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Designation and Analysis of Compliance regarding Radioactive Gasseous Releases subsequent to the TMI-2 Accident

To

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October 1, 1979

by

Louis J. Kosarek
Director

This document is concurrent with a request by Jean R. Kohr, letter dated September 6, 1979 concerning a review of the regulations which govern gasseous emissions at the Three Mile Island (TMI) nuclear power generating plant. The focus of this review is to establish gasseous effluent discharge regulations in perspective with actual documented emissions which have occurred subsequent to the accident on March 28, 1979 at Three Mile Island - Unit 2 (TMI-2).

The regulation of unrestricted gasseous effluent discharged from the two (2) TMI units is based upon the operating license, NUREG-0432 - Appendix B - section 2 (1), the code of federal regulations Title 10 - Part 20 - Appendix B - table 2 - column I (2), and all regulations superceded by the code of federal regulations Title 10 - Part 50 - Appendix A-Q (3). These regulations, as specified in the license, are to incorporate a gasseous dispersion factor (X/Q) of 6.7×10^{-6} sec/m^3. The basis of the regulations contained in the license are established from CFR Title 10, Part 20 (2).

The means by which a maximum allowable gasseous radioactive discharges are calculated is to maintain a sum of the ratios of the radionuclide concentration to the maximum permissible concentration (MPC) much less than one. Table 1 lists various gasseous isotopes and the limits specified in CFR Title 10, Part 20. The limits are in engineering abbreviation to save space. The valve "E( )#" expresses ten to the ( )# power multiplied by the first numeral. An example is, 6E-9 equals 6×10^{-9} or is equivalent to 0.000000006 and is a very small number. Another example is, 2.8E+4 equals 2.8×10^{4} or is equivalent to 28,000. The units of these regulations are uCi/ml or Ci/m^3 which are both equal to each other.

The maximum legally allowable radioactive gas discharge can be calculated by dividing the limit (Ci/m^3) by the dispersion factor (sec/m^3) and the

resultant units are Ci/sec. This maximum discharge rate when multiplied by 1,000,000 equals uCi/sec. The value for the effluent limits pertaining to each gasseous radionuclide is listed in Table 1. As the effluent limits are averaged over a one year period to optimize "a dependable source of power under unusual operating conditions," the annual limits are also listed in Table 1. These gas discharge limits range from 9300 Ci/yr of Iodine-129 to 190,000,000 Ci/yr for Tritium.

The operating license further defines the legal limits which designate compliant levels. Section 2.1.2 segregates the isotopes listed in Table 1 as 1) halogen and other gasseous nuclides with half-lives in excess of eight (8) days, 2) gross gasseous activity except for halogens and isotopes with half-lives longer than eight (8) days, 3) and gross gasseous activity averaged over any calendar quarter. The instantaneous release regulations governing #1 are contained in section b and are 0.3 uCi/sec. The regulation pertinent to #2 are in section a and relate to the sum of the ratios of the radionuclide concentration to the maximum permissible concentration (MPC) being less than or equal to 1.5×10^5 m^3/sec. The regulations associated with #3 are in section c and are that the sum of the ratios of the nuclide levels to the MPC shall be less than or equal to 2.4×10^4 m^3/sec (Table 2).

The key to understanding the gasseous discharge limitations is that the operating license contains suggested regulations while CFR Title 10, Part 20 (2) designates the ultimate limitations plus all gasseous discharge values can be averaged over an annual period. Because of the fact that gasseous discharges can be averaged on an annual basis, the amount of discharge which exceeds the regulation can only be evaluated on an annual basis.

Presently, each gasseous radionuclide which was reported to be released as an aerosol will be reviewed in Table 3 regarding the total quantity of

