

The parameterisation  
of short- and long-term dynamics  
of workers' exposure to low frequency EMF  
when evaluating health and safety hazards,  
or the applicability  
of reducing exposure

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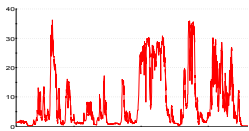
#### Introduction:

- Characterising the health and safety hazards caused by exposure to a low frequency electromagnetic field (LF-EMF) in the work environment is a research priority in bioelectromagnetics
- The epidemiological studies were summarized by the 2B/IARC classification for the carcinogenic impact of long-term LF-EMF exposure – **parameterised by magnetic flux density (B, mT)**
- Workers' exposure to LF-EMF is monitored also to evaluate a compliance with:
  - requirements of labour law, regarding exposure limits – expressed in **B values and dB/dt values** (related to in-body induced electric field)
  - application of technical and organisational measures to manage various electromagnetic hazards in the work place
- The relevant parameterisation of real workers' EMF exposure faced strong practical challenges



#### The aim:

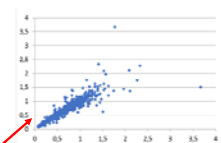
- to test the applicability of short- and long-term dynamics of workers' LF-EMF exposure when evaluating:
  - the health hazards
  - the applicability of reducing exposure in the work place
- B-field exposure is characterised by time-series of RMS (root-mean-square) values samples recorded by a body-worn data logger – **monitoring of unperturbed B-field affecting worker**



#### Methods:

- **The main challenges are the relevant capturing consequences of worker's body movements** (which make significant differences between the outcome from the EMF fixed-location spot measurements and the real EMF exposure experienced by worker in the work environment)
  - Using **spot measurements**, the frequency and time pattern of exposure caused by the fluctuations of EMF emission from its source is monitored
  - Using a **body-worn exposimeter (BWE)** - a data logger sampling in time B-field or E-field), fluctuations of EMF exposure caused by worker's movement in the workplace is monitored
- **Additional challenges are related to practical consequences of using RMS value measurements** (correlated with the electrodynamic EMF exposure effects, such as the cell membrane excitation by induced in body electric field, **only in case of the continuous sinusoidal EMF exposure**)

$$X_{RMS} = \sqrt{\frac{1}{T} \int_0^T x^2(t) dt}$$



Exposure to B-field  
near HV power line  
Poincaré plot: B(t) v. B(t+1)  
(covered by IARC/2B)

#### Methods:

- The dynamics of LF-EMF exposure was monitored
  - by exposimeter sensitive to isotropic B-field RMS value
  - by oscilloscopic recordings of the actual B-field waveform in time
- The short- and long-term dynamics of B-field exposure profile were analyzed using
  - parameters of descriptive statistics (median value, interquartile and 5-to-95 centile ranges)
  - the Poincaré representation of recorded samples
  - the Fourier transform to analyse the frequency composition in oscilloscopic waveforms of exposure

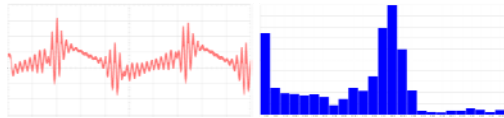
#### Results and discussion:

- The analysis of parameters of exposure of worker moving through the B-field exposed environment was performed
  - in well-controlled laboratory conditions
  - in the real work environment
- Significantly different short-term and long-term variability (dynamics) of LF-EMF interaction near considered EMF sources were found

### Results and discussion:

The way of moving near the source of continuous sinusoidal EMF may:

- significantly modified the frequency composition of EMF exposure experienced by worker comparing to EMF emitted from the source
- **without a significant modification of the descriptive statistics of B-field-RMS values recorded by a body-worn exposimeter**



**Laboratory tests:**  
B-field source:  
50Hz, sinusoidal continuous wave emission

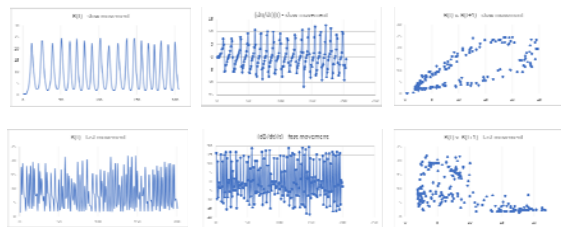
B-field waveform recorded using on-body B-field sensor and fast-sampling in time during rapid movements near B-field source

B-field frequency spectrum (harmonics in the frequency band 4-100 Hz)



### Results and discussion:

Various ways of moving near the source of continuous sinusoidal EMF



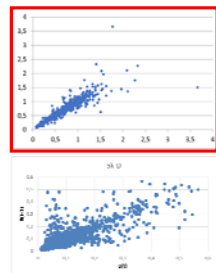
**Laboratory tests:**  
B-field source:  
50Hz, sinusoidal, CW  
1.5 second sampling

**B-field – IQR**  
2.7-14.2 – slow mov.  
3.7-14.5 – fast mov.

**Mod(dB/dt) – IQR**  
1.2-6.3 – slow mov.  
3.8-13.7 – fast mov.



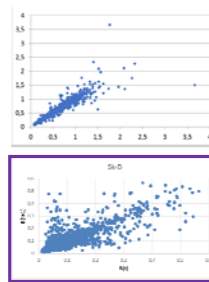
### Results and discussion:



- The effects of LF-EMF exposure in the worker's body are considered mainly with respect to:
  - parameters of B-field penetrating a body (which may influence directly on biochemical processes in tissues) – **B(t)**
  - parameters of E-field induced in a body (which may influence on bioelectrical processes at cell membranes) – **dB/dt(t)**
- It requires special attention that the electromagnetic health impact was studied mainly in the context of **residents' EMF exposure near high voltage electric transmission lines** and indoor transformers (exposure continuous in time with (quasi)sinusoidal waveform and power frequency, affecting a whole body located far from large-dimension EMF sources)
- Similar type of B-field exposure was used also in significant percentage of in vivo and in vitro studies.
- Additionally, this EMF exposure was usually evaluated based on the RMS value measurements using the spot or body-worn B-field data-loggers.



### Results and discussion:



**In case of evaluating and managing electromagnetic hazards at work, significantly different EMF exposure needs to be considered:**

- localised (with high discrepancy over the body located near small-dimension EMF sources),
- to complex in the frequency domain EMF of power frequency with higher harmonics or EMF of other frequencies,
- including magnetic and electric components,
- significantly varying in time (because of pulsed or modulated in time emission from the EMF source, moving the body in the workplace or moving the EMF source there).



### CONCLUSIONS

It was confirmed that using parameters of short- and long-term dynamics of workers' LF-EMF exposure, monitored by the body-worn B-field RMS value data loggers, may

- significantly improve the relevance of the parameterisation of EMF safety and health hazards in real working environments,
- as well as evaluations of the quality of work organisation.

### REFERENCES

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The oldest, 50-years old, EMF meter designed in Poland

**60 years of electromagnetic hazards monitoring in the work environment by research team of Central Institute for Labour Protection (Warszawa, POLAND)**

**Thank you for your time and attention**



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