

Guidelines on the evaluation of amateur radio stations with respect to conformity with RF exposure limits

1. Introduction

The present proposal on this subject is the result of a decision made at the joint EUROCOM and EMC WG meeting held at the IARU R1 Conference at Lillehammer, Norway in September 1999. The EMC WG agreed that an ad-hoc group should be set up to come with "a proposal for a set of sensible guidelines [with respect to harmful exposure] based on the best from the US and German regulations". DJ1ZB, OZ8CY and PA3AVV were appointed as members of the ad-hoc group.

The first draft of this proposal was discussed at the EMC WG meeting at Ham Radio in Friederichshafen on June 24, 2000. Certain alterations were suggested and it was decided that the corrected draft would be sent to the national societies for comments. The present document is this corrected (second) draft.

The following pages are an introduction to the subject for those who are not sufficiently familiar with this material. Later on in the document, the recommendation can be found.

2. A little background...

This chapter briefly discusses the following subjects:

- Effects of EM fields on the human body.
- Exposure limits.
- The ICNIRP limits.
- Near and far fields
- Reference list

2.1 Effects of EM fields of the radio spectrum on the human body

Electromagnetic waves in the radio spectrum are non-ionizing. Their energy levels are too low to ionize atoms like X-ray radiation can do. The only **scientifically proved and agreed upon** causes of undesirable health effects are,

- i) induced currents, (lower range of the RF spectrum - typically below 10 MHz)
- ii) RF heating, (higher range).

Induced currents can stimulate the heart muscles and the nerve fibers.

RF heating, which occurs at higher frequencies, is expressed in a SAR value. SAR, or "**Specific Absorption Rate**", is the power absorbed by body tissue, taken per unit of mass (Watts per kilogram). The power is transformed into heat which has to be drained by the blood circulation. When the input power is larger than the drained power, the temperature of the tissue will rise.

2.2 Exposure Limits.

International and national bodies have published exposure limits in terms of the maximum permissible current density in the body and the maximum permissible SAR. These limits are called basic limits.

Showing compliance with the basic limits isn't always easy. To bypass this problem, compatible limits (the reference limits) have been determined for the *electric field strength*, the *magnetic field strength* and the *power density*. These quantities can be more easily measured and calculated.

In the area where the EM fields of a radio station are at or below the limits, there is no danger of harmful exposure.

2.3 The ICNIRP limits.

Of special interest are the limits set by **ICNIRP**, the **I**nternational **C**ommittee for **N**on-Ionizing **R**adiation **P**rotection, as they are often used as a reference. The Council of the European Union advises these limits in their recommendation "On the limitation of exposure of the general public to electro-magnetic fields (0 Hz to 300 GHz), dated July 12, 1999 (document. 1999/519/EC).

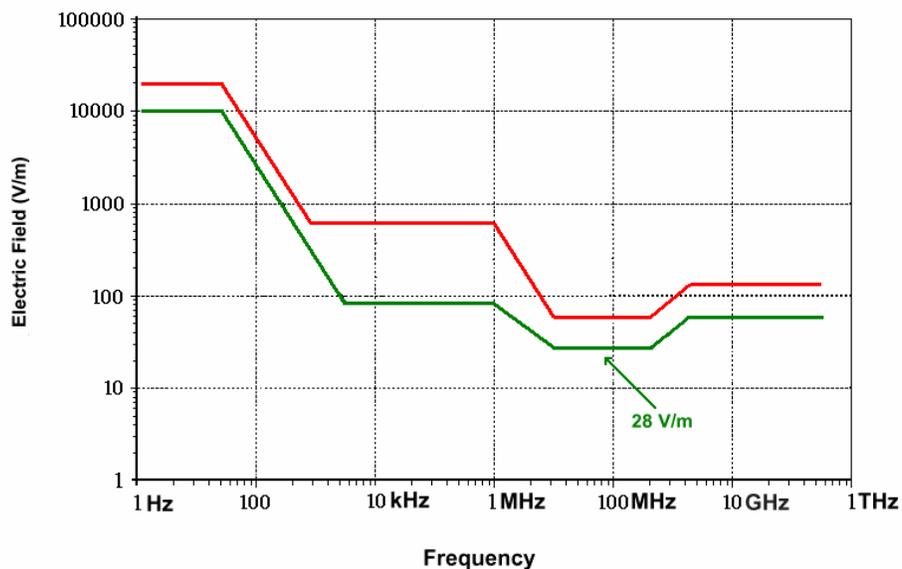
The ICNIRP limits are split in 2 sets:

