ANALYSIS OF HUMAN BODY HIPER-EXPOSURE TO ELECTROMAGNETIC FIELDS ON SEAGOING VESSELS

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1. INTRODUCTION

At sufficiently high frequencies (typically, tens, hundreds of MHz, GHz to a lower frequency, but also at a lower frequency, time varying electromagnetic field propagates at long distance from the source (antenna) under form of electromagnetic waves, high speed, but - finite - speed of light (in vacuum and practically in the free space). Characterization of such a field named radiation field or far-field is done using Maxwell's equations, supplemented by known material laws, without further neglecting the displacement current density, as in the quasi-stationary regime. With the existence of electromagnetic radiation also face vessel's crews. Radiation sources are antenna of transceiver stations, existing on board the vessels, the GMDSS console that provides ship-to-ship communications as well as the ship-to-shore communications made both by direct wave but also by satellite. Besides marine antenna of the transmission system, another source of electromagnetic radiation are directive radar antenna that emit a concentrated beam radiation in the 8-9 GHz range, but due the lobs of propagation from the base of antenna (with the lower power than of central lobe), emit and around the antenna - thereby exposing near the antenna the crew with very high frequency radiation. To achieve the measurements on the vessel of the electromagnetic field corresponding to this phase, we selected a merchant vessel. We performed background measurements and measurements with different transmitting stations in various ranges of frequency (AM-FM modulation amplitude and frequency modulation) based on currently available sensors.

2. USED APPARATUS FOR THE MEASUREMENTS

For the measurements we used the following devices: - Portable Spectrum Analyzer with accessories and specialized software R&S FSP 13 (1164.4391.13); Spectrum analyser 9 KHz-13GHz, -140-+30 dBm, RBW 10 Hz-10MHz. TFT colour display; R&S FSP-B1 (1129.7998.02), Rugged case with variable carrying handle for all FSP models; R&S FSP-B16 (1129.8042.03), LAN interface 10/100 base T for FSP with Nr.1164.4391.XX; R&S FSP-B9 (1129.6991.02), Tracking generator for FSP, 9 HHz-3GHz, I/Q modulator;

R&S FSP-B28 (1162.9915.02), Trigger port for FSP; indication of trigger conditions (necessary for operation with TS-EMF); R&S FSP-B30 (1155.1158.02), DC power supply 12-28V, For FSP spectrum analyser and ESPI test receiver; R&S FSP-B31 (1155.1258.02) NiMH battery pack + charger for FSP, Required FSP-B1 and FSP-B30; R&S FS-K9 (157.3006.02), Measurements with NRP power sensors NRP-Z11/Z21/Z22/Z23/Z24/Z251/Z55/Z91, requires NRp-Z3 or NRP-Z4; R&S NRP-Z4 (1146.8001.02), USB adapter (passive) for NRP-Z sensors powered via USB; R&S NRP-Z22 (1137.7506.02), Average power sensor, 10 MHz-18 GHz, 2 n W- 2W for universal use RF Cable Huber & Suhner (23005046), 13 GHz, 1m long, N male connectors; System TS-EMF-portable isotropic antenna: R&S TS-EMF (1158.9295.03); Portable EMF measurement system 30 MHz-3GHz, 1mV/m-100V/m (without FSH 3, laptop and carrier bag); R&S TS-EMFZ2 (1166.5708.02), Cable set for TS-EMF; R&S TS-EMF-03 (1101.8477.03), EMC-tripod for TS-EMF; R&S RNB (0272.4910.50), Terminal (50 Ohm, 1W, DC-4 GHz, N-male).

3. LEGISLATION REGARDING THE EFFECTS OF ELECTROMAGNETIC FIELD ON THE CREW

Need to conduct a study of electro-magnetic fields that affect seagoing personnel onboard ships in the fact that to date not in the country or abroad there are documents attesting that would have been made research on disruptive effect of radiation electromagnetic on personnel. Also have not been made any precise measurement of electromagnetic radiation levels to see if their values fall within the limits allowed in the documents - adopted by bodies of the Ministry of Transport in accordance with EU directives. This paper presents the danger to the exposed ship's crew in terms of electromagnetic field radiation.

