ANP-10277
Revision 0

Environmental Qualification Program Report

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AREVA NP Inc.

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For information address: AREVA NP Inc.
An AREVA and Siemens Company
3315 Old Forest Road
Lynchburg, VA 24506

U.S. Nuclear Regulatory Commission

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ABSTRACT

The U.S. EPR environmental qualification (EQ) program report describes the EQ program plan and its elements for the AREVA NP U.S. EPR. The U.S. EPR design incorporates defense-in-depth concepts that result in significant improvements in safety. Major features of the U.S. EPR plant design philosophy include redundancy, separation, and diversity in the design of systems, structures and components. These redundancy and separation features minimize the exposure of groups of safety-related components to a potential “common cause failure event.”

This report presents the preliminary EQ program elements that are under development to meet the requirements of 10 CFR 50.49 and the General Design Criteria (GDC) in Appendix A of 10 CFR Part 50. Major topics within this report address AREVA NP’s proposed qualification methodology for EQ. The report demonstrates that AREVA NP’s approach to qualification of mechanical equipment for the U.S. EPR in accordance with Standard Review Plan 3.11 and GDC 4 is based on the methods developed and accepted by the NRC for the current fleet of operating reactors.

This report identifies areas of the U.S. EPR EQ program in which AREVA NP proposes to apply experience gained during the last four decades of nuclear plant experience in qualifying equipment. For instance, the report proposes use of the most recent editions of most applicable industry consensus standards, as well as Regulatory Guides.

Nature of Changes

Item	Section(s) or Page(s)	Description and Justification
	All	Original Issue

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Nomenclature

Acronym/Abbreviation	Definition
ASME	American Society of Mechanical Engineers
BOP	Balance of Plant
CCWS	Component Cooling Water System
CFR	Code of Federal Regulations
COL	Combined License
COC	Certificate of Compliance
DBA	Design Basis Accident
DBE	Design Basis Event
DCD	Design Control Document
EDG	Emergency Diesel Generator
EFWS	Emergency Feedwater System
EMC	Electromagnetic Compatibility
EMI	Electromagnetic Interference
EPRI	Electric Power Research Institute
EQ	Environmental Qualification
EQDP	Equipment Qualification Data Package
EQER	Environmental Qualification Evaluation Report
ESF	Engineered Safety Feature
eV	Electron Volt
FSAR	Final Safety Analysis Report
GDC	General Design Criteria
HELB	High Energy Line Break
HVAC	Heating, Ventilation, and Air Conditioning
IEEE	Institute of Electrical and Electronics Engineers
FMEA	Failure Modes and Effects Analysis
I&C	Instrumentation and Control
IRWST	In-Containment Refueling Water Storage Tank
LOCA	Loss of Coolant Accident
MCC	Motor Control Center
MEL	Master Equipment List
MEQ	Mechanical Equipment Qualification
MFLB	Main Feedwater Line Break
MSLB	Main Steam Line Break

NRC	Nuclear Regulatory Commission
NSR	Non-Safety-Related
NSSS	Nuclear Steam Supply System
PAM	Post Accident Monitoring
QA	Quality Assurance
QL	Qualified Life
RAD	Radiation Absorbed Dose
RCS	Reactor Coolant System
RFI	Radio Frequency Interference
RHRS	Residual Heat Removal System
RIM	Required Input Motion
RMF	Random Multi Frequency
RT	Reactor Trip
SAHRS	Severe Accident Heat Removal System
SB	Safeguard Building
SCEW	System Component Evaluation Worksheet
SIS	Safety Injection System
SQUG	Seismic Qualification Utility Group
SR	Safety-Related
SRP	Standard Review Plan
SSE	Safe Shutdown Earthquake
SSRAP	Senior Seismic Review and Advisory Panel
TA	Thermal Aging
TID	Total Integrated Dose
TSC	Technical Support Center
VAR	Volts Amperes Reactive
ZPA	Zero Period Acceleration

1.0 INTRODUCTION

The U.S. EPR environmental qualification (EQ) program report presents the U.S. EPR EQ program elements currently under development to meet the requirements of 10 CFR 50.49 and the General Design Criteria (GDC) in Appendix A of 10 CFR Part 50.

Major topics within this report address AREVA NP's proposed qualification methodology for EQ. The report demonstrates that AREVA NP's approach to qualification of mechanical equipment for the U.S. EPR is in accordance with the Standard Review Plan (SRP) 3.11 and GDC 4 and is based on methods developed and accepted by the NRC for the current fleet of operating reactors.

2.0 REGULATORY REQUIREMENTS AND LICENSING BASIS

2.1 *Code of Federal Regulations*

Several regulations apply to EQ programs and are addressed in the U.S. EPR EQ program.

2.1.1 General Design Criteria

- GDC 1 - Quality Standards and Records

  "Structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed."

- GDC 2 - Design Bases for Protection Against Natural Phenomena

  "Structures, systems, and components important to safety shall be designed to withstand the natural phenomena effects of earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety function."

- GDC 4 - Environmental and Dynamic Effects Design Bases

  "Structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and post-accidents, including loss of coolant accidents (LOCA)."

- GDC 23 - Protection System Failure Modes

  "The protection system shall be designed to fail into a safe state or another acceptable state on some other basis in the event of system disconnection or loss of energy (e.g., extreme heat or cold, fire, pressure, steam, water, and radiation)."

2.1.2 10 CFR Part 50 Appendix B – Quality Assurance Criteria for Nuclear Power Plants and Refuel Reprocessing Plants

Every applicant that applies for a nuclear plant license must provide a description of their QA program to be applied toward the design, fabrication, construction, and testing of structures, systems, and components of the facility. The description includes information pertaining to the managerial and administrative controls to be used to assure safe operation.

For equipment qualification purposes the QA program must address the Criteria III, XI, and XVII contained in 10 CFR Part 50 Appendix B.

2.1.3 10 CFR 50.49 – Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants

Electrical equipment important to safety within the scope of 10 CFR 50.49 must be capable of performing required safety functions under normal, abnormal, accident, and post-accident service conditions. The 10 CFR 50.49 EQ program provides documented evidence of operability during and following exposure to harsh environments, and minimizes the potential for common mode failure. Qualification is a demonstration that uses type tests, previous operating experience, analysis, or any combination of these to substantiate that equipment is capable of meeting, on a continuing basis, the required performance as specified in the design basis.

The EQ program for electrical equipment provides reasonable assurance that equipment remains operable during and following exposure to harsh environmental conditions (i.e., temperature, pressure, humidity, chemical and demineralized water sprays, radiation, and submergence) imposed as a result of a design basis event (DBE). These harsh environments are defined by the limiting conditions resulting from the complete spectrum of postulated break sizes, break locations and single failures subsequent to a LOCA, or a main steam line break (MSLB) inside the containment, or a high energy line break (HELB) outside the containment.

Engineering consensus standards provide the standard methods and guidelines for performing EQ program activities. The U.S. EPR EQ program will be developed in accordance with 10 CFR 50.49 and will be based on the applicable regulatory requirements and guidance.

Guidance documents for equipment qualification are based on the Institute of Electrical and Electronics Engineers (IEEE) standards. AREVA NP's objective is to qualify equipment to the latest U.S. industry standards. However, as of the date of this report, the latest editions of these standards have not been endorsed by the NRC. The design certification application will adopt the endorsed editions, as of six months prior to the application, of the applicable standards or will justify deviations. Section 2.6.3 contains the rationale for adopting the latest edition of IEEE 323, the key standard for EQ of electrical equipment.

2.2 *Regulatory Guide 1.89, Revision 1*

Reg. Guide 1.89, Rev. 1 describes a method acceptable to the NRC for compliance with 10 CFR 50.49. For example, this Reg. Guide states that plant-specific accident profiles are to be generated rather than using generic profiles shown in IEEE standards.

The radiation source terms used for the U.S. EPR qualification (see Section 5.3.1.2) will be based on the NRC approved methods described in Reg. Guide 1.183, which is different from those of Reg. Guide 1.89, Rev. 1.

2.3 *Regulatory Guide 1.100, Revision 2*

Reg. Guide 1.100 describes a method acceptable to the NRC for compliance with regulations for seismic qualification of electrical and mechanical equipment. The EQ program ensures that required seismic testing and vibration testing are performed in the proper sequence on the same test specimen.

Regulatory Guide 1.100, Rev. 2 currently endorses IEEE 344-1987. AREVA NP proposes to use IEEE 344-2004 to provide the technical requirements for seismic qualification of components that are included in the EQ program, along with other components that are not addressed in the EQ program. Appendix A shows a comparison of IEEE 344-2004 with the current endorsed version, IEEE 344-1987.

2.4 *Regulatory Guide 1.97, Revision 4*

Reg. Guide 1.97 describes a method acceptable to NRC for complying with regulations to provide instrumentation to monitor plant variables and systems during and following an accident. Revision 4 was issued June, 2006 and is intended for licensees of new nuclear power plants and represents an ongoing evolution of thoughts and approaches with regard to accident monitoring. This revision endorses IEEE 497-2002, with certain clarifying regulatory positions, and is part of the licensing basis for the AREVA NP U.S. EPR design and EQ program.

2.5 *Chapter 3.11 of the Standard Review Plan*

Chapter 3.11 of the SRP addresses both electrical and mechanical equipment. However, 10 CFR 50.49 requires an EQ program only for electrical equipment important to safety. Mechanical equipment is addressed in various other regulations from a design standpoint. Design engineering considers all parameters (e.g., pressure, temperature, radiation) that come in contact with the metallic and non-metallic parts of the equipment under normal, abnormal, and accident conditions.

Electrical and mechanical equipment are addressed differently within engineering, plant programs and procedures. The U.S. EPR electrical and instrumentation and control (I&C) equipment will be covered by an EQ program in compliance with 10 CFR 50.49. Mechanical equipment is covered by the engineering design process and is in compliance with 10 CFR Part 50, Appendix A GDC 4. Section 3.4 of this document addresses details of the proposed approach for addressing qualification of mechanical equipment.

2.6 *IEEE Standards*

The IEEE standards listed in Table 2-1 and Table 2-2 play a significant role in defining EQ test requirements for operating plants. The primary standard, IEEE 323-1974, is considered the definitive qualification standard for developing an EQ program for electrical equipment for new plants.

2.6.1 IEEE Standards Endorsed by Regulatory Guides

The EQ program uses Reg. Guides 1.9, 1.40, 1.63, 1.73, 1.89, 1.97, 1.100, 1.131, 1.152, 1.156, 1.158, and 1.180, where applicable. A summary of the EQ-related IEEE standards currently endorsed by these Reg. Guides is provided in Table 2-1 and Appendix A. The latest editions of these standards that are proposed for use on the U.S. EPR are also in Table 2-1 and Appendix A for comparison purposes.

2.6.2 IEEE Standards Not Endorsed by Regulatory Guides

The IEEE publishes EQ-related standards that have not been endorsed by Reg. Guides. These standards are listed in Table 2-2 and will be used in the U.S. EPR EQ program for guidance purposes.

2.6.3 Evolution of IEEE Standards

The IEEE has periodically updated the standards to incorporate evolutionary thinking and approaches of the nuclear industry with regard to equipment qualification. Appendix A provides a summary comparison that highlights the differences and similarities of the various editions to the IEEE EQ standards, which includes IEEE 323-2003.

