

Computed by Paul T. Reichert <i>PTR</i>	Date 08/28/00	CAROLINA POWER & LIGHT COMPANY HARRIS NUCLEAR PLANT CALCULATION SHEET	Calculation ID <u>HNP-F/NFSA-0072</u>	
Checked by: <i>VAG</i>	Date: 08/28/00		Pg. 13 of 35	Rev 0
Project No.: 7870-1.404			File:	
Project Title: SGRP / POWER UPRATE PROJECT		Calculation Title <u>Determine Offsite, CR, TSC & EOF Doses for Selected FSAR Chapter 15 Accidents</u>		

7. BODY OF CALCULATION

7.1. Main Steam Line Break (MSLB) Outside Containment [FSAR Section 15.1.5]

Description: For dose calculations the following three cases are analyzed:

1. Pre-existing iodine spike case (An SRP 15.1.5, Appendix A, Paragraph III.4.(a) Event) A reactor transient has occurred prior to the postulated MSLB and has raised the primary coolant iodine concentration to the Technical Specification limit of 60 $\mu\text{Ci/gm}$ I-131 eq. limit identified in Ref. 11. The secondary coolant activity is assumed to be at the Technical Specification limit of 0.1 $\mu\text{Ci/gm}$ I-131 eq. identified in Ref. 12. No fuel failure is assumed.
2. Accident Generated iodine spike case (An SRP 15.1.5, Appendix A, Paragraph III.4.(b) Event) The reactor trip and/or primary system depressurization associated with the MSLB creates an iodine spike in the primary system. The spiking model is based on an increase in the iodine release rate from the fuel rods to the primary coolant to a value that is 500 times greater than the values that yields an equilibrium reactor coolant iodine concentration of 1 $\mu\text{Ci/gm}$. The resulting releases to coolant used in this assessment are based on appearance rates provided in Ref. 7
3. Postulated Fuel Failure Case (An SRP 15.1.5, Appendix A, Paragraph III.5 Event) A MSLB outside containment with a bounding fuel failure assumption of 1% fuel cladding failure, and 0.7% centerline melt. This activity is released instantly to reactor coolant.

Other parameters applicable to both cases include:

- Steam Releases and Feedwater Flows are from Ref. 14, used as shown in Attachment U.
- A primary to secondary leak rate of 1 gpm (Ref. 10), with 0.30 gpm to the affected steam generator, and 0.70 gpm to the unaffected steam generators. The definition of the affected steam generator for this purpose is that one that is nearest the break, and more importantly, that the event single failure is a failure to close the associated MSIV. This results in primary to secondary leakage in the affected steam generator to be through the break, rather than through the atmospheric dump valves. No partition factor credit is taken for the affected steam generator. A factor of 100 is taken for the unaffected steam generators. This is consistent with Ref. 45 guidance. Note that HNP T.S. 3.4.2 limit leakage through any 1 steam generator to 150 gpd which is 0.104 gpm. Therefore, the above values are a significant conservatism.
- Releases during the 8-hour cooldown period are also modeled in the same manner as in Ref. 13. At 8 hours, the reactor cooling is assumed to be by the RHR system, and cooling using the steam generators and the atmospheric dump valve is assumed to have ceased. Thus, releases from the

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not-affected steam generators have ceased. Some release from the affected steam generator could continue if the isolation valve is not closed. However, given the above conservatism in primary to secondary leakage rate treatment it is considered acceptable to cease the radiological evaluation at 8 hours for this pathway as well. The assumed leakage is almost three times the expected value for the first 8 hours. Improved X/Qs would also apply during the 8-24 hour period. Therefore, the existing 8 hour analysis is bounding.

Radiological Criteria: EAB and LPZ doses less than 10% of 10CFR100 limits of 25 rem whole body (EDE) and 300 rem thyroid, for cases 1 and 2, and 100% of the limits for case 3.

Attachment A contains the spreadsheet which is used to determine EAB, LPZ, CR, TSC, and EOF doses.

