Radiocommunications (Electromagnetic Radiation — Human Exposure) Standard 2003

as amended

made under section 162 of the

Radiocommunications Act 1992

This compilation was prepared on 22 March 2011
taking into account amendments up to *Radiocommunications (Electromagnetic Radiation — Human Exposure) Amendment Standard 2011 (No. 2)*

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Page

Contents

1 Name of Standard [see Note 1]

This Standard is the *Radiocommunications (Electromagnetic Radiation — Human Exposure) Standard 2003*.

2 Commencement

This Standard commences on 1 March 2003.

3 Revocation

The *Radiocommunications (Electromagnetic Radiation — Human Exposure) Standard 2001* is revoked.

4 Object of Standard

This Standard regulates the performance of particular radiocommunications transmitters, to protect the health and safety of persons exposed to electromagnetic radiation from the transmitters.

5 Definitions

(1) In this Standard:

Act means the *Radiocommunications Act 1992*.

ARPANSA Standard means the *Radiation Protection Standard for Maximum Exposure Levels to Radiofrequency Fields – 3 kHz to 300 GHz* published by the Australian Radiation Protection and Nuclear Safety Agency and assigned the number ISBN 0-0642-79400-6.

Note The ARPANSA Standard may be obtained from the Australian Radiation Protection and Nuclear Safety Agency website http://www.arpansa.gov.au .

AS 2772.2 means the Australian Standard *Radiofrequency radiation Part 2: Principles and methods of measurement – 300 kHz to 100 GHz* (AS 2772.2) published by Standards Australia.

aware user device means a hand-held or body-worn radiocommunications transmitter that operates on a push-to-talk basis and is intended for use as:

(a) an ambulatory station; or

(b) a land mobile system station; or

(c) a maritime ship station; or

(d) a citizens band radio station; or

(e) an amateur station.

basic restrictions means the restrictions in Tables 2 and 6, including the notes to Table 2 and 6, of section 2.3 of the ARPANSA standard.

device means a mobile station that section 6 or 8 of this Standard apply to.

EN 50361 means the *Basic standard for the measurement of Specific Absorption Rate related to human exposure to electromagnetic fields from mobile phones – 300MHz to 3GHz* (BS EN 50361:2001) published by the British Standards Institution (BSI) and assigned the number ISBN 0 580 38460 8.

EN 62209-1 means *Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices — Human models, instrumentation, and procedures — Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)*, published by the European Committee for Electrotechnical Standardisation (CENELEC).

Note EN 62209-1 is a European Union harmonised standard based on IEC 62209-1, a standard developed by Technical Committee TC106 of the International Electrotechnical Commission (IEC). Australia has active representation on TC106 through the participation of Standards Australia (http://www.standards.org.au/).

EN 62209-2 means *Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices — Human models, instrumentation, and procedures — Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)*, published by the European Committee for Electrotechnical Standardisation (CENELEC).

Note EN 62209-2 is a European Union harmonised standard based on IEC 62209-2, a standard developed by Technical Committee TC 106 of the International Electrotechnical Commission (IEC). Australia has active representation on TC 106 through the participation of Standards Australia (http://www.standards.org.au/).

human body means the head, neck and trunk but not the limbs.

IEC 62209-1 means *Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices — Human models, instrumentation, and procedures — Part 1: Procedure to determine the specific absorption rate (SAR) for hand-held devices used in close proximity to the ear (frequency range of 300 MHz to 3 GHz)*, published by the International Electrotechnical Commission (IEC).

Note IEC 62209-1 was developed by Technical Committee TC106 of the International Electrotechnical Commission (IEC). Australia has active representation on TC106 through the participation of Standards Australia (http://www.standards.org.au/).

IEC 62209-2 means *Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices — Human models, instrumentation, and procedures — Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)*, published by the International Electrotechnical Commission (IEC).

Note IEC 62209-2 was developed by Technical Committee TC106 of the International Electrotechnical Commission (IEC). Australia has active representation on TC106 through the participation of Standards Australia (http://www.standards.org.au/).

integral antenna means an antenna:

(a) permanently attached to equipment; or

(b) intended for direct attachment to a fixed connector on equipment, without the use of an external cable.

mobile station means a radiocommunications transmitter that is established for use:

(a) in motion, on land, water or in the air; or

(b) in a stationary position at unspecified points on land, water or in the air.

Examples of a mobile station

1 A wireless modem operating in a laptop computer.

2 A hand–held cellular or PCS telephone with a radiating antenna in the handpiece.

non-aware user device means a device other than an aware user device.

normal position of use, of a device, means:

(a) the position specified in the measurement method applicable to the device under section 10, 11 or 12; or

(b) if paragraph (a) does not apply, the common use spatial orientation of the device with respect to the user; or

(c) if paragraphs (a) and (b) do not apply, the spatial orientation of the device with respect to the user defined by the manufacturer.

old standard means the *Radiocommunications (Electromagnetic Radiation — Human Exposure) Standard 2003* as in force immediately before 1 April 2007.

reference levels means the reference levels in Table 7 and 8, including the notes to Table 7 and 8, of section 2.4 of the ARPANSA standard.

RF field means a physical field that specifies the electric and magnetic states of a medium or free space, quantified by the vectors representing the electric field and the magnetic field.

SAR means Specific Absorption Rate.

(2) A reference in this Standard to a publication or other document of:

(a) Standards Australia; or

(b) the British Standards Institution; or

(c) the European Committee for Electrotechnical Standardisation;

includes a reference to the publication or other document as in force from time to time.

(3) A term that is:

(a) used (but not defined) in this Standard; and

(b) defined in the Glossary of the ARPANSA standard;

has the meaning given by the Glossary.

6 Application of Standard: general

(1) This Standard applies to a mobile station that:

(a) on or after 1 April 2007, is:

(i) manufactured or imported; or

(ii) first offered for supply; or

(iii) altered or modified in a material respect; and

(b) is capable of operating in the frequency band 100kHz to 300GHz (inclusive); and

(c) has an integral antenna; and

(d) is not intended to be used as an Emergency Position Indicating Radio Beacon (EPIRB) or distress beacon.

(2) However, this Standard does not apply to a mobile station that is:

(a) used solely as equipment, or as part of a weapons system, used by the Defence Force; or

(b) used solely as equipment, or as part of a weapons system, used by the defence force of another country that is conducting operations with the Defence Force; or

(c) used solely for law enforcement activities by any of the following bodies:

(i) the Australian Federal Police;

(ii) the National Crime Authority;

(iii) the New South Wales Crime Commission;

(iv) the Independent Commission Against Corruption of New South Wales;

(v) the Criminal Justice Commission of Queensland; or

(d) used solely for law enforcement activities by a body that:

(i) is not mentioned in paragraph (c); and

(ii) is responsible for criminal law enforcement, and established by or under a law of the Commonwealth, a State or a Territory; or

(e) used solely for law enforcement activities by a body that:

(i) is not mentioned in paragraph (c); and

(ii) provides support for law enforcement in Australia; and

(iii) is responsible or accountable to the Australian Police Ministers' Council for the performance of that function; or

(f) an aware user device or non-aware user device that is not mentioned in subsection 10 (1), 11 (1) or 12 (1).

Note 1 Exemptions from the operation of the Act are also provided for in:

(a) the Act (subsections 24 (1) and (2) and section 25); and

(b) the *Radiocommunications Regulations 1993* (regulation 6).

The exemptions relate to activities of the Defence Force, the Australian Security Intelligence Service and the Australian Security Intelligence Organisation.

Note 2 The application of this Standard to a device under this section is not relevant to the definition of ***non-standard*** device in section 9 of the Act because the status of the device (as standard or non-standard) was established when the device was last manufactured, imported, altered or modified.

7 Transitional arrangements on and after 1 April 2007

On and after 1 April 2007, the old standard continues to apply to a mobile station if:

(a) the device is not equipment to which this Standard applies under section 6; and

(b) the old standard applied to the device immediately before 1 April 2007.

Note 1 The continued application of this Standard to a device under this section is not relevant to the definition of ***non-standard device*** in section 9 of the Act because the status of the device (as standard or non-standard) was established when the device was last manufactured, imported, altered or modified.

