# ICES

*International Committee on Electromagnetic Safety*

**COMMENTS**

***of***

**THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC. (IEEE) INTERNATIONAL COMMITTEE ON ELECTROMAGNETIC SAFETY (ICES) TECHNICAL COMMITTEE 95, IEEE ICES TECHNICAL COMMITTEE 34, AND INTERNATIONAL ELECTROTECHNICAL COMMISSION (IEC) TECHNICAL COMMITTEE 106 MAINTENANCE TEAM 1**

***on***

# WHO Environmental Health Criteria Consultation Draft

***Submitted by***


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# COMMENTS OF IEEE/ICES TC95

## GENERAL COMMENTS

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 2 - 12 | All | General | The IEEE International Committee on Electromagnetic Safety (ICES) is pleased to be invited to provide a very rapid review of the draft Environmental Health Criteria document on *Radio Fequency Felds*. To begin, we present several general statements regarding the overall assessment of the document. First, the purpose, intended scope, intended audience, and expected contribution to public health and safety has not been described. Second, document is overly detailed in some instances and lacking in sufficient descriptions in others. If WHO wishes to have deeply technical detailed descriptions, then clarifying summaries (for each section and for the complete document) for the non-technical reader are necessary. Third, the document isunnecessarily lengthy. Many topic descriptions appear to be included simply because information is available whether or not inclusion provides support for the undefined thesis. Fourth, the document suffers from multiple inputs and would benefit from a single author redrafting the entire document with each chapter author as a co-author, thereby providing a smoother flow of style. Has WHO considered bringing in a temporary scholar such as done with John Leonowich and Ken Foster? While each chapter more or less begins with a statement of the chapter's purpose and scope, the same is missing for the overall document. Finally, an introduction and executive summary will be needed. Information and facts are presented in overly detailed manner resulting in minutiae that should be summarized facilitating easier communication of concepts and conclusions. | Consider these comments |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 2 | 1- 2041 | General | This document lacks a structure of conclusions drawn from the many areas of investigation that would allow building knowledge in individual topic areas to create definitive conclusions related to human health. It is not apparent how the present compendium of studies can become an informative review of the scientific literature, especially for readers interested in establishing exposure standards and public health policy. | Consider these comments |
| 2 | 1- 2041 | General | A great wealth of information. It is doubtful that all of it is necessary, but there is no evident harm done by its breadth, detail, and extent. | None, but removal of some technology-specific detail would not be missed by most readers – telecomm engineers excepted. |
| 2 | 1-1776 | Technical / General | Some new technologies are missing from the draft. | The whole document should be gone through to add the latest technologies. (For example, add LTE.) |
| 2 - 12 | All | General | This draft seems to be tightly connected to reviewing matters tied to modern wireless systems and almost totally to papers published since 2000. Thus there are few references to key historical investigators like Schwan, Michaelson, Guy, Gandhi etc. Also few references to applications like broadcasting, radar, diathermy, hyperthermia, etc.<br>Thus as a scholarly work this monograph will suffer by its exclusion of the important historical underpinnings of the field of bioeffects and hazards of electromagnetic energy. At the minimum the next draft should reference documents that record the important historical development of this field. | The draft should reference documents that record the important historical development of this field. |
| 2 - 12 | All | General | The 0.4 W/kg SAR in the RF region is much more conservative re threshold for behavioural effect than is generally supposed. | Be mindful in formulating proposed exposure limits that 0.4 W/kg is very conservative. Because of its importance, place this statement or some similar statement in those sections dealing with thermal regulation and in the Executive Summary. |
| 2 – 12 | All | Editorial | Acronyms should be spelled out first use and then used in place of the term. Frequently the term followed by the acronym in parentheses is use repeatedly. | Spell out acronyms on first use and then use them instead of repeating the full spelling each time. |

# CHAPTER 2: SOURCES, MEASUREMENTS AND EXPOSURES

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 2.1.1 | 130 | Editorial | "pointing vector" | "Poynting vector" |
| 2.1.2 | 173 | Editorial | Very low should be Very Low. | Capitalize Low |
| 2.1.2.2 | 165 | Edirorial | | Delete "so" after "increases," |
| 2.1.2.2 | 168 – 174 | Editorial | Tough reading this list. | Create a table with this information to complement Fig. 2.2. |
| 2.1.2.2 | 180-182<br>Figure 2.2 | Editorial | Figure is hard to read. | Rotate figure 90 degrees |
| 2.1.2.2 | 184-6 | Technical | Misleading: "Similarly, the choice of a frequency of 2.45 GHz for heating of food in microwave ovens does not reflect any specific physical property of that particular frequency." | Revise to something like this:<br>"Similarly, the strong energy absorption by water at frequencies over a broad range that includes 2.45 GHz makes that frequency suitable for heating of food in microwave ovens. However, unlike the narrow resonances for transitions between certain atomic and molecular energy levels, the choice of 2.45 GHz does not reflect a physical property specific to that particular frequency." Include the reason why 2.45 GHz was chosen. |
| 2.1.2.2 | Fig. 2.2. | Technical | The conversion factor between eV/Hz In the UV spectrum is not correct! | The conversion factor between eV/Hz is: 1 eV corresponds to 1240 nm, i.e.,<br>12.4 eV – 100 nm<br>124 eV – 10 nm |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 2.1.2.3 | 208-209 | technical | Amend the sentence<br><br>“A typical example of a source producing circular polarisation is a helically wound antenna designed to radiate in its axial direction (normal mode).”<br><br>Because the CP mode is called “axial” | Replace with<br><br>“A typical example of a source producing circular polarisation is a helically wound antenna designed to radiate in its axial direction (axial mode).” |
| 2.1.2.6 | 234-235 | Editorial | Current density unit is $A/m^2$, not A/m. | Correct the current density unit. |
| 2.1.2.6 | Table 2.1 | Technical | The symbol of the unit “Current density” is not A/m. | Correct the units for current density ($A/m^2$) |
| 2.1.3.1 | 259 | Editorial | Abbrevs TERTRA AGNIR and others throughout. | Spell out Terrestrial Trunked Radio previously Trans European Trunked Radio (TETRA) |
| 2.1.3.1 | Fig. 2.3 and lines 271-274 | technical | Not clear why there are 8 nodes in the plot (and associated comment on line 273) while the description at line 272 talks about only 4 possible states | Please capture properly the information about the TETRA signal, for example see http://en.wikipedia.org/wiki/Terrestrial_Trunked_Radio<br><br>and<br><br>http://en.wikipedia.org/wiki/Phase-shift_keying |
| 2.1.3.2 | 276 | Technical | Bandwidth of the LTE system is not mentioned | Mention the bandwidth; it is wider than the one used in former systems and it is up to 20 MHz. |
| 2.1.3.2 | 290 | Editorial | Use the abbreviation throughout the document after the first time it is defined. | Delete International Telecommunications Union and use ITU |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 2.1.3.4 | 322 | Technical | The equation is incorrect. Reverse the denominator and numerator. | Duty Factor = $P_{avg}$ / $P_{peak}$ |
| 2.1.4.2 | 415-416 | Editorial | Confusing sentence structures. Discuss reactive scenarios and then radiating. | Move last sentence to before Conversely,… <br> At telecommunications frequencies of around 900 MHz, the reactive near-field extends to about 5 cm, thus the fields to which a person is exposed when they hold a mobile phone to their head are predominantly reactive in nature. With high power industrial sources operating at frequencies up to a few MHz (such as heat sealers), the operators are exposed to predominantly reactive fields. Conversely, exposure to the fields from base station transmitters in the environment and with radio devices held in front of the body is generally dominated by radiating components of the field. |
| 2.1.4.3 | 427 | Technical | Define terms such as Fresnel zone | Define Fresnel zone |
| 2.1.4.3 | 434-435 Fig. 2.7 (b) | Editorial | The frequency unit is not correct. It should be 1840 MHz instead of 1840 Hz | Correct unit. |
| 2.1.4.3. | 424 | Technical | 5λ is used for wire antennas as the limit between near field and far field. | Adding 5λ as the limit between near field and far field for wire antennas. |
| 2.2.1 | 526-602 | Technical | While the unstated purpose of this section may be to compare and contrast naturally occurring RF with man-made sources, the detail here is unnecessary and actually obscures the point. This is very interesting stuff but it needs to be made more concise and conclusions drawn. Just because information is available doesn‘t mean it is of value in communicating a point. This is overkill. | Rewrite entire section concisely with a purpose. |
| 2.2.1 | 540 | Technical | The units for Planck's constant ($6.626 \times 10^{-34}$ ) are missing | Add the units for Plank's constant, i.e., $m^2$ kg / s |
| 2.2.1.1 | 564 | Editorial | "a peak at $3.4 \times 10^{-14}$ Hz" | "a peak at $3.4 \times 10^{14}$ Hz" |
| 2.2.2.1 | 654 | Technical | term $P_{rad}$ is not explained | Explain what the radiated power is. |

