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IEEE Standard for Qualifying Class 1E Motor Control Centers for Nuclear Power Generating Stations

IEEE Power Engineering Society

Sponsored by the
Nuclear Power Engineering Committee

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IEEE Standard for Qualifying Class 1E Motor Control Centers for Nuclear Power Generating Stations

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Approved 15 September 2006

IEEE-SA Standards Board

Abstract: The basic principles, requirements, and methods for qualifying Class 1E motor control centers for both harsh and mild environment applications in nuclear power generating stations are described. In addition to defining specific qualification requirements for Class 1E motor control centers and their components in accordance with the more general qualification requirements of IEEE Std 323™-2003, this standard is intended to provide guidance in establishing a qualification program for demonstrating the adequacy of Class 1E motor control centers in nuclear power generating station applications.
Keywords: aging, analysis, class 1E, environmental qualification, harsh environment, mcc, mild environment, motor control center, operating experience, operational aging, qualification, qualified life, seismic, test

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Introduction

This introduction is not part of IEEE Std 649-2006, IEEE Standard for Qualifying Class 1E Motor Control Centers for Nuclear Power Generating Stations.

The requirements for qualification of Class 1E equipment are included in the United States Code of Federal Regulations. Among them are the following:

a) 10CFR Part 50, Appendix B, Quality Assurance Criteria, III—Design Control. This requires that design control measures be established and that such measures provide for verifying or checking the adequacy of design. One of the methods of design verification is the performance of a suitable testing program.

b) 10CFR Part 50, Appendix B, Quality Assurance Criteria, XI—Test Control. This requires that a test program be established and that testing be performed under suitable environmental conditions. These requirements, at least in part, can be met by suitable qualification.

c) 10CFR Part 50, Section 50.49, Environmental Qualification of Electric Equipment Important to Safety. This rule codifies the qualification requirements for certain equipment, located in a harsh environment, that is important to safety.

Information pertinent to developing designs and their qualification requirements can be found in the above mentioned documents and in 10CFR Part 50, Appendix A, General Design Criteria 1, 2, 4, and 23. Other governing bodies in the international community also have similar documents relating to qualification of nuclear plant equipment and should be consulted for additional guidance, as deemed appropriate.

IEEE Std 323-2003 provides general guidance for demonstrating and documenting the adequacy of electric equipment used in Class 1E systems. IEEE Std 649-2006 has been revised to deal specifically with motor control center equipment, using IEEE Std 323-2003 as the parent document for guidance.

Adherence to this standard may not assure public health and safety because it is the integrated performance of the structures, fluid systems, instrumentation systems, and electrical systems of the station that limits the consequence of accidents. Each user is responsible for assuring that this standard, if used, is pertinent to his or her application.

Class 1E equipment used in nuclear power generating stations must meet its safety functional requirements throughout its installed life. This is accomplished by a thorough program of quality assurance, design, qualification, production, transportation, storage, installation, maintenance, periodic testing, and surveillance. This standard is for the qualification portion of the program.

The user should note that while this standard covers Class 1E equipment qualification, other documents, such as IEEE Std 603™-1998, also require system integrity. Therefore, attention needs to be given to equipment performance specifications and interfaces to ensure their adequate performance in a system.

The nuclear power generating station safety analysis, in part, considers the station and its safety system design in terms of postulated service conditions.

Inherent to each such analysis are two presumptions that must be evaluated. First, designs must be such that equipment can perform designated safety functions in postulated service environments. Second, in-service aging must not degrade Class 1E equipment to the point where it cannot perform designated safety functions when required.

Production testing, normal service testing, and surveillance may not be able to determine whether the equipment is vulnerable to failure, either as a result of inadequate design or in-service time and environment, because of the special environmental stresses associated with some postulated service conditions included in the station safety analysis. Under these circumstances, common mode failure of redundant Class 1E equipment might occur at the time its safety function(s) is required. It is the fundamental role of qualification to provide reasonable assurance, with due recognition given to the established technology, that common mode failures due to design, manufacture, and age do not exist, and that the design and manufacture are adequate to permit the equipment to perform its safety function(s) during postulated service conditions.

Synergistic effects and ionizing radiation dose-rate effects have become a concern within the industry and remain the subject of continuing research programs. Preliminary results indicate that synergistic effects can be either positive or negative. Such effects should be considered in developing a qualification program. The effects may be significant due to the inclusion of solid-state electronic components into motor control centers control schemes. Detrimental affects on the electronics may occur at radiation levels that have historically been considered a mild environment.

Motor control centers qualified in accordance with this standard will meet the requirements of IEEE Std 323-2003, which provide the basic principles for design qualification for all safety systems equipment for use in nuclear power generating stations. This revision to IEEE Std 649-1991 was made to update the standard to address industry concerns with solid-state electronics and to update references and requirements of other IEEE standards.

This standard defines requirements to qualify motor control centers and their components located in all areas of the nuclear power generating station, including harsh and mild environmental areas. At this time, it appears that the seismic event is the only design basis event with potential for common mode failure in mild environments; however, other environmental service conditions may also be contributors. Particular attention should be paid to the effects of radiation on solid-state electronics and the affects of EMI/RFI fields on the equipment.

Notice to users

Errata

Errata, if any, for this and all other standards can be accessed at the following URL: http://standards.ieee.org/reading/ieee/updates/errata/index.html. Users are encouraged to check this URL for errata periodically.

Interpretations

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Participants

At the time this standard was completed, the Working Group on Motor Control Centers (SC2.14) had the following membership:

Robert L. Francis, *Chair*

Satish K. Aggarwal
Anup K. Behera
Thomas N. Brewington
James M. Dean
Quang H. Duong
Sushant Kapur
Daniel R. Mikow
James Parello
Randy Reynolds

The Subcommittee on Qualification (SC2) of the Nuclear Power Engineering Committee that recommended approval of this standard had the following membership:

Satish K. Aggarwal, *Chair*
Patrick Gove, *Secretary*

Bohumil Bartonicek
Paul D. Baughman
Anup K. Behera
Steven D. Benson
Brij Bharteey
Thomas N. Brewington
Nissen M. Burstein
Steve Casadevall
Suresh Channarasappa
Garry V. Chapman
Javier A. Chicote
Sun Yeong Choi
Choon-Hoon Chung
James M. Dean
Liviu Nicolae Delcea
Dennis E. Dellinger
Philip DiBenedetto
Michael Dougherty
Quang H. Duong
Frank Drumm
Yasutaka Eguchi
Walter Emerson
Wells D. Fargo
Artur J. Faya
Robert L. Francis
James F. Gleason
William L. Hadovski
Hideo Harada
Peter Helander
Thomas R. Hencey III
Jerrell C. Henley
Dirk C. Hopp
David A. Horvath
Yao-Tung Hsu
In-Koo Hwang
Craig S. Irish
Serena A. Jagtiani
Sushant Kapur
Mohsin Khan
Frank W. Kloer
Henry Leung
Bruce M. Lory
P. G. McQuillan
Daniel R. Mikow
Todd Mitton
Asif Mohiuddin
Edward Mohtashemi
Carole Monchy-Leroy
Bill Newell
James Parello
Janez Pavsek
Jan S. Pirrong
Daniel J. Pomerening
Robert Queenan
Edward L. Quinn
John M. Richards
Frederick L. Roy
Steve Sandberg
Glen E. Schinzel
Roderick Simms
Kjell Spang
Richard G. Stark
Hirotsugu Suzuki
Marek Tengler
Marco Van Uffelen
Laszlo Varga
Carl Weber
John Wheless
John White
Toni Wittamore
Richard T. Wood
Toshio Yamamoto

At the time this standard was approved, the Nuclear Power Engineering Committee (NPEC) had the following membership:

John Disosway, *Chair*
John D. MacDonald, *Secretary*

Satish K. Aggarwal
Ijaz Ahmad
George Attarian
George A. Ballassi
Farouk D. Baxter
Brij M. Bharteey
Wesley W. Bowers
Daniel F. Brosnan
Nissen M. Burstein
Robert C. Carruth
John P. Carter
Stephen Fleger
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Robert Fuld
James F. Gleason
Dale T. Goodney
Britton P. Grim
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Paul R. Johnson, Jr.
Harvey C. Leake
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James Parello
Glen E. Schinzel
Neil P. Smith
James E. Stoner
James E. Thomas
John Waclo
John White
Paul L. Yanosy
David J. Zaprazny

The following members of the balloting committee voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Satish K. Aggarwal
Munnu Bajpai
George A. Ballassi
William G. Bloethe
Wesley W. Bowers
Thomas N. Brewington
Daniel F. Brosnan
Nissen M. Burstein
Robert C. Carruth
John P. Carter
Suresh Channarasappa
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Gary R. Engmann
Wells D. Fargo
Robert L. Francis
James F. Gleason
L. Gradin
Ron K. Greenthaler
Randall C. Groves
Ajit K. Gwal
Hamidreza Heidarisafa
Gary A. Heuston
David A. Horvath
Dennis Horwitz
Paul R. Johnson, Jr.
James H. Jones
J. L. Koepfinger
Robert L. Konnik
G. L. Luri
John D. MacDonald
John E. Merando, Jr.
Gary L. Michel
Kimberly Y. Mosley
Michael S. Newman
James Parello
Ted Riccio
Michael A. Roberts
Frederick L. Roy
Bartien Sayogo
David R. Smith
John H. Taylor
S. Thamilarasan
James E. Thomas
James W. Wilson, Jr.

