ATTACHEMENT1 – SUBMISSION TO ICES MEETING

Thanh Dovan (excused absence)
ICES AdCom Meeting – 14 August 2008
Notes for Item 5 “Merging C95.6 into the Revision of CV95.1 -2005

Please see attached the highlighted text difference in the 2 existing documents.

- Combining 0-3 kHz and the 3kHz – 5MHz Sections (New task; Requesting Pat Reilly lead this task; Resource to be provided to JPR: New Task Group/s ?? .)

- Separate and provide more detailed treatment of DC/Static Electric Field and Magnetic Field (New Task/s; Recruiting Experts & Resources; and New Task Group/s …).

ATTACHEMENT 2 – SUBMISSION TO ICES MEETING
Thanh Dovan (excused absence)
ICES AdCom Meeting – 14 August 2008
Notes for Item 5 “Merging C95.6 into the Revision of CV95.1 -2005

IEEE C95.1 AND C95.6 TEXT COMPARISON –
SECTIONS ON BASIC RESTRICTIONS (BRS) AND MAXIMUM PERMISSIBLE EXPOSURES (MPES) FOR FREQUENCIES RELEVANT TO ELECTROSTIMULATION LIMITS

C95.6 – 2002	C95.1 – 2005
5. Exposure Limits	**4. Recommendations**
5.1 Basic restrictions	**4.1 Basic restrictions (BRs) and maximum permissible exposures (MPEs) for frequencies between 3kHz and 5MHz**
	This standard provides recommendations to minimize aversive or painful electrostimulation in the frequency range of 3kHz to 5MHz and to protect against adverse heating in the frequency range of 100kHz to 300GHz. In the transition region of 100kHz to 5MHz, protection against both electrostimulation and thermal effects is provided through two separate sets of limits. Below 100kHz only the electrostimulation limits apply, above 5MHz only the thermal limits apply, and both sets of limits apply in the transition region. In the transition region, where both sets of limits apply, the limits based on electrostimulation will generally be more limiting for low duty cycle exposures, while the thermal-based limits will be more limiting for continuous wave fields.
	4.1.1 BRs: *in situ* electric field
Basic restrictions refer to limits on the *in situ* electrical forces that adequately avoid adverse effects.	For human exposure to electromagnetic energy at frequencies from 3kHz to 5MHz, the basic restrictions refer to limits on the *in situ*

	electric fields that minimize adverse effects associated with electrostimulation.
Such restrictions are derived with consideration of adverse electrical thresholds, their distribution among the population, and safety factors	“ “
(See Clause 6)	, as documented in IEEE Std C95.6-2002
Table 1 lists basic restrictions for particular areas of the body in terms of the electric field within the biological medium.	Table 1 lists basic restrictions for particular areas of the body in terms of the electric field within the biological tissue (*in situ*). The listed parameters apply to frequencies above and below 3kHz to show continuity with standards adopted below 3kHz, i.e., IEEE Std C95.6-2002.
Two parameters are listed in the table: the rheobase *in situ* field, E_0, and a frequency parameter, f_e. Limits are determined from table 1 as shown in Equation (1a) and Equation (1b):	Two parameters are listed in the table: the rheobase *in situ* field, E_0, and a frequency parameter, f_e. Limits are determined from table 1 as:
$E_i = E_0$ for $f \le f_e$ $E_i = E_0 (f/f_e)$ for $f \ge f_e$ where E_i is the maximum allowed induced in situ field.	“ “
The basic restrictions on the *in situ* electric field apply to an arithmetic average determined over a straight line segment of 0.5cm length oriented in any direction within the tissue identified in Table 1.	“ “
For frequencies above 10Hz, a basic restriction on the *in situ* magnetic field is not specified in this standard.	The averaging time for an rms measurement is 0.2s. Basic restrictions expressed in Equation (1) apply to frequencies in the range of 0 to 5 MHz.
Table 1 – Basic restrictions applying to various regions of the body [a, b]	**Table 1 – BRs applying to various regions of the body**

