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Before the
FEDERAL COMMUNICATIONS COMMISSION FCC 96-326
Washington, D.C. 20554

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

REPORT AND ORDER

Adopted: August 1, 1996 ; Released: August 1, 1996

By the Commission: Commissioners Quello and Chong issuing a joint statement.

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I. INTRODUCTION

1. By this action, we are amending our rules to adopt new guidelines and methods for evaluating the environmental effects of radiofrequency (RF) radiation from FCC-regulated transmitters. We are adopting Maximum Permissible Exposure (MPE) limits for electric and magnetic field strength and power density for transmitters operating at frequencies from 300 kHz to 100 GHz.[1] We are also adopting limits for localized ("partial body") absorption that will apply to certain portable transmitting devices.[2] We believe that the guidelines we are adopting will protect the public and workers from exposure to potentially harmful RF fields.

2. In reaching our decision on the adoption of new RF exposure guidelines we have carefully considered the large number of comments submitted in this proceeding, and particularly those submitted by the U.S. Environmental Protection Agency (EPA), the Food and Drug Administration (FDA) and other federal health and safety agencies. The new guidelines we are adopting are based substantially on the recommendations of those agencies, and we believe that these guidelines represent a consensus view of the federal agencies responsible for matters relating to the public safety and health.[3]

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[1] Specifically, we are adopting limits for field strength and power density that are generally based on Sections 17.4.1 and 17.4.2, and the time-averaging provisions recommended in Sections 17.4.1.1 and 17.4.3, of "Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," NCRP Report No. 86 (1986), National Council on Radiation Protection and Measurements (NCRP). With the exception of the limits on exposure to power density above 1500 MHz and the limits for exposure to lower frequency magnetic fields, these MPE limits are also generally based on the guidelines contained in the RF safety standard developed by the Institute of Electrical and Electronic Engineers, Inc. (IEEE) and adopted by the American National Standards Institute (ANSI). See Section 4.1 of ANSI/IEEE C95.1-1992, "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz".

[2] These guidelines are based on those recommended by ANSI/IEEE and NCRP. See Sections 4.2.1 and 4.2.2 of ANSI/IEEE C95.1-1992 and Section 17.4.5 of NCRP Report No. 86.

[3] For example, see letter from Carol M. Browner, Administrator, U.S. Environmental Protection Agency, to Reed. E. Hundt, Chairman, FCC, dated July 25, 1996; and letter from Elizabeth D. Jacobson, Ph.D., Deputy Director for Science, Center for Devices and Radiological Health, Food and Drug Administration, to Richard M. Smith, Chief, Office of Engineering and Technology, FCC, dated July 17, 1996. Both letters have been placed into the docket

3. The MPE limits adopted herein are based on exposure criteria quantified in terms of specific absorption rate (SAR), a measure of the rate of RF energy absorption. The basis for these limits, as well as the basis for the 1982 ANSI limits that the Commission previously specified in our rules, is an SAR limit of 4 watts per kilogram. The new MPE limits are derived by incorporating safety factors that lead, in some cases, to limits that are more conservative than the limits specified by ANSI in 1982. The more conservative limits do not arise from a fundamental change in the RF safety criteria for SAR, but from a precautionary desire for more rigor in the derivation of factors which allow limits for MPE to be derived from SAR limits.

4. This action satisfies the requirements of the Telecommunications Act of 1996 for a timely resolution of this proceeding.[4] We note that research and analysis relating to RF safety and health is ongoing, and we expect changes in recommended exposure limits will occur in the future as knowledge increases in this field. In that regard, we intend to continue our cooperative work with industry and with the various agencies and organizations with responsibilities in this area in order to ensure that our guidelines continue to be appropriate and scientifically valid.

II. BACKGROUND

5. The National Environmental Policy Act of 1969 (NEPA) requires agencies of the Federal Government to evaluate the effects of their actions on the quality of the human environment.[5] To meet its responsibilities under NEPA, the Commission has adopted requirements for evaluating the environmental impact of its actions.[6] One of several environmental factors addressed by these requirements is human exposure to RF energy emitted by FCC-regulated transmitters and facilities.

6. In 1985, the Commission adopted a 1982 ANSI standard for use in evaluating the effects of RF radiation on the environment, noting that the ANSI standard was widely accepted

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record as ex parte filings in this proceeding.

[4] The Telecommunications Act of 1996, which was enacted on February 8, 1996, requires that: "Within 180 days after the enactment of this Act, the Commission shall complete action in ET Docket 93-62 to prescribe and make effective rules regarding the environmental effects of radio frequency emissions." See Section 704(b) of the Telecommunications Act of 1996, Pub. L. No. 104-104, 110 Stat. 56 (1996).

[5] National Environmental Policy Act of 1969, 42 U.S.C. Section 4321, et seq.

[6] See 47 CFR § 1.1301, et seq.

and was technically and scientifically supportable.[7] Since then the Commission has used this standard as its processing guideline for determining the potential environmental impact of RF emissions. The rules now require applicants for certain facilities to prepare an Environmental Assessment (EA) if the transmitter or facility under consideration could expose the general public or workers to levels of RF radiation that are in excess of the 1982 ANSI guidelines.[8] Examples of facilities that could potentially cause exposures in excess of these guidelines because of their relatively high operating power include radio and television broadcast stations and satellite uplink facilities. The rules also address other related matters, such as the evaluation of sites with multiple transmitters.

7. The Commission has "categorically excluded" many low-power, intermittent, or normally inaccessible RF transmitters and facilities from routine evaluation for RF radiation exposure based on calculations and measurement data indicating that they would not cause exposures in excess of the guidelines under normal and routine conditions of use.[9] Examples of currently excluded transmitters include land mobile, cellular and amateur radio stations.

8. In 1992, ANSI adopted a new standard for RF exposure, designated ANSI/IEEE C95.1-1992 to replace its 1982 standard.[10] This new standard contains a number of significant differences from the 1982 ANSI standard. In some respects, the 1992 ANSI/IEEE standard is more restrictive in the amount of environmental RF exposure permitted, although for some situations recommended MPE levels are similar to the 1982 limits. The 1992 ANSI/IEEE standard also extends the frequency range under consideration to cover frequencies from 3 kHz to 300 GHz.[11] The 1992 ANSI/IEEE standard specifies two tiers of exposure criteria, one tier for "controlled environments" (usually involving workers) and another, more stringent tier, for

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[7] See Report and Order, GEN Docket No. 79-144, 100 FCC 2d 543 (1985); Memorandum Opinion and Order, 58 RR 2d 1128 (1985); see also ANSI C95.1-1982, "American National Standard Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 300 kHz to 100 GHz," ANSI, New York, NY.

[8] 47 CFR Section 1.1307(b)

[9] See Second Report and Order, GEN Docket No. 79-144, 2 FCC Rcd 2064 (1987); Erratum, 2 FCC Rcd 2526 (1987). Facilities that are otherwise categorically excluded from RF environmental evaluation may still be required, on a case-by-case basis, to undergo evaluation pursuant to the provisions of 47 CFR § 1.1307(c) and (d). The Council on Environmental Quality, which has oversight responsibility with regard to NEPA, permits Federal agencies to categorically exclude certain actions from routine environmental processing when the potential for individual or cumulative environmental impact is judged to be negligible. See 40 CFR §§ 1507, 1508.4; see also Regulations for Implementing the Procedural Provisions of NEPA, 43 Fed Reg. 55,978 (1978).

[10] ANSI/IEEE C95.1-1992, "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz."

[11] The 1982 ANSI guidelines cover the frequency range 300 kHz to 100 GHz.

