LOFT TECHNICAL REPORT LTR 129-14
MARCH 3, 1978

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RADIATION LEVELS FROM FISSION PRODUCTS
RELEASED TO THE PRESSURE SUPPRESSION TANK

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DEPARTMENT OF ENERGY

IDAHO OPERATIONS OFFICE UNDER CONTRACT EY-76-C-07-1570

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LOFT TECHNICAL REPORT LOFT PROGRAM

FORM EG&G-229
(Rev. 12-76)

TITLE Radiation Levels from Fission Products Released to the Pressure Suppression Tank		REPORT NO. LTR 129-14
AUTHOR N. Maringas		GWA NO.
PERFORMING ORGANIZATION LOFT		DATE March 3, 1978
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SUMMARY

This LTR discusses radiation levels associated with a LOCE where the blowdown is directed to the pressure suppression tank.

This LTR is issued to ensure the contents, originally an appendix to SDD 1.2.9, are retained for reference.

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RADIATION LEVELS FROM FISSION PRODUCTS
RELEASED TO THE PRESSURE SUPPRESSION TANK

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RADIATION LEVELS FROM FISSION PRODUCTS RELEASED TO THE PRESSURE SUPPRESSION TANK

The fission product inventory and release fractions for a LOCE are presented in Appendix C. This appendix discusses the radiation levels associated with a LOCE in which the blowdown is directed to the pressure suppression tank. It is noted that operating sequences discussed in this appendix are not fixed and were assumed to be as described only for the purpose of calculating radiation levels at various times. Supporting calculations for a blowdown to the suppression tank have been performed by the Electric Boat Division of General Dynamics Corporation and are reported in LTR 129-5 and included as Attachment 1 to this appendix.

A. SYSTEM DESCRIPTION AND OPERATING SEQUENCE

The blowdown suppression system as described in Reference D-1 was used in this study. The suppression tank will be a 3000-ft³ tank (11 ft dia. x 32 ft long) and will be located adjacent to the MTA (Figure D-1).

The suppression tank will be shielded by an equivalent of 2 in. of lead. Since the design of this shield is not complete, the shield was assumed to take the form of a 2-in.-thick annulus around the suppression tank, with 2-in.-thick lead plates on either end.

The tank was assumed to be 80% filled with water after a LOCE.

The computer codes RSAC and QAD-P5A (discussed in Appendix C, Section A) were used in the calculations.

To calculate radiation levels from fission products in the suppression tank and the suppression system ion exchanger, the following operating sequence was assumed:

- (1) Reactor operation at 55 MW for 200 hr prior to blowdown.
- (2) Twenty percent of the fuel pins fail at the time of blowdown with 11% of the noble gas and halogen fission products in the core and 0.11% of the solid fission products immediately transported to the suppression tank. Although not all fission products released from the fuel are expected to reach the suppression tank (Appendix C, Section D) no credit is taken for deposition in the loop when calculating radiation levels from fission products in the suppression tank. Deposition on internal surfaces is discussed in Section D of this appendix.
- (3) The suppression system ion exchanger will be in operation shortly after the LOCE to remove halogen and solid fission products. The noble gas fission products are assumed to remain in the pressure suppression tank for the first 72 hr after the LOCE. Removal only by radioactive decay was considered for this time period.

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Fig. D-1 Physical location of proposed blowdown suppression tank.

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- (4) The noble gas fission products are assumed to be removed from the suppression tank after 72 hr. Also by this time, the water in the suppression tank will have been circulated through the suppression system ion exchanger. With a flow rate of 50 gpm (nominal) and a water volume in the tank of 24,000 gal (purification half-life of 5.54 hr), a factor of 1000 reduction in activity in the water could be achieved in about 60 hr if the activity remain in solution. Such a condition is expected but cannot be taken credit for in the shield design because of the lack of explicit experimental data. Thus, the activity is assumed to be reduced by a factor of 10 after 72 hr (see Attachment 2).

