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FEDERAL COMMUNICATIONS COMMISSION
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Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation	)	**ET Docket No. 93-62**
	)	

To: The Commission

REPLY COMMENTS OF

THE AMERICAN RADIO RELAY LEAGUE, INCORPORATED

THE AMERICAN RADIO RELAY LEAGUE, INCORPORATED

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April 25, 1994

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SUMMARY

The American Radio Relay League, Incorporated (the League), the national non-profit association of amateur radio operators in the United States, submits its reply comments in the captioned proceeding. The comments in this proceeding addressed the proposal contained in the Notice; to adopt, as a guideline for Commission use in evaluating the environmental effects of radio frequency (RF) energy in processing applications for new facilities utilizing RF energy, the standard for RF exposure recently adopted by the American National Standards Institute (ANSI) in association with the Institute of Electrical and Electronic Engineers, Inc. (IEEE), known as ANSI/IEEE C95.1-1992.

The comments filed in this proceeding reflect a significant disagreement as to the desirability of Commission adoption of the ANSI/IEEE 1992 standard for RF exposure. There appear to be no comments in the Commission's files, however, which would indicate that experimental radio services such as the Amateur Service should be subject to routine environmental processing of applications for new, modified or renewed station licenses, or upgraded operator licenses in the Amateur Service. Indeed, the comments filed by amateur radio operators note the administrative impracticality of requiring environmental assessments in the face of ever-changing station configurations, variable power levels, different modulation types, and different station locations. Those comments each suggest that amateurs should be exempt from regulations which require routine environmental processing of applications.

Assuming that ANSI/IEEE 1992 or another standard is ultimately adopted, the Commission should continue the categorical exemption from routine environmental processing of all amateur station and operator license applications. There is no evidence that amateur stations would, except in rare circumstances, exceed even the 1992 standard, and the variability in amateur station configuration does not support the filing of an environmental assessment for amateur stations. Amateurs are uniquely subject, however, to operator license examinations, and there are questions in the examination question pool dedicated to RF safety. At the same time, the League has in all relevant publications significant educational materials for amateurs concerning RF safety. These materials are a good and sufficient means of addressing RF exposure from amateur stations, and should be the only regulatory approach adopted.

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REPLY COMMENTS OF THE AMERICAN RADIO RELAY LEAGUE, INCORPORATED

The American Radio Relay League, Incorporated (the League), the national non-profit association of amateur radio operators in the United States, by counsel and pursuant to Section 1.415(c) of the Commission's Rules [47 C.F.R. §1.415(c)], hereby respectfully submits its reply comments in the captioned proceeding, relative to the Notice of Proposed Rule Making (the Notice), FCC 93-142, 58 Fed Reg. 19393, 8 FCC Rcd. 2849, released April 8, 1993. These reply comments are timely filed, per the Order Extending Time For Reply Comments, DA 94-34, 59 Fed. Reg. 9171, published February 25, 1994. The comments in this proceeding addressed the proposal contained in the Notice: to adopt, as a guideline for Commission use in evaluating the environmental effects of radio frequency (RF) energy in processing applications for new facilities utilizing RF energy, the standard for RF exposure recently adopted by the American National Standards Institute (ANSI) in association with the Institute of Electrical and Electronic Engineers, Inc. (IEEE), known as ANSI/IEEE C95.1-1992. In response to the comments filed to date, the League states as follows:

I. Introduction

1. The comments filed in this proceeding reflect a significant disagreement as to the desirability of Commission adoption of the ANSI/IEEE 1992 standard for RF exposure[1]. There appear to be no comments in the Commission's files, however, which would indicate that experimental radio services such as the Amateur Service should be subject to routine environmental processing of applications for new, modified or renewed station licenses, or upgraded operator

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[1] The Comments of certain broadcast entities, and of consulting engineering firms, reflect objections to the standard, but several encourage adoption of it, principally because it is a standard that is likely to be adopted by other agencies, having been adopted by the American National Standards Institute, and by non-Federal sources. The League is not so quick to dismiss the thoughtful comments of the Environmental Protection Agency, which pointed up numerous flaws in the ANSI/IEEE standard as stated. It is suggested that the record in this proceeding does not justify the adoption of the standard at this time, especially without substantive consideration of alternatives not mentioned in the Notice.

The suggestion that the standard is in existence, and will be applied, so it should become the de jure standard, flaws and all, is not the proper approach for a regulatory agency. The Commission should not burden the communications industry with an RF exposure standard that is any more restrictive than is necessary to protect humans from occupational and non-occupational exposure to RF. On the other hand, the degree of necessary protection should be properly ascertained, and it is the Commission's obligation to determine whether a standard adopted by other entities is sufficient to do that. The comments of EPA make it clear to the League that the 1992 ANSI/IEEE standard is in certain important respects not the proper standard to accomplish either of the Commission's obligations. Its determination of the proper limits for uncontrolled environments, for example, is apparently completely arbitrarily established, vice the standard for controlled environments, which is billed by ANSI/IEEE as being "safe for all". The standard should be revisited, perhaps in a multi-agency proceeding. Alternatively, the Commission should terminate this proceeding and rely on an agency with proper expertise in evaluating such standards on a scientific basis to determine a proper standard, which may, for the communications industry, be a hybrid standard.

