

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

Environmental Health Criteria 35

EXTREMELY LOW FREQUENCY (ELF) FIELDS

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



World Health Organization
Geneva, 1984

ISBN 92 4 154095 8

©World Health Organization 1984

Publications of the World Health Organization enjoy copyright protection in accordance with the provisions of Protocol 2 of the Universal Copyright Convention. For rights of reproduction or translation of WHO publications, in part or *in toto*, application should be made to the Office of Publications, World Health Organization, Geneva, Switzerland. The World Health Organization welcomes such applications.

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

	<u>Page</u>
ENVIRONMENTAL HEALTH CRITERIA FOR EXTREMELY LOW FREQUENCY (ELF) FIELDS	
1. SUMMARY AND RECOMMENDATIONS	11
1.1 Purpose and scope	11
1.2 Sources of exposure	11
1.3 Clinical applications	12
1.4 Field measurement and dosimetry	12
1.5 Characteristics of biophysical interactions	13
1.6 <u>In vitro</u> studies	14
1.7 Experimental animal studies	14
1.8 Effects on man	15
1.9 Exposure standards	16
1.10 Conclusions and recommendations	16
2. PHYSICAL CHARACTERISTICS, MEASUREMENT, AND DOSIMETRY	19
2.1 Quantities and units	19
2.2 Computational methods and measurements of ELF electric fields	22
2.3 Field polarization and homogeneity	24
2.4 Energy carried by the field	24
2.5 Determination of ELF field exposure	24
2.6 The physical interaction of man and laboratory animals with electric fields	25
2.6.1 Surface fields and internal current density	25
2.6.2 Capacitive coupling of the electric field to man and laboratory animals	26
2.6.3 Shock currents	27
2.7 Dosimetry and scaling between laboratory animals and man	27
2.8 Magnetic induction of electric fields	30
3. NATURAL BACKGROUND AND MAN-MADE ELF FIELDS	32
3.1 Natural electric fields	32
3.2 Natural magnetic fields	32
3.3 Man-made sources of ELF	34
3.3.1 High-voltage transmission lines	34
3.3.2 Electric fields near transmission lines and substations	37

	<u>Page</u>
3.3.3 Magnetic fields near transmission lines	38
3.3.4 Man-made ELF fields in the home, workplace, and public premises	41
3.4 Corona and noise effects of transmission lines	42
3.5 Electric shock	42
3.6 Interference of ELF fields with implanted cardiac pacemakers	44
4. MECHANISMS OF INTERACTION	47
4.1 Biophysical mechanisms of electric field interactions	47
4.2 Biophysical mechanisms of magnetic field interactions	49
5. BIOLOGICAL EFFECTS IN CELLS AND ANIMALS	50
5.1 Cellular and membrane studies	50
5.2 Neurophysiological studies in animals and animals tissues	53
5.3 Behavioural studies	54
5.4 Sensory phenomena	55
5.5 Effects on the haematopoietic system in animals	55
5.6 Cardiovascular effects	58
5.7 Effects on endocrinology and blood chemistry	58
5.8 Effects on the immune system	58
5.9 Growth and development studies	63
5.10 Reproduction and fertility	64
5.11 Mutagenesis	64
5.12 Circadian rhythms in animals	64
5.13 Bone growth and repair	64
5.14 The problems of extrapolating animal exposure data to human beings	69
6. HUMAN STUDIES	71
6.1 Sources of information	71
6.2 Study design	71
6.3 Health status of occupationally-exposed human beings	72
6.4 Studies on the general population	79
6.4.1 Studies on inhabitants of areas in the vicinity of HV-lines	80
6.5 Studies on human volunteers	81
6.6 Summary	82
7. HEALTH RISK EVALUATION	85

	<u>Page</u>
8. STANDARDS AND THEIR RATIONALES	89
9. PROTECTIVE MEASURES	95
9.1 Goals	95
9.2 Groups to be protected	95
9.3 Protection rationale	96
GLOSSARY OF TERMS USED IN THE DOCUMENT	98
REFERENCES	103
APPENDIX I	129
APPENDIX I REFERENCES	131

NOTE TO READERS OF THE CRITERIA DOCUMENTS

While every effort has been made to present information in the criteria documents as accurately as possible without unduly delaying their publication, mistakes might have occurred and are likely to occur in the future. In the interest of all users of the environmental health criteria documents, readers are kindly requested to communicate any errors found to the Manager of the International Programme on Chemical Safety, World Health Organization, Geneva, Switzerland, in order that they may be included in corrigenda, which will appear in subsequent volumes.

