1 of 1

UNCLASSIFIED CONTROLLED
NUCLEAR INFORMATION
DuPont de Nemours & Company
Official: *[Signature]*
W. J. Panick, AED Class Officer
128/89
EXPLOSIVES DEPARTMENT

Bcc: W File
M. H. Wahl-C. W. J. Wende- ST File
DPW-36-394
SR/H--781
October 29, 1956
1/28/89

Mr. Maynard E. Smith
Leader, Meteorology Group
Brookhaven National Laboratories
Associated Universities, Inc.
Upton, Long Island, New York

UNCLASSIFIED TO
BY *[Signature]*

Dear Mr. Smith:

Your letter has been referred to me for reply.

We are not currently studying the hazards relating to possible dispersion of fission products. We have done some calculations of the hazards attending reactor operation at the request of the Atomic Energy Commission, the Reactor Safeguards Committee and the Advisory Committee on Reactor Safeguards. Most of this work was directed toward the evaluation of possible hazards at Savannah River, and the meteorological data we obtained in the course of the work are applicable to that site. Some of the calculations are perhaps more general in character, but I do not believe we can add to the understanding of the cloud rise and rainout processes. Our work may be divided into the categories you mention in your letter as follows:

Cloud Rise

D. S. St. John, of Savannah River, has used the method of O. G. Sutton* in ANL-WH2-329 to calculate the height to which a high-temperature cloud will rise. We do not know of any experimental work of the proper scale that could be applied to this problem, excepting perhaps the bomb tests, which have been reported by Los Alamos.

Atmospheric Dispersion

Most atmospheric dispersion formulae make use of the 'drunkard's walk' description of eddy diffusion, as suggested by Rayleigh and others. O. G. Sutton used this method in 'A New Theory of Atmospheric Diffusion', Porton-790, March 12, 1930, TIB (ORNL) to derive his generally-used equations.

Our Engineering Department made an extensive microclimate study in South Carolina several years ago. This is reported in 'Savannah River Stack Gas Dispersion and Microclimate Survey', DP-19, January 1953, by L. L. Falk, et al, E. I. du Pont de Nemours and Company, Inc.

* See: Weather, 2, 105, 1947

Mr. Maynard E. Smith
Page 2
October 29, 1956

DPW-56-394

Incidentally, this same theory of eddy diffusion was used by us with partial success in determining the dispersion of wastes and warm water in rivers, but we have not as yet published anything under this head.

Gamma Dosimetry

These dosage calculations are somewhat standardized. We have used the published methods and data, of which you no doubt have a large file.

In matters dealing with possible deaths, we have used the probability of death with gamma exposure given in Figure 1 as a basis.

Fallout and Rainout

At Savannah River, fallout is probably not a process that would contribute much to the number of off-site deaths, for the plant controlled area is large and the probability of an explosion that vaporizes or shatters the reactor and structure is very low. It is conceivable, however, that some land will be rendered unfit for habitation after a fallout. It is conceivable, too, that large amounts of fission products, probably mostly gaseous, could leak from the buildings following an improbable reactor incident. Therefore, we must consider rainout of fission products from a low-lying cloud as a possibility. Our assumptions concerning rainout are given in "Accidental Dispersion of Reactor Poisons and the Controlled Distance Required", DP-105, February 1955, by R. L. Menegus and H. F. Ring, E. I. du Pont de Nemours and Company, Inc. But we had no data on the rainout process to draw from, and the assumptions relating to rainout were originally suggested by the Reactor Safeguards Committee, and later, by the Advisory Committee on Reactor Safeguards.

General Calculations

In the course of estimating the possible hazards to the people living near the periphery of the plant site, we tried to use as a criterion the expectation number of deaths resulting from an incident of arbitrary magnitude. That is to say, if a certain estimated amount of fission products, measured in megawatts, were to escape, one is concerned with how many off-site persons would probably be killed. A similar basis had been used previously to calculate the controlled distance for the two largest reactor plant sites in the country.

We have calculated the danger by three mechanisms: breathing of, and direct radiation from, the poison cloud; and rainout followed by radiation from the ground. An outline of these

Mr. Maynard E. Smith
Page 3
October 29, 1956

DPW-56-394

calculations is given in "Accidental Dispersion of Reactor Poisons and the Controlled Distance Required", DP-105, February 1955, by R. L. Menegus and H. F. Ring, E. I. du Pont de Nemours and Company, Inc.

In terms of expectation deaths, it was found that direct gamma radiation from the cloud is the most hazardous mechanism. In terms of possible deaths, the rainout mechanism can be the most hazardous.

As you are no doubt aware, the poison will be more dangerous if the wind velocity happens to be low when the fission products are released. In order to calculate the expectation number of deaths, the wind velocity probability in the range of low wind velocities is needed. Such data are plotted in Figure 2. Also shown is the wind direction probability, which should vary appreciably from place to place.

With the probability of low wind velocities, the probability of wind direction, and the probability of death with gamma exposure, one can relate the probable number of deaths with the size of the accident and the controlled distance. The results of these calculations, using average atmospheric dispersion parameters, are given in Figure 3 and plotted in Figure 4.

Very truly yours,

ATOMIC ENERGY DIVISION

R. L. Menegus

R. L. Menegus
Reactor Engineering Section

RLM/s

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

NOMENCLATURE

- $P(r)$ = Probability that a person will die if exposed to r roentgens of gamma rays.
- r = Exposure in roentgens from the airborne fission products.
- $P(v)$ = Probability that the wind velocity will be v or less.
- v = Wind velocity in miles/hr.
- $P(\theta)$ = Relative probability that the wind will blow from the reactor toward the receptor at angle θ .
- θ = Angle measured clockwise from North.
- p = Reactor power level in MW.
- f = Fraction of the fission products contained in the reactor that are liberated in the accident.
- a = Afterheat of fission product decay as a fraction of full power.
- $a \approx 0.016 (\text{time after shutdown in hours})^{0.2}$
- t = Time that a receptor remains in the poison cloud in hours.
- τ = Time that it takes for the fission products to be liberated from the reactor in hours.
- D = Controlled distance in miles. No one lives closer to the reactor than D miles. D may be a function of θ .
- N = Number of people per square mile in any sector outside of D . Note from Figure 4 that if $P(\theta)$ or N are large in any direction, then D must be larger in that direction than in any other direction.
- X = Expectation number of deaths per accident. If one chooses to calculate the D required, X must be chosen arbitrarily.

1764

AIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910

301/587-8202

Centimeter

Inches

MANUFACTURED TO AIM STANDARDS
BY APPLIED IMAGE, INC.

DATE

FILMED

12 / 7 / 94

END