FASTFIND/FASTFIND PLUS radiated power safety issues

(A) OCCUPATIONAL LEVELS

Reference: UK Health and Safety Manual, Chapter 9B – NON-IONIZING RADIATION.

Paragraph 4. c., Electromagnetic/ Microwave Radiation:

sic: "Sources not confined in a shielded chamber are to be operated such that exposure intensities to anyone near the apparatus is less than the guidelines listed in the latest edition of the "Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices". Table 9-B-1 is an adaptation from the above reference giving exposure guidelines as a function of frequency. The guidelines are based on maintaining a whole body thermal load of 0.4 W/kg or less.

Frequency (f)	RMS Electric Field Strength (V/m)	RMS Magnetic Field Strength (A/m)	Equivalent Plane Wave Power Density (mW/cm2)
30kHz-100kHz	614	163	
100kHz-3MHz	614	16.3/f	
3MHz-30MHz	1842/f	16.3/f	
30MHz-100MHz	61.4	16.3/f	
100MHz-300MHz	61.4	0.163	1
300MHz-3GHz			f/300
3GHz-15GHz			10
15GHz-300GHz			10

For a transmission frequency of 406MHz, this corresponds to a power density of 1.353mW/cm^2.

The Equivalent Plane Wave Power Density is defined as:

$P = E^2 / 377$, (W/m^2) where E is the field strength in V/m and 377 refers to the impedance of free space.
The equation is only truly valid in the far field.

The theoretical maximum radiated power from an EPIRB is 20W.
Thus the field strength and Equivalent Plane Wave Power Density is

POWER (W)	DISTANCE (m)	FIELD STRENGTH (V/m)	POWER DENSITY (W/m^2)	POWER DENSITY (mW/cm^2)
20	0.1	245	159	15.9
20	0.35	70	12.99	1.3
5	0.1	122.5	39.8	4

However,

1) the equation only applies to far field. The field strength in the near field is very difficult to quantify.

2) The guidelines are for continuous transmission with a 6 minute average exposure. The 406 transmission is 0.52 seconds long every 50 seconds. This equates to 0.624 seconds/minute or 0.0104. It could be argued that this is equivalent to a continuous transmission 20dB lower than the 20W maximum.
On this basis, even at a distance of 5cm, the 'average' power density is only $0.54mW/cm^2$.

For the 121MHz transmission, the allowable limit is 61.4V/m. This equates to a 'safe' distance of 3cm.

(A) GENERAL PUBLIC LEVELS

The HSE document references IEEE/ANSI C95.1. This gives the occupational exposure level as 0.4W/Kg and the general public exposure level as 0.08W/Kg.
For a transmission frequency of 406MHz, this corresponds to a power density of $0.27mW/cm^2 = 2.7W/m^2$.
This equates to a maximum field strength of $\sqrt{2.7 \times 377} = 31.9$ V/m
For an ERP of 20W, the 'safe' distance is 0.78m.
For an ERP of 5W, the 'safe' distance is 0.39m
If we assume that because of the short pulse and duty cycle of the transmission, the average ERP is 20dB less, then the 'safe' distance is 8cm.

For the 121MHz transmission, the allowable limit is 12.3V/m. This equates to a 'safe' distance of 15cm.
As the homing signal is 100% amplitude modulated, with a 35% duty cycle, the average heating power is some 4dB less. On this basis, the 'safe' distance is 9cm.

Neil Jordan
Engineering Manager
25-1-08.

Appendices

1) SUMMARY OF INTERNATIONAL RF EXPOSURE GUIDELINES AND STANDARDS

Internationally, a *whole* body recommended Specific Absorption Rate limit of 0.08W/kg is in place.

Localised SAR limits vary from country to country. The table below summarises the applicable specifications and the SAR levels.

Country	Document	Frequency range	Limits	Averaging mass	Area of application
International [a]	ICNIRP	0.1MHz to 10GHz	2W/kg	10g	Head and Trunk
			4W/kg	10g	Limbs
USA	ANSI C95.1	0.1MHz to 6GHz	1.6W/kg	1g	Body *
			4W/kg	10g	Hands, wrists, feet and ankles
Europe	ENV 50166-2	10kHz to 300GHz	2W/kg	10g	Body *
			4W/kg	10g	Hands, wrists, feet and ankles
Sweden	SS-ENV 50166-2 [b]				
Japan	MPT	0.1MHz to 10GHz	2W/kg	10g	Head and Trunk
			4W/kg	10g	Limbs
Australia	AS/NZS 2772.1-1998 [c]	300KHz to 300GHz			
New Zealand	NZA 2772.1 [d]				

a: World Health Organisation funded guidelines. (International Commission on Non-Ionizing Radiation Protection).
b: Seems to be a Swedish language version of ENV 50166-2
c: Withdrawn in 1999. No standard in place
d: Following Australian withdrawal of AS/NZS 2772.1, New Zealand have adopted ICNIRP guidelines.

*** Except hands, wrists, feet and ankles.**

2) Compliance with legislation

It is unclear in any of the legislation, as to whether emergency equipment is a special case. It has obviously been largely driven by the huge growth in the mobile phone market.
A situation where someone is exposed to levels of RF possibly above the limits for 24/ 48 hours maximum, may well be viewed differently when the prime purpose of the transmission is to save life.
A lot of the specifications average out the exposure over a 6 minute period. I have a suspicion this is the average length of a mobile phone call!

3) Estimation of Field strength to comply with legislation

As was stated previously, the formula for predicting field strength applies to far field conditions only. To establish the true near field signal strength would require testing an EPIRB/PLB in a SAR measurement equipped test house.

$$\mathbf{SAR} = \frac{\sigma \times E^2}{\rho}$$

where σ is specific conductivity (S/m)
E is the incident field strength (V/m)
and ρ is mass density (kg/m^3).

For a model of the human head used in SAR measurement laboratories, σ is taken at 400MHz as 0.87 S/m and ρ is taken as $1000kg/ m^{3.}$

Hence to achieve a SAR of 0.08W/kg, the maximum field strength allowable is 9.6V/m.
To achieve a SAR of 2W/kg, the maximum field strength allowable is 48V/m.

<u>Calculations for Canada</u>

Occupational exposure = 0.4W/kg
General public exposure = 0.08W/Kg

406 duty cycle 1.04% = 41.74(14.93W) = 155mW

$$\text{SAR(W/kg)} = \frac{0.87 s/m \times 7.43^2}{1000}$$

406 Pwr = 0.155W, 21dBm, 36.675V/M, 3.568 W/m^2, = 1.17W/kg
121Pwr = 71.12mW, 18.52dBm, 7.43V/M, 0.1466W/m^2 = 0.048W/kg