Radio Frequency Exposure Limits

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NSMA
National Spectrum Management Association

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Put this date
May 3, 2023
on your calendar

FCC Safety Limitations

Historically Part 101 fixed point to point microwave systems have been exempt from RF exposure limits evaluations

Radiofrequency Radiation Exposure Limits, Limits for Maximum Permissible Exposure (MPE):

§1.1308 Consideration of environmental assessments (EAs); (a) Applicants shall prepare EAs for actions that may have a significant environmental impact (see §1.1307).

§1.1307 (b) (1) Actions that may have a significant environmental effect, for which Environmental Assessments (EAs) must be prepared, Table 1—Transmitters, Facilities and Operations Subject to Routine Environmental Evaluation [Note that the table does not list any Part 101 transmitter (other than Local Multipoint Distribution Service or 70/80/90 GHz Bands, neither of which is of interest in this case).].

Also see Federal Communication Commission (FCC), Evaluating Office of Engineering & Technology (OET) Bulletin 65, Edition 97-01, *Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields*, August 1997, Table 2 of Appendix A [The table does not list any Part 101 transmitter.]

FCC Safety Limitations

On December 4, 2019, the Commission published a new Memorandum Opinion and Order regarding Targeted Changes to the Commission's Rules Regarding Human Exposure to Radiofrequency Electromagnetic Fields (ET Docket No. 19-226).

The Commission changed its "criteria for determining when a licensee is exempt from our RF exposure evaluation criteria, replacing our prior regime of service-based exemptions with a set of formulas for situations in which the risk of excessive RF exposure is minimal."

These rules went into effect May 3, 2021
(Public Notice, ET Docket No. 19-226, DA 21-363, Released: April 2, 2021).

The New Rules

The Commission defined new requirements for evaluating RF exposure at all RF transmitting locations under the Commission's jurisdiction. "RF exposure compliance requirements have been generally applicable to all facilities, operations, and transmitters regulated [licensed and unlicensed] by the Commission." These new rules apply to existing as well as future licensees. The Commission "will allow two years from the effective date [May 3, 2021] of the new rules for licensees to determine if evaluations are required, to perform them where necessary, and to comply with the more specific mitigation requirements we adopt in this order as may be necessary." "… this information is not required to be routinely filed with the FCC." However, it is required for applications for grant or modification of construction permits, licenses or renewals.

The New Rules

"This Second Report and Order revises the rules regarding the two methods of complying with our [i.e., the FCC's] RF exposure limits: exemption—consideration of whether a particular device or deployment is so clearly compliant with our rules that it qualifies as exempt from the requirement to undertake a more thorough analysis; and evaluation—a more specific examination of an individual site or device, which considers factors beyond those used for exemption for less obvious cases and may be performed with a variety of computation and/or measurement methodologies."

The New Rules

Every licensee prior to deployment or commencement of operations must determine if the transmitter is exempt for RF emission evaluation. Evaluation for exemption from analysis must be in accordance with the FCC's formula below :

Single RF Sources Subject to Routine Environmental Evaluation

RF Source Frequency (MHz)	Threshold ERP (watts)
1,500 – 100,000	$19.2R^2$

An exemption calculation is made "… using Table 1 [above] and the minimum separation distance R (in meters) from the body of a nearby person for the frequency (f in MHz) at which the source operates …" The transmitter evaluated is exempt for evaluation if " the ERP (watts) is no more than the calculated value prescribed for that frequency."

Emission Definitions

EIRP(dBm) = Transmitter Power at Antenna (dBm) + Antenna Gain (dBi)

EIRP(dBW) = EIRP(dBm) - 30 dB

EIRP(Watts) = 1.64 ERP(Watts)

EIRP(dBW) = ERP(dBW) + 2.15 dB

ERP(Watts) = 0.6095 EIRP(Watts)

ERP(dBW) = EIRP(dBW) - 2.15 dB

$ERP(Watts) = 10^{ERP(dBW)/10}$

$EIRP(Watts) = 10^{EIRP(dBW)/10}$

The New Rules

If the transmission facility is not exempt, an evaluation of compliance must be made for that facility.