Exposed tissue	**f_e (Hz)**	**General public**	**Controlled environment**
		(E_0 – rms V/m)	**(E_0 – rms V/m)**
Brain	20	5.89×10^{-3}	1.77×10^{-2}
Heart	167	0.943	0.943
Hands, wrists, feet and ankles	3350	2.10	2.10

		Action level[a]	**Persons in controlled environments**
Exposed tissue	f_e (Hz)	E_0 (rms) (V/m)	E_0 (rms) (V/m)
Brain	20	5.89×10^{-3}	1.77×10^{-2}
Heart	167	0.943	0.943
Extremities	3350	2.10	2.10

Other tissue	3350	0.701	2.10

[a] Interpretation of table is as follows: $E_i = E_0$ for $f \le f_e$; $E_i = E_0 (f/f_e)$ for $f \ge f_e$

[b] In addition to the listed restrictions, exposure of the head and torso to magnetic fields below 10 Hz shall be restricted to a peak value of 167 mT for the general public, and 500 mT in the controlled environment

Other tissues	3350	0.701	2.10

[a] Within this frequency range the term "action level" is equivalent to the term "general public" in IEEE Std C95.6-2002.

NOTE – Entries in Table 1 and elsewhere in this standard are sometimes given to three significant digits. This degree of precision is provided so that the reader can follow the various derivations and relationships presented in this standard, and does not imply that the numerical quantities are known to that precision.

5.2 Maximum permissible exposure (MPE) values: Magnetic flux density

4.1.2 MPE for the magnetic field

5.2.1 Exposure of the head and torso to sinusoidal fields

4.1.2.1 Exposure of the head and torso to sinusoidal magnetic fields

Table 2 lists maximum permissible magnetic field limits (flux density, *B*, and magnetic field strength, *H*) for exposure of the head and torso. The averaging time for an rms measure is 0.2 seconds for frequencies above 25Hz. For lower frequencies, the averaging time is such that at least 5 cycles are included in the average, but with a maximum of 10 seconds.

Table 2 lists maximum permissible magnetic field limits (flux density, *B*, and magnetic field strength, *H*) for exposure of the head and torso. The averaging time for an rms measurement is 0.2 second.

Table 2 – Magnetic maximum permissible exposure (MPE) levels: exposure of head and torso[a, b]

	General public		Controlled environment	
Frequency range (Hz)	***B* – rms (mT)**	***H* – rms (A/m)**	***B* – rms (mT)**	***H* – rms (A/m)**
< 0.153	118	9.36 x 104	353	2.81 x 105
0.153-20	18.1/*f*	1.44 x 104/*f*	54.3/*f*	4.32 x 104/*f*
20-759	0.904	719	2.71	2.16 x 103
759-3000	687/*f*	5.47 x 105/*f*	2060/*f*	1.64x106/*f*

[a] *f* is frequency in Hz.

[b] MPEs refer to spatial maximum

Table 2 – MPE for exposure of head and torso: *f* = 3 kHz to 5MHz

Frequency range (Hz)	**General public**		**Controlled environment**	
	***B* – rms (mT)**	***H* – rms (A/m)**	***B* – rms (mT)**	***H* – rms (A/m)**
3.0-3.35	0.687/*f*	547/*f*	2.06/*f*	1640/*f*
3.35-5000	0.205	163	0.615	490

NOTE – *f* is expressed in kHz

[a] Within this frequency range the term "action level" is equivalent to the term "general public" in IEEE Std C95.6-2002

