An Overview of the IEEE Color Books

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Abstract-This paper is intended to serve as an overview of the IEEE Color Book standards series. Because each of the 13 books deals with a different aspect of electrical power production, distribution, and utilization in industrial and commercial power systems, it can be an intimidating process to sift through each book trying to determine its applicability. Furthermore, the rapid globalization of the power industry now requires familiarity with numerous technical standards, including those developed by the International Electrotechnical Commission (IEC) and the Institute of Electrical and Electronics Engineers (IEEE). Each of the 13 Color Books is summarized in this paper, with specific coverage of the area(s) of application for each book. This paper is specifically intended to serve as a companion to the Color Book panel session held at the 2000 IAS Annual Meeting in Rome, Italy. Persons desiring more information on the IEEE Color Books are encouraged to contact the persons responsible for each book and visit the "standards.ieee.org" web site. Information on how to contact the working group chair for each Color Book, at the time of the writing of this paper, is provided in the Appendix.

I. INTRODUCTION

The IEEE Color Book standards series include 13 books with each one focusing on different aspects of electric power. The Working Groups responsible for the development and revision of the Color Book standards are sponsored by the technical committees of the IAS Industrial and Commercial Power Systems Department. The objective of this document is to provide a summary for each of the books to understand what is entailed in each book. The summary will give a general overview of the purpose of each book and some of the actual topics contained in the chapters of each book. The different sections of this document represent the different books by their IEEE Standard number and their IEEE Book Color with the summary following.

II. IEEE STANDARD 141: *IEEE RECOMMENDED PRACTICE FOR ELECTRIC POWER DISTRIBUTION FOR INDUSTRIAL PLANTS* (IEEE RED BOOK)

In today's industrial facilities, continuity of production and related processes is critical. Any downtime can be a costly expense. That is why industry demands reliable electrical systems. Reliable electrical systems adhere to IEEE's Red Book. The Red Book is today's essential source for the most recommended practices for the electrical design of industrial facilities and power distribution in industrial plants.

The IEEE Red Book provides a recommended practice for the electrical design of industrial facilities. It is likely to be of value to the power-oriented engineer with limited industrial plant experience. It can also be an aid to all engineers responsible for the electrical design of industrial facilities. It will enable the engineer to better understand the special requirements of "industrial facilities," and the Codes that govern them. 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 general reference on electrical design for industrial plants and buildings.

The IEEE Red Book provides detailed procedures for planning the electric power distribution system of an industrial plant. Moreover, it provides complete information on electrical design criteria to ensure safety and preservation of property. Tables, charts, and other information that have been extracted from codes, standards, and other technical literature are included in this publication for illustrative purposes. Information on system planning, voltage considerations, short circuit current calculations, protection, grounding, and harmonics are a few of the issues addressed in this book. No other publication contains so much useful, authoritative information on electrical design for industrial facilities.

0-7803-6404-X/00/$10.00 (C) 2000

III. IEEE STANDARD 142: *IEEE RECOMMENDED PRACTICE FOR GROUNDING OF INDUSTRIAL AND COMMERCIAL POWER SYSTEMS* (IEEE GREEN BOOK)

The grounding of electrical systems is vital to the efficient and effective operation of industrial and commercial power systems. That is why electrical engineers charged with planning or modifying electrical distribution systems need the most current, reliable information on grounding today. This information can be found in the IEEE Green Book. The Green Book is today's essential source for providing up-to-date recommended practices and information used throughout industry for the grounding of industrial and commercial power systems.

The IEEE Green Book reviews practices and methods of system grounding in detail. A thorough investigation of grounding problems and methods for solving these problems are presented. This provides electrical engineers worldwide with the basis for applying fundamental principles to specific work situations and applications.

The IEEE Green Book addresses many different aspects of grounding. The problems of system grounding, which include connection to ground of neutral, of the corner of the delta, or of the midtap of one phase, are covered. The advantages and disadvantages of grounded versus ungrounded systems are discussed. Information is given on how to ground the system, where the system should be grounded, and how to select equipment for the grounding of neutral circuits. Connecting the frames and enclosures of electrical equipment to the ground system is addressed. The fundamentals of making the interconnection between the electrical equipment and ground rods, water pipes, etc. are outlined. Even problems relating to static electricity and lightning are covered in the IEEE Green Book, along with a chapter concerning sensitive electronic equipment. No other publication contains so much useful, authoritative information on grounding as IEEE's Green Book.

