ICES

International Committee on Electromagnetic Safety

Approved Meeting Minutes

IEEE/ICES TC95 Subcommittee 4

Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz

Town and Country Resort and Convention Center

500 Hotel Circle North
San Diego, CA 92108
7 June 2008 (Saturday)
0900 – 1700 h

1. Call to Order

Co-chairman Thansandote called the meeting to order at 0905 h.

2. Introduction of those Present

Each of the attendees introduced him/herself. (See Attachment 1 for a list of the attendees.)

3. Approval of Agenda

Following a motion by Bodemann and a second by Chou, the agenda was approved without modification (See Attachment 2.)

4. Approval of the Minutes (November 2007 Meeting)

Following a motion by D'Andrea and a second by Cohen, the minutes of the November 2008 were approved without modification.

5. Secretary's Report

Petersen said that he would provide a detailed report on the status of the C95.1 standards and SASB activities relevant to ICES at the TC95 meeting on Sunday. He pointed out that each of the four standards that were submitted last year for reaffirmation, C95.3-2002, C95.4-2002, C95.6-2002 and 1460-1996 were approved by the SASB. In addition, the PAR for PC95.1a was approved and the PAR extension request for PC95.3.1 (low frequency measurements and computation) was approved for 2 years.

6. Chairman's Report

Co-chairman Thansandote reported that rather than giving a formal report at this time, he would report informally where appropriate during the remainder of the agenda.

7. Old Business

a. Matters arising from the minutes of November 2007 meeting

The action items arising at the November 2007 meeting were reviewed (see Attachment 3). Several that are still open will depend on the outcome of this meeting and approval of PC95.1a.

b. Literature surveillance/evaluation (Update)

Morrissey presented an overview of the literature surveillance process (see Attachment 4). He noted that Bushberg will be added to the Literature Surveillance WG. He showed the current number of studies assigned by sub-category to the Epidemiology, Human Studies, In Vitro and In Vivo working groups, and the current membership of each working group. Regarding membership, he pointed out that the goal is to maintain broad international representation on each working group. He then reviewed the structure of Annex B in the current C95.1 standard noting that each clause would be updated where appropriate to add new studies and the standard will updated to indicate that the literature evaluation contains studies through 2008.

c. Temperature vs. peak spatial-average SAR (Update)

Chou reviewed the status of the temperature versus peak spatial average SAR issue discussed at the November meeting. He reviewed the motion from the November 2007 meeting to pursue the investigation of the relationships between localized tissue temperature rise and peak spatial-average SAR and power density at frequencies between 100 kHz and 3 GHz and at frequencies greater than 3 GHz, respectively. The purpose of the motion was to explore the question of whether or not the localized exposure limits should be based on temperature change. (See Attachment 5.) He noted that temperature rise is better correlated with 10 g averaging mass than it is with 1 g or point SAR. Anderson said that new data seem to suggest that the correlation may not be that good at higher frequencies using IEEE averaging, particularly at the air-tissue interface. He said that the lack of correlation becomes more extreme at the higher frequencies – the crossover frequency appears to be about 6 GHz.

d. Review 1st draft of Amendment 1 (PC95.1a)

Petersen explained the process for developing and balloting PC95.1a (see Attachment 6). Following this meeting a revised draft will be sent to the SC4 ballot group that has already been established. All negative ballots and comments submitted in response to the ballot will be addressed and a recirculation ballot sent to the ballot group showing the comments and how each was addressed. In the meantime, an invitation to ballot will be sent to TC95. Those that accept will be part of the sponsor ballot group, which may contain other IEEE SA members who have an interest. Petersen said that if all goes well, the draft could be sent to the SASB for approval by year's end.

Klauenberg explained one reason the amendment is important is it includes ceiling values for induced and contact current, which were included in C95.1-1991 but were inadvertently omitted in the 2005 revision. He explained that the lack of realistic ceiling values can have a negative impact on NATO operations, where the lack of realistic ceiling values generally result in implementation of

unsupportable lower values. Such inappropriate lower values could present a risk, for example the operation of shipboard HF radio communications equipment during rescue operations.. He noted that ceiling values are not included in the EU Directive, nor are there limits for grasping contact current.

A number of issues raised by Curtis in an e-mail prior to this meeting were discussed. Curtis preferred a 0.2 s averaging time for "touch" contact instead of 1 s as proposed by Klauenberg in his response to the draft of PC95.1a sent to SC4. Curtis explained in his e-mail that this was based evidence obtained using the back of his hand as the "touch" point and observing tissue damage and bleeding very quickly with the longer averaging times. He suggested considering an "instantaneous" value as a basic restriction to prevent secondary safety hazards resulting from a startle reaction, and a second value with a longer averaging time to prevent tissue damage. He noted compliance in a controlled environment can be accomplished with education, gloves, work practices, etc. There was no action taken regarding Curtis' suggestions.

Anderson suggested a different approach and suggested modifications to the current draft (D1.3) of PC95.1a (see Attachment 7). He explained that the most important effects associated with induced and contact current would be shock and burns. He proposed limits for limb currents, which could be measured in a person using a clamp-on current probe placed around the wrist or ankle, and contact current, which could be measured with a clamp-on current probe placed around the wrist. He also recommended averaging times shorter than 6 min, specifically, 1 min for limb currents and 0.2 s for contact current. He said that the important point of his recommendation is that it provides the means for assessing compliance, i.e., measuring the current in the limbs of an exposed individual. He explained that experimental results he obtained using himself as a subject yielded results different from the classic expectations found in the literature. Specifically, the currents that lead to discomfort are higher than expected.

Swicord said that it appears that Anderson is suggesting that the standard should recommend using the human body as part of the measurement system. He pointed out that this could be politically problematic and suggested that perhaps field measurements should be done beforehand and exclusions developed where induced and contact current measurements would be unnecessary. Varanelli pointed out that there are laws that prohibit instructing people to use themselves as subjects for assessing compliance—therefore he could not support Anderson's proposal.

Needy pointed out that a major concern related to contact current are the secondary effects related to startle reactions. He said that the Navy used clamp-on current probes to determine the corresponding contact and grasping current thresholds above which such reactions might occur. Based on these data, an rms voltmeter is now used to ensure that the voltage on surfaces where contact currents potentially could result in a startle reaction is below 140 V rms – which seems to be a protective value. He also reminded everyone that the 2005 C95.1 standard contains E-field limits below which induced and contact measurements are not required.

In response to a question from Gettman, Anderson explained that the effects of body mass, size, physical features of the subject would be expected to be of the order of 10%. Wiart said that 10% seems to an underestimate. McKenzie suggested using Anderson's data to refine the limits in the standard but he was against having users be a part of the measurement system for assessing compliance. Needy pointed out that the Navy was unsuccessful in developing a phantom that could be used to reliably measure induced and contact and he noted that there aren't any corresponding commercial products available.

Reilly explained the rationale for the induced and contact current MPEs in the C95 standards. He noted that the touch/contact current thresholds are related to effects associated with electro-stimulation at low frequencies to tissue heating at the higher frequencies. He showed data based on Chatterjee's work (Attachment 8) that that is supported by other studies. He noted that the curves shown are based on the probability of experiencing pain. Needy noted that based on Navy studies, a contact current of 100 mA was not intolerable and grasping contact was generally not an issue shipboard. He questioned the 6 min averaging time at frequencies above 100 kHz. Reilly pointed out that at frequencies where effects related to electro-stimulation dominate, a short time-constant is necessary; at frequencies where effects related to heating dominate, a longer time constant, perhaps representative of a thermal time constant, is appropriate, but based on sensation, a 6 min averaging time might be unreasonable. Anderson agreed that the averaging time should be less than 6 min. He noted that the data he showed earlier does not apply to spark discharge and that he endorsed the voltage measurement protocol used by the Navy, but noted that 140 V rms may be too conservative.

e. C95.1-2005 Revision

A number of issues relating to the revision of C95.1-2005 and its incorporation with C95.6-2002 into a single 0 to 300 GHz standard, also called C95.1, were discussed. Petersen said that he obtained the MS Word file from IEEE for C95.1-2005. There are a number of issues and inconsistencies that have to be addressed in the process. He said that Osepchuk had a number of suggestions for the Editorial WG (see Attachment 9) as they revise the current draft. Petersen said that he would do a global search for the terms flagged by Osepchuk and make the appropriate changes. There was considerable discussion regarding definition 3.1.33 (localized exposure) which led to replacing the definition in the 2005 standard and the draft of C95.1a with the following: "localized exposure—exposure of a portion of the body." A number of other changes were recommended that will be reflected in the SC4 balloting draft of C95.1a and the revision of C95.1-1005. Petersen said that he will review comments on the current draft sent by Tim Harington and incorporate those that are relevant.

f. Other old business

No other old business.

