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Asia-Pacific EMF Conference

Electromagnetic Fields, Research, Health Effects,
and Standards Harmonization

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Bangkok, Thailand

Symposium Record Abstracts

Organized by

World Health Organization (WHO)

United States Air Force Research Laboratory
Directed Energy Bioeffects Division
Radio Frequency Radiation Branch
Brooks City-Base, Texas

Ministry of Public Health, Thailand

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Welcome Statement & Introduction

The Organizing Committee would like to welcome you to the Asia-Pacific Electromagnetic Field (EMF) Conference in Bangkok, Thailand. In 1996, the World Health Organization (WHO) established the International EMF Project to address global concerns about EMF exposure. As part of the activities under this project, the WHO in collaboration with the Ministry of Public Health of Thailand, the U.S. Air Force Research Laboratory, and Health Canada are hosting the Asia-Pacific Electromagnetic Field Conference this week in Bangkok, Thailand. This conference will serve as a forum where scientists from throughout the world will present recent research and discuss its relevance to EMF health and safety. Scientists from the Asia-Pacific region will have an opportunity to discuss research activities and EMF issues in their countries, and provide input to the Project. The objectives of the conference are:

1. To review and update the biological effects from exposure to electromagnetic fields (EMFs),

2. To review the latest developments in EMF exposure dosimetry,

3. To identify and discuss possible health consequences of EMF exposure,

4. To identify issues relating to electromagnetic interference with medical devices,

5. To discuss EMF exposure policy and risk communication,

6. To summarize a framework for the harmonization of international EMF exposure standards, and

7. To present and discuss a model for EMF exposure regulation and compliance.

The Organizing Committee believes that you will find the Asia-Pacific EMF Conference both informative and interesting. We hope that numerous scientific discussions are held and that many friendships are developed or strengthened this week. We also hope that you enjoy your visit to this wonderful and exciting international city.

Tutorial Agenda

Location: Ministry of Public Health, Nonthaburi

MONDAY, 26 JANUARY 2004	
8:00 am	Registra tion
Session Co-Chairs: **Art Thansandote & Patrick Mason**	
8:30 am	Opening Remarks, ***Organizational Committee***
8:40 am	Electromagnetic Fields: Physical Characteristics and Sources, ***Art Thansandote***, Consumer and Clinical Radiation Protection Bureau, Health Canada
9:00 am	Interactions of EMF with Biological Systems, ***C.K. Chou,*** Motorola Labs, Florida, USA
9:30 am	Overview of Epidemiological Studies, ***Sheila Johnston***, Neuroscience Consultant, London, UK
10:00 am	Overview of Laboratory Studies, ***John D'Andrea***, Naval Health Research Center Detachment, Brooks City-Base, Texas, USA
10:30 am	**Break**
10:50 am	Safety Standards for Exposure to Electric, Magnetic and Electromagnetic Fields: An Overview (tutorial), ***Ron Petersen,*** IEEE
11:20 am	EMF Exposure Assessments, ***John Leonowich,*** Pacific Northwest National Laboratory, Washington, USA (Abstract not available)
11:50 pm	SAR From Tetra Radios and Accessories, ***Philip Chadwick***, MCL, London, UK
12:20 pm	A System for Mapping RF Fields From Mobile Phone Base Stations, ***Art Thansandote***, Consumer and Clinical Radiation Protection Bureau, Health Canada
12:50 pm	**LUNCH**
Session Co-Chairs: **John Leonowich & Martin Meltz**	
1:50 pm	A Report of an RF-Induced Biological Effect Versus an Adverse Human Health Effect: Science Versus Speculation, ***Martin Meltz***, Department of Radiation Oncology, University of Texas Health Science Center, USA
2:10 pm	Overview of RF Bioeffects Research Conducted at the U.S. Air Force Research Laboratory, ***Michael Murphy,*** U.S. Air Force Research Laboratory, Brooks City-Base, Texas
2:40 pm	Overview of the Radiofrequency Dosimetry Research Being Conducted by the U.S. Air Force, ***Patrick Mason***, U.S. Air Force Research Laboratory, Brooks City-Base, Texas
3:00 pm	**Break**
Session Co-Chairs: **John Leonowich & Martin Meltz**	
3:20 pm	Medical Devices and Electromagnetic Compatibility, ***Veronica Ivans***, Medtronic CRM
3:50 pm	Heating of Medical Implants During MRI, ***C.K. Chou***, Motorola Labs, Florida, USA
4:10 pm	Discussion and Closing of Tutorial

Conference Agenda

TUESDAY, 27 JANUARY 2004	
8:30 am	Welcome by Organizational Committee, ***Dr. Vallop Thainua***, Permanent Secretary for Public health
8:45 am	Welcome by Ministry of Public Health of Thailand , ***Mr. Yongyuth Vichaidit***, Assistant Minister of Public Health
9:15 am	Welcome by U.S Government Representative
9:30 am	An Overview of WHO's EMF Project and the Health Effects of EMF Exposure, ***Michael Repacholi***, World Health Organization (WHO)
10:00 am	An Overview of ELF and RF Exposure Standards, ***Ron Petersen***, Lucent Technologies (Retired)
10:30 am	**Group Photo**
Session Co-Chairs: **Ron Petersen & Peter Gajšek**	
11:00 am	Institute of Electrical and Electronics Engineers (IEEE) C95.1-1991 RF Safety Standard Revision Status, ***C.K. Chou,*** IEEE, International Committee on Electromagnetic Safety, Subcommittee 4
11:20 am	ICNIRP's Activities and Approach to EMF Protection***, Maila Hietanen,*** ICNIRP
11:40 am	A Comparative Summary of Guidelines & Standards for Limiting of Exposure to Time-Varying Electric and Magnetic Fields in Frequency Range up to 3000 Hz, ***Philip Chadwick,*** MCL, London, UK
12:00	Overview of the EMF Standards in Korea, ***Jeong-Ki Pack,*** Department of Radio Science and Engineering, Chungnam National University
12:30 pm	**Lunch**
Session Co-Chairs: **Philip Chadwick & Maila Hietanen**	
2:00 pm	EMF Exposure Standards In Japan, ***Chiyoji Ohkubo***, Department of Environmental Health, National Institute of Public Health, Japan
2:20 pm	Discussion on Rationale for China EMF Exposure Standards, ***Huai Chiang,*** Bioelectromagnetics Laboratory, Zhejiang University School of Medicine, China
2:40 pm	RF Safety Standards in Australia and a New Centre of Research Excellence, ***Vitas Anderson,*** RMIT University
3:00 pm	Australasian Standards and the Precautionary Principle, ***David Black***, University of Auckland
3:20 pm	Electromagnetic Field Standards in Eastern European Countries, ***Peter Gajšek***, Institute of Non-Ionizing Radiation (INIS), Ljubljana, Slovenia
3:40 pm	**BREAK**
Session Co-Chairs: **C.K. Chou & Sakari Lang**	
4:00 pm	European EMF Exposure and Emission Standards, ***Philip Chadwick,*** MCL, London, UK
4:20 pm	Compliance with Canadian RF Exposure Standards, ***Art Thansandote***, Consumer and Clinical Radiation Protection Bureau, Health Canada
4:40 pm	WHO Framework for Developing EMF Standards, ***Michael Repacholi,*** World Health Organization (WHO)

6:00 pm	**DEPART HOTEL TO GO TO Dinner**
7:00 pm	Dinner at Silom Village
WEDNESDAY, 28 JANUARY 2004	
Session Co-Chairs: **Vita Anderson & Patrick Mason**	
8:30 am	Biological Effects of RFR: Research Done at the PIOM Laboratory and Within the European Programmes, ***Isabelle LaGroye***, Laboratoire PIOM-UMR, France
9:00 am	The EMF Dosimetry Handbook Project, ***Philip Chadwick***, MCL, London, UK
9:20 am	Age Effect on SAR Evaluation of Dielectric Tissue Properties for Mobile Telephones, ***Jianqing Wang***, Dept. Electrical Engineering and Computer Engineering, Nagoya Institute of Tech., Japan
9:40 am	The Brooks Anatomical Models and the State of Research Commons for Radiofrequency Dosimetry Modeling, ***John Ziriax*** Naval Health Research Center Laboratory, Brooks City-Base
10:00 am	Development of High-Resolution Voxel Models of the Human Body Suitable for the Average Japanese Figure and Numerical Dosimetry for Whole-Body Exposure to RF Electromagnetic Fields, ***Tomoaki Nagaoka***, Department of Medical Engineering, Kitasato University Graduate School of Medical Sciences, Sagamihara, Japan
10:20 am	**BREAK and POSTERS**
Session Co-Chairs: **Marnus Van Wyk & John Ziriax**	
11:00 am	RF Safety Assessment of Metallic Implants, ***Vitas Anderson,*** RMIT University
11:20 am	Active Implantable Medical Devices and Electromagnetic Compatibility, ***Veronica Ivans***, Medtronic CRM
11:40 am	International Criteria for EMF Research for Health Risk Assessment, ***Sheila Johnston***, Neuroscience Consultant, London, UK
12:00	Update of Research on Mobile Telephony and Health, ***Sakari Lang***, Nokia Research Center, Finland
12:20 pm	Management of International Multilateral Collaborative Research, ***Heiki Mäkipää***, Research Affairs, University of Helsinki
12:40 pm	Feasibility and Design of Rodent Carcinogenicity Studies on Cell Phone Radiofrequency Radiation in Reverberation Chambers, ***Ron Melnick***, National Institute of Environmental Health Sciences, USA
1:00 pm	**LUNCH**
Session Co-Chairs: **Art Thansandote & John Leonowich**	
2:00 pm	Electricity Generating Authority of Thailand's (EGAT's) Practice on Managing Electromagnetic Fields in Thailand, ***Kitti Petchsanthad***, Transmission Line Technology and Aviation Department, Transmission System Business, EGAT, Thailand
2:20 pm	Participatory Disease Investigation of Transmission Line Workers at EGAT, ***Mana Sriyudthsak***, Chulalongkorn University, Thailand
2:40 pm	Occupational Exposure Assessment of ELF Electromagnetic Fields in Malaysia, ***Ahmed Farag***, University Tenaga Nasional, Selangor, Malaysia
3:00 pm	GIS Modelling for Estimating the Proportion of Children Exposed to the ELF Magnetic Field of Overhead Power Lines in Flanders (Belgium), ***Gilbert Decat***, Vito-Boeretang 200, Belgium
3:20 pm	Exposure of School Children to Extremely Low Frequency Magnetic Fields in Korea, ***Yoon Joo Hyun*****,** Institute of Environmental and Industrial Medicine, College of Medicine, Hanyang University, Seoul, Korea
3:40 pm	Accurate SAR Assessment Around Base Station Antennas Using the Finite Element and Method of Moments Numerical Techniques, ***Marnus Van Wyk***, EM Software and Systems, Stellenbosch, South Africa

4:00 pm	BREAK
Session Co-Chairs**: Huai Chiang & Sheila Johnston**	
4:20 pm	A Review of Epidemiologic and Long-Term Animal Studies and Their Use in the Evaluation of the Carcinogenic Potential of RF Energy, ***Mays Swicord***, Motorola Labs, Florida, USA
4:40 pm	The Species Specificity and Sensitive Target Organs of Injury Induced by Electromagnetic Radiation (BIOEFFECTS OF EMP AND HPM), ***Wang Dewan***, Institute of Radiation Medicine, Academy of Military Medicine Science, Beijing, China
5:00 pm	Bioeffects of S Frequency High Power Microwave Exposure on Rat Hippocampus, ***Ruiyun Peng***, Department of Experimental Pathology, Beijing Institute of Radiation Medicine, China
5:20 pm	Albumin Leakage and Accumulation in the Nerve Cells of Rat Brain After Whole-Body Exposure to Microwaves from GSM Mobile Phones, ***Bertil Persson***, Department of Medical Radiation Physics, The Rausing Laboratory, Lund University, Sweden
5:40 pm	Intravital Microscopic and Histological Evaluation of Acute Effects on the Brain by Local Exposure to Radio-Frequency Electromagnetic Fields in Rats, ***Chiyoji Ohkubo***, Department of Environmental Health, National Institute of Public Health, Japan
THURSDAY, 29 JANUARY 2004	
7:00 am	**DEPART HOTEL FOR TOUR**
FRIDAY, 30 JANUARY 2004	
Session Co-Chairs: **Michael Murphy & Isabelle LeGroye**	
8:30 am	Research Related to Mobile Telephony and Health in Italy: National and International Programs, ***Carmela Marino***, ENEA, C.Cr. Casaccia, Italy
9:20 am	Effects of High Peak Power 2.8 GHz Microwave Pulses on Rhesus Monkey Corneal Endothelium, ***John D'Andrea***, Naval Health Research Center Detachment, Brooks City-Base, Texas, USA
9:40 am	Effects and Mechanism of EMF and HPM on Optical System in Monkey, Dog, and Rabbit, ***Wang Dewan***, Department of Experimental Pathology, Beijing Institute of Radiation Medicine, China
10:00 am	Effect of Microwave Exposure on Fetal Development in Rat, ***M. Sedehi Esfahani***, Biological Research Center of ISIRI
10:20 am	**BREAK**
Session Co-Chairs: **Carmela Marino & John D'Andrea**	
10:40 am	Biological Effects of 20 kHz MF Exposure, ***Yun-Sil Lee***, EME Research Team, Radio & Broadcasting Technology Laboratory, ETRI, Taejon, Korea
11:00 am	Mammalian Cell Toxicity, Genotoxicity, and Transformation After Radiofrequency Exposure, ***Martin Meltz,*** Department of Radiation Oncology, University of Texas Health Science Center, USA
11:20 am	Mechanism for the Deactivation of Bacterial Spores in a Non-thermal Discharge, ***Joseph Birmingham***, Micro Energy Technologies, Inc., Vancouver, Washington, USA
11:40 am	Apoptosis of Testicular Germ Cell Induced by 60 Hz Magnetic Field Exposure in Mouse, ***Yoon-Won Kim***, Institute of Medical Science, Korea
12:00	WHO Framework for Developing EMF Standards (Panel Discussion Moderated by ***Michael Repacholi***)
12:30 pm	Closing of Conference
12:30 pm	**LUNCH SERVED**
1:30 p.m.	Buses leave the hotel for the Post Conference Tour to the Grand Place & Temple of the Emerald Buddha (tour is free of charge for conference attendees & guests, please sign up to go)

	POSTERS (Wednesday Morning)
P1	Korea-Japan Interlaboratory Comparison Studies on SAR Measurement Systems and Their Calibration, ***K.H. Kim***, Radio Research Laboratory, Ministry of Information and Communication, Seoul, Republic of Korea
P2	Effect of the Hand on SAR Measurement of CDMA Phones, ***Y.H. Jang,*** Radio Research Laboratory, Ministry of Information and Communication, Seoul, Republic of Korea
P3	Personal Exposure to Magnetic Field Over a 24-hour Period in Korea, ***Mun-no Ju***, Electrical Environmental & Transmission Group, Korea
P4	Experimental Prediction Method for ELF Transient Magnetic Field From Electrical Appliances, ***Mun-no Ju,*** Electrical Environmental & Transmission Group, Korea
P5	Electromagnetic Radiation Levels from Mobile Telephone Base Station Towers in the West Bank and Gaza Strip, ***Adnan Lahham***, Department Applied Earth & Environmental Sciences, Al-Quds University, Israel
P6	Design, Conduct, and Interpretation of Epidemiologic Studies, ***Leeka Kheifets***, Dept. Epidemiology, Univ. Calif. Los Angeles School of Public Health
P7	The Effect of Alternative and Rotary Electromagnetic Fields on the Organogenesis of Mouse Embryos in day 4.5 of Gestation, ***Javad Baharara***, Department of Biology, Mashhad, Islamic Azad University
P8	Physiological Effects of Continuous Whole-Body Exposure to Extremely Low Frequency Electromagnetic Fields With or Without Transient Magnetic Fields on Cerebral Microcirculation in Mice With Brain Tumors, ***Akira Ushiyama***, Department of Environmental Health, National Institute of Public Health, Japan
P9	Acute Effects of Whole-Body Exposure to Low Frequency 16 Hz and 50 Hz Electromagnetic Fields on Cutaneous Microcirculation in Mice, ***Akira Ushiyama,*** Department of Environmental Health, National Institute of Public Health, Japan
P10	Cell Isolation and Growth in Electric-Field Defined Micro-Wells, ***W. Mike Arnold***, Industrial Research Limited, Lower Hutt, New Zealand
P11	The Comparison of Rice Growth Due to Vertical and Horizontal Electric Field Treatment, ***Thyanuch Rotcharoen***, Faculty of Engineering, King Mongkut's Institute of Technology, Ladkrabang, Bangkok, Thailand
P12	The Study of Electric Field Treatment Affects on the Growing Based On Electric Field Intensity and Direction, ***Pataree Kiatgamjorn***, Research Center for Communications and Information Technology, King Mongkut's Institute of Technology, Ladkrabang, Bangkok, Thailand
P13	Method, Material, and Device Providing Electromagnetic Compatibility Between Technologically Originated EMR and Biological Systems, ***Igor Smirnov***, Global Quantech, Inc., San Marcos, California, USA
P14	Searching for Biomarkers of Millimeter Wave Exposure, ***Roza Sypniewska***, Advanced Information Technologies, Inc., A General Dynamics Company., Brooks City-Base, Texas
P15	Report on the Review in Progress of Russian EMF Bioeffects Studies, ***Roza Sypniewski***, Advanced Information Technologies, Inc., A General Dynamics Company, Brooks City-Base, Texas.
P16	The Weak EMFs Action on Living Processes of Aquarium Fishes *In Vivo*, ***V.V. Alexandrov***, Environmental Ecology Department of Saint-Petersburg State Polytechnical University, Saint-Petersburg, Russia
P17	Epidemeological Studies In The Mobile Phone Frequency Band In Korea, ***Wook Choi***, Korea University (Abstract not available)

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Monday: Tutorial

Electromagnetic Fields: Physical Characteristics and Sources

Art Thansandote
Consumer and Clinical Radiation Protection Bureau, Health Canada
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The industrialization and electrification of society has resulted in the exposure of population to a complex environment of electromagnetic fields (EMFs), which include static electric and magnetic fields, extremely low frequency fields (normally having frequencies up to about 300 Hz) and radiofrequency (RF) fields (3 kHz to 300 GHz). While EMFs in our environment extend over all frequency ranges, the dominant exposure to the general public is due to the generation, distribution and domestic use of electricity at a power frequency of 50 or 60 Hz. Public exposures may also result from high frequency sources such as computer monitors, microwave ovens, radio and TV broadcast stations, radio communication equipment, security and surveillance systems, and traffic and navigation radars. In many workplaces, employees may be exposed to high intensity EMFs during the course of their jobs. This includes individuals working in electrical utility substations and persons working near active power lines, induction furnaces, RF heating devices, and radio and TV antennas. The past 15 years have seen remarkable advances in personal communication technology and a rapid expansion in the use of mobile phones. The rapid growth of the mobile phone industry has resulted in the installation of numerous base stations to relay phone calls. Base station antennas appear everywhere in both urban and rural areas, either mounted on freestanding towers or attached to rooftops or the sides of buildings. In the assessment of risks from EMF exposures, it is important to understand the characteristics of exposure fields and their interactions with biological organisms. EMFs from different sources may have widely different characteristics, and thus their effects on biological organisms should not be assumed to be the same. Because of the complex mechanisms of interaction, the study of the biological effects of EMFs requires knowledge in a wide range of disciplines, including biology, chemistry, engineering, environmental health, mathematics, medicine and physics.

