IEEE white BOOK™

602™

IEEE Recommended Practice for

Electric Systems in Health Care Facilities

Published by the
Institute of Electrical and
Electronics Engineers, Inc.

IEEE Std 602™-2007
(Revision of
IEEE Std 602-1996)

IEEE Std 602™-2007
(Revision of
IEEE Std 602-1996)

IEEE Recommended Practice for Electric Systems in Health Care Facilities

Sponsor

Power Systems Engineering Subcommittee
of the
Industrial and Commercial Power Systems Department
of the
IEEE Industry Applications Society

Approved 26 March 2007

IEEE-SA Standards Board

Abstract: A recommended practice for the design and operation of electric systems in health care facilities is provided. The term *health care facility* as used here encompasses buildings or parts of buildings that contain hospitals, nursing homes, residential custodial care facilities, clinics, ambulatory health care centers, and medical and dental offices. Buildings or parts of buildings within an industrial or commercial complex, used as medical facilities, logically fall within the scope of this recommended practice.
Keywords: anesthesizing, clinical, critical branch, emergency system, equipment system, essential electrical system, examination, fire alarm, ground-fault circuit-interrupter, ground-fault protection, grounding, life safety branch, medical, nurse call, patient care, recovery, safety, standby generator, surgical, transfer switch, treatment, wet location

---

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

Print: ISBN 0-7381-5306-0 SH95609
PDF: ISBN 0-7381-5307-9 SS95609

Grateful acknowledgment is made to the following for having granted permission to reprint material in this document:

Brian Prechtel Photography.

El Camino Hospital, Mountain View, CA.

John Muir/Mt. Diablo Health System, Walnut Creek, CA.

Kaiser Foundation Health Plan, Inc.

Siemens Medical Solutions USA, Inc.

Sutter Medical Center, Sacramento, CA.

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

Use of an IEEE Standard is wholly voluntary. The IEEE disclaims liability for any personal injury, property or other damage, of any nature whatsoever, whether special, indirect, consequential, or compensatory, directly or indirectly resulting from the publication, use of, or reliance upon this, or any other IEEE Standard document.

The IEEE does not warrant or represent the accuracy or content of the material contained herein, and expressly disclaims any express or implied warranty, including any implied warranty of merchantability or fitness for a specific purpose, or that the use of the material contained herein is free from patent infringement. IEEE Standards documents are supplied "**AS IS**."

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. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, 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 publishing and making this document available, the IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity. Nor is the IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing this, and any other IEEE Standards document, should rely upon the advice of a competent professional in determining the exercise of reasonable care in any given circumstances.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of concerned interests, it is important to ensure that any interpretation has also received 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 interpretation requests except in those cases where the matter has previously received formal consideration. 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, explanation, or interpretation of the IEEE.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Comments on standards and requests for interpretations should be addressed to:

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

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

Introduction

This introduction is not part of IEEE Std 602-2007, IEEE Recommended Practice for Electric Systems in Health Care Facilities.

IEEE Std 602, known as the *IEEE White Book*™, was last published in 1996. This version of the *White Book* updates topics and categories to 2006.

IEEE Std 602 is written primarily for the practicing electrical design engineer, who may have limited experience with health care facilities, and for hospital operating personnel. It will also be useful for those who supply products and services for health care facilities. While the text deals with a broad range of topics relevant to the design and operation of health care facilities, it focuses on those aspects of facility design and operation that are unique to health care facilities. These include patient electrical safety, patient care issues, continuity of electric service, and a reliable source of power to sensitive computer-based clinical and biomedical equipment. The text also touches on communication and alarm systems that are unique to the health care facility.

Notice to users

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: http://standards.ieee.org/reading/ieee/updates/errata/index.html. Users are encouraged to check this URL for errata periodically.

Interpretations

Current interpretations can be accessed at the following URL: http://standards.ieee.org/reading/ieee/interp/index.html.

