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U.S. ATOMIC ENERGY COMMISSION

REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

REGULATORY GUIDE 1.4

ASSUMPTIONS USED FOR EVALUATING THE POTENTIAL RADIOLOGICAL CONSEQUENCES OF A LOSS OF COOLANT ACCIDENT FOR PRESSURIZED WATER REACTORS

A. INTRODUCTION

Section 50.34 of 10 CFR Part 50 requires that each applicant for a construction permit or operating license provide an analysis and evaluation of the design and performance of structures, systems, and components of the facility with the objective of assessing the risk to public health and safety resulting from operation of the facility. The design basis loss of coolant accident (LOCA) is one of the postulated accidents used to evaluate the adequacy of these structures, systems, and components with respect to the public health and safety. This guide gives acceptable assumptions that may be used in evaluating the radiological consequences of this accident for a pressurized water reactor. In some cases, unusual site characteristics, plant design features, or other factors may require different assumptions which will be considered on an individual case basis. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

B. DISCUSSION

After reviewing a number of applications for construction permits and operating licenses for pressurized water power reactors, the AEC Regulatory staff has developed a number of appropriately conservative assumptions, based on engineering judgment and on applicable experimental results from safety research programs conducted by the AEC and the nuclear industry, that are used to evaluate calculations of the radiological consequences of various postulated accidents.

This guide lists acceptable assumptions that may be used to evaluate the design basis LOCA of a Pressurized Water Reactor (PWR). It should be shown that the offsite dose consequences will be within the guidelines of 10 CFR Part 100. (During the construction permit review, guideline exposures of 20 rem whole body and 150 rem thyroid should be used rather than the values given in § 100.11 in order to allow for (a) uncertainties in final design details and meteorology or (b) new data and calculational techniques that might influence the final design of engineered safety features or the dose reduction factors allowed for these features.)

C. REGULATORY POSITION

1. The assumptions related to the release of radioactive material from the fuel and containment are as follows:

a. Twenty-five percent of the equilibrium radioactive iodine inventory developed from maximum full power operation of the core should be assumed to be immediately available for leakage from the primary reactor containment. Ninety-one percent of this 25 percent is to be assumed to be in the form of elemental iodine, 5 percent of this 25 percent in the form of particulate iodine, and 4 percent of this 25 percent in the form of organic iodides.

b. One hundred percent of the equilibrium radioactive noble gas inventory developed from maximum full power operation of the core should be assumed to be immediately available for leakage from the reactor containment.

c. The effects of radiological decay during holdup in the containment or other buildings should be taken into account.

d. The reduction in the amount of radioactive material available for leakage to the environment by containment sprays, recirculating filter systems, or other engineered safety features may be taken into account, but the amount of reduction in concentration of radioactive materials should be evaluated on an individual case basis.

e. The primary reactor containment should be assumed to leak at the leak rate incorporated or to be incorporated as a technical specification requirement at peak accident pressure for the first 24 hours, and at 50 percent of this leak rate for the remaining duration of the accident.[1] Peak accident pressure is the maximum pressure defined in the technical specifications for containment leak testing.

2. Acceptable assumptions for atmospheric diffusion and dose conversion are:

a. The 0-8 hour ground level release concentrations may be reduced by a factor ranging from one to a maximum of three (see Figure 1) for additional dispersion produced by the turbulent wake of the reactor building in calculating potential exposures. The volumetric building wake correction, as defined in section 3-3.5.2 of Meteorology and Atomic Energy 1968, should be used only in the 0-8 hour period; it is used with a shape factor of 1/2 and the minimum cross-sectional area of the reactor building only.

b. No correction should be made for depletion of the effluent plume of radioactive iodine due to deposition on the ground, or for the radiological decay of iodine in transit.

c. For the first 8 hours, the breathing rate of persons offsite should be assumed to be 3.47×10^{-4} cubic meters per second. From 8 to 24 hours following the accident, the breathing rate should be assumed to be 1.75×10^{-4} cubic meters per second. After that until the end of the accident, the rate should be assumed to be 1.75×10^{-4} cubic meters per second. After that until the end of the accident, the rate should be assumed to be 2.32×10^{-4} cubic meters per second. (These values were developed from the average daily breathing rate [2×10^7 cm^3/day] assumed in the report of ICRP, Committee II-1959.)

d. The iodine dose conversion factors are given in ICRP Publication 2, Report of Committee II, "Permissible Dose for Internal Radiation," 1959.