Note 2 For paragraph (a) a device that was manufactured, imported, altered or modified before 1 April 2007 is equipment to which this Standard does not apply under section 6.

9 Performance standards

(1) For paragraph 162 (1) (a) of the *Radiocommunications Act 1992*, the standard for performance for an aware user device to which subsection 6 (1) of this Standard applies is that the device must not expose the user to electromagnetic radiation at a level greater than the basic restrictions for occupational exposure when the device is used in its normal position of use.

(2) For paragraph 162 (1) (a) of the *Radiocommunications Act 1992*, the standard for performance for a non–aware user device to which subsection 6 (1) of this Standard applies is that the non–aware user device must not expose the user to electromagnetic radiation at a level greater than the basic restrictions for general public exposure when the device is used in its normal position of use.

10 Measurement methods for performance standards: aware user device or non-aware user device in close proximity to the human ear

(1) This section applies to an aware user device or non-aware user device to which this Standard applies that:

(a) is designed to be used, or held with the radiating part of the aware user device or non-aware user device in close proximity to the human ear; and

(b) transmits on a frequency in the frequency band 300MHz to 3GHz (inclusive).

(2) The measurements to determine if the aware user device or non-aware user device meets the standard for performance in subsection 9 (1) or 9 (2) are the measurements identified in the table.

Item	For the period ...	The measurements are the measurements in ...
1	before 1 March 2009	Schedule 2 or EN 50361or EN 62209-1
2	beginning on 1 March 2009 and ending on 31 January 2011	EN 62209-1
3	beginning on 1 February 2011	EN 62209-1 or IEC 62209-1

(3) A test report must comply with the requirements in EN 62209-1 or IEC 62209-1 which contained the measurements identified in accordance with subsection (2).

11 Measurement methods for performance standards : aware user device or non–aware user device 20cm or less from the human body

(1) This section applies to an aware user device or a non–aware user device to which this Standard applies that:

(a) is designed to be used, or held with the radiating part of the aware user device or non-aware user device in close proximity to the human body but not more than 20cm from the human body; and

(b) transmits on a frequency in the frequency band 150MHz to 5.8GHz (inclusive); and

(c) is not mentioned in subsection 10 (1).

(2) The measurements to determine if the aware user device or non-aware user device meets the standard for performance in subsection 9 (1) or 9 (2) are the measurements identified in the table.

Item	For the period ...	The measurements are the measurements in ...
1	before 1 February 2011	Schedule 2
2	beginning on 1 February 2011 and ending on 31 January 2013	Schedule 2 or EN 62209-2 or IEC 62209-2
3	beginning on 1 February 2013	EN 62209-2 or IEC 62209-2

(3) A test report must comply with the requirements in Schedule 2 or EN 62209-2 or IEC 62209-2 which contained the measurements identified in accordance with subsection (2).

12 Assessment methods for performance standards: aware user devices and non-aware user devices more than 20cm from the human body

(1) This section applies to an aware user device or a non-aware user device to which this Standard applies that:

(a) is designed to be used, or held, more than 20cm from the human body; and

(b) transmits in the frequency band 300kHz to 100GHz (inclusive).

(2) The RF field produced by an aware user device or a non-aware user device, at the position of the user with the device operated at the normal position of use, must be assessed in accordance with the requirements in AS 2772.2.

(3) An aware user device is taken to meet the standard for performance of subsection 9 (1) if the RF field assessed under subsection (2) is less than the relevant reference levels for occupational exposure.

(4) A non-aware user device is taken to meet the standard for performance of subsection 9 (2) if the RF field assessed is less than the relevant reference levels for general public exposure.

Schedule 2 Measurement method for devices 20cm or less from the human body

(subsection 11 (2))

Part 1 Information for documenting SAR compliance

1.1 General

1.1.1 The information described in this Part must be included in test reports. The information is necessary to evaluate test results and to determine RF exposure compliance.

1.2 Information on test device and exposure categories

1.2.1 The following information on test device operating configurations and test conditions for SAR measurements must be included in a test report:

(a) a description of the device, including model number where applicable;

(b) a brief description of the test device operating configurations; including:

(i) operating modes and operating frequency range(s);

(ii) maximum conducted power for each operating mode and frequency range;

(iii) operating conducted power tolerances;

(iv) antenna type and operating positions;

(v) applicable body–worn configurations;

(vi) battery options that could affect the SAR results;

(vii) procedures used to establish the test signals;

(viii) applicable source-based time-averaging duty factor and the duty factor used in the tests;

(ix) maximum output power measured before and after each SAR test or SAR drift measurements (see 3.13.1).

1.3 Specific Information for SAR Measurements

1.3.1 The report must set out the measurement system and site description including:

(a) a brief description of the SAR measurement system;

(b) a brief description of the test set up.

1.3.2 The report must set out the electric field probe calibration including:

(a) a description of the probe, its dimensions and sensor offset etc;

(b) a description of the probe measurement uncertainty;

(c) the most recent calibration date.

1.3.3 The report must set out the SAR measurement system verification including:

(a) a brief description of the RF radiating source used to verify the SAR system performance within the operating frequency range of the test device (see Part 3);

(b) a list of the tissue dielectric parameters, ambient and tissue temperatures, output power, peak and ten-gram averaged SAR for the measured and expected target test configurations;

(c) a list of the error components contributing to the total measurement uncertainty.

1.3.4 The report must set out the phantom description including:

(a) a description of the head and body phantoms used in the tests, including shell thickness and other tolerances.

1.3.5 The report must set out the tissue dielectric property including:

(a) the composition of the ingredients for the tissue material used in the SAR tests;

(b) the tissue dielectric parameters measured at the middle of each operating frequency range of the test device;

(c) the temperature range and operating conditions of the tissue material during each SAR measurement.

1.3.6 The report must set out the positioning of the device including:

(a) a description of the dielectric holder or similar mechanisms used to position the test device in the specific test configurations;

(b) a description of the positioning procedures used to evaluate the highest exposure expected under normal operating configurations;

(c) sketches and illustrations showing the device positions, with respect to the phantom; including separation distances and angles, as appropriate;

(d) a description of the antenna operating positions, extended, retracted or stowed etc. and the configurations tested in the SAR evaluation.

1.3.7 The report must set out the peak SAR locations including:

(a) a description of the coarse resolution, surface or area scan procedures used to search for all possible peak SAR locations within the phantom;

(b) a description of the interpolation procedures applied to the measured points to identify the peak SAR locations at a finer spatial resolution;

(c) a description, illustration and SAR distribution plots showing the peak SAR locations with respect to the phantom and the test device;

(d) identify the peak SAR locations used to evaluate the highest ten-gram averaged SAR.

1.3.8 The report must set out the ten-gram averaged SAR including:

(a) a description of the fine resolution, volume or zoom scan procedures used to determine the highest ten-gram averaged SAR in the shape of a cube;

(b) a description of the extrapolation procedures used to estimate the SAR value of points close to the phantom surface that are not measurable;

(c) a description of the interpolation procedures applied to the measured and extrapolated points to obtain SAR values at a finer spatial resolution within the zoom scan volume;

(d) a description of the integration procedures applied to the interpolated SAR values within the zoom scan volume to determine the highest ten-gram SAR in the shape of a cube.

1.3.9 The report must set out the total measurement uncertainty including:

(a) a tabulated list of the error components and uncertainty values contributing to the total measurement uncertainty (see Part 3);

(b) reporting the combined standard uncertainty and expanded uncertainty (for 95% confidence interval) of each measurement.

1.3.10 The report must set out the test results for determining SAR compliance including:

(a) if the channels tested for each configuration (left, right, cheek, tilt/ear, extended, retracted etc.) have similar SAR distributions, a plot of the highest SAR for each test configuration should be sufficient; otherwise additional plots should be included to document the differences;

(b) all of the measured SAR values should be documented in a tabulated format with respect to the test configurations.

