19BME308 - Medical Radiation Safety

UNIT I - INTRODUCTION TO RF AND MICROWAVE RADIATION

1.2 Effects of Radio Frequency Radiation

The nature of potential hazards

1. Direct effect on people:

(a) Thermal effects attributable to the heating of the human body due to the absorption of RF energy. At lower frequencies this includes heating due to excessive current densities in some parts of the body.

(b) Shocks and burns which may result from contact with conductive objects, e.g. scrap metal, vehicle bodies, etc., located in electromagnetic fields.

(c) The so called 'athermal' effects, if any, where it is postulated that the fields act directly on biological tissue without any significant heating being involved.

2. Indirect effects on people:

Effects on people wearing implantable devices such as heart pacemakers, insulin pumps, passive metal plates and other related hardware due to interaction with some aspect of the implantable device. Some effects in this category affect the quality of life rather than physical health, e.g. interference with hearing aids and other electronic devices.

Specific absorption rate (SAR)

This term was used earlier and needs some explanation in the context of safety assessments. It is used to quantify the absorption of energy in tissue and is expressed in watts per unit mass of tissue, usually Wkg–1. It is convenient to use the concept of the 'standard man' to aid discussion of the thermal aspects of RF radiation. The generally adopted standard man has a height of 1.75 m, a weight of 70 kg and a surface area total of 1.85m^2. It is easy to see that the tissue mass of the exposed person is part of the definition of SAR so, for example, if it is known that the total power deposited in the standard man is 7W, then the average whole-body SAR is 7/70Wkg–1 or 0.1Wkg–1.

At very low frequencies (tens of kilohertz) energy absorption is relatively low. Absorption increases to a maximum at human resonance, which for adults is somewhere between 30 and 80 MHz depending on height and whether the person is effectively earthy or not. Above resonance, relative absorption declines somewhat. There is no practical way of measuring the SAR of a human being. In order to make calculations of SAR, either computer modelling or practical experiments with dummy persons using substances which simulate the electric characteristics of human tissues are undertaken.

Practical studies which simulate the human body use either standard shapes of hollow plastic objects such as spheres or hollow plastic human models generally known as phantoms. Their construction will depend on the temperature measurement technique to be used. The most common systems are infrared (IR) scanning and temperature recording systems or the use of implantable temperature probes connected to some form of controller and data logger.

Phantoms in which implantable probes are used may be filled with a liquid or semi-liquid media simulating human tissue. This may be ahomogeneous filling or elaborate layering and scaling may be done to represent the bones and organs of the human body with their different tissue simulations.

Known effects of RF radiation on people

Thermal effects

There is general agreement that the main demonstrable effect on the human body above about 100 kHz is the thermal effect, i.e. the transfer of electromagnetic field energy to the body. A very high percentage of the human body is made up of water and water molecules which are polar molecules liable to be influenced by impinging electromagnetic fields. Hence those tissues having a significant water content are most liable to be influenced by fields. Some other tissues also have large polar molecules. The effect of RF on such body tissues is to cause polar molecules to attempt to follow the reversals of the cycles of RF energy. Due to the frequency and the inability of the polar molecules to follow these alternations, the vibrations lag on them, resulting in a gain of energy from the field in the form of heat which causes an increase in the temperature of the tissue concerned.

RF penetration in human tissues

In considering the amount of energy absorbed by the human body, it is necessary to recognise that the percentage of incident radiation which is actually absorbed depends on frequency and the orientation of the subject relative to the field.

In human tissues, RF radiation may be absorbed, reflected or may pass through the tissue. What actually happens will depend on the body structure and the tissue interfaces involved. These interfaces are the transitions from tissue to tissue or tissue–air–tissue and are clearly complex in the human body.

The depth of RF penetration of the human body is also an important factor. In the HF band, the deeper penetration is used for diathermy treatment where the deposition of heat is intended to have a beneficial effect on that part of the body considered to need treatment. The deep deposition of RF energy needs to be carefully controlled to avoid damage to tissues which might not be noticed by the subject due to lack of sensory perception of heat in the organs concerned.

Effects on people wearing implantable devices

There are a number of implantable devices, active and passive, which are fitted into the human body. Perhaps the most common one is the heart pacemaker on which many people depend. There are two basic types of heart pacemaker. The first could be described as a demand pacemaker which will make up for missed heart beats as needed. The second type is the fixed pacemaker which operates continually at a fixed rate with no other form of control. There may be modern developments of these devices too. It is possible that some sources of RF radiation could interfere with the operation of pacemakers, the significance of such interference depending on the type of pacemaker fitted. The potentially more serious consequences of interference relate to interference with the fixed rate pacemaker. However, the two descriptions above are basic. With current developments in electronic devices there is always the possibility of the use of more sophisticated devices and the possibility of new problems of vulnerability to interference.

Many of these pacemakers are subjected to interference (EMC) testing by the manufacturer but the relevant information does not normally get communicated to those responsible for safety at work, because of patient confidentiality. Consequently, those responsible for the operation of RF transmitters and similar sources who may become involved with visitors wearing a heart pacemaker have no means of carrying out their responsibilities for the individual safety of such people. The only recommendation that can be made is that such sites should have a sign requiring visitors to notify the manager that they are wearing a pacemaker. They can then be excluded from RF fields.

Reference: *Ronald Kitchen - RF and Microwave radiation safety handbook.*