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March 28, 1978

Mr. George E. Lear, Chief
Operating Reactors - Branch 3
Division of Operating Reactors
U.S. Nuclear Regulatory Commission
Washington, DC 20555

Subject: Dresden Station Units 2 and 3
Quad-Cities Station Units 1 and 2
Supplement No. 1 to Dresden Station
Special Report No. 39 and Quad-Cities
Station Special Report No. 14, Analysis
of Hydrogen Generation and Control in
Primary Containment Following Postulated
Loss of Coolant Accident
NRC Docket Nos. 50-237/249 and 50-254/265

Dear Mr. Lear:

Attached to this letter is Amendment No. 2 to Dresden Station Special Report No. 39 and Quad-Cities Station Special Report No. 14. This amendment is made up of revised pages 12-17, 21, 22, 66 and Figures IV.1, IV.2, IV.5, IV.6, IV.9, IV.11-IV.14.

Supplement No. 1 to Dresden Station Special Report No. 39 and Quad-Cities Station Special Report No. 14, "Combustible Gas Control System Design Report", has been based on a 0.23 mils thickness oxide penetration into an all 8 x 8 core. Additionally, the inventory of zirconium in the 8 x 8 core has been increased ~20% to account for the possible higher than expected metal-water reaction results which were being performed at that time.

General Electric has completed another core-wide metal-water calculation utilizing Method 1 described in NEDO-20566. Table 2 of Quad-Cities Station Special Report No. 15 and Dresden Station Special Report No. 40 has been updated to reflect the new calculations which resulted in 0.21% metal-water reaction. For the purposes of the combustible gas control design calculations, this number has been multiplied by 5 and, therefore, 1.05% was used as input to these calculations.

The 0.21% metal-water reaction has been calculated based on an all 7 x 7 core and, therefore, the zirconium inventory is based on a 7 x 7 core. The 8 x 8 core has not been utilized because a 7 x 7 core renders a more restrictive core-wide metal-water reaction.

A second core-wide metal-water reactor calculation has been performed using Method 1 of NEDO-20566 except that the nodal power distribution curve which was considered typical for these plants when operating at 102% of licensed core power was used. This power distribution curve is based on the latest Appendix K MAPLHGR curves. The recalculation using the above assumptions gives a core-wide metal-water reaction of 0.11%.

Attached to Amendment #1 was a curve (Figure 1) depicting the nodal power distribution for 16 operating state points of the CECo. plants. Four data points were selected for each of the four plants using the criterion of highest operating power. The variation of MAPLHGR with exposure was obtained from the latest Appendix K analysis.

The curve is the average of the 16 data points. However, the highest powered bundles were operating at 80% of the Appendix K MAPLHGR's at the time the operating plants were at the highest power. Consequently, the curve was conservatively adjusted such that the highest powered bundles were operating at the Appendix K MAPLHGR's. All of the data points, even when adjusted to rated power conditions, show that the curve in the attached figure is a conservative representation of operating data.

It must be clearly noted that this calculation was not performed in accordance with the NRC approved methods. Also, the power distribution curve is based on past operating data and may not be representative of future conditions.

The above calculation is intended to provide the reviewing staff with another demonstration of the degree of conservatism present in the applicants' design of the ACAD system.

The following pages contain the changes to the original report. These changes reflect the use of the 0.21% metal-water reaction in a 7 x 7 core and as it may be seen, the results are slightly less restrictive on the system than the original report.

Please note that the hydrogen concentration in the wetwell without steam dilution, previously shown in Figure IV.4, is now shown in Figure IV.1, and Figure IV.4 has been eliminated. The drywell and wetwell pressures are now both shown in Figure IV.2, and Figure IV.3 has been eliminated. Similarly, the information previously contained in Figures IV.5 through IV.8 is now contained in Figures IV.5 and IV.6 and Figures IV.7 and IV.8 have been eliminated. Further, the information previously shown in Figure IV.10 is now shown in Figure IV.9 and Figure IV.10 has been eliminated.

The doses given in Table IV.2 were computed with CONCEN-Mark 2. This code is a significant improvement over the original version, but is based upon the same principles and operated in the same general fashion as the first version.

One (1) signed original and fifty-nine (59) copies are provided for your use. Please direct any questions concerning this matter to this office.

Very truly yours,

M. S. Turbak
Nuclear Licensing Administrator
Boiling Water Reactors

attachments

In accordance with the provisions of Branch Technical Position CSB6-2 (Ref. 1), the amount of hydrogen assumed to be generated by metal-water reaction, in establishing the performance requirements for combustible gas control systems, is based on the amount calculated in demonstrating compliance with 10 CFR 50.46 (Ref. 3). The result obtained from this core-wide metal-water reaction calculation is 0.21%. The method used for this calculation has been found acceptable by the USNRC staff and is described in NEDO-20566 (Ref. 4). In accordance with the provisions of Branch Technical Position CSB6-2, the core-wide metal-water reaction calculated, in compliance with 10CFR 50.46 (0.21%), is multiplied by a factor of five (5). This results in a metal-water reaction fraction of 1.05%. This metal-water reaction fraction is greater than the metal-water reaction fraction which results from postulating a reaction of all the metal in the outside surface of the cladding cylinders surrounding the fuel (excluding the cladding surrounding the plenum volume) to a depth of 0.00023 inches. This calculated metal-water reaction fraction, 1.05%, was, therefore, used as input into the computer program CONCEN. The computer program CONCEN is described in Appendix A. Am.

1.2 Long Term Hydrogen Generation

The generation of hydrogen due to radiolysis begins immediately after the LOCA. The guidelines contained in Branch Technical Position CSB6-2 (Ref. 1) have been followed to determine hydrogen generation rates. The details of modeling and the input variables used are described in Appendix A, Section A.2.1.2 and Section A.3.

