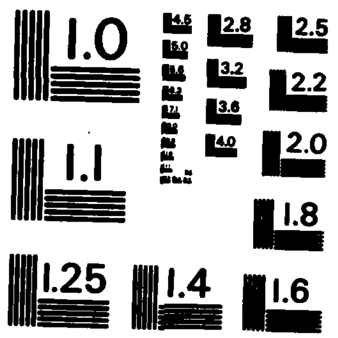
AD-A159 206 AGARD LECTURE SERIES ON THE IMPACT OF PROPOSED RADIO FREQUENCY RADIATION..(U) OFFICE OF NAVAL RESEARCH LONDON (ENGLAND) T C ROZZELL 12 JUN 85 ONRL-C-6-85 1/1

UNCLASSIFIED F/G 13/12 NL

END
FILMED
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

ONRL Report C-6-85

AGARD Lecture Series on the Impact of Proposed Radio Frequency Radiation Standards on Military Operations

Thomas C. Rozzell

12 June 1985

Approved for public release; distribution unlimited

U.S. Office of Naval Research, London

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

1a REPORT SECURITY CLASSIFICATION: UNCLASSIFIED

1b RESTRICTIVE MARKINGS:

2a SECURITY CLASSIFICATION AUTHORITY:

2b DECLASSIFICATION / DOWNGRADING SCHEDULE:

3 DISTRIBUTION / AVAILABILITY OF REPORT: Approved for public release; distribution unlimited

4 PERFORMING ORGANIZATION REPORT NUMBER(S): C-6-85

5 MONITORING ORGANIZATION REPORT NUMBER(S):

6a NAME OF PERFORMING ORGANIZATION: US Office of Naval Research Branch Office, London

6b OFFICE SYMBOL (If applicable): ONRL

7a NAME OF MONITORING ORGANIZATION:

6c ADDRESS (City, State, and ZIP Code):
Box 39
FPO, NY 09510

7b. ADDRESS (City, State, and ZIP Code):

8a. NAME OF FUNDING / SPONSORING ORGANIZATION:

8b. OFFICE SYMBOL (If applicable):

9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER:

8c. ADDRESS (City, State, and ZIP Code):

10 SOURCE OF FUNDING NUMBERS

PROGRAM ELEMENT NO	PROJECT NO	TASK NO.	WORK UNIT ACCESSION NO.

11 TITLE (Include Security Classification): AGARD Lecture Series on the Impact of Proposed Radio Frequency Radiation Standards on Military Operations

12 PERSONAL AUTHOR(S): Thomas C. Rozzell

13a. TYPE OF REPORT: Conference

13b TIME COVERED: FROM ______ TO ______

14 DATE OF REPORT (Year, Month, Day): 12 June 1985

15 PAGE COUNT: 12

16 SUPPLEMENTARY NOTATION:

17 COSATI CODES

FIELD	GROUP	SUB-GROUP
06	18	

18 SUBJECT TERMS (Continue on reverse if necessary and identify by block number):
Radio frequency radiation, AGARD lecture,
Specific absorption rate, Exposure, and
Biological hazards, Epidemiology.

19 ABSTRACT (Continue on reverse if necessary and identify by block number)

During April 1985, the North Atlantic Treaty Organization's Advisory Group for Aerospace Research and Development (AGARD) held a lecture series dealing with the impact of proposed and existing radio-frequency (RF) radiation standards on military operations. This report discusses presentations on specific absorption rate and RF energy, biological effects of RF energy, long-term exposure, accidental exposure, epidemiological studies, power-line frequencies, very low frequency to medium frequency hazards, exposure standards, and measurement problems. The appendix provides background on AGARD and its lecture series.

(Keywords include:

20 DISTRIBUTION / AVAILABILITY OF ABSTRACT: ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT ☐ DTIC USERS

21 ABSTRACT SECURITY CLASSIFICATION: UNCLASSIFIED

22a NAME OF RESPONSIBLE INDIVIDUAL: Larry E. Shaffer

22b TELEPHONE (Include Area Code): (44-1) 409-4340

22c OFFICE SYMBOL: 11

DD FORM 1473, 84 MAR — 83 APR edition may be used until exhausted. All other editions are obsolete.

SECURITY CLASSIFICATION OF THIS PAGE
UNCLASSIFIED

Block 18 (Cont'd)

Standards
Military operations

AGARD LECTURE SERIES ON THE IMPACT OF PROPOSED RADIO FREQUENCY RADIATION STANDARDS ON MILITARY OPERATIONS

During April 1985, the North Atlantic Treaty Organization's (NATO) Advisory Group for Aerospace Research and Development (AGARD) held a lecture series dealing with the impact of proposed and existing radio frequency (RF) radiation standards on military operations. Three sets of lectures were held: in Rome, Lisbon, and Paris. Each series lasted 2 days, and the lectures were given by the same set of speakers at each. In this report I attempt a distillation of the lectures given in Lisbon. (For those not familiar with AGARD, I have discussed its background and organization in the appendix.)