Part 2 Tissue Dielectric Parameters

2.1 General

2.1.1 The head and body tissue parameters given in this Part should be used to test transmitters operating in the cellular, PCS, U-NII, spread spectrum and other frequencies bands (See Reference [1], [3] and [4]). When a transmission band overlaps with one of the target frequencies specified in this Part, the tissue dielectric parameters of the tissue medium at the middle of a device transmission band should be within 5% of the parameters specified at that target frequency. At other frequencies, the dielectric parameters should be linearly interpolated between the closest pair of target frequencies specified in this Part to determine the applicable dielectric parameters corresponding to the middle of a device transmission band. It has been reported that a 5% tolerance in tissue parameters may not be easily achieved at certain frequencies. Under such circumstances, 10% tolerance may be used until more precise tissue recipes are available.

2.2 Tissue Dielectric Parameters for Head and Body Phantoms

2.2.1 The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 in P1528 [6] have been incorporated in the following table. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in a human head (See Reference [2]). Other head and body tissue

parameters that have not been specified in P1528 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equations described in Reference [3] and extrapolated according to the head parameters specified in P1528 [6].

Target Frequency	Head		Body	
(MHz)	ε_r	σ (S/m)	ε_r	σ (S/m)
150	52.3	0.76	61.9	0.80
300	45.3	0.87	58.2	0.92
450	43.5	0.87	56.7	0.94
835	41.5	0.90	55.2	0.97
900	41.5	0.97	55.0	1.05
915	41.5	0.98	55.0	1.06
1450	40.5	1.20	54.0	1.30
1610	40.3	1.29	53.8	1.40
1800 – 2000	40.0	1.40	53.3	1.52
2450	39.2	1.80	52.7	1.95
3000	38.5	2.40	52.0	2.73
5800	35.3	5.27	48.2	6.00

(ε_r = relative permittivity, σ = conductivity and ρ = 1000 kg/m^3)

2.3 Typical Composition of Ingredients for Liquid Tissue Phantoms

2.3.1 The following tissue formulations are provided for reference only as some of the parameters have not been thoroughly verified. The composition of ingredients may be modified accordingly to achieve the desired target tissue parameters required for routine SAR evaluation.

Ingredients (% by weight)	**Frequency (MHz)**									
	450		835		915		1900		2450	
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body
Water	38.56	51.16	41.45	52.4	41.05	56.0	54.9	40.4	62.7	73.2
Salt (NaCl)	3.95	1.49	1.45	1.4	1.35	0.76	0.18	0.5	0.5	0.04
Sugar	56.32	46.78	56.0	45.0	56.5	41.76	0.0	58.0	0.0	0.0
HEC	0.98	0.52	1.0	1.0	1.0	1.21	0.0	1.0	0.0	0.0
Bactericide	0.19	0.05	0.1	0.1	0.1	0.27	0.0	0.1	0.0	0.0

Ingredients (% by weight)	Frequency (MHz)									
	450		835		915		1900		2450	
Triton X-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.8	0.0
DGBE	0.0	0.0	0.0	0.0	0.0	0.0	44.92	0.0	0.0	26.7
Dielectric Constant	43.42	58.0	42.54	56.1	42.0	56.8	39.9	54.0	39.8	52.5
Conductivity (S/m)	0.85	0.83	0.91	0.95	1.0	1.07	1.42	1.45	1.88	1.78

Salt: 99$^+$% Pure Sodium Chloride Sugar: 98$^+$% Pure Sucrose
Water: De-ionized, 16 MΩ$^+$ resistivity HEC: Hydroxyethyl Cellulose
DGBE: 99$^+$% Di(ethylene glycol) butyl ether, [2-(2-butoxyethoxy)ethanol]
Triton X-100 (ultra pure): Polyethylene glycol mono [4-(1,1, 3, 3-tetramethylbutyl)phenyl]ether

Tissue Recipe as reported by Hartsgrove et. al. in "Simulated Biological Materials for Electromagnetic Radiation absorption Studies," Bioelectromagnetics 8:29-36 (1987)

Ingredients (% by weight)	Head/Brain	Body/Muscle
Water	40.4	52.5
Salt (NaCl)	2.5	1.4
Sugar	56.0	45.0
HEC	1.0	1.0
Bactericide	0.1	0.1
Dielectric constant @ 900 MHz	41.2	54.7
Conductivity @ 900 MHz (S/m)	1.22	1.38

Part 3 SAR measurement procedures

3.1 General

3.1.1 The SAR measurement procedures described in this Part are primarily intended for testing wireless handsets and similar transmitters that operate next to a person's head. The test configurations for evaluating body-worn SAR compliance are also described.

3.1.2 SAR is evaluated using simulated tissue medium contained in a realistic human shaped phantom shell that allows a small diameter, miniature electric field probe to measure the electric field within the tissue regions exposed to the transmitter configured in normal operating positions. Since the RF energy absorption characteristics of human tissues are frequency dependent, the dielectric properties of simulated tissue media used for SAR evaluations must match the target tissue properties specified at the operating frequency range of the device (See Part 2).

3.2 Phantom Considerations

3.2.1 Handsets that are held on the side of a person's head next to the ear have been tested using two general types of realistic-shaped head phantoms: with and without a simulated external ear attached to the head model. A simulated ear with a thickness of approximately 2-3 mm, consisting of low-loss dielectric material has been used to model a person's ear compressed by the earpiece of a wireless handset on some head models. Others have used a 2-4 mm thick, circular shaped, low-loss dielectric spacer to simulate the ear separation distance.

3.2.2 The IEEE SCC-34/SC-2 has established criteria for developing a standardized head model to test handsets for SAR compliance. This head model has been derived from selected head dimensions of male, U.S. Army personnel (See Reference [8]). The committee has specified the phantom shell to be constructed of low-loss dielectric material with dielectric constant less than 5.0 and loss tangent not exceeding 0.05. The thickness of the phantom shell should be 2.0 mm with less than ± 0.2 mm variations in shape and thickness for regions where SAR is to be measured and ± 0.5 mm for other regions. A 4.0 mm thick low-loss dielectric spacer is used to simulate the ear separation distance on this head model.

3.2.3 A reference plane has been defined by three points consisting of a point on each ear spacer and the tip of the mouth to minimize test device positioning errors. The points on each ear spacer are known as the ear reference points; each is located at 1.5 cm above the ear canal location in the reference plane. During SAR measurements, the centreline on the front of a handset is aligned to this predefined reference plane and the earpiece is positioned at the level of the ear reference point. The ear spacer is tapered abruptly to zero thickness below the ear reference point, along a line perpendicular to the reference plane. By using a standardized head model with specific ear simulation requirements, device positioning errors are reduced and lower SAR measurement uncertainty is expected (See Reference [6]).

3.2.4 The construction of a liquid phantom must allow unrestricted electric field probe access to search for all possible peak SAR locations produced by a portable transmitter under test. The tissue material within the phantom shell measured from the ear reference point should be at least 15 cm deep. In most situations, split head models are used to test transmitters on the left and right side of the head. A separate flat phantom should be used to test exposures in body-worn configurations and other body regions that are relatively flat, such as the chest and abdomen.

3.3 Recommended Characteristics of Head and Body Phantoms

3.3.1 The following information provides additional guidance on head and body models that are considered acceptable for routine evaluation of most wireless handsets and similar portable transmitters. The SCC-34/SC-2 head conforms to the relevant portions of these criteria:

(a) the shape, dimensions and complexity of a human shaped head phantom should be appropriate for evaluating the near-field exposure

conditions expected by the users of a transmitter device under normal operating conditions;

(b) the head phantom should include a portion of the neck, preferably extending to the base of the neck. Shoulders are not necessary;

(c) body-worn operating configurations should be tested using a flat phantom. The length and width of the phantom should be at least twice the corresponding dimensions of the test device, including its antenna. The body dielectric parameters specified in Part 2 should be used to demonstrate body-worn SAR compliance;

(d) the head and body phantom shell should be made of low-loss dielectric material with dielectric constant and loss tangent less than 5.0 and 0.05 respectively. The shell thickness for all regions coupled to the test device and its antenna should be within 2.0 ± 0.2 mm. The phantom should be filled with the required head or body equivalent tissue medium to a depth of 15.0 ± 0.5 cm.

