Electromagnetic Fields and Radiated Power Case Study: Dammam Coast Radio Station

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Abstract: This paper reports the results of an investigation done to study any possible health hazards resulting from the Dammam Coast Radio Station located near the girls college in Dammam. In the investigation a thorough theoretical studies and field measurement of the radiation power density in the area around the radio station from all directions and outside the girl's college behind the fence was conducted. Measurements were found much lower than the maximum allowable power densities confirmed by the World Health Organization, the IEEE standards for safety levels with respect to human exposure to radio frequency electromagnetic fields, and by the American Conference of Governmental Industrial Hygienists on Threshold Limit Values and Biological Exposure Indices.

Keywords: Electromagnetic Field, EMF measurement, Radiated Power calculation, EMF case study, EMF Standards

1. INTRODUCTION

Modem industrial development has resulted in increasing levels of exposure of people to a complex mixture of artificially elevated electromagnetic fields that span a very wide frequency range. One of the most significant contributions to this changing environment has been the technological advances associated with the growth of electric power generation and transmission systems and their use in domestic and occupational situations. In addition, electromagnetic field generating devices have proliferated in telecommunications and broadcasting, in industrial plants, office buildings, public transportation systems, homes, cars and elsewhere.

International radiological protection offices and boards took the responsibility for advising international health departments and standardization offices of protection for exposure to non-ionizing radiation. This responsibility covers static, low frequency electric and magnetic fields, high frequency and microwave radiation, as well as optical radiation.

To a large measure, the extent of acute effects on the human body and their dependence on the frequency and magnitude of the fields can be predicted from existing knowledge of their effects on humans, from experimental studies of animals, and by the application of modeling studies that predict the efficiency with which animals and humans interact with incident fields. These sources of information, together with the application of appropriate safety margins, have formed the basis of national and international exposure guidelines. Apart from medical exposures, only a relatively small number of people are likely to be exposed to fields at levels large enough to result in acute effects.

Recently reported epidemiological studies and laboratory research have raised questions about the adequacy of the existing guidelines for limiting exposure to electromagnetic fields. These have to take into account the balance of benefits and risks. The benefits associated with the sources of the fields are however clear, while the magnitude of the risks associated with low level exposure, if there are any such risks, is certainly not. If, therefore, it is only sensible at the moment to retain the present guidelines, which are based on known and quantifiable effects, it is essential that the results of recent studies on low level effects are kept under constant review, to ensure that the guidelines are based on the best available information.

The possible effects on human health of exposure to radio frequency and microwave electromagnetic fields and radiation are of public concern in the Dammam area near the- Dammam Coast Radio Station, in particular with regard to the effects on prolonged exposure to very low levels in the Girls College. One of the functions of the Investigation study is to advise on acceptable levels of exposure to these fields and radiation for students, workers, and members of the public. Such advice is based on the measurement of risks to health resulting from these exposures which is derived from studies of the fields, measurements and calculations of such fields and comparison with the safe and allowable limits internationally known.

The first stage of the investigation was to consider and review the radiation characteristics of the different antennas in the area surrounding the Dammam Coast Radio Station. The second stage is to measure these fields around the whole area of interest and to calculate the resulting power densities after obtaining the complete information from the manufacturer. The third stage is to compare attainable calculate and measured values with the safe and acceptable standard radiation.

2. RECOMMENDED STANDARDS

The Maximum Permissible Exposure (MPE) is defined as the rms and peak electric and magnetic field strengths, their squares, or the plane wave equivalent power densities associated with these fields and the induced and contact currents to which a person may be exposed without harmful effect and with an acceptable safety factor.

2.1. Maximum Permissible Exposure in Controlled Environments

For human exposure in controlled environments to electromagnetic energy at radio frequencies from 3 kHz to 300 GHz, the maximum permissible exposure (MPE), in terms of rms electric (E) and magnetic (H) field strengths, the equivalent plane wave free space power densities (S) and the induced currents (I) in the body that can be associated with exposure to such fields or contact with objects exposed to such fields, is given in table 1 as a function of frequency. Exposure associated with controlled environment includes: exposure that may be incurred by persons who are aware of the potential for exposure as a concomitant of employment, exposure of other cognizant individuals, or exposure that is the incidental result of passage through areas where analysis shows the exposure levels may be above those shown in table 2, but do not exceed those in table 1, and where the induced currents may exceed the values in table 2, part (B), but do not exceed the values in table 1, part (B).

