Dear Contributor,

Thank you for participating in the public consultation of the ICNIRP draft guidelines.

Please note that it is important that ICNIRP understands exactly the points that you are making. To facilitate our task and avoid misunderstandings, please:

* be concise
* be precise
* provide supporting evidence (reference to publication, etc.) if available and helpful.

**How to complete the comments table:**

Please use 1 row per comment. If required, please add extra rows to the table.

This response document asks you to provide your ‘comment’, your ‘proposed change’, and the ‘context’ to this comment and proposed change. What is meant by these is the following:

**Comment :** A brief statement describing the issue that you have identified (and that you would like ICNIRP to take into account in the final version of the guidelines).

**Proposed Change:** A brief statement describing how you would like the document changed to account for this issue.

**Context:** A brief statement identifying relevant documents in support of your comment and proposed change.

**Please, provide your details below as per the online form and the provision of the privacy policy**

|  |  |  |
| --- | --- | --- |
| Last name, first name: ZOLLMAN, Peter | Email address: Your email address. | Affiliation (if relevant): Not applicable |
| If you are providing these comments officially **on behalf** of an organization/company, please name this here: Not applicable  |
| [x]  I hereby agree that, for the purpose of transparency, **my identity (last and first names, affiliation and organization where relevant) will be displayed** on the ICNIRP website after the consultation phase along with my comments.[ ]  I want my comments to be displayed anonymously. |

|  | **Document****(Guidelines, App A,****App B)** | **Line Number****#** | **Type of comment (General/ Technical/ Editorial)** | **Comment. Proposed change. Context.** |
| --- | --- | --- | --- | --- |
| **1** | Guidelines |  146, 147, 156,420, 421-423, 602, 605, 854-860  | Technical | Issues:1. The use of the letter H both to represent Htr / Hinc – transmitted- / Incident- energy density and elsewhere H on its own to represent the magnetic field is unnecessarily confusing. Editorially, subscripts are conventionally used as qualifiers to the main letter script and not to completely change the represented variable.
2. With respect to Table 1, radiant exposure is NOT a unit and the term is not used elsewhere in the guidelines.
3. “Energy density” as introduced in these guidelines is not a metric which is generally used or measured in practical radio engineering applications. Further, the term “density” is more commonly associated with a volume or a mass rather than an area so may confuse readers until they really study what ICNIRP intends e.g. <https://en.wikipedia.org/wiki/Energy_density>, <https://energyeducation.ca/encyclopedia/Energy_density>, <https://energyeducation.ca/encyclopedia/Energy_density_vs_power_density>

Alternative expression to Htr and Hinc:An alternative metric can easily be defined which is traceably representative of the intended “energy density”, and which relates better to common practices. Using this would aid comprehension and practical application of the guidelines.Representing the basic restriction limit in terms of the rate of power absorbed accross the skin boundary in a given area – with specified time averaging - is of equal validity in physics and avoids the need to use „transmitted energy density“ at all.Since Htr = Str\*1/t, the basic restriction could equally be expressed in terms of time-averaged Str with (virtually) the same notes and with equal physical accuracy. Similarly, the corresponding reference level Hinc can be expressed in terms of time-averaged Sinc considering Hinc = Sinc\*1/t The key thing for the guidelines to empasise is the ‘tr‘ subscript – i.e. the part of the incident field Sinc which crosses the surface of the body and is absorbed in the body (with specified averaging area) – and the time-averaged qualifier defining the time avaraging. This alternative expression also gives better linkage for comparison of local and whole body restrictions.See also comments 5 and 6**Line 146 – Change to** ....and time-averaged transmitted power density are used....**Line 147 –** Delete Htr **Line 156 –** Delete complete row with Transmitted energy density **Lines 419 – 423 –**Above 6 GHz, ICNIRP specifies the limit in terms of time-averaged transmitted power density (**S**tr) over any 4 cm2 or 1 cm2 area (for >6 to 30 GHz, and >30 GHz respectively), where **S**tr is specified as (5000+3540(t-1)0.5 )/t W m-2 for intervals between 1 and 360 seconds, where ‘t’ is interval in seconds derived from (Foster et al., 2016); for intervals less than a second, the value is set at 5000 W m-2. The SA and **S**tr values are conservative**Line 602** - Table 3 Heading ‘Local Htr (kJ m-2)‘ change to ‘Local Str (W m-2)‘ ‘Occ 2.5+1.770(t-1)0.5 ‘ change to ‘(2500 + 1770 $\sqrt{t-1}$)/t ‘‘GP 0.5+0.354(t-1)0.5 ‘ change to ‘(500 + 354 $\sqrt{t-1}$)/t ‘**Line 605 -** Change Note 2. Htr to be Str**Lines 854– 855**For time intervals < 6 minutes above 400 MHz, SA and time-averaged transmitted power density values Str should be added according to:**Line 856 Eqn.7 -** Replace H with S**Lines 859-860**Str,*i* is the transmitted energy density at frequency *i*; and *S*tr, *L* is the time-average transmitted power density limit given in Table 3. Improving clarity of the guidelines to make them easier to interpret and apply. |
| **2** | Guidelines | 682 | Technical | Table 4 Issue - There should be no discontinuities such as step changes in reference limits at boundaries between frequency ranges. Reasoning:1. Discontinuities in limits at specific frequencies are difficult to accommodate in practical „shaped“ field probes and so constitute an additional measurement uncertainty in compliance measurements.
2. A step change in limit at a specific frequency makes no sense biologically, thereby reducing confidence in the ICNIRP guidence.
3. More precise definitions are no more difficult to implement in computations than less precise definitions.