Table 1. Gasseous radionuclide discharge limitations - CFR Title 10

Isotope	Half Life	Category	Limits of 10 CFR 20 (uCi/ml)	Effluent Limits	Annual Limits	Reference
Bromine-82	35.1hr	Halogen	6E-9	896uCi/sec	2.8E+4Ci	1,2,3,4,5
-83	2.41hr		-	-	-	
-84	31.8m		-	-	-	
-85	3.0m		-	-	-	
Iodine-129	1.7×10^7y	Halogen	2E-9	296uCi/sec	9.3E+3Ci	1,2,3,4,5
-130	12.5hr		-	-	-	
-131	8.06d		1E-8	1493uCi/sec	4.7E+4Ci	
-132	2.3hr		3E-8	4478uCi/sec	1.4E+5Ci	
-133	20.8hr		7E-9	1045uCi/sec	3.3E+4Ci	
-134	52.4m		1E-7	14925uCi/sec	4.7E+5Ci	
-135	6.7hr		1E-8	1492uCi/sec	4.7E+4Ci	
Krypton-83m	1.86hr	Noble Gas	-	-	-	1,2,3,4,5
-85m	4.4hr		1E-7	14925uCi/sec	4.7E+5Ci	
-85	10.3y		3E-7	44776uCi/sec	1.4E+6Ci	
-87	75m		2E-8	2985uCi/sec	9.4E+4Ci	
-88	2.8hr		2E-8	2985uCi/sec	9.4E+4Ci	
-89	3.2m		-	-	-	
-90	33s		-	-	-	
Ruthenium -103	37.5d	Volatile	2E-8	2985uCi/sec	9.4E+4Ci	1,2,3,4,5
-106	369d		3E-9	448uCi/sec	1.4E+4Ci	
Tritium	12.26y	Liquid Gas	4E-5	5970149uCi/sec	1.9E+8Ci	1,2,3,4,5
Xenon -131m	11.80d	Noble Gas	4E-7	59701uCi/sec	1.9E+6Ci	1,2,3,4,5
-133m	2.26d		3E-7	44776uCi/sec	1.4E+6Ci	
-133	5.4d		3E-7	44776uCi/sec	1.4E+6Ci	
-135m	15.8m		-	-	-	
-135	9.14hr		1E-7	14925uCi/sec	4.7E+5Ci	
-137	3.8m		-	-	-	
-138	17m		-	-	-	
-139	43s		-	-	-	

Table 2. Licensee Regulations for airborne radioactive discharges (1)

Isotope	Half-Life	Limiting Regulation	Instantaneous Effluent Limits	Quarter Calender Average Limits	Limit for licensee to notify NRC (calendar quarter average)
Bromine-82	35.1hr	3	-	144uCi/sec	-
-83	2.41hr	3	-	-	-
-84	31.8m	3	-	-	-
-85	3.0m	3	-	-	-
Iodine-129	1.7×10^7y	1	0.3uCi/sec	0.024uCi/sec	0.006uCi/sec
-130	12.5hr	3	-	-	-
-131	8.06d	1	0.3uCi/sec	0.024uCi/sec	0.006uCi/sec
-132	2.3hr	3	-	720uCi/sec	-
-133	20.8hr	3	-	168uCi/sec	-
-134	52.4m	3	-	2400uCi/sec	-
-135	6.7hr	3	-	240uCi/sec	-
Krypton -83m	1.86hr	2	-	-	-
-85m	4.4hr	2	15000uCi/sec	2400uCi/sec	600uCi/sec
-85	10.3y	1	0.3uCi/sec	0.024uCi/sec	0.006uCi/sec
-87	75m	2	3000uCi/sec	480uCi/sec	120uCi/sec
-88	2.8hr	2	3000uCi/sec	480uCi/sec	120uCi/sec
-89	3.2m	2	-	-	-
-90	33s	2	-	-	-
Ruthenium -103	37.5d	1	0.3uCi/sec	0.024uCi/sec	0.006uCi/sec
-106	369d	1	0.3uCi/sec	0.024uCi/sec	0.006uCi/sec
Tritium	12.26y	1	0.3uCi/sec	0.024uCi/sec	0.006uCi/sec
Xenon -131m	11.80d	1	0.3uCi/sec	0.024uCi/sec	0.006uCi/sec
-133m	2.26d	2	60000uCi/sec	7200	1800uCi/sec
-133	5.4d	2	60000uCi/sec	7200	1800uCi/sec
-135m	15.8m	2	-	-	-
-135	9.14hr	2	15000uCi/sec	2400uCi/sec	600uCi/sec
-137	3.8m	2	-	-	-
-138	17m	2	-	-	-
-139	43s	2	-	-	-

Table 3. Documented gasseous discharges

Isotope		Half-Life	Reported Discharge(Ci)	Discharge Level Relative to Regulation	Duration	References
Bromine	-82	35.1hr	-	-	-	-
	-83	2.41hr	-	-	-	-
	-84	31.8m	-	-	-	-
	-85	3.0m	-	-	-	-
Iodine	-129	1.7×10^7y	-	-	-	-
	-130	12.5hr	-	-	-	-
	-131	8.06d	14.1/26.84	low	3/28-4/30/ 3/28-4/12	6,7,9/6 -
	-132	2.3hr	-	-	-	
	-133	20.8hr	2.6	low	3/28-4/30	7,8
	-134	52.4m	-	-	-	-
	-135	6.7hr	-	-	-	-
Krypton	-83m	1.86hr	-	-	-	-
	-85m	4.4hr	-	-	-	-
	-85	10.3y	-	-	-	-
	-87	75m	-	-	-	-
	-88	2.8hr	6.1E+4/5.5E+4	0.65	3/28-3/29	6,8/7
	-89	3.2m	-	-	-	-
	-90	33s	-	-	-	-
Ruthenium	-103	37.5d	-	-	-	-
	-106	36.9d	-	-	-	-
Tritium		12.26y	-	-	-	-
Xenon	-131m	11.8d	-	-	-	-
	-133m	2.26d	1.7E+5/1.1E+6	0.12	3/28-4/6	6,8/7
	-133	5.4d	8.3E+6/9.2E+6	5.7	3/28-4/30	6,8/7
	-135m	15.8m	1.4E+5/1.7E+5	1.0	3/28-3/31	6,8/7
	-135	9.14hr	1.5E+6/1.5E+6	3.2	3/28-4/3	6,8/7
	-137	3.8m	-	-	-	-
	-138	17m	-	-	-	-
	-139	43s	-	-	-	-