IEEE 323-1983/2003 editions place more emphasis on the utility of periodic surveillance and maintenance than IEEE 323-1974, although the standard imposes no new requirements in this area, as noted in Appendix A. In addition, IEEE 323-1983/2003 editions clarify the utilization of margin during testing as applied to environmental transients by either adding the temperature and pressure margin to the postulated service condition profile or by applying the peak transient twice.

IEEE 323-1983/2003 editions incorporate the knowledge and experience gained in the application of the 1974 edition and recognize elements of 10 CFR 50.49. For example, this edition contains a distinction consistent with 10 CFR 50.49 regarding qualification methods applicable to equipment located in mild and harsh environments. AREVA NP acknowledges that equipment may be qualified to either the 1983/2003 or 1974 edition of IEEE 323 to meet the requirements of 10 CFR 50.49. The latest edition of the standard will be preferred for use in the U.S. EPR equipment qualification.

Since most existing test reports were based on IEEE 323-1974 requirements, AREVA NP proposes to apply the following guidelines:

- Equipment certified to IEEE 323-1983/2003 requirements that is also certified to IEEE 323-1974 version of the test report is considered acceptable for use.
- Equipment certified to IEEE 323-1983/2003 that was subjected to a new type test would also have a revised test report to document the new testing. Certification for this material will reflect a later test report, and this report will require approval prior to use of the equipment.
- Certification to IEEE standards alone is insufficient for 10 CFR 50.49 equipment. The vendor must also certify to the applicable test report.

Table 2-1—IEEE Endorsed Standards Summary

IEEE Standard	Regulatory Guide Revision	Equipment Type / Subject	Latest IEEE Standard Edition
317-1983	1.63, Rev. 3	Penetrations	317-2003
323-1974	1.89, Rev. 1	Electrical /I & C	323-2003
334-1971	1.40, Rev. 0	Motors	334-2006
344-1987	1.100, Rev. 2	Seismic	344-2004
382-1974	1.73, Rev. 0	Actuators	382-2006
383-1974	1.131, P1*	Cables	383-2003
387-1974	1.9, Rev. 3	EDG	387-2001
497-2002	1.97, Rev. 4	PAM	497-2002
535-1986	1.158, Rev. 0	Batteries	535-1986
572-1985	1.156, Rev. 0	Connectors	572-2006
7-4.3.2-2003	1.152, Rev. 2	Computers	7-4.3.2-2003
None	1.180, Rev. 1	RFI/EMI	None

*Reg. Guide 1.131, P1, 1979 is a proposed "for comment" version of the Reg. Guide revision.

Table 2-2—IEEE Non-Endorsed Standards

IEEE Standard	Subject
628-2001	Raceways
638-2006	Transformers
649-2005	MCC
650-2005	Charger/Inverter
1202-1991	Cable flame tests
1205-2000	Aging
1290-1996	MOV applications
C37.82-2004	Switchgear
C37.105-1987	Protective relays

3.0 EQUIPMENT QUALIFICATION PROCESS

The equipment qualification process begins during the plant design and continues throughout its operating life. To effectively qualify safety-related electrical equipment, careful consideration is placed on qualification complexities, NRC regulations and criteria, and technically sound qualification approaches. To implement an EQ program that can accommodate the plant design, construction, and operational phases of the qualification process, the following must be established:

- Equipment required to be environmentally qualified
- Harsh environments caused by potential HELBs
- Qualification documentation
- Maintenance and surveillance program to ensure that qualification is maintained continually
- Procedures and specifications to describe the requirements and processes for developing and controlling the documentation of the EQ program

The sections that follow identify how these elements are addressed in the U.S. EPR EQ program.

3.1 *Scope of Equipment Requiring Qualification – 10 CFR 50.49*

Paragraph (a) of 10 CFR 50.49 requires the establishment of a program that will environmentally qualify electrical equipment within the following categories as defined in 10 CFR 50.49(b).

- 10 CFR 50.49(b)(1) safety-related electrical equipment

  Safety-related electrical equipment is relied upon to remain functional during and following DBEs to provide reasonable assurance that the following are maintained:

  - The integrity of the reactor coolant pressure boundary

  - The capability to shut down the reactor and maintain it in a safe shutdown condition
  - The capability to prevent or mitigate the consequences of accidents that could result in potential offsite exposure comparable to 10 CFR Part 100 guidelines

- 10 CFR 50.49(b)(2) non-safety-related electrical equipment

  Non-safety-related electrical equipment consists of equipment whose failure under postulated environmental conditions could prevent satisfactory accomplishment of safety functions of the safety-related equipment.

- 10 CFR 50.49(b)(3) certain post accident monitoring (PAM) equipment

  Specific guidance concerning variables to be monitored is provided in Reg. Guide 1.97. Equipment determined to be classified as Reg. Guide 1.97 items must be qualified in accordance with 10 CFR 50.49 criteria.

  - Instrumentation is included as an integral part of the qualification in accordance with requirements established by 10 CFR 50.49. The detailed systems review and development of the master list of electrical equipment will provide justification for additions or deletions from the master list on a case-by-case basis.
  - The PAM equipment located in rooms subjected to harsh environmental parameters resulting from the LOCA, MSLB, and HELB events will be added to the EQ program.

10 CFR 50.49(c) contains an exclusionary clause from the scope of rule for:

- Dynamic and seismic qualification of electric equipment important to safety
- Protection of electrical equipment important to safety against other natural phenomena and external events
- Environmental qualification of electrical equipment important to safety located in a mild environment

3.2 *Equipment Identification*

The list of components to be qualified will be developed with consideration of equipment located in three groups of structures: Nuclear Island, Turbine Island, and the BOP.

3.2.1 Nuclear Island (NI)

The Nuclear Island consists of the following structures:

- Reactor building
- Safeguards buildings
- Fuel building
- Nuclear auxiliary building
- Emergency power generating building
- Radioactive waste processing building
- Essential service water pump structure
- Essential service water cooling tower structure
- Vent stack

The U.S. EPR plant is designed with a defense-in-depth concept through improvements of safety systems that include redundancy, separation features, and diversification of safety functions. For example, within the Nuclear Island there are four safeguard buildings (SBs). Safety systems within the SBs are designed for redundancy with four trains and are located in physically separated divisions. SBs 1 and 4 are spatially separated on opposite sides of the reactor building while SBs 2 and 3 are housed together in a hardened enclosure.

Each of the four SBs is separated into two functional areas:

- Mechanical
- Electrical - I&C and heating, ventilation, and air conditioning (HVAC)

The SBs are located adjacent to the reactor building and contain the safety injection system (SIS), component cooling water system (CCWS), emergency feedwater system (EFWS), severe accident heat removal system (SAHRS) in SB 1 and 4, main control room and technical support center, equipment for I&C and electrical systems for the Nuclear Island, SB ventilation, and safety chilled water systems.

The SIS design basis is a four train system. To minimize the connection lengths to the reactor coolant system (RCS), the individual trains are radially assigned to the RCS loops.

The CCWS supplies the SIS/residual heat removal system (RHRS) heat exchangers with cooling water. The CCWS is installed close to the connecting SIS/RHRS, but in a different radiation zone, because the activity level of both systems is different. The CCWS is located in a second outer row around the reactor building in the radiological non-controlled area of the SB. The EFWS is also located in the mechanical, radiological non-controlled area of the SB.

The redundancy, separation, and diversification designed into the U.S. EPR within the Nuclear Island add a margin of safety with respect to postulated failures due to environmental stressors. These unique features will minimize the amount of equipment within the EQ program and are described as follows:

- The Nuclear Island design includes unique features such as redundancy and separation in the four SBs. If a break is postulated in one SB, that building function is considered lost and is isolated from the remaining buildings. The loss of function of this SB and the results of the break have no impact on the other three SBs that remain in a mild environment with respect to elevated temperature and pressure.
- High energy lines that connect the containment and the SBs carry post-accident radioactive fluid to the SBs. This can result in a radiation harsh zone in the SBs due to a pipe rupture in the containment. However, the plant layout vertically separates fluid systems from electrical and I&C equipment within each SB.

Table 3-1 shows floor levels in all four SBs where equipment is located. Figure 3-1 depicts the areas projected to be radiation harsh in SBs. These levels are established with concrete floors that physically separate equipment providing a significant amount of protection for the electrical and I&C equipment. In SBs 1 and 4, where steam and main feedwater isolation and main steam relief system equipment is located, rooms are designed to isolate these high energy sources from the rest of the SBs.

- 10 CFR 50.49(c)(3) states ". . . environmental qualification of electrical equipment important to safety located in a mild environment are not included within the scope of this section." The equipment in the SBs is considered to be in a mild temperature and pressure environment due to the postulated break. Components located in the radiation harsh areas of the SBs will be qualified to radiation only conditions. Components located in the remaining areas of the SB will not be included in the 10 CFR 50.49 equipment list. Section 5.7 details the U.S. EPR radiation thresholds for mild environments.
- The reactor building consists of a cylindrical, reinforced concrete outer shield building; a cylindrical, post-tensioned concrete inner containment building with a steel liner; and an annular space between the two buildings. The nuclear steam supply system (NSSS) is located in the containment building. High energy piping that traverses the annulus is routed in guard pipes. Equipment in the reactor building within the scope of 10 CFR 50.49 will require consideration for the principal types of environmental stressors, such as temperature, radiation, pressure, humidity, moisture, steam, water immersion, and chemicals.
- The balance of the plant (BOP) is protected from NSSS postulated large HELBs; postulated BOP DBEs will not impact the NSSS.

3.2.2 Balance of Plant and Turbine Island

The BOP consists of the following structures:

- Switchyard area

- Offsite system transformer area
- Auxiliary power transformers areas
- Generator transformer area
- Demineralized water storage area
- Structure for effluent disposal
- Access building
- Water treatment building
- Cooling tower structure
- Workshop/warehouse
- Central gas supply building
- Auxiliary boiler building
- Office & staff amenities building
- Security access facility

The Turbine Island consists of the following structures:

- Switchgear building
- Turbine building

AREVA NP expects that equipment located in these buildings will not require EQ.

3.3 *Environmental Qualification of Electrical Equipment*

Electrical equipment, which includes I&C, contains components associated with systems that are essential to emergency reactor shutdown, containment isolation, core cooling, containment and reactor heat removal, or are otherwise essential to preventing significant release of radioactive material to the environment.

Included in this equipment scope is:

- Equipment that performs one or more of these functions automatically
- Equipment that is used by operators to perform these functions manually
- Equipment whose failure can prevent the satisfactory accomplishment of one or more of the above safety functions
- Other electrical equipment important to safety as described in 10 CFR 50.49(b)(1) and (2)
- Certain PAM equipment as described in 10 CFR 50.49(b)(3) and noted above

The I&C design consists of four-fold redundancy from sensor to actuator:

- Physical separation in four divisions (SBs 1, 2, 3, and 4)
- Two functionally diverse subsystems
- Two processing levels
- Redundant power supplies for each cabinet

Guidance used to identify I&C equipment is included in the U.S. EPR EQ program as addressed in Section 3.2.