In the interpretation of measured data with and without means of protection documenting was made on a wide electromagnetic field influence on human organism of the crew on board. Analysis and interpretation of measurement results was based on the: Specific Directive 96/98/EC on "Maritime Equipment", implemented in Romania by the Minister of Public Works, Transport and Housing nr.582/2003 for type-approval of technical rules for the equipment and products for ships, under international conventions to which Romania is a party, cod MLPLTL.ANR-EM 2003; Romanian standard SR EN 55011:2001 - Industrial RF equipment, scientific and medical equipment (ISM). Radio disturbance characteristics. Limits and methods of measurement; Romanian Standard SR EN 60945:2001-Equipment and maritime navigation and radiocommunication systems. General rules. Test methods and results required; European and American rules on limits of exposure to the electromagnetic field of the human body in the frequency range 0 Hz to 300 GHz ("Radio Frequency Radiation for Transmitters: A Comparation of U.S. and European Requirements" , Author: Steve Dillingham and Nick Cobb); European document 519/EC-Council Recommandation, on the Limitation of Exposure of the General Public to Electromagnetic Fields (0 Hz to 300GHz) American Standard FCC Radiation Exposure Limits Radio Frequency. Rule Parts 1.1310,2.1091, and 2.1036 (3GHz frequency range-300 GHz), "General safety rules" no. 880, Sections 4 and 5, Annexes No. 72, 73.74 and 75; standards SR EN 50166-1 and 50166-2 SREN, concerning the limits of induced current densities and associated biological effects, specific absorption rate limits, SAR limits of electric current in the magnetic and peak power density in the human body, and uncontrolled environments examined by the range 3 kHz-300 GHz Government Decision HG no.59 of 06.09.2006 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from electromagnetic fields, Annex: Exposure limit values and trigger values of electromagnetic fields action; General rules limiting public exposure to electromagnetic fields from 0 Hz to 300 GHz, issued by the Ministry of Public Health and published in the Official Gazette of Romania, Part I, Nr.895 / 03.11.2006; ICNIRP Recommendations, International Commision Non-Ionizing Radiation Protection on: Guidelines for Limiting Exposure to Time-varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz), Directive

2004/40/EC of the European Parliament and the European Council on minimum safety requirements for workers to the electromagnetic fields exposure.

4. ELECTROMAGNETIC FIELD MEASUREMENT

Normal limits on electric and magnetic fields with frequency of 50/60 Hz, to which can be exposed human body as these standards are: electric field (exposure time = 8/24): 10 kV / m field magnetic (for exposure = 8/24 hours): 500μT.

It is provided the following values domains of induced current density and associated biological effects: under 1mA/m2 – the effects absence; between 1-10 mA/m2-minor biological effects; between 10-100 mA/m2-known biological effects : visual (magnetofosfene) and possible nervous system effects, between 100-100 mA/m2- changes of excitability in the central nervous system; simulation thresholds; possible health risks; over 1000 mA/m2- posibile extrasystoles and ventricular fibrillation, certain health risks.

In case of simultaneous human body exposure to multiple sources of independent field of different frequencies, the actual reference levels assessment was made on the principle of aggregation effects of heat or electrical stimulation of the body-Tab.1, 2.

Table 1. Reference levels for occupational exposure to electric and magnetic fields and time varying electromagnetic fields (unperturbed RMS values)

Frequency range	Electric field strength E (V/m)	Magnetic field strength H (A/m)	Magnetic flux density B (μT)	Power density for equivalent plane wave Sech (W/m^2)
till 1 Hz	-	$1,63 \cdot 10^5$	$2x\ 10^5$	-
1-8 Hz	20.000	$1,63 \cdot 10^5/f^2$		-
8 - 25 Hz	20.000	$2xl0^4/f$	$2x10^5/f^2$	-
0,025 - 0,82 kHz	500/f	2 0/f	25/f	-
0,82-65 kHz	610	24,4	30,7	-
0,065 - 1 MHz	610	1,6/f	2,0/f	-
1-10 MHz	610/f	1,6/f	2,0/f	-
10-400 MHz	61	0,16	0,2	10
400 - 2000 MHz	$3f^{1/2}$	$0,008f^{1/2}$	$0,001f^{1/2}$	f/40
2 - 300 GHz	137	0,36	0,45	50

