T = 60$ min

elemental	particulate	organic
$N^{E}_{131} = 1.668E+6$	$N^{P}_{131} = 1.731E+5$	$N^{O}_{131} = 3.703E+5$
$N^{E}_{132} = 1.750E+6$	$N^{P}_{132} = 1.818E+5$	$N^{O}_{132} = 3.887E+5$
$N^{E}_{133} = 2.649E+6$	$N^{P}_{133} = 2.750E+5$	$N^{O}_{133} = 5.883E+5$
$N^{E}_{134} = 1.606E+6$	$N^{P}_{134} = 1.668E+5$	$N^{O}_{134} = 3.567E+5$
$N^{E}_{135} = 2.524E+6$	$N^{P}_{135} = 2.620E+5$	$N^{O}_{135} = 5.605E+5$
$N^{E}_{DE131} = 2.202E+6$	$N^{P}_{DE131} = 2.285E+5$	$N^{O}_{DE131} = 4.888E+5$

$$N_{DE131} = 2.202E+6 + 2.285E+5 + 4.888E+5 = 2.919E+6$$

$T = 75$ min

elemental	particulate	organic
$N^{E}_{131} = 1.666E+6$	$N^{P}_{131} = 1.347E+5$	$N^{O}_{131} = 3.700E+5$
$N^{E}_{132} = 1.622E+6$	$N^{P}_{132} = 1.313E+5$	$N^{O}_{132} = 3.604E+5$
$N^{E}_{133} = 2.627E+6$	$N^{P}_{133} = 2.124E+5$	$N^{O}_{133} = 5.834E+5$
$N^{E}_{134} = 1.318E+6$	$N^{P}_{134} = 1.066E+5$	$N^{O}_{134} = 2.927E+5$
$N^{E}_{135} = 2.458E+6$	$N^{P}_{135} = 1.987E+5$	$N^{O}_{135} = 5.459E+5$
$N^{E}_{DE131} = 2.193E+6$	$N^{P}_{DE131} = 1.773E+5$	$N^{O}_{DE131} = 4.87E+5$

$$N_{DE131} = 2.193E+6 + 1.773E+5 + 4.87E+5 = 2.857E+6$$

Reference/Comment

$T = 90$ min

elemental	particulate	organic
$N^E_{131} = 1.664E+6$	$N^P_{131} = 1.048E+5$	$N^O_{131} = 3.697E+5$
$N^E_{132} = 1.504E+6$	$N^P_{132} = 9.480E+4$	$N^O_{132} = 3.341E+5$
$N^E_{133} = 2.605E+6$	$N^P_{133} = 1.640E+5$	$N^O_{133} = 5.786E+5$
$N^E_{134} = 1.082E+6$	$N^P_{134} = 6.813E+4$	$N^O_{134} = 2.482E+5$
$N^E_{135} = 2.394E+6$	$N^P_{135} = 1.507E+5$	$N^O_{135} = 5.317E+5$
$N^E_{DE131} = 2.184E+6$	$N^P_{DE131} = 1.376E+5$	$N^O_{DE131} = 4.853E+5$

$$N_{DE131} = 2.184E+6 + 1.376E+5 + 4.853E+5 = 2.807E+6$$

$T = 105$ min

elemental	particulate	organic
$N^E_{131} = 1.662E+6$	$N^P_{131} = 8.154E+4$	$N^O_{131} = 3.694E+5$
$N^E_{132} = 1.394E+6$	$N^P_{132} = 6.845E+4$	$N^O_{132} = 3.097E+5$
$N^E_{133} = 2.583E+6$	$N^P_{133} = 1.267E+5$	$N^O_{133} = 5.738E+5$
$N^E_{134} = 8.879E+5$	$N^P_{134} = 4.366E+4$	$N^O_{134} = 1.971E+5$
$N^E_{135} = 2.332E+6$	$N^P_{135} = 1.143E+5$	$N^O_{135} = 5.179E+5$
$N^E_{DE131} = 2.176E+6$	$N^P_{DE131} = 1.067E+5$	$N^O_{DE131} = 4.835E+5$

$$N_{DE131} = 2.176E+6 + 1.067E+5 + 4.835E+5 = 2.766E+6$$

F059 1531

ATTACHMENT 1

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Reference/Comment

T = 120 min

elemental	particulate	organic
$N^{E}_{131} = 1.660E+6$	$N^{P}_{131} = 6.345E+4$	$N^{O}_{131} = 3.691E+5$
$N^{E}_{132} = 1.292E+6$	$N^{P}_{132} = 4.942E+4$	$N^{O}_{132} = 2.871E+5$
$N^{E}_{133} = 2.562E+6$	$N^{P}_{133} = 9.785E+4$	$N^{O}_{133} = 5.690E+5$
$N^{E}_{134} = 7.286E+5$	$N^{P}_{134} = 2.790E+4$	$N^{O}_{134} = 1.617E+5$
$N^{E}_{135} = 2.271E+6$	$N^{P}_{135} = 8.670E+4$	$N^{O}_{135} = 5.044E+5$
$N^{E}_{DE131} = 2.168E+6$	$N^{P}_{DE131} = 8.284E+4$	$N^{O}_{DE131} = 4.819E+5$

$$N_{DE131} = 2.168E+6 + 8.284E+4 + 4.819E+5 = 2.733E+6$$

T = 135 min

elemental	particulate	organic
$N^{E}_{131} = 1.658E+6$	$N^{P}_{131} = 4.937E+4$	$N^{O}_{131} = 3.688E+5$
$N^{E}_{132} = 1.198E+6$	$N^{P}_{132} = 3.568E+4$	$N^{O}_{132} = 2.662E+5$
$N^{E}_{133} = 2.541E+6$	$N^{P}_{133} = 7.557E+4$	$N^{O}_{133} = 5.643E+6$
$N^{E}_{134} = 5.979E+5$	$N^{P}_{134} = 1.783E+4$	$N^{O}_{134} = 1.327E+5$
$N^{E}_{135} = 2.212E+6$	$N^{P}_{135} = 6.577E+4$	$N^{O}_{135} = 4.913E+5$
$N^{E}_{DE131} = 2.16E+6$	$N^{P}_{DE131} = 6.429E+4$	$N^{O}_{DE131} = 4.802E+5$

$$N_{DE131} = 2.16E+6 + 6.429E+4 + 4.802E+5 = 2.785E+6$$

F059 1532

Consumers Power
POWERING MICHIGAN'S PROGRESS

ATTACHMENT 1

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Rev #

Reference/Comment

T = 150 min

elemental	particulate	organic
$N^{E}_{131} = 1.656E+6$	$N^{P}_{131} = 3.841E+4$	$N^{O}_{131} = 3.685E+5$
$N^{E}_{132} = 1.111E+6$	$N^{P}_{132} = 2.576E+4$	$N^{O}_{132} = 2.468E+5$
$N^{E}_{133} = 2.520E+6$	$N^{P}_{133} = 5.836E+4$	$N^{O}_{133} = 5.596E+5$
$N^{E}_{134} = 4.906E+5$	$N^{P}_{134} = 1.139E+4$	$N^{O}_{134} = 1.089E+5$
$N^{E}_{135} = 2.155E+6$	$N^{P}_{135} = 4.989E+4$	$N^{O}_{135} = 4.785E+5$
$N^{E}_{DE131} = 2.152E+6$	$N^{P}_{DE131} = 4.99E+4$	$N^{O}_{DE131} = 4.786E+5$

$$N_{DE131} = 2.152E+6 + 4.99E+4 + 4.786E+5 = 2.681E+6$$

T = 165 min

elemental	particulate	organic
$N^{E}_{131} = 1.654E+6$	$N^{P}_{131} = 2.989E+4$	$N^{O}_{131} = 3.682E+5$
$N^{E}_{132} = 1.030E+6$	$N^{P}_{132} = 1.860E+4$	$N^{O}_{132} = 2.288E+5$
$N^{E}_{133} = 2.499E+6$	$N^{P}_{133} = 4.507E+4$	$N^{O}_{133} = 5.550E+5$
$N^{E}_{134} = 4.026E+5$	$N^{P}_{134} = 7.279E+3$	$N^{O}_{134} = 8.936E+4$
$N^{E}_{135} = 2.099E+6$	$N^{P}_{135} = 3.784E+4$	$N^{O}_{135} = 4.661E+5$
$N^{E}_{DE131} = 2.144E+6$	$N^{P}_{DE131} = 3.873E+4$	$N^{O}_{DE131} = 4.771E+5$

$$N_{DE131} = 2.144E+6 + 3.873E+4 + 4.771E+5 = 2.66E+6$$

Reference/Comment

T= 180 min

elemental	particulate	organic
N^E_{131} = 1.652E+6	N^P_{131} = 2.326E+4	N^O_{131} = 3.679E+5
N^E_{132} = 9.549E+5	N^P_{132} = 1.343E+4	N^O_{132} = 2.121E+5
N^E_{133} = 2.478E+6	N^P_{133} = 3.481E+4	N^O_{133} = 5.504E+5
N^E_{134} = 3.304E+5	N^P_{134} = 4.652E+3	N^O_{134} = 7.333E+4
N^E_{135} = 2.044E+6	N^P_{135} = 2.870E+4	N^O_{135} = 4.540E+5
N^E_{DE131} = 2.137E+6	N^P_{DE131} = 3.007E+4	N^O_{DE131} = 4.755E+5

N_{DE131} = 2.137E+6 + 3.007E+4 + 4.755E+5 = 2.643E+6

T= 195 min

elemental	particulate	organic
N^E_{131} = 1.651E+6	N^P_{131} = 1.810E+4	N^O_{131} = 3.676E+5
N^E_{132} = 8.853E+5	N^P_{132} = 9.697E+3	N^O_{132} = 1.966E+5
N^E_{133} = 2.457E+6	N^P_{133} = 2.688E+4	N^O_{133} = 5.458E+5
N^E_{134} = 2.711E+5	N^P_{134} = 2.973E+3	N^O_{134} = 6.018E+4
N^E_{135} = 1.991E+6	N^P_{135} = 2.177E+4	N^O_{135} = 4.422E+5
N^E_{DE131} = 2.13E+6	N^P_{DE131} = 2.334E+4	N^O_{DE131} = 4.74E+5

N_{DE131} = 2.13E+6 + 2.334E+4 + 4.74E+5 = 2.627E+6

F059 1534

ATTACHMENT 1

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Reference/Comment

T = 210 min

Values for particulate taken from page 21A.

elemental	particulate	organic
$N^E_{131} = 1.650E+6$	$N^P_{131} = 1.664E+4$	$N^O_{131} = 3.673E+5$
$N^E_{132} = 8.208E+5$	$N^P_{132} = 8.270E+3$	$N^O_{132} = 1.823E+5$
$N^E_{133} = 2.437E+6$	$N^P_{133} = 2.454E+4$	$N^O_{133} = 5.413E+5$
$N^E_{134} = 2.225E+5$	$N^P_{134} = 2.239E+3$	$N^O_{134} = 4.938E+4$
$N^E_{135} = 1.939E+6$	$N^P_{135} = 1.953E+4$	$N^O_{135} = 4.307E+5$
$N^E_{DE131} = 2.124E+6$	$N^P_{DE131} = 2.141E+4$	$N^O_{DE131} = 4.725E+5$

$$N_{DE131} = 2.124E+6 + 2.141E+4 + 4.725E+5 = 2.618E+6$$

T = 240 min

elemental	particulate	organic
$N^E_{131} = 1.649E+6$	$N^P_{131} = 1.661E+4$	$N^O_{131} = 3.663E+5$
$N^E_{132} = 7.058E+5$	$N^P_{132} = 7.108E+3$	$N^O_{132} = 1.568E+5$
$N^E_{133} = 2.397E+6$	$N^P_{133} = 2.413E+4$	$N^O_{133} = 5.322E+5$
$N^E_{134} = 1.498E+5$	$N^P_{134} = 1.508E+3$	$N^O_{134} = 3.326E+4$
$N^E_{135} = 1.840E+6$	$N^P_{135} = 1.853E+4$	$N^O_{135} = 4.086E+5$
$N^E_{DE131} = 2.112E+6$	$N^P_{DE131} = 2.127E+4$	$N^O_{DE131} = 4.692E+5$

$$N_{DE131} = 2.112E+6 + 2.127E+4 + 4.692E+5 = 2.603E+6$$

Reference/Comment

$T = 480$ min

elemental	particulate	organic
$N^{E}_{131} = 1.625E+6$	$N^{P}_{131} = 1.637E+4$	$N^{O}_{131} = 3.610E+5$
$N^{E}_{132} = 2.103E+5$	$N^{P}_{132} = 2.118E+3$	$N^{O}_{132} = 4.671E+4$
$N^{E}_{133} = 2.098E+6$	$N^{P}_{133} = 2.112E+4$	$N^{O}_{133} = 4.657E+5$
$N^{E}_{134} = 6.334E+3$	$N^{P}_{134} = 6.376E+1$	$N^{O}_{134} = 1.406E+3$
$N^{E}_{135} = 1.208E+6$	$N^{P}_{135} = 1.216E+4$	$N^{O}_{135} = 2.682E+5$
$N^{E}_{DE131} = 2.016E+6$	$N^{P}_{DE131} = 2.031E+4$	$N^{O}_{DE131} = 4.479E+5$

$$N_{DE131} = 2.016E+6 + 2.031E+4 + 4.479E+5 = 2.484E+6$$

$T = 720$ min

elemental	particulate	organic
$N^{E}_{131} = 1.602E+6$	$N^{P}_{131} = 1.613E+4$	$N^{O}_{131} = 3.558E+5$
$N^{E}_{132} = 6.265E+4$	$N^{P}_{132} = 6.310E+2$	$N^{O}_{132} = 1.392E+4$
$N^{E}_{133} = 1.836E+6$	$N^{P}_{133} = 1.848E+4$	$N^{O}_{133} = 4.075E+5$
$N^{E}_{134} = 2.678E+2$	$N^{P}_{134} = 2.696E+0$	$N^{O}_{134} = 5.945E+1$
$N^{E}_{135} = 7.928E+5$	$N^{P}_{135} = 7.981E+3$	$N^{O}_{135} = 1.760E+5$
$N^{E}_{DE131} = 1.936E+6$	$N^{P}_{DE131} = 1.949E+4$	$N^{O}_{DE131} = 4.299E+5$

$$N_{DE131} = 1.936E+6 + 1.949E+4 + 4.299E+5 = 2.385E+6$$

F059 1535

ATTACHMENT 1

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PALISADES NUCLEAR PLANT

ANALYSIS CONTINUATION SHEET

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Reference/Comment

T = 1440 min

elemental	particulate	organic
$N^{E}_{131} = 1.539E+6$	$N^{P}_{131} = 1.544E+4$	$N^{o}_{131} = 3.406E+5$
$N^{E}_{132} = 1.656E+3$	$N^{P}_{132} = 1.668E+1$	$N^{o}_{132} = 3.680E+2$
$N^{E}_{133} = 1.230E+6$	$N^{P}_{133} = 1.238E+4$	$N^{o}_{133} = 2.730E+5$
$N^{E}_{134} = 2.042E-2$	$N^{P}_{134} = 2.038E-4$	$N^{o}_{134} = 4.494E-3$
$N^{E}_{135} = 2.241E+5$	$N^{P}_{135} = 2.256E+3$	$N^{o}_{135} = 4.975E+4$
$N^{E}_{DE131} = 1.748E+6$	$N^{P}_{DE131} = 1.76E+4$	$N^{o}_{DE131} = 3.882E+5$

$$N_{DE131} = 1.748E+6 + 1.76E+4 + 3.882E+5 = 2.154E+6$$

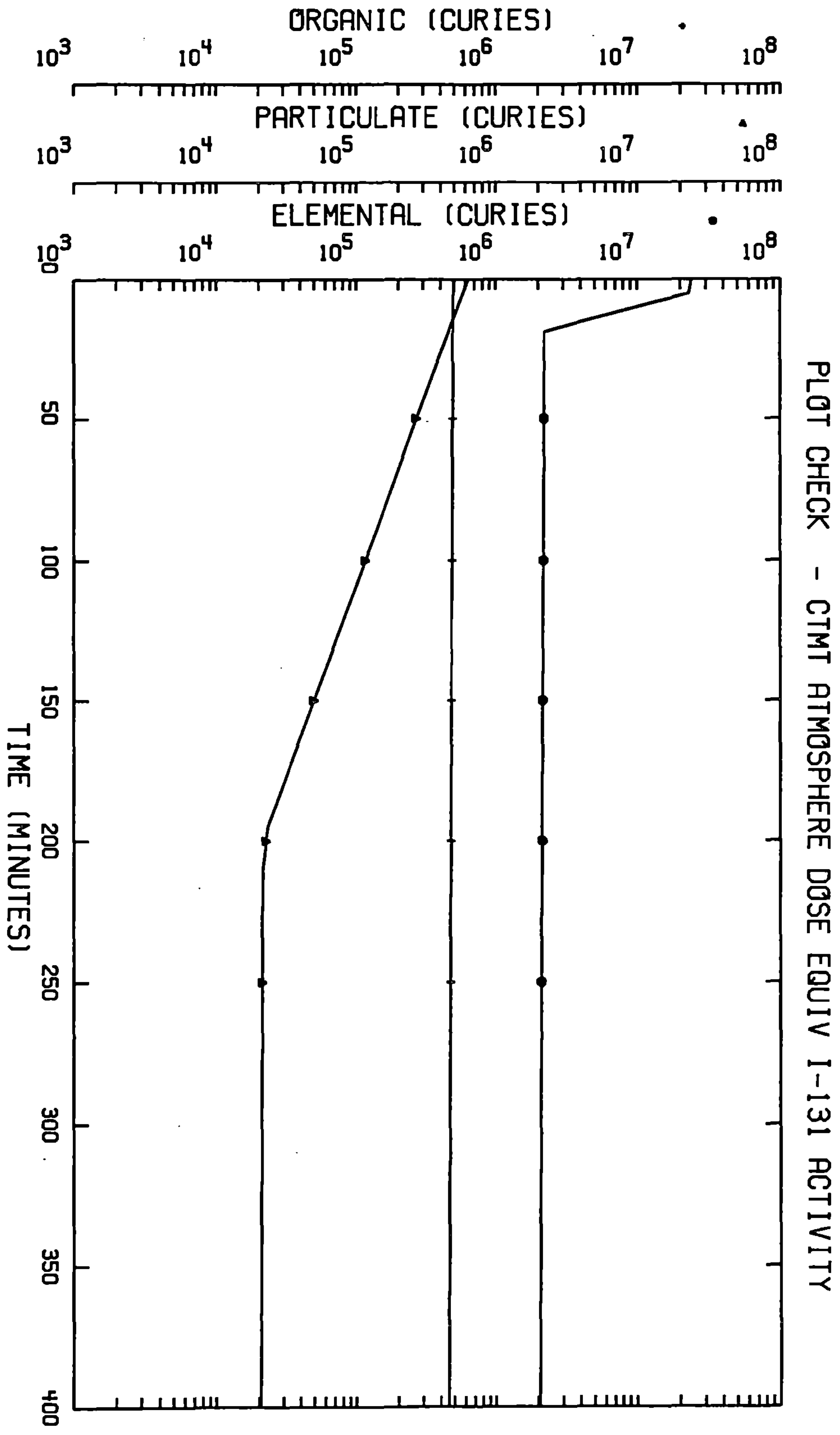
Total DE I-131 Activity plotting stops at 1440 minutes.

Form 3650 6-89

```
FILE: CHKPLOT  DATA     A1  VM/IS 5.1


* VERIFICATION OF C1MPLOT DATA FOR CASE 1
=MHACALC DATA PLOTS
010001   -3    0    2     4      0      0      4
*TABLE 1 - ELEMENTAL IODINE
120100    23
+               0.  2.370E+07
+               1.  2.370E+07
+               2.  2.353E+07
+               3.  2.336E+07
+               5.  2.302E+07
+              19.  2.224E+06
+              30.  2.217E+06
+              45.  2.209E+06
+              60.  2.202E+06
+              75.  2.193E+06
+              90.  2.184E+06
+             105.  2.176E+06
+             120.  2.168E+06
+             135.  2.160E+06
+             150.  2.152E+06
+             165.  2.144E+06
+             180.  2.137E+06
+             195.  2.130E+06
+             210.  2.124E+06
+             240.  2.112E+06
+             480.  2.016E+06
+             720.  1.936E+06
+            1440.  1.748E+06
*TABLE 2 - PARTICULATE IODINE
120200    23
+               0.  6.206E+05
+               1.  6.205E+05
+               2.  6.098E+05
+               3.  5.994E+05
+               5.  5.790E+05
+              19.  4.575E+05
+              30.  3.797E+05
+              45.  2.945E+05
+              60.  2.285E+05
+              75.  1.773E+05
+              90.  1.376E+05
+             105.  1.067E+05
+             120.  8.284E+04
+             135.  6.429E+04
+             150.  4.990E+04
+             165.  3.873E+04
+             180.  3.007E+04
+             195.  2.334E+04
+             210.  2.141E+04
+             240.  2.127E+04
+             480.  2.031E+04
+             720.  1.949E+04
+            1440.  1.760E+04
*TABLE 3 - ORGANIC IODINE
```

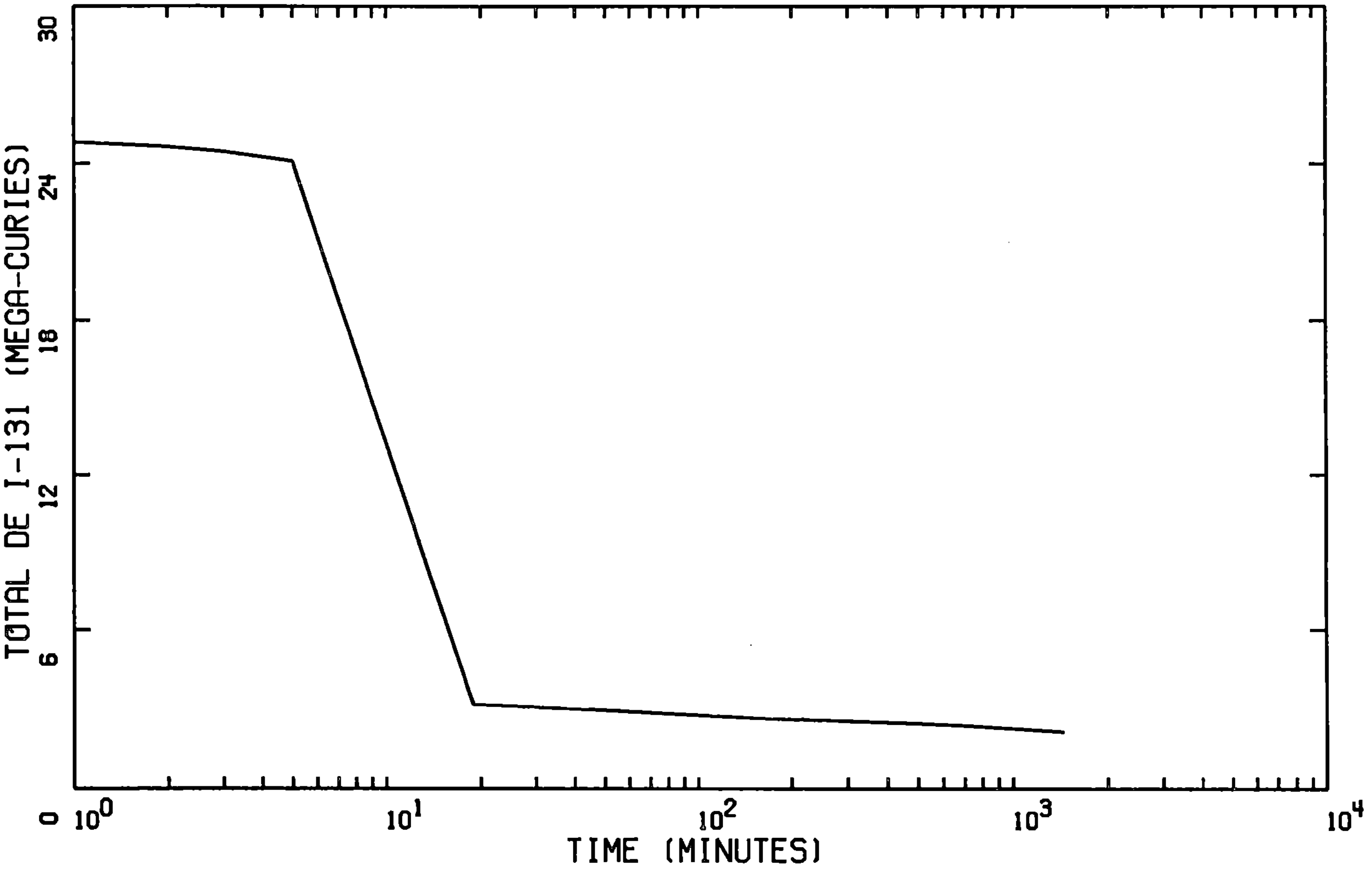
```
FILE: CHKPLOT  DATA     A1  VM/IS 5.1


120300    23
+              0.  4.965E+05
+              1.  4.964E+05
+              2.  4.963E+05
+              3.  4.962E+05
+              5.  4.959E+05
+             19.  4.940E+05
+             30.  4.926E+05
+             45.  4.907E+05
+             60.  4.888E+05
+             75.  4.870E+05
+             90.  4.853E+05
+            105.  4.835E+05
+            120.  4.819E+05
+            135.  4.802E+05
+            150.  4.786E+05
+            165.  4.771E+05
+            180.  4.755E+05
+            195.  4.740E+05
+            210.  4.725E+05
+            240.  4.692E+05
+            480.  4.479E+05
+            720.  4.299E+05
+           1440.  3.882E+05
*TABLE 4 - TOTAL IODINE
120400    23
+              0.  2.482E+07
+              1.  2.482E+07
+              2.  2.464E+07
+              3.  2.446E+07
+              5.  2.410E+07
+             19.  3.176E+06
+             30.  3.089E+06
+             45.  2.994E+06
+             60.  2.919E+06
+             75.  2.857E+06
+             90.  2.807E+06
+            105.  2.766E+06
+            120.  2.733E+06
+            135.  2.705E+06
+            150.  2.681E+06
+            165.  2.660E+06
+            180.  2.643E+06
+            195.  2.627E+06
+            210.  2.618E+06
+            240.  2.603E+06
+            480.  2.484E+06
+            720.  2.385E+06
+           1440.  2.154E+06
020101  'ABCD' 0 'LIN' 8.0 0.0 400.0 'TIME (MINUTES)'
030110  'LOG' 5.0 1.E+03 3.E+07 'ELEMENTAL (CURIES)'
030120  'LOG' 5.0 1.E+03 3.E+07 'PARTICULATE (CURIES)'
030130  'LOG' 5.0 1.E+03 3.E+07 'ORGANIC (CURIES)'
401101  'TABL' 0 -1  * PLOT TABLE 1 ON FRAME 1
```

```
FILE: CHKPLOT  DATA     A1  VM/IS 5.1


401202  'TABL' 0 -2  * PLOT TABLE 2 ON FRAME 1
401303  'TABL' 0 -3  * PLOT TABLE 3 ON FRAME 1
020201  'EFGH' 0 'LOG' 8.0 1.0 1440.0 'TIME (MINUTES)'
030210  'LIN' 5.0 0. 30.0 'TOTAL DE I-131 (MEGA-CURIES)'
402101  'TABL' 0 -4  0. 1.E-06 * PLOT TABLE 4 ON FRAME 2
=PLOT CHECK  - CTMT ATMOSPHERE DOSE EQUIV I-131 ACTIVITY
.
```



PLOT CHECK - CTMT ATMOSPHERE DOSE EQUIV I-131 ACTIVITY

PLOT CHECK - CTMT ATMOSPHERE DOSE EQUIV I-131 ACTIVITY



```
** FILE: BENCHMHA.BAS                                    Created: 02/14/9      5:30
** PAGE: 1    of 1   .  Length: 2405       bytes.        Queued:  02/14/9      5:48
****************************** Lines      1 to 78     ******************************
```

```
10 REM  PROGRAM TO CALCULATE MHA ESF & SIRW RELEASES OVER A TIME INTERVAL
15 DIM QSRW(5),QESF(5),LAMI(5),N(5),ASRW(5),AI2(5),Q(5),C(5),NUC$(5)
20 VTANK = 38767.2
30 VRAS = 3739.3
35 PFESF=10
36 DFESF=2
40 PFSRW = 1
45 KSUBD = 2
46 FI2 = .3
50 LRSRW = .13368
55 LRESF = .053472
60 INPUT"START TIME OF INTERVAL";ST
70 INPUT"END TIME OF INTERVAL"; ET
75 INPUT"SUMP VOLUME AT BEGINING OF INTERVAL, FT**3";VSUMP
80 DT=ET-ST
90 VLIQ=VRAS+(LRSRW*(ST-19))
100 VAIR=VTANK-VLIQ
101 FOR I=1 TO 5
102 READ NUC$(I)
103 NEXT I
104 DATA I-131, I-132, I-133, I-134, I-135
110 FOR I=1 TO 5
115 QSRW(I)=0!
117 QESF(I)=0!
118 Q(I)=0!
120 READ LAMI(I)
130 NEXT I
140 DATA 5.986E-5, 5.045E-3, 5.554E-4, 1.318E-2, 1.754E-3
170 INPUT"INITIAL SIRW ACTIVITY OF EACH IODINE";ASRW(1),ASRW(2),ASRW(3),ASRW(4),
ASRW(5)
175 INPUT"INITIAL I2 SIRW ACTIVITY OF EACH IODINE";AI2(1),AI2(2),AI2(3),AI2(4),
AI2(5)
180 INPUT"INITIAL SUMP ACTIVITY OF EACH IODINE";N(1),N(2),N(3),N(4),N(5)
190 FOR I=1 TO 5
200 C(I)=AI2(I)/(VAIR+PFSRW*VLIQ)
205 Q(I)=C(I)*LRSRW*KSUBD*1
210 NEXT I
220 FOR J=2 TO DT+1
230 VLIQ=VRAS+LRSRW*(ST+J-1-19)
240 VAIR=VTANK-VLIQ
250 FOR I=1 TO 5
260 QESF(I)=QESF(I)+((LRESF*N(I))/(PFESF*DFESF*VSUMP*LAMI(I)))*(1-EXP(-1*
LAMI(I)))
270 ASRW(I)=(ASRW(I)-Q(I))*EXP(-LAMI(I)*1)+(LRSRW*N(I)/(LAMI(I)*VSUMP))*
(1-EXP(-1*LAMI(I)))
271 IF (ASRW(I)<9.999999E-21) THEN ASRW(I)=0!
275 AI2(I)=(AI2(I)-Q(I))*EXP(-LAMI(I)*1)+(FI2*LRSRW*N(I)/(LAMI(I)*VSUMP))*
(1-EXP(-1*LAMI(I)))
276 IF (AI2(I)<9.999999E-21) THEN AI2(I)=0!
280 C(I)=AI2(I)/(VAIR+PFSRW*VLIQ)
282 Q(I)=C(I)*LRSRW*KSUBD*1
285 QSRW(I)=QSRW(I)+Q(I)
287 N(I)=N(I)*((VSUMP-(LRESF+LRSRW)*1)/VSUMP)*EXP(-1*(LAMI(I)))
290 NEXT I
295 VSUMP = VSUMP-(LRESF+LRSRW)*1
300 NEXT J
410 PRINT USING "\          \";"NUC"," Asrw     ","  AI2    ","    Cair ",
"     Qesf","      Qsrw","     Nsump"
415 FOR I=1 TO 5
419 PRINT USING "\   \";NUC$(I);
420 PRINT USING "_ _ ##.####^^^^";ASRW(I);AI2(I);C(I);
425 PRINT USING "_ _ ####.####";QESF(I);QSRW(I);
426 PRINT USING "_ _ #.####^^^^";N(I)
430 NEXT I
435 PRINT "VSUMP =";VSUMP,"VLIQ =";VLIQ,"VAIR =";VAIR
437 PRINT " "
440 PRINT"START NEXT INTERVAL AT END OF THIS ONE (Y or N) ?"
450 X$=INPUT$(1)
460 IF X$="N" THEN 600
470 ST=ET
480 INPUT"END OF NEXT TIME INTERVAL";ET
490 DT=ET-ST
500 FOR I=1 TO 5
520 QSRW(I)=0!
530 QESF(I)=0!
540 NEXT I
550 GOTO 220
600 END
```

F050 #542 ATTACHMENT 2

Page 1 of 4

Consumers Power
POWERING MICHIGAN'S PROGRESS

ATTACHMENT 2

PALISADES NUCLEAR PLANT
ANALYSIS CONTINUATION SHEET

EA - PAH-91-05
Sheet 2 Rev #

Reference/Comment

VERIFICATION OF BENCHMHR.BAS BASIC PROGRAM

Use time interval from 30 → 31 min.

@ 30 min

V_{sump} = 40302.44
V_{LIQ} = 3740.771
V_{AIR} = 35026.43

LR_{SRW} = .13368
LR_{ESF} = .053472

	A_{SRW}	A_{I2}	N_{sump}
I-131	1.3531E+3	4.0592E+2	3.709E+7
I-132	1.6543E+3	4.9628E+2	4.523E+7
I-133	2.1830E+3	6.5487E+2	5.981E+7
I-134	1.9452E+3	5.8355E+2	5.296E+7
I-135	2.1570E+3	6.4709E+2	5.907E+7

From ATTACHMENT 1 Page 9

Constants:

	λ
I-131	5.986E-5
I-132	5.045E-3
I-133	5.554E-4
I-134	1.318E-2
I-135	1.754E-3

$PF_{ESF} = 10$
$PF_{SRW} = 1$
$F_{I2} = .3$

$DF_{ESF} = 2$
$K_D = 2$
$V_{TANK} = 38767.2$

$$C_{AIR} = \frac{A_{I2}}{V_{AIR} + PF_{SRW} \cdot V_{LIQ}} \qquad Q_{SRW} = C_{AIR} \cdot LR_{SRW} \cdot K_D \cdot \Delta t$$

@ 30 min	C_{AIR}	from 29 → 30 min Q_{SRW}
I-131	1.047071E-2	2.799449E-3
I-132	1.280154E-2	3.4226197E-3
I-133	1.689237E-2	4.516344E-3
I-134	1.505267E-2	4.0244819E-3
I-135	1.669169E-2	4.4626902E-3

$$Q_{ESF} = \frac{LR_{ESF} \cdot N_{sump}}{DF_{ESF} \cdot PF_{ESF} \cdot V_{sump} \cdot \lambda}\left[1 - e^{-\lambda \Delta t}\right]$$

$$N_{sump} = N_{sump}(t-1)\left[\frac{V_{sump} - (LR_{ESF} + LR_{SRW})\Delta t}{V_{sump}}\right] e^{-\lambda \Delta t}$$

$$A_{SRW} = \left[A_{SRW}(t-1) - Q_{SRW}(t-1)\right] e^{-\lambda \Delta t} + \frac{LR_{SRW} \cdot N_{sump}}{V_{sump} \cdot \lambda} \left[1 - e^{-\lambda \Delta t}\right]$$

$$A_{Iz} = \left[A_{Iz}(t-1) - Q_{SRW}(t-1)\right] e^{-\lambda \Delta t} + \frac{f_{Iz} \cdot LR_{ESF} \cdot N_{sump}}{V_{sump} \cdot \lambda} \left[1 - e^{-\lambda \Delta t}\right]$$

@ 31 min

$V_{LIQ} = 3740.771 + .13368 = 3740.9047$

$V_{AIR} = 38767.2 - 3740.9047 = 35026.295$

	A_{SRW}	A_{Iz}	C_{AIR}
I-131	1.4760367E+3	4.4279905E+2	1.1422802E-2
I-132	1.795682E+3	5.3867312E+2	1.3895074E-2
I-133	2.3801133E+3	7.1400084E+2	1.8917653E-2
I-134	2.0942381E+3	6.2825877E+2	1.6205936E-2
I-135	2.3489742E+3	7.0467916E+2	1.81772E-2

from 30 → 31 min

@ 31 min

	Q_{SRW}	Q_{ESF}	N_{sump}
I-131	3.8537865E-3	2.4604	3.70876E+7
I-132	3.714987E-3	2.9929	4.5002E+7
I-133	4.9241437E-3	3.9666	5.9777E+7
I-134	4.332819E-3	3.4902	5.2266E+7
I-135	4.859856E-3	3.9152	5.8966E+7

$V_{sump} = 40382.44 - (.13368 + .053472) * 1$
$= 40382.253$

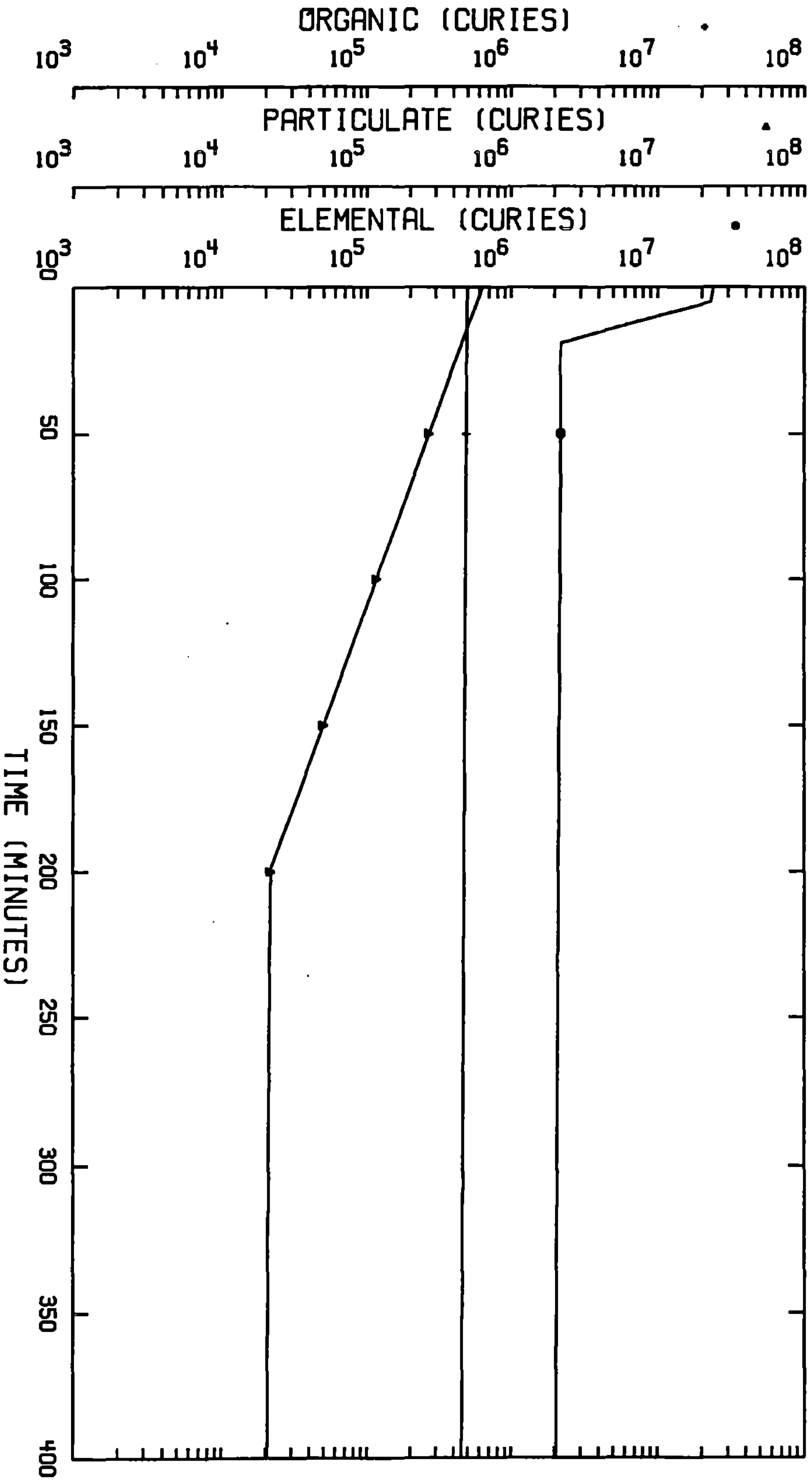
On the following page is a screen dump of the input and output of the BENCHMHA.BAS program for the time interval of 30 → 31 min. As can be seen, the hand calculations show excellent agreement.

```
Ok
RUN
START TIME OF INTERVAL? 30
 D TIME OF INTERVAL? 31
 MP VOLUME AT BEGINING OF INTERVAL, FT**3? 40302.44
INITIAL SIRW ACTIVITY OF EACH IODINE? 1.3531E3,1.6543E3,2.183E3,1.9452E3,2.157E3

INITIAL I2 SIRW ACTIVITY OF EACH IODINE? 4.0592E2,4.9628E2,6.5487E2,5.8355E2,6.4
709E2
INITIAL SUMP ACTIVITY OF EACH IODINE? 3.709E7,4.523E7,5.981E7,5.296E7,5.907E7
NUC        Asrw          AI2          Cair          Qesf         Qsrw      Nsump
I-131   1.4760E+03   4.4279E+02   1.1422E-02      2.4598       0.0031   0.3709E+08
I-132   1.7956E+03   5.3867E+02   1.3895E-02      2.9929       0.0037   0.4500E+08
I-133   2.3801E+03   7.1400E+02   1.8418E-02      3.9668       0.0049   0.5978E+08
I-134   2.0942E+03   6.2826E+02   1.6206E-02      3.4902       0.0043   0.5227E+08
I-135   2.3490E+03   7.0468E+02   1.8177E-02      3.9152       0.0049   0.5897E+08
VSUMP = 40302.26               VLIQ = 3740.904             VAIR = 35026.3

START NEXT INTERVAL AT END OF THIS ONE (Y or N) ?
Ok




1LIST   2RUN   3LOAD"   4SAVE"   5CONT   6,"LPT1  7TRON   8TROFF  9KEY    0SCREEN
```