"uncontrolled environments" (usually involving the general public). The 1982 ANSI standard specified only one set of exposure limits, regardless of whether the individual exposed was a worker or a member of the general public. The 1992 ANSI/IEEE standard also, for the first time, includes specific restrictions on currents induced in the human body by RF fields. These restrictions apply to both "induced" currents and "contact" currents related to shock and burn hazards.

9. The 1992 ANSI standard is generally more stringent in the evaluation of low-power devices, such as hand-held radios and cellular telephones, than the 1982 standard. That is, the 1982 ANSI standard permitted exclusion from compliance with the MPE limits if the localized specific absorption rate (SAR) of a low-power device could be shown to be 8 watts/kilogram (8 W/kg) or less, or if the input power of the radiating device at frequencies between 300 kHz and 1 GHz was 7 watts or less.[12] The 1992 guidelines reduce the allowable localized SAR level for devices operating in "uncontrolled" environments by a factor of five to 1.6 W/kg, while maintaining the 8 W/kg limit for "controlled" environments. Further, the exclusion thresholds based on operating power are significantly reduced for devices that operate in uncontrolled environments and for devices that operate above 450 MHz in controlled environments. The 1992 ANSI/IEEE standard also prohibits the application of the power exclusion to hand-held devices where the radiating structure is maintained less than 2.5 centimeters (cm) from the body of the user.

10. On April 8, 1993, we issued the Notice in this proceeding to consider amending and updating the guidelines and methods used by the Commission for evaluating the environmental effects of RF radiation.[13] In the Notice, we proposed to base our RF safety regulations on the ANSI/IEEE C95.1-1992 standard instead of the 1982 ANSI standard. The major issues addressed in the Notice were: 1) the selection of the appropriate RF exposure standard; 2) use of the 1992 ANSI/IEEE definitions for "controlled" and "uncontrolled" environments to determine application of exposure criteria; 3) implementation of new limits on induced and contact currents; 4) evaluation of low-power devices such as cellular telephones; 5) categorical exclusions from environmental evaluation for certain transmitters; 6) compliance and measurement issues; and 7) administrative procedures and effective dates for implementation.

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[12] Specific absorption rate is a measure of the rate of energy absorption by the body. SAR levels are specified for both whole-body exposure and for partial-body or localized exposure (generally specified in terms of spatial peak values), such as might occur to the head of the user of a hand-held radiotelephone.

[13] See Notice of Proposed Rule Making, ET Docket No. 93-62, 8 FCC Rcd 2849 (1993); see also 8 FCC Rcd 5528 (1993), 9 FCC Rcd 985 (1993), 9 FCC Rcd 317 (1994), 9 FCC Rcd 989 (1994) extending the comment deadlines.

11. More than 100 parties, including telecommunications organizations, other Federal Government agencies, local and state authorities, and individuals, submitted comments in response to the Notice. Many of these parties filed extensive comments addressing the various issues discussed above. In addition, a significant number of parties addressed the issue of Federal preemption of state and local regulations for RF exposure A list of commenting parties is provided in Appendix D

III. DISCUSSION

A. New RF Exposure Guidelines

12. In the Notice, we noted that the 1992 ANSI/IEEE standard reflects recent scientific studies of the biological effects of RF radiation and that use of this standard would thus ensure that FCC-regulated facilities comply with the latest safety guidelines for RF exposure.[14] We also noted that other RF exposure criteria are available, such as those of the National Council on Radiation Protection and Measurements (NCRP) and those of the International Radiation Protection Association (IRPA).[15] We requested comment on whether the differences between these other guidelines and the 1992 ANSI/IEEE guidelines are significant, and whether it would be appropriate to adopt limits for RF exposure that differ from those in the 1992 ANSI/IEEE guidelines.

13. The comments filed in this proceeding have focused primarily on the 1992 ANSI/IEEE and NCRP exposure criteria. In many ways, these two sets of exposure guidelines are similar. Both organizations identify the same threshold level at which harmful biological effects may occur, and the MPE limits recommended for electric and magnetic field strength and power density in both documents are based on this threshold level.[16] Both the 1992 ANSI/IEEE and NCRP guidelines also are frequency dependent, based on knowledge of how whole-body-

[14] The ANSI/IEEE standard was developed by the IEEE Standards Coordinating Committee 28 on Non-Ionizing Radiation Hazards (IEEE SCC28) and subsequently adopted by the IEEE Standards Board and the American National Standards Institute.

[15] Notice at para. 23. The NCRP is a non-profit corporation chartered by Congress to develop information and recommendations concerning radiation protection. NCRP consists of the members and participants who serve on its various scientific committees. Several government agencies and non-government organizations have established relationships with NCRP as "Collaborating Organizations." The FCC is one of these Collaborating Organizations.

[16] Both the ANSI/IEEE and NCRP exposure criteria are based on a determination that potentially harmful biological effects can occur at an SAR level of 4 W/kg as averaged over the whole-body. Appropriate safety factors were then added to arrive at limits for both whole-body exposure (0.4 W/kg for "controlled" or "occupational" exposure and 0.08 W/kg for "uncontrolled" or "general population" exposure, respectively) and for partial-body (localized SAR), such as might occur in the head of the user of a hand-held cellular telephone.

averaged human exposure is a function of the frequency of the RF signal. Further, both ANSI/IEEE and NCRP recommend two exposure tiers, one for "controlled environments" (ANSI/IEEE) or "occupational exposure" (NCRP) and another, more stringent, tier for "uncontrolled environments" (ANSI/IEEE) or "general population" exposure (NCRP). Tables 1, 2 and 3 in Appendix B show the MPE limits for the 1982 ANSI, 1992 ANSI/IEEE and NCRP exposure criteria, respectively.

14. The two sets of guidelines, however, do differ in some respects. The NCRP MPE limits are generally more stringent than the ANSI/IEEE limits for magnetic field strength at frequencies below 3 MHz and for power density at frequencies above 1500 MHz.[17] The NCRP guidelines also include a unique provision (that we are not adopting here) that reduces the exposure limit for workers with respect to certain forms of modulated RF carrier frequencies.[18] The NCRP guidelines specify that the general population MPE limits at higher frequencies are to be averaged over longer periods of time than those recommended by the ANSI/IEEE guidelines.[19] The NCRP, unlike ANSI/IEEE, only specifies MPE limits for frequencies up to 100 GHz. With respect to evaluating low-power devices, although both ANSI/IEEE and NCRP generally recommend the same localized SAR limits, ANSI/IEEE also includes an exclusion clause based on radiated power that is not a part of the NCRP guidelines. Although the ANSI/IEEE and NCRP guidelines differ at higher and lower frequencies, at frequencies used by the majority of FCC licensees the MPE limits are essentially the same regardless of whether ANSI/IEEE or NCRP guidelines are used. Therefore, the overall impact on most of our licensees from our adoption of new guidelines should not be significantly different regardless of which limits we choose.

15. Several federal agencies filed comments in this proceeding expressing varying viewpoints on whether we should adopt the ANSI/IEEE guidelines or some alternative. Within the Federal Government, the EPA is generally responsible for investigating and making recommendations with regard to environmental issues. In its comments, the EPA states that the new ANSI/IEEE guidelines are a significant revision of the 1982 ANSI guidelines and notes that

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[17] For example, in uncontrolled environments the 1992 ANSI/IEEE guidelines recommend a safe power density level of 1 mW/cm^2 at 1500 MHz increasing to a maximum of 10 mW/cm^2 at 15 GHz to 300 GHz, a significant change from the 1982 ANSI standard. The NCRP guidelines specify a fixed level of 1 mW/cm^2 for exposure of the general public at frequencies above 1500 MHz. NCRP limits for magnetic field exposure are also generally more stringent for frequencies below 100 MHz.

