Amateur Radio Service: Self-assessment of Compliance with the Requirements of NZS2772:Part 1: 1999

Introduction

In New Zealand, central government does not have any regulatory responsibility for controlling electromagnetic field exposure from radio transmitting stations. Instead, it is likely that local authorities will increasingly move to control radiofrequency exposure levels under the Resource Management Act. The Palmerston North City Council (PNCC) has set an important precedent in the matter of rules, by not making radiofrequency emissions subject to District Plan Rules, except when emissions fail to comply with New Zealand Standard NZS 2772:1999 [1]. Most importantly, this enables amateur transmissions to be made without any control by the Council, except when excessive emission exposures occur. Furthermore, and very importantly, while amateur radio emission exposures should comply with NZS 2772, operators will not be required to demonstrate compliance provided the Council is comfortable that amateurs in its jurisdiction do in fact comply. Amateur radio operators in New Zealand may use the compliance level framework and self-assessment protocol set out in this document to determine whether or not their station and operation complies with NZS 2772.

Background

Operating an amateur station is a land use in terms of the Resource Management Act, and local territorial authorities are empowered to make rules governing the uses for land. A land use is permitted unless it contravenes a rule in a plan and there are various levels of permissions, ie, permitted, discretionary, limited discretionary, non-complying and prohibited.

Most of our day-to day activities are not controlled by Plan Rules. Nor should amateur radio be, unless it poses a potential risk to the sustainable environment. Radiofrequency emissions are, however, seen as a potential risk to human health, and to mitigate that risk, emission exposure limits have been set which are well below those levels which are seen to perhaps pose a hazard to human health.

To date, local authority concerns have mainly been over the intrusion of antennas and their supporting structures into the visual landscape, and many different rules have been written to put controls into place, mainly relating to height and to position on a property. In recent years, in response to public concerns over health effects from exposure to radiofrequency energy, some Councils have introduced Bylaws (Auckland City) or District Plan Rules (Christchurch City) controlling emission exposures. Amateur radio is not recognised by local authorities as being an ordinary part of our social fabric which can exist without controls, but it is important to amateur operations that such controls are not unduly restrictive. Overly restrictive rules will become a barrier to entry to our hobby, and will impose additional costs on our fraternity.

It is now expected that local bodies will introduce their own controls under the Resource Management Act. In theory, local bodies are free to set their own radiofrequency field exposure limits, but in practice such controls are likely to be in accordance with NZS 2772. This standard has been strongly endorsed by the Ministries of Health and Environment in their document "National Guidelines for Managing the Effects of Radiofrequency Transmitters" also known as "Policy Document ME377" [2]. Document ME377 gives guidance to territorial authorities “on managing the effects of radiofrequency transmission facilities through district plan provisions”. While the main concern is the management of commercial facilities such as TV and FM transmitters and cell phone base stations, (the amateur radio service is not mentioned), neither is the amateur radio service excluded from the scope of the document. The method for demonstrating compliance with NZS 2772 as set out in ME377 (blue box on page 40) requires mandatory assessments, to be carried out by "a radio engineer/technician or physical scientist" and in some cases field testing and reports by the National Radiation Laboratory. While this is reasonable for a high-power commercial transmitting site, it is a prohibitively expensive imposition to place on the amateur service. Since the transmitter power of an amateur station is already limited by licence requirements to modest power levels in order to avoid interference to other spectrum users in close proximity (such as domestic radio and TV receivers), the great majority of amateur stations will comfortably comply with NZS 2772 without having to alter their transmitting station in any way.

The compliance framework and self-assessment protocol which follows provides a process for New Zealand amateurs to demonstrate compliance to NZS 2772. (The NZART two-level compliance framework is the same as that adopted by the Australian Communications Authority (ACA) [3]. This is possible because the ACA has used the radiofrequency field exposure level limits set out in [4] which are identical to those in NZS 2772. The self-assessment protocol is modelled on the ACA Supplements 5 and 6 [5],[6]).

Compliance Framework

Compliance Level 1 category

Compliance Level 1 category applies to a transmitter installation that meets any of the following criteria:

[a] the total average power fed to all antennas at the site does not exceed 100 watts and the antennas are out of reach; OR

[b] the bottom of the lowest antenna is at least 10 metres above ground and the average EIRP does not exceed 3200 watts in any direction; OR

[c] the transmitter installation is a point-to-point link operating above 1GHz; OR

[d] the installation is a mobile transmitter with an average total power of not more than 100 watts.

Compliance Level 2 category

Compliance Level 2 category covers all transmitter installations that do not meet any of the criteria for the Compliance Level 1 category. While the transmitter installation may still comply with NZS 2772, in order to demonstrate compliance, the operator must carry out a self-assessment of compliance. It is advisable for the operator to keep the records of the assessment. The self-assessment protocol (see below) or any other suitable method of modelling or calculation may be used.

