

Attachment 14.2 of Calculation H-1-ZZ-MDC-1880, Revision 4, "Post-LOCA EAB, LPZ, and CR Doses" (GEH Non-Proprietary Information)

Note: Some pages in this attachment include a notation to "LRW-PSG-KT1-10-091" this refers to the GEH letter that provided the material to PSEG

ENCLOSURE 2

LRW-PSG-KT1-10-091

Attachment 14.2 of Calculation H-1-ZZ-MDC-1880, Revision 4

Non-Proprietary Information

Information Notice

This is a non-proprietary version of LRW-PSG-KT1-10-091, Enclosure 1, from which the proprietary information has been removed. Portions of the enclosure that have been removed are indicated by an open and closed bracket as shown here [[]].

Non-Proprietary Information**Attachment 14.2**

Title: Evaluation to Determine the radiological impact of adding 12 Isotope Test Assemblies (ITAs) on the post-LOCA EAB, LPZ, and CR Doses.

1.0 REASON FOR EVALUATION / SCOPE

The purpose of this evaluation is to determine radiological impact of adding twelve (12) Co-60 isotope test assemblies (ITAs) in the Hope Creek reactor core. The resulting post-LOCA dose consequences at the Exclusion Area Boundary (EAB), Low Population Zone (LPZ) and Control Room (CR) are analyzed. The doses are calculated using the Alternate Source Term (AST), guidance in Regulatory Guide (RG) 1.183, and Total Effective Dose Equivalent (TEDE) dose criteria.

2.0 METHODOLOGY

The design basis LOCA radiological consequence analysis documented in Reference 10.4 uses the average uprated core inventory with Co-60 inventory obtained from RADTRAD User's Manual, Table 1.4.3.2-3. The proposed insertion of the Co-60 ITAs will increase the Co-60 inventory in the core. The total Co-60 activity in the core including the Co-60 in the core plus Co-60 ITAs is calculated in Section 7.9. The Co-60 ITA activity is [[]] to account for uncertainty in release of Co-60 present in high concentrations in the cobalt isotope rods. The RADTRAD Nuclide Inventory File (NIF) is modified for the Co-60 inventory calculated in Section 7.9. The newly created RADTRAD NIF file (HEPULOCA2_DEF.txt) is used to calculate the dose consequences at EAB, LPZ, and CR. The following two (2) post-LOCA release paths are evaluated using the design input information in Reference 10.4 and additional Co-60 ITA related design input in Section 5.3:

1. Containment Leakage
2. MSIV Leakage

The ESF leakage dose only accounts for the iodine activity release from the core to the suppression pool water, with the remaining radioactive material assumed to remain in the pool water and retained in the liquid phase (Ref. 10.2, Appendix A, Section 5.3). Therefore, the Co-60 activity is assumed to remain in liquid phase and never becomes airborne and released to the environment.

2.1 Post-LOCA Containment Leakage:

The RADTRAD computer run HEPU300CL00.psf for the containment leakage is modified to use the newly developed Nuclide Inventory File HEPULOCA2_DEF along with other design inputs from Reference 10.4 to calculate the EAB, LPZ, and CR doses. The resulting doses are listed in Section 8.0 and added to the dose contributions from the other post-LOCA release paths, and the total doses are compared with the applicable dose limits.

2.2 Post-LOCA MSIV Leakage:

The RADTRAD computer run H1N300MS00.psf for the MSIV leakage is modified to use the newly developed Nuclide Inventory File HEPULOCA2_DEF along with other design inputs from Reference 10.4 to calculate the

Non-Proprietary Information

EAB, LPZ, and CR doses. The resulting doses are listed in Section 8.0, and added to the dose contributions from the other post-LOCA release paths, and the total doses are compared with the applicable dose limits.

2.3 Post-LOCA CREF Filter Shine

The CREF charcoal and HEPA filter configuration with respect to the CR normally occupied area during a LOCA and modeling of the charcoal bed are described in Reference 10.4, Section 2.5.5.

The aerosol mass collected on the CR HEPA remains essentially the same as that previous collected due to the containment and MSIV leakage. Therefore, the CR filter shine calculated in Reference 10.4, Section 8.1, remains bounding. It is to be noted that the charcoal and HEPA filter iodine loading is not affected by the increased Co-60 activity.

3.0 ACCEPTANCE CRITERIA

The following NRC regulatory requirement and guidance documents are applicable to this HCGS Alternative Source Term LOCA Calculation:

- Regulatory Guide 1.183 (Ref. 10.2)
- 10CFR50.67 (Ref. 10.5)
- Standard Review Plan 15.0.1 (Ref. 10.7)

Dose Acceptance Criteria are:

Regulatory Dose Limits

Dose Type	Control Room (rem)	EAB and LPZ (rem)
TEDE Dose	5	25

Non-Proprietary Information

4.0 ASSUMPTIONS

The assumptions used in evaluating the offsite and control room doses resulting from a Loss of Coolant Accident (LOCA) are the same as those in Reference 10.4, Section 4.0.