3.4 Recommended device test positions for typical Wireless Handset

3.4.1 Specific test positions have been prescribed by the SCC-34/SC-2 for testing handsets using the standardized head model recommended by this committee. For routine SAR evaluation, these test positions, as described below, should be used for testing handsets and similar portable transmitters that operate on the side of a person's head, next to the ear. Flat phantom models should be used to test handsets and push-to-talk (PTT) devices that can be held in front of the user's face or transmit in body-worn operating configurations using belt-clips, holsters or similar accessories. The test device should be placed in a holder or positioner made of low-loss dielectric material with dielectric constant and loss tangent less than 5.0 and 0.05 respectively. If the device holder is suspected to perturb the fields from the test device, which may affect device performance or introduce unacceptable SAR measurement errors, such as handsets with internal antennas, the error must be assessed and accounted for in the total measurement uncertainty. Device holder perturbation may be verified by testing the device on a flat phantom in each frequency band and antenna position with and without using the holder.

3.5 Devices operating next to a person's ear

3.5.1 This category includes most wireless handsets with fixed, retractable or internal antennas located toward the top half of the device, with or without a foldout, sliding or similar keypad cover. The handset should have its earpiece located within the upper ¼ of the device, either along the centreline or off-centred, as perceived by its users. This type of handset should be positioned in a normal operating position with the "test device reference point" located along the "vertical centreline" on the front of the device aligned to the "ear reference point" (See Reference [6]). The "test device reference point" should be located at the same level as the centre of the earpiece region. The "vertical centreline" should bisect the front surface of the handset at its top and bottom edges. A "ear reference point" is located

on the outer surface of the head phantom on each ear spacer. It is located 1.5 cm above the centre of the ear canal entrance in the "phantom reference plane" defined by the three lines joining the centre of each "ear reference point" (left and right) and the tip of the mouth (See Reference [6]). The terms "test device reference point", "vertical centerline", "ear reference point", "phantom reference plane" and "initial ear position" are specific references used to align a test device to the head phantom.

3.5.2 A handset should be initially positioned with the earpiece region pressed against the ear spacer of a head phantom. For the SCC-34/SC-2 head phantom, the device should be positioned parallel to the "N-F" line defined along the base of the ear spacer that contains the "ear reference point". The "test device reference point" is aligned to the "ear reference point" on the head phantom and the "vertical centreline" is aligned to the "phantom reference plane". This is called the "initial ear position". While maintaining these three alignments, the body of the handset is gradually adjusted to each of the following positions for evaluating SAR:

(a) "Cheek/Touch Position" – the device is brought toward the mouth of the head phantom by pivoting against the "ear reference point" or along the "N-F" line for the SCC-34/SC-2 head phantom. This test position is established:

(i) when any point on the display, keypad or mouthpiece portions of the handset is in contact with the phantom; or

(ii) when any portion of a foldout, sliding or similar keypad cover opened to its intended self-adjusting normal use position is in contact with the cheek or mouth of the phantom.

(b) "Ear/Tilt Position" – with the handset aligned in the "Cheek/Touch Position":

(i) if the earpiece of the handset is not in full contact with the phantom's ear spacer (in the "Cheek/Touch position") and the peak SAR location for the "Cheek/Touch" position is located at the ear spacer region or corresponds to the earpiece region of the handset, the device should be returned to the "initial ear position" by rotating it away from the mouth until the earpiece is in full contact with the ear spacer; or

(ii) the handset should be moved (translated) away from the cheek perpendicular to the line passes through both "ear reference points" (note: one of these ear reference points may not physically exist on a split head model) for approximate 2-3 cm. While it is in this position, the handset is tilted away from the mouth with respect to the "test device reference point" by 15°. After the tilt, it is then moved (translated) back toward the head perpendicular to the line passes through both "ear reference points" until the device touches the phantom or the ear spacer. If the antenna touches the head first, the positioning process should be repeated with a tilt angle less than 15° so that the device and its antenna would touch the phantom simultaneously. This test position may require a device holder or positioner to achieve the translation and tilting with acceptable positioning repeatability.

3.5.3 If a device is also designed to transmit with its keypad cover closed for operating in the head position, such positions should also be considered in the SAR evaluation. The device should be tested on the left and right side of the head phantom in the "Cheek/Touch" and "Ear/Tilt" positions. When applicable, each configuration should be tested with the antenna in its fully extended and fully retracted positions. These test configurations should be tested at the high, middle and low frequency channels of each operating mode; for example, AMPS, CDMA, and TDMA. If the SAR measured at the middle channel for each test configuration (left, right, Cheek/Touch, Tile/Ear, extended and retracted) is at least 3.0 dB lower than the SAR limit, testing at the high and low channels is optional for such test configuration(s). If the transmission band of the test device is less than 10 MHz, testing at the high and low frequency channels is optional. A complete set of tests for a handset operating with a retractable antenna has 24 configurations for each operating mode, as shown in the following table:

Recommended handset and head phantom test positions for FCC compliance evaluation

Phantom Configurations	**Device Test Positions**	**Antenna Position**	**SAR (W/kg) Device Test channel, Frequency & Output**		
			Channel: ___ ___ MHz ___ mW	**Channel: ___ ___ MHz ___ mW**	**Channel: ___ ___ MHz ___ mW**
Left Side of Head	**Cheek / Touch**	extended			
		retracted			
	Ear / Tilt	extended			
		retracted			
Right Side of Head	**Cheek / Touch**	extended			
		retracted			
	Ear / Tilt	extended			
		retracted			

3.6 Recommended test positions for body-worn and other configurations

3.6.1 Body-worn operating configurations should be tested with the belt-clips and holsters attached to the device and positioned against a flat phantom in normal use configurations. Devices with a headset output should be tested with a headset connected to the device. The body dielectric parameters specified in Part 2 should be used. Both the physical spacing to the body of the user as dictated by the accessory and the materials used in an accessory affect the SAR produced by the transmitting device. For purpose of determining test requirements, accessories may be divided into two categories: those that do not contain metallic components and those that do.

3.6.2 When multiple accessories that do not contain metallic components are supplied with the device, the device may be tested with only the accessory that dictates the closest spacing to the body. When multiple accessories that contain metallic components are supplied with the device, the device must be tested with each accessory that contains a unique metallic component. If multiple accessories share an identical metallic component (e.g., the same metallic belt-clip used with different holsters with no other metallic components), only the accessory that dictates the closest spacing to the body must be tested.

3.6.3 Body-worn accessories may not always be supplied or available as options for some devices that are intended to be authorized for body-worn use. A separation distance of 1.5 cm between the back of the device and a flat phantom is recommended for testing body-worn SAR compliance under such circumstances. Other separation distances may be used, but they should not exceed 2.5 cm. In these cases, the device may use body-worn accessories that provide a separation distance greater than that tested for the device provided however that the accessory contains no metallic components..

3.6.4 Transmitters that are designed to operate in front of a person's face, in push-to-talk configurations, should be tested for SAR compliance with the front of the device positioned at 2.5 cm from a flat phantom. Frontal face-phantoms are typically not recommended because of the potential of higher E-field probe boundary-effects errors in the non-smooth regions of these face phantoms, such as the nose, lips and eyes etc. For devices that are carried next to the body, such as shoulder, waist or chest-worn transmitters, SAR compliance should be tested with the accessories, including headsets and microphones, attached to the device and positioned against a flat phantom in normal use configurations.

3.7 Documentation

3.7.1 Device test positions should be documented graphically and identify the separation distances and tilt angles used during the SAR evaluation. This will allow, if necessary, the test to be repeated accurately with the device positioned as specified in the test report. A close-up photo(s) of the actual test device positioned against the phantom during the SAR measurement should also be included in the test report to document the test setup.

3.8 Tissue Dielectric Property Requirements

3.8.1 The tissue media should be checked at the beginning of a series of SAR measurements to determine if the dielectric parameters are within the tolerances of the specified target values. The dielectric parameters should be verified daily and more often as required by the ambient conditions. For example, when the liquid temperature deviates by more than 2°C from that recorded for the measured dielectric parameters and under conditions of extremely low humidity or high evaporation rates. The tissue parameters should be measured with the coaxial probe, slotted line or TEM line techniques described in the SCC-34/SC-2 SAR measurement document (See Reference [6]).

