GreenFacts
Facts on Health and the Environment

Scientific Committees
on consumer products
on emerging and newly identified health risks
on health and environmental risks

Security Scanners

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Summary & Details:
GreenFacts

Level 2 - Details on Security Scanners

The answers to these questions are a faithful summary of the scientific opinion produced in 2012 by the Scientific Committee on Emerging and Newly Identified Health Risks (SCENIHR): *"Health effects of security scanners for passenger screening (based on X-ray technology)"*

The full publication is available at: https://copublications.greenfacts.org/en/security-scanners/
and at: http://ec.europa.eu/health/opinions/en/security-scanners/

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- Level 3 consists of the Source document, the internationally recognised scientific opinion which is faithfully summarised in Level 2 and further in Level 1.

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1. Introduction

Passengers are routinely screened at airports using either hand searches or metal detectors. Sometimes, techniques that detect traces of explosives or sniffer dogs are also used. Because of increased concern over terrorist attacks, some countries have introduced more efficient screening devices such as scanners.


Increased concerns for terrorist attacks has led to the development of new passenger screening methods.

There are 4 different types of scanners currently available in the market:

Millimeter-wave scanners, that don't use X-rays:

- A. Passive scanners detect the very low levels of natural radiation emanating from the body surface, the scanners themselves do not emit any kind of radiation.
- B. Active scanners emit radio waves that are reflected back by the body surface. These radio waves are not ionizing.

X-ray scanners:

- A. Backscatter scanners emit low energy X-rays that are reflected back by the body surface.
- B. Transmission scanners send higher energy X-rays through the body in the same way as a traditional medical X-ray machine and can reveal objects inside the body.

Security scanners have been used at airports in Russia for a few years and are being introduced or considered worldwide, especially in the USA. In Europe, a scanner is being trialled in a UK airport but X-ray based scanners are banned in several member states that don't allow the use of ionising radiation for non-medical purposes.

X-rays are one type of ionizing radiation, which also include the radiation from radioactive materials. It is called ionizing because the particles that compose it have enough energy to knock out an electron from a molecule, turning it into an ion by giving it an electric charge. This ion can then react with other molecules, which can cause damage to the components of a cell, and alter its functioning. When these reactions affect the genetic material of a cell, then there is the possibility of causing cancer, and this is the main point of concern for low-levels of radiation.

Radiation is present everywhere and as an example, all Europeans receive a dose of approximately 1 mSv a year from naturally-occurring radiation in the environment. People are also exposed to radiation from space, particularly at high altitudes and when flying. Breathing in indoor radon also contributes 0.1 to 10 mSv of radiation every year.

The main man-made sources of radiation are scans and X-rays for medical diagnosis, and radiotherapy. The doses received from medical diagnosis vary and can be high for some individuals but in general they affect very few people so it is not relevant to calculate population averages.

The harmful effects of exposure to high doses of ionising radiation, above hundreds of mSv, are well known but X-ray security scanners result in very small doses, of the order of a thousandth of a mSv. The cancer risks for such small exposures are not measurable but can be estimated by extrapolating the data from higher doses and assuming that the effects are directly proportional to the exposure and that there is no safe limit of radiation.

2. What are the current guidelines for radiation protection?

Radiation protection is based on three principles:

- Justification: any radiation introduced should produce more good than harm to the individual or to society.
- Optimisation: exposure should be as low as possible.
- Dose limitation: individual doses for non-medical applications should not exceed set limits. For workers, the limit is 50 mSv in a single year with a maximum of 100 mSv in a consecutive five-year period. For members of the public, the current limit is 1 mSv of radiation exposure from man-made sources per year. The doses from security screening are very likely to fall below this limit but they should still be justified and optimised.

From a legal point of view, exposures from security scanners used to fall under the category of "medico-legal procedures", which include exposure to radiation without a medical reason. Under a new directive, these have been re-classified as "non-medical imagining exposures" and the justification and optimisation principles have been strengthened. Individuals should consent to the screening before it takes place and should be offered an alternative that does not involve ionising radiation. However, countries can pass laws so that in some cases screening can be carried out without consent.

