

IEEE Guide for the Design and Installation of Cable Systems in Power Generating Stations

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IEEE Guide for the Design and Installation of Cable Systems in Power Generating Stations

Sponsor

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IEEE Power Engineering Society**

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Foreword

(This foreword is not a part of IEEE Std 422-1977, Guide for the Design and Installation of Cable Systems in Power Generating Stations.)

This guide was prepared by the Wire and Cable Systems Working Group of the Station Design Subcommittee, Power Generation Committee. The membership of the Working Group during the preparation of this draft was:

R. E. Cotta, *Chairman*

F. L. Arndt	W. J. Moseley, Jr.
A. T. Baker	R. A. Peterson
F. D. Burton	C. J. Pirofalo
D. H. Clark	L. F. Rhodes
F. J. Dan	R. G. Scott
G. Doubleday	B. J. Stables
J. J. Garland	C. E. Stine
O. Mazzoni	H. E. Yocum, Jr.
R. W. Metcalfe	R. Zweigler

Past chairmen of the Working Group and continuing advisers are J. B. Sullivan, W. B. Shields and R. Zweigler.

This guide is the result of efforts by the Work Group which cover approximately 6 years. During this time seven drafts of the guide have received comments by membership of the Power Generation Committee and Nuclear Power Engineering Committee of the IEEE. Balloting was done by both PGC and NPEC, and the resulting draft was reviewed by a special Ad-Hoc task force of the Insulated Conductors Committee.

Since approval by the Standards Committee of the IEEE, the Work Group has continued efforts to incorporate in the next revision many of those items requested by commentators during balloting process. An additional section is being addressed concerning seismic supports for Class 1E raceway systems in seismic Category I structures.

It should be noted that Section 12 (Flame Tests) of this guide essentially duplicates the content of IEEE Std 383-1974; Standard for Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations (ANSI N41.10-1975), insofar as the flame test itself is concerned. However, since this guide applies to non-Class 1E electric cables, as well as, those used in nuclear plants, the flame test is repeated herein.

Section 5, "Isolation, Separation, and Identification of Redundant Cable Systems," of this guide does not contain information which conflicts with the work of NPEC concerning IEEE Std 384-1974, Trial Use Standard Criteria for Separation of Class 1E Equipment and Circuits. Material pertaining strictly to Class 1E cable systems is included in the NPEC subcommittee's criteria.

NOTE: For convenience in using this guide, the user should note the following groupings:

Cable Considerations and Recommendations are treated in Sections 2, 3, 4, 5, 6, 7, and 8

Cable Fire Protection Considerations and Recommendations are treated in Sections 9, 10, 11, and 12

Raceway Considerations and Recommendations are treated in Section 13

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IEEE Guide for the Design and Installation of Cable Systems in Power Generating Stations

1. Purpose

This document has been developed as a guide for the design and installation of wire and cable systems in generating stations with the objective of minimizing failures and their consequences. This guide is not intended for use in design considerations of wire and cable systems in switchyards or substations.

Although the function of this document is a design guide, some of the problem solutions are presented in the wording of recommended practices. Users of the guide should be aware that the recommendations offered do not represent the only acceptable practices available for solution of the problems. They do represent principles and methods which are consistent with the goals of this guide.

This guide applies to both nuclear and non-nuclear electric power generating stations. However, for the special requirements of wire and cable installations in Class 1E systems of nuclear stations, the user should also refer to the following standards:

ANSI N45.2-1971, Requirements for Nuclear Power Plants, Quality Assurance Program.

IEEE Std 279-1971, Criteria for Protection Systems for Nuclear Power Generating Stations (ANSI N42.7-1972).

IEEE Std 308-1974, Criteria for Class 1E Power Systems for Nuclear Power Generating Stations.

IEEE Std 317-1976, Electric Penetration Assemblies in Containment Structures for Nuclear Power Generating Stations.