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 2.2.2.1.2 | 785-787 | Technical | “The median population exposure level (VHF and UHF combined) was 50 μW/m$^2$ and around 1% of the population was exposed above 10 μW/m$^2$.” | If 99% of population were exposed below 10 μW/m$^2$ – then median value could not be 50 μW/m$^2$. Revise statement. |
| 2.2.2.1. | 792 | Editorial | An extra tag at (27mV/m') | (27mV/m) |
| 2.2.2.2 | 825 | Editorial | add “there” | …the transmitters are closer together where there is a high density of users. In sparsely populated areas the transmitters… |
| 2.2.2.2.1 | Table 2.4 | Editorial | There should be more info on UMTS (3G) in section 2.2.2.2.1. It is related to CDMA 2000/IMT-2000 in Table 2.4 but needs to be expanded as it is a common term used by service providers upgrading systems from the GSM (2G, 2.5G) to UMTS (3G). | Include UMTS in Table 2.4<br>Under “Generation” column for “3” include the term “UMTS”. Freq bands include 850 MHz and 1900 MHz. |
| 2.2.2.2.2 | line 915 | Editorial | Delete “all” | Others involve measurements being made as an integral part of commissioning or modifying base station sites. |
| 2.2.3.2 | | General | An additional reference can be referenced in this section. | Following paper should be referenced.<br>Tell, R. A., et al. (2013). "Characterization of radiofrequency field emissions from smart meters." J Expo Sci Environ Epidemiol **23**(5): 549-553. |
| 2.2.4 | 1159-1342 | Technical | The realistic exposure levels are missing from the draft | For the users of the wireless communication devices it is important to know what the realistic exposure levels are when they use their devices. It is suggested that a subsection is added to the end of this clause regarding realistic exposure levels. |
| 2.2.4.1.1 | 1173-1174 Table 2.5 | Technical | TX power levels for LTE are missing. | TX power levels for LTE should be added. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 2.2.4.1.1 | 1175-1211 | General | The text is not clear regarding the compliance assessment tests of mobile communication devices. | Text should be clarified to emphasize that the manufacturers test the mobile devices according to international SAR assessment standards and regulations – maybe add references to IEC, CENELEC and IEEE standards, and FCC regulations. |
| 2.2.4.1.2. | 1227 | Technical | There are articles that demonstrate that the contribution of mobile phone users to adjacent persons in enclosed spaces is small. | Add references and revise the paragraph. |
| 2.2.4.1.2. | 1239 | Technical | The typical exposure to smart phones radiation should be revised due to the change of usage pattern (i.e., growing usage of text messages). | Adding more data regarding typical exposure to smart phones. For example:<br>Persson T., Tornevik C., Larsson L. E., Loven J. Out Power Distributions of Terminals in a 3G Mobile Communication Network. Bioelectromagnetics., Vol Pg. 320 - 325, 2012. |
| 2.2.6 | 1382-1426 | Technical | | Consider adding implanted devices such as programmable drug pumps with inductive telemetry; inductive charging of batteries of various implanted devices used for neurostimulation, pacemaking, etc; telemetry for smart wireless communication with implanted biomedical diagnostic and therapeutic devices, which may not be in the market yet. |
| 2.7 | | Technical | Please add a reference literature on whole body SAR from 1y, 3y, 7y, and 20y standard body models and the10$^{th}$ percentile (thin) models. | Lee A-K, Choi H-D (2012). Determining the influence of Korean population variation on whole-body average SAR. Phys Med Biol, 57: 2709-2725. |

# CHAPTER 3: RADIOFREQUENCY ELECTROMAGNETIC FIELDS INSIDE THE BODY

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 3.1.1 | 64 | Editorial | Wavelength in which material? | Should be clarified as 'wavelength in free space'. |
| 3.1.1 | 76 | Editorial | 'Whole body temperature' is arbitrary. In the body core, it is virtually core temperature because of larger blood perfusion rate. | Change from 'whole body temperature' to 'core temperature.' |
| 3.1.2 | 83-84 | Technical | The author discusses contact current indirect effects of shock and burn but here much greater detail would be beneficial since the injury potential is a clear and present danger. | The discussion on RF produced contact currents is a necessary part of any discussion on RF health and safety and should be expanded. |
| 3.1.3. | 114 | Editorial | 'Averaging over a 1 g or 10 g mass of tissue' is actually reasonable when considering previous version of IEEE C95.1. However, now both international guidelines/standards adopt '10 g' as a metric. | In addition to ICNIRP, 1998, IEEE C95.1-2005 should also be cited. |
| 3.1.3. | 130 | Editorial | The following reference should be cited, because more thorough discussion is given; e.g., the effect of ground-human separation on WBA-SAR is discussed. | [Hirata et al 2012] (not listed in the original reference list)<br>A. Hirata, K. Yanase, I. Laakso, K.-H. Chan, O. Fujiwara, T. Nagaoka, S. Watanabe, E. Conil, and J. Wiart, Estimation of whole-body averaged SAR of grounded human models for plane wave exposure at respective resonance frequencies, Physics in Medicine and Biology, vol.57, pp.8427-8442, 2012 |
| 3.1.4.1. | 144 | Technical - Editorial | This expression is technically arbitrary. Even though the human is isolated from ground, WBA-SAR is affected. | Should be changed so that the scenario considered here is 'the human stands in free space'. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.1.4.1. | 145 | Technical | The following sentence is inserted to account for smaller separation that may cause different behavior as compared with ground or in free space. | If the separation between the ground and the person is small, capacitive coupling may alter the resonant frequency and whole-body averaged SAR from that in fully isolated conditions (Hirata et al., 2012).<br><br>Hirata A, Yanase K, Laakso I, Chan K H, Fujiwara O, Nagaoka T, Watanabe S, Conil E and Wiart J (2012). Estimation of the whole-body averaged SAR of grounded human models for plane wave exposure at respective resonance frequencies. Phys Med Biol 57(24):8427-8442 |
| 3.1.4.1. | 147 | Technical | Somewhere in the paragraph, whole-body averaged SAR is characterized by body-mass index both for grounded and in free space conditions, as is similar to the paragraph of 3.1.4.3 (GHz region). | Whole-body averaged SARs in adults and children are estimated in terms of body mass index even for grounded and ungrounded conditions.<br>[Hirata et al 2012] (not listed in the original reference list)<br>(in free space)<br>A. Hirata, O. Fujiwara, T. Nagaoka, and S. Watanabe, Estimation of whole-body average SAR in human models due to plane-wave exposure at resonance frequency, IEEE Trans. Electromagnetic. Compatibility, vol.52, no.1, pp.41-48, 2010.<br>(grounded)<br>A. Hirata, K. Yanase, I. Laakso, K.-H. Chan, O. Fujiwara, T. Nagaoka, S. Watanabe, E. Conil, and J. Wiart, Estimation of whole-body averaged SAR of grounded human models for plane wave exposure at respective resonance frequencies, Physics in Medicine and Biology, vol.57, pp.8427-8442, 2012 |
| 3.1.4.3 | 162 | Editorial | ‘the absorbed energy’ should be replaced as ‘the absorbed power’; energy should be integrated over the time. | ‘the absorbed power’…. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.1.4.3 | 162 | Technical | "Therefore, the absorbed energy is approximately proportional to the exposed surface area of the body"<br>The stated tendency holds only if the frequency is higher than about 1 GHz, becoming more pronounced at higher frequencies (Uusitupa et al., 2010). At 300MHz and 450MHz (which are still clearly "above body resonance"), Uusitupa et al., 2010 observed that the exposure from the side could in some cases cause a higher SAR that the exposure from the front, conflicting with the above statement. | Clarify that the frequency is much higher than body resonance, i.e., it is in the GHz-range. For instance, on line 160, add that the frequencies are much higher than body resonance. |
| 3.1.4.3 | 162–163 | Technical | Gosselin et al. (2009) did not discuss the whole-body averaged SAR for plane wave; this paper is on the base-station antenna or product safety.<br>Original study which suggested that 'the body surface area to mass ratio is essential' is by Hirata (2007)<br>Uusitupa et al. (2010) further verified that the whole-body SAR is proportional to the ratio of exposed area to mass using more anatomical models, postures and exposure scenarios. The frequency range was up to 5 GHz, compared to 2450 MHz in Kuhn's study. | Add reference to Hirata et al (2007) [A] and Uusitupa et al. (2010) [already in the reference list] in addition to that to Kuhn et al. (2009).<br><br>[A] A. Hirata, S. Kodera, J. Wang, and O. Fujiwara, "Dominant factor influencing whole-body average SAR due to far-field exposure in whole-body resonance frequency and GHz regions," Bioelectromagnetics, vol.28, no.6, pp.484-487, 2007. |
| 3.1.4.3 | 162–165 | Technical | Flintoft et al. (2014) studied experimentally the relationship between the absorbed energy, WBASAR and body dimensions in the frequency range from 1 GHz to 12 GHz.<br>Their statistical analysis showed a significant correlation between the body surface area and the absorbed energy (absorption cross section).<br>They also found a correlation between the WBASAR and inverse BMI (height squared divided by mass).<br>Flintoft et al. (2014) is a very valuable reference because it is the only study succeeding to show the correlation experimentally in real subjects, and at the same time, the study with the widest frequency range. | Add a sentence referring to Flintoft et al. (2014) summarizing some of their findings.<br><br>Reference<br>Flintoft I D, Robinson M P, Melia G C R, Marvin A C and Dawson J F (2014). Average absorption cross-section of the human body measured at 1–12 GHz in a reverberant chamber: results of a human volunteer study. Phys Med Biol 59(13):3297–3317 |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.1.4.6 | 215 | General | 'Internal resonances…' may be unclear. Should be clarified (with appropriate reference). | Clarify internal resonances and provide appropriate references. |
| 3.2 | 238 | Editorial | Add IEEE (2005) in addition to ICNIRP (1998) | Add IEEE (2005) in addition to ICNIRP (1998) |
| 3.2.2 | 287 | Technical | In the corresponding paragraph, it should be emphasized that 'appropriate averaging mass is insensitive to the frequency of the antenna'.<br>Add the paper by McIntosh et al., which obtained similar results. | After (Hirata, Shirai &Fujiwara 2008; Razmadze et al., 2009; McIntosh et al. 2011, add the following sentence: The appropriate averaging mass (approximately 10 g) is insensitive to the frequency of the antenna (Hirata and Fujiwara 2009). Then, the next paragraph may be combined.<br><br>**[Ref. not listed in original list]**<br>McIntosh RL, Anderson V. SAR Versus VAR, and the Size and Shape That Provide the Most Appropriate RF Exposure Metric in the Range of 0.5-6 GHz, Bioelectromagnetics 32(4): 312-321, 2011. |
| 3.2.2 | 287 | Technical | The local average SAR is instead useful for estimating local temperature elevation even for whole-body averaged SAR'. This is worth commenting. | Add the sentence: 'Contrary, SAR averaged over 10g of tissue is still good metric to estimate local temperature elevation even for whole-body exposure' (Hirata et al. 2013; not listed in original reference).<br>A. Hirata, I. Laakso, T. Oizumi, R. Hanatani, K. Chan, and J. Wiart, The relationship between specific absorption rate and temperature elevation in anatomically based human body models for plane wave exposure from 30 MHz to 6 GHz, Phys. Med. Biol., vol.58, no.4, 903-922, 2013. |
| 3.3.2.2 | 370 | Technical | In this section, Lee at al., 2009 to be added as a reference. The child model is based on whole-body MR images of a real Korean child. It is already included in REFERENCES. | Line 367: …Nagaoka et al., 2004, Lee at al., 2009)<br>Line 379: … (Christ et al., 2010b; Lee et al., 2009, Lee at al., 2006) |