IV. IEEE STANDARD 241: *IEEE RECOMMENDED PRACTICE FOR ELECTRIC POWER SYSTEMS IN COMMERCIAL BUILDINGS* (IEEE GRAY BOOK)

Because of the increasing size and complexity of today's commercial buildings, there is a growing dependence on adequate and reliable electrical systems. This reliable information for commercial electric systems can be found in the IEEE Gray Book. This book will allow the engineer to better understand the special requirements of commercial facilities and the Codes that govern them.

The IEEE Gray Book provides extensive information on each of the various specialized subjects involved in planning the power system of a new or modernized commercial structure. It can be a great aid to the power oriented engineer with limited commercial building experience. This comprehensive source will alert the electrical engineer or designer to the many problems encountered in designing electrical systems for commercial buildings.

Extensive information is presented on many different electrical aspects. From a power distribution point of view, information is given on load requirements, voltage considerations, power sources and distribution systems. Once the power comes into the commercial facility, some issues addressed include services, vaults, electrical equipment rooms, wiring systems, system protection and coordination, lighting, and electric space conditioning. Other issues associated with the commercial facility covered in the IEEE Gray Book include transportation, communication systems planning, facility automation, expansion, modernization, rehabilitation, special occupancy requirements, and energy management. Thus, the IEEE Gray Book focuses on all electrical aspects of commercial facilities.

V. IEEE STANDARD 242: *IEEE RECOMMENDED PRACTICE FOR PROTECTION AND COORDINATION OF INDUSTRIAL AND COMMERCIAL POWER SYSTEMS* (IEEE BUFF BOOK)

System protection and coordination serve to minimize damage to a system and its components in order to limit the extent and duration of any service interruption occurring on any portion of the system. The IEEE Buff Book deals with the proper selection, application, and coordination of the components which constitute system protection for industrial plants and commercial buildings. It is an excellent resource for power system protection and coordination.

The IEEE Buff Book presents complete information on protection and coordination principles designed to protect industrial and commercial power systems against any abnormalities which could reasonably be expected to occur in the course of system operation. The information is arranged in a convenient step-by-step format, so it is easily understood. It is a valuable, comprehensive sourcebook for use at the system design stage, as well as in modifying existing operations for better system protection.

The IEEE Buff Book recognizes that the goal of system protection is to isolate and remove the problem efficiently. In achieving this goal, certain design features must be utilized. One of the main design features involves the quick isolation of the affected portion of the system while maintaining normal operation elsewhere. Another design feature is to obtain a reduction of the short circuit current to minimize damage to the system, its components, and the utilization equipment it supplies. Another design feature is the provision of alternate circuits, automatic throwovers, and automatic reclosing devices. These design features for system protection are the focus of the IEEE Buff Book.

VI. IEEE STANDARD 399: *IEEE RECOMMENDED PRACTICE FOR INDUSTRIAL AND COMMERCIAL POWER SYSTEMS ANALYSIS* (IEEE BROWN BOOK)

Today's intensely competitive business environment forces plant and building management to be very aware of the total owning cost of the power distribution systems. Further, they demand assurance of maximum return on capital investments in the power system. Power system studies are used to assure that this maximum return is achieved, and the IEEE Brown Book is a valuable source of information about the purpose for and techniques involved in power system studies.

The IEEE Brown Book ties together the essential fundamentals of power system studies, the most common studies for design or operation of a power system, and the basic computational methods with key information on the various types of computer systems and their requirements. Combined with the engineer's experience in power system engineering, computers can help perform detailed studies on both existing and proposed power systems which is why computer studies are a focus in the IEEE Brown Book. This book will help ensure high standards of power system reliability and maximize the utilization of capital investment. It is to be used in conjunction with the other IEEE Color Books.

