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ANSI/IEEE Std 572-1985(R2004)

IEEE Standard for Qualification of Class 1E Connection Assemblies for Nuclear Power Generating Stations

Sponsor

Nuclear Power Engineering Committee
of the
IEEE Power Engineering Society

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IEEE-SA Standards Board

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Foreword

(This Foreword is not a part of ANSI/IEEE Std 572-1985, IEEE Standard for Qualification of Class 1E Connection Assemblies for Nuclear Power Generating Stations.)

The Institute of Electrical and Electronics Engineers, Inc has generated this standard to provide specific direction for the implementation of IEEE Std 323-1983, IEEE Standard for Qualifying Class lE Equipment for Nuclear Power Generating Stations, as it pertains to the qualification of Class lE Connection Assemblies (connectors, terminations, and environmental seals in combination with cables as assemblies). This standard augments the direction given by IEEE Std 383-1974, IEEE Standard for Type Test of Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations, by providing guidance for the qualification of connection assemblies.

It is required that Class lE equipment in nuclear power generating stations meets or exceeds its performance requirements throughout its installed life. This is accomplished by a disciplined program of design, qualification, and quality assurance of design, production, installation, maintenance, and surveillance. This standard is for the qualification portion of the program only.

This standard establishes the general requirements, philosophies, and principles for all types of connection assemblies (except fire stops, field splices, and containment electric penetration assemblies). Emphasis is placed on multipin, quick, disconnect-type connection assemblies primarily utilized for instrumentation, control, and power. Specific qualification information for other types of connection assemblies will be added in the future. Though intended primarily to pertain to connection assemblies for field installation, this standard may also be used to obtain guidance for the qualification of internal connection assemblies of manufactured devices.

Sections 6.2.5 and 6.2.6 describe the consensus of the working group regarding methodology and procedures for age-conditioning connection assemblies to the end of their design life.

Accelerated aging techniques, including Arrhenius methods, are considered state-of-the-art and the users of this standard are cautioned that changing technology and state-of-the-art may produce improved methodology. Aging mechanisms, other than thermal and radiation may exist for the connection assembly and should be considered in any accelerated aging program. Vibration, corrosion, voltage stress, and humidity have been identified by the working group as aging mechanisms for which proven accelerated aging methodology is presently beyond the state-of-the-art.

Suggestions for improvement of this standard will be welcomed. They should be sent to the Secretary

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An American National Standard

IEEE Standard for Qualification of Class 1E Connection Assemblies for Nuclear Power Generating Stations

1. Scope

This standard provides general requirements, direction, and methods for qualifying Class lE connection assemblies for service in nuclear power generating stations. These include connectors, terminations, and environmental seals in combination with related cables or wires as assemblies. This standard does not apply to containment electric penetrations, fire stops, in-line splices, or components for service within the reactor vessel.

2. Purpose and References

2.1 Purpose

The purpose of this standard is to provide specific direction for the implementation of IEEE Std 323-1983 [2][1] on qualification as it pertains to the qualification of connectors, terminations, and environmental seals (related to cables as assemblies). This standard augments the direction given by IEEE Std 383-1974 [4] by providing requirements for the qualification of connection assemblies.

2.2 References

When the following American National Standards referred to in this standard are superseded by a revision approved by the American National Standards Institute, the latest revision shall be used.

[1] ANSI/IEEE Std 99-1980, IEEE Recommended Practice for the Preparation of Test Procedures for the Thermal Evaluation of Insulation Systems for Electric Equipment.[2]

[1]The numbers in brackets correspond to those of the references in Section 2.
[2]ANSI publications are available from the Sales Department, American National Standards Institute, 1430 Broadway, New York, NY 10018.

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[2] ANSI/IEEE Std 323-1983, IEEE Standard for Qualifying Class lE Equipment for Nuclear Power Generating Stations.

[3] ANSI/IEEE Std 344-1975 (R 1980), IEEE Recommended Practices for Seismic Qualification of Class lE Equipment for Nuclear Power Generating Stations.

[4] ANSI/IEEE Std 383-1974 (R 1980), IEEE Standard for Type Test of Class lE Electric Cables, Field Splices, and Connections for Nuclear Power Generating Stations.

[5] IEEE Std 1-1969, IEEE General Principles for Temperature Limits in the Rating of Electric Equipment.[3]

[6] IEEE Std 98-1984, IEEE Standard for the Preparation of Test Procedures for the Thermal Evaluation of Solid Electrical Insulating Materials.

[7] IEEE Std 101-1972 (R 1980), IEEE Guide for the Statistical Analysis of Thermal Life Test Data.

3. Definitions

connection assembly: Any connector or termination combined with related cables or wires as an assembly. This assembly may include environmental seals, but excludes fire stops, in-line splices, and containment electric penetration assemblies.

environmental seal: A device or system that restricts the passage of a gas or liquid through a boundary in conjunction with related cables or wires as an assembly. This does not include fire stops, in-line splices, or containment electric penetrations.

generic connection assembly: A connection assembly that represents a family of connection assemblies having similar materials, manufacturing processes, assembly techniques, limiting stresses, design, and operating principles.

generic qualification: Qualification to a set of requirements designed to envelop the service conditions plus margin of a number of specific applications.

pacing: A method of ongoing qualification by parallel age conditioning.