IEEE Std 323-1974, Qualifying Class 1E Equipment for Nuclear Power Generating Stations.

IEEE Std 336-1971, Installation, Inspection, and Testing Requirements for Instrumentation and Electric Equipment During the Construction of Nuclear Power Generating Stations (ANSI N45.2.4-1972).

IEEE Std 383-1974, Type Test of Class 1E Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.

IEEE Std 384-1974, Trial Use Standard Criteria for Separation of Class 1E Equipment and Circuits.

2. Cable Performance Requirements

2.1 Scope. Cable performance requirements mentioned in this section are particular requirements which should be considered in specifying cable for installation in generating stations. Certain requirements, such as radiation, apply only to nuclear generating stations. No one cable characteristic should be emphasized to the serious detriment of others. A balance of cable characteristics, as well as good installation, design, and construction practices, is necessary to provide a sound cable system.

2.2 Service Conditions

2.2.1 Cables may be subjected to direct burial, installation in conduit above and below ground, enclosed in wireways above ground, and exposed in cable tray runs. Cables should be suitable for operation in wet or dry locations.

2.2.2 Cable operating temperatures in generating stations are normally based on 40° C ambient. Special considerations must be given to cables installed in areas where ambient temperatures exceed 40° C (that is, at boiler fronts, in reactor containment, near steam valves, etc).

2.2.3 Cables should be suitable for all expected plant environmental conditions that may occur in the areas they are to be used.

2.3 Performance Requirements. The basic objective for cable performance is that the cable should have a serviceable life at least equal to

the design life of the power generating station at the design voltage and current ratings, and while subjected to expected plant environmental conditions. The following are requirements of special concern in generating stations.

2.3.1 Reliability. The reliability of a cable is the probability that the cable will function without failure over the design life of the cable when operated within its design limits.

Proper identification of the design limits, proper selection of the cable insulation system, and proper determination of the required installation design and methods will assure the highest reliability.

2.3.2 Thermal Stability. When subject to environmental temperature and its own generated heat during the design life, the cable shall maintain such insulating properties as required by operating conditions.

2.3.3 Moisture Resistance. Moisture resistance characteristics should be considered since cable installed in generating stations may be located in wet locations, especially those installed below grade. In addition, cable installed within a nuclear power generating station containment structure can be temporarily subjected to relative humidity conditions up to 100 percent.

2.3.4 Radiation Resistance. Cable installed in containment structures of nuclear power generating stations (except inside the reactor vessel) and in certain areas in the auxiliary building should be capable of meeting all specified characteristics before and after withstanding a total cumulative radiation dosage dictated by plant design criteria.

2.3.5 Fire Resistance. To minimize the damage that can be caused by a cable fire, cables as installed in cable tray systems should have nonpropagating and self-extinguishing characteristics. These characteristics are essential for all cables installed in power plants but are less critical for cables run in conduit. Section 12 gives recommended procedures for cable fire tests.

3. Ampacity and Derating

3.1 Scope. This section provides a guide for the determination of cable ampacity ratings and the application of derating factors for

various types of cable installations as related to power plants.

3.2 Ampacity Tables. IEEE Publication S-135 (IPCEA Publication P-46-426), AIEE-IPCEA Power Cable Ampacities for Copper or Aluminum Conductors, provides cable ampacity tables for various cable constructions and methods of installation. It also provides guides to the selection of the proper ampacity and the application of derating factors.

Ampacities for nonspaced cables in trays should be determined from tables and application data provided in IPCEA Publication P-54-440 (NEMA Standard WC51-1975), Ampacities in Open Top Cable Trays, or IPCEA Publication P-33-440-1959, Factors for Calculating Ampacities of Cables Installed in Ladder Support, Trays, and Troughs.