For brevity, the changes proposed below also include aspects of comments 3 and 4.**The factors in Table 4 should be adjusted slightly to remove/minimise these steps by including additional significant figures where needed. Proposed amended numeric parts of Table 4 (references to notes also need to be added by the ICNIRP editor):**

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| --- | --- | --- | --- | --- | --- |
| Exposure Scenario | Frequency Range | E-Field strengthV/m | H-Field strengthA/m | SincWm-2 | See Comment# |
| Occupational | 0.1 to 7.18 MHz | 170. | 4.9/f | ---- | 4 |
| >7.18 to 20 MHz | 1228/f | 4.9/f | ---- | 2, 4 |
| >20 to 30 MHz | 61.4 | 4.9/f | ---- | 2 |
| >30 to 400 MHz | 61.4 | 0.163 | 10 | 2 |
| >400 to 2000 MHz | 3.07 $√f$ | 0.00815 $√f$ | f/40 | 2 |
| 2 to 300 GHz | 137 | 0.364 | 50 | 3 |

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| --- | --- | --- | --- | --- | --- |
| Exposure Scenario | Frequency Range | E-Field strengthV/m | H-Field strengthA/m | SincWm-2 | See Comment# |
| General Public | 0.1 to 6.63 MHz | 83 | Minimum[21, 2.19/f] | ---- | 4 |
| >6.63 to 20 MHz | 550/f | 2.19/f | ---- | 2, 4 |
| >20 to 30 MHz | 27.5 | 2.19/f | ---- | 2 |
| >30 to 400 MHz | 27.5 | 0.0728 | 2 | 2 |
| >400 to 2000 MHz | 1.375 $√f$ | 0.00364 $√f$ | f/200 | 2 |
| 2 to 300 GHz | 61.4 | 0.163 | 10 | 3 |

Context – Modelling of the draft 2018 guidelines Table 4 and the proposed amendments: |
| **3** | Guidelines | 682 | Technical | Table 4 issue - reference levels for >2 GHz do not include electric and magnetic field strengths.Reasoning:1. Excluding E and H as valid reference levels implies an evaluation of the Poynting vector in computation.
2. E H exclusion implies need to measure both E and H vectorially at 2 to 6 GHz even in the far field.

Consequence:It would no longer be valid to determine Sinc above 2 GHz by measurement using an instrument with only an electric field isotropic probe. This would have serious practical implications for measuring whether a specific far-field exposure circumstance is within the guidelines. **E and H values for 2 to 300 GHz should be included (to 3 significant figures) corresponding to Sinc = 50 W m-2 (Occ) ,10 W m-2 (GP)**Occupational E-Field 137 V m-1, H-Field = 0.364 A m-1General Public E-Field 61.4 V m-1, H-Field = 0.163 A m-1Seecomment 2To ensure that currently available best practice electric field probes may continue to be used above 2 GHz fully consistent with compliance assessment with these guidelines rather than imply the need to develop and use new instrumentation that doesn‘t currently exist – e.g E H combined vector probes or using thermal-based techniques.Personal experience in development of IEC and CENELEC standards. |
| **4** | Guidelines | 430-434, 682 | Technical | Issue: - The 2018 guidelines do not include the more-restrictive limits from the ICNIRP 2010 guidelines within the overlap frequency range 0.1 to 10 MHz.Reasoning:1. Splitting up the exposure limit guidance between 2010 and 2018 on the basis of health effect AND frequency range is very confusing.
2. For the development of compliance procedures and regulations it is more important the ICNIRP guidelines clearly express the values of the limiting EMF parameters at any stated frequency rather than the limiting effect. Traceability is also required as to what effects are being covered but this can be in the appendices.
3. Where there is a frequency overlap between 2010 and 2018 guidelines (ie 100 kHz to 10 MHz) then the 2018 guidance should give the critical exposure considering all effects which ICNIRP consider relevant at any given frequency.
4. Discontinuities in limits at frequency boundaries should be avoided - see comment 2.