NOTE – The MPEs in Table 2 minimize adverse effects associated

	with electrostimulation; tables 8 and 9 apply to effects associated with tissue heating. All three tables must be considered and the corresponding values for the appropriate tier satisfied at all applicable frequencies.
Compliance with Table 2 ensures compliance with the basic restrictions of Table 1. However, lack of compliance with Table 2 does not necessarily indicate lack of compliance with the basic restrictions, but rather that it may be necessary to evaluate whether the basic restrictions have been met.	“ “
	This would typically be done using analytical methods.
If the basic restrictions for Table 1 are not exceeded, then the MPE values in Table 2 can be exceeded. Consequently, it is sufficient to demonstrate compliance with either Table 1 or Table 2.	“ “
For purposes of demonstrating compliance with this standard, Table 2 and Table 4 shall be considered separately, and not additively. Entries in Table 1 and elsewhere in this standard are sometimes given to three significant digits. This degree of precision is provided so that the reader can follow the various derivations and relationships presented in this standard and does not imply that the numerical quantities are known to that precision.	--
5.2.2 Nonuniform exposure to sinusoidal magnetic fields	**4.1.2.2 Non-uniform exposure to sinusoidal magnetic fields**
When the magnetic field is not constant in magnitude, direction or relative phase over the head and torso, the maximum field over the head and torso shall be limited to the levels in Table 2. Alternatively, it shall be permitted to demonstrate adherence to the basic restrictions.	When the magnetic field is not constant in magnitude, direction or relative phase over the head, torso, or limbs, the maximum field over the head, torso, or limbs shall be limited to the levels in Table 2. Alternatively, it shall be permitted to demonstrate adherence to the basic restrictions.
5.2.3 Exposure of the arms or legs	**4.1.2.3. Exposure of the limbs**
Maximum permissible exposure (MPE) levels for the arms or legs are listed in Table 3. Compliance with Table 3 ensures compliance with the basic limitations of Table 1. However, lack of compliance with Table 3 does not necessarily imply lack of compliance with the basic	The MPEs for the limbs (entire arms and legs) are listed in Table 3. The averaging time for an rms measurement is 0.2 s. Compliance with Table 3 ensures compliance with the basic limitations of Table 1. However, lack of compliance with Table 3 does not necessarily imply