The Commission "will allow two years from the effective date [May 3, 2021] of the new rules for licensees to determine if evaluations are required, to perform them where necessary, and to comply with the more specific mitigation requirements we adopt in this order as may be necessary."

Radio Frequency Exposure

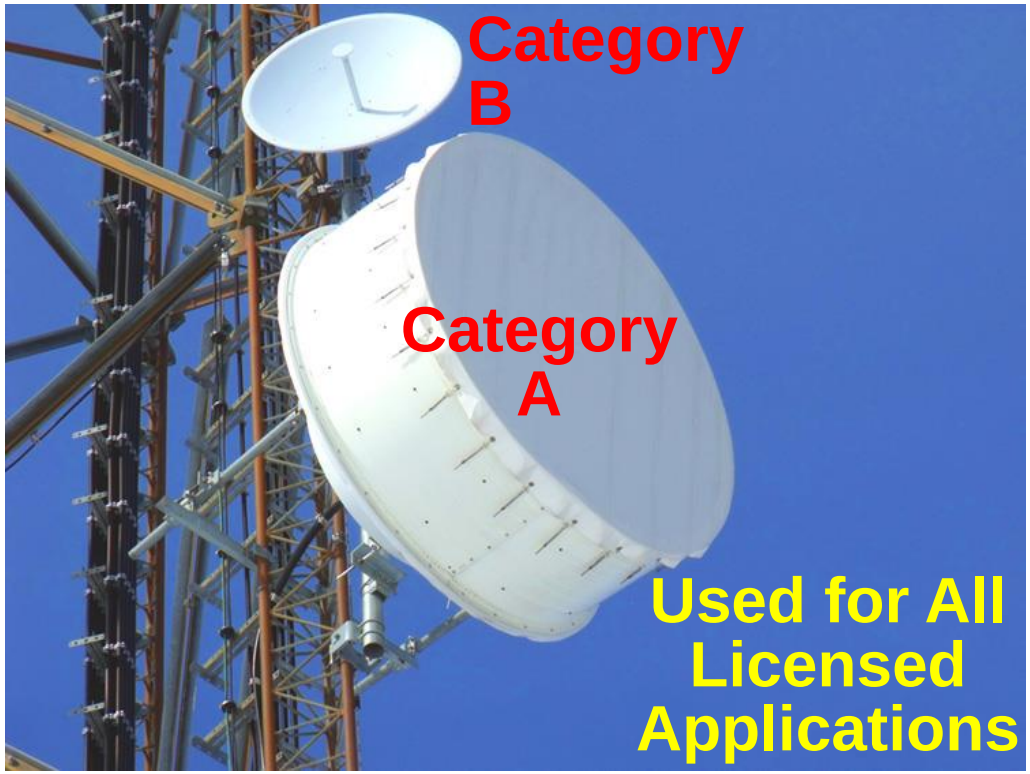
So ……..…….
what do you do it
your transmission
facility is not exempt

First of all, let's keep this in perspective!