F059 1546

ATTACHMENT 3

CR-TMI-11-03
Page 1 of 2



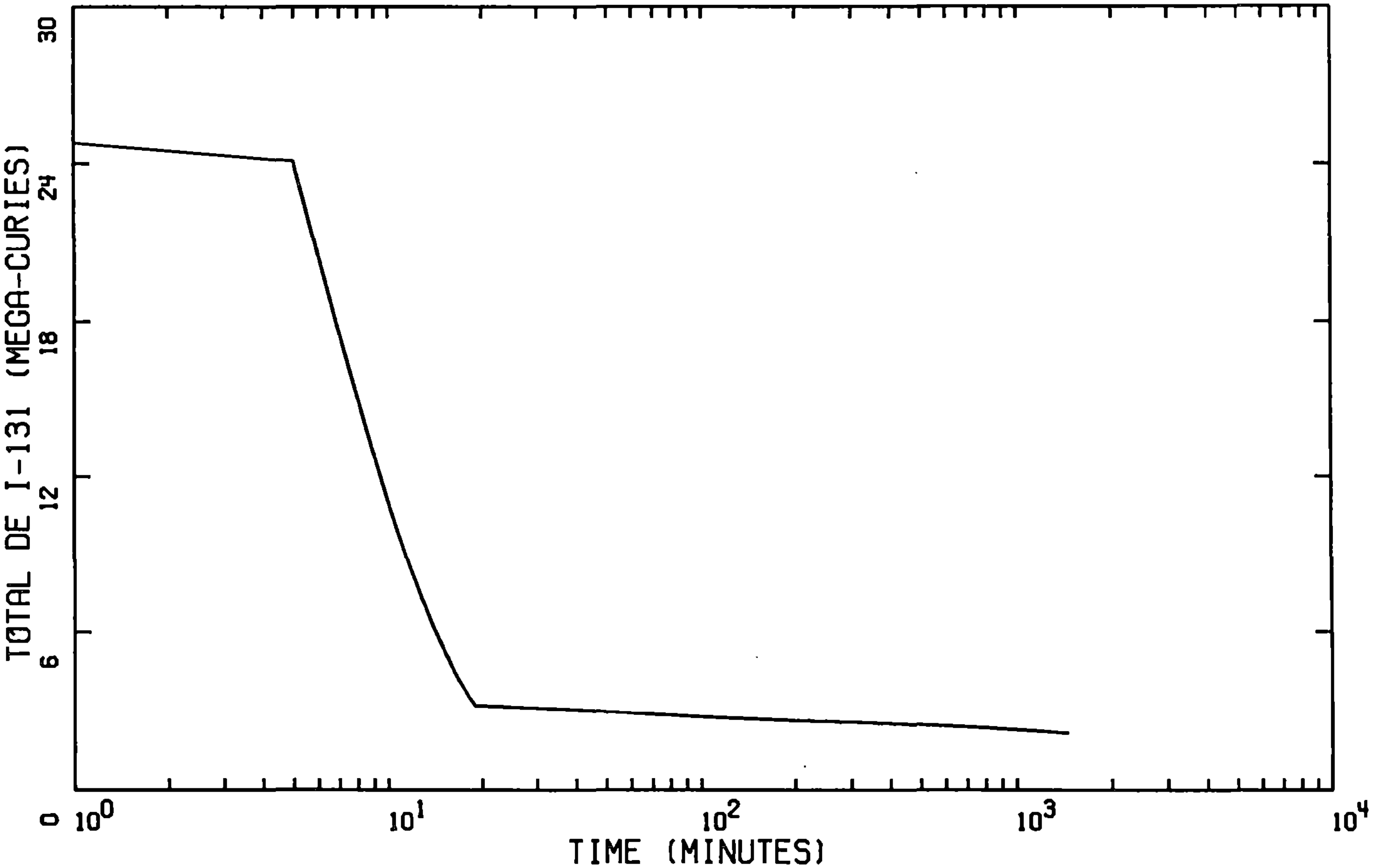
CASE 1: CTMT ATMOSPHERE DOSE EQUIVALENT I-131 ACTIVITY

Page 2 of 2

ATTACHMENT 3

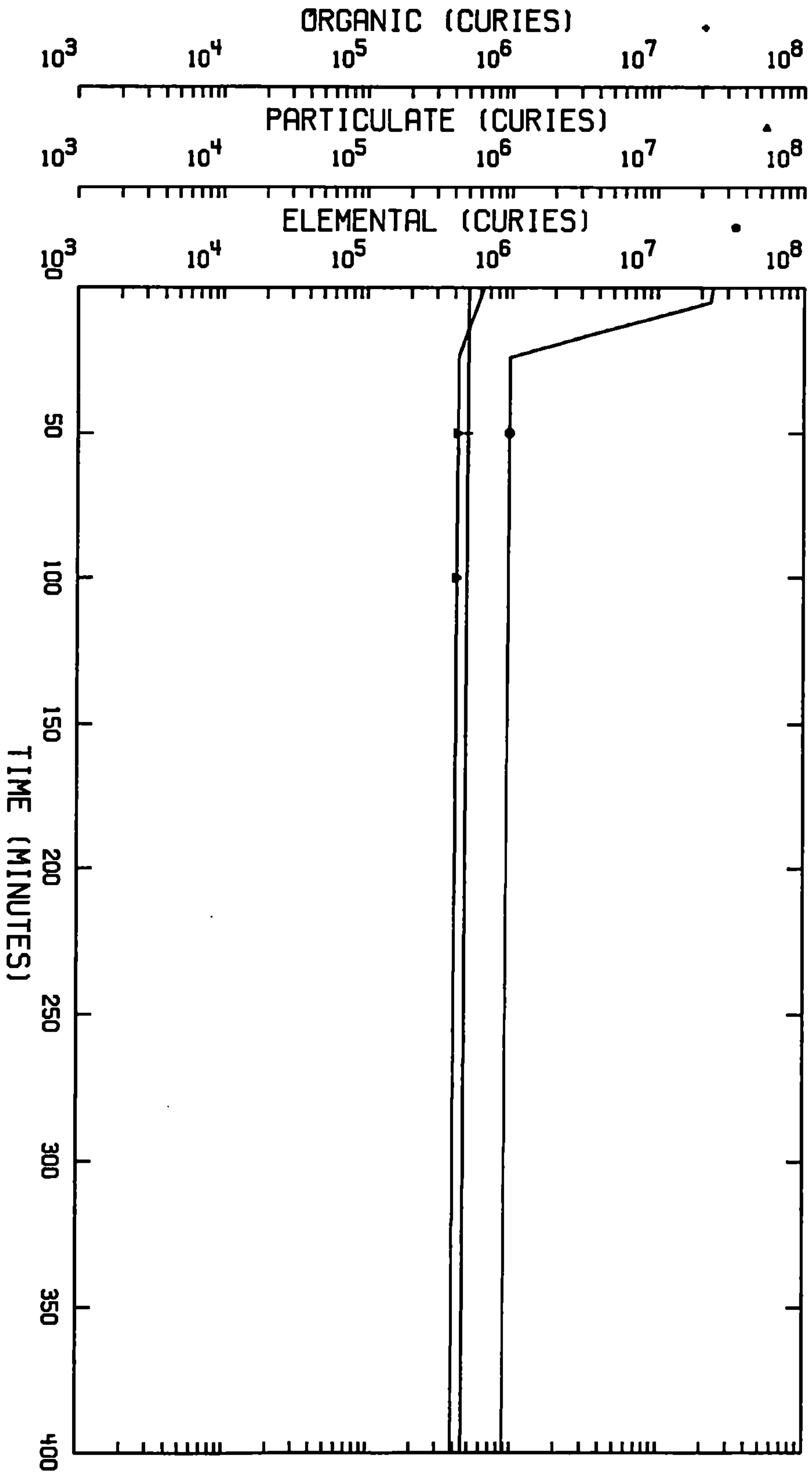
F059 1547

CASE 1: CTMT ATMOSPHERE DOSE EQUIVALENT I-131 ACTIVITY



F059 1548 ATTACHMENT 4

Page 1 of 2



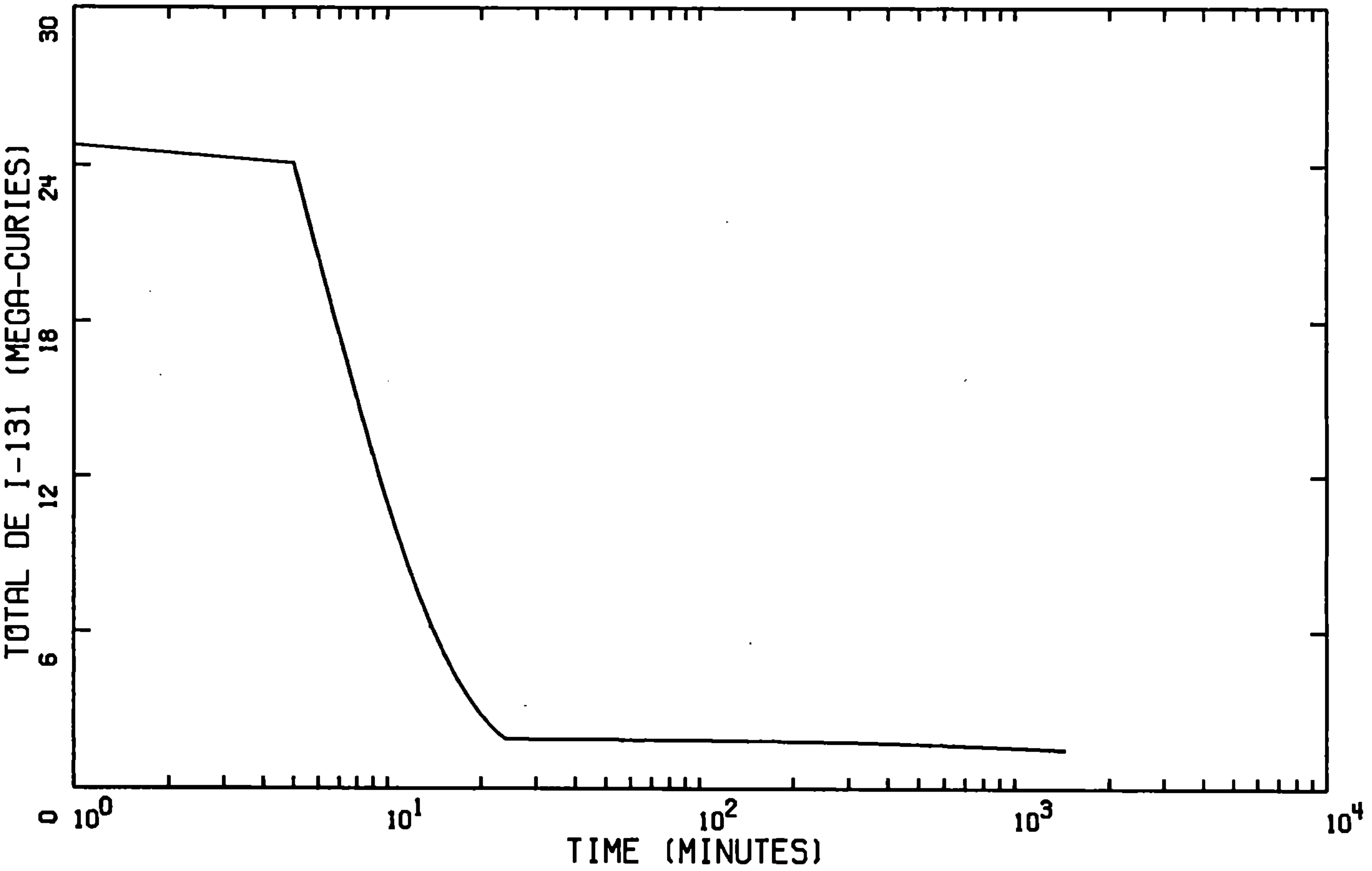
CASE 2: CTMT ATMOSPHERE DOSE EQUIVALENT I-131 ACTIVITY

Page 2 of 2

ATTACHMENT 4

F059 1549

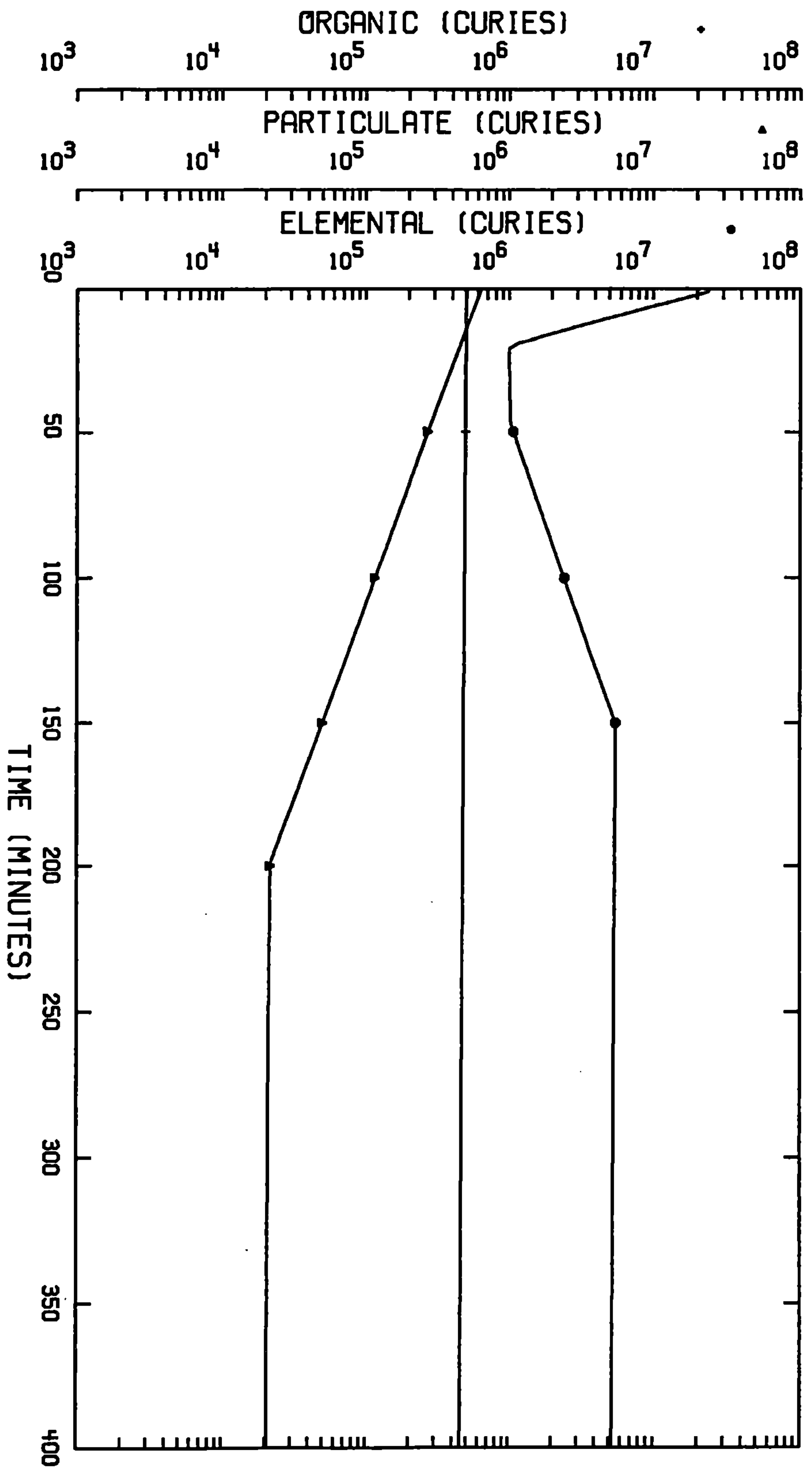
CASE 2: CTMT ATMOSPHERE DOSE EQUIVALENT I-131 ACTIVITY



F059 1550

ATTACHMENT 5

Page 1 of 2

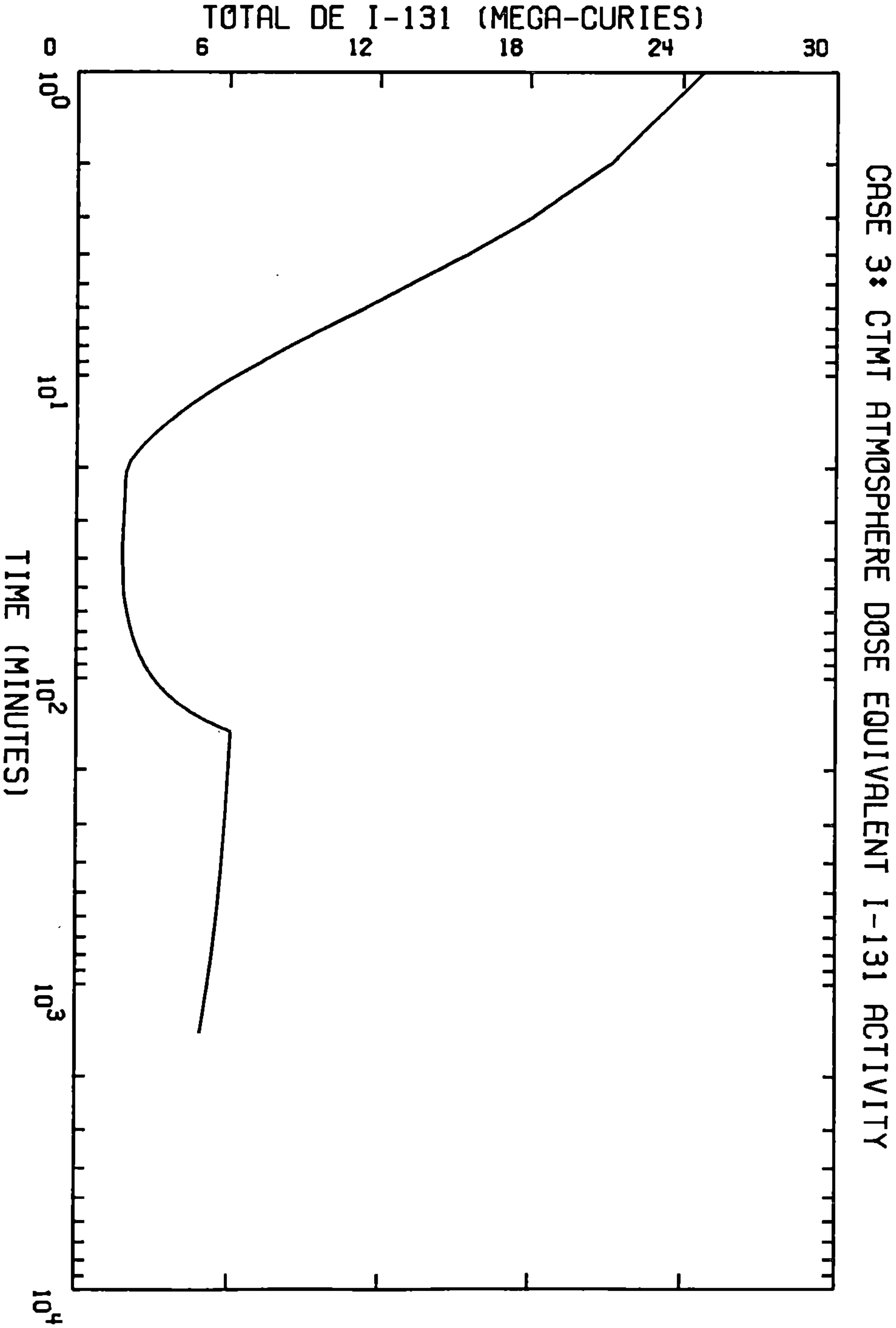


CASE 3: CTMT ATMOSPHERE DOSE EQUIVALENT I-131 ACTIVITY

F059 1551

ATTACHMENT 5

EA-IAA-91-05
Page 2 of 2



CASE 3: CTMT ATMOSPHERE DOSE EQUIVALENT I-131 ACTIVITY

ATTACHMENT 6

EA-PAH-91-05
Page 1 of 3

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555

FAX NO'S 301 - FTS - 504-2260
504-2259
504-1137

VERIFICATION NO. 301 - 504-2262

PLEASE CHECK ONE - LOCAL ( ). LONG DISTANCE (✓)

PLEASE TYPE OR USE BOLD FELD TIP PIN.

(TELECOPIES WILL NOT BE RETURNED)

TO	LOCATION
1. Paul Harden	
FAX # 616-764-8196	VERIFICATION
2.	
FAX #	VERIFICATION
3.	
FAX #	VERIFICATION
4.	
FAX #	VERIFICATION
5.	
FAX #	VERIFICATION

NUMBER OF PAGES 2 AND COVER SHEET

FROM Jay Lee USNRC PHONE EXT. 504-1080

MARTIN MARIETTA

MARTIN MARIETTA ENERGY SYSTEMS, INC.

POST OFFICE BOX X
OAK RIDGE, TENNESSEE 37831

February 5, 1992

Mr. Jay Y. Lee
U.S. Nuclear Regulatory Commission
Mail Stop 10 D4
Washington, DC 20555

Dear Jay:

As a follow-up to our telephone conversations, I will outline a technique for calculating iodine partitioning in a Safety Injection Refueling Water Tank. The steps of the calculation are as follows:

1. Calculate the concentration of iodine in recirculating water. This will be the curies of iodine in containment divided by the volume of recirculating water. To calculate curies of iodine in containment, we would recommend that you use the total core inventory of iodine multiplied by 0.92. The factor 0.92 comes from NUREG/CR-5747 (December 1991) by H. P. Nourbakhsh for a PWR low-pressure sequence.

2. Calculate the total curies of iodine leaked into the Refueling Water Tank. This is the curies per unit volume calculated in step 1 multiplied by the total volume leaked.

3. Calculate the curies of iodine as I_2 that was leaked into the Refueling Water Tank. For this we recommend a fraction of 3×10^{-4} of the total curies leaked into the tank (as calculated in step 2). This factor is based on NUREG/CR-5732 (July 1991) by Beahm et al. and applies to the case where pH control has maintained the pH at ≥7.0.

4. Calculate the partitioning of the curies of I_2 in the Refueling Water Tank. In this calculation, it is safe to assume that the I_2 will not hydrolyze to produce iodide (I^-) and iodate (IO_3^-) because of the pH of 5 in the tank. The partition coefficient for I_2 can be obtained from Equation 26 of NUREG/CR-5732. We may assume an ambient temperature of 25°C (289 K), and this would give a partition coefficient for I_2 of 70.8. By using the definition of partition coefficient, we can obtain the curies of iodine in the Refueling Tank gas:

$$\text{partition coefficient for } I_2 = \frac{\text{curies } I_2 \text{ in water}}{\text{volume water in tank}} \Big/ \frac{\text{curies } I_2 \text{ in gas}}{\text{volume gas in tank}}$$

The curies as I_2 leaked into the tank (calculated in step 3) must be either in the gas or in the water:

$$\text{curies } I_2 \text{ in leakage} = \text{curies } I_2 \text{ in water} + \text{curies } I_2 \text{ in gas} .$$

The partition coefficient equation can be rearranged as:

$$\frac{\text{curies } I_2 \text{ in gas}}{\text{volume gas in tank}} = \frac{\text{curies } I_2 \text{ in leakage}}{[\text{partition coefficient for } I_2 \cdot \text{volume water in tank} + \text{volume gas in tank}]}$$

Obviously, the same unit for volume should be used throughout the calculation.

Best regards,

E. C. Beahm

E. C. Beahm

ECB:bcd

F059 1555

Form 3698 9-89

PALISADES NUCLEAR PLANT

ENGINEERING ANALYSIS CHECKLIST

	Items Affected By This EA	Affected		Revision Required	Identify*	Closeout
		Yes	No			
.	Other EAs	☐	☒			
2.	Design Documents Elec E-38 through E-49	☐	☒			
3.	Design Documents Mech M259, M664, M665	☐	☒			
4.0	LICENSING DOCUMENTS					
4.1	Final Safety Analysis Report (FSAR)	☐	☒			
4.2	Technical Specifications	☐	☒			
4.3	Standing Order 54	☐	☒			
5.0	PROCEDURES					
5.1	Administrative Procedures	☐	☒			
5.2	Working Procedures	☐	☒			
5.3	Tech Spec Surveillance Procedures	☐	☒			
6.0	OTHER DOCUMENTS					
6.1	Q-List	☐	☒			
.2	Plant Drawings	☐	☒			
6.3	Equipment Data Base	☐	☒			
6.4	Spare Parts (Stock/MMS)	☐	☒			
6.5	Fire Protection Program Report (FPPR)	☐	☒			
6.6	Design Basis Documents	☐	☒			
6.7	Operating Checklists	☐	☒			
6.8	SPCC/PIPP Oil and Hazardous Material Spill Prevention Plan	☐	☒			
6.9	EEQ Documents	☐	☒			

Do any of the following documents need to be generated as a result of this EA:

		Yes	No	
1.	Corrective Action Document?	☐	☒	Reference
2.	Safety Evaluation?	☐	☒	Reference
3.	EEQ Evaluation Sheet?	☐	☒	Reference

Is PRC Review of this EA Required? ☐ ☒

ompleted By

Date 2/14/92

*Identify Section, No, Drawing, Document, etc.

Proc No 9.11
Attachment 5
Revision 5
Page 1 of 1

TECHNICAL REVIEW CHECKLIST

EA - PAH-91-05 REV. 0

This checklist provides guidance for the review of engineering analyses. Answer questions Yes or No, or N/A if they do not apply. Document all comments on a 3110 Form. Satisfactory resolution of comments and completion of this checklist is noted by the Technically Reviewed signature on the Initiation and Review record block of Form 3619.

		(Y, N, N/A)
1.	Have the proper input codes, standards and design principles been specified?	Y
2.	Have the input codes, standards and design principles been properly applied?	Y
3.	Are all inputs and assumptions valid and the basis for their use documented?	Y
4.	Is Vendor information used as input addressed correctly in the analysis?	Y
5.	If the analysis argument departs from Vendor Information/Recommendations, is the departure justification documented?	N/A
6.	Are assumptions accurately described and reasonable?	Y
7.	Has the use of engineering judgement been documented and justified?	Y
8.	Are all constants, variables and formulas correct and properly applied?	Y
9.	Have any minor (insignificant) errors been identified? If yes; Identify on the 3110 Form and justify their insignificance.	Y
10.	Does analysis involve welding? If Yes; verify the following information is accurately represented on the analysis drawing (Output document). ● Type of Weld ● Size of Weld ● Material Being Joined ● Thickness of Material Being Joined ● Location of Weld(s) ● Appropriate Weld Symbology	N
11.	Has the objective of the analysis been met?	Y
12.	Have administrative requirements such as numbering and format been satisfied?	Y

3/4/92

[illegible]sumers Power
POWERING MICHIGAN'S PROGRESS

NUCLEAR OPER[illegible]NS DEPARTMENT
Document Review Sheet

Document Title	Document Number	Revision	Revision Number	Page
BENCHMARKING OF THE MHACALC CODE	EA-PAH-91-05	0	0	1 of 13

Item Number	Page and/or Section Number	Comments	Response or Resolution
①	Entire EA	Various typographical errors are noted in the review copy of the document	① Typographical Errors are corrected
2	Assumption 5.1	I Could not find this in the cited reference.	② It was not clear in the reference, so
3	Assumption 5.2	Ref 2.4 §6.5.2 says the ctmt can be modelled as a single well-mixed space if	I expanded the reason for this assumption
		at least 90% of ctmt is sprayed and a ventilation system is available for	③ This assumption has been changed to
		adequate mixing of unsprayed compartments. Two regions bear special consideration:	state what the Standard Review Plan Says.
		the ctmt dome and the 590 elevation. The air in the ctmt dome is removed via a 10"	A full discussion of this has been
		duct connected to VHX3 & VHX-4. You should ascertain whether or not the air flow	added to Section 6.0. The rating
		under accident conditions is ~~not~~ adequate to mix this volume. The 590' elevation	for the coolers under MHA conditions
		is not normally ventilated by the air coolers. During a pipe break event in the	is 37500 cfm from the FSAR. For a
		S/G compartments, the pressure wave will open special panels in the air cooler	large break LOCA there would be
		inlet ducts. These openings will allow the air coolers to draw air from the	a rapid pressure rise in at least 1
		590' elevation. You need to ensure your accident scenario has a rapid pressure	S/G compartment if not both, allowing
		rise in one or both S/G compartments otherwise you may not be able to	air to be drawn from the 590' elev. There
		model the ctmt as a single, well-mixed volume.	should also be large natural convective
4	Assumption 5.3	I couldn't pin down why this assumption was valid (not found or recognized	forces occuring. See Section 6.0.
		in the ~~assumption~~ references). Is it too small to worry about or does the	④ This assumption has been explained
		vent path automatically isolate on CIS? Explanation desired.	in more detail with more references
			added.

Reviewer	Organization	Date	Review Coordinator	Date	Document Sponsor	Date
Steven D. Winter	CPCo/NECO/RASAE/SA	2 DEC 91		2/3/92		2/3/92

Form 3110 1-82

Consumers Power
POWERING MICHIGAN'S PROGRESS

NUCLEAR OPER[illegible]NS DEPARTMENT
Document Review Sheet

Document Title	Document Number	Revision	Revision Number	Page
Benchmarking of the MHACALC Code	EA-PAH-91-05	0	0	2 of 15

Item Number	Page and/or Section Number	Comments	Response or Resolution
5	Assumption 5.5	Pg 12 of SRP §6.5.2 says λ_p changes by a factor of 10 when the particulate	⑤ The code tracks activity, which adds
		aerosol mass, not the activity, drops by a factor of 50. The activity can	conservatism since radioactive decay
		change based on radioactive decay too. Do you use mass or activity?	also decreases activity.
6	Assumption 5.6	Assumption states elemental I removal rate due to sprays ceases when	⑥ Yes. The Reg Guide 1.4 source term
		$\frac{\text{initial elemental I activity}}{\text{elem. I activity @ some time}}$ = DF from SRP §6.5.2. The reference state the	is an instantaneous release. All of
		decontamination factor $\frac{\text{max. elem I conc in ctmt atm}}{\text{elem I conc sometime later}}$ is the parameter to watch.	the iodine that will be released to the
		Is the initial elemental I activity = max elemental I concentration ?	CTMT. ATM. is released initially.
7	Assumption 5.8	Cited Reference should be 2.4, not 2.1.4. Do you use the credits allowed	⑦ Reference # has been corrected.
		by this reference => decay of I between LOCA & RAS? X/Q from SRP 2.3.4 used?	Radioactive decay is credited prior to RAS
		50% core I in sump water per Table 1, RG1.7. Explain the meaning and	and is optional in the code after RAS.
		applicability of the leakage criteria to your assumption (paragraph 3 of page	Ground level X/Q's are used, but not from
		15.6.5-17 of SRP §15.6.5.	SRP 2.3.4. For offsite doses, X/Q in FSAR
8	Assumption 5.10	Why ignore daughter products? Any radioactive daughters would add to the	are used & for control room X/Q are
		dose received (at least the whole body dose)	calculated by Bechtel using an
9	Assumption 5.11	Assumption of homogeneous mixing => @ RAS, SIRWT level is low. Warm sump	approved method. The leakage from
		water could enter the tank and stratify (hot stuff on top, iodine more readily	ESF components must be taken as
		exposed to atmosphere.) Because there would be little mixing going on in the	2 times the T.S. max following SRP 15.6.5.
		tank → simple convection would put the sump water on top.	⑧ Daughter product inclusion generally

Reviewer	Organization	Date	Review Coordinator	Date	Document Sponsor	Date
Steven D. Winter	CPCo/NECO/RS&AE/SA	2 DEC 91		2/3/92		2/3/92

Form 3110 1-82

sumers Power
POWERING MICHIGAN'S PROGRESS

NUCLEAR OPE[illegible]NS DEPARTMENT
Document [illegible]eview Sheet

Document Title	Document Number	Revision	Revision Number	Page
Benchmarking of the MHACALC code	EA-PAH-91-05	0	0	3 of 15

Item Number	Page and/or Section Number	Comments	Response or Resolution
10	Assumption #5.12	This assumption seems disconnected from physical principles. For the air or the water in the tank to xfer heat out, it must come in contact with the walls. There is no postulated mixing method or source of air & water currents to provide the flows.	⑧ cont'd would increase whole body dose by ~20%. It is standard practice for DBA analysis not to include their contribution. Daughter product inclusion is not used in the NRC's TACTS
11	Assumption 5.13	After a period of time, the water in the piping will heat up too, reducing the cooling effect on the sump water. You should see if this takes longer than your assumed event time or change the assumption.	code (NUREG/CR-5106). In discussions with the NRC (Ref. 2.16), they also agreed that this assumption was appropriate.
12	Assumptions 5.11 5.12 5.13 5.14	These assumptions depend strongly on the assumed sump leakage flow rates. At very low flows, the assumptions might be valid. At high flows, maybe not. You need to characterize the flow range you expect to use in this program and be certain the assumptions cover that range.	⑨ There probably would be stratification with the hot water on top, but there would be mixing of the iodine occurring as the water enters the tank. When defining
13	Methodology Para 1 pg 6 of 47	No interaction between the containment atmosphere and the containment sump: Reference 2.3 recalculates the NRC #'s for the ESF room leakage => Did you find a reason for why the NRC apparently assumed no interaction? If the activity removed by the sprays from the ctmt atmosphere does not go to the sump, where does it go? Is it handled conservatively? Your stmt that the regulatory guidance already includes it implies the initial atm & sump distributions of I add up to > 100% Is this true?	the appropriate partition coefficient for iodine in the tank, the temperature must be taken into account & would address this. ⑩ Assumption has been changed. ⑪ This code is designed for small leak rates, sump water is only >212°F for few hours after RAS. ⑫ FLOW RANGE has been stated in Assumption 5.13.

Reviewer	Organization	Date	Review Coordinator	Date	Document Sponsor	Date
Steven D. Winter	CPCo/NE&CO/RESAE/SA	2 DEC 91		2/3/92		2/3/92

Form 3110 1-82

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POWERING MICHIGAN'S PROGRESS

NUCLEAR OPE[illegible]ONS DEPARTMENT
Document Review Sheet

Document Title: Benchmarking the MHACALC code
Document Number: EA-PAH-91-05
Revision: 0
Revision Number: 0
Page 4 **of** 13

Item Number	Page and/or Section Number	Comments
14	Methodology Para 2 pg 6 of 47	Related to Comment #3. Just because one aircooler is running doesn't imply the ctmt is well mixed. You need to ascertain the flow pattern of the circulated air
15	Releases from Ctmt Atm, 2nd Para, pg 8	Reference 2.6 cites ANF-88-107 as a source document showing the earliest fuel melting time to be 41.77 seconds. What is the corresponding value for the new core with higher peaking factors. I think it is > 41.77 seconds.
16	Equation 5	⇒ alternate derivation, taken from "Nuclear Power Reactor Safety" by Lewis confirms this equation. No response required. See attached sheet 5
17	All over	"specie" as a singular form of "species" is a substandard usage per Webster. "Species" is more appropriate in your discussion.
18	pg 11 of 47, last Paragraph	→ for elemental I, is it true that the maximum I concentration is equivalent to the initial I concentration as you state. Later, on pg 12, you state that elemental I could reevolve back into the atmosphere of ctmt. Might the concentration increase above the initial level due to reevolution?
19	pg 12 of 47	Paragraph #1 → you say Iodine can evolve back out of the sump into the atmosphere, yet Comment #13 discusses no interaction between atm & sump. Which is it? Clarify.

Response or Resolution

⑬ The reason for no interaction is that the sump concentration is handled conservatively. Following SRP 15.6.5, analysis for ESF leakage is done separately from CTMT leakage. Statements have been added to methodology.

⑭ More discussion has been added.

⑮ See revised discussion & Assumption 5.3.

⑯ No response required.

⑰ This has been corrected.

⑱ & ⑲ The initial I concentration is the maximum. If I reevolution is accounted for, no more than the initial concentration should be assumed to evolve back at. This goes along with modeling doses from CTMT leakage & from ESF leakage independently as far as the source term is concerned.

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From "Nuclear Power Reactor Safety" by E.E. Lewis, John Wiley & Sons, 1977

Eqn 10-1, competitive rate eqn for radionuclide species in ctmt atmosphere post-LOCA

$$\frac{dC}{dt} = \frac{1}{V_{CT}} \tilde{Q}'(t) - (\lambda^* + \lambda + \tilde{\lambda}) C$$

	EA-PAH-91-05 equivalents
where $\lambda^* = F_{CT}/V_{CT}$	λ_L
$C(t)$ = radionuclide concentration (Ci/m^3)	N_{CA}
$\tilde{Q}'(t)$ = primary system release rate (Ci/sec)	$N_{CA}(t_0)$
V_{ct} = ctmt volume (m^3)	
F_{ct} = ctmt volumetric leak rate (m^3/sec)	
λ = radioactive decay const. (sec^{-1})	λ
$\tilde{\lambda}$ = removal coefficient (sec^{-1})	λ_s (for iodine)

Assuming an instantaneous release @ $t=0$, magnitude $\tilde{Q}$, then the solution to eqn 10-1 is

$$C(t) = \frac{\tilde{Q}}{V_{ct}} e^{-(\lambda^* + \lambda + \tilde{\lambda})t}$$

Containment leakage is $Q'(t) = F_{ct}\, C(t)$

Cumulative release to environment between accident & time t is

$$Q(t) \equiv \int_0^t Q'(t)\,dt$$

For the instantaneous primary system release, the solution is

$$Q(t) = \frac{\lambda^* \left[1 - e^{-(\lambda^* + \lambda + \tilde{\lambda})t}\right]}{(\lambda^* + \lambda + \tilde{\lambda})} \tilde{Q}$$

Allowing for generalizations to specific types of Fission products

$$Q_{CA} = \frac{\lambda_L\, N_{CA}(t_0)}{(\lambda_L + \lambda + \lambda_s)} \left(1 - e^{-(\lambda_L + \lambda + \lambda_s)t}\right)$$

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Item Number	Page and/or Section Number	Comments	Response or Resolution
20	Pg 12 of 47	Terminology → 1st paragraph λ_s^1 is mentioned once, then called λ_s. 2nd paragraph, the λ_s should be λ_s^3 in all cases (the last one already is). 3rd paragraph λ_s^1 would be appropriate	⑳ This has been corrected
21	pg 12/13 of 47	Releases from ctmt sump ⇒ only removal mechanisms are decay & leakage via ESF room components & SIRWT. What about reevolution of elemental iodine to the ctmt atmosphere? This would also remove iodine from the sump. It seems that, in keeping w/the disconnection between the ctmt atm and the sump assumed by your EA, the iodine removed from the atmosphere and re-evolved from the sump would come and go without actually affecting the sump iodine concentration. Is this true? Please clarify.	㉑ The ESF leakage source term is considered independent ~~with~~ of the CTMT atmosphere source Term. The is consistent with following SRP 15.6.5 and is consistent with analyses performed by the NRC.
22	pg 13 last paragraph	It would have been conservative if you had written the code to always multiply SIRWT leakage by 2. This can be done, I presume, by making the input λ_{SRW} 2× its actual value. Correct?	㉒ Correct, the value specified in the input deck could be multiplied by a factor of Two. However, there is no need to perform an analysis more conservative than it already is, considering instantaneous source Term and other things. There is also a user defined multiplier that has been added for the rate at which the iodine in the air leaves the tank, which will provide additional conservatism.
23	pg 13 last paragraph	→ are the ESF & SIRWT leakrates proportional to the volume of sump water recirculating at the time of calculation or just the initial sump volume? In the former, the value of sump volume should be decreased by the leakage amt in each time step. Thus λ_{ESF} & λ_{SRW} rise over time. In the latter case, they do not.	

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Item Number	Page and/or Section Number	Comments	Response or Resolution
24	pg14 Release 6.2.1	You should discuss DF_{est} and PF_{est}, including their derivation and history,	㉓ Due to comment #47, these values will
		in greater detail. Are you using the arguments presented in Reference 2.6	be left in gal/min. versus min^{-1}. Therefore,
		(DF = 2, PF = 10%)? If not, discuss what #'s you plan to use or	this comment is no longer applicable.
		reference where your discussion is located. Also, does the code assume	㉔ A discussion has been included in Input Deck
		all the iodine is instantaneously released to the air, and hence to the environment?	[illegible] Description, Section 7.0.
25	pg 15 Release 6.2.2	You need to characterize the SIRWT recirculation line leakage flow rate.	㉕ The leakage flow rate to the SRW
		The following comments and this section of your EA depend on this.	Tank is expected to be on the order
		See also comments 9, 10, 11, 12 for redundant information. You	of a few tenths of a gallon per minute,
		also need to determine the amount of fluid remaining in the SIRWT	at most. Probably will be <.1gpm. Words
		@ RAS.	have been added to reflect this.
26	pg 15 §6.2.2	You postulate the leakage water to instantaneously become homogeneously mixed	㉖ Instantaneous equilibrium partitioning
		with the remaining sump water. The iodine contained in the leakage is assumed	is conservative. It would, in reality take
		to come to an instantaneous equilibrium partition between the water and the air?	some time before enough iodine evoles
		What about a chemical equilibrium? At some point in the event, you will	out to come to equilibrium. Equilibrium
		be recirculating neutral sump water which is assumed to leak into an acidic	partitioning accounts for the chemical
		SIRWT. For low leakage volumes, the resulting solution will still be acidic which	rxns. that take place. As neutral sump
		is not conducive to long-term iodine retention (SRP 6.5.2). Do you consider an	water leaks in at low leak rates, pH of tank
		increasing Iodine release rate to the SIRWT atmosphere as the event progresses?	will not change. Partition factor must be

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27	Pg 15 §6.2.2	Your assumption of instantaneous homogeneous mixing, etc would seem to be conservative for small leakage rates but not for the release of iodine to the environment. A conservative assumption would be to assume all the iodine is released to the atmosphere instantaneously. To be even more conservative, you should consider the leakage into the SIRWT in a given time to be added at the beginning of the interval.	㉖cont'd chosen for the Temp & pH of the water in the tank. ㉗ There is no reason to take conservatism to an extreme. A user defined multiplication factor has been added to the code for the rate at which iodine exits the SIRWTank.
28	Pg 17 §6.2.2	Eqn 24 -> seems ok except for two things: ① you need to discuss the SIRWT partition factor ⇒ what is it? what is the basis for its determination ② The eqn does not account for any mechanism that would cause Iodine interchange between the vapor and liquid components of the tank, such as pH (comment 26).	㉘ The partition factor is discussed in more detail in Section 7.0, Input Deck Description. The partition factor accounts for the pH of the water.
29	Pg 17 §6.3	Are different time steps used in the control room habitability analysis? Is this why the different methodology is used to calculate the release rates? It seems the original equations could be used with judicious selections of time steps.	㉙ The earlier derived eqns. for release rates would have the release rates changing at every time step (43200 time steps). It would be rediculous to try & use that many release rates, so the release rates are averaged over user-defined time steps.
30	pg 18	Provide the derivation of equation 25 from Reference 2.12. Also, explain where you obtain the dose conversion factors for this equation. If you use something from Reference 2.12, which ~~one~~ table do you use child, teen, adult, etc? Where is the regulatory guidance to use this type of eqn for Iodine? Is the Iodine dose a 50yr dose?	㉚ This eqn. has been changed to be consistent

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31	Pg 18	You say the I calculations are performed separately for the SB and the LPZ using the appropriate atmospheric dispersion factor. This implies each location could have a unique dispersion factor. Since the SB and the LPZ are both far from the release point, the plant would look like a point source ⇒ implies the atmospheric dispersion factors should be the same.	(30) cont'd with the dose methodology of the Control Room Dose Code. See Comment 50 (31) There are different atmospheric dispersion factors for the SB + LPZ that change with time. These are listed in FSAR Tables
32	pg 19	Need reference or source for equation 27	2-17 + 2-18.
33	pg 22	PFESF ⇒ which do you intend to use? earlier analyses used the 10% number.	(32) The eqn. was derived from its definition as
34	pg 22	PFSRW ⇒ earlier comments on SIRWT model could impact this discussion.	stated. This can be verified from the
35	pg 22	VOLRAS ⇒ ~~what~~ does the 20000 gallons include the volume in the lines leading up to the tank (recirc lines)? If not, why not?	attached page from DWC-2 and the dose conversion factors used to obtain the values
36	pg 23	CHISQB + LPZCHI(I) ⇒ Do these values from the FSAR (original Revision!) meet the guidelines in RG1.4	in DWC-2, from the attached page of TID-14844.
37	pg 23	SRRAPR(i) → you need to include the calculation of this variable since these #'s are generally fixed for Palisades.	(33) More discussion has been added, but it is not within the scope of
38	pg 24	TEL(k) ... ~~First Paragraph mentions an adjusted~~ What relationship is used to calculate the λ for reevolution of elemental I from the sump?	benchmarking this code to define the exact values that should be
39	pg 26	EGAMMA → you state β radiation results in skin dose typically. For internal contamination, all of the β dose is absorbed in tissue. β energy should be included for I + noble gases	used for an MHA analysis. (34) - Earlier comments have been resolved.