Using the Compliance Framework

Most amateur stations will easily meet the 100 watt average power requirements of Level 1 because even with reasonable amounts of speech processing, the licence limit of 400 W PEP for SSB will not exceed 100 W average power. Similarly, conversational CW will be unlikely to exceed 100 W average power. Further information on determining the average power is given in Step 1 of the self-assessment protocol. Compliance with Level 1 (a) then needs only a practical determination of what constitutes "out of reach" for the antenna installation.

This is something of a subjective assessment matter and a realistic determination will depend on the situation. For a home installation, a simple guideline such as keeping the lowest point of an antenna at least 2 metres above head height, or installing the antenna at least 2.8 metres from a property boundary can be used. Operators of amateur stations which clearly meet the requirements of Compliance Level 1 need not take any further action to demonstrate compliance with NZS 2772.

Mobile Operation

Clearly, a 2.8 metre separation distance cannot be achieved for mobile installations, so mobile antennas should be installed so as to minimise the possibility of accidental contact. Centre-of-roof or centre-of-boot mountings are preferred, and "gutter-grip" installations should be avoided. When transmitting while stationary, the mobile station operator should be alert to persons in the near vicinity, and cease transmission if anyone approaches within two metres of the antenna.

Repeaters and Beacons

Operators of repeater or beacon installations that can transmit simultaneously on multiple frequencies should determine if their installations comply with either of Level 1(a) or (b). If the installation complies with Level 1, it is recommended that the output power levels achievable on each operating band be recorded, so that such a record could be used to justify treating the installation as Level 1.

Very High Gain Antennas and Microwave Antennas

Operators of specialist stations such as EME or weak-signal tropo-scatter installations that use very high gain antennas are advised to carry out a full self-assessment using the self-assessment protocol, even if the installation does meet the Level 1 compliance criteria. Operators using higher microwave bands may find additional helpful information in "Evaluation Against The ACA's EMR Standard Self-Assessment Supplement 6: General Radio Services" on the ACA web site[6]. (Note: at the time of writing, the ACA Supplements 5 and 6 are based on an earlier standard , and have not been up-dated. The earlier standard is more restrictive above 400 MHz.)

Operators using high-power permits or operators of beacon or repeater stations that do not comply with the Level 1 criteria will need to undertake a full self-assessment using the self-assessment protocol to determine compliance to NZS 2772, and are advised to keep the records of that assessment.

LF Antennas

Amateur use of the low frequency (LF) spectrum is still recent on the international scene, and as yet there is no technical information available to enable amateurs to self-assess LF transmitting installations. It is expected that this information will become available as the 136 kHz European allocation becomes more widely accepted as an international allocation. In the meantime, New Zealand amateurs are advised to take careful precautions to ensure that the high voltage parts of LF transmitting antennas are well out of reach.

Acknowledgement

NZART would like to thank Keith Malcolm VK1ZKM and the Australian Communications Authority (ACA) for permission to use the self-assessment material "Supplement 5" and "Supplement 6" developed by the ACA [5] [6]. Commentary on the use of the compliance framework has been adapted from an editorial in Amateur Radio [7].

References

[1] Standard NZS2772:Part 1: 1999 Radiofrequency Fields - Maximum Exposure Levels 3 kHz to 300 GHz.

[2] "National Guidelines for Managing the Effects of Radiofrequency Transmitters", Ministry for the Environment, ME number 377, December 2000, http://www.mfe.govt.nz/publications/rma/radio-freq-guidelines-dec00.pdf

[3] Radiocommunications Licence Conditions (Apparatus Licence) Determination 2003, Part 3 and Part 4, http://www.aca.gov.au/consumer_info/issues_alerts/info_licensees.htm

[4] "Radiation Protection Standard Maximum Exposure Levels to Radiofrequency Fields - 3 kHz to 300 GHz", Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), http://www.arpansa.gov.au/rf_standard.htm

[5] " “Electromagnetic Radiation Exposure: Assessment Against ACA Mandated Limits Supplement 5: Amateur Radio Services” http://www.aca.gov.au/consumer_info/issues_alerts/amateur.pdf

[6] “Evaluation Against The ACA's EMR Standard Self-Assessment Supplement 6: General Radio Services" http://www.aca.gov.au/consumer_info/issues_alerts/general.pdf

[7] Jim Linton VK3PC "Will your station meet EMR requirements?" Amateur Radio, June 2002 pp 4,5

Self-assessment Protocol to NZS2772 - Amateur Radio Services in the Frequency Bands 1.8 MHz to 24.25 GHz

Introduction

This protocol has been prepared to enable amateur radio licensees to make a simple assessment as to whether proposed or existing facilities comply with the limits for general public human exposure to radiofrequency (RF) fields in accordance with NZS2772: Part 1: 1999 Radiofrequency Fields - Maximum Exposure Levels 3 kHz to 300 GHz.

