



Enclosure 4

Calculation Sheet

Subject ESTIMATED RM-G-22/23 READINGS WITH LOCA AT TS RCS LIMIT		Calc. No. 6612-96-023	Rev. No. 0
Originator PARFITT	Date September 6, 1996	Reviewed by <i>D. David Schurer</i>	Date 9/11/96

1. Problem Statement

The reading on RM-G-22 and 23 during a LOCA at the Tech Spec RCS limit is estimated.

2. Results Summary

Based on the assumptions made in this calculation, it is estimated that RM-G-22 and 23 will read approximately 22 R/hr during a LOCA at the Tech Spec RCS limit.

3. References

- 3.1 TMI ODCM
- 3.2 EPA 400
- 3.3 TDR 989 Rev 1, TMI-1 Cycle 8 Reload (The basis for FSAR Table 14.2-4)

4. Assumptions

- 4.1 The Tech Spec isotopic activity of the RCS was based on TS 3.1.4.3 which prevents operation when RCS dose equivalent iodine (DEI) is above 1 uCi/cc. The isotopic activities for RCS with 1% failed fuel in Reference 3.3 result in a DEI of 7.68 uCi/cc. To develop and RCS activity with a DEI of 1 uCi/cc, the isotopic activities in Reference 3.3 were divided by 7.68. The resulting mix has a DEI of 1 uCi/cc and is assumed to be the TS RCS activity.
- 4.2 The dose rate at the monitor was determined using dose factors for immersion exposure in a uniform semi-infinite cloud. For noble gases, the gamma air dose factors in Reference 3.1 were used. Gamma air dose factors were not available for the iodines, so the TEDE dose factors from Reference 3.2 were used. This is conservative, since the gamma air dose factor would be expected to be higher than the TEDE dose factor.
- 4.3 It is assumed that the volume of the Reactor Building is $2.0E+6 \text{ ft}^3$ and the volume of the RCS is 66,595 gallons.
- 4.4 It is assumed that the activity in the RCS is instantaneously released and dispersed into the Reactor Building when the LOCA occurs.

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5. Data and Calculations

- 5.1 As discussed in Assumption 4.1, the factor used to convert 1% failed fuel to Tech Spec RCS activity is calculated as follows:

ISOTOPE	FSAR 1% FF RCS ACTIVITY (uCi/g)	DCF	FSAR 1% FF RCS DEI (uCi/g)
I-131	5.71E+00	1.48E+06	5.71E+00
I-132	1.92E+00	5.35E+04	6.94E-02
I-133	6.07E+00	4.00E+05	1.64E+00
I-134	7.57E-01	3.73E+03	1.91E-03
I-135	3.08E+00	1.24E+05	2.58E-01
TOTAL DEI			7.68E+00
DEI = (I-137 ACTIVITY) (I-137 DCF) I-131 DCF			

- 5.2 The dose rate from each isotope at the monitor location is the product of the concentration (uCi/cc) and its dose conversion factor (mrad/hr/uCi/cc). The dose from each isotope is then summed to determine the total dose rate at the location. The calculation is summarized below:

ESTIMATED RM-G-22 AND 23 DOSE RATE DURING LOCA AT TS RCS LIMIT							
RB VOLUME		2.00E+06 ft ³					
RCS VOLUME		66595 gal					
FSAR 1% FF RCS (uCi/cc)	TS RCS 1 uCi/cc DEI (uCi/cc)	ISOTOPE	RB ACTIVITY (uCi)	RB CONC (uCi/cc)	DCF mrad/hr uCi/cc	RMG-22/23 DOSE RATE (Rad/hr)	
0.53	6.90E-02	KR-83M	1.74E+07	3.07E-04	2.20E+03	6.77E-04	
2.43	3.18E-01	KR-85M	7.98E+07	1.41E-03	1.40E+05	1.98E-01	
9.75	1.27E+00	KR-85	3.20E+08	5.65E-03	1.96E+03	1.11E-02	
1.28	1.67E-01	KR-87	4.20E+07	7.42E-04	7.04E+05	5.22E-01	
3.95	5.14E-01	KR-88	1.30E+08	2.29E-03	1.73E+06	3.97E+00	
2.68	3.49E-01	XE-131M	8.60E+07	1.55E-03	1.78E+04	2.77E-02	
4.22	5.49E-01	XE-133M	1.39E+08	2.45E-03	3.73E+04	9.13E-02	
392.00	5.10E+01	XE-133	1.29E+10	2.27E-01	4.03E+04	9.15E+00	
0.49	6.32E-02	XE-135M	1.59E+07	2.81E-04	3.83E+05	1.08E-01	
8.37	1.09E+00	XE-135	2.75E+08	4.85E-03	2.19E+05	1.06E+00	
0.69	9.01E-02	XE-138	2.27E+07	4.01E-04	1.05E+06	4.22E-01	
5.71	7.43E-01	I-131	1.87E+08	3.31E-03	2.20E+05	7.28E-01	
1.92	2.50E-01	I-132	6.30E+07	1.11E-03	1.40E+06	1.56E+00	
6.07	7.90E-01	I-133	1.99E+08	3.52E-03	3.50E+05	1.23E+00	
0.76	9.86E-02	I-134	2.48E+07	4.39E-04	1.60E+06	7.02E-01	
3.08	4.01E-01	I-135	1.01E+08	1.79E-03	9.50E+05	1.70E+00	
443.92	5.78E+01	TOTAL				21.5	