When the IEEE-SA Standards Board approved this standard on 15 September 2006, it had the following membership:

Also included are the following nonvoting IEEE-SA Standards Board liaisons:

Contents

IEEE Standard for Qualifying Class 1E Motor Control Centers for Nuclear Power Generating Stations

1. Overview

1.1 Scope

This standard describes the basic principles, requirements, and methods for qualifying Class 1E motor control centers for both harsh and mild environment applications in nuclear power generating stations.

1.2 Purpose

The purpose of this standard is to:

a) Define specific qualification requirements for Class 1E motor control centers and their components in accordance with the more general qualification requirements of IEEE Std 323™-2003[1, 2] and IEEE Std 344™-2004.

b) Provide guidance in establishing a qualification program for demonstrating the adequacy of Class 1E motor control centers in nuclear power generating station applications.

2. Normative references

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

ANSI/IEEE Std 101™-1987 (Reaff 2004), IEEE Guide for the Statistical Analysis of Thermal Life Test Data.

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

[2] Information on references can be found in Clause 2.

ANSI/IEEE Std C37.98™-1987, IEEE Standard for Seismic Testing of Relays.

IEEE Std 7-4.3.2™-2003, IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations.

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

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

IEEE Std 603™-1998, IEEE Standard Criteria for Safety Systems for Nuclear Power Generating Stations.

NEMA ICS 1-2000 (Reaff 2005), General Standards for Industrial Control and Systems.[3]

NFPA 70, 2005 Edition, National Electrical Code® (NEC®).[4]

UL 508-1999, Standard for Industrial Control Equipment.[5]

3. Definitions

The glossary in Annex B and *The Authoritative Dictionary of IEEE Standards Terms* should be referenced for terms not defined in the body of this standard.

4. Other information

4.1 General

The manufacturers and users of Class 1E motor control centers are required to provide assurance that such equipment can meet or exceed its specific performance requirements throughout its installed life. This is accomplished through a quality assurance program that includes, but is not limited to, design, qualification, production quality control, installation, maintenance, surveillance, and periodic testing. This standard treats only the qualification portion of the program.

The purpose of the qualification program is to provide assurance that the motor control center is capable of performing its required safety functions with no failure mechanism that could lead to common mode failures under the postulated service conditions specified in the equipment specification. At the end of the qualified life, the equipment shall be capable of performing the safety function(s) required during the postulated design-basis and post-design-basis events (see IEEE Std 323-2003). In mild environments, Class 1E equipment may include components that have significant aging mechanisms. The qualification process will include information on when these aging mechanisms start, and any replacement/maintenance interval required.

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

[4] The 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/).

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

Qualification may be accomplished by testing, analysis, operating experience, or a combination thereof. This standard provides qualification methods for each of these alternatives. With all qualification methods, the end result is the documented evidence that the motor control center is capable of performing its required function(s).

Note that the demonstration of the equipment's ability to perform required safety functions in accordance with this standard does not constitute a complete design verification of the equipment being qualified. Rather, it supports the overall design verification process only with respect to operation under postulated environmental and service conditions.

5. Principles of qualification

5.1 General

The qualification principles of Class 1E equipment for nuclear power generating stations are specified in IEEE Std 323-2003. These principles shall be observed for the qualification of Class 1E motor control centers.

The fundamental requirement inherent to these principles is that documented evidence that the equipment is capable of performing its required safety functions before, during, and after the postulated design basis events, as specified for that equipment, be provided. In general, such evidence requires a qualification program that includes both an aging evaluation and a performance evaluation. The aging evaluation shall first include identification of potential aging mechanisms of the equipment. For equipment with significant aging mechanisms, as defined in Annex B, it is necessary to establish a qualified life. In these cases, the qualified life, as defined in IEEE Std 323-2003, is determined using the qualification methods described in the remainder of this standard.

The following are the four basic qualification approaches that are addressed in this standard:

a) For equipment that is located in a mild environment and that has no significant aging mechanisms, the qualified life determination is not required. The qualification requirements are reduced to a demonstration of the equipment's capability to perform the required safety functions before, during, and after the specified seismic event.

b) For equipment that is located in a mild environment and that has significant aging mechanisms, an evaluation of aging effects must be addressed in accordance with 9.4 prior to seismic testing or analysis.

c) For equipment that is located in a harsh environment and that has no significant aging mechanisms, preaging is not required prior to seismic and harsh environment testing or analysis, and a qualified life determination is not required. This approach is included herein for completeness but currently has limited applicability to motor control centers (MCCs) qualification in harsh environments due to the existence of significant aging mechanisms in most MCC components currently available.

d) For equipment that is located in a harsh environment and that has significant aging mechanisms, preaging shall be addressed in accordance with 9.4 prior to seismic and harsh environment testing or analysis.

The acceptable methods for qualification are testing, operating experience, analysis, or a combination thereof. Additionally, these methods may be used to extend an established qualified life. Regardless of the method chosen, the end result shall be documented, logical, and auditable evidence that the equipment can meet requirements. This evidence shall be in a form that allows verification by competent personnel, other than the qualifiers, and shall contain the equipment specification, applicable qualification methods, the qualification plan, qualification data, justifications as required, and acceptance criteria. Though it cannot be presumed that the standard set of equipment operational and environmental conditions presented herein envelop all applications, both today and in the future, it does provide a basis for development of both generic qualification programs and user specifications.

5.2 Specific application to MCCs

This standard addresses the principles of qualification described in 5.1 by establishing a standard set of equipment operational and environmental conditions, and then presenting qualification methods (test, analysis, operating experience, or a combination of these) for these conditions.

The test method entails subjecting the equipment to simulated service conditions. The seismic and harsh environment tests shall be done at the assembled or MCC level, unless only component qualification is required. If individual devices or components are to be tested for incorporation into an MCC, the environmental and seismic levels to which they are qualified must be at least as severe as those levels that the device will experience in its installed location in the MCC.

The analysis method involves an analytical determination of the thermal, radiation, and operational aging effects on the equipment followed by either an analysis or test to the design basis events (DBE) conditions to demonstrate the equipment's ability to perform its required safety functions.

The operational experience method involves the use of documented operating experience to show that the same or similar equipment has functioned successfully under service conditions that are at least as severe as those postulated for the new application. Figure 1 shows the qualification process and options in flow chart form.