licenses in the Amateur Service. Indeed, the comments filed by amateur radio operators[2] note the administrative impracticality of requiring environmental assessments in the face of ever-changing station configurations, variable power levels, different modulation types, and different station locations. Those comments each suggest that amateurs should be exempt from regulations which require routine environmental processing of applications. It is understood that the Commission is specifically interested in determining whether or not the existing categorical exemptions from the NEPA requirement of routine evaluation for environmental impact should be maintained.[3]

II. The Comments Support Categorical Exemption of Amateur Station License Applications From Routine Environmental Processing

2. The League wishes to emphasize in these reply comments that, regardless of the standard ultimately chosen as the proper standard for RF exposure limitations generally, the Commission should avoid restriction of Amateur Service communications or subject amateur radio licensees to stringent regulatory burdens such as submission of Environmental Assessments, without good cause therefor. While there are amateur station configurations that could expose the licensee, or perhaps members of his or her family to levels of RF energy that exceed the proposed 1992 ANSI/IEEE

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[2] See, e.g. the comments of Dr. Wayne Overbeck, Ph.D, J.D., and those of Ivan Shulman, M.D., et al.

[3] See the Notice, at paragraphs 19-21, 8 FCC Rcd. at 2852.

standard, these configurations are indeed rare.[4] Furthermore, because amateur station equipment is not specified in FCC applications or in FCC Station Licenses in the Amateur Service, and because there is no standardization to the transmitters, feed lines, power levels, frequencies or antennas used at a given location, there is no point whatsoever in requiring an EA with each Form 610. The station equipment could, and in many cases they do, change from day to day. Nor does it make any sense at all to include amateur equipment in the equipment authorization process for purposes of determining the potential for such equipment to exceed whatever RF standard is adopted. This is because the station components do not themselves determine whether or not the station will exceed the adopted RF standard. Rather, it is the location and configuration of the station components in situ which determine overall RF levels, as the components are assembled by the licensee. Other factors, such as the modulation level and other operating circumstances, also affect the level of RF energy emitted from the station, and the extent to which the station is capable of exceeding the appropriate exposure standard.

3. The Commission recognized the need to exempt amateur stations from routine environmental processing in 1987, as

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[4] The League is aware of studies conducted by the Commission recently of amateur station configurations and the extent to which they might exceed the 1992 ANSI/IEEE standard for controlled environments. Though the results of this study have not been released as yet, the Commission's professional staff has apparently studied a significant number of amateur stations, and found that only a small percentage would exceed the proposed standard for RF exposure with respect to the licensee.

discussed more fully in the League's comments in this proceeding. The Commission's decision was at that time based on a determination of the extent to which amateur stations would or could exceed the 1982 ANSI standard for RF exposure. At that time, the Commission noted[5] that:

> Regarding amateur radio facilities, no specific evidence has been submitted that these facilities present a significant risk to the public that would warrant routine environmental evaluation. While hypothetically, RF radiation limits could be exceeded in a few instances, such situations apparently seldom occur in actual operation. Furthermore, because amateur stations are not individually licensed by frequency, modulation, power output, or location, it would not be administratively feasible to evaluate amateur applications for this environmental factor. Consequently, we find that amateur radio operators, at the time of licensing, should not be required to routinely submit environmental information concerning exposure to RF radiation. Nevertheless, as an added precaution, we agree with [the League] that operator education would help to assure compliance with ANSI guidelines. In that connection, RF radiation safety questions are being incorporated into amateur examination study guides.

2 FCC Rcd at 2066.

The circumstances which led the Commission to this reasonable conclusion in 1987 still appertain, even if the Commission should adopt the 1992 ANSI/IEEE RF exposure standard, and even if it should consider amateur stations to be in "uncontrolled" RF environments[6] rather than "controlled" environments. An amateur

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[5] Second Report and Order, Docket 79-144, 2 FCC Rcd. 2064 (1987); modified by erratum, 2 FCC Rcd. 2526 (1987).

[6] The classification of amateur stations as being in uncontrolled environments has no justification with respect to the exposure of the licensee of an amateur station or his or her family: he or she is in full control of the transmitters and antennas of such stations, and is capable of regulating the level

station is still unlikely, in typical configurations, to exceed the 1992 ANSI/IEEE RF exposure standard. Amateur stations are operated intermittently by their very nature, with low, most often extremely low duty cycles; and the stations use relatively low power levels. As was determined in the Second Report and Order in Docket 79-144, supra, footnote 4, typical amateur station configurations are such that, even using the 1992 ANSI standard for uncontrolled environments, RF emissions would not exceed maximum recommended levels. Those stations which would, such as Earth-Moon-Earth stations with high-gain antenna arrays and high ERPs, are invariably in remote locations, due to the size of the antenna arrays; and high-powered, high-duty cycle mobile installations are rare.

