

COSMIC AND SOLAR RADIATION: FACTS FOR FLIGHT ATTENDANTS

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What is it and how am I exposed?

Cosmic radiation is the term that is used to describe the radiation that reaches us from other stars. Solar radiation is the term used to describe the radiation from our own sun. Exposure to these forms of radiation isn't much of an issue on the surface of the earth because the atmosphere serves as a protective layer. But when you are traveling at altitude, you have less of that protective layer above you and so you are exposed to higher levels of this radiation.

There are basically four factors that will affect your dose.

1. **TIME SPENT IN FLIGHT:** Exposure is cumulative so the more time that you spend in-flight, the higher your potential dose.
2. **LATITUDE:** Exposure is more intense at higher latitudes; for example, at the same altitude, radiation levels at the poles are about twice those at the equator. This is especially important for cabin crew, pilots, and passengers on the polar routes introduced by two airlines in the spring of 2001.
3. **ALTITUDE:** Exposure is more intense at higher altitudes because the layer of protective atmosphere above you is thinner.
4. **SOLAR ACTIVITY:** Although the frequency of flares from our sun peaks every 11 years or so, it isn't the solar flares themselves that are of health concern to passengers and crew, but rather the emissions of charged particles called solar particle events (SPE, also called "solar radiation storms"). SPE can follow solar flares, but are most frequent during the years leading up to and down from a solar maximum. During a SPE, radiation intensity can increase 1,000 fold compared to background levels. SPE are a health concern to pregnant passengers and crew and can also disrupt communications, especially on polar flights. The most recent peak in the solar cycle was 2000, but there was a rash of very intense SPE in 2001, and as of this writing (May 2006), have been at least eight severe (S3 or higher) such storms since then.



Are there regulations that ensure that my exposure is limited?

The short answer is "no". The Federal Aviation Administration (FAA) is solely responsible for publishing Federal Aviation Regulations that protect crewmember safety and health, and there are **no** regulations that protect against cosmic radiation. Highly qualified scientists at the FAA have put a lot of effort into researching the potential health risks associated with exposure and estimating the dose on a variety of flight paths. However, they have only published "guidelines" and "recommendations" which are ineffective.

For example, the FAA did formally recognize cosmic radiation as an occupational exposure for crewmembers in 1990 when it published a list of different exposure levels that you can expect on different flight routes (Advisory Circular No. 120-52 available at <http://www.bts.gov/ntl/DOCS/Ac12052.html>). Keep in mind that these estimates assume "normal solar activity", which is not always the case.

In 1994, the FAA published another document that recommended that the airlines provide crewmembers with educational materials that describe the potential exposures and health risks (AC No. 120-61 available at <http://www.faa.gov/avr/afs/radiation.doc>). Some airlines have distributed brochures to crewmembers. Largely though, the airlines have not responded to the FAA's recommendation because they don't have to.

What about OSHA? Couldn't it help?

OSHA publishes safety and health regulations that are intended to protect workers from on-the-job hazards. Largely because of heavy pressure from the AFA, representatives from the FAA and the Occupational Safety & Health Administration (OSHA) formally committed to a process that was supposed to set the stage for OSHA regulations to be applied to the working conditions of flight attendants on aircraft, as long as the regulations don't compromise aviation safety. This agreement was signed on 7 August 2000. However, as of this writing (December 2003), FAA is still in control and there is no evidence that this will change any time soon. In fact, OSHA hasn't yet regulated exposure to cosmic radiation because OSHA regulations have only applied to workers in specific industries that work on the ground and are therefore protected by the atmosphere. However, OSHA does regulate occupational exposure to ground-based radiation for those workers, so in theory, OSHA could provide similar protections (such as worker education and pregnancy protections) to flight attendants. Cosmic radiation was not included in the "first-pass" list of issues that the FAA and OSHA reviewed in late 2000, but it could still be addressed.

How much radiation exposure is okay?

The amount of radiation absorbed by your body (in fact, your "effective dose") is expressed in units called "millisieverts" and abbreviated as "mSv". Around the world, there is some disagreement over what limit is "the right one" or "the safe one", but the principle of "ALARA" (or keeping your exposure As Low As Reasonably Achievable) is well accepted. Various organizations and committees around the world have established their own standards. None of the standards guarantee a "safe" level – rather they consider what is "acceptable" under different circumstances.