2.2. Maximum Permissible Exposure in Uncontrolled Environments

For human exposure in uncontrolled environments to electromagnetic energy at radio frequencies from 3 kHz to 300 GHz, the maximum permissible exposure (MPE), in terms of rms electric (E) and magnetic (H) field strengths, the equivalent plane wave free space power densities (S) and the induced currents (I) in the body that can be associated with exposure to such fields or contact with objects exposed to such fields, is given in table 2 as a function of frequency.

TABLE 1: MAXIMUM PERMISSIBLE EXPOSURE FOR CONTROLLED ENVIRONMENTS

PART A: ELECTROMAGNETIC FIELDS

Frequency range (MHz)	E (V/m)	H (A/m)	Power Density (S) (mW/cm^2)	Averaging time (minutes)
0.003 - 0.1	614	163	(100,1000000)	6
0.1 - 3.0	614	16.3 / f	$(100,1\,0000/ f^2)$	6
3 - 30	1842 / f	16.3 / f	$(900 / f^2, 10000 / f^2)$	6
30 - 100	61.4	16.3 / f	$(1.0, 10000 / f^2)$	6
100 - 300	61.4	0.163	1.0	6

300 - 3000			f / 300	6
3000 - 15000			10	6
15000 -300000			10	616000 / $f^{1.2}$

f is frequency in MHz

PART B: INDUCED AND CONTACT RADIO FREQUENCY CURRENTS

	Maximum Current (mA)		
Frequency Range	**Through both feet**	**Through each foot**	**Contact**
0.003 - 0.1 MHz	2000 f	1000 f	1000 f
0.1 - 100 MHz	200	100	100

f is frequency in MHz

TABLE 2: MAXIMUM PERMISSIBLE EXPOSURE FOR UNCONTROLLED ENVIRONMENTS

PART A: ELECTROMAGNETIC FIELDS

Frequency range (MHz)	**E (V/m)**	**H (A/m)**	**Power Density (S) (mW/cm^2)**	**Averaging time (minutes) $\|E^2\|$, S or $\|H^2\|$**	
0.003 - 0.1	614	163	(100, 1000000)	6	6
0.1 - 1.34	614	16.3 / f	(100, 10000 / f^2)	6	6
1.34 - 3.0	823.8 / f	16.3 / f	(180 / f^2, 10000 / f^2)	f^2 / 0.3	6
3.0 - 30.0	823.8 / f	16.3 / f	(180 / f^2 , 10000 / f^2)	30	6
30 - 100	27.5	158.3 / $f^{1.668}$	(0.2, 940000 / $f^{3.336}$)	30	0.0636 / $f^{1.337}$
100 - 300	27.5	0.0729	0.2	30	30
300 - 3000			f / 1500	30	
3000 - 15000			f / 1500	90000 / f	
15000 - 300000			10	616000 / $f^{1.2}$	

PART B: INDUCED AND CONTACT RADIO FREQUENCY CURRENTS

	Maximum Current (mA)		
Frequency Range	**Through both feet**	**Through each foot**	**Contact**
0.003-0.1 MHz	900 f	450 f	450 f
0.1 - 100 MHz	90	45	45

f is frequency in MHz

Exposure associated with an uncontrolled environment is the exposure of individuals who have no knowledge or control of their exposure. The exposure may occur in living quarters or work places where there are no expectations that the exposure levels may exceed those in table 2, and where the induced currents do not exceed those in table 2, part (B). In uncontrolled environments, where individuals unfamiliar with the phenomenon of induced RF currents may have access, it is recommended that precautions be taken to limit induced currents to values not normally perceptible to individuals, as well as to prevent the possibility of RF bums.