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5.2.7 Analyze for dose equivalent I-131 as follows:

a. Perform gamma analysis of sample.

Gamma Spectrum Tag Word Number:_________ File Number:_________

Sample Taken By: _________/_______/_______
Signature Date Time

b. Calculate Iodine Dose Equivalent factor using gamma spectrum results using the formula listed below:

	Data		Results
I-131	_________	(μci/ml) x 1.0000 =	_________
I-132	_________	(μci/ml) x 0.0361 =	_________
I-133	_________	(μci/ml) x 0.2700 =	_________
I-134	_________	(μci/ml) x 0.0169 =	_________
I-135	_________	(μci/ml) x 0.0838 =	_________

Sum $\sum_{\text{I-135}}^{\text{I-131}}$ = ______________ I-131 Dose Equivalent Factor

Analysis Performed By: _________/_______
Signature Date

Calculation Verified By: _________/_______
Signature Date

c. Record data as applicable on Attachment 4, "PCS Activity Analysis" of Chemistry Procedure CH 1.5, "Operational Chemistry Logs, Records, Graphs, Labels and Data Sheets."

d. If specific activity is ≥ 1.0 microcurie per gram dose equivalent I-131, sample frequency shall be increased to once every four hours.

5.3 Complete Attachment 3, "PCS Chemistry Analysis" and Attachment 4, "PCS Activity Analysis" of Chemistry Procedure CH 1.5, "Operational Chemistry Logs, Records, Graphs, Labels and Data Sheets."

5.4 Laboratory Supervisor shall complete Acceptance Criteria and Operability Sheets.

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

TID-14844

CALCULATION OF DISTANCE FACTORS FOR POWER AND TEST REACTOR SITES

J. J. Dinunno, et al

Atomic Energy Commission
Washington, D.C.

March 1962

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Table III Dose to Critical Organ Per Iodine Curie Inhaled

Iodine Isotope	T_e(sec)	$D_{\varnothing}/\lambda_r$(rads.curie^{-1})	D.E.
131	6.57×10^5	1.48×10^6	1.0
132	8.39×10^3	5.35×10^4	.036
133	7.52×10^4	4.0×10^5	.270
134	3.11×10^3	2.5×10^4	.017
135	2.42×10^4	1.24×10^5	.024

C. External Gamma Dose Calculations

The external gamma radiation dose at the exclusion and low population zone distances due to fission products contained in the reactor building were determined in the following manner. The source of radiation was considered to be those fission products released from the primary system to the containment building--krypton, xenon, iodines, and a mixture of the remaining "solid" mixed fission products.

From a point source of radiation-given off by a specific gamma emitting isotope, the dose rate at a distance, d (meters), away in air is given by equation (10).

$$\begin{aligned}\text{Dose rate, } D'(\text{rads.sec}^{-1}) &= F_p x P_o (\text{Mw}) \times \left[\frac{q_B}{r}\right] (\text{curies.Mw}^{-1}) \\ &\times 3.7 \times 10^{10} (\text{dis.sec}^{-1}\text{.curie}^{-1}) \times E_\gamma (\text{Mev.dis}^{-1}) \\ &\times 1.6 \times 10^{-6} (\text{ergs.Mev}^{-1}) \times \mu_a (\text{meter}^{-1})\, B\, e^{-\mu d} e^{-\lambda_r t} \\ &\div 1.293 \times 10^3 (\text{grams.meter}^{-3}_{\text{air}}) \times 10^2 (\text{ergs.gram}^{-1}\text{.rad}^{-1}) \\ &\times 4\pi d^2 (\text{meter}^2) \ldots\ldots\ldots\ldots\ldots\ldots (10)\end{aligned}$$

In equation (10), the dose buildup factor, B, is expressed by equation (10a).[12]

$$B = 1 + k\mu d \ldots\ldots\ldots\ldots\ldots\ldots\ldots (10a)$$

After combining terms, equation (10) can be expressed as

$$D' = 0.985\, S_o \times F_p \times P_o\, \mu_a\, d^{-2} [1 + k\mu d] e^{-\mu d} \times e^{-\lambda_r t} (\text{rads.sec}^{-1}) \ldots (11)$$

$$D' = C\, e^{-\lambda_r t}$$

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~~40~~	~~pg 27 line 15~~	~~No # of points in time, other than zero for activity product~~ → ~~to where? Are~~	㉟ No, that is an appoximate value as stated.
		~~the 41 points evenly distributed throughout DURATION?~~	Actual value must be calculated, as it
40	pg 33 Line 4	You use 3.05E5 gallons as recirculation volume from Ref 2.6 pg 37. On page 21	now states. Name also changed to VSRWLIQ.
		of Reference 2.6, the calculated value is 3.3002E5 gal. ~~Why is a~~ Which	㊱ Reg Guide 1.4 is almost as old as Rev 0
		is the correct number?	of the FSAR. The values in the FSAR are
41	pg 25 Line 17	The ESF room leakrate is expressed in gallons/minute (i.e. a volumetric leakrate).	the values we were licensed for.
	and MHACALC.FOR line MHA02020	This ~~[illegible]~~ is apparently treated as constant throughout the MHA and is used	㊲ A reference has been made to the most
		to determine the quantity of curies (or amount of nuclide) of iodine leaked. For	recent EA that calculated them.
		any substance, the mass quantity leaked will vary with it's density. Cooler	However, that EA calculated all spray
		water will contain more mass than hot water for the same leaked volume. Several	removal coefficients, some of which
		questions are asked: What is the range of sump water temperature from start	can change if something such as
		of recirculation to end of event? Do you agree that the iodine mass removal	LOCA blowdown analysis changes.
		rate will vary with time depending on sump water temp? Does the iodine	㊳ There is no standard methodology for
		concentration vary w/water density (it should since concentration ∝ volume).	re-evolution. It would have to be
		Are the effects significant on this analysis?	determined in the EA that would use it.
			㊴ EGAMMA is only used for external dose.
			However, this dose methodology has
			changed for comment #50.

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Item Number	Page and/or Section Number	Comments	Response or Resolution
42	MHACALC FORTRAN Lines 1410-1430	Since code uses fixed time steps of 1 minute duration, any user entered times (TEL, TESF, TSIRW, STOPSPRA, etc) that are used as code switches will automatically introduce error if they are not integral numbers of minutes. For example, If time for start of recirc. is 5.01 minutes, the code will not start recirc until 6 minutes - losing .99 minutes of recirc time and 1 minutes worth of ESF leakage, etc. This could be non conservative w.r.t. released Curies. You should either fix the code to use the input times exactly or put a discussion and warning in the code input section of your EA.	(40) The value used in Ref. 2-6 for the calcs. that are being duplicated is 3.05E+5, regardless of whether either is correct. (41) If the sump volume is Taken as a minimum, as is suggested for line 4 of section 7.0, it is all conservatively encompassed. (42) Limitations have been added in Section
43	MHACALC FORTRAN Lines 2010-2020	These lines VLIQ=VLIQ+LRVLV*1.0 should go <u>after</u> LRVLV is calculated (~ line 2200). As currently coded, the first time recirc is determined, no leakage will be added to the SIRWT liquid volume.	7.0. Changing the code is not necessary since most values needed are whole numers (RAS @ 19.0 min, etc.) and others
44	MHACALC FORTRAN Lines 3290 & 3360	These conditions, apparently put in to avoid divide-by-zero errors, can also have an effect on the results of the calculation. If no credit was being taken for sump nuclide decay (LAMBRAD1=0.0) and, at some point λ_{ESF} & λ_{SIRW} are turned off, the code would calculate no ESF leakage. In reality, Iodine would still exist in the ESF rooms and could leak out. For the SIRWt, the situation is the same.	can be chosen conservatively. (43) No, It should be left as is. It is conservative when calculating the iodine concentration in the air of the SIRW Tank. $C_{AIR}^{IODINE} = \frac{A_{WATER\ SIRW}^{IODINE}}{V_{TOTAL\ TANK} - V_{WATER\ TANK} + PF \cdot V_{WATER\ TANK}}$ Smaller water volume results in slightly higher air concentration for PF>1. For PF=1 it makes no difference. PF always ≥1.

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45	MHACALC FORTRAN Lines 3360 to 3510	Apparent coding errors ⇒ line 3360 LAMBRAD1 should probably be LAMBRAD2 line 3370 if no leakage occurs into SIRWT, the activity in the tank is set to zero. I think you want to set it equal to it's previous value line 3400 LAMBRAD1 should probably be LAMBRAD2 line 3410 LAMBRAD1 should probably be LAMBRAD2 line 3500 LAMBRAD1 should probably be LAMBRAD2 maybe not. Please check! SDW
46	General SIRWT Modelling	You assume that the only way for nuclides to be released from the SIRWT is via the intrusion of leakage water ~~a~~ What about solar heating? As the sun shines on the tank and heats it up, air will escape (carrying Iodine). Later, at night, the tank will cool and draw in fresh air. This cycle could be repeated 30 times over the course of the MHA scenario.
47	Treatment of ESF & SIRWT leakage	Your equations for radionuclide activity levels in the sump and those derived from them (ESF & SIRWT ~~[illegible]~~ leakage) appear to be in error. They treats the ESF & SIRWT leakage in the same fashion as the ctmt atm. leakage → as if the quantity of nuclide in the sump affected the leak rate. This is not true: For the ESF & SIRWT leakages, it is a constant volumetric leakage, independent of the amount of radioactive material present contd..

Response or Resolution

(44) For ESF leakage, all of the iodine that leaks into the room and becomes and remains airborne (accounting for PF_{ESF} + DF_{ESF}) is assumed released to the environment instantaneously. All other iodine in ESF rooms remains in solution or plates-out on surfaces. For SIRW Tank, however, your comment is valid and this has been changed.

(45) In line 3360 it should be LAMRAD1 to prevent divide by zero in line 3390. Line 3370 has been corrected for comment #44. Lines 3400, 3410, + 3500 are correct as is. The only term accounting for decay in the SIRW Tank is the exponential in line 3390.

(46) This would not be significant because it results in a "puff" release for a period of time followed by

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47 continued.		The attached pages show an alternate formulation of the equations that may better represent the situation seen in this event. Page 14 shows the derivation of a revised sump concentration (your equation 16). Note that the λ_{ESF} & λ_{SRW} are gal/min not min^{-1}. Page 15 shows the derivation of the ESF pump room leakage eqn (your equation 18). λ_{ESF} is in gal/min. Note that the revised formulations predict greater releases of ~~iodine~~ nuclides. I would expect the SIRWT leakage eqn (part of 20) to have a similar formulation.	(46) cont'd no release for a period of time. Diffusion in & out the vent may occur during steady conditions, so a user-defined multiplier has been added for the rate at which the iodine exits the tank. (47) This is a valid comment, and the code has been changed for conservatism. However, the difference revolves around
48	Lines 1360 to 5220	strongly suggest that this part of the code be rewritten and cleaned up. Much could be done to simplify & speed up the code. It is very difficult to understand in its current form. Get rid of the II index!	the fact the the sump volume was originally assumed to be constant, whereas it now decreases with time
49	Lines 3250 to 3340	As written, this code fragment will not calculate Q_{iESF} for the first minute of a run. Typically this will not be a problem as recirc starts later than the first minute. ~~In certain cases~~. If recirc were to be modelled @ time 0, the code would underpredict ESF room leakage & release. This should be fixed or documented so future users are aware of it.	due to water leaking into safeguards and SIRW tank. This is conservative since the sump volume would increase significantly after RAS due to condensation of steam in the CTMT Atm, offsetting
50	Dose Calcs	Is the dose calc methodology used in this EA consistent with the methodology used for Control Room Dose Calcs?	the volume that leaks out since ESF + SIRW leakage is small. It is

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19 Mar 17

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$$\frac{d}{dt} N_{s_i}(t) = -\text{decay} - \text{leak}_{ESF} - \text{leak}_{SRW}$$

$$= -\lambda_i N_{s_i}(t) - \lambda_{ESF} C_{s_i}(t) - \lambda_{SRW} C_{s_i}(t) \qquad C_{s_i}(t) = \frac{N_{s_i}(t)}{V_{sump}(t)}$$

$$= -\left(\lambda_i + \frac{\lambda_{ESF} + \lambda_{SRW}}{V_{sump}(t)}\right) N_{s_i}(t) \qquad V_{sump}(t) = V_0 - (\lambda_{ESF} + \lambda_{SRW})t$$

$$= -\left(\lambda_i + \frac{\lambda_{ESF} + \lambda_{SRW}}{V_0 - (\lambda_{ESF} + \lambda_{SRW})t}\right) N_{s_i}(t)$$

$$\int_0^t \frac{dN}{N} = -\int_0^t \left(\lambda_i + \frac{\lambda_{ESF} + \lambda_{SRW}}{V_0 - (\lambda_{ESF} + \lambda_{SRW})t}\right) dt$$

$$\ln\left(\frac{N_{s_i}(t)}{N_{s_i}(0)}\right) \Rightarrow N_{s_i}(t) = N_{s_i}(0) \exp\left[-\int_0^t \left(\lambda_i + \frac{\lambda_{ESF} + \lambda_{SRW}}{V_0 - (\lambda_{ESF} + \lambda_{SRW})t}\right) dt\right]$$

Substitute $a = \lambda_{ESF} + \lambda_{SRW}$

$l = \lambda_i$

$V = V_0$

$$N_{s_i}(t) = N_{s_i}(0) \exp\left[-\int_0^t \left(l + \frac{a}{V - a\cancel{x}}\right) d\cancel{x}\right]$$

$$= N_{s_i}(0) \exp\left[-\int_0^t l\, dx - \int_0^t \frac{a}{V - ax} dx\right]$$

$$\left[-\lambda \cancel{x} - a\left[\frac{1}{-a} \ln(V - ax)\right]_0^t = -\lambda x + \ln(V - ax)\Big|_0^t\right.$$

$$\Downarrow$$

$$-\lambda_i t + \ln(V - at) - \ln V$$

$$= N_{s_i}(0)\, e^{-\lambda_i t} \left[\frac{V - at}{V}\right] \longleftarrow$$

$$\boxed{N_{s_i}(t) = N_{s_i}(0) \left[\frac{V_{sump}(0) - (\lambda_{ESF} + \lambda_{SRW})t}{V_{sump}(0)}\right] e^{-\lambda_i t}}$$ Concentration in sump

VS OLD EQN of $N_{s_i}(t) = N_{s_i}(0)\, e^{-(\lambda_i + \lambda_{ESF} + \lambda_{SRW})t}$

Using $N_{s_i}(0) = 3.717E7$ Ci

$\lambda_i = 5.986E-5 \text{ min}^{-1}$

$\lambda_{ESF} = 0.4$ gpm

$\lambda_{SRW} = 0.05$ gpm

$V_{sump}(0) = 301,500$ gal

time, min	old eqn (Ci)	new eqn (Ci)	(new - old) Δ (Ci)
0	3.717E7	3.717E7	0
10000.0	2.013E7	2.012E7	-2.264 E3
20000.0	1.090E7	1.089E7	-4.953 E3
30000.0	5.900E6	5.894E6	-6.094 E3
43200.0	2.625E6	2.619 E6	-5.697 E3

F059 1574

Given sump activity $N_{s_i}(t) = N_{s_i}(0)\left[\frac{V_{sump}(0) - (\lambda_{ESF} + \lambda_{SRW})t}{V_{sump}(0)}\right] e^{-\lambda_i t}$ curies

leakage into ESF room = (leakrate)(curies in leaked soln) $= \lambda_{ESF}\ C_{s_i}(t) = \lambda_{ESF} \frac{N_{s_i}(t)}{V_{sump}(t)}$

but $V_{sump}(t) = V_0 - (\lambda_{ESF} + \lambda_{SRW})t$

$$\frac{\lambda_{ESF}}{V_0 - (\lambda_{ESF} + \lambda_{SRW})t} N_{s_i}(t) = \frac{\lambda_{ESF}}{V_{sump}(0)} N_{s_i}(0)\, e^{-\lambda_i t}$$

Pg 14 of 10

From EA-PAH-91-05 $\dot{q}_{ESF,i}(t) = \frac{\lambda_{ESF}}{DF_{ESF}\, PF_{ESF}\, V_{sump}(0)} N_{s_i}(0)\, e^{-\lambda_i t} = a e^{bt}$ $a = \frac{\lambda_{ESF}}{DF_{ESF}\, PF_{ESF}\, V_{sump}(0)}$

$b = -\lambda_i$

$$\int_0^t dq = \int_0^t a e^{bt} dt$$

$$Q(t)\Big|_0^t = Q(t) = \frac{a}{b} e^{bt}\Big|_0^t$$

$$= \frac{a}{b} e^{bt} - \frac{a}{b}$$

$$Q_i(t) = \frac{\lambda_{ESF}\, N_{s_i}(0)}{DF_{ESF}\, PF_{ESF}\, V_{sump}(0)\, \lambda_i}\left[1 - e^{-\lambda_i (t)}\right]$$

$$\text{OLD EQN} \Rightarrow Q(t) = \frac{\frac{\lambda_{ESF}}{V_{sump}(0)} N_{s_i}(t_0)}{DF_{ESF}\, PF_{ESF}\left(\lambda_i + \frac{\lambda_{ESF} + \lambda_{SRW}}{V_{sump}(0)}\right)} * \left[1 - e^{-\left(\lambda_i + \frac{\lambda_{ESF} + \lambda_{SRW}}{V_{sump}(0)}\right)t}\right]$$

Using $\lambda_i = 5.986E\text{-}5/min$

$\lambda_{ESF} = 0.4$ gal/min

$\lambda_{SRW} = 0.05$ gal/min

$V_{sump}(0) = 301500.0$ gal

$N_{s_i}(0) = 3.717E7$ Ci

$DF_{ESF} = 2$

$PF_{ESF} = 10$

t	OLD	NEW	Δ (new - old)
0	0	0	0
10000.0	1.843E4	1.855E4	1.241E2
20000.0	2.841E4	2.875E4	3.424E2
30000.0	3.381E4	3.435E4	5.436E2
43200.0	3.735E4	3.809E4	7.375E2

(increase in released activity with new eqn

Re[illegible] of EA-PAH-91-05

F059 1575

$\Delta t = (t_i - t_{i-1})$

$$N_{S_i}(t_i) = N_{S_i}(t_{i-1}) \left[\frac{V_{sump}(t_{i-1}) - (\lambda_{ESF} + \lambda_{SRW}) \Delta t}{V_{sump}(t_{i-1})} \right] e^{-\lambda_i \Delta t}$$

$$V_{sump}(t_i - 1) = V_0 - (\lambda_{ESF} + \lambda_{SRW}) t_{i-1}$$

cancl

$$V_0 - (\lambda_{ESF} + \lambda_{SRW}) t_{i-1} - (\lambda_{ESF} + \lambda_{SRW}) t_i + (\lambda_{ESF} + \lambda_{SRW}) t_{i-1}$$

$$V_0 - (\lambda_{ESF} + \lambda_{SRW}) t_i$$

$N_{S_i}(0)$ = initial concentration

$$N_{Si}(t_1) = N_{Si}(0) \left[\frac{V_{sump}(0) - (\lambda) \Delta t}{V_{sump}(0)} \right] e^{-\lambda_i \Delta t} \longrightarrow$$

$$V_{sump}(t_1) = V_{sump}(0) - \lambda \Delta t$$

$$N_{Si}(t_2) = N_{Si}(0) \left[\frac{V_{sump}(0) - (\lambda) 2\Delta t}{V_{sump}(0)} \right] e^{-\lambda_i (2\Delta t)}$$

$$= N_{Si}(t_i) \left[\frac{\overset{\text{or } V_{sump}(t_1)}{\cancel{V_{sump}(0)}} - \lambda \Delta t}{\underset{V_{sump}(t_1)}{\cancel{V_{sump}(0)}}} \right] e^{-\lambda_i \Delta t}$$

$$N_{Si}(t_2) = N_{Si}(0) \left[\frac{V_{sump}(0) - \lambda \Delta t}{V_{sump}(0)} \right] e^{-\lambda_i \Delta t} \left[\frac{V_{sump}(t_1) - \lambda \Delta t}{V_{sump}(t_1)} \right] e^{-\lambda_i \Delta t}$$

$$= \left(\frac{V_{sump}(0) - \lambda \Delta t}{V_{sump}(0)} \right) \left(\frac{V_{sump}(t_1) - \lambda \Delta t}{V_{sump}(t_1)} \right)$$

$$\left[\frac{\cancel{V_{sump}(0) - \lambda \Delta t}}{V_{sump}(0)} \right] \left[\frac{V_{sump}(0) - \lambda \Delta t - \lambda \Delta t}{\cancel{V_{sump}(0) - \lambda \Delta t}} \right] = \frac{V_{sump}(0) - \lambda 2 \Delta t}{V_{sump}(0)}$$

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			(47) cont'd
			felt that leaving the sump volume
			constant is justifiable, but since
			the suggested method is more
			conservative the code has been
			changed.
			(48) This has been rewritten
			(49) This has been corrected.
			(50) Since dose calcs. for control room
			now use methodology of ICRP-30,
			the dose calcs. in this code have
			been change to use the same
			methodology.
			Due to the extensive modifications
			made to the code, another
			complete Tech. Review is suggested.

Reviewer	Organization	Date	Review Coordinator	Date	Document Sponsor	Date
				2/3/92		2/3/92

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0		These comment sheets document the second review of EA-PAH-91-05.	
	Old Comment 1)	OK	N/A
	Old Comment 2)	OK	N/A
	Old Comment 3)	well-mixed ctmt atmosphere ⇒ one CAC running at 37,500 cfm will circulate 1.64E6 ft^3 in 43.73 minutes ~~at the~~ under ideal conditions. Since the air cooler will probably be drawing from 590' elevation due to the opening of the blast panels, it seems likely that the CAC will be circulating the 590 elevation, ~~one~~ and one of the steam generator compartments at best.* It will be sprays that mix the upper containment. Is this acceptable? See old comment 14 below ↓ * Very nonuniform air flows in ctmt w/only one cooler.	The idea is to prevent large air packets containing iodine, that could leak from CTMT without being depleted from sprays. With the natural circulation that would take place this seems adequate, regardless of flow uniformity.
	Old Comment 4)	OK	N/A
	Old Comment 5)	~~Are you saying that~~ Verify the following reasoning WRT λ_p : Per SRP §6.5.2, λ_p decreases by a factor of 10 when the initial particulate aerosol mass decreases by a factor of 50. The activity in the ctmt atmosphere due to particulates decreases faster than the particulate aerosol mass ~~[illegible]~~ (because of radioactive decay). Tracking activity causes the 50x decrease to occur earlier in the event, leading to a reduced λ_p earlier in the event. The reduced λ_p keeps particulate I in the ctmt atmosphere for a longer	Yes, conservatism results from decreasing the removal rate ealier, therefore leaving more particulates suspended in the air for longer period of time.

Reviewer	Organization	Date	Review Coordinator	Date	Document Sponsor	Date
Steven D. Winter	NE&CO/R&SA/SA	18 Feb 1992		3/2/92		3/2/92

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		period of time. This results in greater I leakage from the ctmt and is	
		conservative. Is this what you meant in your response?	
X	Old Comment 6)	Ok	N/A
X	Old Comment 7)	Ok	N/A
X	Old Comment 8)	Ok	N/A
X	Old Comment 9)	Ok	N/A
X	Old Comment 10)	Ok	N/A
X	Old Comment 11)	Ok	N/A
X	Old Comment 12)	Ok	N/A
X	Old Comment 13)	Ok	N/A
X	Old Comment 14)	well-mixed ctmt revisited again: 10" duct to the top of the ctmt will probably	N/A
		not contribute much flow with the blast panels open on the air coolers (flow	
		resistance would be higher). Convection currents caused by hot PCS & S/G metal,	
		energy release from melting core, etc could circulate the air in the dome at	
		some unknown rate.	
X	Old Comment 15)	OK	N/A
X	Old Comment 16)	OK	N/A
X	Old Comment 17)	Ok Thanks!	N/A

Reviewer: Steven D. Winter	Organization: NE&CO/R4SA/SA	Date: 18 Feb 1992	Review Coordinator:	Date: 3/2/92	Document Sponsor:	Date: 3/2/92

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X	Old Comment 18	Ok, but this disconnection between atm & sump WRT Iodine transport	If iodine re-evolution is to be modeled,	✓
		seems weird. Does MHACALC check to see how much I reevolves? Integrated amount?	it must be done so carefully to	
X	Old Comment 19	Ok	avoid ending up with larger amount of	
X	Old Comment 20	OK	iodine then at the start.	
X	Old Comment 21	OK	N/A	✓
X	Old Comment 22	OK	N/A	✓
X	Old Comment 23	OK	N/A	✓
X	Old Comment 24	OK	N/A	✓
X	Old Comment 25	OK	N/A	✓
X	Old Comment 26	OK	N/A	✓
X	Old Comment 27	OK	N/A	✓
X	Old Comment 28	OK	N/A	✓
X	Old Comment 29	OK	N/A	✓
X	Old Comment 30	OK	N/A	✓
X	Old Comment 31	OK	N/A	✓
X	Old Comment 32	OK	N/A	✓
X	Old Comment 33	OK	N/A	✓
X	Old Comment 34	OK	N/A	✓

Reviewer: Steven D. Winter	Organization: NE&CO/R&SA/SA	Date: 18 Feb 1992	Review Coordinator:	Date: 3/2/92	Document Sponsor:	Date: 3/2/92

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X	Old Comment 35	OK	N/A
X	Old Comment 36	OK	N/A
X	Old Comment 37	OK	N/A
X	Old Comment 38	OK	N/A
X	Old Comment 39	OK	N/A
X	Old Comment 40	OK	N/A
X	Old Comment 41	Questions still apply → even if min sump volume is used, it will get denser as it cools. This should increase the leak rate of "activity" to the ESF rooms and the SIRW tank. Granted, the density change will probably be small and not significant, but merely using the minimum sump volume is not automatically conservative.	Continuous steam condensation would offset this. See EA-GCP-91-04, Att. 1 where min-sump vol. was obtained. Final Vol. of sump is not much lower than the min. vol. chosen. ESF leakage also has a built in factor of 2 conservatism per SRP 15.6.5 App. B. Not much change in final doses would be expected.
X	Old Comment 42	OK	
X	Old Comment 43	OK	
X	Old Comment 44	OK	
X	Old Comment 45	OK	
X	Old Comment 46	OK	N/A
X	Old Comment 47	OK but, since you ignore the addition of I to the sump by the sprays, it only seems consistent to ignore the water addition caused by steam condensation.	Ignoring iodine addition to sump from spray removal is due to the conservative source term. The sump vol. was not chosen conservatively high.

Reviewer	Organization	Date	Review Coordinator	Date	Document Sponsor	Date
Steven D. Winter	NE&CO/R&SA/SA	18 Feb 92		3/2/92		3/2/92

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	Old Comment 48	Thank you! Thank you!	N/A
	Old Comment 49	OK	N/A
	Old Comment 50	OK	N/A
1	Input 4.5 pg 6	See Comment #13	① See response #13
2	Assumption 5.13	It might be a good idea to have the code check for appropriate input on SIRWT leakage. If the user inputs is above some limit (0.3gpm?), the code could print an error message alerting the user to an out-of-bounds condition.	② I don't feel a limit is necessary. It can be Taken care of by user judgement since this EA would have to be read to learn to use the code. A limit on leak rate for this to be valid would be dependent upon amount of time sump temp. is > 212°F, which is relatively shor
3	pg 8, 3rd paragraph	See my response to Old Comment 3).	③ See response to old comment #3
4	Figure 1.	It might be helpful to add a couple of arrows to indicate radionuclide addition to ctmt & ctmt sump. See marked up copy. Also, larger arrowheads would be nice. The existing ones can barely be seen.	④ Since the source term release is assumed to be instantaneous, as opposed to a continuous release over a period of time, I chose not to revise the figure.
5	Section 6.1.1	Reviewed in first version of this EA. No significant changes have been made, to the writeup	⑤ No response required.
6	Section 6.1.2	Reviewed in first version of this EA. No significant changes have been made to the writeup	⑥ No response required.

Reviewer	Organization	Date	Review Coordinator	Date	Document Sponsor	Date
Steven D. Winter	NE&CO/RASA/SA	19 Feb 92		3/2/92		3/2/92

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7	Equation 15	The second expression is missing "$N_{si}(t)$"	⑦ This has been corrected.
8	§6.2 up to 6.21	Ok per equations generated in first round of review	⑧ No response required.
9	§6.2.1	Ok per eqns generated in first round of review.	⑨ No response required.
10	§6.2.2	Ok. No comment	⑩ No response required.
11	pg 21 2nd paragraph	This paragraph states that the SB and LPZ calcs use the same atmospheric dispersion factor (I think). Your response to Old Comment 31 says different dispersion factors are used. Which is it? The tables in the FSAR appear to have different numbers.	⑪ This has been clarified. The point being made is that for offsite doses, χ/Q's are not changed for releases from CTMT and from SIRW Tank due to relative distance to receptor point.
12	pg 22 last para from Eqn 27 down	This needs to be clarified. As we discussed, it implies an additional dose and is confusing to the uninitiated.	⑫ This has been clarified.
13	pg 27 F_{I2}	F_{I2} ⇒ it would be useful to consider the effects of the pH of SIRWT water. While small inleakages of sump water may have a pH of > 7.0, and hence an F_{I2} of 3×10^{-4}, when it mixes with the acidic water in the sump, the pH of the final solution will be much lower (about that of the SIRWT water). It appears, though, that the radiation flux in the SIRWT could be too low to support catalysis of I^- back into volatile I_2. In this case, use of $F_{I2} = 3 \times 10^{-4}$ would be ok. You should mention that an analysis using MHACALC should consider the strength of the radiation field *inside* the SIRWT in	⑬ A statement has been added that a more conservative value than 3.00×10^{-4} should be considered if very high leak rates or high dose rates in SIRW Tank are expected. The value of 3×10^{-4}, however, has been suggested by the researcher at ORNL and has been accepted as appropraite by the NRC Technical

Reviewer: Steven D. Winter
Organization: NE&CO/R&SA/SA
Date: 28 Feb 1992
Review Coordinator:
Date: 3/2/92
Document Sponsor:
Date: 3/2/92

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13	continued	the determination of F_{I2}.	reviewers. Therefore, the same value will probably always be used.
14	page 32 description	This paragraph is confusing as written → unclear as to when and	⑭ This has been clarified and
	of line 41-? input	where ϕ should be input. Also, 3 references are made to INTRVALS	the correct line number for INTRVALS
		on line 42. INTRVALS is on line 40.	has been specified.
15	General	Typos and grammar errors are circled in red or pink where found	⑮ These have been corrected.
		in the EA	⑯ If the plant is in compliance
16	General	Reevolution of Iodine to the containment atmosphere. Your use of an	with regulatory requirements for
		exponential relationship for this process does not seem right. If we	sump pH control, iodine re-
		conveniently ignore decay and leakage, the eqn for reevolution becomes:	evolution will never need to be
		$N_{CA}(t+\Delta t) = N(t)\, e^{\lambda_{evol} \Delta t}$. This says that, the more Iodine	accounted for. If it does need
		there is in the ctmt atmosphere, the faster I_2 will evolve out of	to be accounted for due to sump
		the sump. If given enough time, the concentration of I_2 gets very large.	pH control problems, it must be
		[Example: $\lambda_e = 1/60\ \text{min}^{-1}$. Assuming $\lambda_i << \lambda_e$, $\lambda_s = 0$. @ 10 minutes after revolution starts	done conservatively. There are
		an 18% increase in I_2 will be seen. At 20 min → 40%, at 60 min 272%, etc.]	no regulatory standards or methods
		At some point, more I_2 will reevolve than exists in the sump! [illegible], It seems	for accounting for re-evolution. It
		that I_2 reevolution must be based on the I_2 or I^- in the sump as well as the	would have to be modeled by trying
		ctmt atmosphere. There doesn't seem, contrary to regulatory methods,	cases until the desired amount
		to decouple the atm and the sump for this process. Also, an exponential	of iodine is added to the CTMT

Reviewer	Organization	Date	Review Coordinator	Date	Document Sponsor	Date
Steven D. Winter	NE&CO/R+SA/SA	28 Feb 1992		3/2/92		3/2/92

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		revolution equation just does not seem appropriate. It is unclear	atmosphere in the desired period of
		~~the way~~ whether or not you can use this in the MAACALC code.	time. Although it may be difficult
17	Attachments	Reviewed and spot checked your hand calcs, code listing, and outputs.	+ require alot of Engineering judgement,
		Some things I noticed were:	I feel the code could be used to model
		A) Many divide-by-zero checks are in the code. You missed one for the	iodine re-evolution.
		division on lines 4050 and 4080 and 4400 and 4440	⑰ a) Divide-by-zero checks are not felt
		B) Line 5740 contains a typo => "Increase" should be "Decrease"	To be necessary for those eqns. since
		C) Line 7600 contains the wrong index on CEDE. It should be	every isotope has a decay constant +
		CEDE(2). ~~This~~ The current line causes the total dose to be	there is not much sense in using the
		calculated incorrectly. See your sample output, last page.	code if there isn't a CTMT leak rate.
		D) other minor points are listed in the code listing. Your option to	However, another divide-by-zero check was
		include them.	added at what is now lines 2950, 3080, + 5080.
18	Handcalcs	Attached to the 3110 forms are 9 pages of independent hand calcs I	b) This has been corrected.
		performed to verify important parts of the codes operation. I modified	c) This has been corrected.
		a portion of the code to print out additional data. The modification is	d) Rest of the code has been left as is.
		attached as well as the output listing from my run of C1MCALC DATA.	⑱ No Resolution required.
		No problems found.	All Comments resolved
			Steven D. Winter 4 March 92

Reviewer	Organization	Date	Review Coordinator	Date	Document Sponsor	Date
Steven D. Winter	NESCO/R+SA/SA	28 Feb 92		3/2/92		3/2/92

using input deck C1MCALC DATA

Hand calculations performed on a Hewlett Packard HP-15C calculator.

ource deck echo appears to be accurate

2) Initial activities : Noble Gas $N_{CA_i}(0) = (\text{Power})(\text{Source Term})(\text{fraction to ctmt atm})$

Power = 2530 MWth fraction = 100% = 1.0 as input

Kr-83m $(2530)(2.998E3)(1.0) = 7.585E6$ Ci
Kr-85 $(2530)(2.999E3)(1.0) = 7.587E6$ Ci
Kr-89 $(2530)(1.993E4)(1.0) = 5.042E7$ Ci
Xe-131m $(2530)(1.760E2)(1.0) = 4.453E5$ Ci
Xe 135 $(2530)(9.781E3)(1.0) = 2.475E7$ Ci

match code-calculated values

Iodine $N_{CA}^{k} = (\text{Power})(\text{Source Term})(\text{fraction to ctmt atm})(\text{fraction into } k^{TH} \text{ form})$

I-131 elemental $(2530)(2.938E4)(0.25)(.955) = 1.775E7$
particulate $(2530)(2.938E4)(0.25)(0.025) = 4.646E5$
organic $(2530)(2.938E4)(0.25)(0.02) = 3.717E5$
1.859E7 Ci

I-135 elemental $(2530)(4.922E4)(0.25)(0.955) = 2.973E7$
particulate $(2530)(4.922E4)(0.25)(0.025) = 7.785E5$
organic $(2530)(4.922E4)(0.25)(0.02) = 6.226E5$
3.113E7 Ci

Iodine $N_{IS} = (\text{Power})(\text{Source term})(\text{fraction to ctmt sump})$

I-131 $(2530)(2.938E4)(0.50) = 3.717E7$ Ci
I-135 $(2530)(4.922E4)(0.50) = 6.226E7$ Ci

Match code-calculated values

3) @ time step 1

A) check Noble Gas concentration $N_{CA_i}(t) = N_{CA_i}(t_0)\, e^{-(\lambda_i+\lambda_L)t}$ $\lambda_L = \cdot 1/(100\%)(24)(60) = 6.9444E\text{-}7\ min^{-1}$

$$\left.\begin{array}{lll} 1 & \text{Kr-83m} & (.7588E7)\ (.9938) = .7538E7 \\ 3 & \text{Kr-85} & (.7587E6)\ (.999999) = .7587E6 \\ 6 & \text{Kr-89} & (.5042E8)\ (.8024) = .4046E8 \\ 7 & \text{Xe-131m} & (.4453E5)\ (.99996) = .4453E5 \\ 11 & \text{Xe-135} & (.2475E8)\ (.9987) = .2472E8 \end{array}\right\} \text{- match code output values}$$

B) Noble Gas Leakage from ctmt atmosphere $Q_{CA_i}(t) = \dfrac{\lambda_L N_{CA_i}(t_0)}{\lambda_i+\lambda_L}\left[1-e^{-(\lambda_i+\lambda_L)\Delta t}\right]$

$$\left.\begin{array}{llll} 1 & \text{Kr-83m} & \dfrac{(6.9444E\text{-}7)(.7585E7)}{(\lambda_i+6.9444E\text{-}7)}\left[1-e^{-(\lambda_i+\lambda_L)\Delta t}\right] & = 0.5251E1\ Ci \\ 3 & \text{Kr-85} & \dfrac{\lambda_L\ (.7587E6)}{\lambda_i+\lambda_L}\left[1-e^{-(\lambda_i+\lambda_L)\Delta t}\right] & = 0.5268E0\ Ci \\ 6 & \text{Kr-89} & \text{using the same eqn} & = 0.3143E2\ Ci \\ 7 & \text{Xe-131m} & '' & = 0.3092E0\ Ci \\ 11 & \text{Xe-135} & '' & = 0.1718E2\ Ci \end{array}\right\} \text{- code output values match these.}$$

C) Dose calculations for Noble Gas

Site Boundary: $DDETH(1) = \sum Q_i \left(\frac{\chi}{Q}\right)^{SB}_i DCF_1^i = \left(\frac{\chi}{Q}\right)^{SB} \sum_i Q_i\, DCF_1^i$

$DEWB(1) = \sum Q_i \left(\frac{\chi}{Q}\right)^{SB}_i DCF_2^i = \left(\frac{\chi}{Q}\right)^{SB} \sum_i Q_i\, DCF_2^i$

LPZ $DDETH(2) = \sum Q_i \left(\frac{\chi}{Q}\right)^{LPZ}_i DCF_1^i = \left(\frac{\chi}{Q}\right)^{LPZ} \sum_i Q_i\, DCF_1^i$

$DEWB(2) = \sum Q_i \left(\frac{\chi}{Q}\right)^{LPZ}_i DCF_2^i = \left(\frac{\chi}{Q}\right)^{LPZ} \sum_i Q_i\, DCF_2^i$

* isotopes with non-zero DCF_1 will contribute to DDETH(1) and DDETH(2)

	Q	DCF_1	$Q * DCF_1$
KR-85m	0.1140E2	1.233E-3	1.406E-2
KR-87	0.2020E2	5.550E-3	1.121E-1
KR-88	0.2963E2	1.439E-2	4.264E-1
Xe-133m	0.3433E1	4.317E-4	1.482E-3
Xe-138	0.7602E2	7.811E-3	5.938E-1

$(\chi/Q)^{SB}$ DDETH(1)

$\boxed{1.148E0} * 1.55E\text{-}4 = 1.779E\text{-}4 \approx 1.843E\text{-}4$ as calculated by the code*

* Round off errors account for the difference.