discharge, the duration of discharge, and the discharge level relative to CFR Title 10, Part 20 (2). The only gasseous halogen which was reported to be released was iodine. The two isotopes of iodine which were reported were I-131 and I-133. As designated in Table 3, a total of approximately 14.1 Curies of I-131 and 2.6 Curies of I-133 were reported to be discharged from March 28 to April 30. There is contention regarding a report documented in NUREG-0600 (6) which suggests a total discharge of 26.84 Ci. If the level of 14.1 I-131 release was averaged over its duration of release, this accrues to a value of 4.8E-6Ci/sec. This value multiplied by the dispersion factor (x/Q) results in a product of 3.2E-11uCi/ml. This value is within the specified limits of 1E-8uCi/ml. Utilizing a total discharge of I-131 at 26.84Ci over 16 days, the final value is 1E-10 which is within specified limits (2).

The total release of I-133 took place over a period of thirty-four days. The accumulated release was 2.6 Ci and resulted in a discharge rate of 8.9E-7 Ci/sec and an overall value of 6E-12, which is within regulated guidelines (2).

The release of the noble gas Krypton-88 was detected in gasseous effluents using thermoluminescent dosimeters (TDL's). The actual total amount of Kr-88 which was discharged on the first day of the accident varies depending on the source, but has been reported as either 6.1E+4 or 5.5E+4 Curies. The discharge rate of Kr-88 calculates to either 0.70 or 0.64Ci/sec. Incorporating the dispersion factor (x/Q), this results in a discharge value of either 4.7E-6 or 4.3E-6uCi/ml. This gasseous discharge value exceeds the discharge limitations by a factor of either 235 or 215. However, when the gasseous discharge of Kr-88 is averaged over only an annual period, the levels of discharge do not exceed the regulated guidelines (2).

The noble gas which was measured to be discharged in the greatest quantities subsequent to the TMI accident was Xenon. Again, the documented levels

of this noble gas varied with the source of documentation. To simplify matters, the lowest total values will be used to establish the strongest argument. The total quantity of Xenon gas which was released subsequent to the accident totalled to an excess of 10 million Curies. Of the 10 million Curies of Xenon which were released, the majority was as Xenon-133.

The quantity of Xenon gas released between March 28 and April 30, was measured as being 8.3E+6 Curies. This radioactivity was measured by thermo-luminescent dosimetry. Integrating this gasseous discharge over the duration of the release, the release rate was 2.8Ci/sec or an annual rate of 0.26Ci/sec. Applying the dispersion factor, the actual release concentration was 1.9E-5u-Ci/ml and the annual release level is 1.7E-6uCi/ml. Comparing these values to the regulation of 3E-7, the annual gasseous discharge rate exceeds the annual regulations by a factor of 5.7 (2).

The isotope Xenon-133m was also reported as an effluent gas subsequent to the accident and the total release of Xenon-133m over a ten day period was 170,000 Curies. This amount of radioactivity when averaged over ten days resulted in a release rate of 0.2Ci/sec or an annual rate of 5.4E-3Ci/sec. Applying the dispersion factor (x/Q), this equals an annual value of 3.6E-8-uCi/ml which is in compliance.

The fission product Xenon-135 was monitored using TDL's and the total amount discharged over a seven day period was 1,500,000 Curies. The actual discharge rate is 2.48Ci/sec with an annual rate of 4.7E-2Ci/sec. The annual gasseous discharge rate multiplied by the dispersion factor results in a value of 3.2E-7 which is 3.2 times larger than the regulated limit of 1E-7 (2).

The final isotope of Xenon which was evaluated regarding a gasseous effluent discharge was Xenon-135m. The quantity of 140,000 Curies of Xenon-135m was released from March 28 to March 31, 1979. The actual release rate

was 0.40 Ci/sec and the annual release rate was 4.4E-3Ci/sec adjusting for dispersion, the annual gasseous concentration of Xenon-135m was 2.9E-8uCi/ml which is within regulation specifications (2).