B. RADIATION LEVELS FROM FISSION PRODUCTS IN PRESSURE SUPPRESSION TANK, 0-3 DAYS

To calculate the radiation levels immediately after blowdown, the solid and halogen fission products are assumed to be uniformly distributed in the gas space (20% of the tank volume) above the water.

The gamma dose rate from fission products in the suppression tank immediately following the blowdown with 20% pin failure is shown in Figure D-2 as a function of distance from the containment vessel centerline. The dose rate at 40 ft from the containment vessel centerline for the first 72 hr after the blowdown is shown in Figure D-3. The dose receiver points are located along line AB (Figure D-1).

Radiation levels at the time of blowdown are given in Table D-1 for 20% pin failure. In addition to these levels, the dose rate for areas not requiring occupancy until after the LOCE are listed for both 1% and 20% pin failure. The area classifications in Table D-1 are based on the need to occupy the area and should be evaluated for the 20% pin failure case.

C. RADIATION LEVELS AFTER 3 DAYS FROM FISSION PRODUCTS IN THE PRESSURE SUPPRESSION TANK

After 72 hr, it is assumed that the noble gas fission products will be removed from the suppression tank and that the solid and halogen fission product concentrations in the suppression tank will be reduced by a factor of 10 by the suppression system ion exchanger (Item (4), Section A). Under these conditions, the direct dose rate, at 72 hr, from fission products in the suppression tank is shown in Figure D-4. The radiation level in all locations in the tower will be less than 0.25 mrem/hr. The curve in Figure D-5 indicates the rate of decrease in the radiation level due to radioactive decay.

D. RADIATION LEVEL IN TEST CHAMBER

The radiation level in the test chamber from fission products in the suppression tank is shown in Figure D-6. The receiver is 5 ft from the side of the tank. The results presented assume that the concentration in the tank has been reduced by a factor of 10 by the ion exchanger.

Other sources of radiation in the test chamber result from (a) fission product deposition on the primary system and blowdown system surfaces,

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Fig. D-3 Dose rate 40 ft from containment centerline,
0-3 days after LOCE.

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TABLE D-1

RADIATION LEVELS AFTER (DURING) BLOWDOWN INTO SUPPRESSION TANK

Item	Room Number	Room Description	Distance From g RV (ft)	Thick Earth, Concrete	Access [a] Classification at Time of Blowdown	Radiation Levels (mrem/hr) for 20% Pin Failure at	Time After Blowdown When Access is Needed	Time of Occupancy (hr/8 hr)	Radiation Levels (mrem/hr) at Access Time (Column 3)	
						0 sec			1% Pin Failure	20% Pin Failure
1.	201	Personnel shielded entrance	95	4	C	0.45	0 sec	0.5	<0.25	0.45
2.	202	Shielded vestibule	80	4	C	0.45	0 sec	0.5	<0.25	0.45
3.	203	Hallway	40	2	E	90	7 day	1	<0.25	<0.25
4.	204	Dressing room	55	2	E	90	7 day	1	<0.25	<0.25
5.	205	Shower	55	2	E	90	7 day	1	<0.25	<0.25
6.	206	Change room No. 1	50	2	E	90	7 day	1	<0.25	<0.25
7.	206A	Pipe space	--	-	E	--	--	-	--	--
8.	207	Personnel airlock No. 1	--	-	E	2.3×10^6	7 day	0.5	<0.25	<0.25
9.	208	Personnel airlock shielding room	40	0	E	4.4×10^5	7 day	0.5	<0.25	<0.25
10.	209		--	-	E	--	--	--	--	--
11.	210		--	-	E	--	--	--	--	--
12.	211	Piping labyrinth	40	2	E	90	30 day	0.5	<0.25	<0.25
13.	212	Vestibule	55	3	C	5	0 sec	2	<0.25	5
14.	213	Conduit tunnel	40	0	E	4×10^5	30 day	0.5	<0.25	<0.25
15.	214		--	-	E	--	--	--	--	--
16.	215	Test chamber [b]	--	-	E	2.3×10^6	7 day	8	<0.25	3
17.	217	Cable tray space	--	-	E	--	--	-	--	-
18.	218	Preamp equipment room	60	3.75	B	0.5	0 sec	2	<0.25	0.5
19.	219	Preamp equipment room	60	3.75	B	0.5	0 sec	2	<0.25	0.5

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TABLE D-I (contd.)

