HIGH FREQUENCY OCCUPATIONAL ELECTROMAGNETIC FIELD EXPOSURE ASSESSMENT OF FIELD WORKERS/CLIMBERS IN MOBILE INDUSTRY

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Scope:
Maintenance procedures of electromagnetic field (EMF) emitting equipment are of great significance concerning occupational EMF exposure assessment [1]; mobile industry field workers/climbers are a characteristic case. Records from field workers were analyzed to investigate the EMF exposure levels in occupational environment and other risks faced in their job.

Methods:
The climbers are equipped with EMF personal monitors (fig.3), which exhibit shaped frequency response (100 kHz - 100 GHz) matched to the ICNIRP's occupational standards [2] (that are also adopted by the Greek legislation PD 120/2016 following the European Directive 2013/35/EU [3], (fig.1)). Implemented thermocouple detectors yield accurate true RMS results even from extremely narrow radar pulses. The monitors are used both as logging devices and alarm indicators at preselected levels of the occupational limits. The assessed monitors' records involve maintenance procedures at rural and urban mobile base stations. Typical exposure environment may include Radio & TV transmitters, Mobile Base Stations (3G, 4G, 4G+), links and Wi-Fi antennas (fig.2). Four (4) monitoring devices (worn by 4 different field workers) have been analyzed. More than 156k of records have been considered in this study with a sampling of 1 sec (fig.4). The monitor is worn either in belt or on chest outside clothing. No RF protection clothes were used in this study.

Results: The workers exposure extracted both numerically and graphically, indicates that the majority (almost 98%) of the electric field strength is **below 10% of the current occupational action limit** [5], (fig.5). Two interesting cases studies are shown in this paper. The first one (fig.6) is a typical day (most often conditions) in work where exposure does not exceed the 10% of STD. The second case (fig.7) refers to an intense EMF environment where there is exposure limit excess for certain time period but the average value remains below 100%. Workers use the alarms and LED indications to avoid continuous exposure in high field strength. As the climbers are exposed to many other hazards apart from EMFs, the overall risk assessment is overviewed according to the Greek Mobile Operators strategy and the Occupational Health and Safety (OHS) principles. A risk assessment approach took place in this study. Interviewing the field workers a number of other than EMF hazards came into consideration. Driving in off-road conditions with limited signing, weather conditions, electric currents, fall from height, insect bites (biological risk), musculoskeletal and psychological fatigue, inefficient training and EMF fears (concern) are factors that pose great risk while working in the field. The highest risk is imposed by the driving conditions.

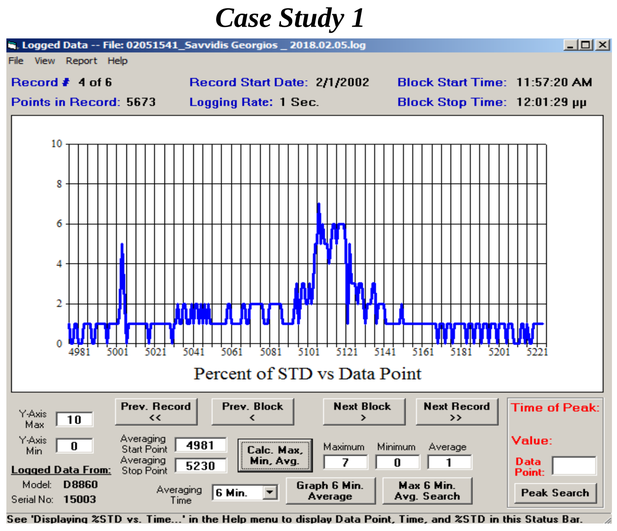
Conclusions: Occupational limits ensure personal safety [4], prohibiting any adverse health effect, even where many RF masts/sources are installed. Moreover, the evolution to digital Radio/TV signals in combination with standard working procedures/instructions and several precaution measures (i.e. power 'shut down' of the base station), has significantly decreased exposure. Nevertheless, the exact workers' exposure identification (mostly from unidentified RF sources) remains a crucial EMF exposure assessment issue; in this sense, future correlation of the monitors' results to direct measurements using spectrum analyzers is challenging. Uncertainty in measurements is compensated by the 50% alarm activation. A factor that can impose uncertainty in measurements is the placement of the monitor on the body. EMFs can be absorbed in the body leading in exposure underestimation by the personal monitor. It is suggested that the worker changes the position of the monitor periodically.