<table>
<tr><td>restrictions, but rather that it may be necessary to evaluate whether the basic restrictions are met.</td><td>lack of compliance with the basic restrictions, but rather that it may be necessary to evaluate whether the basic restrictions are met.</td></tr>
<tr><td>Table 3 – Magnetic flux density maximum permissible exposure levels: exposure of arms or legs [a]</td><td>Table 3 – MPE for the limbs: f = 3kHz to 5 MHz</td></tr>
<tr><td>
<table>
<tr><th>Frequency range (Hz)</th><th>General public B – rms (mT)</th><th>Controlled environment B – rms (mT)</th></tr>
<tr><td>< 10.7</td><td>353</td><td>353</td></tr>
<tr><td>10.7 - 3000</td><td>3790 / f</td><td>3790 / f</td></tr>
</table>
[a] f is frequency in Hz
</td><td>
<table>
<tr><th rowspan="2">Frequency range (kHz)</th><th colspan="2">Action level[a]</th><th colspan="2">Persons in controlled environments</th></tr>
<tr><th>B_{rms} (mT)</th><th>H_{rms} (A/m)</th><th>B_{rms} (mT)</th><th>H_{rms} (A/m)</th></tr>
<tr><td>3.0-3.35</td><td>3.79/f</td><td>3016/f</td><td>3.79/f</td><td>3016/f</td></tr>
<tr><td>3.35-5000</td><td>1.13</td><td>900</td><td>1.13</td><td>900</td></tr>
<tr><td colspan="5">NOTE – f is expressed in kHz.</td></tr>
<tr><td colspan="5">[a] Within this frequency range the term “action level” is equivalent to the term “general public” in IEEE Std C95.6-2002.</td></tr>
</table>
</td></tr>
<tr><td>5.2.4 Pulsed or nonsinusoidal fields</td><td>4.1.2.4 Pulsed or non-sinusoidal magnetic fields</td></tr>
<tr><td>When the magnetic flex density waveform is nonsinusoidal, maximum permissible exposure shall conform to the rms limits of Table 1 or Table 2. In addition, maximum exposure limits shall conform to either 5.2.4.1 or 5.2.4.2. Since both criteria are conservative, adherence to either is sufficient to demonstrate compliance with maximum permissible exposure limits or the basic restrictions.</td><td>When the magnetic flex density waveform is nonsinusoidal, maximum permissible exposure shall conform to the rms limits of Table 3. In addition, maximum exposure limits shall conform to either 4.1.2.4.1 or 4.1.2.4.2 Since both criteria are conservative, adherence to either is sufficient to demonstrate compliance with MPEs or BRs.</td></tr>
<tr><td>5.2.4.1 Restriction based on peak field</td><td>4.1.2.4.1 Restriction based on peak (temporal) field</td></tr>
<tr><td>Demonstration of compliance with either of the following two subclauses is sufficient to demonstrate compliance with restrictions based on the peak field. Subclause 5.2.4.1.1. applies to the in situ induced electric field. Subclause 5.2.4.1.2. applies to the environmental field.</td><td>Demonstration of compliance with either 4.1.2.4.1.1. or 4.1.2.4.1.2 is sufficient to demonstrate compliance with restrictions based on the temporal peak field. Subclause 4.1.2.4.1.1 applied to the in situ induced electric field; 4.1.2.4.1.2 applies to the external field.</td></tr>
<tr><td>5.2.4.1.1 Peak in situ field</td><td>4.1.2.4.1.1 Peak in situ electric field</td></tr>
<tr><td>The peak in situ electric field shall be restricted to a value obtained by multiplying the rms limits of Table 1 by √2. To interpret this table for non-sinusoidal waveforms, frequency, f, is defined as $f = 1/(2t_p)$, where t_p is the phase duration of a peak excursion of the in situ electric field. Phase duration is defined as time between zero crossings of a waveform having zero mean. For an exponential waveform, t_p is</td><td>The temporal peak of the in situ electric field shall be restricted to a value obtained by multiplying the rms limits of Table 1 by √2. To interpret this table for non-sinusoidal waveforms, frequency, f, is defined as $f = 1/(2t_p)$, where t_p is the phase duration of a peak excursion of the in situ electric field. Phase duration is defined as the time between zero crossings of a waveform. For an exponential</td></tr>
</table>

interpreted as the duration measured from the waveform peak to a point at which it decays to 0.37 (e^{-1}) of its peak value. Peak limits apply to instantaneous values measured through a bandwidth from zero to the highest frequency content of the waveform under consideration.	waveform, t_p is interpreted as the duration measured from the waveform peak to a point at which it decays to e^{-1} (~36.8%) of its peak value. Peak limits apply to instantaneous values measured through a bandwidth from zero to the highest frequency content of the waveform under consideration.
5.2.4.1.2 Peak environmental field	**4.1.2.4.1.2 Peak external field**
The peak environmental magnetic field, *B*, shall be limited according to the following procedure, where *B* is a time-varying flux density waveform whose compliance is under question.	The temporal peak of the external magnetic field, *B*, shall be limited according to the following procedure, where *B* is a time-varying flux density waveform whose compliance is under evaluation. For conversion of magnetic field intensity, *H*, to magnetic flux density, *B*, note that $B = 4\pi \times 10^{-7} H$.
a) Determine the time derivative of the environmental field, $dB/dT = B$	a) Determine the time derivative of the external field, $dB/dT = B$
b) Identify the peak and phase duration of any excursion of *B*. Phase duration shall be determined as in 5.2.4.1.1.	b) Identify the peak and phase duration of any excursion of *B*. Phase duration shall be determined as in 4.2.1.4.1.1.
c) Determine the allowable peak limit on *B* from Table 2 as $B_p = \sqrt{2}\, MPE_B(2\pi f)$ where B_p is the maximum permissible value of *B*, MPE_B is the flux density consistent with Table 2 and Table 3, $f = 1/(2t_p)$ and t_p is the phase duration of *B*.	
5.2.4.2 Restriction based on Fourier components	**4.1.2.4.2 Restriction based on Fourier components**
For an exposure waveform consisting of multiple frequencies, a test for compliance of the exposure waveform shall satisfy the following criterion: $\sum_{0}^{5\text{MHz}} \frac{A_i}{ME_i} \le 1$ where A_i is the magnitude of the *i*th Fourier component of the exposure waveform.	For an exposure waveform consisting of multiple frequencies, a test for compliance of the exposure waveform shall satisfy the following criterion: $\sum_{0}^{5\text{MHz}} \frac{A_i}{MPE_i} \le 1$ where A_i is the magnitude of the *i*th Fourier component of the exposure waveform, and *MPEi* is the maximum permissible exposure (Table 2