III. The Amateur Service Provides Opportunities for Educational Efforts In Lieu of Unnecessary Regulation

4. The better approach, and indeed a good opportunity for broad-based education of licensees, as discussed in the League's comments, is to rely on the amateur operator license examination process, and the technical self-training characteristics of the Amateur Service as a means of insuring safety in the operation of

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of RF energy emitted therefrom. Neither is the radio amateur unaware of the possible consequences of exposure to high levels of RF energy, as educational materials on the subject are included in League publications, and questions on the subject are in the syllabus for amateur examinations. As to the possibility of exposure of neighbors of amateurs to RF energy near the antenna, that is not uncontrolled either, since the antennas are on private residential property, and not, generally, in industrial or business areas. Neighbors are therefore kept away from close contact with amateur antennas.

amateur stations. This educational process begins with the examinations for the most popular entry-level amateur licenses, the Novice and Technician Class licenses. Attached hereto as Exhibit A are excerpts from the League's publication "Now You're Talking", which is widely used as a preparatory text for those studying for the Novice or Technician Class amateur radio examination. Attached to the segment of that text dedicated to RF Safety are the questions, answers and distractors included in the qualifying examination question pool for all beginning amateur examinations, related to RF exposure and RF safety.

5. Exhibit B is an excerpt from the current ARRL Antenna Book, which is a thorough encyclopedia of antenna theory for radio amateurs. It is widely read, and in the subchapter on RF safety, it discusses both the 1982 ANSI standard and the then-proposed 1991 ANSI/IEEE standard for RF exposure. Exhibit C is the section on RF Radiation Safety from the 1994 ARRL Handbook, the standard reference for radio amateurs. The extensive section on RF safety includes a list of specific RF Awareness Guidelines, and a table of typical RF field strengths near Amateur Radio antennas, measured as samples by the Commission and by the Environmental Protection Agency in 1990. It is understood that the results of the Commission's sample measurements has shown that amateur stations normally do not exceed the limits of the proposed RF exposure standard.

6. Exhibit D is a segment of the League's current VHF/UHF Experimenter's Manual, which is intended for those radio amateurs

who design and construct equipment for the VHF and UHF bands. The entire second chapter of that book is dedicated to RF safety practices, in the form of an article by the late Dr. David Davidson, a radio amateur and a former member of the ARRL's Committee on the Biological Effects of RF Energy. Because the book is intended for the most technically inclined radio amateurs, the article contains a detailed analysis of calculation of near and far field power densities, including formulas, and RF protection parameters. It includes also a series of protection rules and RF awareness procedures.

7. Exhibit E is a segment of the League's Satellite Experimenter's Handbook, which emphasizes the power density levels in the amateur bands most often used for satellite communications. It also contains a segment on estimating power densities, guidelines for RF awareness, and an extensive bibliography. Exhibit F is a copy of an article by Dr. Ivan Shulman, a member of the League's Committee on the Biological Effects of RF Energy, which appeared in the October, 1989 issue of QST, the League's technical journal, which is a comprehensive discussion of the history of RF exposure concerns and studies, and their relationship to the Amateur Radio Service. It too contains an extensive bibliography. The article emphasizes the concept of "prudent avoidance" of RF exposure, and lists common sense precautions in dealing with RF energy.

8. The conclusion to be drawn from these documents is that RF safety is a basic element of the information imparted regularly and

thoroughly to radio amateurs. In Section 97.1 of the Commission's Rules, the basis and purpose section, technical self-training is an important goal of licensing radio amateurs in the first place. Part of that technical self-training includes training in the safe use of the amateur frequency bands, safe operation of electrical and electronic equipment, and due consideration for the effects of the RF generated during the communications. The League suggests that the ongoing educational efforts it conducts, and those conducted in examination preparation training classes, together with the publications that include sections on RF Safety, are a sufficient means of insuring safe operation of amateur stations, regardless of the standard adopted by the Commission. The Commission has full regulatory control over the examination syllabi and the question pools used in administration of amateur examinations for each class of amateur license, and can determine the proper amount of emphasis to be given this subject in operator license examinations. This is the proper means of addressing issues of RF exposure in the Amateur Service.

IV. The Commission Should Preempt Excessive Non-Federal RF Exposure Standards Which Are Arbitrarily Established

9. A problem that the League has perceived to be on the increase in the past few years is the imposition by state, county and other municipal governmental authorities of RF exposure standards that are more restrictive, often significantly, than the guidelines adopted for environmental processing by the Commission. An ancillary problem is the establishment of procedures on the state or local level for RF power density measurements even when

calculations show that there is no real possibility of a proposed new station exceeding the FCC-adopted guidelines. The most common case involves cellular towers in residential areas, or broadcast antennas[7]. While few of these local regulations have been applied thus far directly to amateur antennas, amateurs suffer a more insidious form of unreasonable local involvement in RF exposure issues, when building permits or conditional use permits are sought by amateurs for antennas in residential areas. Routinely, unquantified, vaguely stated concerns over RF safety are raised in the form of objections to particular amateur antenna installations. These objections are most often raised by neighbors of amateurs whose real concern is the aesthetic impact of an antenna installation, or a new antenna ordinance. In any case, the comments in this proceeding reveal a strong sentiment that, assuming that some revised RF standard is adopted in this or a successor proceeding, it should be determined to be the preemptive standard.

