New licence regulations for RF electromagnetic fields

Part 1 of an ongoing series

In 2020, Ofcom published proposals to modify radio licences "to require compliance with international guidelines for limiting exposure to electromagnetic fields (EMF)".

PHOTO 1: Common amateur activities should easily prove compliant.

These changes were triggered by the global deployment of new telecommunications infrastructure but will affect all radio licensees, including radio amateurs. Over the past year, the RSGB has responded to two Ofcom consultations [1, 2], and is now meeting with Ofcom to clarify how these new requirements will apply to amateurs. The RSGB supports the safe and responsible use of RF communications but we are strongly urging Ofcom to minimise this new administrative burden.

Coincidentally, a similar process is underway in the USA between the FCC, the US regulator, and the American Radio Relay League (ARRL). A small team of RSGB and ARRL experts are cooperating on common technical areas, and sharing experience. In this introductory article, we cover the international background, and start to outline the approach that UK radio amateurs can take to comply with the new licence requirements. In 2021, Ofcom expects to finalise these requirements, and set an implementation time when they come into force. Future articles and support materials are planned by both the RSGB and ARRL to provide more detailed guidance for amateur operators, taking account of our respective national regulations as they are clarified.

What is 'safe'?

Amateur radio is usually regarded as a 'safe' activity and for over 100 years people have enjoyed this hobby of using electromagnetic fields to communicate. However, for EMF exposure, like so many other things in life, there are differences between 'acceptably safe' levels and 'excessive' levels that might lead to health effects. Internationally, the World Health Organization (WHO) coordinates and evaluates the scientific investigation of all sorts of activities and agents that potentially might affect human health. Due to the widespread deployment of mobile telecommunications over the last 30 years, exposure to EMF has become commonplace and so has become a subject for special review by the WHO [3]. The WHO refers to expert groups such as the International Commission on Non-Ionizing Radiation Protection (ICNIRP) [4] and the IEEE [5] that provide guidance on limiting human exposure to EMF, including radio waves used by radio amateurs.

Both ICNIRP and IEEE review the extensive published research data relating to biological effects of exposure to EMF, irrespective of the mechanism or source. They then develop guidelines and recommended exposure limits to prevent potentially harmful effects from excessive exposure. These limits are set well below the levels at which any harmful effects have been detected. Because the work of ICNIRP and IEEE is based on the same underlying science, it is not surprising that they reach similar conclusions and recommend similar exposure limits.

At frequencies above 100kHz, it is generally understood that the most important effects to be avoided are due to excessive heating from too much RF energy being absorbed in body tissues. The human body has an exacting temperature regulation system that holds the normal core temperature close to 37°C, and a variation of just a few degrees can lead to cellular damage. Our bodies are efficient at removing excess heat energy by varying local blood flow, and then offloading the unwanted energy from the body by mechanisms such as sweating and faster breathing. But if the rate of heat generation exceeds the body's ability to remove it, prolonged over-exposure can then lead to harmful effects.

The exposure limits are designed to prevent those effects from occurring. Separate exposure limits are defined for averages over the whole body or for localised maximum values. The limits also recognise that the body can handle short bursts of higher exposure provided the longer-term average remains below the limit. Based on the body's available mechanisms for removing heat, the mandated averaging times are 30 minutes for whole-body exposure but only 6 minutes for local exposures.

In addition to thermal effects, currents and voltages induced in the body by strong external EMFs at frequencies below 10MHz may interact with the electrical nerve pathways and affect the body's 'internal signalling'. To protect against that, there are limits on peak (maximum) exposure that may be more restrictive below 10MHz than the more

