

IEEE Standard Criteria for the Design, Installation, and Qualification of Raceway Systems for Class 1E Circuits for Nuclear Power Generating Stations

Sponsor

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Abstract: Criteria for the minimum requirements in the selection design, installation, and qualification of raceway systems for Class 1E circuits for nuclear power generating stations is provided. It also prescribes methods for the structural qualification of raceway systems for Class 1E circuits.

Keywords: cable tray, conduit, design-by-rule, duct line, raceways, seismic

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Introduction

(This introduction is not a part of IEEE Std 628-2001, IEEE Standard Criteria for the Design, Installation, and Qualification of Raceway Systems for Class 1E Circuits for Nuclear Power Generating Stations.)

The original document was issued in 1987 and reaffirmed in 1992. During the process of reaffirmation, it was agreed to add earthquake experience data as an acceptable method of performing seismic qualification for raceway systems in this revision of the standard. This revision, therefore, incorporates methods developed by the Seismic Qualification Users Group (SQUG). An annex has been added to the document to assist the user with the new methodology. The applicability of this methodology is contingent on its acceptability per the plant licensing basis. It should be noted, however, that the SQUG methodology was approved by the US Nuclear Regulatory Commission (NRC) for verification of seismic adequacy of the cable tray systems at older nuclear power plants that were licensed prior to IEEE Std 344-1975. At this time, the use of experience-based methodology (SQUG) for the qualification of cable tray systems for the balance of nuclear power plants has not been approved by the NRC.

The working group would like to express its appreciation to the SQUG, the Advanced Reactor Corporation, and EQE International for their permission for the use of this material.

The other changes made to this standard were format changes and upgrading of the document references. The definitions contained in the original and reaffirmed documents have been removed as they are now contained in IEEE 100, *IEEE Authoritative Dictionary of IEEE Standards Terms*. Many of the references have been revised, while others have been superseded. In several cases, the reference list of bibliography contains different revisions of the same standard. In those cases, the latest revision is in use unless explicitly stated in the body of the standard.

The working group discussed the use of the term “Safety Class” in place of the term “Class 1E.” The working group felt that definition and usage of these terms were established in IEEE Std 308-1991, IEEE Standard Criteria for Class 1E Power Systems for Nuclear Power Generating Stations, and this standard should conform to the established criteria. Therefore, use of the term “Class 1E” has been maintained.

At the time this standard was completed, the working group had the following membership:

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The final conditions for approval of this standard were met on 5 January 2001. This standard was conditionally approved by the IEEE-SA Standards Board on 7 December 2000, with the following membership:

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1. Overview

1.1 Scope

This standard contains the requirements for the design, installation, and qualification of raceway systems for Class 1E circuits external to electric equipment and components for nuclear power generating stations. Because aging and radiation have no known detrimental effects upon metallic raceway systems and because nonmetallic raceway systems are limited to underground or embedded applications, aging and radiation are not considered in this standard. The embedments or structural members to which a support is attached are beyond the scope of this standard.

1.2 Purpose

The purpose of this standard is to provide criteria for the minimum requirements in the selection design, installation, and qualification of raceway systems for Class 1E circuits for nuclear power generating stations. It also prescribes methods for the structural qualification of raceway systems for Class 1E circuits.

2. References

This standard shall be used in conjunction with the following publications. When the following standards are superseded by an approved revision, the revision shall apply.

ACI 349-97, Code Requirements for Nuclear Safety Related Concrete Structures.¹

¹ACI publications are available from the American Concrete Institute, P.O. Box 9094, Farmington Hills, MI 48333, USA.

ANSI C80.1-1995, American National Standard Specification for Rigid Steel Conduit—Zinc Coated.²

ANSI C80.3-1995, American National Standard Specification for Electrical Metallic Tubing—Zinc Coated.

ANSI C80.5-1995, American National Standard Specification for Rigid Aluminum Conduit (ARC).