Reprints of the lectures are available from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

The Lisbon Series

AGARD Lecture Series No. 138, entitled "The Impact of Proposed Radiofrequency Radiation Standards on Military Operations," was opened by the series director, Mr. John C. Mitchell. Mitchell, who is Chief, Radiation Physics Branch, Radiation Sciences Division, US Air Force (USAF) School of Aerospace Medicine, Brooks Air Force Base, Texas, gave an overview of the use of RF energy by the military as well as by civilian industries. He reviewed not only the many types of RF emitters in general use, but also some of the possible levels to which personnel might be potentially exposed.

The lectures in this series included presentations on: (1) the physical interactions of RF radiation fields with biological systems, (2) the biological effects of RF radiation exposures, (3) the procedures for measuring RF radiation fields in military operations, and (4) the development and operational impact of new RF radiation safety guidelines.

Besides Mitchell, the speakers and their affiliations were: (1) Dr. Carl H. Durney (Electrical Engineering Department, University of Utah); (2) COL Roger B. Graham (USAF Occupational Environmental Health Laboratory); (3) Dr. A.W. Guy (Department of Rehabilitation Medicine and Center for Bioengineering, University of Washington); (4) Dr. Jerome H. Krupp (Radiation Sciences Division, USAF School of Aerospace Medicine); (5) Dr. Norbert J. Roberts (University of Rochester Medical Center); and (6) Dr. Jürgen H. Bernhardt (Institut für Strahlenhygiene des Bundesgesundheitsamtes, West Germany).

The "kickoff" speaker was Professor Durney, who set the stage for understanding much of what was presented in later lectures by introducing the physical concepts of the interaction of RF energy with biological systems, particularly with humans. Durney presented a very good tutorial on dosimetry and its underlying concepts as well as the numerical and analytical techniques used for estimating specific absorption rate (SAR) of RF energy that impinges on animals and phantom models for humans. He pointed out the differences and problems associated with measurements in the near field as opposed to the far field of an RF antenna, and the differences arising due to orientation and configuration of the subject with respect to the field. Finally, he outlined what needs to be done in terms of calculations and measurements of SAR in both the near and the far field of an antenna.

SAR and RF Energy

Guy presented a great quantity of data, most from his own very active laboratory, to illustrate the distribution of heating patterns and the consequences of localized SAR due to exposure to RF energy. He stressed the need to know the relationship between the absorbed energy, the tissue cooling mechanisms, and the temperature if one is going to understand the thermally induced biological effects. He discussed the complexity that arises in the human body due to the different types of tissues, with differing water content, and the many interfaces encountered by the RF energy.

Guy went on to discuss studies on RF-induced cataracts in the eyes of rabbits and how temperature and SAR are measured in such animal models. The cataractogenic threshold for primates as well as rabbits has been found, and the good agreement between the measured and the computed temperature fields found in these experimental animals suggests that it is possible to predict the ocular temperatures and hence the cataractogenic thresholds for man, if the blood flows and the SAR patterns are known. The SAR patterns can be obtained from model studies. However, there are insufficient data about the blood-flow rate to permit realistic estimates of thermal cataractogenic thresholds to be made.

Biological Effects Research Summary

Roberts presented a comprehensive summary of the research findings during the past 10 to 15 years related to the biological effects of RF energy. He reviewed the data available on such systems as single cells, cellular components, the immune and neuroendrocrine systems, integrative and regulatory systems, and metabolism. Roberts, a physician, specializes in immunological effects, and this interest was reflected in his first presentation. He pointed out that an accurate understanding of RF energy interactions with biological systems requires both a careful evaluation of past studies and well-designed and well-executed future investigations.

Roberts also discussed factors that affect RF-energy bioeffects research, giving first the factors that affect the absorption of energy. In addition, there are factors that influence biological responses to the energy. He discussed these and concepts relating to them in some detail. Finally, he made some recommendations for assessing research results and challenged researchers to include critical parameters in their publications in order to make it possible for others to adequately judge the reported results.

