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RADIOLOGIC HAZARDS PREDICTED FOR A GIVEN HEIGHT BURST OF AN ATOMIC BOMB

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HEALTH AND BIOLOGY

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APR 30 1951	LA-1231
Los Alamos	1-20

STANDARD DISTRIBUTION

Argonne National Laboratory	21-28
Armed Forces Special Weapons Project	29
Atomic Energy Commission, Washington	30-52
Battelle Memorial Institute	53
Brookhaven National Laboratory	54-57
Bureau of Medicine and Surgery	58
Carbide & Carbon Chemical Division (K-25 Plant)	59-60
Chief of Naval Research	61
Columbia University (Dunning)	62
Columbia University (Failla)	63
General Electric Company, Richland	64-69
Hanford Operations Office	70
Idaho Operations Office	71-76
Iowa State College	77
Kellex Corporation	78
Knolls Atomic Power Laboratory	79-80
Mallinckrodt Chemical Works	81
Massachusetts Institute of Technology (Kaufman)	82
Mound Laboratory	83-85
National Advisory Committee for Aeronautics	86
Naval Medical Research Institute	87
Naval Radiological Defense Laboratory	88
Naval Research Laboratory	89
NEPA Project	90
New Brunswick Laboratory	91
New York Operations Office	92-94
North American Aviation, Inc.	95
Oak Ridge National Laboratory, X-10 Site	96-103
Carbide & Carbon Chemical Division (Y-12 Area)	104-107
Patent Branch, Washington	108
Public Health Service	109
Sylvania Electric Products, Inc.	110
Technical Information Service, Oak Ridge	111-125
UCLA Medical Research Laboratory (Warren)	126
University of California Radiation Laboratory	127-132
University of Chicago Toxicity Laboratory	133
University of Rochester	134-135
University of Washington	136

[redacted]

HEALTH AND BIOLOGY

Western Reserve University (Friedell)	137-140
Westinghouse Electric Corporation	141
Chicago Patent Group	142
du Pont Company	143-148
New Operations Office	149

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Abstract

An appraisal is made of the radiologic hazard created by a 1000-ft. high air burst of a nominal sized nuclear bomb. Three sets of graphs are included which show the relations between dose rate (milliroentgens per hour), time post-shot, and distance from Ground Zero for a soil having given constituents. Estimates are given for fall-out activity (gamma) for distances up to about 200 miles from Ground Zero immediately after fall-out. It is pointed out that the radiologic hazard due to fall-out in the example cited is insignificant; further, that the radiologic hazard from similar nuclear bombs bursting at different heights above the ground will vary to a considerable extent.

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In this report there are presented the results of some calculations of the radiologic hazards to be expected following a moderately high burst of a nominal sized atomic bomb. In "The Effects of Atomic Weapons", a high burst is defined as one above 500 feet, and it is stated that bursts at about 2000 feet will yield no significant hazard due to residual radiation from the ground under the burst. Certain results have made it possible to make rough estimates of residual radiation following a high burst below 2000 feet, and a height of 1000 feet was chosen for the calculations. It is emphasized that the calculations are subject to considerable uncertainties, but it is not believed that these uncertainties are big enough to render the results useless for the purpose of orientation in radiological defense planning.

The reader is cautioned very strongly that variations in the height above ground at which the bomb is detonated will very markedly affect the degree of residual radiation which is left. A detonation at 2000 feet, as stated before, would leave no residual radiation of any significance to health, while one at 500 feet would leave behind radioactivity of a particularly high level. For this paper a height of burst of 1000 feet has been chosen. In an atomic disaster there would in all probability be no accurate estimates as to the actual height of burst.

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The results of the calculations are in two parts. The first part gives the estimated gamma radiation dosage rate on the ground under the burst. The second part gives estimates of the residual radiation due to fall-out at distances up to about 200 miles from the burst.

Part One

This residual radiation is due solely to activation of the soil by the radiation from the bomb. It is not due to fission products, because the fireball of a nominal atomic bomb at 1000 feet will not touch the ground. The activation of the soil depends on its chemical composition. It appears that, generally speaking, activated sodium is likely to be the most important factor in residual radiation under such circumstances, and the results have been adjusted to an assumed average soil content of 1 to 1.5% sodium by weight.