The annual dose that is considered "acceptable" for workers is typically higher than the "acceptable" annual dose for the general public. For example, the International Commission on Radiological Protection (ICRP) recommends that work-related radiation exposure does not exceed 20 mSv per year, while the recommended limit for the general public is 5 mSv. That isn't based on science; it is based on the fact that people who are exposed at work are assumed to have knowingly assumed that extra risk by choice in exchange for a paycheck. Most flight attendants do not knowingly assume any such risk because, unlike workers in other industries, the airlines are not required to educate them.

What about pregnancy? The ICRP says that the fetus should not absorb a dose that exceeds 1mSv. Conversely, the National Council on Radiation Protection and Measurements (NCRP) says that the dose to the fetus should not be higher than 0.5 mSv in any month.

Remember that these standards can serve as a reference point or they can be used for guidance when developing regulations and laws. However, standards set by scientific committees do not carry the force of law.



What are the health risks?

Basically, there are three types of health risks associated with in-flight exposure to cosmic radiation:

1. Cancer;
2. Genetic damage that might get passed on to a future baby (by men and women); and
3. Damage to the fetus, once conceived.

For more information on pregnancy-related issues, request a free copy of AFA's "Reproductive Health Information For Flight Attendants" information packet, including the bulletins "Benefits You May Be Eligible For During Pregnancy (And After Baby Is Born)" and "Are You Flying Through a Solar Particle Event? (And Why To Avoid Them, Especially When Pregnant)" (also available online).

The following description of these risk estimates is based on materials published by the FAA. Scientists have estimated the health risks by reviewing available health data for people (or cells or animals) who have been exposed to similar *types* of radiation as crewmembers, but at higher levels. Scientists use this information to estimate the health risks associated with exposure to the lower levels of radiation that crewmembers are exposed to. Remember that these are only estimates and that the comparison groups and models are imperfect. In each case, the estimated increase in risk will be smaller for crewmembers who fly fewer hours each year (or fewer years) or who fly at lower latitudes and altitudes (such as short-haul domestic flights). Likewise, the risk will be higher for crewmembers who fly more hours or years with more intense exposures that result from flying at higher altitudes or latitudes and/or during solar radiation events.

Cancer

About 20% of the general population in the US dies (or can expect to die) of cancer related to smoking, chemicals, ground-based radiation, bad genes, or other known or unknown factors. Long-term exposure to cosmic radiation can elevate this risk. For example, the FAA estimates that for a crewmember who flies 900 hours a year for 30 years on flights between the US and Europe, the excess risk of radiation-induced fatal cancer can be as high as 1%. That means that the risk of dying from cancer (in general) might go up from 20% to almost 21%. Another way to look at it is that of every 100 such crewmembers, one can expect to die of radiation-induced cancer. An excess of the following cancers has been observed among crewmembers in health studies over the past 10 years: cancers of the skin (malignant melanoma), female breast, prostate, bone, bladder, colon/rectum, and brain. Radiation has been cited as one *potential* cause, along with electromagnetic fields, chronic fatigue and jet lag, and other known and unknown factors.

In November 2000, researchers at the California Department of Public Health released the results of a study on cancer rates among flight attendants. They searched the California (CA) cancer registry for the names of CA-based AFA members who were diagnosed with cancer between 1988-95. For a comparison group, they chose people in the general population in CA (who were similar to the AFA members in terms of age and gender) and counted how many of *them* were diagnosed with cancer during that same time period.

The proportion of flight attendants diagnosed with all types of cancers combined was no different than the proportion of people in the general population. However, the rate of breast cancer among the *women* flight

attendants was approximately 30% higher than among people in the general population, and the rate of malignant melanoma among flight attendants was approximately two times higher. The fact that a disproportionate number of these two particular cancers were diagnosed among the flight attendants *suggests* that the risk factor(s) could be job-related. Although the reason for these increased rates is not fully understood, the researchers did offer some possible explanations. For example, both breast cancer and malignant melanoma have been associated with radiation exposure. Breast cancer and malignant melanoma have also both been associated with the disruption of circadian rhythms from crossing time zones. Finally, both cancers are associated with higher socioeconomic status. Socioeconomic status can be an indicator of "lifestyle factors" like sun exposure and diet.