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 3.4.2.3 | 608 | Technical | Please add the effect of physique on whole body SAR. | Lee et al. (2012) considered thin child and adult models aged 1, 5, and 20 years (body sizes in the 10th percentile for the horizontal plane). The thin models increased their whole body resonance peak by up to about 20%; a reduction of the body volume raises the whole body SAR. |
| 3.4.2.3 | 615 - 619 | Editorial | Reference is incorrect. Hirata and Fujiwara (2009) should be changed to Hirata, et al. (2009). | Correct Reference:<br>A. Hirata, N. Ito, and O. Fujiwara, Influence of electromagnetic polarization on the whole-body averaged SAR in children for plane-wave exposures, Phys. Med. Biol, vol.54, no.4, pp.N59-N65, 2009. |
| 3.4.2.3 | 620 - 621 | Technical | Uusitupa et al. (2010) did not study the whole-body resonance frequency. | Delete “near the whole-body resonance”. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.4.3 | 664 | Technical | Please add the effect of physique, posture, and relevant safety factor on whole body SAR. | Lee et al. (2012) reported the absorption in the child models can exceed the whole body SAR limit at their resonance frequencies and at 1–3 GHz when they are exposed to the ICNIRP public reference level: by a maximum of about 57% in the resonance frequency range for the isolated 5 year old model (the10$^{th}$ percentile model with arms up), and by about 80% at 2.45 GHz for the grounded 1 year old model (the 10$^{th}$ percentile model with arms up).<br><br>The basic restrictions on whole body SAR were chosen to provide a safety factor of 10 and 50 for occupational and public exposures, respectively (ICNIRP 1998, IEEE 2005).<br><br>The safety factor, i.e. 4 W/kg, divided by the calculated whole body SAR was evaluated under exposure to the ICNIRP public reference; above 30 MHz, the ICNIRP limits showed a safety factor of around 30 for thin infant and children with arms up at frequencies of their whole body resonances and at above 1 GHz (Lee et al., 2012).<br><br>The advantage of a large safety factor is evident from an analysis of SAR conducted in certain child models. As a consequence of resonances in the range 1 – 3 GHz, exposures at the reference level power density results in SARs that exceed the basic restriction (Lee et al., 2012). Although the safety factor for particular circumstances can be reduced below 50, the reduced safety factor remains abundant protection from heat-caused physiological effects.<br><br>Also explain that “arms up” is an unnatural posture that cannot be expected to be held for a time comparable with the relevant thermal constant (6-8 min). |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.5 | 690 | Editorial | ‘thermal response’ should be ‘thermoregulatory response’. In the same year, Wainright (2003) did similar modeling. However, both are not validated via comparison with measurement (even for ambient temperature). For validation, refer to Hirata, Asano, Fujiwara (2008). The formulas used by three research groups are different. | ‘thermoregulatory response’ should be used instead of ‘thermal response’ for further clarification. Refer to the validation paper, which use different formulae.<br>[not listed in original references]<br>A. Hirata, T. Asano, and O. Fujiwara, FDTD analysis of body-core temperature elevation in children and adults for whole-body exposure, Physics in Medicine and Biology, vol.53, pp.5223-5238, 2008. |
| 3.5.1 | 707–724 | Technical | Subsection title includes “thermal time constants”, but these are not presented. | Add that the thermal time constant is 6–8 min for localized exposure, referring the following papers [already listed in the reference list]: Van Leeuwen et al (1999), Wang and Fujiwara (1999), and Bernardi et al (2000). |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.5.1 and 3.5.2 | 707–737 | Editorial | There is no definition of thermal time constant in the document. | Add definition of the thermal time constant.<br>IEEE C95.1-2345 (2014) definition:<br>**thermal time constant:** For purposes of this standard, a measure of the time scale on which a biological system adjusts its temperature in response to added thermal energy.<br>NOTE 1—In the context of RF exposure, the thermal time constant indicates the time scale over which an exposed region of tissue reaches a new steady-state temperature after initiation of exposure to RF energy.<br>NOTE 2—The thermal response of tissue is a complex function of its thermal characteristics and RF exposure parameters, and the thermal time constant is to be understood as a measure of the time scale over which the thermal response occurs. A useful operational definition of the thermal time constant $\tau$ (in seconds) is<br>$$\tau = \frac{c\Delta T_{ss}}{SAR}$$<br>where<br>$\Delta T_{ss}$ is the steady state temperature increase (in K or $^{o}$C) in a region of tissue produced by RF exposure at a specific absorption rate (SAR in W/kg), and *c* is the specific heat of the tissue (in W sec/kg ºC). |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.5.2 | | Technical | Even though individual variability has been discussed extensively, the variability for temperature elevation has not been discussed at all. Discussion on child, fetus and its mother, and the elderly should be presented. | 1. There are several studies which investigate the temperature elevation in the fetus. According to [A] which takes into account the thermal exchange between the mother and the foetus in the placenta, the temperature elevation in the fetus is higher than that in the mother by approximately 30% due to core temperature elevation of mother in addition to the power absorption around/in the foetus.<br>2. The temperature elevation in the elderly is also shown to be higher than that in young adults. This is caused by the decline of the sweating rate, which is mainly attributable to thermal sensation in the skin [B].<br>[not listed in original references]<br>[A] A Hirata, I Laakso, Y Ishii, T Nomura, KH Chan, Computation of Temperature Elevation in a Fetus Exposed to Ambient Heat and Radio Frequency Fields, Numerical Heat Transfer, Part A: Applications 65 (12), 1176-1186, 2014.<br>[B] T Nomura, I Laakso, A Hirata, “FDTD computation of temperature elevation in the elderly for far-field RF exposures,” Radiation protection dosimetry 158 (4), 497-500, 2013. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.5.2 | 725–737 | Technical | The extent of the review in 3.5.2 seems to be very limited.<br><br>It should be clarified how the whole-body averaged SAR is related to the body-core temperature elevation. Also, exposure of children should be discussed. | Add the following information and references:<br><br>According to Laakso and Hirata (2011), the body-core temperature elevation in the thermally steady state is approximately proportional to the ratio of absorbed energy (whole-body SAR times mass) to body surface area.<br><br>Therefore, smaller persons have a lower body core temperature rise for the same whole-body SAR. See also Hirata et al. (2008), where it was observed that adult male model had the highest body-core temperature rise, followed by the adult female. Models of children (high surface area to mass ratio) had the lowest body-core temperature rise for the same whole-body SAR (Hirata et al., 2008).<br><br><u>References</u><br><br>Laakso I and Hirata A (2011). Dominant factors affecting temperature rise in simulations of human thermoregulation during RF exposure. Phys Med Biol, 56(23):7449-7471<br><br>Hirata A, Asano T and Fujiwara O (2008). FDTD analysis of body-core temperature elevation in children and adults for whole-body exposure. Phys Med Biol, 53(18):5223-5238 |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.5.2 | 725–737 | Technical | Only one study is referrenced for the thermal time constants of the body core. | Add the following information and references:<br>The thermal time constants for the body core temperature rise are 20–50 min, depending on the sweating rate (Hirata et al., 2007, 2008). Nelson et al. (2013) observed comparable temperature time courses.<br>References<br>Hirata A, Asano T and Fujiwara O (2008). FDTD analysis of body-core temperature elevation in children and adults for whole-body exposure. Phys Med Biol, 53(18):5223-5238.<br>Nelson D A, Curran A R, Nyberg H A, Marttila E A, Mason P A and Ziriax J M (2013). High-resolution simulations of the thermophysiological effects of human exposure to 100 MHz RF energy. Phys Med Biol, 58(6):1947-1968. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
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| 3.5.3 | 738 - 755 | General - Technical | Relationship of the temperature elevation in the lens and skin (facial burning) should be commented, which has been pointed out by Elder's review (2003). | For localized exposure of the human eye, the temperature elevation in the skin is essential, rather than the lens; the lens temperature did not reach its threshold for cataract formation before facial burning [A]. Note that in that study, thermoregulatory response of the human has been taken into account, and the computational model has been validated at least for the rabbits [B].<br><br>[A] T. Oizumi, I. Laakso, A. Hirata, O. Fujiwara, S. Watanabe, M. Taki, M. Kojima, H. Sasaki, and K. Sasaki, "FDTD analysis of temperature elevation in the lens of human and rabbit models due to near-field and far-field exposures at 2.45 GHz," Radiation Protection Dosimetry, vol.155, no.3, pp.284-291, 2013.<br>[B] Hirata A, Watanabe S, Kojima M, Hata I, Wake K, Taki M, Sasaki K, Fujiwara O and Shiozawa T (2006). Computational Verification of Anesthesia Effect on Temperature Variations in Rabbit Eyes Exposed to 2.45 GHz Microwave Energy. Bioelectromagnetics, 27:602-612. |

