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APR 1 2 1979

MEMORANDUM FOR: Distribution

FROM: Lake H. Barrett, Section Leader, Environmental Evaluation Branch, Division of Operating Reactors, ONRR

SUBJECT: PRELIMINARY ESTIMATES OF RADIOACTIVITY RELEASES FROM THREE MILE ISLAND

Attached is a summary of available information in Bethesda regarding estimates of radioactivity releases from Three Mile Island. We have estimated a total Xe-133 release of approximately 13 million curies and an I-131 release of approximately 14 curies from March 28 through April 5. This estimate was made by back calculating radioactivity releases using measured offsite TLD dose data, radioiodine air concentrations and concurrent meteorological conditions. As more information and time become available, more refined calculations can be made.

As of midday April 9, 1979, the population dose due to noble gases is estimated to be 2400 man-rems with the maximum individual exposure at less than 100 mrem (83 mrem).

Lake H. Barrett, Section Leader
Environmental Evaluation Branch
Division of Operating Reactors
Office of Nuclear Reactor Regulation

Enclosure:
As stated

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SUMMARY OF PRELIMINARY RADIOACTIVITY RELEASES FROM THREE MILE ISLAND AS OF APRIL 7, 1979

Preliminary rough estimates of Xe-133 and I-131 releases from Three Mile Island (TMI) have been made based on reported environmental measurements made with off-site TLDs and radioiodine air samplers using meteorological data concurrent with the environmental measurement times. This approach has been used to obtain a rough estimate of releases because accurate in-plant effluent monitor information is not available at this time. The ventilation exhaust monitors did not provide accurate readings of absolute quantities of radioactivity releases during the accident because of high airborne radioactivity concentrations and direct radiation from auxiliary building components resulted in inaccurate readings, e.g., off scale.

The most feasible method for rough preliminary estimates of the amount of noble gases released during the accident is to back-calculate a curie release based on radiation measurements taken in the environs, the isotopic spectrum of the effluents and actual meteorological conditions. Environmental TLDs have been used to provide the best estimate of the integrated radiation dose at a specific location. Ground survey measurements with portable instrumentation have not been used because the actual measurement reported was for a specific short time period (~10 seconds when the measurement was taken) which is not a long enough time period to permit the calculation of meteorological dispersion conditions.

The isotopic distribution has been assumed to be essentially Xe-133 based upon ARMs data. ARMs aircraft spectrum measurements indicated mostly a Xe-133 spectrum. In the first days, some Xe-135 was detected but levels were an order of magnitude below Xe-133 and quickly decayed (9 hour half-life) to undetectable levels. Consequently, we have assumed a single Xe-133 spectrum for these calculations.

Meteorological dispersion factors (χ/Q) were calculated for the specific time periods and locations of the exposed TLDs. The weather conditions for these calculations were originally based on information from the National Weather Service. Actual meteorological data from the TMI weather tower has recently been obtained by HMB and has been used with the weather service data in determining the dispersion factors for the TLD locations.

The equations and assumptions used for the calculation of the releases is provided in Table 10.

Table 1 is a summary of the Xe-133 release from TMI as a function of the time the TLDs were exposed. Tables 2 through 8 are the TLD and meteorological data used to make the estimated release for each time period. The estimated release for each time period is the average of the release calculated for each of the TLD locations. Considering the assumptions necessary to permit hand calculations, the release estimates based on each of the TLD readings are fairly consistent. The total release of Xe-133 through April 5 using this method of estimation is 13 million curies.

Lawrence Livermore Laboratory (LLL) has also provided a "very rough estimate" of the releases on April 4 based on ARMs information, which is independent of the TLD method used herein. LLL estimated the most "probable release" rate as

20 to 50 Ci/sec of Xe-133. This corresponds to 14 million to 34 million curies of Xe-133 through April 5 which is consistent with the NRC estimate of 13 million.

The iodine 131 releases have also been estimated using a similar method but with measured I-131 concentrations instead of TLD data. Eight offsite iodine sampler locations have been reported. The estimated I-131 release through April 3 is 1.4 curies. The offsite radioiodine concentrations, sampler locations, and meteorological conditions are provided in Table 9.