It can be seen from the following table that if the ICNIRP 2010 guidelines are still valid, then the ICNIRP 2018 guidelines do NOT provide the reference level against the limiting effect for at least some of the frequency range below 10 MHz. The discrepancy being a factor which can be over 60x.

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| **Frequency**  | **2010 Table 3 Occ, E Field** | **2010 Table 4 GP, E field** | **2018 Table 4****Occ, E Field** | **2018 Table 4****GP, E Field** | **Limiting ICNIRP guidelines** |
| 100 kHz | 170 Vm-1 | 83 Vm-1 | 12 200 Vm-1 | 5 600 Vm-1 | 2010 limiting |
| 10 MHz | 170 Vm-1 | 83 Vm-1 | 122 Vm-1 | 56 Vm-1 | 2018 limiting |

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| **Frequency**  | **2010 Table 3 Occ, H Field** | **2010 Table 4 GP, H field** | **2018 Table 4****Occ, H Field** | **2018 Table 4****GP, H Field** |  |
| 100 kHz | 80 Am-1 | 21 Am-1 | 49 Am-1 | 22 Am-1 | 2010/2018 limiting |
| 10 MHz | 80 Am-1 | 21 Am-1 | 0.49 Am-1 | 0.22 Am-1 | 2018 limiting |

See comment 2**Line 432** “....that *do not cause any known health effect including those covered in ICNIRP (2010) low frequency guidelines for the overlap frequency 100 kHz to 10 MHz* using.....**Line 682 Amend ICNIRP Table 4 *(see comment 2):***Table 4 Occupational E Field new frequency range 0.1 MHz to 7.18 MHz with a limit 170 Vm-1 with a new note pointing to ICNIRP 2010 Table 3. A further frequency range 7.18 MHz to 20 MHz would retain the 1228/f. Table 4 GP E Field new frequency range 0.1 MHz to 6.63 MHz with a limit 83 Vm-1 with a new note pointing to ICNIRP 2010 Table 4. A further range 6.63 MHz to 20 MHz would retain the 550/f. Table 4 GP H Field lowest frequency range to specify Minimum[21, 2.19/f] with a new note pointing to ICNIRP 2010 Table 4. A further range 6.63 MHz to 20 MHz would retain the 550/f. **Line 693 Insert new note:** “5. For frequencies 0.1 to 10 MHz the limits take into account ICNIRP 2010 Table 3 and ICNIRP 2010 Table 4 for protection against nerve stimulation.”  Reference: Modelling of ICNIRP 2010 Table 3 and ICNIRP 2018 Table 4Reference: ICNIRP 2010 Table 4 and ICNIRP 2018 Table 42018 should be consistent in establishing the limiting effect at any given frequency and applying the corresponding exposure limit irrespective of whether the limiting adverse biological effect is covered in detail in the ICNIRP 2010 or the ICNIRP 2018 guidance. |
| **5** | Guidelines | 718-738 | Technical | Local exposure Table 6 Issue - Gross discontinuity in local exposure limit at 400 MHzReasoning:The Table 6 reference levels for local exposure of (just under) 360 seconds should be consistent with the 6 minute average reference levels in Table 5 for exposures for >= 360 seconds.Table 6 399.999 MHz Note 2 applies referencing Table 5 Table 5 399.999 MHz Note 2 applies referencing Table 4Table 4 399.999 MHz Occupational Sinc = 10 W m-2Table 6 400.001 MHz Occupational 360 Sec: Hinc = 0.8 \* 0.4^0.51 \* (2.5 + 1.77 Sqrt[360 - 1] ), Hinc = 18.067 kJ m-2If we consider that one watt = one joule per second; Sinc( W m-2) = Hinc(kJ m-2) \*1000/t(seconds)To convert to equivalent Sinc for 360 sec exposure, Sinc = Hinc\*1000/360 = 50.19 W m-2  I.e. At 399.999 MHz, the local peak incident field limit (360.01 sec exposure) is 10 W m-2 whilst at 400.001 MHz the local peak field exposure for 299.999999 sec) is 50.19 W m-2If the same comparison is done at 6 GHzTable 4 6. GHz Occupational, whole body exposure Sinc = 50 W m-2Table 5 6 GHz Occupational 6 mins, local exposure Sinc = 275 \* 6^-0.177 = 200.26 W m-2Table 6 6 GHz Occupational 360 seconds, local exposure: Hinc = 2.75 \* 6.0^-0.177 \* (2.5 + 1.77 Sqrt[360 - 1] ), Hinc = 72.168 kJ m-2Using Sinc( W m-2) = Hinc(kJ m-2) \*1000/t(seconds) gives Sinc = Hinc\*1000/360 = 200.47 W m-2  For the 6 GHz case, the Table 5 and Table 6 local exposure reference levels align reasonably well (proving conversion Hinc to Sinc equiv) and shows a factor of 4 difference between whole body average (over 30 mins) and local peak exposure (over 6 mins) , with the local peak exposure allowed to have the greater instantaneous field level – as might reasonably be anticipated. This discontinuity might have shown up earlier ICNIRP deliberations had the reference values been expressed in consistent units. In the context of a reference level definition, i.e. for fields in the absence of the body, it is far better to express guidance limits in a way which is widely known and well understood. For short-duration local peak exposure, rather than using term “Incident plane wave energy density” the above shows how to continue to use Sinc also for short duration local exposure limits, fully consistent with physics and giving easier comprehension of the ICNIRP limits. See comment 1 **Unable to specify a correction to this problem since it is for ICNIRP to clarify the local exposure limit relaxation with respect to whole body exposure limit at 400 MHz.** Reference: Modelling of ICNIRP 2018 Table 6 (ref Table 5 and Table 4) limits |
| **6** | Guidelines | 697-738 | Technical | Issues: 1. Table 5 and Table 6 both introduce reference limits for local exposure but use different metrics (comment 1).
2. Table 6 refers to Table 5 which refers to Table 4. Table 5 refers forward to Table 6. The complexity of having two tables for local exposure reference levels is unnecessary.
3. The formula in Table 6 for Occupational Incident plane wave energy density for frequency range >6 GHz to 300 GHz is missing an opening “[“.
4. In the presentation of Table 6 formulae for the limits >6 GHz, the “-“ sign is not very clear.
5. In Tables, formulae should be simplified such that constants are multiplied out so that no extraneous multiplication of constants is required to determine the guideline limit. Using square root sign would also make the formulae more readable compared with (.....)0.5. The detailed explanation of how the limit numbers were derived can be included in the Appendix A.
6. The use of numeric and # \* note “numbering“ is unnecessary.
7. Table 5 and Table 6 can easily be combined into a single table expressing a metric which can be measured, and the notes simplified - provided the constraints on t are defined as: t<1, t set to 1; and t>360, t set to 360.
8. Note 2 includes term “equivalent incident plane wave energy density” which is not used anywhere else in the guidelines and hence is undefined.
9. Table 3 includes a note limiting the minimum value of t to 1 second – a constraint which is also needed when defining the local exposure reference levels to avoid having a square root of a negative number in the limit definition.

Reasoning:1. The primary difference between Table 5 and Table 6 is the exposure time. In Table 5 *t* is set at 6 mins (or rather 360 seconds) and “built in” to the formulae for the reference limits while in Table 6 *t* is expressly used in more complex formulae leading to a value for a metric which is not directly measurable (one of the key tenets of a “reference” level).
2. Consider that Sinc = Hinc\*1000/t - (x 1000/t to convert kJ m-2 to W m-2)
3. Having a single table for reference levels for whole body and a single table for reference levels for part body exposures simplifies the guidelines.

See comment 1**Replace Table 5 and Table 6 and associated notes (lines 697 to 738 inclusive) with a single new Table 5 and simplified notes:****Table 5.** Reference levels for local exposure to time varying far-field electric, magnetic and electromagnetic fields, from 100 kHz to 300 GHz (unperturbed rms values).