Table 3-2 shows a listing of systems that at the present time have been designated as safety-related for the U.S. EPR. Table 3-3 contains a listing of typical 1E equipment that may be located in a harsh environment for the U.S. EPR. Equipment in the scope of the EQ program will be identified within the Master Equipment List (MEL) and will be qualified based on the guidelines provided in IEEE 323.

3.4 *Treatment of Mechanical Equipment*

Mechanical equipment is inherently more rugged than electrical equipment and is less vulnerable to environmental conditions. Mechanical equipment is designed to operate under hostile process conditions. 10 CFR 50, Appendix A, GDC 4 “Environmental and

Dynamic Effects Design Bases," states in part, that components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with postulated accidents, including loss-of-coolant accidents. Mechanical equipment will be designed to comply with GDC 4 by verifying the ability of the components to perform their required safety functions when exposed to internal and external, normal and abnormal operating conditions, and when exposed to external postulated accident environments. The engineering design process and program evaluates both metallic and non-metallic components to meet radiation, temperature, and pressure conditions for all safety-related mechanical equipment. The combination of operating temperatures and pressures will be compared to the design parameters of each component to ensure and demonstrate that design limits are not exceeded. The effects of radiation will be considered in the evaluations. These evaluations by design engineering constitute a normal and accident environmental analysis in accordance with 10 CFR Part 50, Appendix A, GDC 4.

The need to maintain a separate mechanical equipment qualification (MEQ) program for the U.S. EPR was determined to be redundant, considering current engineering design programs. This determination was based on the regulatory precedent from current operating reactors which originally maintained an MEQ program. The NRC has determined that engineering design, procurement, maintenance and surveillance programs are acceptable to comply with the guidance in the SRP 3.11 (References 49, 50, 51, and 52) for MEQ. Accordingly, evaluations documented in a separate MEQ program are not necessary to justify compliance for safety-related mechanical components. Compliance with GDC 4 will be initiated and maintained through the engineering design, procurement, maintenance and surveillance programs. These plant programs include inspections, testing, analyses, repairs, and replacements.

Engineering design specifications will be generated and used in the procurement of equipment, components, and parts that are to be qualified. Under the procurement program, compliance with GDC 4 through the evaluation of non-metallic parts in mechanical components will be based on material evaluations and the form, fit, and function methodology used in an item equivalency evaluation.

The equipment qualification operational program described in the FSAR (see Section 5.1.3.2) will identify the plant programs that will be required to provide reasonable assurance that mechanical equipment can accommodate the effects of DBE. For example, the maintenance program will be required to include maintenance, surveillance, and periodic testing of mechanical equipment in accordance with the Reg. Guide 1.33 QA program requirements. Under the maintenance program, routine monitoring of mechanical equipment will be performed to identify and prevent significant age-related degradation of non-metallic parts. The program will also verify that the safety function of the mechanical equipment is maintained in normal, abnormal, and accident environments. Similarly, the procurement, maintenance, and surveillance programs will be required to provide reasonable assurance and generate necessary corrective actions to maintain the equipment in sufficient operating condition. This will be based on documentation that includes vendor certification (Certificates of Compliance), design and purchase specifications for replacement parts, and material evaluations for replacement parts.

To verify the effectiveness of these programs to maintain compliance with GDC 4, the program data and records will be required to be reviewed periodically in accordance with the American Society of Mechanical Engineers (ASME) Section XI. This process will provide reasonable assurance that the equipment has not suffered any degradation, which may include the effects of thermal, radiation, and/or cyclic aging.

3.5 *Seismic Sequence Methodology*

Seismic qualification within the U.S. EPR EQ program will be treated as a required test performed in proper sequence relative to the other EQ program required test events. The seismic qualification tests will be performed after end-of-life age conditioning is conducted and before the design basis accident (DBA) simulation test is performed. The details of the test, adequacy of the seismic test, and acceptability of the results of the testing will be evaluated by seismic experts. Verification of seismic test performance in the proper sequence will be performed.

Table 3-1—Equipment Distribution in Safeguard Buildings

<table>
<tr><th>Contents 1 & 4</th><th>1 & 4 Elevation</th><th>2 & 3 Elevation</th><th>Contents 2 & 3</th></tr>
<tr><td>Main steam valves & piping
Air cooled chillers</td><td>+81</td><td>+79</td><td>HVAC
Battery exhausts</td></tr>
<tr><td>Main steam valves & piping
Feedwater valves & piping</td><td>+69</td><td>+69</td><td>HVAC
Battery exhausts</td></tr>
<tr><td>Feedwater valves & piping</td><td>+55</td><td>+53</td><td>Control room TSC
Support offices
Computer rooms</td></tr>
<tr><td>Chilled water system
HVAC
Battery exhausts</td><td colspan="2">+39</td><td>Cable ducts
Switchgear
Batteries & exhausts</td></tr>
<tr><td>Switchgear
I&C cabinets</td><td colspan="2">+27</td><td>Switchgear
I&C Cabinets</td></tr>
<tr><td>Cable floor</td><td colspan="2">+15</td><td>Cable floor</td></tr>
<tr><td>Process heat exchangers
Containment penetrations
Miscellaneous valve rooms</td><td colspan="2">+0</td><td>Selected process heat exchangers
Containment Penetrations
Miscellaneous valve rooms</td></tr>
<tr><td>Selected heat exchangers and equipment</td><td colspan="2">-16</td><td>Heat exchangers and equipment</td></tr>
<tr><td>Process pumps</td><td colspan="2">-31</td><td>Process pumps</td></tr>
</table>

Table 3-2—U.S. EPR Expected Safety System Listing

Fluid Systems
Fuel Pool Cooling
Fuel Handling System
Component Cooling Water System
Essential Service Water System
Safety Chilled Water System
Extra Borating System
Emergency Feedwater System
In-containment Refueling Water Storage Tank
Safety Injection System/Residual Heat Removal System
Containment Isolation System
Electrical Systems
Class 1E UPS System
Class 1E Emergency Power Supply System
Emergency Diesel Generator Set
Control Rod Drive Power Supply System (trip breakers only)
Instrumentation & Control Systems
Boron Instrumentation
Protection System
Safety Automation System
Priority & Actuator Control System
Safety Information & Control System
Accident Monitoring Instrumentation
Incore Instrumentation
Excore Instrumentation
Reactor Vessel Water Level Measurement
Rod Position Measurement
Rod Pilot System
Hydrogen Monitoring System
Radiation Monitoring System
HVAC Systems
Safeguard Building Controlled Area Ventilation System
Fuel Building Ventilation System
Main Control Room Air Conditioning System
Safeguards Buildings Electrical Division Ventilation System
Diesel Building Ventilation System
Service Water Pump Building Ventilation System (motor cooling)

Table 3-3—List of U.S. EPR Equipment Considered for Environmental Qualification

Equipment Item	Safety Function	Typical Op Time
Batteries	RT, ESF, PAM	2 hrs.
Battery chargers	PAM	2 hrs. – 1 yr.
125 VDC distribution panels	ESF, PAM	2 hrs. – 1 yr.
120 VAC dist panels	RT, ESF, PAM	2 hrs.
Fuse panels	RT, EFS, PAM	2 hrs. – 1 yr.
Transfer switch	RT, ESF, PAM	2 hrs.
480 VAC motor control centers	ESF	24 hrs.
Switchboards	RT, ESF, PAM	2 hrs.
Transformers	RT, ESF, PAM	2 hrs. – 24 hrs.
Inverters	RT, ESF, PAM	24 hrs.
6.9 KV switchgear	RT, ESF, PAM	2 hrs.
Reactor trip switchgear	RT	2 hrs.
Level switches	RT, ESF	2 hrs. – 1 yr.
Neutron detectors, source range	RT, ESF	2 hrs.
Neutron detectors, intermediate range	RT, PAM	2 hrs. – 4 mos.
Neutron detectors, power range	RT	2 hrs.
Radiation monitors	ESF, PAM	24 hrs. – 4 mos.
RTD’s	RT, ESF, PAM	2 hrs. – 4 mos.
RCP speed sensor	RT	2 hrs.
Level transmitters	RT, ESF, PAM	2 hrs. – 4 mos.
Flow transmitters	RT, ESF, PAM	2 hrs. – 4 mos.
Absolute pressure transmitters	RT, ESF, PAM	2 hrs.
Electric cables	RT, ESF, PAM	1 yr.
Electric motors	ESF, PAM	1 yr.
Limit switches	RT, ESF, PAM	2 hrs. – 1 yr.
Pressure switches	RT, ESF, PAM	1 yr.
Differential pressure transmitters	RT, ESF, PAM	2 hrs. – 1 yr.
Electrical penetrations	RT, ESF, PAM	1 yr.
Solenoid valves	RT, ESF	2 hrs.
Motor operators	RT, ESF	2 hrs.
Incore thermocouples	PAM	1 yr.
Thermocouple reference panel	PAM	1 yr.
Electrical connectors	various	2 hrs. – 1 yr.

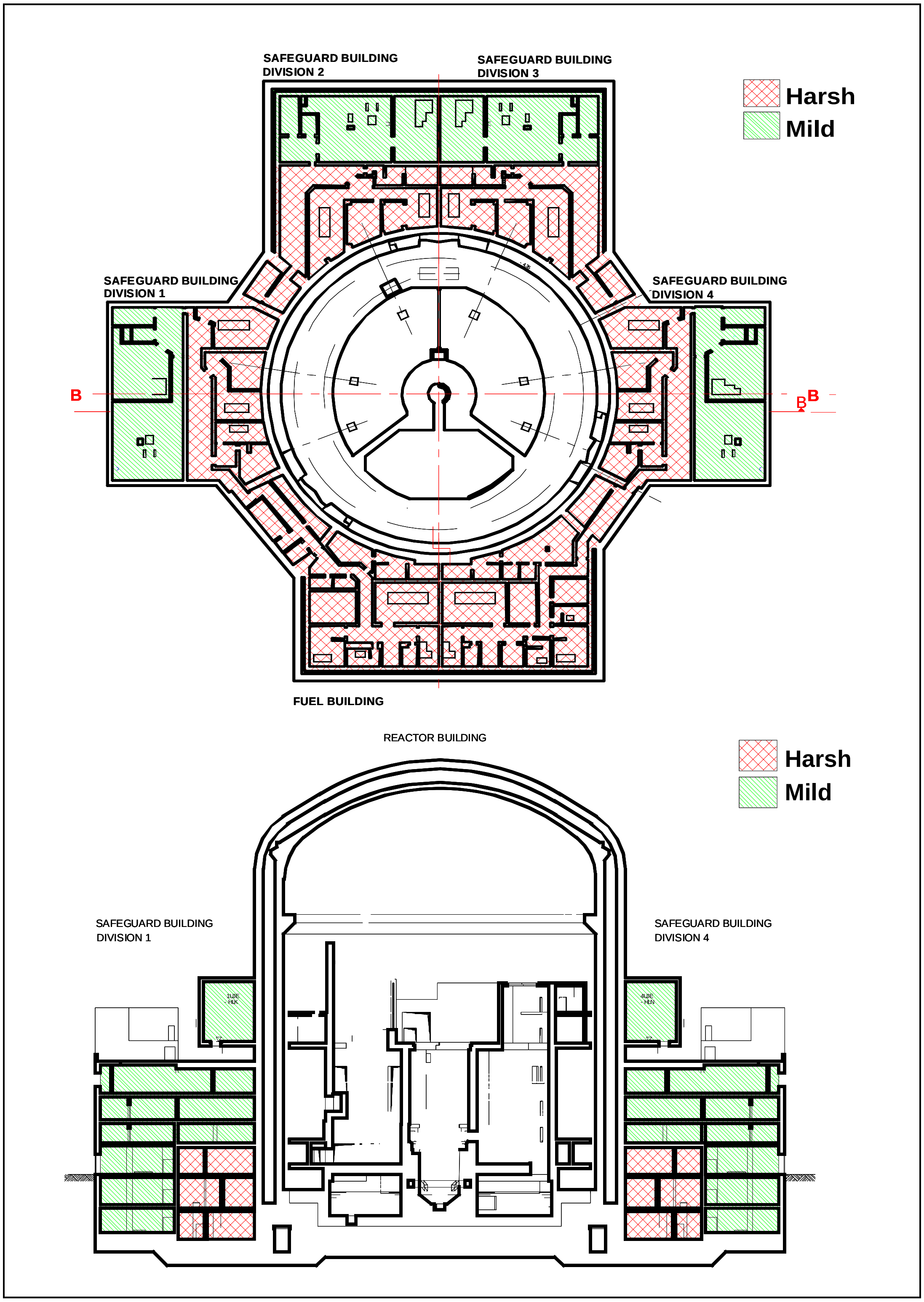

Figure 3-1—Use of Harsh and Mild Zones in Safeguard Buildings

4.0 KEY CONSIDERATIONS FOR EQ PROGRAM DEVELOPMENT

This section describes key considerations for EQ program development, including ongoing activities throughout the development process.

