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IEEE Standard for the Design and Installation of Cable Systems for Class 1E Circuits in Nuclear Power Generating Stations

Sponsor
**Power Generation Committee
of the
IEEE Power Engineering Society**

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Foreword

(This Foreword is not a part of IEEE Std 690-1984, IEEE Standard for the Design and Installation of Cable Systems for Class 1E Circuits in Nuclear Power Generating Stations.)

This standard is the result of efforts by the working group to accommodate requests for a document, such as IEEE Std 422-1977, IEEE Guide for the Design and Installation of Cable Systems in Power Generating Stations, for use as a standard in the design, installation of cable systems for Class 1E circuits in Nuclear Power Generating Stations. This document is written as a standard and as such contains more positive statements (utilization of the word *shall*) than IEEE Std 422-1977. Recommendations and related tutorial information have been separated from the text and provided in an Appendix to this standard.

Many sections have been restructured to identify IEEE standards that apply to cable systems for Class 1E circuits and to establish additional requirements deemed essential for the proper design and installation of cable systems for Class 1E circuits. In addition to the sections covered in IEEE Std 422-1977, a new section has been added to this document which addresses documentation of design.

Cable fire protection considerations have been revised substantially to reflect current approaches to the problem resulting from fire tests conducted by various organizations.

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IEEE Standard for the Design and Installation of Cable Systems for Class 1E Circuits in Nuclear Power Generating Stations

1. General

1.1 Scope

This standard provides direction for the design and installation of safety related electrical cable systems, including associated circuits, in nuclear power generating stations. Also provided is guidance for the design and installation of those nonsafety related cable systems that may affect the function of safety related systems.

NOTES:

- 1 — The term *associated circuits* is not repeated throughout the text; however, all requirements for the design and installation of cable systems for Class 1E circuits shall apply equally to associated circuits unless it can be shown by test or analysis that the associated circuits cannot affect the performance of the Class 1E circuits.
- 2 — Recommendations and related tutorial information regarding cable systems for Class 1E circuits are provided in the Appendix.

1.2 Purpose

The purpose of this standard is to identify existing standards and to establish requirements pertaining to safety related cable systems in nuclear power generating stations. Solutions are recommended for areas of concern such as fire protection, raceways, separation, cable performance requirements, and installation acceptance testing and documentation.

1.3 Definitions

Definitions that apply to only one section are found in that section.

associated circuits: Non Class 1E circuits that share power supplies, signal sources, enclosures, or raceways with Class 1E circuits or are not physically separated or electrically isolated from Class 1E circuits by acceptable separation distance, barriers, or isolation devices.

Class 1E circuits: The safety classification of circuits that are essential to emergency reactor shutdown, containment isolation, reactor core cooling, and containment and reactor heat removal, or are otherwise essential in preventing a significant release of radioactive material to the environment.

design basis events (DBE): Postulated events specified by the safety analysis for the station to establish the acceptable performance requirements of the structures and systems.

2. References

When the following standards are superseded by a revision the revision shall apply.

- [1] ANSI/ANS 59.4-1979, Generic Requirements for Light Water Nuclear Power Plant Fire Protection.¹
- [2] ANSI/ASME NQA 1-1979, Quality Assurance Program Requirements for Nuclear Power Plants.
- [3] ANSI/IEEE Std 100-1984, IEEE Standard Dictionary of Electrical and Electronics Terms.
- [4] ANSI/IEEE Std 336-1980, IEEE Standard Installation, Inspection, and Testing Requirements for Class 1E Instrumentation and Electric Equipment at Nuclear Power Generating Stations.
- [5] ANSI/IEEE Std 383-1974 (1980), IEEE Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.
- [6] ANSI/IEEE Std 384-1981, IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits.
- [7] ANSI/IEEE Std 634-1978, Cable Penetration Fire Stop Qualification Test.
- [8] ANSI/NFPA 10-1981, Standard for Portable Fire Extinguishers.
- [9] ANSI/NFPA 15-1982, Standard for Water Spray Fixed Systems for Fire Protection.
- [10] ANSI/NFPA 70-1984, National Electrical Code.
- [11] ANSI/NFPA 72D-1979, Installation, Maintenance, and Use of Proprietary Signaling Systems.
- [12] ANSI/NFPA 72E-1982, Selection and Placement of Fire Detectors.
- [13] ANSI/NFPA 90A-1981, Standard for the Installation of Air Conditioning and Ventilating Systems.
- [14] ASTM E119-1983, Standard Methods of Fire Tests of Building Construction and Materials.²
- [15] IEEE323-1983, IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.
- [16] IEEE Std 422-1977, IEEE Guide for the Design and Installation of Cable Systems in Power Generating Stations.
- [17] NFPA 13-1983, Standard for Installation of Sprinkler Systems.³
- [18] NFPA 14-1983, Standard for the Installation of Standpipes and Hose Systems.

¹ANSI documents are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

²ASTM documents are available from Sales Service, American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103.

³NFPA documents are available from Publication Sales Division, National Fire Protection Association, Battery-march Park, Quincy, MA 02269.

3. Cable, Field Splice, and Connection Qualification

This section establishes qualification requirements that shall be utilized in specifying cables, field splices, and connections of cable systems for Class 1E circuits.

