



# Introduction to RF Exposure Evaluation

**For**

**Handsets, and Hand-helds**

**Overview**

**October 2005 Updates to May 2003 Training**

**Martin Perrine**

**Federal Communications Commission**

**Office of Engineering and Technology**

**Laboratory Division/Equipment Authorization Branch**



## Supplement C and Handsets, and Hand-helds

### ● Outline

- RF Exposure training background
- Supplement C and Part 22/24 Handsets
- General PTT hand-held devices

October 2005

TCB Workshop

2



## Background

- TCB must receive the following training to certify devices with certain RF exposure concerns
  - ➔ Supplement C handset training (for TCB certification of Pt 22/24 handsets only)
  - ➔ General RF exposure training (for all other devices under July 2002 exclusion list)
- All other TCBs must use 2000 exclusion list.



## RF Exposure Training

- October TCB RF exposure training is meant to update the May 2003 training with all updates that followed. The '03 training videos and materials should be reviewed by the student.
- To bring a context for the training material by referencing past training and updating documents where appropriate.
- This training is not meant to be comprehensive but only refer the student to the training materials at hand and provide necessary updates.

October 2005

TCB Workshop

4



## Supplement C and Part 22/24 Handsets

- Supplement C and Part 22/24 Handsets
  - Section will follow flow and section titles of the May '03 training document. Updates were added as appropriate.
- General PTT hand-helds information inserted in related locations

October 2005

TCB Workshop

5



## TCB Training

**Evaluating compliance/SAR Review of Part 22  
Subpart H and Part 24 Wireless Handsets for  
Equipment Approval**

### **Supplement C – 01-01**

**October 2005 Updates to May 2003  
Training**



## Supplement C - 01-01

- Title: "Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields"
- General in nature regarding mobile and portable devices
- Emphasis for Pt 22/24 handsets based on IEEE STD 1528 standard
- TCBs will apply as standard for SAR reviews of Pt 22/24 devices
- Based on IEEE 1528.

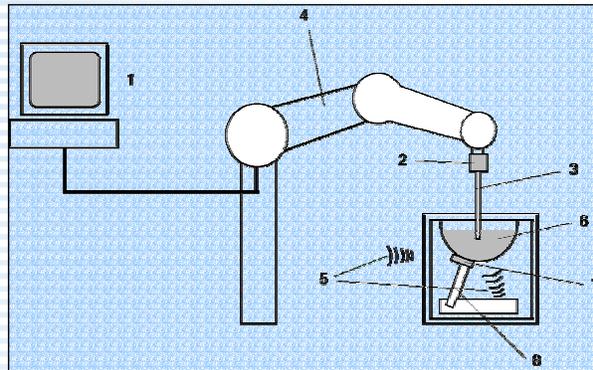
October 2005

TCB Workshop

7



## SAR Measurement Overview



- 1) computer for data recording
- 2) data acquisition unit
- 3) dosimetric E-field probe
- 4) probe positioner
- 5) ambient field
- 6) phantom shell with tissue simulating liquid
- 7) device under test
- 8) device positioner

October 2005

TCB Workshop

8

A typical SAR measurement system may include: E-field probe, phantoms (head, body and planar models), field probe holder and positioner, test device holder and positioner, tissue dielectric property measurement equipment (dielectric probe/sensor, network analyzer etc.), SAR system performance verification equipment (RF signal generator, dipoles & phantom etc.), test device signal control equipment (basestation simulator).



## TCB Training

**Evaluating compliance/SAR Review of Part 22  
Subpart H and Part 24 Wireless Handsets for  
Equipment Approval**

**Supplement C - 01-01: Phantom**

**October 2005 Updates to May 2003  
Training**



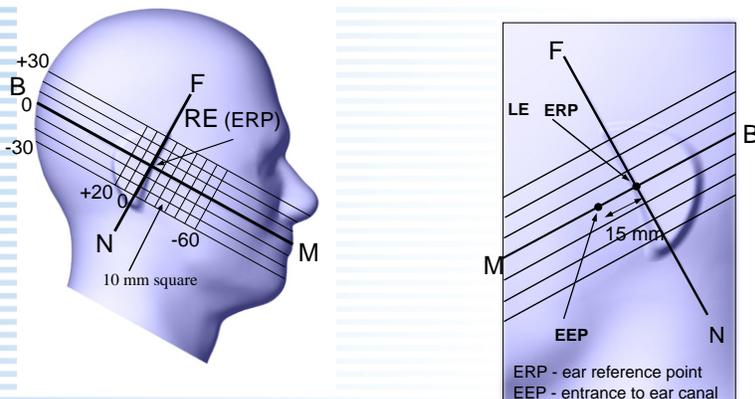
## Supplement C: Phantom Recommendations