2.0 ANALYSIS

In reviewing the results of the forthcoming analysis it should be remembered that the assumed metal-water reaction for this analysis is based on a hypothetical situation and it cannot be related to any credible physical process during the already extremely improbable LOCA. Moreover, the entire design of the system as described in Section III is based on the unrealistic assumption that no water vapor is present in either the drywell or the wetwell and that neither of the two volumes leak during the entire course of the accident.

The analysis of the accident was conducted utilizing the EI proprietary code CONCEN. A full description of the code is contained in Appendix A to this report. Based on the assumptions contained in this section and in Appendix A, the analysis of hydrogen and oxygen production in the drywell and wetwell following the LOCA was conducted. Figure IV.1 shows the hydrogen concentration in the drywell and wetwell as functions of time. Based on this analysis the ACAD system will not be required to be placed in operation until 24 minutes (0.40 hours) after the accident, when the hydrogen concentration reaches 3.56%. It should be noted that the hydrogen concentration continues to increase slowly until it reaches a peak of approximately 3.72% at about 20400 minutes (340 hours = 14.2 days) after the accident. After that time the concentration begins to drop. While the Dilution Air Injection Subsystem is in operation the pressures in the drywell and wetwell will gradually increase as is shown in Figure IV.2. As is shown, and it can be expected, the pressures in the drywell and wetwell will be nearly the same. This is due to the equalizing effect of the vents and vacuum breakers in case the air is injected into one volume at a time. If both of the volumes receive air at the same time the pressures in the two volumes will be equal due to a common connection, the air receiver. The lack of an instantaneous metal-water reaction source is evident by the uniformly and slowly rising curve.

Am. 2

Am. 2

As was discussed earlier, the operation of the Dilution Air Injection Subsystem will gradually raise the pressure in the drywell and wetwell to a level approaching 50% of the design pressure of the two volumes. A value somewhat less than 50%, 42.5 psia, has been used in the analysis as the Pressure Bleed Subsystem actuation pressure. The pressure will not be reached until 8080 minutes (134.7 hours = 5.6 days) after the LOCA. The Pressure Bleed Subsystem will reduce the pressure in the drywell and the wetwell by letting some of the contents of the wetwell and drywell to escape to the environment via the SBGT System. The resulting doses as a result of the system operation are discussed in Subsection 3.0. Am. 2

To provide an estimate of the margin of conservativeness inherent in the design of the ACAD system, an analysis utilizing the fact that water vapor will be present in the containment following a LOCA has been used. The water vapor content history assumption has been based upon the water vapor content history which has been utlized in the licensing of the nitrogen CAD system, for example, Amendment 50 to Browns Ferry Nuclear Plant Final Safety Analysis Report (Ref. 6) and Supplement 2 to Dresden Station Special Report No. 14, Quad Cities Station Special Report No. 7 (Ref. 7). The concentration of steam at anytime following the LOCA was obtained by calculating the ratio of the partial pressure of the water vapor to the total pressure of the containment. The partial pressure of the water vapor was obtained from standard steam tables as a function of temperature. The temperature history used was from the standard post-LOCA containment response analysis, assuming that sprays are operating, as presented in Subsection 14.6 of the Dresden and Quad Cities FSAR's (Refs. 8,9).

The results of this analysis shown in Figures IV.5 and IV.6 show that the ACAD System operation would not be required until 300 minutes (5.0 hours) after the accident, a factor of over 10 greater than the design case. The system would not be required to operate until much later than the design case, but when the air injection begins, the containment will be at a higher pressure than it is in the other case. As a result the Am. 2

pressure which requires the initialiation of the Pressure Bleed Subsystem will be reached somewhat sooner, at 7010 minutes (116.8 hours = 4.9 days) after the LOCA. Am. 2

To illustrate the effectiveness of the ACAD System operation the hydrogen concentration history in the drywell and wetwell is shown if no ACAD System was provided. By comparing Figures IV.1 and IV.9 the effectiveness of the system is clearly demonstrated. Am. 2

3.0 RADIOLOGICAL IMPACT OF ACAD SYSTEM OPERATION

As a result of ACAD System operation, some releases of radioactivity to the environment will be necessary. Consequently, the total dose resulting from these releases. The details of the models and assumptions utilized for calculating the doses are discussed in Appendix A, Section A.3.

As it was discussed in Subsection 2.0, the Pressure Bleed Subsystem begins to release containment atmosphere into the SBGT System 116 hours after the LOCA and continues to release radioactive materials intermittently for the remainder of the assumed duration of the accident. Am. 2

The dose calculation method used employed the actual site meteorology to calculate the diffusion parameters. The diffusion parameters (X/Q) were calculated using the sector_average, gaussian diffusion equation for an evaluated release as described in Appendix A to Quad Cities FSAR (Ref. 9). Values were determined for the low population distance of 5 miles for Dresden and 3 miles for Quad Cities Station. The one-year period (1974) of site data from Dresden was used. Cumulative probability of exceeding a certain dose during ayear was determined assuming that the accident occurs every hour of the year and lasts for 30 days. The EI proprietary code METPER was employed for this calculation. Am. 2

The model for estimating the probability of an individual receiving an integrated dose in excess of a given amount resulting from the containment venting, utilizes long periods of hourly weather measurements to simulate sequences of atmospheric diffusion conditions over a given time period following the postulated accident. These sequences are coupled with a postulated accident which might occur at any random time. The METPER program computes the integrated off-site whole body and thyroid doses over a selected time period (or window). The processing begins for the selected window starting with the first hour of X/Q record being used and continues until the integrated dose over the selected period is complete. The process is then repeated for the same elapsed time period starting a new integrating period with each subsequent hour of X/Q data. Am. 2

In this process, an integrated dose over the given period has been computed and stored effectively assuming that an accident has occurred during each hour of the year. The period length selected for the purposes of this analysis is 720 hours. Assuming that there were 8760 integrated 720-hour doses for each location being investigated, the probability of an individual at any one of these locations receiving a given dose (or greater) is determined by dividing the total number of occurrences of each dose (or greater) at this location by the total number of integration periods. The cumulative probability distribution is computed by finding the total occurrences of doses equal to or in excess of sequentially smaller doses regardless of direction. The distribution represents the chance that any person at any location along the low population distance boundary would receive an exposure equal to or greater than the indicated dose. Am. 2

The results of this analysis are shown on Figures IV.11 through IV.14, where the probabilities of exceeding certain thyroid or whole body dose are plotted. Table IV.1 summarizes the results of the analysis by showing the 5% probable thyroid and whole body doses. These doses when added to the doses calculated for the LOCA by the USNRC Staff and documented in the respective station Final Safety Evaluation Reports (Refs. 11, 12, 13) are well below the 10CRF100 limits (Ref. 14).