8. New Business

No new business.

9. Date and Place of Next Meeting

The venue for the next meeting will be announced at the TC95 meeting on Sunday. It probably will be held in Ft Lauderdale, FL, hosted by Motorola.

10. Adjourn

There being no further business, following a motion by D'Andrea and a second by Sheppard, the meeting was adjourned at 1354 h,

ATTACHMENT 1

Attendance Sheet
TC95/SC4 Meeting
7 June 2008
Towne and Country Resort, San Diego, CA

	Last Name	First Name	Affiliation	Status	E-mail
1.	Anderson	Vitas	Swinburne University of Technology	M	vitasanderson@swin.edu.au
2.	Black	David	Environmental Physician	M	drblack@itmedical.com
3.	Bodemann	Ralf	Siemens AG	M	ralf.bodemann@siemens.com
4.	Borringbo	Anders	Norwegian Broadcasting	O	anders.borringbo@nrk.no
5.	Bushberg	Jerrold	U. of California, Davis	M	jtbushberg@ucdavis.edu
6.	Chou	C.K.	Motorola Labs	M	ck.chou@motorola.com
7.	Cleveland	Robert	EMF Consulting	M	rfcleveland@gmail.com
8.	Cohen	Jules	Independent Consultant	M	jules.cohen@ieee.org
9.	Croft	Rodney	Aus Cntr for RF Bioeffects Research	M	rcroft@swin.edu.au
10.	D'Andrea	John	Naval Health Research Ctr.	M	john.dandrea@navy.brooks.af.mil
11.	DeFrank	John	USACHPPM	M	john.defrank@us.army.mil
12.	Durrenberger	Gregor	ETH	M	gregor@ifh.ee.ethz.ch
13.	Elder	Joe	Motorola	M	joe.elder@motorola.com
14.	Erdreich	Linda	Exponent	M	lerdreich@exponent.com

ATTACHMENT 1

	Last Name	First Name	Affiliation	Status	E-mail
15.	Gallant	Josette	Industry Canada	O	gallant.josette@ic.gc.ca
16.	Gettman	Ken	National Electrical Manufacturers Assoc.	M	Ken_gettman@nema.org
17.	Grant	Marcus	Air Force Research Labs	O	marcus.grant@brooks.af.mil
18.	Ibey	Bennett	Air Force Research Labs	O	bennett.ibey@brooks.af.mil
19.	Klauenberg	B. Jon	USAF	M	betram..klauenberg@us.af.mil
20.	Lang	Sakari	Nokia Corp-Stand & Ind Rel	M	sakari.lang@nokia.com
21.	Lathrop	Janet	Gateway Information Services	O	jlathrop@rs-inc.com
22.	McKenzie	Ray	Telstra, Chief Technology Office	M	ray.mckenzie@team.telstra.com
23.	McQuade	Jill	USAF	M	jill.mcquade@usafa.edu
24.	Mikulski	Tim	US Army Safety Office	O	timothy.mikulski@hqda.army.mil
25.	Morrissey	Joe	Motorola	M	ejm037@email.mot.com
26.	Needy	Robert	Naval Surface Warfare Ctr.	M	robert.needy@navy.mil
27.	Packer	Malcolm	Harris RF Communications	M	mpacker@harris.com
28.	Persson	Bertil	Lund University	M	bertil.persson@radfys.lu.se
29.	Petersen	Ronald	R C Petersen Associates	M	r.c.petersen@ieee.org
30.	Reilly	J. Patrick	Metatec Associates	M	jpreilly@ieee.org
31.	Roberts	Brad	US Army CHPPM	M	brad.roberts@us.army.mil

ATTACHMENT 1

	Last Name	First Name	Affiliation	Status	E-mail
32.	Swicord	Mays	Consultant	M	mays.swicord@comcast.net
33.	Testagrossa	Paul	Alcatel-Lucent	M	ptestagrossa@alcatel-lucent.com
34.	Thansandote	Art	Health Canada	M	art_thansandote@hc-sc.gc.ca
35.	Umbdenstock	Don	Sensormatic	M	djumbdenstock@tycoint.com
36.	van Rongen	Eric	Health Council of the Netherlands	M	e.van.rongen@gr.nl
37.	Varanelli	Arthur	Independent Consultant	M	avaranelli@comcast.net
38.	Weller	Robert	FCC	M	bob@weller.org
39.	Wiart	Joe	France Telecom Orange Labs R&D	M	joe.wiart@francetelecom.com
40.	Ziriax	John	Naval Health and Research Center	M	john.ziriax@brroks.af.mil

M = Member TC95/SC4

O = Observer

ATTACHMENT 2

ICES

International Committee on Electromagnetic Safety

Unapproved Agenda

IEEE/ICES TC95 Subcommittee 4

Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz

Town and Country Resort and Convention Center

500 Hotel Circle North
San Diego, CA 92108
7 June 2008 (Saturday)
0900 – 1700 h

1. **Call to Order** *Thansandote*
2. **Introduction of those Present** *Thansandote*
3. **Approval of Agenda** *Thansandote*
4. **Approval of the Minutes (November 2007 Meeting)** *Thansandote*
5. **Secretary's Report** *Petersen*
6. **Chairman's Report** *Thansandote*
7. **Old Business** *Thansandote*
   a) Matters arising from the minutes of November 2007 meeting
   b) Literature surveillance (Update)
   c) Literature review/evaluation (Update)
   d) Temperature vs. peak spatial-average SAR (Update)
   e) Review 1st draft of Amendment 1 (PC95.1a)
   f) C95.1-2005 Revision
   g) Other old business
8. **New Business** *Thansandote*
9. **Date and Place of Next Meeting** *Thansandote*
10. **Adjourn**

ATTACHMENT 8

Actions Arising from 29 November 2007 SC4 Meeting

Nokia House, Irving, TX

	Action	Assigned to	Due	Status
1.	Establish/staff ad hoc to pursue the investigation of relationships between localized tissue temperature increase and peak spatial-averaged SAR (100 kHz to 3 GHz) or power density (3 GHz to 300 GHz), include Joe Morrissey and additional outside experts.	Meltz (Chair), Ziskin	Ongoing	Ongoing
2.	Prepare MS Word file of C95.1-2005, incorporate accepted changes and recommendations received to date (using text editor) in preparation for the 1st draft of the revision.	Petersen	1 Feb 2008.	Complete
3.	Establish Editorial WG to move forward with revision, including incorporation of C95.6-2002.	Thansandote/Ziskin	1 February 2008	Open
4.	Revive/establish Risk Assessment WG to work with the Literature Evaluation WG.	Tell	1 February 2008	Open

ATTACHMENT 8

5.	Initiate literature review (papers published after those in the C95.1-2005 database.	Literature review WG (Ziskin et al.)	1 January 2008	Closed
6.	Submit PAR for revision of C95.1-2005 (0 to 300 GHz)	Ziskin/Thansandote	1 January 2009	Open until C95.1a is approved

