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DEFINITIONS AND UNITS:

DAEC -	Duane Arnold Energy Center
DBA -	Design Basis Accident
CR -	Control Room
CRDA -	Control Rod Drop Accident
AST -	Alternate Source Terms
RG -	Regulatory Guide
AEP -	Asset Enhancement Program
DE -	Dose Equivalent
EPU -	Extended Power Uprate
EIV -	Early In-vessel
GE -	General Electric
MVP	Mechanical Vacuum Pump
TEDE -	Total Effective Dose Equivalent
TSC -	Technical Support Center

1.0 PURPOSE/OBJECTIVE:

This calculation was prepared to support a Licensing Action Request to eliminate Technical Specifications requirements for automatic isolation of Main Steamline Drains and tripping of the Mechanical Vacuum Pump on High Main Steamline Radiation Levels.

This Calculation will supersede calculation CAL-R02-001 when the licensing amendment is approved.

This analysis was performed in accordance with the requirements of USNRC Regulatory Guide (RG) 1.183 (Reference No. 7.1), RG 1.194 (Reference 7.2), and the Code of Federal Regulations (CFR), Title 10, Section 50.67 (Reference No. 7.3).

2.0 SUMMARY AND CONCLUSIONS:

The radiological dose consequences are summarized in Table 1 below: Results are shown for two sources (Gap Release and Pellet [fuel melt] Release), and Total dose.

Table No. 1: Control Rod Drop Accident Radiological Consequences

Accident Type		Exclusion Area Boundary (2 hr)	Low Population Zone (30 day)	Control Room (30 Day)	TSC (30 Day)
		TEDE (rem)			
Gap Release Dose	MVP Operating	7.0065e+00	3.3335e+00	8.5277e-01	6.6960e-01
	MVP Trip 10 Min	2.6990e+00	1.2172e+00	4.5996e-01	5.2669e-01
	MVP secured	6.3551e-02	3.8052e-02	3.5649e-01	5.1556e-01
Fuel Melt Release Dose	MVP Operating	3.9007e-01	1.8532e-01	2.8787e-02	2.2001e-02
	MVP Trip 10 Min	1.5098e-01	6.7943e-02	1.5133e-02	1.6889e-02
	MVP secured	3.4575e-03	1.8803e-03	1.1413e-02	1.6316e-02
Total Dose	MVP Operating	7.3966E+00	3.5188E+00	8.8156E-01	6.9160E-01
	MVP Manual Trip 10 Min	2.8500e+00	1.2851e+00	4.7509e-01	5.4358e-01
	MVP secured	6.7009E-02	3.9932E-02	3.6790E-01	5.3188E-01
RG 1.183 Acceptance Criteria Guideline		6.25 (25% Of 10 CFR 50.67 Limit)	6.25 (25% Of 10 CFR 50.67 Limit)	5	5
Standard Review Plan Limit		Well Within 10 CFR 50.67 Limit	Well Within 10 CFR 50.67 Limit	5	5
10 CFR 50.67 Limits		25	25	5	5
Fraction of 10 CFR 50.67 Limit for No MVP Trip Case		29.59%	14.08%	17.63%	N/A
Numerical precision of results is shown based on results of software. Some inputs are only specified to 2 significant digits, therefore results are not considered to be accurate beyond two significant digits.					

3.0 ASSUMPTIONS:

The following assumptions are used to evaluate the radiological consequences of a control rod drop accident:

3.1 For the radiological consequences of a control rod drop accident for a Boiling Water Reactor, the accident dose limit per 10 CFR 50.67 (Reference 7.3) at the EAB and LPZ is 25 rem TEDE. The NRC Standard Review Plan states "The plant site and dose mitigating engineered safety features are acceptable with respect to the radiological consequences of a postulated control rod drop accident if the calculated whole-body and thyroid doses at the exclusion area boundaries (EAB) and at the low population zone (LPZ) boundaries are well within the exposure guideline values in 10 CFR Part 100, paragraph 11 (Ref. 1). "Well within" is defined as 25% of the 10 CFR Part 100 exposure guideline values or 75 rem for the thyroid and 6 rem for whole-body doses." Regulatory guidance for dose limits is provided in Table 6 of RG 1.183 (Reference 7.1). RG 1.183 establishes an acceptance criterion of 6.3 Rem TEDE in Table 6 of section 4.4.

3.2 The core inventory for the analysis was obtained from General Electric Report T0802 for the Duane Arnold Energy Center Asset Enhancement Program, "Radiation Sources and Fission Products" (Reference 7.4) Appendix B Table 3.

3.3 Assumptions for the release of radioactivity from the fuel are in accordance with RG 1.183 (Reference 7.2), Appendix C.1. The release from the breeched fuel clad (gap release) is based on 10% of the core noble gas and halogen inventory being in the gap and the estimate of clad damage (1200 rods per Reference 7.5 – see attachment 1). The release from melted fuel is based on release of 100% of the core noble gasses and 50% of the core radioiodine and the percent of fuel that melts (0.77% of the 1200 rods damaged per Reference 7.5 – see attachment 1). Release of other fission products from the fuel is per RG 1.183 Table 3 for the gap release and from Table 1 (Early in Vessel) for the pellet release (fuel melt).

The inventory of fission products in the reactor core and available for release to the containment is based on the maximum full power operation of the core times 1.02 the current licensed rated thermal power per RG 1.183 and RG 1.49 (References 7.1 and 7.5). Fission product inventory is adjusted for the radial peaking factor (1.46).

3.3 The activity released from the fuel gap and from fuel melting is assumed to be instantaneously mixed in the reactor coolant within the pressure vessel in accordance with RG 1.183 (Reference 7.1), Section 3.3 and Appendix C, Section 3.1.

3.4 Credit is not assumed for partitioning in the pressure vessel or by removal by the steam separators in accordance with RG 1.183 (Reference 7.1), Appendix C, Section 3.2.

3.5 Of the activity released from the reactor coolant within the pressure vessel, 100% of the noble gases, 10% of the iodines, and 1% of the remaining radionuclides are assumed to reach the turbine and the condensers in accordance with RG 1.183 (Reference 7.1, Appendix C, Section 3.3.

3.6 Of the activity that reaches the turbine and the condenser, 100% of the noble gases, 10% of the iodines, and 1% of the particulate radionuclides are available for release to the environment. The turbine and condensers leak to the atmosphere as a ground level release at a rate of 1% per day for a period of 24 hours, at which time the leakage is assumed to terminate. No credit is assumed for dilution or holdup in the TB. Radioactive decay during holdup in the turbine and the condenser is assumed in accordance with RG 1.183 (Reference 7.1), Appendix C, Section 3.4.

3.7 The release from the reactor coolant within the pressure vessel is assumed to consist of 95% CsI as an aerosol, 4.85% elemental, and 0.15% organic. The release from the turbine and condenser is assumed to be 97% elemental and 3% organic in accordance with RG 1.183 (Reference 7.1), Appendix C, Section 3.6.

3.8 All radiological nuclides released from damaged or melted fuel are assumed to be transported to the condenser within 5 seconds in accordance with the timeline in GNF Standard Application For Reactor Fuel (US) (reference 7.8) S2.2.3.1.1. This assumption takes no credit for automatic or manual isolation of Main Steam Isolation Valves or Steamline Drains.

3.9 Per the US Supplement to the GESTAR II manual (Reference 7.8) section S2.2.3.1.1 Sequence of Events, the gap release phase is conservatively modeled to begin at T = 0 seconds with a duration of 5 seconds and the fuel melt phase begins at T = 0 seconds with a duration of 5 seconds. This assumption conservatively ignores transport time and assumes the full source term is transported to the condenser during the same period in which it is released from the fuel.