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 3.5.3 | 744–755 | Technical | Eye temperatures under the exposure to RF fields have been studied by several investigators.<br><br>The results of various independent research groups have been remarkably consistent (Hirata et al., 2007) and various modelling uncertainty factors have been studied (Hirata et al., 2007, Laakso 2009).<br><br>Considering these points, it can be said that the characteristics of eye temperature rise under RF exposure are well known. The paragraphs should be revised considering this fact.<br><br>The following references should be added:<br><br>Hirata A, Watanabe S, Fujiwara O, Kojima M, Sasaki K and Shiozawa T (2007). Temperature elevation in the eye of anatomically based human head models for plane-wave exposures. Phys Med Biol, 52(21):6389-6399<br><br>Laakso I (2009). Assessment of the computational uncertainty of temperature rise and SAR in the eyes and brain under far-field exposure from 1 to 10 GHz. Phys Med Biol, 54(11):3393-3403 | The paragraphs should be revised, considering the following points:<br><br>1. Currently, the study with the broadest frequency range is Laakso (2009), who investigated the SAR and temperature rise in the eyes in the frequency range up to 10 GHz.<br><br>2. In the entire frequency range from 1 to 10 GHz, the ratio of the lens temperature elevation to the 10g averaged (or eye-averaged) SAR in the eye is relatively constant, around 0.10–0.16 C for a SAR of 1 W/kg (Laakso 2009), regardless whether the eyes are open or closed. This is consistent with the studies at lower frequencies already cited in the text: Wainwright (2007): ratio is 0.14, Buccella (2007): 0.15–0.16, Hirata et al (2007): 0.11–0.15. Note that each study employed different anatomical models, exposure scenario, and frequencies.<br><br>3. Both localized exposure to antennas of various types [Wainwright (2007), Buccella (2007), Hirata (2005) and Flyckt (2007)] and uniform exposure to plane waves (Laakso 2009, Hirata et al 2007) have been considered.<br><br>4. Note that the above studies did not consider thermoregulatory response. One can hypothesize that if the SAR were strong enough to cause adverse effects, the thermoregulatory system (vasodilation, sweating) would activate, reducing the temperature rise. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.5.3 | 746–747 | General | The results of Bernardi et al. (1998) at 30 GHz may be incorrect due to insufficient FDTD voxel size they employed. (The computational voxel size should be no larger than one tenth of the wavelength. At 30GHz, their voxel size (0.5mm) is about one half of the wavelength in the eye. Hence, the results may be purely computational artefacts.)<br>In addition, the frequency of 30GHz is much higher than frequencies considered elsewhere in the Chapter. For instance, millimeter wave skin exposure was not commented. | The statement should be removed or revised. |
| 3.5.3 | 747–748 | Technical | "These studies also confirmed that the maximum temperature elevation in the lens decreases with increasing frequency."<br>This statement is not true; see Hirata et al. (2007), 1–6 GHz and Laakso (2009), 1–10 GHz. There is no clear trend: the lens temperature may increase, decrease, or remain constant when the frequency is increased, depending on the exposure scenario. (see also the previous comment)<br><br>References:<br>Hirata A, Watanabe S, Fujiwara O, Kojima M, Sasaki K and Shiozawa T (2007). Temperature elevation in the eye of anatomically based human head models for plane-wave exposures. Phys Med Biol, 52(21):6389-6399<br><br>Laakso I (2009). Assessment of the computational uncertainty of temperature rise and SAR in the eyes and brain under far-field exposure from 1 to 10 GHz. Phys Med Biol, 54(11):3393-3403 | The statement should be removed or revised. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.5.3 | 753 | Technical | ‘However, a lower temperature elevation was reported in Flyckt et al … (DIVA)’ is incorrect; this is caused by the inappropriate implementation of thermal parameter by the authors. Actually, later, Hirata et al. (2007) presented that all the results are consistent. | Hirata et al. (2007) later explained that the differences in the lens temperature elevation reported by different researchers are attributable to the choice of the thermal parameters.<br><br>[not listed in the original reference list]<br>A Hirata, S Watanabe, O Fujiwara, M Kojima, K Sasaki, T Shiozawa, “Temperature elevation in the eye of anatomically based human head models for plane-wave exposures,” Physics in medicine and biology 52 (21), 6389, 2007. |
| 3.5.3 | 754–755 | Editorial | The sentence referring to van Leeeuwen (1999) is irrelevant because the paper does not discuss eye temperature. | Remove the sentence. |
| 3.5.4 | | Technical | No discussion is given on child temperature elevation. | Refer the paper by Fujimoto et al. (2006). The temperature elevation in the child due to a dipole antenna is comparable to that in the adult when the same thermal parameter used; blood perfusion rate is the dominant factor affecting the local temperature elevation. Thus, the temperature elevation in the child may be smaller than that of the adult due to higher blood perfusion rate. |
| 3.5.4 | 756 | Editorial | Subsection titled: “Temperature rise in the head” seems to deal with temperature rise from handset antennas. | Change title to “Temperature rise due to handset antennas”, “Temperature rise in the head due to localized exposure” or similar. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.6 | 785 | Technical | Contact currents (currents resulting from a physical contact with an object at a different electric potential) are not discussed at all in the section, even though they are featured in the title. | Discussion should be added about contact currents.<br>There are few dosimetric studies about RF contact currents. Chan et al. (2013) is currently the only study that has investigated RF contact currents using computational dosimetric techniques.<br>One of the main findings of Chan et al. (2013) [A] is that, for contact currents injected in the finger at ICNIRP reference level (20 mA) and IEEE MPE (16.7 mA), the 10g mass-averaged SAR in the finger is up to 40-80 W/kg. The value of SAR is further higher in children (-100 W/kg) [B].<br>References:<br>[A] Chan K H, Hattori J, Laakso I, Hirata A and Taki M (2013). Computational dosimetry for grounded and ungrounded human models due to contact current. Phys Med Biol, 58(15):5153-72<br>[B] Chan K H, Hattori J, Laakso I, Hirata A and Taki M (2014). Computational dosimetry for child and adult human models due to contact current from 10 Hz to 110 MHz. Radiation Protection Dosimetry (in press) |
| 3.6 | 791 | Editorial | Is the citation to Lin (2000) correct? The paper seems to be about exposure of children to mobile phone radiation –- not related to induced or contact currents. | Correct it. |
| 3.7 | 827–845 | General | This section should be moved to Chapter 6: Auditory, Vestibular, and Ocular Function.<br>Reason: Other sections of Chapter 3 consider electromagnetic fields, energy, temperature, or other physical quantities. This section is about biological effects. | Leave a note in 3.7 and move this section to Chapter 6. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.7 | 827-845 | Technical | The discussion on the auditory effect and its mechanisms lacks important references. | The following references should be included:<br>J. C. Lin, *Microwave Auditory Effects and Applications,* Charles. C. Thomas, Publisher, Springfield, Illinois, (1978)<br>J. A. Elder and C. K. Chou, "Auditory Responses to Pulsed Radiofrequency Energy," *Bioelectromagnetics,* Supplement 8; pp. S 162 – S 173. (2003).<br>J. C. Lin, "Auditory Perception of Pulsed Microwave Radiation" in O. P. Gandhi (Ed.), *Biological Effects and Medical Applications of Electromagnetic Fields*, Prentice-Hall, Englewood Cliffs, New Jersey, pp. 277 – 318, (1990).<br>C. K. Chou, A. W. Guy and K. Galambos, "Auditory perception of radiofrequency electromagnetic fields," *J. Acoustical Society of America*, **7**(6), pp. 1321 – 1334 **(1982).**<br>K. R. Foster and E. D. Finsh, "Microwave hearing: Evidence for thermoacoustic auditory stimulation by pulsed microwaves" *Science* **185**(147), pp. 256 – 258, (1974).<br>R. G. Olsen and J. C. Lin, "Microwave-induced pressure waves in mammalian brains," *IEEE Trans. Biomed. Eng.*, **30**(5), pp. 289 – 294, (1983).<br>J. C. Lin, J. L. Su and Y. Wang, "Microwave-induced thermoelastic pressure wave propagation in the cat brain," *Bioelectromagnetics* **9**(2), pp. 141 – 147, (1988).<br>C. K. Chou, R. Galambos, A. W. Guy and R. H. Lovely**,** " Cochlear microphonics generated by microwave pulses", *J. Microwave Power*, **10**(4), pp. 361 – 367, (1975). |

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 3.7 | 827-845<br>(Cont.) | Technical | The discussion on the auditory effect and its mechanisms lacks important references. | C. K. Chou, A. W. Guy and R. Galambos, "Characteristics of microwave-induced cochlear microphonics, *Radio Science*,**12**(6S), pp. 221 – 227, (1977).<br>. |

