

IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz

IEEE Standards Coordinating Committee 39

Developed by the
IEEE International Committee on Electromagnetic Safety

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Abstract: Safety limits for the protection of persons against the established adverse health effects of exposures to electric, magnetic, and electromagnetic fields in the frequency range 0 Hz to 300 GHz are presented in this standard. These exposure limits are intended to apply generally to persons permitted in restricted environments and to the general public in unrestricted environments. These exposure limits are not intended to apply to the exposure of patients by or under the direction of physicians and medical professionals, as well as to the exposure of informed volunteers in medical or scientific research studies, and might not be protective with respect to the use of medical devices or implants.

Keywords: dosimetric reference limit (DRL), exposure reference level (ERL), induced and contact currents, electric fields, electrical excitation, electromagnetic fields, electrostimulation, general public, IEEE C95.1™, magnetic fields, non-ionizing radiation protection, radio frequency (RF), RF exposure, RF safety, restricted environment, specific absorption rate (SAR), unrestricted environment

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Introduction

This introduction is not part of IEEE Std C95.1-2019, IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz.

In 1960, the American Standards Association approved the initiation of the Radiation Hazards Standards project under the co-development of the Department of the Navy and the Institute of Electrical and Electronics Engineers, Incorporated (IEEE; called the “Institute of Radio Engineers (IRE)” at the time). Prior to 1988, C95 standards were developed by Accredited Standards Committee C95 and submitted to the American National Standards Institute (ANSI) for approval and issuance as ANSI C95 standards. Between 1988 and 1990, the committee was converted to the “Standards Coordinating Committee 28 (SCC28)” under the development of the IEEE Standards Board. In 2001, the IEEE Standards Association Standards Board approved the name “International Committee on Electromagnetic Safety (ICES)” for SCC28 to better reflect the scope of the committee and its international membership. In accordance with the policies of the IEEE, C95 standards are issued and developed as IEEE standards and submitted to ANSI for recognition.

In June 1995, the IEEE Standards Board approved the establishment of “Standards Coordinating Committee 34 (SCC34), Product Performance Standards Relative to the Safe Use of Electromagnetic Energy.” Standards developed by SCC34 do not specify limits for human exposure to electromagnetic fields, but refer to established limits found in science-based standards such as IEEE Std C95.1™-2005, IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz.

In 2005, SCC28 and SCC34 became “Technical Committee 95” and “Technical Committee 34,” respectively, under a new IEEE Standards Coordinating Committee, SCC39, which is now called “ICES.”¹

The present scope of IEEE ICES Technical Committee 95 (TC95) is as follows:

“Development of standards for the safe use of electromagnetic energy in the range of 0 Hz to 300 GHz relative to the potential hazards of exposure of man, volatile materials, and explosive devices to such energy. It is not intended to include infrared, visible, ultraviolet, or ionizing radiation. The committee will coordinate with other committees whose scopes are contiguous with ICES.”

There are six TC95 Subcommittees, each of whose area of responsibility is described as follows in correspondence with its designated Subcommittee number:

- SC 1: Techniques, Procedures, Instrumentation, and Computation
- SC 2: Terminology, Units of Measurements, and Hazard Communication
- SC 3: Safety Levels with Respect to Human Exposure, 0 Hz to 3 kHz
- SC 4: Safety Levels with Respect to Human Exposure, 3 kHz to 300 GHz
- SC 5: Safety Levels with Respect to Electro-Explosive Devices
- SC 6: EMF Modeling and Dosimetry

¹ Standards Coordinating Committees are established by the IEEE SA Standards Board and provide a mechanism to oversee the development of standards that are beyond the scopes of individual technical committees within IEEE’s societies.