ASME 1995 Boiler and Pressure Vessel Code, Section IX.³

ASME NQA-1-1997, Quality Assurance Program Requirements for Nuclear Facilities.

ASTMA 123-89, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.⁴

ASTM A 653/A 653M-99, Standard Specification for Sheet Steel, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.

ASTM B 633-98, Standard Specification for Electrodeposited Coatings on Zinc on Iron and Steel.

ASTM B 776-86, Standard Specification for Electro-Deposited Coatings of Cadmium.

AWS D1.1-00, Structural Welding Code—Steel.⁵

AWS D1.3-98, Structural Welding Code—Sheet Steel.

IEEE Std 344-1987 (Reaff 1993), IEEE Recommended Practice for Seismic Qualification of Class 1E Equipment for Nuclear Power Generating Stations.⁶

IEEE Std 384-1992 (Reaff 1998), IEEE Standard Criteria for Independence of Class 1E Equipment and Circuits.

IEEE Std 665-1995, IEEE Guide for Generating Station Grounding.

IEEE Std 690-1984 (Reaff 1996), IEEE Standard for the Design and Installation of Cable Systems for Class 1E Circuits in Nuclear Power Generating Stations.

NEMA FB 1-1993, Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit and Cable Assemblies.⁷

NEMA TC 2-1998, Electrical Polyvinyl Chloride (PVC) Tubing and Conduit.

NEMA TC 3-1999, PVC Fittings for Use with Rigid PVC Conduit and Tubing.

NEMA TC 6-1990, PVC and ABS Plastic Utilities Duct for Underground Installation.

NEMA TC 8-1990, Extra-Strength PVC Plastic Utilities Duct for Underground Installation.

NEMA TC 9-1999, Fittings for PVC Plastic Utility Duct for Underground Installation.

²ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

³ASME publications are available from the American Society of Mechanical Engineers, 3 Park Avenue, New York, NY 10016-5990, USA (<http://www.asme.org/>).

⁴ASTM publications are available from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959, USA (<http://www.astm.org/>).

⁵AWS publications are available from the American Welding Society, 550 N.W. Le Jeune Road, Miami, FL 33126, USA (<http://www.amweld.org/>).

⁶IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

⁷NEMA publications are available from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (<http://global.ihs.com/>).

NEMA VE 1-1998, Metallic Cable Tray Systems.

NFPA 70-1999, National Electrical Code® (NEC®).⁸

UL 1-2000, Flexible Metal Conduit.⁹

UL 6-2000, Electrical Rigid Metal Conduit—Steel.

UL 514A-1996, Metallic Outlet Boxes.

UL 514B-1997, Fittings for Conduit and Outlet Boxes.

UL 514C-1996, Non-Metallic Outlet Boxes, Flush-Device Boxes, and Covers.

UL 797-2000, Electric Metallic Tubing—Steel.

UL 1242-2000, Intermediate Metal Conduit—Steel.

3. Abbreviations and acronyms

ABS	acrylonitrile butadiene styrene
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
AWS	American Welding Society
BWR	boiling water reactor
DL	dead load
EMT	electrical metallic tubing
EPRI	Electric Power Research Institute
HVAC	heating, ventilation, and air conditioning
IMC	intermediate metal conduit
LL	live load
NFPA	National Fire Protection Association
OBE	operating basis earthquake
PE	polyethylene
PVC	polyvinyl chloride
RAC	rigid aluminum conduit
RMC	rigid metal conduit
RSC	rigid steel conduit
RS	response spectrum or spectra
SRSS	square root of the sum of the squares
SRV	safety relief valve
SSE	safe shutdown earthquake
T	thermal load
UL	Underwriters Laboratories
ZPA _h	horizontal zero period acceleration

⁸The NEC is published by the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269, USA (<http://www.nfpa.org/>). Copies are also available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

⁹UL standards are available from Global Engineering Documents, 15 Inverness Way East, Englewood, Colorado 80112, USA (<http://global.ihs.com/>).