Interactions of EMF with Biological Systems

C.K. Chou, Ph.D.
Motorola Florida Research Laboratories, Fort Lauderdale, Florida, U.S.A.

Unlike ionizing radiation (above the ultraviolet region of the EM spectrum), lower-frequency nonionizing radiation with the same external EM field intensity can produce significantly different levels of energy absorption. Biological effects of ionizing and non-ionizing radiation are also very different. The fundamental quantities associated with the interaction are the electric and the magnetic fields induced within tissues, and the currents and energy associated with these internal fields. These interactions may produce highly non-uniform distributions of EM fields within the object, regardless of the external exposure field uniformity. The results obtained from animal and *in vitro* experiments are not directly applicable to human beings. To interpret a biological effect, one must determine the internal field strength or the energy dose that can cause such an effect in the experimental subject. The complexity of dosimetry has been the one of the main reasons for controversy over the health effects of nonionizing radiation. Examples will be shown in this presentation.

Below 100 kHz and for ELF fields, the established adverse effect is painful or aversive electrostimulation. The exposure limit is in situ electric field (V/m). Between 100 kHz and 6 GHz for RF fields, the dosimetric quantity (Specific Absorption Rate, known as SAR) is defined as the rate at which energy is absorbed per unit mass (W/kg). The SAR is determined not only by the incident electromagnetic waves, but also by the electrical and geometric characteristics of the exposed subject and nearby objects. In this frequency range, a threshold of ~4 W/kg for disruption of behavioral performance in several animal species and under diverse exposure conditions, based upon thermal effects and often (but not always) accompanied by an increase in core body temperature of ~1.0 ^{o}C, has been used since 1982 as a basis for human exposure guidelines that establish limits well below this threshold for known, repeatable effects. Recently, 11 review articles published in Bioelectromagnetics and a summary in the Annex B of the newly drafted revision of IEEE C95.1 standard confirmed that the weight of the evidence continues to support the IEEE Std C95.1-1991 that 4 W/kg is the median threshold for potentially adverse health effects for short-term exposures of animals. More than 50 years of research has shown that thermal effects are the only established adverse effects for fields above 100 kHz. Nonthermal RF bioeffects have not been established and none of the reported nonthermal effects are proven adverse to health. For RF frequencies higher than 6 GHz, the penetration depth is within millimeters. Therefore, incident power density (W/m^2) is used for setting limits to protect human health.

The International Agency for Research on Cancer (IARC) has classified ELF magnetic fields "Group 2B - possibly carcinogenic" to humans, same as coffee and pickled vegetables, due in large part to early epidemiological studies. IARC assigned static electric and magnetic fields and ELF electric fields a "Group 3 - not classifiable" label as to carcinogenicity to humans. The IEEE C95.6-2002 standard established safety limits to protect against recognized short-term effects. In setting the standard, IEEE found insufficient evidence of adverse effects from exposures found in community or occupational environments, and no confirmed mechanism to support the existence of such effects, including cancer. Health risk assessments associated with RF energy benefit from a database spanning more than 50 years and currently including more than 350 studies specifically related to mobile telephony. Half of the 350 studies relate to cancer and to date have been overwhelming in finding no evidence that RF exposure can cause or promote cancer. IARC is conducting a multinational collaborative study and will issue a cancer classification of RF fields in 2005.

An Overview of EMF Epidemiological Studies

Asia-Pacific EMF Conference-Tutorial, Bangkok, January 26, 2004. Sheila Johnston PhD, Neuroscience Consultant, London UK sajohnston@btclick.com

This tutorial reviews the major importance of epidemiology in EMF research, for evaluation of possible adverse effects of EMFs on human health. For ELF and RF exposure, the molecular mechanisms, the dosimetric units, the exposure measurements, the exposure limits and the known adverse effects (at high levels, over guideline limits) are different. It is essential to distinguish ELF epidemiology from RF epidemiology. Review of ELF epidemiology focuses on childhood cancer (1979-) adult cancer (1982-) and occupational cancer (1982-). Measurement methods are reviewed. Conclusions of the expert bodies on the carcinogenicity of ELF are presented: IARC (June 2001), the Doll Report and ICNIRP (Dec 2001). Evidence is strongest for childhood leukemia >0.4 μT but further studies on specific hypotheses in relation to selection bias and exposure are required. Review of RF epidemiology focuses on key studies in occupational exposure (1958-), residential exposure (1996-) and mobile telephony exposure (1996-). Measurement methods are reviewed. The merits of cohort studies over case studies are discussed. Presently there is no convincing evidence for an association between phone use and cancer however these RF epidemiology studies are open to question because of large uncertainties in the levels and durations of exposure and in the reliability of the data from interviews and the responses to questionnaires used. A short review of the on-going, intense, RF epidemiological research is given in conclusion.

Overview of Laboratory Studies

John A. D'Andrea
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In the last thirty years, many experiments have been conducted to assess biological effects of electromagnetic field (EMF) exposure from extremely-low-frequency (ELF) to radiofrequency (RF) in the range of 0 Hz to 300 GHz. Much of this research was performed at frequencies related to electric power use at 50-60 Hz and mobile phone use near 1-2 GHz. Many results have been found with relatively high exposure levels. It is well known that high strength time-varying magnetic fields can have effects on the visual system, nervous system, and can lead to hazardous cardiovascular effects. At high power densities, during RF exposure, thermal effects are prevalent and can lead to adverse consequences. Most of these results are not in question. On the other hand, some results have been found which suggest EMFs at low-power levels can alter biological systems especially following long-term exposures. There are a variety of reports of low-level exposures producing negative effects on the nervous system, visual system, cardiovascular system and cellular regulation and proliferation. Some epidemiological studies have concluded that ELF EMFs may be linked to an increased risk of cancer, particularly childhood leukemia. The hallmark of science and wide acceptance of reported effects has been the replication of such experiments by other laboratories. However, replication attempts for many of the experiments reporting low-level effects have been unsuccessful. Thus, there are no known, well documented, effects, which lead to health risks for weak induced fields at ELF and low-level RF fields. There is much scientific evidence, based on existing research, that warrants limiting exposure to high-level ELF and RF fields.

Safety Standards for Exposure to Electric, Magnetic and Electromagnetic Fields: An Overview

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This tutorial briefly discusses the history and rationale of safety standards for human exposure to electric, magnetic and electromagnetic fields. The standards development process and the bases of contemporary standards and guidelines are discussed. Distinctions between emission (product) and exposure standards are explained as are the distinction between standards, guidelines and recommended practices. Basic restrictions and derived limits (reference levels or maximum permissible exposure values) are described using as examples contemporary standards and guidelines, such as the Institute of Electrical and Electronics Engineers (IEEE) Standard C95.1 and the International Commission on Non-Ionizing Radiation Protection (ICNIRP) guidelines. Topics such as spatial averaging, time averaging, induced current limits, peak spatial-average specific absorption rate (SAR) and whole-body average SAR will be discussed. The focus will be on limits and basic restrictions applicable to frequency bands of interest, e.g., 50/60 Hz, and the radiofrequency (RF) bands used for personal wireless telecommunications applications, e.g., 800-1000 MHz and 1900-2200 MHz. Examples of how these standards and guidelines are incorporated into regulations to protect the worker and the public will be discussed, as will standards for assessing compliance, e.g., measurement standards.

Key words: basic restrictions, maximum permissible exposure, reference levels, safety standards

SARs From Tetra Radios And Accessories

Philip Chadwick
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TETRA (Terrestrial Trunked Radio) is a digital landmobile radio communication system enabling the deployment of secure, digital PMR services required by the emergency services and other professional bodies. TETRA is becoming a global PMR standard in the same way as GSM has done in cellular telephony. TETRA supports simultaneous, encrypted, high-speed voice and data transmission. It offers direct mode operation that enables two or more users to communicate directly, as well as a GSM-type cellular telephony mode. TETRA is specified to work within the VHF and UHF bands (150 MHz to 900 MHz). In the UK there are frequency allocations between 380 and 430 MHz. TETRA radios are often used in conjunction with accessories such as remote speaker-microphones and hands-free microphone/earpiece sets and there is the potential for the accessory cables to give rise to SARs in the user's body as well for the microphone or earpiece to give rise to SARs in the head.
Head and body SARs from TETRA radios have been investigated using the standard CENELEC phantom and also a whole-body phantom. The CENELEC protocols also have been adapted to allow face measurement. There have been claims that exposures from mobile phone hands-free kits can be greater than exposures from the antennas of the phones themselves. Intuitively, this seems unlikely, and the results of measurements contradicting the original claims have been published by several researchers. However, the proposed mechanism of resonance effects in the cable of the hands-free kit leading to high localised exposures at the earpiece has not been investigated fully.

The CENELEC procedures were used for the measurement of head SAR from hands-free TETRA accessories and to investigate the effect on head SAR of changing the accessory cable length and position. There was evidence of resonant behaviour in the accessory cables, with clear spatial variations in electric field strength, magnetic field strength and SAR. Head SARs from the accessories themselves varied with accessory cable length and also showed strong indications of resonant behaviour. However, all measured head and body SARs were below (and in most cases very much below) the SARs from the antennas of the TETRA radios when used without accessories.

This work was supported by the UK Home Office.

More details of the Home Office TETRA research programme can be found at www.homeoffice.gov.uk/docs/tetra.html

A System for Mapping RF Fields From Mobile Phone Base Stations

G. B. Gajda, ∗A. Thansandote, E.P. Lemay, P. Lemyre and J. P. McNamee
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With the rapid expansion of mobile phone services, increasing numbers of base stations have been installed to relay calls between mobile phone users and the telephone system. To provide adequate signal strength throughout the entire service area, many base stations are located or proposed to be sited near residential areas or on school properties. Such siting or proposals often receive public opposition due to concerns that exposure to radiofrequency (RF) fields from base stations can cause an adverse health consequence. A number of studies linking RF energy from mobile handsets to cancer have fuelled these concerns, even though there is a considerable difference in exposure levels between handset and base station emissions. Over the past decade, a number of spot measurements were carried out to determine RF levels from base stations in an attempt to alleviate public concerns.

In this paper, an instrument for acquiring data on base station RF emissions and results from real time surveys in Ottawa will be presented. The instrument, custom designed and fabricated at Health Canada, is capable of measuring the combined power density in all bands of frequencies used by cellular service providers along with the GPS-derived coordinates of the measurement location. With lightweight and portable features, the instrument can be mounted on a vehicle and measurements taken while driving. Results show that worst-case exposure levels are typically thousands of times below the recommended exposure limits in Health Canada's Safety Code 6.

Key words: mobile (cellular) phone base stations, RF exposure assessment, measurement of RF field patterns

A Report of an RF-Induced Biological Effect Versus an Adverse Human Health Effect: Science Versus Speculation

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Objective 1: The first objective is to make the distinction between a biological effect reported to be due to a radio frequency exposure, and the suggestion of an adverse human health effect.
Conclusion: A positive indication reported for in vitro systems, even when substantiated, does not prove that the effect leads to subsequent biological events. It is these biological events which can have a physiological effect in vivo. A physiological effect must be established before any statement can be made about a human health effect. The human health effect could be beneficial as well as adverse.

Objective 2: The second objective is to present a list of experimental details that are important to consider in designing experiments. Information about these details is essential to include in a publication.
Conclusion: The absence of these details from the publication at best would lead to the paper being of no or marginal assistance for establishing the presence or absence of an RF effect. At worst, the absence of detail would lead to speculation that the study was not performed properly.

Reference:
Meltz, ML. Radiofrequency Exposure and Mammalian Cell Toxicity, Genotoxicity and Transformation (Bioelectromagnetics Suppl. 6, pp. S196-S213, 2003)
Meltz, ML. Biological Effects versus Health Effects: An Investigation of the Genotoxicity of Microwave Radiation. In: Radiofrequency Radiation Standards. Biological Effects, Dosimetry, Epidemiology, and Public Health Policy. NATO ASI Series A: Life Sciences. Vol. 274 (1995) Eds: BJ Klauenberg,
M Grandolfo, and DN Erwin

Overview of RF Bioeffects Research Conducted at the U. S. Air Force Research Laboratory

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Contemporary military activities employ extensive radio frequency (RF) emitting equipment, including communication systems and towers, and radars for detection and ranging. The use of such equipment usually results in some human exposure to low- level RF fields, often for long periods of time, and increases the risk of accidental high-level exposure. One of the missions of the Directed Energy Bioeffects Division of the U. S. Air Force Research Laboratory (AFRL) is to determine and mitigate the potential hazards of RF exposure on personnel health, safety, and job performance. To accomplish this mission, we conduct bioeffects research to assess the risk of RF-induced health effects, develop and evaluate dosimetric tools to improve RF safety, and transition the results to RF standard setting, safety, and medical communities. One recent focus for bioeffects research has been on the effects of short high-peak power pulses (HPM), including pulses with ultrawide band frequency content. Research led by Dr. Andrea Pakhomov has studied the effects of HPM pulses up to a peak e-field of 1.5 MV/m and a peak SAR of nearly 1.0 MW/g. Using biological systems such as the heart pacemaker, hippocampal slice, cell membrane, and yeast cells, all effects seen from HPM pulses have been able to be duplicated with equivalent heating from more conventional RF exposure, indicating equal effect for equal energy deposited. Another focus has been the effects of microwaves and millimeter waves on human subjects. Dr. Eleanor Adair has studied the thermoregulatory responses of humans to 2450, 450, 100, and, most recently, 220 MHz exposure under 3 environmental temperatures and SAR values up to 8 times currently accepted exposure standards. Other scientists at the AFRL have studied the possibly harmful effects mmWave irradiation in the 94-95 GHz range. RF effects on memory and the blood brain barrier are also being evaluated. Our research on RF dosimetry and dosimetric tools will be the subject of a separate talk by Dr. Patrick. The results of our research on RF bioeffects and dosimetry are made available to the relevant RF safety communities through our scientific publications and presentations, and our service to the NATO General Medical Working Party, the IEEE International Committee on Electromagnetic Field (EMF) Safety, and the World Health Organization EMF Project. Overall, our activities are planned to support the maximum safe use of the RF spectrum and the setting of scientifically-based health and safety standards. (*The views, opinions, and/or findings reported are those of the authors and should not be construed as official Department of the Air Force, Department of Defense, or U.S. Government position, policy or decision unless so designated by other documents).*

Overview of the Radiofrequency Dosimetry Research Being Conducted by the U.S. Air Force

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Accurate dosimetry is a critical part of any scientific effort to assess the effects of electromagnetic fields (EMF) on biological systems. In addition, conducting high quality dosimetry and reporting detailed descriptions of the dosimetry are essential to permit precise replications of experiments by independent laboratories. Dosimetry includes the prediction and/or measurement of the incident and internal fields. These fields can be quite different, depending upon the characteristics of the object, including: size and shape, electrical properties, orientation with respect to the incident field, and the frequency of the incident field. The development of mathematical dosimetry modeling techniques and relatively powerful computer hardware has resulted in computer modeling as a principal tool in assessing the biological dose resulting from EMF exposure. Only with the use of realistic anatomical models and methods such as the finite difference time domain (FDTD) has the ability to estimate both whole body and localized specific absorption rate (SAR) values become possible. Laboratory research is aided by the FDTD analysis by indicating where localized SAR measurements should be made. The FDTD analyses show that whole body SAR values exhibit frequency-dependent resonances; as do individual organs and body sections (e.g., limbs, head).

The man dosimetry model developed by the U.S. Air Force and Navy was used in the present study to determine resonance frequencies as a function of: 1) object orientation with respect to the incident field and 2) use of whole body or partial body (e.g., head only) models. Comparison between whole-body model and the partial-body model produced substantial differences in localized SAR values. These differences are important to note since partial body simulations may be used to limit the computing resources required. Different results with whole- versus partial-body simulations would tend to limit the value of partial-body models and suggest that partial-body models must be employed with care.

Since validation of human dosimetry models is difficult or impossible with living human subjects, we have also developed animal dosimetry models that we compare to empirical animal data. Good agreement between the theoretical and empirical animal data provide support for the validity of the SAR values predicted in the man model. Validation of the computer models with empirical results and the subsequent refining of the models are essential in order to earn the confidence and credibility needed to use these models to establish or revise exposure standards.