e. External whole body doses should be calculated using "Infinite Cloud" assumptions, i.e., the dimensions of the cloud are assumed to be large compared to the distance that the gamma rays and beta particles travel. "Such a cloud would be considered an infinite cloud for a receptor at the center because any additional [gamma and] beta emitting material beyond the cloud dimensions would not alter the flux of [gamma rays and] beta particles to the receptor" (Meteorology and Atomic Energy, Section 7.4.1.1—editorial additions made so that gamma and beta emitting material could be considered). Under these conditions the rate of energy absorption per unit volume is equal to the rate of energy released per unit volume. For an infinite uniform cloud containing χ curies of beta radioactivity per cubic meter the beta dose in air at the cloud center is:

$$_{\beta}D'_{\infty} = 0.457\ \bar{E}_{\beta}\chi$$

[1] The effect on containment leakage under accident conditions of features provided to reduce the leakage of radioactive materials from the containment will be evaluated on an individual case basis.

The surface body dose rate from beta emitters in the infinite cloud can be approximated as being one-half this amount (i.e., $_{\beta}D'_{\infty} = 0.23\ \bar{E}_{\beta}\chi$).

For gamma emitting material the dose rate in air at the cloud center is:

$$_{\gamma}D'_{\infty} = 0.507\ \bar{E}_{\gamma}\chi$$

From a semi-infinite cloud, the gamma dose rate in air is:

$$_{\gamma}D'_{\infty} = 0.25\ \bar{E}_{\gamma}\chi$$

Where

$_{\beta}D'_{\infty}$ = beta dose rate from an infinite cloud (rad/sec)
$_{\gamma}D'_{\infty}$ = gamma dose rate from an infinite cloud (rad/sec)
$\bar{E}_{\beta}$ = average beta energy per disintegration (Mev/dis)
$\bar{E}_{\gamma}$ = average gamma energy per disintegration (Mev/dis)
χ = concentration of beta or gamma emitting isotope in the cloud (curie/m^3)

f. The following specific assumptions are acceptable with respect to the radioactive cloud dose calculations:

(1) The dose at any distance from the reactor should be calculated based on the maximum concentration in the plume at that distance taking into account specific meteorological, topographical, and other characteristics which may affect the maximum plume concentration. These site related characteristics must be evaluated on an individual case basis. In the case of beta radiation, the receptor is assumed to be exposed to an infinite cloud at the maximum ground level concentration at that distance from the reactor. In the case of gamma radiation, the receptor is assumed to be exposed to only one-half the cloud owing to the presence of the ground. The maximum cloud concentration always should be assumed to be at ground level.

(2) The appropriate average beta and gamma energies emitted per disintegration, as given in the Table of Isotopes, Sixth Edition, by C. M. Lederer, J. M. Hollander, I. Perlman; University of California, Berkeley; Lawrence Radiation Laboratory; should be used.

g. The atmospheric diffusion model should be as follows:

(1) The basic equation for atmospheric diffusion from a ground level point source is:

$$\chi/Q = \frac{1}{\pi u \sigma_y \sigma_z}$$

Where

χ = the short term average centerline value of the ground level concentration (curie/meter^3)
Q = amount of material released (curie/sec)
u = windspeed (meter/sec)
σ_y = the horizontal standard deviation of the plume (meters) [See Figure V-1, Page 48, *Nuclear Safety,* June 1961, Volume 2, Number 4, "Use of Routine Meteorological Observations for Estimating Atmospheric Dispersion," F. A. Gifford, Jr.]
σ_z = the vertical standard deviation of the plume (meters) [See Figure V-2, Page 48, *Nuclear Safety*, June 1961, Volume 2, Number 4, "Use of Routine Meteorological Observations for Estimating Atmospheric Dispersion," F. A. Gifford, Jr.]

(2) For time periods of greater than 8 hours the plume should be assumed to meander and spread uniformly over a 22.5° sector. The resultant equation is:

$$\chi/Q = \frac{2.032}{\sigma_z u x}$$

Where

x = distance from point of release to the receptor; other variables are as given in g(1).

(3) The atmospheric diffusion model[2] for ground level releases is based on the information in the following table.