Long-Term Exposure

The cumulative effects of long-term exposure to low levels of RF energy were discussed by Krupp. He pointed out that of the more than 6000 articles in the literature today, the vast majority involve acute exposures at levels where significant thermal energy was deposited. The resulting effects, in most cases, could be explained on the basis of the specific energy absorption, expressed as watts per kilogram, with a generally accepted threshold for effects of 4 W/kg. The advocacy of nonthermal mechanisms by means of mathematical modeling, theoretical predictions, and *in vitro* studies has raised the possibility of subtle injury or alteration in function which, over time, would be expressed as a harmful bioeffect. The few studies addressing this problem suffered, according to Krupp, one to several deficiencies in method, including relatively short duration of exposure, small numbers of subjects, inappropriate endpoints, or incomplete dosimetry. Epidemiological appraisals also have not been adequately performed or could not clearly relate findings to exposure history. A recently completed project, performed by personnel at the Bioelectromagnetics Laboratory, University of Washington School of Medicine, Seattle, Washington, and funded by the USAF School of Aerospace Medicine, was directed toward these concerns. Krupp reported that over a 4-year period of planning, pilot study, and definitive experiments, a lifetime exposure was given to a population of 100 test animals whose state of health, growth, and cause of death were closely monitored. An equal number of sham-exposed animals served as a comparison population. After 25 months of exposure, and at the point where 90 percent of both groups had died, the remaining subjects were sacrificed and assayed. The methods and results have been published as a series of nine technical reports. The overall conclusion was that no cumulative ill effects could be attributed to the lifelong exposure at absorption rates of 0.4 W/kg or less.

Krupp went on to point out that until solid human epidemiological data are available, some concern for long-term effects will remain. The difficulty of assessment implied that very subtle effects, without a distinguishing lesion or disease entity, will continue to fertilize the blossoming of anecdotal epidemiology data. In the meantime, rational review of the existing data provides no reason to predict adverse consequences from lifespan exposure to currently allowable levels of RF radiation.

Accidental Exposure

There have been a number of real and imaginary accidental exposures to high levels of RF energy, both in military and industrial situations. This is inevitable, given human fallibility. COL R.B. Graham reviewed several cases with which the USAF has been involved. He reviewed the procedures that have been developed to investigate accidents and to evaluate the health aspects of the person who was overexposed. In every case where the people exposed are employees, according to Graham, they are kept under medical surveillance throughout their lives in order to detect any harmful effects that might develop.

Graham provided a good summary of the results of the USAF's medical evaluations. According to him, medical evaluations have been done on many, but not all of the personnel involved in RF radiation overexposures at USAF bases since 1972. Not all of the personnel involved have been USAF employees. There have been incidents on USAF bases that involved civilian contractors, foreign nationals, US Army, and US Marine Corps personnel.

In many cases the medical data obtained from the evaluations of the accidental RF radiation overexposures are incomplete in several respects, primarily due to a lack of standardization of the clinical examinations. Nevertheless, these case files can and do provide important anecdotal information concerning human exposure to RF radiation fields. This repository of the case files is the only one of its kind known to exist.

Of the more than 330 (as of 1 August 1984) suspected individual overexposure files in the repository, only 58 were positively confirmed to have exceeded the permissible exposure limit (PEL). Of those 58, 26 individuals reported that they clearly felt a warming sensation at the time of the overexposure, 20 felt no warmth, and 12 were not sure. It can therefore be concluded that 45 percent of those overexposed felt the energy, and probably as a consequence of that feeling terminated the exposure. Of the approximately 240 alleged overexposures that were later positively confirmed as not exceeding the PEL, 26 felt a warming sensation and terminated the exposure before the PEL could be exceeded, 173 individuals felt no sensation and 39 were not sure. In the remaining cases, no determination could be made about whether exposure occured.

Tables 1 through 6 summarize the accidental RF radiation exposures as a function of frequency, average power density, and exposure time.

Graham revealed that medical examinations conducted on persons who were overexposed to RF energy have shown few, if any, consistent clinical patterns. This contradicts several reports in the popular media. In a few cases there was edema or erythema or both, or even minor imperfections in the lens of the eyes. However, these all either disappeared or caused no ill health. According to Graham, psychological and neurological examinations have also been uncharacteristic, except for anxiety in several cases where the individuals were so concerned about the possible consequences of the exposure that they exhibited such symptoms.

