

## **The Harmful Impact of the Electro Magnetic Fields on Seafarers**

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### **ABSTRACT**

No seafarer whoever wants to do errors or mistakes, seafarers have been always blamed of being responsible of more than 80 % of marine accidents. Many of accident analysts related the causes of accidents to the human errors without consideration to the marine environment where seafarers always spend most of their times. One of the influences which extremely affect the seafarers behavior and response is the exposure to the local Electro Magnetic Fields (EMF) inside the ships frame. The main aim of this paper is to prove that seafarers are daily exposed to high EMF levels and indicate the harmful impact of exposure on seafarers. This paper also put some recommendations on how to minimize the impact and open the door for further researches and investigations in this crucial new era.

### **1. Introduction**

The marine environment is a unique one , seafarers work, eat, entertain and sleep at the same environment 24 hours a day for at least six months , they are always exposed, influenced, and contaminated by the surrounding interventions introduced by the ship's noise, vibration, and the local electromagnetic and low voltage electric fields.

As well known, ships are mainly built of steel and power generated by electricity, hundreds of electrical cables, circuits, and lines circulate ship in different directions. However, seafarers especially those in key positions always dealing very close to control devices and equipment which mainly operated by electricity such as radars, radio ship earth stations, and gyro compass.

Electric and magnetic fields, whether we feel them or not, regulate our life functions. Without natural electromagnetic stimulation, no heart would beat, no brain would think, no eye would see, no muscle would move, no metabolism (no enzymes) would exist. Every body, every organ, muscle, nerve and cell is an antenna for electromagnetic fields (EMFs) and frequencies. Every human is individual and reacts in an individual way, depending on the resonance, frequency and strength of the impact and the susceptibility to other pollutants. Generally, a nerve ending can be stimulated (e.g. to make a muscle twitch) with only 20 Millivolt in an instant of time. What happens to an organism, which is exposed to thousands of Millivolts for hours, days, weeks, a lifetime?

Many biological studies showed that the human nervous cells are very sensitive to even low frequencies, this is due to the magnetic properties of the nervous systems mainly the human brain cells. This will lead to behavioral and response changes during exposure. The impact of the EMF exposure depends on the time of exposure, the amount of doses, distance from the source, and the intensity of the field. The human cells response to electric fields of about (5 - 6 K.V.) and magnetic field of intensity about (8-10  $\mu$ T). (Cook H.r, Graham C,1992), (Morgan M,1992).

## 2. Typical EMF Exposures on Board Merchant Ships

EMFs distribution within ship frame is very complicated. Seafarers are usually exposed to EMF from a large number of sources every day. Officers of the watch (deck or engine) always expose to a considerably high average field intensity level eight hours a day during ship control, even during rest hours between the two successive watches, they are still exposed to a lower average field intensity within accommodation. Fields change both in time and space. A person's EMF exposure depends to a large degree on what he or she is doing in the field at the time.

## 3. Measurement of the Electromagnetic Average Field Intensity on Board Merchant Ships

Measurements of EMF at different spaces on board number of merchant ships have been carried out using a TESLA METER device. The main purpose of these measurement was to provide evidences that EMF flux intensity on board merchant ships is above the normal universe levels (54.4  $\mu$ T), and exceeding any estimations. The TESLAMETER device has been calibrated, adjusted and used by a professional technician. The spaces selected to be measured are those usually attended by seafarers especially key persons and decision makers.

The following conditions were customized during measurements :

- two radars were in operation.
- steering gear system operated by main and auxiliary pumps.
- navigation lights were illuminated.
- gyro compass was in operation.
- full GMDSS equipments were in full capacity.
- two main generators were in full capacity.

*Table 1: The average values of the electro magnetic fields intensity at different spaces onboard merchant ships*