Utilizing the Regulatory Guide 1.3 (Ref. 15) assumptions and meteorology, which is a more conservative approach than using the actual site meteorology and the METPER code, the incremental doses resulting from the ACAD System operation are listed in Table IV.2. Am. 2

Based on the above discussion, it is concluded that the ACAD System operation meets the dose criteria of Branch Technical Position CSB6-2 (Ref. 1).

TABLE IV.1

INCREMENTAL 30 DAY LOW POPULATION ZONE DOSES RESULTING FROM ACAD SYSTEM OPERATION UTILIZING ACTUAL SITE METEOROLOGY

	QUAD CITIES, UNITS 1 & 2 5% Probable Dose	DRESDEN STATION, UNITS 2 & 3 5% Probable Dose
Thyroid	8.11 rem	5.94 rem
Whole Body	.072 rem	.037 rem

Am. 2

NRC Staff LOCA doses:

	QUAD CITIES, UNITS 1 & 2	DRESDEN STATION, UNITS 2 & 3
Thyroid	108 rem	90 rem
Whole Body	3 rem	2 rem

TABLE IV.2

INCREMENTAL 30 DAY LOW POPULATION ZONE DOSES RESULTING FROM ACAD SYSTEM OPERATION UTILIZING REGULATORY GUIDE 1.3 METEOROLOGY

	QUAD CITIES, UNITS 1 & 2	DRESDEN STATION, UNITS 2 & 3
	4-30 Days	4-30 Days
Thyroid	36.1 rem	22.6 rem
Whole Body	0.112 rem	0.070 rem

Am. 2

NRC Staff LOCA doses:

	QUAD CITIES, UNITS 1 & 2	DRESDEN STATION, UNITS 2 & 3
Thyroid	108 rem	90 rem
Whole Body	3 rem	2 rem

TABLE A.2

INPUT PARAMETERS FOR DRESDEN AND QUAD CITIES ACAD SYSTEM DESIGN

PARAMETER		NUMERICAL INPUT FOR CONCEN DRESDEN AND QUAD CITIES	
R1		35.0 scfm	Am. 2
R2		100.0 scfm	
R2ON		0.0356	
R2POFF		0.0320	
R1POFF		42.5 psi	
R1POFF		41.5 psi	
ENC1		430.22 moles	
ENSP1		318.52 moles	
TC		529.7 °R	
TSP		529.7 °R	
CCH1		0.00163	
CCO1		0.210	
CSH1		0.00	
CSO1		0.210	
VC		158236. ft^3	
VSP		117245. ft^3	
FILEFF	HALOGENS		
	ELEMENTAL	.90	
	PARTICULATE	.90	
	ORGANIC	.70	
	NOBLE GASES		
MZO		63679. lb	
FMW		0.01050	Am. 2
POW		2561 MWt	
GC		0.5	
GW		0.5	
FG		0.1	
FGB		0.01	
FI		0.5	

