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(Revision of IEEE Std 446-1987)

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

Sponsor

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

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IEEE Standards Board

Abstract: This Recommended Practice addresses the uses, power sources, design, and maintenance of emergency and standby power systems. Chapter 3 is a general discussion of needs for and the configuration of emergency and standby systems. Chapter 9 lists the power needs for specific industries. Chapters 4 and 5 deal with selection of power sources. Chapter 6 provides recommendations for protecting both power sources and switching equipment during fault conditions. Chapter 7 provides recommendations for design of system grounding, and Chapter 10 provides recommendations for designing to reliability objectives. Chapter 8 provides recommended maintenance practices.
Keywords: batteries, emergency generators, emergency power, emergency system, emergency system design, engine generators, standby power, standby system, stored energy systems, transfer switch, uninterruptible power supplies, UPS, UPS batteries

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Introduction

(This introduction is not a part of IEEE Std 446-1995, IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications.)

In 1968 the Industrial and Commercial Power Systems Committee within the Industry and General Applications Group of the Institute of Electrical and Electronics Engineers recognized that a need existed for a publication that would provide guidance to industrial users and suppliers of emergency and standby power systems.

The nature of electric power failures, interruptions, and their duration covers a range in time from microseconds to days. Voltage excursions occur within a range from 20 times normal (or more) to a complete absence of voltage. Frequency excursions can vary as widely in many forms, from harmonics to direct current. These variables occur due to a multitude of conditions both in the power system ahead of the user's service entrance and following the service entrance within the user's area of distribution.

Such elements as lightning, automobiles striking power poles, ice storms, tornadoes, switching to alternate lines, and equipment failure are but a few of the causes of interruptions in the electric power supply ahead of the service entrance.

Within the user's area of distribution are such elements as short and open circuits, undersized feeders, equipment failures, operator errors, temporary overloads, single-phasing unbalanced feeders, fire, switching, and many other causes of power interruption or failure.

In the past the demand for reliable electric power was less critical. If power was completely interrupted too often, another source was found. If voltage varied enough to cause a problem, a regulator or a larger conductor was installed. As processes, controls, and instrumentation became more sophisticated and interlocked, the demand developed to shorten the length of outages. Increased safety standards for people required emergency and exit lighting. Many factories added medical facilities that needed reliable electric power.

With the advent of solid-state electronics and computers, the need for continuous, reliable, high-quality electric power became critical. Many installations required uninterruptible power, virtually free of frequency excursions and voltage dips, surges, and transients.

In 1969 a working group was established under the Industrial Plants Power Systems Subcommittee of the Industrial and Commercial Power Systems Committee to collect data and produce a publication entitled "Emergency Power Systems for Industrial Plants." Later that year the scope of the work was enlarged to include standby power since, in meeting various needs, the two systems were often found to be intertwined, or one system served multiple purposes.

As the work progressed, it became apparent that industrial and commercial needs contained more similarities than differences. Systems available to supply the required power to industry were found applicable to both fields. Once again the scope of the work was expanded to include commercial requirements. The existing working group was changed to the status of a subcommittee under the Industrial and Commercial Power Systems Committee to have direct

responsibility, not only for the Orange Book Working Group, but for other matters concerning emergency and standby power. The proposed publication was redirected toward establishing recommended practices. As a result of subsequent organizational changes, this Emergency and Standby Power Systems Subcommittee is now under the Power Systems Engineering Committee of the Industrial and Commercial Power Systems Department.

This third revision of the IEEE Orange Book contains updating and expansion of existing material. In addition, a new chapter has been added that addresses design criteria for achieving reliability objectives.

This IEEE Recommended Practice continues to serve as a companion publication to the following other Recommended Practices prepared by the IEEE Industrial and Commercial Power Systems Department:

— IEEE Std 141-1993, IEEE Recommended Practice for Electric Power Distribution for Industrial Plants (IEEE Red Book).

— IEEE Std 142-1991, IEEE Recommended Practice for Grounding of Industrial and Commercial Power Systems (IEEE Green Book).

— IEEE Std 241-1990, IEEE Recommended Practice for Electric Power Systems in Commercial Buildings (IEEE Gray Book).

— IEEE Std 242-1986, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems (IEEE Buff Book).

— IEEE Std 399-1990, IEEE Recommended Practice for Industrial and Commercial Power Systems Analysis (IEEE Brown Book).

— IEEE Std 493-1990, IEEE Recommended Practice for the Design of Reliable Industrial and Commercial Power Systems (IEEE Gold Book).

— IEEE Std 602-1996, IEEE Recommended Practice for Electric Systems in Health Care Facilities (IEEE White Book).

— IEEE Std 739-1995, IEEE Recommended Practice for Energy Management in Industrial and Commercial Facilities (IEEE Bronze Book).

— IEEE Std 1100-1992, IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment (IEEE Emerald Book).

The Orange Book Working Group for the 1995 edition had the following membership:

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Chapter 2: Definitions—**Neil Nichols**, *Chair;* Marco W. Migliaro; Joseph S. Dudor

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Contents

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

Chapter 1
Scope

This standard presents recommended engineering principles, practices, and guidelines for the selection, design, installation, application, operation, and maintenance of emergency and standby power systems. This information is primarily presented from a user's viewpoint; however, managing the effects of power system disturbances requires close cooperation between users, electric utilities, and equipment manufacturers.

This standard addresses the following questions:

- Is an emergency or standby power system (or both) needed, and what will it accomplish?
- What types of systems are available, and which can best meet the users' needs?
- How should the most suitable system be designed and applied to the existing power system?
- What are the maintenance and operating requirements for maintaining system reliability?
- Where can additional information be obtained?
- What are the design considerations for maintaining system reliability?

Definitions to specialized technical terms used throughout this standard are provided in Chapter 2. Emergency and standby power requirements of both industrial and commercial users are outlined and discussed, including a distinction made between mandatory laws, regulations, codes, and standards applicable to each. Knowledge of these requirements enables electric utility companies to meet specific power supply needs and equipment manufacturers to design efficient, practical, and reliable equipment and systems. Recommendations are made for various types of installations, based on technical and economic information on available hardware and systems provided by equipment manufacturers.

Technical guidelines for protecting and grounding emergency and standby power systems are presented in Chapter 6 and Chapter 7, respectively. Guidelines for the maintenance of specific types of equipment are presented in Chapter 8. Chapter 9 provides information on applications of emergency and standby power for specific industries. Chapter 10 presents design and operation guidelines that will improve emergency and standby power system reliability.

The following industries and fields are considered specialized and beyond the scope of inclusion and direct address by this standard: transport, government, military, and utility.