All amateur radio service installations operating in the frequency bands from 1.8 MHz to 24.25 GHz and at maximum power levels up to 400 watts PEP or 100 watts mean are covered by this protocol. Operators of specialist stations such as EME or weak-signal tropo-scatter installations that use very high gain antennas are advised to carry out a full self-assessment using the self-assessment protocol, even if the installation does meet the Level 1 compliance criteria. Operators using higher microwave bands may find additional helpful information in "Evaluation Against The ACA's EMR Standard Self-Assessment Supplement 6: General Radio Services" [6].

Undertaking the assessment

The optional worksheet (starting on page 13) may assist in the evaluation process. Examples of the use of this supplement are provided from page 12.

The steps outlined below provide a simple process to demonstrate compliance to NZS 2772. If the initial assessment of station operation indicates non-compliance, a more accurate assessment may show that operation is, in fact, in compliance. The section 'Making the assessment more accurate' (page 5) may assist.

STEP 1: Determine and record the antenna gain and transmitter output power that is applicable.

Note that transmitter power can be specified as either peak envelope (PEP) or mean power. The determination of human exposure levels, and consequently, minimum separation distances, is based on the mean power. Accordingly, where only PEP is known, the power shall be multiplied by the conversion factor (form factor) appropriate to the mode of operation. Table 1 provides form factors for transmission modes commonly used in the amateur service.

For example, an SSB transmitter has a power rating of 100W PEP and the form factor from Table 1 is 0.2 (no speech processing in use). Therefore the mean power is 20W. An FM transmitter provides 25W output power and form factor is 1, therefore the mean power is 25W.

See also notes 1–3 following.

Table 1. Form Factors of modes commonly used by amateurs

Mode	Form Factor	Notes
Conversational SSB	0.2	Note 1
Conversational SSB (with speech processing)	0.5	Note 2
FM voice or data	1	
AM voice, 50% modulation	0.5	
AM voice, 100% modulation	0.3	
Digital modes (*eg* PSK31, AMTOR, MFSK)	1	
Conversational CW	0.4	
Carrier	1	Note 3
Analogue TV	0.6	Note 4

Notes to table 1:

1: Includes voice characteristic and syllabic duty factor. No speech processing.

2: Includes voice characteristic and syllabic duty factor. Heavy speech processing employed.

3: A full carrier is commonly used for tune-up purposes.

4: Monochrome or PAL, NTSC or SECAM coded video.

STEP 2: Consult Table 2a or Table 2b, as appropriate to the operating frequency band.

STEP 3: Record the minimum separation distance to be observed for each combination of operating band, antenna gain and transmitter power level.

STEP 4: If the station antenna(s) is (are) installed in such a way that the minimum separation distance(s) recorded at step 3 is (are) maintained during all operational periods (that is, the antenna(s) is (are) out of reach and people cannot inadvertently approach closer than the specified separation distance to the antenna(s)), record this fact and the compliance evaluation is completed.

It would be convenient to record the details of the evaluation process in the station logbook.

STEP 5: In the event that Table 2a or 2b cannot be used (for example, the antenna gain might not be known or the transmitter power level different from that in tables 2a or 2b), consult tables 3 to 12 (starting on page 9) which provide minimum separation distances for a number of antenna types representative of those used in the amateur service.

STEP 6: Having identified an appropriate antenna type in Step 5, record the minimum separation distance that is applicable to the transmitter power level in use.

STEP 7: If the station antenna(s) is (are) installed in such a way that the minimum separation distance(s) recorded at Step 6 is (are) maintained during all operational periods (that is, the antenna(s) is (are) out of reach and people cannot inadvertently approach closer than the specified separation distance to the antenna(s)), record this fact and the compliance evaluation is completed.

It would be convenient to record the details of the evaluation process in the station log book.

STEP 8: As necessary, implement measures to reduce exposure levels by reducing transmitter power or changing the modulation method to one where the average power is less, or changing the location or height of the antenna.

NOTES:

1. The tables provide data for power levels and antenna gains that are representative of those typically used by stations in the amateur service. It is possible to extrapolate or interpolate the data to derive minimum separation distances for other power levels or antenna gain figures. Note that separation distance is proportional to the *square root* of the ratio of the power levels or gains expressed numerically[1]. For example, if operation is on 100 W, multiply the separation distance for 50 W by the square root of two, 1.414. However, it may be easier to simply adopt the separation distance for the nearest higher power level or antenna gain case.

2. The tables are based on transmitter output power and do not include an allowance for feed-line attenuation or other losses. In cases where the feed-line loss is accurately known for each operating band, the power level used for evaluation purposes can be reduced by the feed-line loss. For example, if transmitter output power is 50 W and feed-line loss is 3 dB, the power level used for evaluation should be 25 W.

