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ESTIMATE OF THE PARTICULATE HAZARD

IN UNDERGROUND EXPLOSION OF 1 KT U-235 BOMB

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1. In connection with the underground detonation of an atomic bomb, the inhalation of a high specific activity dust particle and the subsequent lodgment of this particle in the lung has been suggested as a possible source of radiological hazard. In order to evaluate this hazard it is necessary to determine the maximum specific activity which such a particle might have. The most probable size of a particle which might remain lodged in the lung is about one micron. Larger particles tend to be trapped in the nasal passages and subsequently expelled. Furthermore, large particles (100 microns or greater) will not remain airborne for any appreciable distance of travel. Nevertheless, in order to evaluate the possible hazard, it is desirable to calculate the maximum specific activity per particle which might be obtained on particles up to 100 microns.

2. The volume of earth mixed with the fission products will be greater than the total volume of earth included in the fireball and less than the total volume of earth thrown up from the crater. Since mixing within the fireball is certain to be complete, the fireball volume will give the absolute maximum specific activity per particle while the crater volume will give a more reasonable average specific activity. These two volumes are therefore used to cover the range of specific activities which may be encountered.

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3. Calculation of Specific Activity per Particle.

Vol of 1 micron (μ) particle = 4×10^{-12} cm^3

1 yd^3 = 8×10^5 cm^3

$\therefore$ 1 yd^3 = 2×10^{17} 1μ particles

Total β activity at 24 hr = 1.3×10^7 curies

Sr^{89} (53 day half-life) = 3×10^4 curies

Sr^{90} - Y^{90} (25 yr half-life) = 5×10^3 curies

		Fireball	Crater
Radius	=	15 feet	200 feet
Depth		(15) "	120 "
Vol of earth		500 yd^3	1.5×10^5 yd^3
Total 1μ particles		10^{20}	3×10^{22}
Total β activity per 1μ particle		1.3×10^{-13} curies	4×10^{-16} curies
Sr^{89} activity per 1μ particle		3×10^{-16} curies	1×10^{-18} curies
Sr^{90} -Y^{90} " " " "		5×10^{-17} curies	2×10^{-19} curies

For 10μ particle activity will be 10^3 times greater than for 1 micron particle

For 100μ particle activity will be 10^6 times greater than for 1 micron particle

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CALCULATION OF HAZARDS FROM SURFACE OR UNDERGROUND DETONATIONS

Assumptions for Worst Possible Situation:

a. All radioactive material stays in cloud and none is deposited in or around crater.
b. Cloud moves along ground and does not lift.
c. Cloud spread and rise minimized.

1 KT U-235 Bomb; Wind 10 mi/hr or less; inhalation rate 10 m^3 /8 hrs (20ℓ/min.)

Time hrs	Total γ Curies	Total β Curies	Sr^{89} Curies 0.1%@12hr (53 d)	Sr^{90} + Y 90 Curies 0.2% @ 28 d (25 y)	Cloud dia. mi.	Cloud thickness mi.	Cloud Volume $mi.^3$	Cloud Volume liters	Transit Time min.	Maximum Distance Traveled mi.	Amount Inhaled Liter	Concentration (Curies/liter) β	Concentration Sr^{89}	Concentration Sr^{90} + Y^{90}	Concentration γ
1	$30x10^7$	$60x10^7$	$3x10^4$	$5x10^3$ 2											
3	$8x10^7$	$16x10^7$	$3x10^4$	$5x10^3$ 2	2	1/5	0.6	$3x10^{12}$	12	30	240	$5x10^{-5}$	$1x10^{-8}$	$2x10^{-9}$ -10	$3x10^{-5}$
6	$3.5x10^7$	$7x10^7$	$3x10^4$	$5x10^3$ 2	3	1/5	1.4	$6x10^{12}$	18	60	360	$1x10^{-5}$	$5x10^{-9}$	$1x10^{-9}$ -10	$5x10^{-6}$
12	$1.5x10^7$	$3x10^7$	$3x10^4$	$5x10^3$ 2	6	2/5	11	$50x10^{12}$	36	120	720	$6x10^{-7}$	$6x10^{-10}$	$1x10^{-10}$ -11	$3x10^{-7}$
24	$0.7x10^7$	$1.3x10^7$	$3x10^4$	$5x10^3$ 2	10	1/2	40	$200x10^{12}$	60	240	1200	$7x10^{-8}$	$2x10^{-10}$	$3x10^{-11}$ -12	$4x10^{-7}$

γ-intensity (r/hr) I c = $3x10^5$ X Conc in γ curies/liter

Time hrs	Total β Curies Inhaled	Total β Curies Absorbed	INHALATION Sr^{89} μ curies Inhaled	Sr^{89} μ curies Absorbed (6%)	Sr^{90} - Y 90 μcuries Inhaled	Sr^{90} - Y 90 μcuries Absorbed (6%)	External Ic r/hr	External Dose r
3	$1.2x10^{-2}$	(10%) $1.2x10^{-3}$	2.4	~~0.02~~ 0.14	.0.5	~~.0.005~~ .003	9	2
6	~~$3.6x10^{-3}$~~ 4.2	~~$3.6x10^{-4}$~~ 4.2	1.8	~~0.018~~ 0.11	.0.36	~~.0.003~~ .002	1.5	0.45
12	$4.3x10^{-4}$	$4.3x10^{-5}$	0.4	~~0.004~~ 0.024	.0.07	~~.0.0007~~ .0004	~~0.9~~ .09	0.054
24	$8x10^{-5}$	$8x10^{-6}$	0.24	~~0.002~~ 0.014	.0.04	.0.0004 .00024	~~0.1~~ .012	0.012

Tolerances - Chalk River Conference

1% of inhaled Sr^{90} - Y^{90} is absorbed

Same for Sr^{89} 6% (Hamilton)

Sr^{89} - 1 μc absorbed in body

Sr^{90} - 0.5 μc absorbed in body

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