4. Design

4.1 General

Raceway systems for Class 1E circuits are not Class 1E; however, they shall be designed to seismic Category 1 requirements to prevent failure during a seismic event. Documentation requirements for the raceway system shall be in accordance with Clause 7 of this standard.

The raceway system shall be designed to perform its functions and shall not damage adjacent safety-related systems below an acceptable level during and after experiencing all conditions postulated to occur in its environment. As a minimum, the design shall adhere to the basic requirements of this standard and IEEE Std 384-1992.¹⁰

In the design and installation of raceway systems, consideration shall be given to the relative structural integrity of aluminum versus steel when subjected to heat from postulated fires.

Clearances with respect to other systems shall be established and provided to ensure that movement due to loads and load combinations (see 4.10.1) will not affect the integrity of the raceway system.

Raceways shall not be located close to heat sources unless cables are selected or derated for the highest expected ambient temperature. Longitudinal expansion of raceways shall be considered in areas with varying temperatures.

Relative displacement of the raceway system to other systems, equipment, or structures shall be considered in the design of raceway systems. The raceway supports shall be designed to accommodate differential settlement and deflections between structures.

The design of raceways shall accommodate the installation of qualified fire stops where raceways penetrate a fire barrier. For additional fire considerations, see IEEE Std 690-1984.

NOTE—Flexible conduit may not accommodate relative displacement in all installations.

For additional guidelines pertaining to raceway systems, see Annex B.

4.2 Separation criteria

4.2.1 Design requirements

The design requirements for physical independence and separation of raceways containing Class 1E circuits are contained in IEEE Std 384-1992.

4.2.2 Raceways

Raceways shall be separated according to the voltage classification of the cables contained within them. See IEEE Std 690-1984.

4.3 Grounding

Metallic raceways shall be electrically continuous and electrically connected to the station ground grid in accordance with IEEE Std 665-1995.

¹⁰Information on references can be found in Clause 2.

4.4 Raceway identification

Raceways shall be marked in accordance with the requirements of IEEE Std 384-1992; embedded conduit shall be marked at all access points.

4.5 Raceway system protection

Raceway systems in hazardous areas shall be designed in accordance with IEEE Std 384-1992.

4.6 Environmental considerations

The selection of materials used for raceway systems and the finishes required shall be based on the environmental conditions expected where the raceway systems are installed.

To meet the requirements for combustible gas control, materials for raceway systems to be installed in containment shall be selected with due consideration to minimizing the generation of hydrogen gas following a design basis event.

4.7 Materials

Physical properties of materials used for raceway systems shall meet or exceed the minimum requirements established for the design and qualification of these systems. Conduits shall meet the minimum requirements in 4.7.1 and 4.7.2; cable trays shall meet the minimum requirements of 4.7.3.

4.7.1 Metallic conduit

4.7.1.1 Rigid steel conduit (RSC)

RSC shall meet the requirements of ANSI C80.1-1995 and UL 6-2000.

4.7.1.2 Rigid aluminum conduit (RAC)

RAC shall meet the requirements of ANSI C80.5-1995.

4.7.1.3 Intermediate metal conduit (IMC)

IMC shall meet the requirements of UL 1242-2000.

4.7.1.4 Electrical metallic tubing (EMT)

EMT shall meet the requirements of ANSI C80.3-1995 and UL 797-2000.

4.7.1.5 Flexible metal conduit

Flexible metal conduit shall meet the requirements of UL 1-2000.

4.7.1.6 Fittings and accessories

Conduit fittings and accessories shall meet the requirements of NEMA FB 1-1993, UL 514A-1996, UL 514B-1988, and UL 514C-1988.

4.7.2 Nonmetallic conduit

4.7.2.1 Polyvinyl chloride (PVC) conduit

PVC conduit shall meet the requirements of NEMA TC 2-1998, NEMA TC 6-1990, or NEMA TC 8-1990.

4.7.2.2 Polyethylene (PE) conduit

PE conduit shall meet the requirements of NEMA TC 2-1998.