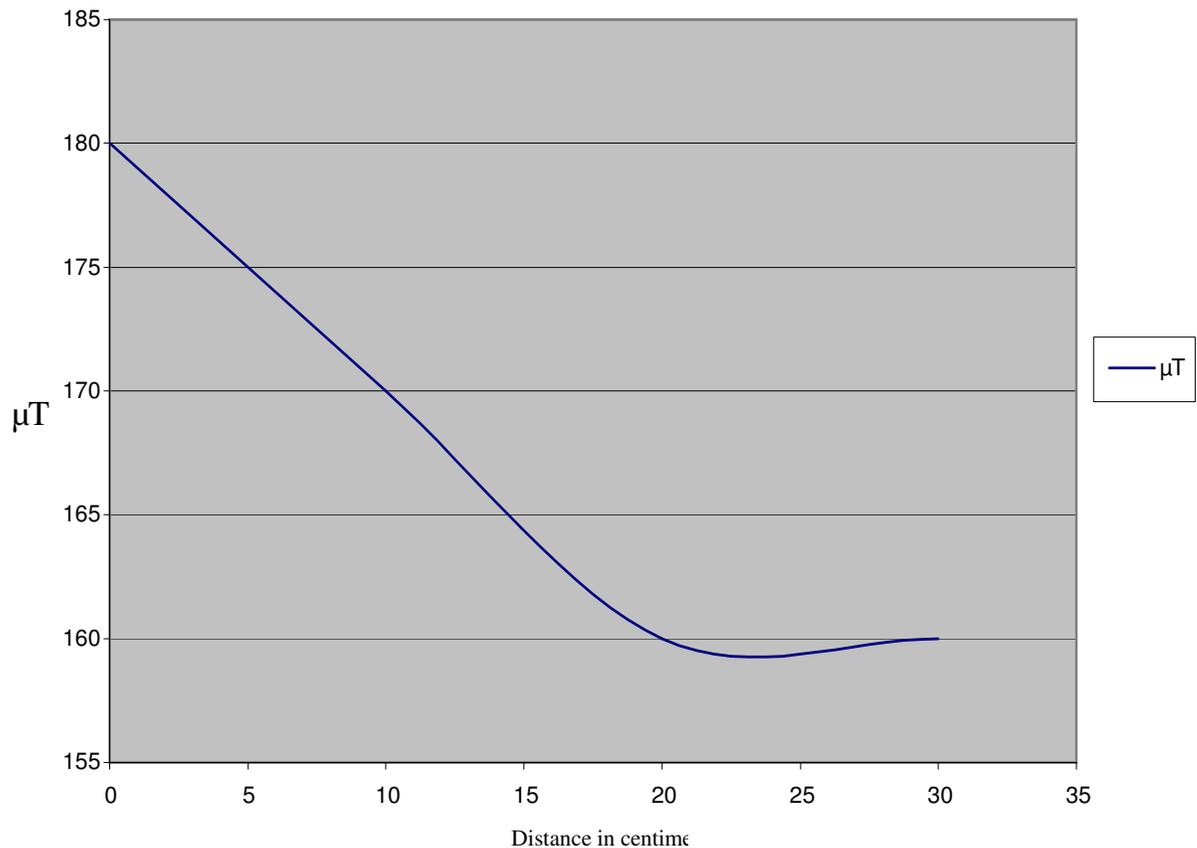
<b>Ship's spaces</b>	<b>EMF flux intensity in <math>\mu</math>T.</b>
In front of ARPA Radar	160-180
Mid bridge	160-170
In front of control panel	150-160
Radio station	160-170
Engine room control station	160-170
Engine room electricity switch board	160-170

Main engine-between two running generators	300-350
Captain's bed room and office	140-160
Chief engineer's bed room and office	160-180
Dining room	150-160
Alleyways	150-160

*Source: field study in Alexandria port*

As it is obviously indicated in table 1. , the average EMF flux intensity at ship's inner spaces exceeds 160  $\mu\text{T}$  , triple the normal value of the universe value, this however indicate the significance of the harmful impact of EMF on seafarers as they are being regularly exposed during their normal stay on board ships. The following diagram illustrates the relation between field intensity emitted by ARPA radar and distance apart.

**Diagram 1: The relation between the EMF field intensity and the distance apart in front of ARPA equipment in operation within bridge environment**



*Source: Results of EMF field measurement during experiment*

### 3.1 Experiment Results

As it is clearly indicated from diagram 1. the EMF intensity is gradually decreased as a function of distance which agrees with the inverse square law. In addition, the field within the bridge space never diminish , as the main average field intensity was around 160  $\mu$ T, vice versa, it started to rise again as entering nearby fields.

Moreover, an examination was carried out of those seafarers just arrived to Alexandria port after sailing for periods of time between five to thirteen days, the following development of physical – health effects could be identified: feeling of illness, fatigue, headache, over tension, some sustain irregular sleeping periods, sleepiness. All the above mentioned symptoms were developed without any apparent reasons.

## 4. The Biological Effects of the EMF on the Human Body

Different biological effects have been observed during electro magnetic fields studies. Studying brain properties and the central nervous systems function of the human body proved its high sensitivity to the EMF intensity. The exposure to the EMF hinder the formulation of MELANINE compounds produced by the pineal gland in the brain cells.(Ney MM,1995).

