

The revised ICNIRP guidelines on exposure to RF fields

Zenon Sienkiewicz
Main Commission, ICNIRP

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 now closed (9 October 2018)

Revision as necessary underway

- 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
 - scientifically substantiated
 - independent replication, sufficient quality, scientifically explicable
- Identification of adverse health effect threshold
 - minimum 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 restrictions 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

External 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 restrictions)
 - electrostimulation (described in ICNIRP 2010 ELF Guidelines; not considered here)
 - electroporation (no problem in practice; no restrictions)

Scientific Basis

No evidence that RF fields cause diseases such as cancer

- NTP, Falcioni studies (animals, lifetime exposure) not convincing (statement on ICNIRP website)

No evidence that RF fields impair health beyond effects that are due to established mechanisms of interaction

- Thermophysiology 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 RF, such as environmental temperature, humidity, 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 mechanisms (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 threshold)

- 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)
- Higher WBA SAR required 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 !
- Energy generation in human adult ~1 W/kg at rest, ~2 W/kg standing, ~12 W/kg running

SAR and Frequency

1998 guidelines

- SAR up to 10 GHz, power density at higher frequencies

Revised draft guidelines

- 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 specific tissue types for limiting exposure

Therefore use regions

- **Head & Torso** (head, eye, abdomen, back, thorax, pelvis)
- **Limbs** (hand, forearm, upper arm, 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/m²: 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/m² averaged over 6 min**
- **averaging area: 6-30 GHz: 4 cm², 30-300 GHz: 1 cm²**

Contact currents

Effect = pain

Threshold:

- Adults: 20 mA
- Child: 10 mA

Basic Restrictions and Differences with 1998

Parameter	Freq. range	ΔT	Spatial	Aver. time	Health effect level	Red F	Workers	RF	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	5°C	4 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
	30-300 GHz 10-300 GHz		1 cm ² 20 cm ²						
Pain (contact current)	100 kHz-110 MHz (guidance level reference level)	--	--	10 sec	20/10 mA	1	20 mA 40 mA	1	20/10 mA 20 mA

Reference Levels

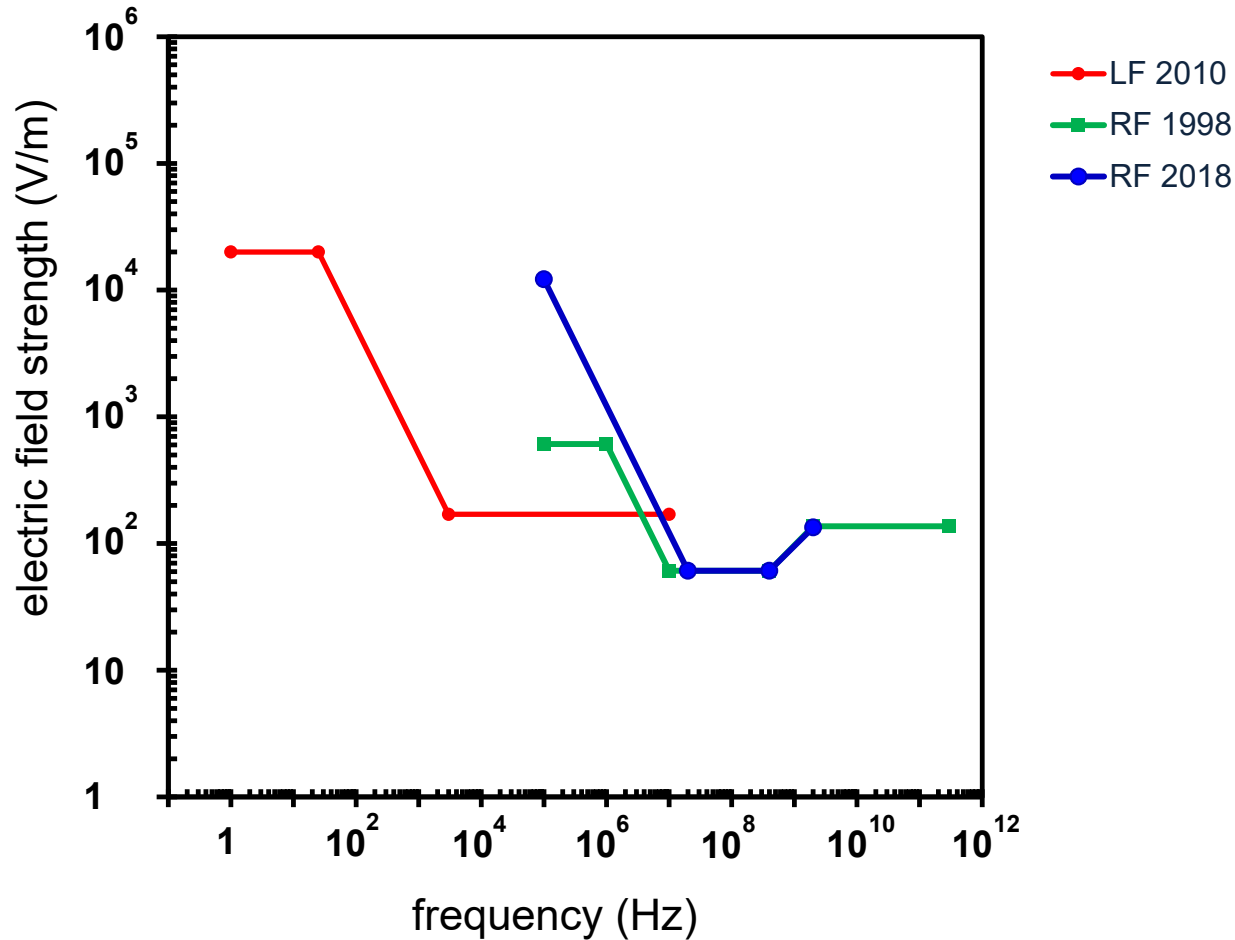
100 kHz – 300 GHz:

- Whole-body, far field
- Local, far field, exposure ≥ 6 minutes
- Local, far field, exposure < 6 minutes

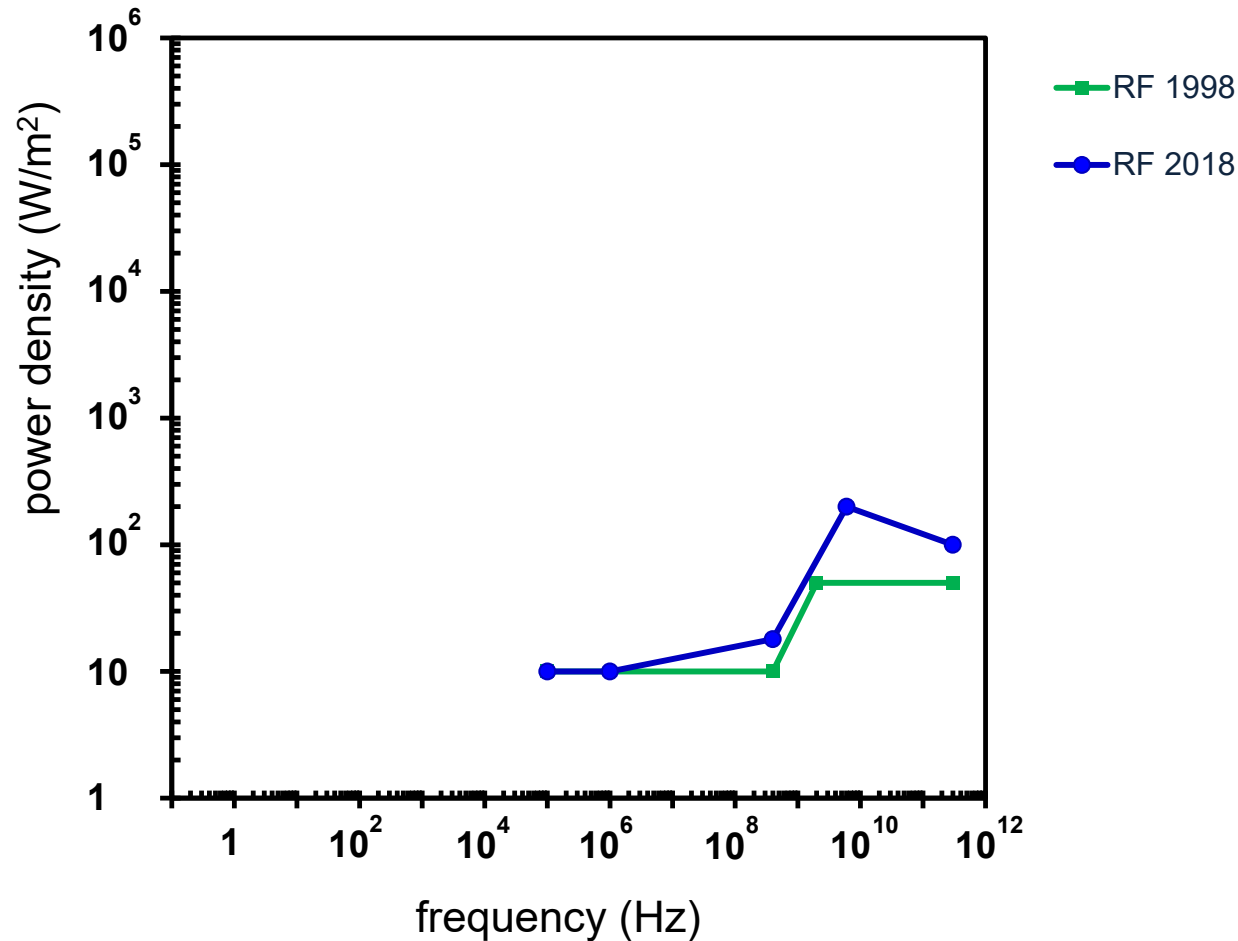
100 kHz – 110 MHz:

- Limb current (occupational 100 mA, public 45 mA)

Reference Levels (whole body, far field, workers)



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



Ongoing revision

- Discussion of all comments received
- Incorporate changes as necessary to finalize document
- Publication of revised guidelines (mid 2019)

Thank you for your attention
and continued patience

Dziękuję za uwagę i ciągłą
cierpliwość