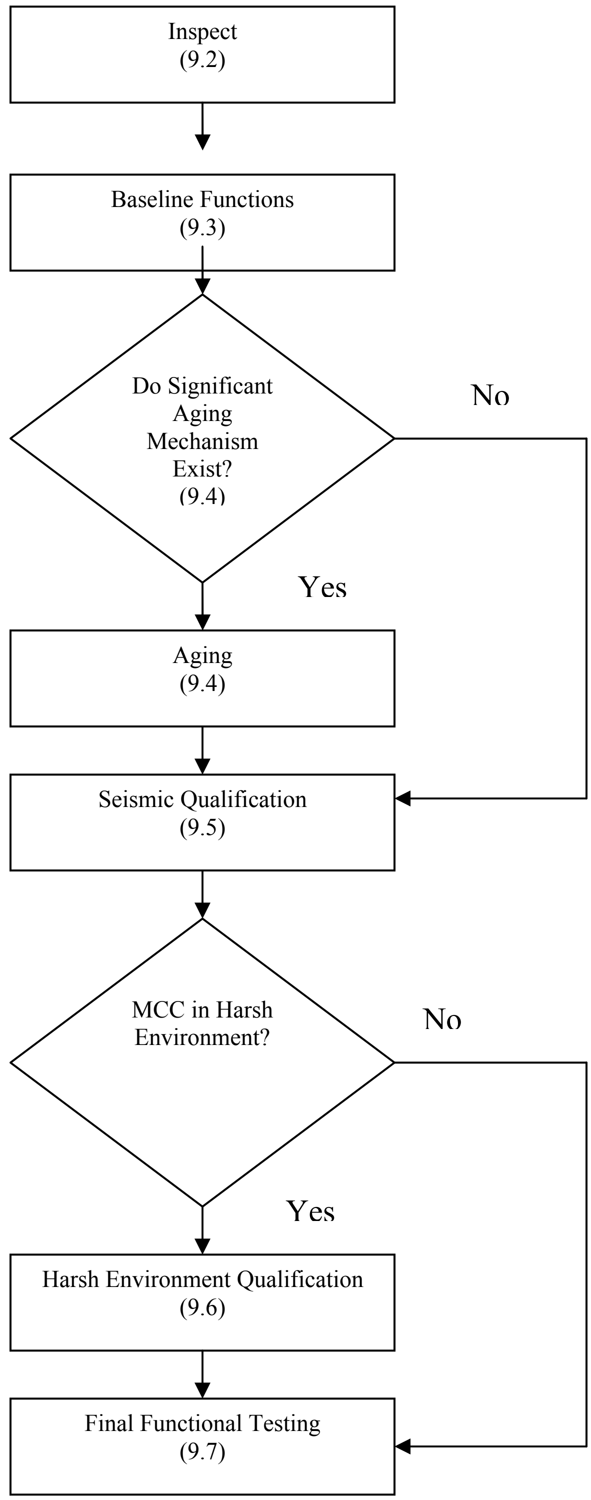

Figure 1—MCC qualification requirements

In all cases in which a specific set of requirements is not encompassed by the standard set of conditions assumed in this standard, the qualification program shall either be revised to meet the specified qualification requirements, or the qualification results shall be extrapolated based upon suitable and documented justification.

The elements of the qualification process for MCCs and their components as presented in this standard are discussed in the following list:

a) *Equipment specification*. For a given application, a specification shall be developed in accordance with Clause 8.

b) *Qualification program*. The qualification program required by this standard is conducted in the following sequence:

    1) *Development of a qualification plan*. The purpose of a documented qualification plan is to provide an auditable link between the equipment specifications and the results of the qualification program presented in the qualification report. A qualification plan is required. It shall describe the method(s) for identifying any significant aging mechanisms, the qualification program as determined from the identification of the significant aging mechanisms, the specified DBEs, and other requirements. It shall contain other information as specified in Clause 11.

    2) *Identification of significant aging mechanisms*. MCC equipment is composed of devices and components having a variety of materials, designs, and functions. Each device or component must be reviewed in terms of its materials, design, function, and specified environments to identify significant aging mechanisms that could prevent the performance of its required safety functions. The more common aging mechanisms for motor control center equipment are the effects produced by

        i) Operational cycling

        ii) Temperature

        iii) Radiation

    When other service conditions such as humidity, altitude, or normal vibration exist that could potentially produce aging mechanisms, the conditions shall be specified by the user and addressed in the qualification program. For motor control center applications, the temperature and radiation effects apply primarily to nonmetallic materials. When it can be demonstrated and documented that these or other aging mechanisms are not significant, no further evaluation of aging is required.

    There is a significant amount of technical evidence available that documents the effect of radiation doses on the solid-state electronics. If designed and manufactured with the same techniques used to manufacture the commercial grade equivalent of mil-spec components, and applied within their design ratings, the aging effect is not significant within the qualified life objective of the equipment and within a environment radiation dose environment of 1.0E+03 rads. Radiation dose rates should also be considered in this evaluation.

    3) *Implementation of the qualification plan*. Qualification procedures described in Clause 9 shall then be used to qualify the MCC and/or its components based on the results of the significant aging mechanisms identification. Variations from the conditions specified in the qualification plan require alteration of the procedure and appropriate justification. The qualification sequence, when the test method is utilized, shall be as follows:

        i) Device (and component) level qualification

            — Inspection

            — Baseline data measurement

- Aging (if significant aging mechanisms are identified)
- Functional tests (if aging is performed)
- Seismic qualification
- Other tests required by the qualification plan (see 9.6.2)
- Final functional test

ii) Assembled motor control center level qualification (if required)

- Device and component testing per the inspection, baseline data measurement, aging, and functional tests
- Seismic qualification
- Other tests required by the qualification plan (see 9.6.2)
- Final functional test

4) Determination of qualification. Qualification shall be determined as outlined in 9.8.

c) *Documentation*. Documentation shall be provided as specified in Clause 11.

6. Environmental conditions

6.1 General

The environmental conditions that the equipment will experience under normal, abnormal, DBE, and post-DBE conditions shall be provided to the qualifier in the equipment specification. The motor control center and its components must then be qualified for these conditions in accordance with Clause 9 of this standard. The specific environmental conditions shall be clearly identified in the qualification plan. The mild environment principles described in 5.1 and 5.2 may be used in accordance with Clause 9 for specific components if so warranted and justified, i.e., when it can be shown that the specified environment is considered a mild environment for the component(s) being qualified.

7. Margin

7.1 General

The purpose of margin in the qualification program is to account for reasonable uncertainties in demonstrating satisfactory performance and normal variations in commercial production, thereby providing greater assurance that the equipment can perform under the most adverse service condition specified. IEEE Std 323-2003 provides guidance for the application of margin in the qualification process.

8. Equipment specification

8.1 General

The equipment specification for motor control centers shall contain the criteria to be met to qualify the equipment for its intended application. This specification may be written by either the end user or the equipment manufacturer, depending on who has the responsibility for providing the qualification requirements to the organization performing the qualification program. As a minimum, the following shall be included:

a) *Equipment description*. The equipment specification shall describe the motor control center in terms of physical and electrical configuration.

b) *Equipment safety functions*. The specification shall describe the performance requirements and specific safety functions of the motor control center equipment, including the required operating times, when in the DBE sequence these functions are required to occur, and the maximum allowable time that a contact subject to chatter can remain in its unintended state.

c) *Interfaces*. Interfaces and loadings via physical attachments to the equipment at the equipment boundary shall be specified. These interfaces include mounting requirements, cable and cable raceway connections, as well as bus duct connections.

d) *Design standards*. Specifications shall indicate, by number and date, applicable UL, NEMA, ANSI, IEEE, and other industry standards or sections of standards.

e) *Service conditions*. The range of values for operational and environmental parameters shall be specified for the application. They may include the following, as applicable:

   1) Supply and control voltages and frequency
   2) Design ambient temperature
   3) Ambient time/temperature profile
   4) Ambient time/pressure profile
   5) Duty cycle
   6) Seismic requirements
   7) Radiation
   8) Percent relative humidity
   9) Abnormal vibration or altitude
   10) Spray
   11) Electrical loading at rated voltage (inductive and/or resistive)
   12) EMI/RFI and surge voltages (considered for solid-state electronic components)

   NOTE—Information on susceptibility testing for EMI/RFI and surge voltages is given in Annex B of IEEE Std 603-1998 and Annex C of IEEE Std 7-4.3.2-2003. EMI/RFI susceptibility testing may be performed on a separate test specimen.[6]

   Normal and abnormal service conditions and conditions resulting from design basis events shall be specified. The service conditions for these events should be expressed as a time history for each parameter that may affect equipment functions during the event.

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

f) *Margin*. It should be indicated whether or not margin has been included in the specified values.

g) *Operational aging parameters*. Operational aging parameters given in Table 1 reflect typical requirements for a generic qualification program. Where specific applications require different values, the values shall be specified.