- Supplement C recommends IEEE 1528 SCC-34/SC-2 SAM head phantom, see Public Notice 02-1438
- Supplement C specifies flat phantom for body-worn and held to face tests, and system verification.
  - Phantom should be twice the size in critical dimensions of the DUT.
- Phantom to hold homogeneous tissue simulating liquid.



## IEEE STD 1528 Draft: Phantom

### SCC-34/SC-2 head model - SAM



(Source: IEEE SCC-34/SC-2, IEEE STD 1528 Draft)

October 2005

TCB Workshop

11



## TCB Training

**Evaluating compliance/SAR Review of Part 22  
Subpart H and Part 24 Wireless Handsets for  
Equipment Approval**

**Supplement C - 01-01: Tissue Parameters**

**October 2005 Updates to May 2003  
Training**



## Supplement C: Tissue Parameters

Target Frequency (MHz)	Head		Body	
	$\epsilon_r$	$\sigma$ (S/m)	$\epsilon_r$	$\sigma$ (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

All head marked \* and body are Non IEEE STD 1528 values

( $\epsilon_r$  = relative permittivity,  $\sigma$  = conductivity and  $\rho = 1000 \text{ kg/m}^3$ )

October 2005

TCB Workshop

13

SCC-34/SC-2 has head tissue parameters for 300 MHz – 3000 MHz only

.Head parameters for 150 MHz and 5800 MHz are extrapolated using the SCC-34/SC-2 worst-case homogeneous head parameters with respect to the slope of the 4-Cole-Cole parameters for average white and gray matters (brain). The SCC-34/SC-2 head parameters are derived based on numerical simulations using the various 4-Cole-Cole head tissue parameters.

.Parameters of average white and gray matters (brain) based on the 4-Cole-Cole have been used in 97-01 version of Supplement C. The curve for these parameters is quite similar to the new SCC-34/SC-2 head parameters, but shifted by a scale factor because SCC-34/SC-2 has derived the new parameters for use in a worst-case homogeneous phantom.



## Supplement C: Tissue Parameters

- transmission band overlaps with tissue target frequency
  - ➔ tissue parameters at mid-band  $< \pm 5\%$  of target values
- otherwise, at other frequencies
  - ➔ linearly interpolate tissue parameters between closest pair of target frequencies
  - ➔ tissue parameters at mid-band  $< \pm 5\%$  of target values
- up to 10% tolerance above 2 GHz (**outdated**) -- newer recipes should be within 5% up to 3 GHz. Above 3 GHz greater tolerance may be needed.

October 2005

TCB Workshop

14



## TCB Training

**Evaluating compliance/SAR Review of Part 22  
Subpart H and Part 24 Wireless Handsets for  
Equipment Approval**

**Supplement C – 01-01 Scan Procedures**

**October 2005 Updates to May 2003  
Training**



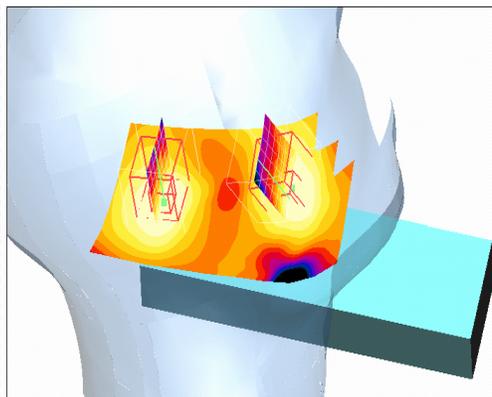
## Supplement C: Scan Procedures

### ● field scan considerations

- homogeneous phantom
  - peak SAR near phantom surface
- probe boundary effects error
  - probe tip  $> \frac{1}{2}$  probe diameter from phantom surface unless compensated
- evaluate near-field exposure conditions
  - area scan to search for peaks
  - zoom scan to determine 1-g SAR



