ICNIRP
INTERNATIONAL COMMISSION ON
NON-IONIZING RADIATION PROTECTION

ITU-D Study Group 2
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The draft ICNIRP radiofrequency guidelines

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Scope

- Limit exposure to radiofrequency EMFs (100 kHz – 300 GHz)
- Provide protection against adverse health effects to humans under realistic conditions
- Consider occupational and general public exposure
- Consider direct and indirect exposure (but only contact with charged objects)

- Not included:
  - Electromagnetic interference
  - Exposure for medical purposes
  - Compliance issues (e.g. measurement)

Current status

- Public consultation until 9 October 2018
- Draft guidelines (exposure limits & rationale)
- Technical appendix (dosimetry issues, background reference levels)
- Biological appendix (overview health effects)

Identification of adverse health effect thresholds

- Identification of scientific data on effects of exposure on biological systems
- Determination of effects considered both
  - adverse to humans and
  - scientifically substantiated (independent replication, sufficient quality, scientifically explicable generally)
- Identification of adverse health effect threshold
  - minimum RF EMF exposure level shown to produce harm, or
  - where insufficient RF/biology research, minimum exposure predicted to cause harm from non-RF literature (i.e. *operational* adverse health effect threshold)

Derivation of Basic restrictions

- Application of reduction factors to health effect thresholds
  - account for scientific uncertainty, relative importance of the health effect, variation across the population
  - reduction factors may differ based on these parameters
  - consistency across limit types is sought unless there is *substantive* reason for variation
- Reduction factors for general public are higher than for occupational
  - general public may not be aware of exposure and will not have any training to mitigate harm
  - variation in sensitivity may be larger in general public

Reference levels

- Field strength values derived from basic restrictions, to provide a practical method for determining compliance with basic restrictions
  - Reference levels are derived so as to be conservative for all *realistic* exposure conditions, but not all *possible* exposure conditions

Scientific basis

- Draft WHO RF EHC, SCENHIR + original papers not included
- Extensive body of relevant literature, ranging from cellular research to cancer epidemiology
- Research has only found evidence of potentially harmful effects from:
  - temperature elevation above thresholds
  - microwave hearing (thermal effect; not considered harmful, no limits)
  - electrostimulation (described in ICNIRP 2010 ELF Guidelines; not considered here)
  - electroporation (no problem in practice; no limits formulated)

Scientific basis (cont.)

- No evidence that RF EMF causes such diseases as cancer
  - Results NTP, Falcioni studies (animals, lifetime exposure) not convincing (statement on ICNIRP website)
- No evidence that RF EMF impairs health beyond effects that are due to established mechanisms of interaction
- Thermo-biology literature also considered

Interaction mechanisms (temperature elevation)

- Temperature increases taken to represent health effects, and restrictions set to avoid these
- Health effects primarily related to absolute body core or local temperature
- Body core and local temperature depend on many factors that are independent of EMF, such as environmental temperature and physical activity
- Therefore: temperature increase used that is indicative of adverse health effects *assuming thermonormal baseline state*

Body core temperature

- Mean body core temperature (approximately 37 °C) typically varies over the day by 0.5 °C
  - thermoregulatory functions (e.g.vasodilation, sweating) to keep body core temperature in thermonormal range
  - most health effects induced by hyperthermia (>38 °C) resolve readily with no lasting effects, but risk of accident and heat stroke increases
- Increase >1 °C in body core temperature is defined as potentially harmful (=operational standard)
  - for comparison: ACGIH heat stress at work standard aims at protecting against >1 °C core body temperature increase

SAR and body core temperature

- RF modelling predicts:
  - ~6 W/kg WBA SAR, 1 h, ambient temperature of 28 °C: core body temperature increase ~1 °C (consistent with the limited human measurement research)
  - WBA SAR higher in children (more efficient heat dissipation)

- **ICNIRP suggests as adverse health effect threshold a WBA SAR of 4 W/kg averaged over 30 min**