Table 1—Typical operational aging parameters

	Test per 5 year aging period	
Device	**AC application**	**DC application**
Contactor	750 operating cycles (maximum 6/min) at nominal voltage and the following: (1) Load currents per NFPA 70-2005 values through the power contacts. Typical values at 460 V are NEMA Size 1:14A NEMA Size 2: 34A NEMA Size 3: 65A NEMA Size 4: 124A NEMA Size 5: 240A (2) Rated inductive load current through one auxiliary contact.	Same as ac. Typical values for reduced voltage starters at 240 V are NEMA Size 1: 20A NEMA Size 2: 38A NEMA Size 3: 89A NEMA Size 4: 140A NEMA Size 5: 255A
Overload relay	5 operations at 200% rated current.	Same as ac.
Molded case circuit breaker 100–600 A frame size	(1) 2 overload trips at 200%–600% rated current for thermal magnetic breakers. (2) 125 manual operations at 100% rated conditions (voltage and current; maximum 4/min).	Same as ac.
Above 600 A frame size	(1) 2 overload trips at 200%–600% rated current for thermal magnetic breakers. (2) 60 manual operations at 100% rated conditions (voltage and current; maximum 1/min).	Same as ac.
Fuse and fuse holder	See note.	
Transformers		
(1) Control power	No operational aging required.	Not applicable.
(2) Distribution	No operational aging required.	
Auxiliary relay and timing devices	750 operating cycles (maximum 6/min at nominal voltage with rated inductive load on one contact).	Same as ac.

Table 1—Typical operational aging parameters *(continued)*

	Test per 5 year aging period	
Device	**AC application**	**DC application**
Pushbuttons and selector switches	750 operating cycles (maximum 6/min at nominal voltage with rated inductive load on one contact).	Same as ac.
Indicating light modules	No operational aging required.	Same as ac.
Solid-state devices	Special consideration must be given to solid-state devices. Supplier should be consulted for specific aging parameters.	Same as ac.
Ground fault-sensor/ relay	Same as solid-state devices.	Same as ac.
Undervoltage and overvoltage relays	Supplier should be consulted for specific operational aging parameters.	Same as ac.
Disconnect switches	125 manual operations at 100% rated conditions (voltage and current).	Same as ac.
Resistors (power)	Not applicable.	No operational aging required.
Transfer switches	Supplier should be consulted for specific operational aging parameters.	Same as ac.
Stab-on-connections	Five insertions and removals.	Same as ac.
Pull apart terminal blocks	Five connect and disconnects.	Same as ac.

NOTE 1— Operational aging of fuses may be accomplished by either natural aging or accelerated aging techniques. Alternatively, the manufacturer's documentation or other documentation may be provided to verify that, subject to the application, age is not a factor in causing common mode failures of fuses.

NOTE 2—ANSI/IEEE Std 37.105™ may be used as an additional source of guidance for the requirements of relays.

h) *Qualified life objective*. The desired qualified life objective shall be stated for the MCC or its component(s) that are subject to significant aging mechanisms.

i) *Acceptance criteria*. Acceptance criteria shall be defined so that all failures to perform the specified safety function(s) in the service conditions for which the equipment is being qualified can be identified. The operational tests given in Table 2 reflect typical requirements for a generic qualification program. Where specific applications require different values, the values shall be specified; however, care should be taken to ensure that the acceptance criteria selected are not overly restrictive or based on measurements not related to the specified safety functions.

Table 2—Typical functional tests

	Operational test	
Device	**AC application**	**DC application**
Contactor*	Pick up at 110% and 85% of rated coil voltage. Device shall not drop out at or above 70% rated coil voltage.	Pick up at 110% and 80% of rated coil voltage. Device shall not drop out at or above 70% rated coil voltage.
Overload relay*	Trip on 200% overload within manufacturer's time current/ curves.	Same as ac.
Molded case circuit breakers*	(1) Manual operation. (2) Trip on 200% of rated current within manufacturer's time current/curves. (3) Trip on 80%–120% of maximum instantaneous trip setting (except molded case switches).	Same as ac.
Fuse and fuse holder	Conduct rated current	Same as ac.
Transformers (control power and distribution)	(1) Proper secondary voltage is present when rated voltage is applied to the primary leads. (2) Check insulation strength by dielectric leakage current measurement.	Not applicable.
Auxiliary relays*[†]	Pick up at 110% and 85% of rated coil voltage. Device shall not drop out at or above 70% rated coil voltage.	Pick up at 110% and 80% of rated coil voltage. Device shall not drop out at or above 70% rated coil voltage.
Timing devices *[†]	Operate within the limits of manufacturer's specified repeat accuracy at 110% and 85% of rated coil voltage. Device shall not drop out at or above 70% rated coil voltage.	Operate within the limits of manufacturer's specified repeat accuracy at 100% and 85% of rated coil voltage. Device shall not drop out at or above 70% rated coil voltage.
Pushbuttons and selector switches*	Make and break at rated conditions (voltage and current).	Same as ac.
Indicating light modules	No operational test required. Failure of the indicating light module shall not result in the degradation of the circuit in which the light is located (for example, no short circuit).	Same as ac.
Solid-state devices	Special consideration shall be given to solid-state devices. Supplier should be consulted for specific operational parameters.	Same as ac.
Ground fault-sensor/relay*[†]	Same as solid-state devices.	Same as ac.

Table 2—Typical functional tests *(continued)*

	Operational test	
Device	**AC application**	**DC application**
Undervoltage and overvoltage relays*†	Supplier should be consulted for specific operational parameters.	Same as ac.
Disconnect switches*	Make and break at rated conditions (voltage and current).	Same as ac.
Resistors (power)	Not applicable.	Conducts rated current.
Transfer switches*	Supplier should be consulted for specific operational parameters.	Same as ac.
Stab-on connections	Check electrical and mechanical integrity of connections. No over-heating while conducting rated current.	Not applicable.
*Device contacts shall be monitored to verify make and break load conditions.		
†Requirements for qualification of relays for other than motor control center application may be found in ANSI/IEEE Std C37.98-1987. The user of this standard may wish, in development of a motor control center qualification program, to incorporate some of these other requirements to achieve broader qualification of relays than just for motor control centers. In any event, the requirements for qualification of relays in a motor control center program shall be at least as stringent as specified herein.		

Not all of the acceptance criteria in Table 2 can be demonstrated with the equipment inside a test chamber. Therefore, the specifier must determine which criteria are to be demonstrated during and after a harsh environment test. Alternative criteria such as the following may also be used:

a) No unwanted tripping of thermal sensitive devices such as circuit breakers, fuses, and overload relays

b) No dielectric breakdown that results in the permanent loss of control or main power voltage

c) No spurious circuit operations

9. Qualification procedures

9.1 General

This clause presents qualification procedures for the three qualification methods: testing, analysis, and the use of operating experience. (See Figure 1 to determine the applicability of the subclauses contained in this clause.)

Equipment may be qualified by test, analysis, operating experience, or any combination thereof. Combined qualification shall be developed on a case-by-case basis by applying the procedures presented in this clause. The qualification methods used shall provide auditable data by which they can be shown to constitute a complete qualification program.

Regardless of the method(s) used in the qualification program, the equipment is considered to be qualified when it meets the acceptance criteria listed in the equipment specification (see Clause 8). Any failure to meet the acceptance criteria shall be analyzed to determine its cause and overall effect on the equipment's qualification as discussed in 9.8.

9.2 Inspection

Each device to be qualified shall be inspected to verify that the equipment used in the qualification program is the same as that specified in the qualification plan. The inspection shall also ensure its installation configuration reflects the actual installation in the power plants. A detailed listing of test specimens by model numbers and serial numbers, when available, shall be maintained and included in the documentation.

9.3 Baseline data measurement

Each device shall be operated under normal environmental conditions to the extremes of all performance and electrical characteristics given in the equipment specifications. Sufficient data must be taken to serve as baseline data for subsequent functional tests. As a minimum, the functional tests specified in Table 2 shall be performed. The values specified in Table 2 are typical, and the actual test values may vary. The specifier or qualifier shall assure that the values used are suitable for the specific application.

9.4 Aging

9.4.1 Aging methods

Aging may be addressed by several methods. These methods include age conditioning (testing), analysis, operating experience, in-service surveillance and maintenance for extension of qualified life, or any combination thereof. An aging method shall be selected based on an evaluation of the materials and application of the specific device or component. Age conditioning or analysis need not be performed, even if significant aging mechanisms exist, if naturally aged equipment with proper documentation, which meets the requirements of IEEE Std 323-2003, is used as the test specimen.