4.1 *Criteria for the 10 CFR 50.49 List*

Equipment within the 10 CFR 50.49 scope will be evaluated to establish the U.S. EPR EQ program as addressed in Section 3.2. The 50.49 list of equipment will be derived from the safety-related electrical equipment found in the MEL that is required to mitigate the consequences of LOCAs, MSLBs, and HELBs and from non-safety-related equipment within the scope of 10 CFR 50.49. Not all safety-related electrical equipment requires 10 CFR 50.49 EQ for accident mitigation. Depending on system design, certain equipment may not be required to perform a safety function or to mitigate the consequences of an accident in order for the system to accomplish its design basis safety function. Several systems only require that the containment isolation portion of the system remain functional. Safety-related equipment categorized as 1E PAM and located in a harsh environment will be explicitly evaluated for meeting the criteria for inclusion in the EQ program. The equipment will be either categorized as 50.49, or justified for exclusion from the EQ program; the exclusion will be documented and maintained in the MEL classification process.

The equipment that must remain functional will be identified by review of system descriptions and appropriate drawings (i.e., piping and instrumentation drawings, schematics, electrical one line diagrams, and control logic diagrams). Equipment not requiring 10 CFR 50.49 EQ will be reviewed to provide reasonable assurance that its failure will not impact other safety-related equipment or systems, or mislead an operator.

A review of the specific location of the equipment will be performed. Required equipment that is not located within a harsh environment will be deleted from the list. In addition, certain equipment that will not be exposed to a harsh environment during the time required to perform a safety-related function will be deleted, provided that their postulated failure would not affect the safety function or mislead an operator. Based on these results, the 50.49 list of safety-related electrical equipment that requires EQ will be developed. This list will be controlled on a continuing basis to reflect plant design changes and new information.

4.2 *Identification of Equipment Location*

Plant areas exposed to DBE environments will be identified. The U.S. EPR plant areas with values of environmental parameters (e.g., pressure, temperature, humidity, radiation level, submergence levels) that could increase significantly above normal ambient conditions as a direct result of the DBE will be considered as harsh areas. An environmental service conditions database will provide a listing of these harsh environmental areas as well as the conditions in each area under normal, abnormal, and accident conditions. A review of the specific equipment location will be performed to determine the service conditions.

4.3 *Identification of Service Conditions*

Service conditions will be based on the following classifications:

- Harsh environments: plant areas where the environmental conditions significantly exceed the normal design conditions as a direct result of a DBE.
- Mild environments: an environment that at no time would be significantly more severe than the environment during normal plant operation, including anticipated operational occurrences (Reference 2).

The term “significantly” is identified in 10 CFR 50.49; however, it is not defined. As the Electric Power Research Institute (EPRI) “Nuclear Power Plant Equipment Qualification Reference Manual,” (Reference 32) notes, “the distinction between mild and harsh environments cannot be simply defined since several plant areas experience rather severe mild (e.g., normal) environments.” For the U.S. EPR, plant-specific environmental parameter limits for mild environments have yet to be determined. These limits will be based on recognized equipment and material capabilities, and the possible existence of concurrent high levels of individual environmental stresses (e.g., temperature, pressure, humidity, radiation).

Equipment in a mild environment will be controlled through design specifications, engineering evaluations, certificate of compliance (COC), and plant maintenance programs and will not be covered within the scope of the EQ program. These controls will be described in the FSAR as mentioned in Section 5.1.3.1.

Environmental service conditions resulting from DBEs will be generated and identified throughout the plant where HELBs are postulated. Steps will include:

- Identifying and defining all DBEs applicable to the EQ program
- Identifying harsh environment areas (areas designated as "mild" are also identified, for exclusion purposes)
- Generating environmental profiles for postulated accident conditions
- Identifying, determining, and maintaining normal and accident environmental service parameters

Service conditions are used to determine required qualification levels and to provide input to determine component qualified life and thermal equivalency calculations as discussed in Section 5.3.

A key issue for new plant equipment, especially for digital I&C systems, is electromagnetic compatibility (EMC). Addressing EMC involves testing to show that critical equipment will not be adversely affected by electromagnetic interference (EMI) in the plant environment. It is typically addressed by design engineering and monitoring by system engineering, maintenance, and surveillance programs.

EMC will be addressed within the U.S. EPR EQ program as a service condition that must be considered to address proper operation under adverse conditions for digital equipment. EMC is addressed in detail in the EPRI TR-102323, Revisions 1, 2, and 3 and Reg. Guide 1.180, Rev. 1.

4.4 *Inadvertent Containment Spray Actuation and Submergence*

While the U.S. EPR does not require containment spray during a LOCA, inadvertent actuation will be analyzed and considered for EQ. In addition to the safety-related containment cooling systems, the U.S. EPR design incorporates a non-safety-related containment spray system for severe accident heat removal and mitigation. The system, designed to support severe accident mitigation features only, can be aligned to the IRWST to pump water to redundant spray headers located near the top of the containment. The water is sprayed through nozzles into the containment atmosphere, scrubbing any radioactive particles from the atmosphere to the IRWST. Aligning the spray system requires actions that include opening a series of valves used for severe accidents only.

Inadvertent actuation of the containment spray system may produce flooding or submergence. The exposed equipment will be qualified to demonstrate that it maintains its design function following the event.

4.5 *Procurement of Qualified Equipment*

The procurement of qualified equipment for the U.S. EPR will include the following basic elements:

- Prepare EQ evaluations
- Prepare calculations in support of EQ evaluations
- Prepare equipment qualified data package (EQDPs) to document qualification of EQ equipment
- Review, approve, revise, resolve, and forward documentation to the AREVA NP records management organization, per procedures

These controls will be described in the FSAR as noted in Section 5.1.3.2.

4.6 *Documentation of Qualification*

The U.S. EPR EQ program will require both engineering and procurement processes so that EQ components are supported by evaluations and that qualification tests are properly documented. The U.S. EPR EQ program will require evaluations to determine the adequacy of qualification reports and documentation of the evaluation results in an EQDP. The EQ program will also require procurement control to ensure that EQ components are purchased in conformance with test reports specified in the documented qualification package.

When qualification tests are reviewed and approved for particular components, the typical EQDP package (e.g., test report, review and evaluation documents, and output documents to the plant organizations) will be documented and stored in the AREVA NP records management system. Future changes to the component will result in a revision to the documented EQDP, which will be revised under the same process as the original package.

4.7 *Equipment Qualification Programmatic Controls*

The qualification process by its very nature will be ongoing as long as the equipment is in service. This preservation phase encompasses activities that provide reasonable assurance that the installed equipment remains qualified throughout its installed life. These activities include preventative maintenance, equipment repair, refurbishment, replacement, evaluation, and interpretation of new information (i.e., experienced feedback). Also, plant modifications will be addressed for their qualification impact during the preservation phase (Reference 32).

The controls for the qualification phase will be identified in the equipment qualification operational program described in FSAR Chapter 3.11 and will include:

- Requirement that plant equipment be designed and controlled through design engineering, procurement, and plant services (e.g., Operations, Maintenance, In-service Testing, Inspection, and QA Services). Refer to Section 4.6 for additional information.

- Controls necessary to ensure ongoing qualification. For example, operating experience feedback to the EQ program on conditions that have affected or could affect EQ equipment will be identified. This feedback usually involves notice of failures, performance malfunctions, or changes in environmental conditions that could affect EQ equipment. Similarly, the program controls will be identified to manage changes to radiation conditions. During the life of the plant, additions or modifications to the plant will be processed. These modifications will be evaluated for impact to the EQ program.

5.0 SUMMARY OF ACTIVITIES SUPPORTING DEVELOPMENT OF THE U.S. EPR EQ PROGRAM

The summary of activities supporting development of the U.S. EPR EQ program section duplicates, in some cases, information presented in earlier sections. However, the information is presented in this section to illustrate the level of detail considered in the design certification or combined license (COL) applications.

5.1 *Development of FSAR Chapter 3.11*

This section identifies technical information that will be included in Chapter 3.11 of the DCD or the COL FSAR.

5.1.1 Environmental Qualification of Electrical Equipment

Chapter 3.11 will address EQ of electrical equipment, providing the U.S. EPR approach to EQ of equipment. This approach will provide reasonable assurance that applicable items of equipment (i.e., electrical as well as I&C) are capable of performing their design safety functions under all normal environmental conditions, anticipated operational occurrences, and accident and post-accident environmental conditions. This approach is intended to conform to the requirements of 10 CFR Part 50, Appendix A, GDC 1, 2, 4, and 23; the requirements of 10 CFR Part 50, Appendix B, QA Criteria III, XI, and XVll; and the requirements of 10 CFR 50.49.

5.1.2 Equipment Identification and Environmental Conditions

Electrical and I&C equipment covered by this section will be consistent with information presented in Section 3.2. It will include equipment associated with systems that are essential to emergency reactor shutdown, containment isolation, core cooling, and containment and reactor heat removal, or are otherwise essential to preventing significant release of radioactive material to the environment. Included in this equipment scope is:

- Equipment that performs this function automatically
- Equipment that is used by the operators to perform these functions manually

- Equipment whose failure can prevent the satisfactory accomplishment of one or more of the above safety functions
- Other electrical equipment important to safety as described in 10 CFR 50.49 (b)(1) and (2) and certain PAM equipment, as described in 10 CFR 50.49(b)(3)

5.1.2.1 *Definition of Environmental Conditions*

As noted earlier in Section 3.3, the FSAR will indicate that environmental conditions will include anticipated operational occurrences and normal, accident, and post-accident environments. The environmental parameters (e.g. radiation, temperature, chemical spray, humidity, pressure, flooding), applicable to the various plant locations, will be defined.