[18] This provision recommends that the stricter public exposure limits apply where workers are exposed to electromagnetic fields with carrier frequencies that are modulated at a depth of 50 percent or greater at frequencies between 3 and 100 hertz. See NCRP, supra, Section 17.4.

[19] For measuring MPE levels, the NCRP guidelines use an averaging time of 6 minutes for occupational exposure and 30 minutes for public exposure. For frequencies above 15 GHz, the ANSI/IEEE guidelines reduce this averaging time in a manner that is inversely proportional to the frequency raised to the 1.2 power.

certain aspects of the new guidelines are improvements with regard to protection.[20] However, the EPA submits that some of the provisions of the new ANSI/IEEE guidelines are not acceptable. For example, EPA does not support the relaxation in MPE limits for power density at higher microwave frequencies, and it opposes the application of the same exposure limits to both controlled and uncontrolled environments for frequencies from 15 GHz to 300 GHz. The EPA states that the ANSI/IEEE exposure limits for these frequencies are not sufficiently protective for public exposure. The EPA also argues that the terms controlled and uncontrolled environments used in the ANSI/IEEE guidelines are not well defined and are not directly applicable to any specific population group.

16. The EPA recommends that we adopt the NCRP's recommended MPE limits along with sections of the 1992 ANSI/IEEE guidelines dealing with localized exposure and induced and contact body currents. In terms of MPEs for power density and field strength, the EPA argues that the NCRP guidelines would better protect the public from potential long term effects of RF exposure at higher microwave frequencies where the two sets of guidelines differ. The EPA maintains that, "[t]here are no substantive differences in the literature base supporting 1986 NCRP and 1992 ANSI/IEEE except for the literature on RF shocks and burns." In addition, the EPA notes that NCRP is chartered by the U.S. Congress to develop radiation protection recommendations.

17. The EPA generally supports the use of the ANSI/IEEE limits for dealing with induced and contact currents to protect against shock and burn hazards. EPA states that those guidelines are not included in the NCRP exposure criteria, and they are a result of research and knowledge acquired since development of the NCRP recommendations. The EPA also supports the FCC proposal to use ANSI/IEEE SAR limits that apply to low-power devices such as cellular telephones (see discussion below). These values are similar to those recommended by the NCRP.

18. The FDA has general jurisdiction for protecting the public from potentially harmful radiation from consumer and industrial devices and in that capacity is expert in RF exposures that would result from consumer or industrial use of hand-held devices such as cellular telephones.[21] The FDA generally supports our proposed use of the 1992 ANSI/IEEE guidelines, although it does express some reservations. It states that these guidelines will provide a greater level of protection to the general public, and it particularly supports use of the values for SAR that would apply to consumer and industrial devices. As discussed below, however, the FDA expresses significant concern about the radiated power exclusion clause included in the ANSI/IEEE standard that would apply to some hand-held devices.[22]

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[20] EPA Comments at 1

[21] See 21 CFR § 1000 et seq.

[22] FDA Comments at 1

19. The National Institute for Occupational Safety and Health (NIOSH), an agency of the U. S. Department of Health and Human Services, is responsible for performing research and analysis with respect to worker safety and health. In its comments, NIOSH expresses general support for our efforts to update our RF exposure regulations and notes that the MPE limits defined in the 1992 ANSI/IEEE guidelines are similar to those contained in recommendations of the NCRP and the International Radiation Protection Association.[23] NIOSH states that we should take a more conservative approach when uncertainty exists with respect to applying certain features of the exposure guidelines. In particular, NIOSH agrees with the EPA that it would be more appropriate to use the MPE limits recommended by NCRP guidelines at higher frequencies. NIOSH also supports the use of the ANSI/IEEE limits on induced RF currents.

20. The Occupational Safety and Health Administration (OSHA) has jurisdiction over Federal regulations dealing with worker safety and health. In its comments, OSHA generally endorses our proposal to update our RF exposure guidelines by adopting the new ANSI/IEEE guidelines.[24] OSHA also urges us to require applicants to implement a written RF exposure protection program which appropriately addresses traditional safety and health program elements including training, medical monitoring, protective procedures and engineering controls, signs, hazard assessments, employee involvement, and designated responsibilities for program implementation. It notes that the exposure limits in the ANSI/IEEE guidelines may be useful in determining when specific elements of an RF safety program should be implemented. However, OSHA objects to the two categories of exposure environments contained in the new ANSI/IEEE standard, finding it unacceptable that employees may be subjected to a higher level of risk than the general public simply because they "are aware of the potential for exposure as a concomitant of employment." Rather, OSHA proposes that we adopt the uncontrolled environment criteria as an "action limit" which determines when an RF protection program will be required. That is, under OSHA's proposal, persons who are exposed in excess of the limits specified for uncontrolled environments would be protected by a program designed to mitigate any potential increase in risk.

21. The majority of industry comments favor adoption of the 1992 ANSI/IEEE guidelines. For example, American Personal Communications (APC), American Telephone and Telegraph Company (AT&T), Electromagnetic Energy Policy Alliance (EEPA), Ericsson Corporation (Ericsson), McCaw Cellular Communications, Inc. (McCaw), National Association of Broadcasters (NAB), Telecommunications Industry Association (TIA), and others urge that we adopt the new ANSI/IEEE guidelines, arguing that they represent the most up-to-date standard available. Telocator (now the Personal Communications Industry Association, PCIA) agrees that

[23] NIOSH Comments at 1

[24] OSHA Reply Comments at 1.

the ANSI/IEEE standard is the most recent and comprehensive RF exposure guideline, noting that an international committee of over 120 scientists and engineers was involved in its drafting. However, Telocator submits that the actual impact of the ANSI/IEEE, NCRP or IRPA standards would be about the same on Personal Communications Service (PCS) operations, since all three standards are based on the same specific absorption rates, and the power densities each provides for the PCS band are essentially the same.[25]

22. AT&T submits that the new ANSI/IEEE standard agrees with the latest proposals for controlled environments issued by the American Conference of Governmental Industrial Hygienists.[26] AT&T also states that the members of the IEEE committee that developed the new guidelines represent a larger and more complete group of experts than those who developed other guidelines, such as the NCRP and the IRPA guidelines. TIA notes that the IEEE committee represents the most competent and expert scientists and specialists in the world in the area of RF biological effects.[27] McCaw also states that the ANSI/IEEE standard incorporates substantial safety factors and addresses all of the environmentally significant aspects of RF exposure.[28]

23. NAB recommends that we adopt the new ANSI/IEEE guidelines and provide procedures and guidance for its application. NAB submits that there is substantial agreement among the available standards with respect to exposure limits in the 30 to 300 MHz range.[29] It also states that where the standards differ at extreme frequencies, the ANSI/IEEE standard should be followed, since it is based on more recent scientific information. For example, NAB notes that while there are differences between the ANSI/IEEE standard and the NCRP guidelines at lower frequencies, these differences lie in the MPE limits for the magnetic field. It states that in developing the NCRP guidelines, the magnetic field strength limit was merely made equal to the electric field strength limit and that the electric field strength was capped at a value of 614 volts per meter because of shock and burn considerations. NAB contends that such a value should not apply to the magnetic field strength, since high magnetic fields are not associated with shock or burn. Consequently, NAB argues that the limits contained in the ANSI/IEEE standard, which are based on limiting the SAR of the magnetic field, are more scientifically correct.

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[25] Telocator Comments at 3

[26] AT&T Comments at 6

[27] TIA Comments at 27

[28] McCaw Comments at 3

[29] NAB compared the ANSI/IEEE standard to standards of NCRP, IRPA, and the American Conference of Governmental Industrial Hygienists (ACGIH). NAB Comments at 32-33.

