Radiological Doses Due to Postulated Steam Tunnel Leakage

Document Number ***BSA-L-96-03***
Revision 0

Gerald P. Lahti
BWR Safety Analysis

ComEd
Nuclear Fuel Services Department
Downers Grove, Illinois

Prepared by: Gerald P. Lahti Date: 11 JAN 1996

Reviewed by: Raymond A. Mi[illegible] Date: 1/11/96

Approved by: Robert W. Tsai Date: 1/12/96
(Date Issued)

Statement of Disclaimer

This document was prepared by the Nuclear Fuel Services Department for use internal to the Commonwealth Edison Company. It is being made available to others upon the express understanding that neither Commonwealth Edison Company nor any of its officers, directors, agents, or employees makes any warranty or representation or assumes any obligation, responsibility or liability with respect to the contents of this document or its accuracy or completeness.

Release of Information Statement

This document is furnished in confidence solely for the purpose or purposes stated. No other use, direct or indirect, of the document or the information it contains is authorized. The recipient shall not publish or otherwise disclose this document or information therein to others without prior written consent of the Commonwealth Edison Company, and shall return the document at the request of the Commonwealth Edison Company.

Abstract

Off-site radiological doses due to postulated steam leakage in the LaSalle County Station steam tunnel have been calculated. The calculations indicate that a steam leak of 200 gallons per minute will result in a whole body dose rate of 1.9E-3 mrad/hour and a radioiodine release of 9.8E-2 microcuries per second.

Table of Contents

List of Tables

1. Introduction

The purpose of this calculation is to determine the allowable steam leakage to the main steam tunnel that would not exceed applicable regulatory radiological dose limits.

2. Model Description and Assumptions

2.1 Noble Gases

Noble gases are assumed to be released from the reactor fuel at the design-basis rate given in Table 3-3 of NEDO-10871 (Ref. 1) . This release rate is the commonly referenced "100,000 uCi per second at 30 minutes decay" and is the design basis for all BWR radiological calculations. For this calculation, no credit is taken for radiodecay. Table 1 lists the nuclides considered [col. 1], their half-life and decay constant [col. 2 & 3], the average gamma ray energy released per disintegration [col. 4 (Ref. 4)], and the release rates at 30 minutes and zero decay time [col. 6 and 7, respectively]. (Nuclides with half-lives less than 40 seconds have not been considered in this assessment.)

The data of Table 1, column 7 (zero radiodecay), is the release rate of radioactivity from the reactor fuel and is assumed to be mixed in the total steam flow for the present calculation.

2.2 Radioiodine

The release of radioiodines from the reactor fuel, Section 4.2 (and Figure 4-2) of Reference 1, establish a design basis leakage rate of iodine-131 (I-131) of 700 uCi/sec. This is assumed to be mixed completely with the total steam flow for the present calculation.

2.3 Steamline Flow

The release rate of radionuclides (col. 7) is assumed to be borne by the total steam flow [14.3 million pounds per hour]. Only a part of this, 100,000 pounds per hour, (assuming a sump liquid flow rate of 200 gallons per minute at 62.4 pounds of water per cubic foot) is released to the steam tunnel. Thus the doses due to the leakage are only 1E+5/14.3E+6 (or 0.00699) of that due to releasing all of the radioactivity released from the fuel. This scaling will be made in the final steps of the calculation.

2.4 Site Boundary Dose

The ComEd ODCM (Ref. 2) contains the methodology and site specific data for calculating the offsite doses presently considered. The ODCM methodology for the whole body dose rate is simply of the form

[whole body dose rate] = [radionuclide release rate]*[finite cloud dose factor]

The "finite cloud dose factors" are included in the ODCM (Table F-7) and have the units of [mrem/year per uCi/sec released]. These data have been calculated from a site-specific meteorological data base for a finite cloud model and site-specific restricted area boundary distances. These data for an elevated release [Sbar] and ground level release [Gbar] are given in columns 10 and 11 of Table 1.