5.0 DESIGN INPUTS

5.1 General Considerations

5.1.1 Applicability of Prior Licensing Basis

Same as that in Reference 10.4, Section 5.1.1

5.1.2 Credit for Engineered Safety Features

Same as that in Reference 10.4, Section 5.1.2

5.1.3 Assignment of Numeric Input Values

Same as that in Reference 10.4, Section 5.1.3.

5.1.4 Meteorology Considerations

Atmospheric dispersion factors (χ/Q_s) for the onsite release points such as the FRVS vent for containment and ESF leakage release path and turbine building louvers for MSIV leakage release path are the same as those in Reference 10.4, Sections 5.1.4, 5.6.9 , 5.6.11, 5.7.1, and 5.7.3.

5.2 Accident-Specific Design Inputs/Assumptions

The design inputs/assumptions utilized in the EAB, LPZ, and CR habitability analyses are the same as those in Reference 10.4, Sections 5.3 through 5.7, except noted as follows:

Non-Proprietary Information

Design Input Parameter	Value Assigned	Reference			
5.3 CONTAINMENT AND MSIV LEAKAGE MODEL PARAMETERS					
5.3.1 Source Term					
5.3.1.1 Thermal Power Level	3,917 MWt	10.4, Section 7.9			
5.3.1.2 Isotopic Average Core Inventory (Ci/MWt) (10.4, Section 5.3.1.3)					
Isotope	Ci/MW_t	Isotope	Ci/MW_t	Isotope	Ci/MW_t
CO-58*	1.529E+02	RU103	7.700E+04	CS136	1.860E+03
CO-60**	[[]]	RU105	2.700E+04	CS137	6.760E+03
KR 85	3.330E+02	RU106	2.940E+04	BA139	4.950E+04
KR 85M	7.350E+03	RH105	2.530E+04	BA140	4.780E+04
RB 86	1.420E+04	SB127	2.800E+03	LA140	5.080E+04
KR 87	2.000E+04	SB129	8.490E+03	LA141	4.510E+04
KR 88	6.350E+01	TE127	2.780E+03	LA142	4.370E+04
SR 89	2.690E+04	TE127M	3.710E+02	CE141	4.540E+04
SR 90	2.640E+03	TE129	8.350E+03	CE143	4.220E+04
SR 91	5.300E+04	TE129M	1.240E+03	CE144	7.424E+04
SR 92	3.610E+04	TE131M	2.764E+04	PR143	4.080E+04
Y 90	2.810E+03	TE132	3.810E+04	ND147	1.810E+04
Y 91	3.440E+04	I131	2.670E+04	NP239	5.220E+05
Y 92	3.620E+04	I132	3.870E+04	PU238	9.040E+01
Y 93	4.160E+04	I133	5.510E+04	PU239	1.090E+01
ZR 95	4.850E+04	I134	6.060E+04	PU240	1.410E+01
ZR 97	1.468E+05	I135	6.220E+04	PU241	4.090E+03
NB 95	4.870E+04	XE133	5.300E+04	AM241	4.600E+00
MO 99	5.100E+04	XE135	1.820E+04	CM242	1.090E+03
TC 99M	4.460E+04	CS134	5.350E+03	CM244	5.240E+01
* CO-58 activity is obtained from RADTRAD User's Manual, Table 1.4.3.2-3 (Ref. 10.3)					
** CO-60 activity is obtained from Section 7.9					
Note: Additional daughter isotopes added to parent isotopes are shown in Reference 10.4, Table 1C					
5.3.1.3 Radionuclide Composition					
Group		Elements			
Noble Gases		Xe, Kr		10.2, RGP 3.4, Table 5	
Halogens		I, Br			
Alkali Metals		Cs, Rb			
Tellurium Group		Te, Sb, Se, Ba, Sr			
Noble Metals		Ru, Rh, Pd, Mo, Tc, Co			
Lanthanides		La, Zr, Nd, Eu, Nb, Pm, Pr, Sm, Y, Cm, Am			
Cerium		Ce, Pu, Np			
5.3.1.4 Timing of Release Phase (Ref. 10.2, Table 4)					
Phase	Onset	Duration			
Gap Release	2 min	0.5 hr	Gap release starts at 0.0 sec		
Early In-Vessel Release	0.5 hr	1.5 hr			
5.3.1.5 Iodine Chemical Form					
Iodine Chemical Form	%				
Aerosol (CsI)	95.0%		10.2, Section 3.5		