TABLE 4.3

Dose Factors for Noble Gases and Daughters*

Radio-nuclide	Gamma Total Body Dose Factor(a) K_1 (mrem/yr per $\mu\text{Ci}/\text{m}^3$)	Beta Skin Dose Factor(b) L_1 (mrem/yr per $\mu\text{Ci}/\text{m}^3$)	Gamma Air Dose Factor M_1 (mrad/yr per $\mu\text{Ci}/\text{m}^3$)	Beta Air Dose Factor N_1 (mrad/yr per $\mu\text{Ci}/\text{m}^3$)
Kr-83m	7.56E-02**	—	1.93E+01	2.88E+02
Kr-85m	1.17E+03	1.46E+03	1.23E+03	1.97E+03
Kr-85	1.61E+01	1.34E+03	1.72E+01	1.95E+03
Kr-87	5.92E+03	9.73E+03	6.17E+03	1.03E+04
Kr-88	1.47E+04	2.37E+03	1.52E+04	2.93E+03
Kr-89	1.66E+04	1.01E+04	1.73E+04	1.06E+04
Kr-90	1.56E+04	7.29E+03	1.63E+04	7.83E+03
Xe-131m	9.15E+01	4.76E+02	1.56E+02	1.11E+03
Xe-133m	2.51E+02	9.94E+02	3.27E+02	1.48E+03
Xe-133	2.94E+02	3.06E+02	3.53E+02	1.05E+03
Xe-135m	3.12E+03	7.11E+02	3.36E+03	7.39E+02
Xe-135	1.81E+03	1.86E+03	1.92E+03	2.46E+03
Xe-137	1.42E+03	1.22E+04	1.51E+03	1.27E+04
Xe-138	8.83E+03	4.13E+03	9.21E+03	4.75E+03
Ar-41	8.84E+03	2.69E+03	9.30E+03	3.28E+03

*Dose factors are for immersion exposure in uniform semi-infinite cloud of noble gas radionuclides that may be detected in gaseous effluents. Dose factor values are taken from Regulatory Guide 1.109 (Rev. 1), Table B-1.

**7.56E-02 = 7.56×10^{-2} .

(a) Total body dose factor for gamma penetration depth of 5 cm into the body..

(b) Skin dose factor at a tissue depth or tissue density thickness of 7 mg/cm².

Table 5-3 Dose Conversion Factors (DCF) and Derived Response Levels (DRL) for External Exposure Due to Immersion in Contaminated Air

Radionuclide	DCF ^a rem per $\mu\text{Ci} \cdot \text{cm}^{-3} \cdot \text{h}$	DRL ^b $\mu\text{Ci} \cdot \text{cm}^{-3} \cdot \text{h}$
H-3	0.0E+00	0.0E+00
C-14	0.0E+00	0.0E+00
Na-22	1.3E+03	7.8E-04
Na-24	2.7E+03	3.7E-04
P-32	0.0E+00	0.0E+00
P-33	0.0E+00	0.0E+00
S-35	0.0E+00	0.0E+00
Cl-36	4.8E-06	2.1E+05
K-40	9.2E+01	1.1E-02
K-42	1.7E+02	6.0E-03
Ca-45	9.3E-09	1.1E+08
Sc-46	1.2E+03	8.4E-04
Ti-44	7.7E+01	1.3E-02
V-48	1.7E+03	5.8E-04
Cr-51	1.8E+01	5.6E-02
Mn-54	5.0E+02	2.0E-03
Mn-56	1.1E+03	9.4E-04
Fe-55	1.3E-02	7.6E+01
Fe-59	7.0E+02	1.4E-03
Co-58	5.8E+02	1.7E-03
Co-60	1.5E+03	6.7E-04
Ni-63	0.0E+00	0.0E+00
Cu-64	1.1E+02	9.2E-03
Zn-65	3.4E+02	2.9E-03
Ge-68	5.2E-02	1.9E+01
Se-75	2.3E+02	4.4E-03
Kr-85	1.3E+00	7.8E-01
Kr-85m	9.3E+01	1.1E-02
Kr-87	5.1E+02	2.0E-03
Kr-88	1.3E+03	7.8E-04

Table 5-3, Continued

Radionuclide	DCF ^a rem per $\mu\text{Ci} \cdot \text{cm}^{-3} \cdot \text{h}$	DRL ^b $\mu\text{Ci} \cdot \text{cm}^{-3} \cdot \text{h}$
Sb-126	1.6E+03	6.2E-04
Sb-127	3.9E+02	2.6E-03
Sb-129	8.6E+02	1.2E-03
Te-127m	1.8E+00	5.6E-01
Te-129	3.1E+01	3.2E-02
Te-129m	2.0E+01	5.1E-02
Te-131m	8.5E+02	1.2E-03
Te-132	1.2E+02	8.0E-03
Te-134	5.1E+02	2.0E-03
I-125	6.3E+00	1.6E-01
I-129	4.8E+00	2.1E-01
I-131	2.2E+02	4.6E-03
I-132	1.4E+03	7.4E-04
I-133	3.5E+02	2.9E-03
I-134	1.6E+03	6.4E-04
I-135	9.5E+02	1.1E-03
Xe-131m	4.9E+00	2.0E-01
Xe-133	2.0E+01	5.0E-02
Xe-133m	1.7E+01	5.9E-02
Xe-135	1.4E+02	7.0E-03
Xe-135m	2.5E+02	4.1E-03
Xe-137	1.1E+02	9.2E-03
Xe-138	7.1E+02	1.4E-03
Cs-134	9.1E+02	1.1E-03
Cs-136	1.3E+03	7.8E-04
Cs/Ba-137 ^c	3.5E+02	2.9E-03
Cs-138	1.4E+03	6.9E-04
Ba-133	2.1E+02	4.8E-03
Ba-139	2.1E+01	4.9E-02
Ba-140	1.1E+02	9.3E-03