3. In principle it is also permissible to reduce the power level used for evaluation purposes by the ratio of transmission to reception time in each 6-minute averaging period. Because of the highly variable nature of amateur operations, including the possibility of an extended transmission period, this factor has not been used in the calculation of separation distances. However, should the duty cycle of transmission be known and *always* maintained, multiply the separation distance by the *square root* of the duty cycle. For example, if the station always operates two minutes transmit, two minutes receive, two minutes transmit the worst case duty cycle in six minutes is two thirds. The separation distance would be multiplied by 0.82, the square root of two thirds.

Making the assessment more accurate

[1] To convert from decibel gain to numerical gain, use the following formula:

$$\text{numerical gain} = 10^{\left(\frac{\text{dB gain}}{10}\right)}$$

The gain of an antenna varies with direction. As a result, different minimum separation distances may need to be maintained in different directions from the antenna.

A very simple model for antenna pattern is to make a distinction between 'main beam or lobe'/outside 'main beam or lobe'. References to 'main beam' exposure then assume the main lobe extends to angles of ±45° to the boresight/boom axis. The maximum gain of the antenna is used when assessing compliance. Outside the main beam a gain of 0 dBi is used to assess compliance. This is the simplest way of accounting for antenna directivity. However, in many circumstances it will be overly conservative.

Table 13 (page 11) lists representative 3 dB angles for Yagi antennas in terms of the boom length of the antenna. The 3 dB angle may be taken as the boundary of the main beam for the purpose of determining compliance. Outside the main beam a gain of 0 dBi may be used. Example 2 on page 12 demonstrates this method.

If the actual antenna radiation pattern is known, it should be used when assessing compliance. This may be a pattern supplied by the manufacturer of the antenna or one calculated, for example using MININEC or similar software.

In the near-field of an antenna the gain will be less than in the far-field. Using far-field equations may result in calculation of too large a separation distance. Dealing with near-field effects is described in NZS 2772.

Assessment Tables

Table 2a HF/VHF Bands
Estimated distances (in metres) from transmitting antennas necessary to meet RF field limits for general public exposure.

Frequency (MHz/Band)	Antenna Gain (dBi)	Power 10 watts	Power 25 watts	Power 50 watts	Power 120 watts	Power 200 watts
2 MHz (160m)	0	0.28	0.45	0.63	0.99	1.28
	3	0.41	0.65	0.92	1.42	1.83
4 MHz (80m)	0	0.41	0.65	0.92	1.42	1.83
	3	0.57	0.90	1.27	1.97	2.54
7 MHz (40m)	0	0.54	0.85	1.20	1.86	2.40
	3	0.76	1.20	1.70	2.63	3.40
	6	1.04	1.65	2.33	3.62	4.67
10 MHz to 144 MHz (30 m to 2 m)	0	0.63	1.00	1.41	2.19	2.83
	3	0.89	1.40	1.98	3.07	3.96
	6	1.27	2.00	2.83	4.38	5.65
	9	1.77	2.80	3.96	6.13	7.91
	12	2.50	3.95	5.60	8.65	11.17
	15	3.54	5.60	7.90	12.27	15.84
	20	6.29	9.95	14.10	21.80	28.14

NOTE: These separation distances apply only in the direction of the main beam/lobe of the antenna. The figures for 0 dBi gain can be applied outside the main lobe, which can be taken as being ±45 degrees off boresight/antenna boom axis for the purpose of compliance. If the actual radiation pattern is known (manufacturer's specification or calculation) then this should be used instead. For Yagi antennas, the appropriate angle from Table 13 should be used to determine the boundary of the main lobe rather than 45°; see also example 2 on page 12.

Table 2b UHF/microwave Bands

Estimated distances (in metres) from transmitting antennas necessary to meet RF field limits for general public exposure.

Frequency (band)	Antenna Gain (dBi)	Power 10 watts	Power 25 watts	Power 50 watts	Power 120 watts	Power 200 watts
430 MHz (70 cm)	0	0.65	1.04	1.45	2.27	2.93
	3	0.92	1.45	2.07	3.18	4.11
	6	1.32	2.07	2.90	4.54	5.86
	9	1.84	2.90	4.15	6.36	8.20
	12	2.59	4.10	5.81	8.97	11.58
	15	3.67	5.81	8.19	12.72	16.42
	20	6.52	10.32	14.62	22.60	29.18
614 MHz (50 cm)	0	0.78	1.24	1.73	2.71	3.51
	3	1.10	1.73	2.48	3.80	4.91
	6	1.57	2.48	3.47	5.43	7.00
	9	2.19	3.47	4.96	7.59	9.80
	12	3.10	4.89	6.94	10.72	13.84
	15	4.39	6.94	9.79	15.20	19.62
	20	7.79	12.33	17.47	27.01	34.86
	23	11.01	17.41	24.68	38.15	49.25
922 MHz (32 cm)	0	0.96	1.52	2.13	3.32	4.30
	3	1.35	2.13	3.04	4.66	6.01
	6	1.93	3.04	4.25	6.65	8.58
	9	2.69	4.25	6.07	9.31	12.01
	12	3.80	6.00	8.50	13.13	16.96
	15	5.37	8.50	11.99	18.63	24.05
	20	9.55	15.11	21.41	33.10	42.72
	23	13.49	21.34	30.24	46.75	60.35
1240 MHz (23 cm)	0	1.11	1.76	2.46	3.86	4.98
	3	1.57	2.46	3.52	5.41	6.97
	6	2.24	3.52	4.93	7.71	9.95
	9	3.12	4.93	7.04	10.79	13.93
	12	4.40	6.95	9.86	15.23	19.67
	15	6.23	9.86	13.91	21.60	27.89
	20	11.07	17.52	24.83	38.38	49.55
	23	15.64	24.75	35.07	54.22	69.98
2396 MHz and higher	0	1.41	2.24	3.13	4.90	6.33
	3	1.99	3.13	4.47	6.86	8.85
	6	2.84	4.47	6.26	9.79	12.63
	9	3.96	6.26	8.94	13.71	17.69
	12	5.59	8.83	12.52	19.34	24.98
	15	7.92	12.52	17.66	27.44	35.42
	20	14.06	22.25	31.53	48.75	62.92
	23	19.87	31.43	44.54	68.86	88.88

