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MEETING OF A COMMITTEE
TO CONSIDER THE FEASIBILITY AND CONDITIONS
FOR A PRELIMINARY RADIOLOGIC SAFETY SHOT
FOR JANGLE
LOS ALAMOS SCIENTIFIC LABORATORY
MAY 21 AND 22, 1951

491

PRESENT:
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(And a few more)

The function of the Committee is to determine whether an underground burst of an atomic bomb that will rupture the surface to a substantial degree can be carried out with safety in the continental United States and, in the event that this is determined feasible, to recommend the site and the meteorological, physical, and biological data to be obtained as a result of the burst.

The Atomic Energy Commission has accepted responsibility for the series of tests so far as radiologic safety, cratering, and blast effects are concerned. The factors that led to the abandonment of the Amchitka site were discussed.

After a general review of the data available and the data desirable to be obtained in an underground test primarily aimed at determination of radiologic safety, each of the participants outlined those points of importance within his field of competence. With these as a basis, the discussion became general.

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It was unanimously agreed that a one-kiloton, U^{235} bomb was desirable for the test. It was further agreed that from a standpoint of operational efficiency, no more than two weeks should elapse between the series of tests, the results of the instrumentation of each test being taken as the controlling factor for the following test or tests.

In the discussion, it was clearly recognized that the Committee was dealing with a series of problems in statistical probability. The Alamogordo fall-out data are the most pertinent because the fireball there came in contact with the earth. In light of the data available, beta or gamma external radiation hazard would not occur beyond a 40-mile radius under the proposed test conditions.

The remaining hazard was considered to be from the inhalation and retention in the lung of radioactive particles. It was pointed out that particles up to 10 micra in diameter may be carried for hundreds of miles. The most significant particles from the harmful standpoint are those of about one micron in diameter, owing to their retention in the lung; those over 10 micra are not significant insofar as inhalation hazard is concerned; and those of 5 micra and above are of only minor significance.

The hazard in the lung is that of carcinogenesis. It was pointed out that isolated particles retained in the lung would probably not be carcinogenic, owing to the small number of cells affected by each, even though an effective total dose of radiation might be provided in the immediate vicinity of a given particle. It was further pointed out that there already exists an opportunity for appreciable portions of the population of the Northern Hemisphere to inhale and retain particles, as a result of previous tests, but the significance of this event and its statistical probability are so slight as to render the actual hazard negligible. The actual risk involved is currently under study.

As a result of the discussion up to this point, it became apparent that there were two sites within the continental United States which might be expected to meet suitable criteria: at the Las Vegas site and at Camp Irwin, California.

The general criteria for the initial or radiologic safety test are as follows:

<u>Criteria</u>

A. <u>Geological</u>

1. A basin at least partly enclosed by mountain ranges, in the expectation that the rise would tend to hold large particulate matter within the basin -- and additionally, to produce a deposit of finer particulate matter on the far sides of the ranges by descending air currents.

2. A low level of ground water. The large amount of fission products in the crater will not be adsorbed and held because of the absence of clay, and hence may tend to migrate to the ground water and show up in water supplies of grazing stock.

3. A soil predominantly silica. Preliminary studies should be made of soil chemistry and particle size distribution.

4. For the test itself, there is required a deep, unconsolidated mass of soil with an absence of faulting in the area to be instrumented for ground shock.

5. The depth of the first shot should be planned so that the resultant cloud will be contained initially between the 1000 and 4000-foot levels.

B. Meteorological

1. Wind velocities in the lowest 1000 feet should be 5-10 mi/hr with persistent direction with time -- that is, steady for at least 2 hours just prior to the test. Vertical wind shear in direction and velocity is acceptable provided the trajectory of the entire cloud mass is confined to a sector which contains minimal population within a radius of 50 miles.

C. Radiological Safety.

1. The external dose to non-participating inhabitants, of radiation from gamma rays, shall not exceed the accepted international permissible dose level of 300 mr/wk (1.8 mr/hr).

2. At any point of human habitation, the activity of radioactive particles in the atmosphere, averaged over a period of 24 hours, shall be limited to one microcurie per cubic meter of air (corresponding approximately to a ground level gamma intensity of 0.3 mr/hr).

3. The 24-hour average radioactivity per cubic meter of air, due to suspended particles having diameters in the range 0.5 micron to 2.0 microns, shall not exceed 10^{-2} microcurie; nor is it desirable that any individual particle in this size range have an activity greater than 10^{-2} microcurie calculated to 4 hours after the blast.

Note: It is assumed that the particulate matter comprising the allowable activity of one microcurie per cubic meter of air will have a normal distribution of particle sizes ranging from a few tenths of a micron to possibly several hundred microns. See Appendices II and III.