10. At several times in the past, the Commission has been asked by communications industry representatives to preempt stringent local regulation of RF emissions. The National Association of Broadcasters made such a request in 1986. The League has, in a number of instances, made similar requests. The Commission has heretofore refused to preempt state or local regulation of RF emissions because of a claimed lack of expertise

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[7] For example, in Multnomah County, Oregon, Ordinance MCC.7035(F)(4)(b) requires measurements to be taken by a registered professional engineer, over long periods of time, if those measurements show RF levels greater than one-fifth of the RF power densities permitted by the ordinance.

in the subject matter. That rationale, however, is discomforting for a number of reasons. First, if the Commission is not sufficiently expert in the area of RF exposure as to be able to determine what levels of RF its licensees should be able to emit, then it has no business adopting any standard at all. It should delegate the task to a Federal agency with primary jurisdiction, such as the EPA. However, if, as the Commission states in the Notice in this proceeding, it has an obligation to adopt a standard that is acceptable in the industry, then that standard should be the standard by which the Commission's licensees are determined to be operating safely and in the public interest. Furthermore, even if the Commission does not have the expertise to determine the biological effects of RF on humans, it is certain that virtually all local governments, most counties and a large number of state regulatory agencies also lack such expertise.

11. The Commission, if it should adopt a Federal standard applicable to its licensees for maximum RF exposure, should at the same time specifically state that existing RF exposure regulations that are more stringent than those adopted by the Commission are preempted, unless the state, county or local government agency submits a showing that it has conducted specific studies of the matter and that those studies have established a compelling need for more stringent regulations. The burden should be placed on the state or local government to justify with specific findings the more restrictive standard. Without such, this indirect and insidious control over communications licensees will continue. Most

recently, for example, the State of New Jersey Department of Environmental Protection and Energy has promulgated proposed rules[8] which would provide for regular measurement of RF from all emitters, whether licensed by the Commission or not. These rules would require the registration of all RF emitters with the state, and the payment of significant fees, both initially and annually, for the privilege of annual inspections for RF emission compliance. Tentatively, New Jersey has proposed to exempt amateur radio stations, but that issue is not concluded. The League views the New Jersey proposal as a state licensing and taxation measure, which is on its face preempted by the Communications Act. The proposal is one instance of a more widespread problem, however, the principal adverse effect of which is to preclude or significantly inhibit amateur station operation by precluding the installation of reasonable antennas. Long ago, it was held that a patchwork of state and local regulations on the operation of radio facilities would not be satisfactory. Unified, national regulation has been found by the United States Supreme Court to be necessary.[9]

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[8] DEPE Docket 60-93-11/142, 25 N.J.R. 5422 et seq.

[9] The power of the Federal Government to regulate radio communications exclusively on a nationwide basis was determined as early as 1933, in Federal Radio Commission v Nelson Brothers Bond & Mortgage Co., 289 U.S. 266, 279; 53 S. Ct. 627, 634 (1933) ("No state lines divide the radio waves, and national regulation is not only appropriate but essential to the efficient use of radio facilities"). See also Whitehurst v. Grimes, 21 F.2d 787 (E.D. Ky. 1927); Fisher's Blend Station v Tax Commission of State of Washington, 297 U.S. 650 (1936). To eliminate any doubt about the exclusive Federal authority to regulate radio communications, the Congress in 1982 modified Section 301 of the Communications Act of 1934 to delete the words "interstate or foreign" from the phrase "to maintain the control of the United States over all the channels

Assuming that there is some specific Federal standard for RF exposure ultimately to be adopted, either in this proceeding or, more appropriately, in a separate, more comprehensive review of alternative RF safety standards, the standard ultimately adopted by the Commission should be stated to be preemptive of more stringent standards by non-Federal authorities.

V. Conclusions

12. The Commission has in this proceeding no consensus on the advisability of the adoption of the ANSI/IEEE 1992 standard for RF exposure. Certain comments, principally from broadcasters, urge adoption of the standard, though this is done apparently without consideration of alternative standards. In this respect, the inadequacy of the Notice in this proceeding is apparent: the record is devoid of consideration of reasonable alternative standards for RF exposure. The comments of the Environmental Protection Agency note that certain alternatives are preferable. This proceeding should be recast as a Notice of Inquiry, to consider alternatives to the 1992 ANSI/IEEE standard.

13. Assuming for the moment, however, that ANSI/IEEE 1992 or another standard is ultimately adopted, the Commission should continue the categorical exemption from routine environmental

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of interstate or foreign radio transmission...". See, the 1982 U.S. Code Cong. & Ad. News 2237, 2275-76. The Communications Act of 1934 gave the FCC "unified jurisdiction", "broad authority" and a "comprehensive mandate" with "not niggardly but expansive powers". United States v. Southwestern Cable Co., 392 U.S. 157 at 172 (1943); See also National Broadcasting Co. v. United States, 319 U.S. 190 (1943). Section 2 of the Communications Act confers on the FCC regulatory authority over all communications by wire or radio.

processing of all amateur station and operator license applications. There is no evidence that amateur stations would, except in rare circumstances, exceed even the 1992 standard, and the variability in amateur station configuration does not support the filing of an environmental assessment for amateur stations. Amateurs are uniquely subject, however, to operator license examinations, and there are questions in the examination question pool dedicated to RF safety. At the same time, the League has in all relevant publications significant educational materials for amateurs concerning RF safety. These materials are a good and sufficient means of addressing RF exposure from amateur stations.

Therefore, the foregoing considered, the American Radio Relay League, Incorporated respectfully requests that the Commission terminate this proceeding without action, and revisit the matter in a separate proceeding incorporating a more comprehensive analysis of available alternatives. Alternatively, should the Commission adopt a standard in this proceeding, it should continue to exempt amateur station applications from routine environmental processing.