4. Introduction

It is required that Class lE connection assemblies meet or exceed the specified performance requirements throughout their installed life. This is accomplished through a quality assurance program that includes, but is not limited to design, qualification, production quality control, installation maintenance, periodic testing, and surveillance. The qualification portion of the program is discussed in this standard. The other steps in the quality assurance program require strict control to ensure that manufactured connection assemblies are generic and are suitably applied, installed, and maintained, and, where required, periodically tested.

It is the primary role of qualification to ensure that Class lE connection assemblies can perform as specified and that no failure mechanism exists that could lead to common mode failures under postulated service conditions.

It is the degradation with time (aging), followed by exposure to the environmental extremes of temperature, pressure, humidity, radiation, vibration, or chemical spray resulting from design basis events (DBE), or a combination of these which present a potential for causing common mode failures of Class lE connection assemblies. For these reasons it is necessary to establish a qualified life for connection assemblies required to function during and are located in areas subject to DBEs that cause the environments to exceed their normal and abnormal levels. This shall be accomplished

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using the qualification methods described in the following sections of this standard, including type testing, operating experience, analysis as a supplement to type testing and operating experience, ongoing qualification, or any combination thereof.

Connection assemblies located in areas where the environment does not exceed the postulated normal and abnormal conditions during a DBE (except seismic) may not require pre-aging prior to seismic testing to establish a qualified life. This is appropriate where data have demonstrated that the connection assembly can perform its Class lE function and has no significant aging mechanisms. The requirements of 5.4(4) can satisfy this requirement to demonstrate significant aging mechanisms. If data show that the connection assembly can perform its Class lE function, then the equipment's qualified life may be equated to its design life. If evaluations of particular connection assemblies' designs and applications so indicate, pre-aging prior to seismic testing is not required by this standard. The documentation required to qualify the connection assembly may be less than that required for connection assemblies described in the preceding paragraph.

For all qualification the end result shall be documentation that demonstrates the connection assembly's adequacy to perform its Class lE function(s). The documentation shall be in an auditable form that allows verification by competent personnel, other than the qualifier, and shall contain the connection assembly's qualification specification, documents that demonstrate compliance with the qualification specification, periodic inspection and maintenance requirements, summaries, and conclusions.

5. Principles of Qualification

An objective of qualification is to establish a qualified life for connection assemblies. The qualified life of the connection assemblies shall be expressed in years. Qualification of Class lE connection assemblies shall be accomplished using either a specific or generic qualification process.

1) *Specific Qualification*. In specific qualification, the qualification specification criteria are established for a specific application. The qualification program shall be defined to demonstrate a connection assembly's operability, with margin, under all applicable service conditions, including time.
2) *Generic Qualification*. In genetic qualification, the qualification specification criteria are established for a generic set of requirements designed to envelop a number of applications. To establish qualification for a specific application, the specific requirements plus margin shall be equal to or less severe than the genetic qualification requirements.

The specific or genetic qualification of the Class lE connection assembly and its interfaces shall be accomplished by using one or more of the methods described in the following subsections.

5.1 Qualification by Type Testing

Type testing of a sample connection assembly is the preferred method of qualification. The type tests shall be designed to demonstrate that the connection assembly is capable of performing its Class lE function during or after, or both, after being subjected to stresses due to specified service condition, including DBE, for its qualified life. The tests shall simulate conditions that meet or exceed the expected or specified service conditions, with margin, at the location of the connection assembly(s). Test samples shall be assembled by documented production assembly methods and then subjected to the test program. The components of the sample connection assemblies shall be selected at random if in production, or a prototype shall be manufactured and assembled using simulated production procedures. They shall be mounted in a manner that represents their most severe or actual plant application. The cable part of the connection assembly shall be qualified according to appropriate IEEE standards (see 2.2).

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Qualification by type testing shall include the analysis necessary to demonstrate that

1) The specimen or test sample is generically equivalent to the assembly in actual plant application to allow direct application, interpolation, or extrapolation of the test results
2) The test conditions are at least as severe as the service conditions, plus margin, including DBEs given in the qualification specification (see 6.1)

5.2 Qualification by Operating Experience

5.2.1

Operating experience can be used as a basis for the qualification of connection assemblies which are generically equivalent to other connection assemblies in other plants or plant areas. The documentation of the operating environment shall include details of physical location and the installation information of the connection assemblies in the operating facilities. The connection assembly shall be considered to be qualified by demonstrating that

1) The recorded service conditions are at least as severe as the design service conditions plus margin
2) The assembly being qualified is generically equivalent to the assembly in service
3) The performance of the in service connection assembly(s) is equal to or exceeds the specified performance requirements

Justification shall be documented in the qualification report, identifying any differences that exist in satisfying the above three requirements. The period of time for which this demonstration can be documented shall be the qualified life.

5.2.2

In the event that the required service conditions for the connection assembly to be qualified are more severe than the actual service conditions of the installed connection assembly, sample(s) of the installed connection assemblies shall be removed from service and successfully subjected to supplemental type tests before the connection assembly shall be considered qualified.