ATTACHMENT 4

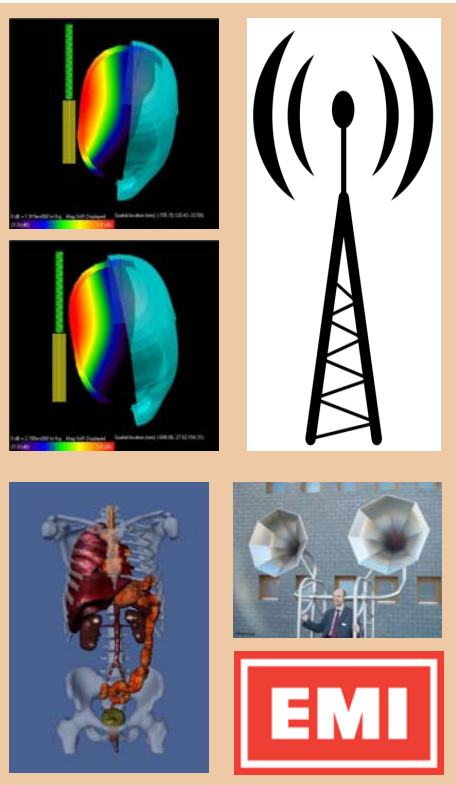
ICES TC95 SC4 Literature Surveillance Report

WG Members

Joe Morrissey
Dariusz Leszczynski
Joe Elder
[Sheila Johnston]

Literature Database

Total Citations: **3265** (3087 at last meeting)
Reviews: **909** (842 at last meeting)
Primary Publications Since Jan 2004: **650**



Category: Epidemiology	
Subcategory: Case Control Epi Study	59
Subcategory: Cohort Epi Study	2
Subcategory: Cohort Epi (Geographical Correlation)	18
Subcategory: Case Study of a Patient(s)	2
Subcategory: Exp Dosimetry in Humans (epi exposure assessment)	6
Total	**87**

Category: Human Studies	
Subcategory: EEG, Event Related Potentials, Sleep Disturbances	33
Subcategory: Cognitive Function & Memory	21
Subcategory: Subjective Symptoms (Headaches, Hypersen, Fatigue)	22
Subcategory: Blood Pres, Heart Rate, Circulation, and Respiratory Rate	10
Subcategory: Auditory Pathology & MW Hearing	18
Total	**104**

Category: In Vitro	
Subcategory: DNA Breaks, Damage & Mutation	22
Subcategory: Proliferation, Growth Rate, & Cell Cycle Analysis	10
Subcategory: Transformation	1
Subcategory: Gene & Protein Expression & Activity	62
Subcategory: Micronuclei & Chromosome Aberrations	21
Subcategory: Calcium / ion (Efflux, Neuron, Sm Muscle Contraction)	8
Subcategory: Oxidative Stress	19
Subcategory: Membrane Biochemistry and Fluidity Studies	2
Total	**145**

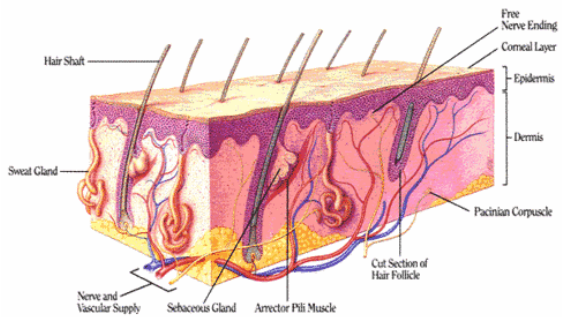
Category: In Vivo	
Subcategory: Long Term Rodent Bioassay	7
Subcategory: Chemical-Radiation-Genetically Initiated Tumor Bioassay	12
Subcategory: Blood Brain Barrier, Brain and Tissue Blood Flow	14
Subcategory: Animal Behavior, Brain Biochem, Neuropathology	18
Subcategory: Teratogenicity, Reproduction, & Development	13
Subcategory: Immune Function & Hematology	12
Subcategory: Hormone Changes	7
Subcategory: Eye Pathology	6
Total	**89**

Review Volunteers / Teams

- ALL TC95/SC4 members
- Epidemiology
  - Linda Erdreich (Exponent)
  - Dan Krewski (Health Canada)
- Human Studies
  - Rodney Croft (EEG, sleep)
- In Vitro
  - Dariusz Leszczynski (STUK)
  - James McNamee (Health Canada)
  - Lutz Haberland (U Rostock/FGF)
- In Vivo
  - Jerry Bushberg (UC Davis)
  - Dave McCormick (IITRI)
  - Dariusz Leszczynski
- International Representation
  - Salome Ryf - Swiss BAG (Health Agency)
  - Myron Malanyj (HPA)
  - Gert Kelfkens (Nat Inst Public Health Environ Netherlands)
  - Barney de Villiers (University Stellenbosch)
  - Tom Zickero (Inst Occup Safety, Slovenia)
  - Georg Neubaur (ARCS, Austria)
  - Isabelle Lagroye (U Bordeaux, France)
  - Martine Vrijheid (IARC / U Barcelona)
- Engineering Support
  - Art Thansandote (Health Canada)
- Statistical Support:
  - Philip Dixon (U Iowa)

Local Tissue Temperature Limits

- Whole body basic restriction taken from animal behavioral data (4 W/kg work stoppage)
  - occupational = 10x safety factor (0.4 W/kg)
  - general public = extra 5x safety factor (0.08 W/kg)
- Local limits (IEEE C95.1, 1995) applied 20x peak / average ratio to WBA value (= 1.6 W/kg)
- Current standard (IEEE C95.1, 2006) considers
  - upward revision of peak/average SAR (Bernardi 2003)
  - harmonizing with ICNIRP
  - 2 W/kg (per 10 grams) is conservative
- Limited information on tissue temperature thresholds for local adverse effects



General Structure of Annex B

B.6.9 Human provocation studies

B.6.9.1 Cognitive function and memory

Studies have reported that mobile phone RF exposures result in either improved (Preece et al. [R664]) (Kellnyi et al. [R707]) (Jech et al. [R795]) (Koivisto et al. [R796]) (Lee et al. [R844]) or hindered (Lass et al. [R985]) cognitive function and memory in humans …. Blah blah blah …..

B.6.9.2 EEG, sleep disturbances, and event related potentials

…. blah blah blah …..

B.6.9.3 Headache and fatigue

…. blah blah blah …..

B.6.9.4 Hypersensitivity

…. blah blah blah …..

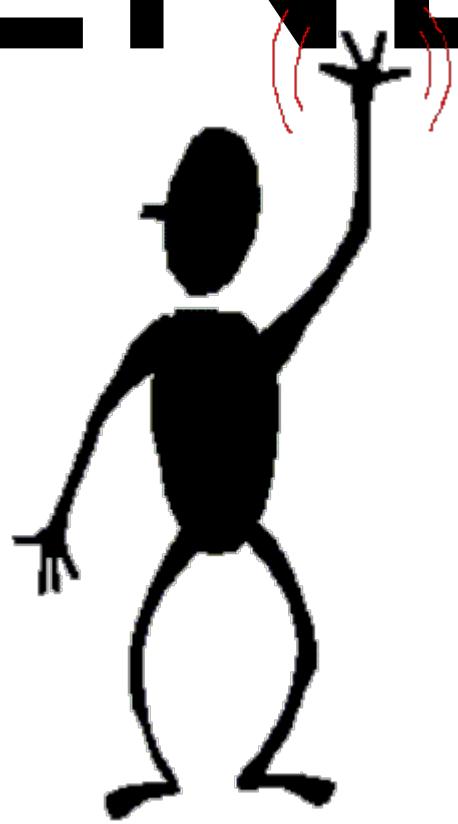
B.6.9.5 Effects on blood pressure/heart rate

…. blah blah blah …..

B.6.9.6 Summary of human provocation studies

No consistent evidence exists to indicate an adverse effect of low-level RF exposure on the nervous system. However, because of the variety of different effects reported by some investigators and the many contradictory reports, research in this area continues.

END



ATTACHMENT 5

Report of November 29, 2007 SC4 meeting discussion

Motion: Move that ICES TC95/SC4 pursue the investigation of relationships between localized tissue temperature increase and peak spatial-average SAR (100 kHz to 3 GHz) or power density (3 GHz to 300 GHz) as a basis for revising a decision on the need to revise the localized exposure limits at frequencies from 100 kHz to 300 GHz.