The planning, design, and operation of industrial and commercial power systems require several studies to assist in the evaluation of the initial and future system performance, system reliability, safety, and the ability to grow with production and/or operating requirements. The power system analyses discussed in the IEEE Brown Book can help answer many questions about an existing system, such as the impact of expansion, the stability of the system, the load distribution of the system, etc. Chapters are devoted to different types of studies and indicate what is needed and how to prepare for the different studies. Some of the studies discussed are load flow studies, short-circuit studies, stability studies, motor-starting studies, harmonic analysis studies, switching transient studies, reliability studies, cable ampacity studies, ground mat studies, coordination studies, and DC auxiliary power system analysis. Therefore, the IEEE Brown Book is an excellent sourcebook for power system analyses.

VII. IEEE STANDARD 446: *IEEE RECOMMENDED PRACTICE FOR EMERGENCY AND STANDBY POWER SYSTEMS FOR INDUSTRIAL AND COMMERCIAL APPLICATIONS* (IEEE ORANGE BOOK)

Today, the demand for continuous, reliable, high-quality electric power is critical. Many installations require uninterruptible power, virtually free of frequency excursions and voltage dips, surges, and transients. However, the nature of electric power failures, interruptions, frequency excursions, voltage dips, and their duration can cover a wide range in time and may be due to elements out of human control. This led to the need for the IEEE Orange Book which would provide guidance to industrial users and suppliers of emergency and standby power systems.

The IEEE Orange Book presents the recommended engineering practices for the selection and application of emergency and standby power systems. It provides commercial and industrial facility designers, operators, and owners with guidelines for assuring uninterrupted power. In this aspect, it addresses the uses, power sources, design, and maintenance of emergency and standby power systems.

The IEEE Orange Book addresses practically all aspects of emergency power. One chapter is a general discussion of the needs for and the configuration of emergency and standby power systems. Another chapter lists the power needs for specific industries. Several chapters deal with the selection of power sources. Recommendations are also given for protecting both power sources and switching equipment during fault conditions, for the design of system grounding, and for designing to reliability objectives. Thus, the IEEE Orange Book is an excellent source for emergency and standby power systems.

VIII. IEEE STANDARD 493: *IEEE RECOMMENDED PRACTICE FOR THE DESIGN OF RELIABLE INDUSTRIAL AND COMMERCIAL POWER SYSTEMS* (IEEE GOLD BOOK)

The design of reliable industrial and commercial power distribution systems is important because of the high cost associated with power outages and their significant impact on society. It is necessary to consider the cost of power outages when making decisions for new power distribution systems as well as to have the ability to make quantitative "cost-versus-reliability" trade-off studies. The IEEE Gold Book aims to provide credible data concerning equipment reliability and the cost of power outages so that these trade-off studies can be conducted.

The purpose of the IEEE Gold Book is to provide sufficient information so that reliability analysis can be performed on power systems without requiring cross references to other texts. Information included in the book is the result of extensive surveys of reliability of electrical equipment in industrial plants and also the costs of power outages for both industrial plants and commercial buildings. The reliability survey provides historical experience to those who have not been able to collect their own data.

The IEEE Gold Book contains many reliability aspects. The basic concepts of reliability analysis by probability methods, fundamentals of power system reliability evaluation, the economic evaluation of reliability, and cost of power outage data are included in the book. Reliability

data as well as electrical preventive maintenance for different types of equipment are provided. Some concepts of emergency and standby power such as reliability compliance testing are also included in the IEEE Gold Book. Another aspect of the book focuses on the improvement and evaluation of reliability in existing facilities. Voltage sags and a methodology for estimating the frequency of these sags are also a topic of discussion in the IEEE Gold Book. Therefore, the IEEE Gold Book is an excellent guide for reliability issues.

IX. IEEE STANDARD 602: *IEEE RECOMMENDED PRACTICE FOR ELECTRIC SYSTEMS IN HEALTH CARE FACILITIES* (IEEE WHITE BOOK)

Because of their increasing size and complexity, today's health care facilities have become more and more dependent upon safe, adequate, and reliable electrical systems. "Health care facilities" include buildings or parts of buildings that contain hospitals, nursing homes, residential custodial care facilities, clinics, ambulatory health care centers, and medical and dental offices. Most of the equipment used is sensitive to electrical disturbances and requires a very reliable power source. The IEEE White Book provides the recommended practice for the design and operation of electric systems in these health care facilities.