Epidemiological studies also showed that there is a close relation between the exposure to EMF (produced by an electric current (50 – 60 Hz) and general human behavior and response include (Depression, Tension, Psychiatric disorder, malfunctions, Irritability and Hopelessness). Further more, the development of illness headache, and fatigue. (US Dep. Of Energy,1997).The following effects have been also reported in some laboratory studies :

- Changes in functions of cells and tissues
- Decrease in the hormone melatonin
- Alterations of immune system
- Accelerated tumour growth
- Changes in biorhythms
- Changes in human brain activity and heart rate
- Somatic Symptoms, Neuropathy or Psychopathy,
- social jobs and Psychiatric disorder.

The experimental evidences achieved by the authors proved that brain sensitivity and the EMF mechanism effects, could be considered as a (function) key role for the real understanding of these malfunctions. (Arnt Ing,1997), (Suleiman.YM,1999)

Table 2 presents the mean value of the conductivity and the relative permissibility of some organs and/or parts of the human body when exposed to the EMF produced by electric power source of frequency 915 MHz (mobile telephone).

**Table 2: The mean value of conductivity and Permissibility of human body main organs**

The organs	Density (g/cm <sup>3</sup> )	Conductivity (S/M)	Permissibility
Skin / fats	1.21	0.62	34.50
Bones	1.88	0.12	8.00
Muscles	1.24	1.25	58.50
Brain	1.33	1.25	55.00
Lenses (eyes)	1.25	0.79	44.50

*Source: Calculated and arranged by authors*

As shown in table 2. the Average Specific Absorption Rate (S.A.R) could indicate the amount of absorbed energy over the unit of mass of an organ. This could be considered as basic variables in studying malfunctions developed due to the changes in the composition of the nervous center systems. The Average Specific Absorption Rate (S.A.R) can be calculated using the following equation:

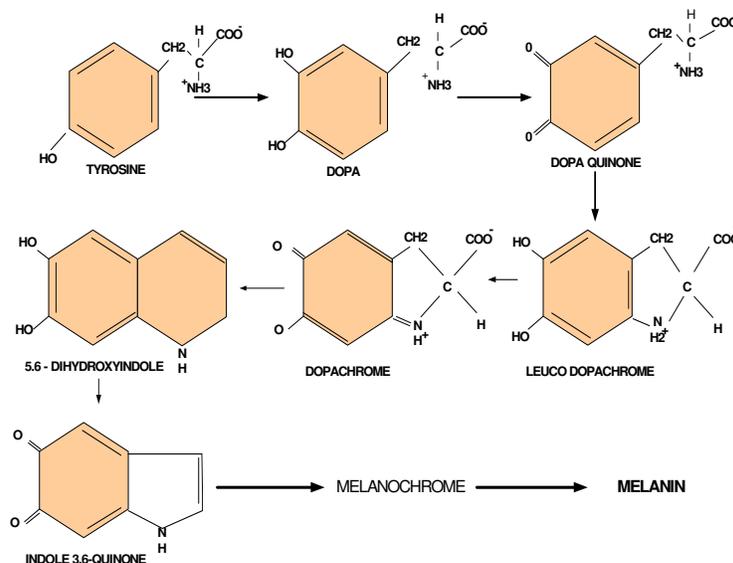
$$(S.A.R)_n = \frac{\sigma_n}{2\rho_n} (E_n)^2$$

Where  $E_n$  = refers to the electric field's intensity,

$\sigma_n$  = refers to the Tissue conductivity exposed to the EMF,

$\rho_n$  = refers to the density of that organs

Figure 1 below illustrates the transmutation chains and subsequent compounds formation and its derivatives. As clearly indicated, compounds are very sensitive to ionizing radiation sources (EMF exposure), releasing  $H^+$  - ion which form H- gas by continuous ion formation at the point of interaction, producing apparent damage in the quinone compounds. Figure 2. below illustrates the interaction chains or the stages of MELANINE formation and other cyclic compounds, from TYROSINE compound.



