Computational Dosimetry

Ongoing research work

Hybrid voxel-mathematical models of a pregnant female have been produced. Mathematical models of the developing fetus at 8-, 13-, 26- and 38-weeks gestation were converted into voxels and combined with the adult female model, NAOMI. As the dimensions and mass of NAOMI correspond to the ICRP adult reference female the fusion of the adult and embryo/fetus models was relatively smooth in the matching of position and the extension of the female torso. This set of models was used to calculate induced current densities and electric fields in the fetus from applied 50 Hz magnetic and electric fields.

Calculations have been carried out and a paper written on the frequency dependence of SAR in seated adult and scaled child models of the male voxel phantom NORMAN. Results show that the sitting posture causes a second, smaller resonance condition not seen in resonance curves for the phantom in the standing posture. This second resonance condition is due to the upper and lower regions of the body having their own resonant frequencies when the model is orientated in the sitting posture. These peaks combine to produce the second resonance condition in the whole-body SAR.

A new combined electromagnetic and thermal model of the human head has been developed to compute temperature rises in the human eye due to irradiation by near-field radiofrequency sources. This model combines a FDTD electromagnetic model with 2 mm resolution and a finite element thermal model with 1 mm resolution in the eye. It is being used to compare the SAR with temperature rises due to radiation from antennas and handsets at 380, 900 and 1800 MHz.


Contract work

ASSESSING THE COMPLIANCE OF EMISSIONS FROM BBC MF BROADCASTING TRANSMITTERS WITH EXPOSURE GUIDELINES

This project defined the theoretical maximum electric field strengths and magnetic flux densities that people could be exposed to at the MF band frequencies used by the BBC World Service without the basic restrictions on exposure being exceeded. This should be helpful in establishing more precise boundaries to regions around antennas for compliance with exposure guidelines. A review of the calculations relating external electric and magnetic fields to basic restrictions in the
The body was made for frequencies from 500 to 1500 kHz. Specifically, the review included calculations of the induced current density in the brain, spinal cord and retina, the whole body averaged SAR and localised SAR in the leg. It was assumed that for the MF antennas the electric field would be vertically polarized. The calculations had been performed on the voxel (volume pixel) models, NORMAN and NAOMI. The calculated external field values required to produce the internal basic restrictions in the body were compared with the ICNIRP occupational and public exposure reference levels.

The NRPB in its recent advice on limiting exposure to electromagnetic fields recommended the adoption of the ICNIRP guidelines. The ICNIRP electric field reference levels provide a conservative estimate of the basic restrictions for both occupational and public exposure. The localised SAR in the leg is the most restrictive quantity. The ICNIRP magnetic flux density reference levels provide a conservative estimate of the basic restrictions. The localised SAR in the leg is the most restrictive quantity.

ASSESSING THE COMPLIANCE OF EMISSIONS FROM BBC HF BROADCASTING TRANSMITTERS WITH EXPOSURE GUIDELINES

Making assessments against the basic restrictions for HF transmissions is much more complicated, but potentially more worthwhile, than doing this in the case of MF transmitters. The difference arises because the ICNIRP reference levels are based on the worst case condition where a body is aligned with the field. This is appropriate for a person standing near a vertically polarized MF transmitting antenna, but not a horizontally polarized HF transmission. Previous work suggests that the coupling at HF is substantially lower when the field is at 90 degrees to the body and therefore the reference levels could be particularly conservative in this case.

In practice, the field from a typical HF broadcast transmitting antenna usually also has a vertical component. Whilst this may be relatively small compared with the main horizontal component, the coupling to the body is much greater and so it was felt that, for the purposes of the study, it could not be ignored. It was also recognized that a person’s posture affects the coupling of the body to the field. In particular, it was expected that, for horizontal polarization, there could be a significant increase if the arms were outstretched. This is because the arms would then be aligned with the field and have an overall electrical length similar to that of the person’s height.

The HPA study therefore considered both vertical and horizontal polarization. In the case of vertical polarization, the three conditions as used for the MF study were considered, i.e. grounded, with shoes and isolated. For horizontal polarization, the grounding of the feet was not considered to be very relevant and so the isolated condition only was studied, but for an “arms out” posture as well as the usual “arms down” case.