# CHAPTER 4: BIOPHYSICAL MECHANISMS

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 4 | 1 - 691 | General | The descriptions in this chapter appear sometimes a bit over-detailed and sometimes not concise enough. As a result, the scientific content does not always appear very clearly. A few examples ar noted below. | Extensive revision for clarity of thought, precise and concise exposition, and style. |
| 4 | 1 – 691 | General | Although the document mainly treats established mechanisms and others amenable to quantitative biophysical analysis, it omits all mention of well-known and well-studied controversial mechanisms. These include modulated-RF effects on membrane-associated calcium. In cell biology, calcium ions are a topic of great mechanistic significance. Despite the absence of a consensus for the existence of robust calcium-related RF effects or their biological significance, there is a large bioelectromagnetics literature in this area that continues to the present. | Prepare a well-focused review of mechanistic studies related to (modulated) RF effects on calcium and other ions, with particular attention to membrane-associated calcium ions, proposed resonance models (which can be evaluated using ideas and conclusions relating to mechanistic plausibility already in this chapter), biochemical mechanisms, purely physical mechanisms, recognition of the biological significance of a calcium effect as potentially seminal if it were shown to exist, and other points that can be found in the literature. |
| 4 | 1- 691 | General | The chapter gives he impression of too heavy (~30 citations) reliance on Sheppard, Swicord, Balzano (2008]) (vs a few to ICNIRP [2009] and one to IARC [2013]), thereby limiting the appearance of an authoritative voice's independent review. | To the extent possible, rewrite where the observations of Sheppard, Swicord, Balzano (2008) are not necessary to the text. Rewritten text would review topics based on primary sources, citing Sheppard et al. (2008) only as necessary. E.g., section 4.1 did not cite Sheppard et al. (2008) but reviewed some papers also reviewed by Sheppard, Swicord, Balzano (2008). The same is true for a number of other topics, some just one paragraph long. Of course, citations should be given as needed in observance of good scholarship and to avoid plagiarism. |
| 4.3 | 146 - 208 | Editorial and Technical | Too much detailed derivation of well-known relationships in contrast with other sections that do not conduct similar derivations. The main point seems to be to show how resonances arise and get the velocity of a charged entity, i.e., a dipole. | Reduce step-by-step derivation in favor of initial equation, quoted results and citing a source for the derivation. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 4.3 | 148 – 149 | Technical | "the magnitude of these motions depends on the strength and frequency of the field and may be impeded by inertia and viscous forces."<br>Re molecular motion in water—viscous drag is by far the dominating factor. The influence of inertia can therefore be neglected. | "the magnitude of these motions depends on the strength and frequency of the field and is impeded by viscous forces." |
| 4.3 | 157-161 | Technical | "Water molecules can rotate freely in an oscillating low frequency electric field with little energy loss; however, at frequencies above $10^8$ Hz, the rotational inertia of the molecules begins to inhibit rotation, causing energy absorbed from the field to be dissipated by collisions or nearest neighbor interactions in the medium" is incorrect.<br><br>Inertia is not a factor. Also water molecules do not rotate in the presence of a RF field. Rather the applied field superimposes a very tiny net orientation on the molecules along the field direction, which builds up and decays as a first order process with changing field strength, being limited by the viscosity of the water. The net orientation is tiny compared to the extent of random thermal agitation of the molecules - like the effects of blowing on a leaf in the middle of a hurricane. | Water molecules experience torques by applied electric fields, but their response is limited by viscous drag of the surrounding fluid. At frequencies above a few GHz, the dominant source of energy loss is associated with frictional drag on the water molecules, which produces heat. At frequencies below about 1 GHz the dominant source of energy dissipation is heating of the liquid due to Joule heating of the electrolyte (which also results from frictional forces on the ions). At any plausible field strength, the motions induced in water molecules by external electric fields are many orders of magnitude smaller than motions due to random thermal agitation. |
| 4.3 | 162-174 | Technical | The paragraph surrounding equation 4.1 is not very clear regarding either the topic or the described model. If the paragraph ~~deals~~ with dipolar molecules, one should refer to established physical models." | If the author is talking about dipolar molecules, refer to Debye theory. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 4.3 | 198-205 | Technical | The reason that charged particles cannot respond instantly in an applied electric field is again viscous drag, which is independent of the mass of the particle*. The preceding theoretical discussion appears not to be applicable to real molecular systems.<br>Also, in this connection it is well established that the frequency dependence of the dielectric properties of tissues is determined at RFs by charging of cellular membranes through tissue electrolyte, and at microwave frequencies by dipolar relaxation of water. There are comparatively tiny effects due to dipolar loss of proteins and other effects but they are small. | Revise the paragraph. |
| 4.4 | 220 | Technical | Prohofsky (2004) should be added to that of Adair(2002).; viz: Prohofsky, E. W. (2004), "RF absorption involving biological macromolecules," *Bioelectromagnetics, 25(6), pp. 441 – 451* | Add Prohofsky, E. W. (2004), "RF absorption involving biological macromolecules," *Bioelectromagnetics, 25(6), pp. 441 – 451* |
| 4.4.1 | 268-271 | Technical | Electroporation due to application of brief intense pulses is a consequence of the DC content of the pulses. It has nothing to do with RF. | Delete paragraph or :<br>Make Electroporation either a new sub-sub section or, preferably, a parenthetical topic here with an introduction like this: "It is of incidental interest to mention here that the cell membrane is a highly effective barrier to transport of ions and proteins except through integral channels that are an essential feature of cell physiology. However, strong external pulses can briefly breach membrane integrity in the process of electroporation. [place suitably edited lines 268-271] here." |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 4.4.2 | 284 | Technical | "there is no evidence of comparable RF-sensitive receptors in biological systems." is incorrect.<br>There is actually quite strong evidence that avian species can respond, in a way, to RF fields around 1 MHz which appears to be due to a free radical mechanism which is presumably located in specialized proteins in the retinas of the animals. The free radical hypothesis as a mechanism for biological sensitivity is still unproven but there is a body of serious physical theory and it is at least credible | Revise or delete sentence. |
| 4.4.2 | 286 - 287 | Technical - Editorial | The sentence, "In other words, the biological systems did not develop ways to detect RF because this would not have given them any survival advantages," confuses the issues. As written, it seems RF signals are there, but don't have survival value. The point is quite the opposite: there's no suitable RF signal and therefore no way to use it for survival advantage. | Rewrite. |
| 4.4.3 | 299-300 | Technical | "Adair (2002) suggested that, while coupling of RF EMF to biological systems may exhibit resonance behaviour, strong damping of the vibrational motion by interactions with the aqueous environment prevents the... " is not correct.<br>Actually, Adair showed that any plausible model for resonances would be overdamped due to dissipative forces. | Adair (2002) showed that any plausible model for resonances would be overdamped due to dissipative forces. |
| 4.4.6 | 351- 353 | Editorial | Unclear that sentence refers to the reviewed literature: "...has been studied (Foster & Repacholi, 2004). Generally, RF signals are modulated at low frequencies to which neurons and neuronal networks...are particularly sensitive, and so even weak demodulation could be biologically significant." | Revise along this line: "Generally, the experiments reviewed used RF signals modulated at low frequencies typical of neuronal activity in order to test whether..." |
| 4.4.7 | 406-409 | Editorial, technical | Awkward and misleading: "The minimum average field strength required for pulsed fields to produce pearl chains is equal to the minimum average field strength for CW fields, suggesting that pulsed fields are no more effective than CW fields in inducing the pearl-chain effect." | Not "suggesting," but "showing".<br><br>A less awkward and equivalent expression: "Pulsed and CW RF fields create pearl-chains at levels above the same minimum average field strength." |
| 4.4.7 | 409 – 411 | Technical, editorial | Awkward, misleading, and unclear: "On the basis that the pearl-chain effect can be produced by a single pulse without a significant temperature rise, the pearl-chain effect is regarded as being caused by forces induced by RF electric fields, not by a biologically significant temperature elevation." | For example, "Pearl-chain formation using a single pulse that does not increase temperature demonstrates that the effect is due to forces created by the RF electric field independent of heating." |

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 4.5 | 538-539 | Technical-Editorial | There's no previous discussion of "metabolic oscillations" and it's unclear what is meant. | Place this as a new topic before this summary or, most likely, expand in section 4.4.5 or 4.4.6 to define metabolic oscillations. Treat either from the RF literature or, as seems was likely intended, by incorporating the ideas from the third paragraph from the end of the paper by Sheppard, Swicord & Balzano (2008). In that paper the point is to consider demodulation of RF to low frequency energy that would impart energy to oscillatory processes but, as described in that paper, there is insufficient energy and no demodulation. |

# CHAPTER 5: BRAIN PHYSIOLOGY AND FUNCTION

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 5 | 1 - 4235 | General | Many studies on effects of mobile phone use are not related to RF exposures. They are mixed in the tables. | Point out that effects of mobile phone use can be unrelated to EMF exposures. |
| 5.1.1.1 | 53-72 | Technical | Follow up paper: Li et al. (2003) The effect of the duration of exposure to the electromagnetic field emitted by mobile phones on human attention.<br>Lee TM, Lam PK, Yee LT, Chan CC.<br>Neuroreport. 2003 Jul 18;14(10):1361-4. | Add review of this paper. |
| 5.1.3.1 | 158-164 | Technical | In Cao (2000) study, other than the sex and age matching, the social economical status of the two groups was very different. The phone user group has much higher income, more smoking and drinking than the control group. | Add the comments to the review. |
| 5.1.5 | 57 | Technical | No reasons were given why the papers are excluded? (Al-Khlaiwi & Meo, 2004; Navarro et al., 2003; Santini et al., 2002; 2003) | Add reasons. |
| 5.1.5 -5.2.2. | 39-888 | Technical | In the EEG discussion, RF interference with EEG signals was mentioned many times. However the RF induced current in metallic leads during RF exposure into the brain is not discussed. A paper by Angelone et al. (2010) should be included in the discussion. It is well known that metallic rim glasses should not be heated in a microwave oven. Johnson and Guy (1972) showed great intensification of field at the tip of metal electrode in cat brains. | Include the discussion of RF induced current problem as indicated by LM Angelone, G Bit-Babik, C-K. Chou. Computational electromagnetic analysis in a human head model with EEG electrodes and leads exposed to RF sources at 915 MHz and 1748 MHz. Radiation Research 174, 91-100 (2010). |

# CHAPTER 6: AUDITORY, VESTIBULAR AND OCULAR FUNCTION

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 6.1.1 | 175 | Editorial | "were answers were given…" | "where answers were given…" |
| 6.1.1 | 196 | Editorial | *Excluded study*<br>Landgrebe et al. (2009)<br><br>Unlike in other sections, there is no explanation why this paper is excluded. There are 6 papers discussed above not included in the Table and not listed in the excluded list. | Include all excluded studies, not just one, and explain why the Landgrebe et al. (2009) was excluded. |
| 6.1.2 | 200 | Editorial | Microwave hearing is not discussed in chapter 3.5, but in section 3.7. | Change the sentence to read "The mechanism of this hearing phenomenon is explained in Chapter 3.7." Or provide a much more complete discussion of microwave hearing in this chapter. |
| 6.1.2 | 355 | Editorial | "Minor nystagmus was observed in three participants, all controls, in<br>356 two after sham exposure and in one after RF exposure."<br><br>"All controls" cause confusion. | Change to "Minor nystagmus was observed in three participants, all in non- IEI-EMF individuals, in two after sham exposure and in one after RF exposure." |
| 6.1.2 | 361 | Editorial | unsufficient statistical… | Change to "insufficient statistical…" |
| 6.1.2 | 382 | Technical | Any explanations for why these papers are excluded? | Add explanations. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 6.1.2. | 197-385 | General | A general remark – the exposure time of the studies (which is up to 30 minutes) is short regarding the possibility to detect an effect, which (if one exists) is probably small (unless the end-point is only short-term effects, such as "microwave hearing") . It should be mentioned that human studies of noise exposure effects (proven effects) are generally medium or long-term studies, while short-terms studies are generally limited to high-level (blast, impulsive or high industrial etc.) noise exposure due to limitation of detecting small effects (using PTA, DPAOE, TEOAE, ABR etc.). | Mentioning the limitations of the studies. |
| 6.2 | 535-853 | Technical | Possible effects on human vision are not only related to RF exposure. The effects of viewing the screen of mobile phone are not discussed. | Add explanation that many visual effects related to mobile phone use are not related to RF exposure. |
| 6.2.2.1 | 600-697 | Technical | There are more recent Japanese studies on the lens.<br><br>ACUTE OCULAR INJURIES CAUSED BY 60-GHz MILLIMETER WAVE EXPOSURE<br>Health Phys, Vol. 97, Pg. 212 - 218, 2009<br>Kojima M., Hanazawa M., Watanabe S., Taki M., Sasaki K., et al .<br>FDTD ANALYSIS OF TEMPERATURE ELEVATION IN THE LENS OF HUMAN AND RABBIT MODELS DUE TO NEAR-FIELD AND FAR-FIELD EXPOSURES AT 2.45 GHZ.<br>Radiation Protection Dosimetry., Vol. 155, Pg. 284 - 291, 2013<br>Oizumi T., Laakso I., Hirata A., Watanabe S., Kojima M., et al. | Add reviews of the newer papers. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 6.2.2.2 | 714-716 | Editorial | This sentence does not make sense: The technique used for the identification of corneal lesions (specular microscopy) was the same as that used by Kues et al. (1985), although these authors used histological techniques to confirm damage to both the cornea and retina, in contrast to Kamimura et al. (1994).<br><br>Since it is the technique used by the Kamimura et al., how can it be in contrast to Kaminura et al.? | Delete “, in contrast to Kaminura et al. (1994)”. |