NOTE: These separation distances apply only in the direction of the main beam/lobe of the antenna. The figures for 0 dBi gain can be applied outside the main lobe, which can be taken as being ±45 degrees off boresight/antenna boom axis for the purpose of compliance. If the actual radiation pattern is known (manufacturer's specification or calculation) then this should be used instead. For Yagi antennas, the appropriate angle from table 13 should be used to determine the boundary of the main lobe rather than 45°; see also example 2 on page 12.

TABLE 3. Three-element "triband" Yagi

Distance (meters) from any part of the antenna for compliance with exposure limits.

Power (watts)	14 MHz, 6.5 dBi	21 MHz, 7 dBi	28 MHz, 8dBi
10	1.33	1.42	1.58
25	2.10	2.25	2.5
50	2.97	3.18	3.54
120	4.60	4.93	5.48
200	5.94	6.36	7.07

TABLE 4. Omnidirectional HF quarter-wave vertical or ground plane antenna (estimated gain 1 dBi)

Distance (meters) from any part of the antenna for compliance with exposure limits.

Transmitter Power (watts)	3.5 MHz	7 MHz	14 MHz	21 MHz	28 MHz
10	0.41	0.60	0.70	0.70	0.70
25	0.65	0.95	1.1	1.1	1.1
50	0.92	1.34	1.56	1.56	1.56
120	1.42	2.08	2.41	2.41	2.41
200	1.83	2.69	3.11	3.11	3.11

TABLE 5. Horizontal half-wave dipole wire antenna (estimated gain 2 dBi)

Distance (meters) from any part of the antenna for compliance with exposure limits.

Transmitter Power (watts)	3.5 MHz	7 MHz	14 MHz	21 MHz	28 MHz
10	0.47	0.66	0.79	0.79	0.79
25	0.75	1.05	1.25	1.25	1.25
50	1.06	1.48	1.77	1.77	1.77
120	1.64	2.30	2.74	2.74	2.74
200	2.12	2.97	3.54	3.54	3.54

TABLE 6. VHF 1/4 wave plane or mobile whip antenna at 146 MHz (estimated gain 1 dBi)

Transmitter Power (watts)	Distance (m) from any part of the antenna to comply with exposure limits
10	0.71
25	1.12
50	1.58
120	2.45
200	3.16

TABLE 7. UHF 5/8 wave ground plane or whip antenna at 446 MHz (estimated gain 4 dBi) main beam exposure

Transmitter power (watts)	Distance (m) from any part of the antenna to comply with exposure limits
10	1.00
25	1.58
50	2.24
120	3.46
200	4.67

TABLE 8. Seventeen (17) element Yagi on five-wavelength boom designed for weak-signal communications on 144 MHz (estimated gain 16.8 dBi); main beam exposure

Transmitter power (watts)	Distance (m) to comply with exposure limits
10	4.40
25	6.90
50	9.75
120	15.12
200	19.52

TABLE 9. HF Discone antenna (estimated gain 2 dBi); main beam exposure

Distance (meters) from any part of the antenna for compliance with exposure limits.

Transmitter power (watts)	3.5 MHz	7 MHz	14 MHz	28 MHz
10	0.47	0.66	0.79	0.79
25	0.74	1.05	1.26	1.25
50	1.05	1.48	1.78	1.78
120	1.62	2.30	2.75	2.75
200	2.09	2.97	3.55	3.55

TABLE 10. VHF/UHF Discone antenna (estimated gain 2 dBi) main beam exposure

Distance (meters) from any part of the antenna for compliance with exposure limits.