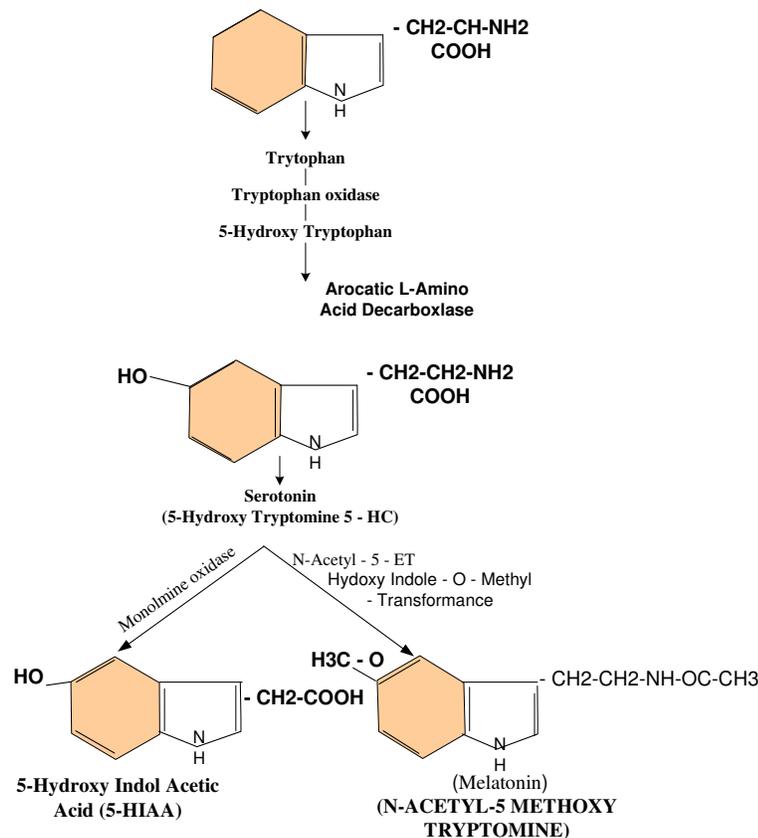
**Figure 1: The interaction chains of MELANINE compounds and other cyclic compounds from TYROSINE compounds.**

*Source: Arranged and composed by the researchers*

Figure 2 below also illustrates the interaction chain of MELATONIN and DOPAMINE free radicals formation as a result of TRYPTOPHAN corruption by the EMF.

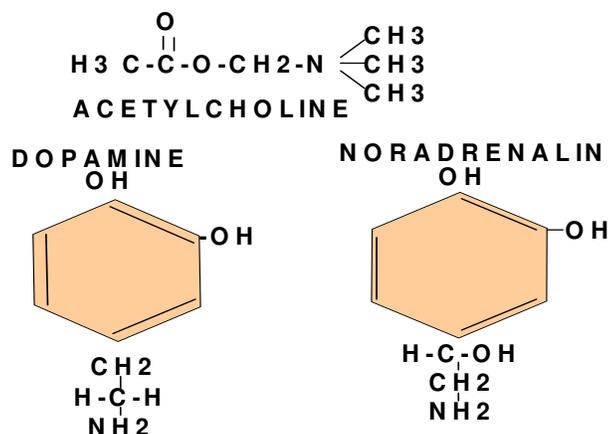
## 5. Impact of exposure to the Electromagnetic fields on Brain Nervous System

The most important compound carries the nervous order is the SEROTONIN (or 5- Hydro TRYPTOMINE). It consists of AMINO acid TRYPTOPHAN, 90% of it is produced by the body by the digestive system (enteron), the rest (10 %) is formed in the central nervous system (HYPOTHALAMUS) and the medium brain MESENCEPHALON . The SEROTONIN compound could be digested (metabolized) into the (5-HI- AA ) compound and MILATONIN compound (see figure 2). It is transformed in the pineal - gland (or organ) to (N – Acetylation) and (5- Methylation) to the MELATONIN compound which could be clearly observed in figure 2.



**Figure 2: Formation chains of MELANIN, DOPAMINE, ACETYLCHOLIN as result of EMF exposure**

*(to be continued)*



*Source: Arranged and composed by the authors*

Figure 2, in addition, shows the transformation states of TYROSINE – to – the MELANINE compound through a long chains of transformation and/or transmutation. The corruption of these compounds by the acute exposure to EMF, leads to disruption of chemical bonds and joint back its molecules such as:



This will produce the free radicals which will affect the physiological functions of those nerves carriers. Consequently, there will be a reduction (asthenia) in the (MELATONIN) compound formation. However, these outcomes play an important role in the free radicals interaction and escalate its harmful effects. This in turn causes the acute psychiatric and nervous symptoms that previously mentioned.

The accumulation of free radicals and its recombination with the AMINO ACIDS, FATS PHOSPHORIC and other cell components in the course of prolonged periods of exposure – leads to the continuous change in these components and will reduce its functions.

## 6. The EMF Effects and the PARKINSONS Disease

PARKINSONISM is a nervous disease mainly take place in the nervous cells that contains the MELANIN, located in the base of brain, as consequences of the absence of MELANIN in nervous cells and the formation of glutinous compound. However, chemical studies prove a decrease in the amount of DOPAMINE – compound in that black substance due exposure to EMF. This could be proved by giving patients the (MP-TP) compound, which causes a random destruction of the neurons cells and the appearance of Parkinson's disease.

