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IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations

IEEE Power and Energy Society

Sponsored by the
Nuclear Power Engineering Committee

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3 Park Avenue
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USA

16 January 2013

IEEE Std 308™-2012
(Revision of
IEEE Std 308-2001)

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Approved 5 December 2012

IEEE-SA Standards Board

Abstract: Class 1E portions of ac and dc power systems and I&C power systems in single-unit and multiunit nuclear power generating stations are covered in this standard. The provision of criteria for the determination of Class 1E power system design features, criteria for sharing Class 1E power systems in multiunit stations, the requirements for their testing and surveillance, and the requirements for documentation of the Class 1E power system is the intent of this standard.

Keywords: Class 1E power systems, IEEE 308, nuclear power station design, nuclear safety

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PDF: ISBN 978-0-7381-8120-2 STD98081
Print: ISBN 978-0-7381-8121-9 STDPD98081

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Introduction

This introduction is not part of IEEE Std 308™-2012, IEEE Standard for Class 1E Power Systems for Nuclear Power Generating Stations.

This standard presents criteria and requirements for the electrical power systems of nuclear power generating stations specifically related to providing protection for the health and safety of the public. IEEE has developed these criteria to provide guidance in the determination of the design features and the surveillance requirements and testing related to the station electric power systems. Each applicant for a construction permit or an operating license for a nuclear power generating station in the United States is required to develop these items to comply with the Title 10, Code of Federal Regulations, Part 50. Adherence to these criteria may not suffice for assuring public health and safety because it is the integrated performance of the structures, the fluid systems, the instrumentation, and the electric systems of the station that limits the consequences of accidents. Failure to meet these requirements may be an indication of system inadequacy. Each applicant has the responsibility to assure all applicable parties that this integrated performance is adequate.

Background

IEEE Std 308-1970[a,b] was prepared by Subcommittee 4, Auxiliary Power Systems of the Joint Committee on Nuclear Power Standards (JCNPS) of the IEEE Nuclear Science Group and the IEEE Power Engineering Society (PES). IEEE Std 308-1971 incorporated the experience of the first edition and added multiunit considerations. IEEE Std 308-1974 was completed by Working Group 4.1 of Subcommittee 4 of JCNPS, which had become the Nuclear Power Engineering Committee (NPEC) of the PES in 1973. IEEE Std 308-1978 clarified the interface between the functional requirements of the Class 1E power system and the safety systems for elements of the safety system that are within the Class 1E power system. IEEE Std 308-1980 implemented the recommendations of the Ad Hoc IEEE 308/603 Committee regarding the scope diagram for the IEEE Std 308 and IEEE Std 603™ interface. IEEE Std 308-1991 added criteria for interfacing the Class 1E power system with IEEE Std 765™-1983, IEEE Standard for the Preferred Power Supply for Nuclear Power Generating Stations, and IEEE Std 741™-1990, IEEE Standard Criteria for the Protection of Class 1E Power Systems and Equipment in Nuclear Power Generating Stations. The standard was also updated to reflect the latest requirements of IEEE Std 387™-1984, IEEE Standard Criteria for Diesel-Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations; IEEE Std 946™-1985, IEEE Recommended Practice for the Design of Safety-Related DC Auxiliary Power Systems for Nuclear Power Generating Stations; and the recommendations of the NPEC Ad Hoc Committee on Shared Safety Systems. These recommendations resulted in a complete rewrite of the multiunit station considerations clause.

IEEE Std 308-2001 added criteria for design and testing documentation of Class 1E power systems, including verification and validation. The standard added to the criteria for power quality to include potential effects of harmonic distortion and degraded grid conditions. A general update to correct references and to address comments since the standard was last revised was also performed.

[a]Information on references can be found in Clause 2.
[b]IEEE publications are available from The Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA (http://standards.ieee.org/).

Safety function concept

A safety system, by definition, shall encompass all of the elements required to achieve a protective or safety function. Figure 1, Figure 2, and Figure 3 illustrate the systems and equipment needed to perform a typical safety function, such as post-accident heat removal. As part of the safety system, the role of the Class 1E power system is clearly that of an auxiliary supporting feature, providing electric power to other safety systems (e.g., recirculation spray system, containment spray system, etc.). In this capacity, the portions of the Class 1E power system that contribute to performing a safety function must comply with the requirements of IEEE Std 603. However, the components, equipment, and systems within the Class 1E power system that perform no direct safety function (e.g., overload devices, protective relaying, etc.) must meet the requirements in IEEE Std 603 that assure that those components, equipment, and systems do not degrade the Class 1E power system below an acceptable level.