≈ 0.1 to 4 watts of electromagnetic radiation

≈ 7 watts of electromagnetic radiation

Parabolic (“Dish”) Reflector Antennas

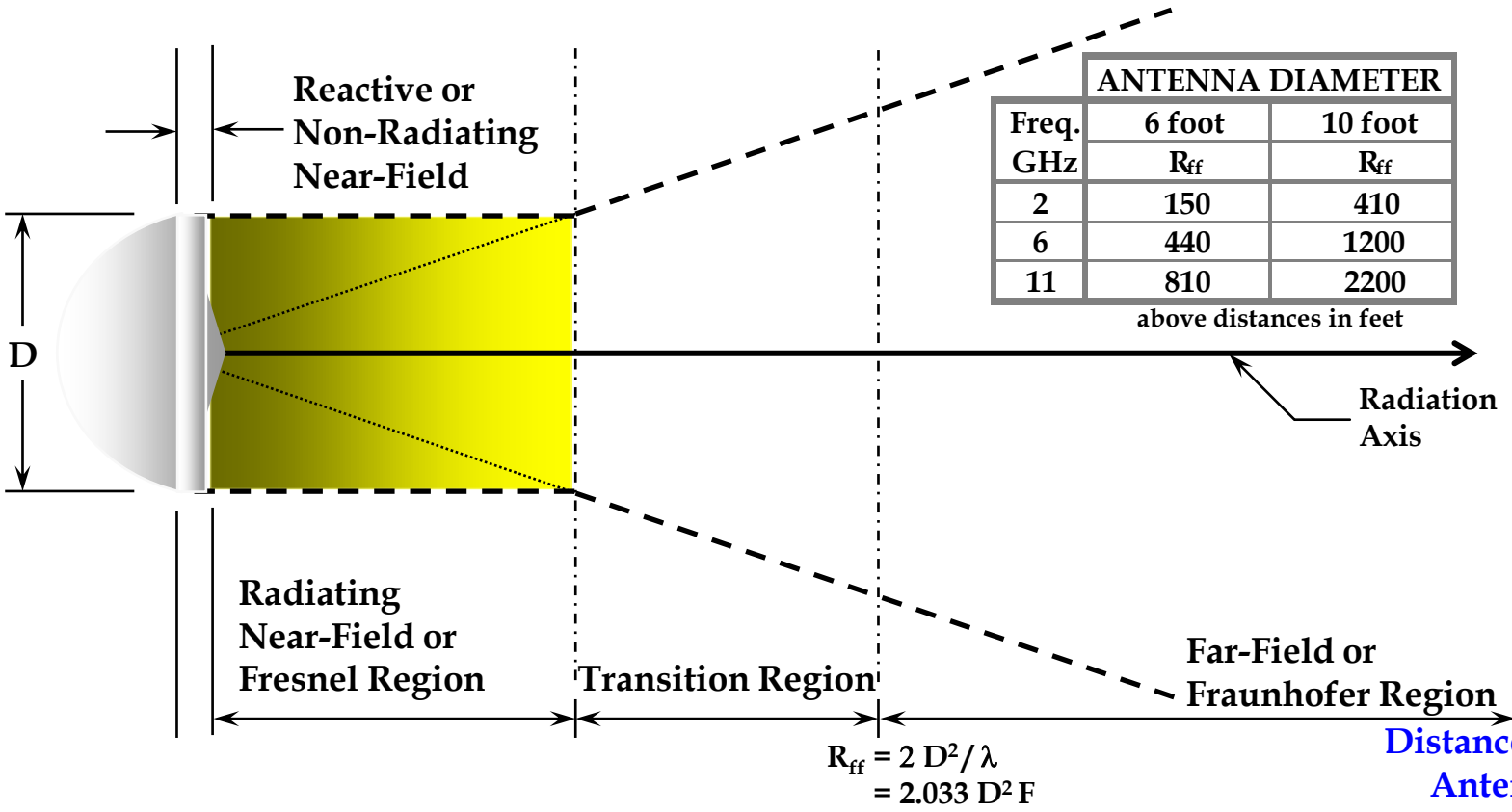


With proper feedhorn, reflector antennas can operate over a very wide frequency range

Square (“Panel”) Antennas

Only applicable for relatively low frequencies unlicensed applications
Relatively narrow frequency bandwidth

