DEFINITIONS AND GLOSSARY OF TERMS

amplitude The maximum value of the electric field, E_o, or of the magnetic field, H_o. For waves travelling in free space, E and H are mutually orthogonal and are in phase, i.e., maxima and minima occur at the same point in time and space. The units of E are volts/meter and for H, amperes/meter.

antenna A means of radiating or receiving Radio Frequency Radiation (RFR).

antenna gain The ratio of the power gain of an antenna referred to a standard antenna, which is usually an isotropic emitter of RF energy. Gain is a measure of the directionality of an emitter. It may be expressed in decibels or as a pure number.

average power The transmitter power available averaged over a modulation cycle – the power actually available to do work. In a pulsed system, average power is the peak power multiplied by the duty factor. In CW systems, average power is the rated power output, corrected for any transmission line losses.

average (temporal) power (P_{avg}) The time-averaged rate of energy transfer.

averaging time (T_{avg}) The appropriate time period over which exposure is averaged for purposes of determining compliance with a Maximum Permissable Exposure (MPE). For exposure durations less than the averaging time, the MPE', in any time interval equal to the averaging time is found from

$$MPE' = MPE \left[\frac{T_{avg}}{T_{exp}}\right]$$

where T_{exp} is the exposure duration in that interval expressed in the same units as T_{avg} (seconds or minutes).

beam width In a plane containing the main beam of the antenna, the beam width is the angle between the two directions in that plane in which the radiation intensity is some fraction (usually one-half or 3dB) of the maximum value of the main beam intensity.

continuous exposure Exposure for durations exceeding the corresponding averaging time. Exposure for less than the averaging time is called short-term exposure.

controlled environment A location where exposure may be incurred by persons who are aware of the potential for exposure as a condition of employment or by other cognizant persons as a result of transient passage through areas where analysis shows the exposure levels may be above the limits set for uncontrolled environments but do not exceed the limits set for a controlled environment. This includes field levels and induced current levels.

CW system A system designed to produce its output in continuously successive oscillations (continuous waves). Rated output is normally average power.

decibel (dB) The unit to express a numerical ratio. For power considerations the decibel is equal to 10 times the logarithm of a power ratio expressed by the following:

$$dB = 10 \log_{10} (P_1)/(P_2)$$

where P_1 and P_2 are two amounts of power. Power ratios in decibels can be added or subtracted like ordinary numbers.

duty factor The ratio of pulse duration to the pulse period of a periodic pulse train. A duty factor of 1.0 corresponds to continuous-wave (CW) operation. In pulsed systems, the ratio of the pulse width to the pulse period of a periodic pulse train. Mathematically, the duty factor is the product of the pulse width multiplied by the pulse repetition frequency (PW x PRF = DF).

electric field strength (E) A field vector quantity that represents the force (F) on a positive test charge (q) at a point divided by the charge.

$$E = \frac{F}{q}$$

Electric field strength is expressed in units of volts per meter (V/m).

ellipse ratio The variation in response when a field sensing probe is rotated about the axis of its handle, or when a wearable monitor is placed vertically or horizontally in a constantly polarized field. Usually specified in dB.

energy density (electromagnetic field) The electromagnetic energy contained in an infinitesimal volume divided by that volume.

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exposure Exposure occurs whenever and wherever a person is subjected to electric, magnetic, or electromagnetic fields or to contact currents other than those originating from physiological processes in the body and other natural phenomena.

exposure, partial-body Partial-body exposure results when RF fields are substantially nonuniform over the body. Fields that are nonuniform over volumes comparable to the human body may occur due to highly directional sources, standing waves, re-radiating sources or in the near field (see *RF "hot spot"*).

far-field region That region of the field of an antenna where the angular field distribution is essentially independent of the distance from the antenna. In this region – also called the free space region – the field has a predominantly plane-wave character, i.e., locally uniform distributions of electric field strength and magnetic field strength in planes transverse to the direction of propagation (see *Fraunhofer region*).

field . A mathematical specification, in terms of position variables and time, of a physical quantity such as the electric charge density for a *scalar* field and the electric field for a *vector* field. An electrostatic field is produced by stationary charges (such as a common magnet) and an electromagnetic field by moving charges.

Fraunhofer region The electric and magnetic fields are perpendicular to each other, thus making it possible to make measurements of one field and calculate the other (see *far field region*)

frequency (f) The number of wave cycles per second passing a fixed point along the direction of propagation. One cycle is represented as the period in which the magnitude of the electric field vector varies from zero, through its maximum value, back through zero to its minimum value, and finally back to zero. The unit of frequency is Hertz, or 1 cycle per second.