3.1 Definitions

connection: A cable terminal, splice, or hostile environment boundary seal at the interface of cable and equipment.

field splice: A permanent joining and reinsulating of conductors in the field to meet the service conditions required.

qualified life: The period of time for which satisfactory performance can be demonstrated for a specific set of service conditions.

service conditions: Environmental, power and signal conditions expected as a result of normal operating requirements, extremes in operating requirements, and postulated conditions appropriate for the design basis events of the station.

3.2 Requirements

- 1) Cables, field splice, and connections shall have a qualified life for all service conditions that are postulated for the areas where they are to be used and shall be qualified in accordance with IEEE Std 323-1983 [15] and ANSI/IEEE Std 383-1974 [5].⁴
- 2) All cables installed in cable trays shall pass the vertical tray flame test described in ANSI/IEEE Std 383-1974 [5].

4. Conductor Sizing

This section establishes cable conductor sizing requirements for various types of cable installations for Class 1E circuits.

Cables shall be sized to carry load current with the following special considerations:

- 1) Unless the safety analysis of the plant supports other ambient temperatures, the minimum ambient temperatures used in calculating cable ampacities shall be 20°C for buried installations and 40°C for exposed installations. Conductor size shall be selected to carry required normal, emergency overload, and short-circuit current without exceeding rated temperature of the insulation at the maximum postulated ambient temperature. Temperature extremes under design basis events shall be addressed by the qualification of the cable in accordance with ANSI/IEEE Std 383-1974 [5].
- 2) Where cable is routed through several types of installation conditions (direct buried, sun exposure, exposed conduit, cable penetration fire stops, covered cable trays, wireways, near hot steam lines, etc) conductor size shall be selected for the limiting condition.
- 3) Selection of conductor size shall also consider voltage regulation requirements, shield circulating current, and mechanical strength in addition to cable current requirements.

⁴The numbers in brackets correspond to those of the references in Section 2

5. Electrical Segregation

This section establishes requirements for the electrical segregation of cable systems for Class 1E circuits according to voltage levels, signal levels, and vulnerability to electrical noise pickup.

5.1 Cable Classifications

5.1.1 Medium-Voltage Power Cables

Designed to supply power to utilization devices of plant auxiliary systems rated 601 V to 15,000 V.

5.1.2 Low-Voltage Power Cables

Designed to supply power to utilization devices of the plant auxiliary systems rated 600 V or less.

5.1.3 Control Cables

Applied at relatively low-current levels or used for intermittent operation to change the operating status of a utilization device of the plant auxiliary system.

5.1.4 Instrumentation Cables

Used for transmitting variable current or voltage signals (analog) or those used for transmitting coded information (digital).

5.2 Requirements

- 1) Medium-voltage power cables shall be installed so that the medium-voltage cannot be impressed on any lower voltage system through a failure of cable insulation. See Appendix, A4.2.
- 2) Instrumentation cables shall be installed to minimize unacceptable noise pickup from adjacent circuits and equipment. See Appendix, A4.3.

6. Separation and Identification

This section establishes requirements for the separation and identification of cable systems for Class 1E circuits.

6.1 Definition

separation: Physical independence of redundant circuits, components, and equipment. (Physical independence may be achieved by space, barriers, shields, etc.)

6.2 Requirement

Cable systems for Class 1E circuits shall meet the separation and identification requirements of ANSI/IEEE Std 384-1981 [6] (see Section 6 for additional separation requirements).

7. Shielding and Shield Grounding

This section establishes requirements for shielding and shield grounding of medium-voltage power and instrumentation cable systems for Class 1E circuits.

7.1 Medium-Voltage Power Cable

7.1.1 Definition

cable shielding: A nonmagnetic metallic material applied over the insulation of the conductor or conductors to confine the electric field of the cable to the insulation of the conductor or conductors.

7.1.2 Shielding Requirements

Cables rated above 5 kV shall be shielded, except for special applications or cable designs.

7.1.3 Shield Grounding Requirements

Shielded cables shall be terminated with appropriate qualified terminations that do not compromise the integrity or qualification of the cable.

7.1.4 Shield Grounding Requirements

- 1) Cable shields and metallic sheaths/armor shall be solidly grounded at one or more points so that they operate at or near ground potential at all times.
- 2) Shields or sheaths that are grounded at more than one point carry induced circulating current. Compensation for the heating effect of the induced circulating current shall be considered when calculating the cable ampacity.

7.2 Instrumentation Cable

7.2.1 Definition

shield: Braid copper, metallic sheath, or metallic coated polyester tape (usually copper or aluminum), applied over the insulation of a conductor or conductors for the purpose of reducing electrostatic coupling between the shielded conductors and others that may be either susceptible to, or generators of, electrostatic fields (noise). When electromagnetic shielding is intended, the term *electromagnetic* is usually included to indicate the difference in shielding requirement and material.

7.2.2 Requirements

- 1) Cable shields shall be electrically continuous except where specific reasons dictate otherwise. When two lengths of shielded cable are connected at a terminal block, an insulated point of the terminal block shall be used for connecting the shields.
- 2) The shield of each cable shall be isolated to prevent stray and multiple grounds to the shield.
- 3) The shield shall not be used as an electrical conductor when only designed to reduce electrostatic or electromagnetic coupling.
- 4) The shielding criteria (for example, shield effectiveness, grounding techniques, etc) of coaxial, triaxial, and instrumentation cables shall be in accordance with system design requirements and equipment manufacturer's instructions.