A capsule guide to these standards is given in Figures1-3

The instrumentation used to detect and measure potentially hazardous electromagnetic radiation from RF and microwave sources is the portable, battery operated meter "RAHAM" Model 4C. This model is ideally suited for use with microwave ovens, medical equipment, radar installations, microwave heaters and dryers, communication systems, and electronic warfare Systems

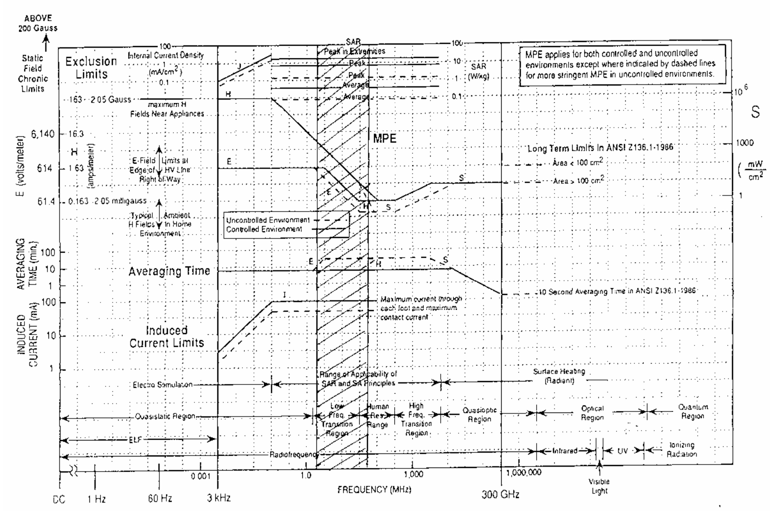

Fig. 1. Capsule Guide to the Standard

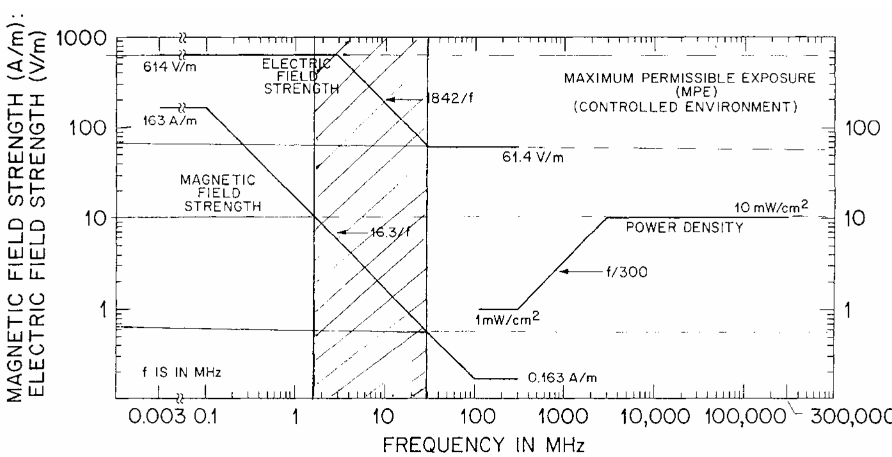

Fig. 2. Graphic Representation of Maximum Permissible Exposure in Terms of Fields and Power Density for a Controlled Environment

3. CALCULATED POWER DENSITIES AROUND THE ANTENNA SITE

The calculated power densities are based on the assumption of two types of antenna radiators. These types are the typical antennas used in this site. Full details of their electrical specifications are given in the appendix. The two antenna types are:

1. Omni-directional short dipole antenna used for AM broadcasting with maximum radiated power of 10 kW, and operating in the frequency range (415 - 525 kHz).
2. A high gain log periodic antenna with gain of 15.2 dB and operating in the frequency range (4 -30 MHz)

The power densities were calculated in both cases in the direction of maximum radiation to ensure the worst case situation and to yield the maximum power densities that will result in any horizontal direction away from the antenna site.

The predicted power density levels were calculated at distances of 10, 75, and 100 meters from the radiation sources. These distances were chosen to account for the real distances of the road, residential areas and educational buildings around the site.

