Marine Radar 2kW/4kW Non Ionizing Radiation Hazards

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Preface

The radiation hazard posed by marine radome scanners is a gray and sometimes controversial subject area and in this respect is similar to many long term environmental exposure health risks (mobile phones, dental amalgam etc) which are difficult to prove or disprove due to the logistics in collecting conclusive long term epidemiology data. The purpose of this report is to provide some background material for informed discussion.

Recognised Standards / Authorities

Probably the highest worldwide authority on this subject is the International Commission on Non-Ionizing Radiation Protection (ICNIRP) which produces guidelines for exposure limits for all non-ionizing electromagnetic frequencies and magnetic fields. These guidelines are published on the web here: www.icnirp.de and for X-band marine radar the radiosity limits can be summarised as:

- for occupational exposure: 100W/m^2 or 10mW/cm^2
- for general public exposure: 10W/m^2 or 1mW/cm^2

The occupational category is based on the presumption that a worker is informed of the risk by knowing the location of the risk, what that risk is, and the required procedures in place if exposure limits are likely to be exceeded. He is getting paid to work with the risk so there is some remuneration for the exposure so is close to **"*voluntary*"** exposure as part of employment.

The general public category is for unwitting **"*involuntary*"** exposure to ordinary folk going about their life.

A crew member could be expected to work around the radar to the occupational limit but passengers should not be expected to be able to get closer than the general public min safe distance – this should be taken into consideration during planning the radar installation. The leisure marine market demands the relevant guideline be general public exposure levels so that people enjoying their leisure time are not exposing themselves to workplace level radiation hazards. Most boaters will have guests and family aboard who need to be protected or properly informed.

The International Maritime Organization apply these below exposure limits through the IEC standards 60936 and 62252 which both state that the minimum safe distance to these radiosity levels should be published in the user handbook / installation manual. A selection of the published data is given in the following table.

		Min Safe Distance*	
	Power / Antenna Size	**Occupational (100W/m^2)**	**General Public (10W/m^2)**
Navico BR24 solid state radome	**100mW / 18"**	**Nil**	**Nil**
Navico 9174 series magnetron radomes	2kW / 18"	0.5m	1.4m
Raymarine RD218	2kW / 18"	Nil	1.0m
Furuno 1724C	2kW / 18"	Nil	1.5m
Navico 9174 series magnetron radomes	4kW / 24"	0.9m	2.8m
Raymarine RD424	4kW / 24"	Nil	1.0m
Furuno 1734C	4kW / 24"	0.4	4.0m
Simrad DX45	4kW / 18"	0.69m	2.18m
Simrad DX60	4kW / 24"	0.79m	2.50m

[*] measured from the centre axis of the radome not from the outside edge of the radome itself.

Calculations and Measurement

Due to near field propagation and practical antenna design limitations, measuring radiosity is the only effective way of determining these minimum safe distances; however a simplified theoretical calculation based on a point radiator can be used as a rule of thumb for establishing a lower bound for a given transmit average power level and antenna gain:

Approximate distance to near field / far field intersection $$d_i = \frac{G\lambda}{8\pi} \quad m$$

Where G is the antenna gain, λ is the electromagnetic wavelength and d is distance in meters. This distance can be used as the absolute minimum safe distance if the far field radiosity calculation shows less than this value.

Far field radiosity, Q, can be calculated as $$Q = \frac{PG}{4\pi d^2} \quad Wm^{-2}$$

Which can be rearranged: $$d = \sqrt{\frac{PG}{4\pi Q}} \quad m$$

So for 10W/m^2, minimum safe distance can be calculated as: $$d_{10Wm^{-2}} = \sqrt{\frac{PG}{40\pi}} \quad m$$

And for 100W/m^2, minimum safe distance can be calculated as: $$d_{100Wm^{-2}} = \sqrt{\frac{PG}{400\pi}} \quad m$$

Example: an X-band 2kW radome with long pulse duration of 1us, repetition frequency 600Hz and antenna gain 158.5 (22 dB) can be analysed as follows:

$$d_i = \frac{158.5 \times 0.032}{8\pi} = 0.20 \quad m$$ *(near/far field intersection)*

$$d_{10Wm^{-2}} = \sqrt{\frac{2000 \times 0.000001 \times 600 \times 158.5}{40\pi}} = 1.23 \quad m$$ *(general public exposure)*

$$d_{100Wm^{-2}} = \sqrt{\frac{2000 \times 0.000001 \times 600 \times 158.5}{400\pi}} = 0.39 \quad m$$ *(occupational exposure)*

Note that these calculations are not a replacement for radiosity measurement but serve as a general guide in the absence of accurate measurement data.

Summary

The lower power 2kW and 4kW marine radome scanners are not absolutely intrinsically safe by the non-ionizing radiation hazard definition given by ICNIRP so sensible precautions should always be applied to their installation and use in the field. This is the primary reasoning behind the IMO minimum safe distance requirements. Even considering the fact that the antenna is (normally) rotating which will significantly reduce the overall average exposure, it remains advisable to avoid prolonged eye exposure and close proximity of critical medical electronics, added to that it is probably sensible to restrict exposure to pregnant women and young children even if current opinion is that this would be safe at the ICNIRP limits. We live with environmental and man made hazards all the time and personal judgement is required within current limits, but if a “safer” option such as that offered by low power solid state radar is available for smaller vessels where minimum safe distances are harder to comply with, then the general public should be properly informed of the radiation hazards in order to make their own choices on the matter.

<u>End-of-report</u>