24. Jules Cohen & Associates (JC&A) argues that although the ANSI/IEEE exposure limits are at some points less restrictive than the NCRP limits, the averaging times must also be taken into consideration.[30] JC&A states that skin burning is the applicable consideration at higher microwave frequencies. JC&A, therefore, submits that the new ANSI/IEEE limits represent a better standard because at frequencies above 3 GHz the lower averaging times recommended allow much less energy absorption than the NCRP guidelines. EEPA argues that the ANSI/IEEE limits for higher frequencies above 15 GHz are appropriate and consistent with "well-established biologically based" national and international limits for infrared lasers.[31] EEPA and NAB note that at 300 GHz the MPE limits contained in the 1992 ANSI/IEEE standard are the same as the MPE limits in ANSI Z136.1-1993 and the International Electrotechnical Commission (IEC) laser standard, and that all three standards use the same 10-second averaging time.[32] EEPA also states that the six-minute averaging time recommended by the NCRP guidelines is not sufficiently short to protect against skin burning for exposure to short pulses at higher frequencies where most of the energy is deposited in surface layers of tissue

25. JC&A, EEPA, Ericsson, Motorola, Raytheon Company (Raytheon), and TIA argue that there is no scientific evidence to support the modulation provisions contained in the NCRP guidelines.[33] JC&A contends that this requirement has no practical application because broadcast transmitters are not modulated at these frequencies at a depth of 50 percent or greater except for very short intervals. Therefore, JC&A concludes that circumstances would not arise that would call for application of this stricter standard in a controlled environment.[34] EEPA notes that no other standard-setting organization in the United States or in other countries regards modulation considerations as a meaningful issue. Ericsson claims that the IEEE committee looked at the issue of modulation effects at frequencies between 3 and 100 Hz and concluded that there is no scientific data to support the modulation provisions in NCRP's guidelines.[35] Similarly, Motorola states that there is insufficient scientific data upon which to base regulations for amplitude-modulated radio signals. Motorola recommends that we monitor any relevant biological research

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[30] JC&A Comments at 8

[31] EEPA Comments at 8 See also, NAB Comments at 54

[32] (1) American National Standard for the Safe Use of Lasers, ANSI Z136.1-1993, American National Standards Institute, New York, N.Y. (1993). (2) Radiation Safety of Laser Products, Equipment Classification, Requirements and User's Guide, Publication 825, International Electrotechnical Commission, Geneva, Switzerland (1993).

[33] As noted above, the NCRP guidelines require use of the general population exposure limits, even for the workplace, if the exposure is to carrier waves modulated at a depth of 50 percent or greater at frequencies between 3 and 100 Hz.

[34] JC&A Comments at 9

[35] Ericsson Comments at 12.

on this type of modulation and take appropriate regulatory action as warranted in the future.[36] Raytheon and TIA point out that studies over the last several years observed that within the recommended safe exposure levels, no reliable scientific data exists which indicates that modulation of the electromagnetic fields is a factor meaningfully related to human health.[37]

26. The IEEE's Standards Coordinating Committee 28 (IEEE/SCC28), which developed the ANSI/IEEE guidelines, took issue with several of the points made by the EPA. IEEE/SCC28 states that the new guidelines and the NCRP recommendations are actually quite similar, with the exception of the MPEs at higher microwave frequencies. In addition, it points out that both the ANSI/IEEE and the NCRP guidelines are based on the use of SAR as the fundamental dosimetric parameter, the same criterion for biological effect (behavioral disruption), and the same safety factors to define the two tiers of exposure.[38]

27. In comments filed late in this proceeding, Dr. Arthur W. Guy, former Chairman of both ANSI/IEEE and NCRP committees on RF exposure expresses his view that, "it would be a mistake for the FCC to adopt the older 1986 NCRP standard at this time considering the fact that newer and more advanced standards have been developed since the publication of the NCRP standard."[39] Similar views are expressed in letters submitted to the Commission by Dr. Eleanor Adair and Dr. C.K. Chou, both of whom have been involved in ANSI/IEEE and NCRP RF committees.[40] All of these individuals urge that we adopt the ANSI/IEEE standard instead of the NCRP exposure criteria.

28. Decision. Although most commenting parties generally support our proposal to adopt the 1992 ANSI/IEEE guidelines, some of the Federal agencies filing comments in this proceeding, principally those with responsibility for oversight regarding health and safety issues, object to the use of certain aspects of these guidelines. In the past, the Commission has stressed repeatedly that it is not a health and safety agency and would defer to the judgment of these

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[36] Motorola Comments at 21-22.

[37] Raytheon Comments at 2.

[38] IEEE/SCC28 Reply Comments at 1-7.

[39] See "Reply Comments of Arthur W. Guy, Ph.D.," March 9, 1996, and letter of A. W. Guy to Reed E. Hundt, Chairman, FCC, dated March 14, 1996. Both placed in the record of this proceeding as ex parte filings.

[40] See, letter from Eleanor R. Adair, Ph.D., to Reed E. Hundt, Chairman, FCC, dated March 14, 1996, and letter from C.K. Chou, Ph.D., to Thomas P. Stanley, Chief Engineer, FCC, dated March 20, 1996.

expert agencies with respect to determining appropriate levels of safe exposure to RF energy.[41] We continue to believe that we must place special emphasis on the recommendations and comments of Federal health and safety agencies because of their expertise and their responsibilities with regard to health and safety matters. Accordingly, as recommended by the EPA, we are adopting exposure limits for field strength and power density based on those recommended by the NCRP for frequencies from 300 kHz to 100 GHz (see Appendix C). As noted previously, over a wide frequency range these limits are also based on those recommended in the ANSI/IEEE 1992 standard.[42] We believe that the exposure criteria we are adopting will protect workers and the general public from potentially harmful RF emissions due to FCC-regulated transmitters.

29. We recognize that the NCRP guidelines do not address exposure at frequencies below 300 kHz or above 100 GHz, as do the ANSI/IEEE guidelines. However, the FCC-regulated transmitters of concern operate at frequencies between 300 kHz and 100 GHz. Therefore, we see no need at this time to adopt guidelines for frequencies outside of the range of the NCRP recommendations.

30. We appreciate the concerns raised by NAB with respect to NCRP guidelines for low-frequency magnetic-field exposure, and we recognize that the NCRP guidelines may be conservative for frequencies below 100 MHz. However, compliance with these limits would appear to be an issue only in occupational situations, e.g., in the immediate vicinity of an AM broadcast transmitter; and, there is nothing in the record to indicate that significant problems exist with respect to compliance with these magnetic field limits in the workplace.

31. We also recognize the merit of arguments as to whether, at the higher microwave frequencies, incorporating different time-averaging values, such as those specified by the ANSI/IEEE guidelines may be desirable. As discussed by JC&A, IEEE/SCC28 and others, the level of energy density allowed by the 1992 ANSI/IEEE guidelines can actually be more restrictive at higher frequencies than the NCRP guidelines when time-averaging is considered. For frequencies above 3 GHz (uncontrolled) and 15 GHz (controlled) the ANSI/IEEE time-averaging values are less than those of NCRP, and they continue to decrease at higher frequencies. Because of the lengthier NCRP averaging times at these frequencies, very short exposures at very high power densities might comply with NCRP limits as long as they are followed by insignificant exposures for the duration of the time-averaging interval. In that sense,

[41] See, e.g., Report and Order, GEN Docket 79-144, at para. 26 note 6 supra. See also, letter from Mark S. Fowler, Chairman, FCC, to Anne M. Burford, Administrator, EPA, February 22, 1983; letter from Dennis R. Patrick, Chairman, FCC, to Lee M. Thomas, Administrator, EPA, November 29, 1988; and letter from Thomas P. Stanley, Chief Engineer, FCC, to Ken Sexton, Director, Office of Health Research, Office of Research and Development, EPA, October 24, 1990

[42] See note 1, supra

ANSI/IEEE could be viewed as affording a greater degree of protection from skin burning at the higher microwave frequencies. However, we are not aware of any practical situations involving FCC-regulated transmitting facilities where such exposures are likely to occur. Of far greater significance, we believe, is the case of a consumer-product without any identifiable usage pattern, where continuous exposure would have to be assumed and time-averaging would not be relevant.

