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ATOMIC INDUSTRIAL FORUM INC.

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August 9, 1961

Mr. Harold L. Price,
Acting Director of Regulation,
U.S. Atomic Energy Commission,
Washington 25, D.C.

Dear Mr. Price:

You will recall that during our recent discussion of AEC's proposed reactor site criteria, I expressed some concern that time had precluded our submitting with our redraft an example based on a different fission product release than had been assumed in the AEC example.

Such an example has now been prepared and we are enclosing it herewith with the request that it be attached to the redrafted criteria forwarded to you under cover of our letter of June 6, 1961.

Although we still believe that the criteria should be published without the inclusion of example calculations, we would favor as a second alternative the inclusion of multiple examples instead of a single example as contained in the draft criteria prepared by the AEC. If a decision were made to include multiple examples, we believe you might wish to consider inclusion of the enclosed example.

Sincerely yours,

Original Signed By
W. K. DAVIS
W. Kenneth Davis, Chairman
Committee on Reactor Safety

WKD:ewd
Enclosure

cc Mr. John Graham
Mr. Robert Lowenstein
Dr. Clifford Beck

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APPENDIX "A-5"

Example of a Calculation of Reactor Siting Distances

I. Calculations made in this appendix are for a pressurized boiling-water reactor with forced recirculation and an integral nuclear superheater. The reactor produces 200 Mw thermal during normal operation. An incident consisting of a recirculation-line rupture followed by the melting of 25% of the core fuel is postulated. A mathematical model is developed to determine the thyroid dose downwind resulting from an assumed effluent-leakage from the reactor building at ground level. Also an expression is developed for the whole-body dose as a result of the direct gamma radiation from the reactor-building source.

a. The assumed releases from the fuel that is melted, to the reactor building are: noble gases 75%, halogens 25%, and solids 1%. No credit is taken for absorption of halogens within the reactor building. The assumed releases are equivalent to 10.8% of the total inventory.

b. Utilizing the design leakage rate (0.2%/day, one half of which is assumed to be at ground level and one half of which is considered noncontributing since it is released to other buildings) and energy loss considerations, a representation for the leakage rate from the reactor building is obtained:

$$L.R. = 8.36 \times 10^{-4}\, V\, t^{-0.076}\, \frac{ft^3}{day},$$

where,

V = reactor building free volume
t = time after attainment of peak pressure

No credit is taken for the reduction in leakage rate that occurs when water is pumped into the building via the feedwater line.

c. It is assumed that the fission products mix with the air and steam in the reactor building and then leak out of the reactor building. Assuming that the fission products decay at the normal rate while in the reactor building, and during cloud travel as well, the source term for the i^{th} isotope after operation at normal power is given by:

$$Q_i = 1.46 \times 10^3\, y_i\, f_i\, e^{-\lambda_i t}\, (1 - e^{-\lambda_i \tau})\, t^{-0.076}\, \frac{curies}{hour},$$

where,

y_i = yield of the isotope
f_i = fraction of the isotope released from the reactor
λ_i = decay constant of the isotope
t = time after attainment of peak pressure
τ = reactor operating time (assumed infinite)

d. Sutton's atmospheric dispersion model is assumed to predict isotopic concentrations following leakage from the reactor building. Due to the turbulence caused by the reactor building, the downwind distance is corrected by use of a virtual source located 30 meters upwind, a value derived by approximating the diffusion at the true source. A factor of two is included in the event the isotopes are reflected by the ground. However, it is expected that certain amounts of elements such as Iodine are absorbed rather than reflected. The resulting equation is:

$$\chi_i = \frac{2\,Q_i}{\pi\, C_y\, C_z\, \mu (x + 30)^{2-n}} \quad \frac{\text{curies}}{\text{meter}^3}$$

Q_i = source as in paragraph c above
C_y and C_z = diffusion coefficients
μ = wind velocity
n = stability parameter
$x + 30$ = virtual-source-corrected downwind distance

e. It is assumed that a severe inversion exists throughout the incident. This condition is defined by:

C_y = 0.4 meters n/2 $\qquad \mu$ = 3600 meters/hour
C_z = 0.07 meters n/2 $\qquad n$ = 0.5

In as much as a finite time is required for the cloud to reach a downwind point, χ_i has a finite value only for $t > t/_\mu$. The zero time is accordingly shifted by allowing $t = t' - x/_\mu$. The above meteorological conditions are substituted in the modified Sutton's equation; a breathing rate of 0.9 cubic meters/hour is assumed; the activity concentrations are summed over the isotopes and integrated over the exposure time; then the inhalation dose is given by:

$$D = \sum_i \frac{8.3\, \gamma_i\, f_i\, (1 - e^{-\lambda_i \tau})\, (\text{S.D.})_i}{(X + 30)^{1.5}} \int_{\frac{x}{\mu}}^{t} e^{-\lambda_i t} \left(t' - \frac{x}{\mu}\right)^{-0.076} dt' \ \text{rem},$$

where: $(S.D.)_i$ = the specific dose for the i^{th} isotope

f. Specific doses for the Iodines were taken from Burnett, N.S. and E., May 1957, viz.,

Isotope	$(S.D.)_i$ $\frac{rem}{curie}$
I^{131}	9.63×10^5
I^{132}	3.66×10^4
I^{133}	2.22×10^5
I^{134}	1.77×10^4
I^{135}	6.3×10^4

Using the above values and the developed expression, the distances at which an integrated thyroid dose of 300 rem occurs for exposure times of 2 hours, and 336 hours (effectively infinity for long-lived Iodines) are calculated. These results are reported in Section 2.