## Area and Zoom Scans



October 2005

TCB Workshop

17



## Supplement C: Scan Procedure

### ● Area Scan

- cover an area of the phantom larger than that projected by the device and its antenna
- at a fixed distance from the inside surface of .5 probe diameter < distance  $\leq 8.0 \pm 1.0$  mm
- measurement resolution
  - sufficient to allow interpolation algorithms to identify SAR peaks to  $\pm 5.0$  mm
  - 1 - 2 cm spatial resolution is typically sufficient (1 cm is typically used)



## Supplement C: Scan Procedure

### ● Area Scan

#### ➔ peak locations

- identify on SAR plots with respect to device outline and phantom reference grid
- perform zoom scan on all peaks within 2.0 dB of the highest peak
- repeat area scan with expanded boundaries if peaks are closer than 5.0 mm (10.8 mm for 10-gram SAR) from scan boundary
- consider probe boundary effects and isotropy errors when scan near phantom side-wall - tilt probe or phantom as necessary



## Supplement C: Scan Procedure

### ● zoom scan

- centered at peak locations interpolated from area scan measurements
- scan extends 1.5 times the linear dimension of 1 or 10 gram cube in all directions from each area scan peak (including extrapolation to surface) (extends 3 times linear dimension from surface)



## Supplement C: Scan Procedure

### ● zoom scan

- points near the phantom surface
  - Measured in the z direction
    - first 2 points - within 1.0 cm from surface
    - last point - SAR value < 25% of first point
    - adjacent points - < 5.0 mm separation
  - points at surface are extrapolated from measured points in z direction



## Supplement C: Scan Procedure

### ● zoom scan

- ➔ measurement resolution
  - sufficient to allow the interpolation algorithms to compute SAR values on a 2.0 mm grid with < 5% error
  - 5 - 8 mm spatial resolution is typically sufficient (depends on gradient of SAR contour)
  - 7x7x6 points typical for 5mm spacing (7th point in z extrapolated)
- ➔ determine the highest 1-g SAR
  - typically by trapezoidal integration



## TCB Training

**Evaluating compliance/SAR Review of Part 22  
Subpart H and Part 24 Wireless Handsets for  
Equipment Approval**

**Supplement C – 01-01 Test Device**

**October 2005 Updates to May 2003  
Training**



## Supplement C: Test Device

### ● test sample requirement

- ➔ §2.908 - test sample identical to production units
- ➔ §2.909 - grantee responsibility

### ● device conditions

- ➔ Power target and tolerances
- ➔ Operational and test modes
- ➔ Physical configurations and accessories
- ➔ Collocated devices i.e. BT or WLAN



## Supplement C: Test Device

### ● Signaling modes

- Multiple modes operating in same frequency band see PN 02-1438
- Modes with substantially low duty factor
- New technologies i.e. CDMA 2000, and UMTS



## Frequency Criteria Update

- Currently indicated in Appendix D of Supplement C 01-01, last paragraph of section “Device Operating Next to a Person’s Ear,”
  - “If the SAR measured at the middle channel for each test configuration (left, right, Cheek/Touch, Tilt/Ear, extended and retracted) is at least 2.0 dB lower than the SAR limit, testing at the high and low channels is optional for such test configuration(s).”
  - SCC-34/SC-2 has revised its recommended SAR measurement procedures from 2.0 dB to 3.0 dB



