QUESTION: "We develop equipment that creates an electromagnetic radiation in the frequency ranges of 9-15 kHz, 900 MHz. 2.4 GHz. What are the field limits, considering the human health factor? Could you pinpoint the relevant references"

ANSWER: The most common criteria for human exposure to electric, magnetic and electromagnetic fields are those developed by committees sponsored by the Institute of Electrical and Electronics Engineers [IEEE, 1999], the National Council on Radiation Protection and Measurements [NCRP, 1986] and the International Commission on Non-Ionizing Radiation Protection [ICNIRP, 1998]. The frequency range covered by these standards and guidelines extends from 3 kHz to 300 GHz (IEEE), 300 kHz to 100 GHz (NCRP) and 0 to 300 GHz (ICNIRP). Different limits are usually specified depending on the exposure environment, e.g., controlled versus uncontrolled, or population group, e.g., worker versus general public. For frequencies below about 300 MHz where exposure could occur in the near field of the source, the limits are expressed in terms of the electric (E) and magnetic (H) field strengths. At frequencies above about 300 MHz, the limits are expressed in terms of equivalent plane-wave power density (S). E and H are related to S by

$$S = \frac{E^2}{\eta} = \eta H^2 \ \text{W/m}^2$$

where E is in V/m, H in A/m and η is the impedance of free space (≈ 377 ohms). Limits for induced and contact current are usually specified for frequencies below about 100 MHz.

The field and contact and induced current limits for the frequencies of interest are shown in the tables below.

9-15 kHz

	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Plane Wave Equivalent Power Density (W/m^2)	Induced and Contact Current (mA)
IEEE				
(Controlled)	**614**	**163**		**9-15**
(Uncontrolled)	**614**	**163**		**4.1-6.8**
NCRP				
(Worker)	NA	NA	NA	NA
(General Public)	NA	NA	NA	NA
ICNIRP				
(Worker)	**610**	**24.4**		**3.6-6.0**
(General Public)	**87**	**5**		**1.8-3.0**

900 MHz

	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Plane Wave Equivalent Power Density (W/m^2)	Induced and Contact Current (mA)
IEEE				
(Controlled)			**30**	NA
(Uncontrolled)			**6**	NA
NCRP				
(Worker)			**30**	NA
(General Public)			**6**	NA
ICNIRP				
(Worker)			**22.5**	NA
(General Public)			**4.5**	NA

2.4 GHz

	Electric Field Strength (V/m)	Magnetic Field Strength (A/m)	Plane Wave Equivalent Power Density (W/m^2)	Induced and Contact Current (mA)
IEEE				
(Controlled)			**80**	NA
(Uncontrolled)			**16**	NA
NCRP				
(Worker)			**50**	NA
(General Public)			**10**	NA
ICNIRP				
(Worker)			**50**	NA
(General Public)			**10**	NA

NOTES:

(a) The power density and the squares of the E field and H field are averaged over any 6 minute interval for exposures in controlled environments (worker) and over any 30 minute interval for exposures in uncontrolled environments (for frequencies between 100 kHz and 10 GHz – ICNIRP).

(b) The power density and the squares of the E field and H field may be spatially averaged over the projected area of the body provided the specific absorption rate (SAR) does not exceed 0.4 and 0.08 W/kg whole-body-averaged for the controlled and uncontrolled environments, respectively and the peak spatial averaged SAR does not exceed 8 and 1.6 W/kg in any gram of tissue (NCRP and IEEE) for the controlled and uncontrolled environments, respectively, and 10 and 2 W/kg in any 10 grams of tissue (ICNIRP). The SAR limits apply over the frequency range of 100 kHz to 6 GHz (IEEE, NCRP) and 100 kHz to 10 GHz (ICNIRP).

(c) The IEEE limits for induced current and contact current are permissible through each foot (induced current) and through an impedance equivalent to the human body (contact current).

References:

[IEEE, 1999] "IEEE Standard for Safety Levels With Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz," IEEE Standard C95.1-1991, IEEE, New York, NY, 1999.

[NCRP, 1986] *Biological Effects and Exposure Criteria for Radio Frequency Electromagnetic Fields*, NCRP Report No. 86, National Council on Radiation Protection and Measurements, Bethesda, MD, 1986.

[ICNIRP, 1998] "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*, vol. 74, no. 4, pp. 494-522, 1998.