To date we have not received any useful information from the radioiodine in-plant monitors. The radioiodine samplers should have been continuously sampling the effluents from the station vent except for the period from 0100 to 0330 on March 30 when the auxiliary building fans were secured in an attempt to reduce the release rate. When the fans were secured some unsampled building exfiltration took place, however, this was only for a short period. The iodine sampler contains a charcoal cartridge which can be removed and analyzed for radioiodines in a laboratory. Data from the inplant radiation detector which normally monitors the charcoal cartridge has not been reliable because noble gases also accumulate on the charcoal cartridge resulting in abnormally high readings. These charcoal cartridges can be counted in a laboratory within a few weeks and accurately predict what the actual I-131 release had been.

No historical information can be established from the effluent instrumentation for noble gases when the monitors are off scale. Information such as area radiation monitor readings could be useful in the future for estimating airborne concentrations, however, direct radiation from components will make this approach difficult, if not impossible.

The noble gas release history in Table 1 is generally consistent with various activities that occurred during the post-accident period. The higher release rate of the 28th and 29th probably correspond to the pumping of the contaminated water from the containment sump to the Auxiliary Building tanks which overflowed onto the Auxiliary Building floor. The noble gases then evolved from the water as it was exposed to the building air and was then exhausted by the auxiliary building ventilation system. On about 3/29 much of the water that had spilled on the floor had been pumped into tanks which reduced the evolution of gases to the air. The release rate after 3/29 and before 3/31 was reduced possibly because the letdown flow path of primary coolant was to the Reactor Coolant Bleed Holdup tanks and waste gas system. The increase in release on 3/31 could correspond to the establishment of the normal letdown path through the Makeup Tank. Establishment of normal letdown resulted in several gaseous releases as problems were encountered with leakage of dissolved gases evolving from the makeup tank vent. Also, during this period the bubble in the reactor vessel was the main concern and efforts were directed toward degasification of the primary system. The method of degasification was through the makeup tank to the vent gas system and waste gas decay tanks as well as venting the pressurizer to containment. During this mode of operation there were apparent leaks in the vent gas system between the makeup tank and waste gas decay tanks. Although little verified information concerning waste gas decay tank pressures exist at this time, it appears that the waste gas decay tank pressures did not increase as much as was expected, also indicating vent gas system leakage. The degasification of the primary system through the makeup tank could well have removed much more than 10% of the noble gases from the primary system. The initial core inventory of xenon at 0400 on 3/28 was 140 million curies. It is possible when considering the amount of Xe-133 available to be released to the primary coolant, the severe core overheating, the method of primary system degasification and the leaks in the vent gas system between the makeup tank and waste gas decay tanks that the release of 13 million curies of Xe-133 is feasible.

It is again stated that these quantitative estimates have been based on data reported from the TMI site. Much of the information was provided verbally from the site and cannot be verified at this time. As more information becomes available, more accurate estimates can be made.

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TABLE 1

Preliminary Estimate of Noble Gas Releases (Xe-133)

Time Period	Noble Gas Release (Curies Xe-133)
3/28 - 3/29	4.2×10^6
3/29 - 3/31	2.2×10^6 (2 days)
3/31 - 4/1	2.1×10^6
4/1 - 4/2	0.4×10^6
4/2 - 4/3	1.1×10^6
4/3 - 4/4	0.07×10^6
4/4 - 4/5	0.2×10^6
Total	$\sim 13.0 \times 10^6$

0400 2/28 Core Inventory Xe-133 140×10^6 curies

Annex to Appendix C

TABLE 2

Noble Gas Release Estimates

Time Period 3/28 - 3/29 (1500 hours) (35 hr period)

TLD Location (Miles)	TLD Location (Direction)	TLD Dose* (mrem)	χ/Q (sec/m^3)	Calculated Release (Ci Xe-133)
0.4	NW	82	5×10^{-6}	3.5×10^{6}
0.7	NE	31	1×10^{-5}	6.6×10^{5}
15	SE	4.2	1×10^{-7}	9.0×10^{6}
9	SE	2	1×10^{-7}	4.3×10^{6}
2.3	SE	3	(2×10^{-7})	3.2×10^{6}
0.5	ENE	5	1×10^{-6}	1.1×10^{6}
1.6	WSW	4	2×10^{-6}	4.1×10^{5}
2.6	N	7	1×10^{-6}	1.5×10^{6}
13	S	3.3	5×10^{-8}	1.4×10^{7}
			AVERAGE	4.2×10^{6}

* Background corrected.