Non-Proprietary Information

Design Input Parameter	Value Assigned	Reference
Elemental	4.85%	
Organic	0.15%	
5.3.1.6 Release Fraction (Ref 10.2, Table 1)		
BWR Core Inventory Fraction Released Into Containment		
Group	Gap Release Phase	Early In-Vessel Release Phase
Noble Gases	0.05	0.95
Halogens	0.05	0.25
Alkali Metals	0.05	0.20
Tellurium Metals	0.00	0.05
Ba, Sr	0.00	0.02
Noble Metals	0.00	0.0025
Cerium Group	0.00	0.0005
Lanthanides	0.00	0.0002
5.3.1.7 Co-60 Isotope Test Assembly Parameters	12 [[]]	10.1, RAI# 17, Section 4.3.4
Number of ITAs		
Number of Rod/ITA		
Co-60 Activity/Rod		
Total Activity		
Uncertainty Multiplying Factor		

Non-Proprietary Information**6.0 COMPUTER CODES AND COMPLIANCE WITH REGULATORY REQUIREMENTS****6.1 Computer Codes**

All computer codes used in this calculation have been approved for use with appropriate Verification and Validation (V&V) documentation. Computer codes used in this analysis include:

- **RADTRAD 3.02** (Ref. 10.3): This is an NRC-sponsored code approved for use in determining control room and offsite doses from releases due to reactor accidents. This code was used by PSEG NUCLEAR in various AST license amendments, which are approved by the NRC. PSEG NUCLEAR performed in-house V&V of the code (Ref. 10.6). Therefore, the code is considered acceptable to be used for the HCGS AST analysis.

RADTRAD 3.02 is used rather than the current RADTRAD 3.03 to maintain consistency with Calculation H-1-ZZ-MDC-1880, which is the basis for this Technical Evaluation, and the code version accepted by the NRC for the AST license amendment. Per the RADTRAD 3.03 V&V report, the following technical modifications, which have minimal impact on the RADTRAD 3.02 dose results, have been incorporated into RADTRAD 3.03:

- Modifications to correct logic errors that existed in the previous version
 - Multiple release paths from a compartment to the environment caused a significant conservative error in the control room dose, it became proportional to the number of paths
 - Control room filter deposition used incorrect array (< 0.1% effect on calculated dose)
 - Invalid filter loading values for all cases (no effect on calculated dose)
 - Suppression pool decontamination used incorrect volume (NAI-11) (< 0.1% effect on calculated dose)
 - A coefficient for the Gormley & Kennedy turbulent deposition model was in error (no effect on calculated dose)
 - Natural deposition model for APWR had a coefficient error (NAI-12) (no effect on calculated dose)
 - Powers natural deposition model used a derived removal coefficient instead of the current value (< 0.1% effect on calculated dose)
 - Dose conversion filename length could cause the code to terminate (no effect on calculated dose)
 - RADTRAD control of time steps to improve dose accuracy (RADTRAD v3.02) (< 1% effect on calculated dose)
 - Suppression pool decontamination that removed noble gases was corrected to allow their passage through the pool. (RADTRAD v3.02) (potential significant non-conservative effect on calculated dose)
- Modification to the definition of a control room
 - This modification was essentially a change to the definition of a control room. The control room was defined to be a compartment not included in the mass balance. This allows the offsite dose to be independent of the existence of a control room. Previously, the offsite dose would change (<1%) when a control room with a significant through flow was added. (NAI-7)
 - NRC Acceptance Test Case 16 (Table 8-1) originally called the auxiliary building a control room. As the mass balance excludes the control room, the input for this case was modified to allow a correct offsite and control room dose calculation. Doses can still be calculated in the auxiliary room by using an effective inlet γ/Q and an iodine protection factor formulation as was done in the rebaselining (Callan 1998) or by executing the model twice, first with the control room modeled as

Non-Proprietary Information

the control room and second with the auxiliary building modeled as the control room. This is the same procedure one would use to evaluate dose on the Technical Support Center.

6.2 Compliance With Regulatory Requirements

As discussed in Reference 10.4, Section 4.0, Assumptions, the analysis in this calculation complies with line-by-line guidance in Regulatory Guide 1.183, Rev 0 (Ref. 10.2).

Non-Proprietary Information

7.0 CALCULATIONS

7.1 HCGS Plant Specific Nuclide Inventory File (NIF) For RADTRAD3.02 Input

The RADTRAD nuclide inventory NIF HEPULOCA2_DEF.txt is used in this analysis.

7.2 Determination of MSIV Leak Rates

The post-LOCA MSIV leak rates are the same as those calculated in Reference 10.4, Section 7.2 and listed in Table 7.

7.3 Main Steam Line Volumes and Surface Area for Plate-out of Activity

The volumes and plate-out surface areas are same as those calculated in Reference 10.4, Section 7.3 and listed in Tables 2 through 5.

7.4 Plate-out of Activity in Main Steam Lines

The aerosol removal efficiencies are calculated in Reference 10.4, Section 7.4 and listed Table 6.

