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# P4 7 No Mr Bond: I expect a better suit!

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**Abstract**

We follow up from our previous paper where we found the power of the laser in the 1964 Bond film *Goldfinger* to be 35.14 kW. In the film the laser is shut off just before contacting Bond, here we assume it touches Bond for 0.5 s. We find the change in temperature of Bond's clothing for the case of it being made of cotton fibre and kevlar, for different radii of the laser spot, to assess how a more focused laser can cause more heating. It is found if the laser is double the focusing we use in our previous paper, at 2 cm, and Bond is wearing a suit made of kevlar, he might walk away with severe burns, but otherwise would survive.

## Introduction

In our previous paper titled "No Mr Bond: I expect you to Die" [1], we investigated the power of the laser portrayed in the famous scene from *Goldfinger*, where James Bond is tied down to a table with a sheet of gold below him, and there is a powerful laser slowly approaching him. Factoring in the losses due to heat conduction with the surface we determined that the laser has a power of $P \approx 35.16$ kW. However, in the scene, the laser is switched off just before it comes into contact with Bond. In this paper we consider the case that the laser was shut off just a fraction of a second later, so the laser comes into brief contact with Bond. We assess how good MI6's issued suit has to be to protect Bond from the laser. To account for the technological limits of the time, we consider varying the laser spot size, as the focusing we suggested in the previous paper may not be realistic. Then we identify different materials that Bond's standard issue suit should be made from, to find what MI6 should invest in.

## Temperature Change Equation

For the purposes of this model we treat the laser as a continuous wave with a power of $P = 35.16$ kW. A circular spot of radius $r$, would deliver an intensity given by

$$I = \frac{P}{\pi r^2} \tag{1}$$

Some of heat that is produced in this event will be absorbed by the fabric of Bond's clothing. We call this absorption a parameter $\gamma$. Therefore there is some amount of energy $Q_{abs}$ that will be absorbed by this layer of the material given by

$$Q_{abs} = \gamma I A t \tag{2}$$

Where $A$ is the area that is covered by the laser and $t$ is the time that the area is exposed for.

$$Q_{abs} = \gamma P t \tag{3}$$

This will correspond to a temperature rise on the layer that is irradiated, that will be given by

$$Q_{abs} = \rho c A h \Delta T \tag{4}$$

Where $\rho$ is the density of the material, $c$ is the specific heat capacity, and $\Delta T$ is the change in temperature. If we assume that the fabric has some thickness $h$, then we can write equation (4) as

$$Q_{abs} = \rho c(\pi r^2 h)\Delta T \tag{5}$$

So now we can set equations (3) and (5) equal to one another to achieve an expression for the temperature change.

$$\Delta T = \frac{\gamma P t}{\pi r^2 \rho c h} \tag{6}$$

This expression allows us to observe what the dominant scaling for the safety of Bond will be, that is a smaller focus and higher absorption will cause a greater temperature rise. It should be noted that this overestimates the temperature slightly, as we have not considered any lateral heating effects that would occur.

## Suit Materials

The suit materials that we consider are cotton fibre and kevlar. This is so we can consider both the standard suit for comfort, and one for potential gunfights. We need to know the specific heat capacity, absorption and density of these materials which are as follows. For (black) cotton this heat capacity is $c_c = 1340$ Jkg$^{-1}$K$^{-1}$ [2], absorption is $\gamma_c = 0.61$ [3] and a density of $\rho_c = 1520$ kgm$^{-3}$ [4]. This is considering black cotton as that is what Bond is wearing, though it should be noted that the absorption will change depending on colour.

Then for kevlar we have, the heat capacity $c_k = 2010$ Jkg$^{-1}$K$^{-1}$ [5], absorption $\gamma_k = 0.5$ and a density of $\rho_k = 1440$ kgm$^{-3}$ [5]. Here we are assuming kevlar 29, however there is little practical difference between the variants. The value for absorption is an estimate as there is no data on the absorption of kevlar. We have assumed a value just lower than cotton, since the colour is also black, and generally kevlar performs worse than cotton when exposed to light.

## Spot Size

Using these parameters, we consider the case that the laser just touches Bond and then is shut off. So we assume a small time $t = 0.5$ s. Finally we assume a clothing thickness of about 5 mm. We can now vary the spot size for each of the materials to determine how safe Bond would be from such a short exposure. This allows us to plot figure 1. At the largest spot radius, the minimum value of $\Delta T$ is found to be 838 K and 483 K for cotton and kevlar respectively.

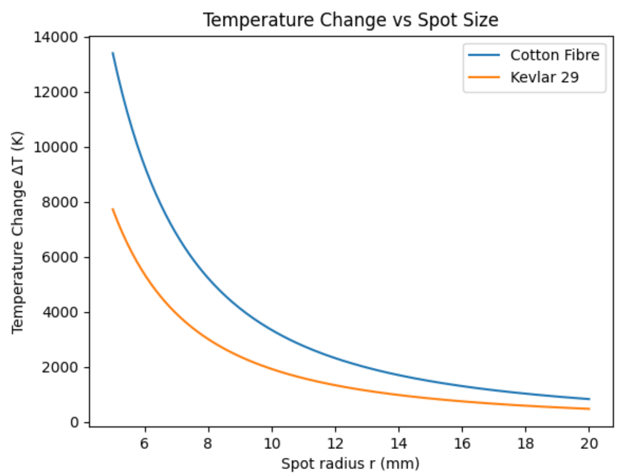


Figure 1: Plot of the temperature change as a function of spot size, for both cotton fibre and kevlar. We notice that kevlar results in lower temperature changes.

## Discussion and Conclusion

It is clear from our results that if the laser was as focused as it appears to be in the film, then Bond would not fare well regardless of the material. The temperature changes are into the thousands and would result in extreme burning for Bond, the kind from which he may not recover. However the minimum value for the kevlar, corresponds to $\approx 210°$ C, this would also result in severe burning, but would at the very least be recoverable from, and could heal.

Overall, MI6 may want to consider running an inner lining of kevlar for their operatives suits. Primarily for bullet protection, however it might just save them in the case of them being attacked by lasers.

## References


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