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TABLE 3

Noble Gas Release Estimates

Time Period 3/29 (1500 hrs) - 3/31 (1000 hrs) (43 hr period)

TLD Location (Miles)	TLD Location (Direction)	TLD Dose (mrem)	χ/Q (s/m^3)		Calculated Release (Ci Xe-133)
2.3	SSE	9.3	2×10^{-6}		1.0×10^{6}
13	S	1.7	2×10^{-7}		1.8×10^{6}
15	NW	2.1	8×10^{-8}		5.6×10^{6}
15	SE	1.7	1×10^{-7}		3.6×10^{6}
2.6	N	2.9	1×10^{-6}		6.2×10^{5}
9	SE	1.2	2×10^{-7}		1.3×10^{6}
10	ENE	1.3	2×10^{-7}		1.4×10^{6}
				Avg.	2.2×10^{6}

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TABLE 4

Noble Gas Release Estimates

Time Period 3/31 - 4/1 (22 hr. period)

TLD Location (Miles)	TLD Location (Direction)	TLD Dose (mrem)	x/Q (s/m^3)	Calculated Release (Ci Xe-133)
0.5	ENE	25	1×10^{-6}	5.4×10^{6}
0.8	NE	7	6×10^{-7}	2.5×10^{6}
13.8	NW	4.6	1×10^{-7}	9.8×10^{6}
9.6	NW	5.5	2×10^{-7}	5.8×10^{6}
1.5	W	3	2×10^{-5}	3.2×10^{5}
7.0	SE	2.5	4×10^{-7}	1.3×10^{6}
4.2	SE	3.0	9×10^{-7}	7.1×10^{5}
2.[illegible]	W	1.1	1×10^{-6}	2.4×10^{5}
7.1	W	1.2	5×10^{-7}	5.1×10^{5}
5.3	W	1.0	1×10^{-6}	2.2×10^{5}
2.5	S	1.6	2×10^{-6}	1.7×10^{5}
6.2	S	1.0	7×10^{-7}	1.1×10^{5}
3.4	NE	1.6	3×10^{-6}	4.5×10^{5}
7.6	NE	2.1	1×10^{-6}	4.5×10^{5}
			Avg.	2.1×10^{6}

TABLE 5

Noble Gas Release Estimates

Time Period 4/1 - 4/2 (24 hr. period)

TLD Location (Miles)	TLD Location (Direction)	TLD Dose* (mrem)	X/Q (s/m^3)		Calculated Release (Ci Xe-133)
2.6	303°	1.5	1×10^{-6}		3.2×10^5
1.3	263°	1.0	$1. \times 10^{-6}$		2.1×10^5
7.8	297°	0.6	4.0×10^{-7}		3.2×10^5
1.8	200°	0.6	6.0×10^{-7}		2.1×10^5
9.3	223°	0.3	6.0×10^{-8}		1.1×10^6
				Avg.	4.3×10^5

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*Corrected for Background (0.19 mrem/day)

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TABLE 6

Noble Gas Release Estimates

Time Period 4/2 - 4/3

TLD Location (Miles)	TLD Location (Direction°)	TLD Dose* (mrem)	x/Q (s/m^3)	Calculated Release (Ci Xe-133)
7.8	297	0.4	2×10^{-8}	4.3×10^{6}
1.3	263	1.2	3×10^{-7}	8.6×10^{5}
1.8	200	1.0	1×10^{-6}	2.1×10^{5}
5.1	272	0.5	5×10^{-7}	1.1×10^{6}
2.4	203	1.1	5×10^{-7}	4.7×10^{5}
2.5	169	2.0	2×10^{-6}	2.1×10^{5}
6.2	178	1.3	2×10^{-7}	1.4×10^{6}
8	181	1.3	3×10^{-7}	9.3×10^{5}
7	225	0.6	1×10^{-7}	1.3×10^{6}
9.3	225	0.6	6×10^{-8}	2.1×10^{6}
12	184	1.2	1×10^{-7}	2.6×10^{6}
1.9	162	4.2	2×10^{-6}	4.5×10^{5}
1.0	151	8.9	5×10^{-6}	3.8×10^{5}