5.3 Qualification by Analysis

Qualification of connection assemblies by analysis alone is not acceptable. Analysis shall be performed only as a supplement to type testing and operating experience as follows:

1) To support test assumptions and results
2) To evaluate test data or operating experience data
3) To determine the cause of failure of the components resulting from tests in order to justify accepting the qualification results for less stringent acceptance criteria
4) To apply type-test results to the connection assemblies for in-plant applications
5) To augment the test of genetic connection assembly samples, to demonstrate that their performance-related physical properties are similar, that the materials are compatible, and that the materials interact in a manner similar to those used on a qualified connection assembly

5.4 Ongoing Qualification

Ongoing qualification may be employed in situations where accelerated age-conditioning degradation that could prevent the connection assembly from meeting the acceptance criteria has been identified and the established qualified life is less than the anticipated installed life. There are several methods of ongoing qualification, which include those discussed below.

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1) A connection assembly that is to be installed prior to completion of qualification shall be qualified for a duration based on available data. Subsequently, while operating within the initial qualified life period, the accelerated age condition data and other qualification data shall be accumulated. A connection assembly of the same type as that which has been qualified for less than the anticipated installed life shall be placed in an environment that ages it under controlled conditions. Then it shall be removed from the age-conditioning environment and qualified to the service conditions including DBE and post DBE, with margin. The qualified life of the installed connection assembly is then extended to that established by the tested connection assembly.
2) A connection assembly that is to be installed prior to completion of qualification for an anticipated installed life shall be qualified to a specific qualified life based on available data.
   An additional sample connection assembly shall be installed in a location where service conditions equal or exceed, in severity, those of the assembly for which qualification is to be extended. The samples assembly(s) shall be removed after a planned period less than the previously qualified life and subjected to qualification-type testing similar to that performed prior to its installation. The type testing shall include additional accelerated age conditioning and qualification testing. Successful completion of the type test extends the qualified life of the installed connection assembly by the additional aging period. This procedure shall be repeated until the qualified life equals the required installed life of the connection assembly or until the maximum life of the connection assembly is reached, if it is less than the required installed life.
3) When a naturally aged connection assembly is available, pacing may be used (see 6.2.5.3).
4) Where service conditions are no different during a DBE environment than the normal and abnormal environment, a monitoring program shall be used to extend the qualified life of connection assemblies accessible for periodic monitoring. This requires that the connection assembly characteristics subject to aging deterioration be monitorable and be compared to baseline parameters at specific intervals. Absence of a change (beyond the acceptance criteria) from the baseline parameters indicates that the assembly is not adversely affected by aging and is qualified for another interval. Should periodic monitoring indicate deterioration beyond the acceptance criteria, corrective action is required. The acceptance criteria shall be consistent with the level for which the connection assembly has already been qualified. Corrective action can be specific maintenance, modification, or replacement.
5) If it has been demonstrated that only certain components possess age related degradation which could prevent the connection assembly from meeting the acceptance criteria, the periodic replacement of those components with identical components, providing replacement does not adversely affect the other components, is an acceptable method of extending successive qualified life periods toward the anticipated installed life.
   Any of these methods is considered ongoing qualification. Other methods with proper justification may be acceptable. The applicability of any of the above methods or other ongoing qualification methods shall be justified. The specific program to be followed shall be documented and auditable evidence of qualification status shall be maintained.

5.5 Combined Qualification

A connection assembly may be qualified by combinations of type test, documented previous operating experience, and analysis. Connection assembly type tests may be augmented by tests of components where application, time, or other test limitations preclude the use of a connection assembly type test. Type tests with reasonable extrapolation by analysis and operating experience with extrapolation by analysis, are examples of the use of combined qualification. The qualification shall provide auditable data by which the combined methods can be shown to constitute a complete qualification program.

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6. Qualification Procedures and Methods

6.1 Qualification Specification

6.1.1 General

The qualification specifications for Class lE connection assemblies shall describe the connection assembly, its components, and all criteria to be met to qualify the assembly for its intended application during its design life.

6.1.2 Connection Assembly Description

The qualification specification shall include a description of the connection assembly being qualified including design life, mounting configuration, physical boundary, support, and interface equipment. The qualification specifications shall also include a description of various components.

6.1.2.1 Connection Assembly

All materials and material interfaces of the connection assembly shall be included in the qualification specification.

6.1.2.2 Cable

The cable description shall include, where applicable

1) *Conductor.*Material identification, size, stranding, and coating
2) *Insulation.*Material identification and thickness
3) *Construction (multiconductor cables only).* Number and arrangement of conductors, fillers, and binders
4) *Shielding*. Material identification, type dimensions, and method of application
5) *Covering*. Jacket or metallic protection or both, material identification, thickness and method of application
6) *Characteristics*. Basic impulse level (BIL) rating, rated voltage, rated cable temperature and rated maximum continuous and short time overload current, short-circuit rating and duration, and conductor resistance. For instrumentation cable, the rated capacitance, attenuation, characteristic impedance, and insulation resistance.
7) *Identification*. Manufacturer, trade name, and identification number

6.1.2.3 Connector

The connector description shall include where applicable

1) *Contact*. Type, material, finish, conductor termination, and method of installation
2) *Shell*. Material, finish, coupling system, strain relief, locking system, method of sealing, mounting to other equipment, and cable shield termination
3) *Rating*. BIL rating, rated voltage, rated connector temperature and rated maximum continuous and short-time overload current, short-circuit rating and duration, and contact resistance. For instrumentation connectors, the rated capacitance, attenuation, characteristic impedance, and insulation resistance.
4) *Identification*. Manufacturer, trade name, identification number, and, when available, manufacturer's design drawing

6.1.2.4 Termination

The description shall include, where applicable, type, material identification, and method of assembly.