The resulting doses are:

CASE 1: Pre-Existing Iodine Spike, no Fuel Damage
SRP 15.1.5, Appendix A, Section III.4.(a) based Event

EAB	LPZ	CR	TSC	EOF	
3.67E+00	2.17E+00	7.72E-01	2.92E-01	1.16E-01	Total Thyroid Dose (rem)
1.01E-03	9.14E-04	1.03E-03	4.73E-04	2.03E-05	Total Whole Body Dose (rem)
1.28E-03	1.17E-03	3.40E-02	1.51E-02	9.16E-04	Total β-Skin Dose (rem)

CASE 2: Accident Generated Iodine Spike, no Fuel Damage
SRP 15.1.5, Appendix A, Section III.4.(b) based Event

EAB	LPZ	CR	TSC	EOF	
5.38E+00	1.31E+01	4.66E+00	1.76E+00	7.01E-01	Total Thyroid Dose (rem)
1.01E-03	9.14E-04	1.03E-03	4.73E-04	2.03E-05	Total Whole Body Dose (rem)
1.28E-03	1.17E-03	3.40E-02	1.51E-02	9.16E-04	Total β-Skin Dose (rem)

CASE 3: Bounding Fuel Damage
SRP 15.1.5, Appendix A, Section III.5. based Event

EAB	LPZ	CR	TSC	EOF	
8.45E+01	7.57E+01	2.70E+01	1.02E+01	4.06E+00	Total Thyroid Doses (rem)
7.03E-01	6.38E-01	7.20E-01	3.30E-01	1.42E-02	Total Whole Body Doses (rem)
7.63E-01	6.92E-01	2.02E+01	8.95E+00	5.44E-01	Total β-Skin Dose (rem)

These doses are within the identified acceptance criteria.