TABLE 6 (Continued)

Noble Gas Release Estimates

Time Period 4/2 - 4/3

TLD Location (Miles)	TLD Location (Direction°)	TLD Dose* (mrem)	χ/Q (s/m^3)	Calculated Release (Ci Xe-133)
5.3	310	0.4	$6. \times 10^{-8}$	1.4×10^{6}
2.6	303	1.1	$2. \times 10^{-7}$	1.2×10^{6}
1.3	252	0.8	$2. \times 10^{-6}$	8.6×10^{4}
2.9	270	0.6	$1. \times 10^{-6}$	1.2×10^{5}
7.1	262	0.7	7×10^{-7}	1.5×10^{5}
				Avg. 1.1×10^{6}

* Corrected for Background (0.19 mrem/day)

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TABLE 7

Noble Gas Release Estimates

Time Period 4/3-4/4

TLD Location (Miles)	TLD Location (Direction°)	TLD Dose* (mrem)	χ/Q (s/m³)	Calculated Release (Ci Xe-133)
1.0	151	0.24	4×10^{-6}	1.28×10^{4}
1.9	162	0.68	3×10^{-6}	4.85×10^{4}
2.5	169	0.91	2×10^{-6}	9.73×10^{4}
6.2	178	0.33	2×10^{-6}	3.53×10^{4}
8.0	181	0.28	1×10^{-6}	5.99×10^{4}
12.0	184	0.14	1×10^{-6}	3.00×10^{4}
1.8	200	0.91	4×10^{-6}	4.87×10^{4}
2.4	203	0.18	2×10^{-6}	1.93×10^{4}
7.0	225	0.46	1×10^{-6}	9.84×10^{4}
9.3	225	0.43	1×10^{-6}	9.20×10^{4}
1.3	263	1.51	2×10^{-6}	1.62×10^{5}
1.3	252	0.43	4×10^{-6}	2.30×10^{4}
2.9	270	0.91	2×10^{-6}	1.30×10^{5}
5.1	272	0.23	1.0×10^{-6}	4.92×10^{4}

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TABLE 7 (Continued)

Noble Gas Release Estimates

Time Period 4/3-4/4

TLD Location (Miles)	TLD Location (Direction°)	TLD Dose* (mrem)	χ/Q (s/m^3)	Calculated Release (Ci Xe-133)
7.1	262	0.46	1.0×10^{-6}	9.84×10^{4}
2.6	303	0.11	2×10^{-6}	1.18×10^{4}
5.3	310	0.21	1×10^{-6}	4.49×10^{4}
7.8	297	0.21	4×10^{-7}	1.12×10^{5}
			Avg.	6.5×10^{4}

*Corrected for Background (0.19 mrem/day)

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TABLE 8

Noble Gas Release Estimates

Time Period 4/4 to 4/5

TLD Location (Miles	TLD Location (Direction°)	TLD Dose* (mrem)	χ/Q_3 (s/m^3)	Calculated Release (Ci Xe-133)
1.0	151	0.73	6×10^{-7}	2.60×10^{5}
1.9	162	0.19	4×10^{-7}	1.02×10^{5}
2.5	169	0.18	1×10^{-7}	3.85×10^{5}
6.2	178	0.13	7×10^{-8}	3.97×10^{5}
8.0	181	0.21	6×10^{-8}	7.49×10^{5}
12.0	184	0.26	5×10^{-8}	1.11×10^{6}
1.8	200	0.18	1×10^{-6}	3.85×10^{4}
2.4	203	0.11	6×10^{-7}	3.92×10^{4}
7.0	225	0.26	3×10^{-7}	1.85×10^{5}
9.3	225	0.26	3×10^{-7}	1.85×10^{5}
1.1	263	1.11	4×10^{-6}	5.94×10^{4}
1.3	252	0.53	2×10^{-6}	5.67×10^{4}
2.9	270	0.23	3×10^{-6}	1.64×10^{4}
5.1	272	0.26	2×10^{-6}	2.78×10^{4}

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TABLE 8 (Continued)