Action item: Meltz will establish/staff an ad hoc to pursue the investigation of relationships between localized tissue temperature increases and peak spatial-averaged SAR (100 kHz to 3 GHz) or power density (3 GHz to 300 GHz). In addition to Meltz, the ad hoc will include Morrissey, Ziskin plus additional outside experts.

Meltz agreed to report on the results of the ad hoc's work by 2009.

Recent results on SAR and Temperature

Temperature rise is better correlated to 10 g averaged SAR than 1 g averaged SAR, or point SAR

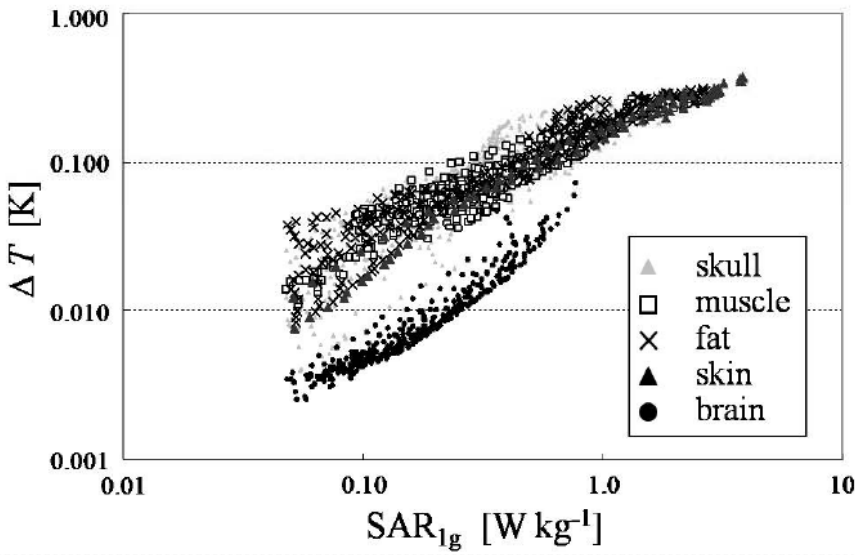
Shown by two papers:

- Hirata et al. [2008]
- McIntosh et al. [2008]

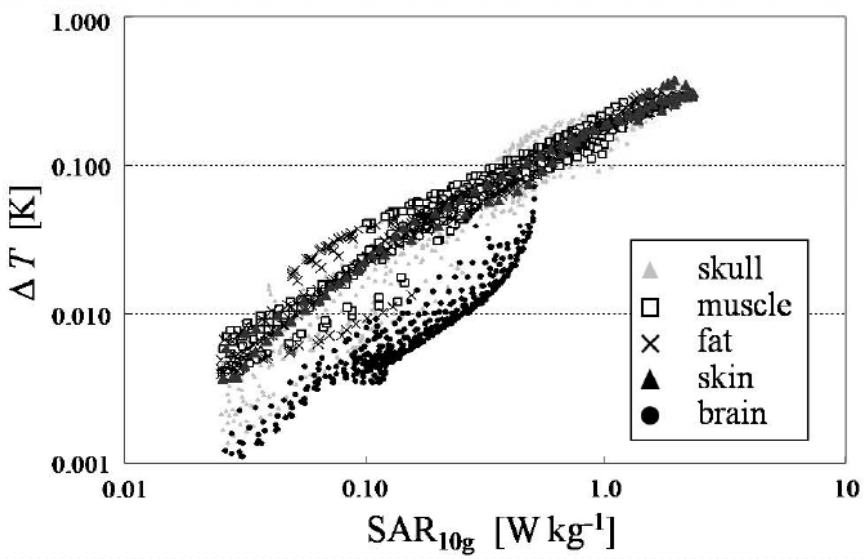
and one presentation

- Bit-Babik et al. [2007]

Temperature elevation versus SAR averaged over (a) 1 g and (b) 10 g tissues for voxels