3.10 No automatic or manual isolation of the Control Room or TSC is assumed. Normal ventilation flow rates are assumed. Control room ventilation also assumes 1000 CFM of unfiltered inleakage.

3.11 Mechanical Vacuum Pump operation is modeled at a constant 1800 cfm (design flow capacity).

4.0 DESIGN INPUTS:

The following design inputs are used to evaluate the radiological consequences of a control rod drop accident:

4.1 The design thermal power, for licensed power uprate, is 1912 MWt per section 2.C.1 of the Facility Operating License (Reference 7.9). A thermal power of 1950 MWt was utilized to account for a power uncertainty factor of 1.02 (see Section 3.2.2), as required per RG 1.183 and RG 1.49 (References 7.1 and 7.5).

4.2 Per NSA-00-145 (Reference 7.6) (Attached), the CRDA results in fuel clad damage and melted fuel.

4.3 Per RG 1.183 (Reference 7.1), Appendix C.1, and Section 3.2 Table 3, the fraction of equilibrium core inventory assumed to be in the gap for the various radionuclides is as follows:

Table No. 2:

Released from Gap (1200 Rods damaged but not melted)

Group	Release Fraction
Noble Gases	0.10
Halogens	0.10
Alkali Metals	0.12

4.4 Per RG 1.183 (Reference 7.1) section 3.2 Tables 1 and 3, and Appendix C.1 the fuel melt release fractions are as follows:

Table No. 3: BWR Core Inventory Fraction

Released from Melted Fuel (9.24 equivalent rods) (0.77% of 1200 rods Damaged)

Group	Release Fraction		
	Gap Release(1)	Fuel Melt Release(1)	Total
Noble Gases	0.10	0.9	1.0
Halogens	0.10	0.4	0.5
Alkali Metals	0.12	0.13	0.25
Tellurium Metals	0.00	0.05	0.05
Ba, Sr	0.00	0.02	0.02
Noble Metals	0.00	0.0025	0.0025
Cerium Group	0.00	0.0005	0.0005
Lanthanides	0.00	0.0002	0.0002

(1) Release from gap already accounted for in gap release described in 4.3. Pellet release calculations from melted fuel fraction release the remainder as calculated in column headed Fuel Melt Release.

4.5 Maximum core fission product inventory at T = 0 seconds is taken from GE Power Uprate Task Report T0802 (Reference 7.4), Appendix B, Table 3. This is conservative, because the limiting CRDA occurs when the reactor is just at the point of criticality. Using the full power equilibrium source term ignores decay that would have occurred since the reactor was at full power.

4.6 Post-accident offsite meteorology (χ/Q's) at the Exclusion Area Boundary (EAB) and Low Population Zone (LPZ) for the CRDA are provided in the following tables from the referenced calculations:

Table 4
Ground Level Release X/Q's to EAB and LPZ
(sec/m^3) - CAL-R00-PUP-001 (Ref. 7.10)
Calculated Using PAVAN code

Time Period	EAB (629m, ENE)	LPZ (3218m, NE)
0 – 2 hours	5.57E-04	1.34E-04
2 - 8 hours	3.42E-04	6.43E-05
8 – 24 hours	2.69E-04	4.46E-05
1 - 4 days	1.59E-04	2.01E-05
4 – 30 days	7.43E-05	6.42E-06

Table 5
Ground Level Release X/Q's to CR and TSC
from the Condenser (sec/m^3) to the TSC and CR – CAL-R00-PUP-002 (Ref. 7.11)
Calculated Using ARCON96 code

Includes Occupancy Adjustment Factors for ARCON96 Values		
Time Period	CR	TSC
0 – 2 hours	1.48E-03	2.14E-03
2 – 8 hours	1.27E-03	1.86E-03
8 – 24 hours	5.56E-04	8.44E-04
1 – 4 days	2.04E-04	3.66E-04
4 – 30 days	1.06E-04	1.88E-04

Table 6
Stack Release X/Q's to EAB and LPZ
(References 7.1, 7.2 per RG 1.194)

Time Period	**EAB**	**LPZ**
0 – 30 min (Fumigation)	7.03E-05	3.15E-05
30 min to 2 hrs	6.95E-06	6.69E-06
2 - 8 hours	3.61E-06	3.58E-06
8 – 24 hours	2.61E-06	2.61E-06
1 - 4 days	1.28E-06	1.32E-06
4 - 30 days	4.64E-07	4.99E-07

4.7 Post-accident meteorology atmospheric dispersion factors (χ/Q's) for the Control Room and TSC were calculated using inputs from CAL-R00-PUP-002 (Reference 7.11) and the methodology described in RG 1.194 (Reference 7.2) section C.3.2.2. The maximum χ/Q using PAVAN or ARCON96 is used for the 0 – 2 hour interval. ARCON96 values are used for the intervals from 2 hours to 24 hours. The "1 – 4 Day" and "4 – 30 Day" intervals are calculated using a weighted average assuming 1 hour at the PAVAN value and 23 hours at the ARCON96 value per day. Results are summarized as follows:

Table 7
Stack Release X/Q's to CR

Time Period	**ARCON96**	**PAVAN**	**CR**
	CAL-R00-PUP-002		**RG 1.194**
0 – 30 Min (Fumigation)	Not Calculated	2.62E-4	N/A
0 – 8 Hours	3.80E-07	4.70E-06	N/A
0 – 2 Hours	3.93E-07	1.68E-05	1.68E-05
2 - 8 Hours	3.75E-07	Not Calculated	3.75E-07
8 – 24 Hours	1.33E-07	2.49E-06	1.33E-07
1 - 4 Days	6.24E-08	3.74E-07	7.54E-08
4 - 30 Days	3.75E-08	3.42E-08	3.74E-08

Table 8
Stack Release X/Q's to TSC

Time Period	ARCON96	PAVAN	TSC
	CAL-R00-PUP-002		RG 1.194
0 – 30 Min (Fumigation)	Not Calculated	2.38E-04	N/A
0 – 8 Hours	2.20E-07	3.65E-06	N/A
0 – 2 Hours	2.32E-07	1.37E-05	1.37E-05
2 - 8 Hours	2.16E-07	Not Calculated	2.16E-07
8 – 24 Hours	8.00E-08	1.89E-06	8.00E-07
1 - 4 Days	3.69E-08	2.71E-07	4.67E-08
4 - 30 Days	2.16E-08	2.31E-08	2.17E-08

4.8 The core radial peaking factor is 1.46 as per GEDA-AEP-0208 (Reference 7.12).

4.9 The total number of damaged fuel rods for 10 X 10 fuel as a result of the CRDA is 1,200, per NSA-00-145 (Reference 7.6).

4.10 The fraction of damaged fuel rods that melt as a result of the CRDA is 0.0077, per NSA-00-145 (Reference 7.6).

4.11 The total number of GE 14X14 full length fuel rods per assembly is 87.33 per NSA-00-145 (Reference 7.6) and the total number of assemblies in the DAEC core is 368 as per Reference AE-39-0484 (Reference 7.13).

4.12 The condenser free air volume is 55,000 ft^3 per CAL-M94-010 (Reference 7.14).

4.13 The Control Building Volume is 155,000 cubic feet per NG-00-503 (Reference 7.15).

4.14 The Control Building Normal Ventilation Rate is 3150 cfm per NG-00-503 (Reference 7.15). An allowance of 1000 cfm is assumed for unfiltered inleakage for a total of 4150 cfm.

