RF Safety and the Radio Amateur

An advisory guidance for the placement and use of antennae.

The quick solution

You don't have time to read this leaflet!

Use the following rule of Thumb.

For example, if you use a dipole, and 400Watts, take the frequency in MHz, and use that spacing in feet (ft).
i.e. on 14 MHz a spacing of 14 ft is required as a safety distance.
Or...
If you use a beam with a gain of 9dB, and a transmit power of 100W, take the frequency in MHz, and use that spacing.

Introduction

RF Safety is of primary concern to the Society and its Members, and this advice has been compiled with the cooperation of the Technical Committee, EMC Committee and the Planning Advisory Committee. References are made to the Guidelines published by recognised independent safety organisations.

It is intended to provide broad guidelines which if followed will result in an RF safe Radio Amateur installation.

In this context 'RF safe' means that no known harm will be caused to the station operator, or to persons who may visit the station or come within the vicinity of apparatus or antennas.

In the United Kingdom all stations and site equipped for the transmission of radio signals come under the administration of Ofcom[1]. They grant licences, and control the frequency bands and power levels that operators may use. Ofcom have the powers to close a station that is not being operated in accordance with the regulations.

The output power that Radio Amateurs may use on the various frequencies has been optimised to ensure that on one hand meaningful communication may be made, but with due regard to the issue of safety and minimisation of interference.

The licence conditions imposed in the UK are very similar to those generally available throughout Europe and the United States.

This is an important element of the international licensing regime afforded to Radio Amateurs when they travel.[2]

The minimum health and safety requirements are set out in the European Commission Directive 1999/519/EC[3]. This uses guidelines established for safety in general public situations. Guidelines, which are more applicable to those frequencies authorised for use by amateur radio stations in the UK, as shown in Schedule 1 (tables A, B and C) of the Amateur Radio Licence, issued by Ofcom. This is a summary of the NRPB guidance on exposure to electromagnetic fields.[7]

The scientific community in Europe has undertaken a great deal of academic work, but the data presented below is based on practical work conducted in the United States by the FCC and the ARRL.

Safety

Radio Amateurs should be concerned about two aspects of RF safety when planning a station and the associated antennas.

Physical contact with antennas and parts of the station, which may be RF 'Hot' where there is a risk of RF burn or electric shock, must be a primary consideration.
This might include feeders to the antennas, or ungrounded metallic objects within the station or nearby.
The second aspect is safety near the antennas. 'Near field', and many other definitions of interest to the technically competent may be found in the ICNIRP Guideline[4, 7].

It is the subject of RF near field, which will be dealt with more thoroughly here.

A particularly useful yet much generalised definition of near field is: The region where the distance from a radiating antenna is less than the wavelength of the radiated EMF.

This implies that on the lower HF bands, say on 160metres (Top Band), the near field could extend considerable distance from the antenna.

However, in practice such an antenna would also be physically large, and would result in the incident power being widely distributed over a large area. For resonant dipoles there is a significant magnetic field near the feed, and a high E field near the antenna tips - both of these need to be considered as a safety consideration.

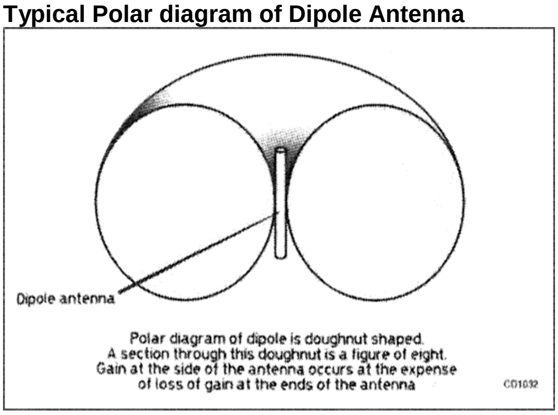
If an antenna is suspended and well away from anyone, it ca be considered safe, but it does mean that an 80m loop antenna wrapped around the gutter of a bungalow - or in a loft above the shack - is "not recommended".

The ‘near-field’ is an area that depends upon the type and location of the antennas employed at the station. The diagrams show the approximate Radiation Pattern for some representative types of antennae.