Successful thermal aging of equipment is possible only through careful review of the equipment, its application, and the qualified life objective. Particular considerations for this part of the qualification program are:

a) *The aging model*. Thermal aging conditions may be established by the use of the Arrhenius relationship (see ANSI/IEEE Std 101-1987). Acceleration factors and test conditions shall be conservatively chosen based on the time/temperature sensitivity of materials in the device. Where a specific thermal aging acceleration factor for a specific formulation of a material is not available, the activation energies for the generic class of materials used and the temperatures involved may be employed to develop conservative values for the property of interest.

b) *Temperatures*. Selection of aging temperature depends upon the practical upper limit of the materials involved, the desired aging time, and the in-service ambient air temperature of the equipment. The internal temperature rise in the MCC compartment shall be included in the Arrhenius analysis. Typical thermal aging conditions are given in Table 3.

Table 3—Typical thermal aging conditions

	Typical temperatures
In-service MCC* external ambient temperature	30 °C
Average MCC external to internal air temperature difference	10 °C
Average in-service device† ambient temperature	40 °C
Thermal aging oven internal ambient air temperature	100 °C
Resultant thermal aging differential temperature	60 °C

* The thermal aging portion of this qualification program shall be based upon a 40 °C in-service MCC internal ambient temperature, or upon an appropriately derived equivalent temperature based on the plant temperature profile analysis for the locations of the motor control center equipment. The latter option is preferred because it may result in a more likely temperature value that will produce a significantly longer qualified life of the equipment. The specifier shall provide the temperature profile analysis data to the qualifier, who shall be responsible for deriving and documenting the equivalent temperature value.

† This temperature represents the internal ambient air temperature surrounding the devices and does not include temperature rises within the devices due to self-heating effects.

c) *Qualified life objective*. At the outset, a qualified life objective shall be chosen for each device that has significant aging mechanism(s). This determination should be made after a review of each device and its design, materials, and available operating history for possible indications of limits on life.

d) *Self-heating effects*. Device self-heating effects are a significant factor in the life of the equipment. They are dependent upon the degree of self-heating, the in-service duty cycle, and other factors. Each device must, therefore, be reviewed in terms of these factors, and the appropriate effects shall be accounted for. The specifier shall supply to the qualifier the anticipated duty cycle. In the event that device self-heating effects are not known, heat rise can be calculated using the guidelines of NEMA ICS 1-2000 or UL 508-1999.

9.4.1.1 Age conditioning method

The aging mechanisms addressed in this procedure are time/temperature effects, operational cycles, and radiation. One or all of these aging mechanisms may be addressed via the analysis or operating experience methods. In the aging test program, the time/temperature effects, radiation exposure, and operational cycles may be accumulated on an incremental basis.

In this method, each device and component with significant aging mechanisms shall be subjected to an accelerated aging test, which includes thermal aging, operational aging, and radiation exposure, as applicable. It is recommended that thermal aging and operational cycling be accumulated on an incremental basis. Additionally, the normal and accident radiation may be combined. A typical sequence is as follows:

a) Thermally age the device by exposing it to the temperature specified in the qualification specification for an equivalent of five years real time. (See Table 3.). A nominal value that may be varied at the discretion of the qualifier.

b) Remove the device from the high temperature environment. Operationally age the device for an equivalent of five years, as specified in Table 1, at nominal room temperature.

c) Subject the device to gamma radiation to simulate exposure to a total integrated radiation dose equivalent to the aging period used in step a) above. Alternatively, the total integrated dose, plus margin, specified for the device may be administered. This test may be omitted if documented justification is provided.

d) Subject device to functional tests and compare the results to the baseline data. Document the results of the analysis.

e) Perform manufacturer's recommended periodic maintenance, if desired, to minimize the probability of failure during the aging test. If maintenance is performed, its relevance to the determined qualified life and the post installation periodic maintenance requirements shall be analyzed and stated in the qualification report.

f) Repeat the above sequence the necessary number of times until an equivalent of the qualified life objective has been accumulated or a qualified life has been established. Following the last increment of aging that precedes the DBE test, no maintenance shall be performed.

Radiation and/or operational aging may be required to be done first in the above sequence if shown and documented to be required to adequately address synergistic effects.

At the completion of the aging cycles, subject the device to the functional tests performed in accordance with 9.3 to demonstrate operational capabilities. Analyze any anomalies found for potential impact on the ability of the device to perform its safety function(s). Document the results of the analysis.

9.4.1.2 Aging analysis method

Aging by use of analysis shall consider three separate types of aging, i.e., thermal aging, radiation aging, and operational aging. The analysis must take into account any known synergistic effects among the identified aging mechanisms. The analysis sequences shown in this clause are some of several potentially acceptable analysis methods that may be used when properly justified and documented.

9.4.1.2.1 Thermal aging analysis

The thermal aging effects on a device shall be evaluated by considering the aging characteristics of the age-sensitive materials and the specified environmental and operating conditions. The analysis may be performed as follows:

a) Identify all age-sensitive materials used in the device.

b) Obtain Arrhenius-type data or other applicable time/temperature data (plots of time vs. temperature, etc.) for each material. Ensure that the material properties for which data are developed are pertinent to the design requirements of the device (dielectric strength, flexural strength, etc.) that are necessary for it to perform its safety function.

c) For the specified qualified life objective, determine the expected useful life of each material at the specified environmental and operating conditions. The temperatures used in this analysis shall be based on the material operating temperature expected for each application. These temperatures shall consider self-heating effects and the in-service device ambient air temperature.

d) If the expected useful life exceeds the qualified life objective of the device being analyzed, the material can be considered to have no significant thermal aging mechanisms in the analyzed environment. If the expected useful life is less than the qualified life objective, the expected useful life then becomes the qualified life for that material. The qualified life of the device is equal to the shortest qualified life of the materials in the device that are necessary for it to perform its safety function.

e) Results of the analysis shall be documented.

Other analysis methods may be used.

9.4.1.2.2 Radiation aging analysis

The radiation aging effects on a material, component, or device are evaluated by consideration of the aging characteristics of the radiation-sensitive materials and the radiation dosage to which they are subjected. The analysis may be performed as follows:

a) Identify all radiation-sensitive materials used in the equipment.

b) Obtain radiation damage threshold data, based on selecting the applicable failure modes for each material as used in the application. Ensure that the material properties and acceptable degradation level are appropriate for the failure mode of the material in order to ensure that the device will perform its safety function.

c) Compare each material's radiation damage threshold level to the specified radiation value and determine if the radiation levels to which the materials may be exposed will cause material property degradation to a level that could adversely affect the device's ability to perform its safety function.

d) When all material radiation damage threshold levels exceed the specified radiation value, the equipment shall be considered as having no significant radiation aging mechanisms. If the damage threshold level for any material is less than the specified radiation value, the qualified life must be determined based on the dose rate and duration of exposure that the equipment will experience in its installed environment and analysis of property degradation that the material will experience. The qualified life of the device is equal to the shortest qualified life of the materials in the device that are necessary for it to perform its safety function.

e) Results of the analysis shall be documented.

9.4.1.2.3 Operational aging analysis

The operational aging effects on a component or device generally must be evaluated by performing operational aging testing, as described in 9.4.1.1, because operational aging effects on seismic fragility cannot be accurately forecasted without actual test data. Operational aging effects can be considered using the analysis method when there is documented evidence from existing test data that the component or device does not exhibit any deterioration due to aging that effects the ability of the device to function during or after a seismic event.

The analysis may be performed as follows:

a) Estimate the total number of operations in each of the Class 1E motor control circuits and components over the qualified life objective.

b) Obtain test data that includes life cycle test data that was performed prior to seismic testing on each piece of installed equipment. This data shall specify the electrical contact loading utilized. Only testing where the contacts were loaded equal to or greater than the in-service loading can be utilized for this analysis.

c) If the number of cycles in the test data exceeds the in-service required number of cycles, and the seismic test data shows no significant deterioration in the seismic fragility levels from the unaged levels, then the equipment can be considered to have no significant operational aging mechanisms.

d) The results of the analysis shall be documented.

9.4.1.2.4 Review of aging analysis

The results of the thermal, radiation, and operational aging analyses shall be utilized to determine the overall aging status of the equipment. Any known synergistic effects of combined thermal, radiation, and operational aging must be considered in this determination. If the thermal aging, radiation aging, operational aging, and synergistic analyses all demonstrate that no significant aging mechanisms exist, then the equipment does not require age conditioning. If any of the thermal, radiation, or operational aging analyses result in a qualified life less than the qualified life objective, then the equipment shall be considered to have the lowest of these qualified life values.