References:

[1] Gourzoulidis GA et al. Occupational exposure to EMFs, the situation in Greece. Phys Med 32(276);2016.
[2] ICNIRP GUIDELINES (UP TO 300 GHz), Heal Phys 74(4):494-522;1998.
[3] Directive 2013/35/EU OJ L 179/1.
[4] Radiofrequency radiation dosimetry handbook, William P.Roach, July 2009.
[5] European Commission. Non-binding guide to good practice for implementing Directive 2013/35/EU.

Case Studies

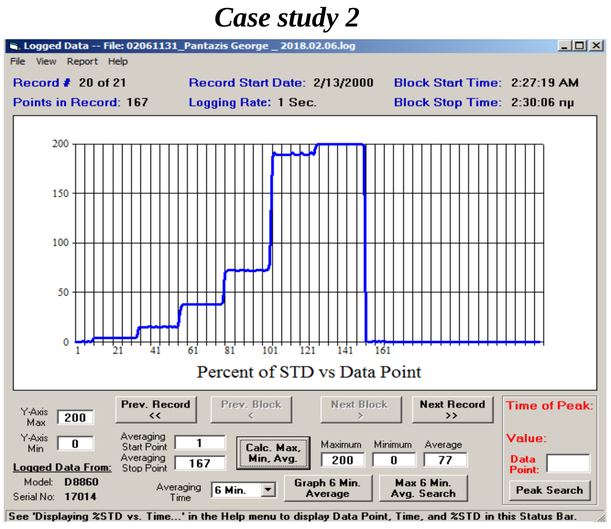
Case Study 1



- Max Exposure 7% of STD
- Average Exposure 1% of STD
- Exposure time 4,15min
- Sampling 1sec
- Field Worker safe even in continuous exposure in this level
- No alarm – No LED indication activated

Figure 6: *Graph from Nardalert XT (exposure percentage vs recording time (sec)*

Case study 2



- Max Exposure 200% of STD
- Average Exposure 77% of STD
- Exposure time 2,70min
- 49sec recorded in 100-200% of STD – LED activated
- 25sec recorded in 50-100% of STD – LED & Alarm activated

Figure 7: *Graph from Nardalert XT (exposure percentage vs recording time (sec)*

Action Levels – Directive 2013/35/EU

ALs for exposure to electric and magnetic fields from 100 kHz to 300 GHz

Frequency range	Electric field strength ALs(E) [Vm^{-1}] (RMS)	Magnetic flux density ALs(B) [μT] (RMS)	Power density ALs(S) [Wm^{-2}]
100 kHz ≤ f < 1 MHz	$6{,}1 \times 10^2$	$2{,}0 \times 10^6/f$	—
1≤ f < 10 MHz	$6{,}1 \times 10^8/f$	$2{,}0 \times 10^6/f$	—
10 ≤ f < 400 MHz	61	0,2	—
400 MHz ≤ f < 2 GHz	$3 \times 10^{-3}\ f^{½}$	$1{,}0 \times 10^{-5}\ f^{½}$	—
2 ≤ f < 6 GHz	$1{,}4 \times 10^2$	$4{,}5 \times 10^{-1}$	—
6 ≤ f ≤ 300 GHz	$1{,}4 \times 10^2$	$4{,}5 \times 10^{-1}$	50

Note B1-1: f is the frequency expressed in hertz (Hz).

