

(1/12/18) Deux chercheurs suisses (Zurich) Institut Fédéral des Technologies ETH et Fondatio

Health Physics 2018

Systematic Derivation of Safety Limits for Time-Varying 5G Radiofrequency Exposure Based on Analytical Models and Thermal Dose

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Health Physics, December 2018 Extreme broadband wireless devices operating above 10 GHz may transmit data in bursts of a few milliseconds to seconds. Even though the time- and area-averaged power density values remain within the acceptable safety limits for continuous exposure, these bursts may lead to short temperature spikes in the skin of exposed people. In this paper, a novel analytical approach to pulsed heating is developed and applied to assess the peak-to-average temperature ratio as a function of the pulse fraction α (relative to the averaging time [INCREMENT]T; it corresponds to the inverse of the peak-to-average ratio). This has been analyzed for two different perfusion-related thermal time constants (τ_1 = 100 s and 500 s) corresponding to plane-wave and localized exposures. To allow for peak temperatures that considerably exceed the 1 K increase, the CEM43 tissue damage model, with an experimental-data-based damage threshold for human skin of 600 min, is used to allow large temperature oscillations that remain below the level at which tissue damage occurs. To stay consistent with the current safety guidelines, safety factors of 10 for occupational exposure and 50 for the general public were applied. The model assumptions and limitations (e.g., employed thermal and tissue damage models, homogeneous skin, consideration of localized exposure by a modified time constant) are discussed in detail. The results demonstrate that the maximum averaging time, based on the assumption of a thermal time constant of 100 s, is 240 s if the

maximum local temperature increase for continuous-wave exposure is limited to 1 K and $\alpha \geq 0.1$. For a very low peak-to-average ratio of 100 ($\alpha \geq 0.01$), it decreases to only 30 s. The results also show that the peak-to-average ratio of 1,000 tolerated by the International Council on Non-Ionizing Radiation Protection guidelines may lead to permanent tissue damage after even short exposures, highlighting the importance of revisiting existing exposure guidelines.