Patents

Attention is called to the possibility that implementation of this recommended practice may require use of subject matter covered by patent rights. By publication of this recommended practice, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents or patent applications for which a license may be required to implement an IEEE recommended practice or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Participants

Hugh O. Nash, Jr., and Walter N. Vernon were co-chairmen of this edition of the *IEEE White Book.* The following authors were responsible for the drafts of the individual chapters. Walter N. Vernon provided guidance, review, and editorial revisions to the submitted chapters. Walter N. Vernon's assistant, Matthew Kenney, was responsible for conforming the presentation of text, tables, charts, and figures to IEEE guidelines. James Harvey served as secretary.

The following members of the White Book Working Group contributed to these chapters:

Hugh O. Nash, Jr., *Co-Chair*
Walter N. Vernon, *Co-Chair*

Chapter 1: Overview—**Hugh O. Nash, Jr.,** *Chair*

Chapter 2: Electrical loads—**Walter N. Vernon,** *Chair;* Adrienne Hendrickson, Mary Kobaly

Chapter 3: Electrical power distribution systems—**Matt Dozier,** *Chair;* Edgar Galyon, James Harvey, Philip Keebler, James E. Meade, Ron Wilson

Chapter 4: Electrical power systems for delivering patient care—**David Stymiest,** *Chair;* Bill Bonn, Jason D'Antona, Jan Ehrenwerth, Phil Janewicz, Philip Keebler, Leilani Kicklighter, Paul Konz, Neil McGrath, David Norton, Cornelius Regan, Walter N. Vernon, Gerald W. "Jerry" Williams

Chapter 5: Emergency power systems—**Herbert Daugherty,** *Chair;* Lawrence Bey, Bill Bonn, Mark Halpin, James Iverson, James E. Meade, David Norton, Jeffrey Steplowski, Walter N. Vernon, Herbert Whittall

Chapter 6: Lighting—**Jeffrey N. Rosengard,** *Chair;* Rebecca Boulter, Anthony J. Denami, Mary Claire Frazier, Beverly K. Shimmin, Eric Strandberg

Chapter 7: Communications systems—**James R. Duncan,** *Chair;* Spencer L. Bahner, Gregory S. Batie, Carl Cox, Robert J. Eastman, Steven Goegebuer, Nathan T. Larmore, Thomas A. Leonidas, Jr., Brady A. McCoy, Terry Miller, Thomas O. Moore, Scott P. Roberts, Walter N. Vernon, Bill Van Vlack, David F. Zehrung

Chapter 8: Medical equipment instrumentation—**Walter N. Vernon,** *Chair;* Tony Freitas, Rich Fries, Nazrul Islam, Philip Keebler, Paul King, Bill Rostenberg, Bogue Waller

Chapter 9: Health care renovations—**Walter N. Vernon,** *Chair;* Edgar Galyon, James Harvey, William R. Jennings, Jr., Mark Saphire

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

Satish K. Aggarwal
Ali Al Awazi
Wallace B. Binder, Jr.
Michael J. Bio
Stuart H. Bouchey
William A. Byrd
Thomas P. Callsen
Juan C. Carreon
Keith Chow
Donald M. Colaberardino
Bryan R. Cole
Tommy P. Cooper
Stephen Dare
F. A. Denbrock
Carlo Donati
Gary L. Donner
Neal B. Dowling, Jr.
Sourav K. Dutta
Gary R. Engmann
Dan Evans
Carl J. Fredericks
Randall C. Groves
Nancy M. Gunderson
Ajit K. Gwal
Werner Hoelzl
Dennis Horwitz
Jim Kulchisky
Saumen K. Kundu
Blane Leuschner
William Lumpkins
G. L. Luri
Faramarz Maghsoodlou
Keith N. Malmedal
Mark F. McGranaghan
Gary L. Michel
Michael S. Newman
Gregory L. Olson
Lorraine K. Padden
Joshua S. Park
Ralph E. Patterson
Howard W. Penrose
Edward P. Rafter
Charles W. Rogers
Randall M. Safier
Vincent Saporita
Peter E. Sutherland
S. Thamilarasan
Raul Velazquez
Walter N. Vernon
James L. Wiseman
Donald W. Zipse
Ahmed F. Zobaa