The study concluded that, for a vertical electrical field, the ICNIRP electric field reference level is conservative at the frequencies in the lower HF bands but is not low enough to provide compliance with the basic restrictions at the frequencies in the higher HF bands. However, there is also an ICNIRP limb current reference level specified for frequencies above 10 MHz, and the calculations show that this ensures compliance at the higher frequencies. The graph shows the ankle currents and wrist currents, corresponding to the SAR restrictions in the limbs, in relation to the ICNIRP induced current reference levels for public exposure. The study also concluded that, for the horizontal electric field component, the reference levels are conservative even for the “arms out” posture. Moreover, in the case of the “arms down” posture, the ICNIRP reference levels are significantly lower than those needed to ensure compliance with the basic restrictions.

**Experimental dosimetry**

**Residential (magnetic field) sources study**

A study has been completed to identify the main sources of residential exposure to power frequency magnetic fields. A sample of homes from the UK Childhood Cancer Study (UKCCS) was investigated. In the absence of any link between exposure and childhood malignancy in the UK, the UKCCS data provide a large and unique source of information broadly representative of residential magnetic field exposure in the UK. In Stage 1, 196 homes were the subject of an external assessment, including 102 of the study time-weighted average (TWA) residential exposure estimates above 0.2 µT and 21 above 0.4 µT. In Stage 2, 19 householders consented to internal home inspections. Scientific interest and public concern have tended to focus on HV power lines as the primary sources of the elevated magnetic fields that are associated with the leukaemia risk. The results of this study place a different emphasis in terms of average exposure over time, identifying unbalanced currents associated with the LV supply in and around the home as an important source of elevated exposure. LV sources accounted for 77% of average exposures above 0.2 µT and 57% above 0.4 µT. The study supports measurement-based approaches over the field calculation and distance proxy if average magnetic field exposure is the cause of the increase in risk. The results are relevant to public health policy considerations with respect to exposure reduction, and minimising net currents in and around the home may provide an effective way of mitigating exposure across the population.

**Microcell and picocell base station exposure assessments**

Masts and rooftop-mounted radio transmitters have spread throughout the environment wherever people use mobile phones. Sometimes concern is expressed about exposure to the radio waves, and key elements of any risk assessment are measured exposure levels. Data have been published for exposures near to such macrocell base station transmitters, but not for exposures near microcell and picocell base stations, which are less visually obvious but have their antennas deployed nearer to ground level.

The former NRPB (now part of HPA) carried out a project under the UK’s Mobile Telecommunications and Health Research Programme to address this lack of information and the results have just been published in the Journal of Radiological Protection. The paper reports the results from visits to 20 randomly chosen microcell and picocell transmitter sites and finds exposures comfortably within accepted guideline levels, even when people are standing directly beneath the antennas. Nevertheless, exposures can be higher than with macrocells because people can approach nearer to the antennas.


**Biological studies**

A scientific paper will be published soon in the International Journal of Radiation Biology on work on "935 MHz cellular phone radiation: An in vitro study of genotoxicity in human lymphocytes". This work was carried out in collaboration with ENEA, Rome and funded by the MMF.

A scientific paper was electronically published recently in Radiation Protection Dosimetry titled 'Chromatid damage in human lymphocytes is not affected by 50Hz electromagnetic fields'. This was work funded by the United Kingdom EMF Trust.
The Radiation Protection Division of the HPA has a contract from the United Kingdom EMF Trust, working in collaboration with the Gray Cancer Institute. This is to use 50 Hz intermittent exposures repeated over 18 h to human fibroblasts to see if the genotoxicity reported by the REFLEX programme that claimed an effect for intermittent but not continuous exposures to fibroblasts can be reproduced.

Another recently acquired contract is from the Swiss Research Foundation on Mobile Communication. This is to use 935 MHz signals to investigate apoptosis induction in cultured human and mouse brain cells. This contract includes IT'IS on the dosimetry and University of Bristol who will do some molecular biology on the cells.

**Stakeholder Advisory Group on ELF EMFs (SAGE)**

SAGE was set up in late 2004 has a remit for the whole of the UK, it is funded equally by English Department of Health, the charity Children with Leukaemia, and the electricity industry. The aims of SAGE are:

"To bring together the range of stakeholders to identify and explore the implications for a precautionary approach to ELF EMF (electric and magnetic fields) and make practical recommendations for precautionary measures"

The HPA is represented on SAGE. Two working groups have been active, one looking at precaution within the home related to wiring and appliances, the other looking at precautionary measures for high voltage power lines. Both working groups will report soon with recommendations for the Government about the implications, costs and benefits of precautionary measures that they could adopt after relevant due process. The draft WHO precautionary framework has been one of the documents used by SAGE in developing its precautionary approach. Working groups looking at lower voltage distribution wiring and transport may be set up in the future.

[http://www.rkpartnership.co.uk/sage/](http://www.rkpartnership.co.uk/sage/)