1) *Rating*.BIL rating, rated voltage, rated termination temperature and rated short-time overload currents, short-circuit rating and duration, and termination resistance. For instrumentation terminations, the rated capacitance, attenuation, characteristic impedance, and insulation resistance.
2) *Identification*. Manufacturer, trade name, and identification number.

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6.1.2.5 Environmental Seal

The description shall include the type, material identification, method of assembly and, where required by the service conditions, maximum leak rate.

Identification: Manufacturer, trade name, and identification number.

6.1.3 Applicable Codes and Standards

The qualification specification shall include a specific listing of the codes and standards or parts that are applicable to the connection assembly and its components. In cases where only specific sections are applicable, these sections shall be identified and listed.

6.1.4 Service Conditions

The service conditions description shall include electrical loading and signal conditions; normal ranges, abnormal extremes, DBE and post DBE environmental conditions. Their sequence and duration shall be specified. The qualification specification shall include

1) *Atmosphere*. Gas composition, moisture content, temperature, and pressure
2) *Temperature*. Normal range and expected abnormal operating extremes including duration, and number of abnormal temperatures cycle expected during their design life
3) *Radiation*. Type(s), dose rate(s), and integrated dose during normal abnormal, and DBE and post-DBE conditions for the duration for which the safety function is required
4) *Electrical*. Voltage, current or signal characteristics, or both, including their ranges
5) *Fluids*. Composition, spray or immersion rate and time, temperature, and pressure
6) *Mechanical*. Vibration (both seismic and nonseismic), bending or flexing, connect-disconnect cycles, and tension

NOTE — If the equipment, when installed, is to be subjected to conditions not listed above, these conditions shall be defined in the qualification specification and become part of the qualification program.

6.1.5 Performance Requirements

The qualification specification shall include a description of the required Class lE function and duration of operation of the connection assembly under all normal, abnormal, DBE, and post-DBE conditions. All parameters shall be given as a range of values where applicable.

6.1.6 Acceptance Criteria

The acceptance criteria for establishing qualified life shall include values of input, duration, and performance required from the connection assembly under the specified service conditions.

6.1.7 Applicable Margin

The qualification specification shall include a statement indicating margin(s) to be applied.

Margin is required to account for reasonable uncertainties in demonstrating satisfactory performance, such as normal variations in commercial production. It shall be added to the performance and environmental parameters that affect the ability of the connection assembly to function as required. The margins may be positive or negative, or both, in accordance with what increases the severity of the test. Margin shall be applied to the service conditions for which the connection assembly is to be qualified (suggested margins are given in Appendix A). The qualification program shall include provisions to verify that margin exists. Margin is not applied to aging.

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6.2 Multipin Quick Disconnect Connection Assemblies Type Test Procedure

This section applies to only multipin quick disconnect connection assemblies. The application of generic connection assembly type test results for qualification of specific connection assembly shall be justified by analysis and documented in the qualification report.

6.2.1 Sample Selection

Generic connection assembly samples or individual specific connection assembly samples shall be used for type testing. Each specific sample shall be included in all portions of the test procedures.

6.2.2 Test Plan

Prior to type testing of connection assemblies, a written test plan shall be prepared, reviewed, and approved. The plan shall meet requirements of the qualification specification and shall contain sufficient details to describe the required sequence of tests. The plan shall indicate the adequacy of the test methods by providing an auditable link between the qualification specification and the type test results. The test plan shall include, as a minimum, the following information:

1) Qualification specification (see 6.1)
2) A list of connection assemblies to be tested, their Class lE function, and installation configuration
3) Detailed instructions pertaining to the tests required, sequence of tests, test equipment, and the steps to be accomplished, including the following steps:
   a) Description of the test sample, in accordance with 6.1.2
   b) Number of connection assemblies to be tested
   c) Mounting and connection requirements
   d) The service conditions to be simulated
   e) Aging procedure (see 6.2.5) including the basis for selecting the accelerated age-conditioning parameters
   f) Performance and environmental variables to be measured, the placement of measurement devices used to monitor the variables, and test equipment requirements including accuracies
   g) Environmental, operating, and measurement sequence (see 6.2.3)
   h) Acceptance criteria
   i) Test duration
4) Support information, calculations, and assumptions
5) Control and documentation of modification during testing
6) Documentation requirements

6.2.3 Test Sequence

The type test sequence shall be chosen to demonstrate the connection assembly's ability to meet the acceptance criteria of the qualification specification. The test conditions shall be at least as severe as the service conditions plus margin.

NOTE — Margin is not applied to aging conditions. Unless experience dictates a different sequence, the sequence shown by the flowchart in Fig 1 shall be followed.

If the connection assembly materials have no significant aging mechanisms or are known to improve in performance with age, then an unaged connection assembly shall be subject to the tests described in 6.2.3 (1), (2), (4), and (5). Sample connection assemblies which shall be age conditioned shall be tested in the sequence shown in Fig 1.

