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Occupational Exposure to Electromagnetic Fields: paving the way for a future EU initiative

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Numerical calculations
A realistic approach for compliance with the directive?

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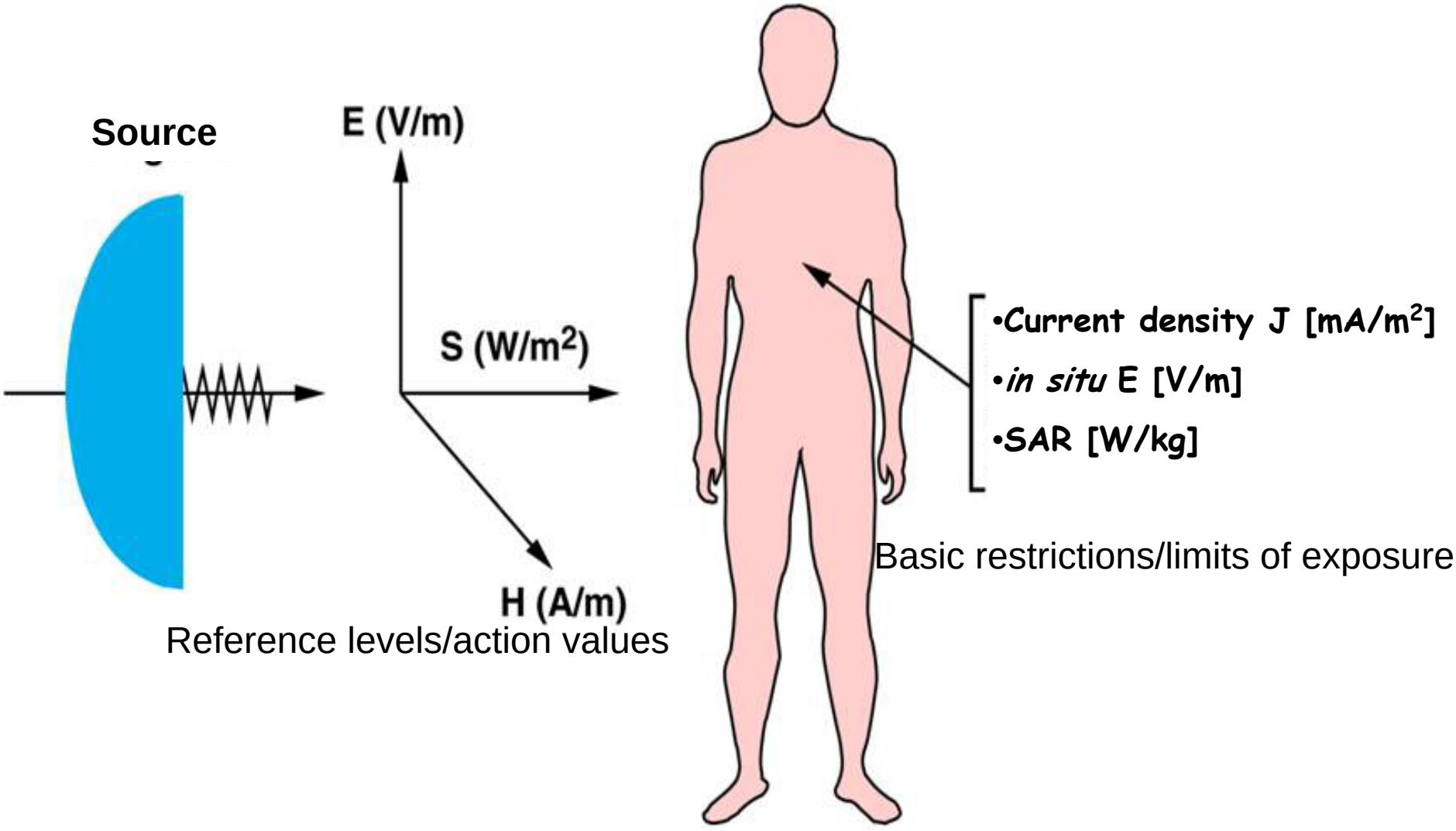
OUTLINE

- Why numerical dosimetry in the frame of directive 2004/40/CE?