- Very conservative !
- Generation energy in human adult: ~1 W/kg at rest, ~2 W/kg standing, ~12 W/kg running

SAR and frequency

- Previous: SAR up to 10 GHz, power density at higher frequencies
- Now: WBA SAR 4 W/kg up to 300 GHz
- Local SAR up to 6 GHz
- 6-300 GHz: *transmitted* (=incident - reflected) power density

Local exposure: tissues

- Excessive localized heat can cause pain and damage cells. Tissue damage can occur at local temperatures >41-43 °C (time-dependent)
- Operational adverse health effect thresholds:

- **Type-1 tissues** (thermonormal temperature < 33-36 °C): **5 °C**
  - upper arm, forearm, hand, thigh, leg, foot, pinna, cornea, anterior chamber and iris of the eye, epidermal, dermal, fat, muscle and bone tissue

- **Type-2 tissues** (thermonormal temperature < 38-38.5 °C): **2 °C**
  - all tissues in the head, eye, abdomen, back, thorax and pelvis, excluding those defined as Type-1 tissue

Local exposure: regions

- Difficult to use tissue types for exposure limits
- Definition of regions:

- **Head & Torso** (head, eye, abdomen, back, thorax and pelvis)
- **Limbs** (upper arm, forearm, hand, thigh, leg and foot)

Averaging mass

- SAR:
  - 10 g
  - shape: cube (provides a better match with temperature increase than contiguous tissue)

Local exposure: adverse health effect levels

- Modelling/extrapolation suggests:
  - ≤ 6 GHz: SAR_{10g} of 20 W/kg: temperature increase max. 2 °C (4 °C with 40 W/kg)
  - >6 GHz: transmitted power density of 200 W/m^2: temperature increase max. ~5 °C in superficial, less in deeper tissue
- **ICNIRP suggests as health effect levels:**
  - **100 kHz - 6 GHz:**
    - **Head & Torso: local SAR_{10g} 20 W/kg averaged over 6 min**
    - **Limbs: local SAR_{10g} 40 W/kg averaged over 6 min**
  - **>6 - 300 GHz:**
    - **transmitted power density 200 W/m^2 averaged over 6 min**
    - **averaging area: 6-30 GHz: 4 cm^2, 30-300 GHz: 1 cm^2**