4.15 The TSC Volume is 68,300 cubic feet per reference 7.15.

4.16 The TSC normal ventilation rate is 900 cfm per reference 7.15.

5.0 METHODOLOGY

The following methodology is used to evaluate the radiological consequences of a control rod drop accident that considers fuel damage and fuel melt:

5.1 Source Term

5.1.1 <u>Calculation of Gap Activity Released into the Reactor Coolant (0 to 5 sec)</u>

$$GARRC = \Sigma\left(CA_i * \frac{DRF}{FRPA * APC} * RPF * GARF\right)$$

where:

GARRC = Gap activity released to reactor coolant (Ci/MWt)

CA_i = Core activity for $isotope_i$ (Ci/MWt) at T = 0 seconds, Section 4.5

DRF = # damaged fuel rods, Section 4.9

FRPA = # fuel rods per assembly, Section 4.11

APC = # assemblies per the core, Section 4.11

RPF = Core radial peaking factor, Section 4.8

GARF = Gap activity release fraction, Section 4.3, Table 3

5.1.2 <u>Calculation of Total Gap Activity In Condenser Available for Release to the Envir. (0 – 5 sec)</u>

$$GARE = GARRC * FGARC * FGARE$$

where:

GARE = Gap activity released to the environment (Ci/MWt)

GARRC = Gap activity released to reactor coolant (Ci/MWt), Section 5.1.1

FGARC = Fraction of gap activity reaching the condenser, Section 3.5

FGARE = Fraction of gap activity available for release from the condenser/turbine to the environment, Section 3.6

Utilizing the methodology of Sections 5.1.1 and 5.1.2, the gap activity in the condenser available to be released to the environment is calculated in Attachment 2 (EXCEL Spreadsheet).

5.1.3 <u>Calculation of PELLET Activity Released into the Reactor Coolant (0 to 5 sec – see Sec 4.6)</u>

$$PELLETARRC = \Sigma\left(CA_i * \frac{DRF}{FRPA * APC} * FDFRWM * RPF * PELLETARF\right)$$

where:

PELLETARRC = PELLET activity released to reactor coolant (Ci/MWt)

CA_i = Core activity for isotope$_i$ (Ci/MWt) at T = 0 seconds, Section 4.5, Table 11

DRF = # damaged fuel rods, Section 4.9

FRPA = # fuel rods per assembly, Section 4.11

APC = # assemblies per the core, Section 4.11

FDFRWM = Fraction of damaged fuel rods which melt, Section 4.10

RPF = Core radial peaking factor, Section 4.8

PELLETARF= PELLET activity release fraction, Section 4.3, Table 9

5.1.4 <u>Calculation of Total PELLET Activity In Condenser Available for Release to the Envir. (0 – 5 sec.)</u>

$$PELLETARE = PELLETARRC * FPELLETARC * FPELLETARE$$

where:

PELLETARE = PELLET activity released to the environment (Ci/MWt)

PELLETARRC = PELLET activity released to reactor coolant (Ci/MWt), Section 5.3

FPELLETARC = Fraction of PELLET activity reaching the condenser, Section 3.5

FPELLETARE = Fraction of PELLET activity available for release from the condenser/turbine to the environment, Section 3.6

Utilizing the methodology of Sections 5.3 and 5.4, the PELLET activity in the condenser available to be released to the reactor coolant is calculated in Attachment 3 (EXCEL Spreadsheet).

5.2 Calculation Of Doses

5.2.1 RADTRAD Model (See Figure 1)

Dose Consequences were calculated with the RADTRAD code version 3.03 (Reference 7.7). This code is classified as a safety-related application in accordance with the DAEC Software Quality Assurance Program.

Two basic models were used Mechanical Vacuum Pump Operating and Mechanical Vacuum Pump Secured. In all cases the entire source term is assumed to be released to the condenser within 5 seconds of the Control Rod Drop in accordance with assumption 3.8.

For the cases with Mechanical Vacuum Pump Secured, the activity released to the environment calculated in the previous Sections is assumed to be released at ground level from the Condenser at a leakage rate of 1%/day over a 24 hours period (Section 3.2.6). All leakage is immediately released to the environment via direct leakage out of the TB without holdup, plateout, or dilution (Section 3.6).

RADTRAD cases were run to account for the damaged (gap release) and fuel melt (pellet release) activity releases. The RADTRAD model inputs for the cases consist of 4 volumes (Condenser, Environment, a holdup volume (1.75 minute delay for the offgas treatment system piping used for the MVP Operating case only) and Control Room or TSC), 5 flow pathways (Condenser to Environment for the MVP secured scenario, Environment to CR or TSC Intake, CR or TSC Exhaust and MVP flow from the condenser to the holdup volume and from the holdup volume to the environment), and 3 dose locations (EAB, LPZ, and CR or TSC).

A total of 12 computer runs were performed.

5.2.2 **Mechanical Vacuum Pump Secured** (Case 1 Gap, Case 2 Gap TSC, Case 3 Pellet, Case 4 Pellet TSC)

5.2.2.1 Volumes

RADTRAD Volume 1 represents the DAEC Condenser:

- DAEC condenser is modeled as 55,000 ft^3 (Section 4.12)
- 1% per day for 24 hours of the available AST CRD source term is released to the Environment (Section 3.6)
- Natural Deposition – N/A
- No additional inputs

RADTRAD Volume 2 represents the Environment:

- No inputs

RADTRAD Volume 3 represents the Control Room (Cases 1, 3) or TSC(Cases 2, 4)

- Control Room Volume is 155,000 ft^3 (Section 4.13)
- TSC Volume is 68,300 ft^3 (Section 4.15)

5.2.2.2 Pathways

RADTRAD Pathway 1 represents the arbitrary Condenser leakage term (total release within 24 hours):

- Condenser leakage rate modeled as 1 % per day for a total of 24 hours (Section 3.6). Note, given a 1% per day leak rate, the volume selected in Section 5.5.1 does not impact the amount of activity released.
- No additional inputs

RADTRAD Pathway 2 represents the Control Room or TSC Normal Ventilation Intake

- Control Room Ventilation rate is 4150 cfm (Section 4.14).
- TSC Ventilation Rate is 900 cfm (Section 4.16).

RADTRAD Pathway 3 represents the Control Room or TSC Normal Ventilation Exhaust

- Exhaust rate for CR and TSC equals the ventilation rate.

5.2.2.3 Dose Locations

RADTRAD Dose Location 1 – EAB:

- X/Q values per Section 4.6 Table 4.
- Use RADTRAD default breathing rate values which are consistent with Reference 7.1
- No additional inputs

RADTRAD Dose Location 2 – LPZ:

- X/Q values per Section 4.6 Table 4.
- Use RADTRAD default breathing rate values which are consistent with Reference 7.1
- No additional inputs

RADTRAD Dose Location 3 – Control Room or TSC

- Control Room and TSC dose locations used the default occupancy and breathing rates.
- X/Q values per Section 4.6 Table 5.