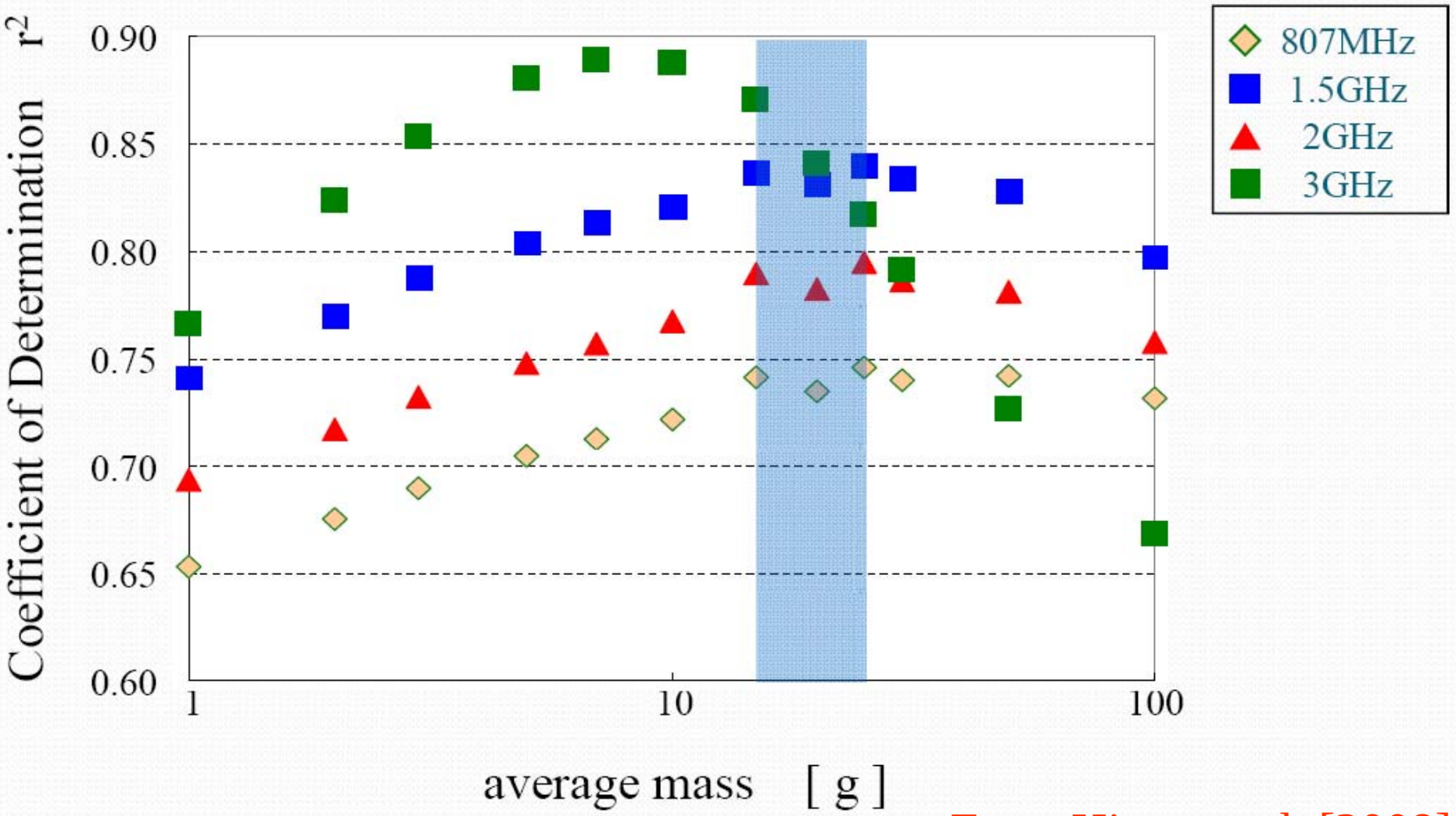
1 g



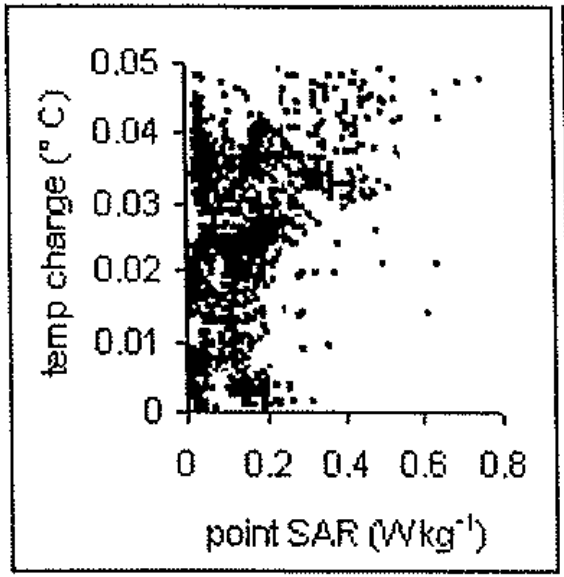
10 g

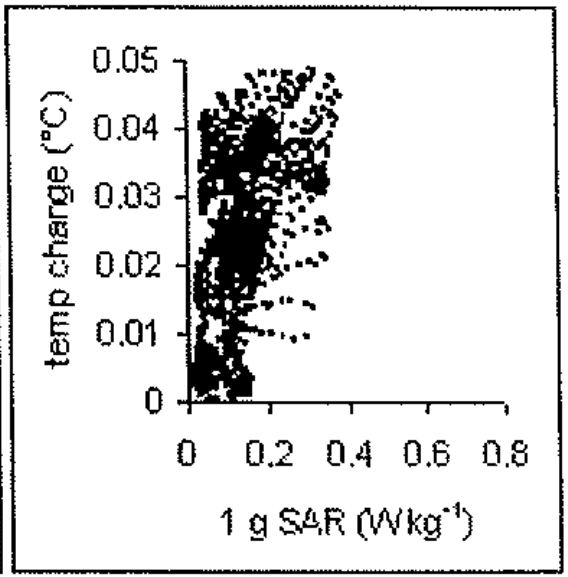
From Hirata et al. [2008]

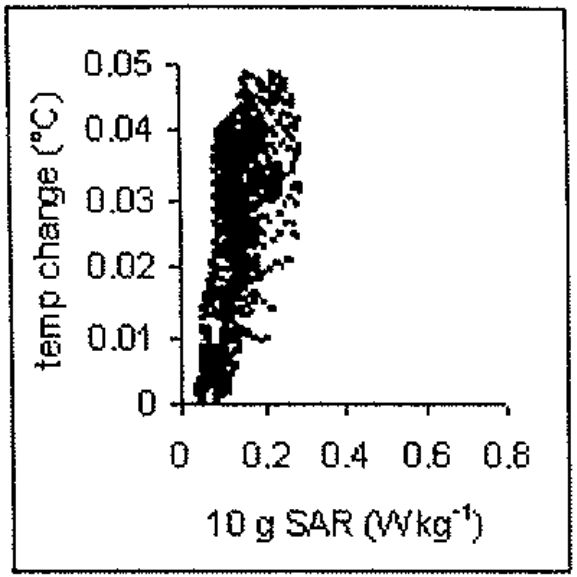
Effect of Averaging Mass on Correlation between SAR and ΔT



From Hirata et al. [2008]

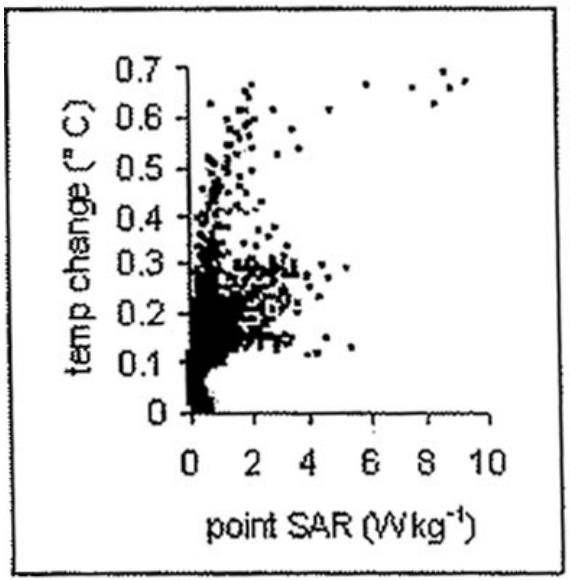


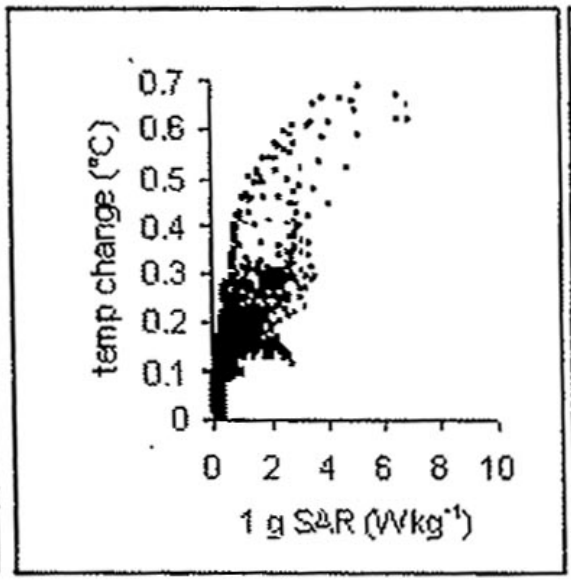


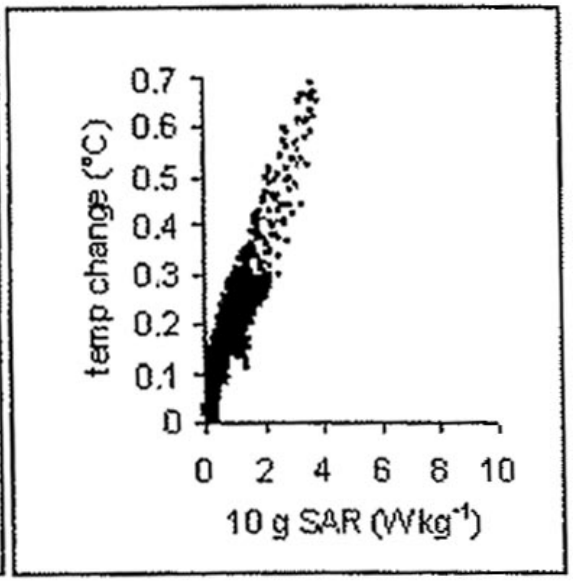


A: 300 MHz

From McIntosh et al., [2008]