Epidemiological Studies

There have been several attempts to conduct epidemiological studies of human exposures to RF energy. To date, none has been fully accepted because of a number of complications attendant to such studies with RF energy. Roberts reviewed several such attempts and went on to discuss the requirements for good epidemiological investigations, how these general principles might be

Table 1

Confirmed Overexposures as a Function of Frequency

Number of Individuals	Frequency Range
1	20 MHz
7	200-500 MHz
18	1.5-6 GHz
24	8.0-10 GHz
5	15-35 GHz
3	Unknown

Table 2

Confirmed Overexposures as a Function of Average Power Density

Number of Individuals	Power Density Range (mW/cm^2)
9	15-30
16	40-100
14	120-250
13	350-1000
3	1000-3000
1	16,000-100,000
1	100,000-160,000
1	Unknown

Table 3

Confirmed Overexposures as a Function of Exposure Time

Number of Individuals	Exposure Time Range
7	1-10 sec
11	15-60 sec
18	1-6 min
21	8-60 min
1	Unknown

Table 4

Accidental RFR Exposures Within the PEL* as a Function of Frequency

Number of Incidents	Frequency Range
2	1-10 MHz
3	20-90 MHz
14	0.1-0.9 GHz
61	1.0-6.0 GHz
30	8-10 GHz
3	10-14 GHz
20	15-35 GHz
66	Unknown

Table 5

Accidental RFR Exposures Within the PEL* as a Function of Average Power Density

Number of Incidents	Power Density Range (mW/cm^2)
95	0-1
57	1-14
20	15-39
23	40-100
1	101-250
1	251-1000
2	Unknown

Table 6

Accidental RFR Exposures Within the PEL* as a Function of Exposure Time

Number of Incidents	Exposure Time Range
29	0-1 sec
39	1-11 sec
36	15-60 sec
29	1-6 min
45	8-60 min
14	2-100 hr
3	101-500 hr
4	Unknown

*PEL=3600 $mW\text{-}s/cm^2$ in any 6-min period.

applied to RF energy studies, and why some of them can never be achieved. There are many pitfalls when one attempts to look back at a population that may have been exposed to RF energy, and Roberts cautioned the course attendees about these pitfalls. One of the most critical bits of information that is always lacking is the level to which the sample population was exposed. Since there is no such thing as an RF personnel dosimeter, people who work in occupations where they are likely to be exposed have no way to keep a record of that exposure. This then, as Roberts pointed out, is one of the most severe limitations to epidemiological studies in this field.

It is interesting to note, as an aside, that a prominent Polish scientist, Dr. Stan Szmigielski of the Center for Radiobiology and Radioprotection, Warsaw, has just reported in an informal communication the results of an epidemiological study carried out on a group of military workers in Poland that were exposed to heavy doses of microwaves. Szmigielski claims to have found "a definite increased risk of neoplasms resulting from the exposure."

Although only 3 percent of the Polish soldiers received heavy doses of microwaves, that group suffered 8.8 percent of the cancers found among the soldiers in the study.

Exposed soldiers were six to seven times more likely to contract cancer of the lymphatic system and the blood-forming organs, and four to five times more likely to suffer thyroid cancer. The rate of lung cancer, the commonest type of cancer among Polish soldiers, was virtually the same regardless of the extent of exposure. Smoking may have evened this out.

The increase in cancer rates varied with age. Soldiers in their twenties who received high doses of microwaves were five to six times more likely to get cancer than their compatriots of the same age. Those in their fifties were only one to two times more at risk.

It is not certain how many people were included in the populations studied. This information has not been released by the Polish authorities. Szmigielski plans to present further details of this study at a major meeting in 1985 and to submit results of the study for publication.

Power-Line Frequencies

Most of these lecturers dealt with RF energy in the frequency range above 2 MHz. However, Bernhardt addressed the portion of the spectrum below 100 kHz, with particular emphasis on power-line frequencies of 50 to 60 Hz.

There is very little theoretical or experimental data available on the specific field strengths that humans can tolerate without ill effects in the frequency range between 0 and 100 kHz, with the exception of power-line frequencies. There are several industrial operations, other than in the power industry, where people are likely to be exposed to substantial field intensities at frequencies below 100 kHz. Sources such as RF sealers and heating units are examples of these types of equipment. Here magnetic fields are of particular interest because they can penetrate deeply into the human body. However, biological effects, should they occur, are likely to be due primarily to induced electric fields within the body. Examples of some effects that have been reported are movement of hair on the body, generation of magnetophosphenes, and subjective complaints such as fatigue or headaches. In medicine, the effects of magnetic fields are being used both for diagnosis (nuclear magnetic resonance) and therapy (bone stimulation by induction and magnetotherapy).

There is much uncertainty in the determination of personnel health limits for frequencies below 100 kHz--largely because so far a good model has not been developed for estimating the risk in the frequency range involved here. Such a concept, however, is necessary as one cannot expect that the full frequency range can be studied by experiments with results similar to those obtained in power engineering fields. Bernhardt's lecture described a simple concept that may serve as a basis in the discussion of the definition of personnel health limits. Parts of these ideas and considerations have already been adopted in the West German regulations defining limits for frequencies above 10 kHz (see *ESN* 38-10:530-532 [1984]). The same considerations are employed in the "Safety Regulations for Working Places with Risks of Health Hazards by Electromagnetic Fields," issued by the trade association in West Germany; the regulations set limits for the electric and magnetic field strengths above 1 kHz.