## TCB Training

### **Evaluating compliance/SAR Review of Part 22 Subpart H and Part 24 Wireless Handsets for Equipment Approval**

#### **Supplement C – 01-01 Device Test Position**

**October 2005 Updates to May 2003  
Training**

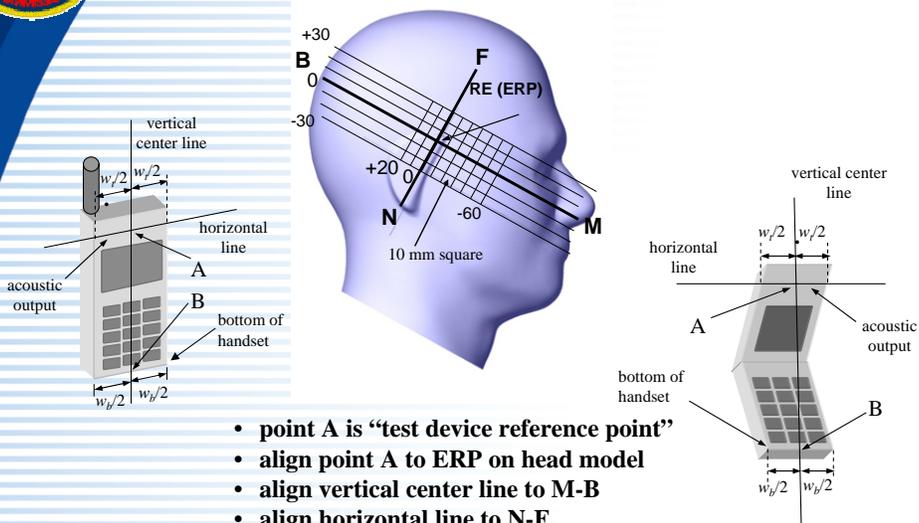


## Supplement C: Device Test Position

- IEEE STD 1528 standardizes head test positions for Pt 22/24 like handsets
  - ➔ two test positions - “cheek/touch” and “ear/tilt”
- Supplement C gives body-worn test positions
- test other positions based on expected/intended use e.g. pocket, necklace or held to face test positions.
- test worst case conditions as appropriate



## Supplement C: Device Test Position



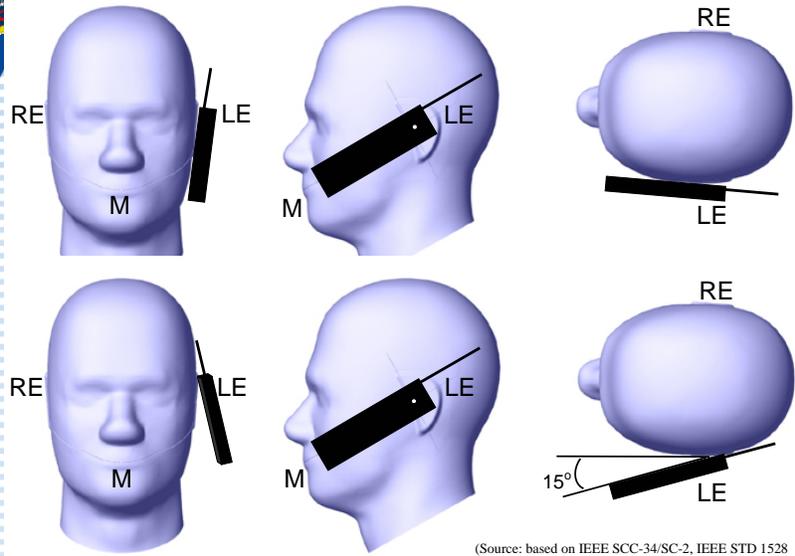
October 2005

TCB Workshop

29



# IEEE STD 1528 Draft: Device Test Positions



(Source: based on IEEE SCC-34/SC-2, IEEE STD 1528 Draft)

October 2005

TCB Workshop

30



## Supplement C: Device Test Position



- Body-worn operating configurations
  - Test with or without a body-worn accessory
  - Should be corresponding user manual statement and grant comment.
  
- Body-worn, held to face, held on lap, and other next to body tests are performed using a flat phantom.