It is not clear whether exposure to staff that are required to be screened such as airline crews, airport workers or couriers, can be regarded as occupational. Under the current framework they are considered as being part of the general public so the annual dose limit of 1 mSv would apply.

3. What are the technologies used in the proposed security scanners?

A modern backscatter unit showing a passenger being screened.
[see Annex 1, p. 7]

Four types of security scanners have currently been developed for airport security use:

- X-ray backscatter scanners expose the subject to low energy X-rays. This low energy radiation passes through clothing but any dense object will reflect it back towards the source. Detectors measure this radiation and make an image of the subject's body and any objects under the clothing. Usually the person is scanned twice, once from the front and then from the back, and a single scan lasts up to 8 seconds.
- X-ray transmission units use X-rays with significantly higher energies so that they pass directly through the person being examined. The image produced is similar to a medical X-ray and shows any concealed items that are sufficiently dense, even if the person has swallowed them or inserted them in a body cavity. Some units can operate in either a "low dose" or a "medium dose" mode, and a single scan takes from 5 to 15 seconds.
- Scanners that don't use ionising radiation are being developed and there are two main types:
  - Active scanners work in the same way as X-ray backscatter units but use radio waves instead of X-rays. During a scan, the individual is exposed to an electromagnetic field for up to 2 s. These units don't produce any heating of body tissues but there is some uncertainty about the long-term effects of extremely low frequency and radiofrequency fields.
  - Passive systems detect the very low levels of non-ionising radiation that are naturally emitted from the body or concealed objects. These systems produce no radiation of any type.

X-ray units are fitted with safety systems so the controls are password protected. Warning lights show clearly whether X-rays are being emitted or not and there are emergency stop buttons. Interlocks are fitted so that X-rays are cut off if a panel is removed for maintenance or if there is a fault in the machine. Finally, lead shielding is fitted around the machine so that radiation doses outside the scanning area are very low.

4. How is radiation exposure measured and assessed?


Frequent flyers and airline crews might be exposed to more radiation than the limits set for the general public

When dealing with radiation, the **absorbed dose** gives the amount of energy that reaches a very small amount of material, and is measured in Grays (Gy). Different types of radiation have different biological effects so a weighting factor is introduced to account for this. In radiation protection, this leads to a new quantity, the "**equivalent dose**" which is measured in Sieverts (Sv).

If the incident X-rays have high energies, one could assume that the dose would be uniformly distributed around the whole body. However, at low energies, organs which are closer to the surface (such as the lense of the eye, the female breast or the testes) will be more exposed than those deeper inside the body so it is necessary to calculate the dose that each different organ would receive. This is called the organ dose. The risk that ionising radiation is going to lead to cancer or mutations, varies between different organs and this is also considered to calculate the potential risks for each individual organ and then added together to work out the risk for the whole body, the "effective dose". This dose is an average for the population but the risk to individuals varies depending on their gender, how old they were when they were exposed and other risk factors.

It is difficult to measure doses of ionising radiation directly within the body so organ doses are typically evaluated using computer models of humans called Voxel phantoms. These have very realistic anatomies and there are phantoms that represent different ages and both genders. It is very difficult to give reliable estimates on children under 14 years of age because they vary widely in height and size. Similarly, the doses calculated for adults are just an average but depending on the physical characteristics of the individual, the range of doses to an adult can vary by up to a factor of two.

The amount of radiation that a person would receive from a scan is similar to what they would get from background radiation on the ground for 1 hour, or during 10 minutes of flying in a commercial airplane. These are average values but it is important to consider that some people, because of their age, sex or other factors, are more sensitive to radiation than others.

Some groups of people such as air crews, airport staff, frequent flyers and couriers are likely to be scanned frequently so to assess the maximum dose they would receive from security scanners, it was assumed that a member of one of these groups could be scanned up to three times a day , every working day, so 720 times a year. For a typical X-ray backscatter scanner this would result in an annual dose of 0.3 mSv, which is still below the limit set for members of the public. However, if all the scans were done with an X-ray transmission scanner, the cumulative dose would be nearly 3 mSv, which is well above the limit.