Medical Devices And Electromagnetic Compatibility

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This presentation intends to give a brief overview of medical devices potential behavior in the presence of electromagnetic interference, technologies for compatibility and standards addressing Electromagnetic Compatibility (EMC). In recent years there has been a rapid proliferation of emitters across all spectrum of frequencies, such as expanded use of electromagnetic fields in medical therapeutic applications, wireless and personal communications devices, RFID, metal and theft detectors, etc., that also raised the visibility of compatibility with medical devices.

The following topics will be addressed in detail:
1. Definitions and description of medical devices and implantable systems
2. Discussion of electromagnetic interference sources that may affect medical devices and implantable systems
   - EMI Sources frequently encountered in a non-controlled environment:
     - Power lines
     - Cellular telephones/personal communication devices
     - Electronic Article Surveillance Systems (EASS)
     - Metal detectors
   - EMI Sources frequently encountered in a controlled environment:
     - Magnetic Resonance Imaging Systems
     - Electrocautery
     - Lithotripsy
     - External Defibrillation
     - Diathermy
3. Discussion of medical devices potential response to electromagnetic interference
4. Design solutions for electromagnetic interference protection
5. International standards addressing electromagnetic interference for medical devices and implantable medical devices.
   - European Standards: EN 45502-1, EN 45502-2-1 and –2-2
   - International: ISO 14708-1, IEC 60601-1, IEC 60601-1-1, IEC 60601-1-2, IEC 60601-1-4
   - USA: AAMI EMC PC69

Key Words: EMC, medical devices

Heating of Medical Implants During MRI

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Magnetic Resonance Imaging involves magnetic and radio frequency (RF) exposures. In a strong static magnetic field and a pulsed RF field, five potential adverse effects are anticipated with metallic implants: 1) force on the implant by the strong static magnetic field, 2) current induced in the implants by the RF field, 3) damage of implant electronic circuitry by RF exposure, 4) MRI image distortion caused by the implant, 5) implant and adjacent tissue heating due to absorption of RF energy. Only the last of these, RF tissue heating, will be addressed in this presentation. Since RF energy absorption is a function of body size, the implant heating can only be tested in a full-size phantom human model. Although the RF field is strongest inside the MRI scanner, there is no guaranty that body parts outside the scanner do not affect the energy absorption in the exposed region. Therefore, a whole body model is necessary. While at the City of Hope National Medical Center in Duarte, California, the author worked on three projects evaluating the safety of three medical implants during MRI: auditory implants, spinal fusion stimulators, and cervical fixation devices. In these studies, temperature rises adjacent to the implants during MRI exposures were measured.

A full-size phantom model was used to study the possible tissue heating due to the induced RF current near metallic implants during magnetic resonance imaging. Dielectric properties and geometry of the human tissues as well as the implants were modeled as close to real conditions as possible. With auditory implants, there was no heating detected with fiberoptic temperature sensors. For the spinal fusion stimulator, when properly implanted, the maximum temperature rise in a static phantom model was less than 2 ^{o}C, which was within the FDA guidelines for the torso. However, if an electrode lead was broken, the temperature rise could be very high (14 ^{o}C). Careful radiological examinations must be done to ensure that there are no broken leads in the patient before an MRI scan. Seven cervical fixation devices (different halos and tongs) and two types of skull pins were evaluated. For an open back halo with standard titanium skull pins, up to 48.3^{o}C temperature rise was measured. A closed back halo with standard titanium skull pins yielded lower (6.8 ^{o}C), but still an excessive temperature rise. For the tongs, significant heating (26.4 ^{o}C) also occurred with standard titanium skull pins. In all cases, heating was minimal when titanium/ceramic insulated skull pins were used. These results show that during MRI scans excessive patient heating due to RF induced current may occur in conductive halos, tongs, and skull pins. The degree of RF tissue heating depends on the conductivity, shape, and orientation of the fixation device. Heating may be reduced significantly by using insulated skull pins, which isolate the RF induced current from the head. These studies were done on a static phantom and, therefore, no blood flow was simulated. In a patient, due to blood flow, maximum temperature rise should be lower than the phantom model measurements. Therefore, these results provide a worst-case estimation. These studies also show that RF tissue heating is difficult to predict. A case by case evaluation is necessary.

Keywords: RF heating, phantom, implants, MRI, safety

Tuesday: Oral Presentations

An Overview of WHO's EMF Project and the Health Effects of EMF Exposure

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The World Health Organization (WHO), through its International EMF Project, has conducted a number of reviews of possible health effects from exposure to fields from various parts of the electromagnetic spectrum. These fields can be grouped into radiofrequencies (RF), intermediate frequencies (IF) and the static and extremely low frequencies (ELF). In addition, there have been substantial reviews published by other organizations, many of which WHO representatives have participated. This paper describes WHO's International EMF Project activities and their results so far, briefly reviews the biological effects from EMF exposure, identifies gaps in knowledge needing further research and overviews WHO's current published position on these issues.

The main conclusion from the WHO reviews is that EMF exposures below the limits recommended in the guidelines by the International Commission on Non-Ionizing Radiation Protection (ICNIRP) do not appear to have any known consequence on health. However, there are still some key gaps in knowledge needing further research before better health risk assessments can be made. These research needs are being promoted to funding agencies by WHO. Because of remaining uncertainties in the science database, there has been some pressure to introduce precautionary measures until gaps in knowledge are filled. If precautionary measures are introduced to reduce EMF levels, it is recommended that they are made voluntary, and that health-based exposure limits be mandated to protect public health.

An Overview of ELF and RF Exposure Standards

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The results of studies of effects on animals and humans exposed to electromagnetic energy have appeared in the literature for well over a century. For at least five decades, the results of such studies have been used throughout the world to develop safety standards and guidelines to protect humans from exposure to RF energy. Over this period, significant advances have been made in the characterization of radio-frequency/microwave (RF/MW) fields (3 kHz – 300 GHz) and energy absorption, as well as in the quantification of biological responses of organisms exposed to this kind of electromagnetic energy, which resulted in a number of significant changes to the earlier standards and recommendations. The limitations of the earlier standards and key developments that led to their resolution and the confirmed biological effects that have formed the basis of the ever more sophisticated human exposure standards and guidelines are discussed. Although safety standards and guidelines for use at power frequencies (50/60 Hz) have a shorter history than RF safety standards, science-based standards and guidelines have become available during the past decade for use at these frequencies. Examples of such standards are presented and their rationale described. The process followed by the IEEE International Committee on Electromagnetic Safety (ICES) is described to illustrate how the scientific literature is used to develop the basic restrictions of contemporary standards and address the issue of margin of safety. A number of issues related to standards setting, such as the poor quality of much of the research, are briefly discussed. Similarities and differences between different contemporary standards and guidelines are described and an update on the revision of IEEE Standard C95.1 (RF safety standard) is provided.

Key words: basic restrictions, ELF safety, exposure, maximum permissible exposure, RF safety, safety guidelines, standards development

IEEE C95.1 –1991 RF Safety Standard Revision Status

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The IEEE C95.1 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz was published in 1991 and modified in 1999 with essentially no changes in the exposure limits and without updating and reevaluating the supporting scientific literature. A complete revision of the standard now in progress is based on the literature published up to the end of 2003 that is listed in a database containing more than 2000 references. Relevant research papers (more than 1300) are evaluated by two randomly selected members of the Engineering Evaluation Working Group and by two members of the appropriate biological evaluation working group (in vitro, in vivo, and epidemiology). In addition, 11 review papers have been prepared on cancer, reproduction, calcium efflux, behavior, thermoregulation, nervous system, ocular and auditory effects, homeostasis and metabolism, longevity, epidemiology, and in vitro studies. The review papers have been published in November 2003 as a special issue "Reviews of Effects of RF Fields on Various Aspects of Human Health" in Bioelectromagnetics as Supplement 6. The papers are available from <http://www3.interscience.wiley.com/cgi-bin/jhome/34135>.

Summaries of working group evaluations are forwarded to the Risk Assessment Working Group (RAWG) to evaluate the levels of possible risk to humans and define the lowest threshold SAR above which potentially deleterious effects are likely to occur. A Mechanisms Working Group works in parallel with the RAWG to evaluate possible mechanisms of interaction between electromagnetic fields and biological entities and to address the scientific basis for effects reported at SAR levels well below the threshold established for thermal mechanisms. The current draft revised standard retains the same whole-body-average SAR basis and MPE limits as before. Peak spatial-average SAR limits were proposed to harmonize with those of ICNIRP, although the parts of the body that these limits apply to are not identical. A final draft of the revision will be voted by the Subcommittee 4 in the spring of 2004.
IEEE safety standards are developed through a fully documented and open process in which broad scientific consensus and involvement of all interest groups are essential. The 125 members of SC4 are from 21 countries where they work in government, academia, industry, and consultancies. Approval of the draft by SC4 and subsequently by its parent committee require consent by at least 75% of the voting members of each group after circulation and resolution of concerns raised on negative ballots. This process serves the goal of developing scientifically based exposure limits that protect against known adverse effects with an adequate safety margin.

Keywords: RF safety standard, adverse health effects, SAR, evaluation, harmonization.

ICNIRP's Activities and Approach to EMF Protection

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The International Commission on Non-Ionizing Radiation Protection (ICNIRP) was established as an independent scientific advisory body in 1992 by a charter from the International Radiation Protection Association (IRPA). Over the past 10 years, the rapid expansion in the application of sources of non-ionizing radiation (NIR) has resulted in increased exposure of both workers and the general public. The most notable cause for this has been the dramatic global growth of use of mobile telephones. Currently also electronic article surveillance (EAS), radio frequency identification (RFID) and metal detection devices are commonly used in shops, airports etc. This presentation will clarify how ICNIRP has met these issues, and how it will face future new challenges.

This presentation also explains the procedures that ICNIRP uses in formulating its advice on human exposure to NIR. The evaluation of the scientific literature on health risks of NIR consists of three steps: 1) data from single studies, 2) examination of specific health effects, and 3) overall assessment. Following the literature evaluation, it is possible to identify NIR exposures and health effects that are judged to be well established. Such established effects have formed the necessary background for the development of the present ICNIRP guidelines for RF fields.

The general philosophy and detailed approaches have been described in a recent ICNIRP Statement (see the reference below).

References:

ICNIRP Statement, 2002. General approach to protection against non-ionizing radiation. Health Physics 82(4):540-548

ICNIRP 1998. Guidelines for limiting exposure to electric, magnetic and electromagnetic fields (up to 300 GHz). Health Physics 74(4):494-522.

(both are available as a pdf-file at **www.icnirp.org**)

A Comparative Summary of Guidelines & Standards for Limiting of Exposure To Time-Varying Electric and Magnetic Fields in Frequency Range up to 3000 Hz

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During the recent years, a number of national and international organisations have published or revised publications on guidelines or standards for safety protection of humans against adverse health impacts from exposure to environmental electric, magnetic, and electromagnetic fields ranging from static or direct current (DC) up to 300 GHz. These include the following publications:

The ICNIRP* "Guidelines for Limiting exposure to Time-Varying Electric, Magnetic, and Electromagnetic Fields (up to 300 GHz)" (1998),
The Heath Council of the Netherlands (HCN[+]) "Exposure to Electromagnetic Fields (0-10 MHz)", (2000), and The IEEE[#] Standard C95.5 "IEEE Standard for Safety Levels with Respect to Human Exposure to Electromagnetic Fields, 0-3kHz", (2002)

[*] *International Commission on Non-Ionizing Radiation Protection.*
[+] *Health Council of the Netherlands.*
[#] *The Institute of Electrical & Electronics Engineers, Inc .*

This paper summarises approaches used in determining the fundamental exposure restrictions referred to as Basic Restrictions (BR), and calculation/modelling methods used to derive the equivalent external field exposure Reference Limits (RL) for compliance purposes. In an effort to cover the same frequencies common to the three documents, this paper limits its discussion to electric and magnetic fields in the frequency range from about 1 Hz to 3000 Hz.

Overview of the EMF Standards in Korea

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In this paper, the EMF standards in Korea are reviewed. In Dec. 1999, the Article 47-2 of the 'Radio Wave Act' was revised in order to enact a provision for protection from EMF exposure, and it was proclaimed in January 2000. Based on that, the Ministry of Information and Communication officially four separate ordinances for exposure limits, measurement methods for EMF intensities and SAR value, and installations and devices to which the exposure limits apply, in December 2000. The ordinances are in effective from January 2002.

The ordinance for exposure limits regulates EMF fields generated by stationary installations in the frequency range of 0 Hz to 300 GHz, and SAR value from a mobile telephone within the frequency range of 100 kHz to 10 GHz. The exposure limits for EMF intensities closely follow the ICNIRP guideline, and the SAR limit is based on the IEEE/ANSI guideline. The exposure limits for EMF intensities have two-tier structure (worker and general public), but the SAR limit has only one-tier structure (general public). One peculiar thing in Korean standards is that basic restrictions are not applied when showing the compliance to EMF limits..

From April 2002, the regulation for SAR limit for mobile phones has been mandatory, and the information on SAR values of mobile phones currently on market is open to general public from this year. On the other hand, the regulation for EMF limits is just recommendation until now. Precautionary policies are not adopted yet in Korean standards.

Key Words: EMF standard, exposure limit, regulation, SAR limit, Korea

EMF Exposure Standards In Japan

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ELF-EMF

When 500 kV power transmission lines were constructed, an electric field standard of 3 kV/m was set by the Ministry of Economy, Trade and Industry (METI, formerly known as the Ministry of International Trade and Industry) in 1976 to prevent perceptible electrostatic induction. Currently, there are no guidelines or standards limiting exposure to power frequency magnetic fields.

RF-EMF

The Telecommunication Technology Council (TTC) under the Ministry of Public Management, Home Affairs, Posts and Telecommunications (MPHPT, formerly the Ministry of Posts and Telecommunications) published a report entitled "Radio-Radiation Protection Guidelines for Human Exposure to Electromagnetic Fields" in June 1990. This report indicated measures to be taken to protect the public. Based on the report, the Association of Radio Industries and Businesses (ARIB) set up private guidelines, "Radiofrequency-Exposure Protection ARIB Standard" (ARIB STD-38) in September 1993, a standard that has been used by radio operators and manufacturers.

To address the rapid growth of mobile telecommunications, an MPHPT study group recommended that principal sections of the 1990 TTC guidelines required no revision, but that additional radio-radiation protection guidelines should be established for radio equipment acting as a source of radiation in close proximity to humans. In April 1997, TTC reported that further guidelines on local absorption were needed for radio equipment used in close proximity to the human body, such as cellular phone terminals, and that radio-radiation protection regulations should be introduced. In March 1998, an MPHPT panel, Studies on Desirable Application of Radio-Radiation Protection Guidelines for Human Exposure to Electromagnetic Fields, made a report favoring a shift toward compulsory standards from private guidelines.

In September 1998, the Radio Regulatory Council submitted a report to MPHPT stating that an amendment, "Rules for Enforcement of the Radio Law", would be appropriate for establishing "Radio-Radiation Protection Regulations for Human Exposure to Electromagnetic Fields". The revised rules were promulgated by MPHPT on October 1, 1998, and became effective as of October 1, 1999. In November 2000, SAR (specific absorption rate) measuring methods from cellular phone devices intended for use in close proximity to the side of the head were developed as partial absorption guidelines for "Radio-Radiation Protection Guidelines". MPHPT subsequently revised relevant rules, and introduced a standardized measurement method and an SAR limit in June 2001, which took effect on June 1, 2002.

Key words: electric fields, magnetic fields, EMF exposure standards, Japan

Discussion on Rationale gor China EMF Exposure Standards

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The current RF exposure standards were set up in 1989, which have been performed for over 10 years. They have promoted many valid measures to reduce exposure levels in China. However, because of the new and rapid development of telecommunication facilities, the economic globalization, and the need for standard harmonization, a draft of the amended EMF exposure standards was proposed by a United Working Group in China.

The main differences (with ICNIRP) and its own rationale are as follows:
(1) ICNIRP guidelines are based on short-term, immediate health effects such as stimulation of peripheral nerves and muscles, and elevated tissue temperature resulting from absorption of energy during exposure to EMF. However, there is a body of literature, which reports that health effects can be shown at such a level of radiation that does not produce heating or stimulation.

For RF exposure, the SAR thresholds of behavior-disruption have been observed at the levels much lower than 4 W/kg. Some examples and the underlying neural mechanisms are reviewed. A series of experiments on immune function of chronic exposure are introduced including the development of autoimmune status, and suppression of neutrophil phagocytosis after chronic exposure of animals to microwave at 50 or 500$\mu W/cm^2$. The bi-phasic changes in immune system were reported at even lower power densities in some labolatories, and the bi-phasic changes in immune function of neutrophil phagocytosis were also observed in human exposed to environmental low-level RF radiation. In vitro studies, the evidence of RF non-thermal bioeffects is increasing, and the knowledge regarding the molecular mechanisms of low-level EMF potentially adverse health effects is growing In summary, there are many reports of non-thermal potential health effects from microwave radiation using both *in vivo* and *in vitro*. The SAR threshold for the adverse effects in the frequency range from 100 kHz to 10 GHz may be at 0.5 to 1.0 W/kg, rather than 4.0 W/kg. Thus, a whole body average SAR of 0.1 W/kg is chosen as the restriction for occupational exposure, and 0.02 W/kg for general public exposures in the draft of amending China exposure standard .

