ULTRASOUND

(*Documentation* Date – 2001)

These TLVs® represent conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse effect on their ability to hear and understand normal speech. Previous TLVs® for the frequencies 10 kilohertz (kHz) to 20 kHz, et to prevent subjective effects, are referenced in a cautionary note to Table 1. The 8-hour TWA values are an extension of the TLV® for Noise, which is an 8-hour TWA of 85 dBA. The ceiling values may be verified by using a sound level meter with slow detection and 1/3 octave bands. The TWA values may be verified by using an integrating sound level meter with 1/3 octave bands. All instrumentation should have adequate frequency response and should meet the specifications of ANSI S1.4-1983 (R1997)(1) and IEC 804.(2)

TABLE 1. TLVs® for Ultrasound

	One-third Octave-Band Level(3)		
	Measured in Air in dB re: 20 µPa; Head in Air		Measured in Water in dB re: 1 µPa; Head in Water
Mid-Frequency of Third-Octave Band (kHz)	Ceiling Values	8-Hour TWA	Ceiling Values
10	105[A]	88[A]	167
12.5	105[A]	89[A]	167
16	105[A]	92[A]	167
20	105[A]	94[A]	167
25	110[B]	—	172
31.5	115[B]	—	177
40	115[B]	—	177
50	115[B]	—	177
63	115[B]	—	177
80	115[B]	—	177
100	115[B]	—	177

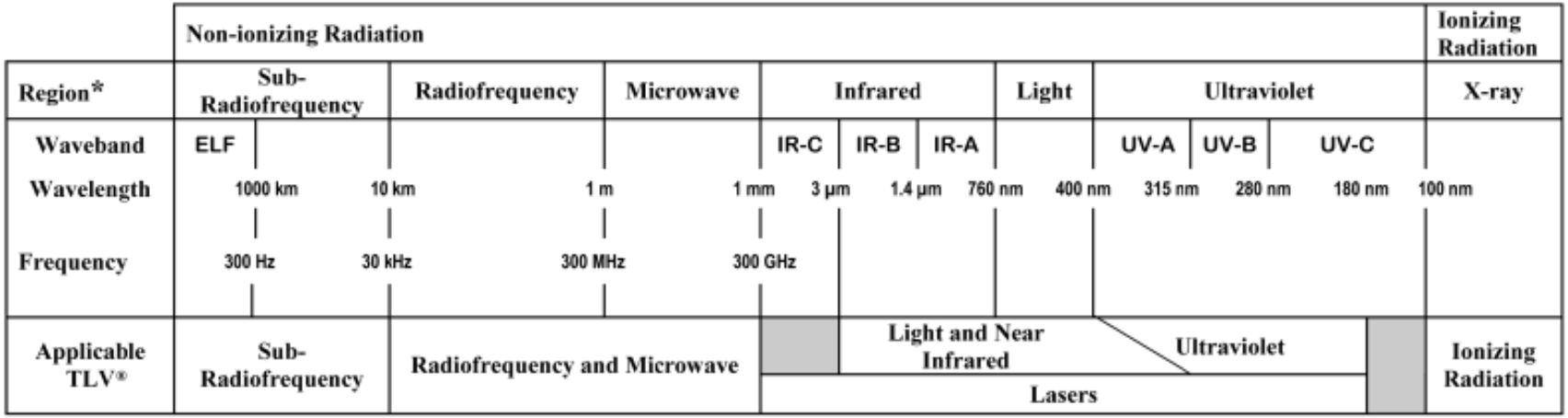
[A] Subjective annoyance and discomfort may occur in some individuals at levels between 75 and 105 dB for the frequencies from 10 kHz to 20 kHz especially if they are tonal in nature. Hearing protection or engineering controls may be needed to prevent subjective effects. Tonal sounds in frequencies below 10 kHz might also need to be reduced to 80 dB.

[B] These values assume that human coupling with water or other substrate exists. These thresholds may be raised by 30 dB when there is no possibility that the ultrasound can couple with the body by touching water or some other medium. [When the ultrasound source directly contacts the body, the values in the table do not apply. The vibration level at the mastoid bone must be used.] Acceleration Values 15 dB above the reference of 1 g rms should be avoided by reduction of exposure or isolation of the body from the coupling source (g = acceleration due to the force of gravity, 9.80665 meters/second^2; rms = root-mean-square).