When the IEEE-SA Standards Board approved this recommended practice on 26 March 2007, it had the following membership:

Steve M. Mills, *Chair*
Robert M. Gown, *Vice Chair*
Don Wright, *Past Chair*
Judith Gorman, *Secretary*

Richard DeBlasio
Alex Gelman
William R. Goldbach
Arnold M. Greenspan
Joanna N. Guenin
Julian Forster*
Kenneth S. Hanus
William B. Hopf
Richard H. Hulett
Hermann Koch
Joseph L. Koepfinger*
John Kulick
David J. Law
Glenn Parso.
Ronald [illegible]terse[illegible]
Tom A. [illegible]evi[illegible]st
Narayanan Ramachandran
Greg Ratta
Robby Robson
Anne-Marie Sahazizian
Virginia C. Sulzberger*
Malcolm V. Thaden
Richard L. Townsend
Howard L. Wolfman

*Member Emeritus

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

Satish K. Aggarwal, *NRC Representative*
Alan H. Cookson, *NIST Representative*

Jennie Steinhagen
IEEE Standards Project Editor

Patricia A. Gerdon
IEEE Standards Program Manager, Technical Program Development

Contents

IEEE Recommended Practice for Electric Systems in Health Care Facilities

Chapter 1
Overview

1.1 Scope

IEEE Std 602, commonly known as the *IEEE White Book™,* is published by the Institute of Electrical and Electronics Engineers (IEEE) to provide a recommended practice for the design and operation of electric systems in health care facilities. It has been prepared on a voluntary basis by design engineers and health care end users as well as electrical and medical manufacturers functioning as the White Book Working Group within the Power Systems Design Subcommittee of the Power Systems Engineering Subcommittee.

This recommended practice will probably be of greatest value to the power oriented engineer with limited health care experience. It can also be an aid to all engineers responsible for the electrical design of health care facilities. However, it is not intended as a replacement for the many excellent engineering texts and handbooks commonly in use, nor is it detailed enough to be a design manual. It should be considered a guide and a general reference on electrical design for health care facilities.

1.2 Health care facilities

The term *health care facility*, as used here, encompasses buildings or parts of buildings that contain hospitals, nursing homes, residential custodial care facilities, clinics, and medical and dental offices. Buildings or parts of buildings within an industrial or commercial complex, used as medical facilities, logically fall within the scope of this book. Thus the specific use of the building in question, rather than the nature of the overall development of which it is a part, determines its electric design category.

Today's health care facilities, because of their increasing size and complexity, have become more and more dependent upon safe, adequate, and reliable electrical systems. Every day new types of sophisticated diagnostic and treatment equipment, utilizing microprocessors or computers, come on the market. Many of these items are sensitive to

electrical disturbances and some require a very reliable power source. Invasive medical procedures such as cardiac catheterization make electrical safety extremely important. Moreover, new medical and surgical procedures are constantly being developed, and new technologies are being utilized. Modern facilities use robotics, telemedicine, picture archiving and communications systems (PACS), and the mixing of diagnostic and treatment modalities (i.e., surgical procedures combined with various types of medical imaging). In addition to the special safety and reliability requirements, health care facilities have unique life safety and communication requirements, because patients are generally unable to care for themselves or evacuate in the event of an emergency. For these reasons, perhaps no area of design or construction is changing as fast as health care facilities.