ME_i is the maximum permissible exposure or the basic *in situ* field restriction with a single sinusoidal waveform at a frequency f_i. The summation is carried out from the lowest frequency of the exposure waveform, to a maximum frequency of 5MHz. Note that A_i and ME_i must measure the same quantity, as well as be in the same units. For instance, if Ai is the magnitude of a flux density waveform, then ME_i must also be a measure of flux density. Alternatively, both A_i and ME_i could be measures of the tie derivative of the field, the induced *in situ* electric field, or induced current density.	or Table 3) or the basic *in situ* field restriction (Table 1) for a single sinusoidal waveform at a frequency f_i. The summation is carried out from the lowest frequency of the exposure waveform to a maximum frequency of 5 MHz. Note that A_i and MPE_i must measure the same quantity, as well as be in the same units. For instance, if A_i is the magnitude of a flux density, then *MPEi* must also be a measure of flux density. Alternatively, both A_i and MPE_i could be measures of the time derivative of the field, the induced in situ electric field, or induced current density.
It may be necessary to evaluate Equation (2) at frequencies outside the limits of this standard. For purposes of such evaluation, the ME_i values applying to frequencies greater than 3 kHz shall be determined as follows. a) *Basic restrictions* (Table 1). Rheobase values of the *in situ* electric field (E_{ob}) shall be assumed for frequencies from f_e to 5MHz. b) *Magnetic field MPEs* (Table 2 and Table 3). The MPE value of *B* or *H* shall be determined to a maximum frequency of 3350 Hz using the formulae listed in the last row of the table. From 3350Hz-5 MHz, the MPE value shall equal that at 3350 Hz. c) *Electric field MPEs* (Table 4). The MPE value applicable to 3000 Hz shall be assumed to a maximum frequency of 5 MHz. d) *Induced and contact current MPEs* (Table 5). The MPE value listed at 3000 Hz shall be extrapolated to a maximum frequency of 5 MHz using the relationship: $MPE_i = MPE_{3000}$ (f/3000) where MPE_i is the limit at the appropriate frequency between 3 kHz and 5 MHz, MPE_{3000} is the limit at 3000 Hz, and f is the frequency in Hz.	It may be necessary to evaluate Equation (2) at frequencies outside the limits of this standard. For purposes of such evaluation, the ME_i values applying to frequencies greater than 3 kHz shall be determined as follows. a) *Basic restrictions* (Table 1). The BRs from 0Hz to 3 kHz shall be determined as given in Table 1. b) *Magnetic field MPEs* (Table 2 and Table 3). The MPE for *B* or *H* below 3kHz shall be determined as given in IEEE Std C95.6-2002. c) *Electric field MPEs* (Table 4). The MPE for the external electric field below 3kHz shall be determined as given in IEEE Std C95.6-2002. The MPE applicable to 3kHz shall be assumed up to a maximum frequency of 5 MHz. d) *Induced and contact current MPEs* (Table 5). Values of induced and contact current below 3 kHz shall be determined as given in IEEE Std C95.6-2002.
5.3. Maximum permissible exposure values: environmental	**4.1.3.MPE for the external electric field**

