The draft ICNIRP radiofrequency guidelines

Eric van Rongen
Chairman, 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 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

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Freq. range</th>
<th>ΔT</th>
<th>Spatial</th>
<th>Aver. time</th>
<th>Health effect level</th>
<th>RF</th>
<th>Occup. RF</th>
<th>General public RF</th>
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</thead>
<tbody>
<tr>
<td>Core ΔT</td>
<td>100 kHz-300 GHz</td>
<td>1°C</td>
<td>WBA</td>
<td>30 min 6 min</td>
<td>4 W/kg</td>
<td>10</td>
<td>0.4 W/kg</td>
<td>50 0.08 W/kg</td>
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<td>Local ΔT (Head &amp; Torso)</td>
<td>100 kHz-6 GHz</td>
<td>2°C</td>
<td>10 g</td>
<td>6 min</td>
<td>20 W/kg</td>
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<td>Local ΔT (Limbs)</td>
<td>100 kHz-6 GHz</td>
<td>5°C</td>
<td>10 g</td>
<td>6 min</td>
<td>40 W/kg</td>
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<td>20 W/kg</td>
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<td>Local ΔT (Head, Torso, Limbs)</td>
<td>&gt;6-30 GHz</td>
<td>5°C</td>
<td>4 cm²</td>
<td>6 min 68/f\textsuperscript{1.05}</td>
<td>200 W/m²</td>
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<td>100 W/m²</td>
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<td>30-300 GHz</td>
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<td>1 cm²</td>
<td>6 min</td>
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<td>Pain (contact current)</td>
<td>100 kHz-110 MHz</td>
<td>--</td>
<td>--</td>
<td>10 sec</td>
<td>20/10 mA (adult/child)</td>
<td>1</td>
<td>20 mA</td>
<td>1 20/10 mA (ad./child)</td>
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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)

![Graph showing reference levels for electric field strength (V/m) vs. frequency (Hz). The graph compares LF 2010, RF 1998, and RF 2018 reference levels.]
Reference levels (local, far field, >6 min, occupational)

![Graph showing reference levels for power density vs frequency. The graph includes data from RF 1998 and RF 2018.](image)
Next steps

- Public consultation until 8 October 2018
- Discussion of comments, finalizing guidelines
- Publication
Thanks for your attention and your patience!