# CHAPTER 8: NEURODEGENERATIVE DISEASES

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 8 | | Editorial | Needs a conclusion. | Prepare a conclusion. |
| 8.1 | 37-38 | Technical | “The income distribution in the cohort was compared to that in the general population.”<br>The above sentence is not informative in itself with respect to assessment of potential confounding. Consider deleting this sentence or describe the result of the comparison. The results of the comparison, however, are not clearly presented in the original paper by Schuz et al. (2009). | This statement should be revised or removed. |
| 8.1 | 44-45 | Technical | “For ALS, MS, and epilepsy in women, no associations were found.”<br>In the above sentence, it is ambiguous whether ALS and MS results refer to women only or to the entire population of subscribers. | Suggested modified sentence:<br>“For ALS and MS in the entire subscriber cohort, and for epilepsy in women, no associations were found.” |
| 8.1 | 63-64 Table 8.1.1. | Technical | A footnote to the table should be inserted to explain that the reference group was the entire population of Denmark after excluding the subscriber cohort. | Add suggested footnote. |

# CHAPTER 9: CARDIOVASCULAR SYSTEM AND THERMOREGULATION

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 9.2.2.2 | 1229 – 1246 | Technical | The same measured data are used in the paragraph (1229-1235) and that (1236-1246). Should be merged. In Hirata et al. (2011), no measurement has been conducted. Instead, the computational model for discussing the thermoregulatory response has been developed there. | Merge two paragraphs into one; statistical analysis is not needed in Hirata et al (2011) as the paper is physical (computational). |

# CHAPTER 12: CANCER

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 12 | | General | The level of detail in the text is too often excessive. Large portions of the methods and results of papers are included beyond what is needed for a critical review. In places, generally within square brackets, critical comments appear “off-hand” rather than rooted in scientific principles of epidemiology and statistics. | Revise to remove material not essential to critical evaluations on the question of cancer. Edit for comments that are not or cannot be substantiated by rigorous analysis (itself not required, of course, for the critique). An achievable goal for such a vast review is to provide enough detail to make critical comments meaningful in a way that lends weight to overall conclusions without arbitrary comments that reflect personal views. Details that don’t importantly inform and give weight (+ and -) to final conclusions can be ignored, put into footnotes, or left in tables or footnotes with little or no comment. |
| 12.1.1 | 69-71 | Technical | “A cross-sectional design should never be used for cancer outcomes, but is common in studies of `soft` outcomes like various types of symptoms, headaches, sleep disturbances, behavioural problems, and similar outcomes”<br>The above sentence is valid for etiologic research of all types of outcomes, not only cancer outcomes. | Suggested modified sentence:<br><br>“A cross-sectional design should never be used for etiologic research of any health outcomes, but is common in studies of `soft` outcomes like various types of symptoms, headaches, sleep disturbances, behavioural problems, and similar outcomes” |
| 12.1.2.1 | 101-1217 | Editorial | Subsections should be numbers by study designs (e.g., 12.1.2.1.1. Cohort studies; 12.1.2.1.2. Case-control studies) | Number subsections as indicated. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 12.1.2.1 | 217-218 | Technical | "Thus, the effect of the non-differential exposure misclassification introduced from using subscriptions to identify mobile phone use is likely to be minimal."<br>This is a debatable statement. Of the over 723,000 subscribers in the original Danish cohort, more than 40% were excluded. This segment of the population would be added to the "unexposed" group along with the corporate subscribers; the latter group may actually represent the heaviest mobile phone users. This may substantially dilute any potential effects, and reduce the power of the study to detect any potential association.<br>The fact that a person, other than the subscriber, may regularly use the phone of the subscriber may result in further exposure misclassification.<br>The combined effect of all of these potential exposure misclassifications, which may tend to bias the effect estimate in the same direction (towards no effect), is not adequately discussed, and is fairly easily dismissed. | Revise statement to include concern for the additional source of bias. |
| 12.1.2.1 | 270-271<br>Table<br>12.1.1. | Technical | Reference populations have not been indicated. | Reference populations should be indicated for all comparisons in either the table or in footnotes. |
| 12.1.2.1 | 316 | Editorial | The word "completed" should be replaced by the word "complemented." | Replace "completed" with "complemented" |
| 12.1.2.1 | 356-357 | Editorial | "…the matching had been resolved, using unconditional logistic regression to estimate…" | "…the matching had been broken and unconditional logistic regression was used to estimate… |
| 12.1.2.1 | 552 | Technical / Editorial | "…surprisingly…"<br>Words expressing subjective opinion or judgement should be avoided throughout the entire documents, as much as possible. Some facts and findings may be surprising to some, but not to others. | Delete "surprisingly" |

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 12.1.2.1 | 1089-6070<br>Table 12.1.2. and all similar successive tables | Technical | Reference categories are missing from tables and footnotes. | Reference categories should be indicated in tables and in footnotes. |
| 12.1.4.2.1 | 2490 | Editorial | The section is incorrectly labeled. It should be labeled 12.1.4.2.2 | The section should correctly be labeled as 12.1.4.2.2. (not 12.1.4.2.1.) |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 12.1.5.1 | 2764 - 2772 | Technical, editorial | These lines have a short piece of text (~150 words) that provides a specific example of a difficulty found widely in this chapter, although this paragraph is by all means not an example of the most troubling instances of cluttered excessive detail, imprecise information, and wobbly critical interpretation. Yet, it has them all to a degree. | For example, the gist of the de Vocht et al. (2011) paper can be given thusly (~106 words):<br><br>"Time trends of malignancies (mostly gliomas) among UK mobile phone users did not rise significantly over the years 1998-2007 (sic!) when household phone use grew from 0 to 65% (de Vocht, Burstyn & Cherrie, 2011). However, incidence rates for the temporal and frontal lobes had statistically significant increasing trends whereas there were decreasing trends for parietal, cerebrum, cerebellum and overlapping tumors. The increasing trend for temporal lobe tumors suggests a possible relationship to exposures from mobile phones held nearby, but overall the positive and negative trends are not consistent with exposure patterns, plausible explanations, or the lack of a trend in overall brain cancer incidence."<br><br>Other Information can be made available in table 12.1.19 or as a footnote. E.g., this could be a footnote to the above text:<br><br>* The authors note that improved diagnostic methods (e.g., greater use of MRI) may have influenced reported tumor incidence over the study period. |

# Combined comments of IEEE/ICES TC34 and IEC TC106-MT 1

## Chapter 2: Sources, Measurements and Exposures

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 2 | | General | The section on measurements is missing! | |
| 2 | Scope | General | The scope of the document should be defined earlier. At present, the frequency range covered is not discussed until p14, line 484. | |
| 2 | | General | Other sources which could fall within the scope of this document are not discussed are: wireless power transfer systems, induction hobs (which can use frequencies of 100kHz), and Dedicated Short Range Communications (DSRC) for road tolling. | |
| 2.1.1 | 125 - 130 | Technical | Distinction should be made between RF radiation in general and planewave radiation. | Consider re-wording the paragraph. |
| 2.1.1 | 130 | Editorial | Pointing vector ***S*** should be Poynting vector. | |
| 2.1.2.1 | 151 - 152 | Technical | Figure 2.1 appears to describe a linearly polarized electromagnetic wave. | Indicate figure refers to planewave propagation. |
| 2.1.2.1 | 157 | Edirorial | (see section 2.1.3) is incorrect. | Change to (see section 2.1.4) |
| 2.1.2.4 | 214 - 216 | Technical | Wave impedance is generally not constant | Reword and add reference to Figure 2.6 |
| 2.1.2.4 | 215 - 217 | Editorial | The impedance should be *Z*. The symbol should be consistent with the table of quantities in line 234. | Use same symbol; for wave impedance throughout document. |
| 2.1.3.1 | 246 | Editorial | Spell the word with hyphen or without hyphen; amplitude modulated (AM) or frequency-modulated (FM) | |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| | 348, 322, 338, etc | General | When reference a regulatory standard, the author use the convention: (standard organization name, year the standard was published), for example, line 348, compliance tests of cellular phones (IEC, 2005; IEEE, 2003), it is very difficult for readers to find out the origins of the contents by only knowing the organization's name. It is recommended to provide exact standard's name in the document, such as: compliance assessmnet of cellular phones (IEC 62209, 2005; IEEE 1528, 2003). There are many places in Chapter 3 referencing a regulatory standards this way, such as line 322, 338 etc. | |
| 2.1.4.2 | 410 | Technical | | Add the statement "A consequence of this that the power density in the near field of a transmitter cannot be determined from measurement of only the E or H field, and this is an important consideration when assessing exposure levels in the near field of a transmitter." |
| 2.1.4.3 | 427 | Technical | The term Fresnel zone has not been introduced.<br>**Note:** For sources that are large compared to the wavelength, the reactive near field zone extends to R = $0.62\times\sqrt{(D^3/\lambda)}$. For FAR field conditions, $R > 2D^2/\lambda$ **and** $R>>\lambda$ **and** $R>>D$. This is not stated in the text. | Suggest changing line 423 "…have a radiating near-field region, ***known as the Fresnel zone***, that extends……" |
| 2.2 | 505 | Technical | The E and H-fields inside the body and the SAR are referred to as dose. They are not quantities that have been integrated with respect of time, so dose is not the correct term. | |
| 2.2.1 | Fig. 28 | Editorial | | For consistency, write 1 V/m to 1 kV/m and not as fractions |
| 2.2.1 | Fig. 28 | Technical | The quoted figure of 1.3mW/m$^2$ for the earth is inconsistent with the value given on page 17, line 583 which is 2.4mW/m$^2$. | |
| 2.2.1 | 541 | Editorial | The peed of light in a vacuum, equal to $2.998 \times 10^{-8}$ m/s; should be $2.998 \times 10^{+8}$ m/s; | |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 2.2.1.1 | 564 | Editorial | Its spectrum shows a peak at 3.4 × 10−14 Hz, a wavelength of 880 nm, should be $3.4 \times 10^{+14}$ Hz, a wavelength of 880 nm. | |
| 2.2.1.1 | 564 | Editorial | Should be “shows a peak at $3.4 \times 10^{14}$ Hz”, and not $3.4 \times \mathbf{10^{-14}}$ Hz as quoted. | |
| 2.2.2.1.1 | 688 | Technical | “963 MHz” is not in the HF band. Please check this frequency value. | |
| 2.2.2.2.2 | 883 | Editorial | Do not break the number across the two lines | |
| 2.2.2.2.2 | Fig 2.15 | Technical | The term “bin separation” is not defined, and it is not clear what this term actually refers to. | |
| 2.2.3 | | General | Should this section include pico cell base stations, which are generally used indoors?<br>Ref. T G Cooper, S M Mann et al, “Exposure of the general public to radiowaves from Microcell and Picocell base stations for mobile telecommunications”, NRPB-W62, Sept 2004, ISBN 0-85951-543-**5.** | |
| 2.2.3 | 1059 – 1067 | Editorial | Should relate to exposure levels, rather than transmitted power, to be consistent with the other sections. | |
| 2.2.3 | 1153 | Editorial | A reference is required to the product performance standards | |
| 2.2.6 | 1398 – 1400 | Technical | The larmor frequency is given by 42.57 times the static magnetic field strength” This does not define the units for the RF frequency or the static field, and is only correct for hydrogen atoms. Also, the value should be 42.58. | Consider replacing with;<br>“In MRI, the radio frequency field is applied at the Larmor frequency, which is obtained by multiplying the static field strength of the magnetic by the gyromagnetic ratio. For hydrogen atoms, as normally imaged in MRI, the gyromagnetic ratio is 42.58 MHz/Tesla. Thus a 1.5T scanner involves the application and measurement of RF fields at approximately 64 MHz.” |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 2.2.6 | 1402 | Technical | The term “RF dose” should be replaced with “RF exposure”. Dose is a measure of the total energy deposited in the tissues, and would have units of J/kg and not W/kg. | |
| 2.2.6 | 1403 | Technical | The values of 0.1 W/kg to 4W/kg. I cannot find these values in the quoted reference (HPA, 2008). Also, the values of 0.1W/kg to 4 W/kg refer to the SAR averaged over the entire body, but this is not stated explicitly in the text. No reference is made to the local (10g averaged) SAR values, yet these are the limiting factor for patient exposure at 3T and above. | It would be better to replace “The RF dose (SAR) received by patients inside MRI scanners is reported by the systems and can vary from less than 0.1 W/kg to about 4 W/kg for more complex settings” with<br>“For the operation of MRI machines under medical supervision, MRI safety standards [1, 2] specify limits for patient exposure over a 6 minute period of 4 W/kg for whole body averaged SAR. The local SAR (averaged over a 10g mass of tissue) may be 5 to 10 times higher than the whole body SAR. Typical exposures may be lower than this.” |