1.2.1 Industry Applications Society

The IEEE is divided into 42 societies that specialize in various technical areas of electrical engineering. Each group or society conducts meetings and publishes papers on developments within its specialized area. The Industry Applications Society (IAS) presently encompasses 18 technical committees covering electrical engineering in specific areas (petroleum and chemical industry, cement industry, glass industry, industrial and commercial power systems, and others). The Power Systems Engineering Subcommittee, which has responsibility for the White Book Working Group, is part of the Industrial and Commercial Power Systems Department of the IAS. Papers of interest to electrical engineers and designers involved in the field covered by the *IEEE White Book* are, for the most part, contained in the *IEEE Transactions on Industry Applications* of the IAS. The IAS also publishes the *IEEE Industry Applications Magazine,* which reports on the development and application of electrical systems, apparatus, devices, and controls to the processes and equipment of industry and commerce; the promotion of safe, reliable, and economic installations; the encouragement of energy conservation; and the creation of voluntary engineering standards and recommended practices.

1.2.2 Engineering in Medicine and Biology Society

Another IEEE group of interest to the electrical engineer involved in health care facility design is the Engineering in Medicine and Biology Society (EMBS). The *IEEE Transactions on Biomedical Engineering*[1] and the *IEEE Engineering in Medicine and Biology Magazine* include articles on the physiological effects of electrical shock and other subjects pertinent to electrical safety. Articles dealing with electrical equipment and instrumentation also appear in *IEEE Transactions on Biomedical Engineering*.

1.3 Professional registration

Most regulatory agencies require that design for public buildings be prepared by state-licensed professional architects or engineers. Information on such registration may be obtained from the appropriate state agency or from the National Council of Examiners for Engineering and Surveying (NCEES). The NCEES offers engineering registration, and

[1]Information on references can be found in 1.12.

this registration helps in obtaining registration in the various states through reciprocity. All engineering graduates are encouraged to start on the path to full registration by taking the engineer-in-training examination as soon after graduation as possible. The final written examination in the field of specialization is usually conducted after 4 years of progressive professional experience.

Clinical engineering certification is available through an international commission. When possible, the hospital's clinical engineer should be involved in the electrical design process.

1.4 Codes and standards

1.4.1 National Electrical Code® and other NFPA standards

The electrical wiring and design requirements in the National Electrical Code® (NEC®) (NFPA 70) are vitally important guidelines for health care facility engineers. Article 517 of the NEC deals exclusively with installation criteria for health care facilities. The NEC is revised every 3 years, and care should be taken to use the edition that is current and adopted by the authority having jurisdiction (AHJ) for enforcement at the time of construction. The NEC is published and available from the National Fire Protection Association (NFPA). It does not represent a design specification, but only identifies minimum requirements for the safe installation and utilization of electricity on the premises. The introduction to the NEC, Article 90, covers purpose and scope, and describes the AHJ's role in interpreting and enforcing the code. The *National Electrical Code® Handbook*, published by the NFPA, contains the complete NEC text plus explanations. This book is edited to correspond with each edition of the NEC.

NFPA 99 addresses performance and testing criteria for electric systems in health care facilities as well as requirements for medical gas systems; heating, ventilation, and air conditioning systems; laboratories; emergency management; and other topics of interest to health care designers. Approximately two thirds of NEC Article 517 is extracted from NFPA 99. The *Health Care Facilities Handbook* [B2],[2] published by NFPA, contains the entire NFPA 99 text as well as comments and explanatory material. The book is published on a 3-year cycle to correspond with each edition of NFPA 99.

The NEC and other selected NFPA codes are generally adopted by local and state governments for enforcement by electrical and building inspectors and fire marshals.

1.4.2 Health care codes and standards

Additional electrical requirements for health care facilities are included in the *Accreditation Manual for Hospitals*, published by the Joint Commission, formerly the Joint Commission for the Accreditation of Healthcare Organizations (JCAHO). Hospitals seeking Joint Commission accreditation must undergo periodic inspection by their

[2]The numbers in brackets correspond to those of the bibliography in 1.13.