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 SAFETY AND RADIATION PROTECTION FOR NEVADA TESTS

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Since 1951 there have been six series of full scale nuclear tests at the Nevada Test Site with a total of 69 detonations. The three principal effects from these detonations have been the thermal radiation, the blast wave, and the radioactive fallout.

Thermal Radiation

The thermal radiation, at distances out from the Test Site, is insignificant except for the flash of light. Some detonations, because of their low yield, position of firing, or time of firing (daylight hours) do not require offsite precautions for the flash of light. For other shots the public is advised not to look directly at the fireball except through very dark glasses and is cautioned never to use binoculars. To assist the passing motorists, road blocks are established shortly before a detonation to inform them of the expected flash of light. Likewise a circle of about 65 miles is established around the Nevada Test Site, in which aircraft travel is restricted from about 30 minutes before the planned time of detonation to 30 minutes afterward.

There have been four cases of eye injuries from thermal radiation, all to military participants in the tests. One participant onsite received a permanent eye injury when, contrary to orders, he looked at the fireball; three others at another time received minor eye injuries when participating in planned exposures. There have been no cases of thermal injury to the general populace.

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Blast

The time of detonation is publicly announced before each and every shot. If there seems to be any likelihood that the blast wave may be greater than usual in a particular community, the people are advised to open their windows and doors. In the past, there have been 373 allowable claims for blast damage to structures for a total amount of about 44,000 dollars. There are some claims yet to be settled. No personal injuries have been associated directly with these structural damages, but one man claimed a muscle spasm was produced in his neck from suddenly turning his head when two windows in his home were broken by a blast wave. In addition, it may be mentioned that about 1,300 dollars have been paid in claims for turkeys which were allegedly startled by one of the blasts and stampeded, resulting in deaths from piling up and suffocation.

Radioactive Fallout

Of the three principal effects, the one that has received the most attention has been radioactive fallout. These radioactive particles emit two types of radiations, i.e., gamma rays and beta particles. The latter have short ranges and are of principal concern only when a relatively large amount of fallout material remains in contact with the skin. In such cases, the effect on the skin is to produce burns, not dissimilar to ordinary (thermal) burns, but usually of deeper character, and having a longer period of recovery. Some cattle and horses, all grazing within twenty miles of ground zero, have shown such beta burns, for which about 7,000 dollars has been paid in claims. There have been no known cases of skin burns on humans, from the Nevada Tests.

The gamma rays are similar to X-rays and have relatively great penetrating power. The radiation doses they deliver have effects like those from natural sources of radiation; therefore, the two may rightfully be compared. In general, the average yearly exposure from natural sources is about 0.1 to 0.15 roentgens (a unit used in measuring radiation doses), but in some areas of the world may be several times this amount. Comparisons may also be made with the medical uses of radiation. For example, a chest X-ray may deliver from 0.05 to 2.0 roentgens, and a fluoroscopic examination 10-20 roentgens per minute.

Others have described in detail the measures taken to protect the public offsite and the workers onsite. Let us, therefore, proceed to the radiation criteria used and to the record of exposures.

Onsite

For the participants onsite during Operation Plumbbob the operational guide for radiation exposure was a maximum of five roentgens. This is consistent with the National (United States) Committee on Radiation Protection which recommends

"... -The maximum permissible accumulated dose, in rems, at any age, is equal to 5 times the number of years beyond age 18, provided no annual increment exceeds 15 rems. Thus the accumulated MPD = $5(N-18)$ rems where N is the age and greater than 18. This applies to all critical organs except the skin, for which the value is double - - -"

We have recognized the prerogative of the Test Manager and Test Director to permit somewhat higher exposures in individual cases if this is required to obtain essential data.

The highest radiation dose experienced onsite was a security guard who in 1955 inadvertently was exposed to 39 roentgens. He showed no ill effects, including no changes in his blood picture. Almost all other exposures have

been appreciably lower. For example, of more than 9,000 participants in Operation Plumbbob, only 18 received exposures in excess of 5 roentgens. The highest was 10.1 roentgens, which was anticipated, in order to obtain essential data.