Individually speaking, the measured radionuclides which exceeded the specified regulations were Xenon-133 and Xenon-135. As the regulations state that all known isotope ratios are additive (2), the total release of gasseous isotopes that were directly a result of the accident added to an excess of 10 million Curies (9,10) while actually exceeded the legal requirements by only a factor of 10.4. The measured gasses which were the source of the violations were only noble gasses and the legal halogen levels were not exceeded.

The conclusions reached in this designation and analysis of compliance regarding radioactive gasseous releases subsequent to the Three Mile Island Nuclear Power Plant Accident are concurrent with conclusions reached in the aforementioned references: 6, 7, 8, 9 and 10. However, it should be noted that references 7, 8, 9, and 10 did not address the factor by which the discharges exceeded the regulations.

References

1. Nuclear Regulatory Commission. 1978. Three Mile Island Nuclear Station Unit 2. Environmental Technical Specifications - Appendix B. NUREG-0432.

2. Code of Federal Regulations. 1978. Title 10, Part 20, Appendix B, Table 2, column 1. pp 202-211

3. Code of Federal Regulations. 1979. Title 10, Part 50, Appendix A-Q, pp. 350-392.

4. Rowe, W.D. 1973. Environmental Analysis of the Uranium Cycle - Part II, NTIS #PB-235 805 (EPA 520/9-73-003-C).

5. Lederer, C.M., J.M. Hollander and I. Perlman. 1967. Table of Isotopes 6th ed. John Wiley & Sons, New York, NY.

6. U.S. Nuclear Regulatory Commission. 1979. Investigation into the March 28, 1979 Three Mile Island Accident by Office of Inspection and Enforcement. NUREG 0600. July, 1979.

7. Metropolitan Edison Company. 1979. Second Interim Report on the Three Mile Island Nuclear Station Unit-2 (TMI-2) Accident. June 15, 1979.

8. Metropolitan Edison Company. 1979. Third Interim Report on the Three Mile Island Nuclear Station Unit-2 (TMI-2) Accident. July 16, 1979.

9. Civil Action #79-658. 1979. Defendant GPU's answers to Plaintiffs Interrogatories set #1. Attachment 1, July 18, 1979.

10. Civil Action #79-658. 1979. Defendant Nuclear Regulatory Commissions' answers to Plaintiff's Interrogatories set #1. Tables 1 and 2.

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RECEIVED JAN 16 1980

Dated: January 14, 1980

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
METROPOLITAN EDISON COMPANY	)	Docket No. 50-289
	)	(Restart)
(Three Mile Island Nuclear Station, Unit No. 1)	)	
	)	

LICENSEE'S FIRST SET OF INTERROGATORIES
TO INTERVENOR THREE MILE ISLAND ALERT, INC.

These interrogatories are filed pursuant to 10 C.F.R. §2.740b, which requires that the interrogatories be answered separately and fully in writing and under oath or affirmation. Licensee recognizes that Intervenor Three Mile Island Alert, Inc. ("TMIA") may not now be able to completely answer all interrogatories propounded below, since some areas are the subject of discovery by TMIA, although Licensee notes that it has already responded to two sets of TMIA interrogatories. Licensee therefore requests that each of these interrogatories be answered within the time specified in §2.740b to the extent that responsive information is presently available to TMIA. With respect to those interroga
responsive information is not r
requests that revised answers b
the discovery period establishe
December 18, 1979 First Special

Any reference to Intervenor Three Mile Island Alert, Inc. ("TMIA") shall be deemed to include all members of TMIA. When knowledge or information of TMIA is requested, such request includes knowledge or information of TMIA's members and, unless privileged, its attorneys.

The following definitions apply to each of the interrogatories below:

A. "Document" means all writings and records of every type including, but not limited to memoranda, tapes, correspondence, reports, surveys, tabulations, charts, books, pamphlets, photographs, maps, bulletins, minutes, notes, diaries, logs, speeches, articles, transcripts and all other records, written, electrical, mechanical or otherwise.

B. "Identify" means:

(1) With respect to a natural person, name, present or last known home or business address, present or last known job title or position, and the dates of tenure in that position;

(2) With respect to a document, the type of document (e.g., letter, record, list, memorandum, memorandum of telephone or face-to-face conversation, etc.), date of the document, title of the document, subject of the document, name of person who prepared the document, and name of person for whom the document was prepared or to whom it was delivered.

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
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METROPOLITAN EDISON COMPANY	)	Docket No. 50-289 (Restart)
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(Three Mile Island Nuclear Station, Unit No. 1)	)	

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