- Critical points:
  - economical-practical
  - scientific

- Suggestions for new regulation

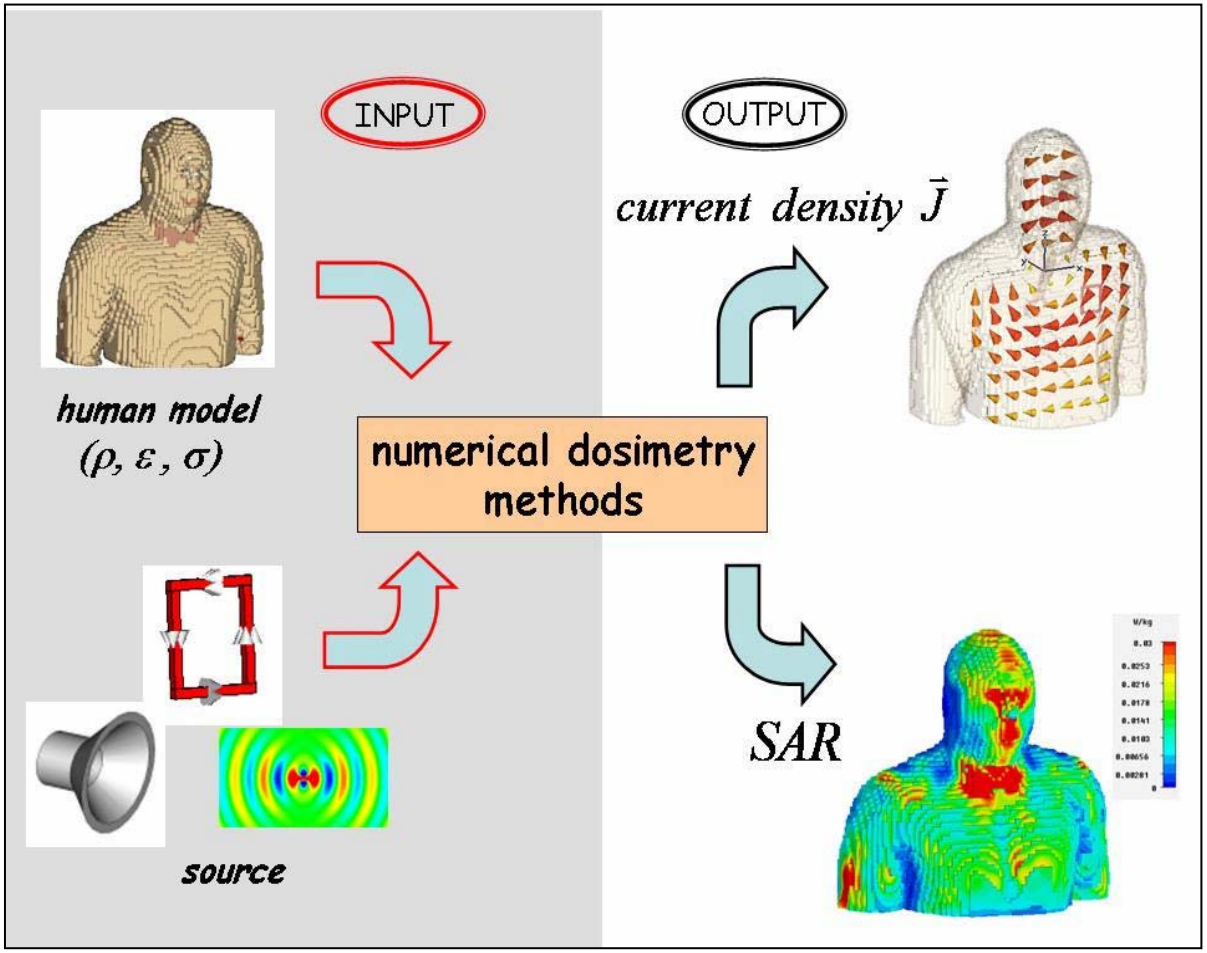
Exposed subject



Reference levels/action values

Basic restrictions/limits of exposure

Numerical dosimetry



different calculation methods:

- ✓BEM
- ✓FDFD
- ✓FDTD
- ✓FEM
- ✓FIT
- ✓MoM
- ✓CVP

In which situations is there a need for numerical dosimetry in the application of directive?

