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TECHNICAL DATA RECORD		PAGE 1 OF 9	
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TITLE Doses from Ablation Particle Fallout Based on AI Arc Jet Particle Size Distribution		S/A NO 11610 TWR	SECURITY CLASSIFICATION (CHECK ONE BOX ONLY)
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DISTRIBUTION R. Detterman 2 R. Gimera 2 J. Hale 2 A. Piccot 2		AUTHORIZED CLASSIFIER SIGNATURE C A Willis 3-2-67	
STATEMENT OF PROBLEM Reevaluate the external radiation field hazard from the fallout of SNAP Reactor ablation particles using AI Arc Jet particle distribution.			
ABSTRACT: For zero net wind transport conditions the doses obtained with the AI particle size distribution are not significantly different from those obtained with the BMI distribution. Small (<20 micron) particle data are needed.			
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I. ANALYSIS

The particle size distribution obtained in the AI Aerospace Safety arc jet experiments is presented in Figure 1. This curve is composed of two exponentials which fit the actual data within the limits of experimental error. Other distributions, such as the lognormal, could have been used but the exponentials appear most convenient. For particles of less than 575μ diameter, the fraction of the core mass in particles between D and $D+dD$, is given by

$$F'dD = 3 \times 10^{-7} e^{0.0182 D} dD \quad \dots D \leq 575\mu$$

For larger particles the distribution is

$$F'dD = 0.3 e^{-0.0071 D} dD \quad \dots D \geq 575\mu$$

The equations used to calculate the fallout concentration and the external radiation field dose are developed in NAA-SR-MEMO-10774.⁽¹⁾ It is assumed here that essentially all the nongaseous fission products are retained in the particles and distributed uniformly along the last 10 km of the burn path ($L = 10$ km). For the most hazardous situation, zero net transport by winds, the burn path length provides a spread in one direction and lateral dispersion is provided by turbulent eddy diffusion. It is assumed that the cloud is spread so its peak concentration corresponds to a width given by

$$W = 2 \times 10^{-4} t \quad (\text{km})$$

where t is fall time in seconds. If the release is at 50 km altitude and particles fall within the Newton's Law terminal

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velocity, the lateral spread of the particles when they reach the ground is

$$W = 7.34 D^{-1/2} \text{ (km)}$$

where the particle diameter is expressed in microns and the particle density is 6 gm/cm^3 . Actually, 500μ particles experience considerable "intermediate flow" fall and would be dispersed somewhat more than this expression indicates.

The fraction of the core mass in particles between D and $D+dD$ produces centerline concentrations of

$$dq = 0.85 \frac{QF'}{WL} dD \text{ (km}^{-2}\text{)}$$

where Q is the total core activity and 0.85 is the non-gaseous fraction. The total concentration is

$$q = 0.85 \frac{Q}{L} \int_0^{\infty} \frac{F}{W} dD$$

$$q = \frac{0.3 \times 0.85Q}{10 \times 7.34} \left[10^{-6} \int_0^{575} D^{1/2} e^{0.0182D} dD + \int_{575}^{\infty} D^{1/2} e^{-0.0071D} dD \right]$$

$$\text{Let } \varphi = 0.0182D; D = 55\varphi; D^{1/2} = 7.42\varphi^{1/2}$$

$$D^{1/2} dD = 408 \varphi^{1/2} d\varphi$$

$$q = 0.0035 Q \left[4.08 \times 10^{-4} \int_0^{10.4} \varphi^{1/2} e^{\varphi} d\varphi + \int_{575}^{\infty} D^{1/2} e^{-0.0071D} dD \right]$$

$$\text{Let } \psi = 0.0071D; D = 141\psi; D^{1/2} = 11.9\psi^{1/2}$$

$$D^{1/2} dD = 1690 \psi^{1/2} d\psi$$

$$q = 0.0035 Q \left[4.08 \times 10^{-4} \int_0^{10.4} \varphi^{1/2} e^{\varphi} d\varphi + 1690 \int_{4.08}^{\infty} \psi^{1/2} e^{-\psi} d\psi \right]$$

Plots of the functions to be integrated (Figures 2 and 3) reveal that these functions can be replaced with simple exponentials with negligible error

$$q = 0.0035 Q \left[7.95 \times 10^{-4} \int_0^{10.4} e^{+1.051\psi} d\psi + 2280 \int_{4.08}^{\infty} e^{-0.9\psi} d\psi \right]$$
$$q = 0.0035 Q \left[7.55 \times 10^{-4} e^{10.93} + 2540 e^{-3.68} \right]$$

II. RESULT

$$q = 0.371 Q \text{ (ci km}^{-2}\text{)}$$

As a square mile is 2.57 square km

$$q = 0.96 Q \text{ (ci/mi}^2\text{)}$$

or
$$q = 0.96 \text{ (core/mi}^2\text{)}$$

The NAA-SR-MEMO-10774 dose criteria, 25 rem equivalent residual dose, will not be exceeded unless the peak concentration exceeds 1 (core/mi²) for a 40 kw reactor.

III. DISCUSSION

The results obtained here indicate that the Aerospace Safety arc jet spectrum of particle sizes results in essentially the same dose as that given by particles with the BMI size distribution, for zero net wind transport conditions. The BMI particles were much larger (2000 μ vs 500 μ) but the fall times are proportional to the square root of the diameter for the larger particles. This would suggest that the BMI distribution would produce twice the dose that would be obtained with AI particles. A mitigating factor for the BMI

KE SEMI-LOGARITHMIC 46 5813
3 CYCLES X 140 DIVISIONS
MADE IN U.S.A.
KEUFFEL & ESSER CO.

FIGURE 2

46 5813
MADE IN U.S.A.
SEMI-LOGARITHMIC
5 CYCLES X 140 DIVISIONS
KEUFFEL & ESSER CO.

FIGURE 3

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distribution was that some $2/3$ the mass was in very small particles ($< 20\mu$). It would be desirable to make some small particle ($< 20\mu$) measurements.

Several factors have been ignored which will further reduce the dose. For example, width of the initial cloud, escape of high temperature volatile fission products, and induced turbulence would reduce the total dose.

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REFERENCE

1. C. A. Willis, "The External Radiation Field Hazard from Fallout of Ablation Particles from SNAP Reactors," NAA-SR-MEMO-10774, (February 15, 1965)