When possible health risks from the influence of electric and magnetic fields on man are evaluated, primarily those biologic effects are considered which originate from a direct action on the cells in nerve and muscle tissues. The physical quantity determining the biological effect is the electric field strength in the tissue surrounding the living cell. This can be inferred from both theoretical considerations where the depolarization of the cell membrane potential is directly related to the magnitude of the electric field strength in the cell environment, and from the experiments confirming this concept. A great volume of experimental data on stimulus thresholds for different nerves and muscle cells, however, has often been expressed in the form of electric current values and not as field strength values. Very few papers disclose data on the field strength thresholds. More data, however, exist on current density thresholds. Therefore, the electric current density must be employed as the decisive parameter in assessment of the biologic effects at the cell level. As far as necessary, the values given for the specific conductivity can be employed to convert the current density in the tissues into field strength.

By selecting the current density as a measure of an action on the cellular level, the possibility exists that one can extrapolate to conditions in the human body from studies of animal experiments or from measurements taken at isolated cells, by way of mutual comparison of the current densities. It is important to know whether the electric current density surrounding a cell is introduced into the body through electrodes or induced in the body by external electric or magnetic fields; the current paths within the body may be different.

Bernhardt listed the following considerations in the evaluation of human exposure to electric and magnetic fields below 100 kHz:

1. The experimental data on the thresholds for stimulation of excitable cells must be combined in a current density/frequency diagram. A current density "envelope" should be employed as the "threshold curve of possible acute health hazard" while another current density curve is plotted as the "injury threshold."

2. Some experimental values in relation to phenomena depending on current densities below the stimulus thresholds, in combination with theoretical considerations, define a current density curve below which a direct influence on neurons can no longer be expected ("limit of the safe range").

3. The current density curve, between the "safe" and the "dangerous" current density curves, may serve as the limit value curve in evaluation of the exposure to external electric and magnetic fields.

4. Electric and magnetic field strengths in the environment should be related to the electric current densities they induce within the human body. This allows correlation of the internal current density curves with the external field strengths and permits definition of "safe" and "dangerous" field strengths.

5. It must be verified that there exist no other direct or indirect biological effects caused by other mechanisms which could lead also to a hazard of humans at lower field strengths than those defined in item 4.

Bernhardt presented calculated threshold values of the electric current density for different biological effects in nerve and muscle tissue. The values were summarized in current density/frequency diagrams. Using extensive data found in the literature, Bernhardt derived threshold values for the electric current densities for stimulation of neurons or muscle cells and, where possible, correlated these with frequency.

VLF to MF Hazards

Moving up somewhat in frequency, Guy discussed the biological hazards to humans exposed to the very low frequency (VLF) to medium frequency (MF) bands extending from 3 kHz to 3 MHz. He pointed out that these hazards may result from any one of several phenomena: (1) electric shock, (2) spark discharge, (3) elevation of tissue temperature, (4) burns, (5) pacemaker interference, or (6) the so-called neuroasthenic syndrome reported widely in the Soviet and East European literature.

As Guy pointed out, most of these have been well studied and documented. However, there is considerable controversy about the neuroasthenic syndrome, which produces a number of subjective responses such as fatigue, loss of memory, decreased sex drive, and inattentiveness. The fact is that there have not been a large number of really good studies of the subtle and long-term biological effects due to electromagnetic energy in the VLF-MF range.

Guy has compiled a summary of the published literature reporting biological effects due to VLF-MF fields in both Western and Eastern-bloc countries. Most of the studies in the Western world have been carried out on animals, while more than half of the Soviet studies were done on human workers. While most of the effects reported were on the central nervous system and cardiovascular system, there seems to be an inconsistency between reported effects in animals and humans in terms of the same calculated SAR.

