SAFETY GUIDE 5

ASSUMPTIONS USED FOR EVALUATING THE POTENTIAL RADIOLOGICAL CONSEQUENCES OF A STEAM LINE BREAK ACCIDENT FOR BOILING 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 steam line break accident 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 safety guide gives acceptable assumptions that may be used in evaluating the radiological consequences of this accident for a boiling water reactor.

B. Discussion

In the process of reviewing a large number of applications for construction permits and operating licenses, the regulatory staff has developed, based on engineering judgment and on applicable experimental results from safety research programs conducted by the AEC and the nuclear industry, a number of appropriately conservative assumptions which are used by the regulatory staff to evaluate the applicant's estimate of the radiological consequences of various postulated accidents. This safety guide lists the assumptions[1] used by the regulatory staff to evaluate the steam line break accident for a boiling water reactor.

C. Regulatory Position

The assumptions related to the release of radioactive material are:

1. The steam line breaks[2] with the reactor at full power[3] and the reactor scrams.
2. The steam line isolation valves close in the maximum time incorporated or to be incorporated in the technical specifications. This closure time will be verified by suitable periodic testing.
3. The total mass of coolant released is that amount in the steam line and connecting lines at the time of the break plus the amount that passes through the valves prior to closure. (Ruptures within the turbine complex are not considered in this guide.)
4. The radioactivity in the coolant is assumed to be the maximum amount incorporated or to be incorporated in the technical specifications, provided that no further fuel failures are assumed to occur as a result of delays in valve closure.
5. All of the iodine (no credit for plateout is allowed) and noble gases from the released coolant are released to the atmosphere within 2 hours at a height of 30 meters with a fumigation condition.
6. The assumptions for dose conversion and atmospheric diffusion are:
   (a) No correction is made for depletion from the effluent plume of radioactive iodine due to deposition on the ground, or for the radiological decay of Iodine 131 in transit.

[1] In some cases, plant design conditions may exist which require special consideration and different assumptions.

[2] For purposes of this guide a steam line break is defined as a complete severance of the pipe and the pipe centerline is offset by at least the pipe diameter.

[3] For certain designs other operating modes (i.e., hot standby) may represent a worse condition. These designs will be evaluated on an individual case basis.

(b) The breathing rate of persons offsite is assumed to be 3.47×10^{-4} cubic meters per second. (This value is developed from the average daily breathing rate [2×10^{7} cm^3/day] assumed in the report of ICRP, Committee II–1959.)

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

(d) External whole body doses are 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.[4]

The following specific assumptions are used:

(1) The dose at any distance from the reactor is calculated based on the maximum concentration in the plume at that distance taking into account special 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 is always 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.

(e) (1) The equation used to determine the atmospheric diffusion from an elevated release at 30 meters, uniform wind direction with a fumigation condition existing is:

$$\chi/Q = \frac{0.0133}{\sigma_y u}$$

Where:

χ = the short term average centerline value of the ground level

[4] Meteorology and Atomic Energy—1968, Chapter 7, "Radioactive Cloud-dose Calculations," lists the following equations:

A. For an infinite uniform cloud containing χ curies of beta radioactivity per cubic meter the beta dose rate in air at the cloud center is:

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

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

B. 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: $_{\gamma}D' = 0.25\bar{E}_{\gamma}\chi$.

Where:

$_{\beta}D'_{\infty}$ = beta dose rate from an infinite cloud (rad/sec)

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$\bar{E}_{\beta}$ = 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)