Which provisions from 2004/40/EC?

Two aspects of implementation:

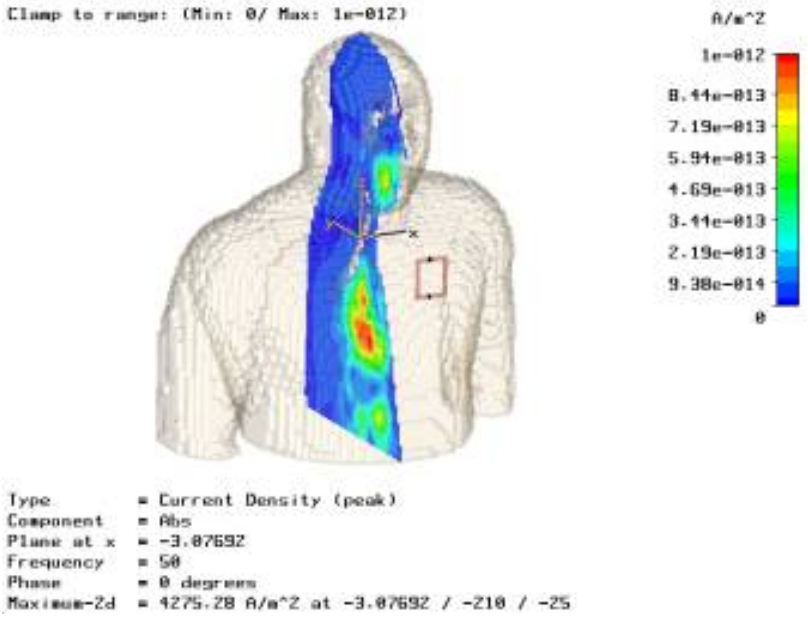
risk assessment in the workplace (obligation for employers)

product standardization (obligation for manufacturers)

Critical points (economical-practical)

Art.4 Directive 2004/40 – Risk assessment

1. *the employer shall assess and, if necessary, measure and/or calculate the levels of electromagnetic fields to which workers are exposed.*
2. *if the action values referred to in Article 3 are exceeded, the employer shall assess and, if necessary, calculate whether the exposure limit values are exceeded*



Risk assessment in workplace

The application of ND is a very complicated and expensive task requiring high skilled expertise, to-date available only in research centres or institutions.

Furthermore, there is no a priori certainty that protective measures will not be necessary, with further costs

example: at ISPESL current price list, considering travel, measurement campaign, dosimetric evaluation, technical report, etc., the cost of a single assessment is around **30,000 Euros**

a costs in most situations exceeding the immediate implementation of protective measures

Risk assessment in products standardization

*On the other side dosimetric evaluation is a relatively **low burden for manufacturers** (small percentage of the cost of the production). Compliance with EU directive provisions is achievable during manufacturing of the equipment and gives an added value to the product.*

The assumption is reasonable also for risk assessment in large sized company or industry, where many occupational exposures can be focused with one or little more calculations.