electric fields

5.3.1 Constant whole-body exposure to sinusoidal electric fields

Table 4 lists maximum electric field limits in terms of the undisturbed (absent a person) environmental field, *E*. It is assumed that the undisturbed field is constant in magnitude, direction, and relative phase over a spatial extent that would fit the human body. The averaging time for an rms measure shall be 0.2 seconds for frequencies above 25 Hz. For lower frequencies, the averaging time is such that at least 5 cycles are included, with a maximum of 10 seconds. For a controlled environment in which an exposed individual is not within reach of a grounded object, it may be acceptable to exceed the limits listed in Table 4. This standard does not specify limits for situations involving contact with ungrounded objects.

For purposes of demonstrating compliance with this standard, Table 2 and Table 4 shall be considered separately, and not additively.

Table 4—Environmental electric field MPEs, whole body exposure

General public		Controlled environment	
Frequency range (Hz)	**E – rms (V/m)**	**Frequency range (Hz)**	**E – rms (V/m)**
1-368[c]	5000[a,d]	1-272[c]	20000[b,e]
368-3000	1.84 x 106/*f*	272-3000	5.44 x 106/*f*
3000	614	3000	1813

[a] Within power line rights-of-way, the MPE for the general public is 10 kV/m under normal load conditions.
[b] Painful discharges are readily encountered at 20 kV/m and are possible at 5-10 kV/m without protective measures.
[c] Limits below 1 Hz are not less than those specified at 1 Hz
[d] At 5 kV/m induced spark discharges will be painful to approximately 7% of adults (well-insulated individual touching ground)

4.1.3.1. Uniform whole-body exposure to sinusoidal electric fields

Table 4 lists MPEs in terms of the undisturbed (absent a person) external electric field, *E*. It is assumed that the undisturbed field is constant in magnitude, direction, and relative phase over a spatial extent that would encompass the human body. The averaging time for an rms measurement shall be 0.2 s. For a controlled environment in which an exposed individual is not within reach of a grounded object, it may be acceptable to exceed the MPEs in Table 4. This standard does not specify limits for situations involving contact with ungrounded objects, e.g. , a person above ground on an elevated, insulated platform. (See Annex C.)

Table 4—Electric field MPE – whole body exposure: f = 3 kHz to 100 kHz

	Action level [a]	**Persons in controlled environments**
Frequency range (kHz)	**E (rms) (V/m)**	**E (rms) (V/m)**
3 kHz to 100 kHz	614	1842

[a] Within this frequency range the term “action level” is equivalent to the term “general public” in IEEE Std C95.6-2002