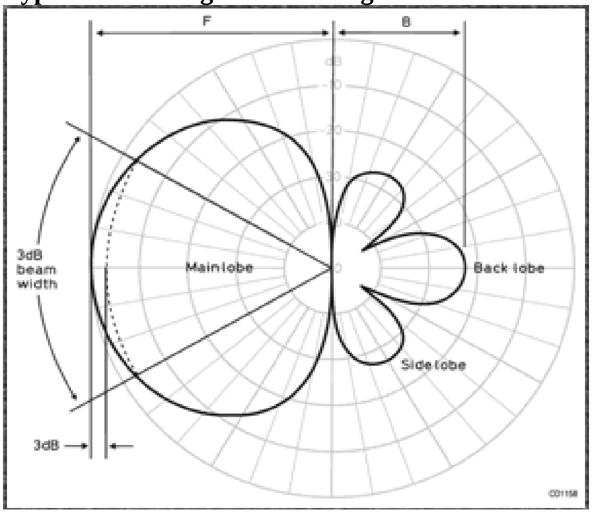
Every Radio Amateur should always ensure that persons in or near the station are not within the Near-field Safety zone recommendation of an antenna when transmitting. The far field/near field boundary is given by (lambda x gain)/(4 x Pi) - anything less than this distance has a greater uncertainty on the levels of E (Electric) and H (Magnetic) field.

Typical radiation patterns for commonly used Radio Amateur antennae. See [8].

Typical Polar diagram of Dipole Antenna



Typical Polar diagram for a Yagi Antenna



Near-Field

In the near field, the power pattern for any antenna is a complex, but using the models available for typical antennas, such as a dipole, a long wire, or Yagi-beam types good approximations can be derived by modelling.

The modelled field patterns have an accuracy, which makes them suitable for a safety assessment to the internationally agreed recommendations.

To arrive at safety distances, it is necessary to understand three factors, power delivered to the antenna, the type of antenna, and the frequency.

Table 1 shows the typical safety distance from an antenna, using a typical 100Watt and maximum legal power 400Watt transmitter.

Table 1. HF Antennas

Recommended safety distance in Feet (ft) for a Horizontal half-wave dipole wire antenna.

Transmit Power (Watts)	3.5MHz	7MHz	14MHz	21MHz	28MHz
100	2	3.5	7	11	14
400	3.8	7	14	21	30

This data is based on the FCC Bulletin ET65B supplement B. See[5]

The tables 1 and 2 err on the side of caution, for example, the power delivered to the antenna will be somewhat less than to 100Watts generated by the typical transmitter by virtue of feeder losses, and it is assumed that this is a CW transmission, key down. In practice the 'continuous' near-field power will be considerable less, depending on the mode being used.

Even a CW station has the key down for only a fraction of the time during normal operation, and an SSB transmitter, even with heavy speech processing has a much lower duty cycle than the key-down situation. See Table 4 below.

Having a detailed understanding of the radiation pattern of a particular antenna is not essential; the power delivered to it is the important issue. For example a dipole, which has been bent to fit into a small garden, will still require the same safety distance as for a regular dipole. The radiation pattern may be distorted but the field Generated will be the result of the power input. It will still be 100Watts.

In the case of a beam antenna, which has gain in a particular direction, the gain must be taken into account, simply because it is directing most of the power in one direction. Table 2 shows the safety distance for a typical HF tri-band beam antenna.

Table 2

Recommended safety distance in Feet (ft) for three element 'triband' Yagi antenna.

Transmit Power (Watts)	14MHz	21MHz	28MHz
100	14	21	28
400	28	42	56

This data is based on the FCC Bulletin OET65B supplement B. See[5]

Frequency is a factor simply because in the near-field power effects become less relevant as the wavelength shortens, until at VHF/UHF the wavelength becomes so short, that antenna gain and position (polarisation) become the dominant feature as far as safety distance is concerned.

However in this table, the safety distance increases, since the forward gain of a tri-band Yagi increases as the frequency increases.

A Useful Calculator

If the data provided in tables 1 and 2 does not fit your station profile, you can calculate your own safety distances using a Windows utility developed by Stacey E Mills - W4SM. This has been distributed as shareware on the Internet, and was included on the 2008 Yearbook CD.

Table 3

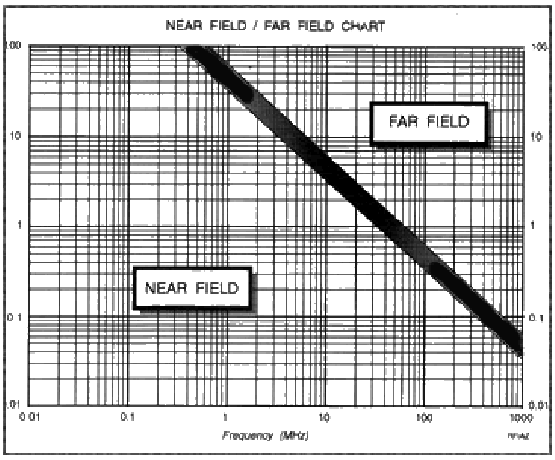


Table 3 shows the relationship between Near-Field and Far-Field distances vs. Frequency.

This illustrates the relationships of Frequency and Distance in an easy to understand although simplistic manner, for a simple current loop antenna. It takes no account of power, and it ignores 'ground effects' which disturb the uniformity of the near field. However, it provides a good 'feel' for the relationships involved.