5.2.2.4 RADTRAD Source Term:

- User Inventory file CRD-GAP.NIF.
- Modeled DAEC AEP power level as 1950 MW_{th} (Section 4.1)
- Model isotopic decay and daughter in-growth
- Use the user defined RADTRAD release fraction file, CRD-GAP.RFT
- Use the default RADTRAD FGR 11 & 12 (Reference 7.7) dose conversion factors for the MACCS 60 isotope inventory, FGR11&12.inp

- Iodine chemical fraction is 97% elemental & 3% organic (Section 3.2.7)
- No additional inputs

5.2.2.5 RADTRAD Control Options:

- All Control Options are selected for the additional data supplied in the output printout
- Supplemental Time Steps are selected to allow for detailed assessment of the early transient

5.2.2.6 Changes to RADTRAD Base Case Inputs - Model PELLET Activity Release (Cases 3, 4)

- Replace user Inventory file CRD-GAP.NIF with CRD-EIV.NIF
- Replace user defined RADTRAD release fraction file CRD-GAP.RFT with CRD-EIV.RFT
- No additional inputs

5.2.3 **Mechanical Vacuum Pump Operating** (Case 5 Gap, Case 6 Gap TSC, Case 7 Pellet, Case 8 Pellet TSC)

5.2.3.1 Volumes

- Volume 3 is a 1.75 minute holdup volume representing the offgas system delay time. At MVP flow rate of 1800 cfm the volume is 3150 ft^3.

5.2.3.2 Pathways

- The leakage pathway from the condenser to the environment is eliminated in this scenario
- The Mechanical Vacuum Pump Operation is modeled at a constant flow rate of 1800 cfm (Section 3.11).

5.2.3.3 All other model inputs are consistent with Cases 1 through 4 described in section 5.2.2.

5.2.4 Mechanical Vacuum Pump Manually Tripped at 10 Minutes (Case 9 GAP, Case 10 Gap TSC, Case 11 Pellet, Case 12 Pellet TSC)

5.2.4.1 These cases use the same RADTRAD model as the MVP Operating Case. At 10 minutes the Mechanical Vacuum Pump is assumed to be manually secured by the operators. Up until 10 minutes all inputs in the RADTRAD model are identical to the MVP Operating Cases. After 10 minutes all inputs are identical to the MVP secured cases except that the MVP Holdup Volume model is still present. Since it has zero flow rate after the assumed pump trip it does not affect results after that time.

6.0 CALCULATION

6.1 The activity released to the environment for the gap and pellet releases are determined in Attachment Nos. 2 & 3, utilizing an EXCEL Spreadsheet. The EAB, LPZ, CR, and TSC doses were determined for the bounding fuel damage/melt case described previously, utilizing the RADTRAD computer code and summing the results. RADTRAD computer outputs are included as Attachment Nos. 8 through 15 of this calculation as follows:

Table No. 9: CRDA File Name/Attachment Key

Case	.psf File Name	Attachment
1	CRDA GAP.psf	8
2	CRDA GAP TSC.psf	9
3	CRDA PELLET.psf	10
4	CRDA PELLET TSC.psf	11
5	CRDA GAP MVP.psf	12
6	CRDA GAP MVP.psf	13
7	CRDA PELLET MVP.psf	14
8	CRDA PELLET MVP TSC.psf	15
9	CRDA GAP MVP TRIP 10 MIN.psf	16
10	CRDA GAP MVP TRIP 10 MIN TSC.psf	17
11	CRDA PELLET MVP TRIP 10 MIN.psf	18
12	CRDA PELLET MVP TRIP 10 MIN TSC.psf	19

6.2 Accident Summaries

The analyzed CRDA event is bounding for a CRDA with no/minimal fuel damage. The resultant doses at the EAB for the CRDA without crediting a trip of the mechanical vacuum pump listed in Table 1 of Section 2.0 exceeds the guideline for acceptance criteria dose of 6.25 rem TEDE (25% of 25 rem) in Regulatory Guide 1.183 (Reference 7.1). However, if approved by NRC, the EAB calculated dose may be considered to meet the Standard Review Plan acceptance criteria of "well below" the 10 CFR 50.67 limit of 25 Rem TEDE. If credit for manual isolation is taken at 10 minutes all doses meet regulatory guidelines. All other calculated doses meet the acceptance criteria of RG 1.183, 10 CFR 50 Appendix B Criterion 19, and 10 CFR 50.67.

7.0 REFERENCES

7.1 Regulatory Guide 1.183, "Alternative Radiological Source Terms For Evaluating Design Basis Accidents At Nuclear Power Reactors", dated July 2000.

7.2 Regulatory Guide 1.194 "Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants", dated June 2003

7.3 Code of Federal Regulations, Title 10, Section 50.67, "Accident Source Term.".

7.4 GE Project Task Report T0802 for the Duane Arnold Energy Center Asset Enhancement Program, "Radiation Sources and Fission Products", GE-NE-A22-00100-58-01, R0, Class III, dated May 2000.

7.5 USNRC Regulatory Guide 1.49, "Power Levels of Nuclear Power Plants", Revision 1.

7.6 GE Letter No. NSA 00-145, Nader Sadeghi (GE) to Juan Cajigas (AAC), "DAEC EPU Response to Information Request", dated April 20, 2000. (See Attachment 17)

7.7 NUREG/CR-6604 Supplement 2 "RADTRAD: A Simplified Model for RADioactive Nuclide Transport and Removal and Dose Estimation" dated October 2002.

7.8 Global Nuclear Fuels – Americas Report NEDE-24011-P-A-14-US "General Electric Standard Application for Reactor Fuel (US Supplement)", dated June 2000.

7.9 DAEC Facility Operating License Number DPR-49

7.10 CAL-R00-PUP-001 Revision 1, "Accident Offsite Radiological Atmosphere Dispersion Factors (Chi/Q)"

7.11 CAL-R00-PUP-002 Revision 1, "Accident Control Room and TSC Radiological Atmosphere.

7.12 GE Letter No. GEDA-AEP-208, W. F. Farrell (GE) to Juan Cajigas (AAC), "Request for DAEC PUREC Radial Peaking Factor Data", dated April 19, 2000.

7.13 GE Document AE-39-0484, "DAEC Radiological Effects of Power Uprate", April 1984.

7.14 CAL-M94-010

7.15 R. McGee to J. Cajigas, "Transmittal of DIR T0901 Accident Radiological Analyses" (AAC DIR #T0901-4), NG-00-0503, 3/23/00.