g. Since fifty-five per cent of the reactor-building free volume is above grade, the gamma activity for the whole-body dose is:

$$A = 6.03 \times 10^{16}\ t^{-0.21}\ \frac{ergs}{hour},$$

where

t = time after attainment of peak pressure

With a reactor-building wall-attenuation factor of 0.15, the dose at a distance, x, is given by:

$$D = \frac{2.83 \times 10^7\ Bd\ e^{-\mu x}\ t^{0.79}}{x^2}\ \text{rem}$$

where,

Bd = buildup factor = $1+\mu x+\frac{(\mu x)^2}{3}$

μ = attenuation coefficient for air = 0.01 m^{-1}

x = distance from reactor building

t = time after attainment of peak pressure

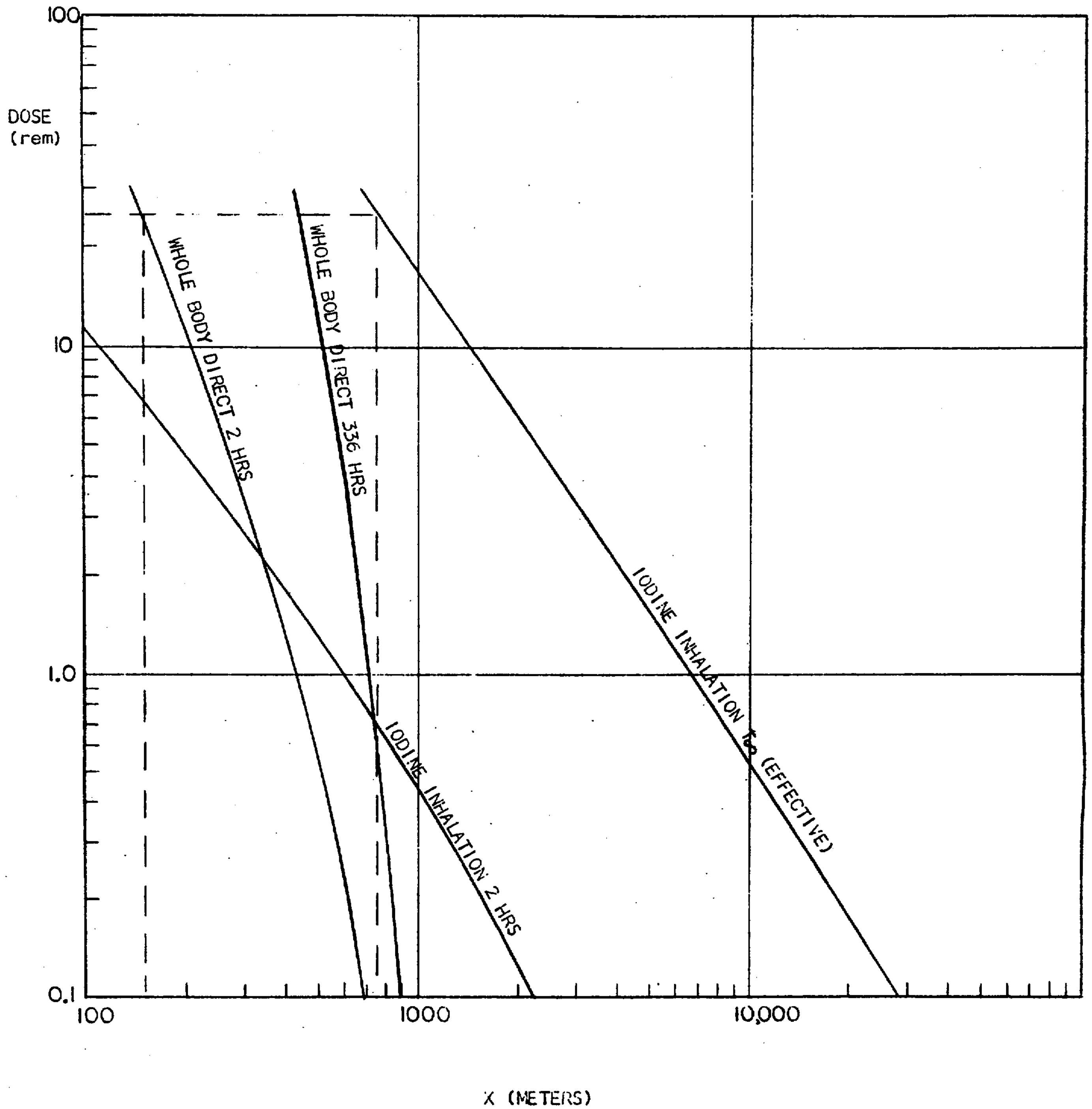
h. Using the expression developed in paragraph g, the distance at which a dose of 25 rem occurs for an exposure time of 2 hours is computed. The dose that is accumulated in 336 hours at the low-population zone boundary (determined from the thyroid-dose calculations) is found. These results are reported in Section 2 below.

2. For the normal operating power (200 Mwth) the exclusion area boundary is 150 meters from the reactor building. This distance is governed by the whole-body dose limitation. The thyroid dose is considerably below the maximum permissible limit at this distance.

For the normal operating power the low-population zone boundary is 750 meters from the reactor building. This dose is governed by the thyroid limit. The whole-body dose is insignificant at this distance.

A graph of the functions used in these computations is given on the following page.

EQUIVALENT WHOLE-BODY DOSE DUE TO IODINE INHALATION
(300 REM TO THE THYROID - 25 REM EQUIVALENT WHOLE-BODY DOSE)
AND
WHOLE-BODY DIRECT RADIATION DOSE



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REMARKS: