EMF-3: Communicating with Neighbours and General Public about EMF Compliance

Public Draft for comments and suggestions

In May 2021, Ofcom issued new Amateur Radio Licence conditions which now require an assessment of **EMF compliance** for each individual station **equipment configuration** that you are currently using. All bands down to 1.8MHz can now be checked using the RSGB EMF calculator app.

EMF assessments introduce many new concepts that can only be briefly outlined here. For further information, downloadable apps, calculators, and practical advice, follow the RSGB EMF web portal at www.rsgb.org/emf

Key references on that web page are the companion RSGB Technical Notes:

- **EMF-1: What You Need to Know about Electromagnetic Fields**
- **EMF-2: RSGB Guidance on EMF Compliance Checking.**

How to Use this Technical Note

This RSGB Technical Note is intended as a source of information and suggestions, in case you need to talk about EMF compliance to members of the general public such as your neighbours. It is mostly intended for lookup and reference, rather than being read through like a book, so here is a guide to the chapter contents:

1. **Be Prepared** – what you need to know, and have done, before offering information to anyone else. **Above all, make your own EMF exposure assessments** (your licence now requires this).
2. **Frequently Asked Questions** – understand **there is one key question** behind all the others.
3. **Concepts Useful in Communicating with Neighbours and the General Public** – a collection of topics, ideas and advice.
4. **Glossary of Terms and Abbreviations** – the specialised language of EMF Exposure, including **terms to avoid, because they are misleading or liable to be misunderstood**.

Acknowledgements

This RSGB Technical Note is based on the work of the International Amateur Radio EMF Oversight group, with representation from the USA, the Irish SWL Club, RSGB and Sweden. We are particularly grateful to Ric Tell K5UJU and Greg Lapin N9GL for their work on the original US version, published on the ARRL website. This version from RSGB reflects the European approach based on ICNIRP Guidelines.

1. BE PREPARED

Sometimes neighbours might want to know more about their exposure to your amateur radio signals – in other words, the electromagnetic fields or EMFs. They might ask many wide-ranging questions about your station, about the regulations and about amateur radio in general.

This guide provides some useful answers about the EMF regulations and the underlying science.

If you have carried out the EMF assessments of your station following the guidance from Ofcom and RSGB, you will already know where you stand in relation to the regulatory limits.

Be Prepared

- **You need to do your EMF assessments** as required by your licence conditions.

If you also have a good grasp of the information in this document, you will feel far more confident about answering any questions that come your way.

If you are responsible about this, and operate your station in compliance with the relevant regulations, then you can be confident that your station is safe**.**

How to Prepare

- Be sure that your amateur radio station has been evaluated for EMF exposure for all the equipment configurations – meaning every combination of frequency bands, antennas, and maximum power level – that are currently in use. For further details, see RSGB Technical Note EMF-2 at www.rsgb.org/emf

  If you have not yet evaluated your station for EMF compliance, your position will be much weaker (regardless of the facts).

- **Where possible, use the RSGB online EMF calculator** at www.rsgb.org/emf This is compatible with the Ofcom EMF calculator, but the RSGB version is easier to use and offers more help and guidance.

- If you think it would be helpful, you could offer to show your neighbour the results of the evaluation (if using the RSGB calculator, click **Save PDF** and then print that summary if desired).

  From the printout, be able to identify the minimum compliance distance (or where possible, the shape and size of the EMF Exclusion Zone). Ideally, you should be able to point out that all locations **accessible** to your neighbour are outside of that zone.

- When you have established to your own satisfaction that your station is compliant, the rest of this document deals with several frequently asked questions (FAQs). The answers can help you in understanding how to share this conclusion with your neighbours, should they enquire. Each FAQ includes at least one example answer that you can adapt in whatever way your neighbour finds most understandable.

- Following the FAQs is some additional background material that can help you in thinking about how to respond to various inquiries. The **Glossary** section contains some technical explanations that you might need to use.

  Further background can be found at https://www.rsgb.org/emf

- Make yourself familiar with the terminology and language of this topic – for example, the basic units of RF exposure such as electric and magnetic field strengths and power density. The **Glossary** section will help in this.

- **Avoid using terms that are well proven to cause misunderstandings.** The ⚠ **Caution** signs in the FAQ and Glossary will warn you, and will explain why care is needed. For example:

  ⚠ **Caution:** Avoid using the word 'radiation' on its own. Many pople are likely to interpret that as 'dangerous nuclear radiation'. EMFs at radio frequencies are non-ionizing, a different category with a much lower level of risk.

Don't try to answer every question

- **You are not expected to know everything.** Sometimes the best answer is: "That is a very specialist topic. It goes far beyond what I am required to know, so I would need to look it up."
- **Off-topic questions.** Sometimes, questions from non-amateurs can fly far away from the main topic. The best answer for those is: "That isn't directly connected to what we've been talking about so far, but we can talk about that afterwards if you like."

2. FREQUENTLY ASKED QUESTIONS

The Key Question

Q: Are amateur radio stations safe for me and my family?

This is the question most likely to underlie all of your neighbour's other concerns.
You must expect to hear the same question asked several times, but probably in different ways as your neighbour's understanding begins to grow.

Therefore, this chapter will answer that key question twice: a short answer below, and a much more detailed reply at the end of the chapter. In between is the **More Detailed FAQs** section, which answers the many more specific questions.

Here is the Short Answer:
"Yes, for a number of good reasons that I would be happy to explain."

More Detailed FAQs

Q: What is amateur radio all about?

This question is off-topic, but you need to be prepared for it. There are many good sources of information, starting with from https://rsgb.org/main/faq-2/amateur-radio-faqs/ for example.

Q: What are "EMFs"?

A: "EMFs" is short for "Electromagnetic fields" – the modern technical term for "radio waves".

Background: RSGB Technical Note EMF-1 and also the **Glossary** section in this document.

Q: Are radio amateurs required to comply with any government regulations for safety?

A: Yes – radio amateurs all around the world require a licence issued by the national regulatory authority after passing one or more examinations. The licensing authority in the UK is Ofcom, and the licence to operate a transmitter requires us to comply with several different sets of regulations, including the limits for EMF exposure.

Background: References to similar regulations in different countries can be found at the end of this document.

Q: Who sets these limits for EMF exposure?

A: In common with all the rest of Europe and most other countries around the world, the UK and Ireland follow the recommendations of ICNIRP, the International Commission on Non-Ionizing Radiation Protection. When these recommendations are adopted by national regulatory authorities, such as Ofcom and the Health & Safety Executive in the UK, or by an act of government as in Ireland [25], they then become compulsory.

Background: ICNIRP (pronounced "**ick**-nerp") is an independent non-profit organisation that is recognised by the World Health Organization (itself an agency of the United Nations). Widely

cited as an authoritative reference, ICNIRP's mission is to provide national governments and intergovernmental organisations (like the WHO and the EU) with guidance about protection from non-ionizing radiation (radio, microwave, infrared, visible and ultraviolet).

To preserve its independence, ICNIRP refuses support from commercial sources, and provides its science-based advice free of charge.

ICNIRP draws together scientific information from the international community that has been working on EMF exposure for several decades now, and is continually screening and evaluating current knowledge and recent findings. Over that time, ICNIRP's EMF exposure recommendations have been accepted and adopted into law by many highly respected national and international organisations – including the UK itself.

ICNIRP recommendations are often called "ICNIRP limits" for short. In the UK, you may also hear them called "licence limits" or "Ofcom limits".

Q: How do we know these ICNIRP/Ofcom limits are safe?

A: Around the world, scientists, engineers, biologists, and medical professionals collaborating with ICNIRP carry out their own research and continue literature surveillance on the topic, all to help ensure that the existing standards and guidelines are adequate for protecting health. Collaboratively, a consensus emerges about the levels of EMF exposure that might result in what ICNIRP calls "substantiated adverse health effects".

ICNIRP then has an established procedure for translating the scientific evidence into a system of recommended exposure limits – the aim being that **people exposed up the limit will not experience the adverse health effect in question**. To achieve this aim, ICNIRP has further reduced the maximum allowable exposure to protect against worst-case possibilities for the EMF itself and for individual personal sensitivity. **The outcome is that people are very well protected, and are unlikely to even notice any effect at all,** much less experience any harm from it.

Background: As well as ICNIRP, the other global focus of scientific collaboration about protection from EMFs is the IEEE, the Institute of Electrical and Electronics Engineers. The IEEE is based in the USA, where the licensing and regulatory authority is the FCC, the Federal Communications Commission. For historical reasons the two organisational structures have their own procedures, and these result in different terminology and slightly different exposure limits. Even so, there are no fundamental conflicts between (ICNIRP + Ofcom) and (IEEE + FCC). They are all working from the same world-wide scientific evidence base, and with the same objective to provide regulations that will deliver an adequate degree of protection to everyone.

Q: Do radio waves from an amateur station get into in my home?

A: To some degree, yes. Just like broadcast radio and TV, the signals from my antenna spread out everywhere. However, my personal interest is transmitting radio signals to other amateur stations a very long distance away – and EMFs inside nearby homes are not contributing to that.

While it is not possible to eliminate those signals completely, I can strongly assure you that the signal levels found inside your home or on your property will be kept well below the mandatory exposure limits.

Background: Transmitting antennas produce radio waves around them. That is the purpose of an antenna, but each antenna has its own specific characteristics. The antenna's transmission

pattern can be directional – it will increase signal strength in the wanted directions, but will also reduce signals in other directions. In many cases, increasing the signal strength for stations far away will actually decrease the signal strength at locations close by, including inside nearby homes.

Directionality is also affected by the height of the antenna above ground. A higher antenna will almost always decrease the signal strength at ground level nearby.

RSGB Recommendations for Antenna Height

Wherever possible, the minimum recommended antenna height is **2.4 m**. Increasing the antenna height is always recommended. This will increase the communication range and minimize local RF interference problems on both transmit and receive.

Exceptions requiring separate assessment**:**

- Low power VHF/UHF handheld radios
- Antennas with some parts unavoidably close to ground.

Q: How much EMF exposure am I getting from your amateur radio station?

A: Not very much: always less than the mandatory exposure limits; and in many cases far less.
As required by my licence, I have carried out station assessments to confirm this.

Background: To be a credible source of information, it is important that you have assessed your own station (as mandated by Ofcom) to check that the estimated EMFs in areas accessible to the general public will be below the relevant ICNIRP limits. These areas include your neighbours' homes and property (as well as you can estimate from the outside, of course).

In the UK, the relevant areas also include your own home, because non-licensed family and visitors are classified as 'general public'. If an assessment shows that the exposure in any of these areas could exceed the limits, you must immediately apply mitigation measures to rule out this possibility.

Q: Can I measure the EMFs from your amateur radio station?

A: Accurate EMF measurements are very difficult, even for professionals. To be worth doing at all, they require expensive equipment, and much training and experience. That is why the preferred method for 'first-look' EMF assessments is to use online assessment tools from reliable sources.

Background: Amateur station EMF evaluations are generally not based on measurements because reliable test equipment is very expensive (with ongoing calibration costs) and still requires considerable training and experience to avoid inaccurate results.

⚠ **Caution:** Amateurs and concerned neighbours both need to be aware that cheap 'EMF measurement instruments' usually deliver very unreliable results. They are most unlikely to resolve any questions between you.

In contrast, computer modelling methods for antenna performance have advanced greatly in the past few decades, and accurate modelling of antenna performance for communication is now well within the skill-set of many radio amateurs. When computer modelling is correctly applied and its limitations understood, this is now the preferred method for EMF compliance assessment for most amateurs.

In practice, most of the hard work has already been done. RSGB volunteers have modelled massive numbers of generic antennas and exposure situations, and published the results in the form of Pre-Assessed Equipment Configurations that are acceptable to Ofcom. These PAEC results are also being incorporated into the RSGB EMF Calculator.

Q: I tried to read some of these standards – all these different units are confusing me! Does it really need to be so technical?

A: I am not an expert either, so I know what you mean! This is a far more technical subject than I bargained for, so I rely on volunteer experts from the amateur radio community.

Background: if you want to know more about EM fields and units, read RSGB Technical Note EMF-1, What You Need to Know about EMFs . However, this is not suitable for individuals with no technical background and no interest in science whatsoever.

Q: Does my exposure to your amateur radio transmissions need to be reduced?

A: No, because the exposure limits are already set far below the levels where you could experience any harmful effect. Imposing further arbitrary restrictions "just in case" would not bring you any additional benefit as my neighbour – but it would have an unjustified and unfair impact on my own legal use and enjoyment of amateur radio.

Background: Note that the exposure limits are based on long-term continuous exposure, right up to the limit. This may be appropriate for the neighbours of broadcasting stations that operate 24/7 at high power, but it will generally be over-cautious for amateur stations that are only operated in spare time, and usually at much lower power.

Also be prepared to explain that EMF exposure is non-ionizing radiation, and the effects are different from exposure to ionizing (nuclear) radiation. The main effect of EMF exposure is heating of body parts, which our bodies have very good mechanisms to cope with. When the EMF exposure stops, the body (part) cools down quickly without long-term effects.

Unlike nuclear radiation, EMF exposure leaves no cumulative or latent effects in the longer term. In particular, **EMF exposure does not cause cancer.** (ICNIRP keeps a keen watch on publications about this topic, and continues to find no reliable evidence of harm.)

All of this means there is no justification to impose any further reductions of EMF exposures, "just in case".

Q: What would happen to us if you accidentally exceed the limits?

A: Nothing would happen, for two good reasons. First: even by accident, I cannot exceed the exposure limits by any large amount – my amateur transmitter is simply not powerful enough. Second: the ICNIRP exposure limits are deliberately set far below the levels where you could experience any harmful effect. These two factors combined mean that I can confidently say: "Nothing happens".

Background: The exposure limits are based on long-term continuous exposure, right up to the regulatory limit. This may be appropriate for broadcasting stations that operate 24/7 at high power, but it will generally be over-cautious for amateur stations that are only operated in spare time, and usually at much lower power.

That key question, again

Q: Are amateur radio stations safe for me and my family?

The Longer Answer: Yes. The risks from amateur radio stations are very low for *everyone* involved – for you, for me, and for our families and friends – because:

- All radio amateurs in the UK require a licence issued by Ofcom. By law, that licence compels us to comply with the regulatory limits for EMF.
- EMF exposure limits are recommended by ICNIRP, an independent and globally respected group of scientists. ICNIRP recommendations are adopted into law by national governments (over 130 countries around the world, including the UK).
- Exposure to EMF ("radio waves") is not like exposure to nuclear radiation. The main effect of EMF exposure is heating of body parts, which our bodies have very good mechanisms to cope with. When the EMF exposure stops, the body (part) cools down quickly without long-term effects.
- EMF exposure limits are based on ensuring that people continually exposed right up to the limit will still not experience any harmful health effect (and in most practical cases will not even notice).
- Low-level radio waves do get inside houses from a wide range of sources. That is why broadcast radio, TV, mobile phone, Wi-Fi etc all work well inside our homes, without needing an outside antenna. These familiar radio signals are accompanied by many others with which we do not normally interact at all; and my amateur radio signals fall into that category. What all these signals have in common is that they come from licensed and regulated user services that must comply with EMF exposure limits for the general public.
- My personal aim is for my radio signals to be heard by other radio amateurs in faraway places. The EMFs inside your home are not contributing to that, so I try to keep them as small as possible. 'Laws of Physics' dictate that they cannot be eliminated completely, but my transmitting licence from Ofcom requires me to make sure that EMF exposures always fall below the regulatory limits.
- This is not just guesswork. My licence also requires me to make assessments of the EMFs around my antenna and in the local area. I have done that, and can share those with you if you are interested in the technical detail.

More detailed information about each of the above points has been given in earlier pages. Backup can be found in the **Glossary**, and in official publications and statements by many national and international health and safety organizations (see **References**).

3. CONCEPTS USEFUL IN COMMUNICATING ABOUT EXPOSURE TO AMATEUR RADIO SIGNALS

This chapter focuses mainly on interpersonal communications, and how to present yourself as a knowledgeable and trustworthy source.

Know your station before you talk about it

Before talking to your neighbour, you must have performed an exposure assessment for your station as required by OFCOM [12]. For practical advice, see RSGB Technical Note EMF-2 .

The assessment must show that your station is operated in compliance with the regulatory limits. To do this, you must:

1. Know the physical dimensions of the EMF Exclusion Zone; and
2. Be sure that your neighbour (or your family and friends, or any other member of the general public) cannot access or remain in this zone while you are transmitting.

Talk about the EMF Exclusion Zone

The concept of an "Exclusion Zone" around an antenna is something your neighbour can probably understand – and all the more easily if both of you are standing outside, looking at your antennas.

Try to secure some initial engagement by starting with a case that is easy to understand – for example, a small VHF/UHF vertical antenna used for low-power local communications, and mounted out of reach on a mast or chimney. The size of the Exclusion Zone is typically only a few metres (check this example using the RSGB EMF Calculator) and in this example it will be far out of reach. Therefore this system will comply with the EMF regulations.

Securing initial agreement about such an easy case lays a good foundation to talk about the less simple cases – typically involving beam antennas, higher power and/or longer wavelengths – where the Exclusion Zone may be larger and may need extra precautions to prevent access.

No transmission = no EMF Exclusion Zone

When explaining about the EMF Exclusion Zone, make sure to point out that the Exclusion Zone only exists while you are transmitting.

Be ready to explain what amateur radio is about

When interacting with neighbours, you should offer to answer any questions about your station, or any interest that the neighbour might have about amateur radio in general.

Amateur radio has many facets, and it is useful to stand back and look at the hobby from an outsider's perspective. Try to see what might engage this person's interest, and help them to understand and respect the hobby. In case the discussion moves into this more general territory, it can be helpful to be prepared for most of the following questions:

- What is amateur radio?
- How does amateur radio work?

- What is “radio frequency”?
- How does amateur radio use radio frequencies for communication?
- Different types of amateur radio stations?
- How amateur radio can provide communications in emergencies.

In the UK, the Radio Society of Great Britain will have material to help you cover these points ([20], [21], [22], [23]). In other countries, contact your own national amateur radio society.

Things to consider when engaging

First of all, accept that **you want something from this interaction**, and that you will **need to work for it**. What you want is the freedom to pursue your hobby without worry or interruption – and in order to achieve that, you will need to establish a level of trust and empathy, so that your neighbour will accept the information that you give to them. That may require some effort.

Effective interaction with another person depends on the kind of relationship you already have, and on the state of mind of both yourself, and that other individual. If your neighbour is angry, accept that you may not be able to achieve much from a single conversation – and if you become angry, that applies to you too!

If confronted by a neighbour who is angry, acknowledge their concern. Give them a chance to express themselves in their own words. Don’t talk down to them, and never assume an attitude of superiority. Listen a lot more than you talk, and do not interrupt. If you disagree over some point they are making, try to use nonverbal signals such as a mild headshake to show them you disagree, but are not going to interrupt. Be patient… and keep on deciding not to interrupt until they are finished.

When it does become possible, explain that you understand why they are worried that the signals from your station might be harmful. Acknowledge that “There’s a lot of bad information about, and to be honest this is a complicated topic.” When the opportunity arises, say that “I would like a chance to explain what I have found out, and why my signals are not harmful to you.”

On the other hand, when confronted by someone who already has strong beliefs about EMF health effects, do not expect an instant change of mind. For example, some individuals may not accept the idea that current exposure regulations offer sufficient protection. In this case, there is generally little benefit in entering into a confrontational style of argument. The person may sincerely believe they have “researched” the matter fully; in such cases, merely stating that that they are misinformed will not work. Instead, try helping your neighbour to understand that the existing exposure regulations are based on a wide scientific consensus that is worthy of our trust.

You might then add: “Living right underneath my antennas, and with a family of my own, I should be the most concerned of all. That is why I looked into the situation. But having done so, I do trust the regulations and the supporting science to keep me and my family safe; and that in turn will keep you and your family safe as well.”

Many reputable information sources are listed at the end of this document, including more guidance on risk communication [19]. Numerous reputable agencies have reviewed and interpreted the scientific evidence relating to exposure to EMF, and those references are also listed. The main conclusion of these reviews is that if the levels of exposure to RF fields are below defined limits, then such exposures strike a good balance between the benefits of using radio

signals and the very low levels of risk involved. This position has been endorsed by well over 100 health and safety organizations/agencies around the world [4].

Unfortunately, there are also some individuals and organisations that have selectively interpreted information in a way that is deliberately intended to alarm people and raise concerns that there are (or could be) health impacts from very low-level exposure to RF energy. However, those viewpoints have failed to convince the health and safety organisations that have united around the present guidelines.

Scientific consensus includes routine uncertainties

Faced with the questions of everyday life, most people just want to 'know the answer' as simply and concisely as possible. In everyday life, all of us find it challenging to deal with uncertainties and unknowns. Regardless of the facts, any idea communicated with confidence and lack of doubt is more readily perceived as being accurate, and by default is often believed to be the "truth". Our longing for certainty is how misinformation and oversimplification can lead to a widespread belief that something is factual, when the real evidence is to the contrary.

In complete contrast, science is all about questioning, testing, and taking nothing for granted. It aims to come up with ideas about the functioning of the world and the universe around us, and then seeks ways to test them. But science is also honest about the fact that we cannot know everything. That is why good-quality scientific studies routinely include some acknowledgement of uncertainty in their findings, along with statements about "more work needed", "next investigation should look at..." etc. It is important to note that in scientific language these reservations are regarded as sensible, proportionate, and completely routine. They do not contradict or detract from the major conclusions of the study.

Radio amateurs must understand that the current EMF exposure limits are the result of exhaustive scientific investigations and analyses over several decades. In line with how science works, the conclusions of scientific reports express routine levels of uncertainty. Because of that, and based on the scientific consensus, EMF exposure regulations include considerable safety factors.

What does "safe" mean?

⚠ **Caution:** Despite being the most important word in this entire document, "safe" can be a difficult word to use, and is the cause of many misunderstandings. Until some common ground has been established, we can never be certain how the other person will interpret what we mean.

We cannot avoid our neighbour asking, "Is this safe?" The problem is that they will be using everyday language, while we need to reply in more scientific terms. Many examples are given in the FAQ chapter.

So, what do people mean by "safe" in everyday language? Safety is a very complex subject, with wide scope for different interpretations depending on our individual attitudes, values and the information available to us. Whatever our own views, we always need to start from the other person's position. We cannot 'jump' them into understanding our point of view, but we can try to steer the conversation towards that goal.

Background: If asked to think about it, most people will agree that absolute safety is an unreachable ideal. Safety in real life is a much more complex issue that always involves conditions, limitations and trade-offs. If we claim that something is "safe" without mentioning

those complexities, we are trying to take a shortcut – but that hoped-for shortcut will very often turn into a setback. Also, the more complexities we see, the greater is the temptation to try that shortcut. Such conversations are unlikely to end well.

What we usually mean by "safe" is something more nuanced, about weighing and balancing the risks. In our personal behaviour, we tend to consider something "safe" or "safe enough" if the risks are not great enough to make us change our behaviour – entirely in our own personal judgement, of course. We also ignore many other risks completely, often without being fully aware of having done so. These differences in personal perceptions and judgements make safety a very difficult subject to discuss, because nothing can be taken for granted.

For all of those reasons, safety professionals in Europe almost never expect the word "safe" to carry that whole weight of meaning, all on its own. For example, the ICNIRP Guidelines avoid using "safe" in any sense that could be construed as an absolute claim. Even the more neutral word "safety" tends to be used only in a general sense. If we as radio amateurs wish to use ICNIRP as a quotable reference, it is wise to follow ICNIRP's use of language.[1]

When ICNIRP is deciding upon its recommended exposure limits, they take a more rigorous approach by including societal rather than personal attitudes to risk. They also balance the risks of individual EMF exposure against the established societal benefits of using radio waves, and then recommend exposure limits accordingly. Also, it is not widely enough known that EMF exposure limits deliberately include reduction factors (see the **Glossary**) that tilt the balance strongly towards protection.

Summary: the exposure limits strike a balance between protection from excessive levels of EMF, while still permitting everyone to enjoy the benefits of using radio waves without harm to themselves or their neighbours.

[1] When reading US publications, be aware that usage in the USA may be different, and that "safe" on its own can be more acceptable.

4. GLOSSARY OF TERMS AND ABBREVIATIONS

This Glossary is mainly intended for UK users, so its primary references are to ICNIRP Guidelines for RF exposure limits, and to Ofcom as the licensing authority. A companion version has been published by ARRL in the USA, where the corresponding references are to the IEEE Standard C95.1, and the FCC.

⚠ **Caution: Only use the standards and regulations that apply to you.** Although most countries use similar terms and set very similar standards, there are important differences in detail. If you wish to quote official publications as backup or evidence in any debate, be sure to use the right ones.

Antenna: modern word for the old-fashioned UK "radio aerial". ("Antenna" is used universally in engineering, US English and in most other languages.) The antenna is the part of the radio station that converts conducted power in wires and cables into radio waves and *vice versa*.

Basic Restriction (ICNIRP): a term used by **ICNIRP** for the maximum permitted human **exposure** from a transmitted RF signal. The aim of Basic Restrictions is to avoid **established adverse health effects**. Generally refers to effects occurring inside the body, which may be difficult to measure or compute. Basic Restrictions are frequency dependent. Also see **Reference Level**.

ComReg (Ireland): Commission for Communications Regulation, Telecommunication Regulation – the licensing and regulatory authority in Ireland.

Conservative, conservatism (ICNIRP, IEEE): in scientific usage, a conservative approach is one that purposefully prioritises the need to take full account of all sources of risk. The intention is that any errors or uncertainties may result in over-caution, but will never underestimate the true level of risk. Scientific conservatism is usually applied to address areas of uncertainty; but when framing regulations or making risk assessments, over-use of this approach can lead to unnecessary restrictions.

⚠ **Caution: This specialised scientific meaning of 'conservative' is a huge source of confusion,** because everyday usage and dictionary definitions are all about politics! Since it is almost impossible to avoid using the word in discussions about EMF exposure standards, we need to be ready to define this term when we use it.

The rest of this Glossary entry is about conservatism of the strictly scientific kind. For some people, a better word may be 'cautious' or 'careful'.

In an EMF compliance assessment, there are two major layers of conservatism that need to be kept separate.

1. **ICNIRP's conservatism in setting exposure limits.** Compliance with ICNIRP's **Basic Restrictions** or **Reference Levels** is a mandatory part of the UK licence, and the exposure limits themselves are not open to question by licensees. But when we make site-specific compliance assessments for our own station (see below) we need to be aware of the conservative assumptions that ICNIRP has already made, in order to avoid applying them a second time.

ICNIRP applies many layers of conservatism in defining the Basic Restrictions. For each **substantiated adverse health effect**, ICNIRP identifies a threshold that is "the lowest exposure level known to cause the health effect". In ICNIRP's own words, these threshold levels are "strongly conservative for typical exposure situations and populations". Further reduction factors are then applied to account for biological variability in the population, environmental factors such as temperature and clothing that are relevant for thermal health effects; and generous allowances where applicable for the "uncertainty associated with health science". The resulting **Basic Restrictions** are thus strongly biased towards conservatism.

ICNIRP then derives **Reference Levels** "to provide an equivalent level of protection to the Basic Restrictions", but in more practical and measurable formats. Once again, further layers of conservative assumptions are applied, so that for all people, even in worst-case conditions (which ICNIRP judges are highly unlikely to occur in practice) compliance with Reference Levels will result in similar exposures to those specified in the Basic Restrictions – and in the vast majority of cases, "**compliance with Reference Levels will result in substantially lower exposures than the Basic Restrictions"**.

The reason for all that detail is to understand that the conservative and worst-case assumptions are already built into those ICNIRP standards, and **should not** be applied a second time within our own compliance assessments. We also should not consent to other parties applying further layers of conservatism or restriction without any scientific justification.

2. **Conservatism in our own EMF exposure assessments.** In EMF exposure assessments, a conservative approach implies that, considering all the uncertainties in measurement or computation, the indicated exposure is more likely than not to be greater than the true value. In other words, we need to bear in mind that a conservative estimate is also likely to be an overestimate.

   Conservative methodologies are often a good starting point because they are usually the simplest to apply. For example, the Ofcom EMF Calculator and the entry-level of the RSGB EMF calculator both make use of the ITU-T K.52 methodology [29] which always calculates a spherical EMF Exclusion Zone. This assumption is very simple to calculate, but for directional antennas (meaning, all practical antennas) it is contrary to physical fact. Presence of ground nearby is accounted for by a simple reflection factor; but this too is applied in all directions, and is again contrary to physical fact. Such a simplified methodology will not underestimate the EMF in any direction, so it is dependably conservative; but in most directions it will almost certainly overestimate the EMF.

   If conservative calculations indicate compliance with ICNIRP Reference Levels despite all their pessimistic assumptions, that is a positive and reliable outcome. No further assessment is needed. The drawback of conservative methodologies is that indications of non-compliance are far less reliable, meaning that some activities may be unnecessarily restricted. Therefore, failing to show compliance using a conservative methodology should not be regarded as the last word; it only indicates that a more accurate assessment is required. In many cases these are available as **Pre-Assessed Equipment Configurations**.

DRL (IEEE): Dosimetric Reference Limit, a term used for the maximum safe energy absorption rate. The term DRL is comparable to **Basic Restriction (ICNIRP)**.

Since DRLs and Basic Restrictions are difficult to determine, equivalent frequency-dependent exposure levels have been determined that are less difficult to measure or model, and are intended to protect all people from exposures above the corresponding DRL or Basic Restriction. See **ERL (USA)** and **Reference Level (ICNIRP)**.

Electric field: one of the two components of an **electromagnetic field** (EMF), the other being the **magnetic field**. The units of electric field are volts per metre (V/m). For further information, see RSGB Technical Note EMF-1.

Electromagnetic Field (EMF): In radio communication, electromagnetic fields are the means by which **RF** energy is transferred from a transmitting antenna to a receiving antenna.

For a basic introduction to EMFs, see RSGB Technical Note EMF-1.

RF electromagnetic fields have two components, an **electric field** and a **magnetic field.** These two fields vary together, at a rate that is called the **radio frequency**. Close to the antenna, the ratio between these components will vary depending on the specific location; this is called the **near-field** region. At greater distances, that ratio tends towards a fixed value, which is a defining feature of having reached the **far-field** region.

There are also many other forms of EMF, including visible, infra-red and ultraviolet light. Radiated energy in all of these forms can also be absorbed by people, depending on the circumstances of **exposure**.

EMF Exclusion Zone (Ofcom, RSGB): the zone around the antenna within which the general public could be exposed above the relevant EMF limits, if they are present (or can be expected to be present) when transmission is taking place [28].

⚠ **Caution:** you may need to stress – repeatedly – that **actual** exposure can only occur if member(s) of the general public **genuinely, physically, literally ARE** present when transmission is taking place. Many people (including amateurs) find this point extremely hard to grasp.

Emissions, RF emissions: radio-frequency energy (also known as **Electromagnetic Fields**) radiated from a transmitting source, commonly for communication purposes. RF emissions from amateur radio stations originate mainly from the antenna, but may also be found close to other parts of the station (e.g. the transmission line feeding the antenna, or unshielded parts of the transmitter output circuitry including antenna tuners).

ERL (IEEE): Exposure Reference Level, a term used for maximum permitted exposure from a transmitted signal as a function of frequency. ERLs use quantities such as field strengths that are more easily evaluated than the **DRL**, to provide a more practical means of demonstrating compliance with the guidelines. ERLs typically have units of **field strength**.

Established adverse health effect (IEEE): see **Substantiated adverse health effect (ICNIRP).**

Exclusion Zone: see **EMF Exclusion Zone**.

Exposure: the presence of electric, magnetic, or electromagnetic fields at a specified location (or contact with a current or voltage source).

Human EMF exposure can never take place unless TWO conditions are met: the presence of and EMF AND the presence of a person within that EMF. If the source of EMF is not transmitting at the relevant time, then there is no human EMF exposure. If there is no-one present at the location in question, again there is no human EMF exposure.

Exposure Limit: Formally, a maximum RF exposure level that is specified for protection against established adverse health effects.

'Exposure limit' is less formally used to mean any RF exposure level that for some reason should not be exceeded. Reasons may depend on the national regulatory framework, and probably also the exact circumstances.

Exposure limits are deliberately set far below the levels where a person could experience any harmful effect, even if continuously exposed right up to the limit for a long period. See **IEEE Standard (USA)** and **ICNIRP Guidelines**.

RF exposure limits are most commonly expressed in terms of electromagnetic **field strength** (or sometimes **power density**) and often with specific requirements about their average values over their time-span, and/or with average values over the human body.

RF exposure limits typically provide significant protection against **established adverse health effects**. RF exposure limits commonly distinguish between more stringent limits for the general population and less stringent limits for persons who are subject to a safety and training programme.

Far field region: the region of an electromagnetic field (EMF) at long distances from the antenna. This is the region commonly used for radio communication, but signals are extremely weak. EMF exposures of possible regulatory concern almost always take place much closer to the antenna in the **near field** region, where EMFs are much greater.

For a basic introduction to EMFs, see RSGB Technical Note EMF-1.

FCC (USA): the Federal Communications Commission – the licensing and regulatory authority in the USA.

Field strength: see **electromagnetic field (EMF)**, **electric field**, **magnetic field** and RSGB Technical Note EMF-1.

Frequency: see **Radio frequency (RF)**.

ICNIRP: the International Commission on Non-Ionizing Radiation Protection, an independent global organization providing scientific information and science-based advice on protection from non-ionizing radiations.

Around the world, scientists, engineers, biologists, and medical professionals continue both research and literature surveillance on the topic to help ensure that the existing guidelines and the resulting exposure limits remain adequate for protecting health.

ICNIRP Guideline: Because ICNIRP is an advisory body and has no powers to make legally binding regulations, it publishes **'guidelines'** for implementation by national or international regulators that do have those powers.

The UK licensing authority **Ofcom** currently continues to use the ICNIRP 1998 Guidelines as the legal basis for protection of the general public. A similar situation currently exists in Ireland. Ofcom has stated its intention to adopt ICNIRP 2020 in due course, and already allows UK licensees to use ICNIRP 2020 for EMF assessment purposes.

⚠ **Caution: The word 'Guideline' does NOT imply any freedom of discretion by individual licensees.** Compliance with ICNIRP Guidelines under the terms set out by Ofcom is a **compulsory** part of the UK Amateur licence (just like compliance with frequency allocations).

IEEE Standard (USA): IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz. IEEE Std C95.1-2019. Note: a Standard is not legally binding unless implemented by national regulators. In the USA, the FCC has that authority and specifies regulatory limits that (as of 2023) are based on an older version of IEEE Std C95.1.

Ionizing radiation: includes any form of electromagnetic field that has enough energy to force electrons out of their orbits, leading to chemical changes that can be dangerous to life. Examples include x-rays and gamma rays. **Radio-frequency EMFs do not belong in this category as they are NON-ionizing, and are thus in a much lower category of risk.**

More detail: The ability of a radio-frequency EMF to ionize molecules depends solely on the frequency of the electromagnetic waves. Radio-frequency EMFs are NON-ionizing because their frequency is **millions to billions** of times below the threshold where ionization begins. The electromagnetic spectrum continues far beyond the 300 THz defined upper limit of radio waves, including infrared, visible light and near-ultraviolet, yet all of these are non-ionizing too. Ionizing radiation only begins around the transition region between the far-ultraviolet and x-rays.

Magnetic field: one of the two components of an **electromagnetic field** (EMF), the other being the **electric field**. The units of magnetic field strength are amps per metre (A/m). For further information, see RSGB Technical Note EMF-1.

Margin of safety: A common way to talk about safety – but **use with care**, as there are several alternative definitions that can sometimes causes misunderstandings, even between professionals.

When applied to EMF **exposure limits**, a margin of safety is provided by multiple layers of **conservatism**. When applied to EMF exposure limits, a margin of safety is provided by multiple layers of conservatism, providing a high level of protection for exposures at or below those limits.

Microwaves: a range of **radio frequencies**, typically in the low GHz (gigahertz) range.

MPE (USA): Maximum Permissible Exposure, the US regulatory specification of an exposure limit for RF fields. The exposure limit is a function of frequency and defines averaging over time and space. Note: The term is replaced by **ERL** in IEEE C95.1-2019.

Near field region: A useful working definition is "Any part of the **electromagnetic field** (EMF) around an antenna where **far field** conditions do not prevail." In practice the near field region always covers the entire physical structure of the antenna and extends some way beyond, but further details will depend on the type of antenna.

At greater distances, the near field region transitions into the far field region, but without any sharp physical boundary.

(Some definitions of 'near field' include conceptual sub-regions such as 'reactive' and 'radiative', but these are not helpful in considering EMF exposure.)

For a basic introduction to EMFs, see RSGB Technical Note EMF-1.

Non-ionizing radiation: electromagnetic fields that (unlike **ionizing radiation**) do not have enough energy to cause changes to chemical structures. All radio frequencies are non-ionizing, and therefore in a much lower category of risk. The main effect of non-ionizing radiation is to

generate heat in exposed parts of the body (the most common type of non-ionizing radiation is visible sunlight) but these **thermal effects** are only harmful if they generate more heat than the body can deal with. Heat generation from EMF exposure is proportional to **SAR**.

Ofcom (UK): the Office of Communications – the spectrum licensing and regulatory authority in the UK, overseeing the broadcasting, telecommunications and postal industries, including licensing of amateur radio stations.

PAEC: see **Pre-Assessed Equipment Configuration (RSGB, Ofcom)**.

Power density: The power flux density in an EM wave is the amount of energy flowing through unit area of the wavefront in unit time. The name is often shortened to power density.

The usual symbol for power density is S and the units are watts per square metre (W/m^2).

Pre-Assessed Equipment Configuration (RSGB, Ofcom): Ofcom allows EMF compliance to be demonstrated by a variety of routes, including the use of Pre-Assessed Equipment Configurations. A PAEC is a set of generic equipment parameters that have been assessed by a recognised third party to be compliant with the relevant EMF exposure limits. The individual licensee must still confirm that the actual equipment configuration corresponds with the selected PAEC.

Relevant equipment parameters include the generic antenna type (e.g. '4-element Yagi'), height above ground, frequency and averaged transmit power. RSGB is one of the third-party organisations recognised by Ofcom, and RSGB volunteers have analysed hundreds of different antenna types and millions of different combinations of parameters. PAEC reports are published periodically, and are available through the RSGB EMF portal.

PAEC analyses aim to provide more detailed and accurate estimates of the EMF Exclusion Zone than can be achieved using simpler calculators. This often achieves some very worthwhile operational freedoms, e.g. by establishing that the Exclusion Zone is completely above ground level.

PTS (Sweden): the Swedish Post and Telecom Authority, with responsibilities similar to the **FCC (USA)**, **Ofcom (UK)** and **ComReg (Ireland)**.

PTT, **PTT Authority:** generic term for any national telecommunications authority.

Radiation: in this context, another word referring to electromagnetic fields (**EMF**). It highlights the property of EM energy that causes the electric and magnetic fields to spread out, and to travel away from the antenna.

⚠ **Caution:** Avoid using the word 'radiation' on its own. Many pople are likely to interpret that as 'dangerous nuclear radiation'. EMFs at radio frequencies are non-ionizing, a different category with a much lower level of risk. See **non-ionizing radiation** and **ionizing radiation** for explanations.

Radio Frequency (RF): frequencies of radio waves that are useful for transmission and reception at a distance (includes all amateur frequency allocations). Sometimes used by radio amateurs as a general term for 'RF energy', and/or for **EMF**.

The radio frequency is the rate at which the electromagnetic field varies with time. The old units were cycles per second. The modern unit of frequency is the **hertz (abbreviation Hz)** where **1 Hz = 1 cycle per second.**

Radio frequencies are commonly measured in units of kilohertz (kHz, thousands of hertz), megahertz (MHz, millions of hertz) or gigahertz (GHz, billions of hertz) as appropriate.

Frequency ranges are classified by the International Telecommunications Union (ITU) as follows:

ELF	Extremely Low Frequency	0 Hz to 3 kHz
VLF	Very Low Frequency	3 kHz to 30 kHz
LF	Low Frequency	30 kHz to 300 kHz
MF	Medium Frequency	0.3 MHz to 3 MHz
HF	High Frequency	3 MHz to 30 MHz
VHF	Very High Frequency	30 MHz to 300 MHz
UHF	Ultra High Frequency	300 MHz to 3 GHz
SHF	Super High Frequency	3 GHz to 30 GHz
EHF	Extremely High Frequency	30 GHz to 300 GHz

RF: abbreviation for **Radio Frequency**.

Radio waves: electromagnetic fields or travelling waves with frequencies in the **radio frequency** range. Radio waves can be characterized by their frequency or wavelength, and by their strength (expressed as electric or magnetic **field strength** or **power density**).

Reduction factor (ICNIRP). A factor that decreases the allowable exposure to account for the variations in human biology and environmental conditions. To define the regulatory exposure limits, the reduction factor is applied to the exposure level above which established adverse health effects might occur. For example, the **SAR** for whole body exposure of the general public includes a reduction factor of 50, which provides a significant margin of safety across the wide range of real-life circumstances.

Reference Level (ICNIRP): Term used by ICNIRP to describe quantities (such as field strengths) that are more easily evaluated than the ICNIRP **Basic Restrictions** and thus provide a more practical means of demonstrating compliance.

RF fields: The components of radio waves, namely electric, magnetic and/or electromagnetic fields.

RSGB (UK): the Radio Society of Great Britain, the UK national society (and publisher of this document).

⚠ **Safe (ICNIRP):** for all the reasons explained in the previous chapter, ICNIRP publications rarely use the word ‘safe’ on its own. In any country where EMF regulations are based on ICNIRP Guidelines, it is wise to follow ICNIRP’s example.

You can avoid this problem by using a more specific term like ‘below the ICNIRP **exposure limit**’. This shifts the topic towards compliance, and also allows you quote ICNIRP for backup.

⚠ **Safety factor:** Not used by ICNIRP. For alternatives that do have backup from ICNIRP publications, see **Conservative (ICNIRP) and** see **Reduction factor (ICNIRP)**.

Safety factor (IEEE): see **Reduction factor (ICNIRP)**.

Safety programme (IEEE): Defined in **IEEE Standard** C95.7-2021 as "an organized system of policies, procedures, practices, and plans designed to help ensure compliance with exposure limits associated with electric, magnetic, and electromagnetic fields; contact voltage; and contact and induced currents."

SAR (ICNIRP): Specific Absorption Rate, the rate at which incident electromagnetic energy is absorbed in a person's body. Measured in units of watts per kilogram (W/kg) or milliwatts per gram (mW/g) – numerically, the values are the same.

Since SAR is difficult to determine, equivalent frequency-dependent **reference levels** of exposure have been determined that are less difficult to measure or model, and are estimated to produce the same or lower SAR in the body. See **DRL (USA)** and **Reference Level (ICNIRP)**.

Substantiated adverse health effect (ICNIRP) or **Established adverse health effect (IEEE):** An effect of exposure to an electric, magnetic, or electromagnetic fields, or to induced or contact currents, that is specifically detrimental to the health of an individual. Internationally respected standards-setting bodies are careful to base their recommendations on health effects that are **shown to be both 'adverse' and 'established'**.

Adverse health effects are defined as being detrimental to health. Not to be confused with *detectable* effects of EMF exposure. Depending on the circumstances, some detectable effects may be experienced or measurable at quite low levels of EMF, but fail to meet the criterion of being detrimental to health.

To qualify further as being 'established' (or 'substantiated'), a claimed adverse health effect must also meet all three of the following criteria:

1. It must be supported by the weight of the evidence of that effect, in studies published in the scientific literature; and
2. It must have been demonstrated by independent laboratories; and
3. There must be consensus in the scientific community that the effect does occur for the specified exposure conditions.

These conditions result in a strong consensus between **ICNIRP Guidelines** and **IEEE Standards**.

Thermal health effects: biological adverse effects caused by release of heat energy when **EMF**s interact with body tissues.

Transmissions: see emissions.

5. REFERENCES

[To be edited before final release.]

[1] CEPT ECC: Harmonised Amateur Radio Examination Certificate, Recommendation T/R 61-02 https://docdb.cept.org/download/e4b9c459-5726/TR61-02.pdf

[2] EC: European Commission, Opinion on the need of a revision of the annexes in the Council Recommendation 1999/519/EC and Directive 2013/35/EU, in view of the latest scientific evidence available with regard to radiofrequency (100kHz - 300GHz), Scientific Committee on Health, Environmental and Emerging Risks (SCHEER), 18 April 2023 https://health.ec.europa.eu/document/download/aaf66644-cfb2-4f9b-8a73-df7ef2b3a2a4_en?filename=scheer_o_044.pdf

[3] ICNIRP: Guidelines for limiting exposure to electromagnetic fields (100 kHz to 300 GHz). International Commission on Non-ionizing Radiation Protection. Health Phys 118(5):483-524; 2020. https://www.icnirp.org/cms/upload/publications/ICNIRPrfgdl2020.pdf

[4] IEEE: IEEE list of statements from 92 national/international health agencies: Statements from Governments and Expert Panels Concerning Health Effects and Safe Exposure Levels of Radiofrequency Energy (2010-2022). Institute of Electrical and Electronics Engineers. https://www.ices-emfsafety.org/publications/expert-reviews/

[5] ITU: International Telecommunications Union EMF guide: https://www.itu.int/en/ITU-T/emf/Documents/Introduction%20to%20the%20ITU%20EMF%20Guide%20%2817%2012%2014%29.pdf

[6] WHO: World Health Organization international EMF project https://www.who.int/initiatives/the-international-emf-project

[7] Ireland - COMREG: Non-ionising radiation information. https://www.comreg.ie/industry/radio-spectrum/site-viewer/non-ionising-radiation-information/

[8] UK - Ofcom: Electromagnetic fields (EMF). https://www.ofcom.org.uk/spectrum/emf

[9] UK - Ofcom: Ofcom's rules on EMF exposure. https://www.ofcom.org.uk/spectrum/emf/policy

[10] UK - Government: Advice on exposure to electromagnetic fields in the everyday environment, including electrical appliances in the home and mobile phones. https://www.gov.uk/government/collections/electromagnetic-fields

[11] UK - Health and Safety Executive: Electromagnetic fields. https://www.hse.gov.uk/radiation/nonionising/electro.htm

[12] UK - RSGB: EM Field Exposure home page https://rsgb.org/emf/

[13] UK - RSGB: What You Need to Know about EMFs

[14] USA - FCC: Radio Frequency Safety https://www.fcc.gov/general/radio-frequency-safety-0

[15] Sweden – Swedish Radiation Safety Authority, SSM: (General public) Magnetic fields and wireless technology https://www.stralsakerhetsmyndigheten.se/omraden/magnetfalt-och-tradlos-teknik/

[16] Sweden – Swedish Radiation Safety Authority, SSM: (General public) Electromagnetic fields AFS 2008:18, recommendations

https://www.stralsakerhetsmyndigheten.se/contentassets/c4057ae5e05b4bf198e9fc8e6ae78bcb/ssmfs-200818-stralsakerhetsmyndighetens-allmanna-rad-om-begransning-av-allmanhetens-exponering-for-elektromagnetiska-falt.pdf

[17] Sweden – Swedish Work Environment Authority, AV: (Workplace) Electromagnetic fields https://www.av.se/en/health-and-safety/electromagnetic-fields/

[18] Sweden – Swedish Work Environment Authority, AV: (Work place) Electromagnetic fields (AFS 2016:3), regulations https://www.av.se/arbetsmiljoarbete-och-inspektioner/publikationer/foreskrifter/elektromagnetiska-falt-afs-20163-foreskrifter/

[19] Risk communication website (Peter M. Sandman) https://psandman.com/

[20] USA – ARRL: website https://www.arrl.org/

[21] UK – RSGB: website https://rsgb.org/

[22] Ireland – IRTS: website https://www.irts.ie/

[23] Sweden – SSA: website https://www.ssa.se/

[24] IEEE – EMF standards available free of charge (subject to sign up) via "GET program" e.g., IEEE Std C95.1™-2019, IEEE Std C95.3™-2021, IEEE Std C95.7™-2022 https://ieeexplore.ieee.org/browse/standards/get-program/page/series?id=82

[25] Ireland – Statutory Instrument 192/2009 - Wireless Telegraphy (Amateur Station Licence) Regulations 2009 https://www.irishstatutebook.ie/eli/2009/si/192/made/en/print?q=wireless+telegraphy+amateur

[26] Ireland – ComReg Amateur Station Licence Guidelines 09/45 https://www.comreg.ie/industry/radio-spectrum/licensing/search-licence-type/radio-amateurs-2/

[27] Ofcom – Guidance on EMF Compliance and Enforcement. V1.0, May 2021.

[28] Ofcom – Ofcom's EMF licence condition - What you need to know as an Amateur Radio user. V2.0, June 2021.

[29] ITU: International Telecommunication Union – K.52 : Guidance on complying with limits for human exposure to electromagnetic fields. Recommendation 06/21.