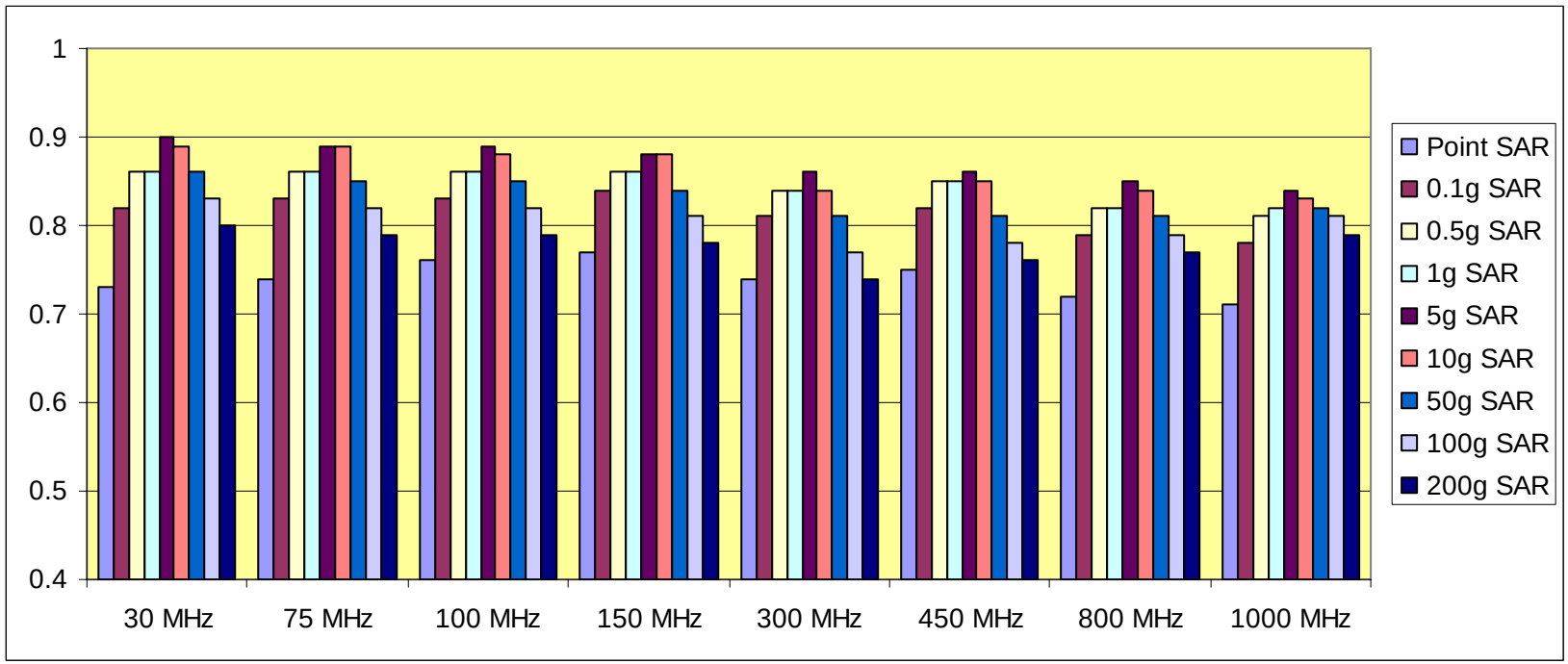




E: 3000 MHz

Correlation of SAR averaging mass with temperature rise

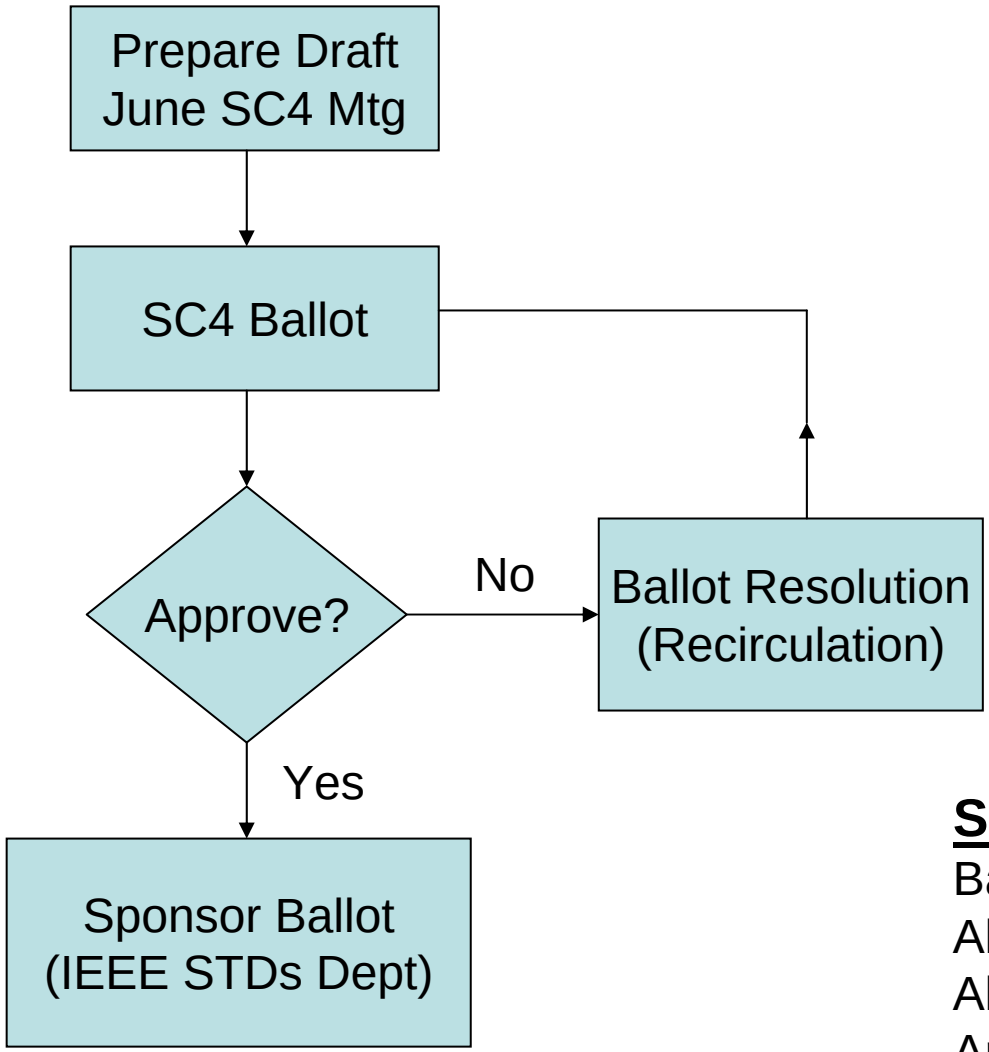
In the frequency range 30 - 1000 MHz the *SAR* averaging over 5 g and 10 g of tissue correlates better with temperature rise in the body



From Bit-Babik et al. [2007]

ATTACHMENT 6

What's Next?



Sponsor Ballot

Ballot Pool:
All TC95 Members
All IEEE SA members,
Anyone who pays a fee

ATTACHMENT 7

Proposed text for induced current limits in C95.1

Vitas Anderson (Swinburne University, Melbourne)
18th May 08

LIMB CURRENTS

The lower and upper tier reference levels for limb currents (I_L) are provided in Table 1.

Exposure category	Frequency range	I_L (mA)
Lower tier	100 kHz – 110 MHz	50
Upper tier	100 kHz – 110 MHz	100

Table 1 Reference levels for limb currents.

The following rules shall apply to the evaluation of I_L:

a) I_L shall be time averaged over any continuous 1 minute period.
b) I_L in the lower limb (leg) shall be evaluated as the total current flow through the ankle.
c) I_L in the upper limb (arm) shall be evaluated as the total current flow through the wrist while making grasping contact with an RF energised conductor.
d) Measured evaluations of I_L should be performed using a current probe (see definition) clamped on the wrist or ankle.

CONTACT CURRENTS

The lower and upper tier reference levels for contact currents (I_C) are provided in Table 2.

Exposure category	Frequency range	I_C (mA)
Lower tier	3 – 100 kHz	$0.2 \times f$
	0.1 – 110 MHz	20
Upper tier	3 – 100 kHz	$0.4 \times f$
	0.1 – 110 MHz	40

Table 2 Reference levels for contact currents. The variable f is the exposure frequency in kHz.

The following rules shall apply to the evaluation of I_C:

a) I_C shall be time averaged over any continuous 0.2 sec period.
b) I_C shall be evaluated as the total current flow through the wrist when making fingertip contact with an RF energised conductor.
c) Measured evaluations of I_C should be performed using a current probe (see definition) clamped on the wrist.

DEFINITIONS

Contact current*:* The rms magnitude (I_C) of RF current flowing through the wrist when making fingertip contact with an RF energised surface. It is expressed in units of mA.

Limb current*:* The rms magnitude (I_L) of RF current flowing in a wrist or ankle which has been induced by an RF exposure. It is expressed in units of mA.

Current probe*:* A clamp-on 'loop' current transformer for measuring current through the ankle or wrist.

RF Exposure*:* The subjection of a person to ambient RF EMF and/or contact with an RF energised conductor. RF exposure induces RF EMF inside a person which is limited by the basic restrictions.