Offsite

In establishing radiological safety criteria for persons offsite, we have such guide lines as the statement of the National (U.S.) Academy of Sciences - National (U.S.) Research Council, the National (U.S.) Committee on Radiation Protection and the International Commission on Radiological Protection. In 1956 the NAS-NRC recommended

"- - -that individual persons not receive more than a total accumulated to the reproductive cells of 50 roentgens up to age 30 years (by which age, on the average, over half of the children will have been born), and not more than 50 roentgens additional up to age 40 (by which time about nine-tenths of their children will have been born . . .) - - -"

and "---- that for the present it be accepted as a uniform national standard that X-ray installations (medical and non-medical), power installations, disposal of radioactive wastes, experimental installations, testing of weapons, and all other humanly controllable sources of radiation be so restricted that members of our general population shall not receive from such sources an average of more than 10 roentgens, in addition to background, of ionizing radiation as a total accumulated dose to the reproductive cells from conception to age 30 - - -"

In 1957 the NCRP recommended

"- - -The maximum permissible dose to the gonads for the population of the United States as a whole from all sources of radiation, including medical and other man-made sources, and background, shall not exceed 14 million rems per million of population over the period from conception up to age 30, and one-third that amount in each decade thereafter. Averaging should be done for the population group in which cross-breeding may be expected - - -".

In general, the recommendations of the (British) Medical Research Council are similar to these. As a guide, we adopted an upper limit of 3.9 roentgens exposure offsite for Operation Plumbbob (Spring and Summer 1957), although

great efforts were made to keep the actual exposures to as low values as possible.

The highest gamma exposure offsite from fallout has been at a motor court near Bunkerville, Utah (about 100 miles from the Test Site) where about 15 people might have accumulated 7-8 roentgens if they had continued to live there. This fallout occurred during the 1953 tests at Nevada. The next highest exposure has been at Lincoln Mine, about 45 miles from the Test Site, (having a changing population averaging about 350 people) with 5.25 roentgens. These are total exposures from all nuclear tests that have occurred in the world, although nearly all of these radiation doses have accrued from the nuclear tests in Nevada.

In terms of "general population", and considering the million people living closest to the Nevada Test Site (the highest exposure group), their average exposure has been slightly over 0.1 roentgen for the seven years of testing. This is at the rate of one-half a roentgen per thirty years - 1/20 of the NCRP value.

In addition to the monitoring programs near the Nevada Test Site, the U. S. Atomic Energy Commission, in cooperation with the U. S. Weather Bureau and the U. S. Public Health Service, maintains over one hundred collection stations across the country. In summary, the highest radiation exposure at any community measured in the United States outside of the immediate area around the test site has been less than 0.15 roentgens. These estimates do not include the effects of weathering of the fallout material or the shielding afforded by buildings, that is, the actual radiation dose probably is substantially lower than these values. Thus, this highest exposure resulting

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from seven years of testing is less than the exposure received each year from naturally occurring radioactive materials in the environment. The average for the United States is, of course, less. It has been estimated by the National (United States) Academy of Sciences that

"- -U. S. residents, on the average, have been receiving from fallout over the past five years a dose which, if weapons testing were continued at the same rate, is estimated to produce a total 30-year dose of about one tenth of a roentgen; and since the accuracy involved is probably not better than a factor of five, one could better say that the 30-year dose from weapons testing if maintained at the past level would probably be larger than 0.02 roentgens and smaller than 0.5 roentgens."

One-tenth of a roentgen per thirty years is 1/100 of the NCRP value.

We also maintain a world-wide network of monitoring stations. Except for some of the Pacific Islands, the gamma exposures average lower than for the United States. For example, the (British) Medical Research Council stated in the spring of 1956 that

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"- -The average inhabitant of this country may therefore receive in the next 50 years between 0.001 and 0.002 r from this fallout ^{b.}, or 0.02 to 0.04 percent of the radiation that he will receive during the same period from natural surroundings."

The other principal factor besides external gamma radiation in evaluating the health aspects of fallout is the presence of strontium-90. This is a long-lived radioisotope (27.7 years half-life) and when taken internally will be deposited in the bones. As with external radiation, it is not the mere presence of strontium-90 that is of possible concern, but rather the question of how much. This subject has been, and continues to be, one of

a. England

b. All fallout anticipated from all tests conducted to that date. The tests held since then will not change the general magnitude of these numbers.

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the major studies pursued by scientific bodies the world over. In summary, the consensus of opinion is that the maximum permissible body burden for general populations should not exceed 100 micromicrocuries of strontium-90 per kilogram of calcium, i.e., 100 "strontium units".

Today, in the United States (the country of greatest strontium contamination) we are seeing less than one "strontium unit" in young people and about one-fifth of a "strontium unit" in adults. As more of the fallout from past tests descends from the stratosphere to the earth and becomes a part of the soil-plant-animal cycle, these values might be increased by 3 or 4 times. It becomes difficult to extrapolate far into the future, but estimates have been made that if nuclear tests were continued ^{to 1965} at the same rate as in the past, the predicted body burden might be 10 to 25 "strontium units." ~~over many years (probably over 20) the body burden might reach 20 to 30 units.~~

This is, of course, only a very brief summary concerning strontium-90 but rather than attempt a full discussion now, we will leave any possible further considerations to the "Question and Answer" period.