Using the Tables.
To be able to apply these principles to a particular station, it is important to understand how the safety distance may be applied, and how it is scaled for lower and higher power stations.

The safety distance is directly related to the square of the power applied to the antenna. Increase the power four fold (6dB power) and the safety distance halves. Thus applying the information shown in Table 1, for 25W power at 3.8MHz using a dipole antenna the theoretical safety distance becomes 0.5 Metre.

Although in practice a station operator would be wise to maintain a much great separation between an antenna and any persons.

One consequence of being in the near field is that the actual field may be magnetic or electric, but in both cases the signal falls rapidly with Distance or with Frequency.

The effects of altering the frequency or the distance are in reality the same since both change the number of wavelengths from the antenna to the boundary of the safety distance.

If the safety distance around an antenna is doubled, the incident near-field power is reduced by a factor of four, making it at least four times as safe. In practical terms, a station set-up running moderate power (100W) with wire antennas with separations of more than 33ft (10 Metres) from surrounding objects or persons can be considered safe.

In the far field the signal falls off much less rapidly, with increasing distance. This of course is important for Radio Amateurs communicating with other stations over great distances.

Practical considerations.

The safety distance provided by Table 1 is the actual physical distance from the Radio Amateur or persons with access to the station, and the antenna, and has to take account of the radiation patterns described in the diagrams.
There are many other variables, which have been considered for the distances stated in Tables 1 and 2. For example ground reflections have been included, as they contribute to the incident power.
The Duty Factor of the transmitted signal will depend on operating mode. Table 4 gives the approximate duty factors for commonly used Radio Amateur modes of transmission.

In fact most Radio Amateurs are very good listeners, and will transmit for only a fraction of their time in the station, which may be only a few hours a week.

Table 4 - Duty factor considerations for some typical Amateur transmission modes

Mode	Duty Factor	Comment
SSB QSO	20%	Factored for voice and syllabic characteristics
SSB QSO with Compression	50%	As above, but with heavy speech processing
Voice FM	100%	
AFSK/FSK/ RTTY	100%	
CW QSO	40%	Normal QSO operations
Carrier	100%	Full output power- for tune up.

Height

The height of an antenna above ground must be taken into account, in general the higher the antenna the better, since it ensures that the safety distance requirement is easily met.

A dipole antenna that is 15Metres above ground and clear of buildings by the same distance is safe on any of the HF Bands with up to 400Watts A 3 Element HF Band beam on a typical 15Meter high tower will result in the major lobe touching ground at a distance of 45ft from the tower, beyond the requirement of safety distance, and any disturbance of the near field radiation pattern due to ground effect will be minimised, but still noticeable.

So, once again more height is desirable.

One word of caution is important in respect of crank-up towers; the safety distance will be shortened when operating with the tower lowered, and ground effects will disturb the near field radiation pattern.

The same principles apply to VHF/UHF beam antennas. **Height is a big advantage.**

With much greater antenna gains possible with large stacked arrays the safety distance may be surprisingly large. With antenna gain of up to 13dB being readily available, the safety distance in front of the major lobe is increased by a factor 3.

It is therefore important to ensure that the antenna does not 'fire' into nearby buildings, particularly if they are occupied, although the usual desire for height will most times over-ride this issue. Near 'line-of-sight' being the VHF/UHF station operator's biggest objective.

Many operators will have access to manufacturer’s data on VHF/UHF antenna gain and radiation pattern. If this data is not forthcoming a good approximation of the gain and polar diagram is available in the RSGB VHF/UHF Manual [6]

It is useful to remember that height and distance are mutually inclusive when considering the Safety Distance. Getting the antenna up high and away from buildings is both good radio practice, and Good Radio Housekeeping.’

So, in conclusion, the station operator will maintain the recommended safety distances as a very minimum to ensure the safety of himself/herself, and that of any visitors and persons with access to the periphery of the site.

References

1. Ofcom. Riverside House, 2a Southwark Bridge Road London, SE1 9HA.
2. CEPT equivalent licence regime.
3. Official Journal of the European Union, Directive 89/391/EEC and Directive 204/40/EC.
4. Near field. See International Commission on Non-Ionizing Radiation Protection, Guideline, published 1998.
5. Evaluating Compliance with FCC Guidelines for Human exposure to Radio Frequency Electromagnetic fields, FCC Bulletin OET65b Supplement B.
6. VHF/UHF Manual by George Jessop. RSGB ISBN 0 900612 63 0
7. HPA Reference Levels for UK Amateur Radio Bands, www.hpa.org.uk
8. Les Moxon – HF Antenna for all Locations. ISBN 1 872309 15 1
9. The utility "RF Safety" was distributed on the RSGB 2008 Yearbook CD.

Footnote

The Radio Society of Great Britain represents amateur radio in the UK. This leaflet was produced by: RSGB EMC Committee
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