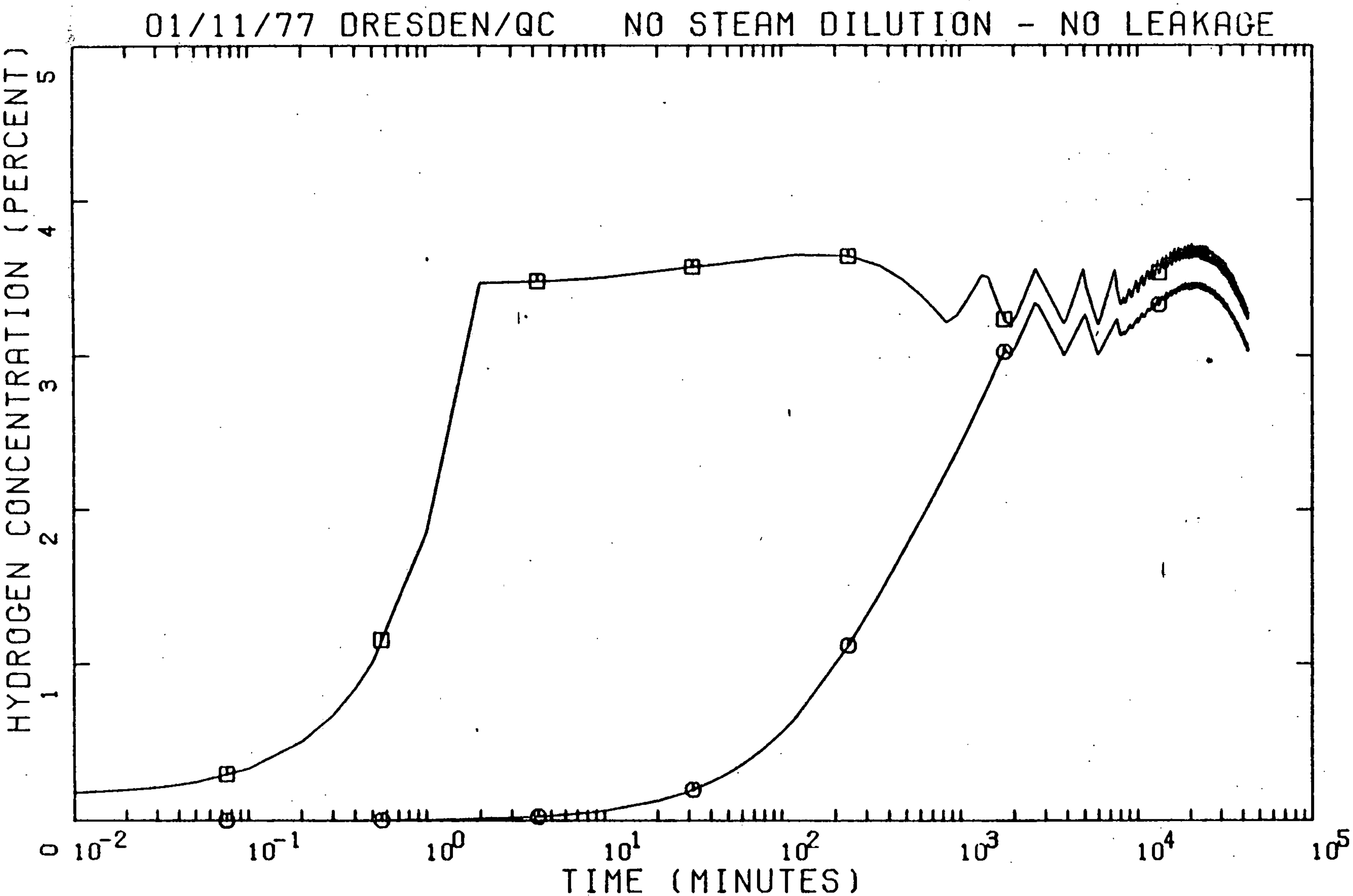

Figure IV.1 Hydrogen concentration in the drywell (squares) and wetwell (circles) following a loss-of-coolant accident, without steam dilution

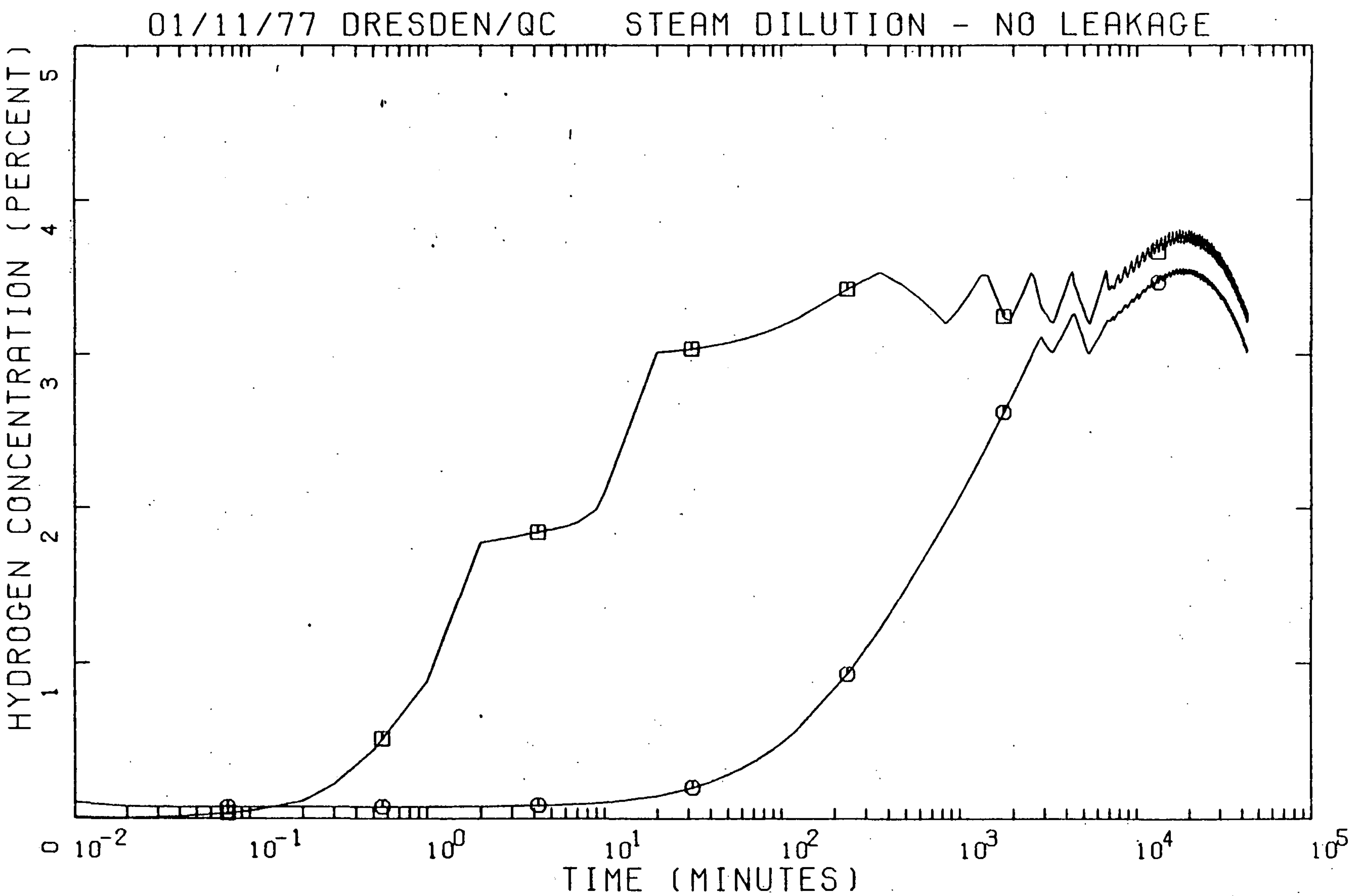

Figure IV.5 Hydrogen concentration in the drywell (squares) and wetwell (circles) following a loss-of-coolant accident, with steam dilution