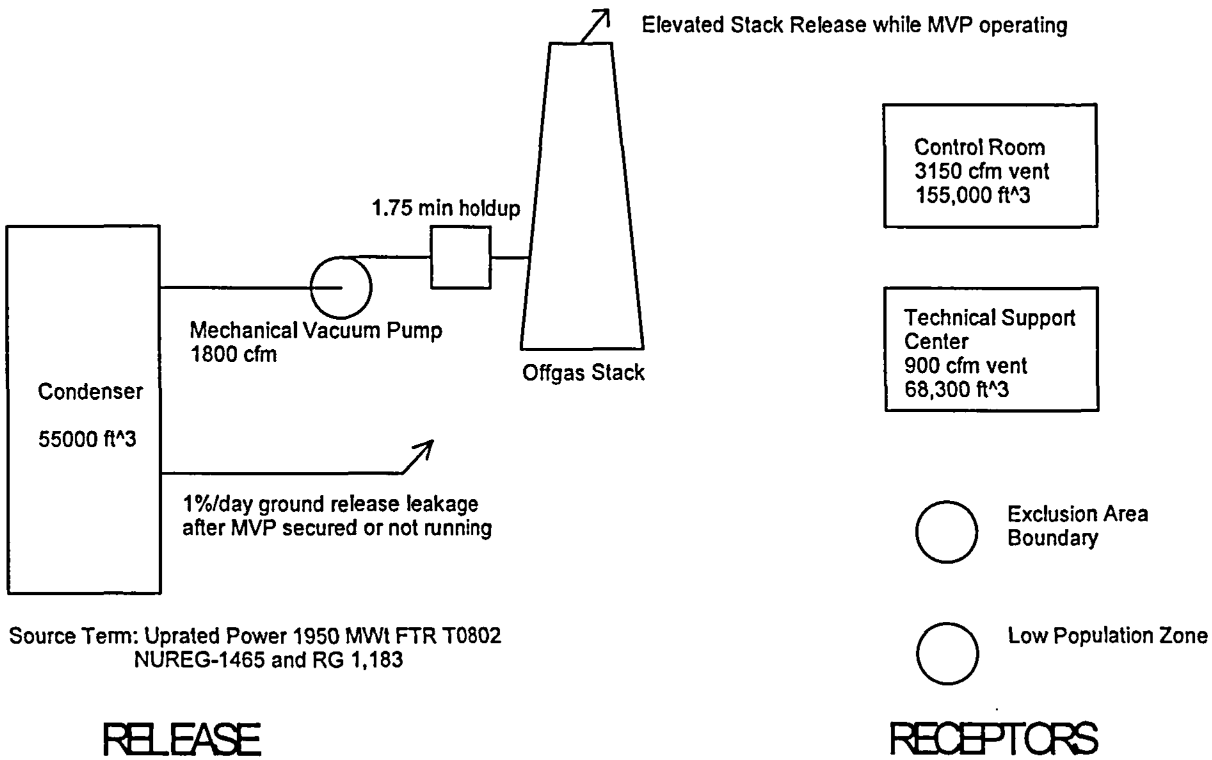

Figure 1: CRDA WITH/WITHOUT MVP OPERATION

Attachment 1
Reference 7.6

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GE Nuclear Energy

General Electric Company
175 Curtner Avenue, San Jose, CA 95125

April 20, 2000 NSA 00-145

From: Sadeghi, Nader

To: Juan Cajigas, Applied Analysis Corporation

Subject: DAEC EPU Response to Information Request

The following input was required from GENE to support the non-LOCA accident analyses for Task T0901: Number of fuel rods postulated to fail as a result of the Control Rod Drop Accident (CRDA).

The number of fuel rods postulated to fail is 1200 for 10x10 fuel (GE14). This is based on GE14 (10x10) having 87.33 equivalent full-length standard fuel rods. The number of failed rods obtained includes an allowance of 10% for uncertainties in the calculation.

Please call me if there are any questions on this information.

Nader Sadeghi
Nuclear & Safety Analysis
(408) 925-1162

cc: Jason Post
Margaret Harding
Jose Casillas

Attachment 2
CRDA RADTRAD
Input Source Term
Gap Release

ATTACHMENT NO. 2
CRDA - INPUT RADTRAD SOURCE TERM
(GAP RELEASE)

	A	B	C	D	E	F	G	H	I
1-5	Isotope/ RADTRAD No.	Ref. 7.3 App. B, Table 3 DAEC EPU Core Inventory (CI/MWt) T = 0	Damaged Fuel Fraction of Core	Damaged Fuel Radial Peaking Factor	Ref. 7.1 Table 3 Gap Fraction Released	Gap Activity Released Into RC (CI/MWt)	Fraction of Gap Activity Reaching Condenser	Fraction of Gap Activity in Condenser Available to the Environ.	Total Gap Activity in Condenser Available for Release (0-0.5 Hr) (CI/MWt)
6									
7	I-131(33)	2.749E+04	3.734E-02	1.46	0.10	1.499E+02	0.10	0.10	1.499E+00
8	I-132(34)	3.950E+04	3.734E-02	1.46	0.10	2.153E+02	0.10	0.10	2.153E+00
9	I-133(35)	5.496E+04	3.734E-02	1.46	0.10	2.996E+02	0.10	0.10	2.996E+00
10	I-134(36)	6.021E+04	3.734E-02	1.46	0.10	3.282E+02	0.10	0.10	3.282E+00
11	I-135(37)	5.150E+04	3.734E-02	1.46	0.10	2.808E+02	0.10	0.10	2.808E+00
12									
13	Kr-85(3)	4.501E+02	3.734E-02	1.46	0.10	2.454E+00	1.00	1.00	2.454E+00
14	Kr-85m(4)	6.702E+03	3.734E-02	1.46	0.10	3.654E+01	1.00	1.00	3.654E+01
15	Kr-87(5)	1.274E+04	3.734E-02	1.46	0.10	6.945E+01	1.00	1.00	6.945E+01
16	Kr-88(6)	1.792E+04	3.734E-02	1.46	0.10	9.769E+01	1.00	1.00	9.769E+01
17									
18	Xe-133(38)	5.279E+04	3.734E-02	1.46	0.10	2.878E+02	1.00	1.00	2.878E+02
19	Xe-135(39)	1.908E+04	3.734E-02	1.46	0.10	1.040E+02	1.00	1.00	1.040E+02
20									
21	Cs-134(40)	1.065E+04	3.734E-02	1.46	0.12	6.967E+01	0.01	0.01	6.967E-03
22	Cs-136(41)	2.964E+03	3.734E-02	1.46	0.12	1.939E+01	0.01	0.01	1.939E-03
23	Cs-137(42)	5.233E+03	3.734E-02	1.46	0.12	3.423E+01	0.01	0.01	3.423E-03
24									
25	Rb-86(7)	9.876E+01	3.734E-02	1.46	0.12	6.461E-01	0.01	0.01	6.461E-05

26		
27	CRDA - Damaged Fuel Rods =	1200
28	GE 14x14 Full Fuel Rods per Assembly =	87.33
29	DAEC - Total Assemblies per Core =	368
30	DAEC - GE 14x14 Radial Peaking Factor =	1.46
31	Fraction - CRDA Damaged Fuel Rods Which Melt =	0.0077
32		
33	DAEC FHA - Elemental Species Fraction =	0.97
34	DAEC FHA - Organic Species Fraction =	0.03

ATTACHMENT NO. 2
CRDA - INPUT RADTRAD SOURCE TERM
(GAP RELEASE)