Since TRYPTOPHAN, TYROSINE, HYSTEDINE, MILANINE, and the MELATONINE compounds are of amino acids rings see figure 2. – the thermal activation agent varies between (0.11 – 0.45 e.v) will give an E.S.P (Electron Spin Resonance) as shown in figure 3. and rearrange the electrons in its molecules due to the absorption of energy that produce the electronic detachment out of these molecules, and form free radicals. This could be proved by the measurement of its E.S.R spectrum before and after the exposure to the EMF.

The E.S.R spectrum measurements showed that the formed free – radical –concentration in the MELANIN compound was about ( $10^{17} sp./ gm$ ). It is worth to mention that the data obtained from the epidemiological (epidemical) studies have not indicated the mechanism of damage formed in the basic compounds that constitute the brain nervous cells and also the methods of free radical's formation produced by the acute and chronic exposure to the EMF fields.

The epidemiological studies also showed that the increase percentage of ALZAHEIMER and PARKINSON diseases (in the peoples living under /or nearby ) the electrical power transmission lines could be attributed to the accumulation effects of the free radicals formation under the effects of the absorbed EMF doses by the neurons cells (transfusion). However, the relation between magnetic field intensity (B) and the wave length ( $\lambda$ ) can be calculated by the following equation:

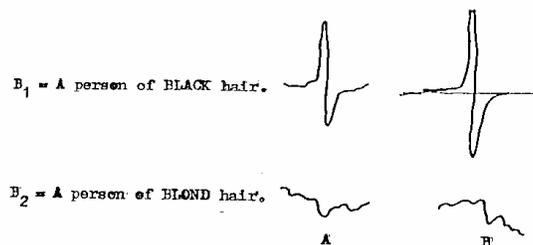
$$B = \frac{(mv^2)}{2h}(\lambda)$$

Where:

- h refer to the planks constant,
- m refer to the mass,
- v refer to the velocity of the electron

Since every body has its own specific magnetic field and differs from one to another, the color or spectrum of every body is characterized by a definite wave length ( $\lambda$ ) . Therefore, people were affected by the EMF could be described as IRRITABLE, NERVOUS or IRRESCIBLE, MELANCHOLIC ones. These behaviors produced a special spectrum . The difference between these moods lead to different spectra, ( i.e. different wave lengths), and thus different values of thermal energy radiated by the body, mainly in the psychiatric disorder situations, depend on the wave lengths of (O,H) elements which mainly constitute the human body.

Therefore, if we could change the value of ( $\lambda$ ) of a person's spectrum, could we change his mode , cast (state) of mind, temperamental, behavior, disposition nature, by exposing him to different EMF doses? This still need further advanced studies to be proved. See figure (3) the E.S.R spectrum of persons with different hair color.



**Figure 3: The E .S .R spectrum of persons with different hair color**  
**Source: Results of experimental studies carried out by the authors**

The difference between the two shapes of the E.S.R. spectrum could be related to the following:

- A. person with a black hair:  
In this case the absorbed amount of energy is high because black hair contain high percentage of MELANIN, so that more radicals are formed.
- B. person with black hair:  
In this case the amount of absorbed energy is lower because the blond hair contains lower percentage of MELANIN compound, therefore, the degree of damage formed by the absorbed EMF energy is lower and lower number of free radicals are formed.

## **7. Conclusion and Recommendations**

EMFs are a factor we are often unaware of, when we consider the stress factors of ship environment and yet, they are forces unnatural to our body with obvious consequences for many of us. In this paper, the authors are focusing on new era which still needs more advanced studies in order to achieve safe environment for seafarers and minimize the human errors at sea. The electromagnetic fields were measured on board number of merchant ships and found of very high levels, nearly three times the earth field intensity. As well known seafarers are well surrounded by EMF fields during their stay on board ships for long periods and well influenced, contaminated and affected by this unnatural forces. The biological malfunctions in the seafarers` body as a result of exposure to the high levels of EMF have been examined and analyzed. Examples of the psychological symptoms determined are (Depression, Tension, Psychiatric disorder, Malfunctions, Irritability and Hopelessness).

Manufacturers are required to put efforts forward to minimize the EMF flux intensity of equipments mainly used in control rooms and stations, for example radars magnetron could be located in remote areas while only screen and control panel could be placed inside the bridge. Seafarers are also required to be aware of the EMF exposure harmful impact and avoid staying in enclosed spaces especially accommodation for long periods, in addition, utilize any chance to get out of the accommodation and be well surrounded by open areas. Seafarers also could release EMF charges accumulated in their bodies by touching their bare feet to the ships steel at safe areas.

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