Item	Room Number	Room Description	Distance From RV (ft)	Thick Earth/Concrete	Access[a] Classification at Time of Blowdown	Radiation Levels (mrem/hr) for 20% Pin Failure at	Time After Blowdown When Access is Needed	Time of Occupancy (hr/8 hr)	Radiation Levels (mrem/hr) at Access Time (Column 3)	
						0 sec			1% Pin Failure	20% Pin Failure
20.	222	HV duct labyrinth	40	2	E	90	30 day	2	<0.25	<0.25
21.	224	Electrical equipment room	100	6	A	<0.25	0 sec	2	<0.25	<0.25
22.	225	Air-conditioning equipment room	70	4.5	A	<0.25	0 sec	2	<0.25	<0.25
23.	226	Toilet	55	4	C	0.45	0 sec	1	<0.25	0.45
24.	227	Duct enclosure	40	0	E	4×10^5	30 day	1	<0.25	<0.25
25.	229		40	3	E	5	7 day	2	<0.25	<0.25
26.	B-105	Manuever space	100	6	B	<0.25	0 sec	4	<0.25	<0.25
27.	B-106	Air intake	100	5	B	<0.25	0 sec	0.5	<0.25	<0.25
28.	B-107	Air intake	100	5	B	<0.25	0 sec	0.5	<0.25	<0.25
29.	B-201	Electrical equipment room	85	5	B	<0.25	0 sec	4	<0.25	<0.25
30.	B-202	Hallway	85	5	B	<0.25	0 sec	1	<0.25	<0.25
31.	B-203	HV and piping equipnent room	40	5	B	<0.25	0 sec	4	<0.25	<0.25
32.	E-203A		55	5	B	<0.25	0 sec	2	<0.25	<0.25
33.	B-203B		55	5	B	<0.25	0 sec	0.5	<0.25	<0.25
34.	B-204	Stair No. 5	60	3	C	5	0 sec	1	<0.25	5
35.	B-205	Janitor closet	50	3	C	5	0 sec	0.5	<0.25	5
36.	B-206	Piping labyrinth	40	4	D	0.45	0 sec	1	<0.25	0.45
37.	B-207	Stair No. 6	55	3	C	5	0 sec	3	<0.25	5

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TABLE D-I (contd.)