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 2.2.6 | 1406 – 1408 | Technical | | **Line 1406 to 1408**: Should be replaced with:<br>"In general, the RF exposure of clinicians and other people who are near to the magnet during the scans will be low because the RF fields decrease rapidly with distance from the end of bore of the scanner. The exception will be staff carrying out interventional procedures, particularly on open scanners, where the hands, arms and possibly the head, may be exposed to levels similar to those experienced by the patient or volunteer undergoing the procedure [3, 4]."<br>Refs.<br>[1] IEC 60601-2-33, 2010, "Medical Electrical Equipment, particular requirements for the safety of magnetic resonance equipment for medical diagnostics"<br>[2] ICNIRP Statement on magnetic resonance (MR) procedures: Protection of patients", Health Physics 87 (2):197-216, 2004.<br>[3] Final Report of EU project VT/2007/017, "An investigation into the occupational exposure to electromagnetic fields for personnel working with and around medical magnetic resonance imaging equipment", April 2008.<br>[4] Bassen H, Schaefer DJ, et al., IEEE Committee on Man and Radiation (COMAR) technical information statement, "Exposure of medical personnel to electromagnetic fields from open magnetic resonance imaging systems", Health Phys. 89, pp 684-9, 2005. |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 2.2.7.2 | 1442 – 1443 | Technical | These are average power densities. It is important to note that the systems use pulse modulation, and the power density averaged over the duration of the pulse is over the order of 1 $kW/m^2$ [1], which is around 10% of the current ICNIPB limit.<br>Reference [1] ICNIRP "Statement on health effects associated with millimetre wave whole body imaging technologies", Health Physics 102(1) pp 81-82, 2012. | |
| 2.2.8 | 1447 – 1494: | General | No indication is given of the likely occupational or public exposure levels from these systems. | |
| 2.5.1.1 | 1650 | General | | Consider adding the comment after line 1650 that "Thus, TEM cells are suitable for generating far field exposure conditions, such as those arising from base station antennas, but not near field exposures, such as those arising from mobile telecommunications handsets." |
| 2.5.2 | Figure 2.5.2 | Editorial | The picture of the TEM cell is very unclear, and it needs annotation to show the central conductor etc. | |
| 2.5.3.1 | 1746 | Editorial | Typo "of controls if affords" should be "of controls **it** affords" | |
| 2.5.3.1 | 1782 | General | Please consider adding reference to the following papers in this section | [1] Loader BG, "Dosimetry for the Mobile Telecommunications and Health Research (MTHR) Program", Biological Effects of EMF, 4th Int. WS, Crete, Oct 2006.<br>[2] N Kuster et al, "Methodology of Detailed Dosimetry and Treatment of uncertainties and variations for in-vivo studies", Bioelectromagnetics, Vol 27, Issue 5, pp 378-391 |

# Chapter 3: Radiofrequency Electromagnetic Fileds Inside the Body

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.2 | 41 and 221 – 222 | Technical | This statement is not strictly correct. The human body is not magnetic (i.e. $\mu_r$ =1), so the incident magnetic field is not changed as it passes through the body. However, circulating currents induced within the body by the incident EMF will give rise to additional magnetic fields inside the body. | |
| 3.1.1 | 55 | General | The simple models for the human as a monopole antenna (for vertical polarized E-field) and as a spheroid (for H-field) are quite useful to explain the coupling of fields to the body at low RF frequencies, and could be included in this section (reference Durney et al (1986)). This would provide a better explanation of the body resonance effects describe in section 3.1.4.1. | |
| 3.1.2 | 83 – 87 | Editorial | "At frequencies below 100kHz (and therefore not in the scope of this document) the physical quantity identifiable with the biological effect is the electric field strength in the tissue…." This is confusing because: as later stated electrical stimulation of the tissues can occur up to 10 MHz. Further, internal electric field in the tissues is actually the relevant quantity at all frequencies, as this also gives rise to the tissue heating. | |
| 3.1.2 | 89 – 90 | Editorial | This is confusing as it could be interpreted as "indirect effects that result from current flow in the body tissues", which are in fact direct effects. | Suggest this is changed to "Currents can be induced on conducting objects which are exposed to electromagnetic fields, and electric shocks or burns can occur when a person comes into contact with these objects. Such effects, which are not cause directly by exposure of the person to the EMF, are termed ***indirect effects***. Indirect effects also include malfunction of active implanted medical devices due to exposure to the EMF." |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.1.3 | 104 – 105 | Editorial | Units for ***E*** missing | Add units |
| 3.1.2 | 105 | Editorial | | Consider replacing this equation 3.1 with $SAR = \frac{1}{2}\frac{\sigma}{\rho}E^2 = \frac{1}{2}\frac{J^2}{\sigma} = C\frac{dT}{dt}$ as this shows the equivalence of current density and internal electric field, and also the temperature rise. |
| 3.1.2 | 121 | Editorial | SAR may also be measured in human equivalent phantoms, and this should be added to this sentence. | |
| 3.1.4.4 | 177 - 178 | Editorial | "Skin depths of tissues with low water content such as fat and bone are greater than those with higher water content such as muscle and skin". The content of this sentence is repeated in line 184 to 187 so it could be removed. | |
| 3.1.4.4 | 194 | Technical | **Table 3.1** should be removed. *The WHO should not adopt or endorse the tissue dielectric data from one particular study by including it in its monograph, given the variability of the data from different sources, as highlighted by Gabriel et al.* (Gabriel, Gabriel and Corthout, 1996). See additional comments for dielectric parameter uncertainty for section 3.3.3. | |
| 3.1.4.6 | | General | This should include a discussion of anisotropy of the tissue properties. It is clear that the properties of muscle, bone and nerve fibre will be highly anistropic at the lower RF frequencies i.e. below 10 MHz, and this could significantly change the induced currents in the body. | |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.2 | All | Technical | This section fails to distinguish between dosimetry for exposures in the far field of sources and exposures in the reactive near field of sources, and also between partial body and whole body exposures.<br>**For far field sources**, exposure estimates are based on the incident unperturbed field strength at the location of the person, and for frequencies below 110 MHz, the limb currents can also be measured directly using a limb current meter. From these measurements a conservative estimate for the SAR and internal electric field can be made. For this type of exposure it is usually impractical and also unnecessary to perform measurements in phantoms. | |
| 3.2 | **All** | Technical | This section fails to distinguish between dosimetry for exposures in the far field of sources and exposures in the reactive near field of sources, and also between partial body and whole body exposures.<br>**In the reactive near field of a transmitter**, the mutual coupling between the body and the source antenna must be taken into account to determine the exposure. Therefor the SAR from a transmitter which is used in close proximity to the body, such as a mobile phone, is obtained directly by measurement of the electric field or temperature rise in a homogeneous tissue equivalent phantom placed next to the antenna, or by computer simulations. | |