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	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	Main Steam Line Break Outside Containment Dose Assessment (FSAR 15.1.5)													
2														
3	CASE 1: Pre-Event Iodine Spiking Case													
4	SRP 15.1.5, Appendix A, Paragraph III.4.(a) Event													
5														
6	Dose from Initial Blowdown of Secondary Coolant													
7														
8	0.1 Secondary Coolant Activity (uCi/gm) I-131 Equivalent T. S. Limit													
9	7.35E+07	Secondary Coolant Blowdown (gms)			Based on 162,000 lbs from Ref. 14									
10	7.35E+00	Release (Ci) of I-131 equivalent												
11	1.08E+06	Inhalation Dose Conversion Factor (Rem/Ci) for I-131												
12														
13	EAB	LPZ	CR	TSC	EOF	(Ci/min) appearance rates at 500x normal, corresponding to a normal 132 gpm cleanup and 1.0 uCi/gm								
14	6.17E-04	1.40E-04	4.08E-03	1.81E-03	1.10E-04	X/Q (sec/cu.m.)								
15	3.47E-04	3.47E-04	3.47E-04	3.47E-04	3.47E-04	Breathing Rate (cu.m./sec)								
16	1	1	61.8	96.0	14.7	Iodine Protection Factor								
17	1.70E+00	3.86E-01	1.37E-01	5.19E-02	2.07E-02	Thyroid Dose from Secondary Coolant Blowdown (rem)								
18	Noble Gas Release considered negligible and no Whole Body or Skin Dose Calculated													
19														
20	Dose from Reactor Coolant Leakage and Secondary Releases During Cooldown Period													
21	(pre-existing iodine spike case)													
22														
23	Parameters for Release Assessment													
24	60	Reactor Coolant Activity (uCi/gm) I-131 Equivalent T. S. Limit												
25	0.1	Secondary Coolant Activity (uCi/gm) I-131 Equivalent T. S. Limit												
26	1	Primary to Secondary Leak Rate (gpm)												
27	0.3	gpm through affected SG				0.7 gpm through intact SGs								
28	0-2 hr	0-2 hr	2-8 hr	2-8 hr	UPRATE STEAM AND FEEDWATER FLOW ADJUSTMENTS									
29	Steaming	Feedwater	Steaming	Feedwater										
30	386,000	482,000	892,000	967,000	From Ref. 14									
31														
32	100 Iodine Partition Factor for Leakage through intact steam generators													
33	1 Iodine Partition Factor for Leakage through affected steam generators													
34	8.50E+00	I-131 Eq. Release over 0-2 hour period (Ci)												
35	2.54E+01	I-131 Eq. Release over 2-8 hour period (Ci)												
36	2.83E+02	Xe-133 WB Eq. Release over 0-2 hour period (Ci)												
37	8.49E+02	Xe-133 WB Eq. Release over 2-8 hour period (Ci)												
38	2.15E+02	Xe-133 β -Skin Eq. Release over 0-2 hour period (Ci)												
39	6.44E+02	Xe-133 β -Skin Eq. Release over 2-8 hour period (Ci)												
40														
41	1.08E+06	Inhalation Dose Conversion Factor (Rem/Ci) for I-131												
42	5.77E-03	Air Submersion WB Dose Conversion Factor (Rem-M ³ / Ci-Sec) for Xe-133												
43	9.70E-03	Air Submersion β -Skin Dose Conversion Factor (Rem-M ³ / Ci-Sec) for Xe-133												
44														
45														
46														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
47	CASE 1 DOSE ASSESSMENT RESULTS													
48	EAB	LPZ	CR	TSC	EOF									
49	6.17E-04	1.40E-04	4.08E-03	1.81E-03	1.10E-04	X/Q (sec/cu.m.)								
50	3.47E-04	3.47E-04	3.47E-04	3.47E-04	3.47E-04	Breathing Rate (cu.m./sec)								
51	1	1	81.8	96.0	14.7	Iodine Protection Factor								
52	1.97E+00	1.78E+00	6.35E-01	2.40E-01	9.55E-02	Cooldown Period Thyroid Dose for Case 1								
53	1	1	25.8	25.0	35.3	Geometry Factors								
54	1.01E-03	9.14E-04	1.03E-03	4.73E-04	2.03E-05	Cooldown Period WB Dose (rem) for Case 1								
55	1.28E-03	1.17E-03	3.40E-02	1.51E-02	9.16E-04	Cooldown Period β -Skin Dose (rem) for Case 1								
55														
57	3.67E+00	2.17E+00	7.72E-01	2.92E-01	1.16E-01	Total Thyroid Dose (rem) Initial Blowdown + Cooldown								
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95	CASE 2: Accident Generated Iodine Spiking Case													
96	ISRP 15.1.5, Appendix A, Paragraph III.4.(b) Event													
97														
98	Dose from Initial Blowdown of Secondary Coolant													
99														
100	0.1	Secondary Coolant Activity (uCi/gm) I-131 Equivalent T. S. Limit												
101	7.35E+07	Secondary Coolant Blowdown (gms)				Based on 162,000 lbs from Ref. 14								
102	7.35E+00	Release (Ci) of I-131 equivalent												
103	1.08E+06	Inhalation Dose Conversion Factor (Rem/Ci) for I-131												
104														
105	EAB	LPZ	CR	TSC	EOF	X/Q (sec/cu.m)								
106	6.17E-04	1.40E-04	4.08E-03	1.91E-03	1.10E-04	Breathing Rate (cu.m./sec)								
107	3.47E-04	3.47E-04	3.47E-04	3.47E-04	3.47E-04	Iodine Protection Factor								
108	1	1	81.8	96.0	14.7	Thyroid Dose from Secondary Coolant Blowdown (rem)								
109	1.70E+00	3.86E-01	1.37E-01	5.19E-02	2.07E-02	Noble Gas Release considered negligible and no Whole Body or Skin Dose Calculated								
110														
111														
112	Dose from Reactor Coolant Leakage and Secondary Releases During Cooldown Period													
113	(Accident-generated iodine spike case)													
114														
115	Parameters for Release Assessment													
116	113.4	Reactor Coolant Activity (uCi/gm) I-131 Equivalent During the 0-2 hour post-MSLB period												
117	540.3	Reactor Coolant Activity (uCi/gm) I-131 Equivalent During the 2-8 hour post-MSLB period												
118	0.1	Secondary Coolant Activity (uCi/gm) I-131 Equivalent T. S. Limit												
119	1	Primary to Secondary Leak Rate (gpm)												
120	0.3	gpm through affected SG				0.7 gpm through intact SGs								
121	0-2 hr	0-2 hr	2-8 hr	2-8 hr	UPRATE STEAM AND FEEDWATER FLOW ADJUSTMENTS									
122	Steaming	Feedwater	Steaming	Feedwater	From Ref. 14									
123	386,000	482,000	892,000	967,000										
124														
125	100	Iodine Partition Factor for Leakage through intact steam generators												
126	1	Iodine Partition Factor for Leakage through affected steam generators												
127	1.59E+01	I-131 Eq. Release over 0-2 hour period (Ci)												
128	2.26E+02	I-131 Eq. Release over 2-8 hour period (Ci)												
129	2.83E+02	Xe-133 WB Eq. Release over 0-2 hour period (Ci)												
130	6.49E+02	Xe-133 WB Eq. Release over 2-8 hour period (Ci)												
131	2.15E+02	Xe-133 β-Skin Eq. Release over 0-2 hour period (Ci)												
132	6.44E+02	Xe-133 β-Skin Eq. Release over 2-8 hour period (Ci)												
133														
134	1.08E+06	Inhalation Dose Conversion Factor (Rem/Ci) for I-131												
135	5.77E-03	Air Submersion WB Dose Conversion Factor (Rem-M ³ / Ci-Sec) for Xe-133												
136	9.70E-03	Air Submersion β-Skin Dose Conversion Factor (Rem-M ³ / Ci-Sec) for Xe-133												
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138														
139														
140														

