

45092

This report contains the collective views of an international group of experts and does not necessarily represent the decisions or the stated policy of the United Nations Environment Programme, the International Radiation Protection Association, or the World Health Organization.

Environmental Health Criteria 137

ELECTROMAGNETIC FIELDS (300 Hz to 300 GHz)

Published under the joint sponsorship of
the United Nations Environment Programme,
the International Radiation Protection Association,
and the World Health Organization



World Health Organization
Geneva, 1993



WHO Library Cataloguing in Publication Data

Electromagnetic fields (300 Hz to 300 GHz)

(Environmental health criteria ; 137)

1. Electromagnetic fields - adverse effects 2. Environmental exposure I. Series

ISBN 92 4 157137 3

(NLM Classification: QT 34)

ISSN 0250-863X

The World Health Organization welcomes requests for permission to reproduce or translate its publications, in part or in full. Applications and enquiries should be addressed to the Office of Publications, World Health Organization, Geneva, Switzerland, which will be glad to provide the latest information on any changes made to the text, plans for new editions, and reprints and translations already available.

©World Health Organization 1993

Publications of the World Health Organization enjoy copyright protection in accordance with the provisions of Protocol 2 of the Universal Copyright Convention. All rights reserved.

The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

The mention of specific companies or of certain manufacturers' products does not imply that they are endorsed or recommended by the World Health Organization in preference to others of a similar nature that are not mentioned. Errors and omissions excepted, the names of proprietary products are distinguished by initial capital letters.

CONTENTS

PREFACE	11
1. SUMMARY AND RECOMMENDATIONS FOR FURTHER STUDIES	15
1.1 Summary	15
1.1.1 Physical characteristics in relation to biological effects	15
1.1.2 Sources and exposure	16
1.1.2.1 Community	16
1.1.2.2 Home	16
1.1.2.3 Workplace	16
1.1.3 Biological effects	17
1.1.4 Laboratory studies	18
1.1.5 Human studies	20
1.1.6 Health hazard assessment	21
1.1.6.1 Thermal effects	21
1.1.6.2 Pulsed fields	22
1.1.6.3 Amplitude-modulated RF fields	22
1.1.6.4 RF field effects on tumour induction and promotion	22
1.1.6.5 RF-induced current densities	22
1.1.6.6 RF contact shocks and burns	22
1.1.7 Exposure standards	23
1.1.7.1 Basic exposure limits	23
1.1.7.2 Occupational exposure limits	24
1.1.7.3 Exposure limits for the general population	25
1.1.7.4 Implementation of standards	25
1.1.8 Protective measures	25
1.2 Recommendations for further studies	26
1.2.1 Introduction	26
1.2.2 Pulsed fields	26
1.2.3 Cancer, reproduction, and nervous system studies	27
1.2.4 Weak-field interactions	27
1.2.5 Epidemiology	28
2. PHYSICAL CHARACTERISTICS	29
2.1 Introduction	29

2.2	Electric field	29
2.3	Magnetic field	31
2.4	Waves and radiation	32
3.	NATURAL BACKGROUND AND HUMAN-MADE SOURCES	36
3.1	General	36
3.2	Natural background	37
3.2.1	Atmospheric fields	37
3.2.2	Terrestrial emissions	38
3.2.3	Extraterrestrial fields	38
3.3	Human-made sources	39
3.3.1	General	39
3.3.2	Environment, home, and public premises	43
3.3.3	Workplace	45
3.3.4	Medical practice	48
4.	EXPOSURE EVALUATION - CALCULATION AND MEASUREMENT	51
4.1	Introduction	51
4.2	Theoretical estimation	51
4.3	Measurements	56
4.3.1	Preliminary considerations	56
4.3.2	Near-field versus far-field	57
4.3.3	Instrumentation	57
4.3.4	Measurement procedures	58
5.	DOSIMETRY	61
5.1	General	61
5.2	Low frequency range	62
5.2.1	Magnetic fields	62
5.2.2	Electric fields	65
5.3	High-frequency range	72
5.4	Derivation of exposure limits from basic quantities	78
6.	INTERACTION MECHANISMS	80
6.1	General	80
6.2	Electrical properties of cells and tissues	81
6.2.1	Permittivity	81
6.2.2	Non-linear effects	84
6.2.3	Induced fields at the cellular level	85