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| --- | --- | --- | --- |
| Exposure Scenario | Frequency Range | Incident plane wave power density (Sinc)(W m-2) See notes 1,4 | See PZ Comment-issue |
| Occupational | 100 kHz to 400 MHz | See notes 2, 5 | 1, 6-7 |
| >400 MHz to 6 GHz |  [2000 + 1416 $\sqrt{t-1}$ ] \* f 0.51/*t*  See note 5 | 1, 5(not fixed), 6-4, 6-5, 6-7, 8 |
| >6 to 300 GHz | [ 6875 + 4867.5 $\sqrt{t-1}$ ] \* f -0.177 /*t* See notes 3, 6 | 1, 6-3, 6-4, 6-5, 6-7, 8 |
| 300 GHz | 100/t | 1, 6-7, 8 |
| General Public | 100 kHz to 400 MHz | See note 2, 5 | 1, 6-7 |
| >400 MHz to 6 GHz |  [400 + 283.2 $\sqrt{t-1}$ ] \* f 0.51/*t* See note 5 | 1, 5(not fixed), 6-4,6-5, 6-7, 8 |
| >6 to 300 GHz | [ 1375 + 973.5 $\sqrt{t-1}$ ] \* f -0.177 /*t* See notes 3, 6 | 1, 6-4, 6-5, 6-7, 8 |
| 300 GHz | 20/t | 1, 6-7 |

Notes to Table 5:1. *f* is frequency in GHz. *t* is time interval in seconds. For *t*<1, *t* shall be set to 1. For *t*>360, *t* shall be set to 360.2. For frequencies 100 kHz to 400 MHz, exposure is compliant with the reference levels if the spatial peak value, averaged over 6 minutes, is less than the corresponding whole body average far-field reference levels (from Table 4). Where relevant, equivalent incident plane wave power density can be used in place of incident plane wave power density.3. **S**inc is to be averaged over t seconds, over a 4 cm2 (6 to 30 GHz) or 1 cm2 (>30 to 300 GHz) square region in space, approximating the body surface.4. The exposure from any group of pulses, or subgroup of pulses in a train, delivered in any *t* seconds, should not exceed the limits in this table. 5. For frequencies up to 6 GHz, far-field reference levels are also applicable to radiative and reactive near-field exposure conditions. 6. For frequencies above 6 GHz, far-field reference levels are also applicable to radiative near-field exposure conditions; no reference levels are provided for reactive near-field exposure conditions within this frequency range. **ICNIRP editor to define consequential changes to subsequent Table numbers and cross references elsewhere in the guidelines and appendices.** **Define equivalent incident plane wave power density in Appendix A line 96-98 as part of (Eqn 2.13)**In the case of the far-field or transverse electromagnetic (TEM) plane wave, the incident (plane wave) power density and the equivalent incident (plane wave) power density are derived as:$S\_{inc}=EH$ (Eqn. 2.13a)$S\_{eq}=\frac{E^{2}}{Z\_{0}}=Z\_{0}H^{2}$ (Eqn. 2.13b)Simplification of guidelines. |
| **7** | Guidelines | e.g 699 All | Editorial | Editorially express frequency ranges in a consistent format. Choose a clear format.**Use form as per line 707 “ >400 MHz to 6 GHz“ rather than the form of line 709 “>30-300GHz“.** Clear presentation. Personal experience in development of IEC, CENELEC, IEEE standards which have strict drafting guides.  |

Add further rows if needed. For this copy the above row.

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| 8 | Guidelines | All Tables with notes | Editorial | The note numbering and referencing is challenging to follow. There is the „a“ type for reference which seems to be to all notes, then there is the „1, 2, 3 ...“ and also „\*“ and „#“ notation for sub-notes.Sometimes the note „1“ indication is used to signify that this is relevent – but then not all of the notes under the table are expliciely referenced within a table.**Review and revise all tables applying the following editorial formatting rules:**1. „Notes to Table ....“ – heading for notes under the Table
2. For notes applicable to complete columns, include “see note 1..” as part of the column header
3. For notes applicable to complete rows, include “see note 1..” as part of the row header
4. For notes applicable to specific cells, include “see note 1..” as part of the cell information
5. If there are notes remaining which are not then referenced, delete them since they are not relevant to that table.

Clear presentation. Personal experience in development of IEC, CENELEC, IEEE standards which have strict drafting guides.  |
| 9 | Guidelines | 522, 523 | Editorial | Care should be taken to avoid confusing line breaks due to automatic justification by the editing software. The numeric value and ALL the text defining the associated unit should be on the same line. Having the „2“ on the following line to „W m-„ is really poor presentation. **Line 523 -** 200 W m-2 Clear presentation. Personal experience in development of IEC, CENELEC, IEEE standards which have strict drafting guides.  |