For power frequency (ELF) magnetic field (MF), the exposure limits in ICNIRP were derived from the assumption that magnetic fields act through its induced electric fields, and the current density of 10 mA/m^2 is adopted as the basic restriction to prevent stimulation of peripheral nerves and muscles for occupational exposure. However, there is growing evidence that the magnetic fields penetrate cells, tissues and cause bio-effects by themselves. For example, the suppression of gap junction intercellular communication (GJIC) is induced by MF itself rather than the induced electric field. The threshold of GJIC suppression caused by 50 Hz MF exposure is about 0.4 mT, and 0.2 mT MFs enhanced TPA induced GJIC suppression The mechanisms of the GJIC inhibition induced by 50 Hz MF exposure, have been also discovered. Rapid induction of heat shock proteins by 60 Hz MF exposure at only microtesla level with the related molecular mechanism.have been reported. There are many reports showing that 0.1 mT ELF MF exposure may affect cell functions. For example, 50 Hz MF at 0.1 mT specifically interacts with 5-HT1B receptors, which may be involved in mood disorders complained by exposed workers. Induction of DNA strand breaks by intermittent exposure to 50 Hz was observed with a dose-response relationship at the threshold level of 0.07 – 0.1 mT. Coincidently, adverse health effects induced by 0.1 mT ELF MF exposure were also reported in *in vivo* studies.

Key words: EMF, exposure standard, rationale

RF Safety Standards in Australia and a New Centre of Research Excellence

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For most of the 1990's, a joint committee from Standards Australia and Standards New Zealand worked on drafting an Australasian radiofrequency (RF) safety standard. As is normal practice for these committees, its membership was based more on ensuring a diverse representation of stakeholder interests, rather than on technical expertise. This led to a very large and fractious committee, which perhaps not surprisingly was unable to reach the required 80% consensus level for promulgation of a final standard. Disagreement over the inclusion of a mandatory precautionary approach was a major sticking point. In 1999, the committee disbanded, and the New Zealanders subsequently settled on a slightly modified version of the last AS/NZS draft (NZS 2772:Part 1:1999), with exposure limits based on the 1998 ICNIRP Guidelines. In Australia, the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) convened a new, smaller and more technically focussed committee to finish off the task of drafting an Australian RF safety Standard. The new ARPANSA Standard was also based on the 1998 ICNIRP Guidelines, and the approach taken was to review the RF literature since publication of the ICNIRP Guidelines to determine if further changes were warranted. A number of omissions and inconsistencies were identified and addressed, including ICNIRP's approach to the summation of multiple frequency exposures and its lack of specification of averaging times for instantaneous field and contact current limits or for spatial averaging schemes. Additional features were also added, such as advice on compliance testing issues and implementation of OH&S control measures, and a more user friendly and precise specification of reference levels. Flaws in the ARPANSA standard that have become apparent since its release in 2002 include an unrealistically short averaging time (1 μs) for the 'instantaneous' limits and the impracticality of implementing its precautionary requirements for general public exposures. The latter problem is compounded by the lack of objective and transparent rationales for the safety factors of the ICNIRP exposure limits.

On the research front, a consortium of five Australian universities and research institutes have received a federal government grant from the National Health and Medical Research Council to establish an Australian Centre for Radiofrequency Bioeffects Research (ACRBR). Commencing in March 2004, the Centre will have an initial program of 5 years and will be coordinated from RMIT University in Melbourne. It will form the hub of RF bioeffects research conducted in Australia and will seek to establish cooperative links with other similar groups around the world. Research directions of the Centre will include: short and long term effects on nervous tissue in experimental animals and tissue cultures; laboratory and population studies on responses in human subjects; modelling of molecular interactions and research into the absorption of radio waves into human tissue (SAR dosimetry). It will also train a new generation of Australian RF bioeffects scientists, provide information to the public and assist the development of government and standards policies in RF safety.

Australasian Standards and the Precautionary Principle

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The revision of the New Zealand and Australian Standard for radio frequency exposure was commenced in an environment of public concern and a rising level of activism as new technologies and increased use of radio frequency technology evolved in the early 1990s. An attempt was made to develop a joint Australian and New Zealand Standard, however, this failed to achieve sufficient consensus to proceed and the process was abandoned in 1998. The work was taken back to New Zealand and negotiations with dissenting committee members resulted in the New Zealand Standard NZS2772.1 with the incorporation of provisions which were intended to, and have since been interpreted as a cautionary approach. This Standard was published in 1999, was immediately successful and has resulted in stabilisation of radio frequency deployment in New Zealand. In Australia, failure of the Standards process resulted in the Standard being taken over by the Government Regulating Agency (APANSA) who embarked on a wide ranging consultative process and developed a document which has evolved from the previous Australasian work resulting in the Australian Standard, RPS3 which was published in 2002 and is currently being incorporated into Australian regulations and cited by new legislation. This Standard also incorporates recommendations for precaution similar to those in the New Zealand Standard and these have already been applied. Both Standards retain the basic restrictions recommended by ICNIRP and are consistent with other international standards. Case studies will be presented demonstrating the application of the Standard, in two cases accepting and resolving a politically generated requirement for a cautionary approach which is consistent with the recommendations of the World Health Organisation. This has been genuinely achieved without recourse to pseudo-standards or alternative thresholds.

Electromagnetic Field Standards in Eastern European Countries

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Electromagnetic field (EMF) standards in the West are based on a well established acute biological effects that could be considered as signaling a potentially adverse health effect. The specific absorption rate, which is proportional to the tissue heating (thermal effects), represents the basic restriction of exposure to Radio-Frequency fields. On the other hand, Eastern European (EE) standards are designed to protect from potential non-thermal effects that might be caused by chronic exposure to very low intensities, where a so-called "power load" (a product of field intensity and duration of exposure) represents the basic limitation. Thus, EMF standards in EE countries differ considerably from those which are proposed by the International Commission of Non-ionizing Radiation Protection (ICNIRP) and the Standards Coordinating Committee 28 of the Institute of Electrical and Electronics Engineers, Inc. (IEEE).

Basic questions about the biological effects in Western as well as in EE countries concern the possibility of effects of prolonged exposure to low level EMF, in addition to the heating or thermal effects. While Western experts do not consider such effects suitable for basing standards upon, this premise has strongly shifted the research focus and influenced the rationale for standards setting in EE. The lack of published data from EE research groups in peer reviewed journals including unknown scientific criteria for establishment of the health hazards makes validation of the rationale used in EE standards very difficult. An effort to analyze the available research data, which were used as a basis for EE standards, is underway.

In the last 10 years, new political and economic situations in EE countries have dramatically changed international relations and the geopolitical map in this part of the world. In most countries, new, democratically-elected authorities decided to join the European Union (EU) and NATO and adapt their regulations and standards. Therefore, both standards and existing legislation in the field of EMF in many EE countries are a subject for harmonization with EU legislation for civilian and NATO standardization for military purposes. This is, no doubt, the first step in a long-lasting process of the global harmonization of the EMF standards. The next step calls for a coordinated program of work, based on an international consensus of what needs to be done. In collaboration with many countries world wide, which are now considering new EMF standards, the World Health Organization (WHO) has launched a project for establishing internationally-acceptable EMF standards.

In the presentation, the strategies for development of exposure limit values in electromagnetic fields standards currently in force in EE countries will be discussed. Some differences as well as similarities of the national health and safety standards and the main obstacles to harmonization of these standards with those being established by Western national and international organizations and agencies will be presented.

European EMF Exposure and Emission Standards

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Europe has a coherent framework for the restriction of public exposure to electromagnetic fields. There is an EU Recommendation which effectively implements the guidelines of the International Commission on Non-Ionizing Radiation (ICNIRP) for public exposures to electromagnetic fields. The European Committee for Electrotechnical Standardisation (CENELEC) produces EMF assessment standards for products. Various European Directives make it compulsory that any product that produces electromagnetic fields and is sold or imported into the EU is demonstrably "safe". The CENELEC assessment standards are the officially-recognised route for showing compliance with the safety requirements of the Directives. The CENELEC standards refer to the exposure levels in the Recommendation.

The result is that, effectively, any product for public use (such as mobile phones or domestic appliances) sold or imported (and in some cases operated) in the EU must comply with ICNIRP guidelines and be assessed using CENELEC standards, even if it is manufactured outside Europe.

There is presently a proposed European Directive for occupational EMF exposure. The Directive will be mandatory throughout Europe and will require employers to assess EMF exposure of workers. The proposed limits are very similar to the ICNIRP guidelines for occupational exposures, and it is expected that new CENELEC standards will be mandated for assessment of workplace exposures from a range of equipment.

Compliance with Canadian RF Exposure Standards

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Studies of possible hazards to human health from exposure to radiofrequency (RF) energy have led to the development of exposure guidelines and regulations, which are generally referred to as standards. A regulation is essentially a mandatory standard and is normally promulgated under an act of legislation. A guideline by itself has no legal force and is issued for guidance as a voluntary standard. However, guidelines become mandatory if they are referred to in a regulation.

The Canadian RF human exposure guideline, known as Safety Code 6, was first issued by the former federal Department of Health and Welfare in1979 and subsequently revised in 1991 and then 1999. The development of this guideline was originally carried out in response to requirements in the Canada Labour Code for guiding federally employed personnel engaged in the operation and maintenance of RF devices. Safety Code 6 has been adopted by many organizations across Canada and referred to in a number of federal and provincial regulations.

In this paper, an overview of Safety Code 6 and the responsibilities of the Canadian government for protection of workers and the general public from exposure to RF energy will be presented. These include the establishment of standards and procedures to ensure the compliance of RF devices with the Code.

Key words: RF exposure standards, regulatory compliance, workers and general public safety

WHO Framework for Developing EMF Standards

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The following provides the elements of a draft WHO Framework for developing EMF standard. This paper gives a summary of the various components of the Framework, but the details of the finally approved Framework may change slightly. For the final version, readers are referred to the EMF Project web site when completed: http://www.who.int/peh-emf/standards/en/.

Globalisation of trade and the rapid expansion of devices using electromagnetic fields (EMF) has focused attention on differences existing in exposure guidelines or standards limiting exposure to EMF. In some cases, the differences in the exposure limits are large. Since protecting populations is part of the political process, it is expected that different countries may choose to provide different levels of protection against environmental hazards, responding to their citizens' wishes.

However, some of the disparities in EMF standards around the world appear not to arise from this fact alone. In some cases they seem to have arisen from different interpretations of the scientific data and from different philosophies for public health standards development. Such differences in EMF exposure guidelines might reflect, in part, deficiencies in communications among scientists between different regions. Large disparities between national limits and international guidelines can increase public anxiety. This anxiety is further exacerbated by the introduction of new technologies, often associated with increased EMF exposure.

In November 1998, WHO's International EMF Project commenced an activity aimed at the harmonization of EMF standards worldwide. Over 45 countries and 8 international organizations are involved in WHO's International EMF Project, providing a unique opportunity to bring countries together to develop a framework for harmonizing EMF standards and to encourage the development of exposure limits and other control measures that provide the same or similar level of health protection for all people. Such an endeavour is in line with the World Trade Organization (WTO) requirement for countries who are a signatory to the General Agreement on Tariffs and Trade (GATT) to harmonize with international standards, where they exist.

A number of national organizations have formulated guidelines establishing limits for occupational and residential EMF exposure. There is currently one international guideline that has been widely adopted into national legislation: the guidelines of the International Commission on Non-Ionizing Radiation Protection (ICNIRP, 1998, http://www.icnirp.org).

Public exposure to EMF is regulated by a variety of voluntary and legal limits. Present guidelines for EMF exposure are designed to avoid established hazards, from short and long term exposure, with a margin of safety incorporated into the limit values. Currently, the international guidelines focus on prevention of acute neural and cardiac effects at lower frequencies, and heating at radio frequencies. Evidence of potential long-term effects is considered insufficient as a basis for limiting human exposure.

A summary of the national EMF standards adopted around the world is available from the WHO's International EMF Project website at http://www.who.int/docstore/peh-emf/EMFStandards/who-0102/Worldmap5.htm

Wednesday: Oral Presentations

Biological Effects of RFR: Research Done at the PIOM Laboratory and Within European Programmes

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The PIOM laboratory has a 15-year experience in investigating the biological effects of electromagnetic fields. The topic of radiofrequency radiations (RFR) emerged in the laboratory in 1994 with the development of mobile telephony.

The first task was the design and characterization of the setups to be used to expose cells in culture and animals. We used the "wire-patch antenna" designed at the IRCOM laboratory (Limoges, France) to expose cell cultures and the "loop antenna" system to locally expose rats to GSM-900 and 1800 mobile phone signals. Genuine base stations antennas emitting at either 900 or 1800 MHz were used to expose rats in the far field.

The second task was the design of pertinent biological protocols and animal models. The parameters that were studied aimed at detecting a potential role of RFR in cancer and neurodegenerative diseases using both in vivo and in vitro approaches.

Although the power irradiated from the mobile phone is low enough to be considered as non-thermal, the first concern for the public is the risk of brain tumour linked to the use of mobile phones. Over the years, we have tested different hypotheses. In vivo, we tested the hypothesis that low-level energy RFR could (i) behave as a tumour promoter in different rat cancer models (ii) induce DNA damage in cells of rat brain, (iii) promote the onset of the clinical crisis in an animal model of multiple sclerosis, and (iv) alter skin structure and Ornithine DeCarboxylase (ODC) expression in rat skin.

In vitro, we tested the hypothesis that low-level energy RFR could (i) alter spontaneous or induced apoptosis in brain and immune cells, (ii) induce the expression of the ODC and the Nitric Oxide Synthase 2 (NOS2) enzymes, or (iii) alter the expression of heat shock proteins (HSP).

All hypothesis testing was negative as no statistically significant effects could be detected in the range of SAR tested. Only could we observe effects of GSM-900 at whole-body SAR above 1 W/kg in two experiments using a chemically- induced mammary tumors model. This experiment is being replicated within the 5th European framework (Perform A) as well as in China.

The EMF Dosimetry Handbook Project

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This is a project to promote and develop high quality dosimetry for the assessment of human RF/EMF exposure and for *in vitro* and *in vivo* experimental systems. The intention is to create an internationally accepted Dosimetry Handbook which will be a living and substantially on-line document with integrated software tools and guides for dosimetry measurement and calculations.

The project also aims to ensure that researchers all over the world have free access to the highest quality dosimetry information, to provide a state-of-the art resource on the latest developments in dosimetry and to encourage the harmonisation of exposure and assessment standards. Individual handbook chapters are commissioned from individual experts around the world and peer-reviewed by an independent scientific management committee. It is planned to produce 25 chapters covering all major aspects of dosimetry.

Handbook workshops are held in conjunction with other international scientific meetings such as BEMS and EBEA. There is a handbook website at www.emfdosimetry.org.

Age Effect on SAR Evaluation of Dielectric Tissue Properties for Mobile Telephones

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In evaluating electromagnetic absorption of children heads for mobile telephones, the dielectric properties of biological tissues for adults have so far been used due to the lack of children's ones. Due to the higher conductivity reported recently for young rats, a question has arisen for the employment of adult's dielectric properties in the spatial peak specific absorption rate (SAR) evaluation of children heads. To answer this question, in this study we derived an approximate formula for the dielectric properties of various tissues as a function of age based on the rats' data measured by Peyman et al. The approximate formula was based on the finding that all the measured tissues had an almost constant ratio of ε_r'' to ε_r', and ε_r' showed an exponential decrease and approached to a constant value with age. Applying the formula to the dielectric properties of anatomically based 7-year-old and 3-year-old children head models, we calculated the spatial peak SAR for a 900 MHz mobile telephone with respect to the age using the finite-difference time-domain (FDTD) method. As a result, we found that the dielectric properties for the children head models do not affect significantly the one-gram or ten-gram averaged spatial peak SAR, and also that they decrease the ten-gram averaged spatial peak SAR in the brain. The former finding could be explained as an offset effect of the SAR increase at surface tissues due to the high conductivity and the SAR decrease inside tissues due to the high permittivity of children. The latter finding was studied via calculating the penetration depth in children models, which is defined here as the distance where the SAR decreases to e^{-1} of the value at head surface. Since there is not a standard method for the penetration depth calculation, we proposed a new one in which we first defined the SAR value at the head tissue voxel nearest the antenna feeding point as the SAR at the head surface. Then we searched all the voxels where the SAR values were within $e^{-1}\pm0.01$ times the SAR at the head surface. From the average distance between these voxels to the defined head surface voxel, we derived an averaged penetration depth, which exhibited a somewhat shallower penetration than that in the adult model.

Key words: Specific absorption rate, mobile telephone, children, dielectric property, penetration depth, FDTD method

The Brooks Anatomical Models and the State of the Research Commons for Radiofrequency Dosimetry Modeling

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Empirical measurements of localized and whole body specific absorption rates (SAR) can be made using temperature probes, E-field probes, or calorimeters. However, these methods are expensive in terms of skilled labor, materials, instrumentation, and the limited amount of data they provide. Only methods such as the finite difference time domain (FDTD) with realistic- anatomical models have the ability to estimate both whole body and a large number of localized SARs simultaneously. Even at the qualitative level, the FDTD predictions aid empirical research by suggesting which anatomical structures merit added scrutiny. Currently, virtually all exposures in our laboratory, whether human, animal, or phantom, are preceded by an FDTD analysis. On a number of occasions, FDTD results have suggested new experiments and possible mechanisms for observed bioeffects. Attempts at empirical confirmation generate a scientifically desirable hypothesis- testing process.

To further their usefullness to the scientific community, the Brooks anatomical models have been released for the use of the research community (ftp://starview.brooks.af.mil/pub/EMF/). Unfortunately, other anatomical models have very limited distribution, this means that independent replication of reported results is impossible. Because they are not in the intellectual commons, their contribution to the scientific community is limited . To maximize the contribution of any technique or data set to the development of a scientific endeavor, that information must be part of the intellectual commons.