32. We agree with those commenters who maintain that there is insufficient evidence to give special consideration to modulation effects at this time. Since we have no specific indication of exposure hazards related to modulation caused by FCC-regulated transmitters, we believe it would be premature at this time to adopt the NCRP modulation criteria.

33. We believe that OSHA's suggestion that we use the uncontrolled exposure tier of the ANSI/IEEE standard as the basis for an "action limit" for establishment of an RF safety program is beyond the scope of our jurisdiction. Our NEPA responsibilities do not appear to encompass the issuance of specific rules on workplace practices and procedures. If such a policy were to be instituted by the Federal Government it would seem more appropriate for OSHA itself to promulgate this type of rule

34. Both the IEEE and the NCRP have committees that are working on revisions of their respective exposure guidelines. We encourage these organizations and other similar groups developing exposure criteria to work together, along with the relevant federal agencies, to develop consistent, harmonized guidelines that will address the concerns and issues raised in this proceeding. We will consider amending our rules at any appropriate time if these groups conclude that such action is desirable.

B. Definitions of Controlled and Uncontrolled Environments

35. The 1992 ANSI/IEEE guidelines specify two sets of exposure limits based on the "environment" in which the exposure takes place.[45] These environments are classified as either "controlled" or "uncontrolled." Controlled environments are defined as locations where "there is exposure that may be incurred by persons who are aware of the potential for exposure as a concomitant of employment, by other cognizant persons, or as the incidental result of transient passage through areas where analysis shows the exposure levels may be above [the exposure and induced current levels permitted for uncontrolled environment but not those permitted for controlled environments]." Uncontrolled environments are defined as "locations where there is the exposure of individuals who have no knowledge or control of their exposure. The exposures may occur in living quarters or workplaces where there are no expectations that the exposure levels may exceed [the exposure and induced current levels permitted for uncontrolled

[45] The 1982 ANSI guidelines contain a single level of MPE limits and do not differentiate based on environment.

environments]." The NCRP designates exposure limits in terms of "occupational" and "general population" exposure. However, the NCRP report does not provide specific definitions of these terms.

36. In the Notice, we requested comment on the criteria to be used in determining which set of exposure limits would apply to the various situations that would be subject to environmental analysis and whether the definitions of controlled and uncontrolled environments used in the ANSI/IEEE guidelines were practical and supportable for the Commission's purposes. We stated that because matters of possible health and safety are involved, a conservative approach would be appropriate. Accordingly, we proposed to provide that where there is any question of possible exposure of the general public, the more stringent guidelines for uncontrolled environments would apply. We also specifically stated that the guidelines for uncontrolled environments would apply to any transmitter or facility located in a residential area where proximity to the transmitter is unrestricted. On the other hand, we indicated that controlled environment limits would apply to situations where exposure is incidental and transitory or where exposure is incurred when individuals are aware of the exposure potential.

37. Most parties support the use of a two-tier RF exposure standard and the ANSI/IEEE definitions for "controlled environment" and "uncontrolled environment." In general, these parties support applying the ANSI/IEEE definition for uncontrolled environment to those transmitters and facilities in residential areas or locations with unrestricted access. They suggest that the controlled environment should apply to incidental and transitory exposure and in areas where people are aware of potential exposure through warning signs and instructions. The Land Mobile Communication Council (LMCC), NAB, and others propose that the distinction between the two environments be based on the context of the equipment's use and types of communication operations being performed. They argue that the controlled standards should be applied when the equipment is used in a commercial or business setting where the operator is "knowledgeable" in the use of his/her equipment. They state that the uncontrolled standard should apply to the general public where the user or party exposed is not considered "knowledgeable" about the transmitting device and the use of those devices is incidental or personal in nature.[44]

38. JC&A and EEPA state that the ANSI/IEEE uncontrolled/controlled environment designations are less ambiguous than the terms occupational and general population used by NCRP.[45] IEEE/SCC28 states that during consideration of its standard, it explicitly rejected NCRP's occupational and general population categories on the grounds that there is no reliable scientific data indicating that certain subgroups of the population are more at risk than others.[46]

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[44] LMCC Comments at 4. NAB Comments at 2.

[45] JC&A Reply Comments at 2-3, EEPA Reply Comments at 2-3.

[46] IEEE/SCC28 Comments at 2.

On the contrary, IEEE/SCC28 maintains, the important distinction is not population type, but the nature of the exposure environment.[47]

39. A number of parties, such as Broadcast Signal Lab (BSL), Du Treil, Lundin & Rackley, Inc. (DLR), Ericsson and Sprint Cellular Company (Sprint), urge that we define these terms more completely and clearly to minimize any ambiguity in the application of these definitions. These parties argue that without clear definitions of controlled and uncontrolled environments and related terms, such as incidental or transient exposure, many locations could unnecessarily end up subject to the more stringent uncontrolled environment category. AMSC Subsidiary Corporation (AMSC), the Department of Defense (DoD), the Utilities Telecommunications Council (UTC), and others are similarly concerned that applying the more conservative uncontrolled guidelines where there is "any question of possible exposure" of the general public would frustrate the purpose of a two-tiered standard.[48] DLR argues that better definitions are needed to avoid confusion and inconsistent application of the standard and suggests defining a controlled environment as "an area which is restricted from access by all except authorized personnel . . . ."[49] Alternatively, DLR submits that we should adopt a single exposure limit based on the uncontrolled environment. E.F. Johnson Company (E.F. Johnson) states that the controlled/uncontrolled dichotomy may lead some to conclude that exposure levels appropriate in the controlled environment are dangerous and that we should specify measures to ensure that those that are expected to be aware of their environment are, in fact, aware.[50]

40. The EPA opposes use of the terms controlled and uncontrolled environments and recommends that we define exposure environments using the traditional terms of "occupational" and "general population or public" contained in the NCRP guidelines. EPA contends that its own 1984 report on the biological effects of RF radiation and the NCRP have concluded that the general population has groups of individuals particularly susceptible to heat, including the elderly, infants, pregnant women and others.[51] EPA argues that the ANSI/IEEE terms are not directly applicable to any population group and are not well defined.[52] OSHA and NIOSH do not oppose the use of the ANSI/IEEE definitions but raise questions about their application. OSHA, for example, states that employees should not be subjected to a higher level of risk as a condition

[47] See also Raytheon Comments at 1, IEEE Committee on Man and Radiation (COMAR) Comments at 1.

[48] UTC Comments at 3-4

[49] DLR Comments at 2

[50] E.F. Johnson Comments at 4-5.