Table 2. Permitted exposure levels of RF field, the uncontrolled environments

Frequency range (MHz)	Electric field, E (V/m)	Magnetic Field, H (A/m)	Power Density, S (mW/cm^2)	The Mean Time, Tmed (min) E^2, S sau H^2
0,003-0,1	614	163	(10^2; 10^6)	6 6
0,1-1,34	614	16,3/f	(10^2; $l0^4/f^2$)	6 6
1,34-3	823,8/f	16,3/f	($180/f^2$; $l0^4/f^2$)	$f^2/3$ 6
3-30	823,8/f	16,3/f	($180/f^2$; $l0^4/f^2$)	30 6
30-100	27,5	$158,3/f^{1,668}$	($0,2;9,4xl0^5/f^{3,336}$)	30 $0,0636f^{1,337}$
100-300	27,5	0,0729	0,2	30 30
300 - 3000	-	-	f/1500	30 -
3000-15.000	-	-	f/1500	90.000/f
15.000-300.000	-	-	10	$616.000/f^{1/2}$

Maximum values of measured electric field strength does not exceed 1V / m and electromagnetic power density not exceed 0.02 $\mu V/cm^2$. [1,2,3,4,5,6]

Seafarers should be warned of the danger concerning the concentrated high energy and high frequency beam. Exposure to electromagnetic radiation can be harmful to human body and can lead to neurological disorders, cataract, cancer etc. If it is necessary to work at a distance less than about 7 meters at the same level or above the radome's, the system must be disconnected because even when it is not sended a message, the system changes from time to time certain signals (technical information) with satellite. [7]

Given the existence of dangerous radiation onboard the vessels, it is necessary the existence of a research program for the production of protective materials to shield the whell/house (the bridge) of the ship and crew living quarters from the stations broadcasting antennas VHF, MF and HF and focused beam of unidirectional and omnidirectional antennas from the INMARSAT stations. [7]

Also, as a first step that must be done, it is neccessary that the stations to emit as little time as possible for minimum body radiation exposure, which requires that messages to be sent, to be prepared in advance, stored in computer memory and transmitted as soon as possible as a package - making also financial economy for company by logging the system on satellite for transmitting messages within the shortest possible time and in communications by direct wave to seek only the basic necessities: in maneuvering, in communication with other vessels to avoid collisions, etc. Search and Rescue operations.

5. CONCLUSIONS

Effect of intermittent exposure to low frequency electromagnetic field on a crew member is producing of induced currents in the human body. Because you can not insert sensors in the human body to measure these currents, were used analytical calculating methods in which by simplifying assumption the human was considered a homogeneous structure and physico-chemical electrical conductivity of its organs are not considered. From the moment of high frequency excitation the biological human tissues progressively deteriorates and changes its electrical properties leading to destruction of cell membranes and thus to reduction of the breakthrough voltage. Comparing the physical characteristics of the human body with

those of the receiving antenna band, when the body is oriented so that any its dimension is parallel to the plane of radio frequency energy polarization the effects on the body are more pronounced than when it is oriented in other positions. Pathological consequences of the effects induced by electro-magnetic fields on the crew is a matter of dispute among researchers in the bio-medical field and equipment manufacturers. Occupational exposure may occur at higher power density levels than the residential ones. A crew member is aware of this electromagnetic radiation and assumes the risk of working under these conditions being trained on safety procedures to be followed to minimize the consequences of the exposure. We have the following categories of risk estimation: identification of risk factor, estimate the dose-effect ratio, estimating exposure, risk characterization. With how electromagnetic radiation interacts with human tissues, producing their harmful biological effects, the degree of destruction depends on the intensity, frequency, energy level, polarization and duration of exposure. Penetration of electromagnetic energy in the human body, its absorption and its reflection depends on the physical dimensions and dielectric constant of human tissues and the frequency of electro-magnetic radiation. Electromagnetic energy is absorbed by human tissue so produced heat in it must be dissipated.

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