Item	Room Number	Room Description	Distance From C RV (ft)	Thick Earth/Concrete	Access [a] Classification at Time of Blowdown	Radiation Levels (mrem/hr) for 20% Pin Failure at	Time After Blowdown When Access is Needed	Time of Occupancy (hr/8 hr)	Radiation Levels (mrem/hr) at Access Time (Column 3)	
						0 sec			1% Pin Failure	20% Pin Failure
38.	B-208	Equipment access shaft	60	3.75	C	0.45	0 sec	1	<0.25	0.45
39.	B-209	Shielded roadway	70	5	B	<0.25	0 sec	4	<0.25	<0.25
40.	B-211	Personnel airlock No. 2	40	3	D	0.45	0 sec	1	<0.25	0.45
41.	B-212	Cable labyrinth	40	3	D	0.4	0 sec	1	<0.25	0.4
42.	B-213	Sample control center	55	5	B	<0.25	0 sec	8	<0.25	<0.25
43.	B-214	CSM sample room	45	5	B	<0.25	0 sec	8	<0.25	<0.25
44.	B-215	Sample room	55	5	B	<0.25	0 sec	8	<0.25	<0.25
45.	B-216	Locker room	65	5	B	<0.25	0 sec	1	<0.25	<0.25
46.	B-217	Change room	65	5	B	<0.25	0 sec	1	<0.25	<0.25
47.	B-218	Loading area	85	6	B	<0.25	0 sec	4	<0.25	<0.25
48.	B-219	Filter fan room	70	5	B	<0.25	0 sec	1	<0.25	<0.25
49.	B-220	Filter shielding space	70	5	B	<0.25	0 sec	1	<0.25	<0.25
50.	B-221	Corridor	85	5	B	<0.25	0 sec	0.5	<0.25	<0.25
51.	B-222	Sample filter train room	80	5	B	<0.25	0 sec	1	<0.25	<0.25
52.	B-223	Filter train chamber vault	--	--	E	--	--	--	--	--
53.	B-224	Duct enclosure	40	6	D	<0.25	30 day	0.5	<0.25	<0.25
54.	B-225	Valve pit	40	6	D	<0.25	30 day	0.5	<0.25	<0.25
55.	B-225A		55	6	D	<0.25	30 day	0.5	<0.25	<0.25
56.	B-225B		75	6	D	<0.25	30 day	0.5	<0.25	<0.25
57.	B-226	Stair No. 9	60	6	D	<0.25	30 day	0.5	<0.25	<0.25

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TABLE D-I (contd.)

Item	Room Number	Room Description	Distance From G RV (ft)	Thick Earth/Concrete	Access[a] Classification at Time of Blowdown	Radiation Levels	Time After Blowdown When Access is Needed	Time of Occupancy (hr/8 hr)	Radiation Levels (mrem/hr) at Access Time (Column 3)	
						for 20% Pin Failure at 0 sec			1% Pin Failure	20% Pin Failure
58.	B-226A	Stair No. 10	50	3	D	5	30 day	0.5	<0.25	<0.25
59.	B-227	Railroad door machine room	55	3	E	5	30 day	1	<0.25	<0.25
60.	B-228	Railroad door enclosure	--	--	E	--	--	--	--	--
61.	B-229	Railroad door frame	--	--	E	--	--	--	--	--
62.	B-230	Stair No. 13	55	0	E	4x10 ⁵	30 day	0.5	<0.25	<0.25
63.	B-231	Railroad bridge enclosure	40	3	E	5	30 day	0.5	<0.25	<0.25
64.	B-233	Equipment room[c]	40	6	E	<0.25	7 day	1	<0.25	<0.25
65.	B-234	Valve access aisle	40	6	E	<0.25	7 day	1	<0.25	<0.25
66.	B-236	Decontamination equipment room	40	6	E	<0.25	7 day	1	<0.25	<0.25
67.	B-238	Void space	--	--	E	--	--	--	--	--
68.	B-239	ECCS equipment room	100	5	B	<0.25	0 sec	2	<0.25	<0.25
69.	B-240	Stair No. 15	85	5	B	<0.25	0 sec	1	<0.25	<0.25
70.	B-241	Airlock	85	5	B	<0.25	0 sec	1	<0.25	<0.25
71.	B-242	Vestibule	115	5	B	<0.25	0 sec	0.5	<0.25	<0.25
72.	B-243	Tank well	115	5	B	<0.25	0 sec	0.5	<0.25	<0.25
73.	B-244	Stair No. 14	110	5	B	<0.25	0 sec	0.5	<0.25	<0.25
74.	Building TAN-630		120	6	A	<0.25	0 sec	8	<0.25	<0.25
75.	Air-cooled condenser		50	0	E	4x10 ⁵	30 day	0.5	<0.25	<0.25

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TABLE D-I (contd.)