Major role of Class 1E power system

The major role of the Class 1E power system is to provide electric power to the reactor trip system, engineered safety features, and auxiliary supporting features; therefore, the Class 1E power system is an auxiliary supporting feature.

The Class 1E power system is unique in that it extends throughout the plant, having far more complex interfaces than other auxiliary supporting features. Other auxiliary supporting features are usually limited to one area or a single process in the plant and are basically mechanical systems. Characteristic of the complex interfaces of the Class 1E power system is the fact that it is an auxiliary supporting feature; other auxiliary features are auxiliary supporting features for it, and the Class 1E power system may provide support for nonsafety system equipment and provide the means for the execution of the safety system protective actions.

The sense and command features include equipment that produces signals (e.g., current transformer, voltage transformer, etc.), measures electric system parameters (e.g., voltage, current, watts, etc.), or functions to limit degradation effects (e.g., protective relaying, thermal overloads, undervoltage relays, etc.). The sense and command features of the Class 1E power system that directly perform a safety function shall comply with the requirements of IEEE Std 603. Sense and command features of the Class 1E power system that do not have a direct safety function must be analyzed to show that their failure will have no unacceptable effects on the Class 1E power system.

In their execute features role, some Class 1E power system equipment, switchgear, circuit breakers, power cabling, and loads (primarily motors) are not only part of the Class 1E power system, but are also integral parts of the engineering safety features.

Current revision

The guidance provided in this standard was developed for nuclear plant designs that generally have two 100% capacity divisions of Class 1E loads and use diesel generators for standby ac power. Newer plant designs that are currently being licensed differ from earlier designs in that they typically include either three or four divisions of Class 1E loads, with each division consisting of either 50% or 100% capacity systems allowing for an entire division to be out of service for maintenance, testing, or repairs without entering a Technical Specification Limited Condition for Operation. Also, improvements in mechanical equipment and system design have allowed for the substitution of gas turbine generators for diesel generators in some designs. The further innovation of passive reactor designs uses forces of nature such as fluid density differences and heat transfer to create natural circulation cooling on a scale sufficient to replace large active components for accident and operational event response, thus eliminating the need for Class 1E ac generators. The Class 1E dc systems in these passive reactor designs supply power for indication and monitoring as well as the traditional functions of control and breaker operations, but are relied on for 24 h to 72 h as opposed to the typical 2-h discharge duty in earlier designs. Because of these extended duty cycles, batteries for passive reactor designs have qualification requirements beyond those normally encountered for Class 1E batteries with 2-h discharge duty cycles. The user is cautioned to refer to IEEE Std 535™ for the proper guidance on qualification of batteries and to refer to IEEE Std 485™ for the proper guidance on sizing large lead-acid storage batteries in passive reactor applications.

The working group reviewed IEEE Std 308-2001 and determined that no significant changes were required for application to newer plant designs. Several minor changes have been made, tables have been relocated and figures relocated and modified to broaden the document so that its use is compatible with newer as well as older designs. Diesel generator is replaced with standby power supply throughout the standard to allow for prime movers other than diesel engines. The requirement to have a Class 1E ac power system is removed for passive reactor designs that use natural forces to respond to accidents and operational events instead of using large ac equipment. Recognizing the importance of batteries to passive reactor designs during event response with loss of offsite power, a requirement was added to provide for reliable permanent or temporary power to reenergize battery chargers prior to the end of the battery discharge cycles.

Contents

IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations

1. Overview

1.1 Scope

This standard applies to the Class 1E portions of the following systems and equipment in single-unit and multiunit nuclear power generating stations:

- AC power systems
- DC power systems
- Instrumentation and control (I&C) power systems

This standard does not apply to the preferred power supply; the unit generators and their buses; generator breaker; step-up, auxiliary, and start-up transformers; connections to the station switchyard; switchyard; transmission lines; and the transmission network (see Figure 2 and Figure 3).