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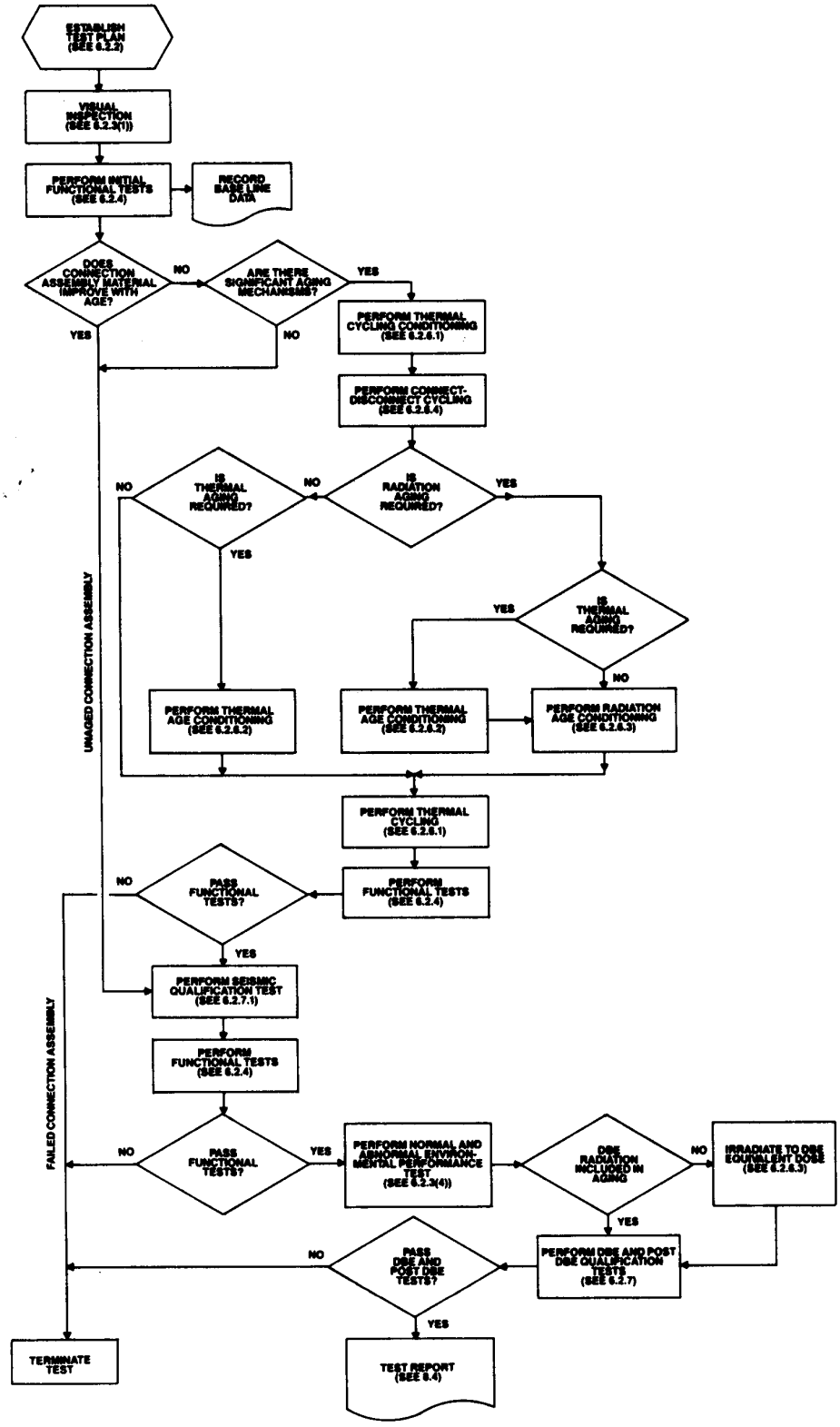


Figure 1—Flowchart of Type-Test Procedure

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NOTE — Any modification in sequence shall be shown to be at least equally severe.

1) The components of the sample connection assembly shall be visually inspected to ensure that no damage has occurred during handling subsequent to manufacture.
2) Perform initial functional tests identified in 6.2.4. Record baseline data.
3) Unless naturally aged samples are used for type-testing, the assembly shall be subjected to an age-conditioning procedure to simulate the effects of normal and abnormal service conditions and environment (6.1.4) during the installed life of the connection assembly. The age-conditioning procedure and a subsequent series of functional tests shall be performed as specified in 6.2.4, 6.2.5, and 6.2.6, respectively.
4) The sample connection assembly shall be subjected to seismic, normal, and abnormal service condition type tests.
   Functional tests of 6.2.4 shall be repeated so as to evaluate the connection assembly integrity upon completion of seismic tests (see 6.2.7.1).
5) The sample connection assembly shall next be exposed to simulated DBE and post-DBE environments as described in 6.2.7. The test sample shall be operated under service voltage and loading conditions including margins specified in 6.1.7. Upon completion of the DBE simulation testing, the connection assembly shall meet the acceptance criteria.

6.2.4 Functional Tests

The following tests shall be performed as a minimum under conditions of temperature, pressure, and humidity as specified in the test plan. The results of the initial tests shall be recorded and used as baseline data for comparison with results obtained in the following steps of the type testing. Suggested test methods described in Appendix B and published industry standards or specifications may be used if compatible with the qualification specification.