Radio Frequency Exposure

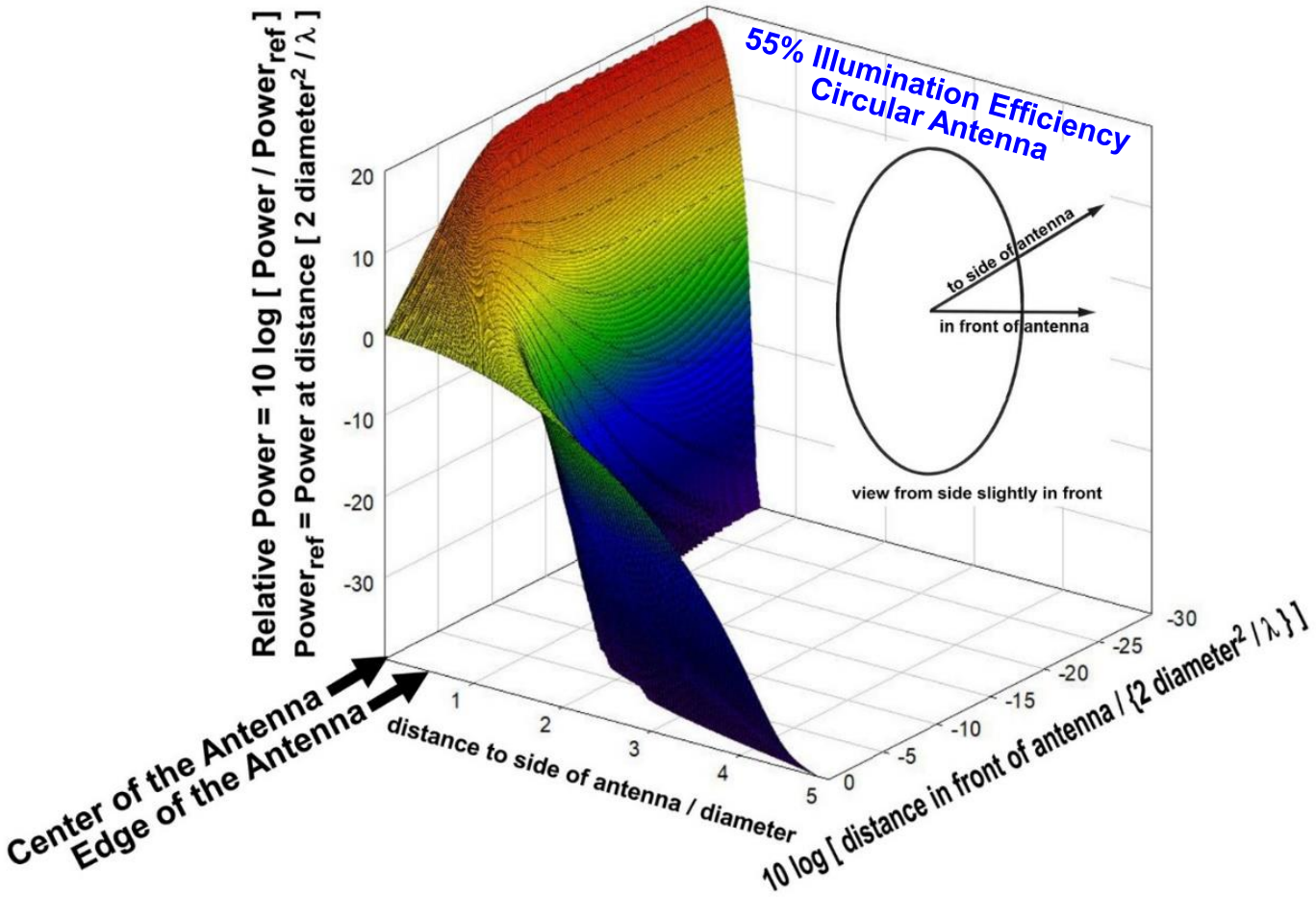


	ANTENNA DIAMETER	
Freq. GHz	6 foot R_{ff}	10 foot R_{ff}
2	150	410
6	440	1200
11	810	2200

above distances in feet

R_{nf} = Distance from the antenna to Near-Field boundary (ft)
R_{ff} = Distance from the antenna to Far-Field boundary (ft)
D = Diameter (or width) of antenna (ft)
λ = Wavelength (ft)
F = Frequency (GHz)

Antenna Near Field Power Density



Maximum Near Field Energy is Directly in Front of the Center of the Antenna

Regulatory Radiated Emission
FCC Safety Limitations

TABLE 1 TO §1.1310(E)(1)—LIMITS FOR MAXIMUM PERMISSIBLE EXPOSURE (MPE)

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(i) 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
(ii) 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

f = frequency in MHz. * = Plane-wave equivalent power density.

CFR Title 47: Telecommunication §1.1310 (e) (1) Radiofrequency Radiation Exposure Limits

Regulatory Radiated Emission
Safety Limitations

Regulatory Region	Uncontrolled Area	Controlled Area	Frequency Range
United States*	1 mW/cm^2	5 mW/cm^2	1.5 < F(GHz) < 100
Canada**	1 mW/cm^2	5 mW/cm^2	6 < F(GHz) < 150
Europe***	1 mW/cm^2	5 mW/cm^2	2 < F(GHz) < 300

***** Cleveland, Jr., R. F., Sylvar, D. M. and Ulcek, J. L., ***Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, FCC OET Bulletin 65***. Washington, D. C.: Federal Communications Commission, Office of Engineering and Technology, pp 26-30 and page 67 (Table 1), 1997.