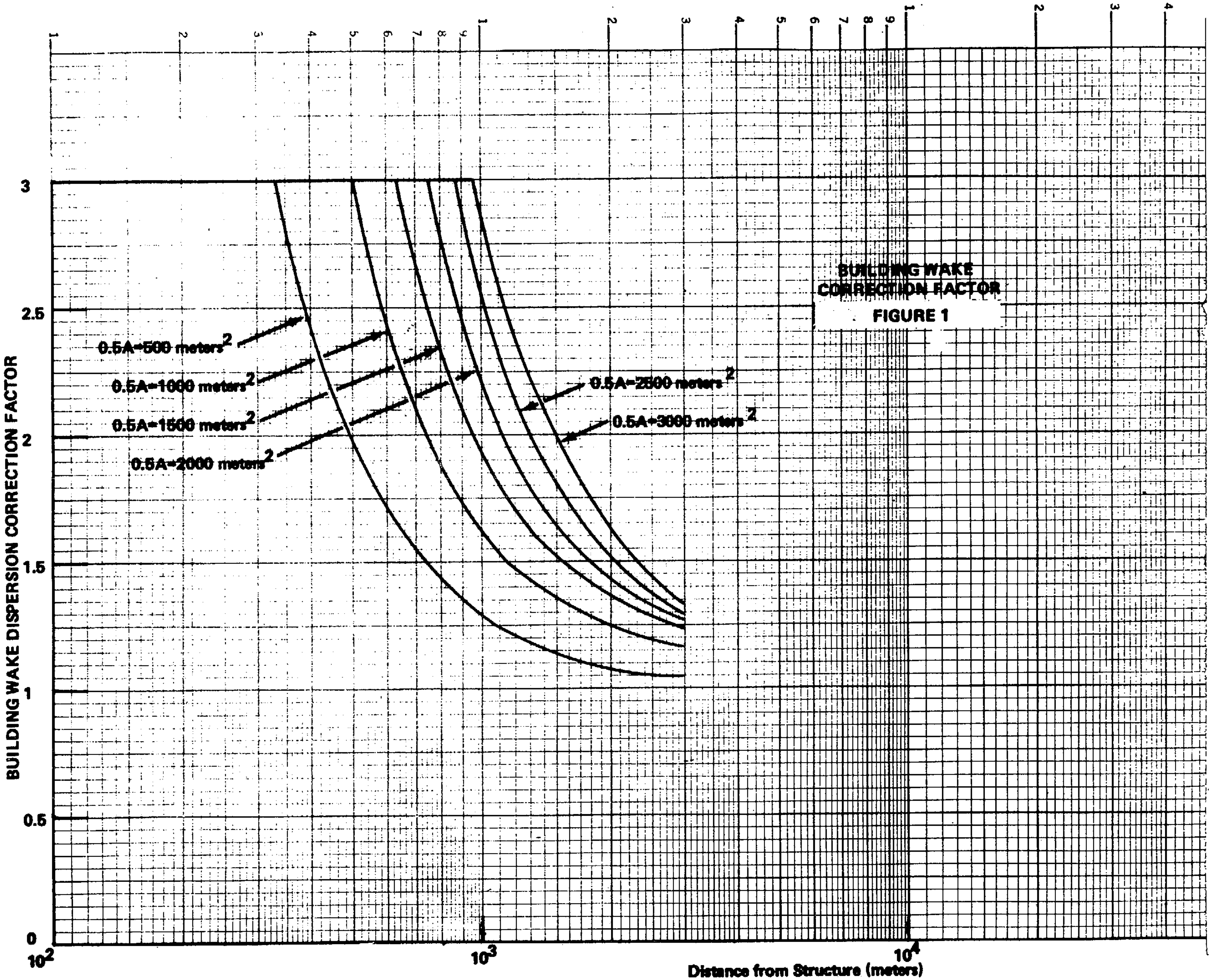
[2] This model should be used until adequate site meteorological data are obtained. In some cases, available information, such as meteorology, topography and geographical location, may dictate the use of a more restrictive model to insure a conservative estimate of potential offsite exposures.

Time Following Accident	Atmospheric Conditions
0-8 hours	Pasquill Type F, windspeed 1 meter/sec, uniform direction
8-24 hours	Pasquill Type F, windspeed 1 meter/sec, variable direction within a 22.5° sector
1-4 days	(a) 40% Pasquill Type D, windspeed 3 meter/sec (b) 60% Pasquill Type F, windspeed 2 meter/sec (c) wind direction variable within a 22.5° sector
4-30 days	(a) 33.3% Pasquill Type C, windspeed 3 meter/sec (b) 33.3% Pasquill Type D, windspeed 3 meter/sec (c) 33.3% Pasquill Type F, windspeed 2 meter/sec (d) Wind direction 33.3% frequency in a 22.5° sector

(4) Figures 2A and 2B give the ground level release atmospheric diffusion factors based on the parameters given in g(3).