1. limits for workers (occupational group), who are knowledgeable about exposure
and
2. limits for the general public which is not aware of the exposure and its consequences.

The limits for the general public are a (power) factor 5 more stringent.

Licensed radio amateurs are to be considered as belonging to the occupational group, in accordance with the definition of radio amateurs in the ITU Radio Regulations as "duly qualified persons".

The ICNIRP reference limits for the electric field strength:



Upper curve: Limit for occupational exposure
Lower curve: Limit for general public exposure

Figure 1.

The lower curve relates to the general public and is of particular importance for the safety of third parties who might be exposed to the EM field of an amateur station. The lowest value is 28 V/m, in the frequency range between 30 and 300 MHz. To get a feel of this, the field strength of an amateur station transmitting in one of amateur bands above 28 MHz, using a horizontal antenna at 10 m height and an RF power of 400 W, will be below this value anywhere at 2,5 meter (max. man's height) above the ground.

As can be seen in the figure, higher field strengths are allowed on the lower amateur HF bands, increasing to 80 V/m at 1 MHz.

There are corresponding limits for magnetic field strength.

The ICNIRP limits are averages over a period of 6 minutes. They are directly applicable to FM transmissions. Transmissions in modes like SSB and CW have a lower average power which can be accounted for by an appropriate duty factor.

The ITU Draft Recommendation K 52 recommends that the ICNIRP limits be used if there are no alternative national limits.

Near and Far Fields.

The means available to evaluate an amateur station on exposure safety depend on the field region considered. Some knowledge of the concepts of the near and the far field regions is advisable to get a feeling of the problem of determining safety distances on the lower amateur HF bands where a typical ham site is entirely in the near field region.

Far field.

Some distance from the antenna, the RF radiation takes the shape of a plane wave with a fixed ratio between the electric and the magnetic field strengths (377Ω). This is the **far field** region where field calculations and calculations of safety distances are relatively simple.

Near field.

Close to the antenna, the fields are quite different. There is no actual propagation, the fields are "quasi static". Field calculations are complex and often do not represent the practical situation as local reflecting objects can disturb the field distribution considerably. This is the **near field** region.

When going away from the antenna, the near field gradually changes into the far field; there is no sharp boundary between the 2 regions. For practical purposes, however, an imaginary boundary is often assumed at a distance d from the antenna, given by,

$$d = 2L^2/\lambda \quad *)$$

where L = the largest dimension of the antenna system and λ the wave length.

The outcome of this formula is, that below 14 MHz, the exposure zone of most ham stations is within the near field region. A 3,5 MHz half wave dipole antenna, mounted 15 meter above the ground, has a near field boundary of 37 m!

At and above 20 MHz one can safely assume to be in the far field region unless very large antenna arrays are used (as for EME).

*) John D. Kraus: Antennas, second edition. McGraw-Hill 1988 ISBN 0-07-100482-3.

It should be kept in mind that d is the distance to a more or less arbitrarily defined boundary as there is no sharp distinction between the 2 regions. Other formulas or yardsticks are also found in the literature. Their differences depend mostly on the degree of transition of the near field into the far field that is used to mark the end of the near field region.

List of references.

There are hundreds of publications on the subject of the effects of human exposure to non-ionizing radiation and even the number of publications on the RF safety of ham stations is not short.

The following list is aimed primarily at being a help for radio amateurs and recommended as a first introduction to the subject. A well comprised list will be found in reference [3].

[1], EMV-Referat of the DARC: "EMVU" by Thilo Kootz, DL9KCE e. a. (in German),

[2], Watt.exe, a DARC computer program for the calculation of safety distances according to Vfg 306/97 and DIN VDE 0848.