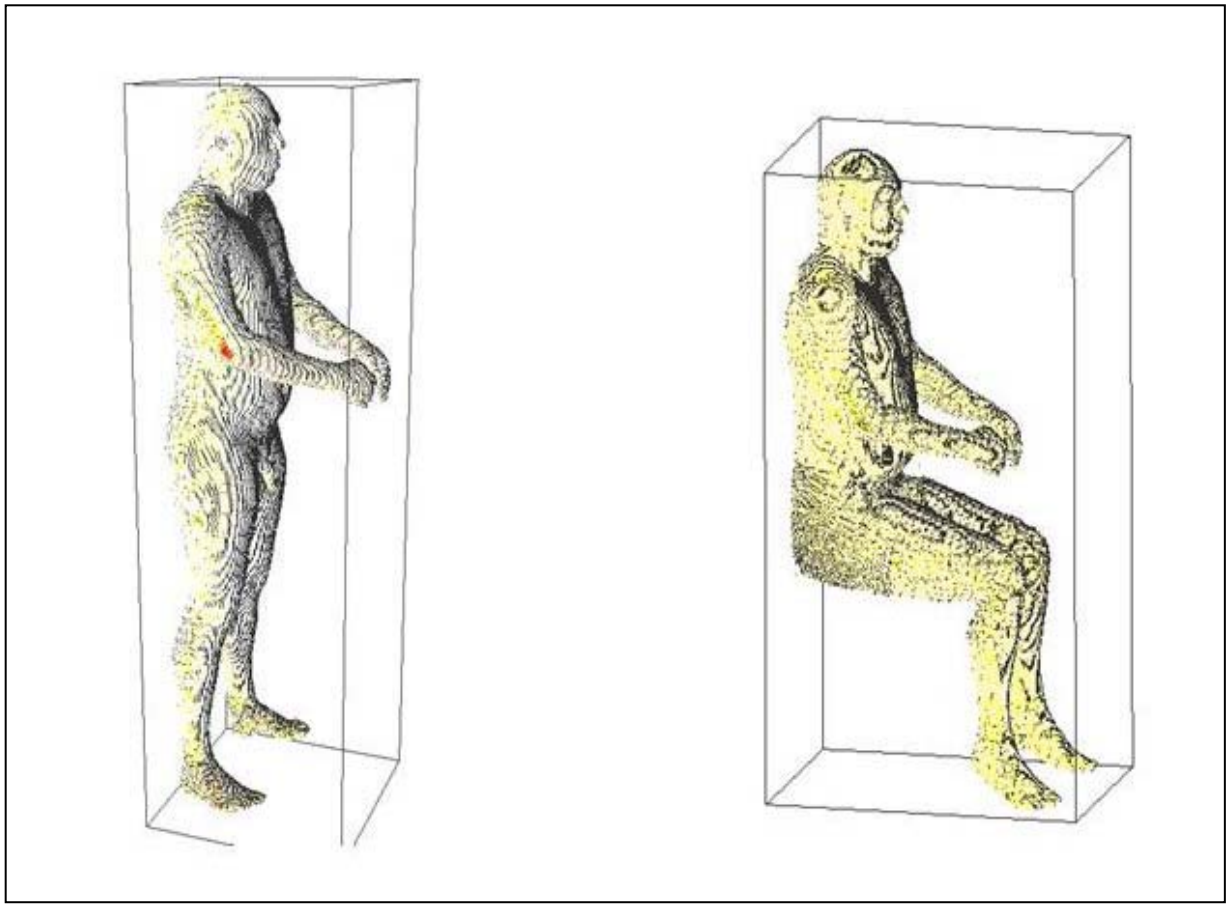
CRITICAL POINTS
(Scientific)

CRITICAL POINTS (Scientific)

- high uncertainties associated with results, expecially at low frequencies
- lack of detailed knowledge of dielectric properties of human tissues at the lowest frequencies
- dependence of results from different models of human body for different ages, dimensions and phenotypes

Different posture in body models

- models able to represent typical occupational complex postures



Uncertainty in ELF calculation

- The computational uncertainty determined by comparison of analytical and numerical results on a simple model (ellipsoid) amounts to a worst-case expanded uncertainty of ± 9.89 dB (**+212%, -68%**) for both the **current density and the *in situ* electric field.**

Bahr et al. 2007

Uncertainty in ELF calculation

- *"The incorporation of the high computational uncertainty in safety factors for ELF EMF exposure has to be discussed."*

Bahr et al. 2007

Does the new ICNIRP proposed basic restriction of 100 mV/m account for safety factors?

Critical point
(RF fields)

It is very important to remind that compliance with local SAR restrictions has always to be achieved.