[51] EPA Comments at 3

[52] EPA Comments at 3-4

of their employment just because they are made aware of the potential for exposure.[53] NIOSH states that where there is any question about exposure category, the more conservative uncontrolled criteria should be applied.[54]

41. The American Radio Relay League, Inc. (ARRL) also opposes use of the ANSI/IEEE definitions, arguing that under these definitions amateur operations would unjustly be categorized as operating in an uncontrolled environment. It suggests that there is no reason to require amateurs to meet the high safety factor below the threshold for adverse health effects that is the basis for the uncontrolled MPE limits. The ARRL indicates that the controlled environment MPE limits "should be safe for all."[55]

42. Decision. We find it appropriate to use the terms "occupational" and "general population" contained in the NCRP report. We note, however, that the NCRP report does not provide explicit definitions of these terms, and we agree with the commenting parties that we need to define these terms more completely and clearly to minimize any ambiguity in the application of the exposure limits. We believe that the ANSI/IEEE definitions for controlled and uncontrolled environments can be used as a basis for applying our use of the two exposure tiers we are adopting, while at the same time accomplishing the intent of the NCRP criteria to protect workers and the public.

43. Accordingly, "occupational/controlled" exposure, as used by the Commission, will apply to situations in which persons are exposed as a consequence of their employment and in which those persons who are exposed have been made fully aware of the potential for exposure and can exercise control over the their exposure. Occupational/controlled exposure will also apply where exposure is of a transient nature as a result of incidental passage through a location where exposure levels may be above general population/uncontrolled limits (see below), as long as the exposed person has been made fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means. We will apply the occupational/controlled exposure limits to amateur radio operators and members of their immediate household, as discussed later (see para. 162, infra).

44. "General population/uncontrolled" exposure, as used by the Commission, will apply to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or can not exercise control over their exposure. Therefore, members of the general public always fall under this category when exposure is not employment-related, as in the case of residents in

[53] OSHA Reply Comments at 1-2.

[54] NIOSH Comments at 2.

[55] ARRL Comments at 11-12.

an area near a broadcast tower. We believe that these definitions will clarify the ambiguities pointed out by many of the commenting parties and will thus ensure that the appropriate level of protection is applied in each situation. We do not agree with those parties that support applying the general population or uncontrolled limits to all situations. This approach would impose significant and unnecessary economic and technical burdens for which adequate justification has not been presented.

45. For purposes of these definitions, awareness of the potential for RF exposure can be provided through specific training as part of an RF safety program. Warning signs and labels can also be used to establish such awareness as long as they provide information, in a prominent manner, on risk of potential exposure and instructions on methods to minimize such exposure risk.[56] However, warning labels placed on low-power consumer devices such as cellular telephones will not be considered sufficient to achieve the awareness necessary to qualify these devices as operating in a controlled environment. We plan to provide further instructions on the application of these definitions in an upcoming revision of OST Bulletin No. 65 concerning compliance with RF exposure guidelines.[57]

C. Evaluation of Low-Power Devices

46. The 1992 ANSI/IEEE guidelines permit low-power devices designed to be used in the immediate vicinity of the body, such as portable and hand-held radios and telephones, to be excluded from compliance with the prescribed limits for field strength and power density provided that such devices comply with specific SAR limits or that the radiated power of the device is below a certain level.[58] "Low-power" devices include mobile transmitters such as automobile and marine radio transceivers, and hand-held portable devices such as cellular telephones and "walkie-talkie" type radios. These low-power exclusions would eliminate the need for making MPE field strength measurements in areas extremely near to the transmitting device where they may not be an appropriate measure of actual energy absorption. For low-power devices in controlled environments, SAR levels must be less than 0.4 W/kg as averaged over the whole-body, and the spatial peak SAR must be less than 8 W/kg as averaged over any 1 gram of tissue at frequencies between 100 kHz and 6 GHz. The corresponding limits for devices operated in uncontrolled environments are 0.08 W/kg for whole-body average exposure and 1.6

[56] For example, a sign warning of RF exposure risk and indicating that individuals should not remain in the area for more than a certain period of time could be acceptable.

[57] "Evaluating Compliance with FCC-Specified guidelines for Human Exposure to Radiofrequency Radiation," OST Bulletin No. 65, October 1985. OST Bulletin No. 65 will be renamed OET Bulletin No. 65 when it is released.

[58] See Notice at para. 14 ("Low-Power Devices/Exclusions). The ANSI/IEEE low-power exclusions are based on consideration of either SAR or a device's radiated power ("radiated power exclusion"). See also ANSI/IEEE C95.1-1992, clauses 4.2.1.1 and 4.2.2.1.

W/kg for spatial peak SAR. These SAR limits are also essentially the same as those recommended by the NCRP for occupational and general population exposure, respectively.[59]

47. With regard to exclusions based on radiated power, the ANSI/IEEE guidelines permit an exclusion in controlled environments if the radiated power of a device is 7 watts or less at frequencies between 100 kHz and 450 MHz. At frequencies between 450 and 1500 MHz, the radiated power is limited to 7(450/f) watts, where f is the frequency in MHz. In uncontrolled environments, the guidelines permit exclusion if the radiated power is 1.4 watts or less for frequencies between 100 kHz and 450 MHz and 1.4(450/f) watts for frequencies between 450 and 1500 MHz. The ANSI/IEEE guidelines also state that exclusions based on radiated power do not apply when the "radiating structure" of the device is within 2.5 cm of the body. The NCRP guidelines do not provide exclusions based on radiated power.

48. In the Notice, we proposed to adopt the ANSI/IEEE SAR exclusion for low-power devices for both controlled and uncontrolled environments, depending on the actual environment in which the device would be used. We also proposed to adopt the radiated power exclusion, but only for those low-power devices that meet the more conservative guidelines for uncontrolled environments. We also requested comment on whether proof of compliance should be required to be submitted as part of the equipment authorization process, and, if so, the form such a showing should take.

49. The various Federal health and safety agencies commenting in this proceeding, including the EPA, FDA, NIOSH and OSHA, generally support the SAR limits contained in the ANSI/IEEE guidelines. EPA states that these limits are similar to those recommended by the NCRP. FDA supports use of the SAR limits as they would apply to consumer and industrial devices. FDA, however, opposes the ANSI/IEEE radiated power exclusions. It argues that recently published scientific studies indicate that some hand-held radiotelephones that meet the exclusion criteria for radiated power can be used in a manner that induces SARs exceeding the 1.6 W/kg limit for uncontrolled environments.[60] Therefore, the FDA does not believe that the

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[59] See NCRP Report No. 86, Section 17.4.5. The NCRP guidelines specify that the criterion for general-population, localized exposure "should allow no more than one-fifth the levels of SAR allowed for occupational exposures [8 W/kg]," i.e., 1.6 W/kg as also recommended by ANSI/IEEE. However, the NCRP also notes that exposure of individuals in the general population who use "radio emitters" such as hand-held transceivers is permitted, "as a personal decision by the individual, provided that the devices are designed and used as designed so that the exposure of the individual does not exceed the occupational guidelines [8 W/kg] and provided that . . . the individual does not expose other persons above the population guidelines."

[60] Letter from Elizabeth D. Jacobson, Ph.D., Deputy Director for Science, Center for Devices and Radiological Health, FDA, to Richard M. Smith, Chief, Office of Engineering and Technology, FCC, December 12, 1994. According to FDA staff, primary studies of concern are: (1) N. Kuster, T. Schmid and K. Meier, "Studies of Absorption in the Extreme Near Field of Transmitters," Proceedings of VDE Meeting, Bad Nauheim, Germany, November 9-10, 1993, and (2) M. Jensen and Y. Rahmat-Samii, "EM Interaction of Handset Antennas and a Human

ANSI/IEEE guidelines for radiated power are sufficient to guarantee compliance with SAR limits. The FDA argues that all low-power devices should be certified by their manufacturers as not exceeding the local SAR limits, as determined under "realistic worst-case conditions."