$(\chi/Q)^{LPZ}$ DDETH(2)

$1.148E0 * 1.09E\text{-}5 = 1.251E\text{-}5 \approx 1.296E\text{-}5$ as calculated by the code*

* isotopes with non-zero DCF_2 will contribute to DEWB(1) and DEWB(2)

~~KR~~	Q_i	DCF_2	$Q_i * DCF_2$
KR-83m	0.5251E1	3.649E-6	1.916E-5
KR-85m	0.1140E2	1.269E-3	1.447E-2
KR-85	0.5269E0	2.314E-5	1.219E-5
KR-87	0.2020E2	5.684E-3	1.148E-1
KR-88	0.2963E2	1.402E-2	4.154E-1
Xe-131m	0.3092E0	1.915E-4	5.921E-5
Xe-133m	0.3433E1	3.823E4	1.312E-3
Xe-133	0.9923E2	3.361E4	3.335E-2
Xe-135m	0.2917E2	3.618E-3	1.055E-1
Xe-135	0.1717E2	7.914E-3	1.359E-1
Xe-138	0.7602E2	7.801E-3	5.930E-1
			1.414E0

$$1.414E0 \ * \ \underset{1.55E-4}{\left(\frac{\chi}{Q}\right)^{SB}} = 2.192E-4 \approx 2.192E-4 \ \boxed{DEWB(1)}$$

Code appears to calculate the correct number

$$1.414E0 \ * \ \underset{\left(\frac{\chi}{Q}\right)^{LPZ}_{0-8}}{1.09E-5} = 1.541E-5 \approx 1.541E-5 \ \boxed{DEWB(2)}$$

D) Iodine Calculations (spray starts at 1 minute, thus, for the first time step, the simple decay/leakage eqns are $\boxed{N_{IA}(t) = N_{IA}(t_0)\, e^{-(\lambda_i+\lambda_c)\Delta t}}$ valid)

I-131
- elemental 1.775E7 (.999939) = 1.775E7
- particulate 4.646E5 (.999939) = 4.646E5
- organic 3.717E5 (.999939) = 3.717E5

} match code output

$\boxed{1.859E7}$ – matches code output @ 1 minute

I-135
- elemental 2.973E7 (0.9982) = 2.968E7
- particulate 7.785E5 (0.9982) = 7.771E5
- organic 6.226E5 (0.9982) = 6.215E5

$\boxed{3.108E7}$ – matches code output @ 1 minute

Release of Iodine

$$Q_{CAI}(t) = \sum_{K=1}^{3} \frac{\lambda_L N_{CAi}^{k}(t_0)}{(\lambda_i+\lambda_L+\lambda_s^k)} \left[1-e^{-(\lambda_i+\lambda_L+\lambda_s^k)\Delta t}\right]$$

NOTE

Round off errors will cause slight differences between the hand calcs and the code-generated results

For 0 to 1 minute, $\lambda_s^k = 0$ as no spray flow has occurred

$$\left(\frac{\lambda_L}{\lambda_i+\lambda_L}\right)\left[1-e^{-(\lambda_i+\lambda_L)\Delta t}\right] = 6.944E-7 \text{ for I-131}$$

6.938E-7 for I-135

I-131 elemental $1.775E7\,(6.944E{-7}) = 1.233E{+1}$

particulate $4.646E5\,(6.944E{-7}) = 3.226E{-1}$

organic $3.717E5\,(6.944E{-7}) = 2.581E{-1}$

$\boxed{1.291E1}$ ← matches code-calculated QIA

I-135 elemental $2.973E7\,(6.938E{-7}) = 2.063E1$

particulate $7.785E5\,(6.938E{-7}) = 5.401E{-1}$

organic $6.226E5\,(6.938E{-7}) = 4.320E{-1}$

$\boxed{2.160E1}$ ←

Doses due to Iodine → since Recirculation has not started @ this timestep, releases and doses from ESF rooms and SIRWT should be zero. The code output supports this.

Site Boundary:

$$CDECA(1) = \sum_{1}^{5} Q_{IA_i}(BR)\left(\frac{\chi}{Q}\right)^{SB} DCF_1 = BR\left(\frac{\chi}{Q}\right)^{SB} \sum Q_{IA_i}\, DCF_1^i$$

$$CEDECA(1) = \sum_{1}^{5} Q_{IA_i}(BR)\left(\frac{\chi}{Q}\right)^{SB} DCF_2 = BR\left(\frac{\chi}{Q}\right)^{SB} \sum Q_{IA_i}\, DCF_2^i$$

LPZ:

$$CDECA(2) = \sum_{1}^{5} Q_{IA_i}(BR)\left(\frac{\chi}{Q}\right)^{LPZ} DCF_1 = BR\left(\frac{\chi}{Q}\right)^{LPZ}_{0-8} \sum Q_{IA_i}\, DCF_1^i$$

$$CEDECA(2) = \sum_{1}^{5} Q_{IA_i}(BR)\left(\frac{\chi}{Q}\right)^{LPZ} DCF_2 = BR\left(\frac{\chi}{Q}\right)^{LPZ}_{0-8} \sum Q_{IA_i}\, DCF_2^i$$

	Q_i	DCF_1^i		$Q*DCF$
I-131	0.1290E2	1.073E6	=	1.384E7
I-132	0.1893E2	6.290E3	=	1.191E5
I-133	0.2111E2	1.813E5	=	3.827E6
I-134	0.2713E2	1.073E3	=	2.911E4
I-135	0.2160E2	3.145E4	=	6.793E5

BR $\left(\frac{\chi}{Q}\right)^{SB}$

$1.849E7 * 3.47E{-4} * 1.55E{-4} = 0.9947$ matches $CDECA_1$ @ t=1 min

$1.849E7 * 3.47E{-4} * 1.09E{-5} = 0.6993$ " $CDECA_2$ @ t=1 min

$\left(\frac{\chi}{Q}\right)^{LPZ}_{0-8}$

	Q_i	DCF_2^i	$Q*DCF$
I-131	0.1290E2	3.256E4	4.200E5
I-132	0.1893E2	3.367E2	6.374E3
I-133	0.2111E2	5.550E3	1.172E5
I-134	0.2713E2	1.106E2	3.001E3
I-135	0.2160E2	1.121E3	2.421E4

BR $\left(\frac{\chi}{Q}\right)^{SB}$

$5.708E5 * 3.47E{-4} * 1.55E{-4} = \boxed{3.070E{-2}}$ matches $CEDE_1$

$* 3.47E{-4} * 1.09E{-5} = \boxed{2.159E{-3}}$ matches $CEDE_2$

Sump Iodine → since no recirculation occurs during this time step, the only change in ctmt sump activity will be caused by decay

$$\begin{array}{lll} & \underline{\text{Initial}} & \\ \text{I-131} & .3717E8 \; e^{-\lambda_i 1} = .3717E8 & \text{w/in limits of the calculator} \\ \text{I-135} & .6226E8 \; e^{-\lambda_i 1} = .6215E8 & \end{array} \Bigg\} \text{- match code output.}$$

4) At time step 2 (2 minutes ⇒ will get some spray removal of iodine)

This is necessary to check code operation with the second set of internal equations (i.e. the ones used for all time steps but the first.

A) Noble Gas concentration (activity level @ end of time step 1) $e^{-(\lambda_i+\lambda_L)1}$

1 KR-83m .7538E7 (0.9938) = .7491E7
3 Kr-85 .7587E6 (0.999999) = .7587E6
6 Kr-89 .4046E8 (.8024) = .3247E8
7 Xe-131m .4453E6 (.99996) = .4453E6
11 Xe-135 .2471E8 (.9987) = .2468E8

} - matches code values

B) Noble Gas release (activity from end of time step 1) $\frac{\lambda_L}{\lambda_i+\lambda_L}\left[1-e^{-(\lambda_i+\lambda_L)1}\right]$

1 KR-83m .7538E7 (6.923E-7) = 5.218E0
3 Kr-85 .7587E6 (6.944E-7) = 5.269E-1
6 Kr-89 .4046E8 (6.239E-7) = 2.522E1
7 Xe-131m .4453E6 (6.944E-7) = 3.092E-1
11 Xe-135 .2471E8 (6.940E-7) = 1.715E1

} - matches code values

c) Noble Gas Doses

	Q	DCF₁	Q * DCF₁
Kr-85m	.1137E2	1.233E-3	1.402E-2
Kr-87	.2002E2	5.550E-3	1.111E-1
Kr-88	.2951E2	1.439E-2	4.246E-1
Xe-133m	.3432E1	4.317E-4	1.482E-3
Xe-138	.7239E2	7.811E-3	5.654E-1
			1.117

$$(1.117)\overset{(\chi/Q)^{SB}}{(1.55E-4)} = 1.731E-4 + \underset{\text{prior time}}{\overset{\text{Dose From}}{1.843E-4}} = 3.574 \approx 3.638E-4 \quad \text{DDETH(1)}$$

code values

$$(1.117)\overset{(\chi/Q)^{LPZ}_{0-8}}{(1.09E-5)} = 1.218E-5 + 0.1296E-4 = 2.514E-5 \approx 2.559E-5 \quad \text{DDETH(2)}$$

Noble Gas Doses, cont'd

	Q	OCF_3	Q×OCF
Kr-83m	0.5218E1	3.649E-6	1.904E-5
Kr-85m	0.1137E2	1.269E-3	1.443E-2
Kr-85	0.5269	2.314E-5	1.219E-5
Kr-87	0.2002E2	5.684E-3	4.633E-4
Kr-88	0.2951E2	1.402E-2	4.137E-1
Xe-131m	0.3092	1.915E-4	5.921E-5
Xe-133m	0.3432E1	3.823E-4	1.312E-3
Xe-133	0.9922E2	3.361E-4	3.335E-2
Xe-135m	0.2788E2	3.618E-3	1.009E-1
Xe-135	0.1715E2	7.914E-3	1.357E-1
Xe-138	0.7239E2	7.801E-3	5.647E-1
			1.265

$\left(\frac{\chi}{Q}\right)^{SB}$

1.265 × 1.55E-4 = 1.961E-4 + 0.2192E-3 = $\boxed{4.153E-4}$

× 1.09E-5 = 1.399E-5 + 0.1541E-4 = $\boxed{2.92E-5}$

$\left(\frac{\chi}{Q}\right)^{LPZ}_{0-8}$

close to computer calculated values

4.328E-3

3.043E-5

D) Iodine Calculations, must use spray $\lambda_s^1 = 0.42\ hr^{-1} = 7.0E-3\ min^{-1}$ $\lambda_s^2 = 1\ hr^{-1} = 1.667E-2$ $\lambda_s^3 = \emptyset$

		$N_{IA}(t_0)$		
I-131	elemental	0.1775E8	(.993) =	1.763E7
	particulate	0.4645E6	(.9834) =	4.568E5
	organic	0.3716E6	(.99994) =	3.716E5
				1.846E7 Ci

matches code values

I-135	elemental	0.2968E8	(.9913) =	2.942E7
	particulate	0.7769E6	(.9817) =	7.627E5
	organic	0.6215E6	(.9982) =	6.204E5
				3.080E7

matches code values

Releases

I-131 elemental 0.1775E8 (6.920E-7) = 1.228E1
particulate 0.4645E6 (6.887E-7) = 3.199E-1
organic 0.3716E6 (6.944E-7) = 2.580E-1
→ Σ = 1.286E1

I-135 elemental 0.2968E8 (6.914E-7) = 2.052E1
particulate 0.7769E6 (6.881E-7) = 5.346E-1
organic 0.6215E6 (6.938E-7) = 4.312E-1
→ Σ = 2.149E1

Both match code output.

Doses due to the Iodine no releases from ESF Rooms & SIRWT.

ite Boundary

	Q_i	DCF_1	$Q*DCF_1$
I-131	.1286E2	1.073E6	1.380E7
I-132	.1807E2	6.290E3	1.137E5
I-133	.2103E2	1.813E5	3.813E6
I-134	.2668E2	1.073E3	2.863E4
I-135	.2149E2	3.145E4	6.759E5
			1.843E7

BR $\left(\frac{\chi}{Q}\right)^{SB}$

$1.843E7 * 3.47E\text{-}4 * 1.556\text{-}4 = 0.9913 + .9949 = \boxed{1.986 \checkmark}$

$* 3.47E\text{-}4 * 1.09E\text{-}5 = 6.971E\text{-}2 + .6996E\text{-}1 = \boxed{1.397E\text{-}1 \checkmark}$

$\left(\frac{\chi}{Q}\right)^{LPZ}_{0\text{-}8}$

	Q	DCF_2	$Q*DCF$
I-131	.1286E2	3.256E4	4.187E5
I-132	.1807E2	3.367E2	6.084E3
I-133	.2103E2	5.550E3	1.167E5
I-134	.2668E2	1.106E2	2.951E3
I-135	.2149E2	1.121E3	2.409E4
			5.685E5

Values from previous time step

Matches Code Output

$\left(\frac{\chi}{Q}\right)^{SB}$

$5.685E5 * 3.47E\text{-}4 * 1.55E\text{-}4 = 3.058E\text{-}2 + .3069E\text{-}1 = \boxed{6.127E\text{-}2 \checkmark}$

$* 3.47E\text{-}4 * 1.09E\text{-}5 = 2.150E\text{-}3 + .2159E\text{-}2 = \boxed{4.309E\text{-}3 \checkmark}$

$\left(\frac{\chi}{Q}\right)^{LPZ}_{0\text{-}8}$

Sump Iodine → because recirculation does not occur during this time step, only radioactive decay will reduce I.

I-131 $0.3716E8 \; e^{-\lambda \cdot 1} = .3716E8$

I-135 $0.6215E8 \; e^{-\lambda \cdot 1} = .6204E8$

} matches code output

5) Verification of elemental spray removal coefficient

@18 minutes $N_{AI}^{1} = .1975E7\ Ci$

$N_{AI}^{1} = .1975E7 \; e^{-(\lambda_i + \lambda_L + .1667)} = .1672E7\ Ci$ → exactly what is found @ 19 minutes

spray removal coeff changes correctly

6) Verification of Sump-related data and other quantities using data @ 29 and 30 minutes into event.

A) Iodine activity in the sump $N_{SI}(30) = N_{SI}(29)\left[\frac{V_{sump}(29) - (LR_{ESF} + LR_{SRW})\,\Delta t}{V_{sump}(29)}\right] e^{-\lambda_i 1}$

$$N_{SI}(30) = 0.3710E8\left[\frac{40{,}300 - (5.347E{-}2 + 1.3368E{-}1)\,11}{40{,}300}\right] e^{-\lambda_i}$$

↳ since recirc started @ 19 minutes, we can use initial sump volume and set Δt = 11 minutes

$= \boxed{0.3710E8}$ virtually no change, matches code value

B) ESF ~~leakage~~ release $Q_{IESF}(30) = N_{Si}(29)\left[\frac{LR_{ESF}}{DF_{ESF}\,PF_{ESF}\,V_S(29)\,\lambda_i}\right]\left[1 - e^{-\lambda_i}\right]$

$$Q_{IESF}(30) = N_{Si}(29)\left[\frac{5.347E{-}2}{2 \cdot 10 \cdot (40300 - (5.347E{-}2 + 1.3368E{-}1)\,10)\,\lambda_i}\right]\left[1 - e^{-\lambda_i}\right]$$

$= \boxed{0.2461E0}$ - matches code value

C) Activity in SIRWT $A_{SRW}(30) = \left[A_{SRW}(29) - Q_{SRW}(29)\right] e^{-\lambda_i} + \frac{LR_{SRW}\;N_{SI}(29)}{(V_S - 1.872)\,\lambda_i}\left[1 - e^{-\lambda_i}\right]$

$$A_{SRW}(30) = \left[0.1231E4 - 0.2546E{-}2\right] e^{-\lambda_i} + \frac{(.13368)(0.3710E8)}{(40300 - 1.872)\,\lambda_i}\left[1 - e^{-\lambda_i}\right]$$

$= \boxed{0.1354E4}$ matches code value

D) Activity of volatile iodine $A_{I2}(30) = \left[A_{I2}(29) - Q_{SRW}(29)\right] e^{-\lambda_i} + \frac{f_{I2}(LR_{SRW})(N_{SI}(29))}{V_{sump}(29)\;\lambda_i}\left[1 - e^{-\lambda_i}\right]$

$$A_{I2}(30) = \left[0.3692E3 - 0.2546E{-}2\right] e^{-\lambda_i} + \frac{(3.0E{-}1)(.13368)(.3710E8)}{(40300 - 1.872)\;\lambda_i}\left[1 - e^{-\lambda_i}\right]$$

$= \boxed{0.4061E3}$ matches code value

E) Q_{SRW} and C_{AIR} $C_{AIR}(30) = \frac{A_{I2}(30)}{V_{air}(30) + PF_{SRW}\,(V_{liq}(30))}$

$$C_{air}(30) = \frac{0.4061E3}{38767.2} = 1.048E{-}2$$

$Q_{SRW} = C_{air}\;LR_{SRW}\;k_D\;\Delta t \doteq (1.048E{-}2)(0.13368)(2) = \boxed{2.801E{-}3}$ matches code value.

7) Verification of LPZCHI change after 480 minutes

$\left(\frac{X}{Q}\right)^{LPZ}$ is used in the calculation of DDETH (2), DEWB(2), CDECA(2), CDESF(2), CDESRW(2), CDETH(2), etc...

Use noble gas DDETH(2) to check

@ 720 minutes, the following ~~dose is calculated~~ data are available:

	Q	DCF₁	Q × DCF₁
Kr-85m	0.1784E1	1.233E-3	2.200E-3
Kr-87	0.2867E-1	5.550E-3	1.591E-4
Kr-88	0.1590E1	1.439E-2	2.288E-2
Xe-133m	0.2929E1	4.317E-4	1.264E-3
Xe-138	0.4359E-13	7.811E-3	3.405E-16

$$2.650E-2 \times 6.94E-6 = 1.839E-7 + \underset{0.165E-2}{\overset{\boxed{719\ min}}{DDETH(2)}} = \boxed{0.1650E-2}$$

matches code output

8) Verification of cessation of SIRWT leakage after 1440 seconds

Equation for volatile iodine inside ~~tank~~ SIRWT (A_{I2}) uses LR_{SRW} $A_{I2}(1800) = \left[A_{I2}(1799) - Q_{SRW}(1799)\right]e^{-\lambda_i} + LR_{SRW}\left(\begin{matrix}other\\stuff\end{matrix}\right)$

I-131 $A_{I2}(1800) = \left[0.4696E5 - 0.00\right]e^{-\lambda_i} = \boxed{0.4696E5}$ matches code output

↳ no release from the SIRWT ie LR_{SRW} is zero. Since there is no inflow of liquid, there is no outflow of air per the assumptions of this model.

F059 1594

C1MCALC.DAT

$$\lambda_L = \left(0.10\,\%/day\right)\left(\frac{1}{100\%}\right)\left(\frac{day}{24\,hr}\right)\left(\frac{hr}{60\,min}\right)$$

$$= 6.9444E-7\ min^{-1}$$

```
Title CASE 1: BENCHMARK RUN OF MHACALC CODE
Debug 1
Duration 43200
   2530.0 Power MWt    0.10 Ctmt LR %/day   40304.5 Vsump
    100.0 FNG noble Gas   25.0 FIA I→Atm   50.0 FIS I→sump
     95.5 FCF(1) elemental   2.5 FCF(2) particulate   2.0 FCF(3) organic      Kd       Vtank, ft3    Vsrw, liq ft3    FI2
      2.0 DFESF   10.0 PFESF    1.0 PFSRW      2.0    38767.2     3739.3    3.00E-01
 3.47E-04   1.75E-04   2.32E-04   Breath (1), (2), (3)
 1.55E-04   CHIEAB sec/m3
 1.09E-05   6.94E-06   2.58E-06   6.25E-07   LPZCHI (1), (2), (3), (4) sec/m3
     1.00 SPRAPR(1) particulate  0.000 SPRAPR(2) after a8% depletion   hr-1
start spray → 1 TEL(1)    0.420 SPRAEL(1) elemental hr-1
        5 TEL(2)   10.000 SPRAEL(2)
       19 TEL(3)    0.000 SPRAEL(3)
      720 TEL(4)    0.420 SPRAEL(4)
        0 TEL(5)    0.000 SPRAEL(5)
    25.57 DFmax         0 STOPSPRA
       19 TESF(1)     0.2 LRESF(1)     19 TSIRW(1) 1.000 LRSRW (1)
        0 TESF(2)     0.0  "  (2)    1440 TSIRW(2) 0.000  "  (2)
        0 TESF(3)     0.0  "  (3)       0 TSIRW(3) 0.000  "  (3)
        0 TESF(4)     0.0  "  (4)       0 TSIRW(4) 0.000  "  (4)
83m      2.998E+03  6.211E-03  0.000E-00  3.649E-06
r85m     6.498E+03  2.579E-03  1.233E-03  1.269E-03
r-85     2.999E+02  1.230E-07  0.000E-00  2.314E-05
r-87     1.155E+04  9.120E-03  5.550E-03  5.684E-03
Kr-88    1.690E+04  4.068E-03  1.439E-02  1.402E-02
Kr-89    1.993E+04  2.201E-01  0.000E-00  0.000E-00
-131m    1.760E+02  4.038E-05  0.000E-00  1.915E-04
e-133m   1.954E+03  2.198E-04  0.000E-00  3.823E-04
X [illegible]648E+04  9.169E-05  4.317E-04  3.361E-04
Xe [illegible]698E+04  4.530E-02  0.000E-00  3.618E-03
Xe-135   9.781E+03  1.271E-03  0.000E-00  7.914E-03
Xe-137   4.705E+04  1.800E-01  0.000E-00  0.000E-00
Xe-138   4.433E+04  4.881E-02  7.811E-03  7.801E-03
-131     2.938E+04  5.986E-05  1.073E+06  3.256E+04
-132     4.160E+04  5.045E-03  6.290E+03  3.367E+02
-133     4.808E+04  5.554E-04  1.813E+05  5.550E+03
-134     6.218E+04  1.318E-02  1.073E+03  1.106E+02
-135     4.922E+04  1.754E-03  3.145E+04  1.121E+03
       24 Intervals
     0.00 T2(1)     1.00 T2(2)     2.28       5.00      19.00      30.00      45.00      60.00
    75.00 T2(9)    90.00 T2(10)  105.00     120.00     135.00     150.00     165.00     180.00
   195.00 T2(17)  210.00        240.00     480.00     720.00    1440.00    1800.00    5760.00
 43200.00 T2(25)
       24 NPRINT printout intervals
        2 TPRINT(1)    3 TPRINT 2     5         19         30         45         60         75
       90          105           120        135        150        165        180        195
      210          240           480        720       1440       1800       5760      43200
```

1/hr = 1/60 min

0.42/hr = 7E-3   10/60 = .1667

Source(i), λ_i, DCF$_i$' thyroid, DCF$_i$ whole body.

value of Ø here indicates there should be no contribution to DDETH(1) and DDETH(2)

value of Ø here indicates there should be no contribution to DEWB(1) and DEWB(2)

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```
C     OUTPUT CONTAINMENT AND SIRW TANK ACTIVITY AT SPECIFIED TIMES      MHA06680
      IF (NPRINT.NE.0.AND.NPRINT.GE.KPRINT) THEN
         IF ((TPRINT(KPRINT).EQ.(J-1)).OR.(TPRINT(KPRINT).EQ.J).OR.
     +      (TPRINT(KPRINT).EQ.(J+1))) THEN
            WRITE(6,614) J
            DO 410 NUCLIDE=1,18
               IF (NUCLIDE.GT.13) THEN
                  WRITE(6,620) NUCNAME(NUCLIDE), NCA(NUCLIDE),
     +               NIS(NUCLIDE), ASRW(NUCLIDE)
                  WRITE(6,700) QIA(NUCLIDE), QIESF(NUCLIDE),
     +               QISRW(NUCLIDE), AI2(NUCLIDE)
                  WRITE(6,700) NIA(NUCLIDE,1), NIA(NUCLIDE,2),
     +               NIA(NUCLIDE,3), VSUMP
                  WRITE(6,701) QSTACK(NUCLIDE), Q(NUCLIDE)
               ELSE
                  WRITE(6,620) NUCNAME(NUCLIDE), NCA(NUCLIDE),
     +               QSTACK(NUCLIDE), Q(NUCLIDE)
                  WRITE(6,700) DDETH(1), DEWB(1), DDETH(2), DEWB(2)
               ENDIF
  410       CONTINUE
            WRITE(6,702)
            WRITE(6,700) CDECA(1), CDEESF(1), CDESRW(1), CDETH(1)
            WRITE(6,700) CEDECA(1), CEDEESF(1), CEDESRW(1), CEDE(1)
            WRITE(6,700) CDECA(2), CDEESF(2), CDESRW(2), CDETH(2)
            WRITE(6,700) CEDECA(2), CEDEESF(2), CEDESRW(2), CEDE(2)
            WRITE (6,621)
            IF (TPRINT(KPRINT).EQ.J) THEN
               KPRINT=KPRINT+1
            ENDIF
         ENDIF
      ENDIF
  700 FORMAT(8X,4(7X,E11.4))
  701 FORMAT(8X,2(7X,E11.4))
   02 FORMAT(/)

C     IF (NPRINT.NE.0.AND.NPRINT.GE.KPRINT.AND.TPRINT(KPRINT).EQ.J) THENMHA06690
C        WRITE(6,614) J                                                 MHA06700
C        DO 410 NUCLIDE=1,18                                            MHA06710
C           IF (NUCLIDE.GT.13) THEN                                     MHA06720
C              WRITE(6,620) NUCNAME(NUCLIDE), NCA(NUCLIDE),             MHA06730
C    +               NIS(NUCLIDE), ASRW(NUCLIDE)                        MHA06740
C           ELSE                                                        MHA06750
C              WRITE(6,620) NUCNAME(NUCLIDE), NCA(NUCLIDE)              MHA06760
C           ENDIF                                                       MHA06770
C 410    CONTINUE                                                       MHA06780
C        KPRINT=KPRINT+1                                                MHA06790
C        LPAGE=LPAGE+1                                                  MHA06800
C                                                                       MHA06810
C        INSERT PAGE BREAK AFTER ACTIVITY HAS BEEN PRINTED 2 TIMES      MHA06820
C        IF (LPAGE.EQ.2) THEN                                           MHA06830
C           WRITE (6,621)                                               MHA06840
C           LPAGE=0                                                     MHA06850
C        ENDIF                                                          MHA06860
C     ENDIF                                                             MHA06870
      DO 411 NUCLIDE = 14,18                                            MHA06880
         QIA(NUCLIDE)=0.0                                               MHA06890
         NCA(NUCLIDE)=0.0                                               MHA06900
  411 CONTINUE                                                          MHA06910
```

New Section

```
CASE 1: BENCHMARK RUN OF MHACALC CODE
  1
 43200
 2530.0      0.10   40304.5
  100.0      25.0      50.0
   95.5       2.5       2.0
    2.0      10.0       1.0       2.0   38767.2     3739.3   0.30E+00
0.35E-03  0.18E-03  0.23E-03
0.15E-03
0.11E-04  0.69E-05  0.26E-05  0.62E-06
   1.00     0.000
      1     0.420
      5    10.000
     19     0.000
    720     0.420
      0     0.000
  25.57         0
     19       0.2        19     1.000
      0       0.0      1440     0.000
      0       0.0         0     0.000
      0       0.0         0     0.000
0.300E+04 0.621E-02 0.000E+00 0.365E-05
0.650E+04 0.258E-02 0.123E-02 0.127E-02
0.300E+03 0.123E-06 0.000E+00 0.231E-04
0.116E+05 0.912E-02 0.555E-02 0.568E-02
0.169E+05 0.407E-02 0.144E-01 0.140E-01
0.199E+05 0.220E+00 0.000E+00 0.000E+00
0.176E+03 0.404E-04 0.000E+00 0.191E-03
0.195E+04 0.220E-03 0.000E+00 0.382E-03
0.565E+05 0.917E-04 0.432E-03 0.336E-03
0.170E+05 0.453E-01 0.000E+00 0.362E-02
0.978E+04 0.127E-02 0.000E+00 0.791E-02
0.471E+05 0.180E+00 0.000E+00 0.000E+00
0.443E+05 0.488E-01 0.781E-02 0.780E-02
0.294E+05 0.599E-04 0.107E+07 0.326E+05
0.416E+05 0.505E-02 0.629E+04 0.337E+03
0.481E+05 0.555E-03 0.181E+06 0.555E+04
0.622E+05 0.132E-01 0.107E+04 0.111E+03
0.492E+05 0.175E-02 0.315E+05 0.112E+04
     24
   0.00      1.00      2.28      5.00     19.00     30.00     45.00     60.00
  75.00     90.00    105.00    120.00    135.00    150.00    165.00    180.00
 195.00    210.00    240.00    480.00    720.00   1440.00   1800.00   5760.00
43200.00
     24
      2         3         5        19        30        45        60        75
     90       105       120       135       150       165       180       195
    210       240       480       720      1440      1800      5760     43200
 CASE 1: BENCHMARK RUN OF MHACALC CODE


                    INITIAL ACTIVITIES IN CONTAINMENT
```

```
TIME =      0 MIN           ACTIVITY IN CONTAINMENT

                     CTMT. ATM.          SUMP
                      ACTIVITY         ACTIVITY
       ISOTOPE          (Ci)             (Ci)
       --------      ----------       ----------
    -> Kr-83m        0.7585E+07
       Kr-85m        0.1644E+08
    -> Kr-85         0.7587E+06
       Kr-87         0.2922E+08
       Kr-88         0.4276E+08
    -> Kr-89         0.5042E+08
    -> Xe-131m       0.4453E+06
       Xe-133m       0.4944E+07
       Xe-133        0.1429E+09
       Xe-135m       0.4296E+08
    -> Xe-135        0.2475E+08
       Xe-137        0.1190E+09
       Xe-138        0.1122E+09
    -> I-131         0.1858E+08       0.3717E+08
       I-132         0.2631E+08       0.5262E+08
       I-133         0.3041E+08       0.6082E+08
       I-134         0.3933E+08       0.7866E+08
    -> I-135         0.3113E+08       0.6226E+08


TIME =      1 MIN           ACTIVITY IN CONTAINMENT AND SIRW TANK

                     CTMT. ATM.          SUMP           SIRW TANK
                      ACTIVITY         ACTIVITY          ACTIVITY
       ISOTOPE          (Ci)      NCA    (Ci)     QST ACK  (CI)
       --------      ----------  -OK  ----------       --------   Q
       Kr-83m        0.7538E+07       0.5251E+01OK     0.5251E+01
               0.1843E-03 ODETH1  0.2192E-03 DEWB1  0.1296E-04 ODETH2  0.1541E-04 DGWB2
   --> Kr-85m        0.1640E+08       0.1140E+02       0.1140E+02
               0.1843E-03         0.2192E-03        0.1296E-04         0.1541E-04
       Kr-85         0.7587E+06       0.5269E+00       0.5269E+00
               0.1843E-03         0.2192E-03        0.1296E-04         0.1541E-04
    -> Kr-87         0.2896E+08       0.2020E+02       0.2020E+02
               0.1843E-03         0.2192E-03        0.1296E-04         0.1541E-04
   --> Kr-88         0.4258E+08       0.2963E+02       0.2963E+02
               0.1843E-03         0.2192E-03        0.1296E-04         0.1541E-04
       Kr-89         0.4046E+08       0.3143E+02       0.3143E+02
               0.1843E-03         0.2192E-03        0.1296E-04         0.1541E-04
       Xe-131m       0.4453E+06       0.3092E+00       0.3092E+00
               0.1843E-03         0.2192E-03        0.1296E-04         0.1541E-04
    -> Xe-133m       0.4943E+07       0.3433E+01       0.3433E+01
               0.1843E-03         0.2192E-03        0.1296E-04         0.1541E-04
       Xe-133        0.1429E+09       0.9923E+02       0.9923E+02
               0.1843E-03         0.2192E-03        0.1296E-04         0.1541E-04
       Xe-135m       0.4106E+08       0.2917E+02       0.2917E+02
               0.1843E-03         0.2192E-03        0.1296E-04         0.1541E-04
       Xe-135        0.2471E+08 ok    0.1717E+02       0.1717E+02
               0.1843E-03         0.2192E-03        0.1296E-04         0.1541E-04
                                                          ok
```

```
 Xe-137          0.9943E+08          0.7565E+02          0.7565E+02
          0.1843E-03          0.2192E-03          0.1296E-04          0.1541E-04
→ Xe-138          0.1068E+09          0.7602E+02          0.7602E+02
          0.1843E-03          0.2192E-03          0.1296E-04          0.1541E-04
 I-131           0.1858E+08 NCA      0.3716E+08 NTS      0.0000E+00 ASRW
          0.1290E+02 QTA      0.0000E+00 QIESF     0.0000E+00 QIESRW    0.0000E+00 AT2
          0.1775E+08 NIA1     0.4645E+06 NIA2      0.3716E+06 NIA3      0.4030E+05 VCONT
          0.1290E+02 QSTACK   0.1290E+02 Q
 I-132           0.2618E+08          0.5236E+08          0.0000E+00
          0.1823E+02          0.0000E+00          0.0000E+00          0.0000E+00
          0.2500E+08          0.6545E+06          0.5236E+06          0.4030E+05
          0.1823E+02          0.1823E+02
 I-133           0.3039E+08          0.6079E+08          0.0000E+00
          0.2111E+02          0.0000E+00          0.0000E+00          0.0000E+00
          0.2903E+08          0.7598E+06          0.6079E+06          0.4030E+05
          0.2111E+02          0.2111E+02
 I-134           0.3881E+08          0.7763E+08          0.0000E+00
          0.2713E+02          0.0000E+00          0.0000E+00          0.0000E+00
          0.3707E+08          0.9703E+06          0.7763E+06          0.4030E+05
          0.2713E+02          0.2713E+02
 I-135           0.3108E+08          0.6215E+08          0.0000E+00
          0.2160E+02          0.0000E+00          0.0000E+00          0.0000E+00
          0.2968E+08          0.7769E+06          0.6215E+06          0.4030E+05
          0.2160E+02          0.2160E+02


          0.9949E+00 COSCA    0.0000E+00 CDESSP    0.0000E+00 CDESRW    0.9949E+00 CDFTH
          0.3069E-01 CLOSCA   0.0000E+00 CLOESSP   0.0000E+00 CLOESRW   0.3069E-01 CLO4
          0.6996E-01 )-2      0.0000E+00 )-2       0.0000E+00 )-2       0.6996E-01 )-2
          0.2159E-02          0.0000E+00           0.0000E+00           0.2159E-02



TIME =      2 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                      CTMT. ATM.            SUMP            SIRW TANK
                       ACTIVITY           ACTIVITY          ACTIVITY
 ISOTOPE                 (Ci)               (Ci)              (CI)
 --------             ----------         ----------         --------
 Kr-83m              0.7491E+07          0.5218E+01          0.5218E+01
          0.3638E-03          0.4328E-03          0.2559E-04          0.3043E-04
 Kr-85m              0.1636E+08          0.1137E+02          0.1137E+02
          0.3638E-03          0.4328E-03          0.2559E-04          0.3043E-04
 Kr-85               0.7587E+06          0.5269E+00          0.5269E+00
          0.3638E-03          0.4328E-03          0.2559E-04          0.3043E-04
 Kr-87               0.2869E+08          0.2002E+02          0.2002E+02
          0.3638E-03          0.4328E-03          0.2559E-04          0.3043E-04
 Kr-88               0.4241E+08          0.2951E+02          0.2951E+02
          0.3638E-03          0.4328E-03          0.2559E-04          0.3043E-04
 Kr-89               0.3247E+08          0.2522E+02          0.2522E+02
          0.3638E-03          0.4328E-03          0.2559E-04          0.3043E-04
 Xe-131m             0.4452E+06          0.3092E+00          0.3092E+00
          0.3638E-03          0.4328E-03          0.2559E-04          0.3043E-04
 Xe-133m             0.4941E+07          0.3432E+01          0.3432E+01
```

```
** FILE: C1MCALC.LST                                        Created: 02/26/9    :14
** PAGE: 2   of 28 .  Length: 195230    bytes.              Queued:  02/26/92   :22
****************************** Lines    111 to 220    ******************************
          0.3638E-03          0.4328E-03          0.2559E-04          0.3043E-04
 Xe-133              0.1429E+09          0.9922E+02          0.9922E+02
          0.3638E-03          0.4328E-03          0.2559E-04          0.3043E-04
 Xe-135m             0.3924E+08          0.2788E+02          0.2788E+02
          0.3638E-03          0.4328E-03          0.2559E-04          0.3043E-04
 Xe-135              0.2468E+08          0.1715E+02          0.1715E+02
          0.3638E-03          0.4328E-03          0.2559E-04          0.3043E-04
 Xe-137              0.8305E+08          0.6319E+02          0.6319E+02
          0.3638E-03          0.4328E-03          0.2559E-04          0.3043E-04
 Xe-138              0.1017E+09          0.7239E+02          0.7239E+02
          0.3638E-03          0.4328E-03          0.2559E-04          0.3043E-04
 I-131               0.1845E+08          0.3716E+08          0.0000E+00
          0.1286E+02          0.0000E+00          0.0000E+00          0.0000E+00
          0.1762E+08          0.4568E+06          0.3716E+06          0.4030E+05
          0.1286E+02          0.1286E+02
 I-132               0.2586E+08          0.5210E+08          0.0000E+00
          0.1807E+02          0.0000E+00          0.0000E+00          0.0000E+00
          0.2470E+08          0.6404E+06          0.5210E+06          0.4030E+05
          0.1807E+02          0.1807E+02
 I-133               0.3016E+08          0.6075E+08          0.0000E+00
          0.2103E+02          0.0000E+00          0.0000E+00          0.0000E+00
          0.2881E+08          0.7469E+06          0.6075E+06          0.4030E+05
          0.2103E+02          0.2103E+02
 I-134               0.3803E+08          0.7661E+08          0.0000E+00
          0.2668E+02          0.0000E+00          0.0000E+00          0.0000E+00
          0.3633E+08          0.9418E+06          0.7661E+06          0.4030E+05
          0.2668E+02          0.2668E+02
 I-135               0.3080E+08          0.6205E+08          0.0000E+00
          0.2149E+02          0.0000E+00          0.0000E+00          0.0000E+00
          0.2942E+08          0.7627E+06          0.6205E+06          0.4030E+05
          0.2149E+02          0.2149E+02


          0.1986E+01          0.0000E+00          0.0000E+00          0.1986E+01
          0.6127E-01          0.0000E+00          0.0000E+00          0.6127E-01
          0.1397E+00          0.0000E+00          0.0000E+00          0.1397E+00
          0.4309E-02          0.0000E+00          0.0000E+00          0.4309E-02