Noble Gas Release Estimates

Time Period 4/4 to 4/5

TLD Location (Miles)	TLD Location (Direction°)	TLD Dose* (mrem)	χ/Q (s/m^3)		Calculated Release (Ci Xe-133)
7.1	262	0.41	2×10^{-6}		5.85×10^{4}
2.6	303	0.19	1.0×10^{-6}		4.07×10^{4}
5.3	310	0.14	9.0×10^{-7}		3.33×10^{4}
7.8	297	0.19	2.0×10^{-7}		2.03×10^{5}
				Avg.	2.2×10^{5}

* Corrected for Background (0.19 mrem/day)

TABLE 9

Radioiodine Release Estimates
Updated 4/10/79

Time Period 3/28-3/29

Location Miles	Location Direction	Air Concentration pCi/m³	χ/Q sec/m³	Calculated Release Ci
0.4	N	0.47	2×10^{-5}	2×10^{-3}
2.3	SSE	<0.2	4×10^{-7}	$<4.3 \times 10^{-2}$
0.4	E	<0.02	6×10^{-7}	$<2.9 \times 10^{-3}$
15	NW	<0.03	1×10^{-7}	$<2.6 \times 10^{-2}$
9	SE	<0.04	1×10^{-7}	$<3.5 \times 10^{-2}$
2.6	N	0.08	4×10^{-7}	1.7×10^{-2}
1.6	WSW	<0.3	2×10^{-6}	$<1.3 \times 10^{-2}$
13	S.	<0.07	$<4 \times 10^{-8}$	$<4.3 \times 10^{-2}$
			Avg.	$<2.3 \times 10^{-2}$

Time Period 3/29-3/31

Location Miles	Location Direction	Air Concentration pCi/m³	χ/Q sec/m³	Calculated Release Ci
0.4	N	22.6	2×10^{-5}	0.20
2.3	SSE	22.1	2×10^{-6}	1.91
0.4	E	20.3	1×10^{-5}	0.35
15	NW	1.8	8×10^{-8}	3.9
9	SE	0.27	2×10^{-7}	0.23

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TABLE 9 (Continued)

Radioiodine Release Estimates

2.6	N	12.7	2×10^{-6}		1.1
1.6	WSW	23.9	3×10^{-6}		1.38
13	S	0.14	2×10^{-7}		0.12
				Avg.	1.2
Time Period	3/31-4/3				
0.4	N	0.11	2×10^{-5}		1.4×10^{-3}
2.3	SSE	1.39	2×10^{-6}		0.18
0.4	E	0.27	2×10^{-5}		3.5×10^{-3}
9	SE	0.16	3×10^{-7}		0.14
2.6	N	0.051	5×10^{-7}		2.6×10^{-2}
1.6	WSW	0.07	2×10^{-6}		9.1×10^{-3}
13	S	0.36	1×10^{-7}		0.93
15	NW	0.024	1×10^{-7}		6.2×10^{-2}
				Avg.	0.17

Time Period 3/28-4/3 Cumulative Avg. ~ 1.4 Ci

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Equation for Back Calculating Xe-133 Releases

$$N\ (\text{Ci Xe-133}) = C[\chi/Q\ \text{sec/m}^3]^{-1}\ [2.94 \times 10^{-7}\ \frac{\text{rem-M}^3}{\text{pCi-yr}}]\ [\frac{10^{12}\ \text{pCi}}{\text{Ci}}\ \frac{1\text{yr}}{3.15 \times 10^7\ \text{sec}}]\ D\ \text{rem}$$

$$N\ (\text{Ci Xe-133}) = 0.214\ (\text{TLD Dose mrem})\ (\frac{1}{\chi/Q\ \text{sec/m}^3})$$

where $C = [\text{Finite Plume Correction}]^{-1} = 2$

Reg. Guide 1.109 dose conversion of $2.94 \times 10^{-7}\ [\frac{\text{rem-m}^3}{\text{pCi-yr}}]$

Equation for Back Calculating I-131 Releases

$$N\ (\text{ci I-131}) = K[\chi/Q]^{-1}\ t\ c$$

$$N\ (\text{ci I-131}) = 3.6 \times 10^{-9}\ [\chi/Q]^{-1}\ [t\ \text{hrs}]\ c$$

where c = I-131 concentration pci/m^3

t = Time period (hrs)

$k = 3.6 \times 10^{-9}$ (sec/hr)(Ci/pCi)

Annex to Appendix C