IEEE STANDARDS ASSOCIATION IEEE

IEEE Standard for Military Workplaces—Force Health Protection Regarding Personnel Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz

IEEE Technical Committee 95

Sponsored by the
IEEE International Committee on Electromagnetic Safety (SCC39)

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

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

Sponsor

Technical Committee 95
of the
IEEE International Committee on Electromagnetic Safety (SCC39)

Approved 16 May 2014

IEEE-SA Standards Board

Abstract: Recommendations to protect personnel in military environments against established adverse health effects associated with exposure to electric, magnetic, and electromagnetic fields, induced and contact current, and contact and arcing voltages over the frequency range of 0 Hz to 300 GHz are provided in this standard. IEEE Std C95.1-2345™ was developed to replace North Atlantic Treaty Organization (NATO) Standardization Agreement (STANAG) 2345 (Edition 3), Evaluation and Control of Personnel Exposure to Radio Frequency Fields—3 kHz to 300 GHz, (13 February 2003).

Keywords: Dosimetric reference limit (DRL), electric fields, electrical excitation, electromagnetic energy, electromagnetic fields, electrostimulation, exposure limits, exposure reference level (ERL), IEEE C95.1-2345™, induced and contact currents, lowest-observed-adverse-effects-level (LOAEL), lowest-observed-effects-level (LOEL), magnetic fields, personnel protection program initiation level, radio frequency (RF), restricted environment, restricted expert only (REO) zone, RF exposure, RF risk management, specific absorption rate (SAR), unrestricted environment

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2014 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 30 May 2014. Printed in the United States of America.

IEEE is a registered trademark in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

PDF: ISBN 978-0-7381-8982-6 STD98575
Print: ISBN 978-0-7381-8983-3 STDPD98575

IEEE prohibits discrimination, harassment, and bullying.
For more information, visit http://www.ieee.org/web/aboutus/whatis/policies/p9-26.html.
No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading "Important Notice" or "Important Notices and Disclaimers Concerning IEEE Standards Documents."

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association ("IEEE-SA") Standards Board. IEEE ("the Institute") develops its standards through a consensus development process, approved by the American National Standards Institute ("ANSI"), which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. IEEE standards documents are supplied "AS IS" and "WITH ALL FAULTS."

Use of an IEEE standard is wholly voluntary. The existence of an IEEE standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon his or her own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus development process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE should be considered the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE-SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, or be relied upon as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide consulting information or advice pertaining to IEEE Standards documents. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to comments or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854 USA

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not imply compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Copyrights

IEEE draft and approved standards are copyrighted by IEEE under U.S. and international copyright laws. They are made available by IEEE and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making these documents available for use and adoption by public authorities and private users, IEEE does not waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate fee, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Updating of IEEE Standards documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect.

Every IEEE standard is subjected to review at least every ten years. When a document is more than ten years old and has not undergone a revision process, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE standard.

In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit the IEEE-SA Website at http://ieeexplore.ieee.org/xpl/standards.jsp or contact IEEE at the address listed previously. For more information about the IEEE-SA or IEEE's standards development process, visit the IEEE-SA Website at http://standards.ieee.org.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE-SA Website at the following URL: http://standards.ieee.org/findstds/errata/index.html. Users are encouraged to check this URL for errata periodically.

Patents

Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at http://standards.ieee.org/about/sasb/patcom/patents.html. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

Participants

At the time this IEEE standard was completed, the Technical Committee 95 Subcommittee 3 and Subcommittee 4 Working Group had the following membership:

T. Dovan, R. Kavet, *Co-chairs SC3*
A. Thansandote, M. Ziskin, *Co-chairs SC4*
Ronald Petersen, *Secretary*

William Bailey
David Baron
John Bergeron
Ralf Bodemann
Aviva Brecher
Jerrold Bushberg
Chung-Kwang Chou
Robert Cleveland
Rodney Croft
John D'Andrea
John DeFrank
Amnon Duvdevany
Kenneth Gettman
Martin Gledhill
Donald Haes
Akimasa Hirata
Masateru Ikehata
Michel Israel
Kent Jaffa
Hai Jiang
Kenneth Joyner
Efthymios Karabetsos
Bertram Klauenberg
Rajat Mathur
Michael Murphy
Robert Needy
John Osepchuk
Robert Podhrasky
J. Patrick Reilly
Asher Sheppard
Yakov Shkolnikov
Devashish Shrivastava
John Tattersall
Richard Tell
Paul Testagrossa
Donald Umbdenstock
Arthur Varanelli

The following members of the individual balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Max Ammann
David Baron
Ralf Bodemann
Chris Brooks
Chung-Kwang Chou
Keith Chow
Robert Cleveland
Brian Cramer
Robert Curtis
John D'Andrea
John DeFrank
Thanh Dovan
Sourav Dutta
Kenneth Foster
Doaa Galal
Kenneth Gettman
Randall Groves
Donald Haes
James Hatfield
Akimasa Hirata
Werner Hoelzl
Masateru Ikehata
Noriyuki Ikeuchi
Sheila Johnston
Kenneth Joyner
Laszlo Kadar
Efthymios Karabetsos
Yuri Khersonsky
Nam Kim
Bertram Klauenberg
Joseph L. Koepfinger
Michael Lauxman
Greg Luri
Rajat Mathur
Martin Meltz
Michael Newman
John Osepchuk
Malcolm Packer
Ronald Petersen
J. Patrick Reilly
Brad Roberts
Michael Roberts
Ervin Root
Jesse Rorabaugh
Bartien Sayogo
Yakov Shkolnikov
Walter Struppler
Kin Sze
John Tattersall
Richard Tell
Paul Testagrossa
Artnarong Thansandote
Donald Umbdenstock
Arthur Varanelli
Robert Weller
Edward Yandek
Donald Zipse
Marvin Ziskin

Copyright © 2014 IEEE. All rights reserved.