Transmitter power (watts)	50 MHz	144 MHz	440 MHz
10	0.8	0.8	0.8
25	1.25	1.25	1.25
50	1.8	1.8	1.8
120	2.74	2.74	2.74
200	3.54	3.54	3.54

TABLE 11. Quarter-wave half-sloper antenna (estimated average gain 6.7 dBi); main beam exposure

Transmitter power (watts)	7 MHz	14 MHz	21 MHz	28 MHz
10	1.14	1.36	1.36	1.36
25	1.80	2.15	2.15	2.15
50	2.55	3.04	3.04	3.04
120	3.94	4.71	4.71	4.71
200	5.09	6.08	6.08	6.08

TABLE 12. Eight 17-element Yagis with five-wavelength booms designed for "moonbounce" communications on 144 MHz (estimated gain 24 dBi); main beam exposure

Transmitter power (watts)	Distance (m) to comply with general population exposure limit
10	9.99
25	15.80
50	22.35
120	34.62
200	44.69

Table 13. 3 dB angles for Yagi antennas (provided by Guy Fletcher, VK2KU)

Boomlength (in wavelengths)	3 dB angle (degrees)
< 1	50
1–2	31
2–3	22
3–4	18
4–6	16
6–8	14
8–10	11
> 10	10

Note: In each boomlength range, the lower value is inclusive and the upper value is exclusive. This table must not be applied to Yagi arrays, only to single Yagi antennas.

Examples of the use of this supplement

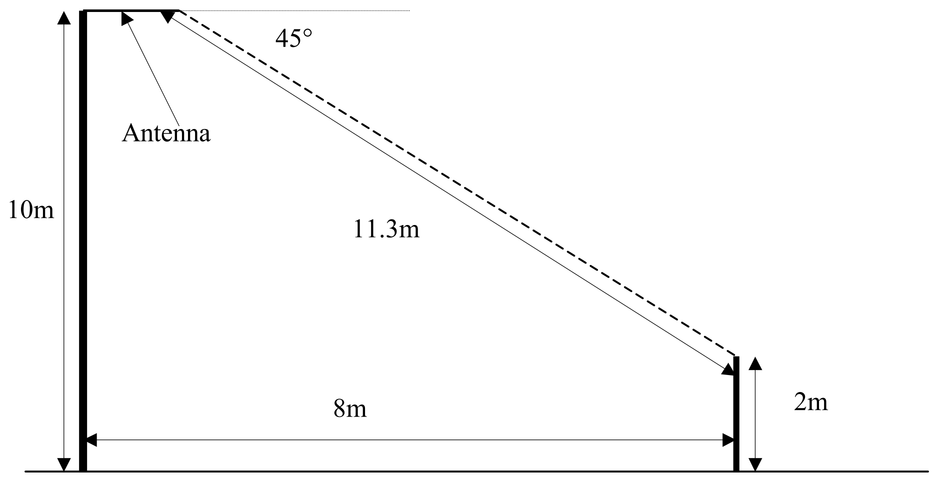
<u>Example 1</u>

Bob uses an SSB transmitter, with a PEP of 100 W, which feeds a discone antenna at 144 MHz. He uses no speech processing. From Table 1, Bob's average power is therefore 20 W. Bob is not sure of his antenna's gain and cannot use Table 2. Instead he refers to Table 10 applicable to VHF discones. As there is no entry for 20 W, he decides to use the next power level, 25 W. This indicates a separation distance of 1.25 metres. Due to its location, people cannot not ordinarily approach this close to the antenna and Bob decides he is in compliance.

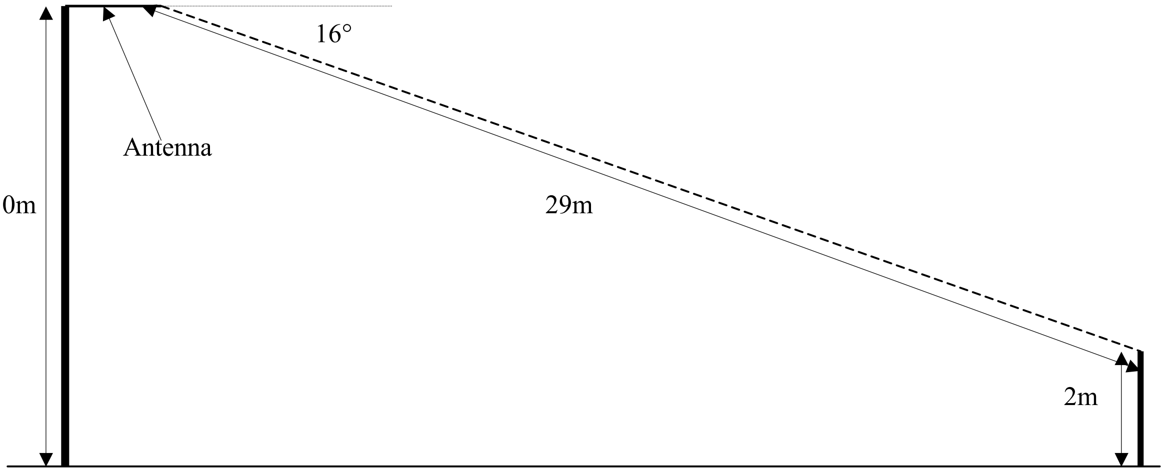
<u>Example 2</u>

Mary has a 17 element, 10.5 metre long Yagi antenna, mounted ten metres above and parallel to the ground, that she uses for FM transmission on 144 MHz with a transmitter power of 120 W. From Table 1, her mean power is also 120 W. There are no elevated areas immediately in front of the antenna.