Graph No. 1 shows the relation which exists between the elapsed time after the burst and the distance from Ground Zero for several constant dose rates. For example, if one did not want to exceed 100 milliroentgens per hour, by referring to curve "B", one notes that at about 4 hours post-burst he may approach to about 800 yards of Ground Zero. After 48 hours, he may approach to about 300 yards.

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If the cleaning up of the bombed area occurs at about 8 hours after the burst, the intersections of line E E' with the various isodose-rate curves shows the distances from Ground Zero corresponding to the given dose-rate levels. Line E E' shows that at about 8 hours post-shot, 1000 mr/hr will be indicated at 390 yards; 100 mr/hr will be indicated at 760 yards; 10 mr/hr will be indicated at 1170 yards; and 1 mr/hr will be indicated at 1700 yards from Ground Zero.

On the other hand, if the area which is to be cleaned up is located, say, at about 800 yards from Ground Zero, one will receive in this area a dose rate of 100 mr/hr at a time 4 and 1/2 hours post-shot, and 10 mr/hr at a time 38 hours post-shot.

Graph No. 2 shows the relation which exists between the same quantities as does Graph No. 1; however, in this case, the distance is kept constant for each curve and the dose rate and time are allowed to vary. Isometric curves are drawn at 100-yard intervals between 300 and 1800 yards from Ground Zero. For example, at 800 yards one will receive a dose rate of about 100 mr/hr at a time 4 and 1/2 hours post-shot. He will receive about 10 mr/hr at a time 38 hours post-shot. Refer to points A and B on the 800-yard curve.

Vertical lines such as line E E' show the relations which exist between dose rate and time post-shot for given distances from

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Ground Zero. For example, line E E' which has been drawn at a time 16 hours post-shot, shows that 9 mr/hr (point C) is indicated at 1100 yards, and 72 mr/hr (point D) is indicated at 700 yards.

The horizontal lines show the relations existing between distance from Ground Zero and hours post-shot for given dose rates. Referring to horizontal line F F', point G has a level of 50 mr/hr at a distance of 700 yards from Ground Zero at a time 21 and 1/2 hours post-shot. Point H has the same radiation level, but at a distance of 400 yards from Ground Zero at a time 50 hours post-shot.

Graph No. 3 shows the relation which exists between similar quantities as above; however, in this case, "time post-shot" has been held constant and the dose rate and distance from Ground Zero are allowed to vary. On the "1 hour" isochronal curve, point A indicates a radiation level of about 100 mr/hr at about 890 yards from Ground Zero. Point B on the same curve indicates a radiation level of 10 mr/hr at 1300 yards from Ground Zero. Similarly, dose rate-distance data are indicated for points C and D on the 51-hour isochronal curve.

Horizontal and vertical lines (examples are lines E E' and F F', respectively) may be used for this set of curves as was done with the above two sets.

These curves may be used to prepare tables showing the relation between dose rate, distance, and time post-shot. From such tables

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it is possible to prepare similar estimates for bomb bursts at heights other than 1000 feet.