ATTACHMENT 8

ICES C95.6 and ICNIRP Standards On Electric and Magnetic Fields 0 to 3 kHz

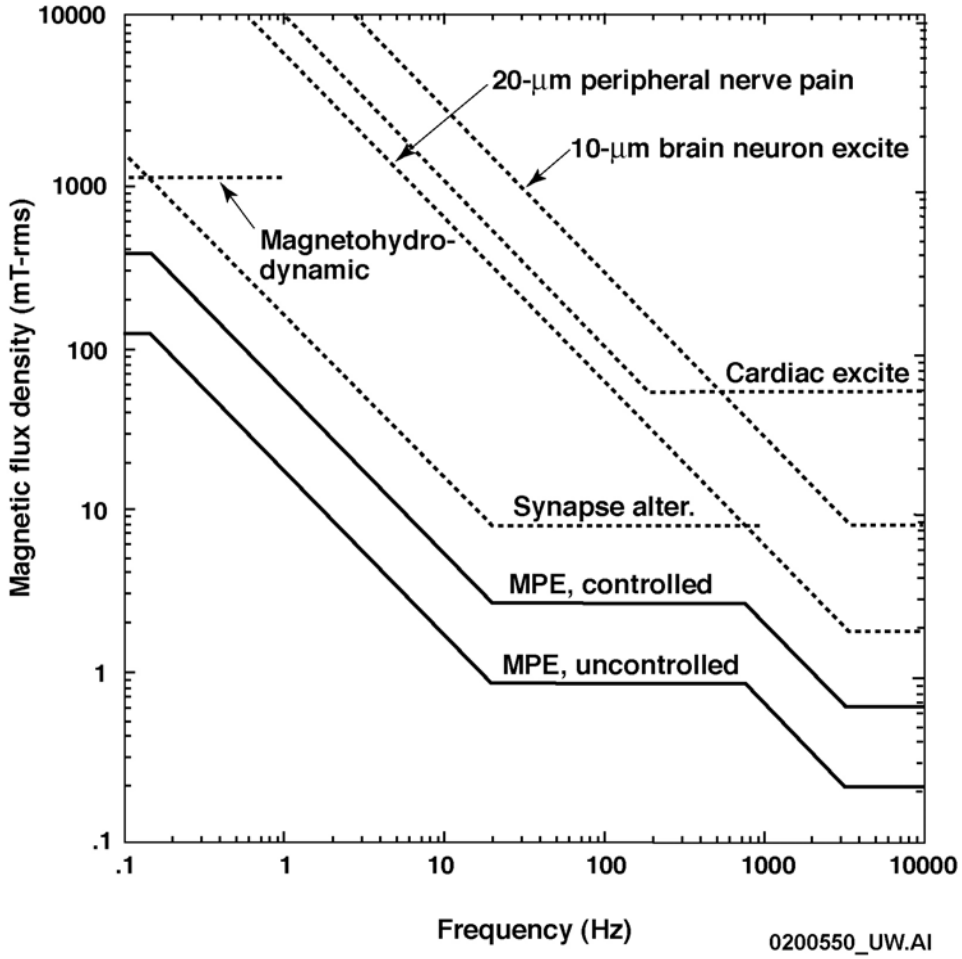
prepared by
J. Patrick Reilly

The Johns Hopkins University
Applied Physics Laboratory
and
Metatec Associates
12516 Davan Drive
Silver Spring, MD, 20904
USA

Prepared for Plenary Session III
on EMF Exposure Standards
Bioelectromagnetics Society 30th Annual Meeting
San Diego, CA
June 10, 2008

ATTACHMENT 8

ICES Max. Permissible Exposure Levels: Whole-body exposure to spatially constant magnetic field



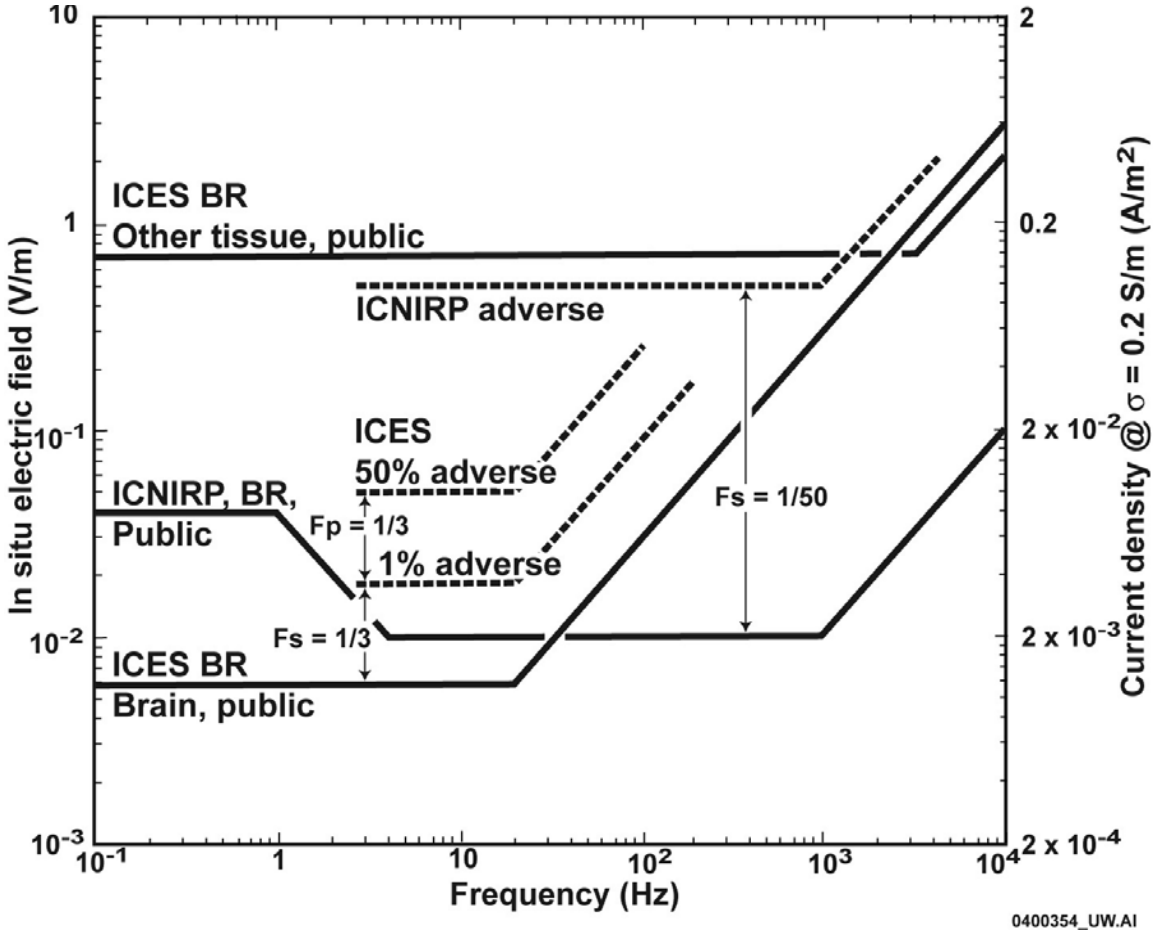
Broken Lines:
Median Adverse Thresholds

Solid Lines:
ICES MPE Levels

From: ICES (2002). "IEEE Standard for Safety with Respect to Human Exposure to Electro-magnetic fields, 0 – 3 kHz," IEEE Standard C95.6