Mary applies Table 8 (10.5 metres is five times the wavelength at 144 MHz) and finds that the minimum separation distance required is 15.12 metres. Assuming a ±45° width of the main beam, Mary finds that she is not in compliance, as at an angle of 45° to the boom axis a two metre tall person will only be 11.3 metres (eight metres in front of the supporting pole) from the antenna when exposed to the main beam (see figure below).



Using table 13, Mary finds that the appropriate angle to use is, in fact, 16° as the boom of her Yagi is five wavelengths long. At this angle, a two metre tall person will be 29 metres from the antenna (28 metres in front of the supporting pole) when exposed to the main beam (see figure below). Thus the minimum separation distance is met.



Note that there will be sidelobes off the boom axis. Due to the low gain in these lobes, the minimum separation distance in these directions would normally be met at a distance less than eight metres and can be ignored. However, if there are sidelobes with significant gain they may need to be considered.

EVALUATION AGAINST NZS 2772: Part 1: 1999
OPTIONAL WORKSHEET

This optional worksheet can be used to assist in determining whether an amateur station complies with the NZS 772. Additionally, amateurs may find the worksheet a useful means of recording the compliance of their stations.

Instructions

If an amateur station is to be operated on more than one band, with different antennas and/or different combinations of apparatus, each is considered to be a separate installation. It might be helpful to complete a separate worksheet for each installation. For a station using two or more transmitters with one antenna on the same band it is only necessary to consider the set up with the highest power fed to the antenna.

Items 1 through 6

These items are general information about the station.

Item 7

Fill in the average power output of the transmitter (or final stage amplifier), in watts, at (A). If only peak envelope power (PEP) is known, multiply by the relevant form factor from Table 1 (on page 4) to convert to average power.

For example, if an SSB transmitter outputs 400 W (PEP) and is transmitting voice with no speech processing, the appropriate duty factor is 0.2. Hence the average power is 80 W. For an FM transmitter, PEP is the same as the average power.

The power written at (A) may be either that specified by the manufacturer of the transmitter, measured using a power meter or calculated from a consideration of the amplifier characteristics. When using a power meter, it is important to know whether the meter measures average or peak envelope power. (Most commonly available power meters measure average power.) If average power is measured *do not* multiply by a form factor.

Item 8

At (B) fill in the average power output in dBW. Use the value at (A) and Table 14 to convert the power output to dBW.

Table 14. Power conversion from Watts to dBW

Watts	dBW
1	0
2	3
3	5
5	7
10	10
15	12
20	13
25	14
30	15
40	16
50	17
80	19
100	20
120	21
200	23

For power levels that fall in between the levels given, use the next higher power. Alternatively, the following formula can be used to do the conversion:

$$\text{power}_{\text{dBW}} = 10 \times \log_{10} \text{power}_{\text{Watts}} .$$

Item 9

Fill in the feed line loss specification, in decibels per 30 metres, at (C). The attenuation or loss of a feed line is higher for higher frequencies. The band of operation must be taken into account when determining what the feed line loss specification is.

The manufacturer of your cable may specify attenuation factors and many amateur radio handbooks or publications include feed line loss specifications. Alternatively, Table 15 may be used.

This table provides conservative approximations for common types of feed lines. It is not meant to represent the actual attenuation performance of any particular product made by any particular manufacturer. The actual attenuation of any particular sample of a feed line type may vary somewhat from other samples of the same type because of differences in materials or manufacturing. If the feed line manufacturer's specification is available, use that instead of the values listed in this table.

Table 15. Feed line loss specifications in dB per 30 metres.

Band	RG-58	RG-8A, RG-213	"9913" & eqv	½″ 50Ω corrugated jacket
160 m	0.5	0.3	0.2	0
80 m, 75 m	0.7	0.4	0.2	0.1
40 m	1.1	0.5	0.3	0.2
30 m	1.4	0.6	0.4	0.2
20 m	1.7	0.8	0.5	0.3
17 m	2.0	0.9	0.6	0.3
15 m	2.2	1.0	0.6	0.3
12 m	2.4	1.1	0.6	0.3
10 m	2.5	1.3	0.7	0.4
6 m	3.5	1.7	0.9	0.5
2 m	6.5	3.0	1.6	1.0
70 cm	12	5.8	2.8	1.9
23 cm	23	11	4.6	3.7

Item 10

Fill in the length of the feed line at (D).