	A	B	C	D	E	F	G	H	I
1–5	Isotope/ RADTRAD No.	Ref. 7.3 App. B, Table 3 DAEC EPU Core Inventory (Ci/MWt) T = 0	Damaged Fuel Fraction of Core	Damaged Fuel Radial Peaking Factor	Ref. 7.1 Table 3 Gap Fraction Released	Gap Activity Released Into RC (Ci/MWt)	Fraction of Gap Activity Reaching Condenser	Fraction of Gap Activity in Condenser Available to the Environ.	Total Gap Activity in Condenser Available for Release (0-0.5 Hr) (Ci/MWt)
6									
7	I-131(33)	27490	=$E$27/($E$28*$E$29)	=$E$30	0.1	=($B7*$C7*$D7*$E7)	0.1	0.1	=$F7*$G7*$H7
8	I-132(34)	39500	=$E$27/($E$28*$E$29)	=$E$30	0.1	=($B8*$C8*$D8*$E8)	0.1	0.1	=$F8*$G8*$H8
9	I-133(35)	54960	=$E$27/($E$28*$E$29)	=$E$30	0.1	=($B9*$C9*$D9*$E9)	0.1	0.1	=$F9*$G9*$H9
10	I-134(36)	60210	=$E$27/($E$28*$E$29)	=$E$30	0.1	=($B10*$C10*$D10*$E10)	0.1	0.1	=$F10*$G10*$H10
11	I-135(37)	51500	=$E$27/($E$28*$E$29)	=$E$30	0.1	=($B11*$C11*$D11*$E11)	0.1	0.1	=$F11*$G11*$H11
12									
13	Kr-85(3)	450.1	=$E$27/($E$28*$E$29)	=$E$30	0.1	=($B13*$C13*$D13*$E13)	1	1	=$F13*$G13*$H13
14	Kr-85m(4)	6702	=$E$27/($E$28*$E$29)	=$E$30	0.1	=($B14*$C14*$D14*$E14)	1	1	=$F14*$G14*$H14
15	Kr-87(5)	12740	=$E$27/($E$28*$E$29)	=$E$30	0.1	=($B15*$C15*$D15*$E15)	1	1	=$F15*$G15*$H15
16	Kr-88(6)	17920	=$E$27/($E$28*$E$29)	=$E$30	0.1	=($B16*$C16*$D16*$E16)	1	1	=$F16*$G16*$H16
17									
18	Xe-133(38)	52790	=$E$27/($E$28*$E$29)	=$E$30	0.1	=($B18*$C18*$D18*$E18)	1	1	=$F18*$G18*$H18
19	Xe-135(39)	19080	=$E$27/($E$28*$E$29)	=$E$30	0.1	=($B19*$C19*$D19*$E19)	1	1	=$F19*$G19*$H19
20									
21	Cs-134(40)	10650	=$E$27/($E$28*$E$29)	=$E$30	0.12	=($B21*$C21*$D21*$E21)	0.01	0.01	=$F21*$G21*$H21
22	Cs-136(41)	2964	=$E$27/($E$28*$E$29)	=$E$30	0.12	=($B22*$C22*$D22*$E22)	0.01	0.01	=$F22*$G22*$H22
23	Cs-137(42)	5233	=$E$27/($E$28*$E$29)	=$E$30	0.12	=($B23*$C23*$D23*$E23)	0.01	0.01	=$F23*$G23*$H23
24									
25	Rb-86(7)	98.76	=$E$27/($E$28*$E$29)	=$E$30	0.12	=($B25*$C25*$D25*$E25)	0.01	0.01	=$F25*$G25*$H25
26									
27				CRDA - Damaged Fuel Rods =	1200				
28				GE 14x14 Full Fuel Rods per Assembly =	87.33				
29				DAEC - Total Assemblies per Core =	368				
30				DAEC - GE 14x14 Radial Peaking Factor =	1.46				
31				Fraction - CRDA Damaged Fuel Rods Which Melt =	0.0077				
32									
33				DAEC FHA - Elemental Species Fraction =	0.97				
34				DAEC FHA - Organic Species Fraction =	0.03				

Attachment 3
CRDA RADTRAD
Input Source Term
PELLET Release

ATTACHMENT NO. 3
CRDA - INPUT RADTRAD SOURCE TERM
(Pellet Release)

	A	B	C	D	E	F	G	H	I	J
1-5	Isotope/ RADTRAD No.	FTR T0802 App. B, Table 3 DAEC EPU Core Inventory *(Ci/MWt) T = 0*	Melt Fraction X Damaged Fuel Fraction *of Core*	Damaged Fuel Radial Peaking *Factor*	RG 1.183 Table 1 EIV Fraction Released *to RC*	EIV Melted Fuel Activity Released to RC *(Ci/MWt)*	Fraction of EIV Activity Reaching *Condenser*	Fraction of EIV Activity In Condenser Available to *the Environ.*	Total EIV Activity In Condenser Available for Release (0.5-2 Hr) *(Ci/MWt)*	
6										
7	Am-241(58)	8.356E+00	2.875E-04	1.46	0.0002	7.015E-07	0.01	0.01	7.015E-11	
8										
9	Ba-139(43)	4.872E+04	2.875E-04	1.46	0.0200	4.090E-01	0.01	0.01	4.090E-06	
10	Ba-140(44)	4.703E+04	2.875E-04	1.46	0.0200	3.948E-01	0.01	0.01	3.948E-06	
11										
12	Ce-141(48)	4.459E+04	2.875E-04	1.46	0.0005	9.359E-03	0.01	0.01	9.359E-07	
13	Ce-143(49)	4.083E+04	2.875E-04	1.46	0.0005	8.570E-03	0.01	0.01	8.570E-07	
14	Ce-144(50)	3.701E+04	2.875E-04	1.46	0.0005	7.768E-03	0.01	0.01	7.768E-07	
15										
16	Cm-242(59)	2.536E+03	2.875E-04	1.46	0.0002	2.129E-04	0.01	0.01	2.129E-08	
17	Cm-244(60)	3.104E+02	2.875E-04	1.46	0.0002	2.606E-05	0.01	0.01	2.606E-09	
18										
19	Co-58(1)	1.529E+02	2.875E-04	1.46	0.0025	1.605E-04	0.01	0.01	1.605E-08	Note 1
20	Co-60(2)	1.830E+02	2.875E-04	1.46	0.0025	1.920E-04	0.01	0.01	1.920E-08	Note 1
21										
22	Cs-134(40)	1.065E+04	2.875E-04	1.46	0.1300	6.812E-01	0.01	0.01	6.812E-05	
23	Cs-136(41)	2.964E+03	2.875E-04	1.46	0.1300	1.617E-01	0.01	0.01	1.617E-05	
24	Cs-137(42)	5.233E+03	2.875E-04	1.46	0.1300	2.856E-01	0.01	0.01	2.856E-05	
25										
26	I-131(33)	2.749E+04	2.875E-04	1.46	0.4000	4.816E+00	0.10	0.10	4.616E-02	
27	I-132(34)	3.950E+04	2.875E-04	1.46	0.4000	6.632E+00	0.10	0.10	6.632E-02	
28	I-133(35)	5.496E+04	2.875E-04	1.46	0.4000	9.228E+00	0.10	0.10	9.228E-02	