References

1. American National Standards Institute: Specification for Sound Level Meters. ANSI S1.4-1983 (R1997). ANSI, New York (1997).
2. International Electrotechnical Commission: Integrating-Averaging Sound Level Meters. IEC 804. IEC, New York (1985).
3. American National Standards Institute: Specification for Octave-Band and Fractional-Octave-Band Analog and Digital Filters S1.11-1986 (R1998). ANSI, New York (1998).

ELECTROMAGNETIC RADIATION SPECTRUM AND RELATED TLVs®



*The boundaries between regions are set by convention and should not be regarded as absolute dividing lines.

TLV®-PA

ELECTROMAGNETIC FIELDS 0–300 GHz

STATIC MAGNETIC FIELDS
(*Documentation* Date – 2015)

These TLVs® refer to static magnetic field flux densities to which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. These values should be used as guides in the control of exposure to static magnetic fields and should not be regarded as fine lines between safe and dangerous levels.

Routine occupational exposures should not exceed 2 tesla (T) in the general workplace environment, but can have ceiling values of 8 T for workers with special training and operating in a controlled workplace environment. Special training involves making workers aware of transient sensory effects that can result from rapid motion in static magnetic fields with flux densities greater than 2 T. A controlled workplace environment is one in which forces exerted by static magnetic fields on metallic objects do not create potentially hazardous projectiles. Exposure of the limbs of workers in the general workplace environment should not exceed 20 T. Workers with implanted ferromagnetic or electronic medical devices should not be exposed to static magnetic fields exceeding 0.5 mT.

These TLVs® are summarized in Table 1.

TABLE 1. TLVs® for Static Magnetic Fields

Exposure	Ceiling Value
Whole body (general workplace)	2 T
Whole body (special worker training and controlled workplace environment)	8 T
Limbs	20 T
Medical device wearers	0.5 mT

SUB-RADIOFREQUENCY (30 kHz and below) MAGNETIC FIELDS

(*Documentation* Date – 2017)

These TLVs® refer to the amplitude of the magnetic flux density (B) of sub-radiofrequency (sub-RF) magnetic fields in the frequency range of 30 kilohertz (kHz) and below to which it is believed that nearly all workers may be exposed repeatedly without adverse health effects. The magnetic field strengths in these TLVs® are root-mean-square (rms) values. These values should be used as guides in the control of exposure to sub-radiofrequency magnetic fields and should not be regarded as fine lines between safe and dangerous levels.

Occupational exposures in the extremely-low-frequency (ELF) range from 1 to 300 hertz (Hz) should not exceed the ceiling value given by the equation:

$$B_{TLV} = \frac{60}{f}$$

where: f = the frequency in Hz

B_{TLV} = the magnetic flux density in millitesla (mT).

For frequencies in the range of 300 Hz to 30 kHz (which includes the voice frequency [VF] band from 300 Hz to 3 kHz and the very-low-frequency [VLF] band from 3 to 30 kHz), occupational exposures should not exceed the ceiling value of 0.2 mT.

These ceiling values for frequencies of 300 Hz to 30 kHz are intended for both partial-body and whole-body exposures. For frequencies below 300 Hz, the TLV® for exposure of the extremities can be increased by a factor of 10 for the hands and feet and by a factor of 5 for the arms and legs.

The magnetic flux density of 60 mT/f at 60 Hz corresponds to a maximum permissible flux density of 1 mT. At 30 kHz, the TLV® is 0.2 mT, which corresponds to a magnetic field intensity of 160 amperes per meter (A/m).[1]

Contact currents from touching ungrounded objects that have acquired an induced electrical charge in a strong sub-RF magnetic field should not exceed the following point contact levels to avoid startle responses or severe electrical shocks:

A. 1.0 milliampere (mA) at frequencies from 1 Hz to 2.5 kHz;

B. 0.4 f mA at frequencies from 2.5 to 30 kHz, where f is the frequency expressed in kHz.

[1] Magnetic fields are expressed in units of amperes/m. In health and safety studies, a more common dosimetric quantity is the magnetic flux density in units of Tesla (T) or Gauss (G). 1 T = 10,000 G. The two quantities are related by the magnetic permeability of the medium. In air, 1 A/m corresponds to a flux density of 1.3 μT.