Environments fall into two general categories of harsh and mild. A harsh location is a location whose environment changes substantially due to a DBA (excluding seismic events which will be discussed in a different section). A harsh environment also includes areas subject to radiation levels that exceed 10^4 Rads gamma. A mild location is essentially an area not subject to DBEs, excluding seismic events, and whose radiation levels are less than or equal to 10^4 Rads gamma. Section 5.7 provides additional information on radiation thresholds.

The equipment service conditions will be described consistent with the results from activities described in Section 5.3.

5.1.2.2 *Equipment Operability Times*

Equipment that is required to be environmentally qualified for the U.S. EPR has one or more of the following safety functions: reactor trip (RT), engineered safeguards actuation, or PAM. These safety functions are identified for applicable equipment. For each safety function identified, a period of operability will be assigned as follows: immediate operability (2 hours), short term (24 hours), medium term (4 months), or long term (1 year). Refer to Table 3-3 for typical U.S. EPR operability times.

5.1.3 Qualification Tests and Analyses

5.1.3.1 *Environmental Qualification of Electrical Equipment*

It will be established that the U.S. EPR electrical equipment (see Table 3-3) in a harsh location will be qualified by type testing, operating experience, analysis, or a combination of these methods using the guidance of IEEE 323 and IEEE 344. Child standards of IEEE 323, such as IEEE 383 (cables), IEEE 382 (motor operated valves), and IEEE 317 (electrical penetrations) will also be employed.

Reg. Guides that provide guidance for meeting the requirements of 10 CFR Part 50, Appendix A, GDC 1, 4, 23, and 50; Appendix B, Criterion III, XI, and XVII to 10 CFR Part 50 and 10 CFR 50.49, include 1.9, 1.40, 1.63, 1.73, 1.89, 1.97, 1.100, 1.131, 1.152, 1.156, 1.158, and 1.180.

The acceptability of safety-related electrical equipment located in a mild environment will be demonstrated and maintained by the use of the following three programs:

- A periodic maintenance, inspection, and/or replacement program based on sound engineering practice and recommendation of the equipment manufacturer, which is updated as required by the results of an equipment surveillance program
- A periodic testing program to verify operability of safety-related equipment within its performance specification requirements (system level testing of the type typically required by the plant technical specifications may be used)
- An equipment surveillance program that includes periodic inspections, analyses of equipment and component failures, and a review of the results of the preventive maintenance and periodic testing program. Mild environmental equipment is also covered by the plant’s maintenance rule program.

5.1.3.2 *Environmental Qualification of Mechanical Equipment*

It will be established that the U.S. EPR qualification of mechanical equipment will be established and maintained through engineering, procurement, maintenance and surveillance programs and procedures. Design engineering equipment specifications establish the environmental conditions for which both metallic and non-metallic parts must be suitable. Non-metallic parts will be periodically replaced in accordance with engineering evaluations and the equipment manufacturer recommendations. Replacement parts will be evaluated to ensure material adequacy and suitability of fit, form, and function. A maintenance program which includes surveillance and periodic testing of mechanical equipment, commensurate with the safety function of the equipment, will be relied upon to identify and evaluate significant age-related degradation of non-metallic parts.

To verify the effectiveness of these programs for maintaining compliance with GDC 4, the program data and records will be reviewed periodically in accordance with ASME Section XI to ensure that equipment has not suffered any degradation that may be due to thermal, radiation, and/or cyclic aging.

5.1.4 Qualification Test Results

It will be noted that summaries and results of the U.S. EPR qualification tests for electrical equipment and components in the harsh environment areas will be documented in the EQDP. Refer to Section 5.4 for EQDP details.

Qualification of electrical equipment and components in a mild location will be based on COC to the procurement specification. The adequacy of mechanical equipment will be based on conformance with engineering and procurement documents and other specific plant procedures.

5.1.4.1 *Loss of Ventilation*

It will be indicated that environments that result from the loss of HVAC equipment typically show slow and minor changes in temperature resulting in steady state conditions that are not harsh by definition. Because the equipment will operate below the maximum stress level capability in its normal environment, it is unlikely that low level, short duration temperature excursions caused by loss of HVAC will result in the maximum stress level capability being exceeded. Temperature monitors throughout the plant record any change in temperature over time. The corrective action program and the maintenance rule program provide adequate controls to initiate repairs, when necessary. In addition, due to the slow nature of this temperature change, time is available for operator action to correct the environmental problem by re-establishing or improvising ventilation. Since several means will be available to the operator for the U.S. EPR to correct the problem, the duration of the transient will be short.

5.1.5 Estimated Chemical and Radiation Environment

It will be identified that estimated normal operation radiation doses will be calculated for initial plant start-up conditions. Measured radiation doses in the operating plant will be continuously monitored. If the actual measured radiation doses are higher than the original calculated doses, the U.S. EPR EQ database will be revised and qualified life adjustments identified through the EQ program and forwarded to plant maintenance.

When area doses exceed the qualified dose of an item of interest, component specific doses/calculations may be performed to determine doses at the specific equipment locations. The use of chemicals for pH control and their effects will be considered in the program.

5.1.6 Methods and Procedures

The methods and procedures will be presented by which electrical equipment important to safety will be qualified and the results of such qualification documented. It is expected that a COL applicant that references the U.S. EPR design certification will identify that the equipment, functional requirements, and qualification levels described envelops the requirements and plant service conditions at their specific nuclear power generating station.

The background for the U.S. EPR qualification will also be provided, as well as program a summary of program objectives, a program outline, and definitions for terms used in the document. Other items to be provided include qualification criteria, design specifications and qualification methods to be utilized for the program (e.g., type-testing, analyses, operating experience, combination of methods, and supplemental methods to aid qualification) and the documentation requirements necessary for qualification.

5.2 *Equipment Identification Development of the Master Equipment List*

The MEL is a database that lists all of the plant equipment. The EQ equipment qualification list for the U.S. EPR will be a subset in the MEL that will be controlled through the EQ program. This subset will serve to satisfy the requirements of 10 CFR 50.49(d), which requires that a list be developed defining all electrical equipment requiring qualification per 10 CFR 50.49.

5.2.1 Equipment and System Lists

The MEL will include safety-related equipment and components required to mitigate the consequences of a DBA and ensure safe shutdown. The MEL will also identify non-safety-related equipment requiring qualification per 10 CFR 50.49. The MEL will also give the room number in which the equipment is located and the equipment category.

5.2.2 Safety-Related System Listing

Safety-related systems are those plant systems necessary to ensure:

- The integrity of the reactor coolant pressure boundary
- The capability to shut down the reactor and maintain it in a safe shutdown condition
- The capability to prevent or mitigate the consequences of accidents which could result in offsite exposures comparable to the guidelines of 10 CFR Part 100

Systems that perform these type functions are required to achieve or support emergency reactor shutdown, containment isolation, reactor core cooling, containment heat removal, core residual heat removal, and prevention of significant release of radioactive material to the environment. A listing of the systems that perform or support these functions will be developed. The listing will identify the function that the system performs (or supports) and include all systems that receive Class 1E power. Systems are typically listed even if only a portion of the system provides a safety-related function. Multiple entries indicate that the system provides multiple safety functions.

A system is identified and listed because a portion of the system provides electrical isolation. This system may not have any other Class 1E function.

Class 1E powered I&C devices will be included in the system that they serve. The I&C devices can be located in three areas of the plant: Nuclear Island, Turbine Island, and BOP.

5.2.3 Equipment List Development

To develop the list of equipment requiring qualification, the U.S. EPR MEL will be used to identify systems and major components. This information will be used to identify design documents for a more detailed equipment listing. Examples of typical design documents to be utilized include piping and instrument drawings, instrument index, instrument list, equipment listings, and equipment specifications.

Upon completing the list, the location of each piece of equipment, by room number, will be identified. When the list is developed and equipment location identified, each piece of equipment will be categorized for each of the three accident groups. The accident groupings will typically include LOCA, MSLB/main feedwater line break (MFLB) inside containment and steam/feedwater, isolation and relief room, and HELB outside containment (except MSLB and MFLB). The equipment located in a harsh environment for any of the three accident groups will be reviewed under the 10 CFR 50.49 program.

5.3 *Development of Equipment Service Conditions*

Equipment needs to be qualified for operability under all potential service conditions. Service conditions are the actual environmental, physical, mechanical, electrical, and process conditions experienced by equipment during service. Plant operation (i.e., normal environments) includes both normal and abnormal operations. Abnormal operation occurs during plant transients, system transients, or in conjunction with certain equipment or system failures. Extreme DBE conditions (i.e., accident environments) are principally those caused by certain postulated pipe ruptures. LOCAs and HELB produce harsh environments for the affected components.

The service conditions developed for the U.S. EPR will be described in the DCD.

5.3.1 Accident Environments

Accident environmental conditions are defined as those that deviate from the normal operating environmental conditions. These conditions will be specified in the U.S. EPR EQ environmental database.

The LOCA/HELB/MSLB pressure, temperature, humidity, radiation, chemical spray, and submergence environmental conditions will be evaluated, and the U.S. EPR plant-unique environmental conditions will be developed. Normal, abnormal, accident and post-accident parameters will be used in the equipment review and evaluation.

5.3.1.1 *Accident Temperature and Pressure Profiles*

10 CFR 50.49(e)(1) states that the time dependent temperature and pressure at the location of the electric equipment important to safety must be established for, or following, the most severe DBA, for which this equipment is required to remain functional.

For qualification requirements:

- 10 CFR 50.49(f)(1) identifies testing an identical item under identical conditions or under similar conditions with a supporting-analysis.
- 10 CFR 50.49(f)(2) identifies testing a similar item with a supporting analysis.
- 10 CFR 50.49(f)(3) identifies experience with identical equipment under similar conditions with supporting analysis.

- 10 CFR 50.49(f)(4) identifies analysis in combination with partial type test data that supports the analytical assumptions and conclusions. Reg. Guide 1.89, Rev. 1, (C2), states that since the test profiles included in Appendix A to IEEE 323 are representative, they should not be considered an acceptable alternative to using plant-specific containment pressure and temperature design profiles unless plant-specific analysis is provided to verify the applicability of those profiles.

The U.S. EPR HELB locations will be identified consistent with guidance provided in the SRP. The energy released is used to determine the temperature and pressure profiles for each location in the plant where EQ equipment is also located. These profiles, along with relative humidity levels, will be used to develop an EQ environmental database for all plant zones.

5.3.1.2 *Radiation Environments*

Using the guidance of 10 CFR 50.67 and Reg. Guide 1.183, post-LOCA radiation environments will be determined in the areas of the containment. The original fission product release data used in this analysis will be obtained from engineering calculations. The isotopic inventory will be for an equilibrium cycle core. The data will be calculated at the end of cycle life and, therefore, represent maximums suitable for post-accident evaluations.

The primary purpose of defining radiation zones is for plant design and to determine shielding requirements. These zone designations are used as equipment design and qualification requirements.

5.3.2 Normal Environments

5.3.2.1 *Pressure, Temperature, Humidity, and Radiation*

Normal operating environmental conditions are defined as conditions that exist during routine plant operations. These environmental conditions represent the normal maximum and minimum conditions expected during routine plant operations. Ranges for these conditions will be specified in the U.S. EPR EQ environmental database.