6.2.4.1 Conductor Continuity

The electrical continuity of each conductor shall be verified by a continuity test across the connection assembly.

6.2.4.2 Connection Assembly Resistance

The ohmic direct-current (dc) resistance of each circuit within the connection assembly shall be measured and corrected to a reference temperature. Caution shall be used in low-energy circuits, such as computer circuits, where normal test methods destroy oxidation and other conditions that can interrupt the signal. Appropriate test methods shall be used in those cases.

6.2.4.3 Insulation Resistance

The insulation resistance measurements shall be made for low-voltage power and for control connection assemblies with 500 V dc (minimum) applied between each conductor and all other conductors including connector shell, if metallic, connected to ground. For instrumentation and signal connection assemblies the test requirements shall be as specified for the system in which they are used. The insulation resistance measured shall be greater than the minimum insulation resistance required by the qualification specification.

6.2.4.4 Dielectric Withstand

The test sample shall be subjected to dielectric withstand voltage test. For low voltage power and for control assemblies, each conductor shall be given a dielectric withstand voltage test for not less than 1 min applied between each conductor and all other conductors including connector shell, if metallic, connected to ground. The initial test voltage value shall be equal to twice the ac (rms) rated voltage of the assembly +1000 V (or a dc test voltage 3 times the ac [rms] test voltage) unless otherwise specified. Subsequent test voltage values shall be 80% of the initial test voltage. For instrumentation and signal connection assemblies, the test requirements shall be as specified for the applications. Breakdown or flashover due to the application of the dielectric withstand voltages shall constitute test failure.

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6.2.4.5 Connector Disconnect Test

The connection assembly shall be disconnected and reconnected a minimum of one cycle to ensure that it can be reconnected and meet the performance requirements. The test shall be performed under electrical load for a load break type connection assembly or de-energized for a nonload break-type connection assembly.

NOTE — Test shall be deleted if connection assembly will not be disconnected during its installed life.

6.2.4.6 Connection Assembly Mechanical Loading

A connection assembly mechanical loading test shall be performed to demonstrate that the connection assembly is able to withstand the installation, maintenance, and service mechanical loading(s) and still meet its performance requirements. The mechanical loading should include, but not be limited to, vibration (nonseismic), bending or flexing, and tension as specified in the qualfication specification (see 6.1.4).

6.2.4.7 Vibration (Nonseismic) Test

If required by the qualification specification, apply sinusoidal motion by exposing the connection assembly to vibration stress due to nonseismic vibration specified in 6.1.4.

6.2.5 Age-Conditioning Methods

The objective of age-conditioning is to put the connection assembly in a condition that will represent its condition at the end of design life excluding the DBE. Several alternative methods for age-conditioning are given in the following subsections:

6.2.5.1 Natural Age-Conditioning

If properly documented naturally aged samples are available, they may be used in the qualification process provided that the service conditions in which the naturally aged sample has been aged are at least as severe as the normal service conditions for the intended application.

6.2.5.2 Accelerated Age-Conditioning

In cases where the conditions of 6.2.5.1 are not satisfied, an age-conditioning procedure shall be used. The age-conditioning procedure shall be based on the normal service conditions at the locations of the connection assembly. Different materials within the connection assembly, such as cable and connectors, shall be evaluated for their interfacial chemical compatibility. Calculations, test results or analysis, or both, shall be available to demonstrate compatibility of materials. Components of a connection assembly which age at different rates shall be subjected to appropriate age-conditioning procedures to determine the component which has the minimum design life provided that interface conditions between components are properly simulated. The connection assembly shall then be assembled and the qualified life of the connection assembly shall be determined using the age-conditioning procedures for the limiting component (component with the minimum design life). If the assembly includes materials such as elastomers that exhibit deformation during accelerated age-conditioning at elevated temperatures, then component accelerated age-conditioning prior to assembly may be used rather than accelerated age-conditioning of the complete assembly. The age-conditioning of the connection assembly may be extended by the periodic replacement of those components which have shorter lives.

Thermal and radiation age-conditioning shall be achieved by accelerated thermal and radiation exposure. Normal radiation levels may be combined with the DBE levels into one equivalent integrated dose with attention given to dose rate effects. If it can be shown that the radiation or thermal aging improves or does not affect the ability of the connection assembly to perform its Class lE function, thermal age-conditioning or radiation exposure may be excluded. Once the parameters and an aging method have been selected, failure modes resulting from the degradation shall be established.

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Acceptance criteria shall be established that will allow the time-to-failure to be estimated from the time dependence of one or more parameters under the accelerating environments. The service conditions of the connection assembly shall be considered in selecting the value of a parameter that causes a degradation. Failure modes, parameters causing failure, and failure criteria shall be documented. Rationale for age-conditioning shall be documented in the qualification report. Accelerated aging techniques, including Arrhenius methods, are considered state-of-the-art and the user of this standard is cautioned that changing technology and state-of-the-art may produce improved methodology.