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Development of High-Resolution Voxel Models of the Human Body Suitable for the Average Japanese Figure and Numerical Dosimetry for Whole-Body Exposure to RF Electromagnetic Fields

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In recent years, several high-resolution whole-body voxel models have been developed with the advancement of computer performance and medical imaging technology, and have been frequently used in numerical dosimetries of electromagnetic waves. Most of the voxel models are those of adult males suitable for the typical Western figure. To evaluate in detail the dosimetry for Japanese subjects, we have developed realistic high-resolution whole-body voxel models of the adult male and female of average Japanese figure using MRI (magnetic resonance imaging) data. The models developed consist of cubic voxels of 2 mm on each side; the models are segmented into 51 different tissue types. Although the masses of some tissues and organs of our models deviated from those of the average Japanese because of limitations in spatial resolution and/or contrast resolution or individual variation, most are close to those of the average Japanese. Our male model also differs markedly from Western male models because the body weight and the masses of most tissues and organs of our model are lighter than those of Western models. Therefore, a highly precise simulation of the dosimetry for Japanese subjects is possible using these whole-body voxel models. The adult female model is the first of its kind in the world and both are the first Asian voxel models (representing the average Japanese) that enable the numerical evaluation of electromagnetic dosimetry at frequencies of up to 3 GHz. As an example of the application of these models, we demonstrated the basic SAR (specific absorption rate) characteristics of the developed models exposed to E-polarized TEM (transverse electromagnetic) waves in VHF/UHF bands using the FDTD (finite-difference time-domain) method.

Key words: voxel model, Japanese figure, MRI, SAR, FDTD

RF Safety Assessment of Metallic Implants

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There are many people who carry metal items of various shapes and sizes inside their bodies due to accidents or for other medical reasons. Whenever a radiofrequency (RF) field impinges on such metallic implants, the field is scattered around the conductor which may redistribute the energy of the incident field to produce significant peak concentrations around certain parts of the implant. A number of RF safety guidelines and standards, including the 1998 ICNIRP Guidelines, require that such persons occupationally exposed to higher field limits should be assessed for the potential to exceed basic restrictions for localised Specific Energy Absorption Rate (SAR) around implants. A more fundamental consideration is whether the resultant temperature increase arising from the redistributed SAR would exceed acceptable levels. The study described in this presentation aims to provide general guidelines for making such assessments for a range of commonly utilised metallic implants and distinguish between those implants which may be assumed a priori to provide no potential for overexposure, and those which require more thorough assessment. It takes a two pronged approach to the RF analyses by firstly examining many simple models of canonical shapes (rods, loops and plates) using a Method of Moments code (FEKO). Further insights are obtained from more anatomically detailed FDTD models of specific case studies. Induced temperature rises around implants have been studied using a finite difference code developed for this project. An interesting by-product of these combined RF and thermal analyses has been the validation of the 10 gram cube as an appropriate SAR averaging mass.

Active Implantable Medical Devices and Electromagnetic Compatibility

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This presentation intends to give an overview of active implantable medical devices potential behavior in the presence of electromagnetic interference, technologies for compatibility and standards addressing Electromagnetic Compatibility (EMC). In recent years there has been a rapid proliferation of emitters across all spectrum of frequencies, such as expanded use of wireless devices, RFID, metal and theft detectors, etc. On the other hand, there has been a demand for smaller size implantable medical devices, with more sophisticated features that would allow physicians to provide and their patients to receive better health care and quality of life. These factors combined have raised the visibility of EMC.

The following topics will be addressed in detail:
1. Definitions and description of implantable systems for cardiac and neurological applications.
2. Operation and components of the following systems: implantable pacemakers, implantable cardioverter defibrillators (ICDs), implantable neurostimulators, and implantable drug infusion.
3. Discussion of electromagnetic interference sources that may affect implantable medical devices. EMI Sources frequently encountered in a non-controlled environment:
Power lines
Cellular telephones/personal communication devices
Electronic Article Surveillance Systems (EASS)
Metal detectors
EMI Sources frequently encountered in a controlled environment:
Magnetic Resonance Imaging Systems
Electrocautery
Lithotripsy
External Defibrillation
Diathermy
4. Discussion of implantable devices response to electromagnetic interference and potential issues for patients.
5. Design solutions for electromagnetic interference protection.
6. International standards addressing electromagnetic interference and implantable medical devices.
European Standards: EN 45502-1, EN 45502-2-1 and –2-2
International: ISO 14708-1
USA: AAMI EMC PC69

Key Words: EMC, active implantable medical devices

International Criteria for EMF Research for Health Risk Assessment

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The WHO EMF Project and its collaborating expert bodies world wide (such as IEEE & ICNIRP), have set out criteria for EMF literature review and research to be followed to fulfil human health risk assessment requirements. These criteria are used for evaluating published EMF research and proposed RF research. Generally studies must demonstrate a reproducible effect of EMF exposure that has the likelihood (or is unlikely) to occur in humans and demonstrate that this effect has a (or no) potential health risk for human populations. Only independently confirmed effects can be considered when assessing a health risk. It is essential that there be replication of key studies to establish the effects. To that end the criteria are set out in detail to insure replication. The accepted methodology includes repeatable quantitative measures. For instance Specific Absorption Rate (SAR) in Watts per kilogram (W/kg) is the fundamental RF dosimetry parameter. The presentation will detail the specific EMF criteria for each of epidemiology, human acute studies, in vivo, and in vitro research. The final summary will conclude with an overview of the contribution of each discipline to complete the human health evaluation.

Update of Research on Mobile Telephony and Health

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In September 2003 it was estimated that the number of mobile phone users was 1.3 billion globally. The increasing use of mobile phones and the increasing amount of mobile phone users has lead to concerns that exposure to electromagnetic (EM) energy emitted by the phones and base stations may lead to adverse health effects.

It is not widely known that biological and health effects of RF emissions have been studied for about 50 years. There are about 1300 peer-reviewed publications, from biophysical theoretical analyses to human epidemiological studies, listed on the WHO website (IEEE Database). Most of the studies are directly relevant to the issue of whether low-level exposure to RF energy can initiate or promote cancers. About 320 studies have been initiated using cell culture, animal, and human models to investigate whether exposure to analog, CDMA, or TDMA-modulated mobile telephony signals can cause adverse health effects

The majority of the cancer studies show no effect and those few studies showing an effect are being addressed through replication. The replication studies that have been completed have failed to confirm the original findings. There are also a large number of non-cancer studies that have not produced an established effect. However, there are also a few hypothesis-generating studies that require further study in order to confirm or reject the original findings. From the health risk assessment point of view (by WHO 2007) it is essential that even all negative findings will be published in peer-review literature.

In summary, the weight of evidence approach shows that mobile phones and base stations cannot be linked to adverse health effects in humans. Moreover, completed and ongoing studies listed in the IEEE database cover an extensive range of RF frequencies and modulation patterns and there are no established data supporting frequency specific or modulation specific health effects (“non-thermal effects”).

Management of International Multilateral Collaborative Research

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During the past years there has been a general trend, where research is increasingly carried out, not in one institution, neither in bi- or tri-lateral forms, but in large international multilateral collaborative research consortiums (IMCRC). This raises challenges for consortium management. International collaborative research has a major role in research programmes and projects where increased public interest is involved. The studies of possible health effects of exposure to EMF belong to the most important ones.

International multilateral collaborative research has more often a knowledge-platform approach than a project-based approach. Syndication of different public and private funds from large number of countries has been a distinctive aspect. Combined research budget could be far greater than that of individual organizations or even countries could afford. Collaborative research is usually more targeted research, coordinated and controlled by the consortium members and addressing the problems that consortium members face. Research area is generally either about non-competitive or pre-competitive subject.

Trust is often described as a precondition and a facilitator for collaborative research. In many cases impartiality and public trust are essential. Therefore trusted third party or firewall between researchers and funding parties could be necessary.
IMCRC have significant budgets, exceeding even 10 million euros in case of single projects. Also the number of participating parties may be large, projects with more than 10 research parties and 10 funding parties are not rare any more. Management of these virtual research organisations becomes a crucial factor of success and failure.
New approaches, a range of organisational forms and management practices developed and used at the University of Helsinki will be covered during the presentation.

Feasibility and Design of Rodent Carcinogenicity Studies On Cell Phone Radio Frequency Radiation in Reverberation Chambers

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With the expanded use of wireless communication devices in the United States and worldwide, the US Food and Drug Administration requested that the National Toxicology Program perform experimental studies of possible chronic health effects (including carcinogenicity) due to exposure to cell phone radio frequency (RF) radiation. The use of a reverberation chamber was considered because it can provide a means for exposing a large number of animals unconstrained in small cages to well-defined electromagnetic fields. To determine the feasibility of using reverberation chambers for long-term studies of RFR in rats and mice, evaluations were made of field uniformity in chambers loaded with bottles containing a tissue simulating fluid (phantoms), SAR uniformity among phantoms, phantom proximity effects, and amplifier power requirements to achieve targeted SAR levels. In an empty chamber, total electric field variability was approximately ±0.7 dB with continuous exposure to 900 or 1900 MHz RFR. In a chamber containing 255 phantoms of 500 g each, total electric field variability was approximately ±2 dB at these frequencies. The efficiency of coupling of the power delivered to the phantoms relative to the power delivered to the chamber was improved as the number of phantoms in the chamber was increased; with 255 phantoms in the chamber the coupling efficiency was nearly 90% at these frequencies. The average SAR variability among phantoms was ±0.75 dB. Numerical simulations were made of whole-body SARs and organ average SARs during lifetime exposures of rats and mice in reverberation chambers. In mice exposed to 900 MHz RFR, absorption by the tail was substantially greater than the absorption by other organs; the SAR distribution was more uniform in mice exposed to 1900 MHz. The opposite was true for rats - greater absorption by the tail was observed at 1900 MHz and a more uniform SAR distribution was apparent at 900 MHz RFR. In pregnant mice, absorption by the embryo is less than that by the dam; in rats, absorption by the embryo was slightly greater than that of the dam. Based on the experimental and modeling data, the NTP plans to conduct carcinogenicity studies of cell phone RFR in both sexes of rats (Sprague-Dawley) and mice (B6C3F1) exposed in reverberation chambers. Rats will be exposed to 900 MHz RFR and mice to 1900 MHz RFR. Each frequency will include GSM and CDMA modulated signals. A thermal pilot study will be performed at each frequency and modulation to determine SAR levels that cause mortality or loss of ability to thermoregulate. Exposure levels for the chronic study will include a sham plus 3 separate SAR levels based on prechronic findings. Intermittent, 20-hour per day exposures (e.g., cycles of 10 min on and 10 min off) will be conducted for five days per week. Exposures will begin on gestation day-6 and continue until animals are 110 weeks of age. Group size will be 50 pregnant animals during gestational exposure with 2 males and 2 females per litter (i.e., N=100) continued for chronic exposure. Endpoints will include: body weights, mortality, clinical signs, body temperature, organ weights, complete necropsy and histopathology, lens optical quality, blood brain barrier permeability, micronuclei, DNA strand breaks in brain cells, and metabonomic profiles. Dose-response analyses will be performed on all observed adverse effects.

Key Words: cell phone RFR, carcinogenicity, reverberation chambers, rats and mice

“ EGAT’s Practice on Managing Electromagnetic Fields in Thailand ”

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Electricity utilities are still investigating the effective ways in which they can reduce public fear of adverse health hazards from exposure to magnetic field near high voltage overhead transmission lines. Electricity Generating Authority of Thailand (EGAT), also concern more about the environmental impact in the ways to reduce both the visual impact and Electromagnetic Field (EMF) effect mainly for the health hazard which still unclear. This paper show the effective ways of EGAT for managing EMF impact and the current practices to explore ways to reduce magnetic fields around high voltage overhead transmission lines without creating new more hazards to public. EGAT staff also reviews the practical concept that normally use in others foreign utilities compare with criteria that EGAT currently use in Thailand. This paper also present the experience problem, question and answers that EGAT mostly faced from public who concern more about the health hazards from magnetic field. Typically for EGAT, the limitation for magnetic field is less than 150 mGauss at the easement boundary. The field survey data for 500 kV transmission system also reported in the paper to show the actual value compare with design value. Finally, the current activities of EGAT in the view to managing the level of environmental impact and public health hazards are discussed. By the long experience of EGAT, the most effective regulation with conservative policy in limiting the EMF impact has been appreciated as a successful means for managing EMF impact with the safety aspect to decrease the risk of health hazards.

Keywords: Overhead Transmission Line – Electromagnetic Field – Health Hazards, Safety Aspects

Participatory Disease Investigation of Transmission Line Workers at EGAT

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Participatory epidemiology study from questionnaire, personal data and health reports of the Electricity Generating Authority of Thailand (EGAT)'s transmission line workers (n=1,898) has been investigated to find out the correlation between prevalence diseases and electrical parameters. The main electrical parameters are job type, distance, voltage level in the transmission line.

Top 5 diseases found in the investigation were hypertension, myalgia, diabetes mellitus, allergy and hypercholesterolemia. Only 5 in 1898 cases were found to be related to cancers. The statistical analysis results could be summarized as follows.

Hypertension: It was found that the relative risk of the disease for the workers who are working with 500 kV comparing to 115 kV line was 0.64. It was also found that the risk for the workers who work near transmission line less than 30 meters was less than other groups. However the relation between the prevalence of the diseases and workers's age was also found.

Myalgia: A major group of workers who participate to myalgia was found in 500 kV transmission line workers. The result may relate to the style of working since these workers have to climb up the high transmission line.
Hypercholesterolemia: It was observed that the hot-line workers have less risk in hypercholesterolemia comparing to the office and generating plant workers. The relative risks were 0.74 and 0.84, respectively.

No correlation between electrical parameters and diabetes mellitus and allergy was observed.

Cancer: All the workers who participate to cancers, 5 in 1898 cases, were found in the group where they are working near the transmission line less than 30 meters. However, correlation between the prevalence of cancer and the voltage level of the transmission line could not be observed.

It should be noted that the relative risk in cardiovascular disease of the 500kV workers was 0.4 comparing to the other group. However, it was also found correlation between age and the prevalence of disease.

In conclusion, if the Hill's criteria is introduced in evaluating the effect of electrical parameters to prevalence of the diseases, it is still difficult to conclude that there is negative effect. However, it is interesting that some positive effect was observed such as in the case of hypertension, hypercholesterolemia and cardiovascular disease even there is also effect of age in the analysis results.

Occupational Exposure Assessment of ELF Electromagnetic Fields in Malaysia

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Exposure assessment is the determination or estimate of the magnitude, frequency of occurrence, and rate of exposure of an individual or a group to an environmental agent. The agents of interest in this case are the electric and magnetic fields (EMF) in the extreme low-frequency range that includes the power frequency of 50 Hz. There are an increasing concern that exposure to EMF may be associated with biological and health effects. This concern has prompted numerous international measurement projects and the development of instrumentation, methodologies, protocols, and exposure models of humans and simulations of field penetrations. This paper identifies the status of EMF exposure assessment research related to occupational exposures in Malaysia. It draws the recent results to emphasize the unique aspects of EMF exposures in the home and utilities environments of substations, transmission systems, and highlights the research needs. The intensities of electromagnetic fields have been measured under transmission and distribution lines, at substations, generating plants beside different industrial plants and near various electric devices including domestic and household electrical equipment. Measurements of fields in transportation systems and medical equipment are also included. The field densities have been related to the exposure time (duration of staying) in the different areas and have been compared with the internationally established levels and standards. The data presented are useful for understanding the levels of electromagnetic fields that can be encountered in various places and will be helpful for estimating possible occupational and residential exposure levels.

GIS Modelling for Estimating the Proportion of Children Exposed to the ELF Magnetic Field of Overhead Power Lines in Flanders (Belgium)

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Since the International Agency on Research of Cancer (IARC, 2001) classified the ELF magnetic field (MF) of power lines as "possible carcinogenic to humans", more and more authorities of European countries consider to use the 0.4 µT contour as a critical exposure zone for planning new dwellings near to power lines (Kelfkens et al., EBEA 2003).

In this respect we developed a GIS model for the Flemish part of Belgium. We were mainly interested in getting to know the proportion of the Flemish children exposed to at least 0.4 µT in average. Therefore we developed an analytical model which was verified by means of the Finite Element Method for Electromagnetic fields (FEM) on the one hand and by controlled and randomized in situ measurements of the MF near power lines on the other hand.

Table 1 shows the diameter of the 0.4 µT contour and the percentage of children (between 0 and 19 years old) exposed to 0.4 µT in average. The data were calculated at a line current load of 50% and 100% (worst case situation), an average height of de line conductors and a flat topography respectively.

Table 1: 0.4 µT corridor and percentage of children exposed to 0.4 µT in average

		Power line type			Total
Current load		70 kV	150 kV	380 kV	
50%	0.4 µT contour (m)	18	30	66	-
100%	0.4 µT contour (m)	36	58	13	-
50%	Exposed children (%)	0,25	0,31	0,13	0,7
100%	Exposed children (%)	0,5	0,63	0,26	1,4

From:
the data of table 1 the cancer registration data of childhood leukaemia in Flanders
the relative risk of 2 for the association between an 0.4 µT exposure and childhood leukaemia we calculated that every two years 1 additional childhood leukaemia is induced by power lines in Flanders.