TIME =      3 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                      CTMT. ATM.            SUMP            SIRW TANK
                       ACTIVITY           ACTIVITY          ACTIVITY
 ISOTOPE                 (Ci)               (Ci)              (CI)
 --------             ----------         ----------         --------
 Kr-83m              0.7445E+07          0.5186E+01          0.5186E+01
          0.5387E-03          0.6410E-03          0.3788E-04          0.4508E-04
 Kr-85m              0.1631E+08          0.1134E+02          0.1134E+02
          0.5387E-03          0.6410E-03          0.3788E-04          0.4508E-04
 Kr-85               0.7587E+06          0.5269E+00          0.5269E+00
          0.5387E-03          0.6410E-03          0.3788E-04          0.4508E-04
 Kr-87               0.2843E+08          0.1984E+02          0.1984E+02
          0.5387E-03          0.6410E-03          0.3788E-04          0.4508E-04
```

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Kr-88            0.4224E+08       0.2939E+02       0.2939E+02
       0.5387E-03       0.6410E-03       0.3788E-04       0.4508E-04
Kr-89            0.2605E+08       0.2024E+02       0.2024E+02
       0.5387E-03       0.6410E-03       0.3788E-04       0.4508E-04
Xe-131m          0.4452E+06       0.3092E+00       0.3092E+00
       0.5387E-03       0.6410E-03       0.3788E-04       0.4508E-04
Xe-133m          0.4940E+07       0.3431E+01       0.3431E+01
       0.5387E-03       0.6410E-03       0.3788E-04       0.4508E-04
Xe-133           0.1429E+09       0.9921E+02       0.9921E+02
       0.5387E-03       0.6410E-03       0.3788E-04       0.4508E-04
Xe-135m          0.3750E+08       0.2664E+02       0.2664E+02
       0.5387E-03       0.6410E-03       0.3788E-04       0.4508E-04
Xe-135           0.2465E+08       0.1713E+02       0.1713E+02
       0.5387E-03       0.6410E-03       0.3788E-04       0.4508E-04
Xe-137           0.6937E+08       0.5278E+02       0.5278E+02
       0.5387E-03       0.6410E-03       0.3788E-04       0.4508E-04
Xe-138           0.9688E+08       0.6895E+02       0.6895E+02
       0.5387E-03       0.6410E-03       0.3788E-04       0.4508E-04
I-131            0.1832E+08       0.3716E+08       0.0000E+00
       0.1277E+02       0.0000E+00       0.0000E+00       0.0000E+00
       0.1750E+08       0.4493E+06       0.3716E+06       0.4030E+05
       0.1277E+02       0.1277E+02
I-132            0.2555E+08       0.5183E+08       0.0000E+00
       0.1785E+02       0.0000E+00       0.0000E+00       0.0000E+00
       0.2441E+08       0.6267E+06       0.5183E+06       0.4030E+05
       0.1785E+02       0.1785E+02
I-133            0.2993E+08       0.6072E+08       0.0000E+00
       0.2087E+02       0.0000E+00       0.0000E+00       0.0000E+00
       0.2859E+08       0.7341E+06       0.6072E+06       0.4030E+05
       0.2087E+02       0.2087E+02
I-134            0.3727E+08       0.7561E+08       0.0000E+00
       0.2615E+02       0.0000E+00       0.0000E+00       0.0000E+00
       0.3560E+08       0.9141E+06       0.7561E+06       0.4030E+05
       0.2615E+02       0.2615E+02
I-135            0.3053E+08       0.6194E+08       0.0000E+00
       0.2130E+02       0.0000E+00       0.0000E+00       0.0000E+00
       0.2916E+08       0.7488E+06       0.6194E+06       0.4030E+05
       0.2130E+02       0.2130E+02


       0.2970E+01       0.0000E+00       0.0000E+00       0.2970E+01
       0.9162E-01       0.0000E+00       0.0000E+00       0.9162E-01
       0.2088E+00       0.0000E+00       0.0000E+00       0.2088E+00
       0.6443E-02       0.0000E+00       0.0000E+00       0.6443E-02



TIME =     4 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                 CTMT. ATM.          SUMP          SIRW TANK
                  ACTIVITY         ACTIVITY         ACTIVITY
ISOTOPE             (Ci)             (Ci)             (CI)
--------         ----------       ----------       --------
Kr-83m           0.7399E+07       0.5154E+01       0.5154E+01
```

```
       0.7092E-03       0.8442E-03       0.4987E-04       0.5937E-04
Kr-85m           0.1627E+08       0.1131E+02       0.1131E+02
       0.7092E-03       0.8442E-03       0.4987E-04       0.5937E-04
Kr-85            0.7587E+06       0.5269E+00       0.5269E+00
       0.7092E-03       0.8442E-03       0.4987E-04       0.5937E-04
Kr-87            0.2817E+08       0.1966E+02       0.1966E+02
       0.7092E-03       0.8442E-03       0.4987E-04       0.5937E-04
Kr-88            0.4207E+08       0.2927E+02       0.2927E+02
       0.7092E-03       0.8442E-03       0.4987E-04       0.5937E-04
Kr-89            0.2091E+08       0.1624E+02       0.1624E+02
       0.7092E-03       0.8442E-03       0.4987E-04       0.5937E-04
Xe-131m          0.4452E+06       0.3092E+00       0.3092E+00
       0.7092E-03       0.8442E-03       0.4987E-04       0.5937E-04
Xe-133m          0.4939E+07       0.3430E+01       0.3430E+01
       0.7092E-03       0.8442E-03       0.4987E-04       0.5937E-04
Xe-133           0.1428E+09       0.9920E+02       0.9920E+02
       0.7092E-03       0.8442E-03       0.4987E-04       0.5937E-04
Xe-135m          0.3584E+08       0.2546E+02       0.2546E+02
       0.7092E-03       0.8442E-03       0.4987E-04       0.5937E-04
Xe-135           0.2462E+08       0.1711E+02       0.1711E+02
       0.7092E-03       0.8442E-03       0.4987E-04       0.5937E-04
Xe-137           0.5794E+08       0.4409E+02       0.4409E+02
       0.7092E-03       0.8442E-03       0.4987E-04       0.5937E-04
Xe-138           0.9226E+08       0.6566E+02       0.6566E+02
       0.7092E-03       0.8442E-03       0.4987E-04       0.5937E-04
I-131            0.1819E+08       0.3716E+08       0.0000E+00
       0.1268E+02       0.0000E+00       0.0000E+00       0.0000E+00
       0.1737E+08       0.4418E+06       0.3716E+06       0.4030E+05
       0.1268E+02       0.1268E+02
I-132            0.2524E+08       0.5157E+08       0.0000E+00
       0.1764E+02       0.0000E+00       0.0000E+00       0.0000E+00
       0.2411E+08       0.6132E+06       0.5157E+06       0.4030E+05
       0.1764E+02       0.1764E+02
I-133            0.2970E+08       0.6069E+08       0.0000E+00
       0.2071E+02       0.0000E+00       0.0000E+00       0.0000E+00
       0.2838E+08       0.7216E+06       0.6069E+06       0.4030E+05
       0.2071E+02       0.2071E+02
I-134            0.3652E+08       0.7462E+08       0.0000E+00
       0.2562E+02       0.0000E+00       0.0000E+00       0.0000E+00
       0.3489E+08       0.8872E+06       0.7462E+06       0.4030E+05
       0.2562E+02       0.2562E+02
I-135            0.3026E+08       0.6183E+08       0.0000E+00
       0.2111E+02       0.0000E+00       0.0000E+00       0.0000E+00
       0.2891E+08       0.7352E+06       0.6183E+06       0.4030E+05
       0.2111E+02       0.2111E+02


       0.3946E+01       0.0000E+00       0.0000E+00       0.3946E+01
       0.1217E+00       0.0000E+00       0.0000E+00       0.1217E+00
       0.2775E+00       0.0000E+00       0.0000E+00       0.2775E+00
       0.8561E-02       0.0000E+00       0.0000E+00       0.8561E-02
```

```
TIME =      5 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                         CTMT. ATM.           SUMP          SIRW TANK
                          ACTIVITY          ACTIVITY         ACTIVITY
          ISOTOPE          (Ci)              (Ci)             (CI)
          --------      ----------        ----------        --------
          Kr-83m         0.7353E+07        0.5122E+01        0.5122E+01
                0.8755E-03        0.1043E-02        0.6157E-04        0.7332E-04
          Kr-85m         0.1623E+08        0.1128E+02        0.1128E+02
                0.8755E-03        0.1043E-02        0.6157E-04        0.7332E-04
          Kr-85          0.7587E+06        0.5269E+00        0.5269E+00
                0.8755E-03        0.1043E-02        0.6157E-04        0.7332E-04
          Kr-87          0.2792E+08        0.1948E+02        0.1948E+02
                0.8755E-03        0.1043E-02        0.6157E-04        0.7332E-04
          Kr-88          0.4190E+08        0.2915E+02        0.2915E+02
                0.8755E-03        0.1043E-02        0.6157E-04        0.7332E-04
          Kr-89          0.1678E+08        0.1303E+02        0.1303E+02
                0.8755E-03        0.1043E-02        0.6157E-04        0.7332E-04
          Xe-131m        0.4452E+06        0.3092E+00        0.3092E+00
                0.8755E-03        0.1043E-02        0.6157E-04        0.7332E-04
          Xe-133m        0.4938E+07        0.3430E+01        0.3430E+01
                0.8755E-03        0.1043E-02        0.6157E-04        0.7332E-04
          Xe-133         0.1428E+09        0.9919E+02        0.9919E+02
                0.8755E-03        0.1043E-02        0.6157E-04        0.7332E-04
          Xe-135m        0.3425E+08        0.2433E+02        0.2433E+02
                0.8755E-03        0.1043E-02        0.6157E-04        0.7332E-04
          Xe-135         0.2459E+08        0.1709E+02        0.1709E+02
                0.8755E-03        0.1043E-02        0.6157E-04        0.7332E-04
          Xe-137         0.4840E+08        0.3682E+02        0.3682E+02
                0.8755E-03        0.1043E-02        0.6157E-04        0.7332E-04
          Xe-138         0.8787E+08        0.6253E+02        0.6253E+02
                0.8755E-03        0.1043E-02        0.6157E-04        0.7332E-04
          I-131          0.1806E+08        0.3715E+08        0.0000E+00
                0.1258E+02        0.0000E+00        0.0000E+00        0.0000E+00
                0.1725E+08        0.4345E+06        0.3715E+06        0.4030E+05
                0.1258E+02        0.1258E+02
          I-132          0.2494E+08        0.5131E+08        0.0000E+00
                0.1742E+02        0.0000E+00        0.0000E+00        0.0000E+00
                0.2383E+08        0.6000E+06        0.5131E+06        0.4030E+05
                0.1742E+02        0.1742E+02
          I-133          0.2948E+08        0.6065E+08        0.0000E+00
                0.2055E+02        0.0000E+00        0.0000E+00        0.0000E+00
                0.2816E+08        0.7093E+06        0.6065E+06        0.4030E+05
                0.2055E+02        0.2055E+02
          I-134          0.3579E+08        0.7364E+08        0.0000E+00
                0.2511E+02        0.0000E+00        0.0000E+00        0.0000E+00
                0.3419E+08        0.8611E+06        0.7364E+06        0.4030E+05
                0.2511E+02        0.2511E+02
          I-135          0.3000E+08        0.6172E+08        0.0000E+00
                0.2092E+02        0.0000E+00        0.0000E+00        0.0000E+00
                0.2866E+08        0.7217E+06        0.6172E+06        0.4030E+05
                0.2092E+02        0.2092E+02


                0.4916E+01        0.0000E+00        0.0000E+00        0.4916E+01
```

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                0.1516E+00        0.0000E+00        0.0000E+00        0.1516E+00
                0.3457E+00        0.0000E+00        0.0000E+00        0.3457E+00
                0.1066E-01        0.0000E+00        0.0000E+00        0.1066E-01



TIME =     18 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                         CTMT. ATM.           SUMP          SIRW TANK
                          ACTIVITY          ACTIVITY         ACTIVITY
          ISOTOPE          (Ci)              (Ci)             (CI)
          --------      ----------        ----------        --------
          Kr-83m         0.6783E+07        0.4725E+01        0.4725E+01
                0.2727E-02        0.3262E-02        0.1917E-03        0.2294E-03
          Kr-85m         0.1569E+08        0.1091E+02        0.1091E+02
                0.2727E-02        0.3262E-02        0.1917E-03        0.2294E-03
          Kr-85          0.7587E+06        0.5269E+00        0.5269E+00
                0.2727E-02        0.3262E-02        0.1917E-03        0.2294E-03
          Kr-87          0.2480E+08        0.1730E+02        0.1730E+02
                0.2727E-02        0.3262E-02        0.1917E-03        0.2294E-03
          Kr-88          0.3974E+08        0.2765E+02        0.2765E+02
                0.2727E-02        0.3262E-02        0.1917E-03        0.2294E-03
          Kr-89          0.9595E+06        0.7453E+00        0.7453E+00
                0.2727E-02        0.3262E-02        0.1917E-03        0.2294E-03
          Xe-131m        0.4450E+06        0.3090E+00        0.3090E+00
                0.2727E-02        0.3262E-02        0.1917E-03        0.2294E-03
          Xe-133m        0.4924E+07        0.3420E+01        0.3420E+01
                0.2727E-02        0.3262E-02        0.1917E-03        0.2294E-03
          Xe-133         0.1427E+09        0.9907E+02        0.9907E+02
                0.2727E-02        0.3262E-02        0.1917E-03        0.2294E-03
          Xe-135m        0.1901E+08        0.1350E+02        0.1350E+02
                0.2727E-02        0.3262E-02        0.1917E-03        0.2294E-03
          Xe-135         0.2419E+08        0.1681E+02        0.1681E+02
                0.2727E-02        0.3262E-02        0.1917E-03        0.2294E-03
          Xe-137         0.4662E+07        0.3547E+01        0.3547E+01
                0.2727E-02        0.3262E-02        0.1917E-03        0.2294E-03
          Xe-138         0.4659E+08        0.3315E+02        0.3315E+02
                0.2727E-02        0.3262E-02        0.1917E-03        0.2294E-03
          I-131          0.2696E+07        0.3713E+08        0.0000E+00
                0.1995E+01        0.0000E+00        0.0000E+00        0.0000E+00
                0.1975E+07        0.3496E+06        0.3713E+06        0.4030E+05
                0.1995E+01        0.1995E+01
          I-132          0.3489E+07        0.4806E+08        0.0000E+00
                0.2589E+01        0.0000E+00        0.0000E+00        0.0000E+00
                0.2556E+07        0.4525E+06        0.4806E+06        0.4030E+05
                0.2589E+01        0.2589E+01
          I-133          0.4372E+07        0.6022E+08        0.0000E+00
                0.3236E+01        0.0000E+00        0.0000E+00        0.0000E+00
                0.3203E+07        0.5670E+06        0.6022E+06        0.4030E+05
                0.3236E+01        0.3236E+01
          I-134          0.4505E+07        0.6205E+08        0.0000E+00
                0.3356E+01        0.0000E+00        0.0000E+00        0.0000E+00
                0.3300E+07        0.5842E+06        0.6204E+06        0.4030E+05
                0.3356E+01        0.3356E+01
```

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I-135          0.4380E+07        0.6033E+08        0.0000E+00
       0.3244E+01        0.0000E+00        0.0000E+00        0.0000E+00
       0.3209E+07        0.5680E+06        0.6033E+06        0.4030E+05
       0.3244E+01        0.3244E+01


       0.1034E+02        0.0000E+00        0.0000E+00        0.1034E+02
       0.3189E+00        0.0000E+00        0.0000E+00        0.3189E+00
       0.7272E+00        0.0000E+00        0.0000E+00        0.7272E+00
       0.2243E-01        0.0000E+00        0.0000E+00        0.2243E-01



TIME =     19 MIN           ACTIVITY IN CONTAINMENT AND SIRW TANK

                 CTMT. ATM.            SUMP           SIRW TANK
                  ACTIVITY           ACTIVITY          ACTIVITY
ISOTOPE             (Ci)               (Ci)              (CI)
--------        ----------         ----------         ---------
Kr-83m          0.6741E+07        0.4696E+01        0.4696E+01
       0.2850E-02        0.3411E-02        0.2004E-03        0.2398E-03
Kr-85m          0.1565E+08        0.1088E+02        0.1088E+02
       0.2850E-02        0.3411E-02        0.2004E-03        0.2398E-03
Kr-85           0.7587E+06        0.5269E+00        0.5269E+00
       0.2850E-02        0.3411E-02        0.2004E-03        0.2398E-03
Kr-87           0.2457E+08        0.1714E+02        0.1714E+02
       0.2850E-02        0.3411E-02        0.2004E-03        0.2398E-03
Kr-88           0.3958E+08        0.2754E+02        0.2754E+02
       0.2850E-02        0.3411E-02        0.2004E-03        0.2398E-03
Kr-89           0.7699E+06        0.5981E+00        0.5981E+00
       0.2850E-02        0.3411E-02        0.2004E-03        0.2398E-03
Xe-131m         0.4449E+06        0.3090E+00        0.3090E+00
       0.2850E-02        0.3411E-02        0.2004E-03        0.2398E-03
Xe-133m         0.4923E+07        0.3419E+01        0.3419E+01
       0.2850E-02        0.3411E-02        0.2004E-03        0.2398E-03
Xe-133          0.1426E+09        0.9906E+02        0.9906E+02
       0.2850E-02        0.3411E-02        0.2004E-03        0.2398E-03
Xe-135m         0.1817E+08        0.1291E+02        0.1291E+02
       0.2850E-02        0.3411E-02        0.2004E-03        0.2398E-03
Xe-135          0.2416E+08        0.1679E+02        0.1679E+02
       0.2850E-02        0.3411E-02        0.2004E-03        0.2398E-03
Xe-137          0.3894E+07        0.2963E+01        0.2963E+01
       0.2850E-02        0.3411E-02        0.2004E-03        0.2398E-03
Xe-138          0.4437E+08        0.3157E+02        0.3157E+02
       0.2850E-02        0.3411E-02        0.2004E-03        0.2398E-03
I-131           0.2386E+07        0.3712E+08        0.0000E+00
       0.1762E+01        0.0000E+00        0.0000E+00        0.0000E+00
       0.1671E+07        0.3438E+06        0.3712E+06        0.4030E+05
       0.1762E+01        0.1762E+01
I-132           0.3074E+07        0.4781E+08        0.0000E+00
       0.2275E+01        0.0000E+00        0.0000E+00        0.0000E+00
       0.2153E+07        0.4428E+06        0.4781E+06        0.4030E+05
       0.2275E+01        0.2275E+01
I-133           0.3869E+07        0.6018E+08        0.0000E+00
```

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       0.2857E+01        0.0000E+00        0.0000E+00        0.0000E+00
       0.2710E+07        0.5573E+06        0.6018E+06        0.4030E+05
       0.2857E+01        0.2857E+01
I-134           0.3936E+07        0.6123E+08        0.0000E+00
       0.2925E+01        0.0000E+00        0.0000E+00        0.0000E+00
       0.2757E+07        0.5670E+06        0.6123E+06        0.4030E+05
       0.2925E+01        0.2925E+01
I-135           0.3871E+07        0.6022E+08        0.0000E+00
       0.2860E+01        0.0000E+00        0.0000E+00        0.0000E+00
       0.2712E+07        0.5577E+06        0.6022E+06        0.4030E+05
       0.2860E+01        0.2860E+01


       0.1048E+02        0.0000E+00        0.0000E+00        0.1048E+02
       0.3231E+00        0.0000E+00        0.0000E+00        0.3231E+00
       0.7367E+00        0.0000E+00        0.0000E+00        0.7367E+00
       0.2272E-01        0.0000E+00        0.0000E+00        0.2272E-01



TIME =     29 MIN           ACTIVITY IN CONTAINMENT AND SIRW TANK

                 CTMT. ATM.            SUMP           SIRW TANK
                  ACTIVITY           ACTIVITY          ACTIVITY
ISOTOPE             (Ci)               (Ci)              (CI)
--------        ----------         ----------         ---------
Kr-83m          0.6335E+07        0.4413E+01        0.4413E+01
       0.3973E-02        0.4770E-02        0.2794E-03        0.3355E-03
Kr-85m          0.1525E+08        0.1061E+02        0.1061E+02
       0.3973E-02        0.4770E-02        0.2794E-03        0.3355E-03
Kr-85           0.7587E+06        0.5269E+00        0.5269E+00
       0.3973E-02        0.4770E-02        0.2794E-03        0.3355E-03
Kr-87           0.2243E+08        0.1565E+02        0.1565E+02
       0.3973E-02        0.4770E-02        0.2794E-03        0.3355E-03
Kr-88           0.3800E+08        0.2644E+02        0.2644E+02
       0.3973E-02        0.4770E-02        0.2794E-03        0.3355E-03
Kr-89           0.8522E+05        0.6620E-01        0.6620E-01
       0.3973E-02        0.4770E-02        0.2794E-03        0.3355E-03
Xe-131m         0.4447E+06        0.3089E+00        0.3089E+00
       0.3973E-02        0.4770E-02        0.2794E-03        0.3355E-03
Xe-133m         0.4912E+07        0.3412E+01        0.3412E+01
       0.3973E-02        0.4770E-02        0.2794E-03        0.3355E-03
Xe-133          0.1425E+09        0.9897E+02        0.9897E+02
       0.3973E-02        0.4770E-02        0.2794E-03        0.3355E-03
Xe-135m         0.1155E+08        0.8204E+01        0.8204E+01
       0.3973E-02        0.4770E-02        0.2794E-03        0.3355E-03
Xe-135          0.2385E+08        0.1657E+02        0.1657E+02
       0.3973E-02        0.4770E-02        0.2794E-03        0.3355E-03
Xe-137          0.6437E+06        0.4897E+00        0.4897E+00
       0.3973E-02        0.4770E-02        0.2794E-03        0.3355E-03
Xe-138          0.2723E+08        0.1938E+02        0.1938E+02
       0.3973E-02        0.4770E-02        0.2794E-03        0.3355E-03
I-131           0.2332E+07 NCA    0.3710E+08 NIS    0.1231E+04 ASRW
       0.1621E+01 QIA    0.2461E+01 QIESP  0.2546E-02 QISRW  0.3692E+03 AI2
```

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            0.1670E+07 NTA1    0.2908E+06 NTA2    0.3710E+06 NTA3    0.4030E+05 ATZ
            0.4083E+01 QSTACK  0.4085E+01 Q
I-132             0.2858E+07         0.4546E+08         0.1512E+04
            0.1992E+01         0.3023E+01         0.3127E-02         0.4535E+03
            0.2047E+07         0.3563E+06         0.4546E+06         0.4030E+05
            0.5015E+01         0.5018E+01
I-133             0.3762E+07         0.5985E+08         0.1986E+04
            0.2616E+01         0.3971E+01         0.4108E-02         0.5957E+03
            0.2695E+07         0.4691E+06         0.5985E+06         0.4030E+05
            0.6587E+01         0.6591E+01
I-134             0.3374E+07         0.5367E+08         0.1792E+04
            0.2361E+01         0.3584E+01         0.3707E-02         0.5376E+03
            0.2417E+07         0.4207E+06         0.5367E+06         0.4030E+05
            0.5945E+01         0.5949E+01
I-135             0.3720E+07         0.5917E+08         0.1964E+04
            0.2588E+01         0.3929E+01         0.4064E-02         0.5893E+03
            0.2664E+07         0.4638E+06         0.5917E+06         0.4030E+05
            0.6517E+01         0.6521E+01

            0.1173E+02         0.1889E+01         0.1074E-02         0.1362E+02
            0.3618E+00         0.5817E-01         0.3308E-04         0.4200E+00
            0.8251E+00         0.1328E+00         0.7553E-04         0.9580E+00
            0.2544E-01         0.4091E-02         0.2326E-05         0.2953E-01



TIME =    30 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                      CTMT. ATM.           SUMP          SIRW TANK
                       ACTIVITY          ACTIVITY         ACTIVITY
ISOTOPE                  (Ci)              (Ci)             (CI)
--------              ----------        ----------       --------
Kr-83m                0.6295E+07         0.4385E+01         0.4385E+01
            0.4076E-02         0.4896E-02         0.2866E-03         0.3443E-03
Kr-85m                0.1522E+08         0.1058E+02         0.1058E+02
            0.4076E-02         0.4896E-02         0.2866E-03       , 0.3443E-03
Kr-85                 0.7587E+06         0.5269E+00         0.5269E+00
            0.4076E-02         0.4896E-02         0.2866E-03         0.3443E-03
Kr-87                 0.2223E+08         0.1551E+02         0.1551E+02
            0.4076E-02         0.4896E-02         0.2866E-03         0.3443E-03
Kr-88                 0.3784E+08         0.2633E+02         0.2633E+02
            0.4076E-02         0.4896E-02         0.2866E-03         0.3443E-03
Kr-89                 0.6839E+05         0.5312E-01         0.5312E-01
            0.4076E-02         0.4896E-02         0.2866E-03         0.3443E-03
Xe-131m               0.4447E+06         0.3088E+00         0.3088E+00
            0.4076E-02         0.4896E-02         0.2866E-03         0.3443E-03
Xe-133m               0.4911E+07         0.3411E+01         0.3411E+01
            0.4076E-02         0.4896E-02         0.2866E-03         0.3443E-03
Xe-133                0.1425E+09         0.9896E+02         0.9896E+02
            0.4076E-02         0.4896E-02         0.2866E-03         0.3443E-03
Xe-135m               0.1104E+08         0.7841E+01         0.7841E+01
            0.4076E-02         0.4896E-02         0.2866E-03         0.3443E-03
Xe-135                0.2382E+08         0.1655E+02         0.1655E+02
```

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            0.4076E-02         0.4896E-02         0.2866E-03         0.3443E-03
Xe-137                0.5376E+06         0.4091E+00         0.4091E+00
            0.4076E-02         0.4896E-02         0.2866E-03         0.3443E-03
Xe-138                0.2593E+08         0.1846E+02         0.1846E+02
            0.4076E-02         0.4896E-02         0.2866E-03         0.3443E-03
I-131                 0.2327E+07         0.3710E+08         0.1354E+04
            0.1618E+01         0.2461E+01         0.2800E-02         0.4061E+03
            0.1670E+07         0.2860E+06         0.3710E+06         0.4030E+05
            0.4079E+01         0.4082E+01
I-132                 0.2838E+07         0.4523E+08         0.1654E+04
            0.1978E+01         0.3008E+01         0.3423E-02         0.4963E+03
            0.2037E+07         0.3487E+06         0.4523E+06         0.4030E+05
            0.4986E+01         0.4989E+01
I-133                 0.3752E+07         0.5981E+08         0.2183E+04
            0.2609E+01         0.3969E+01         0.4516E-02         0.6549E+03
            0.2693E+07         0.4611E+06         0.5981E+06         0.4030E+05
            0.6578E+01         0.6583E+01
I-134                 0.3323E+07         0.5297E+08         0.1945E+04
            0.2325E+01         0.3537E+01         0.4025E-02         0.5836E+03
            0.2385E+07         0.4083E+06         0.5297E+06         0.4030E+05
            0.5862E+01         0.5866E+01
I-135                 0.3706E+07         0.5907E+08         0.2157E+04
            0.2578E+01         0.3922E+01         0.4463E-02         0.6471E+03
            0.2660E+07         0.4554E+06         0.5907E+06         0.4030E+05
            0.6500E+01         0.6505E+01

            0.1186E+02         0.2077E+01         0.1289E-02         0.1394E+02
            0.3656E+00         0.6398E-01         0.3969E-04         0.4296E+00
            0.8338E+00         0.1461E+00         0.9063E-04         0.9800E+00
            0.2571E-01         0.4499E-02         0.2791E-05         0.3021E-01



TIME =    44 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                      CTMT. ATM.           SUMP          SIRW TANK
                       ACTIVITY          ACTIVITY         ACTIVITY
ISOTOPE                  (Ci)              (Ci)             (CI)
--------              ----------        ----------       --------
Kr-83m                0.5771E+07         0.4020E+01         0.4020E+01
            0.5389E-02         0.6502E-02         0.3790E-03         0.4573E-03
Kr-85m                0.1468E+08         0.1020E+02         0.1020E+02
            0.5389E-02         0.6502E-02         0.3790E-03         0.4573E-03
Kr-85                 0.7587E+06         0.5269E+00         0.5269E+00
            0.5389E-02         0.6502E-02         0.3790E-03         0.4573E-03
Kr-87                 0.1956E+08         0.1365E+02         0.1365E+02
            0.5389E-02         0.6502E-02         0.3790E-03         0.4573E-03
Kr-88                 0.3575E+08         0.2488E+02         0.2488E+02
            0.5389E-02         0.6502E-02         0.3790E-03         0.4573E-03
Kr-89                 0.3139E+04         0.2438E-02         0.2438E-02
            0.5389E-02         0.6502E-02         0.3790E-03         0.4573E-03
Xe-131m               0.4445E+06         0.3087E+00         0.3087E+00
            0.5389E-02         0.6502E-02         0.3790E-03         0.4573E-03
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Xe-133m        0.4896E+07         0.3400E+01         0.3400E+01
         0.5389E-02         0.6502E-02         0.3790E-03         0.4573E-03
Xe-133         0.1423E+09         0.9883E+02         0.9883E+02
         0.5389E-02         0.6502E-02         0.3790E-03         0.4573E-03
Xe-135m        0.5853E+07         0.4158E+01         0.4158E+01
         0.5389E-02         0.6502E-02         0.3790E-03         0.4573E-03
Xe-135         0.2340E+08         0.1626E+02         0.1626E+02
         0.5389E-02         0.6502E-02         0.3790E-03         0.4573E-03
Xe-137         0.4326E+05         0.3291E-01         0.3291E-01
         0.5389E-02         0.6502E-02         0.3790E-03         0.4573E-03
Xe-138         0.1309E+08         0.9319E+01         0.9319E+01
         0.5389E-02         0.6502E-02         0.3790E-03         0.4573E-03
I-131          0.2266E+07         0.3706E+08         0.3074E+04
         0.1575E+01         0.2459E+01         0.6359E-02         0.9220E+03
         0.1669E+07         0.2263E+06         0.3707E+06         0.4030E+05
         0.4034E+01         0.4040E+01
I-132          0.2576E+07         0.4214E+08         0.3504E+04
         0.1795E+01         0.2803E+01         0.7248E-02         0.1051E+04
         0.1898E+07         0.2573E+06         0.4215E+06         0.4030E+05
         0.4598E+01         0.4605E+01
I-133          0.3628E+07         0.5935E+08         0.4923E+04
         0.2522E+01         0.3938E+01         0.1018E-01         0.1477E+04
         0.2672E+07         0.3623E+06         0.5935E+06         0.4030E+05
         0.6461E+01         0.6471E+01
I-134          0.2692E+07         0.4404E+08         0.3676E+04
         0.1884E+01         0.2941E+01         0.7605E-02         0.1103E+04
         0.1983E+07         0.2689E+06         0.4404E+06         0.4030E+05
         0.4825E+01         0.4832E+01
I-135          0.3523E+07         0.5763E+08         0.4783E+04
         0.2451E+01         0.3827E+01         0.9896E-02         0.1435E+04
         0.2595E+07         0.3519E+06         0.5764E+06         0.4030E+05
         0.6278E+01         0.6288E+01


         0.1356E+02         0.4712E+01         0.6330E-02         0.1828E+02
         0.4182E+00         0.1451E+00         0.1948E-03         0.5634E+00
         0.9539E+00         0.3314E+00         0.4452E-03         0.1286E+01
         0.2941E-01         0.1020E-01         0.1370E-04         0.3962E-01




TIME =    45 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                 CTMT. ATM.           SUMP           SIRW TANK
                  ACTIVITY          ACTIVITY          ACTIVITY
ISOTOPE             (Ci)              (Ci)              (CI)
--------         ----------        ----------        --------
Kr-83m         0.5735E+07         0.3995E+01         0.3995E+01
         0.5476E-02         0.6608E-02         0.3851E-03         0.4647E-03
Kr-85m         0.1464E+08         0.1018E+02         0.1018E+02
         0.5476E-02         0.6608E-02         0.3851E-03         0.4647E-03
Kr-85          0.7587E+06         0.5269E+00         0.5269E+00
         0.5476E-02         0.6608E-02         0.3851E-03         0.4647E-03
Kr-87          0.1938E+08         0.1352E+02         0.1352E+02
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         0.5476E-02         0.6608E-02         0.3851E-03         0.4647E-03
Kr-88          0.3560E+08         0.2477E+02         0.2477E+02
         0.5476E-02         0.6608E-02         0.3851E-03         0.4647E-03
Kr-89          0.2519E+04         0.1956E-02         0.1956E-02
         0.5476E-02         0.6608E-02         0.3851E-03         0.4647E-03
Xe-131m        0.4445E+06         0.3087E+00         0.3087E+00
         0.5476E-02         0.6608E-02         0.3851E-03         0.4647E-03
Xe-133m        0.4895E+07         0.3400E+01         0.3400E+01
         0.5476E-02         0.6608E-02         0.3851E-03         0.4647E-03
Xe-133         0.1423E+09         0.9883E+02         0.9883E+02
         0.5476E-02         0.6608E-02         0.3851E-03         0.4647E-03
Xe-135m        0.5594E+07         0.3974E+01         0.3974E+01
         0.5476E-02         0.6608E-02         0.3851E-03         0.4647E-03
Xe-135         0.2337E+08         0.1624E+02         0.1624E+02
         0.5476E-02         0.6608E-02         0.3851E-03         0.4647E-03
Xe-137         0.3613E+05         0.2749E-01         0.2749E-01
         0.5476E-02         0.6608E-02         0.3851E-03         0.4647E-03
Xe-138         0.1247E+08         0.8875E+01         0.8875E+01
         0.5476E-02         0.6608E-02         0.3851E-03         0.4647E-03
I-131          0.2262E+07         0.3706E+08         0.3196E+04
         0.1572E+01         0.2459E+01         0.6613E-02         0.9589E+03
         0.1669E+07         0.2225E+06         0.3706E+06         0.4030E+05
         0.4031E+01         0.4038E+01
I-132          0.2559E+07         0.4193E+08         0.3625E+04
         0.1783E+01         0.2789E+01         0.7500E-02         0.1088E+04
         0.1888E+07         0.2518E+06         0.4193E+06         0.4030E+05
         0.4572E+01         0.4580E+01
I-133          0.3620E+07         0.5931E+08         0.5117E+04
         0.2517E+01         0.3936E+01         0.1059E-01         0.1535E+04
         0.2671E+07         0.3561E+06         0.5932E+06         0.4030E+05
         0.6453E+01         0.6463E+01
I-134          0.2653E+07         0.4346E+08         0.3773E+04
         0.1856E+01         0.2902E+01         0.7806E-02         0.1132E+04
         0.1957E+07         0.2610E+06         0.4347E+06         0.4030E+05
         0.4758E+01         0.4766E+01
I-135          0.3511E+07         0.5753E+08         0.4966E+04
         0.2443E+01         0.3820E+01         0.1027E-01         0.1490E+04
         0.2591E+07         0.3454E+06         0.5754E+06         0.4030E+05
         0.6263E+01         0.6273E+01


         0.1368E+02         0.4900E+01         0.6835E-02         0.1859E+02
         0.4219E+00         0.1509E+00         0.2104E-03         0.5729E+00
         0.9623E+00         0.3446E+00         0.4807E-03         0.1307E+01
         0.2967E-01         0.1061E-01         0.1479E-04         0.4029E-01




TIME =    59 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                 CTMT. ATM.           SUMP           SIRW TANK
                  ACTIVITY          ACTIVITY          ACTIVITY
ISOTOPE             (Ci)              (Ci)              (CI)
--------         ----------        ----------        --------
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Kr-83m         0.5258E+07          0.3662E+01          0.3662E+01
         0.6604E-02          0.8003E-02          0.4644E-03          0.5628E-03
Kr-85m         0.1412E+08          0.9817E+01          0.9817E+01
         0.6604E-02          0.8003E-02          0.4644E-03          0.5628E-03
Kr-85          0.7587E+06          0.5269E+00          0.5269E+00
         0.6604E-02          0.8003E-02          0.4644E-03          0.5628E-03
Kr-87          0.1706E+08          0.1190E+02          0.1190E+02
         0.6604E-02          0.8003E-02          0.4644E-03          0.5628E-03
Kr-88          0.3363E+08          0.2340E+02          0.2340E+02
         0.6604E-02          0.8003E-02          0.4644E-03          0.5628E-03
Kr-89          0.1156E+03          0.8979E-04          0.8979E-04
         0.6604E-02          0.8003E-02          0.4644E-03          0.5628E-03
Xe-131m        0.4442E+06          0.3085E+00          0.3085E+00
         0.6604E-02          0.8003E-02          0.4644E-03          0.5628E-03
Xe-133m        0.4880E+07          0.3389E+01          0.3389E+01
         0.6604E-02          0.8003E-02          0.4644E-03          0.5628E-03
Xe-133         0.1421E+09          0.9870E+02          0.9870E+02
         0.6604E-02          0.8003E-02          0.4644E-03          0.5628E-03
Xe-135m        0.2967E+07          0.2108E+01          0.2108E+01
         0.6604E-02          0.8003E-02          0.4644E-03          0.5628E-03
Xe-135         0.2296E+08          0.1595E+02          0.1595E+02
         0.6604E-02          0.8003E-02          0.4644E-03          0.5628E-03
Xe-137         0.2907E+04          0.2212E-02          0.2212E-02
         0.6604E-02          0.8003E-02          0.4644E-03          0.5628E-03
Xe-138         0.6297E+07          0.4481E+01          0.4481E+01
         0.6604E-02          0.8003E-02          0.4644E-03          0.5628E-03
I-131          0.2214E+07          0.3703E+08          0.4913E+04
         0.1538E+01          0.2457E+01          0.1016E-01          0.1474E+04
         0.1667E+07          0.1761E+06          0.3703E+06          0.4030E+05
         0.3995E+01          0.4005E+01
I-132          0.2336E+07          0.3907E+08          0.5197E+04
         0.1627E+01          0.2599E+01          0.1075E-01          0.1559E+04
         0.1759E+07          0.1858E+06          0.3907E+06          0.4030E+05
         0.4226E+01          0.4237E+01
I-133          0.3519E+07          0.5885E+08          0.7811E+04
         0.2446E+01          0.3906E+01          0.1616E-01          0.2343E+04
         0.2650E+07          0.2798E+06          0.5886E+06          0.4030E+05
         0.6351E+01          0.6367E+01
I-134          0.2161E+07          0.3614E+08          0.4827E+04
         0.1511E+01          0.2413E+01          0.9985E-02          0.1448E+04
         0.1627E+07          0.1718E+06          0.3614E+06          0.4030E+05
         0.3925E+01          0.3935E+01
I-135          0.3356E+07          0.5613E+08          0.7455E+04
         0.2334E+01          0.3727E+01          0.1542E-01          0.2236E+04
         0.2528E+07          0.2669E+06          0.5614E+06          0.4030E+05
         0.6062E+01          0.6077E+01


         0.1534E+02          0.7525E+01          0.1593E-01          0.2288E+02
         0.4729E+00          0.2316E+00          0.4900E-03          0.7049E+00
         0.1079E+01          0.5292E+00          0.1120E-02          0.1609E+01
         0.3325E-01          0.1628E-01          0.3446E-04          0.4957E-01
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TIME =    60 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                       CTMT. ATM.           SUMP           SIRW TANK
                        ACTIVITY          ACTIVITY          ACTIVITY
      ISOTOPE             (Ci)              (Ci)              (CI)
      --------         ----------        ----------        --------
      Kr-83m           0.5225E+07        0.3640E+01        0.3640E+01
               0.6680E-02        0.8097E-02        0.4697E-03        0.5694E-03
      Kr-85m           0.1408E+08        0.9792E+01        0.9792E+01
               0.6680E-02        0.8097E-02        0.4697E-03        0.5694E-03
      Kr-85            0.7587E+06        0.5269E+00        0.5269E+00
               0.6680E-02        0.8097E-02        0.4697E-03        0.5694E-03
      Kr-87            0.1691E+08        0.1179E+02        0.1179E+02
               0.6680E-02        0.8097E-02        0.4697E-03        0.5694E-03
      Kr-88            0.3350E+08        0.2331E+02        0.2331E+02
               0.6680E-02        0.8097E-02        0.4697E-03        0.5694E-03
      Kr-89            0.9275E+02        0.7205E-04        0.7205E-04
               0.6680E-02        0.8097E-02        0.4697E-03        0.5694E-03
      Xe-131m          0.4442E+06        0.3085E+00        0.3085E+00
               0.6680E-02        0.8097E-02        0.4697E-03        0.5694E-03
      Xe-133m          0.4879E+07        0.3388E+01        0.3388E+01
               0.6680E-02        0.8097E-02        0.4697E-03        0.5694E-03
      Xe-133           0.1421E+09        0.9869E+02        0.9869E+02
               0.6680E-02        0.8097E-02        0.4697E-03        0.5694E-03
      Xe-135m          0.2835E+07        0.2014E+01        0.2014E+01
               0.6680E-02        0.8097E-02        0.4697E-03        0.5694E-03
      Xe-135           0.2293E+08        0.1593E+02        0.1593E+02
               0.6680E-02        0.8097E-02        0.4697E-03        0.5694E-03
      Xe-137           0.2428E+04        0.1848E-02        0.1848E-02
               0.6680E-02        0.8097E-02        0.4697E-03        0.5694E-03
      Xe-138           0.5997E+07        0.4268E+01        0.4268E+01
               0.6680E-02        0.8097E-02        0.4697E-03        0.5694E-03
      I-131            0.2211E+07        0.3703E+08        0.5036E+04
               0.1536E+01        0.2457E+01        0.1042E-01        0.1511E+04
               0.1667E+07        0.1731E+06        0.3703E+06        0.4030E+05
               0.3993E+01        0.4003E+01
      I-132            0.2321E+07        0.3887E+08        0.5300E+04
               0.1617E+01        0.2586E+01        0.1097E-01        0.1590E+04
               0.1751E+07        0.1818E+06        0.3888E+06        0.4030E+05
               0.4203E+01        0.4214E+01
      I-133            0.3512E+07        0.5882E+08        0.8002E+04
               0.2441E+01        0.3903E+01        0.1655E-01        0.2400E+04
               0.2649E+07        0.2751E+06        0.5883E+06        0.4030E+05
               0.6345E+01        0.6361E+01
      I-134            0.2129E+07        0.3566E+08        0.4883E+04
               0.1490E+01        0.2382E+01        0.1010E-01        0.1465E+04
               0.1606E+07        0.1668E+06        0.3567E+06        0.4030E+05
               0.3871E+01        0.3881E+01
      I-135            0.3346E+07        0.5603E+08        0.7628E+04
               0.2327E+01        0.3721E+01        0.1578E-01        0.2288E+04
               0.2523E+07        0.2620E+06        0.5604E+06        0.4030E+05
               0.6048E+01        0.6064E+01
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          0.1546E+02          0.7712E+01          0.1672E-01          0.2319E+02
          0.4765E+00          0.2373E+00          0.5144E-03          0.7143E+00
          0.1087E+01          0.5423E+00          0.1176E-02          0.1631E+01
          0.3351E-01          0.1669E-01          0.3618E-04          0.5023E-01


TIME =     74 MIN           ACTIVITY IN CONTAINMENT AND SIRW TANK

                 CTMT. ATM.             SUMP             SIRW TANK
                  ACTIVITY            ACTIVITY           ACTIVITY
 ISOTOPE            (Ci)                (Ci)               (CI)
 --------        ----------          ----------          --------
 Kr-83m           0.4790E+07          0.3337E+01          0.3337E+01
          0.7688E-02          0.9356E-02          0.5406E-03          0.6579E-03
 Kr-85m           0.1358E+08          0.9445E+01          0.9445E+01
          0.7688E-02          0.9356E-02          0.5406E-03          0.6579E-03
 Kr-85            0.7587E+06          0.5269E+00          0.5269E+00
          0.7688E-02          0.9356E-02          0.5406E-03          0.6579E-03
 Kr-87            0.1488E+08          0.1038E+02          0.1038E+02
          0.7688E-02          0.9356E-02          0.5406E-03          0.6579E-03
 Kr-88            0.3164E+08          0.2202E+02          0.2202E+02
          0.7688E-02          0.9356E-02          0.5406E-03          0.6579E-03
 Kr-89            0.4257E+01          0.3307E-05          0.3307E-05
          0.7688E-02          0.9356E-02          0.5406E-03          0.6579E-03
 Xe-131m          0.4439E+06          0.3083E+00          0.3083E+00
          0.7688E-02          0.9356E-02          0.5406E-03          0.6579E-03
 Xe-133m          0.4864E+07          0.3378E+01          0.3378E+01
          0.7688E-02          0.9356E-02          0.5406E-03          0.6579E-03
 Xe-133           0.1419E+09          0.9856E+02          0.9856E+02
          0.7688E-02          0.9356E-02          0.5406E-03          0.6579E-03
 Xe-135m          0.1504E+07          0.1068E+01          0.1068E+01
          0.7688E-02          0.9356E-02          0.5406E-03          0.6579E-03
 Xe-135           0.2252E+08          0.1565E+02          0.1565E+02
          0.7688E-02          0.9356E-02          0.5406E-03          0.6579E-03
 Xe-137           0.1954E+03          0.1487E-03          0.1487E-03
          0.7688E-02          0.9356E-02          0.5406E-03          0.6579E-03
 Xe-138           0.3028E+07          0.2155E+01          0.2155E+01
          0.7688E-02          0.9356E-02          0.5406E-03          0.6579E-03
 I-131            0.2173E+07          0.3699E+08          0.6750E+04
          0.1510E+01          0.2455E+01          0.1396E-01          0.2025E+04
          0.1666E+07          0.1370E+06          0.3700E+06          0.4029E+05
          0.3964E+01          0.3978E+01
 I-132            0.2128E+07          0.3622E+08          0.6625E+04
          0.1482E+01          0.2409E+01          0.1371E-01          0.1987E+04
          0.1631E+07          0.1341E+06          0.3623E+06          0.4029E+05
          0.3891E+01          0.3905E+01
 I-133            0.3428E+07          0.5836E+08          0.1065E+05
          0.2382E+01          0.3873E+01          0.2203E-01          0.3195E+04
          0.2628E+07          0.2161E+06          0.5837E+06          0.4029E+05
          0.6256E+01          0.6278E+01
 I-134            0.1742E+07          0.2965E+08          0.5446E+04
          0.1218E+01          0.1980E+01          0.1127E-01          0.1634E+04
          0.1335E+07          0.1098E+06          0.2966E+06          0.4029E+05
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          0.3199E+01          0.3210E+01
 I-135            0.3211E+07          0.5467E+08          0.9984E+04
          0.2233E+01          0.3631E+01          0.2065E-01          0.2995E+04
          0.2462E+07          0.2025E+06          0.5468E+06          0.4029E+05
          0.5864E+01          0.5885E+01


          0.1708E+02          0.1033E+02          0.2984E-01          0.2744E+02
          0.5263E+00          0.3177E+00          0.9175E-03          0.8449E+00
          0.1201E+01          0.7263E+00          0.2099E-02          0.1930E+01
          0.3701E-01          0.2234E-01          0.6452E-04          0.5941E-01