Finally, any standard adopted in this or any successor proceeding should be deemed to be the preemptive standard for communications facilities licensed by the Commission.

Respectfully submitted,

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April 25, 1994

EXHIBIT A

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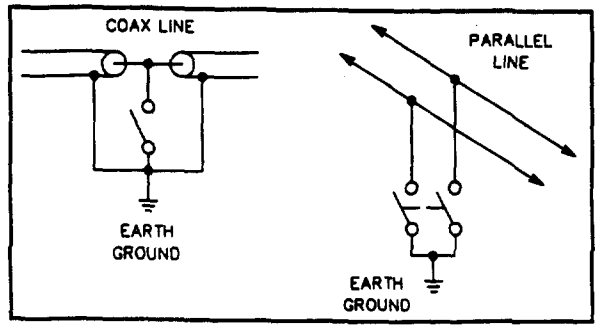


Figure 8-6—A heavy-duty knife switch can be used to connect the wires in your antenna feed line to ground. A clip lead to a ground wire can be used instead of the switch. This will prevent a large static build-up on your antenna. It will also prevent equipment damage caused by voltage on your antenna produced by a nearby lightning strike. There is no sure way to prevent a direct hit by lightning, however.

station (with the switch open, of course!) if the lead from the feed line to the switch is no more than a couple of inches long. An alligator clip can be used instead of the switch. Whatever you use, don't forget to disconnect the ground when you transmit. This precaution is useful only on the HF bands. The switch will cause high SWR if used at VHF and UHF.

Another device that can help protect your equipment in an electrical storm is a *lightning arrestor*. This device connects permanently between your feed line and the ground. When the charge on your antenna builds up to a large enough potential, the lightning arrestor will "fire." This shorts the charge to ground—not through your station. A lightning arrestor can help prevent serious damage to your equipment. Most, however, don't work fast enough to protect your station completely. Lightning arrestors are useful for commercial stations and public service (fire and police) stations that must remain on the air regardless of the weather. Unless you are actually handling emergency communications, you shouldn't rely on them alone to protect your equipment, home or life.

[Now turn to Chapter 12 and study questions N4A06, N4A07 and N4B07. Review this section if you have any difficulty with these questions.]

RF SAFETY

We all know basic safety precautions to follow in the ham shack. We know to pull the plug before taking the covers off a transceiver or power supply, for example. Another important concern, one often overlooked, is **RF safety**. This involves minimizing human exposure to strong radio-frequency fields. These potentially dangerous fields occur near or around antennas.

Biological effects of RF exposure have been studied for several decades. We know that body tissues subjected to large amounts of RF energy may suffer heat damage. It is possible to receive an RF burn from touching an antenna that is being used for transmitting. You don't have to come into direct contact with an antenna to damage body tissues, however. Just being present in a strong RF field can cause problems.

Taken to extremes, we could compare the effects of RF exposure to the way a microwave oven cooks food. A typical microwave oven uses a 500-W RF source operating at 2450 MHz. The Novice 1270-MHz band is about half this frequency, and so can have similar effects. Of course, the microwave oven is designed to concentrate its RF power for heating food and is not directly comparable to Amateur Radio operations. Some studies have shown that persons who are exposed to strong RF fields over a period of time may be at increased risk to develop certain kinds of cancer.

There is no cause for alarm in most amateur installations. But be aware that exposure to strong RF fields—which we cannot see, smell, hear or touch—can cause health risks.

The amount of RF energy that the body absorbs depends on the radio frequency. The body absorbs RF energy most efficiently in the VHF range (30 to 300 MHz). Absorption is greatest if the antenna orientation is parallel to the body (vertically polarized). Sensitive parts of the body, such as the eyes, are particularly prone to damage from RF energy.

Most amateur operation is with relatively low RF power and is intermittent—the transmitter is not operating continuously. Hams spend more time listening than transmitting. If you use modes such as RTTY and FM, in which the RF carrier is present continuously at full power, you'll need to pay more attention to RF safety.

RF Safety Guidelines

Take the time to study and follow these general guidelines to minimize your exposure to RF fields. Most of these guidelines are just common sense and good amateur practice.

• Confine RF radiation to the antenna, where it belongs. Provide a good earth ground for your equipment. Particularly at VHF and UHF, poor-quality feed line and improperly installed connectors can be a source of unwanted RF radiation. Use only good-quality coaxial cable. Be sure the connectors are of good quality and are properly installed. Good-quality coaxial cable and connectors will also help reduce RF loses in your system.

• Don't operate RF power amplifiers or transmitters with the covers or shielding removed. This practice helps you avoid both electric shock hazards and RF safety hazards. A safety interlock prevents the gear from being turned on accidentally while the shielding is off. This is especially important for VHF and UHF equipment. When reassembling transmitting equipment, replace all the screws that hold the RF compartment shielding in place. Tighten all the screws securely before applying power to the equipment.

• In high-power operation in the HF and VHF region, keep the antenna away from people. Humans should not be allowed within 10 to 15 feet of vertical antennas. This is especially important with higher power, high-duty-cycle operation (such as FM or RTTY). Amateur antennas that are mounted on towers and masts, away from people, pose no exposure problem.

• Always install your antennas where people and animals cannot touch them.