Item 11

Divide the value at (D) by 30 and multiply by (C). Fill in the result at (E). This is the feed line loss in dB.

Items 12 and 13

There may be other loss-causing components in the feed line between the transmitter (or external amplifier) and the antenna. For example, there may be antenna switches or relays, directional couplers, duplexers, cavities or other filters.

Usually the losses introduced by these components are so small as to be negligible. For installations operating in the VHF and higher bands, however, the losses introduced can be substantial. If this is the case, fill in a brief description of what these components are at item 12. At (F), write in a conservative estimate of the total loss in decibels.

If the feed line component loss is not known, write 0 (zero) at (F).

Item 14

Fill in the average power fed to the antenna, in dBW, at (G). This is calculated using the following equation:

$$G = B - E - F.$$

Item 15

Fill in the average power fed to the antenna, in Watts, at (H). Convert the result at (G) to Watts using table 14. For power levels that fall in between the levels given, use the next higher power. Alternatively, the conversion may be done with the following formula:

$$\text{power}_{\text{Watts}} = 10^{\frac{\text{power}_{\text{dBW}}}{10}}.$$

Item 16

Fill in a brief description of the antenna, including the manufacturer if applicable.

Item 17

Fill in the antenna gain in dBi at (I).

Item 18

Fill in the antenna efficiency factor at (J). The antenna efficiency factor is the decimal fraction of the input power that is actually radiated by the antenna. For most antennas, the efficiency factor is essentially 1.

For some antennas, for example shortened vertical ground plane antennas, resistor broad-banded antennas and small loops the radiation resistance may be so low that a significant portion of energy is lost as heat in the antenna and ground system.

If the efficiency factor is not known, assume it is 1.

Item 19

At (K) fill in the power radiated by the antenna, that is $K = H \times J$.

Item 20

Using the power information at (K) and the gain at (I), consult the tables to determine the minimum separation distance from the antenna required to ensure compliance with the standard. Fill in this distance at (L). It would be useful to note which table this figure was sourced from.

Item 21

At (M) fill in the distance from the antenna, in metres, between the antenna and the nearest place where a person could be present. Depending on the antenna type, this may be all areas around, below and above the antenna or may only be areas in the boresight of the antenna.

Where the actual antenna pattern is known, this should be used in determining separation distances. For example, if a Yagi is used with 17 dBi gain in the main beam, this gain should be used in determining the minimum separation distance in front of the antenna. If the off-boom gain is 2 dBi, then this should be used in determining the minimum separation distance below the antenna.

If the value at (M) is greater than at (L) then the installation is in compliance. If not, then action must be undertaken to bring the installation into compliance. This may include

- reducing the transmitter power or changing modulation method to one where the average power is less;
- changing the location or height of the antenna.

This worksheet should be completed in accordance with the preceding instructions.

Station information

1. Call sign: 2. Band:

3. Station location:

4. Evaluated by: 5. Date:

6. Description of transmitter and external amplifier (if applicable):

Evaluation

7. Average power output, in Watts: (A) W

8. Average power output, converted to dBW: (B) dBW

9. Feed line loss specification: (C) dB per 30m

10. Feed line length, in metres: (D) m

11. Calculated loss, in decibels: (E) dB

12. Other feed line components:

13. Losses due to other feed line components, in decibels: (F) dB

14. Average power fed to antenna, in dBW: (G) dBW

15. Average power fed to antenna, in Watts: (H) W

16. Antenna description:

17. Antenna gain: (I) dBi

18. Antenna efficiency factor: (J)

19. Average total power radiated by antenna, in Watts: (K) W

20. Minimum separation distance required from antenna: (L) m

21. Measured distance from antenna to nearest place where persons may be present: (M) m

Conclusions

Based on this evaluation, operation of this amateur radio station in accordance with the technical parameters entered above complies with the limits for human exposure to radiofrequency (RF) electromagnetic fields contained in NZS2772: Part 1: 1999. The following statement provides the basis for this conclusion.

It is physically impossible or extremely unlikely under normal circumstances for any person to be in any location where their exposure to RF electromagnetic fields would exceed the standard because:

☐ The antenna is installed high enough on a tower, tree or other support structure such that it is not possible under normal circumstances for persons to get close enough to the antenna to be where the strength of the RF fields exceeds the levels in the standard.

☐ Fences, locked gates and/or doors prevent persons from normally gaining access to locations where the strength of the RF fields exceeds the levels in the standard.

☐ Antenna orientation and directivity is such that occupied areas are not illuminated in excess of the standard.

Although a particular amateur radio installation may by itself be in compliance with the standard, the cumulative effect of all simultaneously operating transmitters (amateur or otherwise) at the same location or immediate vicinity must also be considered. In practice, keep a maximum distance from other antennas.