TIME =     75 MIN           ACTIVITY IN CONTAINMENT AND SIRW TANK

                 CTMT. ATM.             SUMP             SIRW TANK
                  ACTIVITY            ACTIVITY           ACTIVITY
 ISOTOPE            (Ci)                (Ci)               (CI)
 --------        ----------          ----------          --------
 Kr-83m           0.4760E+07          0.3316E+01          0.3316E+01
          0.7756E-02          0.9442E-02          0.5454E-03          0.6640E-03
 Kr-85m           0.1355E+08          0.9420E+01          0.9420E+01
          0.7756E-02          0.9442E-02          0.5454E-03          0.6640E-03
 Kr-85            0.7587E+06          0.5269E+00          0.5269E+00
          0.7756E-02          0.9442E-02          0.5454E-03          0.6640E-03
 Kr-87            0.1474E+08          0.1029E+02          0.1029E+02
          0.7756E-02          0.9442E-02          0.5454E-03          0.6640E-03
 Kr-88            0.3151E+08          0.2193E+02          0.2193E+02
          0.7756E-02          0.9442E-02          0.5454E-03          0.6640E-03
 Kr-89            0.3416E+01          0.2653E-05          0.2653E-05
          0.7756E-02          0.9442E-02          0.5454E-03          0.6640E-03
 Xe-131m          0.4439E+06          0.3083E+00          0.3083E+00
          0.7756E-02          0.9442E-02          0.5454E-03          0.6640E-03
 Xe-133m          0.4863E+07          0.3377E+01          0.3377E+01
          0.7756E-02          0.9442E-02          0.5454E-03          0.6640E-03
 Xe-133           0.1419E+09          0.9855E+02          0.9855E+02
          0.7756E-02          0.9442E-02          0.5454E-03          0.6640E-03
 Xe-135m          0.1437E+07          0.1021E+01          0.1021E+01
          0.7756E-02          0.9442E-02          0.5454E-03          0.6640E-03
 Xe-135           0.2249E+08          0.1563E+02          0.1563E+02
          0.7756E-02          0.9442E-02          0.5454E-03          0.6640E-03
 Xe-137           0.1632E+03          0.1242E-03          0.1242E-03
          0.7756E-02          0.9442E-02          0.5454E-03          0.6640E-03
 Xe-138           0.2884E+07          0.2052E+01          0.2052E+01
          0.7756E-02          0.9442E-02          0.5454E-03          0.6640E-03
 I-131            0.2171E+07          0.3699E+08          0.6872E+04
          0.1508E+01          0.2454E+01          0.1422E-01          0.2061E+04
          0.1666E+07          0.1347E+06          0.3700E+06          0.4029E+05
          0.3963E+01          0.3977E+01
 I-132            0.2115E+07          0.3604E+08          0.6712E+04
          0.1473E+01          0.2397E+01          0.1388E-01          0.2013E+04
          0.1623E+07          0.1313E+06          0.3604E+06          0.4029E+05
          0.3870E+01          0.3884E+01
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I-133           0.3422E+07          0.5832E+08          0.1084E+05
        0.2379E+01          0.3871E+01          0.2242E-01          0.3251E+04
        0.2627E+07          0.2124E+06          0.5834E+06          0.4029E+05
        0.6250E+01          0.6272E+01
I-134           0.1717E+07          0.2926E+08          0.5472E+04
        0.1201E+01          0.1955E+01          0.1132E-01          0.1642E+04
        0.1318E+07          0.1066E+06          0.2927E+06          0.4029E+05
        0.3156E+01          0.3167E+01
I-135           0.3202E+07          0.5457E+08          0.1015E+05
        0.2227E+01          0.3624E+01          0.2099E-01          0.3044E+04
        0.2458E+07          0.1988E+06          0.5459E+06          0.4029E+05
        0.5851E+01          0.5872E+01


        0.1720E+02          0.1051E+02          0.3092E-01          0.2774E+02
        0.5298E+00          0.3234E+00          0.9507E-03          0.8542E+00
        0.1209E+01          0.7394E+00          0.2174E-02          0.1951E+01
        0.3726E-01          0.2274E-01          0.6685E-04          0.6007E-01



TIME =     89 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                 CTMT. ATM.            SUMP           SIRW TANK
                  ACTIVITY           ACTIVITY          ACTIVITY
ISOTOPE            (Ci)                (Ci)              (CI)
--------        ----------          ----------         --------
Kr-83m          0.4364E+07          0.3040E+01          0.3040E+01
        0.8678E-02          0.1060E-01          0.6102E-03          0.7457E-03
Kr-85m          0.1307E+08          0.9086E+01          0.9086E+01
        0.8678E-02          0.1060E-01          0.6102E-03          0.7457E-03
Kr-85           0.7587E+06          0.5269E+00          0.5269E+00
        0.8678E-02          0.1060E-01          0.6102E-03          0.7457E-03
Kr-87           0.1298E+08          0.9053E+01          0.9053E+01
        0.8678E-02          0.1060E-01          0.6102E-03          0.7457E-03
Kr-88           0.2977E+08          0.2071E+02          0.2071E+02
        0.8678E-02          0.1060E-01          0.6102E-03          0.7457E-03
Kr-89           0.1568E+00          0.1218E-06          0.1218E-06
        0.8678E-02          0.1060E-01          0.6102E-03          0.7457E-03
Xe-131m         0.4437E+06          0.3081E+00          0.3081E+00
        0.8678E-02          0.1060E-01          0.6102E-03          0.7457E-03
Xe-133m         0.4848E+07          0.3367E+01          0.3367E+01
        0.8678E-02          0.1060E-01          0.6102E-03          0.7457E-03
Xe-133          0.1417E+09          0.9842E+02          0.9842E+02
        0.8678E-02          0.1060E-01          0.6102E-03          0.7457E-03
Xe-135m         0.7622E+06          0.5415E+00          0.5415E+00
        0.8678E-02          0.1060E-01          0.6102E-03          0.7457E-03
Xe-135          0.2210E+08          0.1536E+02          0.1536E+02
        0.8678E-02          0.1060E-01          0.6102E-03          0.7457E-03
Xe-137          0.1313E+02          0.9990E-05          0.9990E-05
        0.8678E-02          0.1060E-01          0.6102E-03          0.7457E-03
Xe-138          0.1456E+07          0.1036E+01          0.1036E+01
        0.8678E-02          0.1060E-01          0.6102E-03          0.7457E-03
I-131           0.2141E+07          0.3696E+08          0.8583E+04
```

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        0.1487E+01          0.2452E+01          0.1775E-01          0.2574E+04
        0.1664E+07          0.1066E+06          0.3697E+06          0.4029E+05
        0.3940E+01          0.3957E+01
I-132           0.1945E+07          0.3358E+08          0.7817E+04
        0.1355E+01          0.2234E+01          0.1617E-01          0.2345E+04
        0.1512E+07          0.9685E+05          0.3359E+06          0.4029E+05
        0.3588E+01          0.3604E+01
I-133           0.3352E+07          0.5787E+08          0.1344E+05
        0.2329E+01          0.3841E+01          0.2781E-01          0.4032E+04
        0.2606E+07          0.1669E+06          0.5788E+06          0.4029E+05
        0.6170E+01          0.6198E+01
I-134           0.1409E+07          0.2433E+08          0.5688E+04
        0.9856E+00          0.1625E+01          0.1177E-01          0.1706E+04
        0.1096E+07          0.7018E+05          0.2434E+06          0.4029E+05
        0.2611E+01          0.2623E+01
I-135           0.3084E+07          0.5325E+08          0.1238E+05
        0.2145E+01          0.3536E+01          0.2560E-01          0.3712E+04
        0.2398E+07          0.1536E+06          0.5326E+06          0.4029E+05
        0.5681E+01          0.5707E+01


        0.1879E+02          0.1312E+02          0.4803E-01          0.3195E+02
        0.5786E+00          0.4034E+00          0.1476E-02          0.9835E+00
        0.1321E+01          0.9226E+00          0.3378E-02          0.2247E+01
        0.4069E-01          0.2837E-01          0.1038E-03          0.6916E-01



TIME =     90 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                 CTMT. ATM.            SUMP           SIRW TANK
                  ACTIVITY           ACTIVITY          ACTIVITY
ISOTOPE            (Ci)                (Ci)              (CI)
--------        ----------          ----------         --------
Kr-83m          0.4337E+07          0.3021E+01          0.3021E+01
        0.8741E-02          0.1068E-01          0.6147E-03          0.7514E-03
Kr-85m          0.1303E+08          0.9063E+01          0.9063E+01
        0.8741E-02          0.1068E-01          0.6147E-03          0.7514E-03
Kr-85           0.7587E+06          0.5269E+00          0.5269E+00
        0.8741E-02          0.1068E-01          0.6147E-03          0.7514E-03
Kr-87           0.1286E+08          0.8971E+01          0.8971E+01
        0.8741E-02          0.1068E-01          0.6147E-03          0.7514E-03
Kr-88           0.2965E+08          0.2063E+02          0.2063E+02
        0.8741E-02          0.1068E-01          0.6147E-03          0.7514E-03
Kr-89           0.1258E+00          0.9772E-07          0.9772E-07
        0.8741E-02          0.1068E-01          0.6147E-03          0.7514E-03
Xe-131m         0.4436E+06          0.3081E+00          0.3081E+00
        0.8741E-02          0.1068E-01          0.6147E-03          0.7514E-03
Xe-133m         0.4846E+07          0.3366E+01          0.3366E+01
        0.8741E-02          0.1068E-01          0.6147E-03          0.7514E-03
Xe-133          0.1417E+09          0.9842E+02          0.9842E+02
        0.8741E-02          0.1068E-01          0.6147E-03          0.7514E-03
Xe-135m         0.7285E+06          0.5175E+00          0.5175E+00
        0.8741E-02          0.1068E-01          0.6147E-03          0.7514E-03
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Xe-135          0.2207E+08       0.1534E+02       0.1534E+02
         0.8741E-02       0.1068E-01       0.6147E-03       0.7514E-03
Xe-137          0.1097E+02       0.8344E-05       0.8344E-05
         0.8741E-02       0.1068E-01       0.6147E-03       0.7514E-03
Xe-138          0.1387E+07       0.9869E+00       0.9869E+00
         0.8741E-02       0.1068E-01       0.6147E-03       0.7514E-03
I-131           0.2139E+07       0.3695E+08       0.8705E+04
         0.1486E+01       0.2452E+01       0.1801E-01       0.2611E+04
         0.1664E+07       0.1048E+06       0.3696E+06       0.4029E+05
         0.3938E+01       0.3956E+01
I-132           0.1934E+07       0.3341E+08       0.7889E+04
         0.1347E+01       0.2222E+01       0.1632E-01       0.2366E+04
         0.1505E+07       0.9477E+05       0.3342E+06       0.4029E+05
         0.3569E+01       0.3585E+01
I-133           0.3347E+07       0.5784E+08       0.1363E+05
         0.2326E+01       0.3839E+01       0.2819E-01       0.4087E+04
         0.2605E+07       0.1641E+06       0.5785E+06       0.4029E+05
         0.6165E+01       0.6193E+01
I-134           0.1390E+07       0.2401E+08       0.5694E+04
         0.9719E+00       0.1604E+01       0.1178E-01       0.1708E+04
         0.1081E+07       0.6812E+05       0.2402E+06       0.4029E+05
         0.2576E+01       0.2588E+01
I-135           0.3076E+07       0.5315E+08       0.1253E+05
         0.2139E+01       0.3530E+01       0.2592E-01       0.3759E+04
         0.2394E+07       0.1508E+06       0.5317E+06       0.4029E+05
         0.5669E+01       0.5695E+01


         0.1890E+02       0.1331E+02       0.4940E-01       0.3225E+02
         0.5821E+00       0.4091E+00       0.1518E-02       0.9927E+00
         0.1329E+01       0.9357E+00       0.3474E-02       0.2268E+01
         0.4093E-01       0.2877E-01       0.1068E-03       0.6981E-01



TIME =   104 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                  CTMT. ATM.          SUMP           SIRW TANK
                   ACTIVITY         ACTIVITY         ACTIVITY
ISOTOPE              (Ci)             (Ci)             (CI)
--------          ----------       ----------       --------
Kr-83m          0.3975E+07       0.2769E+01       0.2769E+01
         0.9595E-02       0.1177E-01       0.6747E-03       0.8278E-03
Kr-85m          0.1257E+08       0.8741E+01       0.8741E+01
         0.9595E-02       0.1177E-01       0.6747E-03       0.8278E-03
Kr-85           0.7587E+06       0.5269E+00       0.5269E+00
         0.9595E-02       0.1177E-01       0.6747E-03       0.8278E-03
Kr-87           0.1132E+08       0.7895E+01       0.7895E+01
         0.9595E-02       0.1177E-01       0.6747E-03       0.8278E-03
Kr-88           0.2801E+08       0.1949E+02       0.1949E+02
         0.9595E-02       0.1177E-01       0.6747E-03       0.8278E-03
Kr-89           0.5773E-02       0.4485E-08       0.4485E-08
         0.9595E-02       0.1177E-01       0.6747E-03       0.8278E-03
Xe-131m         0.4434E+06       0.3079E+00       0.3079E+00
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         0.9595E-02       0.1177E-01       0.6747E-03       0.8278E-03
Xe-133m         0.4832E+07       0.3356E+01       0.3356E+01
         0.9595E-02       0.1177E-01       0.6747E-03       0.8278E-03
Xe-133          0.1415E+09       0.9829E+02       0.9829E+02
         0.9595E-02       0.1177E-01       0.6747E-03       0.8278E-03
Xe-135m         0.3863E+06       0.2745E+00       0.2745E+00
         0.9595E-02       0.1177E-01       0.6747E-03       0.8278E-03
Xe-135          0.2168E+08       0.1507E+02       0.1507E+02
         0.9595E-02       0.1177E-01       0.6747E-03       0.8278E-03
Xe-137          0.8824E+00       0.6714E-06       0.6714E-06
         0.9595E-02       0.1177E-01       0.6747E-03       0.8278E-03
Xe-138          0.7002E+06       0.4983E+00       0.4983E+00
         0.9595E-02       0.1177E-01       0.6747E-03       0.8278E-03
I-131           0.2115E+07       0.3692E+08       0.1041E+05
         0.1469E+01       0.2450E+01       0.2154E-01       0.3123E+04
         0.1663E+07       0.8294E+05       0.3693E+06       0.4029E+05
         0.3920E+01       0.3941E+01
I-132           0.1783E+07       0.3113E+08       0.8801E+04
         0.1242E+01       0.2071E+01       0.1820E-01       0.2640E+04
         0.1402E+07       0.6993E+05       0.3114E+06       0.4029E+05
         0.3313E+01       0.3331E+01
I-133           0.3288E+07       0.5738E+08       0.1619E+05
         0.2284E+01       0.3809E+01       0.3348E-01       0.4855E+04
         0.2585E+07       0.1289E+06       0.5740E+06       0.4029E+05
         0.6094E+01       0.6127E+01
I-134           0.1144E+07       0.1997E+08       0.5668E+04
         0.7998E+00       0.1334E+01       0.1172E-01       0.1700E+04
         0.8992E+06       0.4485E+05       0.1997E+06       0.4029E+05
         0.2134E+01       0.2145E+01
I-135           0.2971E+07       0.5186E+08       0.1464E+05
         0.2066E+01       0.3445E+01       0.3028E-01       0.4391E+04
         0.2336E+07       0.1165E+06       0.5188E+06       0.4029E+05
         0.5510E+01       0.5541E+01


         0.2046E+02       0.1590E+02       0.7047E-01       0.3643E+02
         0.6301E+00       0.4888E+00       0.2165E-02       0.1121E+01
         0.1439E+01       0.1118E+01       0.4956E-02       0.2562E+01
         0.4431E-01       0.3437E-01       0.1522E-03       0.7883E-01



TIME =   105 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                  CTMT. ATM.          SUMP           SIRW TANK
                   ACTIVITY         ACTIVITY         ACTIVITY
ISOTOPE              (Ci)             (Ci)             (CI)
--------          ----------       ----------       --------
Kr-83m          0.3951E+07       0.2752E+01       0.2752E+01
         0.9654E-02       0.1185E-01       0.6789E-03       0.8331E-03
Kr-85m          0.1254E+08       0.8719E+01       0.8719E+01
         0.9654E-02       0.1185E-01       0.6789E-03       0.8331E-03
Kr-85           0.7587E+06       0.5269E+00       0.5269E+00
         0.9654E-02       0.1185E-01       0.6789E-03       0.8331E-03
```

```
Kr-87          0.1121E+08          0.7824E+01          0.7824E+01
     0.9654E-02          0.1185E-01          0.6789E-03          0.8331E-03
Kr-88          0.2789E+08          0.1941E+02          0.1941E+02
     0.9654E-02          0.1185E-01          0.6789E-03          0.8331E-03
Kr-89          0.4633E-02          0.3599E-08          0.3599E-08
     0.9654E-02          0.1185E-01          0.6789E-03          0.8331E-03
Xe-131m        0.4434E+06          0.3079E+00          0.3079E+00
     0.9654E-02          0.1185E-01          0.6789E-03          0.8331E-03
Xe-133m        0.4830E+07          0.3355E+01          0.3355E+01
     0.9654E-02          0.1185E-01          0.6789E-03          0.8331E-03
Xe-133         0.1415E+09          0.9828E+02          0.9828E+02
     0.9654E-02          0.1185E-01          0.6789E-03          0.8331E-03
Xe-135m        0.3692E+06          0.2623E+00          0.2623E+00
     0.9654E-02          0.1185E-01          0.6789E-03          0.8331E-03
Xe-135         0.2165E+08          0.1505E+02          0.1505E+02
     0.9654E-02          0.1185E-01          0.6789E-03          0.8331E-03
Xe-137         0.7370E+00          0.5608E-06          0.5608E-06
     0.9654E-02          0.1185E-01          0.6789E-03          0.8331E-03
Xe-138         0.6668E+06          0.4746E+00          0.4746E+00
     0.9654E-02          0.1185E-01          0.6789E-03          0.8331E-03
I-131          0.2114E+07          0.3692E+08          0.1053E+05
     0.1468E+01          0.2450E+01          0.2179E-01          0.3160E+04
     0.1663E+07          0.8157E+05          0.3693E+06          0.4029E+05
     0.3918E+01          0.3940E+01
I-132          0.1773E+07          0.3097E+08          0.8859E+04
     0.1235E+01          0.2060E+01          0.1833E-01          0.2657E+04
     0.1395E+07          0.6843E+05          0.3098E+06          0.4029E+05
     0.3295E+01          0.3314E+01
I-133          0.3284E+07          0.5735E+08          0.1637E+05
     0.2282E+01          0.3807E+01          0.3386E-01          0.4910E+04
     0.2583E+07          0.1267E+06          0.5737E+06          0.4029E+05
     0.6089E+01          0.6123E+01
I-134          0.1128E+07          0.1970E+08          0.5659E+04
     0.7888E+00          0.1316E+01          0.1171E-01          0.1697E+04
     0.8875E+06          0.4353E+05          0.1971E+06          0.4029E+05
     0.2105E+01          0.2117E+01
I-135          0.2964E+07          0.5177E+08          0.1478E+05
     0.2061E+01          0.3439E+01          0.3058E-01          0.4434E+04
     0.2332E+07          0.1144E+06          0.5179E+06          0.4029E+05
     0.5499E+01          0.5530E+01


     0.2057E+02          0.1609E+02          0.7212E-01          0.3673E+02
     0.6335E+00          0.4945E+00          0.2215E-02          0.1130E+01
     0.1447E+01          0.1131E+01          0.5072E-02          0.2583E+01
     0.4455E-01          0.3477E-01          0.1558E-03          0.7948E-01




TIME =   119 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                 CTMT. ATM.          SUMP          SIRW TANK
                  ACTIVITY         ACTIVITY         ACTIVITY
ISOTOPE             (Ci)             (Ci)             (CI)
```

```
--------           ----------          ----------          --------
Kr-83m         0.3622E+07          0.2523E+01          0.2523E+01
     0.1045E-01          0.1287E-01          0.7349E-03          0.9051E-03
Kr-85m         0.1209E+08          0.8410E+01          0.8410E+01
     0.1045E-01          0.1287E-01          0.7349E-03          0.9051E-03
Kr-85          0.7587E+06          0.5269E+00          0.5269E+00
     0.1045E-01          0.1287E-01          0.7349E-03          0.9051E-03
Kr-87          0.9870E+07          0.6886E+01          0.6886E+01
     0.1045E-01          0.1287E-01          0.7349E-03          0.9051E-03
Kr-88          0.2635E+08          0.1833E+02          0.1833E+02
     0.1045E-01          0.1287E-01          0.7349E-03          0.9051E-03
Kr-89          0.2126E-03          0.1652E-09          0.1652E-09
     0.1045E-01          0.1287E-01          0.7349E-03          0.9051E-03
Xe-131m        0.4431E+06          0.3077E+00          0.3077E+00
     0.1045E-01          0.1287E-01          0.7349E-03          0.9051E-03
Xe-133m        0.4816E+07          0.3345E+01          0.3345E+01
     0.1045E-01          0.1287E-01          0.7349E-03          0.9051E-03
Xe-133         0.1413E+09          0.9815E+02          0.9815E+02
     0.1045E-01          0.1287E-01          0.7349E-03          0.9051E-03
Xe-135m        0.1958E+06          0.1391E+00          0.1391E+00
     0.1045E-01          0.1287E-01          0.7349E-03          0.9051E-03
Xe-135         0.2127E+08          0.1478E+02          0.1478E+02
     0.1045E-01          0.1287E-01          0.7349E-03          0.9051E-03
Xe-137         0.5930E-01          0.4512E-07          0.4512E-07
     0.1045E-01          0.1287E-01          0.7349E-03          0.9051E-03
Xe-138         0.3367E+06          0.2396E+00          0.2396E+00
     0.1045E-01          0.1287E-01          0.7349E-03          0.9051E-03
I-131          0.2095E+07          0.3688E+08          0.1224E+05
     0.1455E+01          0.2448E+01          0.2532E-01          0.3671E+04
     0.1661E+07          0.6454E+05          0.3690E+06          0.4029E+05
     0.3903E+01          0.3929E+01
I-132          0.1639E+07          0.2886E+08          0.9599E+04
     0.1141E+01          0.1920E+01          0.1985E-01          0.2879E+04
     0.1300E+07          0.5049E+05          0.2887E+06          0.4029E+05
     0.3061E+01          0.3081E+01
I-133          0.3232E+07          0.5690E+08          0.1889E+05
     0.2246E+01          0.3778E+01          0.3907E-01          0.5664E+04
     0.2563E+07          0.9957E+05          0.5693E+06          0.4029E+05
     0.6023E+01          0.6062E+01
I-134          0.9305E+06          0.1638E+08          0.5472E+04
     0.6506E+00          0.1094E+01          0.1132E-01          0.1641E+04
     0.7379E+06          0.2866E+05          0.1639E+06          0.4029E+05
     0.1745E+01          0.1756E+01
I-135          0.2869E+07          0.5051E+08          0.1677E+05
     0.1994E+01          0.3355E+01          0.3470E-01          0.5031E+04
     0.2275E+07          0.8838E+05          0.5053E+06          0.4029E+05
     0.5350E+01          0.5384E+01


     0.2212E+02          0.1867E+02          0.9713E-01          0.4089E+02
     0.6808E+00          0.5738E+00          0.2983E-02          0.1258E+01
     0.1555E+01          0.1313E+01          0.6831E-02          0.2875E+01
     0.4788E-01          0.4035E-01          0.2097E-03          0.8844E-01
```

```
TIME =   120 MIN           ACTIVITY IN CONTAINMENT AND SIRW TANK

                    CTMT. ATM.            SUMP           SIRW TANK
                     ACTIVITY           ACTIVITY          ACTIVITY
         ISOTOPE       (Ci)               (Ci)              (CI)
         --------   ----------         ----------         --------
         Kr-83m        0.3599E+07         0.2507E+01         0.2507E+01
               0.1051E-01         0.1294E-01         0.7387E-03         0.9101E-03
         Kr-85m        0.1206E+08         0.8388E+01         0.8388E+01
               0.1051E-01         0.1294E-01         0.7387E-03         0.9101E-03
         Kr-85         0.7587E+06         0.5269E+00         0.5269E+00
               0.1051E-01         0.1294E-01         0.7387E-03         0.9101E-03
         Kr-87         0.9781E+07         0.6823E+01         0.6823E+01
               0.1051E-01         0.1294E-01         0.7387E-03         0.9101E-03
         Kr-88         0.2624E+08         0.1826E+02         0.1826E+02
               0.1051E-01         0.1294E-01         0.7387E-03         0.9101E-03
         Kr-89         0.1706E-03         0.1325E-09         0.1325E-09
               0.1051E-01         0.1294E-01         0.7387E-03         0.9101E-03
         Xe-131m       0.4431E+06         0.3077E+00         0.3077E+00
               0.1051E-01         0.1294E-01         0.7387E-03         0.9101E-03
         Xe-133m       0.4815E+07         0.3344E+01         0.3344E+01
               0.1051E-01         0.1294E-01         0.7387E-03         0.9101E-03
         Xe-133        0.1413E+09         0.9814E+02         0.9814E+02
               0.1051E-01         0.1294E-01         0.7387E-03         0.9101E-03
         Xe-135m       0.1872E+06         0.1330E+00         0.1330E+00
               0.1051E-01         0.1294E-01         0.7387E-03         0.9101E-03
         Xe-135        0.2124E+08         0.1476E+02         0.1476E+02
               0.1051E-01         0.1294E-01         0.7387E-03         0.9101E-03
         Xe-137        0.4953E-01         0.3769E-07         0.3769E-07
               0.1051E-01         0.1294E-01         0.7387E-03         0.9101E-03
         Xe-138        0.3207E+06         0.2282E+00         0.2282E+00
               0.1051E-01         0.1294E-01         0.7387E-03         0.9101E-03
         I-131         0.2094E+07         0.3688E+08         0.1236E+05
               0.1454E+01         0.2448E+01         0.2557E-01         0.3707E+04
               0.1661E+07         0.6347E+05         0.3690E+06         0.4029E+05
               0.3902E+01         0.3928E+01
         I-132         0.1630E+07         0.2871E+08         0.9646E+04
               0.1135E+01         0.1910E+01         0.1995E-01         0.2893E+04
               0.1293E+07         0.4941E+05         0.2872E+06         0.4029E+05
               0.3045E+01         0.3065E+01
         I-133         0.3229E+07         0.5687E+08         0.1906E+05
               0.2243E+01         0.3775E+01         0.3943E-01         0.5718E+04
               0.2562E+07         0.9787E+05         0.5689E+06         0.4029E+05
               0.6019E+01         0.6058E+01
         I-134         0.9178E+06         0.1617E+08         0.5454E+04
               0.6418E+00         0.1080E+01         0.1128E-01         0.1636E+04
               0.7283E+06         0.2782E+05         0.1617E+06         0.4029E+05
               0.1722E+01         0.1733E+01
         I-135         0.2862E+07         0.5042E+08         0.1691E+05
               0.1990E+01         0.3349E+01         0.3498E-01         0.5072E+04
               0.2271E+07         0.8677E+05         0.5044E+06         0.4029E+05
               0.5339E+01         0.5374E+01
```

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               0.2223E+02         0.1886E+02         0.9906E-01         0.4118E+02
               0.6842E+00         0.5795E+00         0.3042E-02         0.1267E+01
               0.1563E+01         0.1326E+01         0.6966E-02         0.2896E+01
               0.4811E-01         0.4075E-01         0.2139E-03         0.8908E-01


TIME =   134 MIN           ACTIVITY IN CONTAINMENT AND SIRW TANK

                    CTMT. ATM.            SUMP           SIRW TANK
                     ACTIVITY           ACTIVITY          ACTIVITY
         ISOTOPE       (Ci)               (Ci)              (CI)
         --------   ----------         ----------         --------
         Kr-83m        0.3300E+07         0.2299E+01         0.2299E+01
               0.1051E-01         0.1294E-01         0.7912E-03         0.9783E-03
         Kr-85m        0.1164E+08         0.8090E+01         0.8090E+01
               0.1051E-01         0.1294E-01         0.7912E-03         0.9783E-03
         Kr-85         0.7587E+06         0.5269E+00         0.5269E+00
               0.1051E-01         0.1294E-01         0.7912E-03         0.9783E-03
         Kr-87         0.8608E+07         0.6005E+01         0.6005E+01
               0.1051E-01         0.1294E-01         0.7912E-03         0.9783E-03
         Kr-88         0.2479E+08         0.1725E+02         0.1725E+02
               0.1051E-01         0.1294E-01         0.7912E-03         0.9783E-03
         Kr-89         0.7830E-05         0.6082E-11         0.6082E-11
               0.1051E-01         0.1294E-01         0.7912E-03         0.9783E-03
         Xe-131m       0.4428E+06         0.3075E+00         0.3075E+00
               0.1051E-01         0.1294E-01         0.7912E-03         0.9783E-03
         Xe-133m       0.4800E+07         0.3333E+01         0.3333E+01
               0.1051E-01         0.1294E-01         0.7912E-03         0.9783E-03
         Xe-133        0.1411E+09         0.9802E+02         0.9802E+02
               0.1051E-01         0.1294E-01         0.7912E-03         0.9783E-03
         Xe-135m       0.9926E+05         0.7051E-01         0.7051E-01
               0.1051E-01         0.1294E-01         0.7912E-03         0.9783E-03
         Xe-135        0.2087E+08         0.1450E+02         0.1450E+02
               0.1051E-01         0.1294E-01         0.7912E-03         0.9783E-03
         Xe-137        0.3985E-02         0.3032E-08         0.3032E-08
               0.1051E-01         0.1294E-01         0.7912E-03         0.9783E-03
         Xe-138        0.1619E+06         0.1152E+00         0.1152E+00
               0.1051E-01         0.1294E-01         0.7912E-03         0.9783E-03
         I-131         0.2079E+07         0.3685E+08         0.1406E+05
               0.1444E+01         0.2446E+01         0.2908E-01         0.4217E+04
               0.1660E+07         0.5022E+05         0.3687E+06         0.4028E+05
               0.3890E+01         0.3919E+01
         I-132         0.1509E+07         0.2675E+08         0.1023E+05
               0.1051E+01         0.1780E+01         0.2117E-01         0.3069E+04
               0.1205E+07         0.3646E+05         0.2676E+06         0.4028E+05
               0.2831E+01         0.2852E+01
         I-133         0.3183E+07         0.5643E+08         0.2154E+05
               0.2212E+01         0.3746E+01         0.4455E-01         0.6460E+04
               0.2542E+07         0.7690E+05         0.5645E+06         0.4028E+05
               0.5958E+01         0.6002E+01
         I-134         0.7583E+06         0.1344E+08         0.5164E+04
               0.5302E+00         0.8981E+00         0.1068E-01         0.1549E+04
```

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               0.6055E+06      0.1832E+05      0.1345E+06      0.4028E+05
               0.1428E+01      0.1439E+01
      I-135          0.2775E+07      0.4920E+08      0.1879E+05
               0.1929E+01      0.3268E+01      0.3886E-01      0.5635E+04
               0.2216E+07      0.6704E+05      0.4922E+06      0.4028E+05
               0.5197E+01      0.5236E+01

               0.2223E+02      0.1886E+02      0.9906E-01      0.4118E+02
               0.6842E+00      0.5795E+00      0.3042E-02      0.1267E+01
               0.1670E+01      0.1507E+01      0.9000E-02      0.3187E+01
               0.5140E-01      0.4631E-01      0.2763E-03      0.9799E-01



 TIME =    135 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                        CTMT. ATM.            SUMP          SIRW TANK
                         ACTIVITY           ACTIVITY         ACTIVITY
      ISOTOPE              (Ci)               (Ci)             (CI)
      --------          ----------         ----------        --------
      Kr-83m            0.3279E+07          0.2284E+01       0.2284E+01
               0.1051E-01      0.1294E-01      0.7949E-03      0.9830E-03
      Kr-85m            0.1161E+08          0.8070E+01       0.8070E+01
               0.1051E-01      0.1294E-01      0.7949E-03      0.9830E-03
      Kr-85             0.7587E+06          0.5268E+00       0.5268E+00
               0.1051E-01      0.1294E-01      0.7949E-03      0.9830E-03
      Kr-87             0.8530E+07          0.5951E+01       0.5951E+01
               0.1051E-01      0.1294E-01      0.7949E-03      0.9830E-03
      Kr-88             0.2469E+08          0.1718E+02       0.1718E+02
               0.1051E-01      0.1294E-01      0.7949E-03      0.9830E-03
      Kr-89             0.6283E-05          0.4881E-11       0.4881E-11
               0.1051E-01      0.1294E-01      0.7949E-03      0.9830E-03
      Xe-131m           0.4428E+06          0.3075E+00       0.3075E+00
               0.1051E-01      0.1294E-01      0.7949E-03      0.9830E-03
      Xe-133m           0.4799E+07          0.3333E+01       0.3333E+01
               0.1051E-01      0.1294E-01      0.7949E-03      0.9830E-03
      Xe-133            0.1411E+09          0.9801E+02       0.9801E+02
               0.1051E-01      0.1294E-01      0.7949E-03      0.9830E-03
      Xe-135m           0.9486E+05          0.6739E-01       0.6739E-01
               0.1051E-01      0.1294E-01      0.7949E-03      0.9830E-03
      Xe-135            0.2084E+08          0.1448E+02       0.1448E+02
               0.1051E-01      0.1294E-01      0.7949E-03      0.9830E-03
      Xe-137            0.3329E-02          0.2533E-08       0.2533E-08
               0.1051E-01      0.1294E-01      0.7949E-03      0.9830E-03
      Xe-138            0.1542E+06          0.1097E+00       0.1097E+00
               0.1051E-01      0.1294E-01      0.7949E-03      0.9830E-03
      I-131             0.2078E+07          0.3685E+08       0.1418E+05
               0.1443E+01      0.2446E+01      0.2934E-01      0.4254E+04
               0.1660E+07      0.4938E+05      0.3686E+06      0.4028E+05
               0.3889E+01      0.3918E+01
      I-132             0.1501E+07          0.2662E+08       0.1027E+05
               0.1045E+01      0.1771E+01      0.2124E-01      0.3080E+04
               0.1199E+07      0.3567E+05      0.2663E+06      0.4028E+05
```

```
** FILE: C1MCALC.LST                                  Created: 02/26/9    2:14
** PAGE: 14  of 28 .  Length: 195230    bytes.        Queued:  02/26/9    6:22
****************************** Lines  1431 to 1540 ****************************
               0.2816E+01      0.2837E+01
      I-133          0.3180E+07      0.5640E+08      0.2171E+05
               0.2210E+01      0.3744E+01      0.4491E-01      0.6512E+04
               0.2540E+07      0.7559E+05      0.5642E+06      0.4028E+05
               0.5954E+01      0.5999E+01
      I-134          0.7481E+06      0.1327E+08      0.5140E+04
               0.5231E+00      0.8864E+00      0.1063E-01      0.1542E+04
               0.5976E+06      0.1778E+05      0.1327E+06      0.4028E+05
               0.1409E+01      0.1420E+01
      I-135          0.2769E+07      0.4911E+08      0.1892E+05
               0.1925E+01      0.3262E+01      0.3913E-01      0.5674E+04
               0.2212E+07      0.6582E+05      0.4913E+06      0.4028E+05
               0.5187E+01      0.5227E+01

               0.2223E+02      0.1886E+02      0.9906E-01      0.4118E+02
               0.6842E+00      0.5795E+00      0.3042E-02      0.1267E+01
               0.1678E+01      0.1520E+01      0.9155E-02      0.3207E+01
               0.5164E-01      0.4671E-01      0.2810E-03      0.9862E-01



 TIME =    149 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                        CTMT. ATM.            SUMP          SIRW TANK
                         ACTIVITY           ACTIVITY         ACTIVITY
      ISOTOPE              (Ci)               (Ci)             (CI)
      --------          ----------         ----------        --------
      Kr-83m            0.3006E+07          0.2094E+01       0.2094E+01
               0.1051E-01      0.1294E-01      0.8442E-03      0.1048E-02
      Kr-85m            0.1119E+08          0.7783E+01       0.7783E+01
               0.1051E-01      0.1294E-01      0.8442E-03      0.1048E-02
      Kr-85             0.7587E+06          0.5268E+00       0.5268E+00
               0.1051E-01      0.1294E-01      0.8442E-03      0.1048E-02
      Kr-87             0.7508E+07          0.5237E+01       0.5237E+01
               0.1051E-01      0.1294E-01      0.8442E-03      0.1048E-02
      Kr-88             0.2332E+08          0.1623E+02       0.1623E+02
               0.1051E-01      0.1294E-01      0.8442E-03      0.1048E-02
      Kr-89             0.2884E-06          0.2240E-12       0.2240E-12
               0.1051E-01      0.1294E-01      0.8442E-03      0.1048E-02
      Xe-131m           0.4426E+06          0.3073E+00       0.3073E+00
               0.1051E-01      0.1294E-01      0.8442E-03      0.1048E-02
      Xe-133m           0.4784E+07          0.3322E+01       0.3322E+01
               0.1051E-01      0.1294E-01      0.8442E-03      0.1048E-02
      Xe-133            0.1409E+09          0.9788E+02       0.9788E+02
               0.1051E-01      0.1294E-01      0.8442E-03      0.1048E-02
      Xe-135m           0.5031E+05          0.3574E-01       0.3574E-01
               0.1051E-01      0.1294E-01      0.8442E-03      0.1048E-02
      Xe-135            0.2047E+08          0.1423E+02       0.1423E+02
               0.1051E-01      0.1294E-01      0.8442E-03      0.1048E-02
      Xe-137            0.2678E-03          0.2038E-09       0.2038E-09
               0.1051E-01      0.1294E-01      0.8442E-03      0.1048E-02
      Xe-138            0.7785E+05          0.5541E-01       0.5541E-01
               0.1051E-01      0.1294E-01      0.8442E-03      0.1048E-02
```

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I-131          0.2066E+07         0.3681E+08        0.1588E+05
       0.1435E+01        0.2444E+01        0.3285E-01         0.4763E+04
       0.1658E+07        0.3907E+05        0.3683E+06         0.4028E+05
       0.3878E+01        0.3911E+01
I-132          0.1392E+07         0.2480E+08        0.1073E+05
       0.9690E+00        0.1650E+01        0.2218E-01         0.3217E+04
       0.1117E+07        0.2632E+05        0.2481E+06         0.4028E+05
       0.2619E+01        0.2642E+01
I-133          0.3140E+07         0.5596E+08        0.2415E+05
       0.2181E+01        0.3715E+01        0.4994E-01         0.7241E+04
       0.2521E+07        0.5939E+05        0.5598E+06         0.4028E+05
       0.5897E+01        0.5947E+01
I-134          0.6190E+06         0.1103E+08        0.4790E+04
       0.4328E+00        0.7370E+00        0.9907E-02         0.1437E+04
       0.4969E+06        0.1171E+05        0.1104E+06         0.4028E+05
       0.1170E+01        0.1180E+01
I-135          0.2689E+07         0.4791E+08        0.2069E+05
       0.1869E+01        0.3183E+01        0.4279E-01         0.6204E+04
       0.2158E+07        0.5086E+05        0.4794E+06         0.4028E+05
       0.5052E+01        0.5095E+01


       0.2223E+02        0.1886E+02        0.9906E-01         0.4118E+02
       0.6842E+00        0.5795E+00        0.3042E-02         0.1267E+01
       0.1784E+01        0.1701E+01        0.1146E-01         0.3497E+01
       0.5490E-01        0.5224E-01        0.3517E-03         0.1075E+00