On the issue of the difference between the Eastern and Western research, Guy pointed out that the literature on biological effects of VLF to MF electromagnetic fields indicates that the current status of research is essentially at the stage that microwave research was in the early 1960s. As mentioned, there is great inconsistency between the Soviet and Western literatures. The Soviet scientists seem to be further ahead in research activity, especially in hygienic studies. However, their reports are sadly lacking in details of their experiments. In many cases, they do not include the field intensity and frequency. Details are not given of the methodology in either the human or animal studies, making the results difficult, if not impossible, to evaluate. In addition, as Guy pointed out, there is a major deficiency in the area of dosimetry in both Soviet and Western reports. The biological effects of EM fields are related to the amount of current, field strength, or energy in the biological objects. The distribution of current, field, or energy in the exposed objects is determined by the frequency and intensity of the field, and the dielectric properties, size, and geometry of the exposed tissue, as well as by the exposure conditions. The reporting of only the frequency and field intensity of the electric or magnetic field does not give enough dosimetry information about the exposure. Therefore, it is difficult to compare experimental results from various laboratories. Extrapolation from animal research to humans cannot be done without the essential dosimetric information. It would be ideal to be able to estimate the induced current density, electric field intensity, or SAR in tissues for all the reported data. However, it is impossible to give a close estimate because of the lack of essential information on the exposure conditions in most of the papers.

Soviet human studies indicate that the central nervous system, the autonomic nervous system, and the cardiovascular system are affected by VLF-MF radiation. The effects are very similar to those reported for the microwave exposure. There is no Western research to confirm or deny the Soviet findings.

After some lengthy and detailed discussion on dosimetry and some of the problems attendant to the immersion of a human body in various field configurations, Guy gave some practical considerations for using dosimetry data in the application of standards. A number of cases were considered--for example, when the body is in contact with a good ground as opposed to the case when it is shielded from ground. Of course, there are differences, depending upon which part of the body is in contact with the ground and the orientation with respect to ground: hands versus feet, standing versus sitting, etc. Guy concluded that only in very rare circumstances would individuals come close enough to VLF-MF sources to experience the levels of currents and SAR in their bodies that would exceed the safety criteria.

Exposure Standards

The impact on the military and other industries of RF energy in the environment is determined by the limits for human exposure dictated by human exposure standards. In recent years, there has been a proliferation of standards as research has provided more and more data on biological responses. Mitchell reviewed a number of the important standards and guidelines that are currently in use.

For more than two decades, the US and most other Western countries used a single-field intensity of 10 mW/cm^2 (time averaged over any 6-minute period) to protect humans. It was generally believed that this level of exposure included a safety factor of 10. No consideration was given to the frequency of the emitted RF energy. Over the past few years, research has shown that the absorption of RF energy is highly frequency dependent. Mitchell illustrated this by showing the curves in Figure 1, in which SAR values are given for individuals of different height and weight as a function of frequency. Based on this type of information, the American National Standards Institute (ANSI) revised its standard in 1982 to take frequency into account. The new standard, which was published in September 1982, covers the frequency range from 300 kHz to 100 GHz. Depending on the frequency, the incident power may range from 1 to 100 mW/cm^2, but the average SAR must always be 0.4 W/kg or less, and the spatial peak SAR is limited to 8 W/kg averaged over any 1 g of tissue.

Mitchell discussed some of the standards and guidelines and showed how they compared with the ANSI standard. The first was the set of threshold limit values (TLVs) published by the American Conference of Governmental Industrial Hygienists (ACGIH). As with the ANSI standard, the ACGIH TLVs limit the absorption of energy in humans to 0.4 W/kg or less averaged over any 6-minute period. One difference is that the ACGIH TLVs extend down in frequency to 10 kHz on the low end and up to 300 GHz on the upper side. The TLVs are intended only for occupational exposure and are to be applied only by qualified industrial hygienists. Neither the ACGIH TLVs nor the ANSI standard represents federal standards or guidelines backed by force of legislation. However, one or the other is generally adopted and used by those needing to apply them. The different branches of the Department of Defense use versions that are very close to the ANSI standard, with slight modifications. The National Institute of Occupational Safety and Health has been working on its own version of an RF radiation standard for several years now, but as of this writing it has not been published. To further confuse matters, several states and local jurisdictions have established their own standards, which are almost always more stringent than either the ANSI standard or the ACGIH TLVs.

The closest thing to an international standard is the one published as an interim guideline in 1983 by the International Radiation Protection Association (IRPA) and the one published by NATO as a Standardization Agreement (STANAG) 2345. The IRPA guidelines cover both occupational workers and the general public. It is five times lower than the other standards for the general public in the frequency range of 10 to 30 MHz. Mitchell showed Figure 2 to illustrate the differences in the principal guidelines and standards. The Canadian and UK standards are not shown on the figure. The differences between these and the ANSI standard are small.

The new human exposure guidelines have a number of safety features that are seldom considered. However, since the general public often perceives all forms of radiation as hazardous, regardless of level, Mitchell went on to highlight some of the inherent safety features associated with the new generation of standards.