Such point is crucial when the source is very close to the worker and the field is directly coupled with the body.
In some situations it can be done only by numerical calculation. Assessment of local SAR should be recommended if the peak-to-average ratio of power density over the body is more than 6 dB (Jokela, 2007)

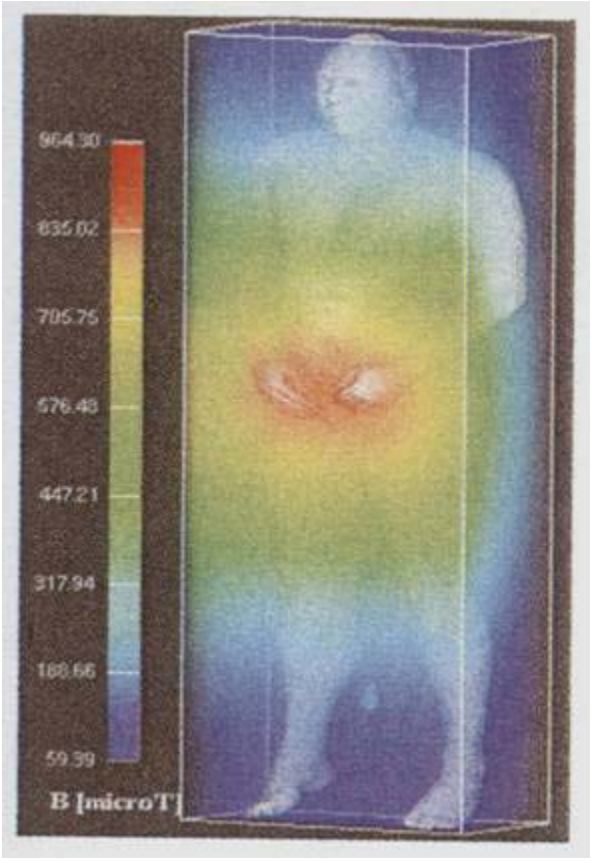
Critical point
(RF fields)

Spatial averaging of the incident field is only suited for compliance with whole-body-averaged SAR and may result in the underestimation of peak spatial SAR. Peak field measurements considering the directivity of the locally incident field are more sound and rigorous.

Kuhn et al. 2009

Example of calculation on a spot welding equipment

"The basic restriction is exceeded alhough the magnetic field spatially averaged over the whole body is well below the reference level". Nadeem et al. 2004



B = 87 μT
reference level (50 Hz) = 500 μT

J_{max} = 14 mA/m^2
basic restriction (50 Hz) = 10 mA/m^2

How to manage critical points? Which is the realistic approach?

Instead of being a tool for routine exposure assessment, numerical dosimetry should be exploited for deriving standardized and practical measurement protocols for a realistic, safe but not too conservative, exposure assessment.

Kari Jokela, EMF-NET/MT2 meeting. September 2007

Suggestions for a new EMF directive

SUGGESTION 1 (scientific)

The current definition of action values as average over the exposed body, is a too poor approximation of real inhomogeneous exposures in most occupational situations, resulting in the need of numerical dosimetry in order to verify compliance with local basic restrictions.

The introduction of proper measurement protocols, and more rigorous criteria to compare measurements with reference levels as suggested by Jokela 2007, Kännälä et al. 2008 (in terms of induced currents measurement), and Kuhn et al. 2009, could resolve many unclear situations and avoid the need of numerical calculation, expecially for RF fields.

SUGGESTION 2 (scientific)

For ELF fields, the informative Annex "Spatial averaging" in the ICNIRP draft 2009 gives indications and criteria for practical exposure assessment.

However, the definition of the basic restriction only for CNS could result in a too conservative approach with strongly localized fields.

Specific basic restrictions and reference levels for tissues different than CNS could contribute to a more realistic assessment, and again save many situations from the need of numerical calculation in inhomogeneous exposure conditions.

SUGGESTION 3 (practical)

Art. 4.2 should be made more flexible, clearly allowing the possibility of adopting protective measures as soon as action values are exceeded.

This will help the employers and inspection authorities in applying the regulation provisions. In many situations this will imply saving money (protective measures may be cheaper than calculation), and reducing all the way workers' exposure

Which is the pathway?

improve the development of appropriate measurement protocols and methods of comparison with action values, able to be assess complex exposure conditions without the need of numerical calculations

such methods must be explicitly adopted in regulation/standards

define a regulatory system where numerical dosimetry is required to manufacturer, but is not in charge of the single employer

create a pathway that the employer can really undertake and follow