TIME =   150 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                  CTMT. ATM.          SUMP          SIRW TANK
                   ACTIVITY         ACTIVITY        ACTIVITY
ISOTOPE              (Ci)             (Ci)            (CI)
--------          ----------      -----------      ---------
Kr-83m         0.2987E+07         0.2081E+01        0.2081E+01
       0.1051E-01        0.1294E-01        0.8476E-03         0.1052E-02
Kr-85m         0.1116E+08         0.7763E+01        0.7763E+01
       0.1051E-01        0.1294E-01        0.8476E-03         0.1052E-02
Kr-85          0.7587E+06         0.5268E+00        0.5268E+00
       0.1051E-01        0.1294E-01        0.8476E-03         0.1052E-02
Kr-87          0.7439E+07         0.5190E+01        0.5190E+01
       0.1051E-01        0.1294E-01        0.8476E-03         0.1052E-02
Kr-88          0.2322E+08         0.1616E+02        0.1616E+02
       0.1051E-01        0.1294E-01        0.8476E-03         0.1052E-02
Kr-89          0.2314E-06         0.1797E-12        0.1797E-12
       0.1051E-01        0.1294E-01        0.8476E-03         0.1052E-02
Xe-131m        0.4425E+06         0.3073E+00        0.3073E+00
       0.1051E-01        0.1294E-01        0.8476E-03         0.1052E-02
Xe-133m        0.4783E+07         0.3322E+01        0.3322E+01
       0.1051E-01        0.1294E-01        0.8476E-03         0.1052E-02
Xe-133         0.1409E+09         0.9787E+02        0.9787E+02
       0.1051E-01        0.1294E-01        0.8476E-03         0.1052E-02
Xe-135m        0.4808E+05         0.3416E-01        0.3416E-01
```

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       0.1051E-01        0.1294E-01        0.8476E-03         0.1052E-02
Xe-135         0.2045E+08         0.1421E+02        0.1421E+02
       0.1051E-01        0.1294E-01        0.8476E-03         0.1052E-02
Xe-137         0.2237E-03         0.1702E-09        0.1702E-09
       0.1051E-01        0.1294E-01        0.8476E-03         0.1052E-02
Xe-138         0.7415E+05         0.5277E-01        0.5277E-01
       0.1051E-01        0.1294E-01        0.8476E-03         0.1052E-02
I-131          0.2065E+07         0.3681E+08        0.1600E+05
       0.1434E+01        0.2443E+01        0.3310E-01         0.4799E+04
       0.1658E+07        0.3842E+05        0.3683E+06         0.4028E+05
       0.3878E+01        0.3911E+01
I-132          0.1384E+07         0.2468E+08        0.1075E+05
       0.9639E+00        0.1642E+01        0.2224E-01         0.3225E+04
       0.1112E+07        0.2576E+05        0.2469E+06         0.4028E+05
       0.2606E+01        0.2628E+01
I-133          0.3137E+07         0.5593E+08        0.2432E+05
       0.2180E+01        0.3713E+01        0.5030E-01         0.7293E+04
       0.2519E+07        0.5838E+05        0.5595E+06         0.4028E+05
       0.5893E+01        0.5943E+01
I-134          0.6107E+06         0.1089E+08        0.4764E+04
       0.4270E+00        0.7274E+00        0.9853E-02         0.1429E+04
       0.4904E+06        0.1136E+05        0.1089E+06         0.4028E+05
       0.1154E+01        0.1164E+01
I-135          0.2683E+07         0.4783E+08        0.2081E+05
       0.1865E+01        0.3178E+01        0.4304E-01         0.6241E+04
       0.2155E+07        0.4993E+05        0.4785E+06         0.4028E+05
       0.5043E+01        0.5086E+01


       0.2223E+02        0.1886E+02        0.9906E-01         0.4118E+02
       0.6842E+00        0.5795E+00        0.3042E-02         0.1267E+01
       0.1792E+01        0.1714E+01        0.1164E-01         0.3517E+01
       0.5513E-01        0.5264E-01        0.3571E-03         0.1081E+00



TIME =   164 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                  CTMT. ATM.          SUMP          SIRW TANK
                   ACTIVITY         ACTIVITY        ACTIVITY
ISOTOPE              (Ci)             (Ci)            (CI)
--------          ----------      -----------      ---------
Kr-83m         0.2739E+07         0.1908E+01        0.1908E+01
       0.1051E-01        0.1294E-01        0.8941E-03         0.1114E-02
Kr-85m         0.1077E+08         0.7488E+01        0.7488E+01
       0.1051E-01        0.1294E-01        0.8941E-03         0.1114E-02
Kr-85          0.7586E+06         0.5268E+00        0.5268E+00
       0.1051E-01        0.1294E-01        0.8941E-03         0.1114E-02
Kr-87          0.6548E+07         0.4568E+01        0.4568E+01
       0.1051E-01        0.1294E-01        0.8941E-03         0.1114E-02
Kr-88          0.2194E+08         0.1527E+02        0.1527E+02
       0.1051E-01        0.1294E-01        0.8941E-03         0.1114E-02
Kr-89          0.1062E-07         0.8249E-14        0.8249E-14
       0.1051E-01        0.1294E-01        0.8941E-03         0.1114E-02
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Xe-131m         0.4423E+06          0.3072E+00          0.3072E+00
           0.1051E-01      0.1294E-01      0.8941E-03      0.1114E-02
Xe-133m         0.4768E+07          0.3312E+01          0.3312E+01
           0.1051E-01      0.1294E-01      0.8941E-03      0.1114E-02
Xe-133          0.1407E+09          0.9774E+02          0.9774E+02
           0.1051E-01      0.1294E-01      0.8941E-03      0.1114E-02
Xe-135m         0.2550E+05          0.1812E-01          0.1812E-01
           0.1051E-01      0.1294E-01      0.8941E-03      0.1114E-02
Xe-135          0.2009E+08          0.1396E+02          0.1396E+02
           0.1051E-01      0.1294E-01      0.8941E-03      0.1114E-02
Xe-137          0.1800E-04          0.1370E-10          0.1370E-10
           0.1051E-01      0.1294E-01      0.8941E-03      0.1114E-02
Xe-138          0.3744E+05          0.2664E-01          0.2664E-01
           0.1051E-01      0.1294E-01      0.8941E-03      0.1114E-02
I-131           0.2055E+07          0.3678E+08          0.1770E+05
           0.1427E+01      0.2441E+01      0.3660E-01      0.5307E+04
           0.1657E+07      0.3040E+05      0.3680E+06      0.4028E+05
           0.3869E+01      0.3905E+01
I-132           0.1285E+07          0.2299E+08          0.1109E+05
           0.8946E+00      0.1530E+01      0.2294E-01      0.3326E+04
           0.1036E+07      0.1901E+05      0.2300E+06      0.4028E+05
           0.2425E+01      0.2448E+01
I-133           0.3101E+07          0.5549E+08          0.2671E+05
           0.2154E+01      0.3684E+01      0.5524E-01      0.8009E+04
           0.2500E+07      0.4587E+05      0.5552E+06      0.4028E+05
           0.5839E+01      0.5894E+01
I-134           0.5058E+06          0.9051E+07          0.4384E+04
           0.3536E+00      0.6048E+00      0.9068E-02      0.1315E+04
           0.4078E+06      0.7482E+04      0.9056E+05      0.4028E+05
           0.9584E+00      0.9675E+00
I-135           0.2608E+07          0.4667E+08          0.2248E+05
           0.1813E+01      0.3100E+01      0.4648E-01      0.6740E+04
           0.2102E+07      0.3858E+05      0.4669E+06      0.4028E+05
           0.4913E+01      0.4960E+01


           0.2223E+02      0.1886E+02      0.9906E-01      0.4118E+02
           0.6842E+00      0.5795E+00      0.3042E-02      0.1267E+01
           0.1897E+01      0.1894E+01      0.1422E-01      0.3805E+01
           0.5836E-01      0.5815E-01      0.4360E-03      0.1169E+00




TIME =   165 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                CTMT. ATM.            SUMP          SIRW TANK
                 ACTIVITY           ACTIVITY         ACTIVITY
ISOTOPE            (Ci)               (Ci)             (CI)
--------        ---------          ----------        --------
Kr-83m          0.2722E+07          0.1896E+01          0.1896E+01
           0.1051E-01      0.1294E-01      0.8973E-03      0.1118E-02
Kr-85m          0.1074E+08          0.7469E+01          0.7469E+01
           0.1051E-01      0.1294E-01      0.8973E-03      0.1118E-02
Kr-85           0.7586E+06          0.5268E+00          0.5268E+00
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           0.1051E-01      0.1294E-01      0.8973E-03      0.1118E-02
Kr-87           0.6488E+07          0.4526E+01          0.4526E+01
           0.1051E-01      0.1294E-01      0.8973E-03      0.1118E-02
Kr-88           0.2185E+08          0.1520E+02          0.1520E+02
           0.1051E-01      0.1294E-01      0.8973E-03      0.1118E-02
Kr-89           0.8522E-08          0.6620E-14          0.6620E-14
           0.1051E-01      0.1294E-01      0.8973E-03      0.1118E-02
Xe-131m         0.4423E+06          0.3071E+00          0.3071E+00
           0.1051E-01      0.1294E-01      0.8973E-03      0.1118E-02
Xe-133m         0.4767E+07          0.3311E+01          0.3311E+01
           0.1051E-01      0.1294E-01      0.8973E-03      0.1118E-02
Xe-133          0.1407E+09          0.9774E+02          0.9774E+02
           0.1051E-01      0.1294E-01      0.8973E-03      0.1118E-02
Xe-135m         0.2437E+05          0.1731E-01          0.1731E-01
           0.1051E-01      0.1294E-01      0.8973E-03      0.1118E-02
Xe-135          0.2006E+08          0.1394E+02          0.1394E+02
           0.1051E-01      0.1294E-01      0.8973E-03      0.1118E-02
Xe-137          0.1503E-04          0.1144E-10          0.1144E-10
           0.1051E-01      0.1294E-01      0.8973E-03      0.1118E-02
Xe-138          0.3565E+05          0.2537E-01          0.2537E-01
           0.1051E-01      0.1294E-01      0.8973E-03      0.1118E-02
I-131           0.2055E+07          0.3678E+08          0.1782E+05
           0.1427E+01      0.2441E+01      0.3685E-01      0.5344E+04
           0.1657E+07      0.2990E+05      0.3680E+06      0.4028E+05
           0.3868E+01      0.3905E+01
I-132           0.1278E+07          0.2288E+08          0.1111E+05
           0.8899E+00      0.1522E+01      0.2298E-01      0.3332E+04
           0.1031E+07      0.1860E+05      0.2289E+06      0.4028E+05
           0.2412E+01      0.2435E+01
I-133           0.3098E+07          0.5546E+08          0.2688E+05
           0.2153E+01      0.3682E+01      0.5559E-01      0.8060E+04
           0.2498E+07      0.4509E+05      0.5549E+06      0.4028E+05
           0.5835E+01      0.5890E+01
I-134           0.4991E+06          0.8933E+07          0.4357E+04
           0.3489E+00      0.5969E+00      0.9010E-02      0.1307E+04
           0.4024E+06      0.7262E+04      0.8938E+05      0.4028E+05
           0.9458E+00      0.9548E+00
I-135           0.2603E+07          0.4659E+08          0.2259E+05
           0.1809E+01      0.3095E+01      0.4672E-01      0.6775E+04
           0.2099E+07      0.3787E+05      0.4661E+06      0.4028E+05
           0.4904E+01      0.4951E+01


           0.2223E+02      0.1886E+02      0.9906E-01      0.4118E+02
           0.6842E+00      0.5795E+00      0.3042E-02      0.1267E+01
           0.1905E+01      0.1907E+01      0.1441E-01      0.3826E+01
           0.5859E-01      0.5855E-01      0.4420E-03      0.1176E+00




TIME =   179 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                CTMT. ATM.            SUMP          SIRW TANK
                 ACTIVITY           ACTIVITY         ACTIVITY
```

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ISOTOPE             (Ci)                (Ci)               (CI)
--------          ----------          ----------          --------
Kr-83m            0.2495E+07          0.1738E+01          0.1738E+01
         0.1051E-01          0.1294E-01          0.9411E-03          0.1177E-02
Kr-85m            0.1036E+08          0.7204E+01          0.7204E+01
         0.1051E-01          0.1294E-01          0.9411E-03          0.1177E-02
Kr-85             0.7586E+06          0.5268E+00          0.5268E+00
         0.1051E-01          0.1294E-01          0.9411E-03          0.1177E-02
Kr-87             0.5710E+07          0.3984E+01          0.3984E+01
         0.1051E-01          0.1294E-01          0.9411E-03          0.1177E-02
Kr-88             0.2064E+08          0.1436E+02          0.1436E+02
         0.1051E-01          0.1294E-01          0.9411E-03          0.1177E-02
Kr-89             0.3911E-09          0.3038E-15          0.3038E-15
         0.1051E-01          0.1294E-01          0.9411E-03          0.1177E-02
Xe-131m           0.4420E+06          0.3070E+00          0.3070E+00
         0.1051E-01          0.1294E-01          0.9411E-03          0.1177E-02
Xe-133m           0.4752E+07          0.3301E+01          0.3301E+01
         0.1051E-01          0.1294E-01          0.9411E-03          0.1177E-02
Xe-133            0.1406E+09          0.9761E+02          0.9761E+02
         0.1051E-01          0.1294E-01          0.9411E-03          0.1177E-02
Xe-135m           0.1293E+05          0.9182E-02          0.9182E-02
         0.1051E-01          0.1294E-01          0.9411E-03          0.1177E-02
Xe-135            0.1971E+08          0.1369E+02          0.1369E+02
         0.1051E-01          0.1294E-01          0.9411E-03          0.1177E-02
Xe-137            0.1210E-05          0.9204E-12          0.9204E-12
         0.1051E-01          0.1294E-01          0.9411E-03          0.1177E-02
Xe-138            0.1800E+05          0.1281E-01          0.1281E-01
         0.1051E-01          0.1294E-01          0.9411E-03          0.1177E-02
I-131             0.2047E+07          0.3674E+08          0.1951E+05
         0.1421E+01          0.2439E+01          0.4035E-01          0.5851E+04
         0.1655E+07          0.2366E+05          0.3677E+06          0.4027E+05
         0.3861E+01          0.3901E+01
I-132             0.1187E+07          0.2131E+08          0.1135E+05
         0.8267E+00          0.1419E+01          0.2347E-01          0.3403E+04
         0.9603E+06          0.1372E+05          0.2133E+06          0.4027E+05
         0.2245E+01          0.2269E+01
I-133             0.3065E+07          0.5502E+08          0.2923E+05
         0.2129E+01          0.3654E+01          0.6044E-01          0.8764E+04
         0.2479E+07          0.3543E+05          0.5506E+06          0.4027E+05
         0.5783E+01          0.5844E+01
I-134             0.4137E+06          0.7427E+07          0.3970E+04
         0.2892E+00          0.4963E+00          0.8210E-02          0.1190E+04
         0.3346E+06          0.4782E+04          0.7432E+05          0.4027E+05
         0.7855E+00          0.7938E+00
I-135             0.2532E+07          0.4545E+08          0.2416E+05
         0.1760E+01          0.3020E+01          0.4996E-01          0.7244E+04
         0.2048E+07          0.2926E+05          0.4548E+06          0.4027E+05
         0.4780E+01          0.4830E+01


         0.2223E+02          0.1886E+02          0.9906E-01          0.4118E+02
         0.6842E+00          0.5795E+00          0.3042E-02          0.1267E+01
         0.2010E+01          0.2086E+01          0.1726E-01          0.4113E+01
         0.6179E-01          0.6404E-01          0.5292E-03          0.1264E+00
```

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** FILE: C1MCALC.LST                                  Created: 02/26/9    2:14
** PAGE: 17  of 28 .  Length: 195230    bytes.        Queued:  02/26/9    6:22
****************************** Lines  1761 to 1870 ******************************

TIME =    180 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                           CTMT. ATM.            SUMP            SIRW TANK
                            ACTIVITY           ACTIVITY          ACTIVITY
        ISOTOPE               (Ci)               (Ci)              (CI)
        --------           ----------         ----------         --------
        Kr-83m             0.2480E+07         0.1727E+01         0.1727E+01
                 0.1051E-01         0.1294E-01         0.9442E-03         0.1181E-02
        Kr-85m             0.1033E+08         0.7185E+01         0.7185E+01
                 0.1051E-01         0.1294E-01         0.9442E-03         0.1181E-02
        Kr-85              0.7586E+06         0.5268E+00         0.5268E+00
                 0.1051E-01         0.1294E-01         0.9442E-03         0.1181E-02
        Kr-87              0.5659E+07         0.3948E+01         0.3948E+01
                 0.1051E-01         0.1294E-01         0.9442E-03         0.1181E-02
        Kr-88              0.2056E+08         0.1430E+02         0.1430E+02
                 0.1051E-01         0.1294E-01         0.9442E-03         0.1181E-02
        Kr-89              0.3138E-09         0.2438E-15         0.2438E-15
                 0.1051E-01         0.1294E-01         0.9442E-03         0.1181E-02
        Xe-131m            0.4420E+06         0.3070E+00         0.3070E+00
                 0.1051E-01         0.1294E-01         0.9442E-03         0.1181E-02
        Xe-133m            0.4751E+07         0.3300E+01         0.3300E+01
                 0.1051E-01         0.1294E-01         0.9442E-03         0.1181E-02
        Xe-133             0.1405E+09         0.9760E+02         0.9760E+02
                 0.1051E-01         0.1294E-01         0.9442E-03         0.1181E-02
        Xe-135m            0.1235E+05         0.8776E-02         0.8776E-02
                 0.1051E-01         0.1294E-01         0.9442E-03         0.1181E-02
        Xe-135             0.1968E+08         0.1368E+02         0.1368E+02
                 0.1051E-01         0.1294E-01         0.9442E-03         0.1181E-02
        Xe-137             0.1010E-05         0.7688E-12         0.7688E-12
                 0.1051E-01         0.1294E-01         0.9442E-03         0.1181E-02
        Xe-138             0.1715E+05         0.1220E-01         0.1220E-01
                 0.1051E-01         0.1294E-01         0.9442E-03         0.1181E-02
        I-131              0.2046E+07         0.3674E+08         0.1963E+05
                 0.1421E+01         0.2439E+01         0.4060E-01         0.5887E+04
                 0.1655E+07         0.2326E+05         0.3676E+06         0.4027E+05
                 0.3860E+01         0.3901E+01
        I-132              0.1181E+07         0.2121E+08         0.1136E+05
                 0.8223E+00         0.1411E+01         0.2349E-01         0.3407E+04
                 0.9554E+06         0.1343E+05         0.2122E+06         0.4027E+05
                 0.2234E+01         0.2257E+01
        I-133              0.3063E+07         0.5499E+08         0.2939E+05
                 0.2128E+01         0.3652E+01         0.6079E-01         0.8814E+04
                 0.2478E+07         0.3482E+05         0.5503E+06         0.4027E+05
                 0.5779E+01         0.5840E+01
        I-134              0.4082E+06         0.7330E+07         0.3942E+04
                 0.2854E+00         0.4898E+00         0.8153E-02         0.1182E+04
                 0.3302E+06         0.4641E+04         0.7334E+05         0.4027E+05
                 0.7752E+00         0.7834E+00
        I-135              0.2527E+07         0.4537E+08         0.2426E+05
                 0.1757E+01         0.3015E+01         0.5018E-01         0.7276E+04
                 0.2044E+07         0.2873E+05         0.4540E+06         0.4027E+05
                 0.4771E+01         0.4821E+01
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          0.2223E+02        0.1886E+02        0.9906E-01        0.4118E+02
          0.6842E+00        0.5795E+00        0.3042E-02        0.1267E+01
          0.2017E+01        0.2099E+01        0.1747E-01        0.4133E+01
          0.6202E-01        0.6443E-01        0.5357E-03        0.1270E+00



 TIME =    194 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                  CTMT. ATM.          SUMP           SIRW TANK
                   ACTIVITY         ACTIVITY         ACTIVITY
 ISOTOPE             (Ci)             (Ci)             (CI)
 --------         ----------       ----------       --------
 Kr-83m            0.2273E+07        0.1583E+01        0.1583E+01
          0.1051E-01        0.1294E-01        0.9855E-03        0.1236E-02
 Kr-85m            0.9967E+07        0.6930E+01        0.6930E+01
          0.1051E-01        0.1294E-01        0.9855E-03        0.1236E-02
 Kr-85             0.7586E+06        0.5268E+00        0.5268E+00
          0.1051E-01        0.1294E-01        0.9855E-03        0.1236E-02
 Kr-87             0.4980E+07        0.3474E+01        0.3474E+01
          0.1051E-01        0.1294E-01        0.9855E-03        0.1236E-02
 Kr-88             0.1942E+08        0.1351E+02        0.1351E+02
          0.1051E-01        0.1294E-01        0.9855E-03        0.1236E-02
 Kr-89             0.1440E-10        0.1119E-16        0.1119E-16
          0.1051E-01        0.1294E-01        0.9855E-03        0.1236E-02
 Xe-131m           0.4417E+06        0.3068E+00        0.3068E+00
          0.1051E-01        0.1294E-01        0.9855E-03        0.1236E-02
 Xe-133m           0.4737E+07        0.3290E+01        0.3290E+01
          0.1051E-01        0.1294E-01        0.9855E-03        0.1236E-02
 Xe-133            0.1404E+09        0.9747E+02        0.9747E+02
          0.1051E-01        0.1294E-01        0.9855E-03        0.1236E-02
 Xe-135m           0.6551E+04        0.4654E-02        0.4654E-02
          0.1051E-01        0.1294E-01        0.9855E-03        0.1236E-02
 Xe-135            0.1934E+08        0.1344E+02        0.1344E+02
          0.1051E-01        0.1294E-01        0.9855E-03        0.1236E-02
 Xe-137            0.8129E-07        0.6185E-13        0.6185E-13
          0.1051E-01        0.1294E-01        0.9855E-03        0.1236E-02
 Xe-138            0.8657E+04        0.6161E-02        0.6161E-02
          0.1051E-01        0.1294E-01        0.9855E-03        0.1236E-02
 I-131             0.2040E+07        0.3671E+08        0.2132E+05
          0.1417E+01        0.2437E+01        0.4409E-01        0.6393E+04
          0.1654E+07        0.1841E+05        0.3673E+06        0.4027E+05
          0.3854E+01        0.3898E+01
 I-132             0.1098E+07        0.1976E+08        0.1151E+05
          0.7644E+00        0.1315E+01        0.2379E-01        0.3450E+04
          0.8903E+06        0.9908E+04        0.1977E+06        0.4027E+05
          0.2080E+01        0.2103E+01
 I-133             0.3032E+07        0.5456E+08        0.3170E+05
          0.2106E+01        0.3623E+01        0.6556E-01        0.9506E+04
          0.2458E+07        0.2736E+05        0.5460E+06        0.4027E+05
          0.5730E+01        0.5795E+01
 I-134             0.3386E+06        0.6094E+07        0.3563E+04
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          0.2367E+00        0.4073E+00        0.7369E-02        0.1068E+04
          0.2746E+06        0.3056E+04        0.6099E+05        0.4027E+05
          0.6440E+00        0.6514E+00
 I-135             0.2460E+07        0.4427E+08        0.2573E+05
          0.1710E+01        0.2942E+01        0.5322E-01        0.7717E+04
          0.1995E+07        0.2220E+05        0.4430E+06        0.4027E+05
          0.4651E+01        0.4705E+01


          0.2223E+02        0.1886E+02        0.9906E-01        0.4118E+02
          0.6842E+00        0.5795E+00        0.3042E-02        0.1267E+01
          0.2121E+01        0.2278E+01        0.2059E-01        0.4420E+01
          0.6521E-01        0.6991E-01        0.6311E-03        0.1357E+00



 TIME =    195 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                  CTMT. ATM.          SUMP           SIRW TANK
                   ACTIVITY         ACTIVITY         ACTIVITY
 ISOTOPE             (Ci)             (Ci)             (CI)
 --------         ----------       ----------       --------
 Kr-83m            0.2259E+07        0.1574E+01        0.1574E+01
          0.1051E-01        0.1294E-01        0.9884E-03        0.1240E-02
 Kr-85m            0.9941E+07        0.6912E+01        0.6912E+01
          0.1051E-01        0.1294E-01        0.9884E-03        0.1240E-02
 Kr-85             0.7586E+06        0.5268E+00        0.5268E+00
          0.1051E-01        0.1294E-01        0.9884E-03        0.1240E-02
 Kr-87             0.4935E+07        0.3443E+01        0.3443E+01
          0.1051E-01        0.1294E-01        0.9884E-03        0.1240E-02
 Kr-88             0.1934E+08        0.1346E+02        0.1346E+02
          0.1051E-01        0.1294E-01        0.9884E-03        0.1240E-02
 Kr-89             0.1156E-10        0.8978E-17        0.8978E-17
          0.1051E-01        0.1294E-01        0.9884E-03        0.1240E-02
 Xe-131m           0.4417E+06        0.3068E+00        0.3068E+00
          0.1051E-01        0.1294E-01        0.9884E-03        0.1240E-02
 Xe-133m           0.4736E+07        0.3289E+01        0.3289E+01
          0.1051E-01        0.1294E-01        0.9884E-03        0.1240E-02
 Xe-133            0.1403E+09        0.9747E+02        0.9747E+02
          0.1051E-01        0.1294E-01        0.9884E-03        0.1240E-02
 Xe-135m           0.6261E+04        0.4448E-02        0.4448E-02
          0.1051E-01        0.1294E-01        0.9884E-03        0.1240E-02
 Xe-135            0.1931E+08        0.1342E+02        0.1342E+02
          0.1051E-01        0.1294E-01        0.9884E-03        0.1240E-02
 Xe-137            0.6790E-07        0.5166E-13        0.5166E-13
          0.1051E-01        0.1294E-01        0.9884E-03        0.1240E-02
 Xe-138            0.8245E+04        0.5867E-02        0.5867E-02
          0.1051E-01        0.1294E-01        0.9884E-03        0.1240E-02
 I-131             0.2039E+07        0.3670E+08        0.2144E+05
          0.1416E+01        0.2437E+01        0.4434E-01        0.6429E+04
          0.1654E+07        0.1810E+05        0.3673E+06        0.4027E+05
          0.3853E+01        0.3897E+01
 I-132             0.1092E+07        0.1966E+08        0.1151E+05
          0.7605E+00        0.1309E+01        0.2381E-01        0.3452E+04
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          0.8858E+06     0.9695E+04     0.1967E+06     0.4027E+05
          0.2069E+01     0.2093E+01
 I-133          0.3030E+07     0.5453E+08     0.3186E+05
          0.2105E+01     0.3621E+01     0.6590E-01     0.9555E+04
          0.2457E+07     0.2689E+05     0.5457E+06     0.4027E+05
          0.5726E+01     0.5792E+01
 I-134          0.3341E+06     0.6015E+07     0.3536E+04
          0.2336E+00     0.4019E+00     0.7314E-02     0.1061E+04
          0.2710E+06     0.2966E+04     0.6019E+05     0.4027E+05
          0.6355E+00     0.6429E+00
 I-135          0.2455E+07     0.4419E+08     0.2584E+05
          0.1707E+01     0.2936E+01     0.5343E-01     0.7747E+04
          0.1991E+07     0.2179E+05     0.4422E+06     0.4027E+05
          0.4643E+01     0.4696E+01


          0.2223E+02     0.1886E+02     0.9906E-01     0.4118E+02
          0.6842E+00     0.5795E+00     0.3042E-02     0.1267E+01
          0.2128E+01     0.2291E+01     0.2082E-01     0.4440E+01
          0.6544E-01     0.7030E-01     0.6382E-03     0.1364E+00



TIME =   209 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                CTMT. ATM.          SUMP          SIRW TANK
                 ACTIVITY         ACTIVITY         ACTIVITY
 ISOTOPE           (Ci)             (Ci)             (CI)
 --------       ----------       ----------       --------
 Kr-83m         0.2071E+07     0.1443E+01     0.1443E+01
          0.1051E-01     0.1294E-01     0.1027E-02     0.1294E-02
 Kr-85m         0.9588E+07     0.6667E+01     0.6667E+01
          0.1051E-01     0.1294E-01     0.1027E-02     0.1294E-02
 Kr-85          0.7586E+06     0.5268E+00     0.5268E+00
          0.1051E-01     0.1294E-01     0.1027E-02     0.1294E-02
 Kr-87          0.4343E+07     0.3030E+01     0.3030E+01
          0.1051E-01     0.1294E-01     0.1027E-02     0.1294E-02
 Kr-88          0.1827E+08     0.1271E+02     0.1271E+02
          0.1051E-01     0.1294E-01     0.1027E-02     0.1294E-02
 Kr-89          0.5304E-12     0.4120E-18     0.4120E-18
          0.1051E-01     0.1294E-01     0.1027E-02     0.1294E-02
 Xe-131m        0.4415E+06     0.3066E+00     0.3066E+00
          0.1051E-01     0.1294E-01     0.1027E-02     0.1294E-02
 Xe-133m        0.4721E+07     0.3279E+01     0.3279E+01
          0.1051E-01     0.1294E-01     0.1027E-02     0.1294E-02
 Xe-133         0.1402E+09     0.9734E+02     0.9734E+02
          0.1051E-01     0.1294E-01     0.1027E-02     0.1294E-02
 Xe-135m        0.3321E+04     0.2359E-02     0.2359E-02
          0.1051E-01     0.1294E-01     0.1027E-02     0.1294E-02
 Xe-135         0.1897E+08     0.1318E+02     0.1318E+02
          0.1051E-01     0.1294E-01     0.1027E-02     0.1294E-02
 Xe-137         0.5463E-08     0.4157E-14     0.4157E-14
          0.1051E-01     0.1294E-01     0.1027E-02     0.1294E-02
 Xe-138         0.4163E+04     0.2963E-02     0.2963E-02
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** FILE: C1MCALC.LST                                   Created: 02/26/9    2:14
** PAGE: 19  of 28 .  Length: 195230    bytes.         Queued:  02/26/9    6:22
******************************* Lines  1981 to 2090 ******************************
          0.1051E-01     0.1294E-01     0.1027E-02     0.1294E-02
 I-131          0.2036E+07     0.3667E+08     0.2313E+05
          0.1414E+01     0.2435E+01     0.4783E-01     0.6935E+04
          0.1652E+07     0.1664E+05     0.3670E+06     0.4027E+05
          0.3849E+01     0.3897E+01
 I-132          0.1017E+07     0.1832E+08     0.1158E+05
          0.7080E+00     0.1219E+01     0.2395E-01     0.3473E+04
          0.8254E+06     0.8312E+04     0.1833E+06     0.4027E+05
          0.1927E+01     0.1951E+01
 I-133          0.3004E+07     0.5411E+08     0.3413E+05
          0.2087E+01     0.3593E+01     0.7058E-01     0.1023E+05
          0.2438E+07     0.2455E+05     0.5415E+06     0.4027E+05
          0.5680E+01     0.5751E+01
 I-134          0.2776E+06     0.5001E+07     0.3174E+04
          0.1941E+00     0.3342E+00     0.6565E-02     0.9519E+03
          0.2253E+06     0.2269E+04     0.5005E+05     0.4027E+05
          0.5283E+00     0.5349E+00
 I-135          0.2394E+07     0.4312E+08     0.2721E+05
          0.1664E+01     0.2865E+01     0.5628E-01     0.8160E+04
          0.1943E+07     0.1956E+05     0.4315E+06     0.4027E+05
          0.4529E+01     0.4585E+01


          0.2223E+02     0.1886E+02     0.9906E-01     0.4118E+02
          0.6842E+00     0.5795E+00     0.3042E-02     0.1267E+01
          0.2232E+01     0.2469E+01     0.2420E-01     0.4725E+01
          0.6860E-01     0.7576E-01     0.7417E-03     0.1451E+00



TIME =   210 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                CTMT. ATM.          SUMP          SIRW TANK
                 ACTIVITY         ACTIVITY         ACTIVITY
 ISOTOPE           (Ci)             (Ci)             (CI)
 --------       ----------       ----------       --------
 Kr-83m         0.2058E+07     0.1434E+01     0.1434E+01
          0.1051E-01     0.1294E-01     0.1030E-02     0.1297E-02
 Kr-85m         0.9564E+07     0.6650E+01     0.6650E+01
          0.1051E-01     0.1294E-01     0.1030E-02     0.1297E-02
 Kr-85          0.7586E+06     0.5268E+00     0.5268E+00
          0.1051E-01     0.1294E-01     0.1030E-02     0.1297E-02
 Kr-87          0.4304E+07     0.3003E+01     0.3003E+01
          0.1051E-01     0.1294E-01     0.1030E-02     0.1297E-02
 Kr-88          0.1819E+08     0.1266E+02     0.1266E+02
          0.1051E-01     0.1294E-01     0.1030E-02     0.1297E-02
 Kr-89          0.4256E-12     0.3306E-18     0.3306E-18
          0.1051E-01     0.1294E-01     0.1030E-02     0.1297E-02
 Xe-131m        0.4415E+06     0.3066E+00     0.3066E+00
          0.1051E-01     0.1294E-01     0.1030E-02     0.1297E-02
 Xe-133m        0.4720E+07     0.3278E+01     0.3278E+01
          0.1051E-01     0.1294E-01     0.1030E-02     0.1297E-02
 Xe-133         0.1401E+09     0.9733E+02     0.9733E+02
          0.1051E-01     0.1294E-01     0.1030E-02     0.1297E-02
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Xe-135m          0.3174E+04          0.2255E-02          0.2255E-02
         0.1051E-01          0.1294E-01          0.1030E-02          0.1297E-02
Xe-135           0.1895E+08          0.1317E+02          0.1317E+02
         0.1051E-01          0.1294E-01          0.1030E-02          0.1297E-02
Xe-137           0.4563E-08          0.3472E-14          0.3472E-14
         0.1051E-01          0.1294E-01          0.1030E-02          0.1297E-02
Xe-138           0.3965E+04          0.2821E-02          0.2821E-02
         0.1051E-01          0.1294E-01          0.1030E-02          0.1297E-02
I-131            0.2036E+07          0.3667E+08          0.2325E+05
         0.1414E+01          0.2435E+01          0.4807E-01          0.6971E+04
         0.1652E+07          0.1664E+05          0.3670E+06          0.4027E+05
         0.3848E+01          0.3897E+01
I-132            0.1012E+07          0.1823E+08          0.1158E+05
         0.7045E+00          0.1213E+01          0.2395E-01          0.3473E+04
         0.8212E+06          0.8270E+04          0.1824E+06          0.4027E+05
         0.1918E+01          0.1942E+01
I-133            0.3002E+07          0.5408E+08          0.3429E+05
         0.2086E+01          0.3591E+01          0.7091E-01          0.1028E+05
         0.2437E+07          0.2454E+05          0.5412E+06          0.4027E+05
         0.5677E+01          0.5748E+01
I-134            0.2740E+06          0.4935E+07          0.3149E+04
         0.1915E+00          0.3298E+00          0.6513E-02          0.9444E+03
         0.2224E+06          0.2239E+04          0.4939E+05          0.4027E+05
         0.5214E+00          0.5279E+00
I-135            0.2390E+07          0.4304E+08          0.2731E+05
         0.1661E+01          0.2860E+01          0.5648E-01          0.8189E+04
         0.1939E+07          0.1953E+05          0.4307E+06          0.4027E+05
         0.4521E+01          0.4578E+01


         0.2223E+02          0.1886E+02          0.9906E-01          0.4118E+02
         0.6842E+00          0.5795E+00          0.3042E-02          0.1267E+01
         0.2239E+01          0.2482E+01          0.2445E-01          0.4745E+01
         0.6883E-01          0.7614E-01          0.7494E-03          0.1457E+00



TIME =   239 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                 CTMT. ATM.            SUMP           SIRW TANK
                  ACTIVITY           ACTIVITY          ACTIVITY
ISOTOPE             (Ci)               (Ci)              (CI)
--------         ----------         ----------         --------
Kr-83m           0.1719E+07          0.1197E+01          0.1197E+01
         0.1051E-01          0.1294E-01          0.1105E-02          0.1401E-02
Kr-85m           0.8874E+07          0.6171E+01          0.6171E+01
         0.1051E-01          0.1294E-01          0.1105E-02          0.1401E-02
Kr-85            0.7586E+06          0.5268E+00          0.5268E+00
         0.1051E-01          0.1294E-01          0.1105E-02          0.1401E-02
Kr-87            0.3304E+07          0.2305E+01          0.2305E+01
         0.1051E-01          0.1294E-01          0.1105E-02          0.1401E-02
Kr-88            0.1617E+08          0.1125E+02          0.1125E+02
         0.1051E-01          0.1294E-01          0.1105E-02          0.1401E-02
Kr-89            0.7194E-15          0.5588E-21          0.5588E-21
```

```
         0.1051E-01          0.1294E-01          0.1105E-02          0.1401E-02
Xe-131m          0.4409E+06          0.3062E+00          0.3062E+00
         0.1051E-01          0.1294E-01          0.1105E-02          0.1401E-02
Xe-133m          0.4690E+07          0.3257E+01          0.3257E+01
         0.1051E-01          0.1294E-01          0.1105E-02          0.1401E-02
Xe-133           0.1398E+09          0.9707E+02          0.9707E+02
         0.1051E-01          0.1294E-01          0.1105E-02          0.1401E-02
Xe-135m          0.8531E+03          0.6061E-03          0.6061E-03
         0.1051E-01          0.1294E-01          0.1105E-02          0.1401E-02
Xe-135           0.1826E+08          0.1269E+02          0.1269E+02
         0.1051E-01          0.1294E-01          0.1105E-02          0.1401E-02
Xe-137           0.2468E-10          0.1877E-16          0.1877E-16
         0.1051E-01          0.1294E-01          0.1105E-02          0.1401E-02
Xe-138           0.9626E+03          0.6851E-03          0.6851E-03
         0.1051E-01          0.1294E-01          0.1105E-02          0.1401E-02
I-131            0.2032E+07          0.3660E+08          0.2673E+05
         0.1411E+01          0.2430E+01          0.5527E-01          0.8014E+04
         0.1649E+07          0.1661E+05          0.3663E+06          0.4026E+05
         0.3842E+01          0.3897E+01
I-132            0.8742E+06          0.1574E+08          0.1153E+05
         0.6086E+00          0.1048E+01          0.2383E-01          0.3456E+04
         0.7094E+06          0.7144E+04          0.1576E+06          0.4026E+05
         0.1657E+01          0.1680E+01
I-133            0.2954E+07          0.5321E+08          0.3887E+05
         0.2052E+01          0.3534E+01          0.8037E-01          0.1165E+05
         0.2398E+07          0.2415E+05          0.5325E+06          0.4026E+05
         0.5586E+01          0.5667E+01
I-134            0.1870E+06          0.3367E+07          0.2475E+04
         0.1307E+00          0.2251E+00          0.5118E-02          0.7422E+03
         0.1517E+06          0.1528E+04          0.3370E+05          0.4026E+05
         0.3558E+00          0.3609E+00
I-135            0.2271E+07          0.4090E+08          0.2989E+05
         0.1579E+01          0.2718E+01          0.6182E-01          0.8964E+04
         0.1843E+07          0.1856E+05          0.4094E+06          0.4026E+05
         0.4297E+01          0.4359E+01


         0.2223E+02          0.1886E+02          0.9906E-01          0.4118E+02
         0.6842E+00          0.5795E+00          0.3042E-02          0.1267E+01
         0.2453E+01          0.2849E+01          0.3228E-01          0.5334E+01
         0.7536E-01          0.8739E-01          0.9888E-03          0.1637E+00



TIME =   240 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                 CTMT. ATM.            SUMP           SIRW TANK
                  ACTIVITY           ACTIVITY          ACTIVITY
ISOTOPE             (Ci)               (Ci)              (CI)
---------        ----------         ----------         --------
Kr-83m           0.1708E+07          0.1190E+01          0.1190E+01
         0.1051E-01          0.1294E-01          0.1107E-02          0.1404E-02
Kr-85m           0.8852E+07          0.6155E+01          0.6155E+01
         0.1051E-01          0.1294E-01          0.1107E-02          0.1404E-02
```

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Kr-85          0.7586E+06       0.5268E+00       0.5268E+00
          0.1051E-01       0.1294E-01       0.1107E-02       0.1404E-02
Kr-87          0.3274E+07       0.2284E+01       0.2284E+01
          0.1051E-01       0.1294E-01       0.1107E-02       0.1404E-02
Kr-88          0.1610E+08       0.1121E+02       0.1121E+02
          0.1051E-01       0.1294E-01       0.1107E-02       0.1404E-02
Kr-89          0.5773E-15       0.4484E-21       0.4484E-21
          0.1051E-01       0.1294E-01       0.1107E-02       0.1404E-02
Xe-131m        0.4409E+06       0.3062E+00       0.3062E+00
          0.1051E-01       0.1294E-01       0.1107E-02       0.1404E-02
Xe-133m        0.4689E+07       0.3256E+01       0.3256E+01
          0.1051E-01       0.1294E-01       0.1107E-02       0.1404E-02
Xe-133         0.1398E+09       0.9706E+02       0.9706E+02
          0.1051E-01       0.1294E-01       0.1107E-02       0.1404E-02
Xe-135m        0.8153E+03       0.5792E-03       0.5792E-03
          0.1051E-01       0.1294E-01       0.1107E-02       0.1404E-02
Xe-135         0.1824E+08       0.1267E+02       0.1267E+02
          0.1051E-01       0.1294E-01       0.1107E-02       0.1404E-02
Xe-137         0.2061E-10       0.1568E-16       0.1568E-16
          0.1051E-01       0.1294E-01       0.1107E-02       0.1404E-02
Xe-138         0.9167E+03       0.6524E-03       0.6524E-03
          0.1051E-01       0.1294E-01       0.1107E-02       0.1404E-02
I-131          0.2032E+07       0.3660E+08       0.2685E+05
          0.1411E+01       0.2430E+01       0.5552E-01       0.8050E+04
          0.1649E+07       0.1661E+05       0.3663E+06       0.4026E+05
          0.3842E+01       0.3897E+01
I-132          0.8698E+06       0.1566E+08       0.1152E+05
          0.6055E+00       0.1043E+01       0.2382E-01       0.3454E+04
          0.7059E+06       0.7108E+04       0.1568E+06       0.4026E+05
          0.1648E+01       0.1672E+01
I-133          0.2953E+07       0.5318E+08       0.3902E+05
          0.2051E+01       0.3532E+01       0.8069E-01       0.1170E+05
          0.2396E+07       0.2413E+05       0.5322E+06       0.4026E+05
          0.5583E+01       0.5664E+01
I-134          0.1845E+06       0.3323E+07       0.2454E+04
          0.1290E+00       0.2221E+00       0.5074E-02       0.7358E+03
          0.1498E+06       0.1508E+04       0.3326E+05       0.4026E+05
          0.3511E+00       0.3562E+00
I-135          0.2267E+07       0.4083E+08       0.2998E+05
          0.1576E+01       0.2714E+01       0.6199E-01       0.8989E+04
          0.1840E+07       0.1853E+05       0.4086E+06       0.4026E+05
          0.4289E+01       0.4351E+01


          0.2223E+02       0.1886E+02       0.9906E-01       0.4118E+02
          0.6842E+00       0.5795E+00       0.3042E-02       0.1267E+01
          0.2460E+01       0.2862E+01       0.3257E-01       0.5355E+01
          0.7558E-01       0.8777E-01       0.9976E-03       0.1644E+00



TIME =    479 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                  CTMT. ATM.            SUMP            SIRW TANK
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                     ACTIVITY           ACTIVITY          ACTIVITY
ISOTOPE                (Ci)               (Ci)              (CI)
--------           ----------         ----------         --------
Kr-83m             0.3870E+06         0.2696E+00         0.2696E+00
          0.1051E-01         0.1294E-01         0.1511E-02         0.2007E-02
Kr-85m             0.4778E+07         0.3322E+01         0.3322E+01
          0.1051E-01         0.1294E-01         0.1511E-02         0.2007E-02
Kr-85              0.7584E+06         0.5267E+00         0.5267E+00
          0.1051E-01         0.1294E-01         0.1511E-02         0.2007E-02
Kr-87              0.3701E+06         0.2582E+00         0.2582E+00
          0.1051E-01         0.1294E-01         0.1511E-02         0.2007E-02
Kr-88              0.6090E+07         0.4238E+01         0.4238E+01
          0.1051E-01         0.1294E-01         0.1511E-02         0.2007E-02
Kr-89              0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.1511E-02         0.2007E-02
Xe-131m            0.4366E+06         0.3032E+00         0.3032E+00
          0.1051E-01         0.1294E-01         0.1511E-02         0.2007E-02
Xe-133m            0.4448E+07         0.3089E+01         0.3089E+01
          0.1051E-01         0.1294E-01         0.1511E-02         0.2007E-02
Xe-133             0.1367E+09         0.9494E+02         0.9494E+02
          0.1051E-01         0.1294E-01         0.1511E-02         0.2007E-02
Xe-135m            0.1619E-01         0.1150E-07         0.1150E-07
          0.1051E-01         0.1294E-01         0.1511E-02         0.2007E-02
Xe-135             0.1346E+08         0.9351E+01         0.9351E+01
          0.1051E-01         0.1294E-01         0.1511E-02         0.2007E-02
Xe-137             0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.1511E-02         0.2007E-02
Xe-138             0.7868E-02         0.5600E-08         0.5600E-08
          0.1051E-01         0.1294E-01         0.1511E-02         0.2007E-02
I-131              0.2003E+07         0.3604E+08         0.5508E+05
          0.1391E+01         0.2396E+01         0.1138E+00         0.1650E+05
          0.1626E+07         0.1637E+05         0.3610E+06         0.4022E+05
          0.3787E+01         0.3901E+01
I-132              0.2604E+06         0.4686E+07         0.7179E+04
          0.1813E+00         0.3123E+00         0.1484E-01         0.2151E+04
          0.2113E+06         0.2128E+04         0.4694E+05         0.4022E+05
          0.4936E+00         0.5084E+00
I-133              0.2585E+07         0.4651E+08         0.7111E+05
          0.1796E+01         0.3093E+01         0.1470E+00         0.2131E+05
          0.2098E+07         0.2113E+05         0.4660E+06         0.4022E+05
          0.4889E+01         0.5036E+01
I-134              0.7905E+04         0.1422E+06         0.2188E+03
          0.5526E-02         0.9518E-02         0.4522E-03         0.6557E+02
          0.6416E+04         0.6461E+02         0.1425E+04         0.4022E+05
          0.1504E-01         0.1550E-01
I-135              0.1491E+07         0.2682E+08         0.4102E+05
          0.1036E+01         0.1784E+01         0.8478E-01         0.1229E+05
          0.1210E+07         0.1218E+05         0.2687E+06         0.4022E+05
          0.2820E+01         0.2905E+01


