ELECTROMAGNETIC RADIATION ON BOARD SHIPS - HAZARDS TO PERSONNEL

Dr.P. Misra, Ph.D.,
Principal Officer,
Mercantile Marine Department,
Chennai, India
purnendumisra@yahoo.com

Prof A. Bhatacharya
Department of E&ECE,
IIT Kharagpur,
Kharagpur, India
amitabha@ece.iitkgp.ernet.in

Prof A. Chakraborty
Department of E&ECE
IIT Kharagpur,
Kharagpur, India
bassein@ece.iitkgp.ernet.in

***Abstract* - EMI and EMR have been a source of problem on board vessels equipment being installed in very close quarterswith kilometers of cabling and other similar radiators and emitters. The results of on board experimental analysis have been put up in this technical paper. A software program has been specifically devised to deal with the compatibility plans for any type of merchant vessel, which has never undergone EMR or mapping during its lifetime.**

Keywords - Electromagnetic Interference, Electromagnetic Radiation, Shielding effectiveness, Noise, Coupling

I. INTRODUCTION

Interference from electromagnetic sources have been a hazard on-board vessels with a number of equipments such as converters, power panels, microprocessors, radar antennae etc installed in very close quarters. In addition, there are kilometers of cabling and other similar radiators and emitters. Though some equipment do comply with either FCC, DNV or BSEU radiation protection standards, most of these equipments or the operations of them cause phantom emissions both in the narrow and broad band of electromagnetic spectrum. Coupling between various antennas and conductors take place giving rise to uncontrolled and undesired fields. It has also been seen that sources radiating almost at noise levels on board ships may be capable of damaging other equipment as well as humans within frequency ranges of 1 KHz to 30 MHz and above. Most of the times even such fittings as ladders, ropeways, derricks become radiators causing injury through electro magnetic emissions and static discharges. Generally a vessel under construction has equipment specified with compatibility regulations such as FCC etc. However, in the entire life cycle of a vessel it is never checked for compatibility. Moreover vessels undergo repairs, change of components, shielding alterations, extra cabling and many of the linkages and joints becomes exposed to weather. Earthing efficiency also reduces over periods of time. Tests conducted by medical bodies and results from the published literature as well as observed occupational occurrences during post-sea medical tests have revealed that some of the unexplained causes of major injuries to human internal organs are consequences of a shock or radiation effect owing to Electromagnetic radiation (EMR). Frequencies beyond 1 GHz to 33 GHz can cause serious damage to persons. In fact most seafarers work under the vicinity of such dangerous emitters without being aware of the consequences. This explains some of the injuries which maritime health specialists and occupational safety experts have complained about.

II. ONBOARD TRIALS

A detailed scientific investigation can result in clearing the doubts about such effects of EMR and so to measure the realistic status of the EMR on board vessels two research vessels and a passenger vessel at Chennai port were chosen. The measurement (**Morgan)** for noise and coupling fields were done by the schematic diagram shown in Fig. 1. The equipment used were specifically 1) Spectrum Analyzer (Agilent Make), range - 100KHz - 3 GHz, 2) Electric-field Sensor, Make ANRITSU, range - 470 MHz -1.7GHz, 3) Magnetic field Probe (Make ANRITSU), 1-50, 5-1000 MHz, and 4) Microwave Amplifier (Agilent Make), Freq. range - 10 MHz - 26.5 GHz. During the measurements some very important findings were observed which are as follows.

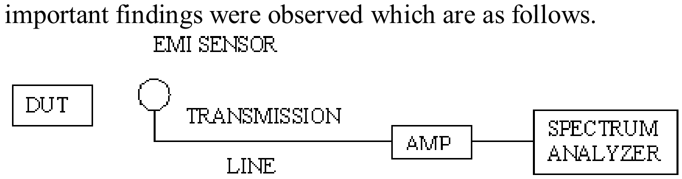

Figure 1 : Measurement Setup

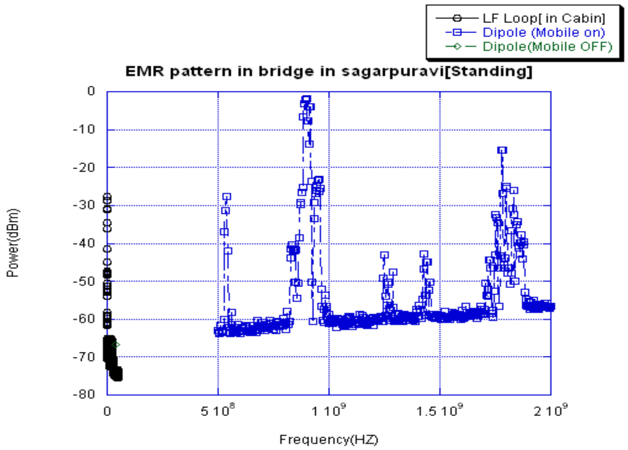

Figure 2: EMR Pattern in Bridge of Research vessel-1(Standing)