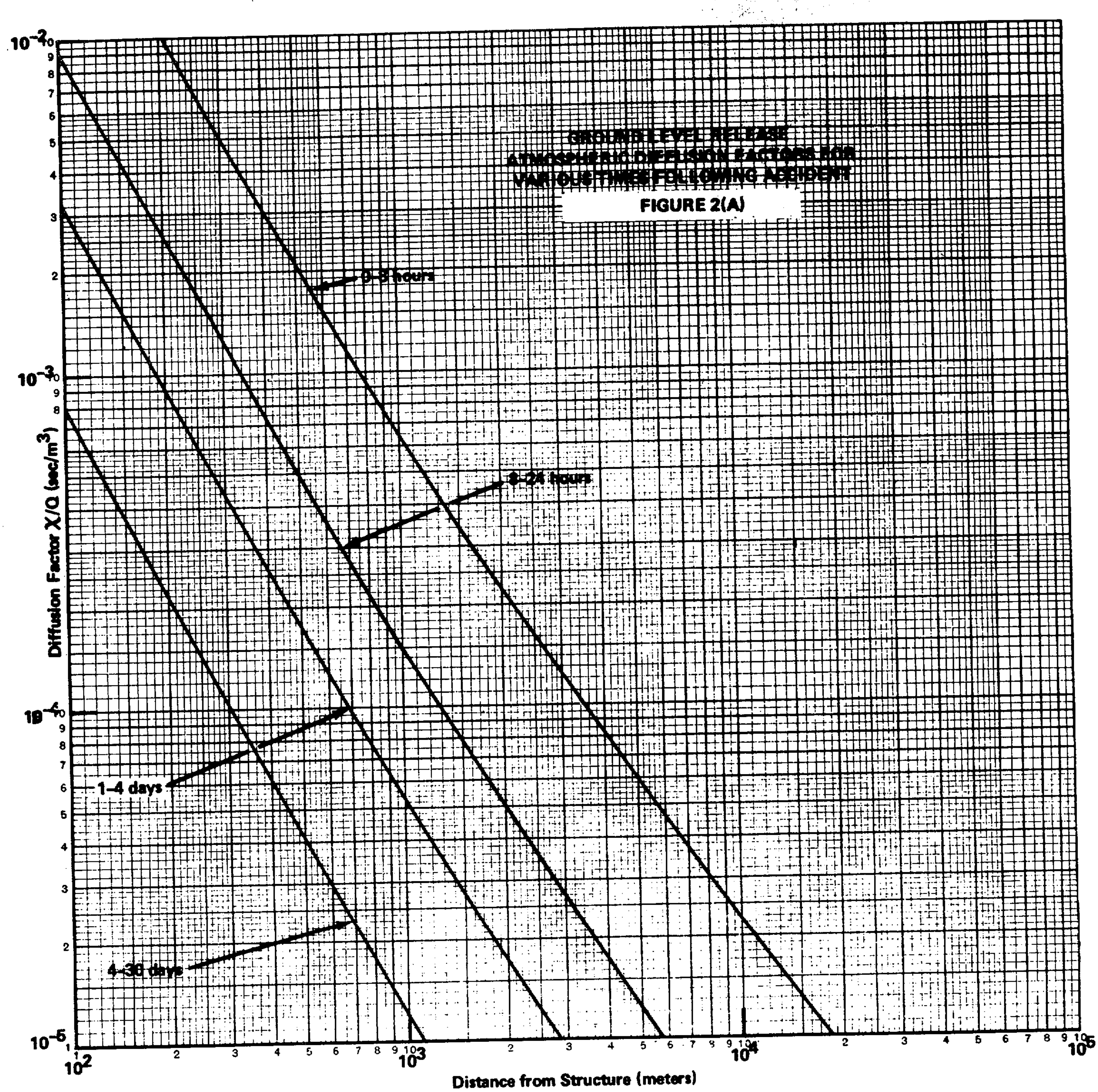
D. IMPLEMENTATION

The revision to this guide (indicated by a line in the margin) reflects current Regulatory staff practice in the review of construction permit applications; therefore, this revision is effective immediately.