## TCB Training

**Evaluating compliance/SAR Review of Part 22  
Subpart H and Part 24 Wireless Handsets for  
Equipment Approval**

**Supplement C – 01-01 Ambient Condition**

**October 2005 Updates to May 2003  
Training**



## Supplement C: Ambient Conditions

- characterize the RF environment of the test site
- monitor ambient conditions during tests
  - RF noise and interference effects
  - verify with SAR measurement with no RF power when necessary
  - temperature and humidity effects

October 2005

TCB Workshop

33



## TCB Training

**Evaluating compliance/SAR Review of Part 22  
Subpart H and Part 24 Wireless Handsets for  
Equipment Approval**

**Supplement C – 01-01 Test Report**

**October 2005 Updates to May 2003  
Training**



## Supplement C: Test Report

- Supplement C addresses test documentation
- FCC Reminder Sheet, based on appendix B

October 2005

TCB Workshop

35



## TCB Training

**Evaluating compliance/SAR Review of Part 22  
Subpart H and Part 24 Wireless Handsets for  
Equipment Approval**

**Preparing for SAR Review**

**October 2005 Updates to May 2003  
Training**



## Preparing for SAR Review

- FCC Reminder Sheet, based on appendix B
- Practice examples given during earlier classes
- Keep up-to-date on FCC policies

October 2005

TCB Workshop

37



## Preparing for SAR Review

- Derive key information from
  - External photographs
  - User manual
  - EMC reports
  - Operational description
  - Tune-up procedure
  - Original/related filing

October 2005

TCB Workshop

38



## SAR Review and Reminder Sheet

- Output Power
- User Manual
- General Report information
- Phantom description
- Tissue Liquid dielectric properties
- Device positioning

October 2005

TCB Workshop

39



## SAR Review and Reminder Sheet

- Coarse Scan
- One-gram averaging
- Total measurement uncertainty
- Test results for required for determining SAR compliance
- Plots

October 2005

TCB Workshop

40



## Related Topics

- System verification and validation using dipole source. See SAR basics and Supplement C for details.
- Verification measurements should be within 10% of target.



## User Instructions and Grant Comments

- Information on test configurations, calculation assumptions, grant comments, other EAS exhibits and user instructions should be consistent.
- User instructions should assure compliant operation of the device and address relevant issues.
  - ➔ Collocation with other transmitters.
  - ➔ Definition of host devices for modular transmitters.
  - ➔ Body worn accessory information.
  - ➔ Minimal MPE distance, and installation and antenna requirements.
  - ➔ Occupational training and labeling.
  - ➔ PTT usage duty factor including VOX and data operations.\*



October 2005

TCB Workshop

42



## Grant Comments

- Recommended formats for PCE/TNE devices;  
Single band

*The highest reported SAR values are: CDMA 800 (Part 22) – head 0.09 W/kg; body 0.75 W/kg; CDMA PCS (Part 24) – head 0.12 W/kg; body 1.41 W/kg.*

- Other key requirements for RFX such as body-worn use, and collocation.



## PTT Hand-helds

Common rule parts 74, 80, 90, and 95

- General Population or Occupational exposure conditions require different handling.
- Apply TCB exclusion list and KDB publication 447498.



## Grant comment and user manual statements

### PTT devices

- For general population exposure when above TCB threshold include:
  - ➔ usage duty factor instructions
  - ➔ Body worn use
- Training and labels are always needed for Occupational exposure



## KDB Publication 447498. SAR for PTTs

- SAR is requested only for GMRS PTTs device over 1.0 W for FCC filings. No change for TCB filings
- Devices marketed for public use must meet general population exposure limits. Other Part 90 devices are implied to operate in occupational conditions only.

October 2005

TCB Workshop

46



## KDB Publication 447498. SAR for PTTs

- TCB filings for categorically excl. devices require SAR evaluation if output power is greater than low thresholds of July02 TCB Excl. List
- FCC and TCB filings do not request SAR for typical **VHF** (e.g., 150 MHz  $f_c$ ) PTT devices
  - ➔ Standard testing and review/approval procedures are still not defined
  - ➔ SAR data if voluntarily submitted can be considered and reviewed by FCC not TCB

October 2005

TCB Workshop

47

Thresholds of July02 TCB Excl. List intended to establish uniform Review & Approval Procedures while allowing TCBs to process SAR for devices other than Parts 22/24 handsets.

Review & Approval Procedures for portable devices are subject to revision as part of RFX rule proceeding (03-137) and FCC Lab RFX policy reviews.

**Contact FCC Lab for guidance if portable PTT with  $P \geq 7$  W is encountered.**