6.2.4	Body impedance	86
6.3	Direct interactions - strong fields	88
6.3.1	Interactions with excitable tissues	88
6.3.2	Thermal interactions	89
6.4	Direct interactions - weak fields	91
6.4.1	General	91
6.4.2	Microelectrophoretic motion	93
6.4.3	Ion-resonance conditions	93
6.4.4	Calcium ion exchange	94
6.5	Indirect interactions	96
7.	CELLULAR AND ANIMAL STUDIES	104
7.1	Introduction	104
7.2	Macromolecules and cell systems	104
7.2.1	Effects on cell membranes	105
7.2.2	Effects on haematopoietic tissue	107
7.2.3	Isolated cerebral tissue, peripheral nerve tissue, and heart preparations	110
7.2.4	Mutagenic effects	111
7.2.5	Cancer-related studies	112
7.2.6	Summary and conclusions: <i>in vitro</i> studies	114
7.3	Animal studies	114
7.3.1	Nervous system	115
7.3.2	Ocular effects	118
7.3.3	Auditory perception	123
7.3.4	Behaviour	124
7.3.4.1	Thermoregulation	124
7.3.4.2	Activity (spontaneous movement)	126
7.3.4.3	Learned behaviours	127
7.3.5	Endocrine system	130
7.3.6	Haematopoietic and immune systems	133
7.3.7	Cardiovascular system	139
7.3.8	Reproduction and development	141
7.3.8.1	kHz studies	141
7.3.8.2	MHz and GHz studies	142
7.3.9	Genetics and mutagenesis	146
7.3.10	Cancer-related studies	148
7.3.11	Summary and conclusions	152
8.	HUMAN RESPONSES	155
8.1	Laboratory studies	155
8.1.1	Cutaneous perception	155

8.1.2 Other perception thresholds	158
8.1.3 Auditory effects	158
8.1.4 Induced-current effects	158
8.1.5 Thermoregulation	159
8.1.6 Contact currents	164
8.2 Epidemiological and clinical comparative studies	164
8.2.1 Mortality and morbidity studies	164
8.2.2 Ocular effects	168
8.2.3 Effects on reproduction	168
8.2.4 VDU studies	171
8.2.5 Conclusions	173
8.3 Clinical case studies and accidental overexposures	173
9. HEALTH HAZARD ASSESSMENT	175
9.1 Introduction	175
9.2 Thermal effects	176
9.3 RF contact shocks and burns	177
9.4 Induced current densities	178
9.5 Pulsed RF fields	179
9.6 RF fields amplitude modulated at ELF frequencies	179
9.7 RF effects on tumour induction and progression	180
10. EXPOSURE STANDARDS	181
10.1 General considerations	181
10.2 Present trends	182
10.3 Recommendations by the IRPA	183
10.4 Concluding remarks	186
11. PROTECTIVE MEASURES	187
11.1 Engineering measures	187
11.2 Administrative controls	190
11.3 Personal protection	191
11.4 Medical surveillance	191
11.5 Interference with medical devices and safety equipment	193
GLOSSARY	194
REFERENCES	206
RESUME ET RECOMMANDATIONS EN VUE D'ETUDES FUTURES	259
RESUMEN Y RECOMENDACIONES PARA ESTUDIOS ULTERIORES	276

WHO/IRPA TASK GROUP ON ELECTROMAGNETIC
FIELDS (300 Hz TO 300 GHz)

Members

Prof J. Bernhardt ^a	Federal Office of Radiological Protection, Institute for Radiation Hygiene, Munich-Neuherberg, Germany
Dr C. F. Blackman	US Environmental Protection Agency, Health Effects Research Laboratory, North Carolina, USA
Dr L.A. Court ^a	Département de Protection Sanitaire, Centre d'Etudes Nucléaires, Fontenay-aux-Roses, France
Mme A. Duchêne ^a	Scientific Secretary, International Non-ionizing Radiation Committee, Fontenay-aux-Roses, France
Prof M. Grandolfo ^a	Istituto Superiore di Sanità, Rome, Italy
Dr M.H. Repacholi ^a	Royal Adelaide Hospital, Adelaide, Australia (<i>Chairman</i>)
Dr R.D. Saunders	National Radiological Protection Board, Didcot, United Kingdom (<i>Co-Rapporteur</i>)
Prof M.G. Shandala ^a	AN Marzeev Research Institute of General and Communal Hygiene, Kiev, USSR
Dr J.A. Stolwijk ^a	Department of Epidemiology and Public Health, Yale University, New Haven, USA
Dr M.A. Stuchly ^a	Bureau of Radiation and Medical Devices, Ottawa, Canada

Dr M. Swicord

Centre for Devices and Radiological
Health, Food and Drug
Administration, Rockville, USA
(*Co-Rapporteur*)

Dr L.D. Szabo^a

National Research Institute for
Radiobiology and Radiation Hygiene,
Budapest, Hungary

Dr S. Szmigielski

Centre for Radiobiology and
Radiation Safety, Warsaw, Poland
(*Vice-Chairman*)

Observer

Dr A. McKinlay^a

National Radiological Protection
Board, Didcot, United Kingdom

^aFrom the International Non-Ionizing Radiation Committee of IRPA.

预览已结束，完整报告链接和二维码如下：

https://www.yunbaogao.cn/report/index/report?reportId=5_30727