[e] The limit of 20 000 V/m may be exceeded in the controlled environment when a worker is not within reach of a grounded conducting object. A specific limit is not provided in this standard.	
5.3.2 Nonuniform or partial body exposure to sinusoidal electric fields	**4.1.3.2 Non-uniform or localised exposure to sinusoidal electric fields**
When the environmental electric field is not constant in magnitude, direction, and relative phase over the dimensions of the human body, the average environmental field shall be restricted to the levels in Table 4. For a controlled environment in which an exposed individual is not within reach of a grounded conducting object, it may be acceptable to exceed the limits listed in Table 4. This standard does not specify limits for such cases. In no case shall the basic limitations of Table 1 or the contact current limits of Table 5 be exceeded.	When the environmental electric field is not constant in magnitude, direction, and relative phase over the dimensions of the human body, the average environmental field shall be restricted to the levels in Table 4. For a controlled environment in which an exposed individual is not within reach of a grounded conducting object, it may be acceptable to exceed the limits listed in Table 4. This standard does not specify limits for such cases. In no case shall the BRs of Table 1 or the contact current limits of Table 5 be exceeded.
5.3.3 Pulsed or nonsinusoidal fields	**4.1.3.3 Pulsed or non-sinusoidal electric fields**
When the waveform of the electric field is nonsinusoidal, such as with pulsed or mixed frequency waveforms, MPE limits shall conform to the rms limits of Table 4 and also to either of the criteria stated in 5.2.4.1 and 5.2.4.2. For this application, the environmental magnetic field is replaced by the undisturbed electric field, A_i is understood to represent the magnitude of the *i*th Fourier component of the environmental electric field waveform, and ME_i is the maximum permissible electric field magnitude at frequency f_i.	When the waveform of the external electric field is non-sinusoidal, such as with pulsed or mixed frequency waveforms, the rms value of the spatially averaged external field shall conform to the MPEs of Table 4, and also to either of the criteria stated in 4.1.2.4.1 and 4.1.2.4.2. For this application, the external magnetic field is replaced by the undisturbed electric field; A_i is understood to represent the magnitude of the ith Fourier component of the external electric field waveform, and MPE_i is the maximum permissible electric field magnitude at frequency f_i.
With respect to electric field exposure, 5.2.4.1.2 and 5.2.4.2 shall apply to frequencies from 368-3000 Hz for the general public, and from 272-3000 Hz in controlled environments. Below those frequencies and above 1 Hz, peak electric fields shall not exceed 7100 and 28000 V/m for the general public and controlled environments, respectively, and 14100 V/m for the general public within powerline rights-of-way.	--
5.4 Contact and induced current maximum permissible exposure limits	**4.1.4 Contact and induced current limits**

5.4.1 Sinusoidal current	4.1.4.1 Sinusoidal current
Contact current shall be limited as indicated in Table 5, subject tot he following conditions: a) Table 5 limits for freestanding individuals without contact with metallic objects shall not exceed the values listed in the rows labeled “Both feet” and “Each foot”. b) Contact limits in Table 6 assume a freestanding individual who is insulated from ground while touching a conductive path to ground. The criteria do not necessarily protect against aversive sensations from spark discharges just prior to and just after the moment of direct contact with the ground path. c) The averaging time for rms current measurements shall be 0.2 seconds for frequencies above 25 Hz. For lower frequencies, the averaging time shall include at least 5 cycles, with a maximum of ten seconds. The limits for peak exposure refer to instantaneous values measured through a bandwidth from zero to the highest frequency of interest. d) In controlled environments, limits for grasp contacts apply where personnel are trained to make grasping contact and to avoid touch contacts with conductive objects that present the possibility of painful contact current. A grasp contact area is assumed to be 15 cm^2. The use of protective gloves, the prohibition of metallic objects, or training of personnel may be sufficient to assure compliance with contact current MPE in controlled environments. For the general public, it is assumed that access, methods of contact, and protective measures are unconstrained. e) for the general public, a touch contact is assumed to have a contact area of 1 cm^2.	Contact current shall be limited as indicated in Table 5, subject tot he following conditions: a) Table 5 limits for freestanding individual without contact with conducting objects shall not exceed the induced current values listed in the rows labeled “Both feet” and “Each foot”. b) Contact limits in Table 5 assume a freestanding individual who is insulated from ground while touching a conductive path to ground. The criteria do not necessarily protect against aversive sensations from spark discharges just prior to, and just after the moment of direct contact with the ground path. c) The averaging time for rms current measurements shall be 0.2 s. The limits for peak exposure refer to instantaneous values measured through a bandwidth from zero to the maximum frequency determined by Fourier decomposition of the waveform of interest. d) In controlled environments, limits for grasping contacts apply where personnel are trained to make grasping contact and to avoid touch contacts with conductive objects that present the possibility of painful contact current. A grasp contact area is assumed to be 15 cm^2. The use of protective gloves, the prohibition of metallic objects, or the training of personnel may be sufficient to assure compliance with the contact current limit in controlled environments. For the general public, it is assumed that access, methods of contact, and protective measures are unconstrained. e) A touch contact is assumed to have a contact area of 1cm^2. f) For long exposure duration (t >> 1s), the values of induced and contact currents in Table 7 for protecting against heating effects in the RF range, are more restrictive than the corresponding values of currents in Table 5 for frequencies

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<td>greater than 100 kHz. Hence, for long exposure duration, compliance with this standard at frequencies greater than 100kHz will be associated with meeting the limits of Table 7.
g) The limits in table 5 protect against adverse electrostimulation effects; the MPEs in Table 8 and Table 9 apply to effects associated with tissue heating.