The purpose of the IEEE White Book is to promote the use of sound engineering principles in the design and operation of health care facilities. It will probably be of greatest value to the power oriented engineer with limited health care experience. It can be an aid to anyone responsible for the electrical design of health care facilities, but it should only be considered a guide and not a replacement for many texts and handbooks in use.

The IEEE White Book will aid electrical systems designers in many aspects. One aspect is for achieving safety of life and preservation of property through operational considerations to reduce electrical failures. It also provides for maintenance with a minimum need for specialized services. Another aspect is to provide design considerations that recognize the flexibility of electrical systems in terms of layout and placement and to fulfill the requirements for proper electrical installation. Thus, the IEEE White Book serves to alert electrical engineers, designers, and health care operating personnel to the many problems that are encountered in the design and operation of health care facilities. This awareness will help in the development of concern for the professional aspects of health care facility engineering.

X. IEEE STANDARD 739: *IEEE RECOMMENDED PRACTICE FOR ENERGY MANAGEMENT IN COMMERCIAL AND INDUSTRIAL FACILITIES* (IEEE BRONZE BOOK)

In today's society, energy management is a key issue for commercial and industrial facilities. The IEEE Bronze Book serves as an engineering guide for use in electrical design for energy conservation. In this book, electrical options are evaluated from an energy standpoint.

The IEEE Bronze Book provides a recommended practice for electrical energy management in industrial and commercial facilities. The intent of the practice is to establish engineering techniques and procedures to allow efficiency optimization in the design and operation of an electrical system considering all aspects involved. By considering all aspects, some things needing to be addressed are safety, costs, environment, and management needs.

By stressing energy management, the IEEE Bronze Book embodies engineering, design, applications, utilization, and to some extent the operation and maintenance of electric power systems to provide for the optimal use of electrical energy. The book focuses on all these aspects. One chapter covers the combined efficient use of electrical and thermal energy in a highly efficient and cost-effective manner. Another chapter emphasizes that a reduction of energy in one area can have a negative effect on energy needs in another area, which focuses on load management. Other topics covered are the effects of fuel cost on electric energy cost, cogeneration and its energy saving potential, and new and existing electrical systems, such as lighting. Thus, the IEEE Bronze Book mainly provides information for the conservation of energy.

XI. IEEE STANDARD 902: *IEEE GUIDE FOR MAINTENANCE, OPERATION AND SAFETY OF INDUSTRIAL AND COMMERCIAL POWER SYSTEMS* (IEEE YELLOW BOOK)

The importance of safety, reliability, maintenance, and operation of electric power systems cannot be stressed enough. Guidelines must be established to ensure that safe procedures are followed for routine maintenance and everyday operation of power systems. The IEEE Yellow Book sets forth some recommended practices to provide these guidelines.

The IEEE Yellow Book provides plant engineers with a reference source for the fundamentals of safe and reliable maintenance and operation of industrial and commercial power systems, regardless of system size or complexity. The most effective utilization of the information contained in this guide would be its inclusion in a long-term maintenance and operation strategy that is tailored to the individual needs of each power system. This strategy would ensure long-term reliability and would need to include a procedure for auditing the performance.

To ensure the safety, reliability, maintenance, and operation of systems, the IEEE Yellow Book establishes certain procedures. Information is provided to offer guidance for the establishment of administrative procedures, control procedures, and the organizational capabilities to ensure reliable system operation. The level of performance reliability is stressed and several maintenance strategies are reviewed including record-keeping, testing and inspection methods, and auditing maintenance and operation performance. Several chapters in the book are devoted solely to safety issues, such as a review of safety equipment and recommendations for the management of unusual or hazardous activities. Thus, safety and reliability are the key issues of this practice.

XII. IEEE STANDARD 1015: *IEEE RECOMMENDED PRACTICE FOR APPLYING LOW-VOLTAGE CIRCUIT BREAKERS USED IN INDUSTRIAL AND COMMERCIAL POWER SYSTEMS* (IEEE BLUE BOOK)

System protection is an important part of power system planning. To provide adequate system protection, the appropriate equipment must be utilized. The IEEE Blue Book focuses on applying the correct low-voltage circuit breaker for different applications to obtain the best possible system protection.