Key words: GIS, Magnetic field, Power lines, Exposed children, 0.4 µT contour, Childhood Leukaemia

Exposure of School Children To Extremely Low Frequency Magnetic Fields in Korea

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Industrializing process including marked increase of electric appliances has expanded personal exposure to magnetic fields (MF) whose effects on human health have long been out of scientific concern. Measurement of personal exposure to magnetic fields have been used to investigate the health effects of magnetic fields in various epidemiological studies. Now, there are 27 elementary schools overhead power transmission lines and children living close to power lines would be apprehended by their exposure level of magnetic fields and their health in Korea. This study to investigate 24 hr personal exposure levels of 60 Hz magnetic fields in a group of 53 children living far away from the power lines and 50 children living near the power lines during February 2003 to October 2003 as well to compare them to exposures estimated using a time activity pattern and micro-environmental model. Twenty-four (24) hour personal exposure measurements to 60 Hz magnetic fields were recorded using EMDEX II and EMDEX Lite (Enertech, Co., Ltd.) carried by the subjects during their at home, school, etc. Children wore a personal exposure instrument in a leather case attached to a belt cross shoulder at the hip. The display was turned off, and the case was sealed, so that the child could not touch any switches. The children kept a diary of activities (activity list) for the period of registration by 20 minutes of time intervals, and this was used to classify the location of the child as at home, at school, at educational institute, at PC game room, and at all other places. After each period of measurement, the data stored in each meter was downloaded into a microcomputer for data management. The 24 hr magnetic field measurements were summarized for each individual by both the arithmetic mean and the geometric mean, since they show a log normal distribution. The results indicated that average 24 hr personal exposures of children (arithmetic mean = 0.159±0.110 μT, geometric mean = 0.114±0.074 μT) was well represented by exposure level at home (awake : AM = 0.207±0.180 μT, GM = 0.195±0.173 μT; sleep : AM = 0.138±0.136 μT, GM = 0.134±0.134 μT) because of high correlations between 24 hr personal exposure and measurement at home ($r = 0.95$, $p < 0.001$) and high time spent at home (57% of 24 hr). Among other micro-environment, children spent about 23% of 24 hr at school, in which exposure level at ground (AM = 0.160±0.143 μT, GM = 0.129±0.110 μT) was higher than exposure level at class room (AM = 0.064±0.029 μT, GM = 0.059±0.029 μT), and as compared with other studies, most of children went to many kind of educational institutes (AM = 0.233±0.199 μT, GM = 0.211±0.181 μT), in which they spent about 8% of 24 hr. Our study shows fairly high correlations between 24 hr personal exposure and measurement at home; correlation coefficients varied between 0.91 and 0.95. In addition, this result suggests that the 24 hr personal exposure of 60 Hz magnetic fields far away from the power lines may affect the level of exposure at home and the level of exposure at home may be indicator of 24 hr personal exposure in Korea. Moreover, we are also analyzing the data measured 24 hr personal exposure of children attending at a school near power line, and in further study we will compare this study with them.

Keywords : magnetic field, 24 hr personal exposure, micro-environment, power lines

Accurate SAR Assessment Around Base Station Antennas Using the Finite Element and Method of Moments Numerical Techniques

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Method of Moments:
The objective of our research is to establish a methodology for occupational human exposure calculations, using numerical simulation techniques, that would yield accurate and realistic SAR results for comparison to basic restriction guidelines around base station antennas operating in GSM900, GSM1800 and UMTS networks. One approach to this problem could be to assume worst-case scenarios wherever information regarding the problem setup, material parameters and/or antenna details is insufficient. However, this will lead to unnecessarily conservative SAR predictions. We believe that through careful investigations and verifications of not only the numerical techniques employed, but also the models used with the techniques to represent reality, accurate SAR predictions can be obtained yielding realistic exposure restrictions for the occupational exposure environments. A hybrid Finite Element Method (FEM) / Method of Moments (MoM) has been implemented and verified by comparison to other numerical techniques. There are two significant advantages of the hybrid FEM/MoM compared to the FDTD technique when applied to human modelling around base station antennas: 1) The large free space region around the base station antenna need not be discretized due to the hybrid approach; 2) The MoM is very efficient and accurate when modeling the geometric detail associated with curved metallic surfaces and wires on the base station antenna. This proved to be of critical importance with the human phantom in very close proximity to the antenna.
A generic base station antenna was designed and manufactured and used together with an upper body generic human phantom (equivalent muscle tissue) for the measurements. The goal was to confirm (through measurements) that the numerical odels are sufficient to accurately predict the SAR inside a human phantom close to a six-element dipole array with reflector. With the human body more than 50cm away from the base station antenna a basic wire (thin wire approximation) and plate model can be used to represent the dipoles and reflector. At less than 50cm, the human body significantly changes the dipole impedances and thus the reactive feed network and hence the dipole array excitation. In this case the dipoles must be modeled in more detail to enable accurate impedance calculations. All this must be taken into account to ensure accurate SAR calculations at these close distances. Results showed excellent agreement if the different models discussed above are used for different problem setups. The FEM / MoM models will further be used to perform SAR calculations on a 3D grid around base station antennas with the purpose of establishing realistic 3D compliance zones, based on basic restrictions, around such antennas.

Keywords: Numerical Dosimetry, SAR, Base Station Exposure, Finite Element Method

A Review of Epidemiologic and Long-Term Animal Studies and Their Use in the Evaluation of the Carcinogenic Potential of RF Energy

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It is incumbent on public health officials to bring closure to public health related questions as rapidly as possible. The question of whether RF is a carcinogen has been raised and this can only be addressed by an appropriate and thorough evaluation of the relevant scientific literature. A fundamental element of any public health analysis is clear definition of the body of research data necessary to allow a decisive and reliable determination of the potential risk of cancer and other adverse health effects from exposure to chemical or physical agents. Since it is impossible to determine whether any agent is absolutely risk-free even with an infinite amount of research results (one can not prove the null hypothesis), the question of how much is necessary has to be answered from a public health perspective and not from interests of researchers.

The Species Specificity and Sensitive Target Organs of Injury Induced by Electromagnetic Radiation (BIOEFFECTS OF EMP AND HPM)

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Electromagnetic radiation (EMR) widely exists in daily life and military applications. The experimental investigation and epidemiological survey have confirmed that EMR can induce human injury and health risks, even fatal effect. Through study on the injury effect induced by electromagnetic pulse (EMP) and high power microwave (HPM) in several experimental animals, we found that injury degree was different between monkeys, dogs, rabbits, rats and mice, and the sensitive degree was also discrepant in various organs. In this paper, by means of observation of behavior, physiology, hematology, biochemical, immunology, pathology and especially, death percentage during one year, we explored the species specificity and sensitive target organs of injury induced by EMR.

Bioeffects of S Frequency High Power Microwave Exposure On Rat Hippocampus

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Objective: The aim is to study the morphology and function changes in rats hippocampus exposure to S frequency high power microwave (HPM). Methods 50 male Wistar rats were used and exposure to S frequency HPM, which were tested learning and memory abilities by means of Y maze and sacrificed on 6h, 1d, 3d and 7d after exposure. The hippocampus was taken off to study the basic pathologic changes, apoptosis and the expressions of NSE and GFAP by means of light microscopy, Nissel body staining, in situ terminal end labeling and immunohistochemistry.

Results: HPM exposure decreased the abilities of learning and memory of rats significantly. It also resulted in rarefaction, edema and hemangiectasia of hippocampus. Nervous cells were degeneration and necrosis. Nissel bodies decreased or disappeared. The injuries were more serious in field CA-4 and dentate gyrus, which showed dose-effect dependent relationship, and were progressive aggravated on 7 days. The apoptosis cells were increased significantly. NSE was increased in nervous cells, which the positive areas were also seen in the interstitial matrix and blood vessels. GFAP was increased in astrocytes, which fiber-like GFAP became short and thick.

Conclusion: S frequency HPM can damage the abilities of learning and memory significantly and result in morphology changes in hippocampus. The major pathologic changes were degeneration, apoptosis and necrosis of nervous cells and edema in interstitium. NSE and GFAP played an important role in the pathologic process.

Key words: high power microwave; Y maze; pathology; apoptosis; NSE; GFAP

Albumin Leakage and Accumulation in the Nerve Cells of Rat Brain After Whole Body Exposure To Microwaves From GSM Mobile Phones

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Background: Since 1988, we have studied in a rat model the effects of microwaves at 915 MHz upon the blood-brain barrier (BBB) of the brain capillaries. In series of more than 1600 animals, we have studied the effect from both pulse-modulated and continuous RF fields– including those from real GSM mobile phones. We have shown that microwave exposure at sub thermal levels gives rise to a significant leakage of albumin through the BBB of exposed rats. The albumin diffuses out into the brain tissue and accumulates in the neurons and glial cells surrounding the capillaries [1-3]. Similar results have been found in other laboratories [4,5] while others have not been able to record the albumin leakage. In the present study including 142 rats we have investigated the long term albumin leakage over the BBB and whether it might cause damage to the neurons.

Method: In the first study 32 young rats were exposed during two hours to 900 MHz microwaves emitted by a GSM mobile phone. Three groups of each 8 rats were exposed in TEM cells to average whole-body specific absorption rates (SAR) of 2 mW/kg, 20 mW/kg and 200 mW/kg, respectively. Eight rats were simultaneously kept for 2 hours in non-activated TEM-cells. By the end of the period they were anaesthetized and sacrificed by perfusion-fixation with 4% formaldehyde. Brain slices were stained for RNA/DNA with cresyl-violet to show damaged (dark) neurons and with albumin antibodies (Dakopatts) to reveal albumin as brownish spotty or more diffuse discolorations.

In the follow study ninety-six male and female Fisher 344 rats were exposed or sham exposed for two hours in TEM-cells to radiation from a software programmable GSM-900 mobile telephone. The animals were awake during the exposure and could move and turn within the exposure chamber. The peak output power fed into the TEM cells were 1, 10, 100 or 1000 mW, resulting into average whole body specific absorption rates of 0.2, 2, 20 or 200 mW/kg. For each exposure condition, 16 animals were exposed and 8 animals were sham exposed in non activated TEM-cells. Half of the animals in each exposure group were allowed to survive 14 days and the rest for 28 days. By the end of the period they were anaesthetized and sacrified by perfusion-fixation with 4% formaldehyde. Brain slices were stained for RNA/DNA with cresyl violet and HSP70 for heat shock protein. Applying albumin antibodies (Dakopatts), albumin is revealed as brownish spotty or more diffuse discolorations.

Results: When the rats were sacrificed at 50 days after exposure we found that exposed animals usually showed several albumin positive foci around the finer blood vessels in white and grey matter. The albumin had spread in the brain tissue between the cell bodies, and surrounded neurons, which were either free of albumin or in some foci containing albumin. We found highly significant ($p<0.002$) evidence for neuronal damage (dark) neurons in cortex, hippocampus and the basal ganglia in the brains of the exposed rats. The occurrence of dark neurons under the different exposure conditions shows a significant positive relation between EMF dosage (SAR: 2-200 mW/kg) and number of dark neurons.

Conclusion: We have found evidence for neuronal damage caused by non-thermal microwave exposure from a GSM mobile telephone. Damaged neurons are recorded in the cortex as well as the hippocampus and the basal ganglia in the brains of exposed rats. The neuronal albumin uptake and other changes described would seem to indicate a serious neuronal damage, which may be mediated through organelle damage with release of not only hydrolytic lysosomal enzymes but also e.g. sequestered harmful material, such as heavy metals, stored away in cytoplasmatic organelles (lysosomes).

Intravital Microscopic and Histological Evaluation of Acute Effects on the Brain by Local Exposure to Radio-Frequency Electromagnetic Fields in Rats

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To investigate the acute effects of radio-frequency electromagnetic fields (RF) exposure on the cerebral microcirculation, we evaluated not only blood-brain barrier (BBB) function but also other several microcirculatory parameters using intravital microscopic approach and histological approach in the rats.

The each head of Sprague-Dawley rats positioned under loop antenna was locally exposed to a 1,439MHz electromagnetic near-field TDMA (time division multiple access) signal for PDC (Personal Digital Cellular, Japanese cellular telephone standard) system in a small anechoic chamber. Using a cranial window method as a intravital microscopic approach, four cerebral microcirculatory parameters, BBB permeability, leukocyte behavior, plasma velocity, and vessel diameter were measured before and after RF exposure for 10 min at brain averaged SARs of 0.18, 1.80, 6.48 W/kg. On the other hand, BBB disruption in a whole brain was histologically observed with the brain sections. The brains were fixed with 4% paraformaldehyde 0-, 2-, 24-hour after RF exposure for 2 hours at a brain averaged SAR of 35W/kg. BBB disruption was estimated by extravasations of three types of molecule, Evans blue (MW: 960), FITC-BSA (MW: 69000), and internal immunoglobulin (MW: 156000).

Using intravital microscopy, we found no noticeable change in BBB permeability, leukocyte behavior, plasma velocity, and vessel diameter after RF exposure for 10 min at up to 6.48 W/kg. In addition, we histologically observed no extravasation of Evans blue, FITC-BSA, and internal immunoglobulin in any brain sections after RF exposure even for 2 hours at 35 W/kg. These results suggest that there is no acute effect on the cerebral microcirculation including BBB function after RF exposure under the present conditions.

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Key words: BBB permeability, cerebral microcirculation, cranial window

Friday: Oral Presentations

Research Related to Mobile Telephony and Health in Italy: National And International Programs

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The national program *Human and Environmental Protection from Electromagnetic Emissions* are conducted through the fund of MIUR (Ministry of the University and research): currently there are 5 research lines comprising 59 units. 1Electromagnetic fields and sources characterization and modelling; 2. EM field levels in environment measurement; 3. Interaction between source and exposed individuals; 4. Control, protection and healing techniques; 5. Activities integration and results divulging

This presentation will be focused on Line 3 (mainly on biological effects): it is sub-divided in different themes: 3.1 Dosimetry: Experimental Measures; 3.2 Dosimetry: Modelling of EM fields; 3.3 Mechanism of interaction; 3.4 Biological effects *in vivo* ed *in vitro*

It is know that well-defined exposure conditions are essential to obtain reproducible and scientifically meaningful results and they are an essential requisite for the repeatability of studies (WHO recommendations in definition of EMF Project): the exposure set-ups, realized in ENEA labs for *in vitro* and *in vivo* experiments, will be presented (these systems are used in some VFP UE Projects); exposure environmental conditions and the analysis of SAR distribution in the human tissues are defined to determine the parameters adopted during the experimental activity.

The *in vitro* experimental activity mainly concern the effects of ELF magnetic field and RF electromagnetic field on P19, GTR1 (ES) (cardiomyocytes), looking at gene expression, transcription factors; LAN 5 (neuroblastoma): proliferation, differentiation, sprouting, apoptosis, gene expression, transcription factors; MG-63, Saos-2 (osteosarcoma), proliferation, morphology, adhesion, molecule expression; Human lymphocytes, genotoxic assay (CA, SCE, MN, PI, Comet assay); Peripheral blood mononucleate (PBMC), proliferation, cell cycle after stimuli, mitochondrial functionality.

Regards on the *in vivo* studies on the immune system (C57BL/6 mice): proliferation, cellularity, cytokine production, interleukins concentrations, activation markers, and auditory system (inner ear-cochlea on Sprague Dawley rats: the morphology and the functionality tests are underway with the exposure to 900 and 1800 MHz GSM-modulated fields.

The experimental protocols and some results will be presented: briefly most of our data show that under the experimental conditions adopted the exposure to RF does not induce considerable changes in the frequency of spleen cell populations, in cell proliferative responses, in cytokine production and activation markers and does not affect peripheral lymphocytes and the onset of T cell-dependent antigen-specific immune responses *in vivo*. Furthermore EMF GSM did not affect peripheral and central auditory function
Several activities are also developed in conjunction with international projects (V°FP-UE and others, on genotoxicity, combined effects, neuro-sensorial systems): the national program has been the background to realize the national and international network and to spread the standardized procedures from physical and biological point of view.

Effects of High Peak Power 2.8 Ghz Microwave Pulses on Rhesus Monkey Corneal Endothelium

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Previous studies have shown that high peak power microwave pulses alter several different eye tissues in nonhuman primates (Kues et al. 1985-1993). The changes have been reported to occur in the corneal endothelium, iris vasculature, and retina of monkeys exposed to 2.45- and 1.3-GHz pulsed microwaves at 10 and 12.5 mW/cm^2. However, our previous research has not shown retinal damage at 1.3 GHz. In this study we evaluate the effects of microwave pulses at 2.8 GHz on corneal endothelium cell counts. Four rhesus monkeys (*Macaca mulatta*) were exposed, while anesthetized, to high peak power microwave pulses. Exposures were conducted 4 hours per day, 3 days per week for 3 weeks. This resulted in 9 exposures total each at a low average power density, but high peak power. Specular microscope (TOPCON SP-2000) endothelium images were obtained of the central and four peripheral areas of the cornea (each 0.2mm by 0.5mm) prior to exposures and periodically after the exposure sequence. Changes were not observed in corneal endothelial cell density or morphology either acutely, or over a 6 month period after the exposures.