Item	Room Number	Room Description	Distance From RV (ft)	Thick Earth/Concrete	Access [a] Classification at Time of Blowdown	Radiation Levels (mrem/hr)		Time After Blowdown When Access is Needed	Time of Occupancy (hr/8 hr)	Radiation Levels (mrem/hr) at Access Time (Column 3)	
						for 20% Pin Failure at 0 sec				1% Pin Failure	20% Pin Failure

- [a] A = Full-time occupancy
 B = Full-time access
 C = Limited access
 D = Exclusion
 E = Exclusion by administrative control - no access is required.
- [b] See Section D for other possible radiation sources in this area.
- [c] See Section E for other possible radiation sources in this area.

See Tables 1-I and 1-II

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Fig. D-4 Dose rate outside containment, 3 days after LOCE.

Fig. D-5 Dose rate after LOCE, 40 ft from containment centerline.

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Fig. D-6 Dose rate, 5 ft from pressure suppression tank.

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(b) deposition on the pressure suppression tank purification system lines, and (c) fission products in the purification system ion exchanger. The latter source is discussed in Section F.

Radiation levels from deposition on the primary system surfaces are shown in Figure D-7. The receiver is at a position 10 ft from the MTA. These levels were calculated assuming 20% of the pins fail during the LOCE, and 10% of the released iodine and solid fission products deposit on the interior surfaces of the primary system^[D-2].

Deposition of fission products in the blowdown loop is assumed to be a factor of 5 greater than deposition in the primary loop^[D-2]. The radiation level from deposition in the blowdown loop is shown in Figure D-8 as a function of time after blowdown. The receiver is assumed to be 10 ft from the MTA.

* E. RADIATION LEVELS FROM PRESSURE SUPPRESSION SYSTEM LINES

Radiation levels in the containment basement (Room B-233) were calculated during the recirculation of the water in the pressure suppression tank. Although the ion exchanger in the blowdown suppression tank system will be removing activity from the water (activity reduction of 10 after 72 hr of operation) no credit was taken for this activity reduction. General area radiation levels in Room B-233 for the first 24 hr after blowdown are shown in Figure D-9. This area will be an exclusion area until a radiation survey is made to identify any hot spots. Local shielding will then be used as necessary.

* F. RADIATION LEVELS FROM PRESSURE SUPPRESSION SYSTEM ION EXCHANGER

* The pressure suppression system ion exchanger and lead shield are shown in Figure D-10. The ion exchanger is assumed to reduce the activity concentration in the pressure suppression system by a factor of 1000. Thus, the source in the ion exchanger is assumed to be 99.9% of the solid and halogen fission products which are released during the LOCE. Twenty percent of the pins are assumed to fail.

The dose rate from fission products in the ion exchanger, 2 days after the blowdown, is shown in Figure D-11 for a 5- and 6-in. lead shield. The curves in Figure D-12 give the radiation level at a distance of 2 ft from the ion exchanger as a function of time after shutdown. The actual thickness of the lead shield has not yet been determined.

G. RADIOACTIVE GAS HOLDUP SYSTEM

One scheme and design analysis for a proposed waste gas decay tank is described in Attachment 3. It is noted, however, that additional designs and locations have been considered. The design of this system has been deferred for the time being; additional analysis will be provided when the system design becomes more firm.

H. REFERENCES

- D-1 Aerojet Nuclear Company, LOFT Project Division, System Design Description 1.1.2, "Blowdown System".

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D-2 Letter, W. H. Layman, Chief, Water Projects Branch, DRDT, to Manger, ID,
"LOFT Radiation Shielding", RDT:ES:WS174 (August 16, 1971).

Fig. D-7 Dose rate from fission products in primary loop.

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Fig. D-8 Dose rate from fission products in blowdown loop.

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Fig. D-9 Dose rate from fission products in blowdown system
cleanup lines.

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Fig. D-10 Suppression system ion exchanger
with removable cask.

Fig. D-11 Gamma dose rate from fission products
in pressure suppression system ion exchanger.

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Fig. D-12 Gamma dose rate from fission products in ion exchanger.

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