3.8.2 The tissue dielectric parameters specified in Part 2 should be used as the target values for testing (See References [2], [3] and [6]). These parameters are generally accepted as equivalent to the corresponding tissue properties at 37°C, for use in single-tissue homogeneous phantom models. Examples of the typical composition of ingredients used to achieve these parameters under normal ambient conditions are also included in Part 2. The use of other compositions and formulations to arrive at the same tissue parameters may also be acceptable. SAR measurements should be performed under normal ambient conditions, suitable for the test equipment, typically within 20-26° C and 30-70% humidity. The temperature of the tissue medium during the SAR measurement should be within ± 2.0°C of the temperature at which the dielectric parameters are measured. The relative permittivity and conductivity of the tissue material should be within 5% of the values given in Part 2, 10% when precise tissue recipes are not available at certain frequencies. Transmitters operating at other frequencies should be tested using tissue parameters based on the linearly interpolated values shown in Part 2, corresponding to the mid-band frequency of each operating mode. The instrumentation error associated with the measured tissue parameters should be accounted for in the overall SAR measurement uncertainty.

3.9 Electric Field Probe Characteristics and Calibration

3.9.1 The E-field probes used for SAR measurements should have a dynamic range of 0.01-100 W/kg to cover the range of signal levels and modulation characteristics used by most mobile stations. The field probes used in SAR measurements are typically calibrated to measure single frequency fields. The probe output follows the square-law response of its detectors at low field strength levels. As the field strength level increases, special circuitry or compensation software are used to achieve a linear response. When measuring pulsed signals with low duty factors or high peak-to-average ratios, the probe must be calibrated with correction factors to accurately measure SAR with respect to the average power. If the signal level exceeds the square-law response of the diode detectors in an E-field probe, the output can become sensitive to the signal modulation and the error is usually dependent on the form of modulation. A probe must be properly calibrated to measure the SAR corresponding to the average energy absorption produced by a modulated signal. A probe linearity of ± 0.25 dB should be ensured at the device test frequencies during routine SAR evaluation.

3.9.2 The variation in sensitivity among the sensors in a field probe must be correctly compensated for during probe calibration. It is highly desirable for a probe to have a uniform response to all incident fields, independent of field polarization and direction of propagation. However, the isotropic response of a probe is often non-ideal due to construction tolerances, asymmetry in sensor location, differences in detector sensitivity among the channels, differences in line impedance and feedback from the feed lines. It is extremely important that these undesirable characteristics are carefully evaluated during probe calibrations by rotating the probe along its axis and orienting the probe and its sensors to different field polarizations and directions of propagation. The axial and hemispherical isotropy errors of a

probe should be within ± 0.25 and ± 0.5 dB, respectively, at the device test frequencies during routine SAR measurement.

3.9.3 A field probe must be calibrated in tissue media with the target dielectric parameters specified in Part 2, corresponding to the operating frequency ranges of the test device. The responses of a field probe are dependent on signal frequency, modulation characteristics, power level, field polarization, field gradients and the direction of field propagation. Other factors such as RF noise, static and ELF fields, temperature, humidity and the proximity of media boundaries from the probe tip can also affect the calibration of a field probe. At less than 800 MHz, probes are calibrated using thermal techniques. At above 800 MHz, an appropriate waveguide filled with the required tissue medium may be used to calibrate the output voltages of a probe against analytically calculated field values (See References [5], [6] and [7]).

3.10 System Verification

3.10.1 Routine record keeping procedures should be established for tracking the calibration and performance of SAR measurement systems. When SAR measurements are performed, the entire measurement system should be checked daily within the device transmitting frequency ranges to verify system accuracy. A flat phantom irradiated by a half-wavelength dipole is typically used to verify the measurement accuracy of a system. The measurement system should also be evaluated periodically with and without the built-in compensation and correction factors to verify the measurement sensitivity and to identify system components that could be out of tolerance. When a radiating source is not available at the operating frequency range of the test device to verify system accuracy, a source operating within 100 MHz of the mid-band channel of each operating mode may be used. The measured ten-gram SAR should be within 10% of the expected target values specified for the specific phantom and RF source used in the system verification measurement.

3.10.2 The following describes the recommended test configuration for verifying SAR measurement systems using a flat phantom and a dipole radiating source to determine if the system meets its performance (Note: systems may be verified at 300 MHz until standard dipoles at below 300 MHz are available):

(a) A balanced half-wave ($\lambda/2$) dipole should be used as the radiating source. The dipole should be matched to the source impedance of the signal generator. The specific flat phantom should be filled with the required tissue medium at its intended operating frequency. The current distribution along the two arms of the half-wave dipole should be matched to within 5% of each other. The thickness of the dipole must not exceed the separation distance between the outer surfaces of the dipole and the phantom shell by 20%. The construction of the dipole should provide extremely stable operating characteristics at its intended operating frequency to produce repeatable SAR distributions in the specific flat phantom. The recommended dipole specifications

described in the latest SCC-34/SC-2 draft on SAR measurement procedures should be used (See Reference [6]).

(b) Before the dipole can be used to verify the performance of SAR measurement systems, its radiating characteristics must be fully characterized at the intended operating frequency.

(c) The phantom shell (or box) should be constructed of low-loss dielectric material with dielectric constant less than 5 and loss tangent less than 0.05. The material thickness on the side that couples to the dipole (the bottom) must not be thicker than 6.5 mm for use at below 1.0 GHz and 5.0 mm at other frequencies. The variations in shell thickness along regions coupled to the dipole must be less than ± 0.2 mm. The material for the other sides must not be thicker than 10 mm.

(d) The phantom should be at least ¾ wavelength long, in the direction parallel to the dipole and ½ wavelength wide, in the direction perpendicular to the dipole. Smaller phantom dimensions may be acceptable if it can be demonstrated that the measured ten-gram SAR is within ± 1% of that produced by a phantom with the required phantom dimensions. The phantom should hold 15 ± 0.5 cm of the required tissue medium.

(e) The SAR system should be verified using this flat phantom setup, preferably, at the mid-band frequency of a test device, but not more than 100 MHz from this frequency.

(f) The dielectric parameters of the tissue medium used to verify the SAR system should be within 5% of those used to obtain the reference data (target SAR values) and should also satisfy the requirements specified in Part 2.

(g) A uniform separation distance of 15.0 mm ± 0.2 mm should be maintained between the dipole axis and the inside surface of the phantom shell (tissue medium surface) at the dipole feed-point location. At above 1.0 GHz, a separation distance of 10.0 mm ± 0.2 mm should be used. A precision low-loss dielectric spacer and holding apparatus should be used to maintain dipole positioning repeatability.

(h) Each end of the dipole should not deviate by more than 2° from the dipole axis with respect to the dipole feed-point. The sagging of the phantom, due to the weight of the tissue medium, at its closest location to the dipole feed-point should be within 1° from the straight line joining the two points on the phantom that are closest to the ends of the dipole, with respect to each of these points on the phantom.

(i) The measured ten-gram SAR at the surface of the phantom above the dipole feed-point should be within 10% of the target reference value. The SAR distribution must be identical to the reference data.

(j) Since the dielectric properties of the phantom shell and its thickness along regions coupled to the dipole may affect the dipole impedance and the measured SAR values, the target SAR values may only be applicable for the specific combination of dipole and flat phantom configuration. The following table contains a summary of the acceptable range of dipole and phantom separation distances for the dipole dimensions described in P1528.