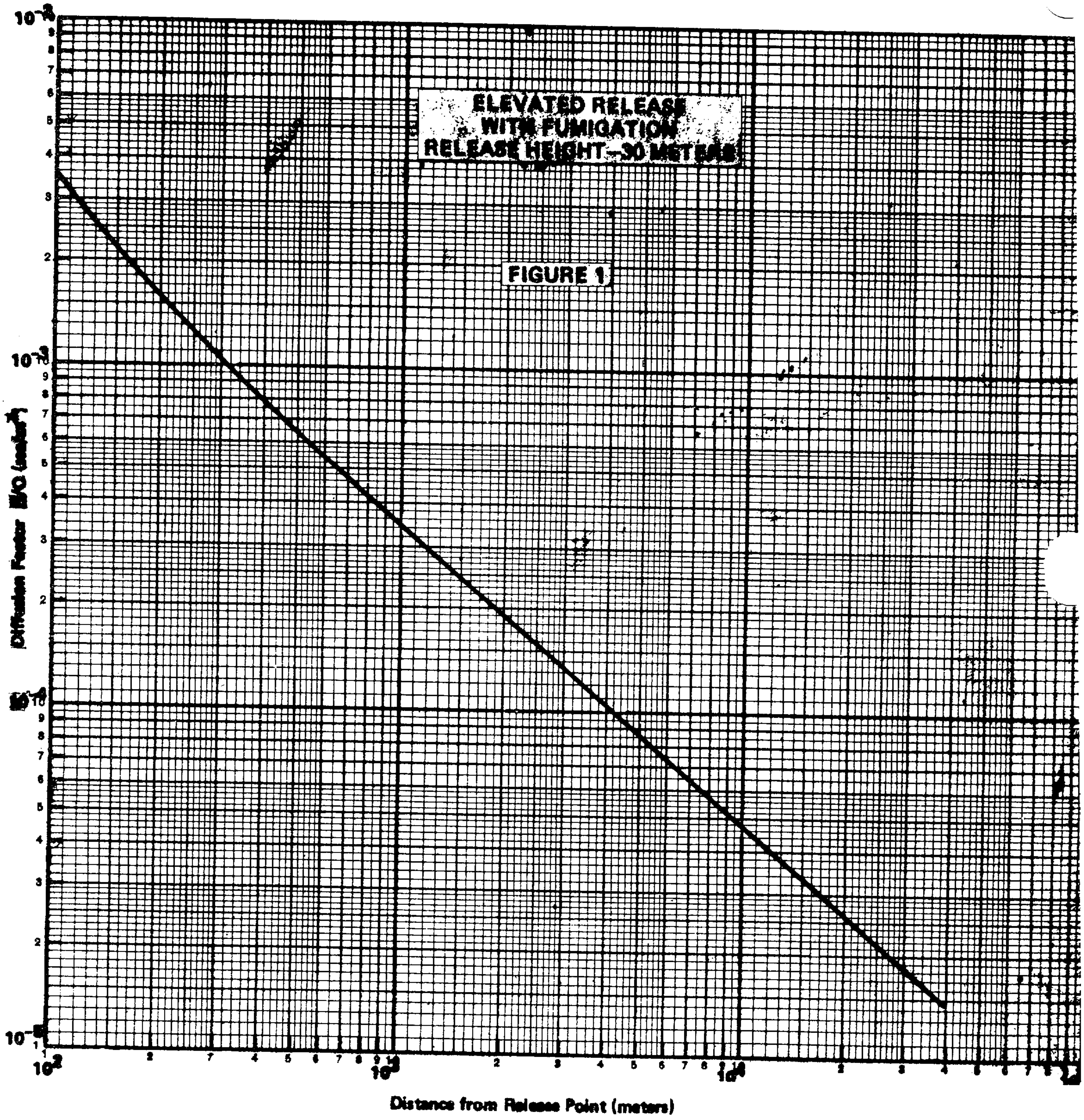
concentration (curies/meter^3)

Q = amount of material released (curies/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.]

u = wind speed (meters/sec)

(2) Figure 1 gives elevated release atmospheric diffusion factors assuming a release at thirty meters, and atmospheric conditions assumed to be Pasquill F, windspeed 1 meter/sec.


ELEVATED RELEASE
WITH FUMIGATION
RELEASE HEIGHT–30 METERS
FIGURE 1
Distance from Release Point (meters)