Notes:

1. These TLVs® are based on an assessment of available data from laboratory research and human exposure studies. Modifications of the TLVs® will be made if warranted by new information. At this time, there is insufficient information on human responses and possible health effects of magnetic fields in the frequency range of 1 Hz to 30 kHz to permit the establishment of a TLV® for time-weighted average exposures.
2. For workers wearing cardiac pacemakers, the TLV® may not protect against electromagnetic interference with pacemaker function. Some models of cardiac pacemakers have been shown to be susceptible to interference by power-frequency (50/60 Hz) magnetic flux densities as low as 0.1 mT. It is recommended that, lacking specific information on electromagnetic interference from the manufacturer, the exposure of persons wearing cardiac pacemakers or similar medical electronic devices be maintained at or below 0.1 mT at power frequencies.
3. Fields in excess of the TLV® are likely to be present only in close proximity to high powered electrical equipment; in most occupational environments sub-RF fields are likely to be far below the TLV®. There should consequently be little need for detailed field surveys in general occupational spaces, although such surveys may help to address workers' concerns. If field surveys are undertaken, however, they should use appropriate equipment that has been calibrated and suitable for the anticipated measurements. In particular, unless they are designed for such measurements, magnetic field meters can be significantly in error when used to measure nonsinusoidal waveforms or fields at frequencies other than 50/60 Hz.

TABLE 1. TLVs® for Sub-Radiofrequency(30 kHz and below) Magnetic Fields

Frequency Range	TLV®
1 to 300 Hz	Whole-body exposure: $\frac{60}{f^*}$ ceiling value in mT
1 to 300 Hz	Arms and legs: $\frac{300}{f^*}$ ceiling value in mT
1 to 300 Hz	Hands and feet: $\frac{600}{f^*}$ ceiling value in mT * where: f = frequency in Hz
300 Hz to 30 kHz	Whole-body and partial-body ceiling value: 0.2 mT
1 Hz to 2.5 kHz	Point contact current limit: 1.0 mA
2.5 to 30 kHz	Point contact current limit: 0.4 f mA where: f = frequency in kHz

SUB-RADIOFREQUENCY (30 kHz and below) AND STATIC ELECTRIC FIELDS

(*Documentation* Date – 2016)

These TLVs® refer to the maximum workplace field strengths of sub-radiofrequency electric fields (30 kHz and below) and static electric fields that represent conditions under which it is believed that nearly all workers may be exposed repeatedly without special protection without adverse health effects. The electric field intensities in these TLVs® are root-mean-square (rms) values. The values should be used as guides in the control of exposure and should not be regarded as a fine line between safe and dangerous levels. The electric field strengths stated in these TLVs® refer to the field levels present in air, away from the surfaces of conductors (where spark discharges and contact currents may pose significant hazards).

Occupational exposures should not exceed a field strength of 25 kilovolts per meter (kV/m) at frequencies from 0 Hz to 220 Hz. For frequencies in the range of 220 Hz to 3 kilohertz (kHz), the ceiling value is given by:

$$E_{TLV} = 5.525 \times 10^6/f$$

where:

f = the frequency in Hz
E_{TLV} = the rms electric field strength in V/m

A rms value of 1842 V/m is the ceiling value for frequencies from 3 to 30 kHz. These ceiling values are intended for both partial-body and whole-body exposures.

Notes:

1. These TLVs® are based on limiting field-induced effects at the body surface and induced currents within the body to levels below those that are believed to be hazardous. These are direct effects.
2. Indirect effects associated with touching charged objects within the electric field can be the limiting phenomena that determine safe practice. A noticeable and potentially annoying spark discharge can be experienced beneath power lines when the ground level field strength is at or below 5 kV/m (EPRI, 2005). Mitigation of such effects requires compliance with safe work practices and electrical safety codes beyond the scope of this TLV®.
3. Certain biological effects have been reported in laboratory studies at electric field strengths below those permitted in the TLV®; however, there is no convincing evidence at the present time that occupational exposure to such field levels leads to adverse health effects.

Modifications of the TLVs® will be made if warranted by new information. At this time, there is insufficient information on human responses and possible health effects of electric fields in the frequency range of 0 to 30 kHz to permit the establishment of a TLV® for time-weighted average exposures.

Reference

Electrical Power Research Institute (EPRI): AC Transmission Line Reference Book — 200 kV and Above, 3rd Edition. EPRI, Palo Alto, CA (2005).

RADIOFREQUENCY/MICROWAVE RADIATION

(*Documentation* Date – 2016)

These TLVs® refer to radiofrequency (RF) radiation in the frequency range of 30 kilohertz (kHz) to 300 gigahertz (GHz). This includes microwave radiation (300 MHz–300 GHz), which is a region of the RF spectrum. These TLVs® represent conditions under which it is believed nearly all workers may be repeatedly exposed without adverse health effects.