50. Most other commenting parties support both the SAR and radiated power exclusions for low-power devices contained in the ANSI/IEEE guidelines. Several parties disagree with our proposal that the exclusion should apply to only those low-power devices that meet the more stringent uncontrolled radiated power guidelines. These parties generally argue that devices intended to be used in a commercial, business or public safety context should be permitted to comply with the exclusion levels for controlled environments. EEPA, LMCC, Motorola, TIA and others state that hand-held devices such as those typically used in a number of the private land mobile services should be included under the controlled environment category because such users are aware of the potential for RF exposure. Motorola and TIA argue that the controlled limits should apply to Part 90 services except Specialized Mobile Radio (SMR) and also to certain services under Parts 21, 74, 80, 94, and 95 of our rules.[61] E.F. Johnson similarly states that if workers who use communications equipment as part of their employment are provided appropriate notification of their exposure, then standards for controlled environments should be used.

51. TRW, Inc. (TRW) states that application of the uncontrolled criteria to all hand-held devices would be unnecessarily restrictive. TRW maintains that the handsets to be used with its mobile satellite service (MSS) system should be regulated under the controlled criteria, since only the MSS user will be exposed to any significant level of RF energy and there will be no danger of exposure to non-users or unaware individuals. It argues that any potential exposure could be mitigated through a combined program of consumer education and strategic design of the equipment.[62] UTC expresses the view that the ANSI/IEEE guidelines already include a wide margin of safety and that additional protective measures are not needed.

52. The Arizona Department of Public Safety (ADPS) argues that the controlled classification is essential to state governmental agencies so that they can continue to operate their existing 7 watt portable radios at frequencies below 450 MHz. ADPS states that undue hazards

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in Personal Communications," Proceedings of the IEEE, 83, pp. 7-17, January 1995.

[61] See also comments from the National Association of Business and Educational Radio, Inc. (NABER) at 3-4. NABER also urges that we consider case-by-case classifications, since not all devices can be easily classified as being applicable to either controlled or uncontrolled environments.

[62] TIA recommends that we dismiss the petition from Ken Holladay, referenced in the Notice, note 21, which requests the prohibition of all hand-held telephones and radios pending evaluation of any health risk, since the petition has met none of the Commission's clearly-enunciated requirements for petitions. To that end we are following TIA's recommendation and dismissing the Holladay petition for this reason and, also, because the Commission's adoption of rules for evaluation of health risk negates the premise for the petition.

of RF exposure from the operation of mobile and portable radio devices can be avoided by appropriate training of personnel.

53. GTE Service Corporation (GTE) maintains that Part 15 and Part 22 mobile transmitters operate at power levels that should not raise concerns under the new ANSI/IEEE standards. It points out that cellular telephones' use of "adaptive power control" provides an additional margin of safety, i.e., the telephones normally operate at a power level less than the 0.6 watt maximum in a typical urban market. According to GTE, as carriers further increase cell density to accommodate growing consumer demand, average transmit power will continue to decline.

54. The Electronic Industries Association/Consumer Electronics Group (EIA) notes that the Notice did not specify whether products that are subject to the Part 15 regulations would be subject to evaluation for compliance with the ANSI/IEEE guidelines. EIA believes that the proposed rules should not apply to intentional and unintentional radiators authorized under Part 15, including wireless video and audio distribution equipment, remote-controlled toys, and similar RF devices used by consumers. According to EIA and others, such devices are already subject to emission limits for purposes of reducing electromagnetic interference and that compliance with these limits essentially precludes human exposure to harmful levels of RF energy.[63] Apple Computer, Inc. (Apple) also asks that if the radiated power exclusion limit for Part 15 devices operating in the Industrial, Scientific and Medical ("ISM") frequency bands is lower than the presently allowable 1 watt, a substantial period of time should be provided for industry to comply. Apple also proposes that the duty cycle of devices be taken into account when setting power exclusion limits due to the extreme variability in the operating characteristics of unlicensed PCS and other Part 15 devices.

55. A number of parties request clarification of various aspects of the low-power exclusion. In particular, several parties request that we specify the method to be used for measuring radiated power for purposes of the exclusion. For example, Alcatel SEL (Alcatel) suggests defining "radiated power" as the root mean square (RMS) value of the radiated power averaged over a six-minute time interval, while Ericsson and TIA recommend the IEEE definition of radiated power.[64] Other parties request that we clarify the applicability of time-averaging

[63] See also Linear Corporation (Linear) Comments at 3-4. Matsushita Communications Industrial Corporation of America (Matsushita) Comments at 12.

[64] Ericsson and TIA note that the IEEE Standard Dictionary of Electrical and Electronics Terms (5th Ed.) defines radiated power output (transmitter performance) as "The average power output available at the antenna terminals, less the losses of the antenna, for any combination of signals transmitted when averaged over the longest repetitive modulation cycle." In 1993, Ericsson requested an interpretation of the term "radiated power" used in defining the low-power exclusions from the IEEE. The IEEE response, which Ericsson forwarded to us on September 12, 1994, was prepared by the Interpretations Working Group of IEEE/SCC28. The response indicates

criteria to the low-power exclusions and define the term "radiating structure." For example, GTE and TRW note that the exposure potential of a device can be considerably less when actual use characteristics are taken into account.[65] Matsushita submits that parts of a device that radiate RF energy at levels that are ten times below the ANSI recommended limits for uncontrolled environments should not be considered as radiating structures.[66]

56. Several parties also recommend extending the range of applicability of the radiated power exclusion clause from its current upper limit of 1500 MHz to 2 GHz or above.[67] Alcatel, for example, maintains that the 1500 MHz limit of the ANSI/IEEE standard is arbitrary and should be extended to 2000 MHz. Alcatel believes that such an extension would make the U.S. standards more consistent with those of Europe. According to BellSouth, extension of the radiated power exclusion criteria to include 2 GHz PCS frequencies would reduce the burden on manufacturers of complying with the new RF exposure standards. Motorola urges that we request ANSI to develop the necessary experimental data to justify extension of the radiated power exclusions up to 5 GHz to accommodate the PCS and other future technologies. TIA recommends extending the applicable range to 6 GHz.

57. A number of parties also address the ANSI/IEEE provision that the radiated power exclusion clause does not apply to devices where the radiating structure is within 2.5 cm of the body. For example, Alcatel maintains that the 2.5 cm separation requirement is arbitrary and renders compliance with the low-power exclusion clause unnecessarily complicated. Alcatel does not believe that the 2.5 cm requirement is supported by the theory of the behavior of electromagnetic fields. Ericsson submits that the IEEE did not intend that the radiated power exclusions not apply to low-power devices where the radiating structure may be within 2.5 cm

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that the term "radiated power" as applied to low-power devices means "the total power radiated into free space in absence of objects that may cause scattering, e.g., 'radiated power' excludes effects caused by the presence of the user's hand or head."

[65] For example, TRW notes that during a three-minute telephone call a user would be both transmitting (talking) and not transmitting (listening). Assuming a conservative "voice activity factor" of 50%, TRW continues, a handset would emit RF radiation for only 1.5 minutes of the call and those emissions would likely be random, short bursts, and not a continuous transmission. GTE notes that 71% of all cellular calls last less than 90 seconds. See TRW Comments at 1, GTE Comments at 10-11.

[66] Matsushita Comments at 6.

[67] See Comments of Bell South Corporation, etc., (BellSouth) at 4, E.F. Johnson Comments at 6-7, LMCC at 8, Northern Telecom Comments at 3-4, PCIA Comments at 5-6, Sprint Comments at 8, TIA Comments at 10-11 and others.

of the head some of the time.[68] E.F. Johnson, LMCC, Motorola, Northern Telecom, TIA and others recommend that we develop a radiated power exclusion for devices with radiating elements within 2.5 cm of the body.

