



IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations

IEEE Power Engineering Society

Sponsored by the
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IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations

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Abstract: Methods for qualifying static battery chargers and inverters for Class 1E installations outside containment in nuclear power generating stations are described. These methods may also be used to qualify similar electronic equipment for use in applications outside containment, where specific standards for such equipment are not available. The qualification methods set forth employ a combination of type testing and analysis, the latter including a justification of methods, theories, and assumptions used. These procedures meet the requirements of IEEE Std 323™-2003.

Keywords: battery charger, inverter, qualification

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Introduction

This introduction is not part of IEEE Std 650-2006, IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations.

This standard provides the methods of qualifying Class 1E static battery chargers and inverters in accordance with IEEE Std 323-2003. The static battery chargers and inverters discussed in this standard are Class 1E. This document, however, addresses this equipment only as a subsystem in the safety-related electrical system.

The techniques and information contained in this standard may be applied to other similar electronic equipment.

The reliability analysis requirements of IEEE Std 577™-2004 and the methods described in IEEE Std 352™-1987 have been used along with statistical data.

The efforts of the working group on this standard and its annexes will continue for the purpose of updating and disseminating more information regarding qualification techniques. The subjects of aging and the use of surveillance/maintenance techniques to address aging will continue to be investigated and will be among the areas considered by the working group in future revisions of this standard..

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IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations

1. Overview

1.1 Scope

This standard describes methods for qualifying static battery chargers and inverters for Class 1E installations outside containment in nuclear power generating stations. The application of this equipment in the plant's electrical system is not within the scope of this standard as other industry standards, such as IEEE Std 308™-2001 [B3],¹ IEEE Std 603™-1998 [B6] and IEEE Std 946™-2004 [B8], exist for this purpose. In addition, industry standards exist for equipment performance, such as ANSI/NEMA PE 5-2003 [B1] and IEEE Std 944™-1986 [B7]. Performance requirements are not specified in this standard.

1.2 Purpose

The purpose of this standard is to provide specific procedures to meet the requirements of IEEE Std 323™-2003.² For the purpose of this standard, battery chargers, inverters, and the associated ancillary equipment must perform their safety function under specified service and environmental conditions.

The demonstration that an installed battery charger or inverter will meet its design specification requires many steps in a program of design, fabrication, quality assurance, qualification, transportation, storage, installation, maintenance, periodic testing, and surveillance. This standard treats only the qualification area of this program. The result of the qualification program may provide a basis for determination of long-term maintenance requirements.

Qualification may be accomplished in several ways: type testing, operating experience, or analysis. These methods may be used individually or in combination. The qualification methods in this standard employ a combination of type testing and analysis. Operating experience is of limited use as a sole means of qualification. Operating experience is, however, of great use as a supplement to testing, as the experience may provide an insight into the change in behavior of materials and components through time under actual service and maintenance conditions. Qualification by analysis shall include a justification of the methods, theories, and assumptions used. In general, battery chargers and inverters are too complex to be qualified

¹ The numbers in brackets correspond to those of the bibliography in Annex F.

² Information on references can be found in Clause 2.

by analysis alone, although analysis is effective in the extrapolation of test data and the determination of the effects of minor design changes to equipment previously tested.

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

EIA 401-73 (Reaff 90), Paper, Paper/Film, Film Dielectric Capacitors for Power Semiconductor Applications.³

EIA 454-78 (Reaff 90), Fixed Paper and Film-Paper Dielectric Capacitors with Non-PCB Impregnants for Alternating Current Applications.

IEEE Std 101™-1987, IEEE Guide for the Statistical Analysis of Thermal Life Test Data.^{4, 5}

IEEE Std 259™-1999, IEEE Standard Test Procedures for Evaluation of Systems of Insulation for Dry-Type Specialty and General-Purpose Transformers.

IEEE Std 323™-2003, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

IEEE Std 344™-2004, IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Generating Stations.

IEEE Std 383™-2003, IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.

IEEE Std 577™-2004, IEEE Standard Requirements for Reliability Analysis in the Design and Operation of Safety Systems for Nuclear Power Generating Stations.

3. Definitions

For the purposes of this document, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standard Terms* [B2] should be referenced for terms not defined in this clause.

3.1 battery charger: Equipment that converts ac power to dc power and is used to recharge and maintain a station battery in a fully charged condition and to supply power to dc loads during normal operation.