Keywords: microwave, pulses, eye, damage, ocular, monkey

Effects and Mechanism of EMF and HPM on Optical System in Monkey, Dog and Rabbit

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Objective: Eye is very sensitive to electromagnetic radiation injury. High power microwave (HPM) and electromagnefic pulse (EMP), as well as peacetime electromagnetic radiation(EMR) accidents will cause eye injury. The aim of this study was to explore the effects of electromagnetic radiation on eye: the pathological changes, the dose-effect relationship and its mechanism.
Methods: The simulated HPM and EMP radiation source device was used. Monkeys, dogs, rabbits, cultured cells were all irradiated for a long-term(one year) and dynamic study after irradiation.By means of ophthalmoscope, microscope, electroamicroscope, immunohistoche -mistry,insitu hybridization,LSCM ,atomic force amicroscope and biochemistry, the effects and mechanism of EMP and HPM on eye were systematicaly studied.
Results: 1. Eye is very sensitive to electromagnetic radiation injury. HPM and EMP can induce eye injury in monkeys, dogs and rabbits. HPM and EMP-induced pathological changes are similar. The radiation dose and injury effect are positively related.
2. Four animal models of eye radiation injury were set up. The sensitivity of eye tissue to radiation injury is as follows: lens>cornea>retina. The degree of EMP-induced injury in 3 kinds of animal eyes is very different: it is more serious in monkeys than in dogs, and it is more serious in dogs than in rabbits. It is suggested that EMR injury to eye have species differents.
3. Lens is very sensitive to radiation injury. Lens capsule membrane thickening, epithelial hyperplasia, lens fibers derangement and pigmenting uneven, lens edema and clouding, and finally cataract were all presented during 45 to 90 days after radiation. Clouding of posterior capsule of lens is easily found in monkeys, and clouding of anterior capsule is seen comparatively frequently in dogs.
4. Radiation interfered proliferation and DNA synthesis in lens epithelial cells. In early days after radiation, AgNOR and DNA content was decreased; afterwards, when lens epithelial cells repaired from injury, the AgNOR and DNA content increased and cell proliferation was activated. Radiation-induced cell proliferation disorder plays an important role in cataract happening.
5. Radiation interfered cell cycle of lens endothelial cells. Radiation-induced abnormal expression of P^{21WAF1} and cyclin E was involved in the change of endothelial cell cycle. The abnormal expression of cell cycle regulating factors played a crucial role in radiation-induced cataract.
6. Cell membrane is a very sensitive target region for EMP and HPM radiation injury. Radiation may induce membrane perforation in cultured endothelial cells, and the ionic concentration in culture medium was increased obviously after radiation. Cell membrane injury plays a crucial role in the mechanism of non-heating effect caused by electromagnetic radiation.
Conclusions: Lens is very sensitive to HPM and EMP radiation injury, and may lead to cataract;
The radiation dose and injury effect are positively related; the degree of injury to 3 kinds of animal (monkey, dog and rabbit) eyes induced by EMP and HPM is very different. EMR injury degree to eye have species difference; Radiation-induced cell proliferation disorder plays an important role in cataract happening; The abnormal expression of cell cycle regulating factors played a crucial role in radiation-induced cataract; Cell membrane injury plays a crucial role in the mechanism of non-thermal effect caused by electromagnetic radiation and irons outflow.

Key Words: High power microwave (HPM); Electromagnetic pulse (EMP); Eye; Pathological changes; Injury mechanism

Effect of Microwave Exposure on Fetal Development in Rat

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40 female Sprague Dawley rat (4 month old) in 5 group (E,F,G,h, I each group containing 8 mated female) were used on the 1st through 18th day of gestation. Tow first group were exposed to microwave radiation at power density of 1 mw/cm2 for different period daily(30 minutes for group G and 5 minutes for group h). Group 1 (control group) were kept under the same condition without any microwave exposure. Conclusion: according to the test results and statistical method, the weight of fetus in treat group was significantly lower than control group and 90% of fetuses in group G and h were hyperemic and hemorrhagic too.

Biological Effects of 20 kHz MF Exposure

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Sprague Dawley rats (10 males and 10 females per group for sham and magnetic field exposed) were exposed in carrousel irradiator to 20 kHz intermediated frequency (IF) magnetic field at 6.5 μT peak intensity for 8 hrs/day, 5 days/week, for 90 days and 1 year. Urine analysis (pH, serum glucose, protein, ketone bodies, RBC, WBC, glucose, bilirubin, and urobilinogen), blood analysis [WBC, RBC, hemoglobin concentration (HGB), hematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and platelet (PLT) or thrombocyte count], blood biochemistry (total protein, blood urea nitrogen, creatinine, glucose, total bilirubin, total cholesterol, aspartate aminotransferase, alanine aminotransferase, alkaline phosphatase, and lactate dehydrogenase), and histopathological analysis for organs such as liver, kidney, testis, ovary, spleen, brain, heart, and lung were performed, and there were no significant differences found in the above analyses between IF magnetic field exposed and sham control rats. In addition, in order to evaluate the importance of gestational age to the exposure to 20 kHz sawtooth magnetic field, pregnant ICR mice at gestational days of 2.5 to 15.5 post-coitus which was the most sensitive stage for the induction of major congenital malformations were exposed in carrousel irradiator to 20 kHz intermediate frequency sawtooth magnetic field at 6.5 μT peak intensity for 8 hrs/day. The animals were sacrificed on the 18th day of gestation and the fetuses were examined for mortality, growth retardation, changes in head size and other morphological abnormalities. From the above conditions, it is concluded that the exposure of 20 kHz magnetic field with 6.25 μT peak intensity does not inflict any adverse effect on pregnant mice fetuses.

Mammalian Cell Toxicity, Genotoxicity, and Transformation After Radio Frequency Exposure

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Objective 1: The first objective is to discuss scientific information about radio frequency exposures of different kinds and durations and cell toxicity.

Conclusion: A wide range of short term and chronic low level exposures in vitro and in vivo do not result in cell death; i.e., RF is a non-toxic agent.

Objective 2: The second objective is to critically examine a limited number of published positive reports that RF exposures cause genetic damage, and describe a broad array of published articles demonstrating the absence of such an effect.

Conclusion: The weight of evidence available today supports the conclusion that radio frequency exposures of different types are not genotoxic. The types of evidence to be discussed include the induction of DNA strand breaks, chromosome aberrations, micronuclei formation, DNA repair synthesis, sister chromatid exchange, and phenotypic mutation. In some instances, the interaction of RF with chemical agents will be discussed.

Reference:

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Mechanism for the Deactivation of Bacterial Spores in a Non-Thermal Discharge

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Complete rupture of the bacterial spore can take place in 15 sec, as evidenced by the appearance of collapsed spore structures under scanning electron microscopy (SEM) and the observed release of small acid-soluble proteins (SASP-B) from the interior of the spore. Based on several experimental results during Phase I, MicroEnergy Technologies has analyzed and sequenced the protein that initially leaves *Bacillus* bacteria that reveals deactivation of spores:

(1) spore membranes are ruptured as seen in SEM micrographs of plasma treated biomaterials,
(2) ultraviolet light generated from an air plasma, high intensity electric fields, and hot air do not produce deactivation of bacterial spores to any large extent. The use of mutant spores with a single protein missing from the spore coat demonstrated similar resistance as standard spores.
(3) matrix-assisted laser desorption ionization (MALDI-MS) mass spectroscopy with a plasma lysis pretreatment illustrated that biomarkers such as proteins are extracted that reveal the mechanism of ionized gas deactivation of spores (and facilitate the identification of biological materials)
(4) modeling of the physical, chemical, and biological mechanism suggests an oxygen reaction pathway for extraction of the protein.

In a typical MALDI-MS experiment, a microorganism is embedded in a liquid matrix that is selectively heated by a laser with simultaneous ejection of ionized biomolecules into the gas phase. Proteins are extracted from the spore (around 6710 mass/charge) that is characteristic of the *Bacillus* bacteria. The extraction of proteins with a corona plasma discharge (CPD) reveals that the ionized gas is breaking bonds in the spore coat that maintain the integrity of the cell structure. The ES-FTICR spectrum of biomarkers isolated from *Bacillus cereus* produces major biomarker consists of a doublet, close in mass to that of a biomarker (6711), observed in the MALDI-TOF mass spectrometry of intact spores. Small acid soluble spore proteins bind to both strands of spore DNA and protect the DNA from damage (including UV-light induced cleavages).

Apoptosis of Testicular Germ Cell Induced By 60 Hz Magnetic Field Exposure In Mouse

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The effects of 60 Hz extremely low frequency magnetic field (MF) exposure were evaluated on the apoptosis of testicular germ cell in mouse. Male BALB/c mice (7 weeks of age) were exposed to a 60 Hz MF of 0.1 mT and 0.5 mT continuously, 24 hr/day, for 8 weeks. Apoptosis of germ cell in the testis was analyzed by histopathological examination, the TdT-mediated dUTP-biotin nick end labeling (TUNEL) assay and flow cytometric examination of isolated spermatogenic cells stained with 7-aminoactinomycin D (7-AAD). There was not significant effect on the body weight of mouse exposed to 60 Hz MF. The weight of the testis slightly decreased in the exposed group. Histopathological examination showed significantly increased incidence of the deaths of testicular germ cells and disorganization of germinal epithelia in the exposed groups. In the exposed groups TUNEL-positive cells of testis were many and those were mainly spermatogonia, but were rarely in the sham control. Apoptotic, TUNEL-positive, germ cells were significantly increased in mice from exposed groups compared with sham control ($P<0.05$), but the difference between two exposed groups was not statistically significant. Both early and late apoptosis of testicular germ cells in mice from exposed groups were increased in comparison with sham control used by 7-AAD assay. This study demonstrated that the apoptosis of testicular germ cell could be induced by continuous exposure of 60 Hz MF.

Key word: 60 Hz, magnetic field, testis, apoptosis

Posters

Korea-Japan Interlaboratory Comparison Studies on SAR Measurement Systems and Their Calibration

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INTRODUCTION: Communications Research Laboratory (CRL) in Japan and Radio Research Laboratory in Korea (RRL) have been playing a role for maintainers of national standards relating to radio waves. Last year, they revised the Memorandum of Understanding (MoU) concerning the mutual research cooperation, which has been ongoing since 1972, and a new topic, "Research for evaluation of Specific Absorption Rate (SAR)", has been added in the MoU. CRL and RRL have agreed to begin mutual comparison of the compliance tests for safety guidelines to cellular telephones because the compliance tests have been mandated since April 2002 and June 2002 in Korea and Japan, respectively.

OBJECTIVES: To enhance knowledge for SAR characteristics and improve SAR evaluation techniques by (1) Mutual comparison of the SAR measurement, (2) Calibration method of SAR measurement system, (3) Development of new recipe of phantom liquid, and (4) SAR evaluation by using phantom models for Asian people. For the mutual comparison, the common frequencies between Korea and Japan digital cellular telephone systems, i.e., 900 MHz and 1950 MHz, have been selected. Numerical dosimetry using anatomical head models based on Korean and Japanese people has also been planned.

MUTUAL COMPARISON OF SAR MEASUREMENT: The mutual comparison of the SAR measurement has been started since last year, described below;
Arrangement of the details of the mutual comparison.
Validation of dielectric-properties measurement systems using reference liquids.
Calibration of SAR probes.
SAR measurement for the system validation test using standard dipoles and a flat phantom.
Interlaboratory comparison using standard phones (not yet planned).
Evaluation of the total uncertainty of the SAR measurement (not yet planned).

At this time, we have planned to perform the step 1 to 4 in the above list by half of this year. Before the system validation, significant factors for the measurement uncertainty, that is, the electrical properties of phantom liquids and the calibration factors of SAR probes, are checked. At the system validation in RRL, for instance, the SAR probe and the standard dipoles are sent from CRL to RRL, then the system validation are performed using RRL's flat phantom and RRL's probe and dipoles or CRL's ones.

We hope that our collaboration studies enhance the validity of SAR measurement in each country and provide technical supports for international Mutual Recognition Arrangement (MRA) for SAR measurement systems.

Key words: SAR (Specific Absorption Rate), Probe and Calibration

Effect of the Hand on SAR Measurement of CDMA Phones

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INTRODUCTION: Currently, numerical and experimental studies have shown that the SAR in the hand is lower than the SAR in the head. Moreover, the large number of possible finger positions and different practices of holding the phones makes it difficult to specify a standard "hand phantom". For these reasons, phones are tested without a hand Phantom. But, in this paper, we specified the practice of holding the phone into two types like as figure 1. And we measured and compared results of the local SAR according to the holding positional of each hand phantom against the phone.

MEASUREMENT METHODS: For the SAR measurement, we used the SAM phantom and the homogeneous head tissue, dielectric constant $\varepsilon r = 41.67$ and conductivity $\sigma = 0.902$ S/m, at 835 MHz . The shapes of hand phantom were decided from statistical using method of phone. The hand phantom A and B are models for phone of bar-type and folder-type respectively. (Fig 1.) Each hand phantom shell is made of polysiloxane, and the inside of the phantoms is filled with the homogeneous head tissue. In the case of the hand phantom A, we measured the SAR at five different positions according as the position of hand phantom was changed to lower direction of the phone about 4 cm at interval of 1 cm from reference test position.
And in the hand phantom B, the setup of each position was in the range of ±3 cm at interval of 1 cm from reference test position.

CONCLUSIONS: The head SAR with the hand phantom was lower about 60% than without hand phantom at the reference test position. And the local SAR value depends on the distance between the hand phantom and the antenna of phone, because the hand phantom perturbed the local field.

Key words: Hand phantom, SAR(Specific Absorption Rate)

Fig. 1. Hand phantoms (a) Hand phantom A (b) Hand phantom B

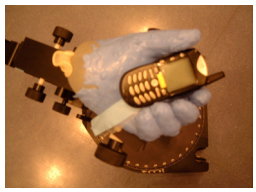

Fig. 2. Reference test positions of hand phantom A and B against phone

Personal Exposure to Magnetic Field over a 24-hour Period in Korea

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The objective of this survey is to characterize personal magnetic field (MF) exposure of the general population in Korea. This is the first-ever unique personal MF exposure survey done in Korea. The participants for the survey on magnetic field exposure were randomly selected, by occupation. The survey was conducted as follows; a participant wears a magnetic field meter for about 25 ~ 28 hours and the data is stored in the meter. MF values are recorded every 4 seconds. The personal magnetic field exposure meter used for this survey is EMDEX-LITE made by Enertech Consultants, Inc., USA. It displays resultant levels, which are the compound of the magnetic field values of 3 axes. Participants are asked to record their activities so that magnetic field exposure can be evaluated for a 24-hour period. The personal MF exposure survey started in July 2001 and 413 respondents have been surveyed. The statistics of the 24-hour exposure data are our major concern in this survey. The survey also provided the opportunity to analyze exposures corresponding to different types of activities. It was analyzed in separate periods of time corresponding to the following activities: entire 24-hour period, in bed, at work and by occupation. Therefore, the database is going to be established to analyze the present status of personal magnetic field exposure and safety.

Key words: EMF, Personal Magnetic Field Exposure, Time-Activity and Human Health

Experimental Prediction Method for ELF Transient Magnetic Field from Electric Appliances

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With biological effects by ELF (Extremely Low Frequency) magnetic field generated from power system, the transient magnetic field (TMF) from electric appliances is a major issue presently. Because the transient magnetic field induces higher current than the power frequency field inside living bodies, transient magnetic field exposure has been much focused. In this paper, it is shown that transient magnetic field from electric appliances can be characterized as magnetic dipole moment. In this method, the dipole moment vector is assumed by allowing an uncertainty of 6dB in the estimated field. A parameter M that represents biological interaction was applied also. The proposed method was applied to 13 types of home appliances (hair drier, heater, vacuum cleaner, toaster etc.) and 8 types of office appliances (personal computer, projectors, printer, monitor etc.), and then their equivalent magnetic dipole moment and harmonic components were estimated. As the results, the useful data for quantifying magnetic field distribution around electric appliances could be obtained.

Key words: Electric Appliance, Harmonic, Transient Magnetic Field, Dipole Moment Vector and Biological Interaction

Electromagnetic Radiation Levels from Mobile Telephone Base Station Towers in the West Bank and Gaza Strip

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Public concern in the West Bank and Gaza Strip relating to possible health effects from exposure to radiofrequency radiation have arisen after the spread of mobile telephone base station towers in the country. The radiation research Unit at the Department of Applied Earth & Environmental Sciences acknowledges the public concern and have decided to carry out scientific research to provide an accessible and understandable information on electromagnetic energy emission levels from these base stations. About 204 GSM mobile telephone base stations operated by the Palestine cellular Communications, Ltd. are located over the West Bank and Gaza Strip, most of them are in highly populated areas. This work deals with the assessment of radiofrequency radiation levels emitted from mobile telephone base station towers located in the West Bank and Gaza. Assessments are based on theoretical calculations using a commercially available software, Telstra's RF-Map from Telstra Research Laboratories. Field calculations are carried out for multiple base station antenna systems at single site and also for multi-system and multi sites. In assessing the EME levels, focus is made on calculating power densities at schools, kindergartens, and areas around the base station towers where people are concerned about their exposure. Technical data, including frequencies and radiated powers, are obtained by the operator. Results of estimations are compared to the exposure limits for general public recommended by INCIRP. Preliminary field calculations at selected locations in Gaza Strip for a configuration of five base station towers yield in a maximum power density of 0.16 □W/cm2 for a survey height of 1.5 m above the ground.

Key words: EME levels, Mobile Base station Towers, Calculations

Design, Conduct and Interpretation of Epidemiologic Studies

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Peer-reviewed scientific literature forms the basis for establishment of adverse health effects. For studies to be useful to health risk assessments, they must be of high scientific quality with clearly-defined hypotheses and proper statistical analysis, estimates should be given of the ability of the study to detect small effects (the study power), and protocols that are consistent with good scientific practice should be used. Quality assurance procedures should be included in the protocol and monitored during the study. A variety of study designs have been used in epidemiologic studies of EMF. Various study designs along with their strengths and limitations would be discussed and illustrated by examples from EMF literature. Tools for critically reading and evaluating epidemiologic studies would be provided.

In addition to the requirements for an individual study described above an integration of data from different studies and disciplines requires a rigorous methodology. Such data integration is important for both Risk Assessment and Guideline Development. Role of epidemiology in the weight of evidence approach will be discussed.

Key words: epidemiology, risk assessment, study design, interpreting literature

The Effect of Alternative and Rotary Electromagnetic Fields on the Organogenesis of Mouse Embryos in Day 4.5 of Gestation.