1. Bridge personnel are exposed to greater EM radiatio due to proliferation of wireless communication and navigational signals.(**Paul**) The power levels are quite high and personnel safety at such high levels should be carefully estimated. The dominant EM radiation affecting the bridge of a passenger vessel (e.g. Research vessel-1) is almost a million times the ambient EM radiation present in the other portions of the vessel. Sailing of the ship may bring this EMR down by a factor of ten, not any further as can be seen from Figure3:

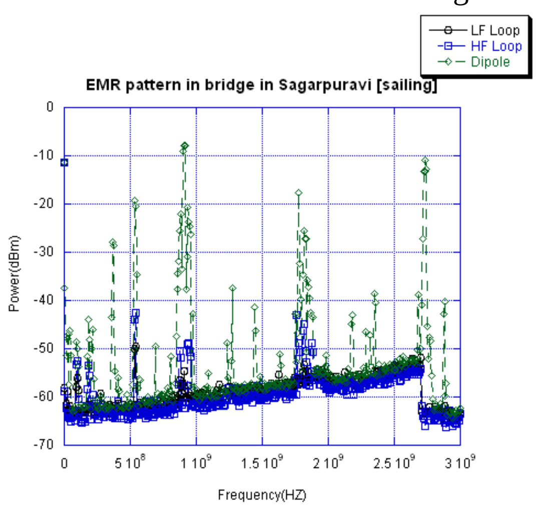

Figure 3 : EMR Pattern in Bridge in Research Vessel-1(Sailing)

2. The engine room, on the other hand, has much lesser contrast between the dominant to ambient radiation. Figure 4 shown the contrast to be only 15 dB indicating the dominant radiation to be coming from mainly communication sources. However Figure 5 shows that near a transformer the communication source gives a high radiation of about 60 dB stronger which clearly points to the shielding failure (**P**.**Misra)**.

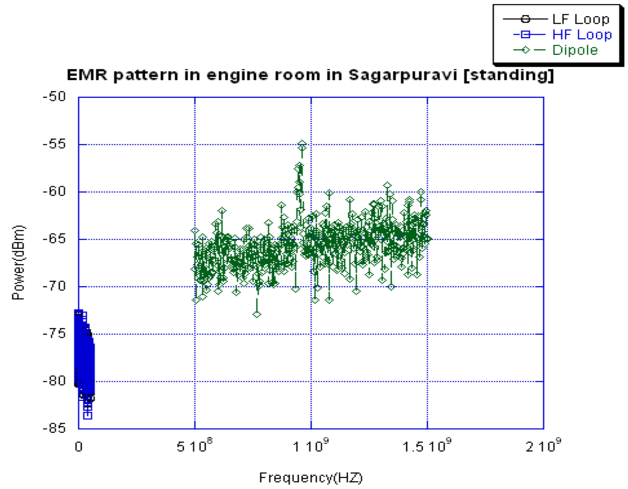

Figure 4 : EMR Pattern in Engine room in Research Vessel-1 (Standing)

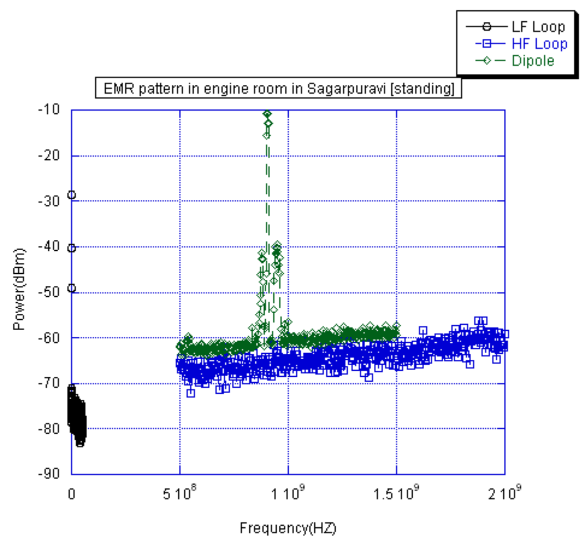

Figure 5 : EMR Pattern in Engine room in Research Vessel-1 (Standing) near transformer

3. Experiments performed on another bigger research vessel -2 reveals similar trends and so are not shown here. The turning ON of bridge equipments increases the ambient level by 10 dBm power which should be factored into the EMR values while the personnel are working.

