

RF Exposure evaluation

1. Standard Requirement

According to §15.247(i) and §1.1307b(1), systems operating under the provisions of this section shall be operated in a manner that ensures that the public is not exposed to radio frequency energy levels in excess of the Commission's guidelines. See KDB 447498 D01 General RF Exposure Guidance V6, section 4.3.1.

a) The 1-g and 10-g SAR test exclusion thresholds for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:

$$\left[\frac{\text{max. power of channel, including tune-up tolerance, mW}}{\text{min. test separation distance, mm}} \right] \cdot [\sqrt{f(\text{GHz})}] \leq 3.0 \text{ for 1-g SAR and } \leq 7.5 \text{ for 10-g extremity SAR, where}$$

- $f(\text{GHz})$ is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation¹⁷
- The result is rounded to one decimal place for comparison

The test exclusions are applicable only when the minimum test separation distance is ≤ 50 mm and for transmission frequencies between 100 MHz and 6 GHz. When the minimum test separation distance is < 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.

b) For 100 MHz to 6 GHz and test separation distances > 50 mm, the 1-g and 10-g SAR test exclusion thresholds are determined by the following (also illustrated in Appendix B):

- 1) $\{[\text{Power allowed at numeric threshold for 50 mm in step a)}] + [(\text{test separation distance} - 50 \text{ mm}) \cdot (f(\text{MHz})/150)]\}$ mW, for 100 MHz to 1500 MHz
- 2) $\{[\text{Power allowed at numeric threshold for 50 mm in step a)}] + [(\text{test separation distance} - 50 \text{ mm}) \cdot 10]\}$ mW, for > 1500 MHz and ≤ 6 GHz

c) For frequencies below 100 MHz, the following may be considered for SAR test exclusion (also illustrated in Appendix C):

1) For test separation distances > 50 mm and < 200 mm, the power threshold at the corresponding test separation distance at 100 MHz in step b) is multiplied by $[1 + \log(100/f(\text{MHz}))]$

2) For test separation distances ≤ 50 mm, the power threshold determined by the equation in c) 1) for 50 mm and 100 MHz is multiplied by $\frac{1}{2}$

3) SAR measurement procedures are not established below 100 MHz.

Prediction of MPE at a given distance

The criteria listed in the following table shall be used to evaluate the environment impact of human exposure to radio frequency (RF) radiation as specified in 1.1310(e)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm ²)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3-3.0	614	1.63	*100	6
3.0-30	1842/f	4.89/f	*900/f ²	6
30-300	61.4	0.163	1.0	6
300-1,500			f/300	6
1,500-100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3-1.34	614	1.63	*100	30
1.34-30	824/f	2.19/f	*180/f ²	30
30-300	27.5	0.073	0.2	30
300-1,500			f/1500	30
1,500-100,000			1.0	30

3. Test Procedure

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = \frac{P \times G}{4 \times \pi \times R^2}$$

Where:

S = power density

P = power input to the antenna

G = numeric gain of the antenna in the direction of interest relative to an isotropic radiator

R = distance to the centre of radiation of the antenna

Measurement Result

NFC

$$E = \text{EIRP} - 20\log D + 104.8$$

where:

E = electric field strength in dB μ V/m,

EIRP = equivalent isotropic radiated power in dBm

D = specified measurement distance in meters.

$$\text{EIRP} = E - 104.8 + 20\log D = 37.25 - 104.8 + 20\log 3 = -77.09 \text{ dBm}$$

According to KDB 447498 D01 General RF Exposure Guidance V6 4.3.1c)2)

$$\text{Power allowed at numeric threshold} = [\text{Step a allowed power}(474 \text{ mW}) + (\text{separation distance } 50 - 50) * (100/150)] * [1 + \log(100/13.56)] / 2 = 442.7 \text{ mW}$$

Mode	Channel Frequency (MHz)	EIRP(dBm)	Max tune-up tolerance Output power (dBm)	Max Output power (dBm)	Max Output power (mW)	Threshold Value (mW)
NFC	13.56	-77.09	-77.09 $\pm$ 1	-76.09	0.00000002	442.7

NFC ANT GAIN: Coil Antenna, Antenna gain 0dBi.

Mode	Frequency (MHz)	Prediction distance (cm)	RF output power		MPE (mW/cm ²)	Limit (mW/cm ²)	SAR Test Exclusion
			dBm	mW			
BLE	2480	20	0.816	1.2067	0.0006	1	Yes
WIFI	2452	20	14.793	30.1509	0.0140	1	Yes

BLE/2.4G WIFI ANT GAIN: FPC Antenna, Maximum Gain is 3.69dBi.

Calculation for Simultaneous Transmission (BLE+2.4GWIFI+NFC):

Max RF exposure ratio _{NFC} /Limit	Max MPE ratio _{BLE} /Limit	Max MPE ratio _{2.4G WIFI} /Limit	Σ MPE ratios	Limit	Result
4.5177*10 ⁻¹¹	0.0006	0.0140	0.0146	1	PASS

The SAR measurement is not necessary.