ATTACHMENT 8

Compare low-frequency ICES and ICNIRP Basic Restrictions for the General Public

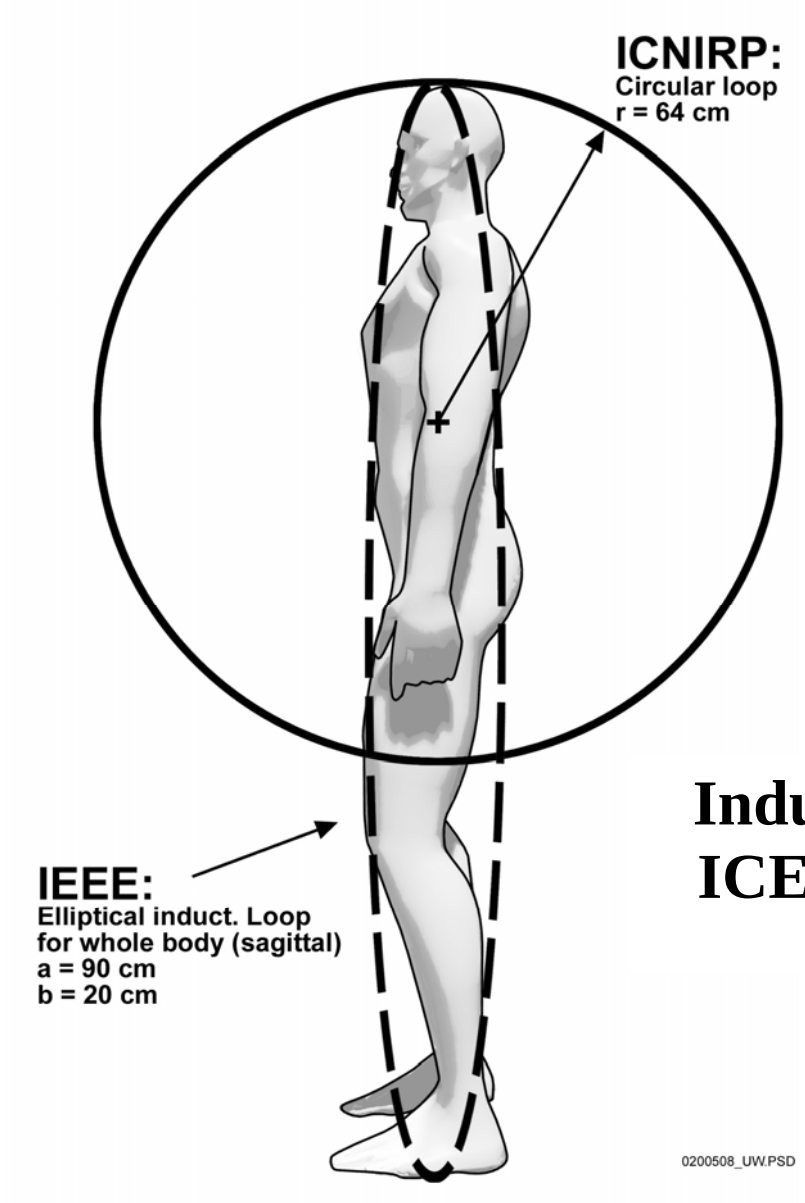


Transition frequency is primary factor for low-frequency difference between the two standards.

Transition frequency:
20 Hz in ICES
1000 Hz in ICNIRP

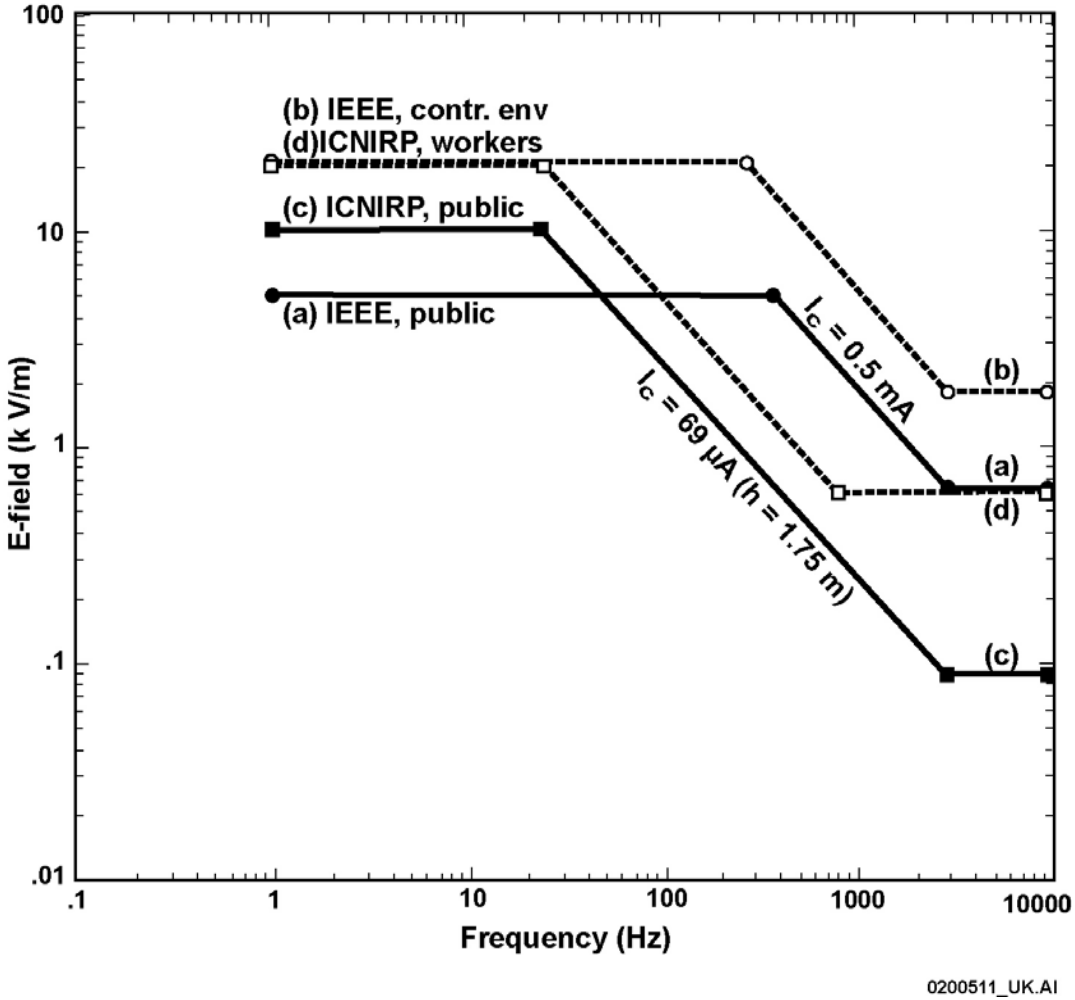
From JP Reilly (2005). An analysis of differences in the low-frequency electric and magnetic field exposure standards of ICES and ICNIRP. *Health Physics* 89(1): 71-80.

ATTACHMENT 8



Induction Loops Assumed in ICES & ICNIRP Standards.

Max. Permissible Exposure to Electric Fields: Exposure Limits of ICES and ICNIRP



ICES Rationale:

- **Touch Contact Current Limits**
- **Capped to limit painful spark discharges.**

ATTACHMENT 8

Identifiable Basis for Differences Between IEEE and ICNIRP Standards, 0 – 3 kHz

Item	IEEE	ICNIRP
Upper transition frequency for CNS synapse effects (*Basic Restrictions*)	20 Hz	1000 Hz
Lower transition frequency for CNS synapse effects (*Basic Restrictions*)	None	4 Hz
CNS synapse effect restricted area (*Basic Restrictions*)	Brain	Entire body (?)
Magnetic field induction model (*Environmental B-field*)	Ellipsoid (body, torso, brain, limb)	Large circular loop
E-field induced current, 1.8 m tall person, worst-case field orientation (*MPE E-field*)	0.5 mA	0.069 mA
Explicit probabilities?	Yes	No

1. Encourage the use of adjectives "temporal" and "spatial" before the word "peak"

2. Develop definitions of "power density" and "energy density". Remember that these terms were initially used in C95.1. When SAR and SA were developed these new terms were given to distinguish them from the old terms which should be defined again.

3. Go through text of C95.1 to make sure these four terms are not mixed. In the 1999 edition , there was an unfortunate definition of "energy density" as a volume density--which really is SA.

4. The present standard doesn't seem to have a discussion where the peak energy density limit comes from. It came from work on the "stun effect" in which the exposure parameters were SA and SAR.

5. If this statement #4 is true should one consider developing peak limits on SAR or SA?