[3], RF Exposure and You. Ed Hare, W1RFI. An ARRL Publication, order No. 6621.
(<http://www.arrl.org>)

[4], EU Council Recommendation of 12 July 1999, on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) (document 1999/519/EC). Published in the Official Journal of the EU. Contact Gaston Bertels, ON4WF, Chairman of the IARU Eurocom WG.

[5], ITU Telecommunication Standardization Sector, Study Group 5 – Contribution 35. "Draft New Recommendation K 52 – Guidance on Complying with limits for human exposure to Electromagnetic fields". Unfortunately, this document is as yet for internal use only and not made available to the public.

[6], Excellent background information on the biophysics of interactions with EM fields, at: www.mcw.edu/gcrc/cop/powerlines-cancer-FAQ/toc.html. [John E. Moulder, Ph.D. – Prof. Of Radiation Oncology, Medical College of Wisconsin].

IARU R1 EMC WG

Recommendation on the RF exposure safety of radio amateur transmitter stations (August 2000)

1. General.

1. The IARU Region 1 respects the wish of governments to ascertain that their citizens are protected against possible harmful effects of exposure to RF fields and wishes to contribute in a positive way to making the operation of radio amateur stations safe in this respect.
2. In order to achieve this, the Union proposes the implementation of a system of self evaluation by amateur radio station licensees in accordance with their qualification as "duly qualified persons" in the ITU definition of the amateur radio services.
3. The determining factor in the evaluation should be the size and location of the region where possible exposure is beyond nationally set limits for the general public. The national limits should preferably follow the **ICNIRP** [1] recommended limits which are also advised by the Council of the European Union [2].

4. Radio amateur transmitter stations have an experimental character and in most cases transmitting equipment, especially antennas, are often changed. Consequently, a leading principle in the self evaluation has to be simplicity and flexibility of the procedure which should allow leeway for changes and which can count on a large support and understanding from the radio amateurs. Amateur radio station licensees should be allowed to fulfill the compliance duty by measurement or by a simple calculation, using tables or computer programs, to show compliance with a set of field strength and/or power density limits. More precise calculations, which take into account the duration and the mode of the transmission, cable losses etc., should be limited to border line cases where there is doubt about compliance.
5. The national radio amateur associations are encouraged to work with their administrations in setting up simple rules, which are a good fit for amateur radio in accordance with the previous clause. They ought to provide guidance to hams in complying with these rules. This might include the publication of simple tables or computer programs which can be used by licensees to establish presumption of compliance and if not, to adjust their station and operation practice accordingly.

2. Station evaluation.

1. Compliance with published **Maximum Permissible Exposure** limits should be compulsory for all amateur radio stations but it is suggested that the evaluation procedure be waived for certain stations which operate at or below specific maximum power limits specified by band. Such waivers could apply to mobile and hand held equipment, to repeaters, or to fixed stations operating in the lower amateur bands where the limits offer ample space and simple far field calculations are a poor representation of the actual electromagnetic fields which are in the near field region.
2. Amateurs should be free to choose from a variety of methods to verify presumption of compliance. These include, but are not limited to, the use of certified tables, of PC programs, of programs offered at the Internet sites of amateur societies and of calibrated field strength measurements.
3. All amateurs should keep a record of their station evaluation.
4. It is suggested that information about the exposure risk that is associated with the operation of an amateur radio station and how to operate a station safely in this respect, including a self evaluation procedure, become part of the requisite material for an amateur license

[1] International Commission on Non-Ionizing Radiation Protection. Guidelines on limits of exposure to time-varying electric, magnetic, and electromagnetic fields (1 Hz - 300 GHz). Health Phys 1998; 74(4): 494-522.

[2] EU Council Recommendation of 12 July 1999, on the limitation of exposure of the general public to electromagnetic fields (0 Hz to 300 GHz) [document 1999/519/EC]. Published in the Official Journal of the EU.

IARU R1 EMC WG, guidelines...(6 and 7), the actual recommendation.