The TLVs® were designed to limit electrostimulation of nerve and muscle tissue at frequencies from 0.03 to 0.1 MHz, and tissue heating above 0.1 MHz. The TLVs® are given in terms of root-mean-square (rms) electric (E), and magnetic (H) field strengths, the equivalent plane-wave free-space power densities (S), and induced currents ($\mathbf{I}$) in the body.

The TLVs® are summarized in Table 1 as a function of frequency, f, in megahertz (MHz). Table 2 summarizes the major dosimetric quantities in different frequency ranges specified in the TLV®, and major hazard mechanisms and typical exposure scenarios that would be of concern.

A. For exposures to electric and magnetic free fields, TLVs® in Table 1, Part A refer to exposure values obtained by spatially averaging over an area equivalent to the vertical cross-section of the human body (projected area). In the case of partial body exposure, the TLVs® can be relaxed. In nonuniform fields, spatial peak values of field strength may exceed the TLVs® if the spatially averaged specific absorption rate (SAR) value remains within the specified limits.

B. Access should be restricted to limit the rms RF body current and potential for RF electrostimulation ("shock," below 0.1 MHz) or perceptible heating (at or above 0.1 MHz) as follows (*see* Table 1, Part B):

1. For freestanding individuals (no contact with metallic objects), RF current induced in the human body, as measured through either foot, should not exceed the following values, where f is the frequency in MHz:

   $\mathbf{I}$ = 1000 f mA for (0.03 < f < 0.1 MHz) averaged over 0.2 s; where mA = milliampere

   $\mathbf{I}$ = 100 mA for (0.1 < f < 100 MHz) averaged over 6 min

2. For conditions of possible contact with metallic bodies, the maximum RF current that can be passed into the body as measured with a contact current meter should not exceed the following values:

   $\mathbf{I}$ = 1000 f mA for (0.03 < f < 0.1 MHz) (where f is the frequency in MHz) averaged over 0.2 s

   $\mathbf{I}$ = 100 mA for (0.1 < f < 100 MHz) averaged over 6 min

TABLE 1. Radiofrequency and Microwave TLVs®

Part A—Electromagnetic Fields[A] (f = frequency in MHz)

Frequency	Power Density, S (W/m^2)	Electric Field Strength, E (V/m)	Magnetic Field Strength, H (A/m)	Averaging Time E^2, H^2, or S (min)
30 kHz–100 kHz		1842	163	6
100 kHz–1 MHz		1842	16.3/f	6
1 MHz–30 MHz		1842/f	16.3/f	6
30 MHz–100 MHz		61.4	16.3/f	6
100 MHz–300 MHz	10	61.4	0.163	6
300 MHz–3 GHz	f/30			6
3 GHz–30 GHz	100			$34000/f^{1.079}$
30 GHz–300 GHz	100			$68/f^{0.476}$

[A]The exposure values in terms of electric and magnetic field strengths are obtained by spatially averaging over an area equivalent to the vertical cross-section of the human body (projected area). At frequencies between 100 MHz and 300 MHz, the TLV® is defined in the near field of the source in terms of electric and magnetic field, and in the far field in terms of the power density of the wave. At frequencies above 30 GHz, the power density TLV® is the limit of exposure averaged over any contiguous 0.01 m^2 of body surface. However, above 30 GHz the maximum power density is 1000 W/m^2 in any one square centimeter.

Part B—Maximum Induced and Contact Radiofrequency Currents (mA)[B]

Frequency	Through Both Feet	Through Either Foot	Grasping[B1]	Averaging Time
30 kHz–100 kHz	2000 f	1000 f	1000 f	0.2 s[C]
100 kHz–100 MHz	200	100	100	6 min[D]

[B] It should be noted that the current limits given above may not adequately protect against startle reactions and burns caused by transient discharges when contacting an energized object.

The ceiling value for induced and contact currents is 500 mA for no more than 15 s per 6 min period.

[B1] Maximum touch current is limited to 50% of the maximum grasping current.

[C] **I** is averaged over a 0.2 s period.

[D] **I** is averaged over a 6-minute period (e.g., for either foot or hand contact, i.e., **I** t < 60,000 mA^2-min). In this table, f is the frequency in Hz.