Dipole Thickness, Flat Phantom Sagging and Separation Distance Requirements

Frequency (MHz)	Dipole Length	Half of Dipole Length	2 ° Dipole Deviation	1 ° Phantom Sagging	Maximum Shell Thickness	Dipole to Tissue Separation	Max. Dipole Dia.	Min. Air Gap	0.5% of 0.6 λ (Sagging)
300	420.0	210.0	7.3	3.67	6.5	15.0	6.4	5.3	3.00
450	288.0	144.0	5.0	2.51	6.5	15.0	6.4	5.3	2.00
835	161.0	80.5	2.8	1.41	6.5	15.0	6.4	5.3	1.08
900	149.0	74.5	2.6	1.30	6.5	15.0	6.4	5.3	1.00
1450	89.1	44.6	1.6	0.78	5.0	10.0	3.8	3.1	0.62
1800	72.0	36.0	1.3	0.63	5.0	10.0	3.8	3.1	0.50
1900	68.0	34.0	1.2	0.59	5.0	10.0	3.8	3.1	0.47
2000	64.5	32.3	1.1	0.56	5.0	10.0	3.8	3.1	0.45
2450	51.8	25.9	0.9	0.45	5.0	10.0	3.8	3.1	0.37
3000	41.5	20.8	0.7	0.36	5.0	10.0	3.8	3.1	0.30

(all dimensions in mm)

3.11 Test Site Ambient Conditions

3.11.1 The RF interference characteristics and ambient conditions at a test facility should be fully characterized to determine their influences on the SAR measurement. RF noise may enter the measurement equipment either by conduction through cables or through radiated fields. These unwanted signals may be rectified by metal-to-metal junctions and semiconductor devices resulting in DC offsets or low frequency signals that cannot be separated from the desired signal detected by the electric field probe. Other conditions such as ground loops and cable conditions that can change the loading conditions of the instrumentation, resulting in noise or oscillation, should also be evaluated regularly. These conditions should be checked daily before SAR measurements are performed. The impact of RF interference on SAR measurements may be verified by performing a SAR measurement with the test device powered off. During compliance measurements, the RF environment should be closely monitored to ensure measurement accuracy. The ambient conditions at a test site, such as the temperature and humidity, may affect the operating stability of the measurement equipment and tissue dielectric parameters. These conditions should also be closely monitored during each SAR measurement to ensure measurement accuracy.

3.12 Test Device Operating Conditions

3.12.1 Most handsets and portable transmitters are battery operated. The devices should operate with a fully charged battery for each SAR test. The performance and operating tolerances of a test device should be fully characterized to ensure that it is identical to the production units for meeting compliance. The output power of the test sample should not be set using test software or test mode sequences to artificially higher or lower output levels than those pre-programmed for production units. Transmitters should be tested at the maximum output level for normal operation within the intended wireless networks, to avoid undesirable performance issues that could lead to SAR changes. The measured SAR values may be scaled to

cover certain output tolerances expected among production units during normal use provided the scaled values are within 5% of the measured values. Unless an external DC power adapter or other signal leads are required for the normal operation of a device, such as connecting a headset to the device for body-worn use, they should not be used in the SAR tests.

3.13 Output Power

3.13.1 In order to determine if device output has been stable during a SAR measurement, conducted power should be measured before and after each SAR test to verify if the output changes are within the tolerance specified for the device. Conducted output power can be measured at a service output port available on most handsets or with an antenna adapter. Alternatively, the SAR should be checked at a reference location, such as above the ear reference point of the head phantom, immediately before and after each SAR measurement to verify device output and SAR drifts.

3.14 Battery Options

3.14.1 Most wireless handsets and portable transmitters may operate with several battery options, such as internally built-in batteries, standard battery packs, a slim pack to save space or a long lasting pack for extended use without frequent recharging. These batteries often have different cell configurations and physical dimensions. In some situations, the battery design may cause some device performance and SAR variations. If the radiated output power of a handset varies with its battery options, the corresponding SAR may also change. An increase in radiated output power could mean higher energy absorption in tissues. However, a reduction in radiated power due to mismatch or increased RF current on the device housing could also lead to higher SAR. For devices that operate linearly, the measured SAR is expected to be proportional to output power. When changes in radiated output are used to estimate whether there is sufficient SAR margin to ensure compliance for all the battery options, the output changes should be linearly proportional to the measured SAR.

3.15 Device operating capabilities

3.15.1 For certain devices that are designed to operate with a substantially low operating duty factor where constant peak output power is neither supported by the hardware nor its battery, SAR compliance should be evaluated at the highest operating duty factor expected during normal use. If a device or its battery is not designed to maintain a constant average output power, SAR should be evaluated with respect to the highest exposure expected based on battery capacity. The measured SAR should typically correspond to the average output power measured before and after the SAR measurement. Testing a device beyond its intended maximum capability and/or capacity may sometimes lead to unpredictable performance conditions that could produce unacceptable test results. These types of test configurations should not be used.

3.16 Device Operating Modes

3.16.1 If a portable transmitter has built-in test modes that can be used to evaluate the highest exposure during normal use, SAR should be tested with these test modes. An unmodulated carrier is usually used in AMPS mode test sequences. For TDMA mode, the test mode signal is usually modulated by the time-division duty factor. Testing TDMA devices with an unmodulated CW signal and adjusting the SAR with a duty factor is not recommended. The test mode signal for CDMA, direct-sequence transmitters should correspond to the full vocoder rate and maximum occupied bandwidth of the device. Frequency hopping spread spectrum devices should be tested at fixed frequencies corresponding to the high, middle and low frequency channels to avoid field probe sampling time incompatibility issues. For devices that operate with a transmission band less than 10 MHz, testing at the middle channel is generally sufficient; otherwise, SAR should be tested at the high, middle and low channels.

3.16.2 The following procedures must be used if the difference between the highest output of a low output mode and the lowest output of the highest output mode is more than 2 dB, otherwise, such low output modes must be tested according to the normal Schedule 2 requirements. The highest and lowest output of an operating mode must be determined with respect to the output for high, middle and low frequency channel of each mode:

(a) test each of the lower output modes in the configuration that resulted in the highest ten-gram SAR in the mode with the highest output; and

(b) test the lower output modes in the following configurations when the ten-gram SAR for the highest output mode of such configurations are greater than 1.0 W/kg:

(i) the antenna position and channel that produced the highest ten-gram SAR in the Left Head Touch Position;

(ii) the antenna position and channel that produced the highest ten-gram SAR in the Left Head Tilt Position;

(iii) the antenna position and channel that produced the highest ten-gram SAR in the Right Head Touch Position;

(iv) the antenna position and channel that produced the highest ten-gram SAR in the Right Head Tilt Position.

(c) if the ten-gram SAR measured for any configuration in each of the lower output mode is greater than or equal to 85% of that measured for the highest output mode, the normal Schedule 2 requirements should be used to complete the entire set of required tests for such lower output mode(s).

3.17 Source-Based Time Averaging

3.17.1 Duty factors related to device usage, software programming or asynchronous operations that are not inherent to or defined by the transmission protocols of the wireless network providing services to the transmitter generally do not satisfy source-based time averaging requirements. However, for certain devices that are hardware limited by design and are restricted to operate with a maximum RF duty factor,

source-based time averaging may be considered. When source-based time averaging is required to demonstrate compliance, the device must be tested for SAR compliance with the source-based time-averaging factor included in the test signal. Devices operating with built-in duty factors should not be tested with CW equivalent signals to avoid over-stressed operating conditions, which could lead to unpredictable device performance and produce unacceptable test results.

3.18 Recommended SAR Measurement Procedures

3.18.1 The SAR measurement protocol and test procedures should be documented. The calibration traceability of field probes and other supporting equipment should be attached to the SAR reports when such information is requested. In each SAR report, the rationale for evaluating a device with the specific test configurations to demonstrate compliance should be clearly documented. The device operating conditions, such as output power stability (drifts), performance variations (tolerances) or other physical, mechanical and electrical variations, which could introduce unacceptable changes in SAR results must be carefully characterized and considered in the SAR evaluation to determine compliance. The test sample used in a SAR evaluation must be substantially identical to production units to ensure the test results are acceptable for demonstrating compliance.

3.18.2 For measurements using homogeneous phantoms, the peak SAR locations are usually located at or near the surface of the phantom. The measurement system must search for these peaks and determine the highest SAR averaged over any ten gram of tissue medium in the shape of a cube through additional measurements at one or more of these peak locations. Since the field probe is calibrated at the geometric centre of its sensor elements, where the measurement point is defined. The highest SAR typically occurring near the surface of a homogeneous phantom cannot be measured by an electric field probe with its sensors located 2-4 mm behind the probe tip. These SAR values must be computed by extrapolating the closest measured points to the surface of the phantom for determining the highest ten-gram averaged SAR.