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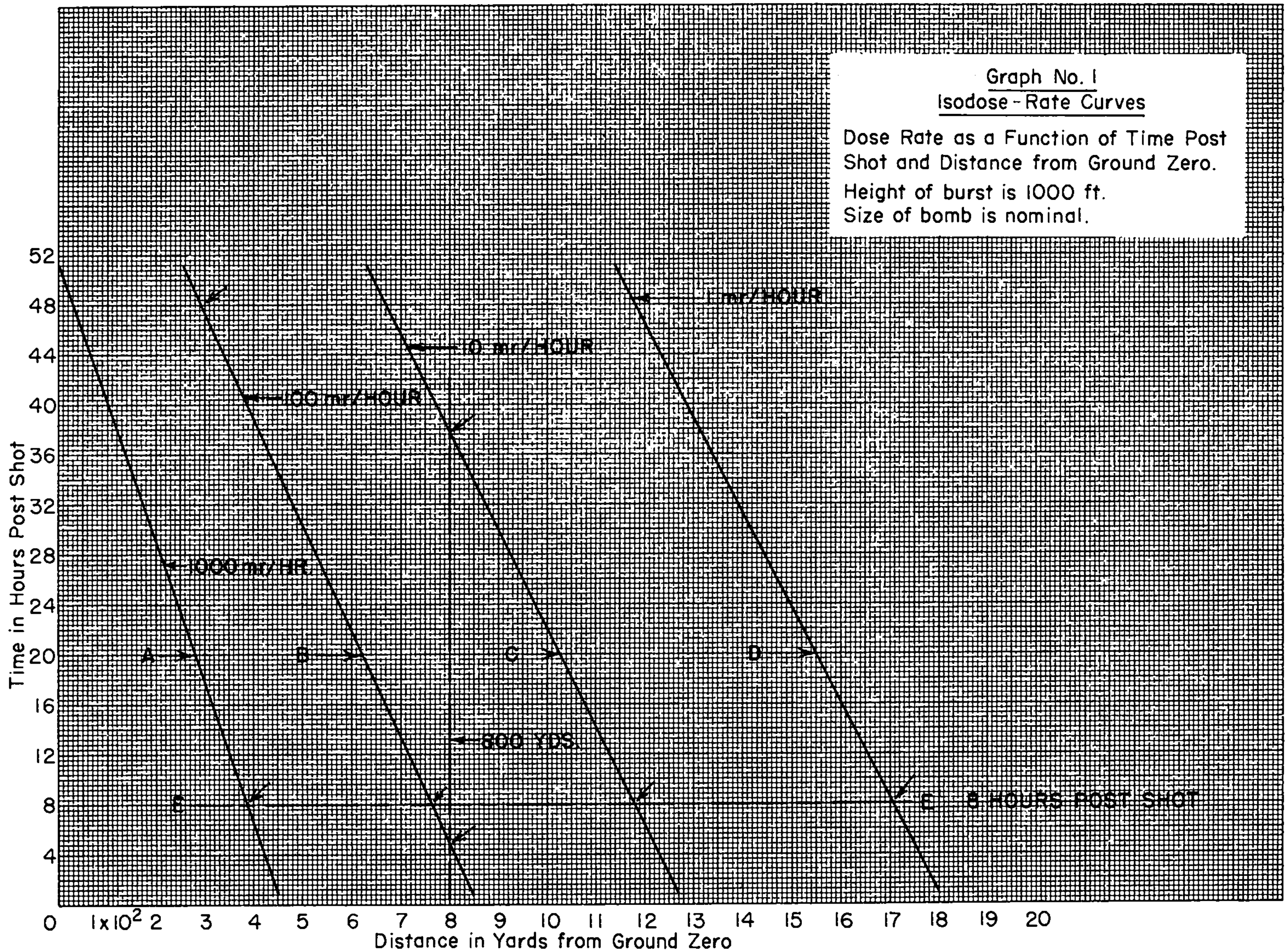