9.4.1.3 Natural aging method

Naturally aged components or devices may be used in lieu of age conditioning to satisfy the aging requirement. The following requirements shall be met in order to use this natural aging method:

a) Justification that the naturally aged component or device and its materials are similar to those that are to be qualified has been established. The following characteristics, among others, may be considerations in establishing adequate justifications:
    1) Component physical arrangement, size, mounting features, interconnections, stresses, heat generation/dissipation, and materials of construction
    2) Aging effects
    3) Environmental effects
    4) Performance requirements

    Analysis or test shall be performed to demonstrate that any differences do not affect the performance of the component or device's safety function.
b) The component or device has been aged in an environment at least as severe as the normal environment for the intended application.
c) Operating and replacement/maintenance records for the naturally aged equipment are available to verify service conditions.
d) The naturally aged equipment was operated under a load at least as severe as that specified for the equipment to be qualified.
e) Documentation supporting the above requirements exists.

9.4.1.4 Surveillance and maintenance method

If naturally aged equipment is not available with proper documentation, and significant aging mechanisms have been identified, surveillance and maintenance may be used to avoid performing age conditioning in a type test program that has extension of qualified life as its objective. Surveillance and maintenance can be used to extend the qualified life of an in-plant device by maintaining the device in a condition in which the significant aging mechanisms previously identified will not affect the safety function in the time period to the next surveillance and maintenance, thereby providing assurance of operability under all conditions.

In order to use this method:

a) A qualified life must have been previously established by test or analysis.
b) It shall be determined either by test or analysis how often surveillance and maintenance must be performed on each device so that significant aging mechanisms cannot affect the safety function(s) of the device being qualified.

The specific maintenance actions that must be performed as the result of this determination shall be clearly delineated in the qualification report. The user shall perform these required actions to maintain qualification during the installed life of the MCC.

All surveillance and maintenance records used in conjunction with this method shall be maintained with the qualification records in an auditable form.

9.5 Seismic qualification

MCCs may be seismically qualified by test, combined analysis and testing, or use of operating experience. Seismic qualification of Class 1E motor control centers shall meet the requirements of IEEE Std 344-2004. The procedures and guidelines of that document shall be followed in demonstrating that the Class 1E motor control centers can meet their qualification requirements. In addition, some specific areas that are peculiar to motor control centers are listed herein with recommended qualification procedures to be used. These procedures are intended to supplement those described in IEEE Std 344-2004 and provide additional guidance for qualifying this kind of equipment. ANSI/IEEE Std C37.98-l987 may be useful in determining qualification of individual devices.

9.5.1 Test method

9.5.1.1 Input motion

Test input motion shall be in accordance with IEEE Std 344-2004. Either single axis, biaxial, or triaxial testing may be utilized subject to the guidance given in IEEE Std 344-2004.

9.5.1.2 Input signal

A random motion, multifrequency test input signal is preferred. If single frequency-type signals (e.g., sine-beat, continuous sine, or decaying sine) are to be used, there must be justification, or it must be demonstrated that the critical frequencies of the various components in the motor control center makeup have been addressed. In addition, if a single frequency-type signal is used, the test response spectrum (TRS) must envelop the 3 dB band pass of the required response spectrum (RRS). If a single frequency signal is to be utilized, both in-phase and out-of-phase tests shall be conducted.

9.5.1.3 Required seismic environment

It is preferred that the seismic environment be defined by a response spectrum for the seismic qualification of motor control centers, i.e., a RRS. For motor control centers, the preferred damping value of the RRS is 5%. Margin, in accordance with IEEE Std 323-2003, shall be included in the RRS.

9.5.1.4 Seismic qualification acceptance

The motor control center is seismically qualified when it has been demonstrated that the equipment is capable of performing its required safety functions before, during, and after the postulated seismic event, as required by the equipment specification. With respect to the levels of seismic input motion, the motor control center equipment is considered to have been subjected to adequate seismic input forces when the TRS envelops the RRS. In developing the TRS at the 5% damping factor, it is recommended that a 1/6 or less octave analysis be utilized.

The general requirement for enveloping the RRS by the TRS can be modified under the criteria given in IEEE Std 344-2004.

9.5.1.5 Monitoring equipment

The seismic monitoring equipment used during testing shall be in accordance with IEEE Std 344-2004.

9.5.1.6 Numbers of tests

There shall be one or more operating basis earthquake (OBE) tests conducted on the same test sample that produce the documented equivalent effect of 5 OBEs (in each principal direction) followed by at least one safe shutdown earthquake (SSE) test.

9.5.1.7 Mounting

The method of mounting the motor control center may be by either welding or bolting, as recommended by the qualifier. The method and procedures used during testing shall be documented and shall be the same as those for the motor control center installed in the plant. Alternate mounting methods shall be justified.

9.5.1.8 Contact chatter (unwanted change of circuit condition)

Representative contacts of each device tested shall be monitored for contact chatter during the operations specified in 9.5.1.10. Selection of these contacts shall be adequate to allow evaluation of equipment performance. The permissible time for contact chatter of any contact due to seismic input is dependent on the effect of chatter on the circuit in which the contact is used. The specifier shall supply to the qualifier the maximum allowable time that a contact subject to chatter may remain in an unintended state.

As an alternative to this approach, devices representing an actual installed configuration may be wired into circuits controlled by contacts subject to chatter. Any unintended change of state of these devices shall be analyzed to determine acceptability.

9.5.1.9 Electrical loading

Unless otherwise justified, all testing shall include electrical loading and energization of representative samples as follows:

a) Devices shall be tested in both the energized and deenergized state. When energized, the tests shall be conducted at the lower voltage excitation limits according to Table 2, unless other values are justified. This includes contactor coils, relay coils, transformers, circuit breakers, and any other device that operates in an energized state.

b) Load contacts of contactors and circuit breakers shall have the specified load current passing through them during testing.

c) Auxiliary contacts associated with contactors, relays, or circuit breakers shall have the specified load current passing through them during testing.

d) Typical starter and circuit breaker thermal overload elements must conduct rated load current during seismic testing.

9.5.1.10 Operation of devices

Seismic testing shall include operation of devices as follows:

a) Devices that are required to change state (energized to deenergized or vice versa) during an SSE by remote means (for example, contactors, relays, or circuit breakers with shunt trips) shall be operated in a similar manner during testing at the SSE level. If such action is required only after an SSE, testing may then be limited to operation after the simulated SSE. Locally operated devices need not be operated during seismic excitation. Representative samples shall, however, be tested to demonstrate functional capability for both energized and deenergized conditions.

b) Contacts whose positions are governed by the state of the device with which they are associated shall be tested and monitored as follows:

    1) With contacts both open and closed

    2) With devices both energized and deenergized

c) Each device must experience the seismic input in each state (energized or deenergized) for the duration specified by the equipment specification. The transfer from one state to the other may be performed at any time once the specified duration has been exceeded. The safety function of equipment shall be demonstrated during the strong motion portion of the earthquake simulation per IEEE Std 344-2004.

d) Operation of devices under abnormal electrical conditions, such as overload or short-circuit currents, is not required.

9.5.1.11 Interfaces

Minimum interface effect on a motor control center is obtained where external means are provided to support the weight and provide flexibility of incoming connections. It is recognized that there are many possible variations. Therefore, anticipated additional weight and external connections shall be simulated during testing and the interface/external connections of the final installations shall be within the boundaries of the anticipated conditions simulated during testing.

9.5.1.12 Number of vertical sections

The test sample may consist of one or more vertical sections. Qualification of motor control centers with a different number of vertical sections than the sample tested is to be justified through analysis of the test data. Justification shall follow the guidance given in IEEE Std 344-2004.

9.5.1.13 Similar devices, units, and arrangements

It is recognized that the possible variations of similar devices, units, and arrangements are numerous. Therefore, qualification of similar equipment using test data of representative samples previously qualified to equal or greater seismic requirements shall follow the guidelines described below.

9.5.1.13.1 Devices

The arrangement (physical position) of units within the vertical sections is critical to the seismic qualification of motor control centers. The arrangements of units shall be as specified in the equipment specification. If no arrangement is specified, then it is recommended that the test sample be arranged in the worst case seismic configuration to provide the greatest freedom for location of units within the motor control center when installed in the plant. Greatest freedom is achieved when the most seismically sensitive units and largest equipment masses are located in the test sample as near the top of the structure as is practical.