Hertz (Hz) The unit for expressing frequency, (f). One hertz equals one cycle per second.

intermediate field region That portion of the Fresnel region of an antenna where the power density is decreasing at a near linear rate (1/r) with range. Not usually used in safety calculations.

isotropic antenna A hypothetical antenna radiating or receiving equally in all (4π) directions. In the case of electromagnetic waves, isotropic antennas do not exist physically but represent convenient reference antennas for expressing directional properties of actual antennas. An isotropic antenna would have a gain of 1.

magnetic field strength (H) A field vector that is equal to the magnetic flux density divided by the permeability of the medium. Magnetic field strength is expressed in units of amperes per meter (A/m).

magnetic flux density (B) A field vector quantity that results in a force (F) that acts on a moving charge or charges. The vector product of the velocity (*v*) at which an infinitesimal unit test charge, *q*, is moving with *B*, is the force that acts on the test charge divided by *q*.

$$\frac{F}{q} = (v \times B)$$

Magnetic flux density is expressed in units of tesla (T). One T is equal to 10^4 gauss (G).

maximum permissible exposure (MPE) The rms and peak electric and magnetic field strengths, their squares, or the plane-wave equivalent power densities associated with these fields and the induced and contact currents to which a person may be exposed without harmful effect and with an acceptable safety factor.

mixed frequency fields The superposition of two or more electromagnetic fields of differing frequency.

near-field region A region generally close to an antenna or other radiating structure, in which the electric and magnetic fields do not have a substantially plane-wave character, but vary considerably from point to point. The near-field region is further subdivided into the *reactive near-field region,* which is closest to the radiating structure and that contains most or nearly all of the stored energy, and the *radiating near-field region* where the radiation field dominates the reactive field, but lacks substantial plane-wave character and is complicated in structure.

near-field region, radiating That region of the field of an antenna where the power density is not inversely proportional to the distance from the source. It is sometimes called the Fresnel region. In this region the power density increases irregularly with range to a maximum level, then decreases at a near linear rate to the onset of the far-field region. It is convenient and adequate from a personnel-hazard viewpoint to consider the power density in the radiating near field to be constant with range and equal to four times the average power density calculated at the antenna aperture itself. Such a power density profile has proven accurate when compared to measured results.

Definitions and Glossary

near-field region, reactive That region of the field immediately surrounding the antenna where the reactive energy of the electromagnetic field is recovered and re-emitted during sucessive oscillations. True reactive near field conditions exist only to a distance of less than one-half wavelength of the emitted radiation from the radiator.

non-ionizing radiation Any electromagnetic radiation incapable of producing ions directly or indirectly.

penetration depth For a plane electromagnetic wave incident on the boundary of a medium, the distance from the boundary into the medium along the direction of propagation in the medium, at which the field strengths of the wave have been reduced to 1/e (36.8%) of the boundary values.

permeability (μ) The ratio of the magnetic flux density produced in a material to the magnetic field strength which produced it. The units of μ are the Henry/meter; 1 H = 1 volt/(amp-sec). The permeability of free space μo has a value of 1.257 x 10^{-6} H/m.

permissible exposure level (PEL) The rms and peak electric and magnetic field strengths, their squares, or the plane-wave equivalent power densities associated with these fields and the induced and contact currents to which a person may be exposed without harmful effect and with an acceptable safety factor.

permittivity (ε) The ratio of the electric flux density in a medium to the electric field strength producing it. The units of are the farad/meter = coulomb/ (volt-meter) = $C^2/nt\text{-}m^2$. The permittivity of free space ε_o has a value of 8.855 x 10^{-12}F/m. The dielectric constant, K (sometimes also given as E_r), is the relative permittivity of a particular medium as compared to free space, $= \varepsilon/\varepsilon_o$.

polarization Polarization of an electromagnetic wave is characterized by the oscillatory behavior and orientation of the electric field vector. A wave referred to as being linearly polarized means that the electric field vector varies in amplitude in only one direction as it travels. It is conventional to describe polarization in terms of the electric field only, not the magnetic field. An electromagnetic wave may exhibit linear, circular, elliptical, or random polarization (such as in a light bulb). A receiver of electromagnetic radiation must have the same sense of polarization as the incoming wave for it to be detected most efficiently.