6.2.5.3 Pacing

This method of aging may be used when an ongoing qualification program is used to qualify a connection assembly. The installed connection assembly shall first be qualified for a qualified life less than the design life and the installed life. Another connection assembly shall be age-conditioned to the qualified life and then subjected to service conditions equal to or greater than the installed connection assembly and allowed to age naturally. This sample connection assembly shall then be removed from the service conditions before the end of the qualified life previously established and subjected to a type-test procedure for extending the qualified life. This process shall be repeated as many times as necessary.

6.2.6 Age-Conditioning Procedure

The age-conditioning of the connection assembly shall be achieved using the age-conditioning procedures presented in the following subsections.

The age-conditioning shall be performed on the connection assembly samples selected for type testing. They shall be aged to the condition corresponding to the end of their design life.

6.2.6.1 Thermal Cycle Conditioning

Each connection assembly shall be subjected to at least half the number of abnormal temperature cycles specified in the service conditions prior to accelerated thermal or radiation age-conditioning, or both, and half after. Each cycle shall consist of a temperature change in the connection assembly which equals file temperature difference between the lowest normal temperature and the highest abnormal temperature including electrical- loading heating effects. These cycles shall allow adequate time for temperature stabilization at both extremes.

6.2.6.2 Accelerated Thermal Age-Conditioning

The sample connection assembly or its components shall be thermally aged at a temperature and for a time to place the sample at its end of design life condition. If the assembly in includes materials such as elastomers that exhibit deformation during accelerated age-conditioning at elevated temperatures, then component accelerated age-conditioning prior to assembly may be used rather than accelerated age-conditioning of the complete assembly. Thermal aging shall be based on data derived from either Arrhenius plot plotting (see IEEE Std 1-1969 [5], IEEE Std 98-1984 [6], ANSI/IEEE Std 99-1970 [1], and IEEE Std 101-1972 [7]).

Electrical loading heating effects shall be considered when determining the aging temperature. If Arrhenius plotting method is used, at least three data points, including one which is 5000 h or greater duration, each separated by at least 10 °C, shall be taken for the Arrhenius regression.

6.2.6.3 Accelerated Radiation Age-Conditioning

Each connection assembly shall be subjected to the total integrated radiation dose with attention given to dose rate effects to which the connection assembly is exposed during its installed life. The test sample shall be exposed to radiation at a rate, without introducing heating to more than the rated operating temperature of the sample, that achieves the total integrated normal and abnormal integrated dose. The aging effects of normal and DBE radiation levels may be combined into one equivalent integrated dose. Radiation aging data for various components of the

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sample connection assembly shall be evaluated to estimate the qualified life of the assembly. In determining the total required test radiation equivalent to that of service conditions, consideration shall be given to oxidation gas-diffusion and dose rate, and radiation type effects.

6.2.6.4 Connect-Disconnect Cycling

Each connection assembly shall be subject to at least the number of connect-disconnect cycles specified in the qualification specification. If the connection assembly is to be used for load break service the connect-disconnect cycles shall be performed while the connection assembly is carrying service condition electrical loads plus margin. If the connection assembly is not to be used for load break service the connect-disconnect cycles shall be performed with the connection assembly de-energized.

6.2.7 DBE Tests

These tests shall demonstrate that Class lE connection assemblies that are required to function during a DBE can adequately perform their safety function(s) during DBE and post-DBE conditions for as long as their operability is required. If the DBE (other than seismic) has no effect on the connection assembly normal service conditions, qualification of the assembly to that event is not required.

6.2.7.1 Seismic Tests

Connection assemblies shall be seismically qualified using the test methods described in ANSI/IEEE Std 344-1975 [3]. The connection assembly mounting for this test shall simulate the intended service configuration and installed conditions, including consideration of external cabling. The vibrations shall be monitored and recorded. If the connection assembly must function during the seismic event, it shall be energized, monitored to ensure performance of the required Class lE function, and the data recorded before, during, and after the test.

Upon completion of seismic tests, functional tests described in 6.2.4 shall be performed, as applicable, and the test results shall be evaluated.

6.2.7.2 LOCA Tests

Connection assemblies located inside the containment or in other areas where they are required to perform a Class lE function during or after a loss of coolant accident (LOCA) shall be subjected to a simulation of these conditions. The LOCA environmental conditions are generally considered to be characterized by a rapid rise in temperature, pressure, radiation, and humidity followed by slow decay toward normal conditions. If the DBE radiation was not included as part of the accelerated aging procedure prior to performing the LOCA simulation test, the sample shall be irradiated to an equivalent dose of radiation simulating the dose expected during and following a DBE up through the time, plus margin, when there is no longer a need to perform a Class lE function.

The DBE environmental conditions differ among different types of reactors and also vary significantly for various locations in the plant. The user shall furnish sufficient environmental data (see 6.1.4) to allow the simulation of the postulated design basis event profile including performance margins specified in 6.1.7. If the qualification specification requires it, the test sample shall be energized with service conditions plus margin.

6.2.7.3 Other DBE Tests

The effects of other DBEs, such as a high energy line break (HELB), shall be considered if they represent, as shown by analysis, more severe hazards to the connection assembly operation. LOCA simulation test profile may then be modified to include the effect of such DBEs and a test procedure similar to 6.2.7.2 is carried out. Alternately, a separate test may be performed to qualify for these more severe conditions. If the qualification specification requires it, the test sample shall be energized with service conditions plus margin.