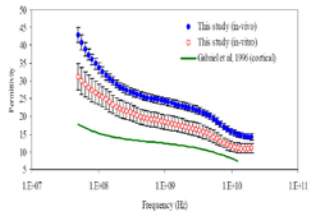
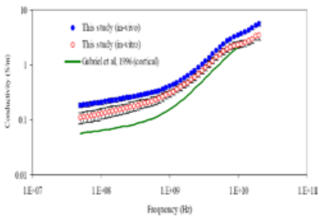
| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.2.2 | All | Technical | The text does not discuss the differences between SAR averaged over a contiguous (i.e. any shape) mass of tissue, as specified by ICNIRP, and the SAR specified over a cube of material which is the value that is normally obtained in measurement systems and from computation. This is discussed in the following three references, which should be cited.<br>IEC MT1 has communicated this issue with ICNIRP and requested to fix the definition such that technically practical/possible assessment methods could be applied. | |
| 3.2.2 | | General | Refernces regarding averaging mass should be added. | **Additional references**<br>N Stevens & L Martens, "Comparison of averaging procedure for SAR distributions at 900 and 1800 MHz", IEEE Trans MTT, vol 48, no. 11, pp 2180-2184, Nov 2000.<br>A. Hirata, K Shirai and O Fujiwara, "On averaging mass of SAR correlating with temperature elevation due to a dipole antenna", PIERS 84, 221-237, 2008.<br>G. Bit-Babik, A Faraone et al, "Correlation between locally averaged SAR distribution and related temperature rise in human body exposed to RF field", Proc. BEMS 2007, pp 2-5, 2007. |
| 3.3.2.1 | 322 | General | Add references to IEEE 1528 standards. | Include reference for muscle simulating liquids , FCC 2001 and add IEEE 1528-2003 and 2013 as additional references. |

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 3.3.2.1 | 320 – 322 | Editorial | | **Line 320 to 322:** consider replacing with:<br>"Phantoms for RF dosimetry are required to simulate the electrical properties of the human body. Homogeneous phantoms are specified in standards for 30 MHz to 6 GHz (IEC 2005, **FCC 2001**). The electrical properties of such phantoms use are selected to give a conservative estimate for absorption in the brain (head simulating liquid) or muscle (body simulating liquid) at the frequency being tested. Normally the phantom is contained in an anatomically shaped vessel for testing head SAR and a flat bottomed tank for body SAR. Note that it is necessary to calibrate the sensitivity of the electric field probe when immersed in the liquid because this will be different to its sensitivity in air. Liquid or gel phantoms are normally used for SAR testing, as the electric field probe can be inserted into the phantom and moved around to determine the spatial peak values of SAR and also the values averaged over a 1g or 10g cube. Some SAR measurement systems have been developed which use solid phantoms with embedded sensors at fixed positions, so that the volumetric distribution of the E-field within the phantom must be estimated from the fields at the sensor positions. As the frequency is reduced below 30 MHz, the real permittivity of brain and muscle increase rapidly, and become significantly higher than that of water (Golombeck 2002), so that liquid phantoms cannot match these properties. Above 6 GHz, few phantoms have been developed, but skin phantoms base on agar have been developed for 64 GHz, for example (N Chahat et al, 2012). |
| 3.3.2.1 | 336 | Technical | This tolerance has been relaxed to ±10% for both permittivity and conductivity in later SAR test standards (e.g. IEEE 1528-2013) | |

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 3.3.2.1 | 339 | Technical | (Gabriel 2007) describes the development of a solid phantom to replicate the effect of the hand on the over the air performance of phones, and not for SAR assessment, so this reference should be removed. A liquid or gel phantom is required for SAR testing, as the probe must be moved through the phantom to determine the mass averaged SAR. Whilst it is possible to embed the sensors at fixed locations to the solid phantom, the local in homogeneity of the materials will affect the isotropic performance of the sensors, particularly where the mix contains chopped carbon fibre strands. An ultra wide band phantom base on agar is presented in (Takuya et al 2005), and this may be either in a gel or solid form, depending on the mix, so this might be a better reference to include here. | |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.2.2.2 | 356 – | Editorial | This section needs better introduction to explain the use of computational models in dosimetry | **Line 356** Insert text:<br>“It is not normally possible to measure the electric fields or temperature rises in the human body, as the measurement probes are invasive. Computer simulations of humans allow the quantities that can be readily be measured outside the body, such as incident fields, power density and limb current to be related to the fields and temperatures inside the body. Such simulations are used to relate reference levels for incident fields to the basic restrictions in exposure guidelines. Also, they provide the rationale for the required real permittivity and conductivity of the homogeneous phantoms in order to ensure they are conservative with respect to the in-vivo exposures.<br>The accuracy of the computer simulation is largely dependent on the input parameters for the human tissues, the relevant parameters being real permittivity, electrical conductivity, and density. In addition, for calculation of the tissue temperatures after exposure, the thermal conductivity, specific heat, tissue metabolic rate, and blood perfusion rate for the tissues must be known. All of the quantities are subject to measurement errors, and this must be taken into account when determining the accuracy and validity of the simulations”. |
| 3.2.2.2 | 387 | Technical | The finest resolution is 0.5mm and not 1mm as quoted, i.e. the Duke model from (Christ et al. 2010b) is 0.5mm resolution. | |

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 3.2.2.2 | 388 – 395 | Technical | The limit of the accuracy of the voxel models is the resolution at which the imaging and segmentation of the tissues has been performed, and this is not improved by surface fitting techniques described. It is far more important to consider the modelling of widely distributed tissues, such as blood and skin, in the voxel models. In early models, such as HUGO, the skin is modelled as discontinuous patches if a mesh resolution of 2 mm or greater is used, but later model, such as Duke (from Christ et al. 2010b) use conformal voxelling techniques to ensure the skin is continuous over the body surface. In this case the total skin mass in the model may be increased from the in-vivo mass with coarse meshes (i.e. greater than the mean skin thickness of 1.6mm). | |
| 3.2.2.2 | 399 | Technical | Whilst good agreement is observed between modelled results from different sources, most are using the tissue electrical properties from (Gabriel et al 2006). It is essentially that the uncertainty in the tissue data on the computational results is accounted for. The two references given, Gabriel et al. 1996, Gabriel 2005, and Peyman et al 2007) in the section 3.3.3 show a factors of 2 to 3 difference from data from different sources. Exposure guidelines include safety factors, and this is partly to account for the accuracy of the available dosimetry. | |

| **Chapter Clause Subclause** | **Line Figure Table** | **Type of comment** (General/ Technical/ Editorial) | **Comments** | **Proposed change** |
|---|---|---|---|---|
| 3.3.3 | 423 | Technical | Gregory et al 2007 provides a more comprehensive review of coaxial probe metrology than Gabriel 2000 and should be cited here instead of (Gabriel 2000).<br>This section omits some important points.<br><br>Fig 1. Real permittivity of porcine bone and comparison to Gabriel 1996, from [1])<br><br>Fig 2. Conductivity porcine bone and comparison to Gabriel 1996 | No mention is made of the **tissue anisotropy**. It is very clear that materials which have elongated cell structures, such as muscle, nerve tissues and bone, will have electrical properties that are very different in the axial and radial directions, and this effect will be particularly prevalent below 10 MHz (circular coaxial probes produce radially polarized fields in the samples). Clearly, the anisotropy of the tissues will significantly alter the current distributions that are induced in the body, and at present this effect is not included in the computation models due to lack of available tissue data.<br><br>**Additional reference**<br><br>AP Gregory & RN Clarke, “Dielectric metrology with coaxial sensors”, Meas. Sc. Technol. Vol 18, No. 5, pp1372-1386, 2007.<br>A Peyman, S Holden & C. Gabriel, Dielectric Properties of Tissues at Microwave Frequencies”, Final Report of project RUM 3 or the Mobile Telecommunications and Health Research Program (MTHR), Dec 2009, available at http://www.mthr.org.uk/research_projects/documents/Rum3FinalReport.pdf |
| 3.4.2.2 | 558 | Editorial | Extra parenthesis | Remove “(“ after (2005) |
| 3.4.2.3 | 594 | Technical | “Starting from the premise that an SAR of 4W/kg for a health adult is equivalent to a 1°C temperature rise,...” *You must cite a reference for where these figures are obtained.* | |
| 3.4.2.3 | 603 | Editorial | Extra parenthesis | Remove second “)” after (2007) |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
|---|---|---|---|---|
| 3.4.2.4 | | Technical | The discussion and references cover far field (plane wave) exposures only. Please consider including the exposures of pregnant women during MRI (JW Hand et al, 2010) and from induction hobs (Bor et al, 2011) | **Additional references**<br>JW Hand, Y Li, JV Hajnal, "Numerical study of RF exposure and the resulting temperature rise in the foetus during a magnetic resonance procedure", Phys Med Biol 55(4) pp913 to 930, 2010.<br>Bor Kos et al. "Pre and post-natal exposure of children to EMF generated by induction cookers", Phys. Med. Biol. 56, pp6149, 2011. |
| 3.4.3 | | General | Grounding conditions have a very large effect below 150 MHz. It is likely that a child holding up their arms will couple energy from a vertically polarised field as effectively as the adult, and will therefore have whole body SAR values that are much higher than the adult due to the lower averaging mass in the case of the child.<br>**Fig 3.4** Probably, this shows the results for a grounded person, but this is not stated in the fig caption. | |
| 3.5 | 692 - 700 | Technical | Actually, equation 3.4 is obtained from<br>dT/dt = C(SAR + M –C –P)<br>where M = metabolic rate, C = heat conduction, P = Heat perfusion, and assuming that the body is in thermal equilibrium prior to the EMF exposure, i.e that M = C+P, see (IEEE C95.3 2002) | |
| 3.7 | | Technical | Note: This is why additional criteria for the duty factor and peak power density apply in the case of pulse modulated fields, and this could be stated | |

| Chapter Clause Subclause | Line Figure Table | Type of comment (General/ Technical/ Editorial) | Comments | Proposed change |
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| | | | Additional refernces | Add the following references:<br><br>Federal Communications Commission, FCC OET Bulletin 65, Supplement C, June 2001, "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields Additional Information for Evaluating Compliance of Mobile and Portable Devices with FCC Limits for Human Exposure to Radiofrequency Emissions", David L. Means, Kwok W. Chan.<br><br>Golombeck MA, Riedel CH, Dössel O., "Calculation of the dielectric properties of biological tissue using simple models of cell patches", *Biomed Tech (Berlin)* 2002, **47** Supp. 1, Pt. 1:253-6.<br><br>N Chahat, M Zhadobov et al, "Human skin equivalent phantoms for on-body antenna measurements in 60 GHz band", Electronics letters, 19th Jan 2012, Vol 48, No 2, 2012.<br><br>Takuya Takimoto, Teruo Onishi, et al., "Evaluation on biological tissue equivalent agar-based solid phantoms up to 10 GHz-aiming at measurement of characteristics of antenna for UWB communications, Proc. ISAP2005, Seoul, Korea, p483-486. |