The annual doses per nuclide FOR TOTAL STEAM RELEASE (14.3 E+6 pounds per hour) are given in column 12 (elevated release) and column 13 (ground level release). The total whole body dose rates for elevated and ground level releases, respectively, are 279 and 2380 mrem per year.

2.4.1 Alternate Model

As an independent check, the corresponding whole body dose as calculated with a semi-infinite cloud model (Ref. 3) is provided. The model is as follows:

[dose rate]=[constant]*[E,gamma]*[release rate]*[X/Q]

E,gamma is the average gamma ray energy release per disintegration and X/Q is the site-specific downwind relative concentration.

The TOTAL STREAM FLOW RELEASE dose rate by this model is 2.03 mrad per hour or 17,800 mrem per year.

The difference between the dose rate calculated by this formulation and that using the ODCM methodology is a measure of the importance of the more realistic finite cloud model.

3. Calculations

3.1 Total Steam Release

Table 1 below shows the calculations for the release rates and whole body doses assuming a total steam release.

Table 1 Total Release Dose

Ref NEDO-10871 and NUREG/CR-1413(Kocher)					RELEASE RATES, uCi/sec		E*Release		FINITE CLOUD MODEL				
						\\\\\V////	[MeV*uCi]		LaSalle Data				
Nuclide	Half-life	Decay const	Ebar,gamma	Decay, min=0	30.00	0.00	0.00	Nuclide	ODCM T. F-7			Release *	Release *
		1/sec	MeV	Seconds = 0	1.80E+03	0.00E+00	minutes		Sbar	Gbar		Sbar	Gbar
							decay		mrem/yr per uCi/sec			mrem/yr	mrem/yr
Kr-83m	1.86 h	1.03E-04	0.0026	3.40E+03	2.82E+03	3.40E+03	8.84E+00	Kr-83m	1.75E-07	2.53E-04		6.62E-04	9.54E-01
Kr-85m	4.4 h	4.38E-05	0.1577	6.10E+03	5.64E+03	6.10E+03	9.62E+02	Kr-85m	7.36E-05	1.61E-03		4.98E-01	1.09E+01
Kr-85	10.74 y	2.05E-09	0.0022	1.50E+01	1.50E+01	1.50E+01	3.30E-02	Kr-85	1.1°E-06	1.76E-05		1.89E-05	2.94E-04
Kr-87	76 m	1.52E-04	0.7931	2.00E+04	1.52E+04	2.00E+04	1.59E+04	Kr-87	4.54E-04	4.99E-03		1.01E+01	1.11E+02
Kr-88	2.79 h	6.90E-05	1.9545	2.00E+04	1.77E+04	2.00E+04	3.91E+04	Kr-88	1.22E-03	1.19E-02		2.70E+01	2.64E+02
Kr-89	3.18 m	3.63E-03	1.8344	1.30E+05	1.89E+02	1.30E+05	2.38E+05	Kr-89	6.77E-04	5.80E-03		9.76E+01	8.36E+02
'r-90	32.3 s	2.15E-02	1.2715	2.80E+05	4.36E-12	2.80E+05	3.56E+05	Kr-90	2.10E-04	8.17E-04		6.53E+01	2.54E+02
Xe-131m	11.96 d	6.71E-07	0.0201	1.50E+01	1.50E+01	1.50E+01	3.02E-01	Xe-131m	1.70E-06	2.34E-04		2.84E-05	3.89E-03
Xe-133m	2.26 d	3.55E-06	0.0415	2.90E+02	2.88E+02	2.90E+02	1.20E+01	Xe-133m	1.06E-05	4.29E-04		3.40E-03	1.38E-01
Xe-133	5.27 d	1.52E-06	0.0453	8.20E+03	8.18E+03	8.20E+03	3.71E+02	Xe-133	7.92E-06	4.91E-04		7.21E-02	4.47E+00
Xe-135m	15.7 m	7.36E-04	0.4307	2.60E+04	6.91E+03	2.60E+04	1.12E+04	Xe-135m	1.97E-04	2.94E-03		5.67E+00	8.48E+01
Xe-135	9.16 h	2.10E-05	0.2479	2.20E+04	2.12E+04	2.20E+04	5.45E+03	Xe-135	1.05E-04	2.18E-03		2.56E+00	5.32E+01
Xe-137	3.82 m	3.02E-03	0.1877	1.50E+05	6.54E+02	1.50E+05	2.82E+04	Xe-137	7.74E-05	8.92E-04		1.29E+01	1.49E+02
Xe-138	14.2 m	8.13E-04	1.1258	8.90E+04	2.06E+04	8.90E+04	1.00E+05	Xe-138	5.81E-04	6.20E-03		5.74E+01	6.12E+02
Xe-139	40 s	1.73E-02	0.0000	2.80E+05	8.38E-09	2.80E+05	0.00E+00	Xe-139	0.00E+00	0.00E+00		0.00E+00	0.00E+00
			TOTAL uCi/sec	1.04E+06	9.94E+04	1.04E+06	7.96E+05				mrem/yr	2.79E+02	2.38E+03
											mrem/hr	3.19E-02	2.72E-01