NOTE—All three tables must be considered the corresponding values for the appropriate exposure group satisfied at all applicable frequencies.</td>
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<tr>
<td>Table 5 – Induced and contact current MPEs (mA-rms) for continuous sinusoidal waveforms, 0-3 kHz [a, b]</td>
<td>Table 5 – Induced and contact current MPEs (mA-rms) for continuous sinusoidal waveforms, f = 3kHz to 100 kHz</td>
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<tr>
<td>
<table>
<tr><th>Condition</th><th>General public (mA, rms)</th><th>Controlled environment (mA, rms)</th></tr>
<tr><td>Both feet</td><td>2.70</td><td>6.0</td></tr>
<tr><td>Each foot</td><td>1.35</td><td>3.0</td></tr>
<tr><td>Contact, grasp</td><td>--</td><td>3.0</td></tr>
<tr><td>Contact, touch</td><td>0.50</td><td>1.5</td></tr>
</table>
[a] Grasping contact limit pertains to controlled environments where personnel are trained to effect grasping contact and to avoid touch contacts with conductive objects that present the possibility of painful contact.
[b] Limits apply to current flowing between body and grounded object that may be contacted by the person.
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<table>
<tr><th>Condition</th><th>Action level [a] (mA)</th><th>Persons in controlled environments (mA)</th></tr>
<tr><td>Both feet</td><td>0.90f</td><td>2.00f</td></tr>
<tr><td>Each foot</td><td>0.45f</td><td>1.00f</td></tr>
<tr><td>Contact, grasp [b]</td><td>--</td><td>1.00f</td></tr>
<tr><td>Contact, touch</td><td>0.167f</td><td>0.50f</td></tr>
<tr><td colspan="3">NOTE 1 – f is expressed in kHz.</td></tr>
<tr><td colspan="3">NOTE 2 – Limits apply to current flowing between the body and a grounded object that may be contacted by the person.</td></tr>
<tr><td colspan="3">NOTE 3 – The averaging time for determination of compliance is 0.2 s.</td></tr>
<tr><td colspan="3">[a] Within this frequency range the term “action level’ is equivalent to the term “general public” in IEEE Std C95.6-2002.</td></tr>
<tr><td colspan="3">[b] The grasping contact limit pertains to controlled environments where personnel are trained to make grasping contact and to avoid touch contacts with conductive objects that present the possibility of painful contact.</td></tr>
</table>
</td>
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<tr>
<td>5.4.2 Nonsinusoidal (pulsed or mixed frequency) current</td>
<td>4.1.4.2 Non-sinusoidal (pulsed or mixed frequency) current</td>
</tr>
<tr>
<td>When the current waveform is nonsinusoidal, such as with pulsed or</td>
<td>When the current waveform is non-sinusoidal, such as with pulsed or</td>
</tr>
</table>

mixed frequency waveforms, MPE limits shall conform to the rms limits of Table 5 and also to either of the criteria stated in 5.2.4.1 and 5.2.4.2. For this application, the environmental field is replaced by the applied current, A_i is understood to represent the magnitude of the *i*th Fourier component of the current waveform, and *ME*i is the maximum permissible current magnitude at frequency f_i.	mixed frequency waveforms, exposure shall conform to the rms MPEs of Table 5, and also to either of the criteria stated in 4.1.2.4.1 and 4.1.2.4.2. For this application, the external field is replaced by the applied current, A_i is understood to represent the magnitude of the ith Fourier component of the current waveform, and MPE_i is the maximum permissible current magnitude at frequency f_i.