This standard was prepared by Subcommittee 3 and Subcommittee 4 of TC95. TC95 has issued three standards, four recommended practices, and one guide. The present versions are as follows:

- IEEE Std C95.1™-2019, IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz.
- IEEE Std C95.1-2345™-2014, IEEE Standard for Military Workplaces—Force Health Protection Regarding Personnel Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz.
- IEEE Std C95.2™-2018, IEEE Standard for Radio-Frequency Energy and Current-Flow Symbols.
- IEEE Std C95.3™-2002 (R2008), IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic Fields With Respect to Human Exposure to Such Fields, 100 kHz to 300 GHz.
- IEEE Std C95.3.1™-2010, IEEE Recommended Practice for Measurements and Computations of Electric, Magnetic, and Electromagnetic Fields with Respect to Human Exposure to Such Fields, 0 Hz to 100 kHz.
- IEEE Std C95.4™-2002 (R2008), IEEE Recommended Practice for Determining Safe Distances from Radio Frequency Transmitting Antennas When Using Electric Blasting Caps During Explosive Operations.
- IEEE Std C95.7™-2014, IEEE Recommended Practice for Radio Frequency Safety Programs, 3 kHz to 300 GHz.²
- IEEE Std 1460™-1996 (R2008), IEEE Guide for the Measurement of Quasi-Static Magnetic and Electric Fields.

Dedication

This edition of IEEE Std C95.1 is dedicated in memory of Ronald C. (Ron) Petersen. Ron served on various IEEE committees beginning in the 1970s, particularly SCC28, SCC34, and SCC39 (ICES). He also served as chair of the International Electrotechnical Commission (IEC) TC 106 (EMF exposure) through its first 15 years. Ron's passing represents a great loss for the IEEE, and especially for ICES. His constant attention to the workings of this committee and the development of standards documents formed the glue that ensured the continued cohesiveness and success of ICES. We will all miss Ron in our meetings—he lives forever in our memories.

² The latest revisions of IEEE Std C95.1, IEEE Std C95.1-2345, IEEE Std C95.2, IEEE Std C95.3, IEEE Std C95.3.1, and IEEE Std C95.7 are available at no cost (at the time of publication of this standard) through the IEEE Get Program. (<https://ieeexplore.ieee.org/browse/standards/get-program/page/series?id=82>).

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IEEE Standard for Safety Levels with Respect to Human Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz

1. Overview

1.1 Scope

This standard specifies exposure criteria and limits to protect against established adverse health effects in humans associated with exposure to electric, magnetic, and electromagnetic fields in the frequency range of 0 Hz to 300 GHz.^{1,2} These limits, incorporating safety margins, are expressed in terms of dosimetric reference limits (DRL) and exposure reference levels (ERL). DRLs are expressed in terms of *in situ* electric field strength, specific absorption rate (SAR), and epithelial power density. ERLs, which are more easily determined, are limits on external electric and magnetic fields, incident power density, induced and contact currents, and contact voltages intended to ensure that the DRLs are not exceeded. The limits, which protect against adverse health effects associated with electrostimulation of tissue and local and whole-body heating, are intended to apply to the described human exposure conditions. However, these levels are not intended to address exposures of patients or human research subjects under the care of medical professionals for which other risks and benefits might apply. These exposure limits might not prevent interference with medical and other devices that might exhibit susceptibility to electromagnetic interference (EMI).

1.2 Purpose

The purpose of this standard is to provide science-based exposure criteria to protect against established adverse health effects in humans associated with exposure to electric, magnetic, and electromagnetic fields; induced and contact currents; and contact voltages, over the frequency range of 0 Hz to 300 GHz.³

¹ The limits in this standard are intended to protect against adverse health effects except in certain cases of contact current exposures or RF arcing exposures that could result in highly localized burns or transient adverse reactions (e.g., startle or pain).

² The limits at 300 GHz for persons permitted in restricted environments are the same as the corresponding values in existing standards for exposure in the infrared frequency range, which begins at 300 GHz (cf. ANSI Z136.1-2014 [B69] and IEC 60825-1 [B653]).

³ The frequencies and wavelengths covered by this standard are in the “nonionizing radiation” region of the electromagnetic spectrum.