          0.2223E+02         0.1886E+02         0.9906E-01         0.4118E+02
          0.6842E+00         0.5795E+00         0.3042E-02         0.1267E+01
          0.4172E+01         0.5811E+01         0.1362E+00         0.1012E+02
          0.1279E+00         0.1778E+00         0.4161E-02         0.3098E+00
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** FILE: C1MCALC.LST                                    Created: 02/26/9      2:14
** PAGE: 22  of 28 .  Length: 195230    bytes.          Queued:  02/26/9      6:22
****************************** Lines  2311 to 2420  ******************************
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 TIME =   480 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                     CTMT. ATM.          SUMP          SIRW TANK
                      ACTIVITY         ACTIVITY        ACTIVITY
      ISOTOPE          (Ci)              (Ci)            (CI)
      --------      ----------        ----------       --------
      Kr-83m         0.3846E+06        0.2679E+00       0.2679E+00
             0.1051E-01      0.1294E-01      0.1513E-02      0.2008E-02
      Kr-85m         0.4766E+07        0.3314E+01       0.3314E+01
             0.1051E-01      0.1294E-01      0.1513E-02      0.2008E-02
      Kr-85          0.7584E+06        0.5267E+00       0.5267E+00
             0.1051E-01      0.1294E-01      0.1513E-02      0.2008E-02
      Kr-87          0.3668E+06        0.2559E+00       0.2559E+00
             0.1051E-01      0.1294E-01      0.1513E-02      0.2008E-02
      Kr-88          0.6065E+07        0.4220E+01       0.4220E+01
             0.1051E-01      0.1294E-01      0.1513E-02      0.2008E-02
      Kr-89          0.0000E+00        0.0000E+00       0.0000E+00
             0.1051E-01      0.1294E-01      0.1513E-02      0.2008E-02
      Xe-131m        0.4366E+06        0.3032E+00       0.3032E+00
             0.1051E-01      0.1294E-01      0.1513E-02      0.2008E-02
      Xe-133m        0.4447E+07        0.3089E+01       0.3089E+01
             0.1051E-01      0.1294E-01      0.1513E-02      0.2008E-02
      Xe-133         0.1367E+09        0.9493E+02       0.9493E+02
             0.1051E-01      0.1294E-01      0.1513E-02      0.2008E-02
      Xe-135m        0.1547E-01        0.1099E-07       0.1099E-07
             0.1051E-01      0.1294E-01      0.1513E-02      0.2008E-02
      Xe-135         0.1344E+08        0.9339E+01       0.9339E+01
             0.1051E-01      0.1294E-01      0.1513E-02      0.2008E-02
      Xe-137         0.0000E+00        0.0000E+00       0.0000E+00
             0.1051E-01      0.1294E-01      0.1513E-02      0.2008E-02
      Xe-138         0.7493E-02        0.5333E-08       0.5333E-08
             0.1051E-01      0.1294E-01      0.1513E-02      0.2008E-02
      I-131          0.2003E+07        0.3604E+08       0.5519E+05
             0.1391E+01      0.2396E+01      0.1141E+00      0.1654E+05
             0.1625E+07      0.1637E+05      0.3610E+06      0.4022E+05
             0.3787E+01      0.3901E+01
      I-132          0.2591E+06        0.4662E+07       0.7158E+04
             0.1804E+00      0.3107E+00      0.1479E-01      0.2145E+04
             0.2103E+06      0.2118E+04      0.4670E+05      0.4022E+05
             0.4911E+00      0.5059E+00
      I-133          0.2584E+07        0.4649E+08       0.7122E+05
             0.1795E+01      0.3091E+01      0.1472E+00      0.2134E+05
             0.2097E+07      0.2112E+05      0.4657E+06      0.4022E+05
             0.4886E+01      0.5033E+01
      I-134          0.7802E+04        0.1404E+06       0.2164E+03
             0.5454E-02      0.9394E-02      0.4473E-03      0.6485E+02
             0.6332E+04      0.6376E+02      0.1406E+04      0.4022E+05
             0.1485E-01      0.1529E-01
      I-135          0.1488E+07        0.2677E+08       0.4104E+05
             0.1034E+01      0.1781E+01      0.8481E-01      0.1230E+05
             0.1208E+07      0.1216E+05      0.2682E+06      0.4022E+05
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             0.2815E+01      0.2900E+01

             0.2223E+02      0.1886E+02      0.9906E-01      0.4118E+02
             0.6842E+00      0.5795E+00      0.3042E-02      0.1267E+01
             0.4179E+01      0.5823E+01      0.1368E+00      0.1014E+02
             0.1281E+00      0.1782E+00      0.4179E-02      0.3104E+00


 TIME =   719 MIN            ACTIVITY IN CONTAINMENT AND SIRW TANK

                     CTMT. ATM.          SUMP          SIRW TANK
                      ACTIVITY         ACTIVITY        ACTIVITY
      ISOTOPE          (Ci)              (Ci)            (CI)
      --------      ----------        ----------       --------
      Kr-83m         0.8716E+05        0.6071E-01       0.6071E-01
             0.1051E-01      0.1294E-01      0.1650E-02      0.2237E-02
      Kr-85m         0.2573E+07        0.1789E+01       0.1789E+01
             0.1051E-01      0.1294E-01      0.1650E-02      0.2237E-02
      Kr-85          0.7583E+06        0.5266E+00       0.5266E+00
             0.1051E-01      0.1294E-01      0.1650E-02      0.2237E-02
      Kr-87          0.4147E+05        0.2893E-01       0.2893E-01
             0.1051E-01      0.1294E-01      0.1650E-02      0.2237E-02
      Kr-88          0.2294E+07        0.1596E+01       0.1596E+01
             0.1051E-01      0.1294E-01      0.1650E-02      0.2237E-02
      Kr-89          0.0000E+00        0.0000E+00       0.0000E+00
             0.1051E-01      0.1294E-01      0.1650E-02      0.2237E-02
      Xe-131m        0.4323E+06        0.3002E+00       0.3002E+00
             0.1051E-01      0.1294E-01      0.1650E-02      0.2237E-02
      Xe-133m        0.4219E+07        0.2930E+01       0.2930E+01
             0.1051E-01      0.1294E-01      0.1650E-02      0.2237E-02
      Xe-133         0.1337E+09        0.9286E+02       0.9286E+02
             0.1051E-01      0.1294E-01      0.1650E-02      0.2237E-02
      Xe-135m        0.3073E-06        0.2183E-12       0.2183E-12
             0.1051E-01      0.1294E-01      0.1650E-02      0.2237E-02
      Xe-135         0.9918E+07        0.6892E+01       0.6892E+01
             0.1051E-01      0.1294E-01      0.1650E-02      0.2237E-02
      Xe-137         0.0000E+00        0.0000E+00       0.0000E+00
             0.1051E-01      0.1294E-01      0.1650E-02      0.2237E-02
      Xe-138         0.6431E-07        0.4577E-13       0.4577E-13
             0.1051E-01      0.1294E-01      0.1650E-02      0.2237E-02
      I-131          0.1974E+07        0.3548E+08       0.8260E+05
             0.1371E+01      0.2362E+01      0.1706E+00      0.2474E+05
             0.1602E+07      0.1613E+05      0.3558E+06      0.4017E+05
             0.3733E+01      0.3903E+01
      I-132          0.7758E+05        0.1395E+07       0.3254E+04
             0.5401E-01      0.9304E-01      0.6721E-02      0.9746E+03
             0.6296E+05      0.6341E+03      0.1398E+05      0.4017E+05
             0.1471E+00      0.1538E+00
      I-133          0.2262E+07        0.4066E+08       0.9468E+05
             0.1571E+01      0.2707E+01      0.1956E+00      0.2836E+05
             0.1836E+07      0.1849E+05      0.4078E+06      0.4017E+05
             0.4278E+01      0.4474E+01
```

```
I-134           0.3343E+03       0.6009E+04       0.1408E+02
         0.2337E-03       0.4025E-03       0.2908E-04       0.4216E+01
         0.2713E+03       0.2732E+01       0.6025E+02       0.4017E+05
         0.6362E-03       0.6653E-03
I-135           0.9782E+06       0.1758E+08       0.4096E+05
         0.6799E+00       0.1171E+01       0.8461E-01       0.1227E+05
         0.7939E+06       0.7995E+04       0.1763E+06       0.4017E+05
         0.1851E+01       0.1936E+01


         0.2223E+02       0.1886E+02       0.9906E-01       0.4118E+02
         0.6842E+00       0.5795E+00       0.3042E-02       0.1267E+01
         0.4706E+01       0.6729E+01       0.1911E+00       0.1163E+02
         0.1441E+00       0.2058E+00       0.5834E-02       0.3558E+00




TIME =   720 MIN           ACTIVITY IN CONTAINMENT AND SIRW TANK

                CTMT. ATM.             SUMP          SIRW TANK
                 ACTIVITY            ACTIVITY         ACTIVITY
ISOTOPE            (Ci)                (Ci)             (CI)
--------        ----------          ----------        --------
Kr-83m          0.8662E+05       0.6034E-01       0.6034E-01
         0.1051E-01       0.1294E-01       0.1650E-02       0.2238E-02
Kr-85m          0.2566E+07       0.1784E+01       0.1784E+01
         0.1051E-01       0.1294E-01       0.1650E-02       0.2238E-02
Kr-85           0.7583E+06       0.5266E+00       0.5266E+00
         0.1051E-01       0.1294E-01       0.1650E-02       0.2238E-02
Kr-87           0.4109E+05       0.2867E-01       0.2867E-01
         0.1051E-01       0.1294E-01       0.1650E-02       0.2238E-02
Kr-88           0.2284E+07       0.1590E+01       0.1590E+01
         0.1051E-01       0.1294E-01       0.1650E-02       0.2238E-02
Kr-89           0.0000E+00       0.0000E+00       0.0000E+00
         0.1051E-01       0.1294E-01       0.1650E-02       0.2238E-02
Xe-131m         0.4323E+06       0.3002E+00       0.3002E+00
         0.1051E-01       0.1294E-01       0.1650E-02       0.2238E-02
Xe-133m         0.4218E+07       0.2929E+01       0.2929E+01
         0.1051E-01       0.1294E-01       0.1650E-02       0.2238E-02
Xe-133          0.1337E+09       0.9285E+02       0.9285E+02
         0.1051E-01       0.1294E-01       0.1650E-02       0.2238E-02
Xe-135m         0.2937E-06       0.2086E-12       0.2086E-12
         0.1051E-01       0.1294E-01       0.1650E-02       0.2238E-02
Xe-135          0.9905E+07       0.6883E+01       0.6883E+01
         0.1051E-01       0.1294E-01       0.1650E-02       0.2238E-02
Xe-137          0.0000E+00       0.0000E+00       0.0000E+00
         0.1051E-01       0.1294E-01       0.1650E-02       0.2238E-02
Xe-138          0.6125E-07       0.4359E-13       0.4359E-13
         0.1051E-01       0.1294E-01       0.1650E-02       0.2238E-02
I-131           0.1974E+07       0.3548E+08       0.8271E+05
         0.1371E+01       0.2361E+01       0.1708E+00       0.2477E+05
         0.1602E+07       0.1613E+05       0.3558E+06       0.4017E+05
         0.3732E+01       0.3903E+01
I-132           0.7719E+05       0.1388E+07       0.3242E+04
```

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         0.5374E-01       0.9257E-01       0.6697E-02       0.9711E+03
         0.6265E+05       0.6309E+03       0.1391E+05       0.4017E+05
         0.1463E+00       0.1530E+00
I-133           0.2261E+07       0.4064E+08       0.9476E+05
         0.1571E+01       0.2706E+01       0.1957E+00       0.2838E+05
         0.1835E+07       0.1848E+05       0.4075E+06       0.4017E+05
         0.4276E+01       0.4472E+01
I-134           0.3299E+03       0.5930E+04       0.1391E+02
         0.2306E-03       0.3973E-03       0.2874E-04       0.4167E+01
         0.2677E+03       0.2696E+01       0.5946E+02       0.4017E+05
         0.6279E-03       0.6566E-03
I-135           0.9765E+06       0.1755E+08       0.4095E+05
         0.6787E+00       0.1169E+01       0.8458E-01       0.1226E+05
         0.7925E+06       0.7981E+04       0.1760E+06       0.4017E+05
         0.1848E+01       0.1933E+01


         0.2223E+02       0.1886E+02       0.9906E-01       0.4118E+02
         0.6842E+00       0.5795E+00       0.3042E-02       0.1267E+01
         0.4708E+01       0.6733E+01       0.1913E+00       0.1163E+02
         0.1442E+00       0.2059E+00       0.5842E-02       0.3560E+00




TIME =  1439 MIN           ACTIVITY IN CONTAINMENT AND SIRW TANK

                CTMT. ATM.             SUMP          SIRW TANK
                 ACTIVITY            ACTIVITY         ACTIVITY
ISOTOPE            (Ci)                (Ci)             (CI)
--------        ----------          ----------        --------
Kr-83m          0.9953E+03       0.6933E-03       0.6933E-03
         0.1051E-01       0.1294E-01       0.1886E-02       0.2613E-02
Kr-85m          0.4015E+06       0.2792E+00       0.2792E+00
         0.1051E-01       0.1294E-01       0.1886E-02       0.2613E-02
Kr-85           0.7579E+06       0.5263E+00       0.5263E+00
         0.1051E-01       0.1294E-01       0.1886E-02       0.2613E-02
Kr-87           0.5831E+02       0.4068E-04       0.4068E-04
         0.1051E-01       0.1294E-01       0.1886E-02       0.2613E-02
Kr-88           0.1225E+06       0.8527E-01       0.8527E-01
         0.1051E-01       0.1294E-01       0.1886E-02       0.2613E-02
Kr-89           0.0000E+00       0.0000E+00       0.0000E+00
         0.1051E-01       0.1294E-01       0.1886E-02       0.2613E-02
Xe-131m         0.4197E+06       0.2915E+00       0.2915E+00
         0.1051E-01       0.1294E-01       0.1886E-02       0.2613E-02
Xe-133m         0.3600E+07       0.2500E+01       0.2500E+01
         0.1051E-01       0.1294E-01       0.1886E-02       0.2613E-02
Xe-133          0.1251E+09       0.8688E+02       0.8688E+02
         0.1051E-01       0.1294E-01       0.1886E-02       0.2613E-02
Xe-135m         0.0000E+00       0.0000E+00       0.0000E+00
         0.1051E-01       0.1294E-01       0.1886E-02       0.2613E-02
Xe-135          0.3970E+07       0.2758E+01       0.2758E+01
         0.1051E-01       0.1294E-01       0.1886E-02       0.2613E-02
Xe-137          0.0000E+00       0.0000E+00       0.0000E+00
         0.1051E-01       0.1294E-01       0.1886E-02       0.2613E-02
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Xe-138            0.0000E+00          0.0000E+00          0.0000E+00
         0.1051E-01          0.1294E-01          0.1886E-02          0.2613E-02
I-131             0.1890E+07          0.3387E+08          0.1604E+06
         0.1312E+01          0.2262E+01          0.3307E+00          0.4795E+05
         0.1534E+07          0.1545E+05          0.3406E+06          0.4004E+05
         0.3574E+01          0.3905E+01
I-132             0.2051E+04          0.3677E+05          0.1745E+03
         0.1428E-02          0.2461E-02          0.3598E-03          0.5217E+02
         0.1665E+04          0.1676E+02          0.3697E+03          0.4004E+05
         0.3889E-02          0.4249E-02
I-133             0.1516E+07          0.2717E+08          0.1287E+06
         0.1053E+01          0.1815E+01          0.2653E+00          0.3847E+05
         0.1230E+07          0.1239E+05          0.2732E+06          0.4004E+05
         0.2868E+01          0.3133E+01
I-134             0.2527E-01          0.4529E+00          0.2158E-02
         0.1766E-07          0.3044E-07          0.4450E-08          0.6453E-03
         0.2051E-01          0.2065E-03          0.4555E-02          0.4004E+05
         0.4811E-07          0.5256E-07
I-135             0.2765E+06          0.4957E+07          0.2349E+05
         0.1922E+00          0.3313E+00          0.4843E-01          0.7022E+04
         0.2244E+06          0.2260E+04          0.4985E+05          0.4004E+05
         0.5235E+00          0.5719E+00


         0.2223E+02          0.1886E+02          0.9906E-01          0.4118E+02
         0.6842E+00          0.5795E+00          0.3042E-02          0.1267E+01
         0.6180E+01          0.9270E+01          0.4672E+00          0.1592E+02
         0.1890E+00          0.2831E+00          0.1423E-01          0.4863E+00



TIME =  1440 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                  CTMT. ATM.            SUMP            SIRW TANK
                   ACTIVITY           ACTIVITY           ACTIVITY
ISOTOPE              (Ci)               (Ci)               (CI)
--------          ----------         ----------         --------
Kr-83m            0.9891E+03          0.6890E-03          0.6890E-03
         0.1051E-01          0.1294E-01          0.1886E-02          0.2614E-02
Kr-85m            0.4005E+06          0.2785E+00          0.2785E+00
         0.1051E-01          0.1294E-01          0.1886E-02          0.2614E-02
Kr-85             0.7579E+06          0.5263E+00          0.5263E+00
         0.1051E-01          0.1294E-01          0.1886E-02          0.2614E-02
Kr-87             0.5778E+02          0.4031E-04          0.4031E-04
         0.1051E-01          0.1294E-01          0.1886E-02          0.2614E-02
Kr-88             0.1220E+06          0.8492E-01          0.8492E-01
         0.1051E-01          0.1294E-01          0.1886E-02          0.2614E-02
Kr-89             0.0000E+00          0.0000E+00          0.0000E+00
         0.1051E-01          0.1294E-01          0.1886E-02          0.2614E-02
Xe-131m           0.4197E+06          0.2915E+00          0.2915E+00
         0.1051E-01          0.1294E-01          0.1886E-02          0.2614E-02
Xe-133m           0.3599E+07          0.2499E+01          0.2499E+01
         0.1051E-01          0.1294E-01          0.1886E-02          0.2614E-02
Xe-133            0.1251E+09          0.8688E+02          0.8688E+02
```

```
** FILE: C1MCALC.LST                                       Created: 02/26/9     2:14
** PAGE: 24  of 28 .  Length: 195230    bytes.             Queued:  02/26/9     5:22
******************************* Lines  2531 to 2640  **********************************
         0.1051E-01          0.1294E-01          0.1886E-02          0.2614E-02
Xe-135m           0.0000E+00          0.0000E+00          0.0000E+00
         0.1051E-01          0.1294E-01          0.1886E-02          0.2614E-02
Xe-135            0.3965E+07          0.2755E+01          0.2755E+01
         0.1051E-01          0.1294E-01          0.1886E-02          0.2614E-02
Xe-137            0.0000E+00          0.0000E+00          0.0000E+00
         0.1051E-01          0.1294E-01          0.1886E-02          0.2614E-02
Xe-138            0.0000E+00          0.0000E+00          0.0000E+00
         0.1051E-01          0.1294E-01          0.1886E-02          0.2614E-02
I-131             0.1890E+07          0.3387E+08          0.1605E+06
         0.1312E+01          0.2262E+01          0.3309E+00          0.4798E+05
         0.1534E+07          0.1544E+05          0.3406E+06          0.4004E+05
         0.3574E+01          0.3905E+01
I-132             0.2041E+04          0.3658E+05          0.1737E+03
         0.1421E-02          0.2449E-02          0.3582E-03          0.5194E+02
         0.1656E+04          0.1668E+02          0.3679E+03          0.4004E+05
         0.3870E-02          0.4228E-02
I-133             0.1515E+07          0.2715E+08          0.1287E+06
         0.1052E+01          0.1814E+01          0.2653E+00          0.3847E+05
         0.1230E+07          0.1238E+05          0.2731E+06          0.4004E+05
         0.2866E+01          0.3131E+01
I-134             0.2494E-01          0.4470E+00          0.2132E-02
         0.1743E-07          0.3005E-07          0.4395E-08          0.6373E-03
         0.2024E-01          0.2038E-03          0.4495E-02          0.4004E+05
         0.4748E-07          0.5187E-07
I-135             0.2761E+06          0.4948E+07          0.2346E+05
         0.1919E+00          0.3307E+00          0.4838E-01          0.7014E+04
         0.2240E+06          0.2256E+04          0.4976E+05          0.4004E+05
         0.5226E+00          0.5710E+00


         0.2223E+02          0.1886E+02          0.9906E-01          0.4118E+02
         0.6842E+00          0.5795E+00          0.3042E-02          0.1267E+01
         0.6182E+01          0.9274E+01          0.4677E+00          0.1592E+02
         0.1890E+00          0.2832E+00          0.1425E-01          0.4865E+00



TIME =  1799 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                  CTMT. ATM.            SUMP            SIRW TANK
                   ACTIVITY           ACTIVITY           ACTIVITY
ISOTOPE              (Ci)               (Ci)               (CI)
--------          ----------         ----------         --------
Kr-83m            0.1064E+03          0.3705E-04          0.3705E-04
         0.1051E-01          0.1294E-01          0.1904E-02          0.2636E-02
Kr-85m            0.1587E+06          0.5516E-01          0.5516E-01
         0.1051E-01          0.1294E-01          0.1904E-02          0.2636E-02
Kr-85             0.7577E+06          0.2631E+00          0.2631E+00
         0.1051E-01          0.1294E-01          0.1904E-02          0.2636E-02
Kr-87             0.2187E+01          0.7628E-06          0.7628E-06
         0.1051E-01          0.1294E-01          0.1904E-02          0.2636E-02
Kr-88             0.2833E+05          0.9856E-02          0.9856E-02
         0.1051E-01          0.1294E-01          0.1904E-02          0.2636E-02
```

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** FILE: C1MCALC.LST                                   Created: 02/26/9[illegible]2:14
** PAGE: 25  of 28 .  Length: 195230    bytes.         Queued:  02/26/9[illegible]6:22
****************************** Lines  2641 to 2750  ******************************
```

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Kr-89           0.0000E+00       0.0000E+00       0.0000E+00
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-131m         0.4136E+06       0.1436E+00       0.1436E+00
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-133m         0.3325E+07       0.1155E+01       0.1155E+01
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-133          0.1210E+09       0.4203E+02       0.4203E+02
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-135m         0.0000E+00       0.0000E+00       0.0000E+00
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-135          0.2512E+07       0.8727E+00       0.8727E+00
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-137          0.0000E+00       0.0000E+00       0.0000E+00
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-138          0.0000E+00       0.0000E+00       0.0000E+00
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
I-131           0.1849E+07       0.3314E+08       0.1571E+06
        0.6421E+00      0.2214E+01      0.0000E+00      0.4696E+05
        0.1501E+07      0.1511E+05      0.3333E+06      0.4002E+05
        0.2856E+01      0.2856E+01
I-132           0.3336E+03       0.5977E+04       0.2840E+02
        0.1161E-03      0.4003E-03      0.0000E+00      0.8491E+01
        0.2707E+03      0.2726E+01      0.6013E+02      0.4002E+05
        0.5164E-03      0.5164E-03
I-133           0.1241E+07       0.2224E+08       0.1054E+06
        0.4310E+00      0.1486E+01      0.0000E+00      0.3152E+05
        0.1007E+07      0.1014E+05      0.2237E+06      0.4002E+05
        0.1917E+01      0.1917E+01
I-134           0.2197E-03       0.3937E-02       0.1878E-04
        0.7680E-10      0.2648E-09      0.0000E+00      0.5616E-05
        0.1783E-03      0.1796E-05      0.3961E-04      0.4002E+05
        0.3416E-09      0.3416E-09
I-135           0.1471E+06       0.2635E+07       0.1250E+05
        0.5111E-01      0.1762E+00      0.0000E+00      0.3737E+04
        0.1193E+06      0.1202E+04      0.2651E+05      0.4002E+05
        0.2273E+00      0.2273E+00


        0.2223E+02      0.1886E+02      0.9906E-01      0.4118E+02
        0.6842E+00      0.5795E+00      0.3042E-02      0.1267E+01
        0.6351E+01      0.9855E+01      0.4677E+00      0.1667E+02
        0.1942E+00      0.3009E+00      0.1425E-01      0.5093E+00



TIME =  1800 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                CTMT. ATM.         SUMP          SIRW TANK
                 ACTIVITY        ACTIVITY        ACTIVITY
ISOTOPE            (Ci)            (Ci)            (CI)
--------        ----------      ----------      --------
Kr-83m          0.1057E+03       0.3682E-04       0.3682E-04
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Kr-85m          0.1582E+06       0.5502E-01       0.5502E-01
```

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        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Kr-85           0.7577E+06       0.2631E+00       0.2631E+00
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Kr-87           0.2167E+01       0.7558E-06       0.7558E-06
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Kr-88           0.2821E+05       0.9816E-02       0.9816E-02
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Kr-89           0.0000E+00       0.0000E+00       0.0000E+00
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-131m         0.4136E+06       0.1436E+00       0.1436E+00
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-133m         0.3325E+07       0.1154E+01       0.1154E+01
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-133          0.1210E+09       0.4202E+02       0.4202E+02
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-135m         0.0000E+00       0.0000E+00       0.0000E+00
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-135          0.2509E+07       0.8716E+00       0.8716E+00
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-137          0.0000E+00       0.0000E+00       0.0000E+00
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
Xe-138          0.0000E+00       0.0000E+00       0.0000E+00
        0.1051E-01      0.1294E-01      0.1904E-02      0.2636E-02
I-131           0.1849E+07       0.3313E+08       0.1570E+06
        0.6421E+00      0.2214E+01      0.0000E+00      0.4695E+05
        0.1501E+07      0.1511E+05      0.3333E+06      0.4002E+05
        0.2856E+01      0.2856E+01
I-132           0.3319E+03       0.5947E+04       0.2826E+02
        0.1155E-03      0.3983E-03      0.0000E+00      0.8448E+01
        0.2694E+03      0.2712E+01      0.5982E+02      0.4002E+05
        0.5138E-03      0.5138E-03
I-133           0.1240E+07       0.2222E+08       0.1054E+06
        0.4308E+00      0.1485E+01      0.0000E+00      0.3150E+05
        0.1007E+07      0.1014E+05      0.2236E+06      0.4002E+05
        0.1916E+01      0.1916E+01
I-134           0.2169E-03       0.3886E-02       0.1854E-04
        0.7580E-10      0.2613E-09      0.0000E+00      0.5542E-05
        0.1760E-03      0.1772E-05      0.3909E-04      0.4002E+05
        0.3371E-09      0.3371E-09
I-135           0.1468E+06       0.2630E+07       0.1248E+05
        0.5102E-01      0.1759E+00      0.0000E+00      0.3730E+04
        0.1191E+06      0.1200E+04      0.2646E+05      0.4002E+05
        0.2269E+00      0.2269E+00


        0.2223E+02      0.1886E+02      0.9906E-01      0.4118E+02
        0.6842E+00      0.5795E+00      0.3042E-02      0.1267E+01
        0.6351E+01      0.9857E+01      0.4677E+00      0.1668E+02
        0.1942E+00      0.3009E+00      0.1425E-01      0.5094E+00



TIME =  5759 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK
```

```
                    CTMT. ATM.             SUMP              SIRW TANK
                     ACTIVITY            ACTIVITY             ACTIVITY
ISOTOPE                (Ci)                (Ci)                 (CI)
--------            ----------          ----------           --------
Kr-83m               0.2211E-08          0.7700E-15           0.7700E-15
           0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
Kr-85m               0.5814E+01          0.2021E-05           0.2021E-05
           0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
Kr-85                0.7563E+06          0.2626E+00           0.2626E+00
           0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
Kr-87                0.4514E-15          0.1575E-21           0.1575E-21
           0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
Kr-88                0.2854E-02          0.9930E-09           0.9930E-09
           0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
Kr-89                0.0000E+00          0.0000E+00           0.0000E+00
           0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
Xe-131m              0.3520E+06          0.1222E+00           0.1222E+00
           0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
Xe-133m              0.1391E+07          0.4829E+00           0.4829E+00
           0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
Xe-133               0.8406E+08          0.2919E+02           0.2919E+02
           0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
Xe-135m              0.0000E+00          0.0000E+00           0.0000E+00
           0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
Xe-135               0.1635E+05          0.5681E-02           0.5681E-02
           0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
Xe-137               0.0000E+00          0.0000E+00           0.0000E+00
           0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
Xe-138               0.0000E+00          0.0000E+00           0.0000E+00
           0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
I-131                0.1457E+07          0.2600E+08           0.1239E+06
           0.5059E+00          0.1747E+01          0.0000E+00          0.3705E+05
           0.1182E+07          0.1191E+05          0.2626E+06          0.3981E+05
           0.2252E+01          0.2252E+01
I-132                0.7017E-06          0.1252E-04           0.5983E-07
           0.2443E-12          0.8433E-12          0.0000E+00          0.1789E-07
           0.5695E-06          0.5735E-08          0.1265E-06          0.3981E+05
           0.1088E-11          0.1088E-11
I-133                0.1374E+06          0.2452E+07           0.1169E+05
           0.4772E-01          0.1647E+00          0.0000E+00          0.3494E+04
           0.1115E+06          0.1123E+04          0.2477E+05          0.3981E+05
           0.2125E+00          0.2125E+00
I-134                0.0000E+00          0.0000E+00           0.0000E+00
           0.0000E+00          0.0000E+00          0.0000E+00          0.0000E+00
           0.0000E+00          0.0000E+00          0.0000E+00          0.3981E+05
           0.0000E+00          0.0000E+00
I-135                0.1414E+03          0.2523E+04           0.1203E+02
           0.4913E-04          0.1696E-03          0.0000E+00          0.3597E+01
           0.1147E+03          0.1155E+01          0.2548E+02          0.3981E+05
           0.2187E-03          0.2187E-03


           0.2223E+02          0.1886E+02          0.9906E-01          0.4118E+02
           0.6842E+00          0.5795E+00          0.3042E-02          0.1267E+01
           0.7879E+01          0.1513E+02          0.4677E+00          0.2347E+02
```

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              0.2406E+00          0.4610E+00          0.1425E-01          0.7158E+00


TIME =  5760 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                        CTMT. ATM.             SUMP              SIRW TANK
                         ACTIVITY            ACTIVITY             ACTIVITY
    ISOTOPE                (Ci)                (Ci)                 (CI)
    --------            ----------          ----------           --------
    Kr-83m               0.2197E-08          0.7652E-15           0.7652E-15
              0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
    Kr-85m               0.5799E+01          0.2016E-05           0.2016E-05
              0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
    Kr-85                0.7563E+06          0.2626E+00           0.2626E+00
              0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
    Kr-87                0.4473E-15          0.1560E-21           0.1560E-21
              0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
    Kr-88                0.2842E-02          0.9889E-09           0.9889E-09
              0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
    Kr-89                0.0000E+00          0.0000E+00           0.0000E+00
              0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
    Xe-131m              0.3520E+06          0.1222E+00           0.1222E+00
              0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
    Xe-133m              0.1390E+07          0.4828E+00           0.4828E+00
              0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
    Xe-133               0.8406E+08          0.2919E+02           0.2919E+02
              0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
    Xe-135m              0.0000E+00          0.0000E+00           0.0000E+00
              0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
    Xe-135               0.1633E+05          0.5673E-02           0.5673E-02
              0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
    Xe-137               0.0000E+00          0.0000E+00           0.0000E+00
              0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
    Xe-138               0.0000E+00          0.0000E+00           0.0000E+00
              0.1051E-01          0.1294E-01          0.2059E-02          0.2774E-02
    I-131                0.1457E+07          0.2600E+08           0.1239E+06
              0.5059E+00          0.1746E+01          0.0000E+00          0.3704E+05
              0.1182E+07          0.1191E+05          0.2626E+06          0.3981E+05
              0.2252E+01          0.2252E+01
    I-132                0.6982E-06          0.1246E-04           0.5952E-07
              0.2430E-12          0.8390E-12          0.0000E+00          0.1780E-07
              0.5666E-06          0.5706E-08          0.1258E-06          0.3981E+05
              0.1082E-11          0.1082E-11
    I-133                0.1373E+06          0.2451E+07           0.1168E+05
              0.4770E-01          0.1647E+00          0.0000E+00          0.3492E+04
              0.1114E+06          0.1122E+04          0.2475E+05          0.3981E+05
              0.2123E+00          0.2123E+00
    I-134                0.0000E+00          0.0000E+00           0.0000E+00
              0.0000E+00          0.0000E+00          0.0000E+00          0.0000E+00
              0.0000E+00          0.0000E+00          0.0000E+00          0.3981E+05
              0.0000E+00          0.0000E+00
    I-135                0.1411E+03          0.2519E+04           0.1201E+02
              0.4904E-04          0.1693E-03          0.0000E+00          0.3591E+01
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          0.1145E+03         0.1153E+01         0.2544E+02         0.3981E+05
          0.2183E-03         0.2183E-03


          0.2223E+02         0.1886E+02         0.9906E-01         0.4118E+02
          0.6842E+00         0.5795E+00         0.3042E-02         0.1267E+01
          0.7880E+01         0.1513E+02         0.4677E+00         0.2348E+02
          0.2406E+00         0.4610E+00         0.1425E-01         0.7158E+00



TIME = 43199 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                  CTMT. ATM.            SUMP            SIRW TANK
                   ACTIVITY           ACTIVITY          ACTIVITY
   ISOTOPE           (Ci)               (Ci)              (CI)
   --------      ----------         ----------         --------
   Kr-83m         0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Kr-85m         0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Kr-85          0.7431E+06         0.2580E+00         0.2580E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Kr-87          0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Kr-88          0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Kr-89          0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-131m        0.7662E+05         0.2660E-01         0.2660E-01
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-133m        0.3661E+03         0.1271E-03         0.1271E-03
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-133         0.2680E+07         0.9305E+00         0.9305E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-135m        0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-135         0.3479E-16         0.1209E-22         0.1209E-22
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-137         0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-138         0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   I-131          0.1529E+06         0.2626E+07         0.1318E+05
          0.5310E-01         0.1857E+00         0.0000E+00         0.3939E+04
          0.1241E+06         0.1250E+04         0.2757E+05         0.3781E+05
          0.2388E+00         0.2388E+00
   I-132          0.0000E+00         0.0000E+00         0.0000E+00
          0.0000E+00         0.0000E+00         0.0000E+00         0.0000E+00
          0.0000E+00         0.0000E+00         0.0000E+00         0.3781E+05
          0.0000E+00         0.0000E+00
   I-133          0.1263E-03         0.2169E-02         0.1089E-04
          0.4388E-10         0.1535E-09         0.0000E+00         0.3255E-05
          0.1025E-03         0.1033E-05         0.2277E-04         0.3781E+05
```

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          0.1973E-09         0.1973E-09
   I-134          0.0000E+00         0.0000E+00         0.0000E+00
          0.0000E+00         0.0000E+00         0.0000E+00         0.0000E+00
          0.0000E+00         0.0000E+00         0.0000E+00         0.3781E+05
          0.0000E+00         0.0000E+00
   I-135          0.0000E+00         0.0000E+00         0.0000E+00
          0.0000E+00         0.0000E+00         0.0000E+00         0.0000E+00
          0.0000E+00         0.0000E+00         0.0000E+00         0.3781E+05
          0.0000E+00         0.0000E+00


          0.2223E+02         0.1886E+02         0.9906E-01         0.4118E+02
          0.6842E+00         0.5795E+00         0.3042E-02         0.1267E+01
          0.9052E+01         0.1919E+02         0.4677E+00         0.2871E+02
          0.2762E+00         0.5843E+00         0.1425E-01         0.8747E+00



TIME = 43200 MIN          ACTIVITY IN CONTAINMENT AND SIRW TANK

                  CTMT. ATM.            SUMP            SIRW TANK
                   ACTIVITY           ACTIVITY          ACTIVITY
   ISOTOPE           (Ci)               (Ci)              (CI)
   --------      ----------         ----------         --------
   Kr-83m         0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Kr-85m         0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Kr-85          0.7431E+06         0.2580E+00         0.2580E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Kr-87          0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Kr-88          0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Kr-89          0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-131m        0.7661E+05         0.2660E-01         0.2660E-01
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-133m        0.3660E+03         0.1271E-03         0.1271E-03
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-133         0.2679E+07         0.9304E+00         0.9304E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-135m        0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-135         0.3474E-16         0.1207E-22         0.1207E-22
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-137         0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   Xe-138         0.0000E+00         0.0000E+00         0.0000E+00
          0.1051E-01         0.1294E-01         0.2142E-02         0.2840E-02
   I-131          0.1529E+06         0.2626E+07         0.1318E+05
          0.5310E-01         0.1857E+00         0.0000E+00         0.3939E+04
          0.1241E+06         0.1250E+04         0.2756E+05         0.3781E+05
          0.2388E+00         0.2388E+00
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F059 1622

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I-132          0.0000E+00        0.0000E+00        0.0000E+00
         0.0000E+00        0.0000E+00        0.0000E+00        0.0000E+00
         0.0000E+00        0.0000E+00        0.0000E+00        0.3781E+05
         0.0000E+00        0.0000E+00
I-133          0.1263E-03        0.2168E-02        0.1088E-04
         0.4386E-10        0.1534E-09        0.0000E+00        0.3253E-05
         0.1025E-03        0.1032E-05        0.2276E-04        0.3781E+05
         0.1972E-09        0.1972E-09
I-134          0.0000E+00        0.0000E+00        0.0000E+00
         0.0000E+00        0.0000E+00        0.0000E+00        0.0000E+00
         0.0000E+00        0.0000E+00        0.0000E+00        0.3781E+05
         0.0000E+00        0.0000E+00
I-135          0.0000E+00        0.0000E+00        0.0000E+00
         0.0000E+00        0.0000E+00        0.0000E+00        0.0000E+00
         0.0000E+00        0.0000E+00        0.0000E+00        0.3781E+05
         0.0000E+00        0.0000E+00

         0.2223E+02        0.1886E+02        0.9906E-01        0.4118E+02 ✓
         0.6842E+00        0.5795E+00        0.3042E-02        0.1267E+01
         0.9052E+01        0.1919E+02        0.4677E+00        0.2871E+02
         0.2762E+00        0.5843E+00        0.1425E-01        0.8747E+00

     TOTAL ACTIVITY OF EACH RADIONUCLIDE RELEASED (Ci)
ISOTOPE          CTMT ATM          ESF ROOMS        SIRW TANK
--------        ----------        ----------        ----------
Kr-83m          0.8479E+03
Kr-85m          0.4372E+04
Kr-85           0.1164E+05
Kr-87           0.2225E+04
Kr-88           0.7287E+04
Kr-89           0.1591E+03
Xe-131m         0.3357E+04
Xe-133m         0.9911E+04
Xe-133          0.5956E+06
Xe-135m         0.6586E+03
Xe-135          0.1243E+05
Xe-137          0.4592E+03
Xe-138          0.1596E+04
I-131           0.1211E+05        0.3804E+05        0.2425E+03
I-132           0.5637E+03        0.6287E+03        0.1283E+02
I-133           0.3464E+04        0.7188E+04        0.2503E+03
I-134           0.4562E+03        0.3082E+03        0.2434E+01
I-135           0.1510E+04        0.2278E+04        0.9540E+02


          RESULTANT OFFSITE DOSES FROM THE EVENT (Rem)

                               CTMT        ESF       SIRWT
                                ATM      LEAKAGE    LEAKAGE      TOTAL
0-2 Hr SB                    --------   --------   --------   --------

   Thyroid (inhalation)       22.226     18.858      0.099     41.183 ✓
   Thyroid (submersion)        0.011       N/A        N/A       0.011 ✓
```

```
   ---------------------------------------------------------------------
   Total Thyroid Dose =       22.237     18.858      0.099     41.193 ✓


   CEDE (inhalation)           0.684      0.579      0.003      1.267 ✓
   Whole Body Dose             0.013       N/A        N/A       0.013
   ---------------------------------------------------------------------
   TEDE (whole body eq)        0.697      0.579      0.003      1.280


0-30 Day LPZ

   Thyroid (inhalation)        9.052     19.193      0.468     28.713
   Thyroid (submersion)        0.002       N/A        N/A       0.002
   ---------------------------------------------------------------------
   Total Thyroid Dose =        9.054     19.193      0.468     28.715


   CEDE (inhalation)           0.276      0.584      0.014      0.875
   Whole Body Dose             0.003       N/A        N/A       0.003
   ---------------------------------------------------------------------
   TEDE (whole body eq)        0.279      0.584      0.014      1.270


TIME AT WHICH DFmax OR THE SPRAY STOP TIME WAS REACHED =    421 MINUTES
*** This is the console file for job JOB8486(8486). ***

TIME IS 17:36:25 EDT WEDNESDAY 02/26/92
CONNECT= 00:00:04 VIRTCPU= 000:00.10 TOTCPU= 000:00.26
DASD 120 LINKED R/O; R/W BY SDWINTER; R/O BY VMBAT001
DMSACP723I X (120) R/O
DMSACP723I W (121) R/O
DMSLIO740I Execution begins...
 MHA RUN COMPLETED
TIME IS 17:44:30 EDT WEDNESDAY 02/26/92
CONNECT= 00:08:09 VIRTCPU= 003:25.23 TOTCPU= 003:27.39
```