Temperature and pressure profiles for normal and abnormal conditions for each location in the U.S. EPR plant will be calculated during the design phase and included in the DCD. Once operational, temperature monitoring begins and monitoring data will be used to adjust the initial calculated temperature profiles.

5.4 *Development of EQ Data Package Format*

The following guidelines outline the preparation of the U.S. EPR EQ files. The EQ files will provide auditable documentation to meet 10 CFR 50.49.

EQ files will contain environmental qualification evaluation reports (EQERs), which are the documented evidence of evaluations performed to demonstrate EQ. These files will be maintained in whole or in part within the EQ configuration management system. EQ files will contain information such as a qualification summary, references, and EQ installation/interface and will be described in the DCD.

5.5 *Development of Aging Evaluation Program*

A critical element of equipment qualification is the determination of how environmental and operational stressors affect equipment during normal operation. Aging assessment is the evaluation of appropriate information to determine the effects of aging on the current and future ability of equipment to function as designed under all service conditions.

Significant degradation could be caused by aging mechanisms that occur from the environment during the service life. Therefore, electrical equipment requiring qualification should be assumed in a degraded state prior to imposing DBE simulations. Significant aging mechanisms during normal and abnormal service conditions cause degradation of equipment that progressively and appreciably renders the equipment vulnerable for failure to perform its safety function(s) during the DBE conditions.

The objective of the U.S. EPR aging evaluation program is to provide reasonable assurance that significant aging mechanisms are accounted for so that safety-related electrical equipment that require qualification, for which a qualified life or condition has been established, can perform its safety function(s) without experiencing common-cause failures before, during, or after applicable DBEs. This ensures successful performance during a subsequent DBE with reasonable assurance.

The aging evaluation program will address the effects of significant aging mechanisms as described in Section 5.6. The techniques available to address the effects of aging include operating experience, testing, analysis, in-service surveillance, condition monitoring, and maintenance activities as noted in IEEE 323-2003. Electrical equipment requiring qualification that is located in a harsh environment, and for which significant aging mechanism(s) have been identified, will have the mechanism accounted for in the qualification program.

5.6 *Development of Aging Parameters*

Known aging parameters include exposure to pressure, temperature, humidity, radiation, vibration, seismic occurrences, chemical, submergence environments and exposure to mechanical cycling, electrical operating conditions under normal, abnormal, and accident conditions. Combinations of these parameters may compound aging and will be considered. Due to the complexity of the effects of these parameters on sensitive equipment, such as electrical and I&C equipment, actual testing will be used to determine qualification.

Operational stresses such as surge voltages, over voltage, mechanical and electrical cycling usually are factored into the aging process by simulation during qualification tests. External stresses caused by the mentioned parameters will also be accounted for by age sequencing prior to the simulated DBA test.

Significant research has been performed to uncover synergistic effects associated with the known aging parameters. Certain materials respond differently based on aging sequence, dose rates, and sequential versus simultaneous testing. The EQ program will be designed to account for material degradation. This will include selection of the proper aging models.

5.7 *Development of Low Level Radiation Threshold - Effects of Gamma Radiation Doses Below 10^4 Rads on the Mechanical Properties of Materials*

An evaluation will be performed to substantiate the radiation qualification of electronic components used in a mild environment, to levels not exceeding 10^4 R, total integrated dose (TID). The radiation threshold position includes all of the electronic equipment and components used in the various safety and non-safety systems, located in a mild environment. Evaluations will be performed, generally in lieu of testing, to provide reasonable assurance that system components do not become degraded by exposure to radiation.

The equipment that will be qualified under this program will be located in a mild environment that will not impose any significant aging mechanisms. A qualified life is not required, and it will not be necessary to perform any pre-aging or including radiation aging of the equipment prior to any seismic tests, or to include aging effects in the analyses.

Extensive studies of raw materials have shown that organic material can withstand a radiation environment up to about 1 x 10^3 R, TID, measured against a damage threshold based on some particular property, including physical and chemical. However, these criteria became misleading because the primary concern for the equipment was its ability to perform specific functions rather than the point at which damage may have first been detected. Testing of equipment items was conducted to determine the difference, if any, between the threshold values and actual degradation of performance with subsequent loss of function.

As a result of equipment tests by EPRI and others, it was subsequently determined that nearly all types of electronic equipment could withstand at least an order of magnitude more radiation exposure before performance degradation became a concern. The NRC and IEEE have suggested that the operability threshold was near 1 x10^4 R, TID, before noticeable degradation of performance occurred. In some cases, levels as high, or higher, than 1 x10^5 R, TID could be tolerated.

The key indicator of radiation withstand capability should be based on equipment performance degradation, not just a threshold value of susceptibility, and a reasonable level of radiation tolerance would be in the range of 1×10^4 R to 1×10^5 R, TID. Therefore, for the U.S. EPR, on the basis of investigations and evaluations of similar equipment exposed to similar radiation environments, systems will be qualified to a radiation environment of at least to the level of 1×10^4 R, TID, except digital equipment containing metal oxide semiconductors, which are limited to 1×10^3 R, TID.

6.0 QUALIFICATION STANDARDS

6.1 *European Standards vs. U.S. Standards*

The first EPR is being built in Europe and many components for that plant will be qualified to European requirements and standards. Some components qualified to European standards may be applicable for use in the U.S. EPR.

Any qualification performed to foreign standards will be evaluated against the U.S. qualification standards, prior to acceptance. Any differences will be justified prior to the use of the equipment in a U.S. nuclear plant.

6.2 *Impact of New U.S. Qualification Standards*

Changes in IEEE standards over the last 20 to 30 years represent improvements to the standards and thus, AREVA NP suggests the latest editions will be most appropriate for new plant design. Therefore, AREVA NP proposes that the latest IEEE standards (identified in Appendix A) be used for new qualification of equipment.

AREVA NP will ensure, at the time of the submittal of the application for design certification for the U.S. EPR, that IEEE standards endorsed by a Reg. Guide are identified as such and that justification is provided for those not endorsed.

7.0 CONCLUSION

AREVA NP's approach to environmentally qualify equipment for the U.S. EPR is two-fold. The first approach is to design the plant to minimize severe service conditions following an accident that can potentially degrade performance of components. The key physical separation and compartmentalization attributes include:

- A four train layout that physically separates each division of safety-related systems outside containment.
- The prevention of steam or main feedwater lines to pass through SBs.
- A vertical layout that minimizes exposure of electrical and I&C equipment to radiation fields from lower floors.
- SBs, assumed to be available for post-accident mitigation, will not experience harsh environmental conditions except in regard to radiation in selected areas.
- Minimal potential for HELBs within SBs at normal operation conditions.

The second approach is to use the last four decades of nuclear plant experience in qualifying equipment. During that time, the approach to EQ has evolved as a result of research and plant experience. Some of that experience has been incorporated into the latest editions of the multiple industry standards written relative to equipment qualification. An AREVA NP objective is to conform to versions of the industry standards that have been endorsed by the NRC. However, many of the Reg. Guides that endorse these standards have not been revised since the 1970s and 1980s and are not scheduled for near term revisions. Therefore, at the time of the design certification application, AREVA NP may propose to use the latest standards, as appropriate, providing the required justification.

8.0 REFERENCES

U.S. Regulations

1. 10 CFR 50.34, “Contents of Applications, Technical Information,” Subsection (f)(2)(ix).
2. 10 CFR 50.49, “Environmental Qualification of Electric Equipment Important to Safety for Nuclear Power Plants.”
3. 10 CFR 50.67, “Accident Source Term.”
4. 10 CFR Part 50, Appendix A, General Design Criterion 1, “Quality Standards and Records;” General Design Criterion 2, “Design Basis for Protection against Natural Phenomena;” General Design Criterion 4, “Environmental and Dynamic Effects Design Basis;” and General Design Criterion 23, “Protection System Failure Modes.”
5. 10 CFR Part 50, Appendix B, Criterion III, “Design Control;” Criterion XI, “Test Control;” and Criterion XVII, “Quality Assurance Records.”
6. 10 CFR 52.47, “Contents of Applications.”
7. 10 CFR 52.97, “Issuance of Combined Licenses.”

U.S. Industry Standards

8. IEEE Standard C37.82-2004, “IEEE Standard for the Qualification of Switchgear Assemblies for Class 1E Applications in Nuclear Power Generating Stations.”
9. IEEE Standard C37.105-1987, “IEEE Standard for Qualifying Class 1E Protective Relays and Auxiliaries for Nuclear Power Generating Stations.”
10. IEEE Standard 7.4.3.2-2003, “IEEE Standard Criteria for Digital Computers in Safety Systems of Nuclear Power Generating Stations.”
11. IEEE Standard 317-1983 (reaffirmed 1992), “IEEE Standard for Electric Penetration Assemblies in Containment Structures for Nuclear Power Generation Stations.”
12. IEEE Standard 323-1974, “IEEE Standard for Qualifying Class 1E Equipment for Nuclear Power Generating Stations.”

13. IEEE Standard 334-1971, “IEEE Trail-Use Guide for Type Tests of Continuous-Duty Class 1 Motors Installed Inside the Containment of Nuclear Power Generating Stations.”

14. IEEE Standard 344-1975, “IEEE Recommended Practices for Seismic Qualification of class 1E Equipment for Nuclear Power Generating Stations.”

15. IEEE Standard 381-1977 (reaffirmed 1984), “IEEE Standard Criteria for Type Tests of Class 1E Modules Used in Nuclear Power Generating Stations.”

16. IEEE Standard 382-1972, “IEEE Trial-Use Guide for Type Test of Class 1 Electric Valve Operators for Nuclear Power Generating Stations.”

17. IEEE Standard 383-2003, “IEEE Standard for Type Test of Class 1E Electric Cables and Field Splices for Nuclear Power Generating Stations.”

18. IEEE Standard 387-1977, “IEEE Standard Criteria for Diesel Generator Units Applied as Standby Power Supplies for Nuclear Power Generating Stations.”

19. IEEE Standard 497-2002, “IEEE Standard Criteria for Accident Monitoring Instrumentation for Nuclear Power Generating Stations.”

20. IEEE Standard 535-1986, “IEEE Standard for Qualification of Class 1E Lead Storage Batteries for Nuclear Power Generating Stations.”

21. IEEE Standard 572-1985, “IEEE Standard for Qualification of Class 1E Connection Assemblies for Nuclear Power Generating Stations.”

22. IEEE Standard 627-1980 (reaffirmed 1991), “IEEE Standard for Design Qualification of Safety Systems Equipment Used in Nuclear Power Generating Station.”

23. IEEE Standard 628-2001, “IEEE Standard Criteria for Design, Installation and Qualification of Raceway Systems.”

24. IEEE Standard 638-2006, “IEEE Standard for Qualification of Class 1E Transformation Nuclear Power Generating Station.”

25. IEEE Standard 649-1980, “IEEE Standard for Qualifying Class 1E Motor Control Centers for Nuclear Power Generating Stations.”

26. IEEE Standard 649-2005, “IEEE Standard for Qualifying Class 1E Motor Control Centers for Nuclear Power Generating Stations.”