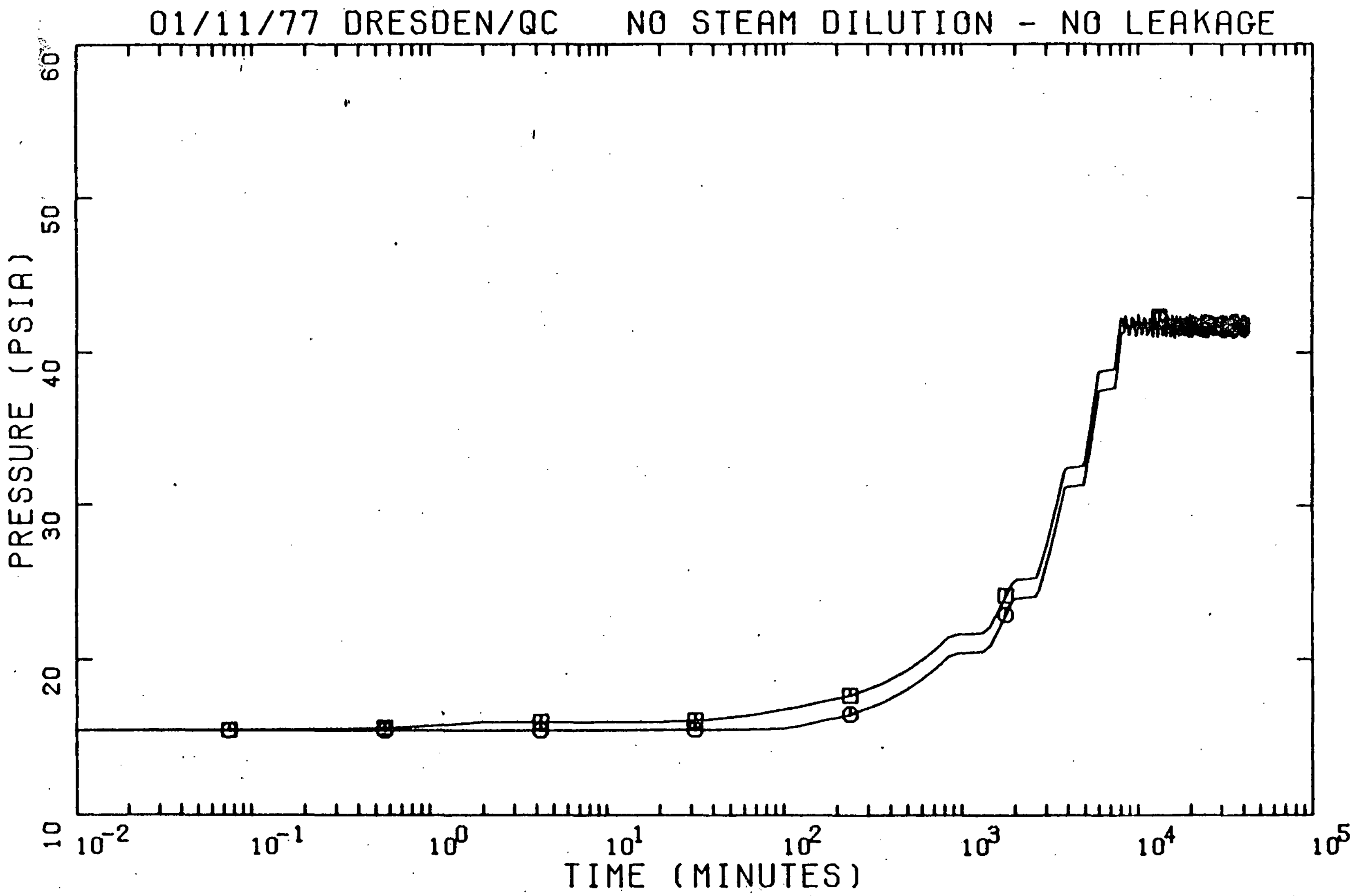

Figure IV.2 Pressure in the drywell (squares) and wetwell (circles) following a loss-of-coolant accident, without steam dilution