Measurement Problems

As might be imagined, there are a number of practical operational problems

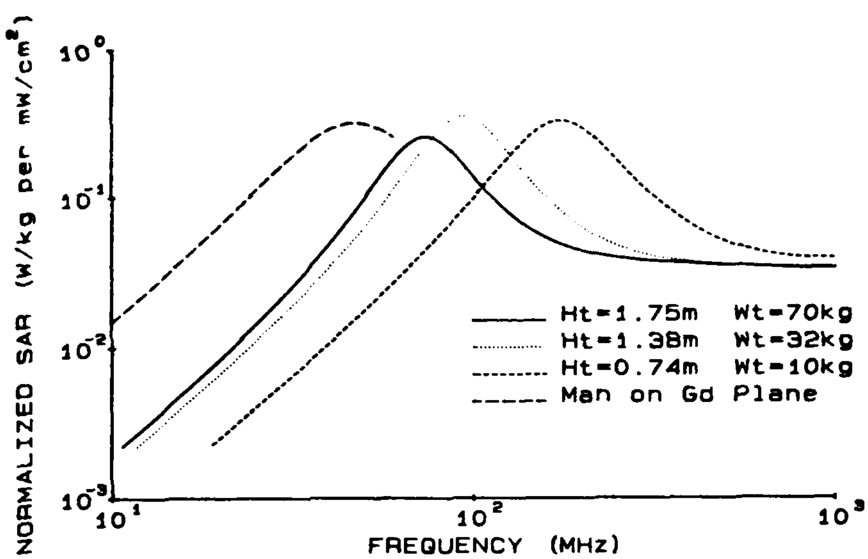


Figure 1. Specific absorption rate for different size humans.

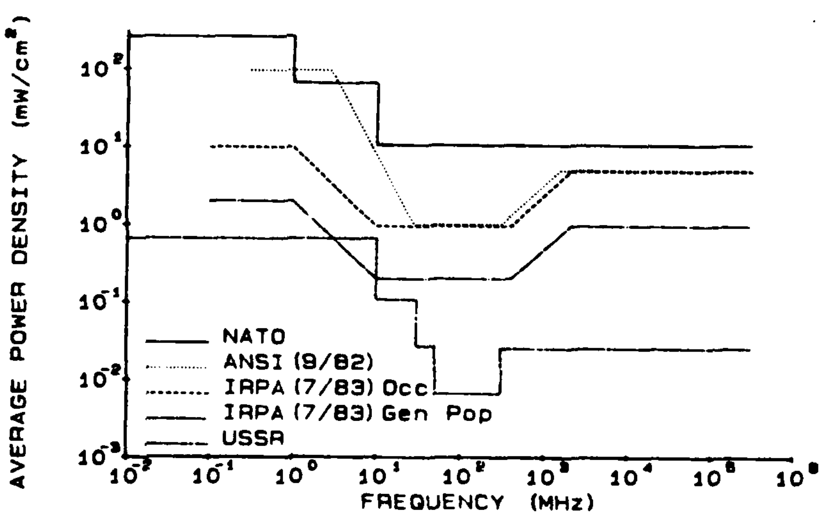


Figure 2. Comparison of RFR safety guidelines.

involved with making measurements in the field and relating these to existing standards for personnel protection. Graham discussed at length a number of these problems and how the USAF Occupational and Environmental Health Laboratory has dealt with them. One of the problems discussed was that of making and comparing measurements using different types of instruments in and around a host of different antenna types. He discussed problems associated with airborne emitters, medical RF emitters, and ground-based emitters. The key element, as pointed out by Graham, is adequate planning and preparation before going into any survey situation.

Conclusion

The series of lectures were very well prepared and expertly delivered. They covered all of the important areas necessary to allow the participants, representatives of several NATO military groups, to evaluate the general impact of new and proposed RF radiation standards on their operations. I am not convinced that those attending actually took away with them all that was intended. This observation is based on the quantity and quality of questions and discussion generated by the participants. Perhaps there was a language problem. While it is true that the USAF has played, and still plays, a major role in RF radiation research, it would be well if the other services were more prominent in future lecture series. This is not to speak lightly of this effort, which was first rate, by any standard.

APPENDIX: NOTES ON THE ORGANIZATION AND OPERATION OF AGARD AND THE LECTURE SERIES

Organization

AGARD is organized around three main elements:

- *The National Delegates Board*, the governing body, assisted by a steering committee and an advisory committee.
- The AGARD staff, the executive body of the agency.
- The Scientific and Technical Panels and the Aerospace Applications Studies Committee, which together constitute the expert bodies of the agency.