9.5.1.13.2 Units

Units may be seismically qualified on a generic basis (by group, family, or type) if it can be demonstrated that their devices' basic operations, function(s), materials, and designs are affected in a similar manner under seismic conditions.

9.5.1.13.3 Arrangements

The arrangement (physical position) of units within the vertical sections is critical to the seismic qualification of motor control centers. The arrangements of units shall be as specified in the equipment specification. If no arrangement is specified, then it is recommended that the test sample be arranged in the worst case seismic configuration to provide the greatest freedom for location of units within the motor control center when installed in the plant. Greatest freedom is achieved when the most seismically sensitive units and largest equipment masses are located in the test sample as near the top of the structure as is practical.

9.5.1.14 Limits of seismic qualifications

Seismic qualification shall be limited to the specific motor control centers identified and shall reference the drawings for the equipment as shipped. Modifications made to the equipment after shipment, except unit relocations or exchanges explicitly permitted by the qualifier, require requalification in accordance with 9.5.1 or 9.5.2.

9.5.1.15 Documentation

The documentation requirements shall be in accordance with IEEE Std 344-2004 and Clause 11 of this standard.

9.5.2 Combined analysis and testing

When seismic test data already exist for a motor control center structure, seismic qualification can be demonstrated for a motor control center of a similar design using a combination of analysis and testing. The guidance and requirements of Clause 8 of IEEE Std 344-2004 shall be followed when this approach is utilized.

9.5.3 Experience analysis

Seismic qualification of MCCs may be accomplished by justifying their similarity with previously qualified equipment or with equipment that has been exposed to more severe seismic excitation. Similarity of the equipment characteristics and of the excitation environment must be established by techniques that can be technically justified.

Experience data may be derived from a variety of sources. It may be:

a) Analysis or test data from previous qualification programs

b) Documented data from equipment in facilities that have experienced earthquakes

c) Data from operating dynamic loading or other dynamic environments

Depending on the source and level of documentation detail available, various approaches are appropriate. The approach selected shall conform to the guidance in IEEE Std 344-2004. Annex A provides information on research and methods that are available for addressing seismic qualification of electrical equipment based on experience data.

9.6 Harsh environment events

9.6.1 General

Motor control center equipment is normally furnished for use in a mild environment in which the seismic event is the design basis event of major concern. Under certain conditions, motor control center equipment is furnished for use in a harsh environment where post-LOCA (loss of coolant accident) or HELB (high energy line break) events are of major concern.

When equipment is furnished for use in a harsh environment, specified conditions such as temperature, pressure, humidity, and radiation shall be addressed in the qualification program. For a given post-LOCA or HELB event, the conditions for which the motor control center and its equipment must be qualified shall be included in the motor control center specification developed in accordance with Clause 8. The acceptable methods for demonstrating equipment capability for these events or conditions are testing, use of operating experience, analysis, or any combination thereof.

9.6.2 Test method

Under this method, it shall be demonstrated by test that MCC equipment can meet or exceed its safety function requirements under the harsh environment conditions specified in the equipment specification.

The test program performed shall be in accordance with the requirements of IEEE Std 323-2003, and shall be done in the sequence shown in 5.2 of this standard. Factors to be considered in the test program that are unique to motor control centers and their components are listed below:

a) *Selection of MCC equipment for testing.* Representative samples of equipment should be chosen with attention given to thermally-sensitive devices such as breakers with thermal trip units, fuses, and overload relays. Determination of derating factors for these devices may be required if they must function at elevated temperatures for extended periods of time. The manufacturers should be consulted in determining the appropriate derating factors.

b) *MCC enclosure design*. The MCC enclosure design tested must represent the installed enclosure so that leakage into the MCC during the test duplicates the locations and quantity of in-leakage that would occur in the actual installation. Particular attention should be paid to the effects of door gaskets, louvers, and conduit penetrations. For component qualification, components need not be tested inside MCC enclosures with documented justification.

c) *Equipment operation during test*. Equipment shall be operated under load during the test as specified in the equipment specification. Operations should be sufficient to confirm conformance with the acceptance criteria in the equipment specification.

d) *Sequence of harsh environment tests*. The harsh environment testing that is required by the qualification plan shall be performed in the following sequence after completion of aging (if required) and seismic qualification:

    1) *Radiation test*. If the radiation levels to which the equipment will be exposed during the post-LOCA or HELB event are greater than those for which the equipment was qualified in 9.4, then the test specimen shall be exposed to additional radiation such that its total integrated dose exceeds the specified level by the required margin.

    2) *Temperature, pressure, and humidity profile test*. The test profile shown in Figure 1 of IEEE Std 323-2003 provides an acceptable method of simulating postulated environmental conditions while including margin. It should be recognized, however, that other possibilities exist to address margin in the test profile.

Where it is impractical to test for the duration of the post-LOCA or HELB event, a higher temperature may be maintained during the post-event temperature transient test so that a shorter test duration may be justified.

9.6.3 Operating experience method

This portion of the qualification program may be satisfied by documented operating experience. If this option is followed, the guidance of IEEE Std 323-2003 shall be followed. The experience data shall include documentation to verify the applicable configuration of the equipment and must be reviewed to verify the configuration is consistent with the plant application.

9.6.4 Analysis method

This portion of the qualification program may be satisfied by using a mathematical or logical assessment to establish that the MCC and its equipment can perform its safety function(s) when subjected to the specified service conditions. When this method is selected, the guidance of IEEE Std 323-2003 shall be followed.

9.7 Final functional tests and inspection

The test sample shall be subjected to final functional tests to demonstrate post-DBE operational capability if required by the equipment specification. These tests shall be conducted at the assembled motor control center level or at the individual device level, whichever is most appropriate.

The test sample shall be inspected after completion of the test program to identify any areas of significant wear, aging degradation, or imminent failure, and the results shall be recorded. The sample shall be disassembled to the extent necessary to perform a complete inspection.

9.8 Determination of qualification

In the evaluation of the qualification program results, the MCC and its components are considered to have passed when they meet the acceptance criteria specified in the equipment specification. Any failure to meet the acceptance criteria shall be analyzed to determine appropriate modification(s) of the equipment or the limitation that shall be imposed on its use. Failures shall be documented as described in 11.2.4.

Failure during the qualification process does not mean that the equipment is disqualified for its intended safety application if it can be demonstrated that the failure was not common mode in nature or if the failure does not affect the motor control center’s safety functions. When such demonstration is possible, the failed device or component may be replaced by a similar, equivalently-aged device or component, and the qualification process may be continued or repeated, provided that the effect on interface connections can be shown to be insignificant. Clause 10 addresses modifications during the qualification program.

Common mode failures may be addressed either by design changes to eliminate the cause of failure, by reducing the qualified life, or by specifying an appropriate component replacement interval, all in conjunction with repeating part or all of the qualification process. A common mode failure must be thoroughly analyzed and its resolution documented.

Continued qualification is based on adherence to specified service conditions, maintenance schedules, and replacement schedules provided by the qualifier to maintain qualified life.

9.9 Extension of qualified life

When a motor control center, or its components, is initially qualified for a period shorter than the current qualified life objective, the methods described in IEEE Std 323-2003 and 9.4.1.4 of this standard may be used to extend qualified life.

10. Modifications

10.1 Modifications during qualification

Any modification made to the equipment or to the equipment specification after the start of the qualification program shall be evaluated to determine its effect on the equipment qualification. This evaluation shall indicate whether or not requalification is necessary.

Requalification is not necessary if the modification is fully justified and documented as:

a) Having no bearing on the validity of qualification tests or on the equipment qualification process

b) Being an equipment replacement, servicing, or adjustment that is included in a prescribed maintenance program for that equipment

When the modification does effect equipment qualification, the change in equipment or operating conditions shall be identified and recorded (materials of construction, lubricant, clearances, dielectric stress levels, etc.), and the equipment shall be requalified with supporting justification. The extent of requalification necessary shall be based on the effects of the modification on the equipment's ability to perform its safety functions. Components of the equipment that can be shown to be unaffected by the modification need not be requalified.

10.2 Modifications after qualification

During the qualified life of the installed equipment, additions or changes may become necessary. Such modifications to motor control centers require evaluation and may require requalification.