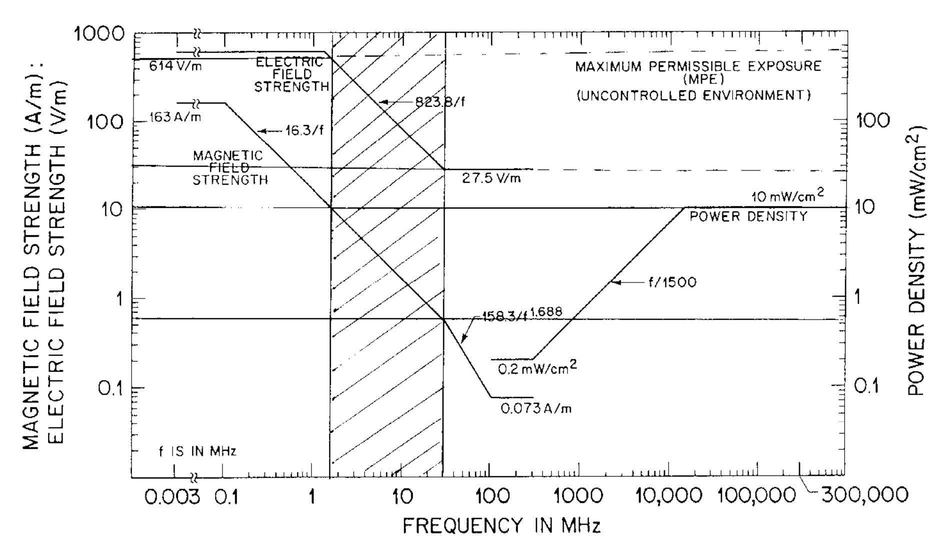

Fig. 3. Graphic Representation of Maximum Permissible Exposure in Terms of Fields and Power Density for an Uncontrolled Environment

3.1 Omni-directional AM transmitter

The power density of an omni-directional AM transmitter is calculated as follows:

$$W = \frac{\mathbf{P}}{\mathbf{4\,\pi\,R^2}}\,\mathbf{G_t}$$

Where: W is the power density in W / m^2
P is the transmitted power in W
R is the distance from the antenna in meter
And G_t is the gain of the short dipole. = 1.5

There for

$$\mathrm{W} = \frac{\mathrm{P}}{4\,\pi\,\mathrm{R}^2}\,\mathrm{G_t} = \frac{10^4}{4\,\pi\,(100)} \times 1.5 = 1194\,\mu\mathrm{W/cm}^2$$

For the other distances:

R = 75 meters W = 21.2 μW/cm^2
R = 100 meters W = 11.94 μW/cm^2

3.2 High gain log periodic antenna with gain of 15.2 dB

The power density of a high gain log periodic antenna with gain of 15.2 dB is calculated as follows:

Antenna gain = 33.1

The previous power densities for the AM omni-directional AM transmitter will be multiplied by a factor of:

$$\frac{33.1}{1.5} = 22.1$$

This will yield the following power densities for the high gain log periodic antennas, when the peak transmitted power is 10 kW. For the other distances refer to Table 4.

TABLE 4 POWER DENSITY OF A HIGH GAIN LOG PERIODIC ANTENNA AT DIFFERENT DISTANCES

R in meters	**Power density in μW/cm^2**
10	26390
75	468.5
100	263.9

These values for the high gain antenna refer to the intended direction of maximum radiation and decay rapidly as you move away from that direction at a rate depending on the shape of the radiation pattern of the particular antenna.

CONCLUSIONS

A comprehensive field measurement and theoretical studies were carried out inside and around Dammam Coast Radio station tower located nearby a girls college. The radiation power density measurement revealed a maximum radiated power density of 52 μW/cm^2 at the gravel road behind the college fence. All other readings ranged between 1.5 and 15 μW/cm^2. Theoretical calculations confirmed the measured reading. Both measure and calculated radiation power densities with their maximum values were found to be far below than the maximum allowable power densities of the world health organization and the LEEE standards for safety levels that are allowed to human exposure to radio frequency electromagnetic field. Values were also lower by the American Conference of Governmental Industrial Hygienists on Threshold Limit Values and Biological Exposure Indices.

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