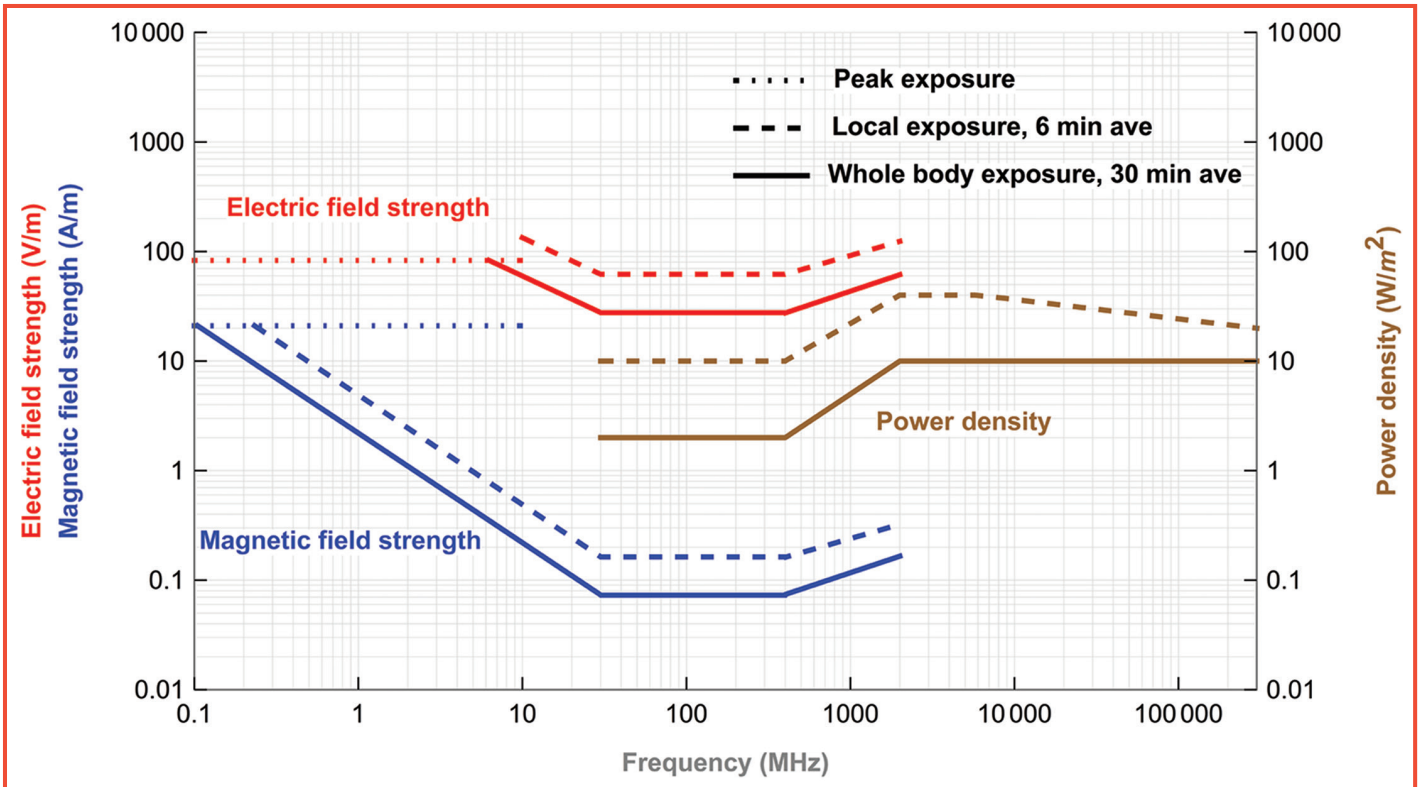

FIGURE 1: ICNIRP 2020 Reference Levels for General Public Exposures

familiar limits for thermal effects. Note that these exposure limits are expressed in terms of the field's peak (maximum) value at any point on the body, meaning that time and spatial averaging cannot be applied.

Why do exposure regulations exist?

Ofcom will require licensees to ensure that the RF energy used for communication does not cause harm to those exposed to it. Ofcom is not expert in the science that determines the safe levels of exposure, so it seeks advice from Public Health England (PHE). In turn PHE uses the ICNIRP guidelines on limiting human exposure as the basis to protect the population. The ICNIRP exposure limits deliberately include large safety margins which help greatly to ensure that, among other things, amateur radio transmissions do not harm the health of radio amateurs or any of the general public around us.

The scientific evidence demonstrates that the EMF exposure limits are not hard thresholds beyond which the situation suddenly becomes dangerous; they are more analogous to road speed limits. We all understand why speed limits exist – because at higher speeds the likelihood of an accident increases and also the consequences can be more serious. However, we are also aware that even though occasionally slightly exceeding the speed limit might not actually result in harm, it still could result in prosecution; and that in the event of an accident, the driver is likely to be considered at fault. Compliance with the ICNIRP exposure limits should be viewed in a similar way: minor excess exposures are unlikely to have caused actual harm; but failing to comply would be a breach of your licence.

The key to complying with the new licence condition is to be able to demonstrate that you have taken steps to ensure that your transmissions do not expose anyone to excessive levels of RF energy. In practical terms you need to be aware of the specific locations around your antennas where excess exposures *could* occur; and if people *could* access those areas, then ensure that you either reduce power or don't transmit while people are *actually present*.

There are also many areas where good RF engineering practice to reduce the risk of interference ('good RF housekeeping') and improve station performance will help to control RF exposure. We will show examples in later articles.

Electromagnetic Fields – What you need to know for compliance with ICNIRP guidelines
http://rsgb.org/emf

How is exposure specified?

Exposure refers to energy absorption in a person's body. This has a hugely important consequence: **If there is no-one present in an area then, by definition, no human exposure occurs.**

ICNIRP defines two types of exposure limit, termed "*basic restrictions*" and "*reference levels*".

Basic restrictions apply to people who are being exposed, and thus specify parameters within the body. For the thermally based effects, the ultimate definition of exposure – and hence the ICNIRP basic restriction – is the rate at which energy is absorbed by tissue. This is termed the Specific Absorption Rate (SAR), and is measured in watts per kilogram of tissue (W/kg). It is difficult to measure or compute the actual SAR in living people, so compliance with basic restrictions is commonly demonstrated using the more convenient reference levels.

Reference levels have been derived to provide a means of demonstrating compliance using quantities that are more easily assessed than basic restrictions, with an equivalent level of protection. Different reference levels are specified according to

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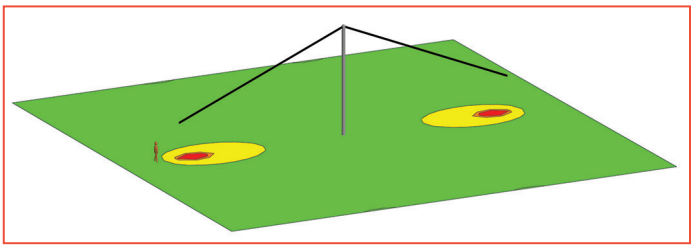

FIGURE 2: **Example exposure plot for people standing on the ground. For an 80m inverted-V dipole, the highest exposures occur below the ends of the antenna.**

the type of exposure that *could* take place if a person were to enter the EM field in that location:

- Whole-body exposure is averaged over time (30 minutes)
- Local exposure is the maximum time-averaged field (6 minutes) at any point
- Peak exposure is the maximum instantaneous field at any point.

There are three common reference level measures:

- Power density (*S*) measured in W/m^2
- Electric field strength (*E*) measured in V/m
- Magnetic field strength (*H*) measured in A/m.

For more details about *E*, *H* and *S*, see *Electromagnetic Fields – What You Need to Know* on the RSGB website [2]. *E* and *H* are commonly used at lower frequencies, roughly below 1GHz and in the near field of antennas. *S* is the only applicable measure at frequencies above 2GHz but can optionally be applied in the far field at any frequencies above 30MHz. **Figure 1** outlines the defining aspects of ICNIRP 2020 reference levels **[6]** applicable to the general public. Note that we have not presented the local and whole-body exposures for frequencies where the peak value is most restrictive. For our own practical purposes, we can treat these ICNIRP reference levels as exposure limits (while also noting, as above, that minor excess exposures are unlikely to have caused actual harm).

Why are exposure limits so complicated?