3.18.3 The spatial resolution of a field probe is related to a small volume surrounding the sensors within the probe. The size of this measurement volume is probe dependent. The measured field values are reduced at maximum field location and enhanced at minimum field locations according to this averaging volume. To minimize this type of measurement error, probes with a tip diameter larger than 8.0 mm should not be used (See Reference [6]). In steep gradient or non-uniform fields, higher isotropy error may be expected because the sensors are displaced at the probe tip and from the probe axis. At boundaries of dielectric interfaces, the tip of a probe must be immersed at least 2-3 probe diameters beyond the sensors to measure SAR correctly within the tissue medium. This boundary effect happens at both the air-to-tissue and tissue-to-phantom-surface interface. To minimize such measurement errors, it is also necessary to avoid making measurements with the probe tip in direct contact with the phantom surface. For most probes, a separation of at least half a probe diameter should be maintained between the probe tip and the phantom surface to avoid

requiring complex compensation procedures to further reduce probe boundary-effects errors.

3.19 Procedures to search for peak SAR locations

3.19.1 Different extrapolation, interpolation and integration algorithms have been used in existing measurement systems to determine the highest ten-gram SAR to show compliance. The following procedures should be used to ensure the test results are acceptable.

3.19.2 To search for the peak SAR locations produced by a test device in a head or body phantom, the electric field probe should be scanned along the inside surface of the phantom filled with the required tissue medium. A coarse resolution scan, also know as area scan, is used to determine the approximate peak locations near the surface of the phantom, typically in an area larger than that projected by the transmitter and its antenna. The measurement should be performed at a fixed distance of 8.0 mm or less from the inside surface of the phantom, with less than ± 1.0 mm variation. Laterally, the measurement points should provide a spatial resolution that is sufficient for the interpolation algorithms used by the SAR measurement system to identify the peak SAR locations to within half the linear dimension of the 10-gram cube (10.8 mm). This typically requires an area scan resolution of 1-2 cm. The SAR distribution may be plotted to verify the peak SAR locations with respect to the near-field exposure characteristics of the transmitter. All peaks within 2.0 dB (63.1%) of the highest peak identified by the interpolated data should be evaluated with a fine resolution volume scan to determine the highest ten-gram averaged SAR (See Reference [6]). A SAR plot of the surface scan region with a sketch or picture of the test device superimposed on the contours should be used to identify the peak SAR locations.

3.19.3 If a peak SAR location is near the edge of a scan region, within 10.8 mm for ten-gram SAR (half the linear dimensions of the cube), the area scan should be repeated with an expanded scanning region. When SAR is measured along the side wall of a phantom or on curved surfaces where the probe axis is not perpendicular to the phantom surface, probe isotropy and probe boundary-effects errors must be carefully considered for making accurate measurements. For some measurement systems, the E-field probe may have been calibrated or compensated to measure SAR with the probe axis oriented within ± 30° from that normal to the phantom surface. If this is not the case, either the phantom or the field probe should be re-oriented to reduce the measurement error.

3.20 Procedures for determining ten-gram averaged SAR

3.20.1 The fine resolution volume scan region, also known as the zoom scan region, should be centred at the peak SAR locations determined by the extrapolated data from the area scan measurements. The number of measurement points required in a zoom scan to provide an accurate ten-gram averaged SAR is dependent on the field gradients at the peak SAR location. In smooth gradients, the ten-gram averaged SAR can be correctly

predicted with only a few measurement points. When steep field gradients exist, many measurement points evenly distributed within the ten-gram volume of the tissue medium may be required to correctly predict the volume averaged SAR. The zoom scan region should extend in each direction for at least 1.5 times the linear dimensions of a ten-gram cube of tissue from each peak. The zoom scan spatial resolution should allow the interpolation algorithms used by the SAR measurement system to compute SAR values on a 2 mm grid with less than 5% error, which typically requires a zoom scan resolution of 5-8 mm.

3.20.2 The peak field values near the surface of a homogeneous phantom are usually not measurable because the sensors in a field probe are located at 2-4 mm behind the tip of the probe and the measurement point is defined at the geometric centre of the sensors where the calibration is defined. These SAR values must be computed by extrapolating the closest measured points to the surface of the phantom to determine the highest ten-gram averaged SAR. The extrapolation algorithm must compensate for the field attenuation based on a series of measurement points along a straight line, extending from the phantom surface through the peak SAR location, in the zoom scan region. The first two measurement points should be inside the ten-gram averaging volume. Both points should be less than 1.0 cm from the phantom and liquid surface. The last measurement point should be outside the ten-gram averaging volume, typically within the zoom scan region. The SAR value for the last measurement point should be less than 25% of the value measured for first point closest to the phantom surface. The separation distance between adjacent measurement points should be less than 5.0 mm. The extrapolation coefficients should be determined with an appropriate curve-fitting algorithm, such as a 4^{th} order polynomial least-square fit. The same set of coefficients should be used to extrapolate the SAR values that cannot be measured within the zoom scan region (See Reference [6]). The extrapolated SAR values should have the same spatial resolution as the zoom scan measurements.

3.20.3 The interpolated and extrapolated SAR values from the zoom scan measurement are integrated in the shape of a ten-gram cube, for example, with a trapezoidal algorithm, to determine the highest volume averaged SAR in the zoom scan region. SAR compliance is determined according to the highest ten-gram SAR measured for all the zoom scans performed for each area scan. The error associated with the extrapolation, interpolation and integration algorithms used in the area and zoom scans should be analysed and included in the total measurement uncertainty.

3.21 Measurement Uncertainties

3.21.1 Measurement uncertainties are calculated using the tolerances of the instrumentation used in the measurement, the measurement setup variability, and the technique used to perform the SAR evaluation. The overall uncertainty is calculated in part by identifying uncertainties in the instrumentation chain used in performing each of the procedures in the evaluation. Methods for evaluating and expressing measurement uncertainties can be found in the NIST Technical Note 1297 (TN1297), entitled ”Guidelines for Evaluating and Expressing the Uncertainty of NIST

Measurement Results" (See Reference [9]). Another source of reference is the NIS 81 document, entitled "The Treatment of Uncertainty in EMC Measurements," published by the National Physical Laboratory of the United Kingdom (See Reference [10]).

3.22 Types of Measurement Uncertainties

3.22.1 In general, the components of uncertainty may be categorized according to the method used to evaluate them. The evaluation of uncertainty by the statistical analysis of series of observations is termed a "Type A" evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of series of observations is termed a "Type B" evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation termed "standard uncertainty", which equals the positive square root of the estimated variance. Details of Type A and Type B uncertainties are explained in NIST - TN1297 (See Reference [9]).

3.22.2 The "combined standard uncertainty" of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both "Type A" and "Type B" evaluations using the usual root-sum-squares method of combining standard deviations by taking the positive square root of the estimated variances.

3.22.3 "Expanded uncertainty" is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a "coverage factor". Typically, the coverage factor ranges from two to three. For a normal distribution, if the combined standard uncertainty is a reliable estimate of the standard deviation, a coverage factor of two defines an interval having a level of confidence of approximately 95%. A coverage factor of three defines an interval having a level of confidence greater than 99%.

3.22.4 A detail report of uncertainty should consist of a complete list of the components specifying for each the method used to obtain its numerical value. The uncertainty in the result of a measurement generally consists of multiple components which may be grouped into either "Type A" or "Type B" uncertainties. There is not always a simple correspondence between the classification of categories "Type A" or "Type B" evaluation of uncertainty and the previously used classification of random and systematic uncertainties in earlier standards. The term "systematic uncertainty" can be misleading and should be avoided.

3.23 Determining Total System Measurement Uncertainty

3.23.1 SAR measurement uncertainties are the results of errors due to system instrumentation, field probe response and calibration, and the dielectric parameters of the tissue medium. Uncertainties due to measurement procedures include test device placement, probe positioning procedures, the extrapolation, interpolation and integration algorithms used to determine the ten-gram averaged SAR. The error components associated with the total

SAR measurement uncertainty for evaluating portable transmitters can be grouped into four main categories - assessment, source, device positioning and phantom uncertainties. Assessment uncertainty is related to the instrumentation and procedures used to assess the spatial peak SAR value in a given SAR distribution for a given setup. Source uncertainty is related to the test and operating parameters of the test device used in an evaluation that produced the SAR distribution. Device positioning uncertainty is related to the changes in SAR due to variations in device test position. Phantom uncertainty describes the variation of a phantom model with respect to the desired model and tissue dielectric parameters defined in the measurement protocol, such as those recommended by SCC-34/SC-2.