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D. Radiological Test Data to be Obtained

1. Gross observations on the cloud:

   a. on the surface: follow the cloud in detail up to 50 miles, taking data on wind, height of cloud, diameter, dissipation, local variations due to wind currents, etc.

   b. in the air: follow the general contour of the cloud until level of twice background is reached. (Details will be worked out with AFOAT.)

2. Measurement of external radiation at ground level during passage of the cloud, along trajectory of the cloud.

3. Ratio of beta to gamma activity at various points and times along the trajectory and at places of appreciable fall-out.

4. Detailed plot of fall-out, from rim of crater through areas showing approximately twice background intensity.

5. Gross observations on the crater, including size, lip formation, quantity of earth deposited nearby, amount of radioactivity retained in the crater, etc.

6. Requirements for off-site monitoring in relation to protection of personnel, including wells and ground water.

7. Sampling for concentration of oxides of nitrogen.

8. An evaluation of decontamination problems about the site, need for filling and covering the crater, etc.

9. Accumulation and distribution of particulate matter in the lungs of test animals. (Note: can this better be done in the laboratory?)

10. Particle studies on the ground and in the air.

    a. Chemical constitution of the soil, and particle size distribution of the soil before the test.

    b. Particle size distribution of radioactive particles at various locations downwind for about 50 miles.

    c. Specific activity of the particles.

    d. Chemical composition and physical constitution -- how much "plating" occurs?

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c. Concentration in the air.

11. Analysis procedures should be previously developed to a point which will permit the above data to be adequately evaluated within a period of 7--10 days.

Note: Item 1. b. will be the responsibility of AFOAT.

Items 10, and 11. are to be primarily the responsibility of the Operations Group.

Other items will be the responsibility of the Division of Biology and Medicine until otherwise assigned.

Recommendations

It is the unanimous agreement of the Committee that a test involving the explosion of a 1 kiloton $Uranium^{235}$ bomb, under the conditions stated in the body of the report, can be carried out without undue hazard. The Committee recommends that the test be made.

The Committee recommends that the two subsequent tests planned for this series follow on schedule, unless some adverse occurrence becomes evident, in which case the Committee would review the evidence for further decision.

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APPENDIX I

Some reasons for thinking that 44 miles from zero is a safe distance from any concentrated fall-out.

1. The two cases of concentrated fall-out that have been observed are:

   (a) Trinity 23 miles from zero
   (b) Eniwetok 25 miles " "

   Both distances are considerably less than 44 miles.

2. 1 KT is 1/20 of Trinity
   1/90 of Eniwetok

3. Cloud height would be much less for an underground blast, and therefore travel before fall-out should be less.

4. Mountain ridges between proposed zero point and population at 44 miles will exert a filtering action.

5. In an underground shot, a large fraction of the activity will remain in the crater.

6. The great amount of earth carried up may cause a density current (base surge) and cause much of the cloud to fall out in the immediate vicinity of ground zero.

7. Observations at Eniwetok show that fall-out is in very large particles (100 to 200 microns) and far too big to be inhaled.

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APPENDIX II

Hazard Due to Radioactive Particles in the Lung

It is not obvious that a very nonhomogeneous distribution of radiation is always more toxic and therefore less tolerable than a uniform distribution. A cell or tissue-mass cannot be killed more than once. Therefore it would seem better, for example, to subject one-tenth of a vital organ to ten times the lethal radiation dose and the other nine-tenths of the organ to no radiation, than to subject the whole organ to the lethal radiation dose.

It is sometimes asserted that a nonuniform distribution of radiation is more likely to produce cancer than uniform distribution. Under some conditions on a macroscopic scale, this appears true. Many early radiologists and workers with radium developed malignant tumors arising from the epithelial tissue of the hands. The same total dose to the skin, if uniformly distributed over the body, would probably have produced no malignant changes anywhere. Yet it does not follow that highly concentrated radiation from a radioactive particle can produce a malignancy.

Many pathologists do not believe that cancer is due to a somatic mutation which produces a malignant cell. There is usually a gradual change from benign to malignant growths -- that is, histological changes from normal to abnormal to malignant. A relatively large group of cells in a tissue must be affected, leading to a struggle for existence. Osteogenic sarcoma due to radiation is nearly always preceded by irritation and inflammation, which is true for other cancers also. Normal metabolic processes, such as one might expect to find in the vicinity of small groups of cells which had been irradiated, are very likely to prevent cancer development. As an example, experiments on rabbit ears have shown that 25,000 r over an area of 1 square millimeter does not cause marked damage, but over an area of 1 square centimeter, that dose produces severely damaging effects.