5. What are the health effects of exposure to ionizing radiation?

Ionising radiation can cause direct harm to body tissues and the severity of the damage increases with the dose. Doses below a threshold value of about 0.1 Gy are usually safe. This type of direct short-term damage is negligible from X-ray scanners not only after single exposures but also during cumulative and repeated exposures.

Cancer and hereditary disorders don't behave the same way, since there is no relation between the severity of the effect and the amount of radiation. Higher exposures to ionising radiation however, makes these events more likely to occur. It is generally considered that there is no safe threshold limit below which the effect does not happen.

Radiation can induce most, but not all cancer types. Typically, cancer develops 10 years after exposure; or 1 to 2 years for leukaemia and thyroid cancer. There are many epidemiological studies on the effects of low-dose radiation and these show that the risk of developing cancer rises uniformly with exposure. People exposed to radiation at a young age have a greater chance of developing cancer, particularly for thyroid, leukaemia and breast cancer. Health risks appear to be similar for different groups of the population although people with some rare inherited diseases are more likely to get secondary cancers after radiotherapy. The effect of low doses of radiation does not depend on whether the dose was given in a single exposure or in more spaced, lower exposures.

Epidemiological studies are subject to several sources of uncertainty. The quality of studies can be limited by bias in the information available or in the selection of the sample studied and there can also be other confounding factors, unrelated to the factor investigated. One of the major limitations of studies that deal with small effects is random errors that arise from variability unrelated to the exposure being investigated. In this case, diseases such as cancer and cardiovascular disease have many causes and it is impossible to tell which of the cancers occurring in a population are caused by radiation and which are caused by other factors. As a result, it is very difficult to demonstrate the effects of very low radiation doses, say below 100 – 200 mSv, in epidemiological studies. The information required to be able to pinpoint the effects caused by the radiation are impossible to achieve in practice. Even if the studies involve large populations, any potential increase in the number of cancer cases would be of the same size as random errors and therefore easy to miss.

The doses to individuals from X-ray scanners are considered negligible so there is no basis to consider separately the risk to potentially vulnerable groups such as children or pregnant women. The risk when considering the whole population is also negligible but not zero. As an estimate, radiation doses of the order of a mSv are expected to increase the occurrence of cancer by 1%.

As the radiation from X-rays scanners are several orders of magnitude lower, the risks can also be assumed to be smaller.

As a comparison, roughly 0.6% of the lifetime cancer risk in the UK might be attributable to diagnostic X-rays and the figure could be larger in many other countries. Approximately 4% of all cases of leukaemia, and 5% to 19% of cases of childhood leukaemia could be attributable to background radiation.

6. Conclusion: are X-ray security scanners safe?

Health risks are close to zero for individuals, but the risk cannot be ignored for populations.

The radiation doses to screened passengers are very low compared with other sources such as cosmic radiation received during a flight, even after taking into account the likely number of scans received by frequent flyers.

Doses from X-ray scanners pose no short-term risks such as tissue damage. The long-term effects such as cancer risks, cannot be entirely excluded but if they exist, they are orders of magnitude below the cancer risk due to other factors.

The annual dose limit for the general public is 1mSv. The radiation dose from a single backscatter scanner is tiny and even if someone was scanned 3 times a day, every working day, he would receive an annual dose well below the set limit. The dose from transmission scanners is at least 10 times higher than that from backscatter scanners but is still safe, even for vulnerable individuals. However, if transmission scanners are used routinely, frequently exposed individuals such as air crews, couriers or frequent flyers could receive doses higher than the limit set for the general public. Scanners using non-ionising radiation such as mm wave or THz scanners are not powerful enough to cause short-term tissue damage, and other health effects have not been proven. There is no scientific evidence to predict long-term effects.

Annex

Annex 1:

Figure 1: A modern backscatter unit showing a passenger being screened.

Source: SCENIHR, ***Health effects of security scanners for passenger screening (based on X-ray technology)****, (2012), 3.3 Technology and 3.4 Safety systems, pp.18-22 [see http://ec.europa.eu/health/scientific_committees/emerging/docs/scenihr_o_036.pdf]*