• When using mobile equipment with 10-W RF power output or more, do not transmit if anyone is standing within 2 feet of the antenna.

• The best location for a VHF/UHF mobile antenna—from an RF safety standpoint and for the best radiated-signal pattern—is in the middle of the automobile roof. This position best protects the car's occupants.

• When using a hand-held transceiver with RF power output of several watts or more, maintain at least 1 to 2 inches separation between the antenna and your forehead to protect your eyes. It is recommended that hand-held radios have a power of no more than 7 watts.

• Never touch an antenna that has RF power applied. Be sure RF power is off and stays off before working on or adjusting an antenna. Also, make sure any nearby antennas are deactivated. Never have someone else transmit into the antenna and monitor the SWR while you are making adjustments. When matching an antenna, you should turn the transmitter off and make the adjustment. Then, back away to a safe distance before turning the transmitter on again to check your work.

• During transmissions, never point a high-gain UHF or microwave antenna (such as a parabolic dish) toward people or animals.

• Never look into the open end of a UHF or microwave waveguide feed line that is carrying RF power. Never point the open end of a UHF waveguide that is carrying RF power toward people or animals. Make sure that all waveguide connections are tightly secured.

The following additional safety guidelines were developed in response to scientific studies done in the mid to late 1980s. (From the October 1989 *QST* article, "Is Amateur Radio Hazardous to Our Health?" by Ivan A. Shulman, MD, WC2S.)

• Do not stand or sit close to your power supplies or linear amplifiers while operating, even when they are in standby mode.

• Stay at least 24 inches away from any power transformer, electrical fans or other source of high level 60-Hz magnetic fields while in operation.

• Do not tune up or operate a high-powered linear amplifier while the shields or covers are off.

• Run your transmission lines away from where you or other people sit in or near your shack.

• Properly terminated coaxial transmission feed lines should be used in preference to open-wire or end-fed antenna installations that come directly into the transmitter, as the RF radiated from a coaxial feed line is much lower.

• Use common sense about placing all antennas well away from yourself and others, especially for VHF, UHF and particularly microwave application. No one should be in the near field of an antenna.

• No person should be near any transmitting antenna while it is operating. This is especially true for mobile or ground-mounted vertical antennas. The use of indoor transmitting antennas that are close to people in a house or apartment should be reconsidered.

• Use the minimum power needed to make a QSO, especially if the antenna is less than 35 feet above the ground.

• Hand-held radios should be used on the lowest power setting needed to carry out communications.

• Hand-helds should be kept as far from the head as possible when operating. The use of a separate microphone or similar device is recommended.

• Transmissions using a hand-held radio should be kept as short as possible.

• Power density measurements should be made before running more than 25 watts in a VHF mobile installation, particularly if the antenna is rear-deck mounted and passengers may ride in the back seat. The safest mobile antenna location is in the center of the metal roof.

• The development of an accurate inexpensive power-density meter would be of major benefit to the Amateur Radio community so that RF power-density measurements could be taken in all radio installations. Because of the current high cost of such devices, groups of amateurs or clubs may wish to purchase one and share in its use.

• Soldering should only be done in a well ventilated area. A small fan should be used to blow away toxic fumes.

• When using toxic chemicals, such as when etching PC boards or repairing fiberglass, wear gloves and goggles, use proper tools, and avoid contact with any of the chemicals. If accidentally contaminated, wash off the compounds immediately with lots of water. Again, the importance of always working in a well ventilated area with personal protective covering cannot be overemphasized.

• Hazardous chemicals, such as those in the PCB class, are used in some capacitors and dummy loads. Use extreme care in handling these materials, and consult with the appropriate local authorities to determine the proper means of disposing of these chemicals in an environmentally responsible way.

[It's time to study questions N4B01 through N4B06 in Chapter 12. Review this section if you have difficulty answering any of these questions.]

THE N7BH WORLD TIME FINDER

You can eliminate errors in local-to-UTC time and date conversion by keeping a two-function clock set to local time and UTC. That solution, however, doesn't help determine the date and time in time zones other than local and UTC. The circular slide rule shown here works simultaneously for all time zones. (Within certain limits; many localities deviate from the system of Time Zones.)

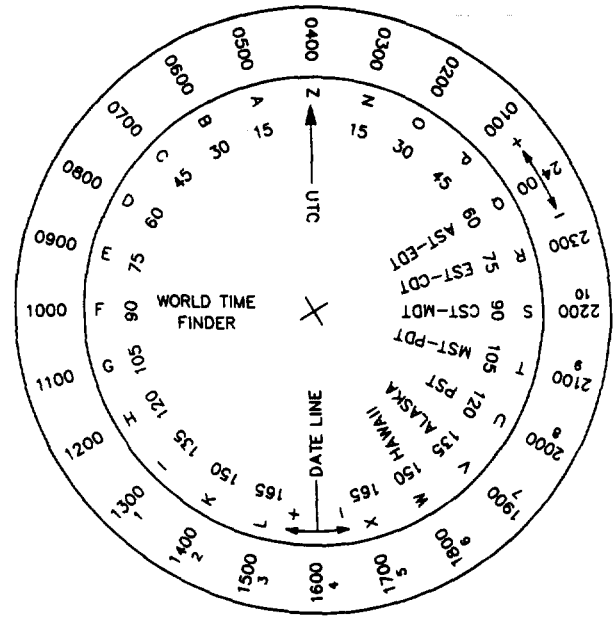
The outer scale shows hours in the 24-hour format with plus and minus signs to show the gain or loss of a day at midnight. The inner scale is labeled with a letter and longitude to identify each Time Zone, UTC, the International Date Line and abbreviations for Time Zones in the US. For example, 2100T indicates 9 PM Mountain Standard Time or Pacific Daylight Time. (Note that adopting daylight time has the same effect as shifting one time zone to the east, and thus one hour closer to UTC.)