When the IEEE-SA Standards Board approved this standard on 16 May 2014, it had the following membership:

John Kulick, *Chair*
Jon Walter Rosdahl, *Vice Chair*
Richard H. Hulett, *Past Chair*
Konstantinos Karachalios, *Secretary*

Peter Balma
Farooq Bari
Ted Burse
Clint Chaplin
Stephen Dukes
Jean-Philippe Faure
Gary Hoffman
Michael Janezic
Jeffrey Katz
Joseph L. Koepfinger*
David J. Law
Hung Ling
Oleg Logvinov
Ted Olsen
Glenn Parsons
Ron Petersen
Adrian Stephens
Peter Sutherland
Yatin Trivedi
Phil Winston
Don Wright
Yu Yuan

*Member Emeritus

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Richard DeBlasio, *DOE Representative*
Michael Janezic, *NIST Representative*

Julie Alessi
IEEE-SA Content Publishing

Joan Woolery
IEEE-SA Technical Community Programs

Copyright © 2014 IEEE. All rights reserved.

Introduction

This introduction is not part of 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.

In 1960, the American Standards Association approved the initiation of the Radiation Hazards Standards project under the co-sponsorship of the Department of the Navy and the Institute of Electrical and Electronics Engineers, Incorporated (IEEE). 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 Standards Coordinating Committee 28 (SCC 28) under the sponsorship of the IEEE Standards Board. In 2001, the IEEE Standards Association Standards Board approved the name "International Committee on Electromagnetic Safety (ICES)" for SCC 28 to better reflect the scope of the committee and its international membership. In accordance with policies of 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, SCC 28 and SCC 34 became Technical Committee 95 and Technical Committee 34, respectively, under a new IEEE Standards Coordinating Committee, SCC 39, 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 five TC95 subcommittees, each of whose area of responsibility is described as follows in correspondence with its designated subcommittee number:

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

This standard was prepared by Subcommittee 3 and Subcommittee 4 of TC95 under a Specific Agreement between NATO Standardization Agency (NSA) and IEEE in accordance with a Technical Cooperation Agreement (TCA) between NSA and IEEE. TC95 has issued four standards, four recommended practices, and one guide. Present versions are as follows:

— 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.

— 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.

[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.

Copyright © 2014 IEEE. All rights reserved.

— IEEE Std C95.2™-1999 (R2005), IEEE Standard for Radio-Frequency Energy and Current-Flow Symbols.

— IEEE Std C95.3™-2002 (R2008), Recommended Practice for Measurements and Computations of Electric, Magnetic and Electromagnetic Fields With Respect to Human Exposure to Such Fields, 100 kHz-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 C95.6™-2002 (R2007), IEEE Standard for Safety Levels With Respect to Human Exposure to Electromagnetic Fields, 0-3 kHz.

— IEEE Std C95.7™-2005, IEEE Recommended Practice for Radio Frequency Safety Programs, 3 kHz to 300 GHz.

— IEEE Std 1460™-1996, (R2008), IEEE Guide for the Measurement of Quasi-Static Magnetic and Electric Fields.

Copyright © 2014 IEEE. All rights reserved.

Contents

Copyright © 2014 IEEE. All rights reserved.

IEEE Standard for Military Workplaces—Force Health Protection Regarding Personnel Exposure to Electric, Magnetic, and Electromagnetic Fields, 0 Hz to 300 GHz

IMPORTANT NOTICE: IEEE Standards documents are not intended to ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading "Important Notice" or "Important Notices and Disclaimers Concerning IEEE Documents." They can also be obtained on request from IEEE or viewed at http://standards.ieee.org/IPR/disclaimers.html.

1. Overview

1.1 Scope

This standard provides recommendations to protect personnel in military environments against established adverse health effects associated with exposure to electric, magnetic, and electromagnetic fields, induced and contact current, and contact and arcing voltages over the frequency range of 0 Hz to 300 GHz. The recommendations, expressed as dosimetric reference limits (DRLs) and exposure reference levels (ERLs), incorporate safety factors that address uncertainties such as uncertainties in the experimental data, measurement uncertainties, and differences in threshold variability between individuals, so as to establish an appropriate margin of safety. The DRLs are expressed in terms of *in situ* electric field strength, specific absorption rate (SAR), and incident power density. The ERLs are expressed in terms of environmental exposure fields and power densities. In the case of contact current, however, only ERLs are provided. The DRLs and ERLs are intended to protect against established adverse human health effects associated with electrostimulation of tissue and partial and whole-body heating, but may not protect against electromagnetic interference (EMI) with implanted medical devices. This standard does not apply to

Copyright © 2014 IEEE. All rights reserved.