Contact current

- Effect = pain
- Threshold:
  - Adults: 20 mA
  - Child: 10 mA

Basic restrictions and differences with 1998 values

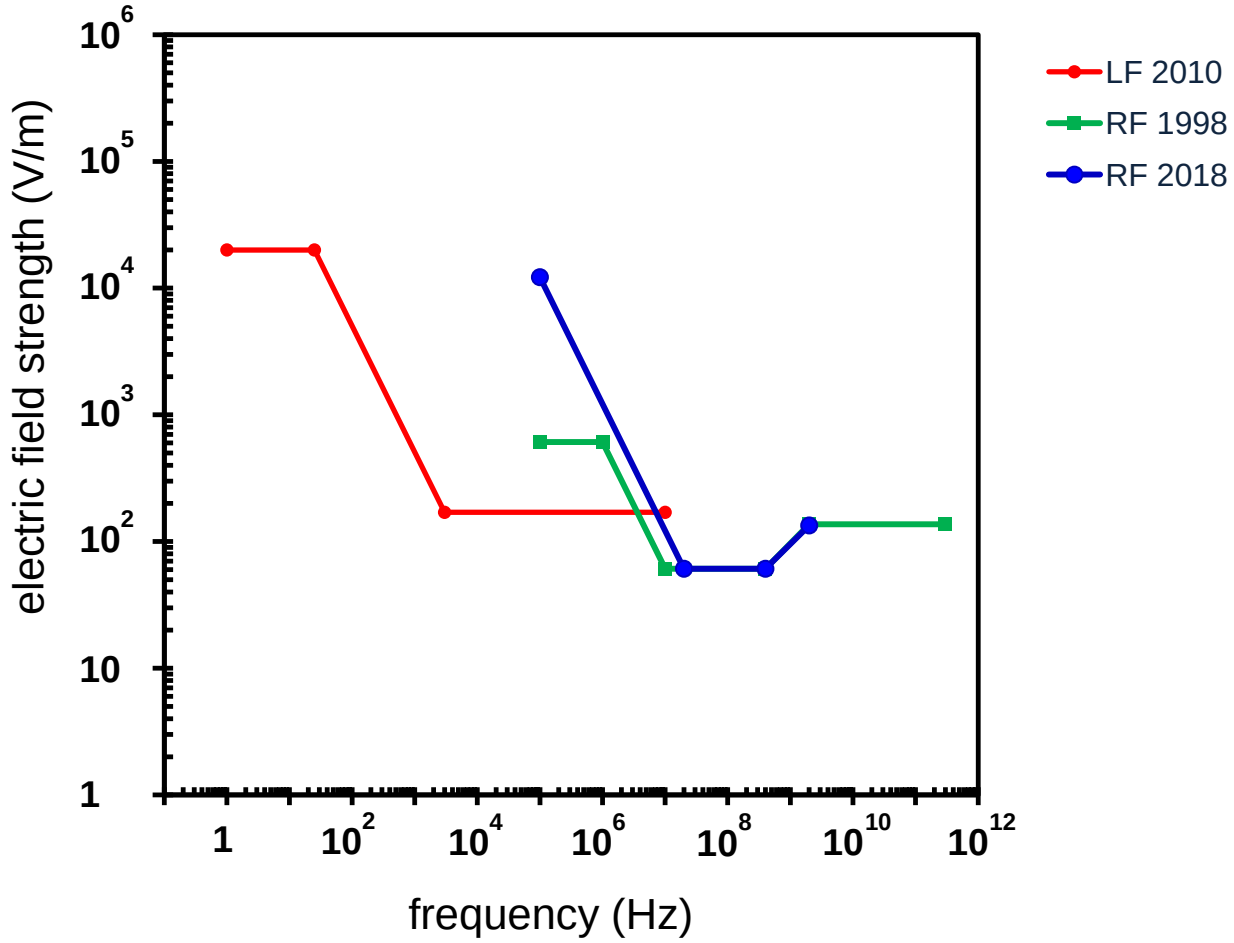
Parameter	Freq. range	ΔT	Spatial	Aver. time	Health effect level	RF	Occup.	RF	General public
Core ΔT	100 kHz-300 GHz	1°C	WBA	30 min 6 min	4 W/kg	10	0.4 W/kg	50	0.08 W/kg
Local ΔT (Head & Torso)	100 kHz-6 GHz	2°C	10 g	6 min	20 W/kg	2	10 W/kg	10	2 W/kg
Local ΔT (Limbs)	100 kHz-6 GHz	5°C	10 g	6 min	40 W/kg	2	20 W/kg	10	4 W/kg
Local ΔT (Head, Torso, Limbs)	>6-30 GHz 30-300 GHz 10-300 GHz	5°C	4 cm^2 1 cm^2 20 cm^2	6 min $68/f^{1.05}$	200 W/m^2	2	100 W/m^2 50 W/m^2	10	20 W/m^2 10 W/m^2
Pain (contact current)	100 kHz-110 MHz *(guidance level* *reference level)*	--	--	10 sec	20/10 mA (adult/child)	1	20 mA 40 mA	1	20/10 mA (ad./child) 20 mA