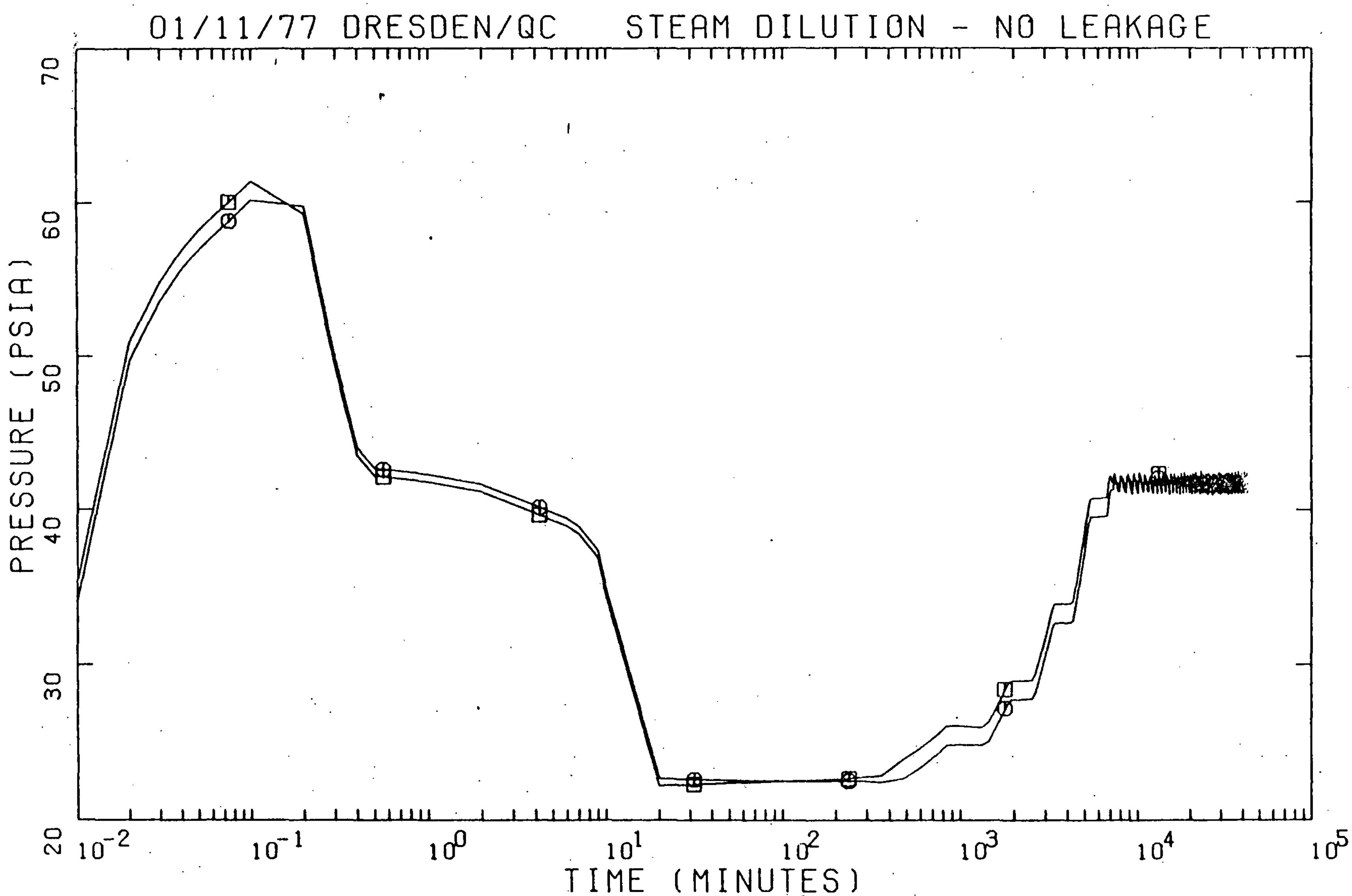

Figure IV.6 Pressure in the drywell (squares) and wetwell (circles) following a loss-of-coolant accident, with steam dilution

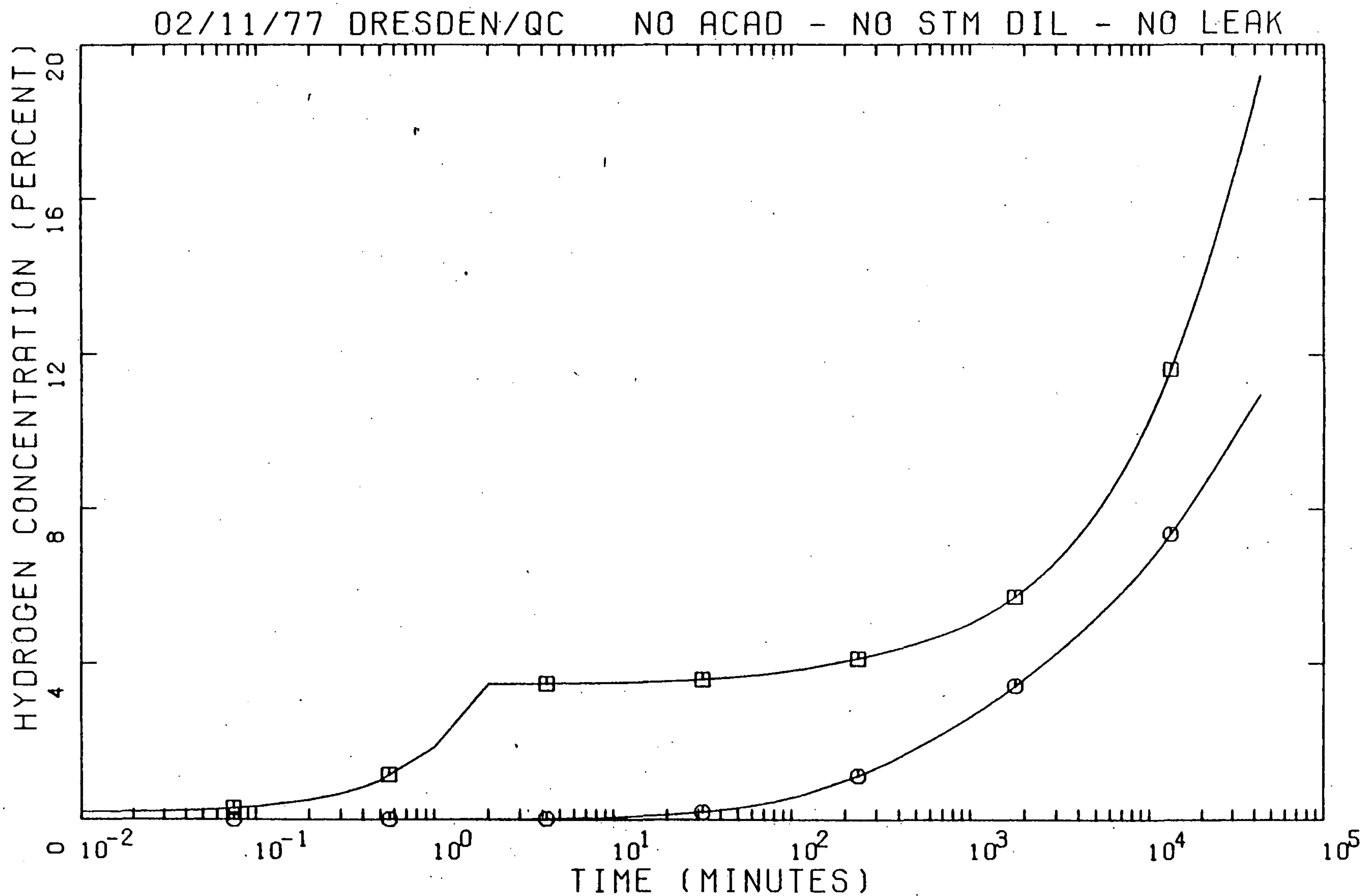

Figure IV.9 Hydrogen concentration in the drywell (squares) and wetwell (circles) following a loss-of-coolant accident, with no ACAD system

