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A5_3 Indiana Jones and the Fridge to Freedom

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Abstract

This paper investigates the plausibility of Indiana Jones being able to survive the initial gamma ray radiation from a nuclear explosion by containing himself within a lead-lined fridge. We find that the fridge needs a thickness of lead to be at least 6.83cm for him to be unharmed by the gamma radiation.

Introduction

In the 2008 film Indiana Jones and the Kingdom of the Crystal Skull Indiana is left stranded in a nuclear test town. He is seemingly doomed to certain death as the nuclear bomb is activated and the siren begins to countdown. With literally seconds to spare he is able to squeeze himself into a lead-lined fridge surviving the explosion and aftermath without any noticeable injuries. In this paper we explore the plausibility of Indiana being able to survive this event by investigating how thick the lead within the fridge would need to be. Such that the initial gamma radiation given off by the bomb is no longer harmful to Indiana.

Theory

To model the process we make the following assumptions: We assume the gamma radiation given off is spherically isotropic and that the gamma rays travel through a vacuum to reach the fridge (loss in energy due to absorption from air and the house is considered negligible). We can then use the solid angle formula[1] divided by 4π,

$$\omega = \frac{A}{4\pi r^2}, \tag{1}$$

to work out the fraction of gamma radiation incident upon the fridge. Where ω is the fraction of gamma radiation incident upon the fridge, r is the distance between the initial explosion and the fridge and A is the surface area of the fridge as seen by the explosion, assumed to be face on. We then use the Beer-Lambert formula [2],

$$I = I_0 \exp(-t\mu) \tag{2}$$

to calculate the loss of energy in gamma radiation as it penetrates the lead-lined fridge. Where I_0 is the energy of gamma radiation incident upon the fridge, μ is the absorption coefficient, t is thickness of the lead within the fridge and I is the energy of the gamma radiation at thickness t.

Results

It is estimated that the bomb's initial explosion is $1000(\pm500)$m away from the fridge which is assumed to have an area of $0.5(\pm0.25)\text{m}^2$. Using Equation (1) gives the fraction of gamma ray incident upon the fridge to be $3.98(\pm3.45)\text{x}10^{-8}$. It is unknown exactly what type of nuclear bomb was used in the film, and consequently its energy output, so we have selected three different

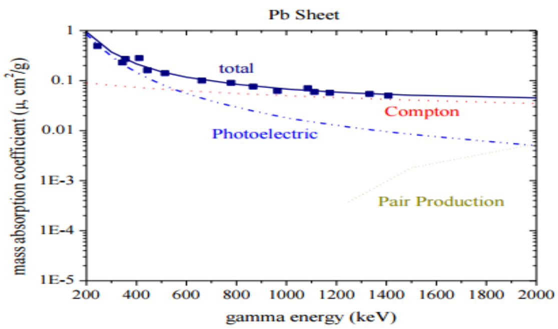

Figure 1: Mass absorpton of gamma radiation by solid lead sheet [6].

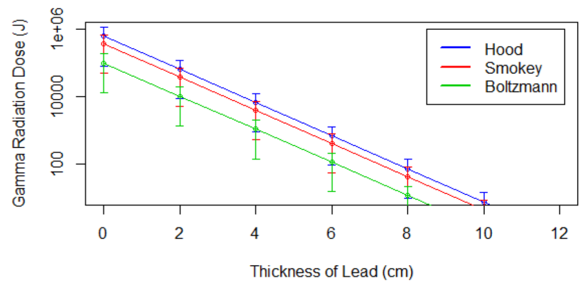

Figure 2: Gamma radiation dose Indiana receives with varying thickness of lead.

nuclear bombs from the Operation Plumbbob nuclear tests which were conducted in the year the film is set (1957). The chosen bombs are the Hood, Smokey and Boltzmann which have total energy outputs of $3.10x10^{14}$J, $1.84x10^{14}$J and $5.02x10^{13}$J respectively [3], where 5% of this energy is being converted to gamma radiation [4]. This gives an energy of gamma radiation incident upon the fridge of $6.17(\pm5.35)x10^5$J, $3.66(\pm3.17)x10^5$J and $9.99(\pm8.66)x10^4$J respectively. From Fig. 1 we see the mass absorption coefficient of lead is approximately $0.1cm^2g^{-1}$ for high energy gamma rays giving a value of the absorption coefficient to be $1.13cm^{-1}$ using a density for lead of $11.3gcm^{-3}$ [5]. From this we obtain the dosage of gamma ray energy Indiana receives for each bomb as a function of the thickness of lead, shown in Fig. 2.

Discussion

From Fig. 2 we see the dosage of gamma ray energy quickly drops as a function of thickness of lead. As Indiana appears unharmed in the film we expect the worst case scenario is he would have only encounter slight blood changes. This corresponds to a gamma radiation dose of $1Jkg^{-1}$ [7] meaning he could have only been able to receive 75J of radiation at most (assuming he is 75kg). Considering the lower limits of the calculation gives a required thickness of lead to be 6.19cm, 5.74cm and 4.58cm for Indiana to remain unharmed by the Hook, Smokey and Boltzmann bombs respectively. Therefore we conclude that it is unlikely Indiana would have remained unharmed from the gamma radiation as the minimum thickness of lead needed is 4.58cm, which is likely to be greater than the thickness of the lead-lining within the fridge. He may, however, have been able to survive the gamma radiation if the whole fridge was made from lead as opposed to just lead-lined. It is unknown exactly what this thickness of the fridge is. All aspects considered however he would have almost certainly been killed by being caught up within the blast of the bomb with the fridge being subject to an enormous amount of force, this however could be further investigated.

References

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