27. IEEE Standard 650-1979, “IEEE Standard for Qualification of Class 1E Static Battery Chargers and Inverters for Nuclear Power Generating Stations.”

28. IEEE Standard 1202-1991, "IEEE Standard for Flame Propagation Testing of Wire and Cable."

29. IEEE Standard 1205-2000, "Guide for Assessing, Monitoring, and Mitigating Aging Effects on Class 1E Equipment used in Nuclear Generating Stations."

30. IEEE Standard 1290-1996, "IEEE Guide for Motor Operated Valve (MOV) Motor Application, Protection, Control, and Testing in Nuclear Power Generation Station."

31. EPRI-TR-102323, Revision 3, "Guidelines for Electromagnetic Interference Testing for Power Plants," 2004 (1003697).

32. EPRI-TR-100516, "Equipment Reference Manual," 1992.

U.S. Regulatory Guidance

33. NUREG-0588, "Interim Staff Position on Environmental Qualification of Safety-Related Electrical Equipment."

34. NUREG/CR-6842, "Advanced Reactor Licensing: Experience with Digital I&C Technology in Evolutionary Plants."

35. NUREG/CR-6901, "Guideline for Electromagnetic Interference Testing in Power Plants."

36. NUREG-0737, "Clarification of TMI Action Plan Requirements."

37. Regulatory Guide 1.30, (Safety Guide 30), "Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment."

38. Regulatory Guide 1.40, "Qualification Tests of Continuous-Duty Motors Installed inside the Containment of Water-Cooled Nuclear Power Plants."

39. Regulatory Guide 1.63, "Electric Penetration Assemblies in Containment Structures for Light Water-Cooled Nuclear Power Plants."

40. Regulatory Guide 1.73, "Qualification Tests of Electric Valve Operators Installed inside the Containment of Nuclear Power Plants."

41. Regulatory Guide 1.89, "Environmental Qualification of Certain Electric Equipment Important to Safety for Nuclear Power Plants."

42. Regulatory Guide 1.97, "Instrumentation for Light-Water-Cooled Nuclear Power Plant to Assess Plant and Environs Conditions During and Following an Accident."

43. Regulatory Guide 1.131, "Qualification Tests of Electric Cables and Field Splices for Light-Water-Cooled Nuclear Power Plants."

44. Regulatory Guide 1.151, "Instrument Sensing Lines."

45. Regulatory Guide 1.156, "Environmental Qualification of Connection Assemblies for Nuclear Power Plants."

46. Regulatory Guide 1.158, "Qualification of Safety-Related Lead Storage Batteries for Nuclear Power Plants."

47. Regulatory Guide 1.180, "Guidelines for Evaluation Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems."

48. Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors."

Regulatory Review Precedent

49. Letter dated December 17, 1996, from L.E. Martin, Houston Lighting & Power, to the U.S. Nuclear Regulatory Commission, "South Texas Project, Units 1 and 2, Docket Nos. STN 50-498, STN 50-499, 10 CFR 50.59 Summary Report."

50. Letter dated April 8, 1998, from Thomas Alexion, NRC, to William Cottle, STP Nuclear Operating Company, "Request for Additional Information on Elimination of Environmental Qualification of Mechanical Components, South Texas Project, Units 1 and 2 (STP) (TAC Nos. M98912 and M98913)."

51. Letter dated May 6, 1998, from S.E. Thomas, STP Nuclear Operating Company, to U.S. Nuclear Regulatory Commission, "Response to Request for Additional Information on Elimination of Environmental Qualification of Mechanical Components," Docket Nos. STN 50-498, STN 50-499, Units 1 and 2 (STP).

52. Letter dated September 24, 1998, from Thomas Alexion, NRC, to PD IV-1 File, "Licensee's 10 CFR 50.59 Evaluation of Elimination of Environmental Qualification of Mechanical Components, South Texas Project, Units 1 and 2 (STP) (TAC Nos. M98912 and M98913)."

Appendix A – Comparison and Recommendations for use of IEEE Standards

IEEE Standard C37.82: Switchgear

Topic	1987 Edition	2004 Edition	Impact	NRC Endorsed IEEE C37.82 & Reg. Guide, Revision	U.S. EPR Recommended IEEE C37.82
All	All	Re-affirmation of entire standard, no changes	None	Not Endorsed	IEEE C37.82-2004 (As a Guide)

IEEE Standard C37.105: Protective Relays

Topic	1987 Edition*	Impact	NRC Endorsed IEEE C37.105 & Reg. Guide, Revision	U.S. EPR Recommended IEEE C37.105
	There are no changes applicable to this document	None	Not Endorsed	IEEE C37.105 -1987 (As a Guide)

*Note: 1987 was the original issue of this standard

IEEE Standard 317: Electrical Penetrations

Topic	1976 Edition	1983 Edition	2003 Edition	Impact	NRC Endorsed IEEE 317 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 317
Performance Criteria	Penetration design addressed in general terms only	Specific electrical, mechanical, structural performance requirements stated	Complete re-affirmation of IEEE 317-1983: No changes	Possible requirement for analysis or retest	IEEE 317-1983 Reg. Guide 1.63, Rev.3	IEEE 317-2003
Accident Function	Penetration accident performance requirements generically given qualitatively	Very specific DBA performance levels specified		Possible requirement for analysis or retest		
Leak Rate	Leak rate requirements presented in general terms	Leak rate requirements given for EPAs, aperture, total assembly		Possible requirement for analysis or retest		
Specimen Selection	Specimen selection requirements presented in general terms	Selection criteria and similarity requirements added and clarified with specific parameters		None, clarification		
Thermal Aging	500 hours minimum thermal aging time requirement	No minimum aging time		None, relaxation of requirements		
Inboard vs. Outboard Test	Test Inboard (containment) side only	Test must address both sides of penetration		Possible requirement for analysis or retest		
Electrical Design	Conductor fill limits given, ampacities specified	Fill and left to designer based on ampacities performance		None, relaxation of requirements		

IEEE Standard 323: EQ General

Topic	1974 Edition	1983 Edition	2003 Edition	Impact	NRC Endorsed IEEE 323 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 323
Type Test	Preferred	Preferred	Initial type test required	None. 99.9% of quals do this anyway	IEEE 323-1974 Reg. Guide 1.89, Rev. 1	IEEE 323-2003
Harsh/Mild	Requirements for both defined	Not addressed	Requirements for both defined. Mild requirements reduced	None if qual is less than 30 years old		
Condition Monitoring	Not addressed	Not addressed	Defines CM requirements and application to license renewal	None. Will not void old qual.		
DBA Transients	Two transients with 15°F margin for DBA test	Two transients for DBA test or Single transient with 15°F margin	Single transient with 15°F margin	Possible requirement for analysis		
EMI / RFI	Not addressed	Not addressed	EMI / RFI Surges must be addressed	Major impact on sensitive electronic items (such as Teleperm)		
Test Sequence Synergism	Suggested thermal aging prior to radiation	Suggested thermal aging prior to radiation	Suggested thermal aging after radiation	None. Most done this way		
Equipment Interfaces	Mentioned, but not in detail	Mentioned, but not in detail	Qual requirements for interfaces clarified and prescribed	None if qual is less than 30 years old		
Documentation	Limited documentation required harsh applications only	Additional documentation required for harsh applications. Mild mentioned but not in detail	Mild and Harsh documentation specified	Minimal. Most older quals are industry accepted		
QL Extension	Not Addressed	Not Addressed	Requirements defined	None. Same methods as older standard		
Aging	Specimen requires aging	Specimen requires aging	Significant aging mechanisms must be addressed and Specimen requires aging	None if qual is less than 30 years old		

IEEE Standard 334: Motors

Topic	1974 Edition	1994 Edition	2006 Edition	Impact	NRC Endorsed IEEE 334 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 334
DBA Transients	Two transients with 15°F margin for DBA test	Two transients for DBA test or Single transient with 15°F margin	Single transient with 15°F margin	Possible requirement for analysis	IEEE 334-1971 Reg. Guide 1.40, Rev. 0	IEEE 334-2006
Condition Monitoring	Not addressed	Not addressed	Defines CM requirements and application to license renewal	None, alternative for extending QL		
Insulation Models	Formettes and motorettes defined, but no explanation of how to include them in qualification	Formettes and motorettes defined, but no explanation of how to include them in qualification	Inclusion of insulation system models (formettes and motorettes) for use as specimens in type testing	None if qual is less than 30 years old		
Loading	Not addressed	Not addressed	Inclusion of loading vs. thermal requirements during qual test. Required to evaluate worst-case in DBA (continuous. run or start/stop)	None, relaxation of requirements		
Update	N/A	N/A	Updated per IEEE 323-2003 update	None, editorial		

IEEE Standard 344: Seismic

Topic	1975 Edition	1987 Edition	2004 Edition	Impact	NRC Endorsed IEEE 344 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 344
Similarity	Briefly discussed	Relevant parameters discussed	Relevant parameters discussed	None	IEEE 344-1987 Reg. Guide 1.100, Rev.2	IEEE 344-2004
SQUG	Not applicable	SQUG and SSRAP mentioned, but very new	Additional SQUG experience for Qualification	None, alternative qualification method		
Multi-axis	Single and biaxial only addressed	Tri-axial preferred, then biaxial, then single axis. Justify independence	Tri-axial preferred, then biaxial, then single axis. Justify independence	None, additional qualification method		
Test Methods	RMF or single frequency tests	RMF or RIM per application RMF can be supplemented with single frequency for peaks	RMF or RIM per application RMF can be supplemented with single frequency for peaks	None, additional qualification method		
Analysis	Static and Dynamic. General info	Several varieties of static and dynamic analyses with specific guidance	Numerous. varieties of static and dynamic analyses with specific guidance	None, additional qualification method		
Exploratory Tests	Resonant search and modal testing discussed	Resonant search and modal testing discussed. Req't to address resonances in testing to justify coupling. Transmissibility plots required	Resonant search and modal testing discussed. Req't to address resonances in testing to justify coupling. Transmissibility plots required	Possible requirement for analysis or retest to meet additional data requirements		
Combined T&A	Low Impedance method defined. Exploratory tests used for qual method selection	Exploratory tests used as input for dynamic/static qual analyses	Exploratory tests used as input for dynamic/static qual analyses	None, additional qualification method		
Damping	Defined only	Method for calculating presented	Method for calculating presented	None, clarification		

IEEE Standard 344: Seismic

Topic	1975 Edition	1987 Edition	2004 Edition	Impact	NRC Endorsed IEEE 344 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 344
Vibration Aging	Seismic vibration defined	Seismic and Non-Seismic vibration defined and addressed	Seismic and Non-Seismic vibration defined and addressed	Minor, line vibration effects need to be addressed		
ZPA	Defined only	Method for calculating presented	Method for calculating presented	None, clarification		