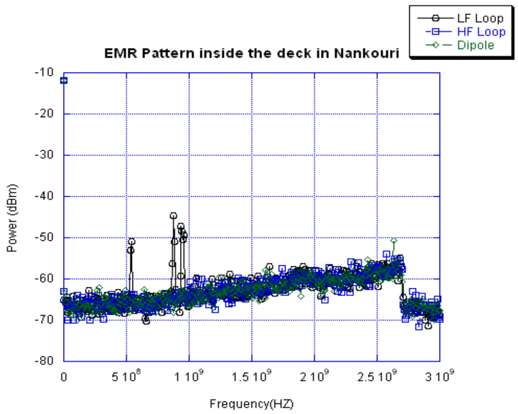

Figure 6 : EMR Pattern inside the Deck in Passenger Vessel

4. Experiments performed on a passenger vessel shows similar trends. The notable thing here is that deck and engine room are exposed to similar EM Radiation. So, while calculating the level of exposed radiation to passengers, a factor of 20 dBm power seems to be a typical figure.

III. RESULTS AND FINDINGS

The results found were startling consequences of the noise generated as well as the radiated currents found were capable of hurting a person physically by shocks or by effects on internal organs. The effect of EMI can range from minor nuisances which are easy to list and tabulate to some serious consequences like communication failure, power failure, shocks, navigational instrument failure. The number of cases in which unexplained power failures, communication equipment failures, shock and other major effects to safety of vessels and personnel are usually analyzed from casualty investigations. Analysis concluded that such unexplained causes were EMI related. All the three vessels did not meet any EMC standards. The navigational and communication equipment are considered adequately protected if they meet EN 50000- 1 - 2 - 3 or DNV standards.

To establish a safety index (**Misra**) it was laid down that the highest level of safety would be a total compliance with same 50000-1–2-3 or DNV standards. Anything less than total compliance would be a percentage in terms of equipment compliance.

The terms of reference were in compliance of
1) Shielding
2) Electromechanical devices
3) Ferrit components
4) Cabling
5) Grounding

The equipment were classed in the following manner,

Class	Margin	Consequence of disturbance
0	0dB	No harmful effect
1	6dB	Equipment that have some consequences and harmful effect
2	10dB	Equipment which can lead to injury, effect on safety
3	20dB	Equipment with major effect on personnel, vessels safety

Table 1- Classification of equipment as per radiation levels

This classification is an input into a software for better management of EMR and EMI(**Rybak and Stefka**).Along with the classing of equipment it was also necessary to sensitise the seafarers on the harmful effects of radiation(**Gordon**) on humans a table of which is given below.

Frequency MHZ	Wavelength(cm)	Site of major tissue effects	Major biological effects
100	Above 200	Not established- Probably whole body	General warming of exposed areas (used in Diathermy)
150-1200	200 – 25	Internal Body Organs	Damage to Internal Organs from Overheating
1000 – 3300	30 – 10	Lens of the Eye	Lens of the Eye particularly susceptible and tissue heating
3300 – 10000	10 – 3	Top layers of the Skin, Lens of Eye	Skin heating with the Sensation of warmth
10 – 100 GHZ	Less than 8	Skin	Skin surface acts as reflector or absorber with heating effects
* Damaging levels vary with frequency, ambient temperatures, and individuals. Safety criteria establish levels above 10 MW / cm^2 at any frequency as being unsafe.			

Table 2- A complete resume of biological effects of microwave damaging levels

IV. CONCLUSIONS

The experimentation clearly showed that radiations from already certified equipments were occurring because of breakdown of shielding. Besides this there was considerable amount of radiations from unintended sources which can be of serious concern for crew as well as passengers.

A software program has been specifically devised to deal with the compatibility plans for any type of merchant vessel, which has never undergone EMR or mapping during its lifetime. Radiation effects on equipment and humans are now being mitigated through assessment, testing and mapping along with personal safety standards on EMR protection.

V. ACKNOWLEDGEMENT

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AUTHORS

Dr.P.Misra is currently the Principal Oficer cum Jt.DG (Tech) of Mercantile Marine Department for Chennai district. He has been avidly pursuing and persevering in efforts to provide higher education opportunities for seafarers in India, in order to facilitate a sound technology base and also vibrant re-employment opportunities.

Dr.Amitabha Bhattacharya is a Professor of Electronics and Electrical Communication Engineering, Indian Institute of Technology Kharagpur, India. He joined the Indian Institute of Technology Kharagpur in 2007. His research is in Power line communication, Microwave Imaging, EMI/EMC and Microwave Antennas. His research is supported by ISRO, Naval EMC Centre, Mumbai and ARMY Centre of Electromagnetics, Mhow.

Dr.Ajay Chakraborthy is a Professor and Head of Electronics and Electrical Communication Engineering, Indian Institute of Technology Kharagpur, India. He joined the Indian Institute of Technology Kharagpur in 1977. His research is in Electromagnetics, Microwave Engineering, Numerical Techniques and Phased array Antennas. His research is supported by ISRO, Departmenr of Science and Technology (India) and ARMY Centre of Electromagnetics, Mhow. Dr. Ajay Chakraborthy received a SMEI (I) award 2003 for contribution to EMC in the field of research and Education. He is a senior member of IEEE and life member of SEMCE (I).