It would certainly be simpler if there could be a single exposure limit for all frequencies! However, radio waves are not absorbed by the human body equally at all frequencies. Just as resonant antenna sizes differ for various frequency bands, structures in the body can be resonant at frequencies with wavelengths related to their sizes. For example, the whole body of a typical adult person is resonant in the lower VHF frequencies, meaning that the body absorbs energy from the RF field more readily, so the exposure limits at those frequencies are reduced. The lowest limits in Figure 1 are between 30MHz and 400MHz, where whole-body and organ structure absorption is the highest for both adults and children.

Local exposure deals with situations in which only part of the body is significantly exposed. A common example is the use of a VHF/UHF handheld radio because the attached antenna most strongly illuminates the head of the user. For such close proximity of the body to the RF source, local exposure limits based on SAR will then apply (see later articles in this series).

While heating is the main consideration, we have already noted that there are other ways that EMF can interact with the body. At frequencies below 10MHz, the potential effects on the nervous system are also important and can become the limiting factor as shown in Figure 1, the peak exposure as shown by a dotted line.

What will I be expected to do?

Compliance may be demonstrated in many ways. We suggest trying a series of stages of increasing complexity, any one of which would be valid. If you can demonstrate compliance simply, then that's fine.

Stage 1 – Screening by configuration: In an effort to make compliance simple for as many people as possible, RSGB and ARRL are developing guidance by identifying typical station configurations that will comply with exposure limits on each of the amateur bands. If you can match your station to one of these pre-assessed configurations on the amateur band in question, that will be the simplest way to demonstrate compliance. Little or no calculation will be required by the end user.

To make that possible, a wide range of different station configurations are being evaluated using advanced modelling techniques. An example for HF is shown in **Figure 2**. This is part of a programme to determine the minimum compliant height for various antennas, for a given transmitted power on each HF band. Similar work is underway for a range of VHF and UHF station configurations.

Stage 2 – Simple calculation: The next level of complexity involves some calculation by you. For example, Ofcom has developed a simple spreadsheet tool and RSGB is working with Ofcom to clarify and improve this method. The output from the Ofcom calculator is a so-called "*safe separation distance*" for the power level, antenna configuration, etc that you are using. If you can be sure that nobody is present within that zone while you are transmitting, then RSGB's understanding is that you will be deemed compliant.

Stage 3 – Further measures: If you cannot initially demonstrate compliance using these first two stages, then you will need to do some more work. You have considerable control over this – for example, you could revisit stages 1 and 2 and look at the effects of changing the antenna configuration, limiting transmit power and/or beam directions, taking measures to ensure that no-one is present in high-exposure locations when transmitting, and so on. If you then are able to demonstrate compliance, the problem is solved. Examples will be discussed in future articles.

Stage 4 – Advanced methods: If you are not able to work within such limitations, it may still be possible that more advanced assessment methods could be applied to your particular circumstances to provide a more accurate exposure estimation; and in some cases that might then demonstrate compliance. RSGB-ARRL team members are already developing advanced computation methods as part of the programme to define the pre-assessed configurations for Stage 1 (see above).

Next steps

The RSGB continues to liaise with Ofcom about the revised licence conditions and the implementation date, likely to be late 2021.

We anticipate that Ofcom will require you to keep records on how you have demonstrated compliance (eg Stage 1 to 4) for each case examined, and as a minimum this will include each amateur band on which you operate.

RSGB plans to provide more detailed advice when this series continues in a future *RadCom,* and on the RSGB website www.rsgb.org/emf.

Websearch

[1] Ofcom proposals: www.ofcom.org.uk/consultations-and-statements/category-1/limiting-exposure-to-emf
[2] RSGB: https://rsgb.org/emf/
[3] World Health Organization: www.who.int/peh-emf/project/en/
[4] ICNIRP: www.icnirp.org/
[5] IEEE: www.ices-emfsafety.org/
[6] From ICNIRP 2020 Table 5, Table 6, and Table 8.

The RSGB-ARRL EMF Team

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