EFFECTS OF ELECTROMAGNETIC RADIATION

We are, from the moment of conception, bathed in a sea of electromagnetic waves. Some of these waves are benign or even beneficial, while others are definitely harmful. Part of this radiation is natural and part is man-made. Natural radiation includes the light, radio-waves and cosmic rays from the Sun, Moon and stars; background radiation from the rocks, soil, water and atmosphere of our planets; and the internal radioactivity of our own bodies. Man-made radiation, which forms an increasingly large porportion of the whole, includes radio and radar waves.

It is obvious that we must be more or less immune to any kind of radiation which normally reaches us from outer space, yet earthworms are killed by sunlight even when kept damp and cool, and occasionally human children are born who are abnormally photosensitive and eventually die from the effects of sunlight. Moreover, sunlight can induce skin cancer as well as an attractive tan, and certain drugs have a strongly photosensitizing effect, which makes it necessary for patients who are taking them to use a barrier cream against the enhanced action of ultraviolet rays.

Safe RF Fields:

The "magic" number for determining a radiation hazard condition is the field strength 10 milliwats per square meter. An explanation of how this value was derived can be found in the Handbook on *Radio Frequency Radiation Hazards* (T.O. 31-1-80) dated 15 April, 1958, published under authority of the Secretary of the Air Force. Two pertinent paragraphs are excerpted as follows:

"Based on evidence given in paragraph 1-7, that injury had been caused to experimental animals and could possibly be caused to personnel, all available information was researched in an effort to establish a safe exposure level to this form of possible injury. Many variables were considered, such as the frequency of the energy to which an individual may be exposed, the nature of the exposure, including time of exposure, field strength, and other aspects.

Sufficient factual data is not available to determine the safe exposure level for each frequency; therefore, it was decided to select one level satisfactory for all frequencies. Past research indicated that a power density of 0.2 watts/cm² was required to produce damage. The accuracy of the methods and instrumentation used was somewhat questionable, and possibly some cases of reported damage might have been caused by power densities of approximately 0.1 watts/cm². The expanded use of electronics has also resulted in adding minute amounts of microwave energy from incidental sources at many frequencies. Since it is impractical to measure the power density at each of these frequencies separately, and since the sum of all these assorted r-f sources would be extremely small, a safety factor of 10 was selected and the present USAF level of 0.01 watts/-cm² was established.

This level of 0.01 watts/cm² is an *average* power level and not peak power, since available data indicates the only detrimental effects are thermal in nature, and these effects depend upon average and not peak power levels. Sufficient data is not available to furnish complete correlation between length of exposure and power density. The present level of 0.01 watts/cm² is the maximum for either continuous or intermittent exposure, and precautions should be taken to avoid exposure of personnel to ambient power levels in excess of 0.01 watts/cm² for any period of time."

The penetration of energy into the body and its absorption (loss of energy), and reflection will depend not only upon the physical dimensions and dielectric constant of the tissues, but also upon the frequency (wavelength) of the r-f radiation.

The percentage of absorbed biologically effective energy approaches 40 percent of the incident energy for frequencies below 1000 mHz (30 cm) and for frequencies above 3000 mHz (10 cm).

The percentage of absorbed biologically effective energy is between 20 and 100 percent of the incident energy for frequencies between approximately 1000 and 3000 mHz (30 to 10 cm wavelength).

The sensory elements of the body are located primarily in the skin tissues; for this reason radiation frequencies below 1000 mHz are considered extremely hazardous because the presence of r-f radiation will not be detected by the human sensory system. Radiation at frequencies below 1000 mHz causes heat to be developed primarily in the deep tissues as a result of the penetration of the energy. The energy absorbed in body tissues may be as high as 40 percent of the incident energy arriving at the body surface.

Frequencies greater than approximately 3000 mHz cause heating of tissues in much the same manner as does infrared radiation or direct sunlight; therefore, the sensory reaction of the skin should normally provide adequate warning of the presence of r-f radiation. In general, the depth of energy penetration decreases rapidly with an increase in radiation frequency, and absorption occurs almost completely in the surface of the body where skin tissues and the sensory elements are located. Also, reflection of energy at the surface of the skin occurs at the higher frequencies. Thus, the percentage of energy absorbed may approach 40 percent of the energy incident on the body surface, with a greater portion of energy being reflected.

Radiation at frequencies between 1000 and 3000 mHz is subject to varying degrees of penetration and is absorbed in both surface tissues and deeper tissues, depending upon the characteristics of the tissues themselves (thickness, dielectric constant, and conductivity) and the frequency of radiation. The percentage of incident energy absorbed varies from approximately 20 to 100 percent because of tissue factors governing impedance values, which range from complete mismatch, to a near perfect match, to the incident energy.

When electromagnetic energy is absorbed in tissues of the body, heat is produced in the tissues. If the organism cannot dissipate this heat energy as fast as it is produced, the internal temperature of the body will rise. This may result in damage to the tissue and if the rise is sufficiently high, in the death of the organism. The body's ability to dissipate heat successfully depends upon many related factors, such as environmental air circulation rate, humidity, air temperature, body metabolic rate, clothing, power density of the radiation field, amount of energy absorbed, and duration of exposure (time).

The limited ability of the body to dissipate heat when its temperature is elevated above normal is complicated by the fact that basal metabolic rate increases as much as 14 percent for every degree of temperature rise above normal. The increase in temperature also causes abnormally rapid breathing, or fever hyperpnea. The lack of oxygen available in the blood for release to cells or tissues results in hemorrhages and damage to the brain cells, the central nervous system, and certain internal organs, and may also result in muscular irritability and sometimes convulsions. If these conditions persist, the results are usually coma and eventual death.

Certain organs of the body are considered to be more susceptible than others to the effects of r-f radiation. Organs such as the lungs, the eyes, the testicles, the gall bladder, the urinary bladder, and portions of the gastrointestinal tract are not cooled by an abundant flow of blood through the vascular system. Therefore, these organs are more likely to be damaged by heat resulting from excessive exposure to radiation.