Particulate matter having a diameter of approximately 1 micron is most likely to be retained indefinitely in the lung, and if the particle be insoluble and radioactive, it might deliver a very high dose of radiation to a small localized region of tissue.

The retention of particles placed directly in the lung is at a minimum (about 20%) for particles of diameter about 0.5 micron, and becomes greater for both larger and smaller particles. When such particles are breathed, however, large particles are either filtered out in the nasal passages or are rapidly swept out by the bronchial cilia, with the result that the number of particles of diameter greater than 5 microns which find their way into the lungs is negligible. A few

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5-micron particles may be retained for a relatively short time, but the retention is of significance only between about 0.5 and 2.0 microns diameter.

A particle of this size which might carry a beta-ray activity of one-hundredth microcurie, and become fixed in one spot in the lung, say 4 hours after the shot, would deliver an average dose of about 385 rep to a millimeter sphere of tissue surrounding it. On the basis of the above discussion, however, it is not considered probable that such a localized dose of radiation from a few such particles would be hazardous. On the other hand, a large number of such foci in the lung, such as might result from breathing a high concentration of such particles, might conceivably interfere with normal metabolic processes and hence lead to lung cancer. It therefore appears desirable to limit the number of such particles which might be breathed and retained.

It was noted, however, that 3 particles per cubic meter is just about the lower limit of measurability. The breathing of air containing particles at or below this limit would be extremely difficult to evaluate statistically.

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APPENDIX III

Permissible Number of Radioactive Particles in the Air

It was suggested that the permissible activity of fission products in the air be limited to one microcurie per cubic meter of air. The external gamma radiation intensity at a point on the ground, due to fission-product activity in an infinite atmosphere above, is given by the formula:

$$\text{Gamma intensity } (r/hr) = 3 \times 10^5 \times (\text{curies/liter})$$

or

$$\text{Gamma intensity } (mr/hr) = 0.3 \times (\text{microcuries/cubic meter})$$

Hence the recommended limit of 1 microcurie/m^3 would result in a ground intensity of 0.3 mr/hr. The maximum permissible level of 300 mr/wk corresponds to approximately 2 mr/hr.

If all the fission products from the bomb (assumed to be 10^8 curies a few hours after the blast) were in the form of 1-micron particles (approximately 10^{21} particles from a 500-cubic-yard crater), each particle would have an activity of 10^{-7} microcuries. The permissible limit of 1 microcurie per cubic meter of air would hence consist of ten million particles per cubic meter. If the particles were 100 microns in diameter, there would be 10 particles per cubic meter.

It may be assumed, however, that the particle sizes will have a normal distribution of diameters from a few tenths to several hundred microns, and that only a few will lie in the range between 0.5 and 2.0 microns. If the number of particles in this range be limited to carry a maximum radioactivity of 10^{-2} microcurie per cubic meter of air, there could conceivably be a hundred thousand 1-micron particles per cubic meter of air, each with the activity of 10^{-7} microcurie. It is also conceivable that all the permissible activity of 10^{-2} microcurie could be concentrated in a single particle, which if lodged in the lung four hours after the blast, would deliver an average integrated dose of 385 rep to the millimeter sphere of tissue immediately surrounding it. It is, however, difficult to conceive how a particle this "hot" could be formed. Also, specific activities following previous tests have been observed to be approximately constant for all particle sizes, and to have a value of 10^{-9} curies per 10-micron particle, 200 hours after the blast. Calculated back to 4 hours, a 1-micron particle would have an activity of about 6×10^{-4} microcurie, and a 2-micron particle would have an activity of about 5×10^{-3} microcurie. Thus it seems improbable that particles in the range 0.5 to 2.0 microns will be found with radioactivities greater than 10^{-2} microcurie. Should such be observed, the phenomenon must be reevaluated in terms of health hazard in connection with the proposed tests to follow.

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APPENDIX IV

There is evidence from Alamogordo and Eniwetok that concentrations of activity resulting from fall-outs are caused by a "plating" of active material on larger soil particles (50-150 microns) that are carried up into the cloud by the blast.

A distinctive feature of the Jangle test is the fact that very large amounts of rock and mineral particles will be involved in the blast. Available data suggest that something on the order of 50,000 cubic yards of dust size particles may be removed from the crater.

It is possible that the dust cloud which may be expected to form in Jangle will include an appreciable number of particles in the 50-150 micron size range which will be active due to the "plating" effect. It is probably necessary to determine the extent to which such an effect will occur before it is possible to predict either the fall-out pattern or the distribution of the activity generated by the blast.

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