3.2 200 GPM Leak Dose Rate

Table 2 below shows the calculations for the whole body dose assuming a 200 gpm leak into the steam tunnel.

Table 2 200 GPM Dose

For an elevated release and		
for a steam leak of :	2.00E+02	gal/min or 1.00E+05 lb/hr
and main steam flow :	1.43E+07	lb/hr, by proportioning the above,
the dose rate is :	2.23E-04	mrem/hour
or	2.24E+04	hours of flow are allowed before mrem limit of 10 CFR 50 Appx I is reached
For a ground level release, and the above steam flow and leakage,		
the dose rate is :	1.90E-03	mrad/hour
or	2.63E+03	hours of flow are allowed before 5 mrem limit of 10 CFR 50 Appx I is reached

3.3 Iodine-131 Release

Table 3 Iodine-131

iodine-131:		7.00E+02 uCi/sec x 2.00E-02	carry-over to steam
	=	1.40E+01 uCi/ sec in total steam flow	
	or	9.79E-02 uCi/sec in steam leakage	
1 Ci limit of Appx I is reached in		1.02E+07 seconds	

4. Results

The whole body dose rates for a specific steam leakage of 200 gpm (100,000 pounds per hour) were scaled from the dose rates calculated for the full stream release calculation. The result for the limiting ground level release scenario show that the resulting dose rate is 1.90E-3 mrem/hour. If this were allowed to persist for 2630 hours, the limiting whole body dose limit of 5 mrem per year [10CFR50, Appendix I] will be exceeded.

The 10CFR50 Appendix I release limit for I-131 is 1 curie per year. Assuming a 2% carry-over of I-131 from reactor water to the main steam (Ref. 1, Table 4-4), and a steam leak rate of 200 gpm results in a 0.0979 uCi/sec I-131 release to the environment. A persistence of 1.02E+7 seconds (2830 hours) would be required before the 1 Curie limit is reached.

5. Conclusions

Based on the model, assumptions and calculations presented above, a postulated 200 gallon per minute release of steam to the steam tunnel will not challenge the applicable 10CFR50 Appendix I dose limits.

6. References

1. General Electric Licensing Topical Report, "Technical Derivation of BWR 1971 Design Basis Radioactive Material Source Terms", NEDO-10871, March 1973

2. ComEd, "Offsite Dose Calculation Manual"

3. USNRC, "Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors", Regulatory Guide 1.3, Rev. 2, June 1974, [Section 2.e, whole body dose calculations]

4. D. C. Kocher, "A Radionuclide Decay Data Base--Index and Summary Table", NUREG/CR-1413, ORNL/NUREG-70, May 1980.