****** Consumer and Clinical Radiation Protection Bureau, ***Limits of Human Exposure to Radiofrequency Electromagnetic Energy in the Frequency Range from 3 kHz to 300 GHz, Safety Code 6***. Health Canada, page 8 (Tables 5 and 6), 2015.

******* International Commission on Non-Ionizing radiation Protection, ***Guidelines for Limiting Exposure to Time-Varying Electric, Magnetic and Electromagnetic Fields (up to 300 GHz)***, Health Physics, pp. 510-511 (Tables 5, 6 and 7), 1998, as referenced in page 6, para. 2, of ETSI TR 101 870, V1.1.1, ***Fixed Radio Transmitter Sites, Exposure to Non-Ionising Electromagnetic Fields, Guidelines for Working Conditions***, 2001,

Regulatory Radiated Emission
FCC Safety Limitations

(2) *Occupational/controlled exposure limits* apply in situations in which persons are exposed as a consequence of their employment provided those persons are fully aware of the potential for exposure and can exercise control over their exposure. The phrase fully aware in the context of applying these exposure limits means that an exposed person has received written and/or verbal information fully explaining the potential for RF exposure resulting from his or her employment. With the exception of transient persons, this phrase also means that an exposed person has received appropriate training regarding work practices relating to controlling or mitigating his or her exposure. In situations when an untrained person is transient through a location where occupational/controlled limits apply, he or she must be made aware of the potential for exposure and be supervised by trained personnel pursuant to §1.1307(b)(2) of this part where use of time averaging is required to ensure compliance with the general population exposure limit. The phrase exercise control means that an exposed person is allowed and also knows how to reduce or avoid exposure by administrative or engineering work practices, such as use of personal protective equipment or time averaging of exposure [less than 6 minutes per Table 1 of §1.1310 (e) (1)].

(3) *General population/uncontrolled exposure limits* apply in situations in which the general public may be exposed, or in which persons who are exposed as a consequence of their employment may not be fully aware of the potential for exposure or cannot exercise control over their exposure. For example, RF sources intended for consumer use shall be subject to the limits for general population/uncontrolled exposure in this section.

CFR Title 47: Telecommunication §1.1310 (e) Radiofrequency Radiation Exposure Limits

Near Field Power Density Areas

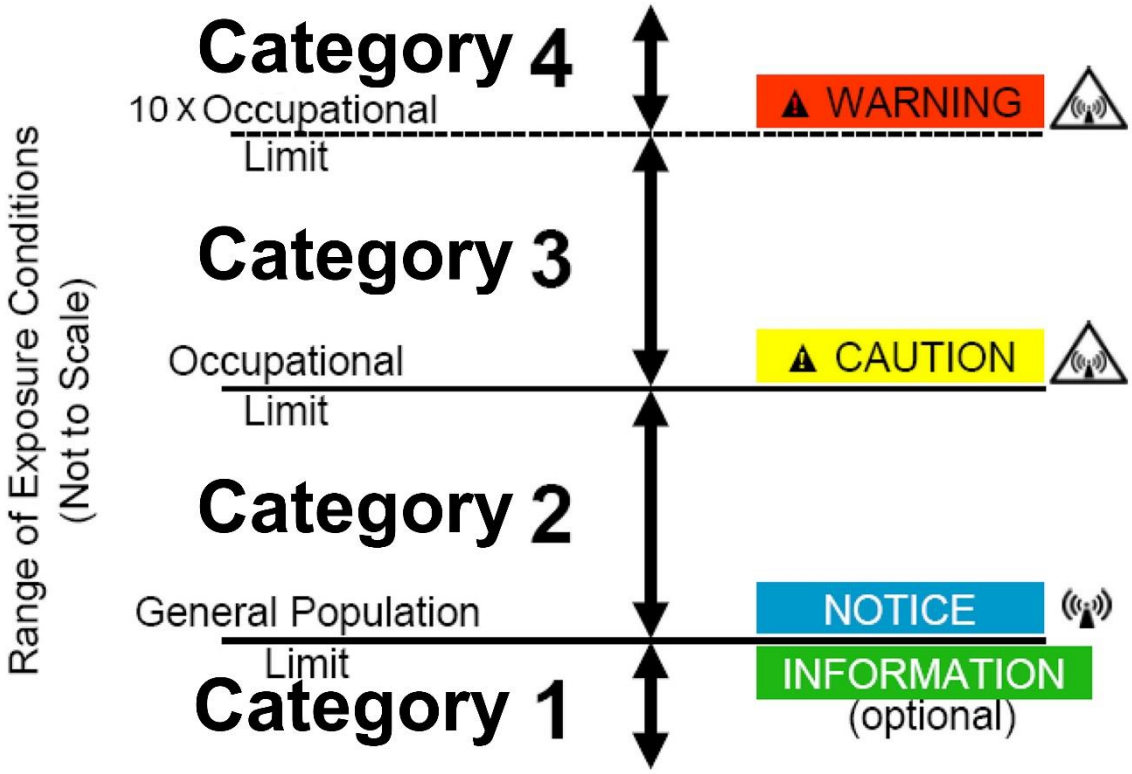
Uncontrolled exposure limits apply to situations in which the general public may be exposed and may not be made fully aware of the potential for exposure or cannot exercise control over their exposure.