Since then, more research papers have been published on the subject. A study of flight attendants in eight European countries reported a slight but non-significant increase in breast cancer deaths among female cabin crew and elevated skin cancer deaths among male cabin crew (Zeeb et. al., 2003). An Icelandic study reported a significant increase in the risk of breast cancer among female cabin crew who had worked five years or more (Rafnsson et. al., 2003). This Icelandic study is especially important because it controlled for age at first childbirth and duration of employment after the introduction of higher-flying jet aircraft in 1971, concluding that "an association between length of employment and risk of breast cancer, adjusted for reproductive factors, indicates that occupational factors may be an important cause of breast cancer among cabin attendants." Finally, a Swedish study reported an increase of malignant melanoma among male and female cabin crew (Linnarsjo et. al., 2003).

Genetic damage to your baby that hasn't been conceived

According to the NAS Committee on the Biological Effects of Ionizing Radiation, about 2.5% of babies in the US are born with one or more birth defects. Unlike the risks associated with pregnancy, both the father and the mother can contribute to genetic damage in a baby that hasn't been conceived. For example, the Committee estimates that if the father works 900 hours a year for 10 years before the baby's conception, then the excess risk of radiation-induced birth defects might be 0.01% or one in 11,000. That means that the total risk goes up from 2.5% to 2.51%. If the mother also worked for 10 years prior, then the risk might increase another 0.01% to 2.52%.

Damage to the fetus when you are already pregnant.

Once pregnant, the degree and nature of the damage to the fetus depends on the stage of development and the degree of exposure. According to a United Nations Scientific Committee and the National Radiological Protection Board, the risks can include decreased mental capacity, severe mental retardation and childhood cancer. An increased risk of miscarriage has also been observed among flight attendants, although radiation has not been definitively identified as the source of this risk (Aspholm et. al. 1999; Cone, 1998).

For example, the FAA reports that the risk of severe mental retardation increases as much as 1 in 10,000 with every 1mSv of radiation dose during the fourth month. If you flew seven roundtrip Athens-New York trips during that month under normal solar conditions, you would absorb almost 1mSv of cosmic radiation, and there would be an increased risk of 1 in 10,000 that your baby would be born severely retarded. This risk would be higher if you flew during periods of high solar activity and lower if you flew less at lower altitudes and latitudes.

Given that there are about 120,000 female flight attendants in the US, if we were to assume that a generous 8% (or about 10,000) are pregnant, then one of those fetuses – assuming that their mothers are

working full-time international flights with normal solar activity – will be born severely retarded. That statistic would probably horrify most mothers-to-be because the damage is preventable. But the devil's advocate might say that it doesn't justify the administrative and financial burden of giving pregnant flight attendants ground jobs or time off with pay. Other people are unsure of what to ask for. Would an enforced limit on flying time for pregnant flight attendants be popular? Could ground jobs be provided? Perhaps the protections or limits would only apply if a woman chooses to formally notify her employer that she is pregnant? There is no doubt that this is a controversial issue, but the current situation provides working women with no good options. On the one hand, the FAA *recommends* that the airlines inform crewmembers of the risks so that you can make an informed decision. On the other hand, if you choose either to not fly or to limit your international trips when pregnant, then financially, you are on your own.



Is it safe to fly when pregnant?

In October 2000, the FAA published a paper on the risks to the fetus (http://www.hf.faa.gov/aar/docs/cami/00_33.pdf). The paper reported that pregnant women who fly more than seven roundtrip international flights (e.g., LGAT to KJFK, 9.4 hours, maximum altitude 41,000 feet) will approach the fetal limit of 1mSv and will need to "modify their work schedules." This calculation assumes normal solar activity. Flying during solar particle events (SPE) will reduce this recommended maximum number of flights dramatically. Incredibly, the ICRP assumes that a mother's belly shields the fetus from 50% of the radiation that the mother is exposed to, even though that same radiation has already penetrated the fuselage of the aircraft. The FAA wisely challenged that assumption in 2000 and concluded that maternal shielding is negligible, and that one must assume that the fetus is exposed to the same levels as the mother. However, the FAA's research has not translated into any regulatory protections for pregnant crewmembers. At the very least, pregnant crew and passengers should have the option to postpone or drop trips scheduled during SPE – when radiation levels can increase by 1,000 times - without penalty or discipline. The National Oceanic and Atmospheric Administration (NOAA) tracks current solar activity and posts the information at http://sec.noaa.gov/rt_plots/pro_3d.html. NOAA gets anywhere between 20 minutes and six hours of warning for a SPE, typically somewhere in the middle of that range. Any airline and anybody can sign up for free SPE alerts from NOAA at www.sec.noaa.gov/alerts/index.html by clicking on "register for alerts." Events with an intensity above 100 PFU (particle flux units) at 10 MeV (S2 and greater) are of health interest, especially during pregnancy.



