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2 March 1951

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SUBJECT: Request for Basic Biological Information

TO: Office of the Surgeon General, United States Army, Washington 25, D. C., ATTN: Special Projects Office

1. Reference is made to document MH-327, dated 17 November 1949, in which the Chief, Chemical Corps, requests information on the predicted signs and symptoms of exposure to ionizing radiations in humans. These same questions will be answered in light of presently available information, as follows:

a. Question 1: A uniform exposure of 50r of external gamma radiation will result in no decrease in combat efficiency of Armed Forces personnel. A uniform exposure of 100r of external gamma radiation will result in occasional cases of nausea and vomiting, but these would be insufficient to decrease the combat efficiency of troops. These statements apply if the exposure occurs in one hour or one day. A uniform exposure of 150r obtained in one hour or one day would result in not more than 10% temporary casualties (nausea and vomiting) with no permanent casualties. Because of the recovery factor exhibited by individuals receiving radiation, a cumulative chronic dose does not cause as much body damage as an acute dose of the total amount. As an example, at the rate of 30r per day approximately 1800r would be necessary for 100% deaths as opposed to approximately 600r for an acute dose. An analysis of the probable effects of chronic whole body radiation doses is given in the table below. It is again assumed that the individual is in good general physical condition and has no injuries of any other type.

PROBABLE EFFECTS OF CHRONIC WHOLE BODY GAMMA RADIATION DOSES

Daily Chronic Dose	Days Exposure	Total Dose	Acute Dose Equivalent
60r	6	360	300
30r	5	150	100
30r	14	420	300
15r	12	180	100
15r	32	480	300

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Declassified by DNA, Chief, ISTS

Date: 8/16/94

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b. Question 2 and 3: It has been determined that approximately 200 beta rep (average energy 1 MEV) is the least dose that will produce erythema in human skin. A dosage of at least 2,000 rep is required to produce damage to the skin. If we assume that the dosage level of beta radiation is less than 2,000 rep there would be no loss in combat efficiency. If any total dosage exceeds this figure, we have to assume skin damage and therefore, casualties. The ratio of rep to r in a fission product contaminated field is approximately 10 to 1, for at least the first thirty days after detonation. We may thereby conclude that if the total gamma exposure does not exceed 200r, then the total beta exposure will be less than 2,000 rep.

c. Question 4: It is felt that an exposure level of 25r per hour or day can be repeated at weekly or longer intervals for a total of eight exposures. More exposures at this level may be feasible but personnel so exposed should be checked and evaluated before a decision is made to exceed an exposure of greater than 200r total.

d. Question 5: Same as Question 4. It is expected that an exposure of 100r should be followed by withdrawal from possible exposure to gamma radiation for a period of six months. There is a possibility that an exposure of greater than 200r may reduce life expectancy in the exposed individual, but not more than 5%.

e. Question 6: Same as Question 10, pages 7 and 8, of MH-275.

f. Question 7: No data is available on this subject. Dr. Schilling at Rochester has found that an exposure of 250r in a rat does not delay the healing time of the standard wound. However, in view of the answer to Question 6, it can be assumed that the healing time of a wound may be increased. Dr. Ham, at the Medical College in Virginia, is currently studying this problem.

g. Question 8: Exposure to dosages of radiation under "acceptable hazard conditions" as listed above, will not reduce the performance ability of Armed Forces personnel. The dosage required to reduce performance ability by at least 10% would probably be at least 200r.

h. Question 9: Military operations resulting in moderate fatigue will not significantly increase the casualty rate among Armed Forces personnel exposed to less than 200r gamma radiation. At dosages above the LD 50 range, it is reasonable to assume that exhaustive exercises will result in increased mortality.

i. Question 10: There is no data presently available to answer this question.

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3. Question 11:

Fission products vary widely in their physical and chemical nature, their route of absorption, the site of deposition, and their metabolism within the body. To determine the worst possible situation from exposure to fission products, it is desirable to consider an isotope which is absorbed with reasonable efficiency and also efficiently deposited and retained in a localized portion of the body. Strontium^{89} and the Strontium^{90}-Yttrium^{90} complex are good examples. If we assume that:

(1) The period of contamination (ingestion) is within one month after detonation,

(2) Daily water consumption is 2.2 liters,

(3) 40% of Strontium in water is absorbed from the stomach and intestinal tract,

(4) The absorbed Strontium reaches a concentration in bone equivalent to that if the absorbed amount were complete and uniformly deposited in 10% of the bone,

(5) The daily radiation dose to any macroscopic region of the body should not exceed 0.7r per day and the total integrated dose of any macroscopic region not exceed 50 rep, and

(6) Calculations developed by Dr. William F. Bale, Dr. Forrest Nesler, Dr. K.Z. Morgan, and Dr. Oliver Hacak, and reviewed by others, for this theoretical situation, are valid,

the permitted emergency uptake of Strontium^{89} is 77 microcuries. If this amount is ingested over a ten-day period, this represents a concentration of 0.0035 microcuries per cc, or 7,700 disintegrations per minute per cc. Animal experiments indicate that the actual absorption of Strontium from the gastro-intestinal tract is in the neighborhood of 7% rather than 40%. Moreover, as outlined above, approximately 10% of the bony tissues would receive beta radiation in this situation. It is apparent then that even if there were pure Strontium contamination of water, we have here an additional safety factor of 10 in these figures.

Present evidence indicates that under the worst conceivable conditions the average adult human can consume 75 microcuries of radioactive fission product contamination with no significant danger. Available evidence indicates also that the consumption of radioactive contaminated water in amounts equivalent to 2,000 microcuries has a very low probability of producing radiation damage. Levels 25 times higher than this carry only minor risk of hazard from radioactivity.

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Based upon these assumptions, the following table is given for levels of beta-gamma activity in drinking water in a period immediately following bomb detonation:

TIME WATER IS TO BE CONSUMED	SAFE		LOW ACCEPTABLE RISK	
	CURIES PER CC	DISINTEGRATIONS PER MIN PER CC	CURIES PER CC	DISINTEGRATIONS PER MIN PER CC
Ten days	3.5×10^{-9}	7.7×10^{3}	$9. \times 10^{-8}$	$2. \times 10^{5}$
One month	1.1×10^{-9}	2.6×10^{3}	$3. \times 10^{-8}$	$7. \times 10^{4}$

Similar assumptions and calculations can be made for alpha activity contamination based upon the presently accepted industrial tolerance of 0.04 microcuries of plutonium deposited in the body with an absorption and retention factor of 0.0. from the gastro-intestinal tract. Again, in these calculations there is the factor of safety of at least 25. The following table lists levels of alpha activity in drinking water:

TIME WATER IS TO BE CONSUMED	SAFE		ACCEPTABLE RISK	
	CURIES PER CC	DISINTEGRATIONS PER MIN PER CC	CURIES PER CC	DISINTEGRATIONS PER MIN PER CC
Ten days	$2. \times 10^{-10}$	440	$5. \times 10^{-9}$	1.1×10^{4}
One month	6.7×10^{-11}	145	1.7×10^{-9}	3.7×10^{3}

SUMMARY

The above answers reflect presently available information based on animal experimentation, Japanese statistics, accidents occurring at AEC projects, and the opinion of the leading radiobiologists in America. Some of the questions cannot be answered well at this time. This is particularly true of question 7. It is requested that before distribution is made of this document, an advance copy be sent to this Headquarters.

It should be remembered that exposure of military personnel to ionizing radiation will depend on a command decision based on the immediate military situation.

FOR THE CHIEF, AFSWP:

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E. E. KIRKPATRICK
Colonel, Corps of Engineers
Chief of Staff