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6.2.8 Qualification Process Evaluation

Results of the functional tests performed during the qualification process (see 6.2.4) shall be compared with the results of the initial functional tests (see 6.2.3 (2)). If the results obtained constitute a deviation, an evaluation, including all pertinent conditions and parameters, shall be made to determine if the connection assembly is still able to meet its performance requirements. If the evaluation concludes that the connection assembly is still able to meet its performance requirements, the type tests shall continue; if not, they shall be terminated.

6.3 Other Than Multipin Quick Disconnect Connection Assemblies Type Test Procedures

Section 6.2 may be used to develop test plans for other types of connection assemblies, where applicable.

When using this standard to qualify connection assemblies other than multipin quick disconnect connection assemblies, an engineering review shall be made to

1) Determine applicability of this standard to the connection assembly being qualified
2) Add or delete special tests or methods to be used, or both
3) Incorporate modifications to be used in the test plan for the connection assemblies being qualified

7. Modifications

When modifications are made to previously qualified connection assemblies in the material, design, manufacturing processes, conditions of installation, or postulated environment, the effects of said modifications shall be evaluated to determine any impact on the connection assembly qualification. This evaluation shall indicate whether or not additional qualification testing is required. If no additional testing is required, the analysis of data and evaluation that demonstrate this fact shall be added to the qualification documentation. If additional testing is required, the modified connection assembly shall be qualified by type testing.

8. Documentation

8.1 General

The qualification documentation shall provide recorded evidence that each type of Class lE connection assembly is qualified for its application and meets its performance requirements as defined in the qualification specification. The documentation shall contain an explanation of bases of qualification that includes the relationship between the facets of proof needed to support the adequacy of the connection assembly. Data used to demonstrate the qualification of the connection assembly shall be pertinent to the application and organized in an auditable form.

8.2 Documentation File

The following documentation shall be included in the qualification file:

1) Test Plan (including qualification specification)
2) Documents that demonstrate compliance with the connection assembly test plan criteria as defined in the qualification test plan
3) Documents that demonstrate compliance with design codes and standard
4) Documents delineating periodic inspection, maintenance, and component replacement requirements, during the qualified life of the connection assembly that were considered in the qualification program
5) Qualification results, type-testing results (8.3), summaries and conclusions, and statement of qualified life

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8.3 Type-Testing Results

The type-testing results shall include

1) List of safety functions or features demonstrated by testing
2) Test plan (6.2.2)
3) Connection assembly qualification specification (6.1)
4) Test report (8.4)
5) Conclusion and summary, approvals, and dates

8.4 Test Report

The test report shall include

1) Objectives
2) Connection assemblies tested
3) Testing procedures
4) Test set-up facilities description (photographs, if applicable)
5) Test equipment or instruments used, calibration, and accuracy
6) Acceptance criteria
7) Results, data, and deviations
8) Modifications and their justifications
9) Conclusions and statement of qualified life
10) Approval signature and date

8.5 Operating Experience Data

The operating experience data shall contain

1) Connection assembly identification
2) Qualification specification
3) Connection assembly interfaces and boundary
4) Specification of the connection assemblies for which operating experience is available
5) Identification of the specific features to be demonstrated by operating experience
6) Comparison of past application and specification with the new connection assembly qualification specification for each feature identified in (1) through (5)
7) Summary and source of operating experience applicable to connection assembly qualification
8) The basis on which the data have been determined to be suitable and the connection assembly qualified with a statement of qualified life
9) Approval signature and date

8.6 Analysis

The analysis data used for qualification shall be included in the type testing results (8.3) or operating experience data (8.5).

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Annex A
Suggested Margins
(Informative)

(These Appendixes are not a part of ANSI/IEEE Std 572-1985, IEEE Standard for Qualification of Class lE Connection Assemblies for Nuclear Power Generating Stations.)

Table A-1—Suggested Values of Margins

Peak temperature:	+15 °F (8 °C) Margin should only be applied to peak temperature when a single transient test profile is used.
Pressure:	+10% of gage but not more than 10 lb/in^2 (0.703 kg/cm^2)
Radiation:	+10% on dose No margin on rate
Voltage:	+10% of service voltage
Frequency:	−5% or +5% of system nominal value
Current:	+10% of service current
Vibration:	+10% added to the acceleration of the response spectrum at location +10% of the period of time the connection assembly is required to operate following the design basis event

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Annex B
Suggested Function Test Methods
(Informative)

B.1 Suggested Functional Test Methods:

1) Dielectric Withstand Voltage: MIL-STD-1344, Method 3001, or MIL-STD-202, Method 301.[4]
2) Insulation Resistance: MIL-STD-1344, Method 3003, or MIL-STD-202, Method 302.
3) DC Resistance: MIL-STD-202, Method 303.
4) Conductor Continuity: There is no known military or industry standard for conductor continuity. Recommended as the potential to be used in the test circuit is 10 V dc.

B.2 Bibliography

[B1] MIL-STD-202 F 1984, Test Methods for Electronic and Electrical Component Parts.

[B2] MIL-STD-1344-A-1983, Test Methods for Electrical Connectors.

[4]MIL publications are available from the Director, US Navy Publications and Printing Service, Eastern Division, 700 Robbins Avenue, Philadelphia, PA, 19111.

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