7.5 ESF Leak Rates

The ESF leak rate is calculated in Reference 10.4, Section 7.5.

7.6 FRVS Vent and Recirc, and CR Charcoal/HEPA Filters Efficiencies

The charcoal and HEPA filter efficiencies are calculated in Reference 10.4, Section 7.7 using the In-place penetration testing information, which are used in this analysis and listed as follows:

Safety Grade Filter	Filter Efficiency Credited (%)		
	Aerosol	Elemental	Organic
FRVS Vent	99	90	90
FRVS Recirc	99	0	0
Control Room	99	99	99

7.7 Drywell Wetted Surface Area

The drywell surface area is calculated to be 33,200 ft² in Reference 10.4, Section 7.10.

7.8 Containment Elemental Iodine Removal Coefficient

The elemental iodine removal by wetted containment surface areas is calculated in Reference 10.4, Section 7.11 using the methodology outlined in NUREG-0800, Standard Review Plan 6.5.2.

Non-Proprietary Information

7.9 Co-60 Activity

Total number of Co-60 isotope test assemblies (ISAs) = 12 (Ref. 10.1, RAI#17, Section 4.3.4)

Number of cobalt isotope rods per ITA = [[]]

Total number of cobalt isotope rods = 12 x [[]] (Ref. 10.1, RAI#17, Section 4.3.4)

Assuming that each cobalt isotope rod contains [[]] of Co-60 (Ref. 10.1, RAI#17, Section 4.3.4)

Total activity = [[]] (Ref. 10.1, RAI#17, Section 4.3.4)

Multiplying factor = [[]] (Ref. 10.1, RAI#17, Section 4.3.4)

Gross activity in 12 ITAs = [[]]

Co-60 activity in core prior to addition of ITAs

= 1.830E+02 Ci/MW_t (Ref. 10.4, Section 5.3.1.3) x 3,917 MW_t = 716,811 Ci = 7.168E+05 Ci

Total Co-60 activity including 12 ITAs

= 7.168E+05 Ci (core activity) + [[]]

RADTRAD NIF Input = [[]]
used in HEPULOCA2_DEF

]] which is

Non-Proprietary Information

8.0 RESULTS SUMMARY

The post-LOCA EAB, LPZ, and CR doses due to combined core inventory including that from the 12 Co-60 ITAs are summarized in the following table:

Post-LOCA Activity Release Path	Post-LOCA TEDE Dose (Rem)		
	Receptor Location		
	Control Room	EAB	LPZ
Containment Leakage	[[
ESF Leakage			
MSIV Leakage			
Containment Purge			
Containment Shine			
External Cloud			
CR Filter Shine			
Total]]
Allowable TEDE Limit	5.0 E+00	2.50E+01	2.50E+01
	RADTRAD Computer Run No.		
Containment Leakage	HCO60CL.o0	HCO60CL.o0	HCO60CL.o0
ESF Leakage	HEPU300ES00.o0	HEPU300ES00.o0	HEPU300ES00.o0
MSIV Leakage	HCO60MS.o0	HCO60MS.o0	HCO60MS.o0

9.0 CONCLUSIONS

This evaluation determines control room, EAB, and LPZ doses due to post LOCA radioactivity releases from containment via three release pathways, i.e., containment leakage, ESF leakage, and MSIV leakage using the combined core inventory including the inventory from 12 Co-60 Isotope Test Assemblies. The resulting dose consequences remained unchanged because [[
]]

The introduction of 12 ITAs (GE14i bundles) at HCGS presents no impact on the AST LOCA source term and resulting doses.

Non-Proprietary Information

10.0 **REFERENCES**

- 10.1 Hope Creek Letter LR-N10-0163, Response to Request for Additional Information – License Amendment Request (H09-01) Supporting the Use of Co-60 Isotope Test Assemblies (Isotope Generation Pilot Project), May 11, 2010.
- 10.2 U.S. NRC Regulatory Guide 1.183, Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors, July 2000.
- 10.3 S.L. Humphreys et al., "RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation," NUREG/CR-6604, USNRC, April 1998.
- 10.4 Calculation No. H-1-ZZ-MDC-1880, Rev. 4, Post-LOCA EAB, LPZ, and CR Doses.
- 10.5 10 CFR 50.67, "Accident Source Term."
- 10.6 Critical Software Package Identification No. A-0-ZZ-MCS-0225, Rev 2, RADTRAD Computer Code
- 10.7 NUREG-0800, Standard Review Plan, "Radiological Consequence Analyses Using Alternative Source Terms," SRP 15.0.1, Rev. 0, July 2000

Attachment 5

LR-N10-0306

**10 CFR 50.59 for Calculation H-1-ZZ-MDC-1880, Revision 4, "Post-LOCA EAB,
LPZ, and CR Doses" (HC-10-125)**