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
141	CASE 2 DOSE ASSESSMENT RESULTS													
142	EAB	LPZ	CR	TSC	EOF									
143	6.17E-04	1.40E-04	4.08E-03	1.81E-03	1.10E-04	X/Q (sec/cu.m.)								
144	3.47E-04	3.47E-04	3.47E-04	3.47E-04	3.47E-04	Breathing Rate (cu.m /sec)								
145	1	1	81.8	95.0	14.7	Iodine Protection Factor								
146	3.68E+00	1.27E+01	4.52E+00	1.71E+00	6.81E-01	Cooldown Period Thyroid Dose for Case 2								
147	1	1	25.8	25.0	35.3	Geometry Factors								
148	1.01E-03	9.14E-04	1.03E-03	4.73E-04	2.03E-05	Cooldown Period WB Dose (rem) for Case 2								
149	1.28E-03	1.17E-03	3.40E-02	1.51E-02	9.16E-04	Cooldown Period β -Skin Dose (rem) for Case 2								
150														
151	5.38E+00	1.31E+01	4.66E+00	1.76E+00	7.01E-01	Total Thyroid Dose (rem) Initial Blowdown + Cooldown								
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168	CASE 3: Bounding fuel damage case (highest worth rod stuck out of core)														
169	SRP 15.1.5, Appendix A, Paragraph III.5 Event														
193															
191	9406	Reactor coolant liquid volume (cu.ft. at 593F, 2250 psia)													
192	0.0229	Specific Volume at 593F, 2250 psia (cu.ft./lbm)													
193	4.11E+05	Reactor Coolant mass (lbm)													
194	1.86E+08	Reactor Coolant mass (gms)													
195	1.13E+08	I-131 equivalent in Core (Ci)													
196	1.29E+07	I-131 equivalent in Gap (Ci)													
197	1.00E+08	I-131 equivalent in Fuel, and not Gap (Ci)													
198	1.11E+10	Xe-133 WB equivalent in Core (Ci)													
199	1.11E+09	Xe-133 WB equivalent in Gap (Ci)													
200	9.98E+09	Xe-133 WB equivalent in Fuel, and not Gap (Ci)													
201	7.16E+09	Xe-133 β -Skin equivalent in Core (Ci)													
202	7.17E+08	Xe-133 β -Skin equivalent in Gap (Ci)													
203	6.44E+09	Xe-133 β -Skin equivalent in Fuel, and not Gap (Ci)													
204	0.01	Assumed Cladding Failure													
205	0.007	Assumed Centerline Melt (of which, 50% of iodines and 100% of noble gasses are released to coolant)													
206	4.80E+05	I-131 equivalent activity release to coolant (Ci)													
207	2.58E+03	Initial I-131 equivalent coolant concentration (uCi/gm)													
208	8.10E+07	Xe-133 WB equivalent activity release to coolant (Ci)													
209	4.35E+05	Initial WB equivalent Xe-133 coolant concentration (uCi/gm)													
210	5.23E+07	Xe-133 β -Skin equivalent activity release to coolant (Ci)													
211	2.81E+05	Initial β -Skin equivalent Xe-133 coolant concentration (uCi/gm)													
212															
213	Dose from Initial Blowdown of Secondary Coolant														
214															
215	0.1	Secondary Coolant Activity (uCi/gm) I-131 Equivalent T. S. Limit													
216	7.35E+07	Secondary Coolant Blowdown (gms)					Based on 162,000 lbs from Ref. 14								
217	7.35E+00	Release (Ci) of I-131 equivalent													
218	1.08E+06	Inhalation Dose Conversion Factor (Rem/Ci) for I-131													
219															
220	EAB	LPZ	CR	TSC	EOF										
221	6.17E-04	1.40E-04	4.08E-03	1.81E-03	1.10E-04	X/Q (sec/cu.m.)									
222	3.47E-04	3.47E-04	3.47E-04	3.47E-04	3.47E-04	Breathing Rate (cu.m./sec)									
223	1	1	81.8	96.0	14.7	Iodine Protection Factor									
224	1.70E+00	3.86E-01	1.37E-01	5.19E-02	2.07E-02	Thyroid Dose from Secondary Coolant Blowdown (rem)									
225	Noble Gas Release considered negligible and no Whole Body or Skin Dose Calculated														
226															
227															
228	Parameters for Release Assessment														
229	2.58E+03	Reactor Coolant Activity (uCi/gm) I-131 Equivalent, with bounding fuel failure													
230	0.1	Secondary Coolant Activity (uCi/gm) I-131 Equivalent T. S. Limit													
231	1	Primary to Secondary Leak Rate (gpm)													
232	0.3	gpm through affected SG				0.7 gpm through intact SGs									
233	0-2 hr	0-2 hr	2-8 hr	2-8 hr	UPRATE STEAM AND FEEDWATER FLOW ADJUSTMENTS										
234	Steaming	Feedwater	Steaming	Feedwater											