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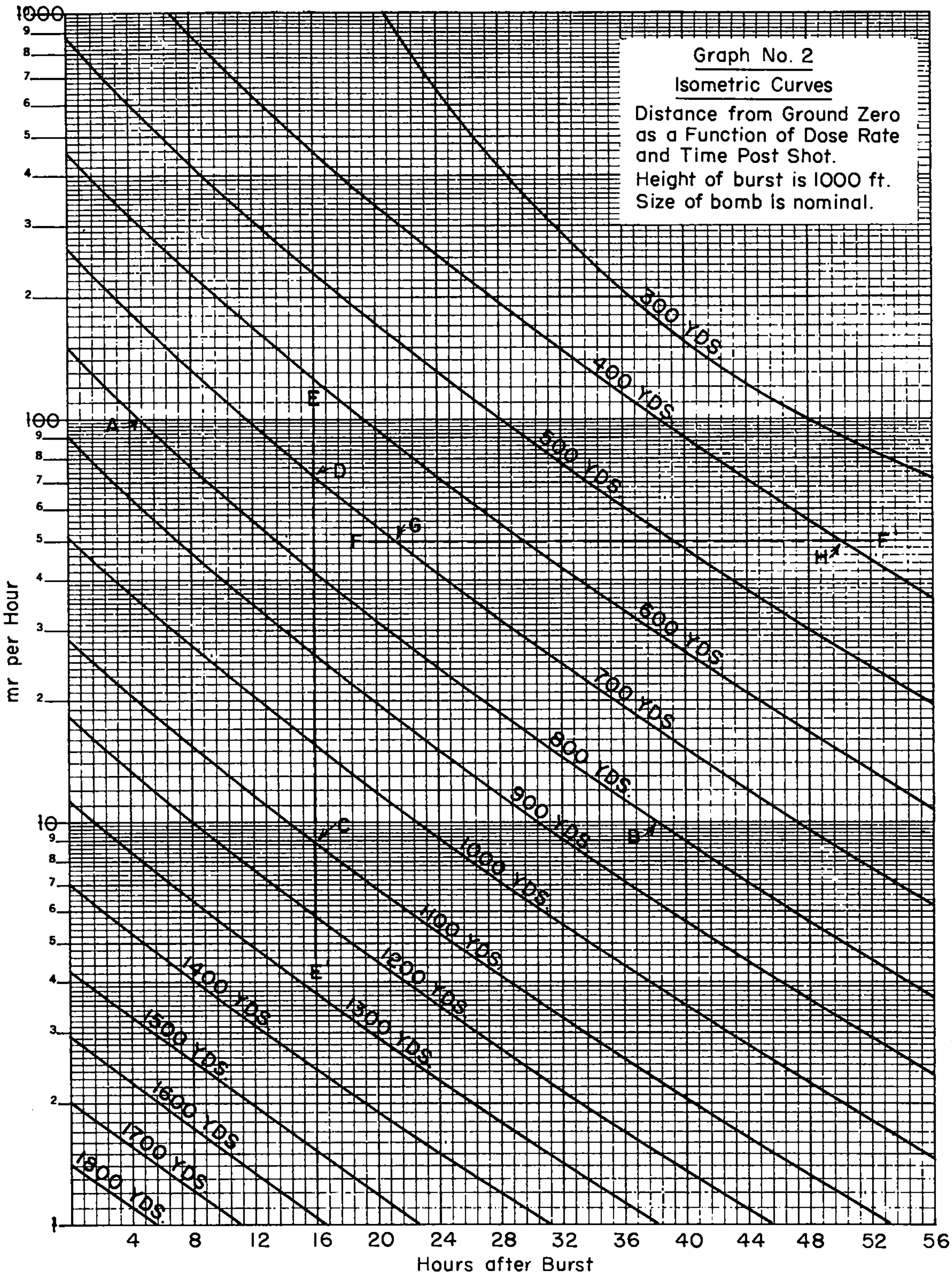