Controlled exposure limits apply to situations in which those persons who are exposed have been made fully aware of the potential for exposure and can exercise control over their exposure.

Area definitions derived from *Evaluating Compliance with FCC Guidelines for Human Exposure to Radiofrequency Electromagnetic Fields, FCC OET Bulletin 65*.

Exposure Categories and New Associated Signage Requirements

Graphical Representation of Exposure Categories and Associated Signage Requirements



NOTE :
Where immediate and serious injury would occur on contact regardless of category, the following sign components DANGER are required.

Occupational Limit = Controlled Area
General Population Limit = Uncontrolled Area

Near Field Power Density Limits

Uncontrolled Area

(General Population Limit)

Maximum antenna input power not exceeding 1 mw/cm^2 power density limit*

Diameter or Width (feet)	Parabolic Antenna (55% efficiency) Maximum Power (dBm)	Square Antenna (100% efficiency) Maximum Power (dBm)
15	44.3	48.0
12	42.3	46.0
10	40.7	44.4
8	38.8	42.5
6	36.3	40.0
4	32.8	36.5
3	30.3	34.0
2.6	29.0	32.7
2	26.8	30.5
1	20.7	24.4
0.5	14.7	18.4
0.25	8.7	12.4

Controlled Area

(Occupational Limit)

Maximum antenna input power not exceeding 5 mw/cm^2 power density limit

Controlled Limit = Uncontrolled Limit + 7 dB

**** Estimating RF Near Field Power Feb 25 2021.pdf***

By the Way

The Federal Communication Commission (FCC) Office of Engineering & Technology (OET) Bulletin 65 equation (13), page 28, for calculating the maximum value of the near-field, on-axis, power density is wrong* and missing the square antenna case.

*** optimistic by 4.5 dB in typical 55% illumination efficiency case**

Radio Frequency Exposure

The Federal Communication Commission (FCC)
Office of Engineering & Technology (OET)
Bulletin 65 equation (13), page 28, is the following:

$$S_{nf} = 16\,\eta\,P / [\,\pi\,D^2\,]$$

S_{nf} = maximum near-field power density [mw/cm^2]
η = aperture efficiency (fraction, typically 0.5 - 0.75)
P = power fed to the antenna [mw]
D = antenna diameter [cm]

It should be the following:

$$S_{nf} = \gamma\,\pi\,\eta\,P / [\,16\,D^2\,]$$

$$\gamma = A + B\,N + C\,N^2 + D\,N^3 + E\,N^4$$

A = 37.71623065015471
B = - 0.6319006509486316
C = 0.007468595697388079
D = - 0.00004997221560688844
E = 0.00000014955941890925 59
N = 100*η

See *Estimating RF Near Field Power Feb 25 2021.pdf*
(article address both circular and square antenna cases)

Remember

Put this date

May 3, 2023

on your calendar

and *do your homework*

Radio Frequency Exposure