The IEEE Blue Book provides information for selecting the right circuit breaker for specific applications. It includes comparisons between standards for low-voltage power circuit breakers and molded case circuit breakers to help the engineer to make more informed choices. These choices can lead to better system protection and reliability.

The IEEE Blue Book aids the application engineer in specifying the type of circuit breaker, ratings, trip functions, accessories, acceptance tests, and maintenance requirements. It provides information for applying circuit breakers at different locations in the power system and for protecting specific components. Guidelines are given for coordinating combinations of line-side and load-side devices. In addition, acceptance testing and maintenance guidelines are provided to ensure reliable operation. Therefore, the IEEE Blue Book is an extensive source for low-voltage circuit breaker information.

XIII. IEEE STANDARD 1100: *IEEE RECOMMENDED PRACTICE FOR POWERING AND GROUNDING SENSITIVE ELECTRONIC EQUIPMENT* (IEEE EMERALD BOOK)

Supplying power to and grounding of sensitive electronic equipment has been a growing concern for commercial and industrial power system designers. With the proliferation of sensitive electronic loads in industrial and commercial power systems due to rapid changes in the electronics and communications industry, new power quality related issues have evolved. As technology advances, sources for electrical power disturbances increase. The IEEE Emerald Book is today's essential source for providing sound engineering principles and practices for supplying power to and grounding of sensitive electronic equipment.

The IEEE Emerald Book presents recommended engineering principles and practices for power and grounding sensitive electronic equipment. The purpose of the book is to recommend design, installation, and maintenance practices for powering and grounding sensitive equipment in commercial and industrial facilities. The main objective is to provide a consensus of recommended practices in an area where conflicting information and confusion have dominated.

Many aspects of grounding are included in the IEEE Emerald Book. Grounding affects power quality, so power quality issues are discussed. Basic grounding information is presented, not just information for electronic equipment. Different measurement instruments are presented that help diagnose problems related to sensitive equipment. Practical analysis of different sites plus some case histories are also given in this book. The IEEE Emerald Book, then, is an excellent source for powering and grounding information related to sensitive electronic equipment.

XIV. IEEE STANDARDS PROJECT P551: *IEEE RECOMMENDED PRACTICE FOR SHORT CIRCUIT CALCULATIONS IN INDUSTRIAL AND COMMERCIAL POWER SYSTEMS* (IEEE VIOLET BOOK)

Note: This is a draft standard in the final stages of the approval process.

Short circuit analyses are essential studies in electric power systems. The focus of the IEEE Violet Book is to provide the understanding and application of analytical techniques of short circuit analysis in industrial and commercial power systems. However, the same engineering principles apply to all electrical power systems, including utilities and systems other than 60 hertz.

The IEEE Violet Book covers in more detail the basics and understanding of short circuit currents than they are discussed in the other texts of the IEEE Color Book series. Some of the different items covered in this book include chapters on the contributions to the short circuit current of re-generative SCR drives and capacitors to faults. The reference chapter in this book is quite extensive and should be very useful for any type of power system analysis.

CONCLUSIONS

A brief synopsis of each of the IEEE Color Books has been provided These books are excellent sources of information for power system analysis and design, but they are not meant to replace any engineering texts and handbooks commonly in use. They are considered to be guides and references on electrical design and analysis.

Appendix

For information on how you can become part of one or more of these Working Groups, contact the Working Group Chair. The professional networking relationships developed through participation provide you immediate access to the most up-to-date, extensive data on implementing power systems in commercial and industrial environments.

Red Book IEEE Std 141-1993

Recommended Practice for Electric Power Distribution for Industrial Plants

Chair: William Moylen
Moylen Engineering
Tel: 313-582-9880 Fax: 313-582-9884
Moylaneng@aol.com

Gray Book IEEE Std 241-1990 (Reaff. 1997)

Recommended Practice for Electric Power Systems in Commercial Buildings

Chair: R. Gerald Irvine
MTA Bridges and Tunnels
Telephone: +1-212-360-3085 Fax: +1-212-360-2935
r.g.irvine@ieee.org

