Are Safety Limits Valid?

A CRITIQUE OF RF EXPOSURE LIMITS AND RECOMMENDATIONS FOR THE BETTER PROTECTION OF WORKERS AND THE PUBLIC

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IONIZING RADIATION

NONIONIZING RADIATION

THE ELECTROMAGNETIC SPECTRUM
Health Effects Microwave and RF Radiation

- Subject of Scientific Research for 70 Years
- Safety Guidelines Promulgated for 50+ Years
- *Deja Vu* ... Been There, Done That!
- “Where’s the Beef?”
- Why Are We Still Discussing Exposure Limits, Guidelines and Standards?
Are There Health Hazards?

- Yes, with High Degree of Agreement
  - Acute, High Intensity, High Absorption Rates Can Produce Adverse Thermal Effects in Tissue

- Controversy Arises From
  - Repeated or Long-Term Exposures (> 6 or 30 min)
  - Possible Delayed Health Effects at Low Levels, e.g., Cancer
Review of Exposure Limit Development

1966: Initially setting $10 \text{ mW/cm}^2$ (100 W/m$^2$) in $\sim 0.1$ hr to limit excessive tissue heating (ANSI)

1982: Minor amendment to replace 0.1 hour by 6 min

1986: Inauguration of SAR in W/kg as basic restriction by NCRP (vs. incident power density)

1992: Introduction of 1-g SAR of 1.6 W/kg in IEEE Standards (Recognized by ANSI)

1996: US FCC implemented rules for permissible exposure based on SAR of 1.6 W/kg in 1-g tissue

1998: ICNIRP published (with same database as IEEE & NCRP) but set 10-g SAR of 2.0 W/kg as Guidelines.
Review of Exposure Limits (cont.)

2001: International Committee on Electromagnetic Safety (ICES) approved to replace IEEE C95.1

2005: ICES revised its standard and adopted ICNIRP’s 2.0 W/kg SAR over 10-g tissue — harmonization?

2019: ICES updated its standards and introduced skin power density restrictions for mm-Wave and 5G

2019: FCC reaffirmed 1996 RF exposure limits, as applicable to 5G

2020: ICNIRP revised its guidelines with emphasis on heating effects and minimized pulse effects

2022: ICBE-EMF (as New international Commission)
### Current Guidelines/Standards Based on Thermal Effect for “Safe” Human Exposure to RF Radiation (ICES 2019; ICNIRP 2020).

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>Tissue Type</th>
<th>ΔT</th>
<th>Ave. Scheme</th>
<th>Ave. Time</th>
<th>Health Effect</th>
<th>Factor</th>
<th>Public Level</th>
<th>Factor</th>
<th>Worker Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>100kHz-6 GHz</td>
<td>Head-Torso</td>
<td>2 °C</td>
<td>10 g</td>
<td>6 min</td>
<td>20 W/kg</td>
<td>10</td>
<td>2 W/kg</td>
<td>2</td>
<td>10 W/kg</td>
</tr>
<tr>
<td></td>
<td>Local Limb</td>
<td>2 °C</td>
<td>10 g</td>
<td>6 min</td>
<td>40 W/kg</td>
<td>10</td>
<td>4 W/kg</td>
<td>2</td>
<td>20 W/kg</td>
</tr>
<tr>
<td>&gt; 6 GHz-300 GHz</td>
<td>Head-Torso</td>
<td>5 °C</td>
<td>4 cm²</td>
<td>6 min</td>
<td>200 W/m²</td>
<td>10</td>
<td>20 W/m²</td>
<td>2</td>
<td>100 W/m²</td>
</tr>
<tr>
<td>30 GHz-300 GHz</td>
<td>Local Limb</td>
<td>5 °C</td>
<td>1 cm²</td>
<td>6 min</td>
<td>400 W/m²</td>
<td>10</td>
<td>40 W/m²</td>
<td>2</td>
<td>200 W/m²</td>
</tr>
<tr>
<td>100 kHz-300 GHz</td>
<td>Body Core</td>
<td>1 °C</td>
<td>WBA</td>
<td>30 min</td>
<td>4 W/kg</td>
<td>50</td>
<td>0.08 W/kg</td>
<td>10</td>
<td>0.4 W/kg</td>
</tr>
</tbody>
</table>
Anomalies and Inconsistencies (1)

• ICNIRP deleted its 1998 restriction of pulse exposure limit — Contrary to recent 5G and persistent concerns
• ICES and ICNIRP exposure limits are revised to emphasize strong conviction for RF heating
• Standards based on:
  • Whole-body temperature increase of 1°C
  • Local tissue temperatures of 2°C to 5°C
  • For short-term exposures of 6 to 30 min
Anomalies and Inconsistencies (2)

• Aside from lack of mm-wave data, New criteria of (5°C) for 5G (6 GHz to 300 GHz) is concerning

• Local tissue temperature of 5°C would induce tissue temperature to increase from a nominal 37 °C to a hyperthermic 42 °C

• Hyperthermic tissue temperature of 42 °C is cytotoxic — well-known exponential cell kills

• It’s the medical foundation for treatment of malignant tumors in hyperthermia therapy for cancer
At both molecular and physiological levels there are different working mechanisms responsible for the additive and synergistic interactions of hyperthermia [Oei et al 2020].
Anomalies and Inconsistencies (3)

- **2011**, IARC classified RF radiation as “a possible carcinogen in humans” based on epidemiological reports but only partial data from animal experiments.

- **2018**, US NTP reported *clear evidence* of RF exposure causing development of *malignant tumor in rats* (schwannoma) at 6 W/kg (1 °C body temp rise) following 2-year exposures.

- **Animal data** IARC sought were provided by NTP study and by Ramazzini Institute in **2018**.

- NTP and Ramazzini *animal cancer reports* logically and scientifically *supplement* IARC’s classification.

- Curiously, the **revised** of safety limits regard IARC classification and animal results — *as not applicable*.
Anomalies and Inconsistencies (4)

- The revisions objected with putative “chance differences” from experimental treatments or resulting body temp rise of 1 °C in rats.
- Overlooked serious error in declaring a 1 °C body temp rise as cancer causing.
- Decision totally ignored the independent variable for the animal experiments — RF exposure.
Anomalies and Inconsistencies (5)

- Other issues such as:
  - Revised limits do not provide any adjustments for effects due to long-term human exposures (> 6 or 30 min).
  - Total lack of appreciation of scientific knowledge on chronic toxicology, genotoxicity, and carcinogenicity regarding RF exposures below the basic restrictions promulgated by the exposure limits.
  - Outdated characterization of SAR, by not accounting for averaging mass and exposure duration dependences.
Correlations among exposure duration, SAR, and temperature elevation for 800 MHz plane wave in anatomic human models.
Conclusions

• Mobile phone and wireless technologies have demonstrated benefit to persons in modern society.

• For impact on health and safety of humans who are unnecessarily subjected to high levels of RF exposure over prolonged durations or even over lifetimes, the jury is IN.

• Epidemiological studies and animal investigations are consistent in indicating RF exposure as probably carcinogenic to humans.

• The principle of ALARA—as low as reasonably achievable—ought to be adopted as a strategy for RF health and safety protection.
THANK YOU!
2. “Incongruities in recently revised radiofrequency exposure guidelines and standards.” Environmental Research, 222, April 2023
6. “FCC Announces Its Existing RF Exposure Limits Apply to 5G.” IEEE Microwave Magazine, Vol. 21/4, pp 15-17, April 2020
Correlation coefficients of linear fitting for different averaging schemes after 30 min (steady state) RF exposure of anatomic model.