Poynting's vector (P) For an electromagnetic wave the power density at any point may be calculated from the vector product of the electric and magnetic field strength vectors, i.e., E x H = P. P is called Poynting's Vector and represents the power density and the direction of energy propagation. Note that if E has dimensions of V/m and H is in units of A/m, the dimensions of P are W/m^2.

power density, average (temporal) The instantaneous power density integrated over a source repetition period.

power density (S) or electromagnetic power flux density Power per unit area normal to the direction of propagation. This is usually expressed in units of watts per square meter (W/m^2), milliwatts per square centimeter (mW/m^2), or microwatts per square centimeter ($\mu W/cm^2$). For plane wave power density, electric field strength (E) and magnetic field strength (H) are related by the impedance of free space, i.e., 377 ohms. In particular,

$$S = \frac{E^2}{377} = 377H^2$$

where E and H are expressed in units of V/m and A/m, respectively, and S in units of W/m^2. Although many survey instruments indicate power density units, the actual quantities measured are E or E^2 or H or H^2.

power density, peak The maximum instantaneous power density occurring when power is transmitted.

power density, plane-wave equivalent A commonly-used term associated with any electromagnetic wave, equal in magnitude to the power density of a plane wave having the same electric (E) or magnetic (H) field strength.

pulse-modulated field An electromagnetic field produced by the amplitude modulation of a continuous wave carrier by one or more pulses.

pulse-repetition frequency (PRF) In pulsed systems, the number of output pulses per unit time, usually expressed in Hertz (sec^{-1}).

pulse width In pulsed systems, the amount of time that each output pulse or burst of energy is on. In radar systems, pulse width is measured in microseconds (10^{-6} sec).

pulse systems A system designed to produce its energy in short pulses or bursts, repeated at regular intervals (see pulse width, duty factor, and pulse repetition frequency). Applications include most radars, and are distinct from CW systems.

radiation The emission or transfer of energy in the form of electromagnetic waves.

radio frequency (RF) Although the RF spectrum is formally defined in terms of frequency as extending from 0 to 3000 GHz, for purposes of this document, the frequency range of interest is 3 kHz to 300 GHz.

TOC

re-radiated field An electromagnetic field resulting from currents induced in a secondary, predominantly conducting object by electromagnetic waves incident on that object from one or more primary radiating structures or antennas. Re-radiated fields are sometimes called "reflected" or, more correctly, "scattered fields." The scattering object is sometimes called a "re-radiator" or "secondary radiator"(see *scattered radiation*).

RF "hot spot" A highly localized area of relatively intense radio-frequency radiation that manifests itself in two principal ways:

(1) The presence of intense electric or magnetic fields immediately adjacent to conductive objects that are immersed in lower intensity ambient fields (often referred to as re-radiation), and

(2) Localized areas, not necessarily immediately close to conductive objects, in which there is a concentration of radio-frequency fields caused by reflections and/or narrow beams produced by high-gain radiating antennas or other highly directional sources.

In both cases, the fields are characterized by very rapid changes in field strength with distance. RF hot spots are normally associated with very nonuniform exposure of the body (partial body exposure). This is not to be confused with an actual thermal hot spot within the absorbing body.

root-mean-square (rms) The effective value, or the value associated with joule heating, of a periodic electromagnetic wave. The rms value is obtained by taking the square root of the mean of the squared value of a function.

scalar A quantity, such as temperature or energy, having a magnitude only.

scattered radiation An electromagnetic field resulting from currents induced in a secondary, conducting or dielectric object by electromagnetic waves incident on that object from one or more primary sources.

short-term exposure Exposure for durations less than the corresponding averaging time.

specific absorption (SA) The quotient of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume (dV) of a given density (ρ).

$$SA = \frac{dW}{dm} = \frac{dW}{\rho dV}$$

The specific absorption is expressed in units of joules per kilogram (J/kg).

specific absorption rate (SAR) The time derivative of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dV) of given density (P).

$$SAR = \frac{d}{dt}\left[\frac{dW}{dm}\right] = \frac{d}{dt}\left[\frac{dW}{\rho dV}\right]$$

SAR is expressed in units of watts per kilogram (W/kg).

threshold limit value (TLV) The rms and peak electric and magnetic field strengths, their squares, or the plane-wave equivalent power densities associated with these fields and the induced and contact currents to which a person may be exposed without harmful effect and with an acceptable safety factor.

uncontrolled environment A location where exposure may be incurred by persons who have no knowledge or control of their exposure. These exposures may occur in living quarters or workplaces where there are no expectations that the exposure levels could exceed those shown in standards that specify uncontrolled limits.

vector A quantity, such as velocity or force, having both magnitude and direction. A vector is denoted by a symbol in bold type.

velocity The velocity of wave propagation, v, represents the speed at which the wave advances. In free space v is at right angles to both E and H and in the same direction as the Poynting Vector. In a vacuum, where the speed of an electromagnetic wave is *c*, the speed of light, $c = \lambda v$

wavelength (λ) The wavelength (λ) of an electromagnetic wave is related to the frequency (f) and velocity (v) by the expression $v = f\lambda$. The velocity of an electromagnetic wave in free space is equal to the speed of light, i.e., approximately $3x10^8$m/s (meters per second).