3.23.2 The total SAR measurement uncertainty stated in a SAR report quantifies the quality and accuracy of the measurements with respect to the uncertainty of the instrumentation and measurement techniques used for the evaluation. A summary of the uncertainty analysis, including the uncertainty components considered for the SAR measurement should be described in the test report to support compliance. A statement of compliance indicating the maximum measured ten-gram averaged SAR with the corresponding expanded measurement uncertainty for each operating mode and operating configuration tested for the device should be included in the SAR report. Expanded uncertainty should be determined for a confidence interval of 95% or higher, which corresponds to a "coverage factor" of two or more. The measurement uncertainty of the SAR values must be less than 30%.

3.23.3 The measurement uncertainty components that should be considered in a typical SAR evaluation, similar to those recommended by the SCC-34/SC-2, are described below (See Appendix A and B). The SAR equipment manufacturer may have evaluated some of these uncertainty components according to specific measurement conditions, however, additional analyses may be required for the uncertainty components that are dependent on the operating conditions and test configurations of an individual test device.

Part 4 References

[1] Chou, C., G. Chen, A. Guy and K. Luk, "Formulas for Preparing Phantom Muscle Tissue at Various Radiofrequencies", Bioelectromagnetics, 5, pp. 435-441, 1984.

[2] Drossos, A., V. Santomaa and N. Kuster, "The dependence of electromagnetic energy absorption upon human head tissue composition in the frequency range of 300-3000 MHz", IEEE Transactions on Microwave Theory and Techniques, vol. 48, no. 11, pp. 1988-1995, Nov 2000.

[3] Gabriel, C., "Compilations of the Dielectric Properties of Body Tissues at RF and Microwave Frequencies", Brooks Air Force Technical Report AL/OE-TR-1996-0037, 1996.

[4] Hartsgrove, G., A. Kraszewski and A. Surowiec, "Simulated Biological Materials for Electromagnetic Radiation Absorption Studies", Bioelectromagnetics, 8, pp. 29-36, 1987.

[5] Hill, D., "A Waveguide Technique for the Calibration of Miniature Implantable Electric Field Probes for Use in Microwave Bioeffect Studies", IEEE Transactions on Microwave Theory and Techniques, pp. 92-99, Jan 1982.

[6] IEEE Standards Coordinating Committee 34 on Product Performance Standards Relative to the Safe Use of Electromagnetic Energy, "Draft Recommended Practice for Determining the Spatial-Peak Specific Absorption Rate (SAR) in the Human Body Due to Wireless Communications Devices: Experimental Techniques", P1528, 2001 (referred to as P1528 and IEEE SCC-34/SC-2 in Schedule 2).

[7] Meier, K., R. Kastle and T. Schmid, "Dosimetric Evaluation of Handheld Mobile Communications Equipment with Known Precision", IEICE Transactions, E80-A(5), pp.1-8, May 1997.

[8] "Military Handbook, Anthropometry of US Military Personnel", DOD-HDBK 743A, February 1991.

[9] NIST Technical Note 1297 (TN1297), "Guidelines for Evaluating and Expressing the Uncertainty of NIST Measurement Results", available at http://physics.nist.gov/Pubs/guidelines/TN1297/tn1297s.pdf. or by contacting NIST Calibration Program, Building 820, Room 232, Gaithersburg, MD 20899-0001 or by telephone at (301)-975-2002.

[10] NIS 81 document, "The Treatment of Uncertainty in EMC Measurements," published by the National Physical Laboratory of the United Kingdom, available by order from United Kingdom Accreditation Services (UKAS), 21047 High Street Feltham, Middlesex TW13 4UN, Tel: +44(0)20 8917 8556, Fax: +44(0)20 8197 8500/8499.

Appendix A Documenting the measurement uncertainty of SAR evaluations

A. Assessment Error (measurement system)
   I. Probe Calibration Error
      1. Axial Isotropy Error
      2. Hemispherical Isotropy Error
      3. Spatial Resolution Tolerance
      4. Boundary-effects Error
      5. Linearity Error
      6. Sensitivity Error
      7. Response Time Error
      8. Integration Time Error
   II. Readout Electronics Error
   III. Errors from RF Ambient Conditions
   IV. Probe Positioner Calibration Error (absolute)
   V. Probe Positioning Error with respect to the Phantom Shell
   VI. Errors from the Extrapolation, Interpolation and Integration Algorithms
B. RF Source Error (test device)
   I. Test Sample Output Power Drift Error
   II. SAR Variation due to Performance Tolerance of the Test Sample
   III. SAR Variation due to Tolerance of Production Units
C. Test Device Positioning Error
   I. Test Sample Positioning Error
   II. Device Holder or Positioner Tolerance
D. Phantom and Setup Errors (See Reference [6])
   I. Phantom Production Tolerance (shape and thickness)
   II. Target Liquid Conductivity Tolerance
   III. Measured Liquid Conductivity Error
   IV. Target Liquid Permittivity Tolerance
   V. Measured Liquid Permittivity Error

Appendix B Documenting the measurement uncertainty for SAR system verification

A. Assessment Error (measurement system)
   I. Probe Calibration Error
      1. Axial Isotropy Error
      2. Hemispherical Isotropy Error
      3. Spatial Resolution Tolerance
      4. Boundary-effects Error
      5. Linearity Error
      6. Sensitivity Error
      7. Response Time Error
      8. Integration Time Error
   II. Readout Electronics Error
   III. Errors from RF Ambient Conditions
   IV. Probe Positioner Calibration Error (absolute)
   V. Probe Positioning Error with respect to the Phantom Shell
   VI. Errors from the Extrapolation, Interpolation and Integration Algorithms
B. RF Source Error (typically a half-wave dipole)
   I. Input Power Measurement Error
   II. Output Power Drift Error
C. RF Source Positioning Error
   I. Separation Distance Error from the Source to the Tissue Medium
   II. RF Source (dipole) Holder or Positioner Tolerance
D. Phantom and Setup Error (See Reference [6])
   I. Phantom Construction Tolerance (shape, dimensions and thickness)
   II. Target Liquid Conductivity Tolerance
   III. Measured Liquid Conductivity Error
   IV. Target Liquid Permittivity Tolerance
   V. Measured Liquid Permittivity Error

Notes to the *Radiocommunications (Electromagnetic Radiation — Human Exposure) Standard 2003*

Note 1

The *Radiocommunications (Electromagnetic Radiation — Human Exposure) Standard 2003* (in force under section 162 of the *Radiocommunications Act 1992*) as shown in this compilation is amended as indicated in the Tables below.

Table of Instruments

Title	Date of notification in *Gazette* or FRLI registration	Date of commencement	Application, saving or transitional provisions
*Radiocommunications (Electromagnetic Radiation — Human Exposure) Standard 2003 (*F2005B00258)	28 Feb 2003 (*see Gazette* 2003, No. S62)	1 Mar 2003	
Radiocommunications (Electromagnetic Radiation — Human Exposure) Amendment Standard 2007 (No. 1)	28 Mar 2007 (*see* F2007L00812)	1 Apr 2007	—
Radiocommunications (Electromagnetic Radiation — Human Exposure) Amendment Standard 2011 (No. 1)	27 Jan 2011 (*see* F2011L00158)	1 Feb 2011	—
Radiocommunications (Electromagnetic Radiation — Human Exposure) Amendment Standard 2011 (No. 2)	21 Mar 2011 (*see* F2011L00456)	22 Mar 2011	—

Table of Amendments

ad. = added or inserted am. = amended rep. = repealed rs. = repealed and substituted

Provision affected	How affected
S. 5	am. 2007 No.1; 2011 No. 1
Heading to s. 6	rs. 2007 No. 1
S. 6	am. 2007 No. 1
S. 7	rs. 2007 No. 1
S. 8	rep. 2007 No. 1
S. 9	am. 2007 No. 1
S. 10	am. 2007 No. 1; 2011 Nos. 1 and 2
S. 11	am. 2011 No. 1
Heading to s. 12	rs. 2007 No. 1
S. 12	am. 2007 No. 1
Schedule 1	rep. 2007 No. 1