Reference levels

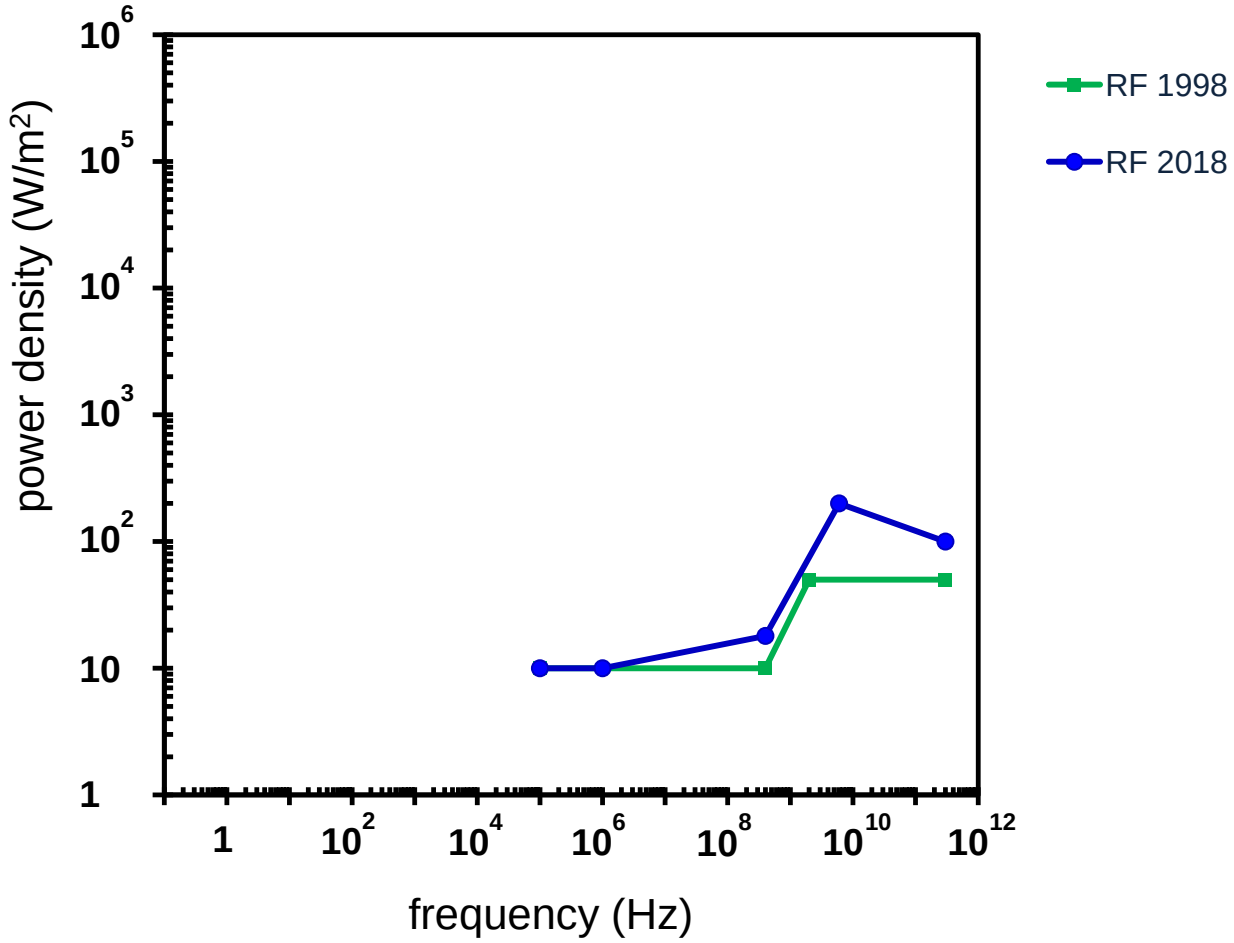
- 100 kHz – 300 GHz:
  - Whole-body, far field
  - Local, far field, exposure ≥ 6 minutes
  - Local, far field, exposure < 6 minutes

- 100 kHz – 110 MHz:
  - Limb current (occupational 100 mA, general public 45 mA)

Reference levels (whole body, far field, occupational)



Reference levels (local, far field, >6 min, occupational)



Next steps

- Public consultation until 8 October 2018
- Discussion of comments, finalizing guidelines
- Publication

Thanks for your attention and your patience!