In addition, experts in any particular field dealt with in the criteria documents are kindly requested to make available to the WHO Secretariat any important published information that may have inadvertently been omitted and which may change the evaluation of health risks from exposure to the environmental agent under examination, so that the information may be considered in the event of updating and re-evaluation of the conclusions contained in the criteria documents.

WHO/IRPA TASK GROUP ON EXTREMELY LOW FREQUENCY (ELF) FIELDS

Members

- Dr J. Bonnell, Central Electricity Generating Board, London, England
- Dr B. Bosnjakovic, Ministry of Housing, Physical Planning, and Environment, Rijswijk, The Netherlands^a
- Dr J. Cabanes, Medical Committee, Electricité de France - Gaz de France, Paris, France
- Dr M. Grandolfo, Laboratory of Radiation, Institute of Public Health, Rome, Italy
- Dr B. Knave, Research Department, National Board of Occupational Safety and Health, Solna, Sweden
- Dr J. Kupfer, Occupational Hygiene Standardization, Central Institute of Occupational Medicine, Berlin, German Democratic Republic (Vice-Chairman)
- Dr R. Phillips, Biology Department, Pacific Northwest Laboratory, Richland, Washington, USA
- Dr A. Portela, Institute of Biophysical Research, National Council of Scientific and Technical Research (CONICET), Buenos Aires, Argentina
- Dr M. Repacholi, Royal Adelaide Hospital, Adelaide, South Australia (Chairman)^a
- Dr A. Sheppard, J.L. Pettis Memorial Hospital, Loma Linda, California, USA (Rapporteur)

IRPA Secretariat

- Mrs A. Duchêne, Commissariat à l'Energie Atomique, Département de Protection Sanitaire, Fontenay-aux-Roses, France^b

WHO Secretariat

- Mr G. Ozolins, Manager, Environmental Hazards and Food Protection, Division of Environmental Health, WHO, Geneva, Switzerland (Secretary)
- Dr M. Shore, National Center for Devices and Radiological Health, Food and Drug Administration, Rockville, Maryland, USA (Temporary Adviser)

^a Members of the International Non-Ionizing Radiation Committee of IRPA.

^b Scientific Secretary of the International Non-Ionizing Radiation Committee of IRPA.

Electric and magnetic field quantities and units in the SI system

Quantity	Symbol	Unit
Frequency	f	hertz (Hz)
Electric field strength	E	volt per metre (V/m)
Electric flux density	D	coulomb per square metre (C/m ²)
Capacitance	C	farad (F)
Current	I	ampere (A)
Current density	J	ampere per square metre (A/m ²)
Electric charge	Q	coulomb (C = A*s)
Impedance	Z	ohm (Ω)
Volume charge density	ρ	coulomb per cubic metre (C/m ³)
Magnetic field strength	H	ampere per metre (A/m)
Magnetic flux density	B	tesla ^a (1 T = 1 Wb/m ²) (weber per square metre)
Permittivity	ϵ^b	farad per metre (F/m)
Permittivity of vacuum	ϵ_0	$\epsilon_0 = 8.854 \cdot 10^{-12}$ F/m
Permeability	μ	henry per metre (H/m)
Permeability of vacuum	μ_0	$\mu_0 = 12.57 \cdot 10^{-7}$ H/m
Time	t	seconds (s)

^a 1 T = 10⁴ Gauss (G), a unit in the CGS unit system.

^b Designates a complex number.

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_30792