BUILDING WAKE CORRECTION FACTOR

FIGURE 1



GROUND LEVEL RELEASE
ATMOSPHERIC DIFFUSION FACTORS FOR
VARIOUS TIMES FOLLOWING ACCIDENT
FIGURE 2(A)
0-8 hours
8-24 hours
1-4 days
4-30 days
Diffusion Factor X/Q (sec/m³)
Distance from Structure (meters)

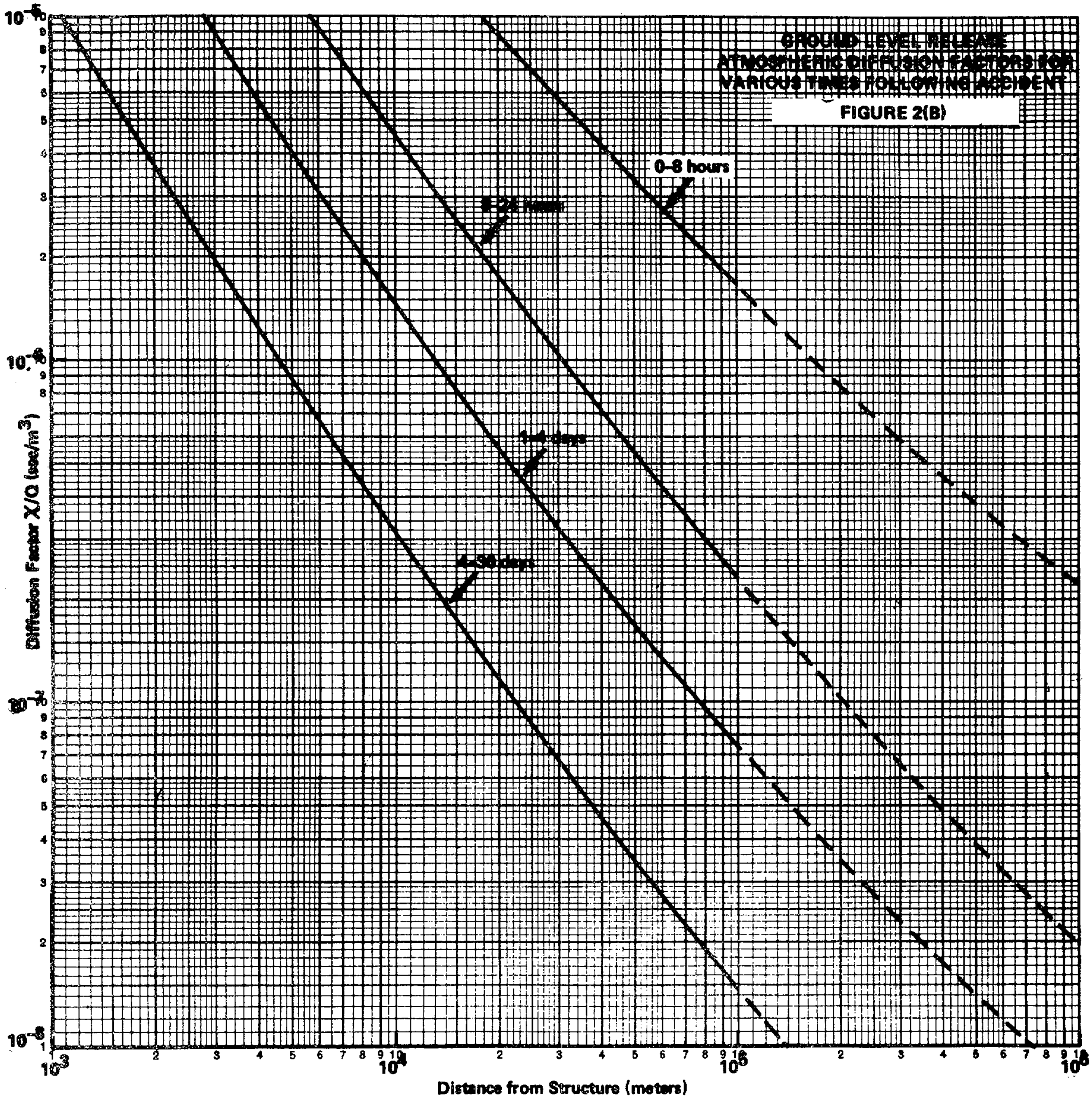

GROUND LEVEL RELEASE
ATMOSPHERIC DIFFUSION FACTORS FOR
VARIOUS TIMES FOLLOWING ACCIDENT
0-8 hours
1-4 days
4-30 days
Diffusion Factor X/Q (sec/m³)
Distance from Structure (meters)

FIGURE 2(B)