Devices that are added to the MCC after completion of qualification are to be qualified as a component of the MCC in accordance with the requirements and procedures of this standard or other applicable standards, and should be qualified to the requirements of the original test plan. The addition of the new component shall be evaluated to determine if there is any impact on the seismic qualification of the MCC as noted in 9.5.1.4.

11. Documentation

11.1 General

The documentation shall be sufficient to provide justification that the motor control center and its subcomponents can meet their specified safety functions for normal service conditions, abnormal service conditions, design basis events, and post design basis events. The documentation shall be presented in an organized and auditable form.

11.2 Equipment qualification data

11.2.1 Service conditions

The documentation shall include a tabulation of all normal, abnormal, DBE, and post-DBE specified service conditions, and the service conditions that the equipment was qualified to.

11.2.2 Specific features

Specific features that were demonstrated by the equipment qualification program shall be identified.

11.2.3 Qualification plan

The qualification plan shall contain sufficient details to identify the acceptance criteria, describe the required procedures, and correlate the qualification methods and results to the equipment specifications.

The qualification plan shall contain the following:

a) Equipment specification (see Clause 8)
b) Number (quantity) of units to be tested
c) Mounting, connection, and other interface requirements
d) Aging simulation procedures, including the qualified life objectives
e) Service conditions to be simulated
f) Performance and environmental variables to be measured
g) Test equipment requirements, including accuracies
h) Environmental, operating, and measurement sequence in step-by-step detail
i) Acceptance criteria
j) Type test data
k) Statement of nonapplicable portions of the specification
l) A description of any conditions peculiar to the motor control center and its subassemblies that are not covered above but that could effect the equipment during testing
m) Method(s) for identification of significant aging mechanisms

11.2.4 Qualification report

The qualification report shall contain the following:

a) Qualification plan
b) Objectives (acceptance criteria)
c) Detailed description of equipment tested
d) Test facility description and identification of instrumentation
e) Test procedures
f) Test data
g) Required periodic maintenance, surveillance, and/or testing
h) Evaluation of any component failure or abnormality encountered during the test

i) Summary and conclusions, including qualified life statement

j) Supporting documentation

k) Approval, signature of the qualifier, and date

11.3 Supporting documentation

Partial type tests of motor control centers that are augmented by operating experience, analysis, extrapolation, or combinations thereof shall include the following items.

11.3.1 Operating experience data

a) Equipment specification (see Clause 8)

b) Interface and boundary conditions of the equipment

c) Specification of equipment for which operating experience is available

d) Identification of the specific features to be demonstrated using operating experiences

e) Comparison of past application and specifications with the new equipment specification for each feature identified in item d) above

f) Summary and source of operating experience applicable to equipment qualification including maintenance/repair history, environmental conditions, electrical loadings, installation configuration, and seismic/vibrational loadings

g) Basis on which the data have been determined to be suitable and the equipment qualified

h) Approval, signature of the qualifier, and date

11.3.2 Analysis

a) Equipment specification (see Clause 8)

b) Interface boundary conditions of the equipment

c) Specific features, postulated failure modes, or failure effects to be analyzed

d) Assumptions, empirically derived values, and the mathematical models used together with justification for their use

e) Test data that supports the assumptions and mathematical models

f) Description of analytical methods or computer programs used

g) A summary of analytically established performance characteristics and their acceptability

h) Approval, signature of the qualifier, and date

11.3.3 Extrapolation

When the test data or operating experience data have been extrapolated, the basis and justification of the validity for the extrapolation shall be provided.

Annex A

(informative)

Use of experience data in seismic qualification of motor control centers

Two types of seismic experience data have been collected for motor control centers as well as other types of electrical equipment. The first type is data that has been assembled by reviewing historic earthquake data and equipment that was exposed to actual earthquakes for post-event damage and functionality. Much of this work was done by the Seismic Qualification Utility Group (SQUG). The second type of experience data is based on the large amount of information collected during seismic qualification testing of nuclear power plant equipment. The use of seismic experience data must be consistent with ANSI/IEEE Std 344-2004.

Information of the SQUG efforts and the review performed by the U.S. Nuclear Regulatory Commission is contained in the following:

Kennedy, R. P., et al., "Use of past earthquake experience data to show seismic ruggedness of certain classes of equipment in nuclear power plants," *Senior Seismic Review and Advisory Panel,* Aug. 1985.

Change, T. Y. "Seismic qualification of equipment in operating nuclear Power plants," NUREG 1030, US Nuclear Regulatory Commission, Washington, DC, 1985.

Information on analyses of existing seismic qualification test data and potential methodologies for its use are contained in the following:

EPRI NP-7484, Guideline for the Seismic Technical Evaluation of Replacement Items for Nuclear Power Plants, Electric Power Research Institute, Palo Alto, CA, Feb. 1993.

EPRI NP-4297, Seismic Equipment Qualification Using Existing Test Data, Electric Power Research Institute, Palo Alto, CA, Oct. 1985.

EPRI NP-5223-M, Generic Seismic Ruggedness of Power Plant Equipment, Electric Power Research Institute, Palo Alto, CA, Aug. 1991.

EPRI NP-3326, Correlation Between Aging and Seismic Qualification for Nuclear Plant Electrical Components, Electric Power Research Institute, Dec. 1983.

EPRI NP-5024, Seismic Ruggedness of Aged Electrical Components: Final Report (Phase 2), Electric Power Research Institute, Jan. 1987.

Annex B

(informative)

Glossary

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

NOTE—The terms Class 1E equipment and safety-related electric equipment are synonymous**.**

design basis events (DBE): Postulated events used in the design to establish the acceptable performance requirements for the structures, systems, and components.

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

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

NOTE—Equipment qualification includes environmental and seismic qualification.

harsh environment: An environment resulting from a design basis event, i.e., loss of coolant accident (LOCA), high energy line break (HELB) and main steam line break (MSLB) (see IEEE Std 323-2003).

mild environment: An environment that would at no time be significantly more severe than the environment that would occur during normal plant operation, including anticipated operational occurrences (see IEEE Std 323-2003).

motor control center: A floor-mounted assembly of one or more enclosed vertical sections having a common horizontal power bus and principally containing combination motor starter units. These units are mounted one above the other in the vertical sections. The sections may incorporate vertical buses connected to the common power bus, thus extending the common power supply to the individual units. Units may also connect directly to the common power bus by suitable connections.

operating basis earthquake (OBE): An earthquake that could reasonably be expected to occur at the plant site during the operating life of the plant considering the regional and local geology and seismology and specific characteristics of local subsurface material. It is that earthquake that produces the vibratory ground motion for which those features of the nuclear power plant, necessary for continued operation without undue risk to the health and safety of the public, are designed to remain functional.

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

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

safe shutdown earthquake (SSE): An earthquake that is based upon an evaluation of the maximum earthquake potential considering the regional and local geology and seismology and specific characteristics of local subsurface material, It is that earthquake that produces the maximum vibratory ground motion for which certain structures. systems. and components are designed to remain functional. These structures, systems, and components are those necessary to ensure the following: a) Integrity of the reactor coolant pressure boundary; b) Capability to shut down the reactor and maintain it in a safe shutdown condition;

c) Capability to prevent or mitigate the consequences of accidents that could result in potential off-site exposures comparable to the guideline exposures of 10 CFR—Chapter 1, Part l00.

significant aging mechanism: An aging mechanism is significant if, in the normal and abnormal service environment, it causes degradation during the installed life of the equipment that progressively and appreciably renders the equipment vulnerable to failure to perform its safety function(s) under DBE conditions.

unit: One independent portion of a motor control center vertical section. It is normally a plug-in module that connects to the motor control center vertical bus.

vertical section: A portion of the motor control center normally containing one vertical bus assembly.

Annex C

(informative)

Typical functions of motor control centers

The typical functions of MCCs are:

a) Upon a signal, start a motor.

b) Upon a signal, stop a motor.

c) Upon a signal, stop a rotating motor and reverse its direction.

d) Sense a thermal overload condition, and open the circuit to a motor, thus protecting the motor and up level circuitry.

e) Sense a current overload condition, and open the circuit to a motor, thus protecting the motor and up level circuitry.

Nuclear safety related applications of MCCs add the following functions:

a) Do not trip when there is no electrical fault.

b) Do not inadvertently start a motor without a signal.

c) Do not inadvertently stop a motor without a signal.

d) Do not inadvertently stop a rotating motor and reverse its direction.