58. Most commenting parties agree that a demonstration of compliance with the RF exposure standards for low-power devices should be part of the equipment authorization process. The Cellular Telecommunications Industry Association (CTIA), EEPA, Motorola, Northern Telecom, Telocator, TIA, and others generally recommend that applications for type acceptance include statements indicating that SAR measurements were performed by approved methods and that the unit meets the appropriate SAR criteria. NABER (now merged with PCIA) states that all equipment authorized under the low-power standards should carry a label certifying that the device complies with the Commission's RF exposure standards.[69] NABER also recommends that equipment manufacturers be required to provide manuals and pamphlets with each device that explain how the equipment should be installed and maintained to ensure safe operation.[70]

59. Telocator recommends that we amend Part 2 of our rules to require manufacturers of portable radio units that do not fall under the low-power exclusion to submit technical showings that the radios are in compliance with the guidelines. Telocator submits that manufacturers are better able to effect compliance because they control the design of the device; that it would be less burdensome overall to monitor compliance through the equipment authorization process than the licensing procedures of the various radio services; and that the public would be best served by preventing the sale of devices that do not comply with the guidelines.[71]

60. A number of parties support the development of standards for measurement of SAR. Ericsson recommends that we designate an appropriate ANSI-accredited standards generating body to develop standardized measurement and calibration procedures for facilities, phantom (human) models, and antenna models to enable manufacturers and the Commission to measure

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[68] Ericsson states that it asked the IEEE to clarify the meaning of the requirement for a distance of 2.5 cm to be maintained between the radiating structure of a device and the body of the user. In response, the Interpretations Working Group of IEEE/SCC28 stated that:

> Subcommittee 4 did not intend to exempt from the exclusion clause hand-held devices where the radiating structure may be within 2.5 cm of the head some of the time. The paragraphs in 4.2.1.1 and 4.2.2.1 that start with "This exclusion does not apply" ... was directed to the use of devices worn on the body with radiating structures maintained within 2.5 cm of the torso."

[69] See also Comments of Northern Telecom at 5

[70] NABER Comments at 6

[71] Telocator Comments at 11

with certainty that RF devices meet appropriate standards.[72] Ford Motor Company (Ford) submits that the Commission, in cooperation with industry and with the guidance of ANSI and the IEEE, should develop recommended modeling techniques for SAR measurement. Ford notes that procedures for measuring RF exposure potential were developed for the broadcast industry, as illustrated in OST Bulletin No. 65, and submits that a similar approach would be appropriate here.[73] Motorola supports the development of standards for measurement procedures and test site construction. TIA states that measurement standards for low-power devices could be developed through an ANSI-accredited standards-setting process and that it is willing to serve as a focal point for such efforts.[74]

61. Many respondents seek clarification regarding the use of analytic methods for SAR evaluation. AT&T notes that the ANSI/IEEE standard does not require laboratory measurements for showing SAR compliance, but rather permits establishing compliance "by appropriate techniques." AT&T, Ericsson and others urge us to clarify that it is permissible to use numerical methods such as high-resolution Finite Difference Time Domain (FDTD) techniques in evaluating SAR compliance.[75] Matsushita recommends that we approve certain analytic techniques, such as those discussed in existing scientific and technical publications by Kuster, Balzano and others, as alternatives to testing by laboratories for demonstrating compliance.[76]

62. Decision. Most commenting parties, including Federal health and safety agencies, support the use of the ANSI/IEEE SAR limits for localized (partial body) exposure for evaluating low-power devices designed to be used in the immediate vicinity of the body. As mentioned above, the SAR limits specified by the ANSI/IEEE guidelines for devices used in controlled and uncontrolled environments are essentially the same as those recommended by NCRP for occupational and general population exposure, respectively. Therefore, in view of the consensus

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[72] Ericsson Comments at 6. See also BellSouth Comments at 7, Comsat Reply Comments at 4.

[73] Ford Comments at 11.

[74] Motorola Comments at 23. TIA Reply Comments at 14.

[75] McCaw submits results of studies performed by Dr. Om Gandhi, of the University of Utah, that illustrate the use of the computer-based FDTD model technique to determine compliance with the ANSI/IEEE guidelines for cellular telephones. Dr. Gandhi applied this model to ten cellular handsets from four different manufacturers and found that the peak SAR averaged over one gram of tissue ranged from 0.09 to 0.29 W/kg, considerably less than the 1.6 W/kg recommended by the standard. For the whole-body average SAR, Dr. Gandhi's results ranged from 0.5 to 1.1 mW/kg, depending on the telephone and antenna used. These values are 70 to 160 times smaller than the 80 mW/kg ANSI/IEEE recommended level. Sprint cites studies reported by the CTIA indicating that the SAR from a portable cellular telephone is approximately 0.45 W/kg (a value three and one-half times lower than the 1.6 W/kg limit recommended by ANSI/IEEE).

[76] See also Comments of EEPA at 4, Matsushita Comments at 10-11.

and the scientific support in the record, we are adopting SAR limits for the determination of safe exposure from low-power devices designed to be used in the immediate vicinity of the body based upon the 1992 ANSI/IEEE guidelines. We will apply the MPE limits we are adopting to certain mobile and unlicensed devices that, although not normally used within the immediate vicinity of the body, can use higher power and may be relatively close to the body of the user and to nearby persons. Examples of the latter are cellular "bag phones."

63. The SAR limits we are adopting will generally apply to portable devices submitted for Commission authorization that are designed to be used with any part of the radiating structure of the device in direct contact with the body of the user or within 20 cm of the body of the user under normal conditions of use. For example, this definition would apply to hand-held cellular telephones. We believe that a threshold of 20 cm is appropriate, since the ANSI/IEEE standard specifies 20 cm as the minimum separation distance where reliable MPE measurements can be made.[77] At these closer distances, we believe an SAR determination is a more appropriate measure of exposure.

64. In addition to SAR limits for portable devices, exposure criteria in terms of the MPE limits will apply to certain mobile and unlicensed devices that would normally be used with radiating structures maintained 20 cm or more from the body of the user. Examples include transportable cellular telephones ("bag" phones), cellular telephones and other radio devices that use vehicle-mounted antennas and certain other transportable transmitting devices. For these types of transmitters, evaluation of compliance with MPE limits rather than SAR limits is more appropriate because of the greater separation distance between radiator and user.

65. We will require routine SAR evaluation, either by laboratory measurement techniques or by computational modeling, prior to equipment authorization or use for the following categories of portable devices: (1) portable telephones or portable telephone devices to be used in the Cellular Radiotelephone Service under Part 22 Subpart H or to be used in the Private Land Mobile Radio Services for certain "covered" SMR systems under Part 90 of our rules;[78] (2) portable devices to be used for PCS under Part 24 of our rules; (3) mobile devices to be used for earth-satellite communication under Part 25 and Part 80 of our rules; and (4) portable unlicensed

[77] Although ANSI/IEEE does not explicitly state a rule for determining when SAR measurements are preferable to MPE measurements, we believe that the 20 cm distance is appropriate based on Sec. 4.3 (3) of ANSI/IEEE C95.1-1992.

[78] "Covered SMR" systems include two classes of SMR licensees: geographic area SMR licensees in the 800 MHz and 900 MHz SMR bands that offer real-time, two-way switched voice service that is interconnected with the public switched network; and Incumbent Wide Area SMR licensees, defined in Section 20.3 as "licensees who have obtained extended implementation authorizations in the 800 MHz or 900 MHz service, either by waiver or under Section 90.629 of these rules, and who offer real-time, two-way voice service that is interconnected with the public switched network."