IEEE Standard 382: Actuators

Topic	1972 Edition	1980 Edition	2006 Edition	Impact	NRC Endorsed IEEE 382 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 382
Documentation	Minimal requirement	Details for actuator specs required. Specimen selection justification required	Detailed specification content defined. Specimen selection justification guidelines defined	None if qual is less than 30 years old	IEEE 382-1974 Reg. Guide 1.73, R0	IEEE 382-2006
Type Testing	Defined and required, but no detail given	More detail added with criteria for applying guidance. Generic requirements given	Methods and philosophies discussed for performance of type testing. Strict requirements specified	None if qual is less than 30 years old		
Test Sequence Synergism	Aging, seismic, accident. aging to include Rad, TA, Cycles, and pressure Cycles (Sim to 323-74)	Per IEEE 323-1974 incl. Vib. aging before seismic and Press. Aging before ACC	Per IEEE 323-2003 incl. Vib. aging before seismic and Press. Aging before ACC	None if qual is less than 30 years old		
Margin	None	Per IEEE 323-74	Per IEEE 323-2003	None if qual is less than 30 years old		
Function Tests	Stated in general terms only	Exact placement of FTs in sequence given. Content of FTs given	Exact placement of FTs in sequence given. Content of FTs given in great detail	Possible requirement for analysis		
Monitoring of Data	Specific variable types of data to be measured	More detail added to type of data required and examples given	Data requirements reformatted, but very similar in practice	None, editorial		
Aging	TA, Rad, Cycle per standard. TA per table value, Rad per industry envelope, cycles are 550 full cycles	TA, Rad, Cycle, Vibration, Pressure per standard. TA per table value, Rad per industry envelope, cycles are 2000 full plus. 100K partial cycles	TA per individual basis, all other aging same as IEEE 382-1980	None, bringing standard up to level of industry practice		

IEEE Standard 382: Actuators

Topic	1972 Edition	1980 Edition	2006 Edition	Impact	NRC Endorsed IEEE 382 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 382
DBA Transients	Two transients with 15°F margin for DBA test	Two transients with 15°F margin for DBA test	One transient with 15°F margin for DBA test	Possible requirement for analysis		
Seismic	Per IEEE 344-71 (RMF)	Per IEEE 344-75 (RIM and/or RMF)	Per IEEE 344-2004 (RIM and/or RMF)	Minor, additional testing, but done typically anyway		
Environmental Requirements	Specified in Std for normal, accident, seismic, Rad, etc.	Specified in Std for normal, accident, seismic, Rad, by 5 "Qual Cases"	Methodology for determination of env. & seismic qual requirements specified instead of environments	None, specific requirements used		
IEEE Refs.	323-71, 334-71, 344-71	323-74, 344-75	323-2003, 344-2004			

IEEE Standard 383: Cable

Topic	1974 Edition	2003 Edition	Impact	NRC Endorsed IEEE 383 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 383
Qual Methods	Type test preferred	Operation experience, ongoing qualification, and analysis have specifically been included in this revision	None, alternative qualification method	IEEE 383-1974 Reg. Guide 1.131, P1*	IEEE 383-2003
Flame Test	Included in standard	Moved to IEEE 1020-1991	None, relaxation of requirements		
Connectors	Included in standard	Moved to IEEE 572-1985	None, relaxation of requirements		
Sample Selection	Sample selection table included in standard for guidance	Table replaced with text description	None, clarification		

IEEE Standard 387: Emergency Diesel Generators

Topic	1972/1977 Edition	1984 Edition	1995/2001 Edition	Impact	NRC Endorsed IEEE 387 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 387
EDG Performance	Basic functions specified on a component level	Additional performance requirement criteria specified for tighter control of EDG	EDG function requirements highly specified. Digital control ready	Possible requirement for analysis or retest	IEEE 387-1974 Reg. Guide 1.9, Rev.3	IEEE 387-2001
Scope	Simple scope, system level	System and component scopes	Intricate process, new scope diagram to help follow process	None, clarification		
Loading Req'ts	Rated load and load rejection addressed. Transient response discussed	Further defined transient response requirements. Loading to account for VAR effects on transient response	No load and Light load operational requirements specified. System performance requirements tightened	Possible requirement for analysis or retest		
Factory and Site Testing	Startup testing and factory testing not requirement for each system	Site test discussed, but not mandatory	Factory and site testing of each system mandatory. Test content minimum specified	None. End user and equipment supplier responsibility on each unit		
Surveillance	Not addressed.	Surveillance testing periodicity suggested, content recommended	Surveillance testing requirements stated	None. End user responsibility		
Testing Selection	Basic test goals stated, user defines testing	General direction on selection of test parameters is given	Additional guidance for test parameter selections is given	None, clarification		
Reliability	Not addressed	Not addressed	Maintenance rule data gathering criteria specified	None, new life extension initiative		

IEEE Standard 387: Emergency Diesel Generators

Topic	1972/1977 Edition	1984 Edition	1995/2001 Edition	Impact	NRC Endorsed IEEE 387 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 387
IEEE 749-1983	Not addressed	Not addressed	Periodic testing per IEEE 749 has been added since this standard has been withdrawn	None, combined 2 standards into one		

IEEE Standard 420: Racks and Panels

Topic	1973 Edition	1982 Edition	2001 Edition	Impact	NRC Endorsed IEEE 420 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 420
IEEE 384 Req'd	Not addressed	Not addressed	Separation requirements parallel IEEE 384	None, consistent with another mandatory standard	Not endorsed	IEEE 420-2001 (As a Guide)
Panel Division Separation	Not addressed	Not addressed	Application of panels and Racks addressed with respect to separation and distance	None. End user responsibility		
Distance and Barriers	Not addressed	Not addressed	Design parameters incorporated into standard	None. Manufacturer responsibility		
Cable Bundling and Support	Not specified	Not specified	Requirements added specifying bundling and cable supports	None. Manufacturer responsibility		
EQ Mild	Not addressed	Addressed generically, but not per IEEE 323-1983	Specifically addressed as Mild Environment per IEEE 323-1983	None, clarification		
Seismic	Per IEEE 344-1971	Per IEEE 344-1975	Added IEEE 344-1987 requirements for additional testing	Possible requirement for analysis or retest		

IEEE Standard 535: Station Batteries

Topic	1979 Edition	1986 Edition	Impact	NRC Endorsed IEEE 535 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 535
References	IEEE 323-1974, 344-1975, 450-1975	IEEE 323-1983, 344-1975, 450-1975	None. Batteries always mild items	IEEE 535-1986 Reg. Guide 1.158, Rev.0	IEEE 535-1986
Float Charge During Thermal Aging	Apply float voltage of 2.19 to 2.25 Volts per cell during thermal aging	Apply float voltage of 50-100 mV above cell voltage during thermal aging	Minor. Float voltage requirements are adjusted per manufacturer's recommendations		

IEEE Standard 572: Electrical Connectors

Topic	1985 Edition*	2006 Edition	Impact	NRC Endorsed IEEE 572 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 572
Definitions	Per IEEE 323-1983	Per IEEE 323-2003	None, editorial.	IEEE 572-1985 Reg. Guide 1.156, Rev.0	IEEE 572-2006
Types of Connectors	Electrical power, control, and non-axial instrument connectors	All electrical connectors for all safety-related applications	None, guidance for all elect. Connectors provided		
Aging & QL	Per IEEE 323-1983	All degrading effects must be addressed. Atypical connectors discussed	None, clarification per IEEE 323-2003		

*Original edition

IEEE Standard 628: Raceway

Topic	1992 Edition	2001 Edition	Impact	NRC Endorsed IEEE 628 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 628
SQUG	Not addressed	SQUG experience database addressed as possible alternate qualification means	None, alternative qual method offered	Not endorsed	IEEE 628-2001 (As a Guide)

IEEE Standard 638: Transformers

Topic	1992 Edition	2006 Edition	Impact	NRC Endorsed IEEE 638 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 638
Aging & QL	Standard Arrhenius methods of QL calculation endorsed	Additional methods of predicting QL based on actual service usage conditions, insulation temperature rating, and hot spot temperature in Appendix A	None, alternative qual method offered	Not Endorsed	IEEE 638-2006 (As a Guide)

IEEE Standard 649: MCCs

Topic	1980 Edition	1991/2005* Edition	Impact	NRC Endorsed IEEE 649 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 649
References	IEEE 323-74, IEEE 344-75	IEEE 323-2003, IEEE 344-2004	None, simple update	Not Endorsed	IEEE 649-2005 (As a Guide)
Mild Rad Limit	1 X 10^4 R	1 X 10^3 R limit on electronics	None. No electronics previously qualified		
Baseline Data Management	Trending discussed with evaluation requirements for changes and trends	Discussed only with respect to acceptance criteria	None, relaxation or requirements		
Cycling in TA	Thermal aging interruptions for cycling specified	Cycling can be done after thermal aging	None, relaxation or requirements		
Rad vs. TA	Radiation after TA in test sequence	Radiation before TA in test sequence	None, analysis to justify		
Seismic Contact Chatter Limit	2 Milliseconds specified	No specific chatter limit specified. Per application	Possible requirement for analysis or retest		
Surge Voltage	Test not required	Must be addressed	Possible requirement for analysis or retest		
Qualified Life	Exempt TA if insignificant	Expected life can establish QL	None, relaxation or requirements		

*2005 edition was merely a reaffirmation only of the 1991 edition

IEEE Standard 650: Chargers and Inverters

Topic	1979 Edition	1990 Edition	2005 Edition	Impact	NRC Endorsed IEEE 650 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 650
References	IEEE 323-1974, IEEE 344-1975 for qual, ANSI for specifications	IEEE 323-1983, IEEE 344-1987 for qual, ANSI for specifications	Updated to reflect PM and reliability requirements from EPRI and NMAC	None, maint. rule convenience items	Not endorsed	IEEE 650-2005 (As a Guide)
Specifications	Briefly states the types of parameters that should be included in user specs	Briefly states the types of parameters that should be included in user specs	Defines general attributes that should be specified for nuclear applications	None, clarification		
Qual Methods	Components classified as SR or NSR per IEEE 577-1976	Requires safety and non-safety parts classification	Requires FMEA for parts, components, subsystems to determine which parts are safety	None, formalized requirement		
Aging	Brief list of age-insensitive items provided. Justification for age exemption required	Types of items that are age-sensitive listed. Selected items listed as "non age sensitive" controversial	Non-safety does not need aging, non-age-sensitive does not need aging, parts that can be maintained do not need aging	None, although this may contradict other IEEE aging positions		
Mild Radiation	1 X 10^4 Rads limit	1 X 10^4 Rads limit	1 X 10^3 Rads limit	May require re-test or analysis for electronics		
Cycling Margin	No margin for cycling specified beyond 10% from IEEE 323-1974	Added 20% margin to cycling and surge testing requirements	Deleted extra 20% margin requirement	None, relaxation or requirements		
Activation. Energy	Use 0.5 eV for unknowns	Use 0.5 eV for unknowns	Allows 0.8 eV for unknowns	None, relaxation or requirements		
Aging of Motors and Pumps	Not addressed specifically. Considered typical subcomponent of system	Not addressed specifically. Considered typical subcomponent of system	New section added to address pumps and motors. Parallels other subcomponents	None, clarification		
Harmonic Distortion Test	Harmonic distortion test required	Harmonic distortion test required	Deleted THD test	None, relaxation or requirements		

IEEE Standard 650: Chargers and Inverters

Topic	1979 Edition	1990 Edition	2005 Edition	Impact	NRC Endorsed IEEE 650 & Reg. Guide, Revision	U.S. EPR Recommended IEEE 650
Post-DBE Stress Test	Post seismic stress test required	Post seismic stress test required	Deletes requirement for post-DBE stress test	None, relaxation or requirements		