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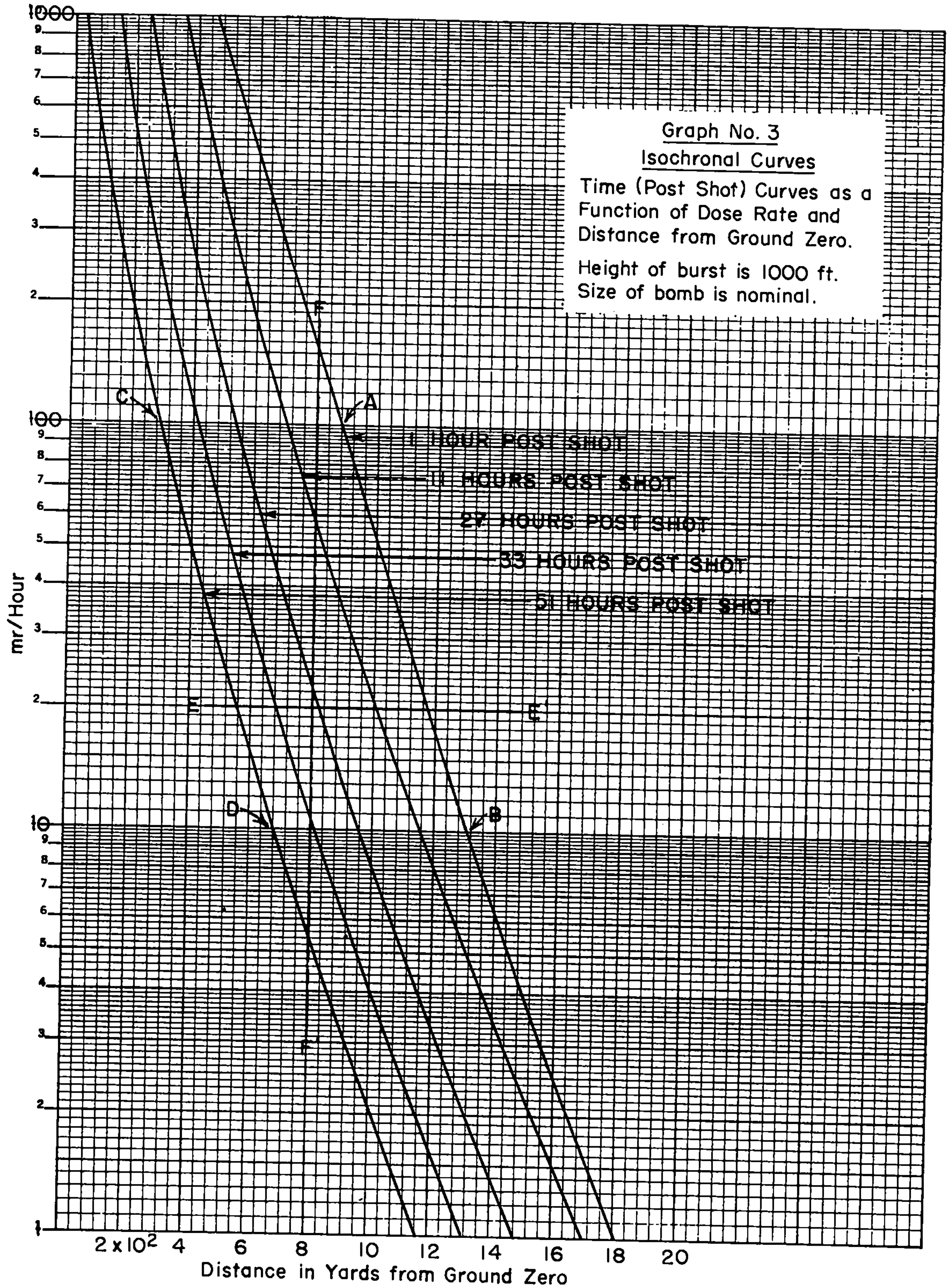

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Part Two

It is emphasized that these estimates depend considerably upon the character of the soil in the target area as well as upon the wind at various altitudes. It is assumed here that we have a loose, dusty soil with a sodium content of about 1 to 1.5% *. It is further assumed that the average wind velocity is 18 to 20 mph at a height of 10,000 feet above the ground. The depth of the dust-bearing "stem" is assumed to be from 2,000 to 16,000 feet above the ground.

One must realize that because of the turbulence of the air in and around the fireball, considerable fission products are mixed in with the ground dust particles in the stem of the cloud. If the stem moves into a mountain peak, in addition to the ground dust fall-out there will be radiation indicated from the airborne fission products. This occurrence will tend to give a false indication concerning fall-out activity.

Assuming that there is no precipitation (rain or snow), it is estimated that the maximum fall-out of activated dust within a radius of 50 miles is of the order of 5 mr/hr of gamma radiation. This radiation level is of course beyond the immediate proximity of

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* Other soil constituents in this estimate are: Mn 0.03 to 0.05%, V $\sim$ 0.01%, and Si about 23%. Refer to "The Nature and Properties of Soils", The MacMillan Company, 1943, page 23, for other selected analyses.

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Ground Zero. If there are airborne fission products present, the instrument reading will be higher accordingly. As an example, 10 mr/hr of gamma radiation could be indicated for such a condition.

In the zone between 50 and 100 miles from the burst, the estimated maximum level due to activated ground dust fall-out is of the order of 2 mr/hr of gamma radiation.

In the zone between 100 and 150 miles from the burst, the estimated maximum level is of the order of 0.1 mr/hr.

Beyond the 150-mile zone the estimated maximum level is of the order of 0.05 mr/hr.

Since the approximate significant level of the activity chosen for this example is about 50 mr/hr, one would suspect that in reality no health hazard is indicated for this type of fall-out. On the other hand, airborne fission products, together with small (0.3 μ) particles of plutonium and/or uranium, present a different problem in regard to inhalation in its relation to the general health hazard problem. This report has not included a discussion of the inhalation problem.

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