These elements carry out the AGARD mission through a number of specialized activities, including:

- Panel programs of conferences, symposia, and specialists' meetings, and meetings of subcommittees and working groups.
- Consultant and Exchange Programs, under which individual consultants are provided to NATO member-nations, lecture series are organized, and personnel exchanges and contacts arranged.
- A Program of Military Committee Studies, consisting of aerospace applications and technology studies initiated at the request of the NATO Military Committee.
- A publications program resulting from the above activities or initiated by them.

NATO funds provide for AGARD's logistic and staff support, for consultants and for the preparation and printing of AGARD publications; NATO funds also provide for a limited number of the officers on the staff of AGARD. However, the main support for AGARD's activities derives directly from the member-nations, who make available their own nationals to serve as members of panels, committees, subcommittees, and working groups; assign national officers and officials to the AGARD staff; and act as hosts to AGARD meetings. The AGARD headquarters building, located in Neuilly sur Seine near Paris, is provided and maintained by the French government.

The National Delegates Board is the highest authority within AGARD; its members are leading personalities in the field of aerospace research and development. They are appointed by and represent the governments of the following NATO member-nations: Belgium, Canada, Denmark, France, West Germany, Greece, Italy, The Netherlands, Norway, Portugal, Turkey, the UK, and the US. Iceland and Luxembourg are not represented on the National Delegates Board, but do receive copies of AGARD publications. Each government appoints one, two, or three members of the board, as it wishes, but each country has only one vote.

The National Delegates Board meets twice a year, in the spring and on the occasion of the AGARD Annual Meeting in the fall. (The original AGARD annual meetings, between 1952 and 1965, were known as general assemblies; they were held each year in a different NATO country and brought together as many AGARD personalities as possible in a variety of scientific and business meetings. After 1965, these general assemblies were replaced by smaller annual meetings, which continue to rotate among NATO nations and thus provide an opportunity for each country in turn to inform the other NATO nations of its aerospace research and development programs.)

Each spring the National Delegates Board reviews the technical program and budget for the following year and receives the director's report for the previous year. Each fall, the board takes the opportunity offered by attendance at the AGARD Annual Meeting to review progress and provide general scientific and administrative guidance. The steering committee normally convenes once a year. Meetings of the panel chairmen take place at the time of each National Delegates Board meeting.

AGARD Panels

There are nine AGARD panels composed of a total of about 400 members, who are experts actively engaged in research, development, or management in academic institutions, government establishments, or industrial enterprises related to the aerospace field. Panel members are appointed by their respective National Delegates, normally for a term of 3 years. Reappointment is permissible, but National Delegates review panel memberships regularly to ensure that the composition of the panels continues to reflect current activity and interests in the scientific speciality concerned.

Each panel defines a program of meetings and publications in its own speciality, within the general constraints of AGARD policy as determined by the National Delegates Board. Panel members are responsible for enlisting the necessary support and participation from their own countries. In all these activities, panels can call upon the resources of the AGARD staff; in particular, each panel is supported by a full-time panel executive, who acts at the AGARD director's representative.

Missions of the Panels

The detailed areas of interest of each panel vary fairly rapidly as the field of aerospace science and technology expands and as interactions between specialist areas become more or less relevant. In very general terms, the goal of each panel is to fulfill the AGARD mission within its own area of scientific and technical interest and competence. One mechanism for achieving this goal is the sponsorship of lecture series.

Basically, the Aerospace Medical Panel, which sponsored the lecture series discussed in this report, is concerned with the effects of aerospace environment factors on pilot performance. The panel has stimulated research activities in the field of air-crew medical standards, human factors related to accident prevention, and anthropotechnical assistance in bioengineering research and development. The Aerospace Medical Panel keeps abreast of the scientific and technological progress in aeronautics and astronautics and is a measure of the achievements of all other AGARD technical panels. The panel has subcommittees concerned with the specific problems of behavioral sciences, biodynamics, special clinical and physiological problems in military aviation, and special senses.

The other panels are as follows: (1) Avionics Panel, (2) Electromagnetic Wave Propagation Panel, (3) Flight

Mechanics Panel, (4) Fluid Dynamics Panel, (5) Guidance and Control Panel, (6) Propulsion and Energetics Panel, (7) Structure and Materials Panel, and (8) Technical Information Panel.

Attendance at AGARD lecture series does not require a specific personal invitation, although participants are generally citizens of NATO member-nations. In special circumstances, highly qualified non-NATO nationals may be invited to participate in unclassified AGARD meetings or lecture series. Such attendance is usually based on the principle that it must be of interest and value to AGARD. Invitations to non-NATO nationals are extended by the director of AGARD following requests and recommendations from AGARD national delegates, and the approval of the NATO Military Committee.

The full texts of the presentations given in the lecture series are normally printed and given to the participants upon registration. Others may obtain them from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

END

FILMED

10-85

DTIC