29	I-134(36)	6.021E+04	2.875E-04	1.46	0.4000	1.011E+01	0.10	0.10	1.011E-01	
30	I-135(37)	5.150E+04	2.875E-04	1.46	0.4000	8.647E+00	0.10	0.10	8.647E-02	
31										
32	Kr-85(3)	4.501E+02	2.875E-04	1.46	0.9000	1.700E-01	1.00	1.00	1.700E-01	
33	Kr-85m(4)	6.702E+03	2.875E-04	1.46	0.9000	2.532E+00	1.00	1.00	2.532E+00	
34	Kr-87(5)	1.274E+04	2.875E-04	1.46	0.9000	4.813E+00	1.00	1.00	4.813E+00	
35	Kr-88(6)	1.792E+04	2.875E-04	1.46	0.9000	6.770E+00	1.00	1.00	6.770E+00	
36										
37	La-140(45)	5.060E+04	2.875E-04	1.46	0.0002	4.248E-03	0.01	0.01	4.248E-07	
38	La-141(46)	4.437E+04	2.875E-04	1.46	0.0002	3.725E-03	0.01	0.01	3.725E-07	
39	La-142(47)	4.272E+04	2.875E-04	1.46	0.0002	3.587E-03	0.01	0.01	3.587E-07	
40										
41	Mo-99(19)	6.193E+04	2.875E-04	1.46	0.0025	5.450E-02	0.01	0.01	5.450E-06	
42										
43	Nb-95(18)	4.455E+04	2.875E-04	1.46	0.0002	3.740E-03	0.01	0.01	3.740E-07	
44										
45	Nd-147(52)	1.797E+04	2.875E-04	1.46	0.0002	1.509E-03	0.01	0.01	1.509E-07	
46										
47	Np-239(53)	6.090E+05	2.875E-04	1.46	0.0005	1.278E-01	0.01	0.01	1.278E-05	
48										
49	Pr-143(51)	3.947E+04	2.875E-04	1.46	0.0002	3.314E-03	0.01	0.01	3.314E-07	
50										
51	Pu-238(54)	2.547E+02	2.875E-04	1.46	0.0005	5.346E-05	0.01	0.01	5.346E-09	
52	Pu-239(55)	1.368E+01	2.875E-04	1.46	0.0005	2.871E-06	0.01	0.01	2.871E-10	
53	Pu-240(56)	2.166E+01	2.875E-04	1.46	0.0005	4.546E-06	0.01	0.01	4.546E-10	
54	Pu-241(57)	6.361E+03	2.875E-04	1.46	0.0005	1.335E-03	0.01	0.01	1.335E-07	
55										
56	Rb-86(7)	9.876E+01	2.875E-04	1.46	0.1300	5.389E-03	0.01	0.01	5.389E-07	
57										
58	Rh-105(24)	3.140E+04	2.875E-04	1.46	0.0025	3.295E-02	0.01	0.01	3.295E-06	
59										
60	Ru-103(21)	4.557E+04	2.875E-04	1.46	0.0025	4.782E-02	0.01	0.01	4.782E-06	
61	Ru-105(22)	3.365E+04	2.875E-04	1.46	0.0025	3.531E-02	0.01	0.01	3.531E-06	
62	Ru-106(23)	2.091E+04	2.875E-04	1.46	0.0025	2.194E-02	0.01	0.01	2.194E-06	
63										
64	Sb-127(25)	3.206E+03	2.875E-04	1.46	0.0500	6.729E-02	0.01	0.01	6.729E-06	
65	Sb-129(26)	9.257E+03	2.875E-04	1.46	0.0500	1.943E-01	0.01	0.01	1.943E-05	
66										
67	Sr-89(8)	2.406E+04	2.875E-04	1.46	0.0200	2.020E-01	0.01	0.01	2.020E-05	
68	Sr-90(9)	3.620E+03	2.875E-04	1.46	0.0200	3.039E-02	0.01	0.01	3.039E-06	
69	Sr-91(10)	3.047E+04	2.875E-04	1.46	0.0200	2.558E-01	0.01	0.01	2.558E-05	
70	Sr-92(11)	3.331E+04	2.875E-04	1.46	0.0200	2.797E-01	0.01	0.01	2.797E-05	
71										
72	Tc-99m(20)	4.548E+04	2.875E-04	1.46	0.0025	4.773E-02	0.01	0.01	4.773E-06	
73										
74	Te-127(27)	3.190E+03	2.875E-04	1.46	0.0500	6.695E-02	0.01	0.01	6.695E-06	
75	Te-127m(28)	4.326E+02	2.875E-04	1.46	0.0500	9.080E-03	0.01	0.01	9.080E-07	
76	Te-129(29)	9.114E+03	2.875E-04	1.46	0.0500	1.913E-01	0.01	0.01	1.913E-05	
77	Te-129m(30)	1.356E+03	2.875E-04	1.46	0.0500	2.846E-02	0.01	0.01	2.846E-06	
78	Te-131m(31)	4.064E+03	2.875E-04	1.46	0.0500	8.530E-02	0.01	0.01	8.530E-06	
79	Te-132(32)	3.880E+04	2.875E-04	1.46	0.0500	8.144E-01	0.01	0.01	8.144E-05	
80										
81	Xe-133(38)	5.279E+04	2.875E-04	1.46	0.9000	1.994E+01	1.00	1.00	1.994E+01	
82	Xe-135(39)	1.908E+04	2.875E-04	1.46	0.9000	7.208E+00	1.00	1.00	7.208E+00	
83										
84	Y-90(12)	3.758E+03	2.875E-04	1.46	0.0002	3.155E-04	0.01	0.01	3.155E-08	
85	Y-91(13)	3.133E+04	2.875E-04	1.46	0.0002	2.630E-03	0.01	0.01	2.630E-07	
86	Y-92(14)	3.347E+04	2.875E-04	1.46	0.0002	2.810E-03	0.01	0.01	2.810E-07	
87	Y-93(15)	3.915E+04	2.875E-04	1.46	0.0002	3.287E-03	0.01	0.01	3.287E-07	
88										
89	Zr-95(16)	4.433E+04	2.875E-04	1.46	0.0002	3.722E-03	0.01	0.01	3.722E-07	
90	Zr-97(17)	4.493E+04	2.875E-04	1.46	0.0002	3.772E-03	0.01	0.01	3.772E-07	
91										
92	CRDA - Damaged Fuel Rods =				1200					
93	GE 14x14 Full Fuel Rods per Assembly =				87.33					
94	DAEC - Total Assemblies per Core =				368					
95	DAEC - GE 14x14 Radial Peaking Factor =				1.46					
96	Fraction - CRDA Damaged Fuel Rods Which Melt =				0.0077					
97										
98	DAEC FHA - Elemental Species Fraction =				0.97					
99	DAEC FHA - Organic Species Fraction =				0.03					
100										
101	Note 1: There is no core inventory provided for Co-58 & Co-60, consequently the default values in the RADTRAD Computer Programs (Ref. 7.7)									
102	were utilized.									