How can I control my exposure?

What makes exposure to cosmic and solar radiation tricky to control is that it can not be shielded; that is, cosmic and solar radiation are not blocked by the fuselage. If pregnant, some flight attendants choose to use up their accumulated sick leave. Currently, the only sure ways to lower your exposure is to reduce your flying time (that is, cut your hours) and/or transfer to lower-altitude/latitude (probably short-haul domestic) flights. Of course, many flight attendants don't have the seniority to pick their flights. Also, most people cannot afford to cut their hours to coordinate their work schedule with the activity of the sun. At the very least, the airlines should be required to notify pregnant crewmembers scheduled to work during solar radiation events, and to give them the option to drop those trips without penalty or discipline. For more information, see



How do other countries deal with cosmic radiation?

In June 1996, the countries of the European Union passed a law that applies to the 27 airlines that operate there. The law says that the airlines must inform flight attendants of the possible health risks so that they can make an informed decision. Airlines must keep a running estimate of the cumulative radiation dose for each flight attendant and if the cumulative dose during one year exceeds a certain limit (6mSv) then additional protections and controls must be applied. Finally, if a flight attendant formally notifies her employer that she is pregnant, then her employer must organize her work schedule such that her radiation dose during the remainder of the pregnancy be kept below a specific low limit (1mSv). We understand that it is her choice to tell her employer if she is pregnant, but apparently, there is little reason not to tell, given that the financial implications of reporting pregnancy are limited, if any, although the benefits are measurable.

All of these requirements must now be met – the deadline was June 2000. We have learned that many airlines in Europe are keeping track of crewmembers' exposures by merging crew rosters with estimates of radiation dose incurred on each trip leg. The airlines have to occasionally confirm these estimates with measurements. According to medical staff at two airlines, few crewmembers even approach the 6mSv limit, so this limit has not affected crew scheduling. Also, once a flight attendant tells her employer that she is pregnant, then the airline must keep her estimated dose below 1mSv for the remainder of the pregnancy. In practice, we have learned that flight attendants are sometimes assigned ground jobs during their pregnancy, but more typically, simply given time off with pay. In 2005, AFA developed a survey for the International Transport Workers' Federation to find out what is working and what is not working so that we have a better sense of what to recommend or ask for in the United States. But no matter what the European experience, the first step is to get the information out to our members.

On this side of the Atlantic, Transport Canada last updated its Advisory Circular on radiation in November 2005 (CBAAC No. 0183), *recommending* protections that are similar to those in the European law with the intent to issue *regulations* in the near future.



How can I keep track of my exposure?

One way to keep a running estimate of your own cosmic radiation dose is to add the doses that have been estimated for different routes according to the trips that you fly. The FAA has published a list of cosmic radiation dose estimates in its 1990 Advisory Circular 120-52 (available at <http://www.bts.gov/ntl/DOCS/Ac12052.html>). Remember that these numbers do not account for any contribution from solar radiation, and they are only estimates.

You can estimate your cosmic radiation dose with a computer program developed at the FAA Civil Aerospace Medical Institute called CARI. It can be downloaded from the FAA radiobiology team website for free. Just do a web search for the terms "CARI-6" and "FAA". CARI estimates the dose of cosmic (galactic) radiation for a variety of different flight paths based on altitude and latitude. The estimates are specific to a given month of travel because the program takes into account the impact of solar activity on the levels of cosmic radiation. For example, if you take a trip in June 2003, the dose on that same trip will likely be different in December 2003. Be warned: CARI does not incorporate exposures from solar radiation events. Also, it may be necessary to ask a pilot for the specific altitude information that the program requires.

Some people want to monitor their own exposure on individual flights. There is a very good description of radiation monitors in a book called "The Invisible Passenger: Radiation Risks for People Who Fly " written by health physicist, Rob Barish (see reference list below). Essentially, because there is more than one type of cosmic radiation, you need more than one type of monitor. One option that Dr. Barish suggests is to use a film badge (which measures the degree to which the film is "developed" by cosmic radiation) in tandem with a track-etch detector, which is basically a sensitive piece of plastic and when radioactive particles hit the plastic, they leave "pock marks" that can be counted and converted into an exposure estimate. Be aware that monitoring your own exposure gets expensive.



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