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In this work the effect of electromagnetic fields together with alternations in body axis on the development of Balb/C mouse embryos were investigated .A function generator to produce full-wave rectified sine of 100 Hz , a pair of Helmholtz coils ,special apparatus to make rotary and alternative motions for animal were designed and constructed and EMFs of 466 gauss were generated .The pregnant female mice of 2-2.5 months age in 4.5 gestation days were exposed to EMFs with rotary and alternative motion, once for 7 hours. The pregnant female was dissected in day 15.5 of gestation and the embryos extruded from their uterine horns, for morphological and historical studies. The embryos under EMFs with alternative motions showed increase in body and placental weights, also crown – rump measurements, 21.64% of them were atrophied, 5.25% embryos were with Lordosis, 9.28% with defect in orientation of lower limbs together with abnormal differentiation of interstitial tissues and decrease of sex cords in testes, and 7.21% with abnormal development of vertebral column .The embryos under EMFs with rotary motions resulted decrease in body and placenta weights and CR measurements ($P<0.05$), 8.24% of the embryo were atrophied , 29.1% with miniature body and syndactyly, significant increase of nucleated red blood cell ($P<0.001$) , significant decrease of liver megakaryocytes ($p <0.05$), 9.7% of embryos without normal curvature of vertebral column , 9.7 %with defect in lower limbs, 2.9% exohepatic and increase in the number of placental macrophages ($p<0.001$) were the main changes in this part of experiments.

Key words: EMF, direction, maldevelopment, day 4.5 gestation

Physiological Effects of Continuous Whole-Body Exposure to Extremely Low Frequency Electromagnetic Fields With or Without Transient Magnetic Fields on Cerebral Microcirculation in Mice With Brain Tumors

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Many reports have suggested a variety of biological effects from extremely low frequency electromagnetic fields (ELF-EMF), however, few in vivo studies have focused on microcirculatory effects of ELF-EMF. Recently, the importance of noise components in EMF has also been recognized. Fifty or 60 Hz EMF in residential environments sometimes include various kinds of noise as transient waves, which arise from the use of electric devises such as switching regulators and inverters.

In this study, we explored the subchronic effects of whole body exposure to 50 Hz EMF with or without transient waves on cerebral microcirculation in brain tumors. For these purposes, we employed a mouse cranial window (CW) technique, allowing for the chronic observation of cerebral microcirculation, and a brain tumor implantation model using CW. SCID (Severe combined immuno-deficiency) mice were used in this study. After CW implantation, a small piece of human glioma U87 tissue was implanted into the CW prior to EMF exposure. Mice were subchronically exposed to plain 50 Hz time-varying EMF at 0.3 and 3.0 mT (rms), or combination of 50 Hz EMF at 3.0 mT (rms) with repetitive transient EMF (1 burst/s, 7.4 kHz waves with duration of 50 msec and peak magnet density of 162.6 μT). Mice were continuously exposed to EMF for 16 days following tumor implantation. During and after the exposure, we measured tumor growth and quantified the microcirculatory parameters of angiogenic vessels in the growing tumor by real-time confocal microscopy, and measured permeability of rhodamine-labeled albumin from blood vessels using a photon counting system.

Although tumor size increased markedly following implantation, tumor growth did not show any significant difference among any of the exposure groups compared with the non-exposure group. Furthermore, ELF-EMF did not affect any of the microcirculatory parameters in the tumors, for instance, vascular density, mean diameter and branched numbers of vessels. These results indicate that no detectable effect on cerebral microcirculation was induced by exposure to plain 50 Hz EMF at 0.3 and 3.0 mT or by the combined exposure of 50 Hz at 3.0 mT and a transient magnetic field.

Key words: electromagnetic fields exposure, transient magnetic fields, brain tumor, microcirculation, mouse

Acute Effects of Whole-Body Exposure to Low Frequency 16 Hz and 50 Hz Electromagnetic Fields on Cutaneous Microcirculation in Mice - EMF-Frequency Dependence of Changes in the Blood Vessels Diameter

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Introduction: The goal of this study was to investigate the possible modulating effect of low-frequency electromagnetic fields with physiotherapeutic parameters on the microcirculation. A number of papers claim, that specific combinations of low-level DC and AC magnetic fields can cause biologically significant effects. Specific combinations of frequencies of these fields evoke these responses fulfilling the theoretical conditions for classical cyclotron resonance. Calcium ions play an important key role in regulation of physiological processes and mediation of interactions of biological systems with external physical and chemical factors. It is well known that calcium ions play important roles in the regulation of vasomotion. Modulation of the microcirculation by external physical factors such as LF-EMF is a main point for understanding the mechanisms involved in the medical application of these fields.

Material and methods: 8-12 week old BALB/c mice were used in this investigation, and a Dorsal Skin-fold Chamber (DSC), were surgically implanted 4 days before the experiment. Intravital video-microscopy (with 3CCD-camera, SONY Inc.) measurements of the vasomotion of micro-blood vessels (diameter between 45 -70 μm) *in vivo* were applied. Vasomotion or temporal changes of the blood vessel diameter was measured by High-speed Digital Machine Vision System CV-2100 (KEYENCE Inc.), using an edge-gap detection algorithm (with a sampling time 200 ms), for calculating the outer diameter of the blood vessels by means of fluorescence-image visualization, after caudal vein injection of (50 μl per 25g animal) Fluorescein Isothiocyanate (FITC)-labeled Dextran 150 kDa (FITC-Dextran-150), concentration 2.5%. Experimental set up include three series of experiments, a Control series: Pre- exposure group, Sham exposure group and Post-exposure group, Exposure series: (16 and 50 Hz; 20 mT; 10 min), containing Pre-exposure group, exposure and Post- exposure groups.

Results: In this investigation we used mean blood vessel diameter for each group as a criteria for microcirculatory activity, demonstrated by blood vessel vasomotion (condition defined by vasodilatation and vasoconstriction of the blood vessel). The results obtained by detection of mean diameter of the blood vessel obtained for 10 min period of time, shows that Control series of experiment do not show significant differences between experimental groups, blood vessel diameter remained without significant ($p<0.05$) changes (0.51±0.01 μm). The exposure series showed a significant ($p<0.05$) difference between pre-exposure mean blood vessel diameter and 10 min post exposure diameter (10.78±1.88 μm) observed at 16 Hz low frequency electromagnetic field exposure. For the series exposed to 50 Hz LF-EMF changes of the mean blood vessel diameter difference between pre-exposure mean blood vessel diameter and 10 min post exposure diameter (5.35±4.38 μm) and therefore not significant.

Conclusion: Increasing of the values for mean blood vessel diameter at EMF with frequency (16 Hz), 10 min after exposure, suggest that possible modulator effect of this field could exist at the skin microcirculation.

Key words: microcirculation, electromagnetic fields, acute effects, blood vessel diameter

Cell Isolation and Growth in Electric-Field Defined Micro-Wells

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Biological cells can be held in RF electric-field-induced traps produced within and slightly above a horizontal array of planar electrodes. Growth
and cell division over several generations can occur within the trap. In a suitable volume of medium, a convection cell will occur above the array. By
the use of voltages too high to give effective trapping, this convection may be used to position or concentrate the cells. Despite continuous exposure to
RF field strengths of 30-45kV/m, growth and division of S. cerevisiae appears to occur normally (or slightly faster than normal).

The Comparison of Rice Growth Due to Vertical and Horizontal Electric Field Treatment

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The effect of electric field varied in the vertical direction and horizontal direction to the growing of rice plants were studied. The comparison is controlled and done under the same treatment condition such as temperature, relative humidity and light with electric field at 28.5 kV/m and without electric field. The results are analyzed base on statistic methods. Some results shows the height of stem and the length of root with electric field treatment over without treatment condition by 24.57% and 27.29 % respectively.

Key words: Biological effect, electric field effect, plants development, rice growing, EMC

The Study of Electric Field Treatment Affects on the Growing Based On Electric Field Intensity and Direction

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In this paper, the review of the effect of the electric field on the bean sprout growing is presented. The bean sprouts are experimented under condition the electric field intensity and direction. The electric field intensity is varied at 10, 20 and 25 kV/m, where the electric field direction is vertical and horizontal direction. Numbers of seed, temperature and reactive humidity are controlled. The height of stem and the length of root are focused. The experimental result shows the bean sprout with high level of electric field intensity at vertical electric field direction is the best treatment based on statistical analysis and supported by finite element method simulation.

Key words: electric field intensity, electric field direction, bean sprout, bio effect, finite element

Method, Material and Device Providing Electromagnetic Compatibility Between Technologically Originated EMR and Biological Systems

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This particular technology relates to subtle electrical effects, and provides some evidence of a fundamental nature on how subtle low frequency electromagnetic fields might be utilized to protect human body against harmful effects of high frequencies electromagnetic radiation. I have focused my efforts on definite polar polymer compound named EMRON (Electromagnetic Radiation Optimum Neutralizer) which is patented in April 2002; US patent No. 6369399 B1, "Electromagnetic Radiation Shielding Material and Device". This polar polymer material was tested by Underwriters Laboratories and received a UL recognition mark in March 2001. This polar polymer compound can be excited by external high frequencies electromagnetic fields of technological origin in order to generate subtle low frequency oscillations that are biologically very active and beneficial for cellular life structures.

This concept is based on the possibility of existence of resonance phenomenon between polar polymers and biopolymers such as proteins, nucleic acids, lipids, etc. Low frequency patterns generated by defined polar polymer compound can interact with biological systems and transmit the signals that support and improve cellular functions in the body. The mechanism of this process was confirmed by number of studies. The animal (including human) brain is affected by electromagnetic waves to the extent that production of Alpha or Theta waves can be directly induced into brain by carrying an ELF (extremely low frequency, 5-12 Hz) signal on a microwave carrier frequency.

EMRON does not reduce the power of electromagnetic fields. This shielding polar polymer can neutralize negative effects of EMR by changing the quality of the electromagnetic field rather than reducing its power. It "shields" the cellular structures of the body against the harmful effects of EMR that was proved by a number of biological experiments in vitro and in vivo. The radiation is still entering the body but the neutralizing effect of EMRON renders the radiation harmless. There is an obvious parallel here with the pharmacological strategy of attempting to protect against bacterial infection, for example, by taking vitamin C, to fortify the immune system, rather than by wearing a protective mask to simply reduce the intensity of the bacterial field to which a person is exposed.

Searching for Biomarkers of Millimeter Wave Radiation Exposure

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Analyzed plasma samples from sham-exposed, environmentally heated (EH), and millimeter wave (MMW) heated rats using 2-D gel electrophoresis. This analysis revealed that creatine kinase and carbonic anhydrase III were increased in plasma of MMW-exposed animals. These proteins have been linked to muscle turnover and may indicate involvement of the panniculus muscle layer in the skin. Analysis also revealed increases in levels of the acute phase proteins α-1-acid glycoprotein, alpha and beta chains of clusterin, apolipoprotein B, and prohaptoglobin. Increases in levels of acute phase proteins indicate stimulation of a non-specific and protective systemic response to MMW and involvement of the liver. Although these proteins individually have been correlated with responses to other types of stimuli and thus are not specific for MMWs, it is possible that a unique multiprotein pattern may exist that could be used to determine overexposure. Overall, the results indicate that MMW overexposure may induce both tissue breakdown products and synthesis of new proteins. Also, although colonic temperature profiles were matched for MMW and environmentally heated rats, the plasma protein profiles were different. This difference may be due to the higher subcutaneous temperatures that exists during MMW versus EH exposures and points to this region as a potentially important site for eliciting release of compounds into the plasma.

Report on the Review in Progress of Russian EMF Bioeffects Studies

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Several abstracts from reports describing the biological effects of exposure to electromagnetic fields (EMF) conducted by Russian scientists on animals were provided by Dr. Yuri Grigoriev. These studies evaluated immunologic parameters such as complement fixation reaction, anaphylactic shock test, T cell blast formation and *in vivo* T cell responses to mitogens. Exposures were conducted in anechoic chambers with EMF (usually 2375 MHz) generated by the medical devices Luch-2 or Luch-58. Some abstracts indicated that the power density was measured by a device named "Medik-Po-1. As an indirect detection of changes in normal cellular proteins, carbohydrates or DNA, the antibody levels were measured after injection of tissue extracts from EMF-exposed animals (50 uW/cm^2 or 500 uW/cm^2) into unexposed animals. This resulted in overall higher titers of antibodies in the animals that were injected with tissue extracts from animals exposed to the higher doses of EMF. In most cases, rats (Wistar, Fisher and wild strains) were used, but also CBA mice, guinea pigs and rabbits were subjects of the experiments designed to study long-term and chronic exposure to EMF (10–500 uW/cm^2). Vinogradov *et al.* (1986) reported that 500uW/cm^2 induced increased immunological responses, such as complement binding reaction, in brain extracts from EMF-exposed animals. Adoptive transfer experiment of lymphocytes from EMF (500 uW/cm^2) donors that were exposed for 15 days into recipients (animals depleted of lymphocytes by gamma irradiation) indicated that their B cells and T cells were less responsive to standard stimulation by mitogen (PHA) than lymphocytes from the non-EMF exposed control group (Vinogradov *et al*., 1991). Another study examined the effects of long-term (4 months/6 hour/per day) EMF exposure (max 500 uW/cm^2) on immunological parameter such as T cell blast formation of fetus and offspring. This study suggested that fetus exposed to 500 uW/cm^2 *in utero* for prolonged time had reduced blasts formation ability even 4 month after birth. Lower levels (10uW/cm^2) of EMF exposure had no effect on the offspring immune-blast formation (Vinogradov *et al.*, 1982). A summary of the abstracts as provided would suggest that long-term exposure at higher EMF levels (100-500 uW/cm^2) for several hours a day could cause variety of changes detected by immunological methods. In these studies that were conducted from 1970 to 1991, the applied methods indicated changes in proteins without naming, isolating and identifying particular molecules of interest. It is not possible to review and evaluate with confidence these studies, since only abstracts and tables containing summary of methods and results were supplied. It is highly recommended that the original manuscripts in their entirety be provided for evaluation. Due to the passing of time, the equipment used for those studies may not be available for evaluation or comparison with modern equipment. In order to confirm the findings reported in these abstracts, new studies should be performed with currently-accepted equipment and techniques and the results should be subjected to the peer-review process.

The Weak EMFs Action on Living Processes of Aquarium Fishes *In Vivo*

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OBJECTIVE: The role of bacteria magnetotropism reaction on Geomagnetic Field Action was shown by american scientists in 1979-1981 [1]. Experimental work in 1979 allowed the author to put forward a hypothesis on the direct influence of the Earth's **EMFs** on the ecosystems of water basin and its synchronizing role in the regulation of the motion activity (MA) of plankton communities in local time [2]. There are monograph published by russian physiologists on the perception of electric and magnetic fields by receptor systems of marine and terrestrial vertebrates [3]. The fine structure of electrokinetic field of the (MA) of fishes in aquarium conditions has been investigated. A link between the biorhythms of activity and geomagnetic storm was demonstrated [4].

METHODS, MATERIALS: The behavior physiology of new variety population of the *Carassius Auratus Japonicus Flabellicaudatus, Slutsky, 1985* goldfish has been investigated to present time. We cultivate it since 1970 by closely-related interbreeding of the organisms having common ancestors (strict inbreeding). The responses of fishes to carry through as effect of low multifunction **EMFs** in laboratory. The method of non-contact behavior reactions registration, used for laboratory environment, is based on their electric activity. The organism's motions (submersion, flotation, rotation) in a dispersional system evoke potentials and currents that can be measured by electrometric method in the draftsman's modification. Apart from has been developmented of measuring methods and equipment, including computer-based video registration system (Grant of Erna and Victor Hasselblad Foundation, Sweden).

The variable component of a magnetic field $\Delta Bvar$ was induced at the background of the regular component $\Delta Bz = (48\pm 0.6)*10^{-6}$ *T*. The statistic spectral analysis is executed for 19 complex experiences with different combination $\Delta Bvar$ and $fvar$ induced by magnetic field (action time 100s).

RESULTS: The exponential function of the spectrum $\mathbf{G}(f) \sim f^{-n}$ which characterize of motional activity fluctuations there was appeared.

The influence of fixed induction weak EMFs in a different frequency range.

Total features of induction influence ΔB=200 nT:

- depressing of fish activity is expressed in abrupt falling of spectrum **G (f)** energy;
- fluctuations $\Delta\phi$ energy lowering within frequency band more than 1 Hz;
- low frequency part of spectrum before and after influence is characterized by an exponent $n \approx ½$;
- at a general indicator of fish activity depressing the weakly intensifying frequency 1 Hz is noticeable, at which the greatest level of **G (f)** energy spectrum is preserved; and on frequencies 3,4,7 and 10 Hz the level is reduced as much as 10 times and even more accordingly;
- after effect 3, 4, 7 and 10 Hz shifted to lower range (0.01÷ 0.1 Hz);

The influence of fixed frequency weak EMFs at different levels of magnetic induction

- electrokinetic fields $\Delta\phi$ before influence really does not differ in spread of amplitudes, and their power spectrums **G (f)** are similar;
- the period of exposure is characterized by sharp falling in energy at **ΔB=200 nT** precisely within the limits of 0.01÷ 0.2 Hz, and for **ΔB=500 nT** and **ΔB=1000 nT** is expanded up to frequency 0.4 Hz;
- After the influence the fish (during the term of observation) does not return in an primery state, especially within the limits of first 0.5 Hz, and further distinctions in spectra **G (f)** get smoothed out;
- the fluctuations of a magnetic field in the laboratory (as registered by magnetometer) during the term of observations (13:00 – 14:20) are homogenous and have typical power maxima at frequencies 0.2 and 0.39 Hz;
- the exponential function of the spectrum **G (f)** during influences at low frequencies is characterized by a parameter $n \approx 1$ within the range 0.01÷ 0.3 Hz (200 nT), $n \approx ½$ in the range 0.01÷ 0.5 Hz (500 nT), and $n \approx {}^{2}/_{5}$ in the range 0.01÷0.6 Hz (1000 nT).

CONCLUSION: At the *first time* it became possible to determine out instrumentally on an organismic level *in vivo* and to show with the use of computer based video registering system origination of fish behavioral response on the influence of weak **EMFs** induction from 200 through 1000 *nT* with frequency from 1 through 10 *Hz*; as it is known, the change of behavioral physiology of an organism make signals about perception of the physical factor influence by a central nervous system.

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