Time Zones

The system of Time Zones is based on a few facts about our planet. Because it takes 24 hours for the earth to rotate 360°, there is one hour of time change for every 15° of longitude. (There are 24 Time Zones, each 1 hour different from those adjacent.) The Prime Meridian (0° longitude) passes through Greenwich, England, and serves as a location for UTC. The International Date Line is 180° longitude and directly opposite the Prime Meridian. While this all forms a mathematical foundation for the Time Zone system, there are many deviations from a strict longitude/Time Zone correspondence for local convenience. For example, portions of Alaska and Hawaii share the same longitude, yet they are in different Time Zones.

Construction

You can assemble your own World Time Finder by making two photocopies of this page. Cut one copy on the line of the inner circle, and other on the line of the outer circle. Put each circle between two pieces of clear plastic, or laminate them between sheets of clear Con-Tact paper (a sticky-backed plastic material sold in many department stores). Punch a hole in the center of each disk and use a ⅛-inch rivet with washers for the center pin.



Use

Operate the World Time Finder by aligning the Time Zone letter for your areas with the current hour. In the example shown, it is 2000 hours (8 PM) at Zone U (PST). Zone U is 120° W longitude, or 8 hours earlier than UTC. If the zone-U date is July 1, then the UTC time and date is 0400 (4 AM) July 2. In Japan (Zone I), which is 135° E longitude and 9 hours later than UTC, it would be 1300 hours (1 PM) on July 2.

Note that this time conversion can be done by traveling either clockwise or counterclockwise around the chart. Going in a counterclockwise direction from Zone U to UTC, you pass midnight (in the direction of the arrow pointing to the plus sign) on the outer scale, thus gaining a day. If traveling in a clockwise direction, you pass the International Date Line (with the arrow to plus), again gaining a day. The gain or loss of date is established easily by the + or – signs next to the arrows.

10 times increase in signal strength to make the meter read 20 dB over S9.

S meters on modern transceivers may or may not respond in this manner. S-meter operation is based on the output of the automatic gain-control (AGC) circuitry; the S meter measures the AGC voltage. As a result, every S meter responds differently; no two S meters will give the same reading. The S meter is useful for giving relative signal-strength indications, however. You can see changes in signal levels on an S meter that you may not be able to detect just by listening to the audio output level.

[Now turn to Chapter 13 and study questions T4D01 through T4D08. Review the material in this section if you have any difficulty with these questions.]

SAFETY WITH RF POWER

Amateur Radio is basically a safe activity but accidents can always occur if we don't use common sense. Most of us know enough not to place an antenna where it can fall on a power line. We don't insert our hand into an energized linear amplifier, or climb a tower on a windy day. We also should not overexpose ourselves to RF energy. Large amounts of RF

energy can be harmful to people because it heats body tissues. The effects depend on the wavelength, energy density of the incident RF field, and on other factors such as polarization.

The most susceptible parts of the body are the tissues of the eyes. They don't have heat-sensitive receptors to warn us of the danger before the damage occurs. Symptoms of overexposure may not appear until after irreversible damage has been done. Though the problem should be taken seriously, with reasonable precaution, Amateur Radio operation can be safe.

SAFE EXPOSURE LEVELS

In recent years scientists have devoted a great deal of effort to determining safe RF-exposure limits. The problem is very complex. It's not surprising that some changes in the recommended levels have occurred as more information has become available. The American Radio Relay League believes that the 1982 **Radio Frequency Protection Guide of the American National Standards Institute (ANSI)** is a good protection standard; it took nearly five years to formulate and has undergone repeated critical review by the scientific community.

This guide recommends that special precautions be taken when transmitting with hand-held VHF and UHF radios. The antenna should be kept at least 1 to 2 inches away from the forehead, and power should be limited to no more than 7 watts.

The ANSI standards recognize the phenomenon of whole-body or geometric resonance and establishes a frequency-dependent maximum permissible RF exposure limit for humans. Exposure levels are expressed in terms of *power density*, measured in milliwatts per square centimeter. It is a measure of the radio-frequency power that strikes a person per square centimeter of body surface.

Whole-Body Resonance

Resonance occurs at frequencies for which the human body's length (height), if parallel to the antenna (vertical), is about 0.4 wavelength long. Because of the range of human heights, the resonant region spans a broad range of frequencies. This whole-body resonance establishes the frequency range for the most stringent (lowest) permissible exposure level. Figure 8-18 shows that the lowest maximum exposure level is 1 mW/cm^2 for frequencies between 30 and 300 MHz. The frequencies in this range cause the greatest potential risk for human beings. RF energy at these frequencies is most easily absorbed by the human body. For this reason, it's important to reattach all shielding to a VHF amplifier after you've adjusted it. If it's turned on before all the shielding is in place, you could be exposed to dangerous amounts of RF energy.