ATTACHMENT NO. 3
CRDA - INPUT RADTRAD SOURCE TERM
(Pellet Release)

	A	B	C	D	E	F	G	H	I	J
1-5	Isotope/ RADTRAD No.	FTR T0802 App. B, Table 3 DAEC EPU Core Inventory (Ci/MWt) T = 0	Melt Fraction X Damaged Fuel Fraction of Core	Damaged Fuel Radial Peaking Factor	RG 1.183 Table 1 E/V Fraction Released to RC	E/V Melted Fuel Activity Released to RC (Ci/MWt)	Fraction of E/V Activity Reaching Condenser	Fraction of E/V Activity In Condenser Available to the Environ.	Total E/V Activity in Condenser Available for Release (0.5-2 Hr) (Ci/MWt)	
6										
7	Am-241(58)	8.356	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B7*$C7*$D7*$E7	0.01	0.01	=$F7*$G7*$H7	
8										
9	Ba-139(43)	48720	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.02	=$B9*$C9*$D9*$E9	0.01	0.01	=$F9*$G9*$H9	
10	Ba-140(44)	47030	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.02	=$B10*$C10*$D10*$E10	0.01	0.01	=$F10*$G10*$H10	
11										
12	Ce-141(48)	44590	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0005	=$B12*$C12*$D12*$E12	0.01	0.01	=$F12*$G12*$H12	
13	Ce-143(49)	40830	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0005	=$B13*$C13*$D13*$E13	0.01	0.01	=$F13*$G13*$H13	
14	Ce-144(50)	37010	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0005	=$B14*$C14*$D14*$E14	0.01	0.01	=$F14*$G14*$H14	
15										
16	Cm-242(59)	2536	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B16*$C16*$D16*$E16	0.01	0.01	=$F16*$G16*$H16	
17	Cm-244(60)	310.4	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B17*$C17*$D17*$E17	0.01	0.01	=$F17*$G17*$H17	
18										
19	Co-58(1)	152.9	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0025	=$B19*$C19*$D19*$E19	0.01	0.01	=$F19*$G19*$H19	Note 1
20	Co-60(2)	183	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0025	=$B20*$C20*$D20*$E20	0.01	0.01	=$F20*$G20*$H20	Note 1
21										
22	Cs-134(40)	10650	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.13	=$B22*$C22*$D22*$E22	0.01	0.01	=$F22*$G22*$H22	
23	Cs-136(41)	2964	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.13	=$B23*$C23*$D23*$E23	0.01	0.01	=$F23*$G23*$H23	
24	Cs-137(42)	5233	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.13	=$B24*$C24*$D24*$E24	0.01	0.01	=$F24*$G24*$H24	
25										
26	I-131(33)	27490	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.4	=$B26*$C26*$D26*$E26	0.1	0.1	=$F26*$G26*$H26	
27	I-132(34)	39500	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.4	=$B27*$C27*$D27*$E27	0.1	0.1	=$F27*$G27*$H27	
28	I-133(35)	54960	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.4	=$B28*$C28*$D28*$E28	0.1	0.1	=$F28*$G28*$H28	
29	I-134(36)	60210	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.4	=$B29*$C29*$D29*$E29	0.1	0.1	=$F29*$G29*$H29	
30	I-135(37)	51500	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.4	=$B30*$C30*$D30*$E30	0.1	0.1	=$F30*$G30*$H30	
31										
32	Kr-85(3)	450.1	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.9	=$B32*$C32*$D32*$E32	1	1	=$F32*$G32*$H32	
33	Kr-85m(4)	6702	=($E$92/($E$93*$E$94))*$E$96	=$E$95	=1-0.1	=$B33*$C33*$D33*$E33	1	1	=$F33*$G33*$H33	
34	Kr-87(5)	12740	=($E$92/($E$93*$E$94))*$E$96	=$E$95	=1-0.1	=$B34*$C34*$D34*$E34	1	1	=$F34*$G34*$H34	
35	Kr-88(6)	17920	=($E$92/($E$93*$E$94))*$E$96	=$E$95	=1-0.1	=$B35*$C35*$D35*$E35	1	1	=$F35*$G35*$H35	
36										
37	La-140(45)	50600	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B37*$C37*$D37*$E37	0.01	0.01	=$F37*$G37*$H37	
38	La-141(46)	44370	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B38*$C38*$D38*$E38	0.01	0.01	=$F38*$G38*$H38	
39	La-142(47)	42720	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B39*$C39*$D39*$E39	0.01	0.01	=$F39*$G39*$H39	
40										
41	Mo-99(19)	51930	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0025	=$B41*$C41*$D41*$E41	0.01	0.01	=$F41*$G41*$H41	
42										
43	Nb-95(18)	44550	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B43*$C43*$D43*$E43	0.01	0.01	=$F43*$G43*$H43	
44										
45	Nd-147(52)	17970	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B45*$C45*$D45*$E45	0.01	0.01	=$F45*$G45*$H45	
46										
47	Np-239(53)	609000	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0005	=$B47*$C47*$D47*$E47	0.01	0.01	=$F47*$G47*$H47	
48										
49	Pr-143(51)	39470	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B49*$C49*$D49*$E49	0.01	0.01	=$F49*$G49*$H49	
50										
51	Pu-238(54)	254.7	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0005	=$B51*$C51*$D51*$E51	0.01	0.01	=$F51*$G51*$H51	
52	Pu-239(55)	13.68	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0005	=$B52*$C52*$D52*$E52	0.01	0.01	=$F52*$G52*$H52	
53	Pu-240(56)	21.66	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0005	=$B53*$C53*$D53*$E53	0.01	0.01	=$F53*$G53*$H53	
54	Pu-241(57)	6361	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0005	=$B54*$C54*$D54*$E54	0.01	0.01	=$F54*$G54*$H54	
55										
56	Rb-86(7)	96.76	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.13	=$B56*$C56*$D56*$E56	0.01	0.01	=$F56*$G56*$H56	
57										
58	Rh-105(24)	31400	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0025	=$B58*$C58*$D58*$E58	0.01	0.01	=$F58*$G58*$H58	
59										
60	Ru-103(21)	45570	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0025	=$B60*$C60*$D60*$E60	0.01	0.01	=$F60*$G60*$H60	
61	Ru-105(22)	33650	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0025	=$B61*$C61*$D61*$E61	0.01	0.01	=$F61*$G61*$H61	
62	Ru-106(23)	20910	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0025	=$B62*$C62*$D62*$E62	0.01	0.01	=$F62*$G62*$H62	
63										
64	Sb-127(25)	3206	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.05	=$B64*$C64*$D64*$E64	0.01	0.01	=$F64*$G64*$H64	
65	Sb-129(26)	9257	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.05	=$B65*$C65*$D65*$E65	0.01	0.01	=$F65*$G65*$H65	
66										
67	Sr-89(8)	24060	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.02	=$B67*$C67*$D67*$E67	0.01	0.01	=$F67*$G67*$H67	
68	Sr-90(9)	3620	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.02	=$B68*$C68*$D68*$E68	0.01	0.01	=$F68*$G68*$H68	
69	Sr-91(10)	30470	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.02	=$B69*$C69*$D69*$E69	0.01	0.01	=$F69*$G69*$H69	
70	Sr-92(11)	33310	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.02	=$B70*$C70*$D70*$E70	0.01	0.01	=$F70*$G70*$H70	
71										
72	Tc-99m(20)	45480	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0025	=$B72*$C72*$D72*$E72	0.01	0.01	=$F72*$G72*$H72	
73										
74	Te-127(27)	3190	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.05	=$B74*$C74*$D74*$E74	0.01	0.01	=$F74*$G74*$H74	
75	Te-127m(28)	432.6	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.05	=$B75*$C75*$D75*$E75	0.01	0.01	=$F75*$G75*$H75	
76	Te-129(29)	9114	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.05	=$B76*$C76*$D76*$E76	0.01	0.01	=$F76*$G76*$H76	
77	Te-129m(30)	1356	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.05	=$B77*$C77*$D77*$E77	0.01	0.01	=$F77*$G77*$H77	
78	Te-131m(31)	4064	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.05	=$B78*$C78*$D78*$E78	0.01	0.01	=$F78*$G78*$H78	
79	Te-132(32)	38800	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.05	=$B79*$C79*$D79*$E79	0.01	0.01	=$F79*$G79*$H79	
80										
81	Xe-133(38)	52790	=($E$92/($E$93*$E$94))*$E$96	=$E$95	=1-0.1	=$B81*$C81*$D81*$E81	1	1	=$F81*$G81*$H81	
82	Xe-135(39)	19080	=($E$92/($E$93*$E$94))*$E$96	=$E$95	=1-0.1	=$B82*$C82*$D82*$E82	1	1	=$F82*$G82*$H82	
83										
84	Y-90(12)	3758	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B84*$C84*$D84*$E84	0.01	0.01	=$F84*$G84*$H84	
85	Y-91(13)	31330	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B85*$C85*$D85*$E85	0.01	0.01	=$F85*$G85*$H85	
86	Y-92(14)	33470	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B86*$C86*$D86*$E86	0.01	0.01	=$F86*$G86*$H86	
87	Y-93(15)	39150	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B87*$C87*$D87*$E87	0.01	0.01	=$F87*$G87*$H87	
88										
89	Zr-95(16)	44330	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B89*$C89*$D89*$E89	0.01	0.01	=$F89*$G89*$H89	
90	Zr-97(17)	44930	=($E$92/($E$93*$E$94))*$E$96	=$E$95	0.0002	=$B90*$C90*$D90*$E90	0.01	0.01	=$F90*$G90*$H90	
91										
92			CRDA - Damaged Fuel Rods =		1200					
93			GE 14x14 Full Fuel Rods per Assembly =		87.33					
94			DAEC - Total Assemblies per Core =		368					
95			DAEC - GE 14x14 Radial Peaking Factor =		1.46					
96			Fraction - CRDA Damaged Fuel Rods Which Melt =		0.0077					
97										
98			DAEC FHA - Elemental Species Fraction =		0.97					
99			DAEC FHA - Organic Species Fraction =		0.03					
100										
101	Note 1: There is no core inventory provided for Co-58 & Co-60, consequently the default values in the RADTRAD Computer Program (Ref. 7.7)									
102	were utilized									