4.7.2.3 Acrylonitrile butadiene styrene (ABS) conduit

ABS conduit shall meet the requirements of NEMA TC 6-1990.

4.7.2.4 PVC conduit fittings

PVC conduit fittings shall meet the requirements of NEMA TC 3-1999 and NEMA TC 9-1999.

4.7.2.5 ABS conduit fittings

ABS conduit fittings shall meet the requirements of NEMA TC 9-1999.

4.7.3 Cable trays, accessories, and fittings

Cable trays, accessories, and fittings shall meet the requirements of NEMA VE 1-1998.

4.8 Metallic raceway system finishes

Metallic raceway systems manufactured from steel oxidize when exposed to air. This oxidation process could ultimately cause failure. To minimize this possibility, a finish (such as galvanizing or plating) shall be applied to the surface of raceway systems in accordance with 4.8.1.1 and 4.8.1.2, respectively. See 4.6 for additional coating requirements that may be needed due to the environmental conditions in the area of installation.

4.8.1 Manufacturer-applied finishes

4.8.1.1 Galvanizing

When a galvanized finish is specified, one of the following standards shall be invoked:

- Prior to fabrication: ASTM A 653/A 653M-99, Coating Class B90
- After fabrication: ASTM A 123-89

4.8.1.2 Plating

When a plated finish is specified, one of the following standards shall be invoked:

- Zinc plating: ASTM B 633-98, Coating Class FE/ZN5
- Cadmium plating: ASTM B 776-86, Coating Class TS

4.8.2 Field-applied finishes

Field-applied finishes shall be compatible with the finishes applied during the manufacturing process.

4.9 Raceway system requirements

Raceways entering enclosures from the top or sides shall be designed to minimize the entrance of condensation or water and to prevent the accumulation of moisture within the equipment. The necessity for equipment drains or conduit seals shall be predicated upon the required environmental parameters of the equipment contained in the enclosure. See IEEE Std 690-1984 for raceway fill requirements. Raceways shall not be connected to electrical equipment unless accounted for in the design.

4.9.1 Conduit system requirements

4.9.1.1 Design

Conduit systems shall be designed and arranged with suitable pull points (such as boxes and manholes) and bend radii so that the allowable cable pulling tensions and side-wall pressures recommended by cable manufacturers or determined by calculation are not exceeded. See IEEE Std 690-1984.

4.9.1.2 Sizing

Conduit shall be sized to avoid critical jamming ratio diameters. See IEEE Std 690-1984.

4.9.1.3 Seismic loading

Unless justification is otherwise provided, rigid metal conduit (RMC) or IMC shall be used in exposed conduit systems designed for seismic loading.

4.9.1.4 Compliance

Where compliance is required by local, state, or federal laws, National Electrical Code® (NEC®) (NFPA 70-1999) shall be used in selecting conduit types for use in hazardous locations.

4.9.1.5 Flexible metal conduit

The length and installed configuration of flexible metal conduit shall be designed to provide for dynamic and thermal movement and to accommodate the largest minimum bending radius of the cables to be installed. The length of flexible metal conduit shall be accounted for in the design and qualification of the conduit system. Flexible entry shall be used for conduit entering Class 1E equipment where relative movement between the conduit and the equipment is anticipated.

4.9.1.6 Welding of conduits

Welding of conduits shall not be permitted.

4.9.1.7 Metallic conduit system

The entire metallic conduit system, whether embedded or exposed, shall be electrically continuous and grounded in accordance with IEEE Std 665-1995. Where used as the equipment grounding conductor, flexible conduit and associated fittings shall be suitable for the anticipated ground fault current; or they shall be paralleled with a ground cable of suitable size.

4.9.1.8 Embedded conduit

Embedded conduit may be either metallic or nonmetallic. When embedded in building walls or floors, it shall meet the requirements of ACI 349-97, unless justification is otherwise provided. Embedded conduit subject to flooding shall slope to either boxes, handholes, or manholes for drainage or be sealed to exclude