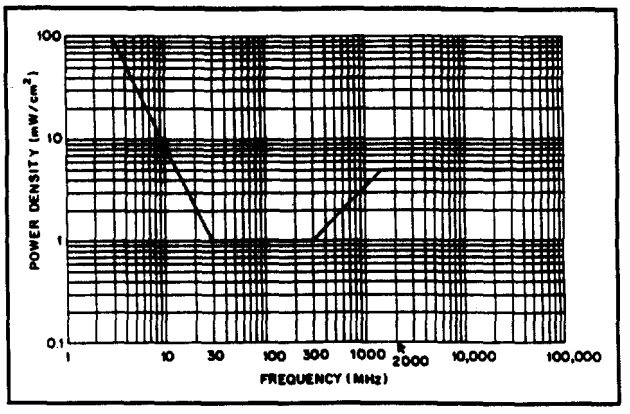


Figure 8-18—American National Standards Institute Radio Frequency Protection Guide for whole-body exposure of human beings.

On either side of those "corner" frequencies the rise is gradual. At 3 MHz the maximum permissible exposure level is 100 mW/cm^2; at 1500 MHz and above, 5 mW/cm^2. The valley region includes some active amateur bands (10, 6 and 2 meters) as well as all FM and TV broadcasting. The rationale for specifying a constant 5 mW/cm^2 above 1500 MHz takes into consideration that the extremely short wavelengths don't penetrate very deep into body tissue.

[This completes your study of Chapter 8. Now turn to Chapter 13 and study questions T4D09 through T4D16. Review the material in this section if you have any difficulty with these questions.]

T4D06
(A)
Page 8-17

T4D06
What minimum rating should a dummy antenna have for use with a 100-watt single-sideband phone transmitter?
A. 100 watts continuous
B. 141 watts continuous
C. 175 watts continuous
D. 200 watts continuous

T4D07
(D)
Page 8-17

T4D07
Why might a dummy antenna get warm when in use?
A. Because it stores electric current
B. Because it stores radio waves
C. Because it absorbs static electricity
D. Because it changes RF energy into heat

T4D08
(A)
Page 8-18

T4D08
What is used to measure relative signal strength in a receiver?
A. An S meter
B. An RST meter
C. A signal deviation meter
D. An SSB meter

T4D09
(B)
Page 8-19

T4D09
How can exposure to a large amount of RF energy affect body tissue?
A. It causes radiation poisoning
B. It heats the tissue
C. It paralyzes the tissue
D. It produces genetic changes in the tissue

T4D10
(A)
Page 8-20

T4D10
Which body organ is the most likely to be damaged from the heating effects of RF radiation?
A. Eyes
B. Hands
C. Heart
D. Liver

T4D11
(D)
Page 8-20

T4D11
What organization has published safety guidelines for the maximum limits of RF energy near the human body?
A. The Institute of Electrical and Electronics Engineers (IEEE)
B. The Federal Communications Commission (FCC)
C. The Environmental Protection Agency (EPA)
D. The American National Standards Institute (ANSI)

T4D12
(B)
Page 8-20

T4D12
What is the purpose of the ANSI RF protection guide?
A. It lists all RF frequency allocations for interference protection
B. It gives RF exposure limits for the human body
C. It sets transmitter power limits for interference protection
D. It sets antenna height limits for aircraft protection

T4D13
According to the ANSI RF protection guide, what frequencies cause us the greatest risk from RF energy?
A. 3 to 30 MHz
B. 300 to 3000 MHz
C. Above 1500 MHz
D. 30 to 300 MHz

T4D13
(D)
Page 8-20

T4D14
Why is the limit of exposure to RF the lowest in the frequency range of 30 MHz to 300 MHz, according to the ANSI RF protection guide?
A. There are more transmitters operating in this range
B. There are fewer transmitters operating in this range
C. Most transmissions in this range are for a longer time
D. The human body absorbs RF energy the most in this range

T4D14
(D)
Page 8-20

T4D15
According to the ANSI RF protection guide, what is the maximum safe power output to the antenna of a hand-held VHF or UHF radio?
A. 125 milliwatts
B. 7 watts
C. 10 watts
D. 25 watts

T4D15
(B)
Page 8-20

T4D16
After you have opened a VHF power amplifier to make internal tuning adjustments, what should you do before you turn the amplifier on?
A. Remove all amplifier shielding to ensure maximum cooling
B. Make sure that the power interlock switch is bypassed so you can test the amplifier
C. Be certain all amplifier shielding is fastened in place
D. Be certain no antenna is attached so that you will not cause any interference

T4D16
(C)
Page 8-20

SUBELEMENT T5—ELECTRICAL PRINCIPLES
[2 exam questions—2 groups]

Subelement T5

T5A Definition of resistance, inductance, and capacitance and unit of measurement, calculation of values in series and parallel.

T5A01
What does resistance do in an electric circuit?
A. It stores energy in a magnetic field
B. It stores energy in an electric field
C. It provides electrons by a chemical reaction
D. It opposes the flow of electrons

T5A01
(D)
Page 3-9

T5A02
What is the ability to store energy in a magnetic field called?
A. Admittance
B. Capacitance
C. Resistance
D. Inductance

T5A02
(D)
Page 3-19