3.2 components: Items from which the equipment is assembled (e.g., resistors, capacitors, wires, connectors, semiconductors, tubes, switches, and electromechanical devices).

3.3 equipment: An assembly of components designed and manufactured to perform specific functions.

³ EIA publications are available from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (<http://global.ihs.com/>).

⁴ IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

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3.4 equipment qualification: The generation and maintenance of evidence to ensure that equipment will operate on demand to meet system performance requirements during normal and abnormal service conditions and postulated design basis events.

NOTE—Equipment qualification includes environmental and seismic qualification.⁶

3.5 inverter: Equipment that converts dc power to ac power. It includes auxiliary devices such as transfer switches, alternate source transformers and regulators, input rectifiers (other than battery chargers), and isolation devices (e.g., blocking diodes).

3.6 margin: The difference between service conditions and the conditions used for equipment qualification.

3.7 operating experience: Accumulation of verifiable service data for conditions equivalent to those for which particular equipment is to be qualified.

3.8 qualified life: The period of time, prior to the start of a design basis event, for which the equipment was demonstrated to meet the design requirements for the specified service conditions.

3.9 stressor: An agent or stimulus that stems from fabrication or perservice and service conditions and can produce immediate degradation or aging degradation of a system, structure, or component. (adapted from IEEE Std 1205™-2000 [B9])

NOTE—At the end of the qualified life, the equipment shall be capable of performing the safety function(s) required for the postulated design-basis and post-design-basis events (IEEE Std 323–2003). Class 1E equipment may include components that have significant aging mechanisms. The qualification process will include information on when these aging mechanisms start and any replacement/maintenance interval required.

4. Specifications

4.1 General

This subclause describes the items to be addressed in the owner's specifications for the equipment to be qualified. These items include the equipment identification, the Class 1E performance characteristics, the input power supply, the environmental conditions, and the effect of changes in input power supply and environmental conditions upon the Class 1E performance characteristics. If the equipment specification includes margins, as defined in Clause 3, their values shall be identified.

4.2 Class 1E performance characteristics and safety function

The nuclear plant owner or its representative shall specify the performance characteristics (including the safety function) of the equipment, including, as a minimum, numerical values and durations for normal, abnormal, design basis event (DBE), and post-design-basis event conditions, as indicated in 4.2.1 through 4.2.3. Stressors, as defined in 3.8 and 4.1 of IEEE Std 1205-2000 [B9], shall be addressed in defining the performance characteristics and safety function.

⁶ Notes in text, tables, and figures are given for information only and do not contain requirements needed to implement the standard.

4.2.1 Class 1E performance characteristics

The following characteristics are suggested conditions, parameters, and performance requirements to be considered in acceptance testing.

- a) Input conditions, such as
 - 1) Voltage
 - 2) Frequency
 - 3) Phase
 - 4) Current (if limiting conditions exist for installed condition)
- b) Output requirements, such as
 - 1) Voltage and voltage regulation
 - 2) Current (minimum and maximum)
 - 3) Current limit
 - 4) Frequency and frequency regulation (inverters only)
 - 5) Load power factor (inverters only)
 - 6) Ripple voltage (battery chargers only)
 - 7) Harmonic distortion (inverters only)
- c) Surge withstand capability
- d) Reverse dc current flow prevention (chargers only)
- e) Characteristics of auxiliary equipment (if used), including
 - 1) Transfer switches (functional operation, e.g., transfer time, high- and low-voltage actuation, and overcurrent actuation)
 - 2) Inverter's input rectifier (same input conditions as battery charger)
 - 3) Isolating device (blocking and conducting function)
 - 4) Alternate source transformer and regulator (input conditions and output requirements)
- f) Other performance characteristics as required by owner/purchaser specifications

4.2.2 Description of the safety function of Class 1E charger or inverter

The safety function(s) of the equipment (including required operating time) shall be specified for applicable service and DBE conditions expected during its qualified life.

4.2.3 Qualified life objective (where applicable)

The equipment qualified life objective shall be specified along with the set of service conditions under which successful performance must be demonstrated before, during, and after a DBE as applicable.

4.3 Environment

All significant environmental parameters shall be specified in the owner's specification. The range of environmental conditions shall include, as a minimum, normal and abnormal conditions and durations, as well as DBE and post-DBE conditions.