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
235	385,000	482,000	892,000	957,000	From Ref. 14									
236														
237	100 Iodine Partition Factor for Leakage through intact steam generators													
238	1 Iodine Partition Factor for Leakage through affected steam generators													
239	3.58E+02	I-131 Eq. Release over 0-2 hour period (Ci)												
240	1.08E+03	I-131 Eq. Release over 2-8 hour period (Ci)												
241	1.97E+05	Xe-133 WB Eq. Release over 0-2 hour period (Ci)												
242	5.92E+05	Xe-133 WB Eq. Release over 2-8 hour period (Ci)												
243	1.27E+05	Xe-133 β -Skin Eq. Release over 0-2 hour period (Ci)												
244	3.82E+05	Xe-133 β -Skin Eq. Release over 2-8 hour period (Ci)												
245														
246	1.08E+06	Inhalation Dose Conversion Factor (Rem/Ci) for I-131												
247	5.77E-03	Air Submersion WB Dose Conversion Factor (Rem-M ³ / Ci-Sec) for Xe-133												
248	9.70E-03	Air Submersion β -Skin Dose Conversion Factor (Rem-M ³ / Ci-Sec) for Xe-133												
249														
250														
251														
252	CASE 3 DOSE ASSESSMENT RESULTS													
253	EAB	LPZ	CR	TSC	EOF									
254	6.17E-04	1.40E-04	4.08E-03	1.81E-03	1.10E-04	X/Q (sec/cu.m.)								
255	3.47E-04	3.47E-04	3.47E-04	3.47E-04	3.47E-04	Breathing Rate (cu.m./sec)								
256	1	1	81.8	96.0	14.7	Iodine Protection Factor								
257	8.28E+01	7.53E+01	2.68E+01	1.01E+01	4.04E+00	Cooldown Period Thyroid Dose for Case 3								
258	1	1	25.8	25.0	35.3	Geometry Factors								
259	7.03E-01	6.38E-01	7.20E-01	3.30E-01	1.42E-02	Cooldown Period WB Dose (rem) for Case 3								
260	7.63E-01	6.92E-01	2.02E+01	8.95E+00	5.44E-01	Cooldown Period β -Skin Dose (rem) for Case 3								
261														
262	8.45E+01	7.57E+01	2.70E+01	1.02E+01	4.06E+00	Total Thyroid Dose (rem) Initial Blowdown + Cooldown								