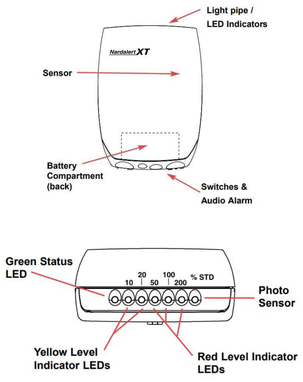
Figure 1: *Action Levels adopted in EU Directive 2013/35/EU up to 100GHz*

Typical Field Working Environment

Radio TV (analogue & digital), Mobile, Links, WiFi

Figure 2: *Antenna parks and mobile pylons in rural environment*

Personal Monitor - Specs



Specs	8860 (Nardalert XT)
Frequency range	100kHz-100GHz
Alarm 1	50% std
Alarm 2	200% std
LED ind.	10,20,50,100,200%
Sampling	1 sec
Size (HxWxD)	10,5 x 7,6 x 3,5 (cm)
Sensors	Diode & Thermocouples (high f)

Figure 3: *Personal Monitor Specifications – Nardalert XT*

Protocol of the Study

Field Workers	4
Number of Records	156.120 (sampling 1s) – 43hrs
Research Period	Aug 2017 - Dec 2017
Frequency Range	100KHz – 100GHz
Mobile technologies	2G, 3G, 4G και 4,5G
Monitor place	Belt / Chest
Exposure Limits (STD)	EU Directive 2013/35
Equipment Uncertainty (*frequency sensitivity & Polarization uncertainty*)	+6/-3dB (100-2.3GHz) +4,5/-2,5dB (2,3 – 30GHz) +2,5/-6dB (30 – 50GHz) +2,5/-6dB (50 – 100GHz)

Figure 4: *Protocol of the study*

Results

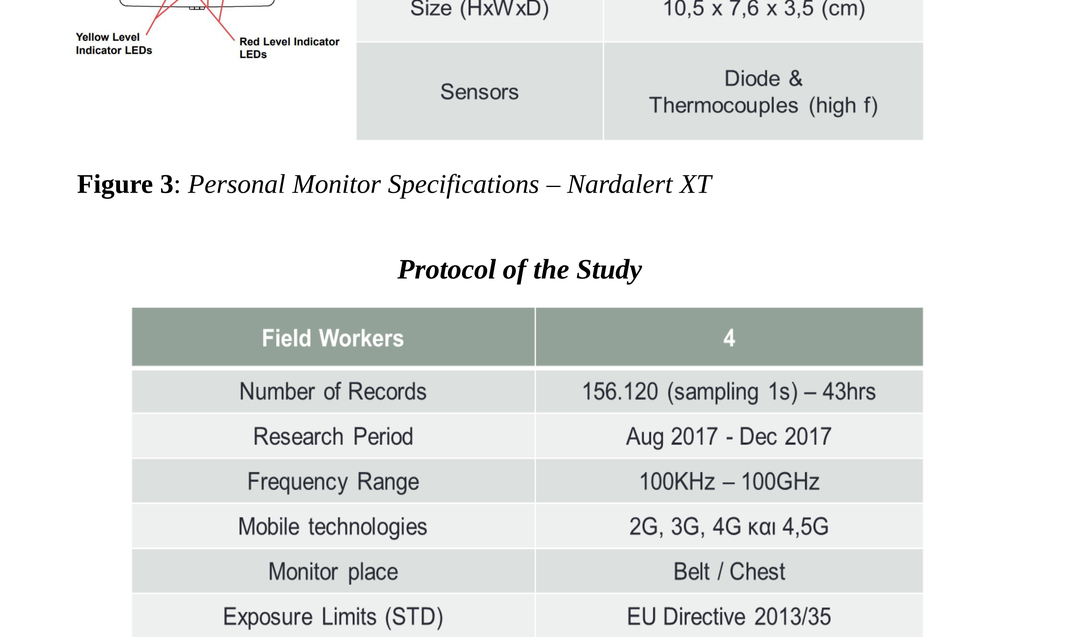


Figure 5: *Exposure time results vs range of exposure as a percentage of the standard.*