Brown Book IEEE Std 399-1997

Recommended Practice for Industrial and Commercial Power Systems Analysis

Chair: Guy Jackson
Jackson & Associates
Tel: 334-626-6890
jackson@powerplot.com

Gold Book IEEE Std 493-1997

Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems

Chair: Don O. Koval
University of Alberta
Tel: 614-321-0968
donkoval@shaw.wave.ca

Bronze Book IEEE Std 739-1995

Recommended Practice for Energy Management in Commercial and Industrial Facilities

Chair: Carl E. Becker
RAST & Associates
Tel: 843-448-9247
beckercarl@aol.com

Emerald Book IEEE Std 1100-1999

Recommended Practice for Powering and Grounding Sensitive Electronic Equipment

Chair: Doug Dorr
EPRI-PEAC
Tel: 865-218-8005 Fax:865-966-7302
d.dorr@ieee.org

Violet Book IEEE Standards Project P551

IEEE Recommended Practice for Short Circuit Calculations in Industrial & Commercial Power Systems

Chair: Guy Jackson
Jackson & Associates
Tel: 334-626-6890
jackson@powerplot.com

Green Book IEEE Std 142-1991

Recommended Practice for Grounding of Industrial and Commercial Power Systems

Chair: Lynn F. Saunders
GM Worldwide Facilities
Tel: 313-974-9919 Fax: 313-974-8785
lynn.saunders@ieee.org

Buff Book IEEE Std 242-1986 (Reaff. 1991)

Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems

Chair: Carey J. Cook
S&C Electric Co.
Tel: 312-338-1000
ccook@sandc.com

Orange Book IEEE Std 446-1995

Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications

Chair: Charles Hughes
Westinghouse Savannah River Co.
Tel: 803-952-4609 Fax: 803-952-4429
cdhughes@ieee.org

White Book IEEE Std 602-1996

Recommended Practice for Electric Systems in Health Care Facilities

Chair: Hugh O. Nash
Nash, Lipsey, Burch, LLC
Tel: 615-329-4460 Fax: 615-329-3660
hnash@nlbengr.com

Yellow Book IEEE Std 902-1998

Guide for Maintenance, Operation, and Safety of Industrial and Commercial Power Systems

Chair: Michael J. Foley
Technical Consultants Group, Ltd.
Tel: 303-797-7125 Fax: 303-797-2667
m.foley@ieee.org

Blue Book IEEE Std 1015-1997

Recommended Practice for Applying Low Voltage Circuit Breakers Used in Industrial and Commercial Power Systems

Chair: George Gregory
Square D Co.
Tel: 319-369-6296 Fax: 319-369-6605
g.d.gregory@ieee.org

The IEEE style is a numeric style, where citations are numbered [1] in the order of appearance. This citation leads your reader to a full reference to the source in the list of references at the end of your work. Each citation number should be enclosed in square brackets on the same line as the text, before any punctuation, with a space before the bracket [2]. Once a source has been cited, the same number is re-used for all subsequent citations to the same source. Here are some examples of IEEE style citationÂ Page numbers are required within citations where material is directly quoted or you refer to a specific part of the source, such as a detail difficult to find. Give page numbers within the square brackets, for example [1, p. 3]. References. @article{Floyd2000AnOO, title={An overview of the IEEE Color Books}, author={H. Landis Floyd and S. M. Halpin and L. Saunders}, journal={Conference Record of the 2000 IEEE Industry Applications Conference. Thirty-Fifth IAS Annual Meeting and World Conference on Industrial Applications of Electrical Energy (Cat. No.00CH37129)}, year={2000}, volume={5}, pages={3226-3231 vol.5} }. H. Landis Floyd, S.M. Halpin, L. Saunders. This paper is intended to serve as an overview of the IEEE Color Book standards series. Because each of the 13 books deals with a different aspect of electrical power productio I. INTRODUCTION The IEEE Color Book standards series include 13 books with each one focusing on different aspects of electric power. The Working Groups responsible for the development and revision of the Color Book standards are sponsored by the technical committees of the IAS Industrial and Commercial Power Systems Department. The objective of this document is to provide a summary for each of the books to understand what is entailed in each book. The summary will give a general overview of the purpose of each book and some of the actual topics contained in the chapters of each book. The diffe