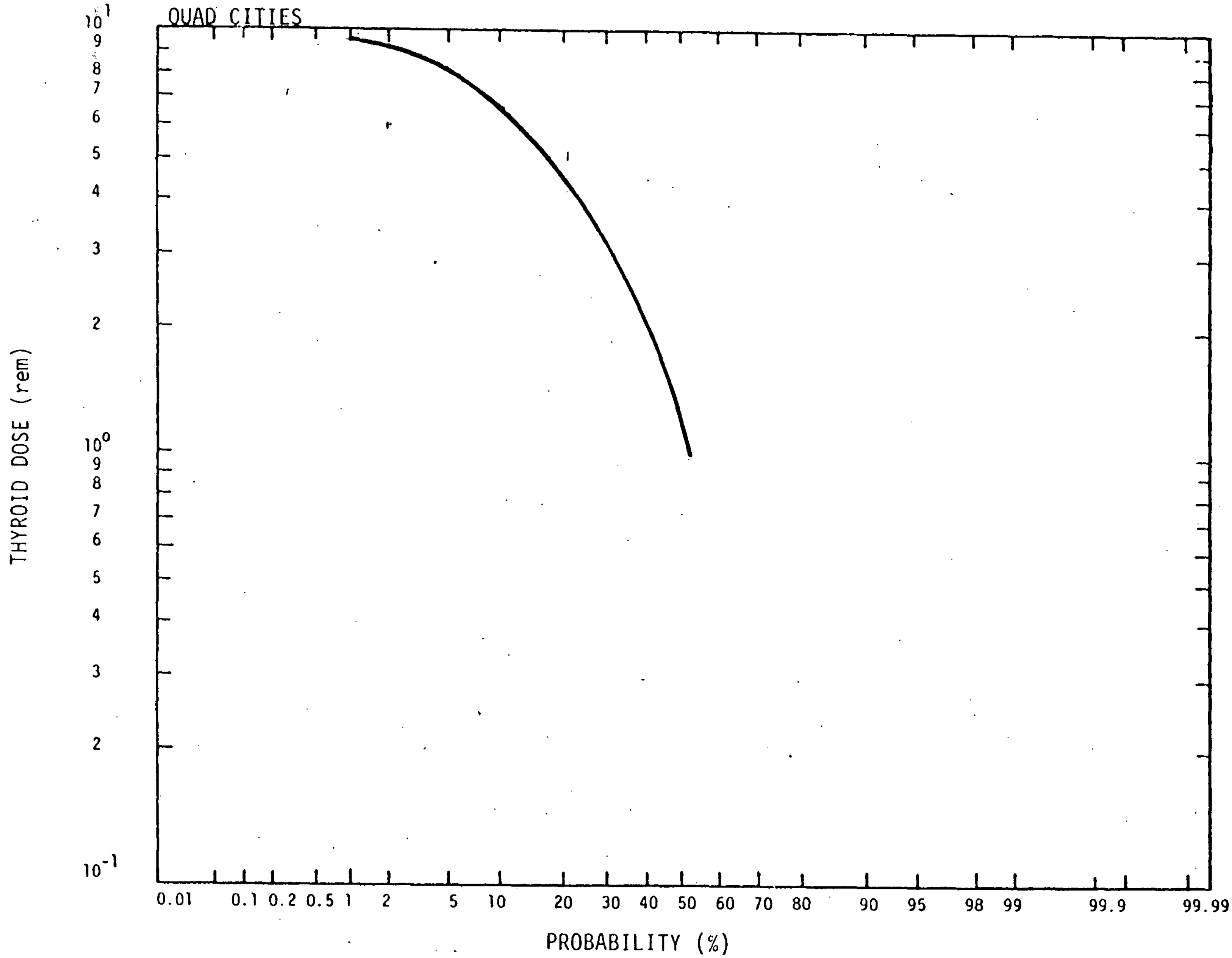

Figure IV.11 Probability Versus Thyroid Dose Quad Cities Units 1 and 2

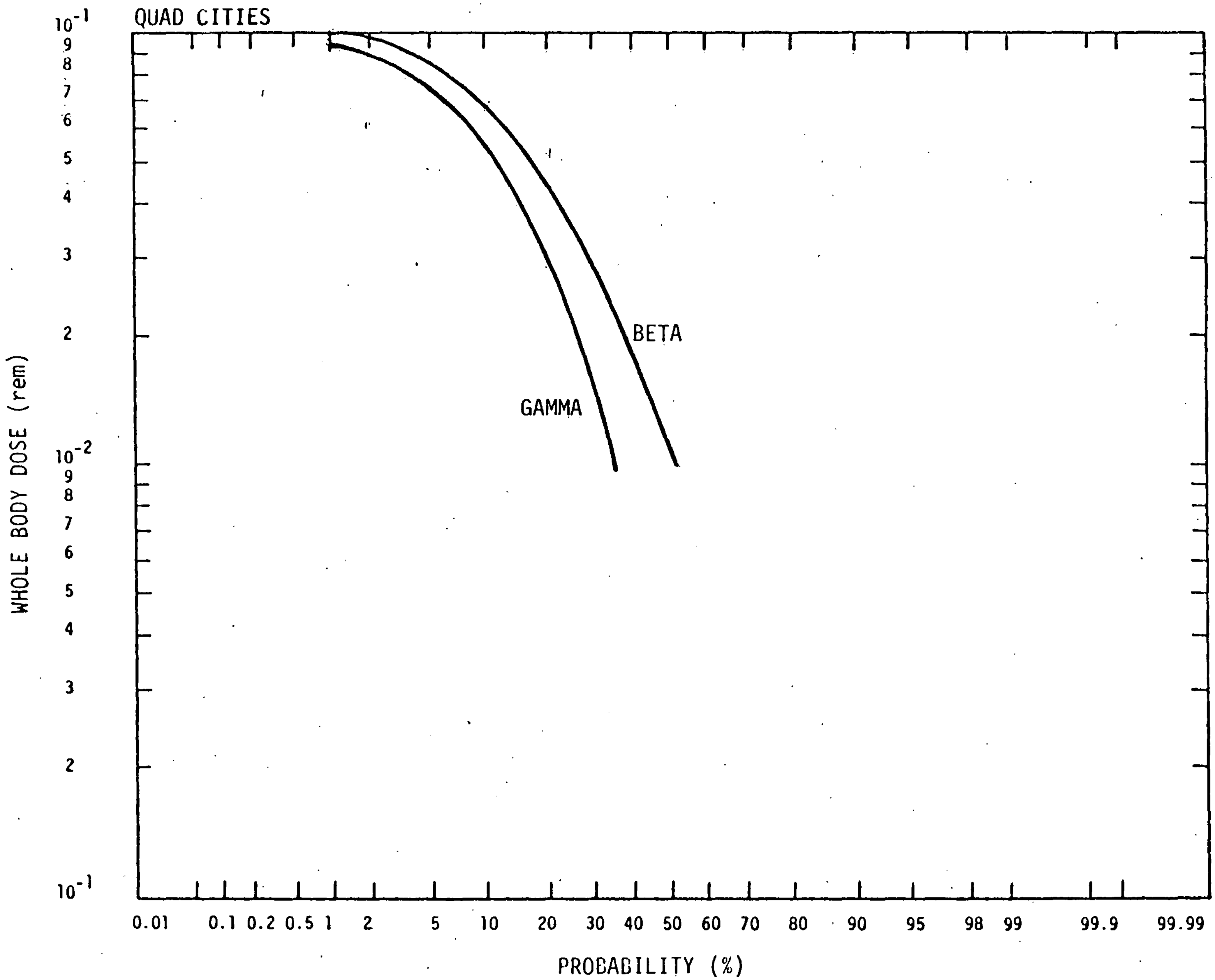