3.3 Design Considerations. Cables for power plant applications should be sized to carry normal and emergency load current under all conditions of plant operation. Special considerations related to power plants are:

(1) Ambient temperatures used in calculating cable ampacity ratings in tables referenced in Section 3.2 are assumed to be 20° C for buried installations and 40° C for exposed conduit or cable trays. Cable ampacity should be adjusted for the ambient temperature of the installation.

(2) Selection of conductor size should consider voltage regulation requirements, short-circuit requirements, shield currents, and mechanical strength in addition to cable ampacities. Short-circuit requirements should be based upon IPCEA Publication P-32-383-1958, Short Circuit Characteristics of Insulated Cable.

(3) Ampacities for cables installed in exposed groups or closely spaced conduits, or closely spaced in cable racks, require derating according to the number of horizontal and vertical rows involved. Derating factors are included with the ampacity tables referenced in Section 3.2.

(4) Power cables should be sized for the overload capability of the equipment served.

(5) Where cable is routed through several types of installation conditions (direct buried, exposed conduit, cable tray), conductor size should be selected for the limiting condition.

4. Physical Separation of Medium-Voltage Power, Low-Voltage Power and Control, and Low-Level Signal Cables

4.1 Scope. This section covers physical separation of various classes of cables according to degree of interference to other classes and vulnerability to spurious signals.

4.2 Definition of Voltage Class

4.2.1 Medium-voltage power cables are designed to supply power to utilization devices of the plant auxiliary system, operated at 601 to 15 000 V.

4.2.2 Low-voltage power cables are designed to supply power to utilization devices of the plant auxiliary system, operated at 600 V or less.

4.2.3 Control cables are those 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.

4.2.4 Low-level analog signal cables are those used for transmitting variable current or voltage signals for the control or instrumentation of plant equipment and systems, or both.

4.2.5 Low-level digital signal circuit cables are those used for transmitting coded information signals, such as those derived from the output of an analog-to-digital converter, or the coded output from a digital computer or other digital transmission terminals.

4.3 Separation Requirements

4.3.1 Medium-voltage power cables should be installed in raceways separate from low-voltage power and control cables and low-level signal cables. In vertically stacked trays, the highest voltage cables should be in the highest position in the tray stack.

4.3.2 Control cables may be mixed with low-voltage power cables if their respective cable sizes do not differ greatly. When this is done in trays, the power cable should be derated as if all cables in the tray were power cable, unless position and grouping are controlled.

4.3.3 Analog signal cables should be run separate from all power and control cables, and from unshielded cables carrying digital or pulse type signals. Separation can be provided by separate raceways, a barrier in a tray, or

other proven means. Separation from other electrical noise sources such as power transformers, motors, etc, should be maintained. If adequately shielded, communications cables may be included in raceways with analog signal cables.

4.3.4 Low-level digital signal cables may be run in control cable raceways, if this meets the requirements of the signal receiving equipment manufacturers.

5. Separation and Identification of Redundant Cable Systems

5.1 Scope. This section suggests methods of separation and identification for cabling associated with redundant equipment in power generating stations.

5.2 Definitions. In this section, the term “redundant” is applied to two or more systems serving the same objective, where they are also either:

(1) Systems where personnel or public safety is involved, such as fire pumps.

(2) Systems provided with redundancy because of the severity of economic consequences of equipment damage. (Turbine-generator ac and dc bearing oil pumps are examples of redundant equipment under this definition.)

5.3 Criteria. The electrical conductors for redundant systems of a power generating station should have separation to assure that no single credible event will prevent operation of the required number of redundant systems. It is also recommended that separation be applied to partial capacity systems, such as three 50 percent systems, to improve service reliability. The degree of separation required varies with the potential hazards in a particular area of the power generating station. These areas may be classified as follows:

- (1) Mechanical damage (missile) area
- (2) Fire hazard area
- (3) Cable spreading room

5.3.1 Mechanical Damage (Missile) Area. Arrangement or protective barriers or both should be such that no credible missile can cause the destruction of cabling, thereby preventing operation of the required number of redundant systems.