Figure IV.12 Probability Versus Whole Body Dose Quad Cities Units 1 and 2

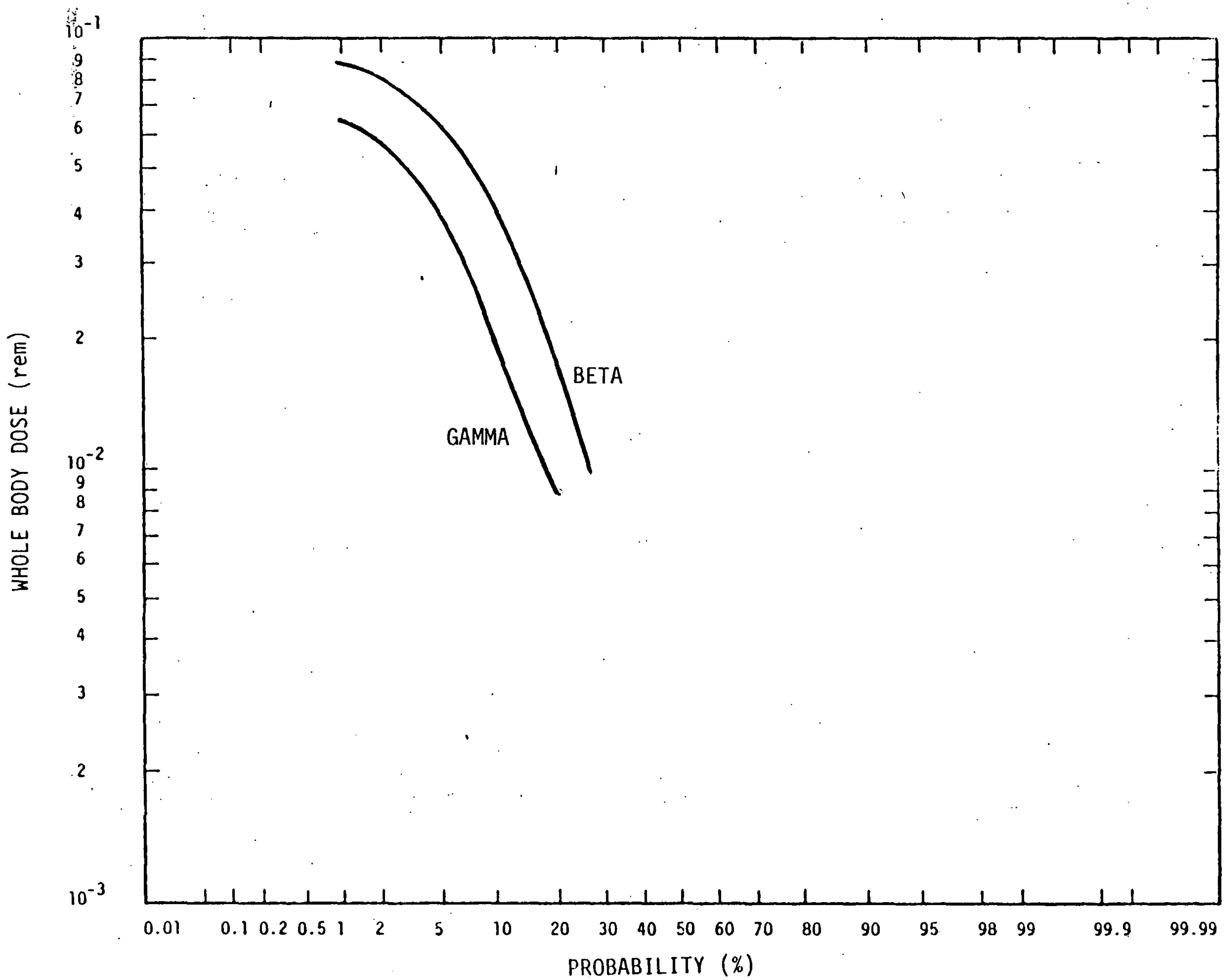

Figure IV.14 Probability Versus Whole Body Dose Dresden Station Units 2 and 3